COLORADO
Department of Transportation
Office of the Chief Engineer

BRIDGE RATING MANUAL

STAFF BRIDGE BRANCH

2022

INTRODUCTION

Each major structure in Colorado is rated to determine its safe live load capacity.

The purpose of this manual is to organize the rating process so that the procedures and results conform to the policies of the Colorado Department of Transportation. However, this manual should not overrule sound engineering judgment.

The user of this manual is expected to have current copies of the AASHTO LRFD Bridge Design Specifications, *AASHTO Standard Specifications for Highway Bridges, the AASHTO Manual for Bridge Evaluation, and the Staff Bridge Design Manual,* and be familiar with the applicable sections of these manuals.

Rating procedures for structure types not identified in this manual shall be developed by the rater and shall be subject to review and approval by the Staff Bridge Engineer.

The questions, "How much total live load can this bridge hold? and, “How does this bridge’s capacity compare with other bridges?” are usually asked after a bridge is designed, constructed, or during service. The questions may be asked by:

- an engineer who has finished designing a bridge;
- a roadway official attempting to determine the quality of the bridges on the system;
- a funding agency which is deciding whether or not a bridge needs to be repaired or replaced; and
- a permit officer concerned about an overweight vehicle using a particular bridge.

In response to these questions a method for estimating the safe live load capacity of highway structures has been developed. This method involves the assignment of specific rating values to structures which define their live load capacity relative to selected standard vehicles. The four types of rating values used by the Colorado Department of Transportation are Inventory, Operating, Posting, and Overload Color Code.

All structures require an Inventory and an Operating rating value in terms of the HS20-44 or HL-93 loading which defines their long term high frequency load capacity, and ultimate permissible load capacity, respectively. If a structure is deficient for the maximum vehicle loads allowed by law, then its capacity is also assessed in terms of the Type "3", "3S2", and "3-2" Posting Vehicles. Structures on the state highway system are given an Overload Color Code rating which defines their capacity for loads heavier than the maximum legal loads, in terms of the Modified Tandem Vehicle, or the Colorado Permit Vehicle. Once computed, these values are recorded on a Rating Summary Sheet and kept in the structure's permanent file.

After the rating is recorded it becomes one of the most important items in a structure's records. It is utilized in reviewing the sufficiency of new designs, evaluating the relative capacities of structures on a roadway system, prioritizing the expenditure of funds for repair or replacement, and preventing structural failures when routing overloads. In summary, it becomes an essential item for insuring the safety and cost efficient maintenance of the structures on a roadway system.

Rating values are normally calculated only for a bridge's superstructure, and then, only with respect to dead and live loads. Rating values are not routinely computed for structures with spans 20 feet or less. The last page of this introduction shows how the Inventory, Operating, and Posting rating values are calculated. See Section 1-16 for an explanation of how color code rating values are computed.

When a new structure is designed, or an existing structure is modified by design, the engineers who performed the design are responsible for providing a rating. In this case, the rating is an integral part of the design and is executed at the final design phase, but before construction commences. When an existing structure is modified by field changes, e.g., collision damage, or additional asphalt, the party responsible for bridge maintenance and inspection is also responsible for insuring that the bridge is promptly rerated. In all cases, the color code for the new or modified structure should be determined.

This manual presents policies, guidelines, and examples illustrating how ratings are to be calculated in the State of Colorado. When rating a highway structure, the specifications, policies, and guidelines that are to be used are those stipulated in the current *AASHTO LRFD Bridge Design Specifications, AASHTO Standard Specifications for Highway Bridges, the AASHTO Manual for Bridge Evaluation, the Staff Bridge Design Manual and this manual.* In order to effectively perform a rating, it is imperative that the rater obtain and become familiar with these manuals.

The calculation of rating values is defined in general by the following formulas which are taken from the *AASHTO Manual for Bridge Evaluation*:

- **Load and Resistance Factor Rating (LRFR);**

$$RF_{LRFR} = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_{LL}) \cdot (LL + IM)}$$

$$Rating \;\; in \;\; Tons = (RF_{LRFR}) \cdot W$$

C = Capacity = $\varphi_c \varphi_s \varphi R_n$; where $\varphi_C \varphi_S \geq 0.85$ for Strength Limit State

C = f_R for service limit state

DC = Dead load due to structural components and attachments

DW = Dead load due to wearing surface and utilities

f_R = Allowable Stress per LRFD code

IM = Dynamic load allowance

LL = Live load

P = Permanent loads other than dead loads

RF_{LRFR} = Rating factor for LRFR

R_n = Nominal member resistance

W = Weight (tons) of vehicle used to determine live load effect.

φ_C = Condition factor

φ_S = System factor

φ = LRFD resistance factor

γ_{DC} = Dead load factor for structural components and attachments

γ_{DW} = Dead load factor for wearing surface and utilities

γ_P = Load factor for permanent load = 1.0

γ_{LL} = Live load factor

- **Load Factor Rating (LFR) and Allowable Stress Rating (ASR)**

$$RF_{LFR;ASR} = \frac{C - A_1 \cdot D}{A_2 \cdot L \cdot (1 + I)}$$

$$Rating \quad in \quad Tons = (RF_{LFR;ASR}) \cdot W$$

$RF_{LFR;ASR}$ = Rating factor for LFR or ASR

C = The capacity of the structural member

C = f_R for ASR

D = Dead load on Structural Member

f_R = Allowable Stress per the code

L = Live load effect on Structural Member

W = Weight (tons) of vehicle used to determine live load effect

I = The impact factor used with the live load effect

A_1 = Factor for dead load

A_2 = Factor for live load

$A_1 = A_2$ = 1.0 for ASR

The HL-93 load rating for the Load and Resistance Factor Rating (LRFR) method is reported as a rating factor. All other ratings are reported as a rating in tons.

Effective July 1, 2002 CDOT will use the AASHTOWare Virtis computer application to perform bridge ratings. With the exception of post-tensioned superstructures, all ratings performed after July 1, 2002 for bridges in CDOT right-of-way shall be based on Virtis. In addition to post-tensioned superstructures, other bridges of unusual geometry or construction type may be waived from this requirement. Post-tensioned superstructures shall be rated as provided for by the CDOT Bridge Rating Manual.

All of the instructions and examples in the CDOT Bridge Rating Manual use the strip method of analysis (see AASHTO LRFD 4.6.2) and the AASHTO LFD live load distribution factors. Until otherwise provided for by the CDOT Bridge Rating Manual, curved superstructures and bridges designed by a refined method of analysis (LRFD 4.6.3) shall be rated using Virtis and the strip method unless the Staff Bridge Branch Bridge Rating Program Engineer approves an exception. Equivalent distribution factors for composite dead loads and live loads shall be used to obtain the appropriate rating at the sections required by the CDOT Bridge Rating Manual (see AASHTO LRFD 4.6.3.1, modified here as may be required for composite dead loads).

Rating requirement have changed with time. The following is a summary of the rating method requirements in this manual.

- All on-system and off-system bridges designed after October 1, 2010 are to be rated with LRFR.
- All on-system and off-system LRFD bridges rated or rerated after October 1, 2010 are to be rated with LRFR.
- All on-system and off-system ASD & LFD bridges rated or rerated after January 1, 1994 are to be rated with LFR, to the extent LFR is applicable to the structure type per the AASHTO specifications.
- All on-system and off-system ASD and LFD bridges on the NHS are to be rated with LFR, to the extent LFR is applicable to the structure type per the AASHTO specifications.
- When any on-system bridges that were constructed after 1985 are rated or rerated they shall receive a permit vehicle operating rating for interior and exterior girders with full impact and multilanes loaded.
- When any on-system bridges constructed before or during 1985 are rated or rerated they shall receive permit vehicle and modified tandem operating ratings with full impact and one lane loaded.

For the maintenance of the CDOT’s Opis/Virtis database it is essential to use the most current version of Virtis. Ratings submitted to CDOT that are based on older versions will be rejected. Check with the CDOT Rating Engineer to verify the software version in use by CDOT.

REVISION LOG

This revision log is a record of all the revisions to the Bridge Rating Manual since March 1996. It shows the date of the current and previous versions of each Subsection, and the initials of the persons who wrote the Subsection for the Staff Bridge Engineer.

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GENERAL REQUIREMENTS

1.1 DEAD LOADS USED TO DETERMINE BRIDGE RATINGS

The dead load unit weights given in the current AASHTO LRFD Bridge Design Specifications and the current CDOT Bridge Design Manual shall be used, except where superseded by this Manual in Table 1-1.

Bridge decks with bare or asphalt wearing shall be rated for a minimum asphalt thickness of 3”; or an average asphalt thickness that is shown in the most current inspection report, whichever governs.

Bridge decks with Polyester Polymer Concrete (PPC) overlay shall be rated for a minimum overlay thickness of ¾”; or a thickness that is shown in the as-built plans, whichever governs. The overlay of PPC shall be omitted from the deck section properties.

The unit weight of fill soil on all buried structures shall be per Table 1-1, unless otherwise specified in the as-built plans. A pavement thickness of 6” above the buried structure shall be assumed if the roadway pavement thickness is unknown.

The uniform weight of permanent steel deck form shall be included if it is used for concrete decks placed between girders, and inside box girders.

Table 1-1: Unit Weights of Materials

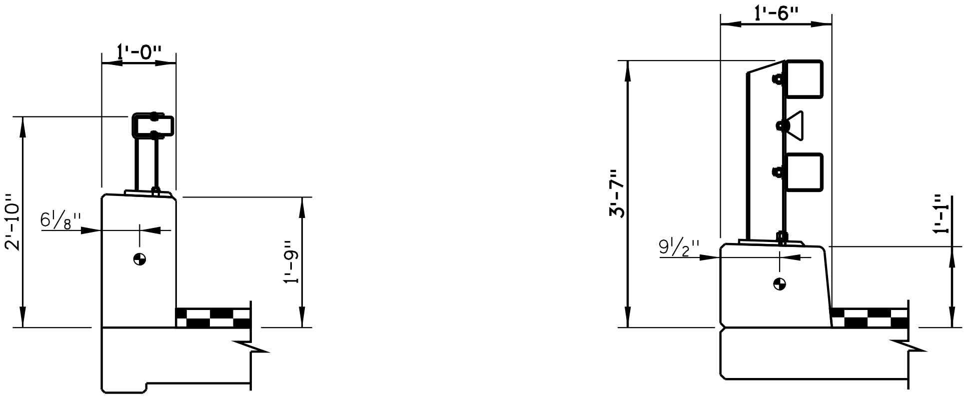
Material	Unit	Unit Weight
Asphalt	lbs/ft^3	146.67
Polyester Polymer Concrete (PPC)	lbs/ft^3	135.0
Fill Soil	lbs/ft^3	125.0
Permanent Steel Deck Form	lbs/ft^2	5.0
Reinforced Cast-in-Place Concrete	lbs/ft^3	150.0
Reinforced Precast Concrete	lbs/ft^3	163.0

The weight of bridge rails to be used for rating shall be based on the most current as-built plans. Verifications of bridge rail weight shall be required, except values from Table 1-2 can be used for the MASH (Manual for Assessing Safety Hardware) bridge rails (i.e. Type 8R, Type 9 and Type 10), and the previous standard bridge rails (i.e. Type 3, Type 4, Type 7, Type 8, and Type 10).

Table 1-2: Unit Weights of Standard Rail Systems

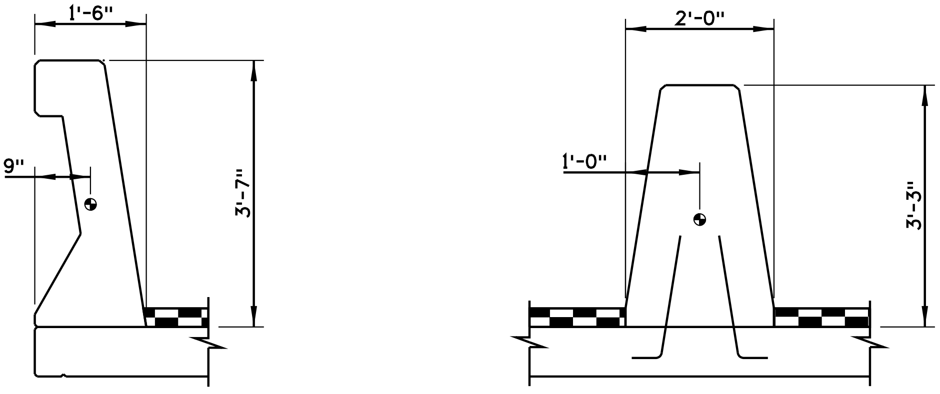
Rail Type	Structural Steel (lbs/ft)	Concrete Curb (*) (lbs/ft)	Total (lbs/ft)
Type 3	45.4	142.6	187
Type 4	N.A.	426.1	426
Type 7	N.A.	481.8	482
Type 7, style C-C	N.A.	538.4	538
Type 8	26.5	437.4	464
Type 8R MASH	19.5	262.5	282
Type 9 MASH	N.A.	483.8	484
Type 9, style CC MASH	N.A.	758.8	759
Type 10 MASH	45.8	243.7	290
Type 10 (10, 10M, 10R)	45.1	244.4	290

(*) The concrete curb weights are computed from the Figure 1-1. The concrete curb weight shall be re-computed if the existing curb geometry is different.



TYPE 8R MASH
(10'-0" MAX. POST SPACING)

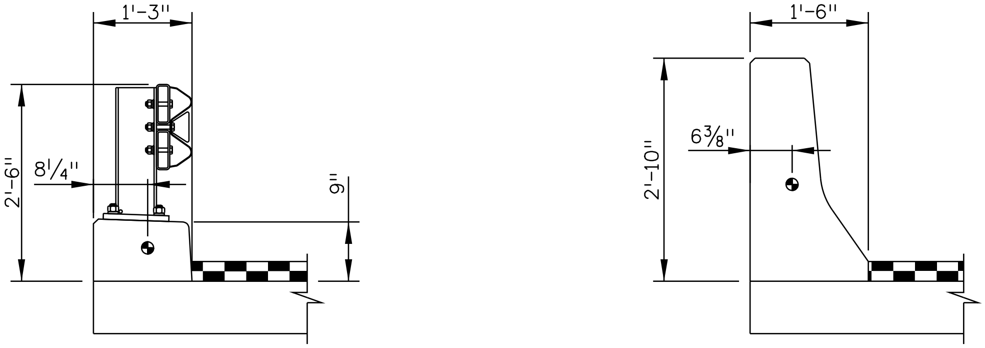
TYPE 10 MASH
(10'-0" MAX. POST SPACING)



TYPE 9 MASH

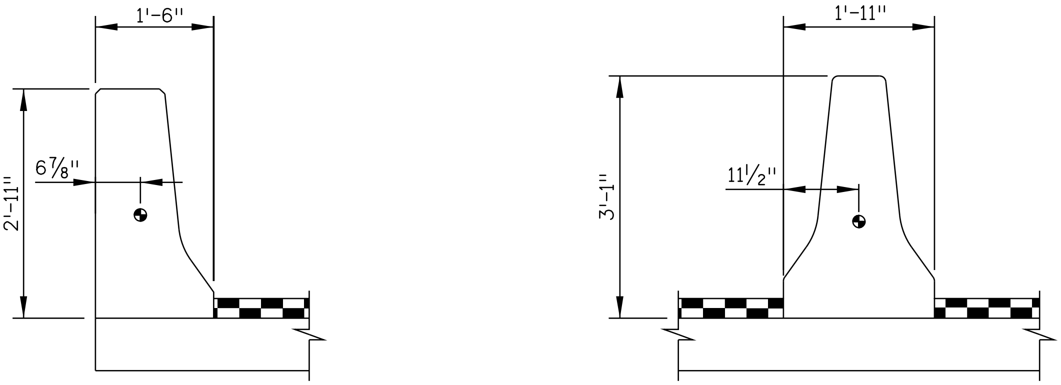
TYPE 9 STYLE CC

Figure 1-1
MASH Bridge Rails



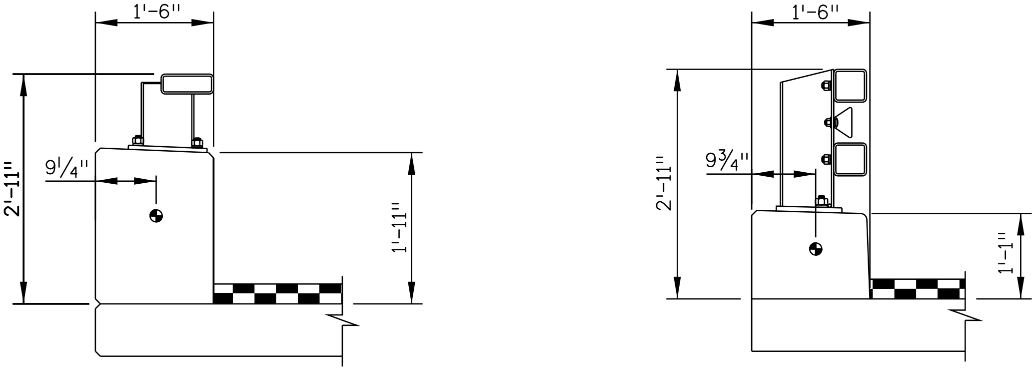
TYPE 3
(6'-3" MAX. POST SPACING)

TYPE 4



TYPE 7

TYPE 7 STYLE C-C



TYPE 8
(10'-0" MAX. POST SPACING)

TYPE 10
(10'-0" MAX. POST SPACING)

Figure 1-1 (Continued)
Old Standard Bridge Rails

1.2 LIVE LOADS USED TO DETERMINE BRIDGE RATINGS

Colorado Bridge Ratings are required at three different levels: Design Load Rating, Legal Load Rating, and Permit Load Rating and shall be reported on the Rating Summary Sheet. The vehicles of three levels are as specified hereon and in the current AASHTO Manual for Bridge Evaluation (MBE).

These three different levels shall be used to compute the load ratings for all structure types and for all 3 rating methods: Allowable Stress Rating (ASR), Load Factor Rating (LFR), and Load and Resistance Factor Rating (LRFR).

1.2.1 Design Load Rating Level

A) For ASR and LFR methods: The HS20-44 Loading consisting of a Standard HS20 Truck or Standard Lane Load shall be used when computing the Inventory and Operating Load Ratings in US tons. See Figure 1-2.

B) For LRFR method: The HL-93 Design Load shall be used when computing the Inventory and Operating Rating Factors. See Figure 1-3.
Additional HL-93 Load Models:
- 90% of Design Truck pair that is spaced a minimum of 50 feet between the lead axle of one truck and the rear axle of the other truck, combined with 90% of the Design Lane Load shall be used to compute the ratings factor at the pier(s) for negative moment.
- For steel bridges, the fatigue truck shall be required to compute the Inventory Rating Factor. The fatigue truck consists of one design truck, similar to the truck in Figure 1-3, but with a constant spacing of 30 feet between the 32-kip axles.

1.2.2 Legal Load Rating Level

The Legal Vehicles are required to be used when computing the Operating Load Rating in US tons. The structure is required to be posted when the load rating is less than the gross vehicle weight limit.

A) Colorado Legal Vehicles:
- Colorado Legal Trucks of Type 3, Type 3S2, and Type 3-2 shall be used for bridges on State highway routes or Interstate business routes. See Figure 1-4.
- Interstate Legal Trucks of Type 3, Type 3S2, and Type 3-2 are State-Specific Vehicles modified from the AASHTO and the Colorado Legal Loads. See Figure 1-5. These Interstate Legal trucks shall be used for bridges on Interstate highway routes or Interstate access ramps.

Legal Vehicles are composed of the maximum vehicle loads allowed by law in Colorado. The difference between the live loads in Figures 1-4, and 1-5, is due to the maximum legal loads allowed on Interstate highways being different from those allowed on other Colorado roadways.

B) Specialized Hauling Vehicles (SHV):
- Notional Rating Load (NRL). See Figure 1-6.
- Single Unit Bridge Posting Loads of SU4, SU5, SU6 and SU7. See Figure 1-6.

C) FAST Act's Emergency Vehicles (Fixing America's Surface Transportation Act):
- ▪ Emergency Vehicles of EV2 and EV3 are Notional vehicles. See Figure 1-7.

NOTE: AASHTO Legal Loads of Type 3, Type 3S2 and Type 3-3, and AASHTO Lane-Type Legal Load Model are NOT required for load ratings.
Colorado has a grandfather provision under Federal law (23 CFR Part 658, Appendix C) to allow the Interstate Legal Trucks of Type 3, Type 3S2, and Type 3-2 supplanting the AASHTO Legal Loads of Type 3, Type 3S2 and Type 3-3 on the Interstate highways.

If the load rating factor for the NRL is 1.0 or greater, then there is no need to rate for the single-unit SU4, SU5, SU6 and SU7 Vehicles. See Subsection 1.14 for how to report the rating results.

Legal Vehicle Weight Limits:

- *Maximum gross weight of vehicle that is legal on any Non-Interstate Colorado highways shall be satisfied with the Colorado Bridge Formula.*
  Gross Weight (lbs) = (L + 40) x 1,000 (C.R.S. 42-4-508 (1)(b))
- *Maximum gross weight of vehicle that is legal on any Interstate highways shall be satisfied with the Federal Bridge Formula B except Emergency Vehicles.*
  Gross Weight (lbs) = 500 (LN / N-1 + 12N + 36)
  Where:
  L = the distance in feet between the outer axles of any two or more consecutive axles.
  N = the number of axles.

The Gross Vehicle Weight (GVW) of SU6 and SU7 do not meet the Colorado Bridge Formula. See Subsections 1.15.1 & 1.15.2 for how to post weight limits of SU6 & SU7 on non-interstate roads.

The GVW of EV2 and EV3 do not meet Federal Bridge Formula B, but could cover situations when emergency vehicles need access to Interstate Highways, or Reasonable Access.

1.2.3 Permit Load Rating Level

The Operating Load Ratings in US tons of the Permit Load Rating Vehicles shall be used to determine the Color Code of the bridge. See Subsection 1.16.

A) Colorado Permit Vehicle. See Figure 1-8.
The Colorado Permit Vehicle is also required to be used for the design of new bridges for AASHTO LRFD Load Combination Strength II. Therefore, the Colorado Permit Trucks' configurations are currently used to institute the Colorado maximum allowable permit weight per axle group.

B) Colorado Modified Tandem Vehicle. See Figure 1-8.

HS20-44 Loading

Used to determine the Inventory and Operating load ratings in US tons

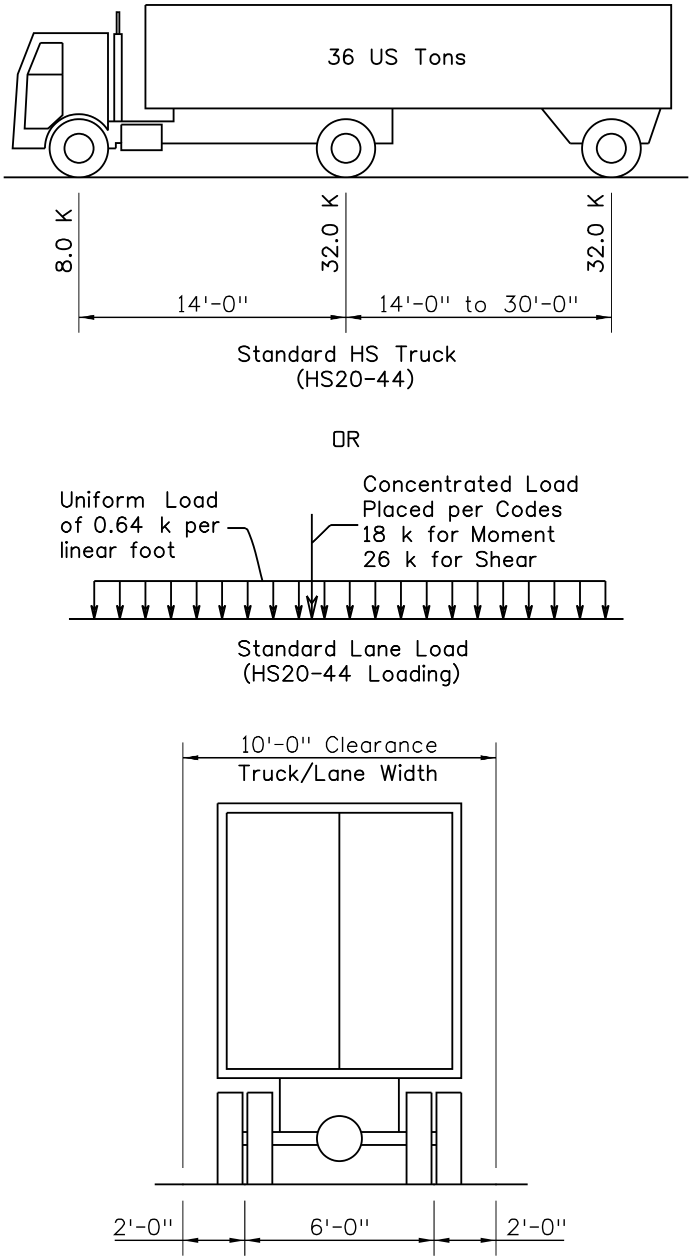


Figure 1-2

HL-93 Design Load - Notional Vehicle

Used to determine the Inventory and Operating rating factors

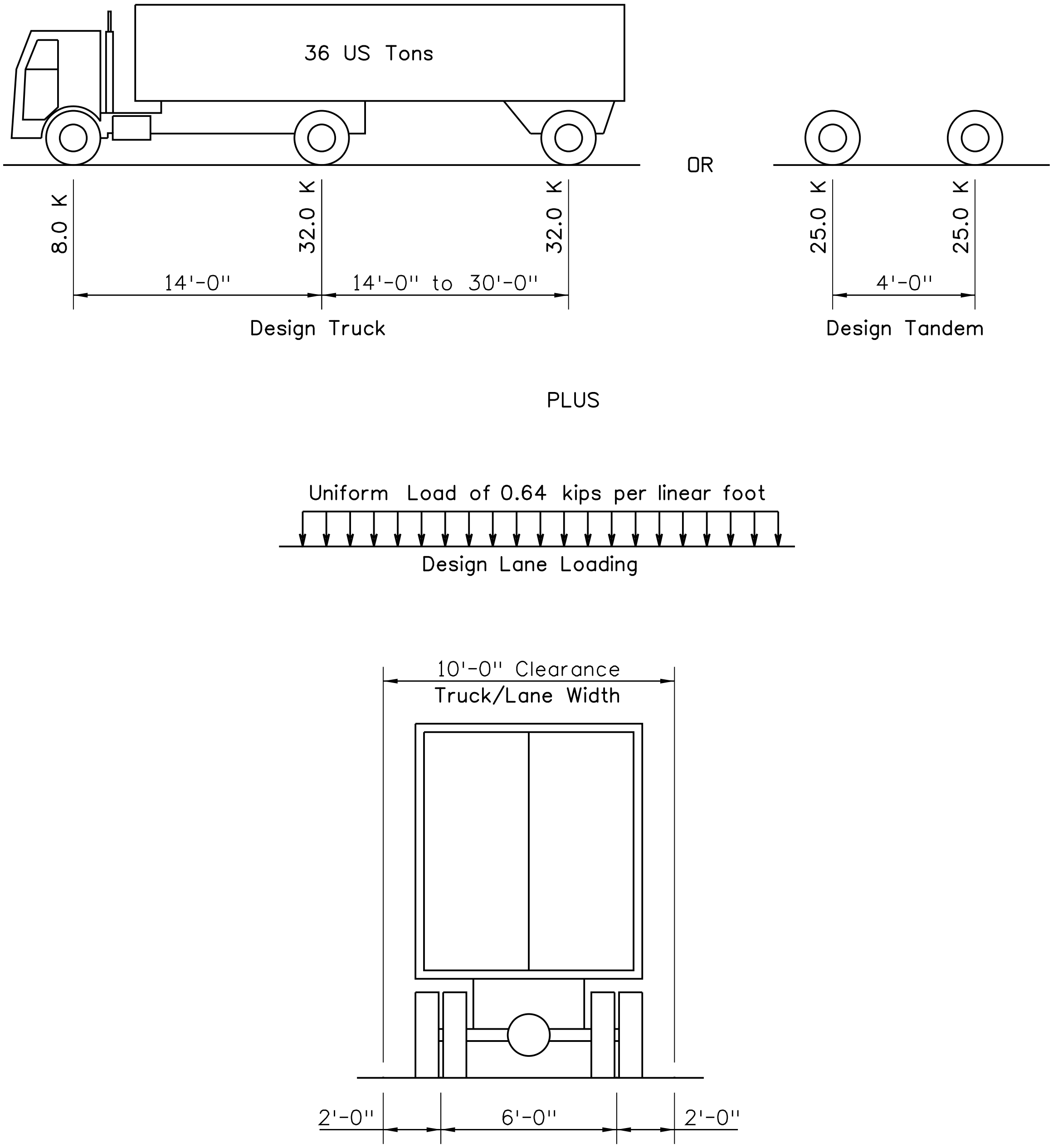
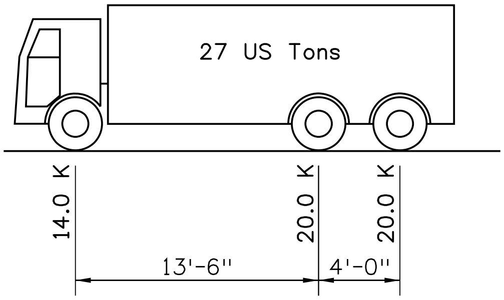


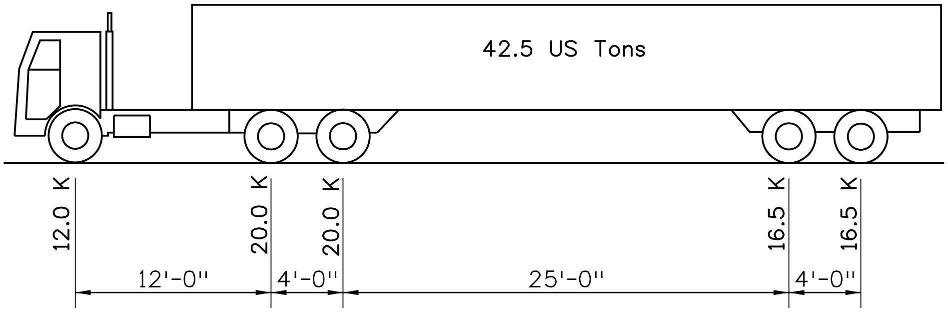
Figure 1-3

Colorado Legal Trucks

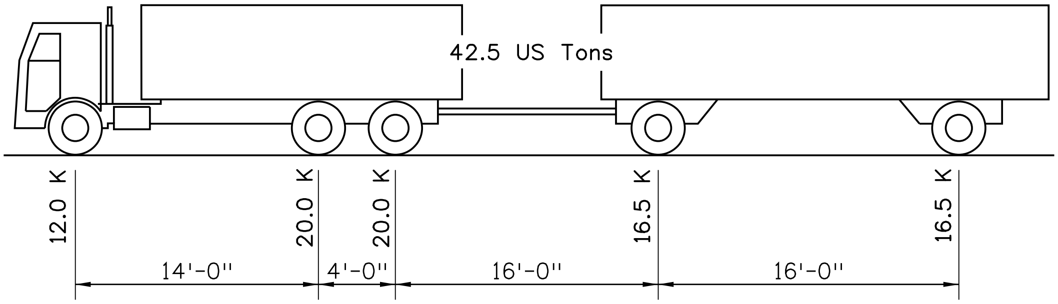
Used to determine the Operating load ratings in US tons along Colorado State Highways
Truck width: 10’-0”
Axle gage width: 6’-0”



Type 3



Type 3S2

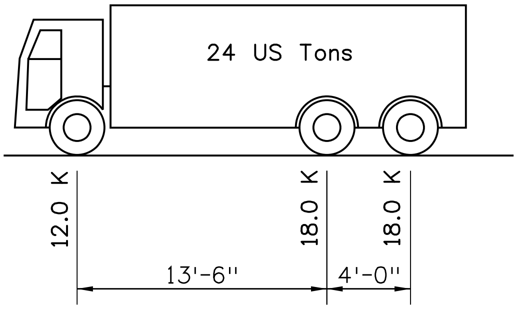


Type 3-2

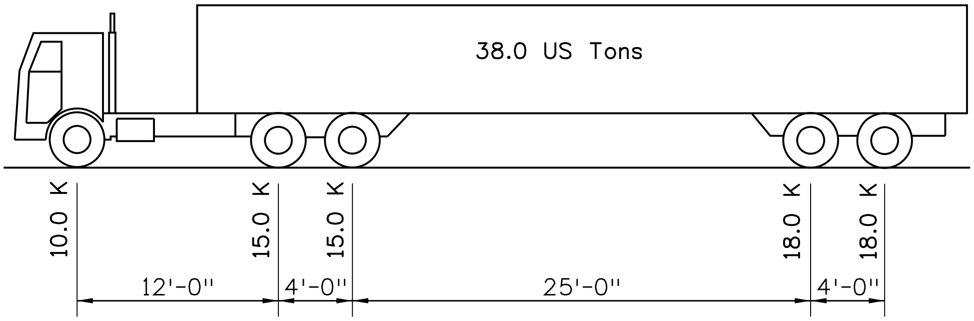
Figure 1-4

Interstate Legal Trucks

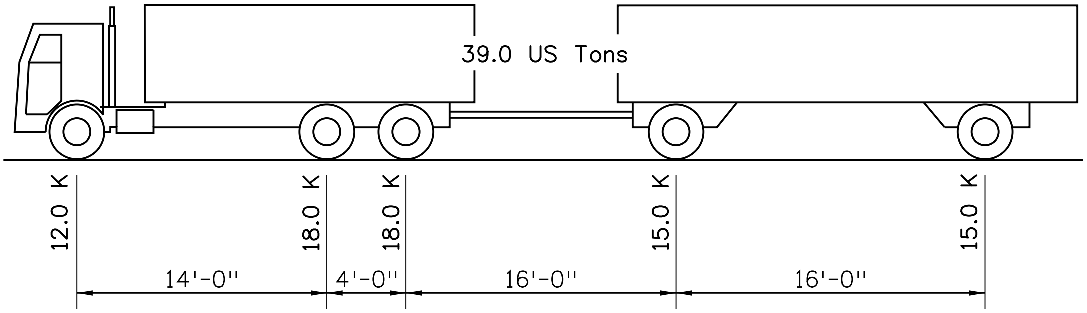
Used to determine the Operating load ratings in US tons along Interstate Highways
Truck width: 10’-0”
Axle gage width: 6’-0”



Type 3



Type 3S2



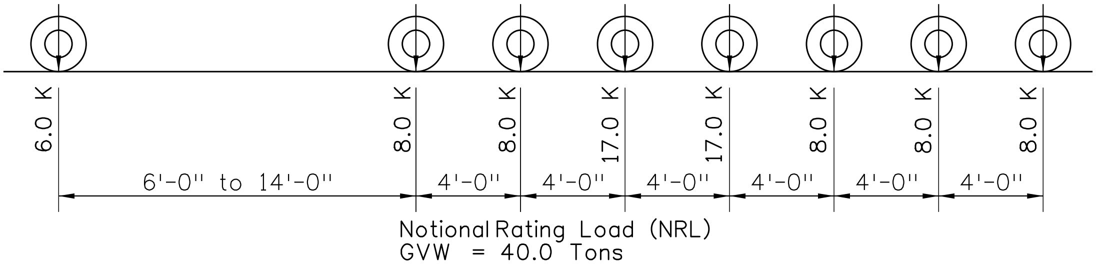
Type 3-2

Figure 1-5

Specialized Hauling Vehicles

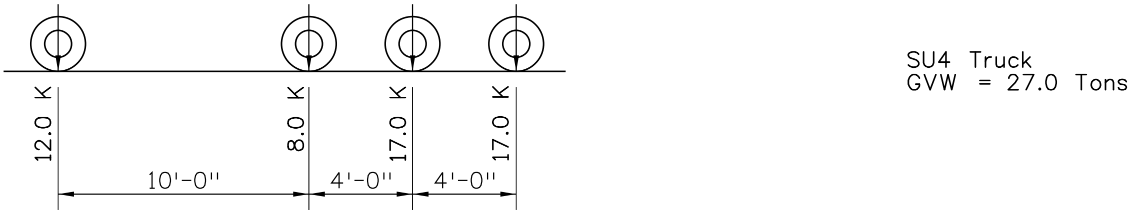
Used to determine the Operating load ratings in US tons
Truck width: 10'-0"
Axle gage width: 6'-0"

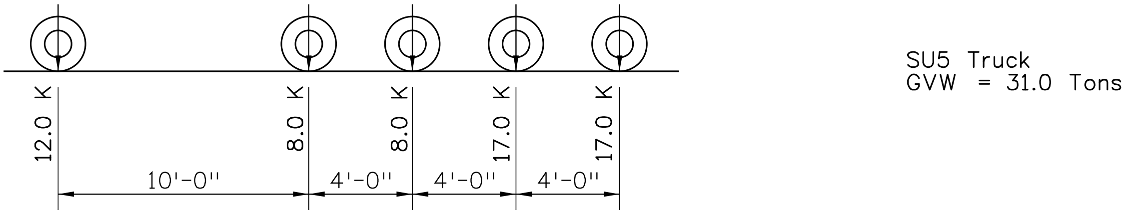
A. Notional Rating Load (NRL)

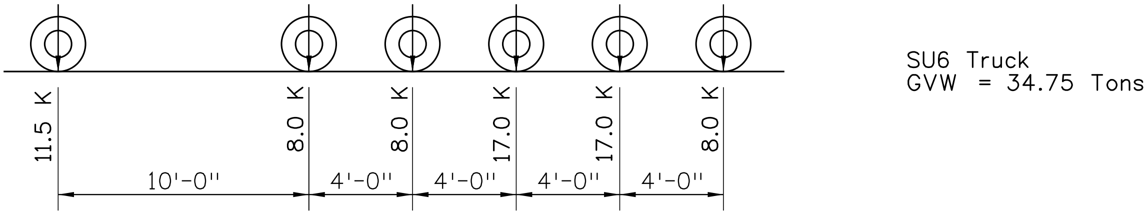


B. Single Unit Bridge Posting Loads

GVW = Gross Vehicle Weight







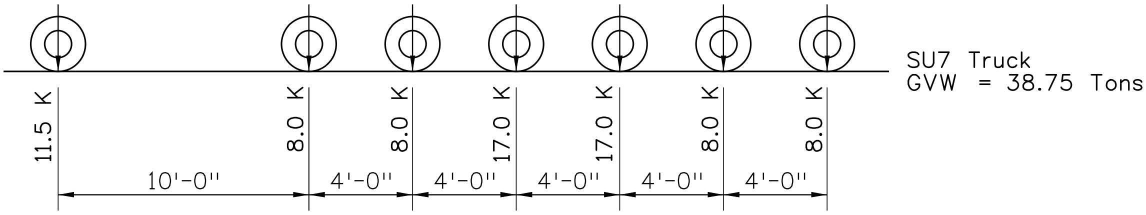
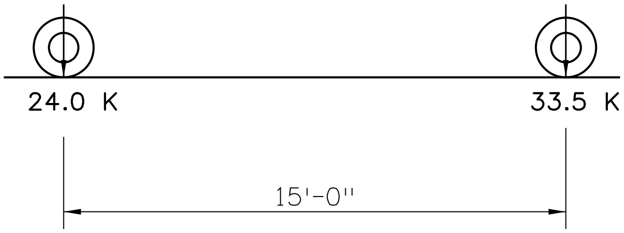


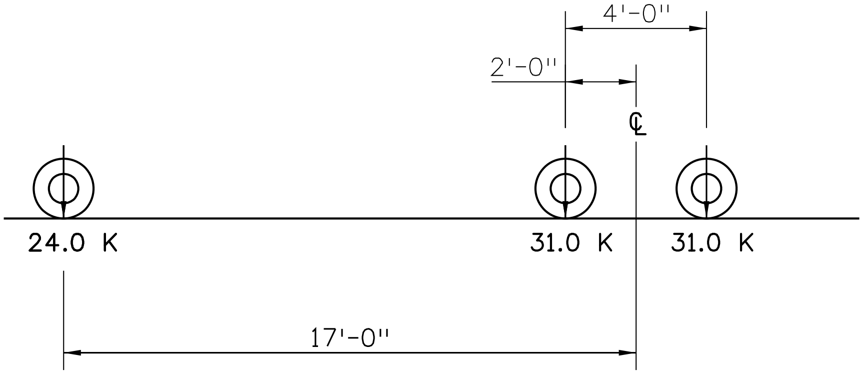
Figure 1-6

Emergency Vehicles – Notional Vehicles

Used to determine the Operating load ratings in US tons
Truck width: 10’-0”
Axle gage width: 6’-0”



EV2 Vehicle
GVW = 28.75 Tons



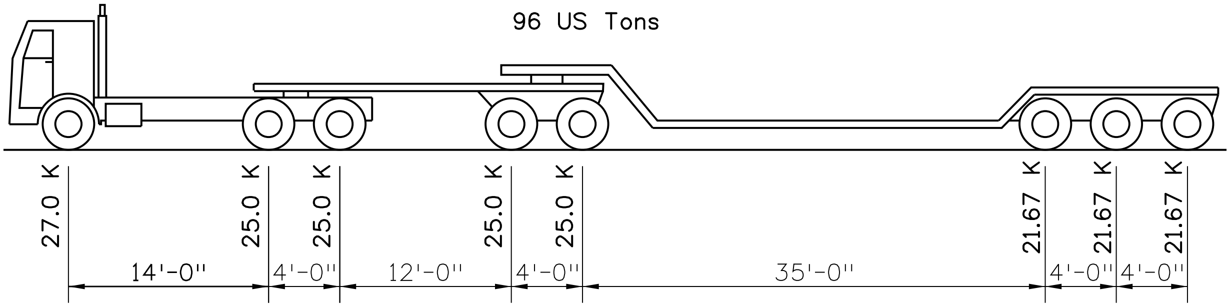
EV3 Vehicle
GVW = 43.0 Tons

GVW = Gross Vehicle Weight

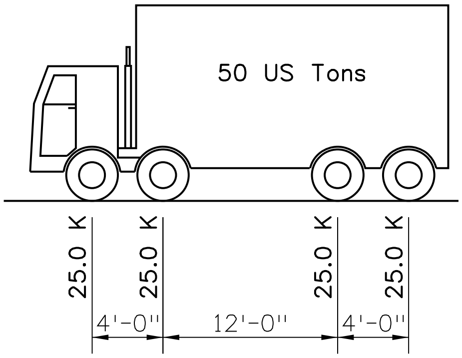
Figure 1-7

Colorado Permit Trucks

Used to determine the Operating load ratings in US tons
Truck width: 10'-0"
Axle gage width: 6'-0"



Colorado Permit Vehicle



Colorado Modified Tandem Vehicle

Figure 1-8

1.3 IMPACT, LOAD FACTOR, AND DISTRIBUTION OF LIVE LOADS

The live load impact used for rating shall be as specified in the current AASHTO LRFD and Standard Specifications for Highway Bridges, as applicable, except as noted. The live load impact shall be applied for all bridge types, except to timber bridges.

The live load distribution factors used for rating shall be as specified in the current AASHTO LRFD and Standard Specifications for Highway Bridges, except as noted and elsewhere in the manual.

The load factors used for rating shall be as specified in the Standard Specifications for Highway Bridges and the current AASHTO Manual for Bridge Evaluation, except as noted and elsewhere in the CDOT Rating Manual.

A) Based on CDOT historical practice of overload permit analysis using LFR method (e.g., gross vehicle weight over 200,000 lbs), when reduced vehicle speed to 10 mph is enforced, impact can be reduced by 67% when crossing the structure.

B) Impact shall not be considered for timber bridges.

C) For bridges constructed or rehabilitated after 1985, all ratings shall use multi-lane live loaded distribution factor. A single lane live load distribution factor for Permit Vehicles may be used with approval by the Bridge Rating Engineer.

D) For bridges constructed in 1985 or earlier, or bridges with one-lane traffic, rating and re-rating for Legal Load vehicles and Colorado Permit vehicles may be performed using a single lane live load distribution factor. The vehicle may be assumed to occupy the center of a single driving lane without concurrent live loading in any other lane. Non-redundant (fracture-critical) structures shall only utilize multi-lane live loaded distribution factors due to the likelihood of failure of entire structure if one part fails. The design vehicle ratings shall be rated with multi-lane live load distribution factor.

E) When bridge geometric constraints (e.g., span length, number of girder and girder spacing) are outside the range of live load distribution formulas specified in the AASHTO Specifications, the lever rule method or other software may be used to calculate the live load (single or multi-lane) distribution factors.

F) When the lever rule method is used to determine distribution factors for exterior stringers, exterior deck girders, through girders, and trusses, place the first truck wheel 2’-0” from the front face of curb or railing. The transverse distance from centerline to centerline of the standard gage trucks shall be 12’-0” or the width of one traffic lane for narrow bridges.

G) For any load rating methods, the placement of the wheel load shall be 1 foot from the face of the curb or railing for rating of deck overhang, and 2 feet for rating of girders.

H) For LFR load ratings, when ratings for Legal or the Permit vehicles are less than the gross vehicle weight limits, the Rater may use the Distribution Factor-Line Girder setting in BrR (NSG analysis) to improve the load ratings with approval by the Bridge Rating Engineer. The NSG analysis shall not be used for culverts, timber, or fracture-critical structures.

I) For LRFR load ratings, the refined distribution factor method is not allowed for load ratings of bridges, except if it is approved in advance by the Staff Bridge Rating Engineer.

J) Live load distribution factors for two-girder bridge systems and trusses shall be calculated using the lever rule method.

K) The distribution of non-composite and composite dead loads shall be as specified in the current CDOT Bridge Design Manual.

L) For all bridge types, load factors for load rating shall comply with the AASHTO MBE, except a minimum live load factor of 1.3 for operating rating may be used for Emergency Vehicles on all levels of traffic volume for LRFR and LFR methods.

M) For all buried pipe/arch culverts and CBCs, the LRFR live load factor for operating rating of 1.35 shall be used for design vehicle, 2.0 for legal loads, and 1.4 for permit loads on all levels of traffic volume. Only the single loaded lane with multiple presence factor of 1.0 may use for legal load and permit load ratings; while 1.2 is used for design load rating.

N) The maximum and minimum depths of fill on CBCs may be determined at the roadway pavement areas. Distribution of wheel loads through earth fills shall be neglected where the depth of fill exceeds the limits as specified in the current AASHTO LRFD, Section 3.6.1.2.6. See Subsection 1.14 for how to report the rating results.

O) The Emergency Vehicles may be performed using a single lane live load distribution factor for existing or new bridges.

P) For reinforced and prestressed concrete structures, the service I & III limit states may ignore in ratings for the Legal and Permit Vehicles.

Q) For timber structures with stagger stringers at piers, an average stringer spacing of the exterior bays on both sides may be used for ratings.

R) For two-girder bridge systems, trusses, floor-beams, and culverts, an equivalent double-dolly truckload to a regular 10 feet wide truckload shall NOT be allowed for overload permit ratings.

1.4 STRUCTURAL ANALYSIS METHODS USED TO DETERMINE BRIDGE RATINGS

The load ratings shall include analysis of the superstructure for components defined as primary members such as girders, in-span hinges, stringers, deck, truss, floor-beams, truss connections, etc. The substructures / foundations will not be required for load ratings except as requested by the Bridge Inspection Engineer, being necessary due to vehicle impact and scour substructure elements, etc.

Major structures (i.e. total span length greater than 20 feet) are required to have load ratings, and minor structures (i.e. span length from 4 feet to less than or equal to 20 feet) will be required to have load ratings per Subsection 1.8.

A) All bridges designed with LRFD method or designed after September 30th, 2010 shall be rated or re-rated with LRFR method.

B) All existing ASD & LFD bridges designed before October 1st, 2010, except existing timber bridges, shall be rated or re-rated with LFR or LRFR methods.

C) All timber bridges shall rated or re-rated with ASR method.

D) All existing buried pipe/arch culverts may be rated or re-rated with LFR or LRFR methods. New buried culverts shall be rated with LRFR method.

E) For multiple lines of buried pipe structure that meets the minimum spacing between pipes per AASHTO LRFD, Section 12.6.7, a single pipe instead of multi-pipe may be modeled for load rating analysis.

F) All existing concrete and metal plank decks of bridges designed before October 1st, 2010, shall be rated or re-rated with LFR method. Bridges constructed with partial or full-depth precast pre-stressed concrete decks are not required for ratings except as requested.

G) All concrete decks of bridges designed after September 30th, 2010 are not required to be rated except as requested. New metal plank decks shall be rated with LRFR method.

H) All decks shall be rated for design trucks only.

I) When existing bridges are re-decked, the girders shall be re-rated with the same method used to design the new deck, except if approved in advance by the Bridge Rating Engineer.

J) When existing LFD or ASD bridges are widened with LRFD method, the widened portion shall be rated with LRFR method, and the original part may be re-rated with LFR method.

K) For precast pre-stressed concrete girders, the transformed section properties and the AASHTO refined method for losses may be used for load ratings.

L) For multi-span precast pre-stressed concrete continuous girders that are designed with LRFD method, the degree of continuity at pier(s) shall be determined in accordance with the current CDOT Bridge Design Manual, Section 5.7.3.

M) For LRFD reinforced and pre-stressed concrete bridges constructed after December 2001, the load ratings for shear shall be required.
Commentary: Per CDOT-Staff Bridge's Technical Memorandum dated Jan. 31st, 2000, all structures shall be designed and checked with the LRFD design method beginning in January 2002.

N) For existing reinforced and pre-stressed concrete bridges constructed in December 2001 or earlier, when the LFR load-rating factor for shear is less than 1.0, the bridges may be rated with LRFR Modified Compression Field Theory (MCFT) method.

O) For existing reinforced and pre-stressed concrete bridges constructed in December 2001 or earlier, the load ratings for shear shall be required for bridges that have visible signs of shear distress; or if the Colorado NBI condition coding is less than 5. The shear load rating may be ignored by the Bridge Rating Engineer approval for bridges that have no visible signs of shear distress, and the Colorado NBI condition coding is 5 or greater.

P) For all steel bridges, the load ratings for shear shall be required.

Q) For ASD and LFD steel bridges, the field splices and pin connections are not required for ratings, except as requested by the Inspection Unit due to severe corrosion or section loss by vehicular hit.

R) All LRFD steel bridges shall include field splices and pin connections in ratings.

S) Pedestrian bridges that are designed to carry maintenance or emergency vehicles shall be rated in accordance with the current CDOT Bridge Design Manual. The pedestrian load shall not be considered concurrently with the vehicle load.

T) For roadway bridges with sidewalk, the use of pedestrian load shall not exceed the value given in AASHTO Standard Specifications, Section 3.14.1.1. If the sidewalk is not protected by a traffic barrier, the sidewalk loadings shall be considered for two cases:
  - Vehicles on the sidewalk without pedestrian load.
  - Full pedestrian load on the sidewalk without vehicle load.

U) For a curved bridge with straight girders, and variable overhangs, the bridge may be modeled with maximum overhang on one side and minimum overhang on the other.

V) Existing ASD or LFD multi-span continuous bridges designed with simple span made continuous that have load ratings for negative moments less than the gross vehicle weight limits may be rated or re-rated for single span by applying a hinge at the pier location or by using single span models with approval in advance by the Bridge Rating Engineer.

W) If a curved bridge can be designed as straight segments, as per the requirements of the AASHTO LRFD Section 4.6, the horizontally curved girders may be rated as straight girders with a span length based on the arc length of the longest interior girder. This engineering judgment shall be approved in advance by the Bridge Rating Engineer.

X) For LRFR method, the frequency of the permit vehicle properties will be selected for unlimited crossing, and the loading condition will be selected for mixed with traffic.

Y) For complex structures such as curved, and varying skews at supports that cannot be modeled in the BrR program, a 3-D finite element model or appropriate software may be used for rating with approved in advance by the Bridge Rating Engineer.

Z) Any engineering judgment that is made for structural analysis shall be approved in advance by the Bridge Rating Engineer.

AA) For CBCs constructed before 1992, the loading data that is specified in the corresponding M-Standards, as-built plans, or in the corresponding design specifications may be used for LFR, or LRFR ratings.

1.5 MATERIAL PROPERTIES USED TO DETERMINE BRIDGE RATINGS

For all structures, the material properties used for the rating shall be based on the material grade or design stresses specified in the plans. When plans are not available or do not specify material grade or design stresses, the Rater must then use their best judgment to determine the appropriate material properties based on the information available. Normally, this decision is based on the year the bridge was constructed.

The year of construction may also be determined by engineering judgement by using comparable structures with known plans or other similarly constructed bridges such as parallel bridges.

Table 1-3 shows the material properties based on year of construction, used by the Colorado Department of Transportation. This material property table is based on the predominant grade of materials used by the Colorado Department of Transportation during the years indicated.

After making a thorough investigation into all possible sources of information concerning an existing structure, if the rater is still unable to determine the grade of material used, or year of construction, then a conservative estimate of the construction year should be made. Then, the material property in Table 1-3 can be used.

For steel structures, it is possible that the year of construction and the year of member fabrication do not coincide; e.g., when salvaged members have been utilized. In this case, the year of fabrication shall be used in determining the steel yield stress (F_y).

For metal and plastic pipe/arch culverts, the material properties shall use default values from the CANDE rating software.

Year of Construction for CDOT Bridge Rating

(When the Actual Grade of the Material is Unknown)

LFR and LRFR Ratings

Material	Year of Construction	LFR or LRFR	ASR	
		F_y or f'_c (psi)	Inventory (psi)	Operating (psi)
			0.55 F_y	0.75 F_y
Structural Steel - Bending	Prior to 1905	26,000	14,000	19,500
	1906 to 1936	30,000	16,000	22,500
	1937 to 1963	33,000	18,000	24,500
	After 1963	36,000	20,000	27,000
				0.45 F_y
Structural Steel - Web Shear	Prior to 1905	26,000	8,500	11,500
	1906 to 1936	30,000	9,500	13,500
	1937 to 1963	33,000	11,000	15,000
	After 1963	36,000	12,000	16,000
Reinforcing Steel	Prior to 1954	33,000	18,000	25,000
	1955 to 1971	40,000	20,000	28,000
	After 1971	60,000	24,000	36,000
Structural Concrete	Prior to 1959	2,500	1,000	1,500
	1960 to 1976	3,000	1,200	1,900
	1977 to 1981	4,000	1,600	2,200
	After 1981	4,500	1,800	2,450
Prestressed Concrete	Based on the Actual Grade of Material Used			
Prestressing Steel Strands	Based on the Actual Grade of Material Used			

Allowable Stress Ratings (ASR)

Material	All Years of Construction	Inventory (psi)	Operating (psi)
Timber (Douglas Fir Select Structural)	Bending (F_b)	1,600	2,128
	Shear (F_v) *	113	150
	Shear (F_v) **	98	[c] 130
	Shear (F_v) ***	85	113

* Use when more than 75% of the total number of stringers have NO splits or shear critical cracks.

** Use when 25% or more of the total number of stringers are repaired for splits or shear critical cracks.

*** Use when 25% or more of the total number of stringers are not repaired for splits or shear critical cracks.

[c] Agreeing to Anthony J. Lamanna, Arda Akbiyik, James C. ray, and Gerardo I. Velazquez (May 2007), "Feasibility Investigation into Strengthening of Timber Bridge Stringers". Use approximately a 44% increase of operating shear strength after timber stringers with horizontal splits or cracks are repaired.

Table 1-3

1.6 AVAILABLE RATING COMPUTER PROGRAMS

A) BrR Software:
CDOT requires the use of AASHTOWare Bridge Rating (BrR) software to perform load ratings for bridges and reinforced concrete box culverts (CBC).

https://www.aashtowarebridge.com/bridge-rating-and-design/

The main advantages of the program are:

- Its utility for automated batch analysis.
- Easily updated load rating when the condition of a structure changes or with new live loads requirements.
- The BrR software is currently used for CDOT Oversize Overweight Permitting and Routing (COOPR) program.

Due to limitations of the BrR software or for other reasons, such as post-tensioned bridges other than the post-tensioned multi-cell box girders, steel box girders, flexible culverts, or complex structures, hand calculations or other software that complies with AASHTO codes may be used to determine the load ratings with approval in advance by the Bridge Rating Engineer.

The BrR software is the AASHTO analytical engine for Load and Resistance Factor Rating (LRFR), Load Factor Rating (LFR), and Allowable Stress Rating (ASR). This software supports two or three dimensional bridge descriptions.

The BrR software can perform load ratings for most common bridge types. The software allows the user to define many bridge alternatives (models) with different structure types to the same bridge.

The BrR software can select the desired analysis type from the Analysis Settings window for CDOT's bridge ratings:

- Line Girder setting (Standard Analysis) is required for all ASR, LFR or LRFR load ratings.
- Distribution Factor-Line Girder setting (NSG) can be used for non-standard gage vehicles, or improving the LFR load ratings for legal or permit vehicles as stated in Subsections 1,3 (H), 1.15.1 & 1.16.
- 3D Finite Element Method setting (FEM) may be used for complex structures (i.e. curved bridges) with approval in advance by the Bridge Rating Engineer.

The BrR tolerance feature can be set by clicking on the CONFIGURATION BROWSER / SYSTEM DEFAULTS / TOLERANCE in the interface WINDOW. Failure to set the tolerance values will cause errors during the analysis. When a newer version of the software is installed, the BrR tolerances must be reset on each user's computer.
The following tolerance values shall be used with bridge ratings located in CDOT's jurisdiction:

US Unit	Tolerance	SI Unit	Tolerance
ft.	0.01	m	0.003048
in.	0.25	mm	6.35
mi.	0.01	km	0.01

For structures that designed in SI unit, the Raters should perform the rating in the SI unit. Advantageously, the BrR load rating outputs will automatically report in US unit.

When rating a structure in BrR, the structure number provided by the Bridge Asset Management Unit (Staff Bridge) will be used for the Structure ID Number. The following naming convention shall be used to organize the explorer window in BrR.
Overload critical bridges used for routing will be assigned the prefix (Z). Only structures on the critical list (e.g. older posted and color coded bridges) should be assigned the prefix (Z). When a rating is in progress or when re-rating a structure, BrR users will add a (7) as the prefix. Once a rating is completed and sent to the Bridge Rating Unit, the Staff Bridge Rating Coordinator will remove any prefix before placing in the BrR global database. Therefore, any structure without a prefix is the final rated structure.
Examples:
F-17-BY: a final accepted rated structure
7F-17-BY: a structure being re-rated or a new rating in progress.
ZF-17-BY: a structure on the critical list used for overload routing.

Before finalizing the rating package for submittal, BrR users shall verify with the Staff Bridge Rating Coordinator that the correct version of the software is used in the analysis. This ensures proper maintenance of CDOT'S BrR database for future use. Ratings submitted to CDOT that are based on older versions will be rejected.

Consultants working with CDOT, or various City and County agencies within the State of Colorado, can obtain BrR at a discounted rate from the AASHTO; however, a written certification is required from CDOT Staff Bridge Rating Engineer.

B) CANDE Software:
CANDE software is a program that requires two parts of analysis including CANDE modeling & CANDE toolbox. CANDE Modeling software is used to model half of culvert in 2D finite element (levels 1 & 2 analysis), and CANDE Toolbox software uses to convert the half culvert model to full culvert model (level 3 analysis), and compute the Rating factor (RF) for any vehicles. Both parts shall be used together to rate the buried pipe/arch culverts for all shapes and materials including reinforced concrete, metal and plastic.

The CANDE software can be downloaded for free at the following address:

http://www.candeforculverts.com/download.html

Buried pipe/arch culverts that are rated with the LRFR method shall use the latest version of CANDE software.
See BRM Section 14A for culvert rating example with CANDE.
CANDE software is an AASHTO sponsored culvert analysis and design software. Programs other than the CANDE must be approved in advance by the CDOT Bridge Rating Engineer.

C) Staff Bridge Software Library:
Below is a current list of computer rating software available from the Staff Bridge Branch Software Library available online at:

https://www.codot.gov/business/engineeringapplications/available-software.html

Any questions regarding the software, including software access, should be directed to the Staff Bridge Rating Engineer.

1) PLANK-Corrugated Steel Plank Rating: Rates asphalt filled, corrugated metal plank decks placed perpendicular to traffic.

2) SLAB-Concrete Slab Rating: Rates slabs continuous over three or more supports with reinforcing placed perpendicular to traffic. The slab must be supported by longitudinal girders, and cannot be pre-stressed.

3) Timber Bridge Rating: Rates plank timber decks with asphalt filled placed perpendicular to traffic. Do not use this program for timber stringer rating.

D) Other Structural Software:
When BrR is not applicable for load ratings, other structural software that complies with the AASHTO codes may be used to support the hand calculations with Staff Bridge Rating Engineer's approval. The following software programs are used by CDOT:

CSI Bridge
SAP2000
LARSA
MDX
LEAP
BRASS
MathCad
Excel, and
Other software as approved

1.7 LOAD RATING OF BRIDGES WITHOUT PLANS

Structural dimensions and material properties are needed to perform load ratings. However, existing bridges built years ago may not have the construction plans (as-built plans).

The Rater shall cooperate with the Bridge Asset Management Unit to search for the as-built plans and any design/rating calculation notes that are available in the ProjectWise database, bridge Briar server, or structure paper inspection folder; and shall make a notification to the Bridge Rating Coordinator if the bridge's information is not available.

Alternatively, the as-built plans may be determined by engineering judgement of comparable structures with known Standard plans, or plans of other similarly constructed bridges such as parallel bridges.

When the as-built plans cannot be located, the following may be used to determine the load carrying capacity:

1.7.1 Bridge Ratings with Field Investigation and Year of Construction

Steel or timber structures may be rated with BrR software using field dimensions, and year of construction:

- Measurable superstructure dimensions such as span length, girder dimension, girder spacing, diaphragm dimensions and locations, deck width, deck overhang, and deck thickness.
- Based on year of construction, the material properties can be determined by using Table 1-3.

1.7.2 Bridge Ratings Based on Physical Inspection

A) Load Capacity Ratings through Engineer Judgment for existing On-system Concrete Bridges:

As per AASHTO Manual for Bridge Evaluation, 3rd Edition 2018 Section 6.1.4: *"A concrete bridge with unknown details need not be posted for restricted loading if it has been carrying normal traffic for an appreciable period of time and shows no distress. The bridge shall be inspected regularly to verify satisfactory performance"*; therefore, the concrete bridges without as-built plans, evaluated with a Colorado NBI condition coding of 5 or better for girders, and showing no signs of distress due to load, can be considered having sufficient live load capacity for the design vehicles.

History of CDOT's design vehicles according to year of construction:

< 1944	H20 Design Vehicle
1944 to Dec., 1993	HS20 Design Vehicle
Jan., 1994 to Dec., 2001	HS25 Design Vehicle
Jan., 2002 to present	HL93 Design Vehicle

The Rater uses the appropriate design vehicle above to back-calculate for reinforced steel area:

1. Determine the material properties based on year of construction by using Table 1-3.
2. Measurable superstructure dimensions such as span length, girder dimension, girder spacing, diaphragm dimensions and locations, deck width, deck overhang, and deck thickness.
3. Based on the field girder dimensions, determine the cracking moment (M_{CR}) of the concrete girders.
4. Determine the factored moment (LL + DL) using the multi-lane design vehicle with full impact.
5. Estimate the reinforcing area or pre-stressed steel area based on the greater of the factored moment (LL + DL) and the cracking moment.
6. The estimated reinforcing or pre-stressed steel area and field dimensions shall be used for load rating with BrR software.

B) Field Inspection Load Ratings for Concrete Culverts and off-system bridges:

When an existing major Concrete Box Culvert (CBC), concrete arch/pipe, masonry arch, concrete deck, or off-system concrete bridge without as-built plans that is evaluated with a Colorado NBI condition coding of 5 or better (item 59 for bridges, or item 62 for culverts); shows no signs of distress due to load, and no change of earth fills or dead loads for an appreciable period of time, the Professional Engineer registered in the State of Colorado can assign maximum load ratings as followings:

- Assign inventory load rating = 36 tons, and operating load rating = 40 tons for the Design Vehicle.
- Assign weight limits for the Legal Vehicles by using Table 1-4. Omit the Single-Unit and Emergency Vehicles on the Rating Summary Sheet (RSS).

- Assign load rating = 96 tons for the Permit Vehicle. Value not necessary for off-system structures.

When there are signs of distress, change of earth fill, or deterioration on the structure rating components, an appropriate judgment should be made to reduce live load carrying capacities as guidance in sections 8.4 & 14.2.

1.7.3 Non-Destructive Test Loading in the Field

For concrete bridges or concrete culverts, when the amount of reinforcing steel is unknown and the Colorado NBI condition coding is less than 5, or shows signs of distress due to load, a non-destructive diagnostic load test in the field shall be required to estimate the reinforcing area based on the field strain data. The estimated steel area and field dimension shall be used for load rating with BrR software. For other methods of determining the steel area, CDOT is not currently confident with scanning. Destructive load tests are not advised per stability concerns.

Notes for bridges without plans:

1. For steel bridges, if the top flanges of the steel girders are embedded into the bottom of the concrete deck, the steel girders and concrete deck should be considered as non-composite slab-girder.
   Commentary: per CDOT historic practical design for simplest steel girder types of non-composite sections, when the top flanges of the steel girders do not have shear studs, the top flanges shall be embedded into the bottom of the concrete deck for receiving full lateral bracing.
2. For concrete bridges, the concrete girders and concrete deck shall be considered as composite slab-girder.
3. For concrete bridges with no visible shear distress, the non-destructive test loading for shear is not required.
4. The existing multi-span continuous bridges may be rated as a single span as specified in Subsection 1.4.

1.8 MINOR STRUCTURE LOAD RATINGS

A minor structure such as a bridge, culvert or cattle/deer guard is a structure where the total crossing length, parallel to the centerline of the roadway, is 4.0 ft. to 20.0 ft. The following shall be considered for load ratings:

A) All existing minor structures will not require load ratings, except when the structural physical condition does not ensure the safe use of such a structure for vehicles.
   - Load ratings are required for all existing minor bridges or culverts with a Colorado NBI condition coding of 4 or lower for item 59, superstructure or item 62, culvert. The Bridge Inspector shall review the bridge inspection report, and make a request as needed. The load rating shall be completed within 60 days after the Rating Engineer receives the notice.

B) All new or widened minor structures shall require load ratings as follows:
   - Steel pipes, steel arches, reinforced concrete pipes, reinforced concrete arches, cast-in-place CBCs, and precast CBCs that do not meet minimum requirements for section modulus, material properties, or construction details from the CDOT M-Standards or ASTM Standards.
   - New Cattle/Deer guards within CDOT ROW not meeting the minimum M-standard requirements will require a rating unless they service private roads or accesses.

- All girder, slab, and truss bridges.

C) Load ratings are not required for minor structures when the earth fill depth exceeds the limit as specified in the AASHTO LRFD, Section 3.6.1.2.6:
  - For single span structures, load ratings are not required where the depth of fill is more than 8.0 ft. and exceeds the span length.
  - For multiple spans structures, load ratings are not required where the depth of fill exceeds the distance between inside faces of end walls or abutments.

1.9 OFF-SYSTEM STRUCTURE LOAD RATINGS

There is no different load rating performance between on-system and off-system bridges. The current AASHTO Manual for Bridge Evaluation, and the CDOT Bridge Rating Manual (except the Overload Color Code Rating, Subsection 1.16) shall be applied to the off-system structure ratings.

(SUBSECTION 1.10 RESERVED FOR FUTURE USE)

1.11 SUMMARY OF RATING PROCEDURE (IN-HOUSE)

1.11.1 Purpose

The purpose of the rating process is twofold. First, it determines and documents the maximum safe inventory and operating live load capacities of bridges. Second, the rating process can help find possible miscalculations or omissions in new superstructure designs. The design can then be corrected and the plans revised before the structure is built.

1.11.2 Responsibility

The Rater is the person selected to compute the ratings of a bridge. The Rater is responsible for gathering all of the required materials, making all of the necessary calculations, and completing the rating package as outlined in Subsection 1.13. The Rater must also ensure that the most up-to-date Rating Summary Sheet, computer program manuals, and any other materials required to perform bridge ratings are used.

The Checker is the person responsible for verifying that the rating is accurate, that follows established procedures, and that the rating package is complete. If the Checker finds any inaccuracies or omissions, the Checker will return the rating package to the Rater for corrections.
Either the Rater, the Checker or the Engineer responsibly in charge must be a Colorado Registered Professional Engineer and shall stamp the Rating Summary Sheet (RSS).

1.11.3 Procedure

See Figures 1.9, 1.10, 1.11 and 1.12 for flow charts of the following:
Rating: The Rater makes the necessary sketches and calculations to show how the structure was modeled, dead loads were derived, and how other computer input was defined. The rater shall indicate the source of the structural data. The only sources of information used for rating shall be Advanced Plans, Construction

Plans, As-Constructed Plans, and Field Surveys. The ratings are then completed using the proper rating procedure for the type of structure being assessed.

For new or rehabilitated bridges, if any load rating value is not equal to or greater than the rating factor limit of 1.0 or the gross vehicle weight limit, the bridge should be investigated to determine whether or not a re-design is needed. To finish the rating documentation and complete the rating package, the Rater shall do all of the following:

A) Completely fill in all of the required forms.
B) Initial and date the computer output.
C) When rating a new design, on a separate sheet of paper, document the construction status for BMS (Bridge Management System) and state if the rating is for a new bridge or for the reconstruction of an existing bridge. This sheet is to be kept with the Rating Summary Sheet.
D) Bind the rating package together.
E) Forward the rating package to the Checker.

Checking: The Checker shall verify all calculations and ratings, e.g., proper modeling of the structure, accurate calculations, and proper computer input. If the rating is not complete, it shall be returned to the Rater. The Checker shall sign and date all of the rating material including RSS, load rating result outputs from computer programs, and QA/QC check list form once the rating is accepted as complete and accurate.

Final Step: When the rating and checking is completed, the rating package shall be forwarded to the Bridge Rating Unit by the Rater via email. The Rating unit will review the package and if the documentation is incomplete or has errors, the package will be returned to the Rater. The completed rating package shall be archived and updated into the BrR & BrM (Bridge Management) database by the Bridge Rating Unit.

If the load rating is for a new bridge or bridge rehabilitation, the completed rating package shall be sent to the Bridge Rating Unit at Final Submittal and placed in ProjectWise prior to Advertisement in accordance with the current CDOT Bridge Design Manual.

For a description of what shall be included in the rating package, see Section 1.13.

1.11.4 Rating Engineer (Rating Program Manager)

The Staff Bridge Rating Engineer is responsible for the following: managing the BrR global database for all structures, testing the new versions of the BrR software for updating the BrR database, provide assistance to in-house staff and Consultants on bridge rating issues, update the CDOT Rating Manual; coordinate BrDR migration, coordinate bridge rating software needs; and act as a liaison for Office of Information Technology (OIT) on bridge rating related matters.

If the rating of an existing structure requires posting or color code, the Bridge Rating Engineer shall report to the State Bridge Engineer for final determination and will notify the Region RTD, Region Maintenance Superintendent and the Permit Office. The Bridge Rating Engineer shall be the signing authority on RSS for posted or color coded structures based on the Bridge Engineer decision.

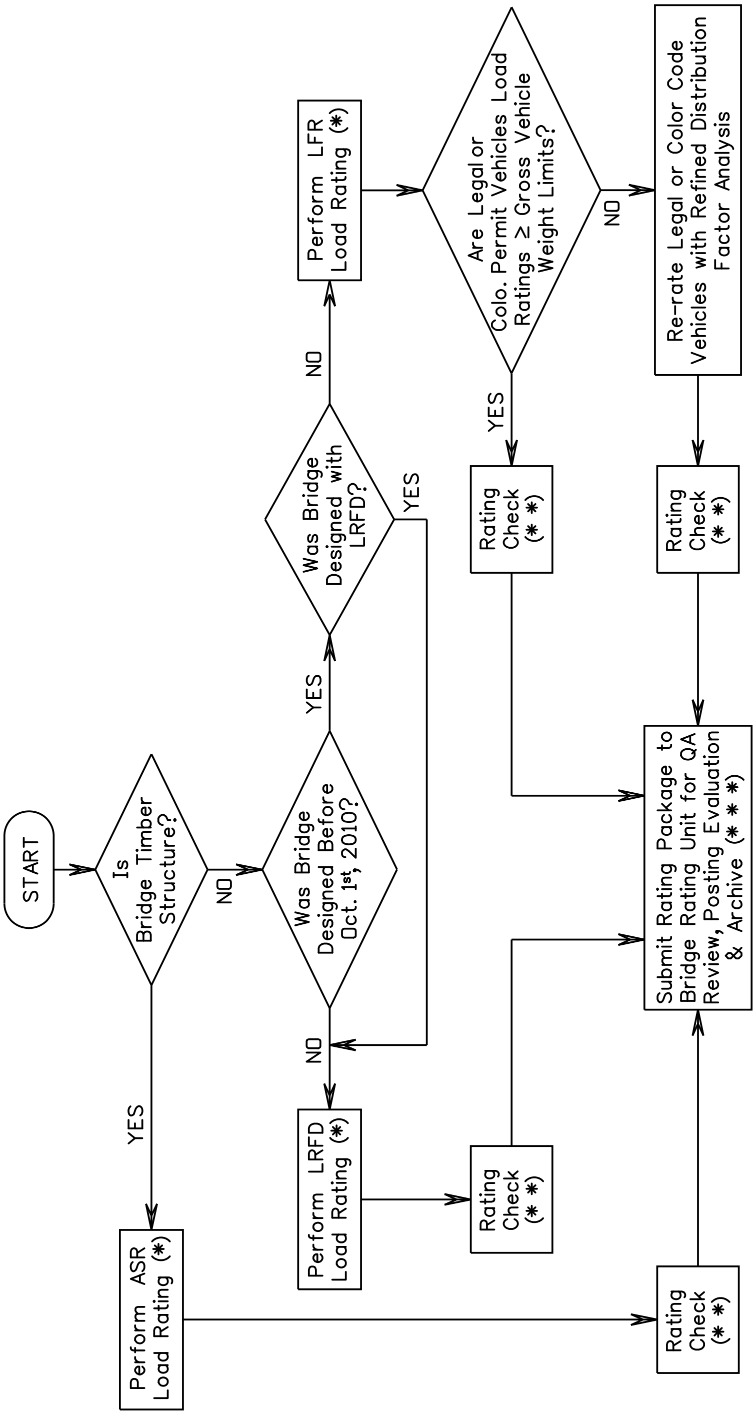


Figure 1.9 Flowchart for Load Rating

(*) Rater Responsibilities, see Figure 1.10
(* *) Checker Responsibilities, see Figure 1.11
(* * *) Bridge Rating Unit Responsibilities, see Figure 1.12

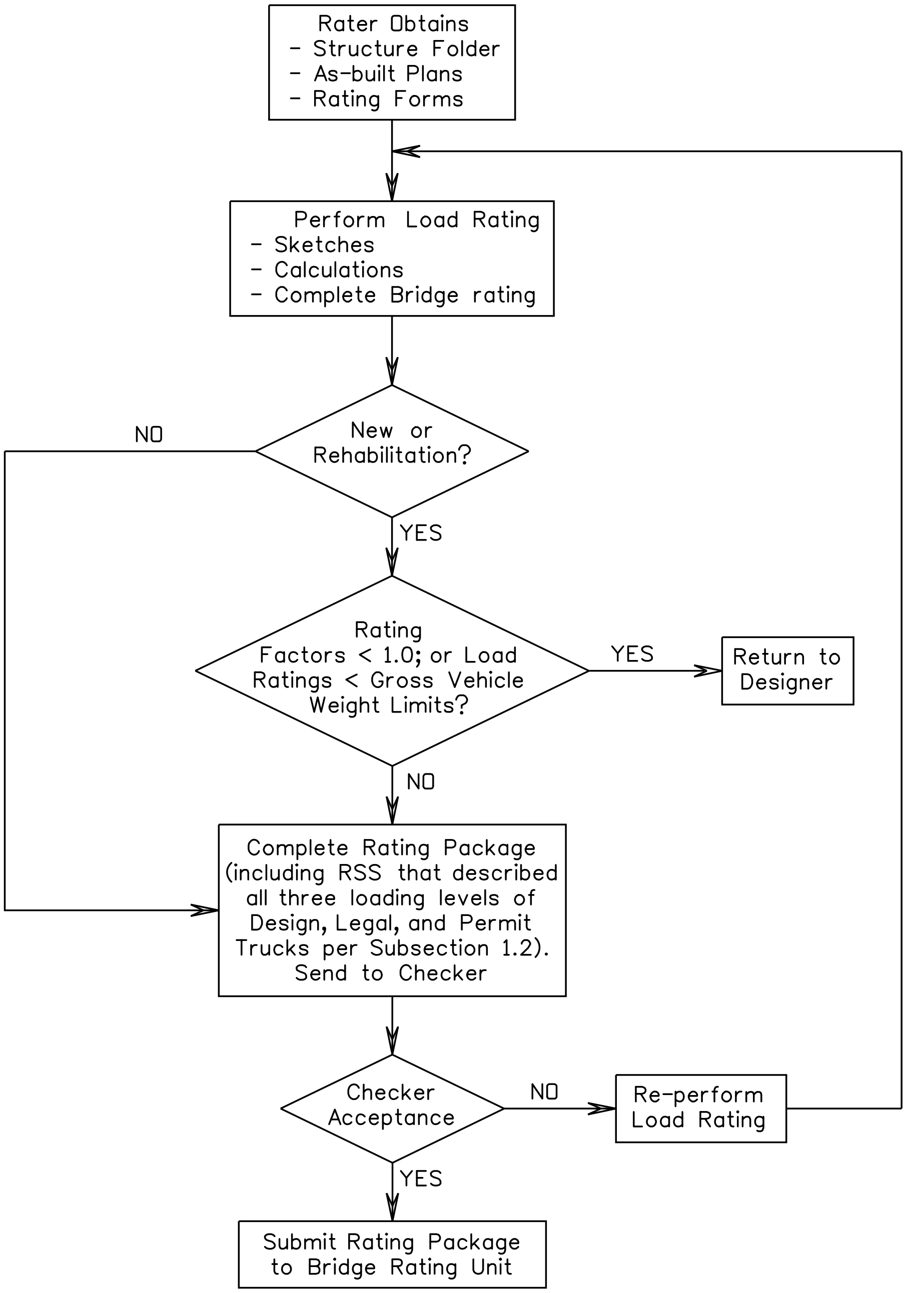


Figure 1.10 Flowchart for Rater Responsibilities

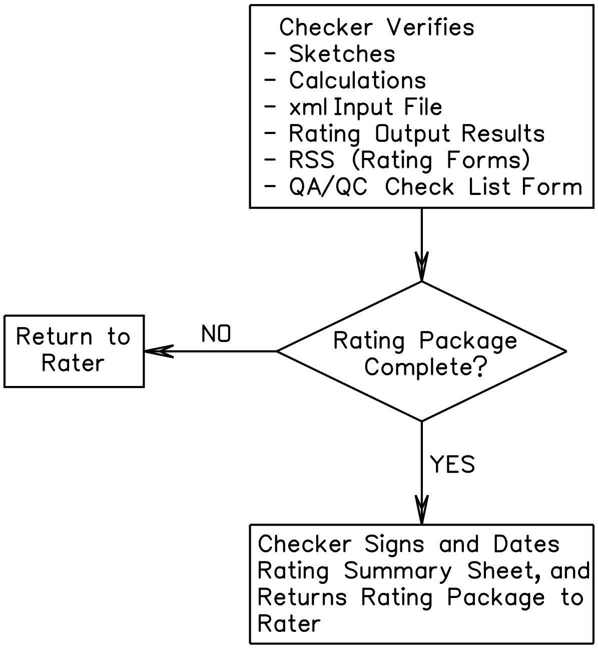


Figure 1.11 Flowchart for Checker Responsibilities

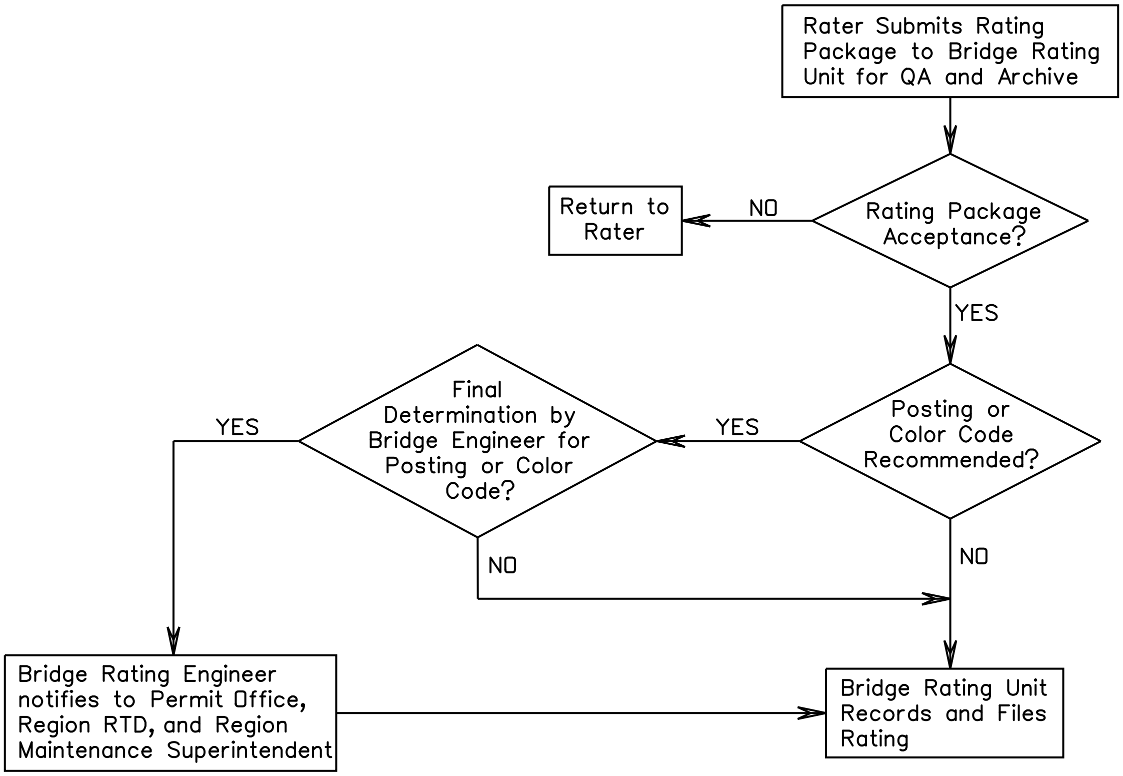


Figure 1.12 Flowchart for Bridge Rating Unit Responsibilities

1.12 SUMMARY OF RATING PROCEDURE (CONSULTANTS)

The rating procedure for consultants is similar to the procedure described for Staff Bridge Design's "In-House" ratings. The differences arise in preparing for rating, defining responsibilities, and in directing lines of communications. Nonetheless, a complete description of the process, with defined responsibilities and definitions follows.

See Figure 1.9, 1.10, 1.11 & 1.12 for flow charts of the following:

Rating: For ratings performed by Consultants, the term Rater, as used in this subsection, relates to an individual who is an agent of the hired consultant. This person will be responsible for structure ratings and will be the point of contact with the Colorado Department of Transportation Staff Bridge Design. The Staff Bridge Design contact for the Rater will be arranged at the outset of the contract. Any rating questions or requests should be communicated between the consultant's rater and the identified Staff Bridge Design contact.

The Rater will be responsible for gathering all the required materials, performing all the necessary calculations, and completing the rating package as stipulated in Subsection 1.13.

The Rater must have the most up-to-date computer program manuals, Rating Summary Sheets, and any other materials required to perform bridge ratings. The Rater can do this by simply checking with their Staff Bridge Design contact.

The formal rating analysis now begins. The Rater shall make the necessary calculations and sketches to show how the structure was modeled, how dead loads were derived, and to identify any other pertinent information. The rater shall indicate the source of the structural data. The only sources of information used for rating shall be, advance plans, construction plans, as-constructed plans, and field surveys. At no time shall design notes be used to rate a structure.

After this information is compiled, the Rater shall then use the appropriate analysis and computer programs to determine the structural capacity of the bridge. Subsection 1.6 in this manual covers the appropriate structural type for a description of the computer programs and analysis to be used.

If the rating is for an existing bridge, completely constructed and in service, then all the rating documents shall be completed, signed, and dated by the Rater, and then forwarded to the Checker.

If the rating is for a new design, the Rater shall check to see that the new design is adequate. If any load rating value is not equal to or greater than the rating factor limit of 1.0 or the gross vehicle weight limit, the cause should be identified and the structural designer contacted for a possible redesign. Otherwise, all the rating material shall be completed, signed, and dated by the Rater and forwarded to the Checker.

The Consulting firm's name shall also appear on all submitted sheets of the rating package.

Checking: The term Checker, as used in this subsection, refers to a person who is an agent of the hired consultant. The Checker has the responsibility for verifying that the rating calculations, structure modeling, and computer inputs are proper and accurate. If the Checker finds any errors or omissions, the Checker shall return the rating to the Rater for corrections. Once the rating is complete, the Checker shall sign and date all rating materials before forwarding them for the final step.

Either the Rater, the Checker or the Engineer responsibly in charge must be a Colorado Registered Professional Engineer and shall stamp the Rating Summary Sheet.

Final Step: The rating package shall be submitted by the Consultant to the appropriate Staff Bridge Design contact via e-mail. This ensures that the contact is aware of the rating submittal.

If the load rating is for a new bridge or bridge rehabilitation, the completed rating package shall be sent to the Bridge Rating Unit at Final Submittal and placed in ProjectWise prior to Advertisement in accordance with the current CDOT Bridge Design Manual.

The package of materials received by the Staff Bridge Design contact will then be transmitted to the Bridge Rating Unit for recording. Bridge Rating Unit DOES NOT verify the accuracy of bridge ratings. If the information is not complete at this step, the rating will be returned to Staff Bridge Design’s contact for completion. The contact will have the Rater complete the rating documentation before returning it to the Bridge Rating Unit. The completed rating package will be recorded and filed by the Bridge Rating Unit. For a description of what shall be included in the rating package, see Subsection 1.13.

If the rating is for an off-system bridge, a duplicate submittal of the rating package shall be delivered to the applicable entity by the Rater if requested or required by the entity.

1.13 RATING PACKAGE REQUIREMENTS

The following defines what the minimum requirements are for a complete rating package submittal. The rating examples contained in this manual further illustrate what is described below.

A) For a completed Rating Summary Sheet, refer to Subsection 1.14 of this manual for a description on how this sheet shall be filled out. The summary sheet should be printed on colored paper to designate the analysis method used. See Appendix A for copies of these forms.

B) A set of calculation sheets showing the derivation of dead loads, live load distribution factors, sketches for how the structure was modeled, engineering judgment, computer input information, emails, and other relevant considerations. Where applicable, the calculation sheets should show how any deterioration or damage was modeled. Indicate from what source the information was gathered. The only sources of rating information shall be, Advance Plans, Construction Plans, As-constructed Plans, Field Surveys, and the most updated Structure Inspection Report. Design notes are not acceptable. One copy of pertinent plan sheets used during the rating process, preferably 8.5”x14”, shall be included with the rating package (includes new structures and existing structures rerated for designed changes).

C) BrR users shall use the tabular report format to generate the output report to be included in the rating package. For users of other computer programs, output from each of the programs used to rate a structure shall be included in the rating package.

D) To enable CDOT to reproduce an analysis of the structure in the future, all rating packages shall include rating input files in electronic format as follows:

1) File names shall be based on Structure Number (i.e. H-02-FK.PDF or H02FK.SLB or H02FK.XML).

2) File extensions should generally refer to the rating package used (i.e. *.SLB refers to SLAB Rating Program and *.xml refers to BrR Rating Program).

3) The electronic file submittal must be placed in ProjectWise unless otherwise specified by the Rating Engineer.

This is required for all bridges, regardless of what software is used for rating.

A) A rating for the bridge deck, except for LRFR rating, shall accompany each package.

B) When the rating is for a new design, on a separate sheet of paper, state the status of construction for the project and state if the rating is for a new bridge or for the reconstruction of an existing bridge. This sheet is to be kept with the Rating Summary Sheet.

C) The Rater and Checker's signature, date, and a Colorado PE seal from either the Rater, Checker or the Engineer in responsible charge are required on the Rating Summary Sheet. For other items in the rating package (e.g., calculation sheets, first page of each set of computer output), the Rater and Checker’s initial and date are required. In addition, the structure number is required to be shown on all items in the rating package.

D) All of the items that compose the rating package shall be placed in an inspection file folder and an electronic rating folder that is clearly labeled with the structure number. Each structure rated shall have its own folder with a complete rating package. This requirement includes structures whose rating results or calculations duplicate those used for another structure.

1.14 REPORTING THE RESULTS OF RATING CALCULATIONS

The results of rating calculations are to be reported by the Rater on the appropriate CDOT Rating Summary Sheet (Timber/ASD Rating Summary or Load Factor Rating Summary or Load and Resistance Factor Rating Summary). See Figures 1.13, 1.14, and 1.15. The electronic editable of these forms are also available in the Appendix A for Rater’s use.

- Yellow paper shall designate use of the AASHTO ASD method.
- Green paper shall designate use of the AASHTO LFD method.
- Blue paper shall designate use of the AASHTO LRFR method.

For load rating of a special vehicle that is not specified in the Rating Summary Sheet such as maintenance H5 truck used for pedestrian bridge, the Rater may modify the Rating Summary Sheet.

For structures that do not need to be rated, such as the case when the depth of fill exceeds the limits, or structures that no required ratings for the single-unit trucks when the NRL rating factor is 1.0 or greater. The Raters may use the Gross Vehicle Weight (GVW) as shown in the Figures 1-1 to 1-8 of Subsection 1.2 to report on the RSS. The inventory and operating of the design vehicles may be reported as 36 tons and 40 tons respectively for LFR methods, and RFs of 1.0 and 1.1 for LRFR method.

The Rating Summary Sheet is retained in the structure folder as a record of the adequacy of the structure. The following items are to be observed when filling out the sheet.

A) The sheet is to be filled out in black ink.

B) All lettering should be clearly printed.

C) Crossing out of incorrect data will not be permitted. If an error is made, fill out a new RSS.

D) The sheet must be signed and dated by both the Rater and Checker. Do not initial the sheet. When rating is performed by a consultant, the name of the consulting firm shall also be shown. The sheet must be PE-sealed by either the Rater, Checker or Engineer in responsible charge registered in the State of Colorado.

E) When the bridge is re-rated, the old Rating Summary Sheet shall be crossed out, and still kept in the inspection structure folder.

Information to be shown by the Rater on the Rating Summary Sheet:

A) Record the structure number, state highway number, BrR BID number (to be filled in at a later date in the Rating Unit), abbreviation of structure type and, when appropriate, the parallel structure number. In addition to entering the state highway number, if the structure is located on a divided highway and carries traffic in one direction only, indicate the direction of traffic (EB, SB, etc.). Indicate if the structure carries ramp traffic.

B) Within the Summary Sheet, record the Inventory and Operating ratings obtained for each element requiring an analysis, show controlling load ratings in the comments box. All ratings shall be reported in truncated tenths of a US ton, or truncated hundredth of a rating factor if applicable (see also section 15-9 for LRFR reporting).

   1) Stringers or Girders
      a) When an exterior girder is rated, both the interior and the exterior girder ratings shall be shown. The columns of the Summary Sheet shall be marked to identify the interior and exterior girders.
      b) When the refined distribution factor method is used for the legal loads or permit vehicles to avoid the posting or color code action, the controlling load ratings of interior girder or exterior girder shall be shown on a separated column named "NSG". The exterior girder load rating of the permit vehicles does not need to be recorded on this column.
      c) For rolled steel beams, state the girder type and size.
      d) When applicable, state if the girder is an original girder or a girder installed during structure widening.

Note: If a structure is widened with girders that are different from the original in either cross-section or material properties, both the original and the widened girders shall be rated and the critical original and critical widened girder loads shown on the summary sheet.

2) Decks
   a) For all existing decks designed before October 1st, 2010, and new metal / timber plank decks, record load ratings for design truck only.
      - Transversely mild steel reinforced concrete deck slab that are continuous over more than 3 supporting girders shall not be used to control the overall bridge load rating.
      - The load rating of other deck types (e.g. timber decks, metal plank decks, etc.) may be used to control the bridge load rating.
   b) For new concrete decks, no need to record load ratings except as requested.

3) Trusses
   a) Record the critical member ratings, gusset plate, floor beam or stringer ratings in the appropriate columns of the Rating Summary Sheet.
   b) Label the truss members shown in the report using standard truss notation. See Section 10A.

C) If a posting vehicle analysis is required for Colorado Legal Vehicles, record the posting ratings in the chart portion of the summary sheet only. For State on-system Highway bridges, the State Bridge Engineer will make the determination of actual posting load and the pictorial trucks will then be filled in. For bridges that are not on the state system, the appropriate entity officials will determine structure load postings for structures under their jurisdiction.

D) Indicate the amount of surfacing used in the rating calculations.

E) The Comments section of the Rating Summary Sheet should contain the following information, when applicable:

1) State if the individual critical member rates considerably below the other structure members, and is not representative of the entire structure.

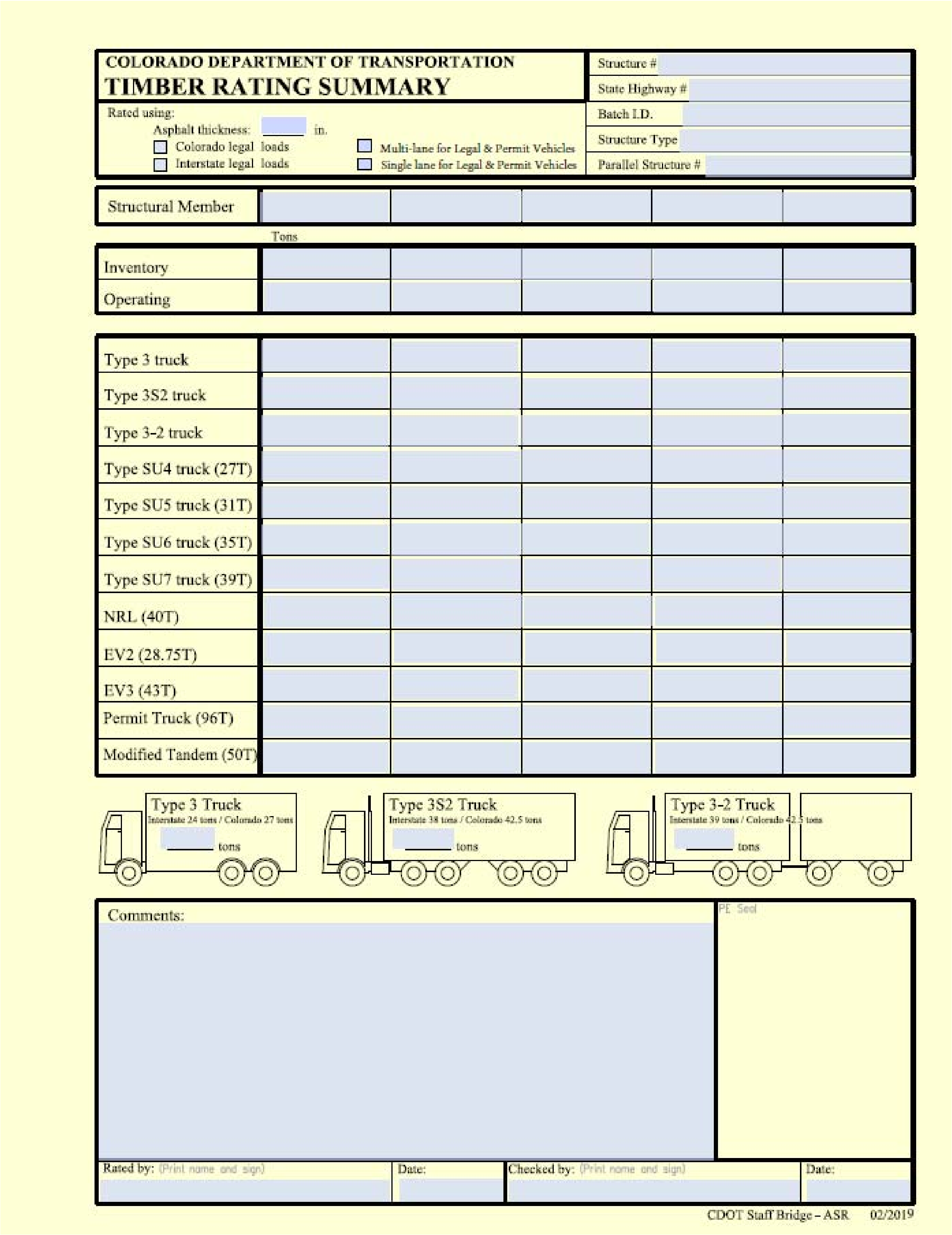
2) State any reductions in cross-section or allowable stresses used to rate the member and the reason for the reduction.

3) The recommended color code for on-system bridges. The State Bridge Engineer must approve any color code recommendations of black, orange, and yellow.

4) State reason for rating: New structure or Rerating due to asphalt changes / dead load changes/ Damage per Inspection, etc.

F) If an original structure rated by LFR method, and the widening part is rated by LRFR, both Rating Summary Sheets of LFR and LRFR need to be filled out appropriately.

G) When rating timber members, the “Comments” section of the Rating Summary Sheet shall contain the allowable stresses for moment and shear used to rate the structure. A statement should be made to indicate if the rating was controlled by moment or shear.



COLORADO DEPARTMENT OF TRANSPORTATION
TIMBER RATING SUMMARY

Structure #
State Highway #
Batch I.D.
Structure Type
Parallel Structure #

Rated using:
Asphalt thickness: ______ in.
☐ Colorado legal loads
☐ Interstate legal loads
☐ Multi-lane for Legal & Permit Vehicles
☐ Single lane for Legal & Permit Vehicles

Structural Member					

Tons

Inventory					
Operating					

Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
______ tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
______ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
______ tons

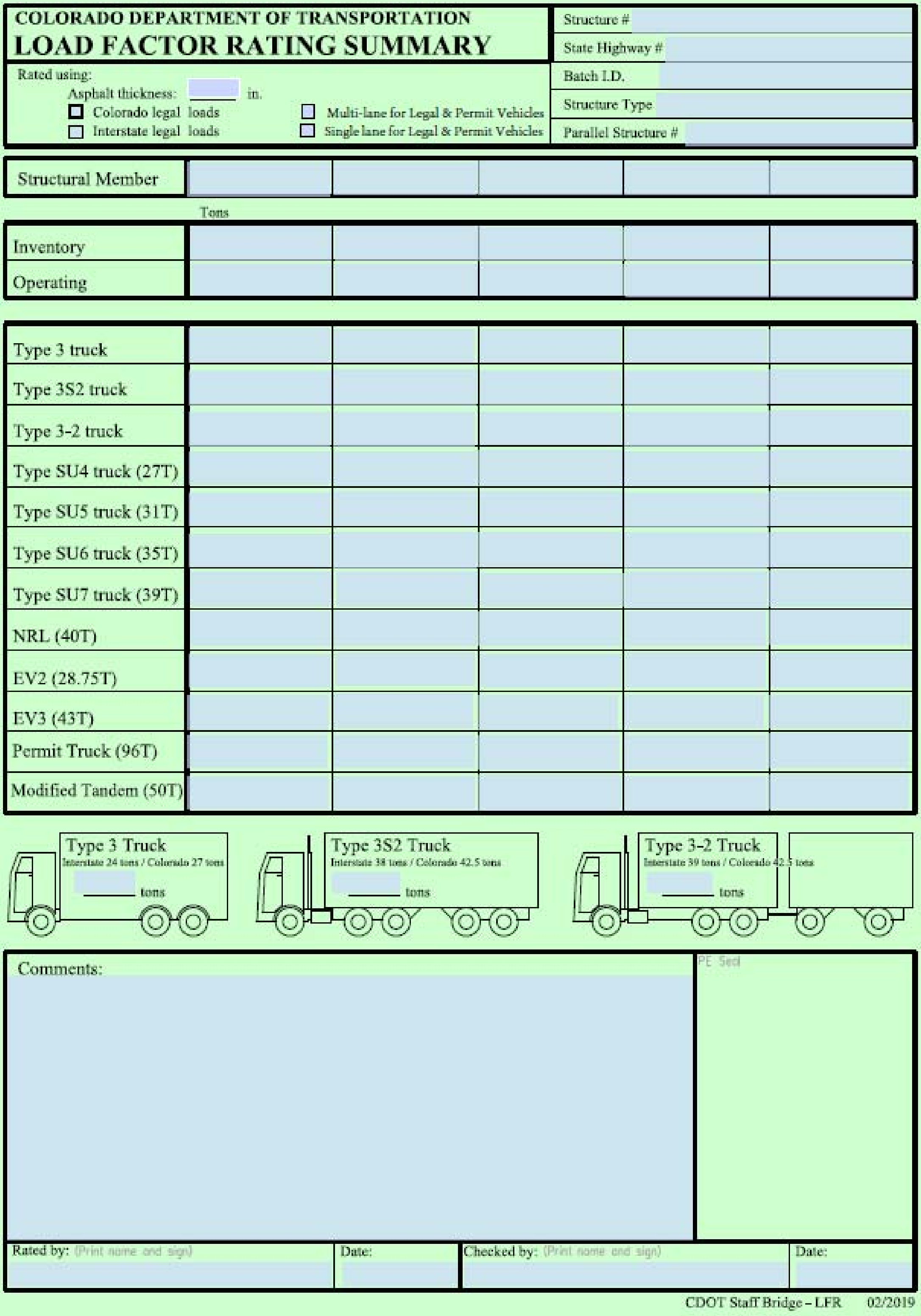
Comments:

PE Seal

Rated by: (Print name and sign)
Date:
Checked by: (Print name and sign)
Date:

CDOT Staff Bridge – ASR 02/2019

Figure 1.13



COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

Structure #

State Highway #

Batch I.D.

Structure Type

Parallel Structure #

Rated using:

Asphalt thickness: ______ in.

☐ Colorado legal loads

☐ Interstate legal loads

☐ Multi-lane for Legal & Permit Vehicles

☐ Single lane for Legal & Permit Vehicles

Structural Member					

Tons

Inventory					
Operating					

Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
______ tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
______ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
______ tons

Comments:

PE Seal

Rated by: (Print name and sign)

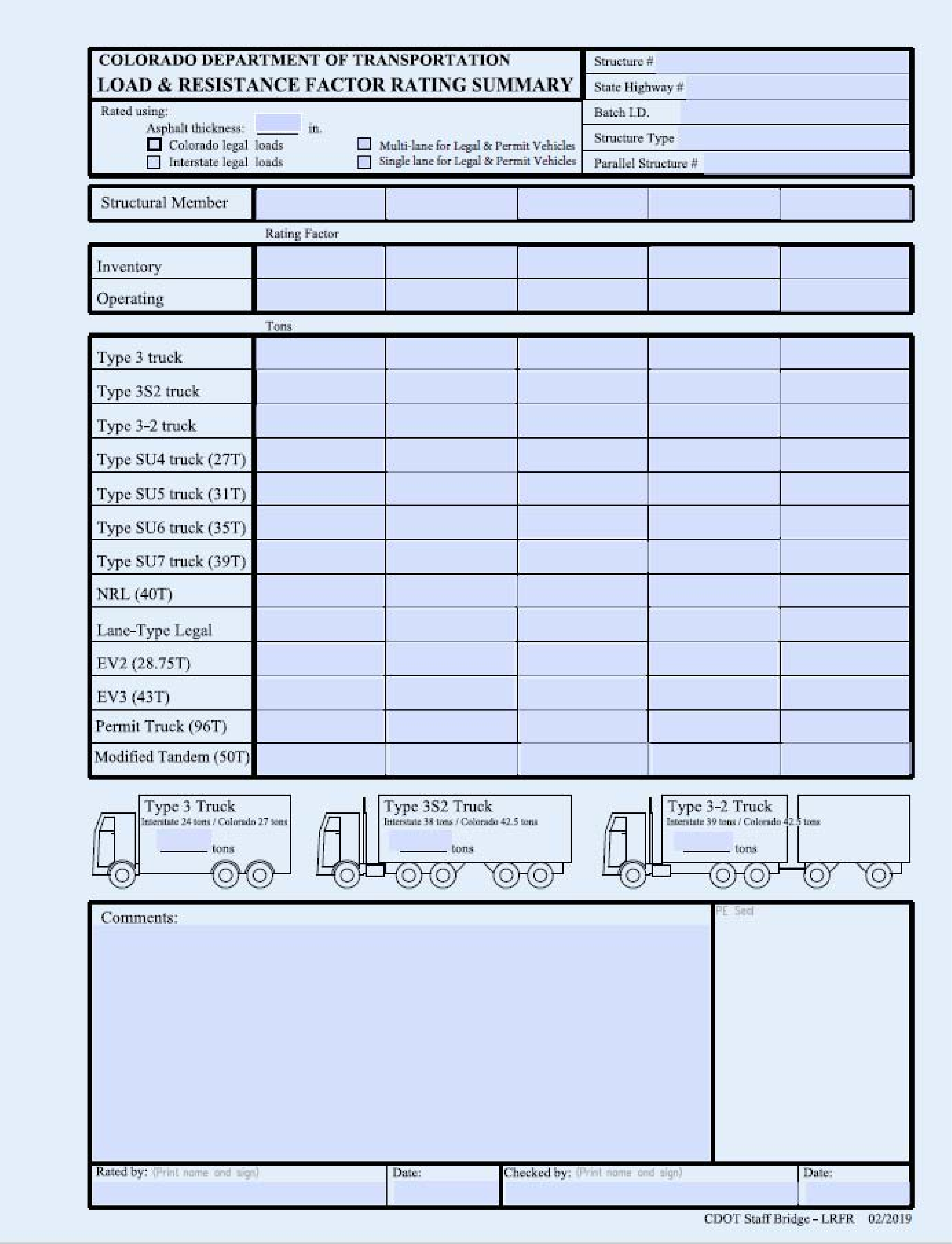
Date:

Checked by: (Print name and sign)

Date:

CDOT Staff Bridge – LFR 02/2019

Figure 1.14



COLORADO DEPARTMENT OF TRANSPORTATION

LOAD & RESISTANCE FACTOR RATING SUMMARY

Rated using:

Asphalt thickness: ______ in.

☐ Colorado legal loads

☐ Interstate legal loads

☐ Multi-lane for Legal & Permit Vehicles

☐ Single lane for Legal & Permit Vehicles

Structure #

State Highway #

Batch I.D.

Structure Type

Parallel Structure #

Structural Member					

Rating Factor

Inventory					
Operating					

Tons

Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
Lane-Type Legal					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					

Type 3 Truck

Interstate 24 tons / Colorado 27 tons

______ tons

Type 3S2 Truck

Interstate 38 tons / Colorado 42.5 tons

______ tons

Type 3-2 Truck

Interstate 39 tons / Colorado 42.5 tons

______ tons

Comments:

PE Seal

Rated by: (Print name and sign)

Date:

Checked by: (Print name and sign)

Date:

CDOT Staff Bridge – LRFR 02/2019

Figure 1.15

1.15 POSTING AND CLOSURE OF A BRIDGE DUE TO RATING REPORT OF LEGAL LOAD VEHICLES

1.15.1 Posting Legal Load Vehicles

Posting vehicles are used to determine the maximum legal load vehicles that will be allowed to travel on bridges. The posting for legal load vehicles are composed of the maximum vehicle loads currently permitted by law. Consequently, the Posting Ratings are a means for ensuring the safe use of bridges by vehicles that do not exceed the legal loads.

The legal load vehicles for posting are as follows:
A) Colorado or Interstate Legal Loads Type 3, Type 3S2 and Type 3-2.
B) Single-Unit trucks SU4, SU5, SU6 and SU7.
C) Emergency vehicles EV2 and EV3.

The maximum weight limits for Colorado legal vehicles, Single-Unit Truck and Emergency Truck are shown in Tables 1-4, 1-5 and 1-6 respectively.

Postings for the Single-Unit trucks SU4, SU5, SU6 and SU7 loads are not required if the load rating for the NRL vehicle has the capacity of 40 tons or greater. Otherwise, load ratings for the single-unit SU4, SU5, SU6 and SU7 loads shall be performed to determine which single-unit vehicles will be restricted from crossing the structure. Currently, the gross vehicle weights of SU6 and SU7 do not meet the Colorado Bridge Formula. Therefore, maximum gross weight limits for posting of SU6 & SU7 on non-interstate roads shall supersede with values that are determined by the Colorado Bridge Formula. See Table 1-5.

The deck slab ratings are not to be used in the determination of legal load postings.

The posting load for Emergency Vehicles shall only be required for bridges on the Interstate highways, and within one-road-mile of the reasonable access.
NOTE: Reasonable access is the access between the Interstate highways and the facilities for food, fuel, repairs, and rest, which includes the Interstate access ramps, and the State's roads.

Based on successful of CDOT historical practice, a safe posting load as specified in the MBE, equation 6A.8.3-1 should not use.

The posting load for Legal vehicles shall be based on the lowest load rating in truncated US tons of any primary members such as girders, in-span hinge, stringers, truss, floor-beam, and truss connections, etc.

When the operating rating factor of any legal load vehicle falls below 0.3, then the bridge shall be restricted for all legal load vehicles.

For possibilities of adjustment to the distribution of live load to increase load ratings and avoid the posting action, see Subsection 1.3 (H).

For structures that do not use 1.3 (H), when the operating ratings of the legal loads are greater than or equal to 95%, the structure can be exempted from posting requirements.

The State Bridge Engineer will make a final determination for posting. The decision for bridge posting shall be based on the bridge physical condition, visible distress, structure redundancy, and traffic volume. If a structure rating indicates a need for posting, the Bridge Rating Engineer is the signing authority for structure posting, and shall notify to the Permit Office, Region RTD and Region Maintenance Superintendent. The Region Maintenance or bridge owner has 30 days to install the posting signs after receiving the formal letter.

	US Units	Non-interstate Road	Interstate Hwy
Type 3 Vehicle	Tons	27.0	24.0
Type 3S2 Vehicle	Tons	42.5	38.0
Type 3-2 Vehicle	Tons	42.5	39.0

Table 1-4: Maximum Weight Limit for Type 3, Type 3S2, and Type 3-2 Legal Trucks.

	US Units	Non-interstate Road	Interstate Hwy
SU4	Tons	27.0	27.0
SU5	Tons	31.0	31.0
SU6	Tons	33.0 (∗)	34.75
SU7	Tons	35.0 (∗)	38.75

Table 1-5: Maximum Weight Limit for Single-Unit Trucks

(∗) Use maximum gross weight limits computed from the Colorado Bridge Formula for non-interstate roads.

	US Units	Non-interstate Road	Interstate & Reasonable Access Roads
EV2	Tons	N/A	28.75 (∗∗)
EV3	Tons	N/A	43.0 (∗∗)

Table 1-6: Maximum Weight Limit for Emergency Trucks.

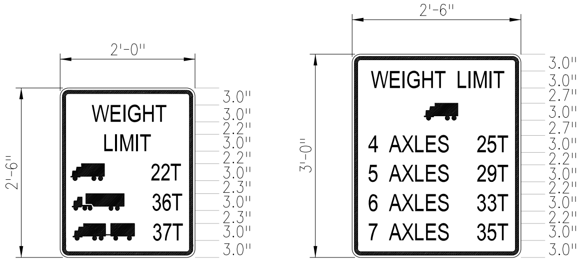
(∗∗) Does not meet Federal Bridge Formula B, but they could cover situations when Emergency Vehicles need access to Interstate Highways, or Reasonable Access.

1.15.2 Posting Signs

The posting signs shall comply with the MUTCD (Manual on Uniform Traffic Control Devices) requirements, and CDOT's Sign Design Manual, latest edition.

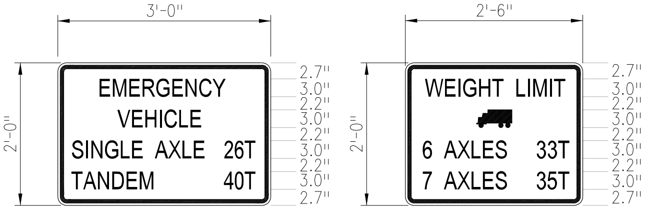
Figure 1.16 shows examples for weight limit posting signs of Colorado/Interstate Legal Vehicles, Specialized Hauling Legal Vehicles, and Emergency Vehicles, which are appropriate for conventional roads, expressways, and freeways using different letter heights of 3.0", 5.0", and 6.0" respectively.

- Conventional road is a road that allows direct access to homes and businesses along it, or a low-volume highway of less than 400 Annual Average Daily Traffic (AADT).
- Expressway is a highway that allows partial control of access.
- Freeway is an Interstate highway that allows full control of access.



Colorado / Interstate
Legal Vehicles

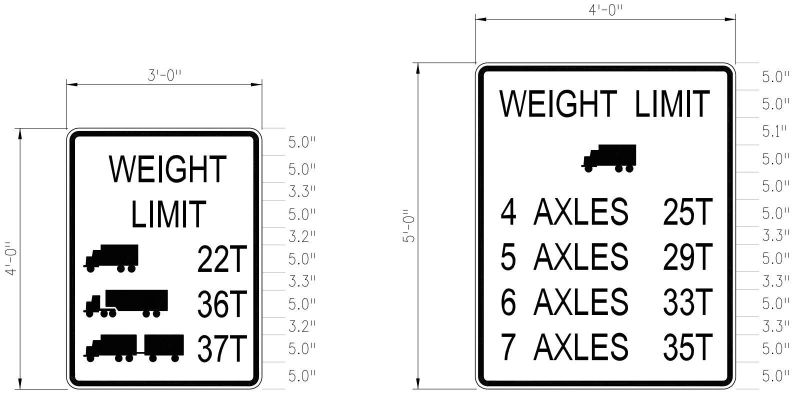
Specialized Hauling
Vehicles



Emergency Vehicles

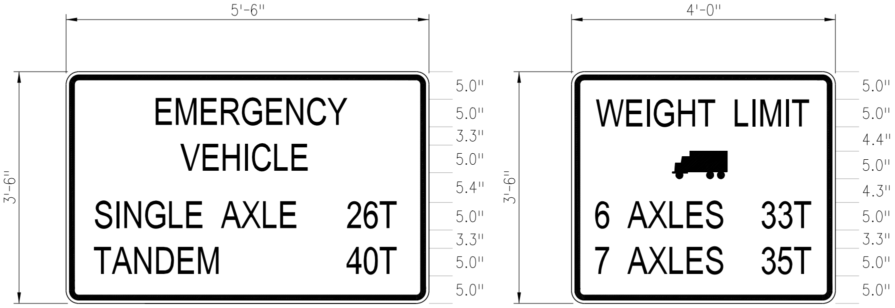
Specialized Hauling Vehicles

LEGAL LOAD POSTING SIGNS FOR CONVENTIONAL ROADS
(3.0" Letter Height, Series E)



Colorado / Interstate
Legal Vehicles

Specialized Hauling
Vehicles

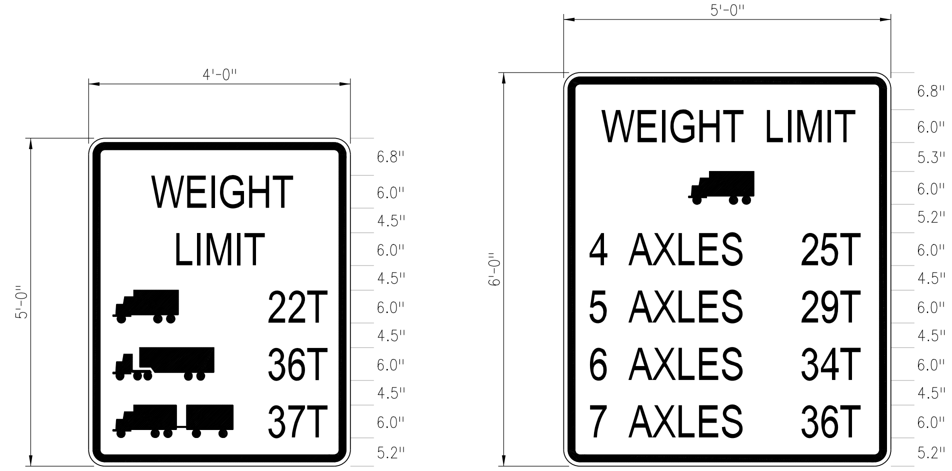


Emergency Vehicles

Specialized Hauling Vehicles

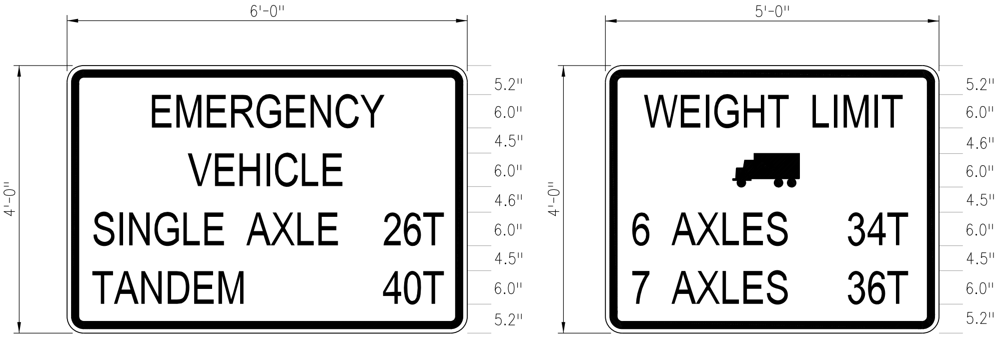
LEGAL LOAD POSTING SIGNS FOR EXPRESSWAYS
(5.0" Letter Height, Series E)

Figure 1.16



Colorado / Interstate Legal Vehicles

Specialized Hauling Vehicles



Emergency Vehicles

Specialized Hauling Vehicles

LEGAL LOAD POSTING SIGNS FOR FREEWAYS
(6.0” Letter Height, Series E)

Figure 1.16 (Continued)

1.15.3 Closure of a Bridge Due to a Rating Report of Legal Load Vehicles

When the operating load rating of any Legal Load vehicle type not capable of carrying a minimum gross live load weight of three tons, the bridge must be closed.

The Rating Engineer and the Inspection Engineer shall review the rating package and the inspection report accordingly before making a recommendation to the State Bridge Engineer to close or restrict the bridge. An appropriate Plan of Action (POA) for closing the bridge shall be determined by the State Bridge Engineer that follows the procedures of the Structure Management Manual (SMM).

1.16 OVERLOAD COLOR CODE RATING

The Overload Color Code ratings are used to determine the routes, and the maximum group axle weights of the permit vehicles that will be allowed to travel on Colorado bridges.

The Colorado Permit Load Rating Vehicles (Colorado Permit Vehicle and Colorado Modified Tandem Vehicle) need to be used to determine the Overload Color Code.

The Overload Color Code shall be based on the primary element ratings such as interior girders, in-span hinges, truss members, exterior/interior stringers of a truss structure, floor-beams, truss connections, etc. The deck slab and the exterior girder ratings are not to be used in the determination of Color Code.

When a bridge that was constructed or rehabilitated after 1985 is rated or re-rated, it shall receive a Colorado Permit Vehicle operating rating with full impact and multi-lanes loaded as per Subsection 1.3.

When a bridge that was constructed in 1985 or earlier is rated or re-rated, it may receive Colorado Permit Vehicle operating rating with full impact and one lane loaded as specified in the Subsection 1.3.

When a bridge with span length of 60’ or less that was constructed in 1985 or earlier is rated or re-rated, it may receive Colorado Permit Vehicle and Colorado Modified Tandem operating ratings with full impact and one lane loaded as specified in the Subsection 1.3. If the Overload Color Code based on the Colorado Permit Vehicle rating causes more severe restriction on the bridge, the Colorado Modified Tandem Vehicle rating may be used to determine for bridge’s color code.

When existing LFD bridges are widened with the LRFD method, the permit vehicle load ratings of the original structure part shall be used to determine the Overload Color Code.

For possibilities of adjustment to the distribution of live load to increase load ratings and avoid the color code action, see Subsection 1.3 (H).

Overload Color Code is not applicable to off-system structures.

The Overload Color Codes Table is shown below:

Table 1-7: Overload Color Codes

	Unit	White	Yellow	Orange	Black
Permit Vehicle	US tons	96 ≤ X	96 > X ≥ 88.5	88.5 > X ≥ 80.5	80.5 > X
Modified Tandem Vehicle	US tons	50 ≤ X	50 > X ≥ 46	46 > X ≥ 42	42 > X

X = Operating load rating value of Colorado Permit Vehicle or Modified Tandem Vehicle.

The State Bridge Engineer will make a final determination for the structure color code. The decision for bridge color shall be based on the bridge physical condition, visible distress, structure redundancy, and traffic volume. If a structure rating indicates a need for colors of BLACK, ORANGE, or YELLOW, the Bridge Rating Engineer will be notified for approval and generation of a formal letter to the Permit Office, Region RTD and Region Maintenance Superintendent. The Bridge Rating Engineer shall be the signing authority on RSS for color coded structure based on the State Bridge Engineer decision.

1.17 RE-RATING EXISTING / NEW BRIDGES

When the condition of a structure changes such as the condition state, dead load, new live loads requirements, or rehabilitations, a re-rating of the structure may be required. Examples when re-rating may be considered:

- Bridge damaged by vehicular hits.
- Bridge deterioration due to severe corrosion / section loss in steel elements, cracking / spalling in concrete superstructure, or split / decay in timber stringers.
- Additional loads of sidewalk, railing, barrier, utilities, fill or deck overlay, etc.
- Deck replacement, widening, adding new girders.
- Section loss reported on gusset plates.
- New Federal regulation or specification requiring new live loads such as Notional Rating Load (NRL) Vehicles, Single-Unit vehicles, and Emergency Vehicles.

Specifically, the requirements for re-rating of the structures are as followings:

A) When requested from the Inspection Unit after the bridge inspection report, or the accident report was reviewed by a senior Inspection Engineer, due to reduced structural capacity at critical locations. The load re-rating shall be completed in-house, within the Staff Bridge Rating Unit within 60 days after the Rating Engineer receives notice.

B) For any structural design work on an existing bridge that has not yet been rated with the BrR program, the bridge shall be re-rated by the Design Engineer or Staff Bridge Rating Unit.

C) For changes of dead load due to a structural work on the existing structure that is rated with BrR program, if the operating load rating for any vehicle changes more than 3.0%; or affects the posting and the color code, the BrR input file and the Rating Summary Sheet (RSS) shall be updated by the Design Checker or Designer.

D) When two parallel structures are connected by a median closure project, the bridge shall be re-rated by the Design Checker or Designer.

E) For culvert extension, bridge widening, or rehabilitation, the bridge shall be re-rated by the Design Checker or Designer.

F) For structure under construction revised by a Value Engineering Change Proposal (VECP), or a Contract Modification Order (CMO), the proposed structure shall be rated / re-rated by the Contractor’s Engineer, or the Engineer of record.

G) A re-rating is required for a change in thickness of asphalt overlay greater than or equal to 3”.

H) If 25% of the total number of timber girders or stringers are split, cracked, or repaired, a new load rating based on reduction of allowable stresses is required.

SECTION 3

Bridge Decks

Section Subject Page No.

3-1 Introduction to Rating Bridge Decks. 3.2

3-2 Concrete Slab Ratings. 3.3

  Cantilever Portions of Concrete Bridge Decks........3.7

  Slab Example..3.8

3-3 Corrugated Steel Plank Ratings. 3.12

  Plank Example...3.14

3-1 Introduction to Rating Bridge Decks

This section covers the rating of bridge decks.

Reinforced concrete decks supported by longitudinal girders, with main reinforcement placed perpendicular to traffic, and asphalt filled metal plank decks placed perpendicular to traffic will be rated with the CDOT computer programs discussed in subsections 3-2 and 3-3.

When design plans are available, use the applicable concrete strength and steel yield stress or use the values shown in table 100-1 (Year of Construction - Allowable Bending Stress Table) for the appropriate year of construction. See Subsection 100-4.

When plans are not available for a concrete deck, and the deck shows no signs of failure, then the assignment of rating values will not be required. However, if the condition of the deck indicates probable failure, then rating values shall be assigned as stipulated in subsection 600-5. The rater shall indicate on the rating summary sheet that plans are not available for the deck.

Transverse nail laminated and transverse plank timber decks are to be rated using the guidelines in Section 300, Timber Bridges.

All other types of bridge decks will be rated in compliance with the applicable guidelines within this manual and the AASHTO code. Hand computations will be acceptable.

For reinforced concrete slabs with main reinforcement parallel to traffic, see Section 600 - Concrete Bridges, for rating directions.

3-2 Concrete Slab Rating

Reinforced concrete deck slabs meeting the following conditions shall be rated with the SLAB computer program by the load factor method using current AASHTO Specifications:

A. The slab must be supported by longitudinal girders or stringers with the main slab reinforcement placed perpendicular to the girders or for skews less than or equal to 20º.

> Skew is defined as the deviation in degrees of the reinforcement from perpendicular to the girders. The reinforcement may have a different skew than the structure.

B. The slab must be continuous over three or more supports. See the current Staff Bridge Design Memo 601 for descriptions of effective span and general deck slab design information.

A load factor rating example is shown in this subsection.

Description of **Input** for Concrete Slab Rating Program

Column	Description	Units	Data Type
1	Load Type		One Numeric Character
	1 = Colorado Trucks (use for bridges carrying Colorado Highways, i.e. SH287) 2 = Interstate Trucks (use for bridges carrying Interstate Highways, i.e. I70 or I25)		
2 - 8	Structure Number		Seven Alpha or Numeric Characters
	Use the Colorado structure number or other designation for the structure such as county or city structure number.		
9 - 11	Rater		Three Alpha or Numeric Characters
	Used to designate who the rater is. Typically the initials are used.		
12 - 14	Highway Number		Three Alpha or Numeric Characters
	Used to designate the Highway Number (i.e. I70 = 70 or SH287 = 287).		
15 - 20	Batch ID		Six Alpha or Numeric Characters
	The Batch ID is assigned by the Staff Bridge BRIAR Unit and uniquely identifies the structure.		
21 - 41	Comments		21 Alpha or Numeric Characters
	Any additional information needed to define the slab (i.e. 70 Degree Skew).		

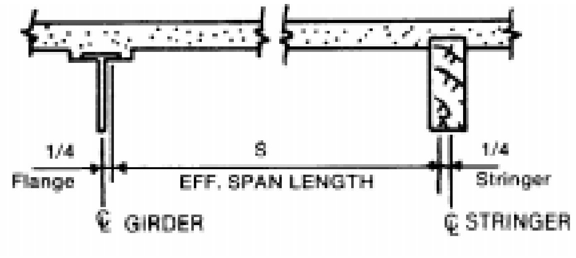
3-2 Concrete Slab Rating

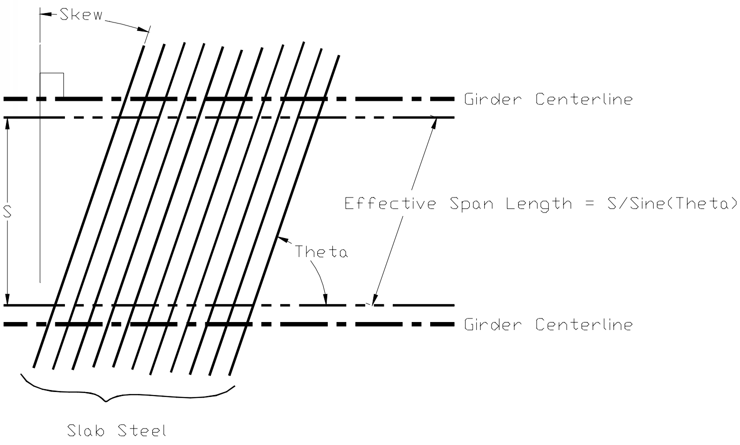
Column Description Units Data Type

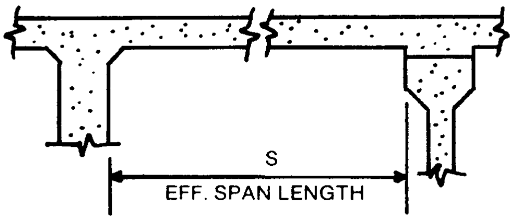
42 - 46 Effective Span Length (feet) Five Numeric Characters

The effective span length input as an integer to three decimal places, see the drawings below. The rater shall exercise care in determining the effective span length for slabs having main reinforcement placed at angles other than 90 degrees measured from the centerline of girder. For these cases, the effective span shall be the distance calculated parallel to the main reinforcing steel.

Use all decimal places even if they are zeros because the program does not recognize blank input as a zero..







47 - 51 Actual Slab Thickness (inch) Five Numeric Characters

The actual slab thickness input as an integer to three decimal places, see the drawing on the following page.

52 - 56 Distance to Top Reinforcing Steel (inch) Five Numeric Characters

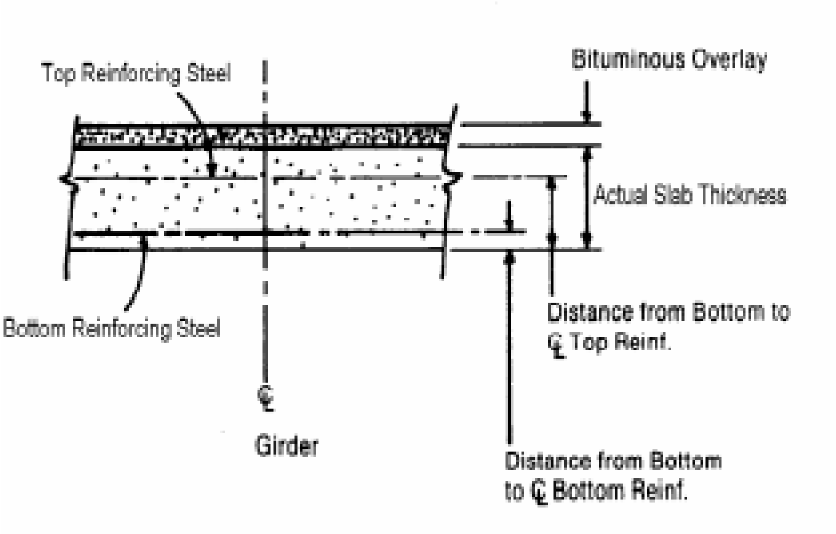
The distance from the from the bottom of the slab to the center line of the top reinforcing steel as an integer to three decimal places, see the drawing on the following page.

57 - 59 Top Reinforcing Steel Area (sq.in.) Three Numeric Characters

The area of the top reinforcing steel over the girders as an integer to two decimal places, see the drawing on the following page.

3-2 Concrete Slab Rating

Column	Description	Units	Data Type
60 - 63	Bituminous Overlay The average asphalt thickness as an integer to two decimal places, see the drawing below.	(inch)	Four Numeric Characters
64 - 67	f'_c for Concrete The value of concrete strength is from the plans or table 1-1 (Year of Construction - Allowable Bending Stress Table) for the appropriate year of construction.	(psi)	Four Numeric Characters
68 - 72	F_y for Reinforcing Steel The value of steel yield stress is from the plans or table 1-1 (Year of Construction - Allowable Bending Stress Table) for the appropriate year of construction.	(psi)	Five Numeric Characters
73 - 74	Leave Blank for Load Factor For a load factor analysis, the rater shall leave "N" blank for program input.		
75 - 77	Distance to Bottom Steel The distance from the bottom of the slab to the center line to the bottom reinforcing steel, taken at a point midpoint between the girders shown as an integer to two decimal places. see the drawing below.	(inch)	Three Numeric Characters
78 - 80	Bottom Reinforcing Steel Area The area of the bottom reinforcing steel midpoint between the girders shown as an integer to two decimal places. see the drawing below. *Typically the bottom and top steel areas are the same.*	(sq.in.)	Three Numeric Characters



3-2 Concrete Slab Rating

Description of **Output** for Concrete Slab Rating Program

I. Input Data

The input data coded by the rater is printed. The reported value of N is the calculated value for load factor analysis.

II. Output Results

A. Total dead load moment for the portion being analyzed.

B. Live load plus impact moment due to HS 20 loading.

C. Gross vehicle weight of HS 20 truck.

D. Calculated concrete and reinforcing steel stresses based on a HS20 vehicle.

E. Total member capacity at inventory and operating level.

F. Member capacity for live load plus impact at inventory and operating level.

G. Ratings in tons at inventory and operating level.

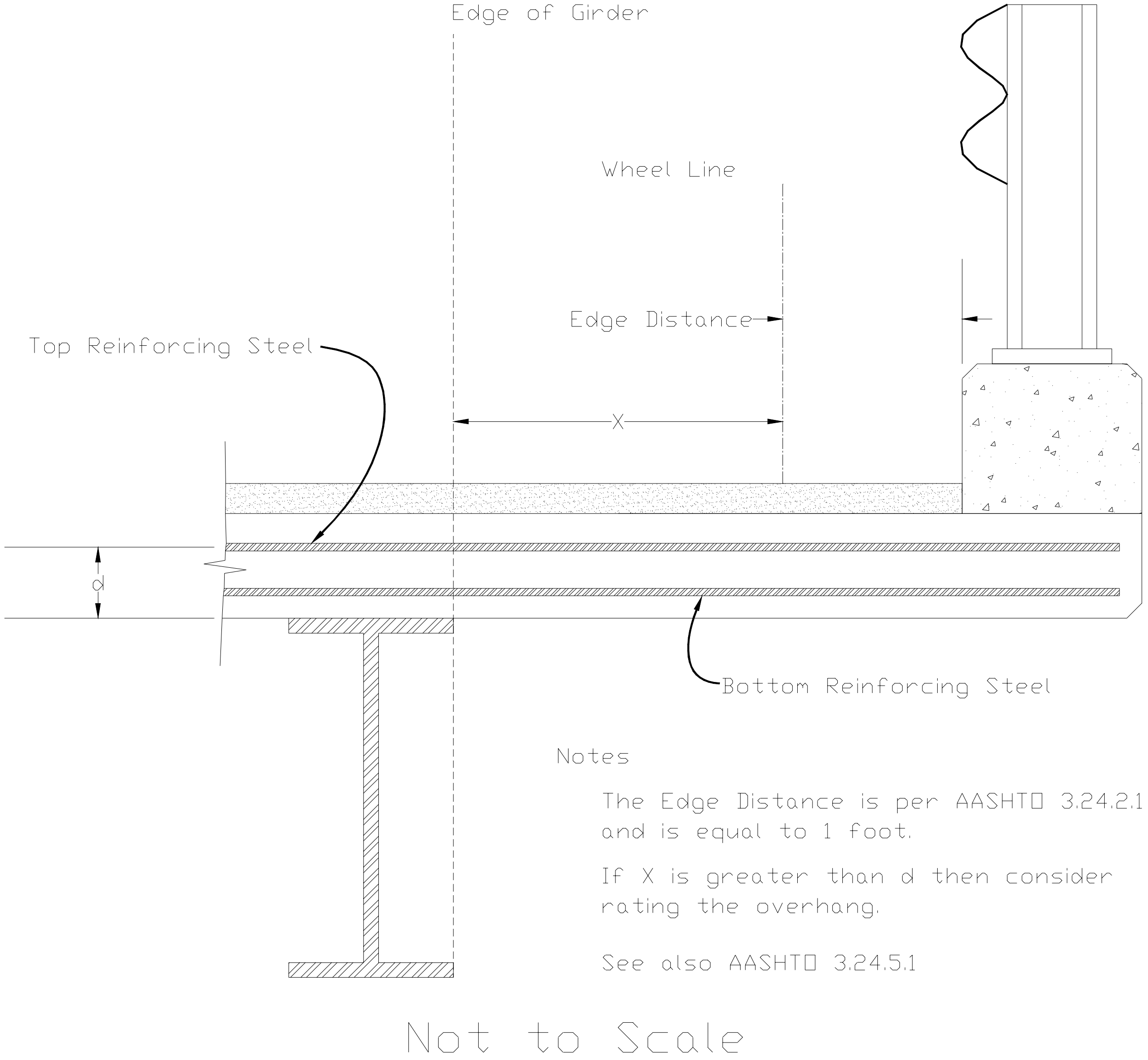
H. Ratings for posting vehicles when operating rating is less than 36.0 tons. The program analyzes either the Colorado Legal Loads or the Interstate Legal Loads depending on user input. Ratings for posting vehicles are determined from the operating capacity.

3-2 Concrete Slab Rating

Guideline for Rating Cantilever Portions of Concrete Bridge Decks

Usually, deck overhangs at the exterior girder do not control the slab rating. However, the rater should use judgment in determining if the overhang should be rated. A criteria that may be used is:

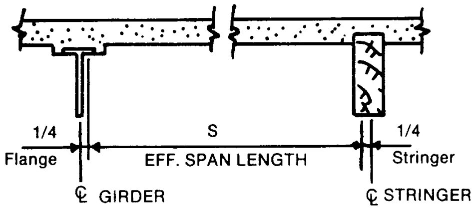
> Rate the cantilever portion of the concrete bridge deck if the wheel load can be applied outside the exterior girder by a distance equal to or greater than the distance from the bottom of the slab to the centerline of the top reinforcement, see the following drawing.

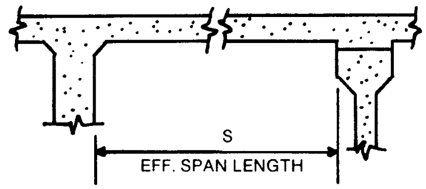


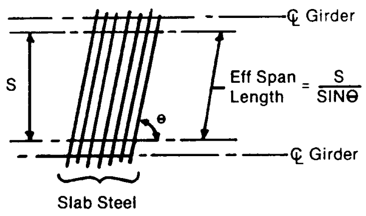
CDOT Staff Bridge
Rating Manual Example

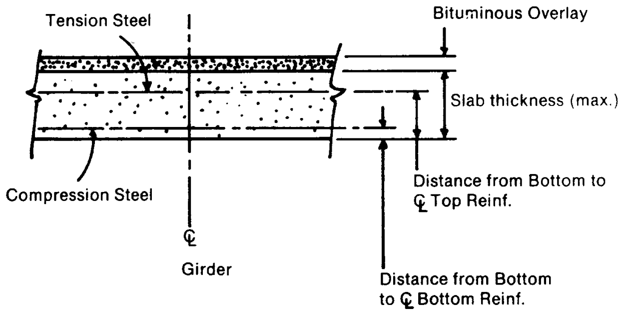
CONCRETE SLAB RATING

DESCRIPTION	INPUT	UNITS	CARD IMAGE COLS.
LOAD TYPE: 1 = Colo. Trucks 2 = Interstate	2		1
STRUCTURE NUMBER:	E-17-HY		2 - 8
RATER:	MAN		9 - 11
HIGHWAY NUMBER:	70		12 - 14
BATCH I.D.:	H73002		15 - 20
COMMENTS:	MEDIAN CLOS URE		21 - 41
EFFECTIVE SPAN LENGTH:	9.667	FEET	42 - 46
ACTUAL SLAB THICKNESS:	8.000	INCHES	47 - 51
Distance to Top Reinforcing Steel	6.188	INCHES	52 - 56
Top Reinforcing Steel Area:	0.61	In2/Ft	57 - 59
ASPHALT OVERLAY:	4.00	INCHES	60 - 63
Concrete Strength (f'c):	4500	P.S.I.	64 - 67
Steel Yield Strength (Fy):	60000	P.S.I.	68 - 72
Leave Blank for Load Factor:		Es/Ec	73 - 74
Distance to Bottom Reinforcing Steel:	1.81	INCHES	75 - 77
Bottom Reinforcing Steel Area:	0.61	In2/Ft	78 - 80









3-2 Concrete Slab Load Factor Rating Example

Computer Program Output

```
                           SLAB RATING Version 1.0
                                DATE: 95/03/21

     STRUCTURE NO. E-17-HY     RATER: MAN     STATE HWY NO. = 70
     BATCH ID= H73002  DESCRIPTION:  MEDIAN CLOSURE
 LOAD FACTOR RATING-COMP STEEL NOT USED---LOAD FACTOR RATING

                    INPUT DATA
                    ----- ----
     EFF. SPAN(FT)=  9.667                EFF. DEPTH(INS)=     6.188
     REINF.(SQ.IN)=   .61
     SLAB TK(IN)=    8.000                WEARING SURFACE(IN)= 4.00
     CONC. STRENGTH(PSI)  INV= 4500.  OPER= 4500.
     STEEL  YIELD  (PSI)  INV=60000.  OPER=60000.
     N=  8.
     D1= 1.81               AS1=  .61

DEAD LOAD MOMENT        1.38 K-FT
LL+I MOMENT             6.07 K-FT
GROSS WEIGHT           36.0  TONS

                                    INVENTORY     OPERATING
ACTUAL CONCRETE STRESS     (PSI)     1500.48       2325.40
ACTUAL REINF. STEEL STRESS (PSI)    27987.38      43374.04
ACTUAL COMP. STEEL STRESS  (PSI)      612.67        949.50
MEMBER CAPACITY           (K-FT)       15.89         15.89
MEMBER CAPACITY (LL+I)    (K-FT)       14.09         14.09
     RATING               (TONS)       38.60         64.33
```

Manual calculations to convert from U.S. Tons to Metric Tons

Inventory = 38.60 * 2000 / 2204.6 = 35.0 metric tons

Operating = 64.33 * 2000 / 2204.6 = 58.4 metric tons

1300-2 Concrete Slab Load Factor Rating Example

Given Information:

Structure Number: E-17-HY

Rater: MAN

Higway Number: 70

Batch I.D.: H73002

Comments: Median Closure

LOAD TYPE: $L_t := 2$

1 = Colorado Trucks

2 = Interstate Trucks

Effective Span Length (feet) = $L := 9.667$

Actual Slab Thickness (inches) = $T := 8.000$

Asphalt Thickness (inches) = $HMA := 4$

Reinforcing Steel:

Area (in²/ft) — Location from the bottom of the slab (inches)

Top Mat Over the Supports= $A_t := 0.61$ Top Mat Location = $D_t := 6.188$

Bottom mat between the supports = $A_b := 0.61$ Bottom Mat Location = $D_b := 1.81$

Reinforcing Steel Yield Strength (psi) = $f_y := 60000$

Concrete Compressive Strength (psi) = $f_c := 4500$

Calculations:

Deadload:

Distributed Deadload:

Concrete: $W_c := \frac{T}{12} \cdot 150$ $W_c = 100$

Asphalt: $W_a := \frac{HMA}{12} \cdot 144$ $W_a = 48$

Total (lbs/foot) = $W := W_c + W_a$ $W = 148$

Deadload Moment (ft-k): $M_{dl} := \frac{W \cdot L^2}{8} \cdot 0.8 \cdot \frac{1}{1000}$ $M_{dl} = 1.383$

Note: 0.8 is the Continuity Factor

Live Load Moment: $M_{ll} := 16 \cdot \frac{L+2}{32} \cdot 0.8 \cdot 1.3$ $M_{ll} = 6.067$

Note: 1.3 is the impact factor
The live load formula is from AASHTO 3.24.3.1

1300-2 Concrete Slab Load Factor Rating Exampl (Continued)

Resisting Moment over the Support (ft-kips):

Steel Tension (pounds) = $T_t := A_t \cdot f_y$ $T_t = 3.66 \cdot 10^4$

Concrete Compression Block (inches) = $a_t := \frac{T_t}{(0.85 \cdot f_c \cdot 12)}$ $a_t = 0.797$

Strength Reduction Factor: $\phi := 0.9$

$$M_u := \phi \cdot \frac{T_t \cdot \left(D_t - \frac{a_t}{2}\right) \cdot \frac{1}{12}}{1000} \qquad M_u = 15.892$$

Final Rating:

Inventory Rating (metric tons) = $\frac{M_u - 1.3 \cdot M_{dl}}{2.17 \cdot M_{ll}} \cdot 36 \cdot \frac{2000}{2204.6} = 34.963$ ←

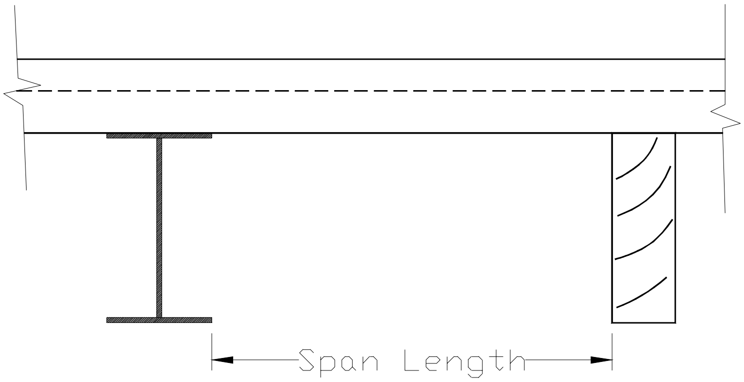
Operating Rating (metric tons) = $\frac{M_u - 1.3 \cdot M_{dl}}{1.3 \cdot M_{ll}} \cdot 36 \cdot \frac{2000}{2204.6} = 58.361$ ←

3-3 Corrugated Steel Plank Rating

The Plank Rating Program investigates corrugated metal flooring based on a one-inch strip transverse to traffic. Currently, the Plank Rating Program will only produce a working stress rating which satisfies the AASHTO specifications, except the program assumes a 20-inch by 20-inch tire contact area. However, the program can be used to generate the Deadload and Liveload Moments. The values produced by the program can then be used to generate a Load Factor Rating using the appropriate factors and formulas. The hand calculation rating analysis in this subsection illustrates the methods used by the program except for the final step which produces a Load Factor Rating.

Description of **Input** for the Plank Rating Program

Column	Description	Units	Data Type
1 - 7	Structure Number Use the Colorado structure number or other designation for the structure such as the county or city structure number.		7 Alpha or Numeric Characters
8 - 10	Rater Used to designate who the rater is. Typically the rater’s initials are used.		3 Alpha or Numeric Characters
11 - 13	State Highway Number Used to designate the highway number (i.e. I70 = 70, SH287 = 287, CR113 = 113).		3 Alpha or Numeric Characters
14 - 19	Batch I.D. The Batch I.D. is a 6 digit Alphanumeric code assigned by the Staff Bridge BRIAR unit which uniquely identifies the structure.		6 Alpha or Numeric Characters
20 - 40	Comments Any additional comments needed to define the plank or the structure.		21 Alpha or Numeric Characters
41 - 44	Span Length Input the span length as an integer to 2 decimal places, see the drawing below.	(inch)	4 Numeric Characters



Use all decimal places even if they are zeros because the program does not recognize blank input as zeros..

3-3 Corrugated Steel Plank Rating

45 - 48 Section Modulus (in^3/in) 4 Numeric Characters

Input the section modulus as an integer to 3 decimal places.

49 - 51 Weight of Plank (lb/ft^2) 4 Numeric Characters

Input the weight of the plank as an integer to 1 decimal place.

51 - 54 Leave Blank 4 Numeric Characters

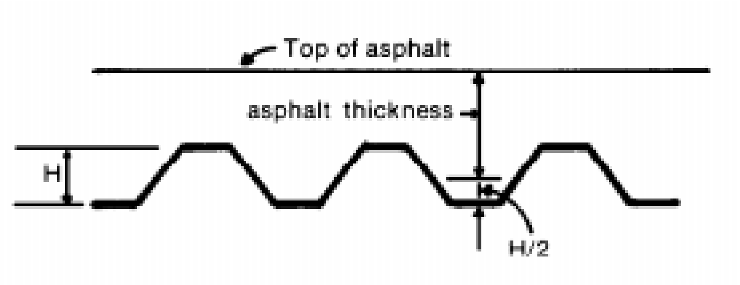
This field is normally used for the inventory stress of a Working Stress Rating. However for a Load Factor Rating, leave this field blank.

55 - 57 Steel Yield Strength (ksi) 4 Numeric Characters

This field is normally used for the operating stress of a Working Stress Rating. However for a Load Factor Rating, input the steel yield strength as an integer to 1 decimal place.

58 - 61 Asphalt Thickness (inch) 4 Numeric Characters

Input the asphalt thickness as an integer to 2 decimal places, see the drawing below.



Description of **Output** for the Plank Rating Program

I. INPUT DATA

The input data coded by the rater is printed.

II. OUTPUT RESULTS

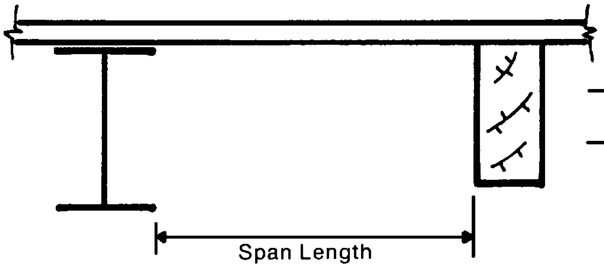
A. Live load plus impact moment due to HS 20 loading.
B. Dead load moment for the strip being analyzed.
C. Capacity for live load plus impact at inventory level.
D. Capacity for live load plus impact at operating level.
E. Inventory rating in tons.
F. operating rating in tons.
G. Posting ratings based on the Colorado legal loads when operating rating is less than 36.0 tons.

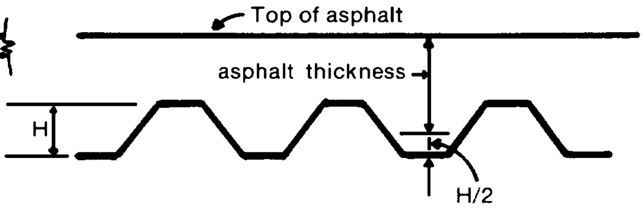
The Plank Rating Program will be updated to produce a Load Factor Rating directly at a future date. When the update is accomplished, this section of the rating manual will be reissued.

CDOT Staff Bridge
Rating Manual Example

CORRUGATED STEEL PLANK RATING

DESCRIPTION	INPUT	UNITS	CARD IMAGE COLS.
STRUCTURE NUMBER	F-11-Q		1 - 7
RATER	MAN		8 - 10
STATE HIGHWAY NUMBER	70		11 - 13
BATCH I. D.	F11Q		14 - 19
COMMENTS	FRONTAGE RO AD		20 - 40
SPAN LENGTH	43.55	IN	41 - 44
SECTION MODULUS	0.335	IN3/IN	45 - 48
WEIGHT OF PLANK	10.5	PSF	49 - 51
INVENTORY STRESS		KSI	52 - 54
OPERATING STRESS (F_y)	45.0	KSI	55 - 57
ASPHALT THICKNESS	5.00	IN	58 - 61





1300-3 Corrugated Steel Plank Rating Example

Computer Program Output

```
                              STEEL BRIDGE PLANK RATING
                                   DATE: 3/21/95

        STRUCTURE NO: F-ll-Q
        RATER: MAN
        BATCH ID: FllQ
        STATE HWY NO: 70
        COMMENT: FRONTAGE ROAD

        NET SPAN LENGTH (IN) =    43.55
        SECTION MODULUS (IN3/IN) =  .335
        PLANK WEIGHT (PSF) =      10.5
        INVENTORY STRESS (KSI)      .0
        OPERATING STRESS (KSI)    45.0
        ASPHALT THICKNESS (IN)     5.00

        LL-1 MOMENT (IN-K) = 6.978
        (LL MOMENT BASED ON A WHEELPRINT 20IN X 201N)
        DL MOMENT (IN-K) =    .093
        INVENTORY LL-1 MOMENT CAPACITY (IN-K) =  -.093
        OPERATING LL-1 MOMENT CAPACITY (IN-K) = 14.982

        INVENTORY RATING (TONS) -.48

        OPERATING RATING (TONS)77.29
```

Note: The computer program is **only** being used to generate the Live Load and Dead Load Moments. The moment rating can then be determined from the computer values by using the appropriate Load Factor formulas and factors.

Manual calculations to produce a Load Factor rating in Metric Tons

Resisting Moment Capacity = Fy*S = 0.335 * 45 = 15.075 in-kips/in

$$\text{Inventory} = \frac{15.075 - 1.3 * 0.093}{2.17 * 6.978} * 36 * \frac{2000}{2204.6} = 32.3 \text{ metric tons}$$

$$\text{Operating} = \frac{15.075 - 1.3 * 0.093}{1.3 * 6.978} * 36 * \frac{2000}{2204.6} = 53.8 \text{ metric tons}$$

Plank Rating

Structure F-11-Q

Information from the field:

Plank:

Thickness is 5/32 of an inch

Distance between corrugations is 12"

Height of corrugations is 4"

Girder:

Spacing (feet): $S_p := 4.5$

Type: W30x99

Average Asphalt Thickness (inches): $T := 7.0$

Information derived from field information:

From AISC 8th Edition: Girder Flange Width (inches): $b_f := 10.45$

From AISI 4th Edition: Type A - 4¼x12x9ga. Plank

Steel Yield Stress (ksi):	$F_y := 45$	Moment of Inertia (in^4/ft)	$I := 8.83$
Weight of Plank (lbs/ft^2):	$W_p := 10.5$	Section Modulus (in^3/ft)	$S := 4.02$

Calculations:

Effective Span (inches): $L := S_p \cdot 12 - b_f$ $\quad L = 43.55$

Distributed Deadload (lbs/in/in): $W := \left(\frac{T}{12}\cdot 144 + W_p\right)\cdot\frac{1}{144}$ $\quad W = 0.656$

Continuity Factor (AASHTO 3.24.3.1) = $C_f := 0.8$

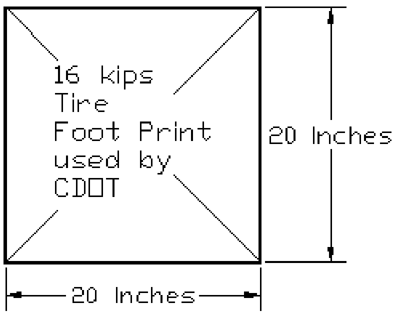
Deadload Moment (in-kips/in): $M_{dl} := \frac{W\cdot L^2}{8\cdot 1000}\cdot C_f$ $\quad M_{dl} = 0.124$

Distributed Live Load (kips/in/in):

$W_{ll} := \frac{16}{20\cdot 20}$ $\quad W_{ll} = 0.04$

Live Load Reaction (kips/in):

$R := W_{ll}\cdot\frac{20}{2}$ $\quad R = 0.4$



Live Load Moment (in-kips/in):

$M_{max} := R\cdot\frac{L-20}{2} + \frac{R}{2}\cdot 10$ $\quad M_{max} = 6.71$

Impact Factor = $I_f := 1.3$

$M_{llI} := C_f\cdot I_f\cdot M_{max}$ $\quad M_{llI} = 6.978$

3 - 3 Plank Rating Example (continued)

Calculations (continued):

Member Capacity (in-kips/inch):

$$M_{cap} := F_y \cdot \frac{S}{12} \qquad M_{cap} = 15.075$$

CDOT *Assumes the plank to be braced Noncompact which eliminates the need to do a Servicablity Rating because plastic properties are not used.*

Moment Rating (metric tons):

Inventory

$$Inv_{mom} := \frac{M_{cap} - 1.3 \cdot M_{dl}}{2.17 \cdot M_{llI}} \cdot 36 \cdot \frac{2000}{2204.6} \qquad Inv_{mom} = 32.163$$

Operating

$$Opr_{mom} := \frac{M_{cap} - 1.3 \cdot M_{dl}}{1.3 \cdot M_{llI}} \cdot 36 \cdot \frac{2000}{2204.6} \qquad Opr_{mom} = 53.688$$

SECTION 8 – REINFORCED CONCRETE STRUCTURES

8-1 INTRODUCTION TO RATING REINFORCED CONCRETE BRIDGES

This section covers the rating of reinforced concrete girders and slabs reinforced longitudinally. This section does not cover prestressed concrete members. All reinforced concrete girders and slabs are to be rated using the policies and guidelines in section 1, and subsections 8-2 and 8-3.

The rating of reinforced concrete decks supported by girders is discussed in Section 3.

The following discussion and examples assume the load factor method is being used for rating.

When there are no plans available for the reinforced concrete member being rated, the requirements in subsection 8-4 will govern the rating.

The types of bridges covered by this section are:

CBG - Concrete Box Girder
CBGC - Concrete Box Girder Continuous
CS - Concrete Slab
CSC - Concrete Slab Continuous
CSG - Concrete Slab and Girder
CSGC - Concrete Slab and Girder Continuous

8-2 POLICIES AND GUIDELINES FOR RATING CONCRETE BRIDGES

I. General

A. All longitudinally reinforced concrete members shall be rated by the Virtis program using the guidelines in subsection 8-3.

B. Concrete girders with considerable stress/strain effects due to horizontal curvature, skew, temperature, or other influences shall be modeled as simple, straight beams on pin or roller supports. The Virtis output results can then be supplemented with hand calculations to consider any of these significant influences, as necessary.

C. All bridges shall be rated using the Load Factor Method.

D. When plans are available, use the minimum yield strength values given in the plans; otherwise, values used in Section 1 for the applicable year of construction may be followed. If the condition of the girder indicates that full strength should not be used, the rating should be reduced as appropriate.

E. All new concrete structures constructed after December 2001 shall be rated for shear at the controlling sections. Except for timber structures, shear rating will not be required for all other structures including rerating of existing structures.

F. All new concrete structures constructed after December 2001, moment rating shall be performed at standard section locations (i.e. 0.5 point for a simple span structure or the 1.4 point, 2.0 point, 2.5 point, etc. for a three span structure) and any controlling rebar cut-off section location. All other structures including rerating of existing structures shall be performed at standard section locations.

G. When rating a cast-in-place concrete box girder bridge, separate out the boxes into I shapes and rate a typical interior and exterior girder. Dead loads and live load shall be applied as appropriate.

II. Girders Requiring Rating

A. Interior Girders - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, differences in loads, moments, concrete strength and/or reinforcing, etc.

B. Exterior Girders - An exterior girder shall be rated under the following guidelines:

1. When the section used for an exterior girder is different than the section used for an interior girder.

2. When the overhang is greater than S/2.

3. When the plans indicate that the curb and floor slab were poured monolithically, the live load distribution factor for the exterior girder should be calculated and compared to the live load distribution factor (LLDF) for the interior girders. If the LLDF for the exterior girder is equal to or greater than 75% of the LLDF for the interior girders, the exterior girder shall be rated.

4. When the rater determines the rating would be advantageous in analyzing the overall condition of a structure.

III. Calculations

A. A set of calculations, separate from computer output, shall be submitted with each rating. These calculations shall include derivations for dead loads, derivations for live load distribution factors, and any other calculations or assumptions used for rating.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.

2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt, curbs, sidewalks, railing, etc.

3. Use 5 psf for the unit weight of formwork when it is likely the formwork will remain in place. An example is closed cell construction, such as cast-in-place concrete box girders.

4. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as non-composite loads. Examples of this type of dead load are deck slabs, girders, fillets, and diaphragms. The weight of diaphragms may be treated as point loads or as an equivalent uniform dead load for the span.

   EXAMPLE: For two diaphragms (P) at 1/3 points

   $$(PL)/3 = M = (wL \times L)/8$$

   equivalent uniform load . . . . $w = (8P)/3L$

5. The method of applying dead loads due to utilities is left to the rater's discretion.

IV. Rating Reporting/Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. Any variation from the original design assumptions shall be added to the Rating Summary Sheet as applicable. The rating package requirements shall be per Section 1-13 of this manual and as amended herein:

Consultant designed projects – Before finalizing the rating package and when VIRTIS is used as the analysis tool, the Rater shall verify with the Staff Bridge Rating Engineer that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower version of the program shall be rejected. It is required for the CDOT data archive, since the data base management feature inside the program would not work satisfactorily. After the analysis is completed, the rater shall save the data file. When saving is finalized, the rater shall export the data file in *.bbd format (i.e., O-18-BY.bbd format; bbd = Bridgeware Bridge Data File) on an IBM-compatible 3.5" PC Disk for delivery with the rating package. Also, the version number used during analysis shall be typed on the diskette label. This ensures proper importation of bridge data archive by the Staff Bridge at a later date.

8-3 GUIDELINES FOR USING THE VIRTIS RATING PROGRAM

The VIRTIS computer program performs the analysis and rating of simple span and multi-span concrete girder bridges. It uses the BRASS ASD or the BRASS LFD engine for analysis. This program was developed in accordance with the AASHTO STANDARD SPECIFICATIONS, 16TH EDITION AND THE AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES.

A maximum of thirteen (13) spans can be modeled using the program. Linear, none or parabolic girder web depth variation over the length of a defined cross-section can be modeled using the Virtis. When a structure model is finalized, it can be rated using the ASD or the LFD method. The LRFD rating module is currently being developed and will be available in the future. When a structure model is being generated and before any analysis can be performed, it is recommended that Virtis users save the data to memory periodically. This can be accomplished by using the File and Save feature of this program.

The library explorer can be used to save commonly used items (beam shapes, nonstandard vehicles, materials, appurtenances etc.) and this eliminates the need for all users to define the same items repeatedly throughout the program. Once a new girder shape is defined or copied from the library, Virtis automatically computes the required section properties and beam constants.

Dead load due to the girder self-weight, deck slab and appurtenances (i.e. rails, median barrier etc.) are calculated automatically by the program. Dead load due to the haunch, wearing surface and stiffener weight (for steel bridges) is defined by the user. For a detailed description of the girder loads, refer to the Opis/Virtis Help Menu index item - dead loads. During modeling a structure, help menu can also be activated by using the F1 key when the user requires clarification on a particular item in the GUI window.

In the Live Load Distribution Factor window, when the compute button is used to calculate the DF’s automatically by the program, Virtis users shall verify that these numbers are accurate and matches their calculated numbers.

All Colorado BT girder shapes, the Colorado permit vehicle, the Colorado posting trucks and the Interstate posting trucks have been added to the Virtis library explorer and may be copied by the user. The Staff Bridge Rating Engineer shall be responsible for updating existing information or adding new information (i.e. beam shapes, vehicles etc.) to the library explorer.

The configuration browser provides access to the configuration features of Virtis. It may be employed to provide specific access privileges, i.e. read, write, delete etc., to the users. This feature is extremely powerful, since Virtis/Opis uses and shares the bridge data from one common source. Therefore, it is required that users of this program create a folder from the bridge explorer window (**EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

8-4 RATING CONCRETE BRIDGES WITH UNKNOWN REINFORCING STEEL

It is anticipated that all bridges designed after January 1994 will have as constructed plans.

When there are no plans or other documentation for a particular concrete structure, its numerical rating shall be determined by a Professional Engineer Registered in the State of Colorado. This rating shall be based on its live load history, the condition of the bridge, a complete and comprehensive inspection of the structure and directions from the AASHTO Manual for Bridge Evaluation. If the structure shows no signs of distress due to load, the Engineer can assign it a maximum inventory rating of 36 tons.

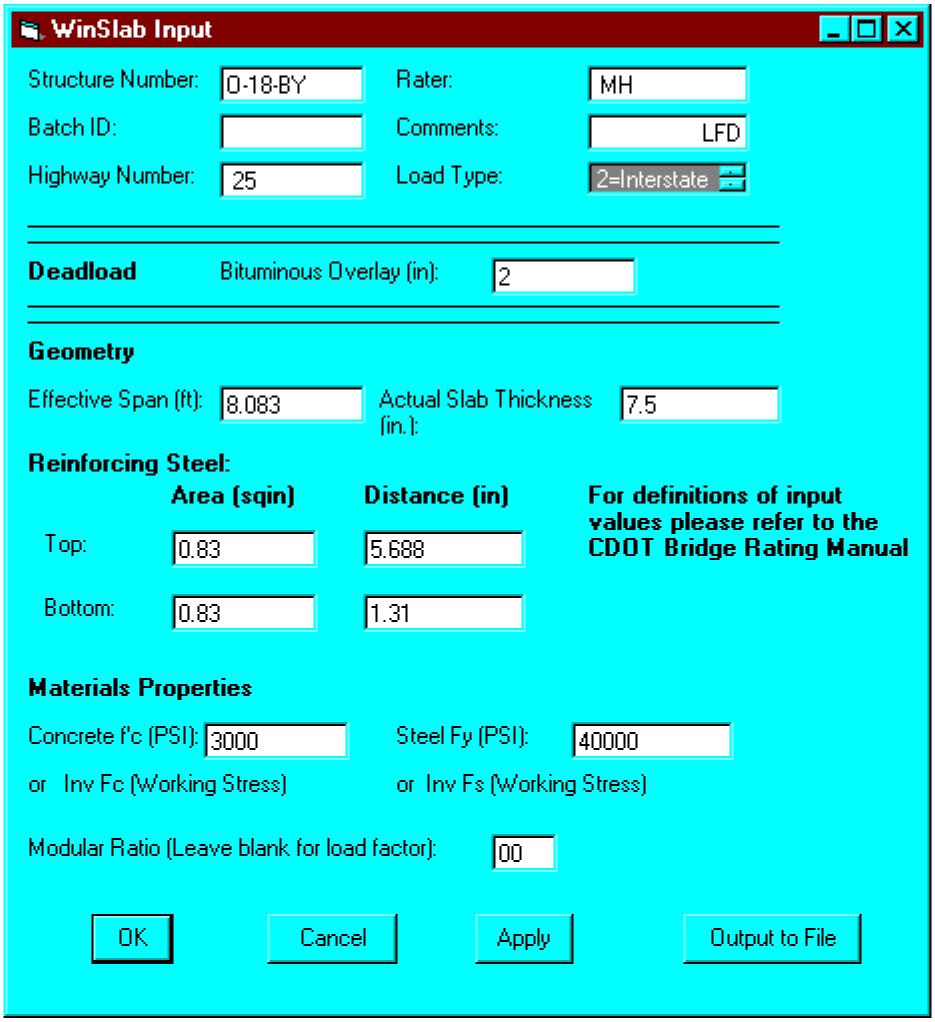
When there are signs of capacity-reducing distress or deterioration, an appropriate judgment should be made and an inventory rating less than 36 tons shall be given to the concrete structure. The process is the same for operating rating; only difference is that a maximum rating of 40 tons can be assigned. No distress condition shall have a maximum permit vehicle operating rating of 96 tons. A rating is not required for concrete bridge decks with unknown reinforcing steel where the bridge deck is supported by girders or stringers.

A Rating Summary Sheet is required for these bridges. For bridges owned or maintained by the Colorado Department of Transportation, the Staff Bridge Engineer will approve this type of rating and sign the Rating Summary Sheet.

8-5 CONCRETE GIRDER BRIDGE RATING EXAMPLES

Two examples are presented in this section. First, Structure O-18-BY is a five (5) span concrete-tee girder bridge with a skew of -30° degrees. It has four (4) concrete-tee girders. Since all piers have expansion joints, only the span with the most critical condition as reported in the field inspection report will be modeled in this example. Only the interior girder has been modeled for this structure. The second structure, L-18-AV, is a 4-span continuous concrete-tee girder bridge with a skew of –27.3° degrees. It has seven (7) concrete-tee girders. For simplicity, only the interior girder has been modeled for this structure.

Slab Rating Program Input, Structure No. O-18-BY



Structure Number: 0-18-BY
Rater: MH
Batch ID:
Comments: LFD
Highway Number: 25
Load Type: 2=Interstate

Deadload Bituminous Overlay (in): 2

Geometry

Effective Span (ft): 8.083
Actual Slab Thickness (in.): 7.5

Reinforcing Steel:

	Area (sqin)	**Distance (in)**
Top:	0.83	5.688
Bottom:	0.83	1.31

For definitions of input values please refer to the CDOT Bridge Rating Manual

Materials Properties

Concrete f'c (PSI): 3000
or Inv Fc (Working Stress)
Steel Fy (PSI): 40000
or Inv Fs (Working Stress)

Modular Ratio (Leave blank for load factor): 00

Effective Span Length: Per AASHTO Article 3.24.1.2(a)

(Clear span)*1/cos30° = (8.67-1.67)*1/cos30° = 8.083’

Slab Rating Program Output, Structure No. O-18-BY

```
WinSlab Rating Version 1     Date: 12/13/2001

 Structure NO. O-18-BY     Rater: MH      State HWY NO. = 25
     Batch ID=        Description: LFD

 LOAD FACTOR RATING-COMP STEEL NOT USED

 INPUT DATA

       Bituminous Overlay(in)=    2.000
       Eff. Span(ft)=             8.083         Slab Thickness(in)= 7.500
       Top Reinf. (sq.in)=         0.83         Eff. Depth(in) =    5.688
       Bottom Area(sq.in)=         0.83         Bottom Dist.(in)=   1.31
       Conc. Strength(PSI) Inv =   3000         Oper. =             3000
       Steel Yield (PSI)   Inv =  40000         Oper. =             40000
       Modular Ratio =                9

Dead Load Moment   0.77 K-Ft
LL+I Moment        5.24 K-Ft
Gross Weight       36.0 Tons
                                    Inventory     Operating
Actual Concrete Stress      (PSI)     997.12       1579.66
Actual Reinf. Steel Stress  (PSI)   18433.86      29203.39
Actual Comp. Steel Stress   (PSI)    5304.24       8403.10
Member Capacity             (K-Ft)     12.81         12.81
Member Capacity (LL+I)      (K-Ft)     11.81         11.81
     Rating                 (Tons)     37.43         62.39
```

Virtis Bridge Rating Example, Structure No. O-18-BY

Effective slab width: Per AASHTO Article 8.10.1.1

0.25(L)= 0.25(57*12)= 171”
12t+ Web Thickness = (12*7.5)+ 20 = 110”
C.L. - C.L. of girder= 8.6667’= 104” Controls

Dead Load:

Intermediate Diaphragm = ((0.75)*(3.25)*(8.67-1.83) + 0.5*2*0.33*0.33*
(8.67-1.83))*(1/Cos30°)*(0.150)= 3.02 kips
Use 3.1 kips

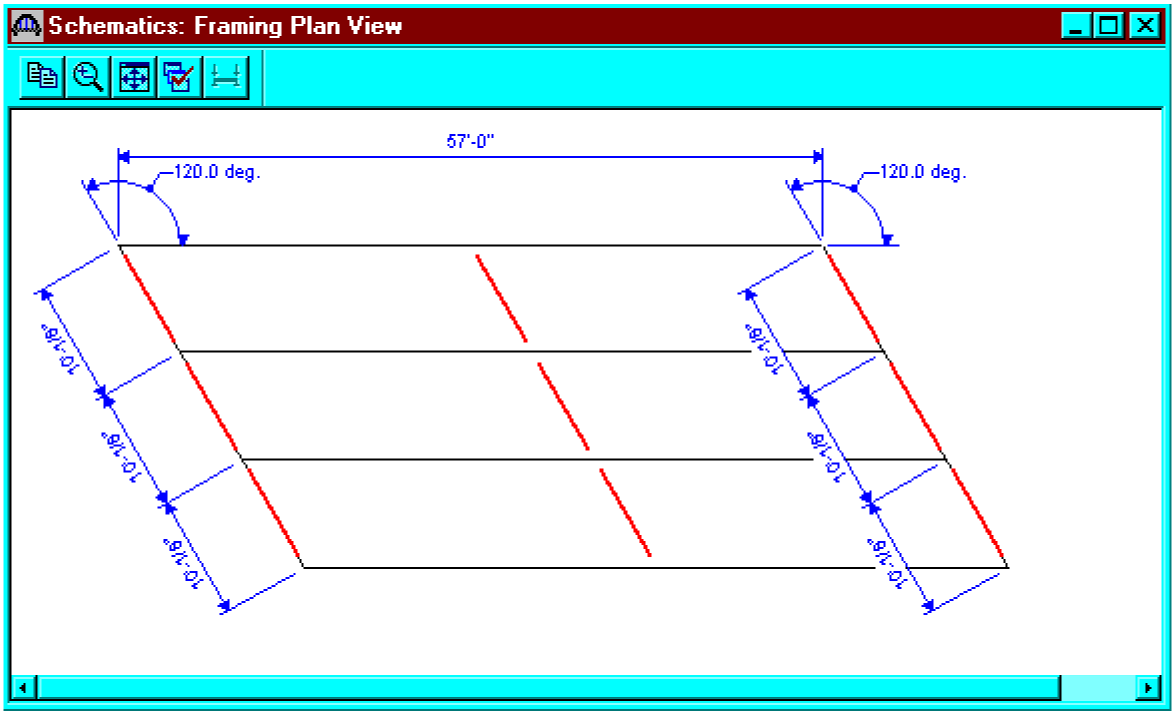
Abutment Diaphragm = Weight Varies
Use 6.2 kips

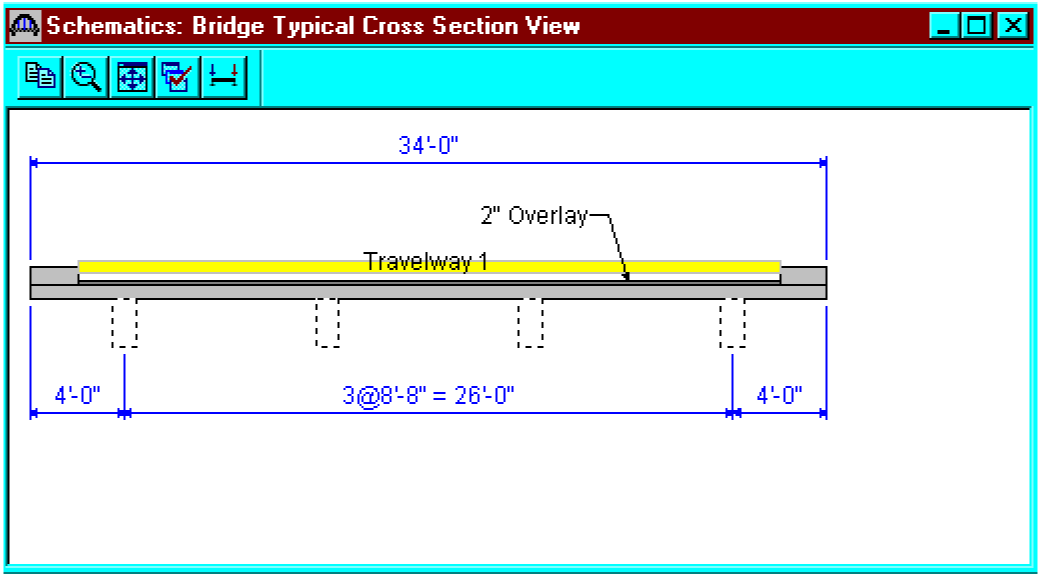
Distribution Factor:

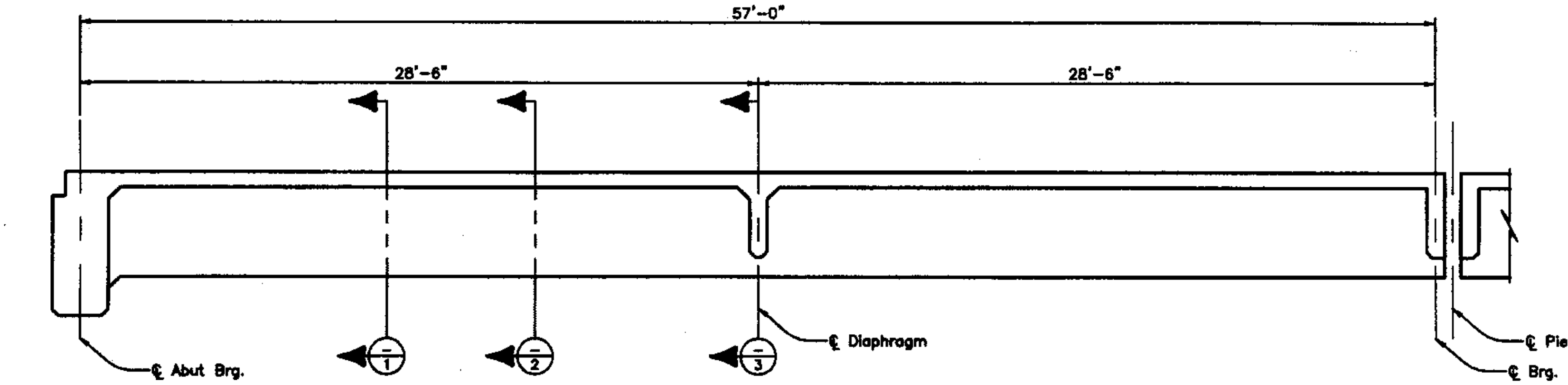
Multi-Lane = S/6 = 8.667/6 = 1.444

Single Lane = 1+ 2.667/8.667 = 1.308

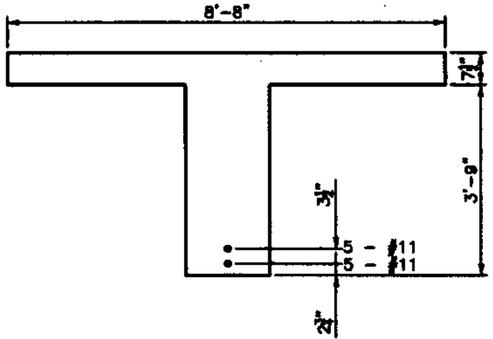
Virtis Bridge Rating Example, Structure No. O-18-BY (contd.)



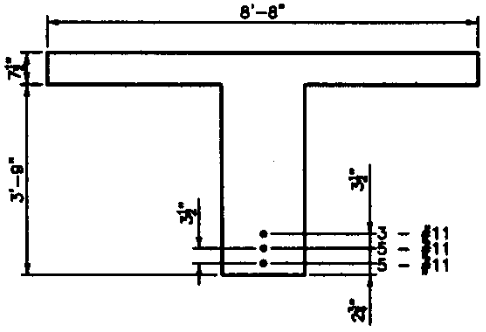




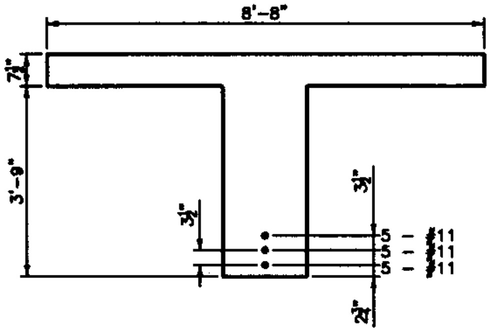
SPAN #1



SECTION 1
Rebar cutoff 12.08' from left support



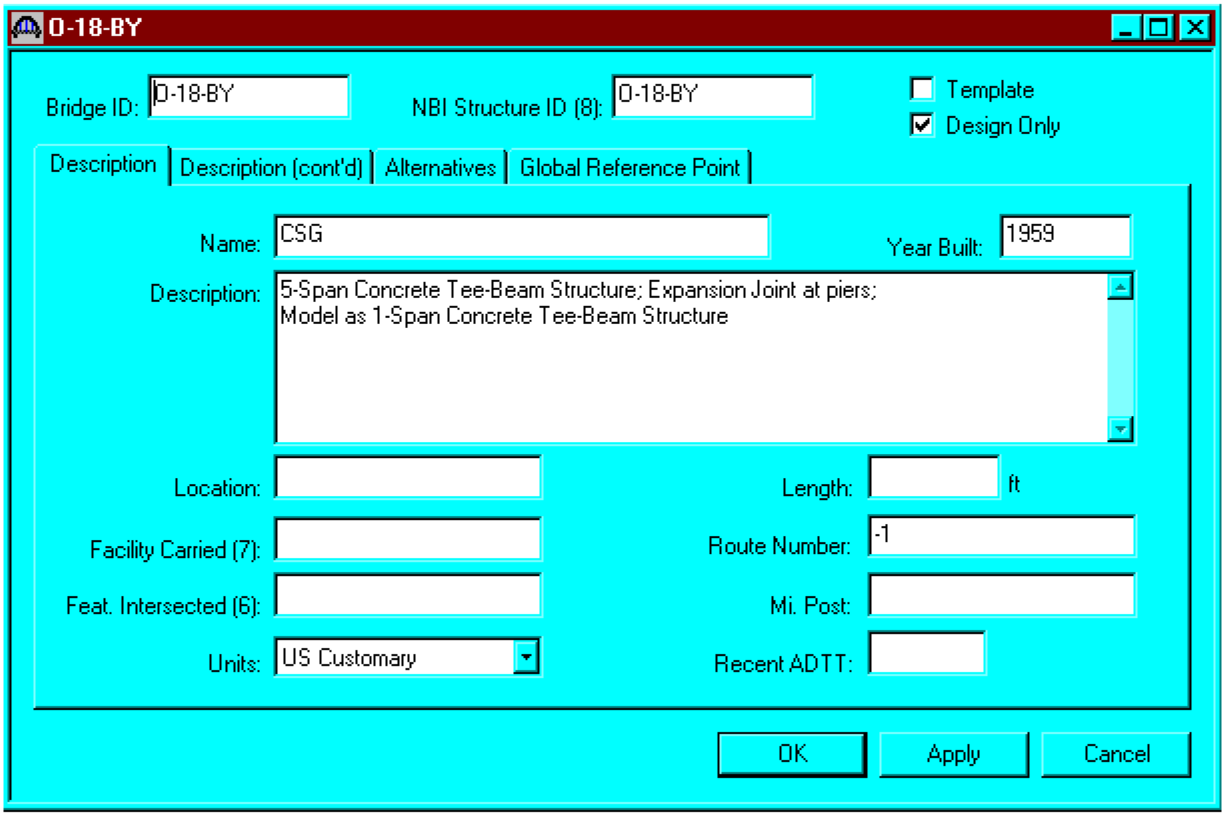
SECTION 2
Rebar cutoff 19.05' from left support



SECTION 3

Project No: I-25-1(21)31 Structure No: 0-18-BY

From the bridge explorer, create a new bridge and enter the following information.



Bridge ID: 0-18-BY

NBI Structure ID (8): 0-18-BY

☐ Template

☑ Design Only

Name: CSG

Year Built: 1959

Description: 5-Span Concrete Tee-Beam Structure; Expansion Joint at piers; Model as 1-Span Concrete Tee-Beam Structure

Location:

Length: ft

Facility Carried (7):

Route Number: -1

Feat. Intersected (6):

Mi. Post:

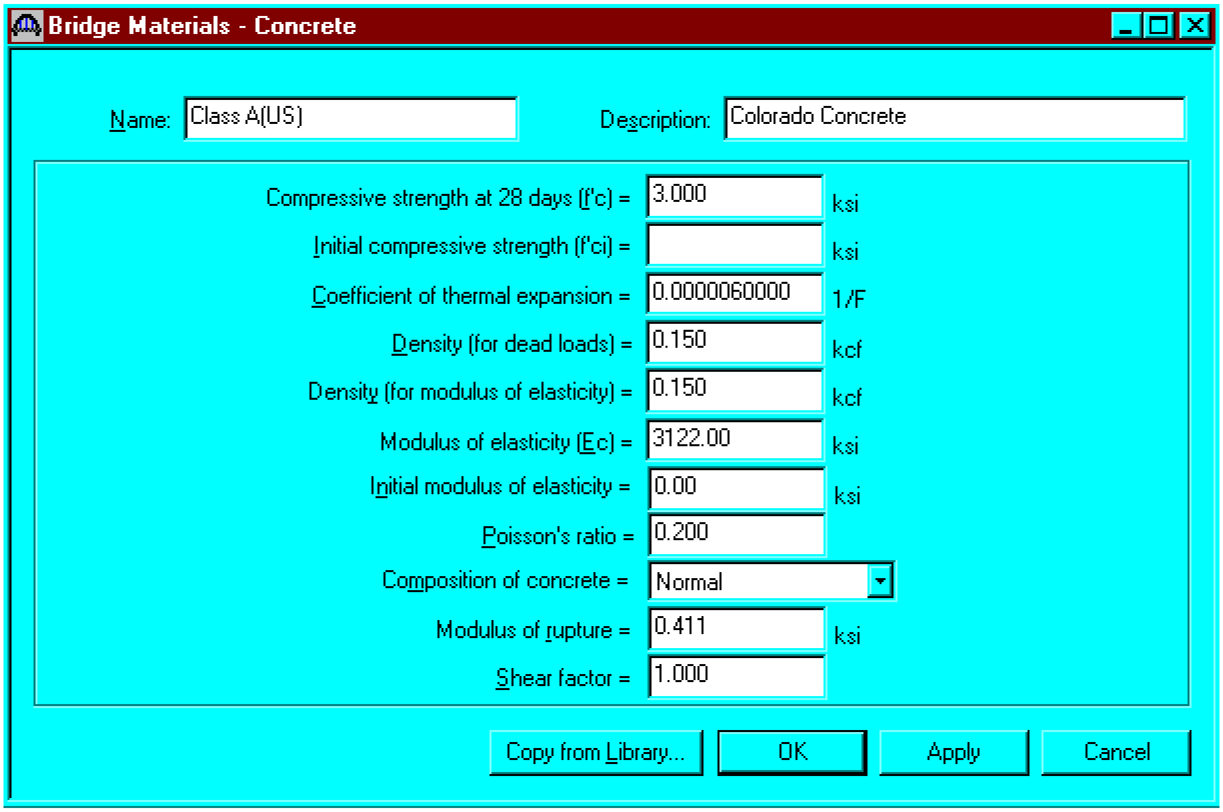
Units: US Customary

Recent ADTT:

Click OK. This saves the data to memory and closes the window.

NOTE: Since Virtis uses a common/shared database, it is required that users of this program create a folder from the bridge explorer window **(EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Concrete from the library. Click OK and the following window will open. Click OK to save this concrete material to memory and close the window.



Name: Class A(US)

Description: Colorado Concrete

Compressive strength at 28 days (f'c) = 3.000 ksi

Initial compressive strength (f'ci) = ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.150 kcf

Density (for modulus of elasticity) = 0.150 kcf

Modulus of elasticity (Ec) = 3122.00 ksi

Initial modulus of elasticity = 0.00 ksi

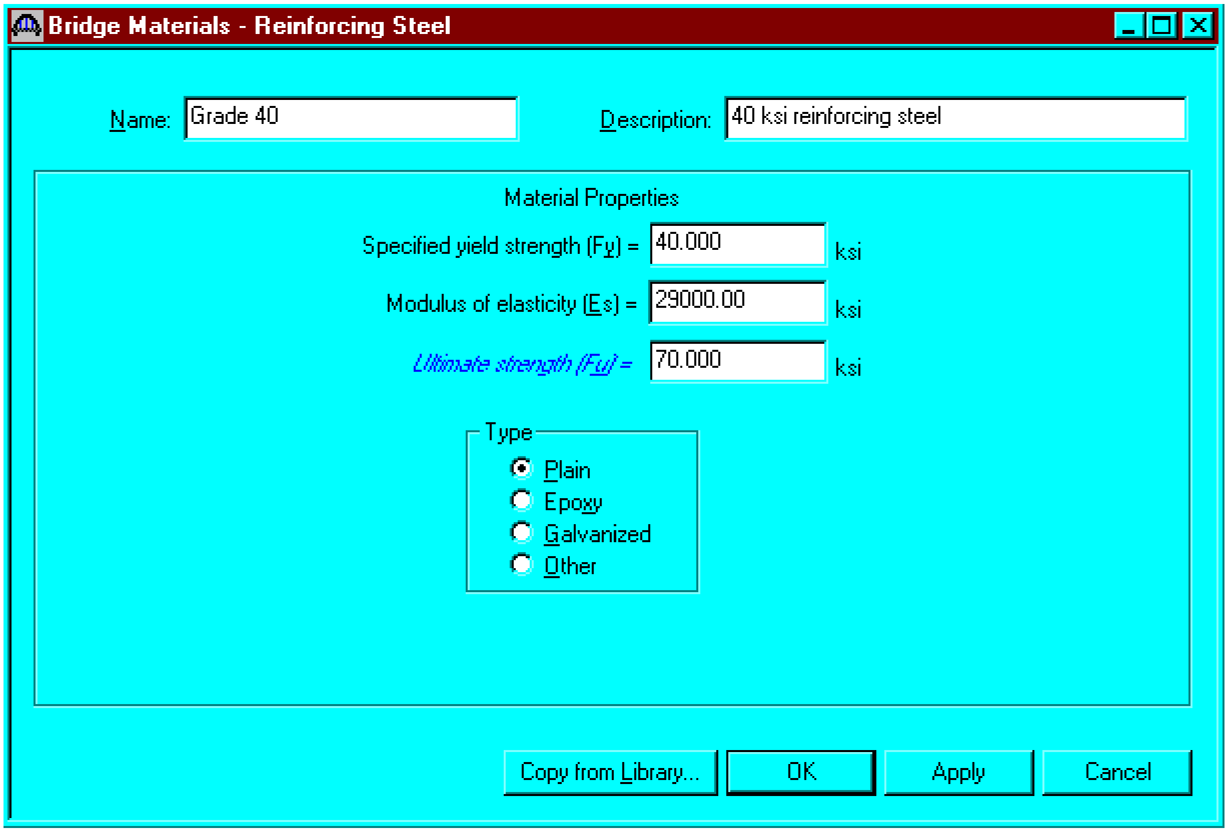
Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.411 ksi

Shear factor = 1.000

Using the same techniques, create the following Reinforcing Steel Material to be used for the girder.



Name: Grade 40

Description: 40 ksi reinforcing steel

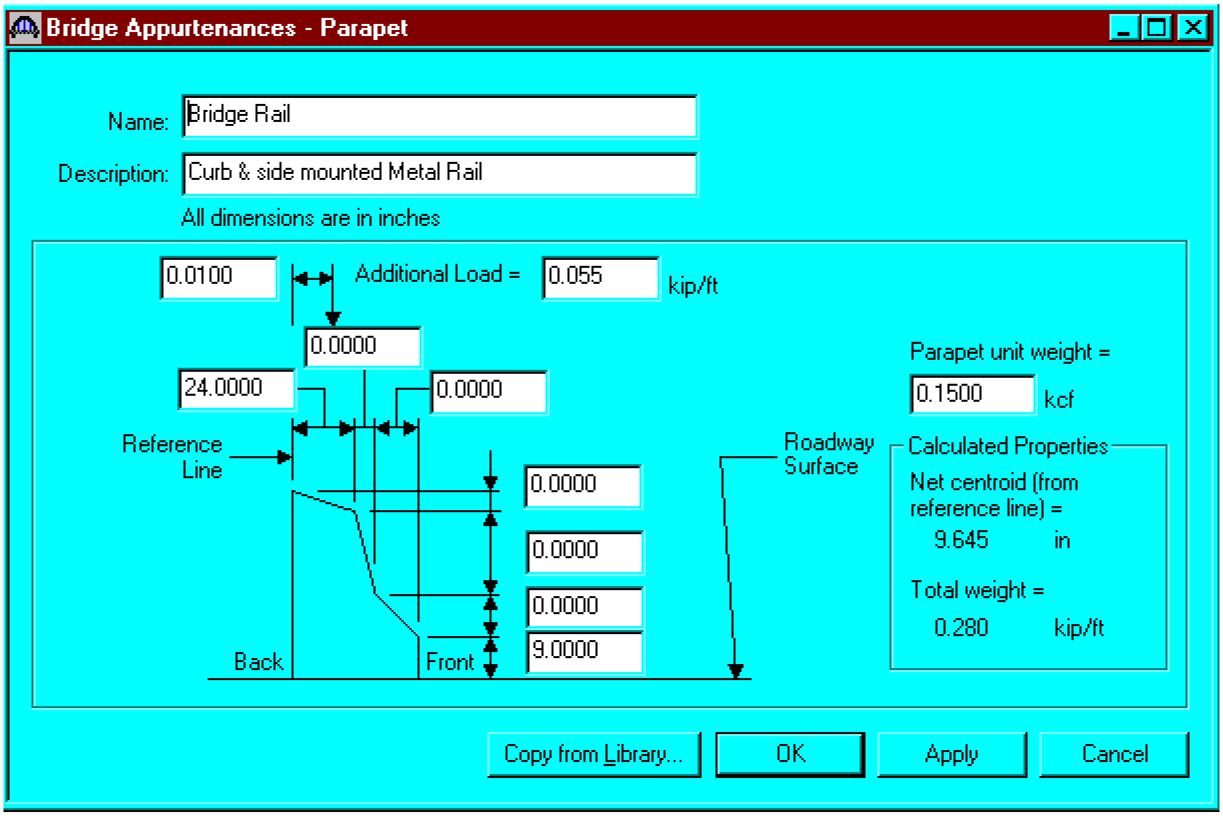
Specified yield strength (Fy) = 40.000 ksi

Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 70.000 ksi

Type:
- ● Plain
- ○ Epoxy
- ○ Galvanized
- ○ Other

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, and select New. Fill in the parapet properties as required. Click OK to save the data to memory and close the window.



Name: Bridge Rail

Description: Curb & side mounted Metal Rail

All dimensions are in inches

Additional Load = 0.055 kip/ft

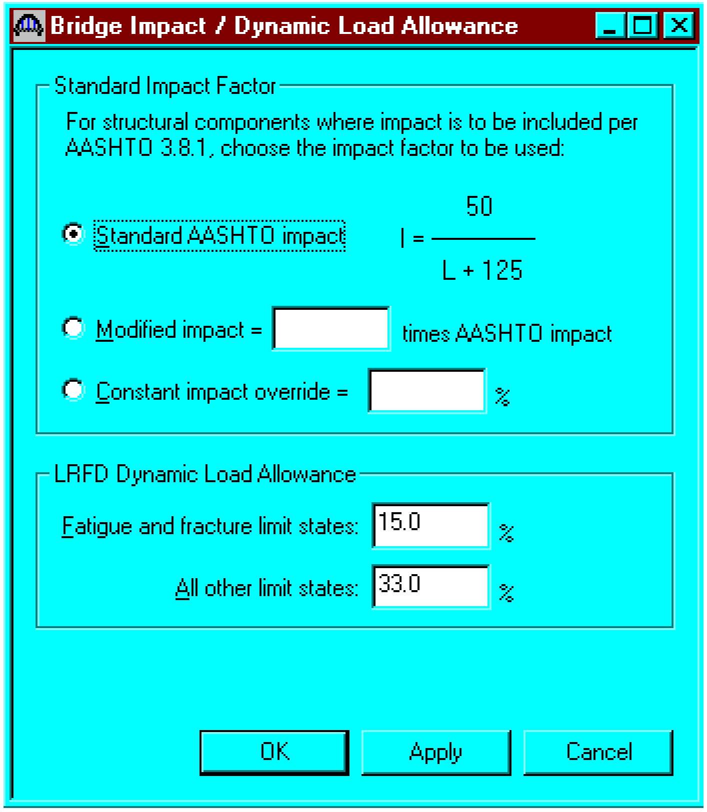
Parapet unit weight = 0.1500 kcf

Calculated Properties

Net centroid (from reference line) = 9.645 in

Total weight = 0.280 kip/ft

Double click on Impact/Dynamic Load Allowance in the tree. The Bridge Impact window shown below will open. Accept the default values by clicking OK.



Bridge Impact / Dynamic Load Allowance

Standard Impact Factor

For structural components where impact is to be included per AASHTO 3.8.1, choose the impact factor to be used:

● Standard AASHTO impact $I = \frac{50}{L + 125}$

○ Modified impact = ☐ times AASHTO impact

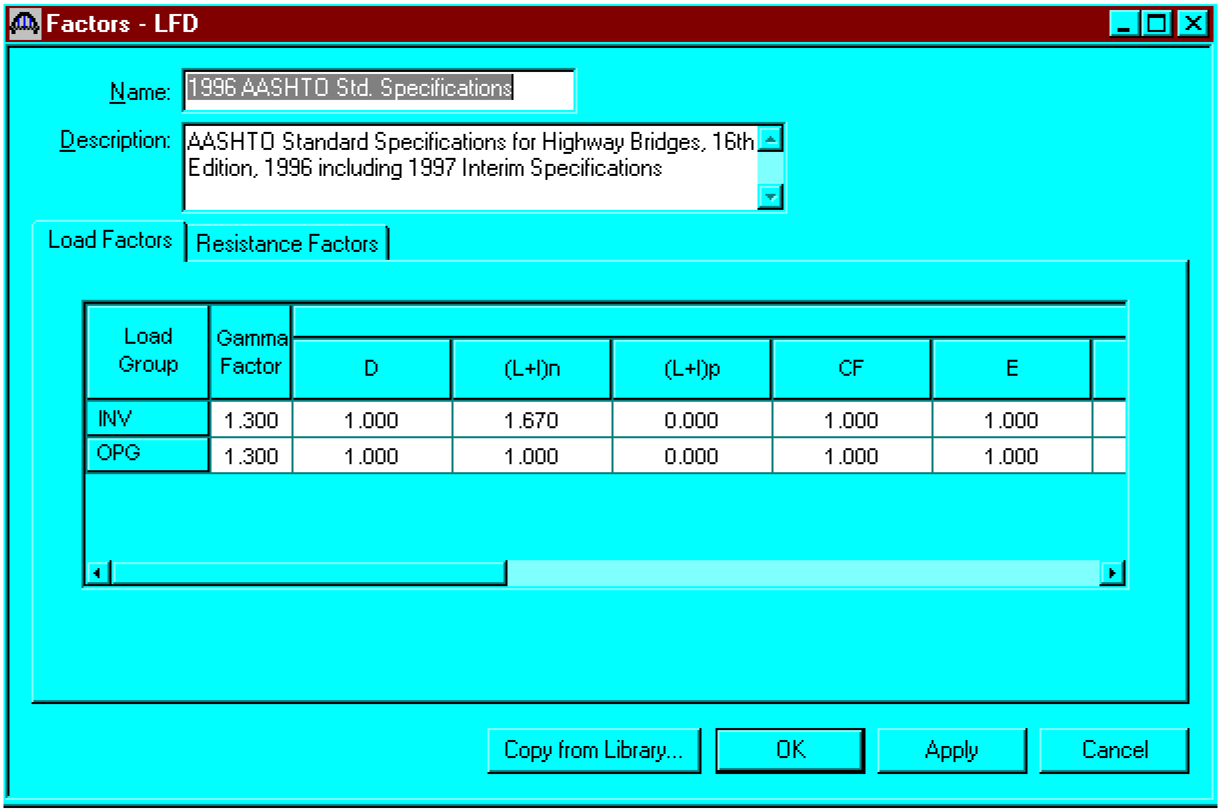
○ Constant impact override = ☐ %

LRFD Dynamic Load Allowance

Fatigue and fracture limit states: 15.0 %

All other limit states: 33.0 %

Click on Factors, right mouse click on LFD and select New. The LFD-Factors window will open. Click the Copy from Library button and select the 1996 AASHTO Standard Specifications from the library. Click Apply and then OK to save data to memory and close the window.



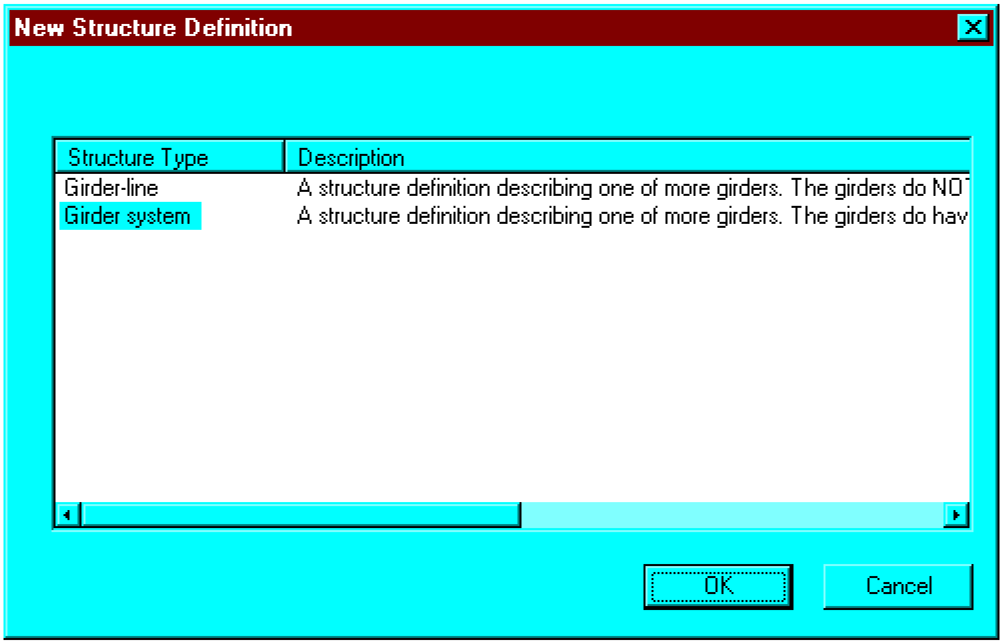
Name: 1996 AASHTO Std. Specifications

Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

Load Group	Gamma Factor	D	(L+I)n	(L+I)p	CF	E
INV	1.300	1.000	1.670	0.000	1.000	1.000
OPG	1.300	1.000	1.000	0.000	1.000	1.000

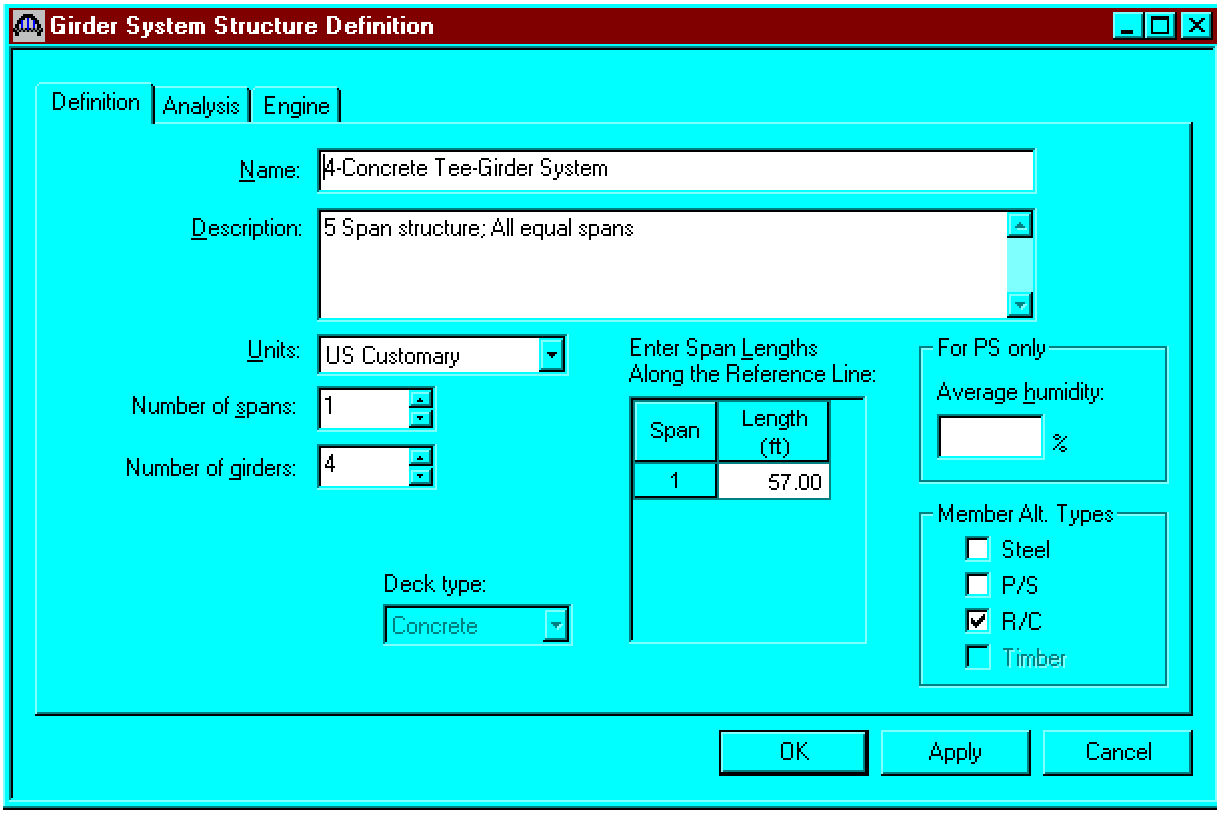
We will now skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



Structure Type	Description
Girder-line	A structure definition describing one of more girders. The girders do NO
Girder system	A structure definition describing one of more girders. The girders do hav

Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



Name: 4-Concrete Tee-Girder System

Description: 5 Span structure; All equal spans

Units: US Customary

Number of spans: 1

Number of girders: 4

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	57.00

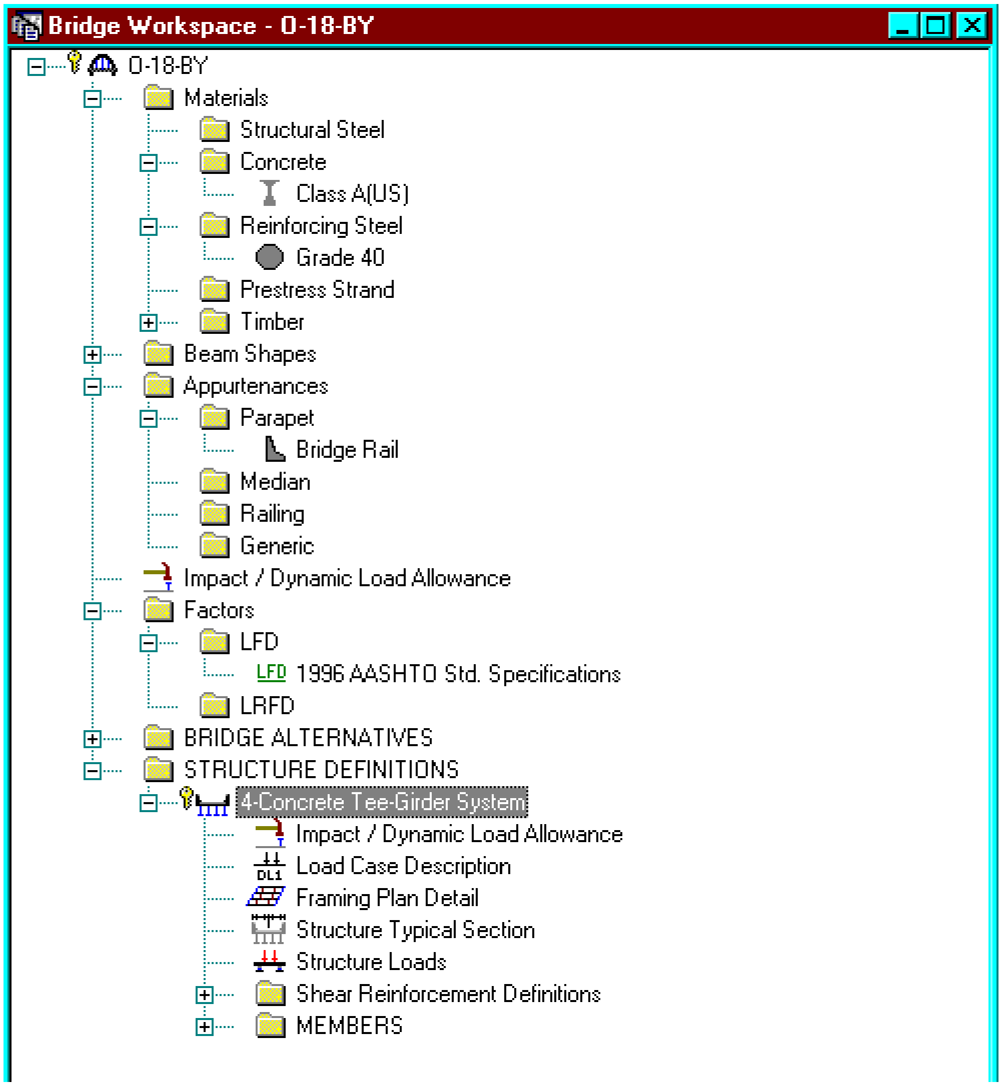
For PS only

Average humidity: %

Member Alt. Types

☐ Steel
☐ P/S
☑ R/C
☐ Timber

The partially expanded Bridge Workspace tree is shown below:

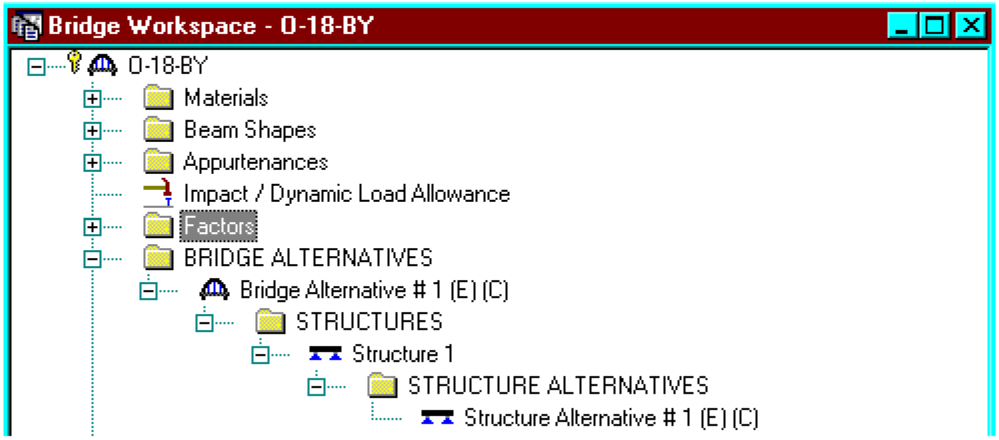


Bridge Workspace - 0-18-BY

- 0-18-BY
  - Materials
    - Structural Steel
    - Concrete
      - Class A(US)
    - Reinforcing Steel
      - Grade 40
    - Prestress Strand
    - Timber
  - Beam Shapes
  - Appurtenances
    - Parapet
      - Bridge Rail
    - Median
    - Railing
    - Generic
  - Impact / Dynamic Load Allowance
  - Factors
    - LFD
      - 1996 AASHTO Std. Specifications
    - LRFD
  - BRIDGE ALTERNATIVES
  - STRUCTURE DEFINITIONS
    - 4-Concrete Tee-Girder System
      - Impact / Dynamic Load Allowance
      - Load Case Description
      - Framing Plan Detail
      - Structure Typical Section
      - Structure Loads
      - Shear Reinforcement Definitions
      - MEMBERS

We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

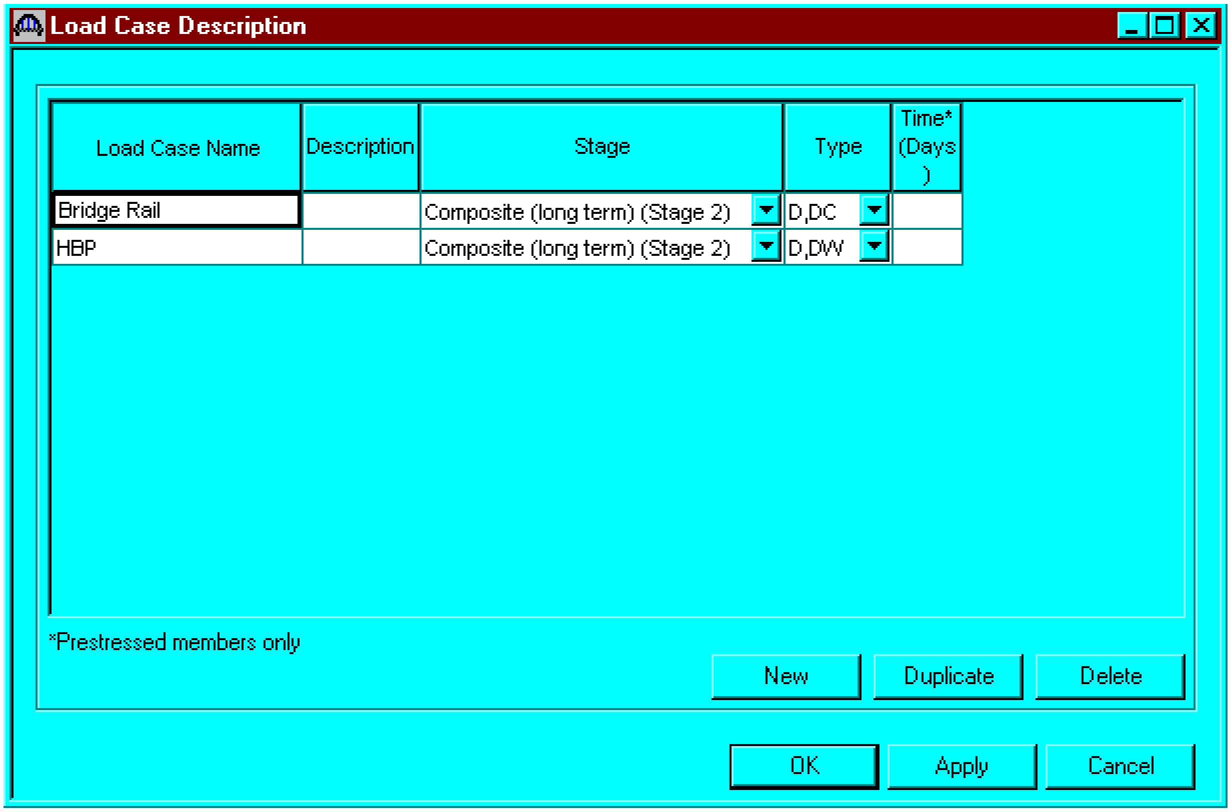
The partially expanded Bridge Workspace tree is shown below:



Bridge Workspace - 0-18-BY

- 0-18-BY
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
  - BRIDGE ALTERNATIVES
    - Bridge Alternative # 1 (E) (C)
      - STRUCTURES
        - Structure 1
          - STRUCTURE ALTERNATIVES
            - Structure Alternative # 1 (E) (C)

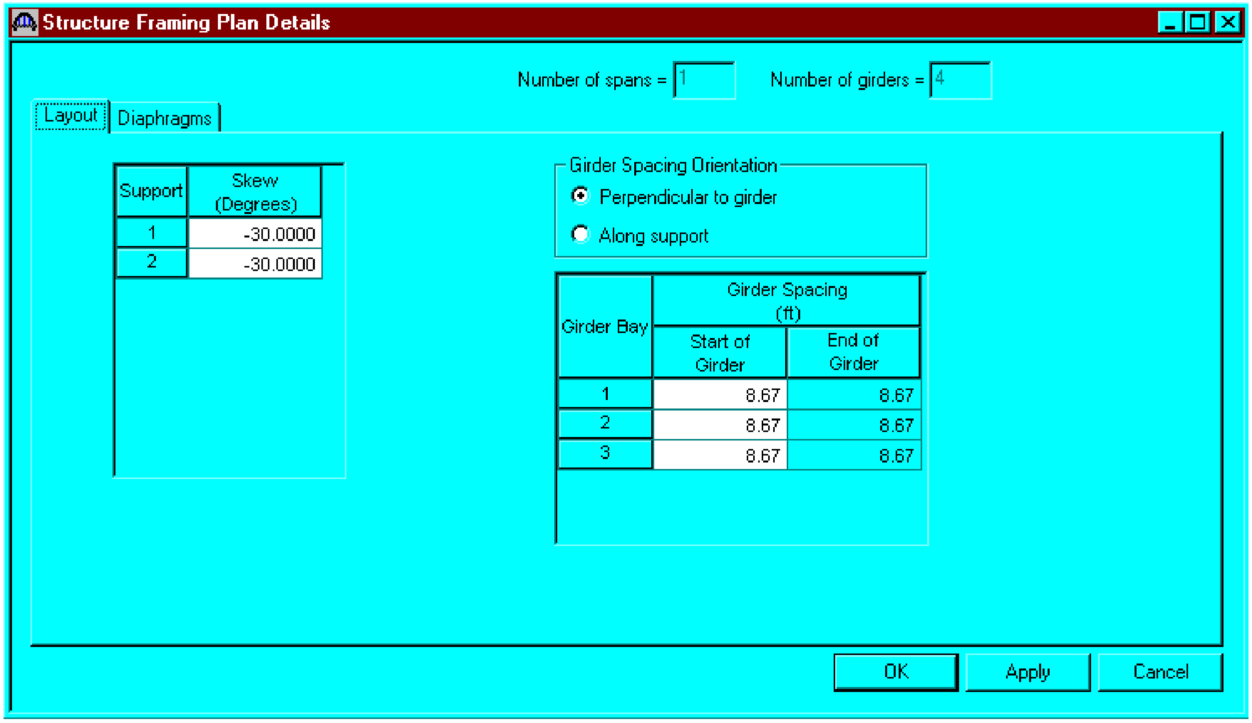
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.



Load Case Name	Description	Stage	Type	Time* (Days)
Bridge Rail		Composite (long term) (Stage 2)	D,DC	
HBP		Composite (long term) (Stage 2)	D,DW	

*Prestressed members only

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



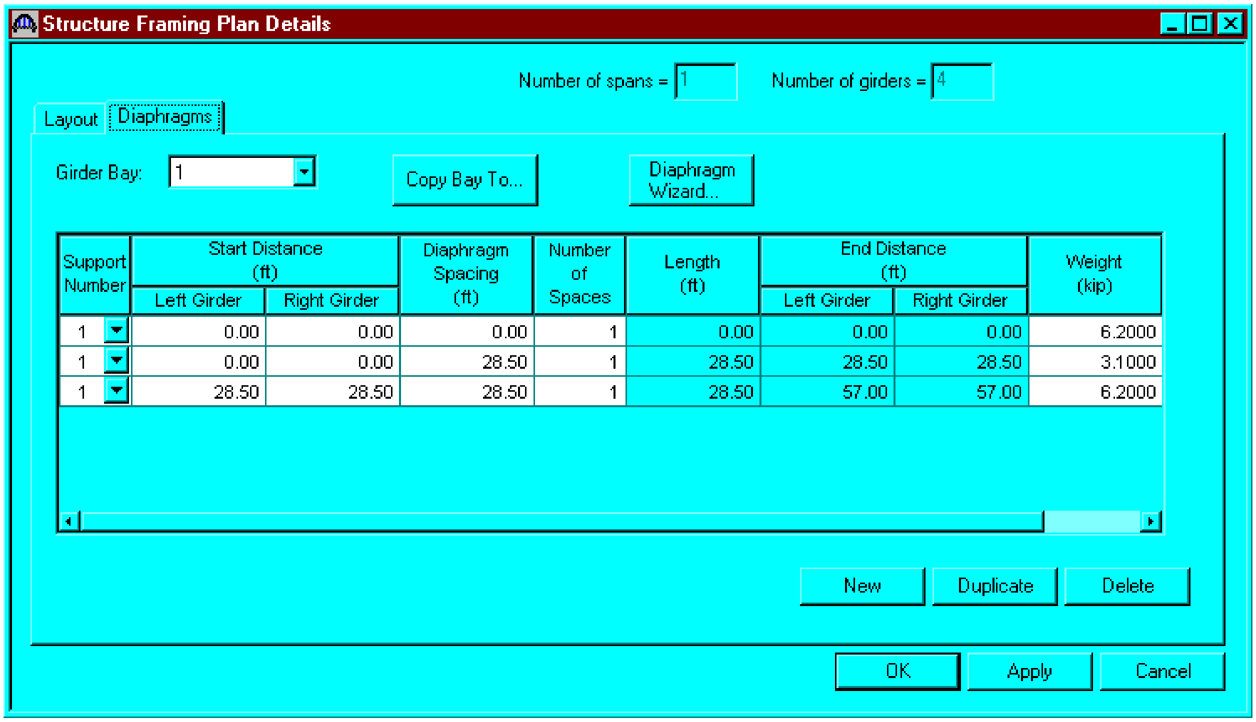
Number of spans = 1   Number of girders = 4

Support	Skew (Degrees)
1	-30.0000
2	-30.0000

Girder Spacing Orientation
● Perpendicular to girder
○ Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	8.67	8.67
2	8.67	8.67
3	8.67	8.67

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.

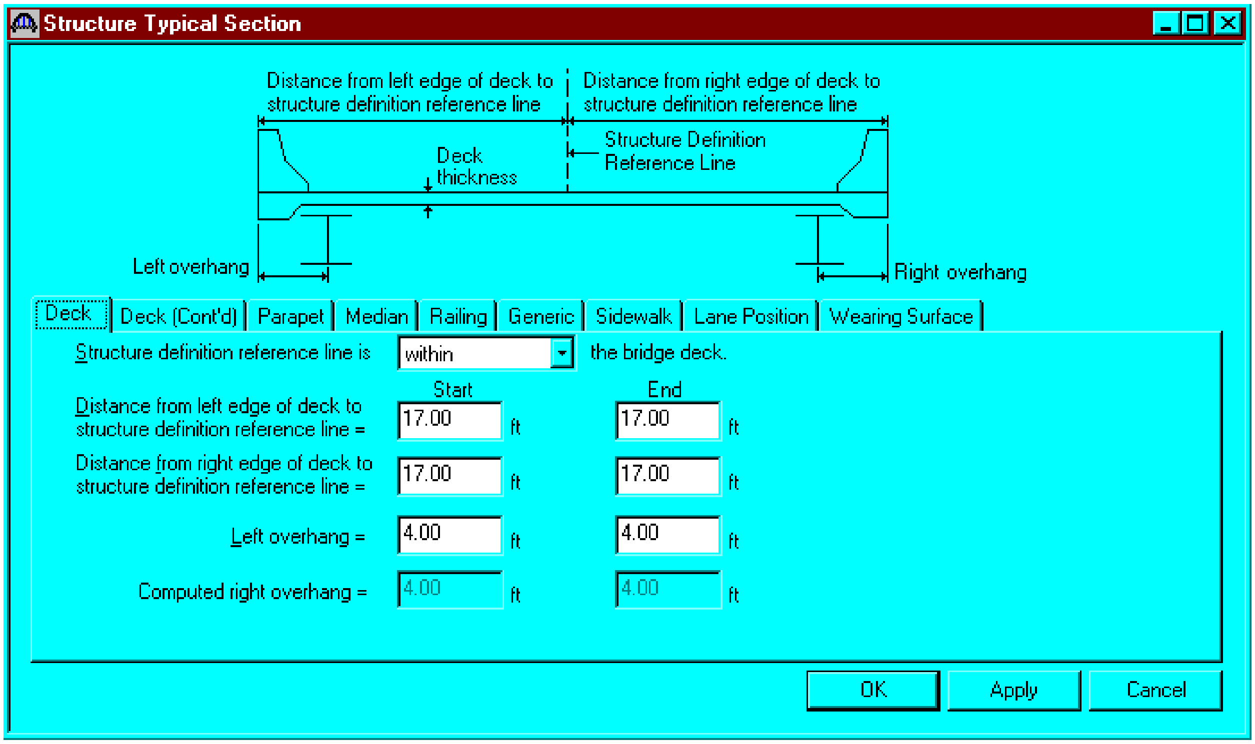


Number of spans = 1
Number of girders = 4

Girder Bay: 1

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	6.2000
1	0.00	0.00	28.50	1	28.50	28.50	28.50	3.1000
1	28.50	28.50	28.50	1	28.50	57.00	57.00	6.2000

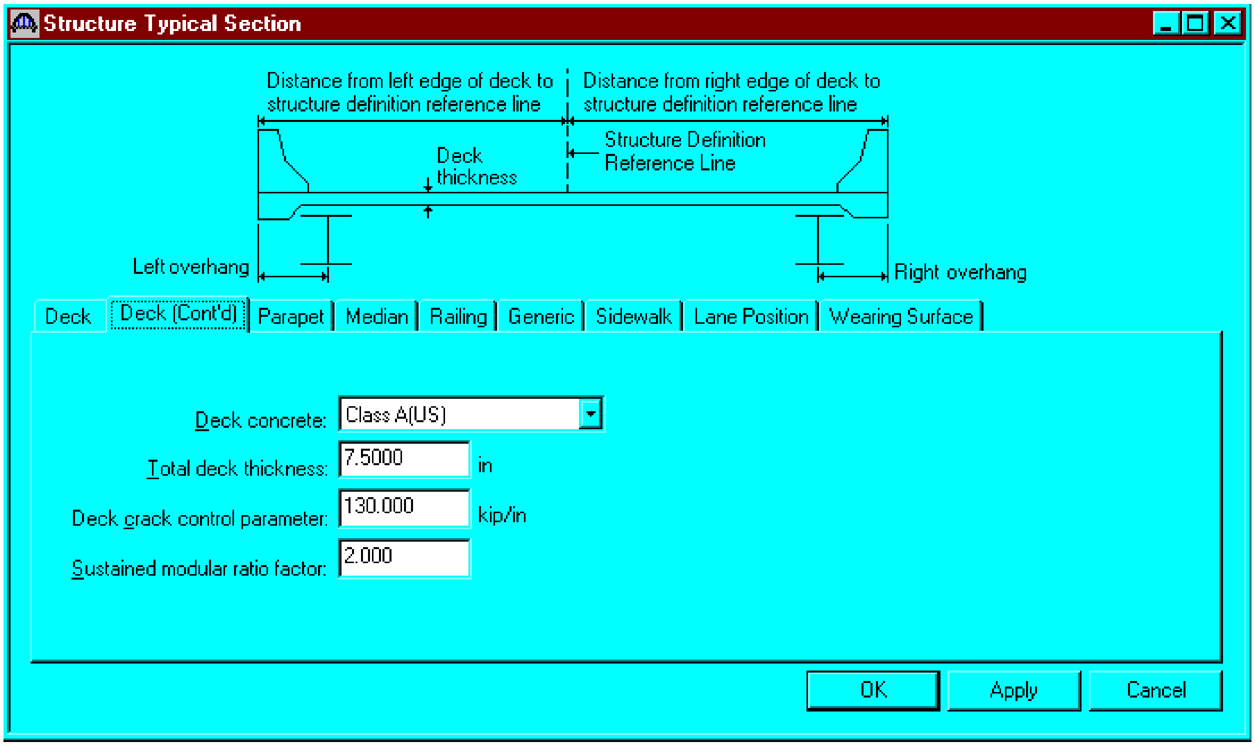
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



Structure definition reference line is within the bridge deck.

	Start		End	
Distance from left edge of deck to structure definition reference line =	17.00	ft	17.00	ft
Distance from right edge of deck to structure definition reference line =	17.00	ft	17.00	ft
Left overhang =	4.00	ft	4.00	ft
Computed right overhang =	4.00	ft	4.00	ft

The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



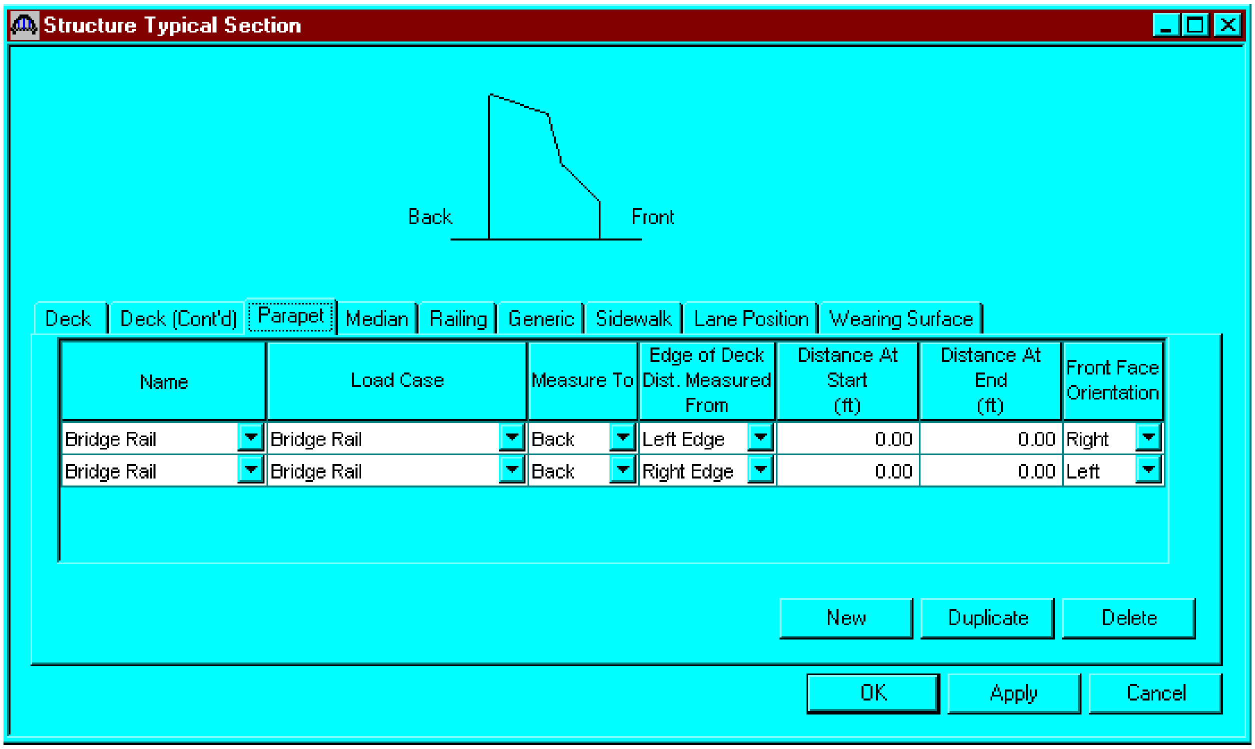
Deck concrete: Class A(US)

Total deck thickness: 7.5000 in

Deck crack control parameter: 130.000 kip/in

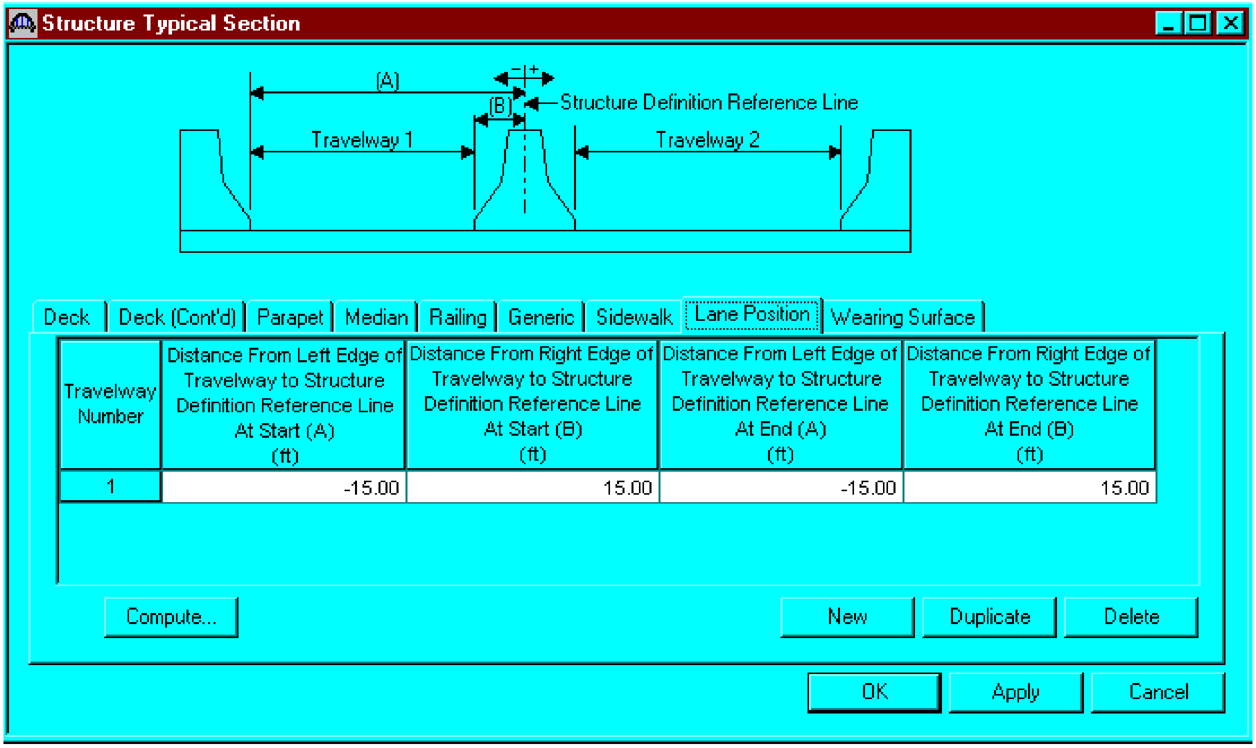
Sustained modular ratio factor: 2.000

Parapets:
Add two parapets as shown below.



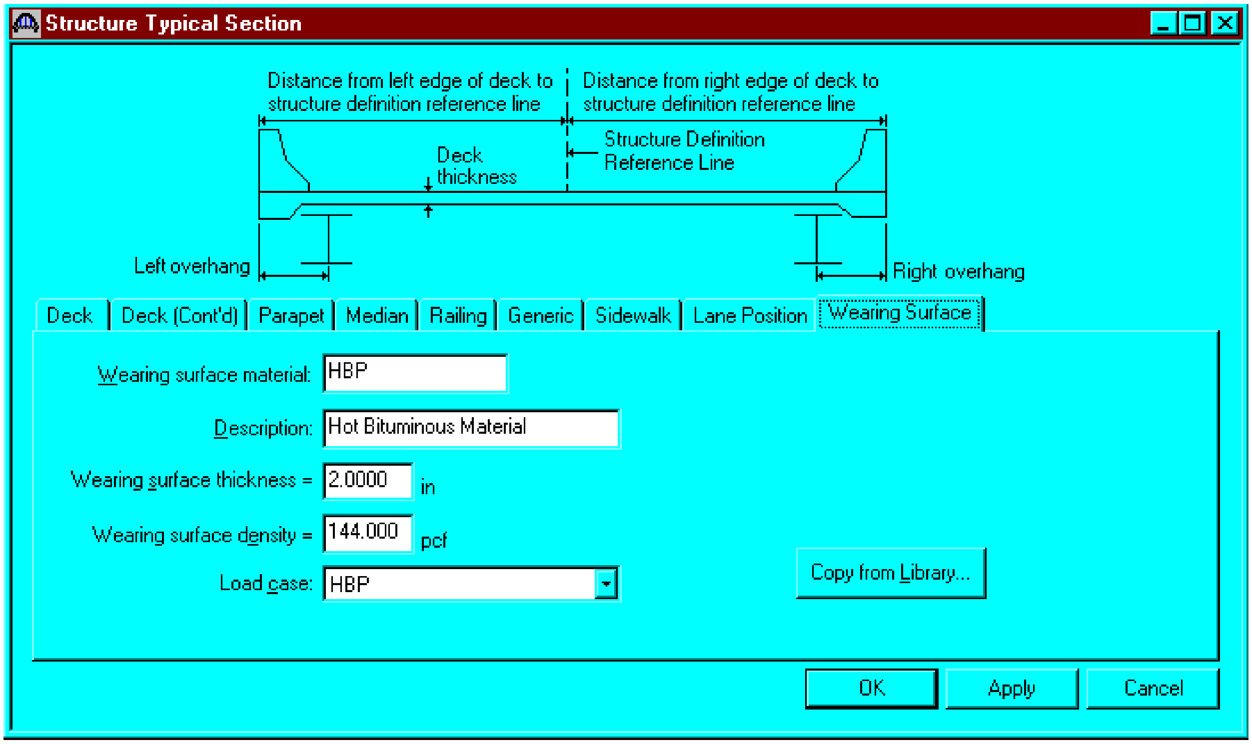
Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Bridge Rail	Bridge Rail	Back	Left Edge	0.00	0.00	Right
Bridge Rail	Bridge Rail	Back	Right Edge	0.00	0.00	Left

Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to apply the computed values. The Lane Position tab is populated as shown below.



Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At End (B) (ft)
1	-15.00	15.00	-15.00	15.00

Enter the following wearing surface information on the Wearing Surface tab.



Wearing surface material: HBP

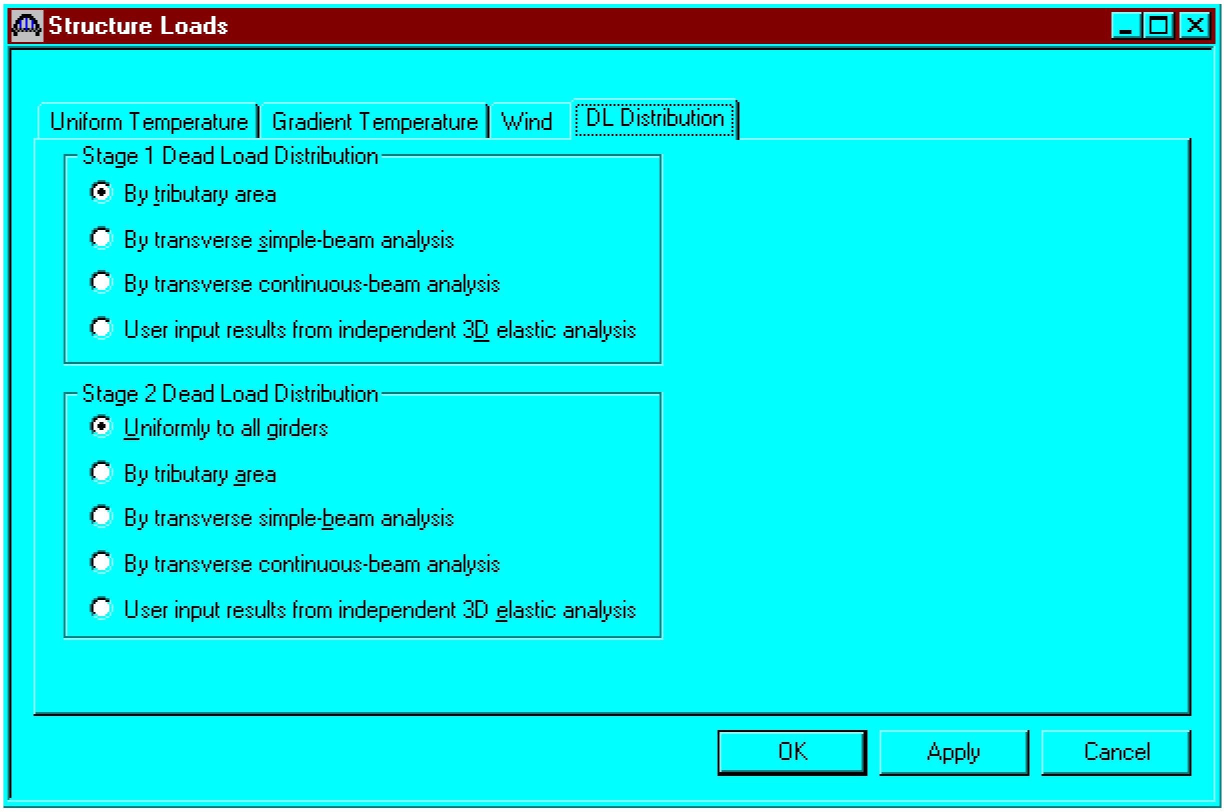
Description: Hot Bituminous Material

Wearing surface thickness = 2.0000 in

Wearing surface density = 144.000 pcf

Load case: HBP

Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



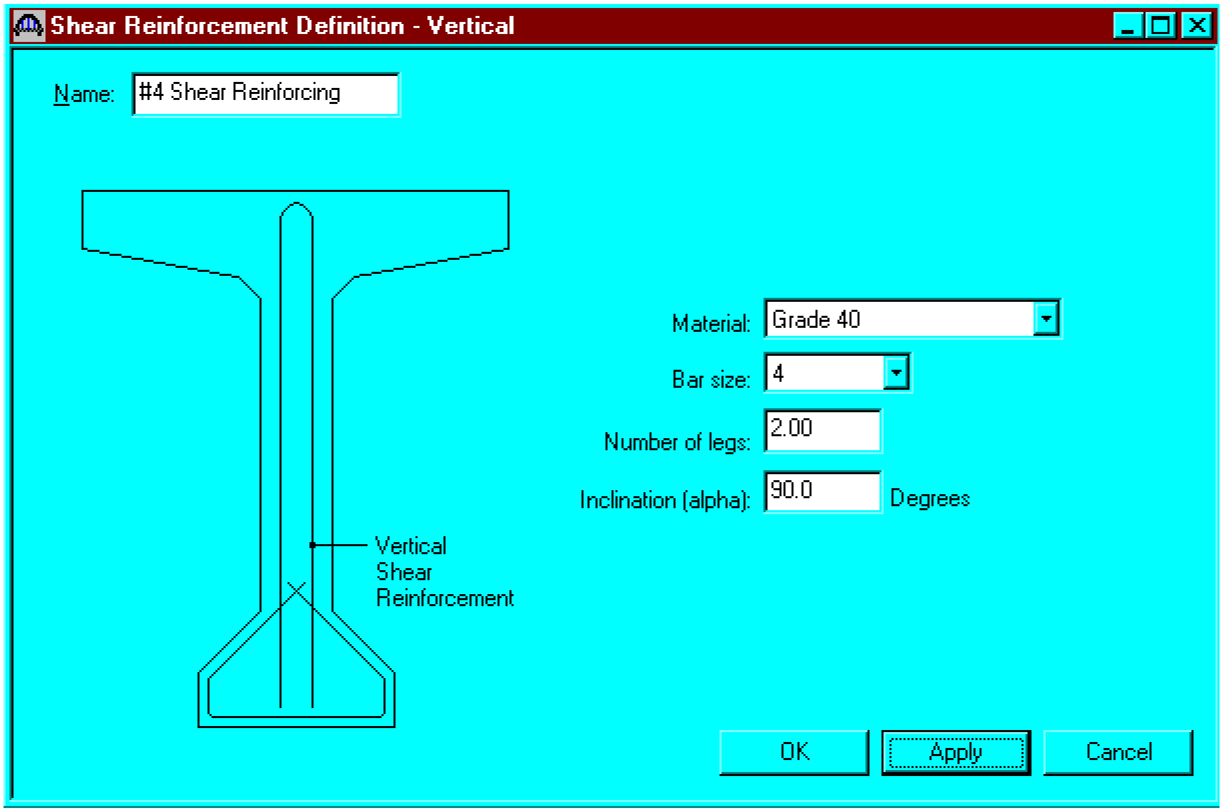
Stage 1 Dead Load Distribution

● By tributary area
○ By transverse simple-beam analysis
○ By transverse continuous-beam analysis
○ User input results from independent 3D elastic analysis

Stage 2 Dead Load Distribution

● Uniformly to all girders
○ By tributary area
○ By transverse simple-beam analysis
○ By transverse continuous-beam analysis
○ User input results from independent 3D elastic analysis

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



Name: #4 Shear Reinforcing

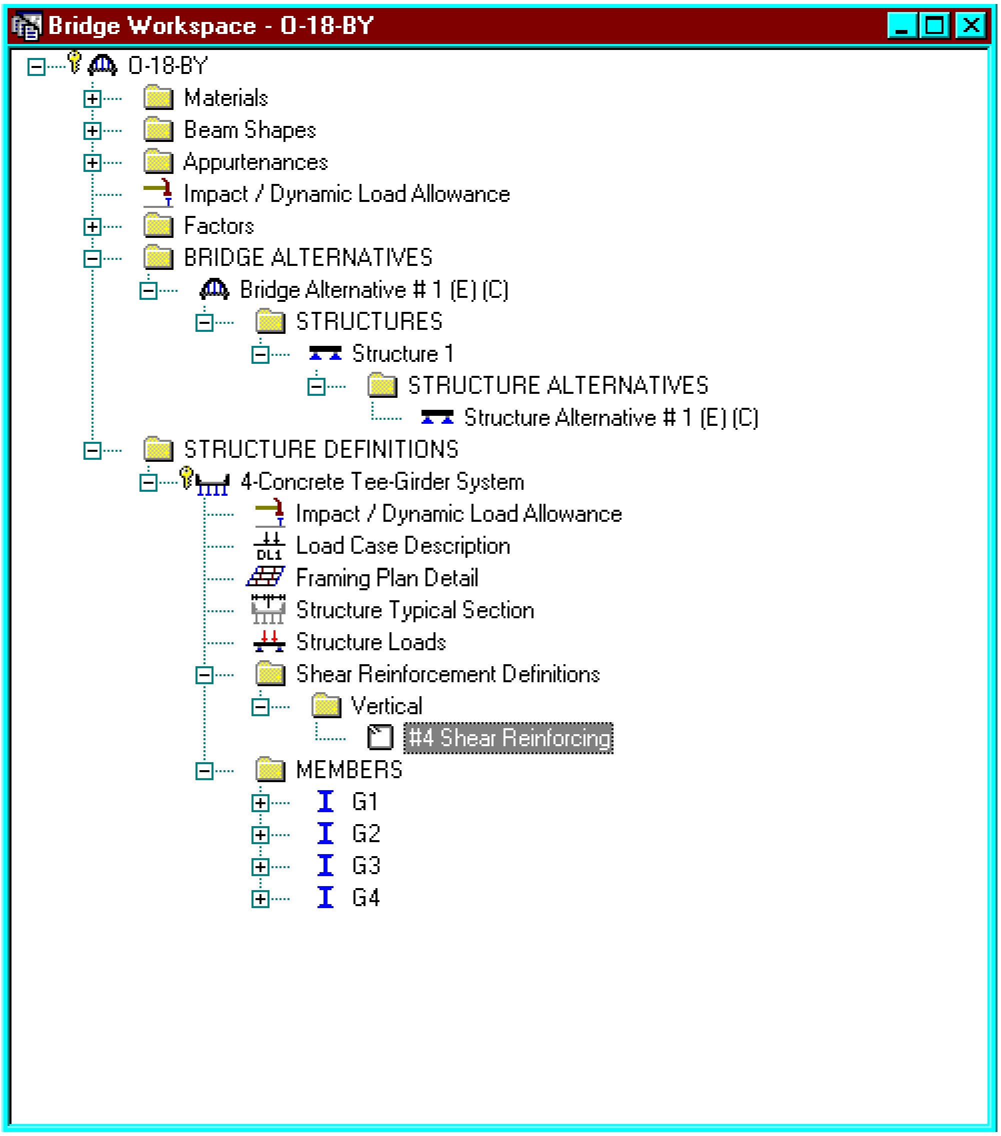
Material: Grade 40

Bar size: 4

Number of legs: 2.00

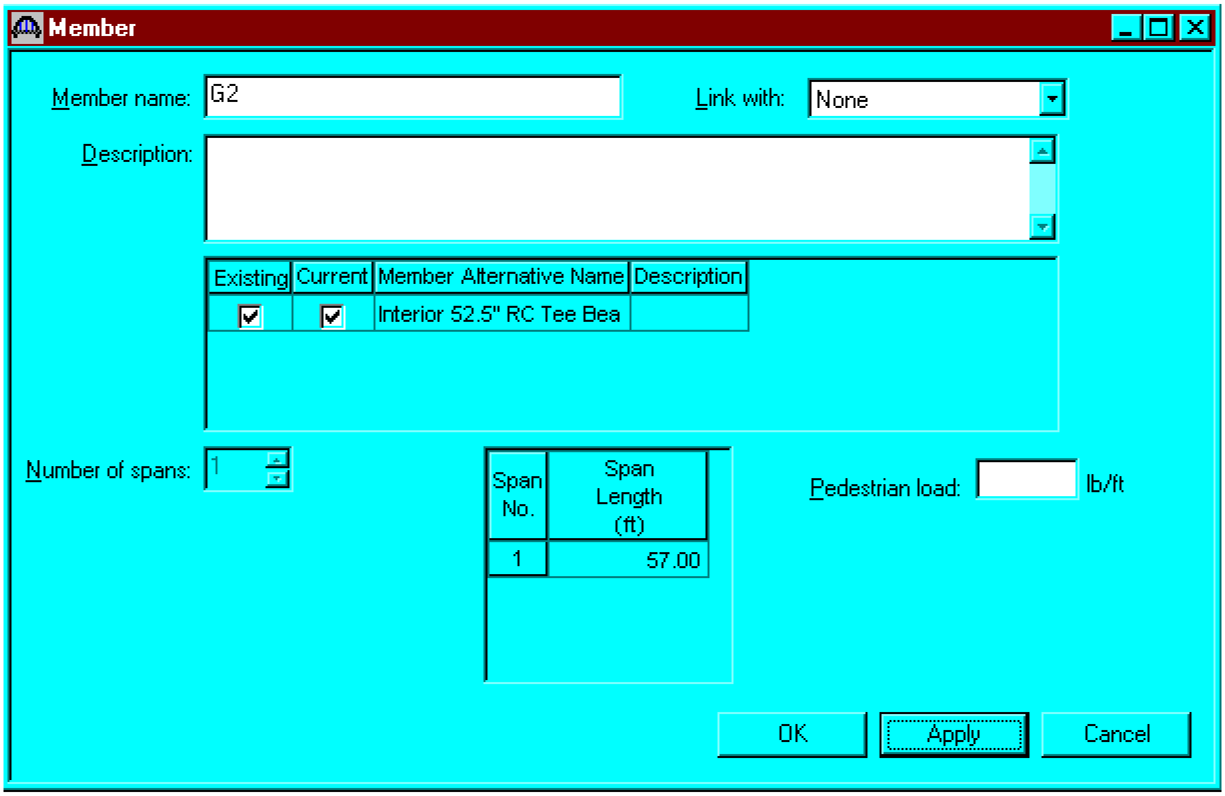
Inclination (alpha): 90.0 Degrees

The partially expanded Bridge Workspace tree is shown below:



- 0-18-BY
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
  - BRIDGE ALTERNATIVES
    - Bridge Alternative # 1 (E) (C)
      - STRUCTURES
        - Structure 1
          - STRUCTURE ALTERNATIVES
            - Structure Alternative # 1 (E) (C)
  - STRUCTURE DEFINITIONS
    - 4-Concrete Tee-Girder System
      - Impact / Dynamic Load Allowance
      - Load Case Description
      - Framing Plan Detail
      - Structure Typical Section
      - Structure Loads
      - Shear Reinforcement Definitions
        - Vertical
          - #4 Shear Reinforcing
      - MEMBERS
        - G1
        - G2
        - G3
        - G4

Describing a member:
The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.



Member name: G2

Link with: None

Description:

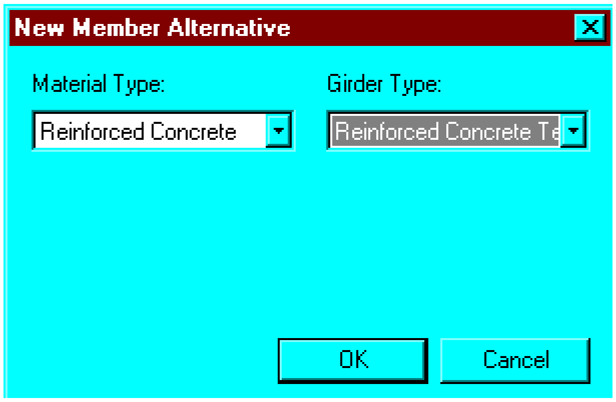
Existing	Current	Member Alternative Name	Description
☑	☑	Interior 52.5" RC Tee Bea	

Number of spans: 1

Span No.	Span Length (ft)
1	57.00

Pedestrian load: lb/ft

Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Reinforced Concrete for the Material Type and Reinforced Concrete Tee for the Girder Type.

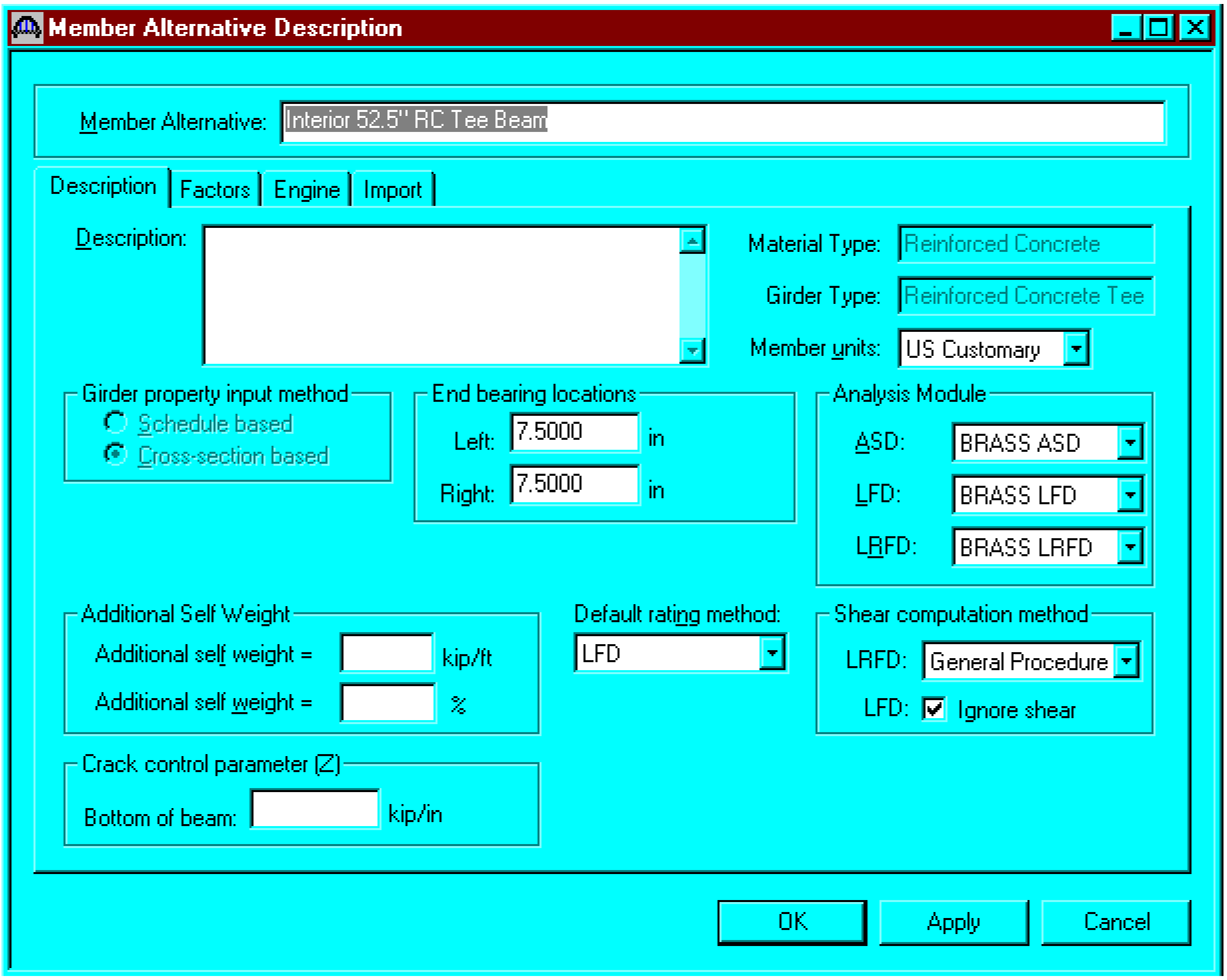


Material Type: Reinforced Concrete

Girder Type: Reinforced Concrete Te

Click OK to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below.



Member Alternative: Interior 52.5" RC Tee Beam

Description:

Material Type: Reinforced Concrete

Girder Type: Reinforced Concrete Tee

Member units: US Customary

Girder property input method
○ Schedule based
● Cross-section based

End bearing locations
Left: 7.5000 in
Right: 7.5000 in

Analysis Module
ASD: BRASS ASD
LFD: BRASS LFD
LRFD: BRASS LRFD

Additional Self Weight
Additional self weight = kip/ft
Additional self weight = %

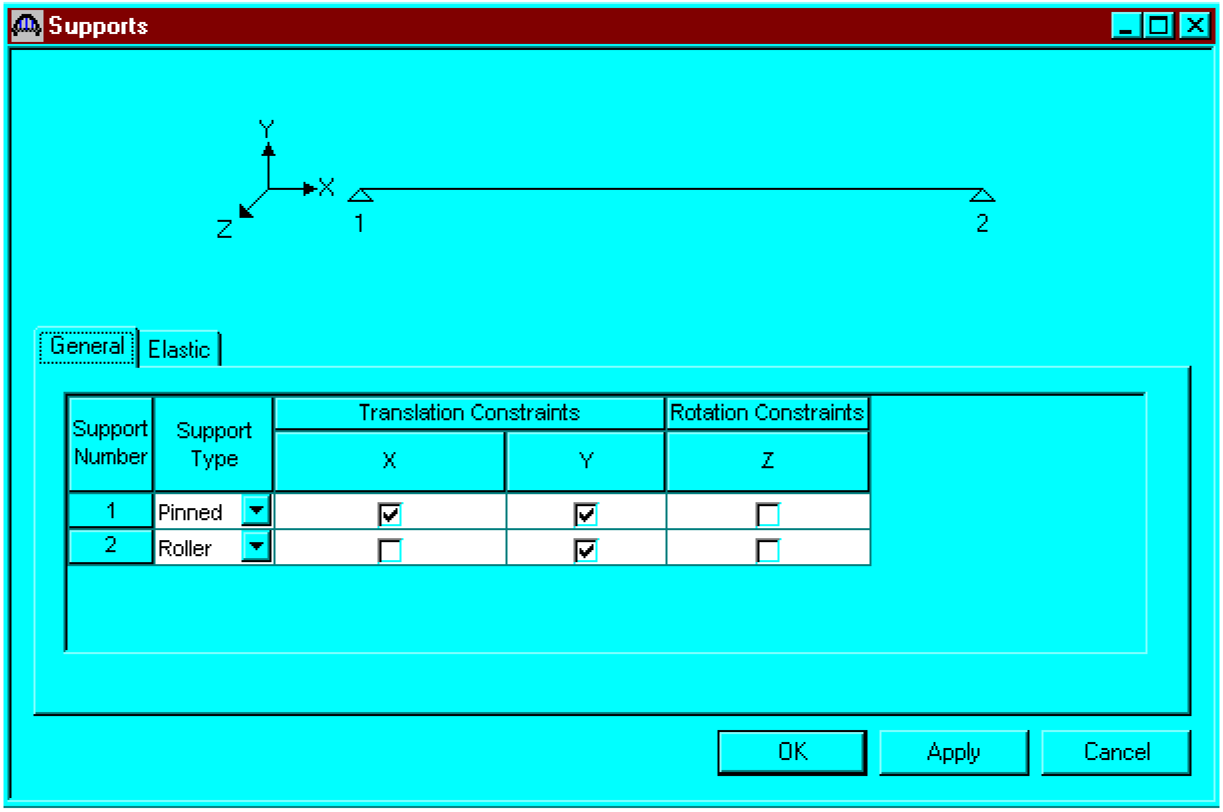
Default rating method: LFD

Shear computation method
LRFD: General Procedure
LFD: ☑ Ignore shear

Crack control parameter (Z)
Bottom of beam: kip/in

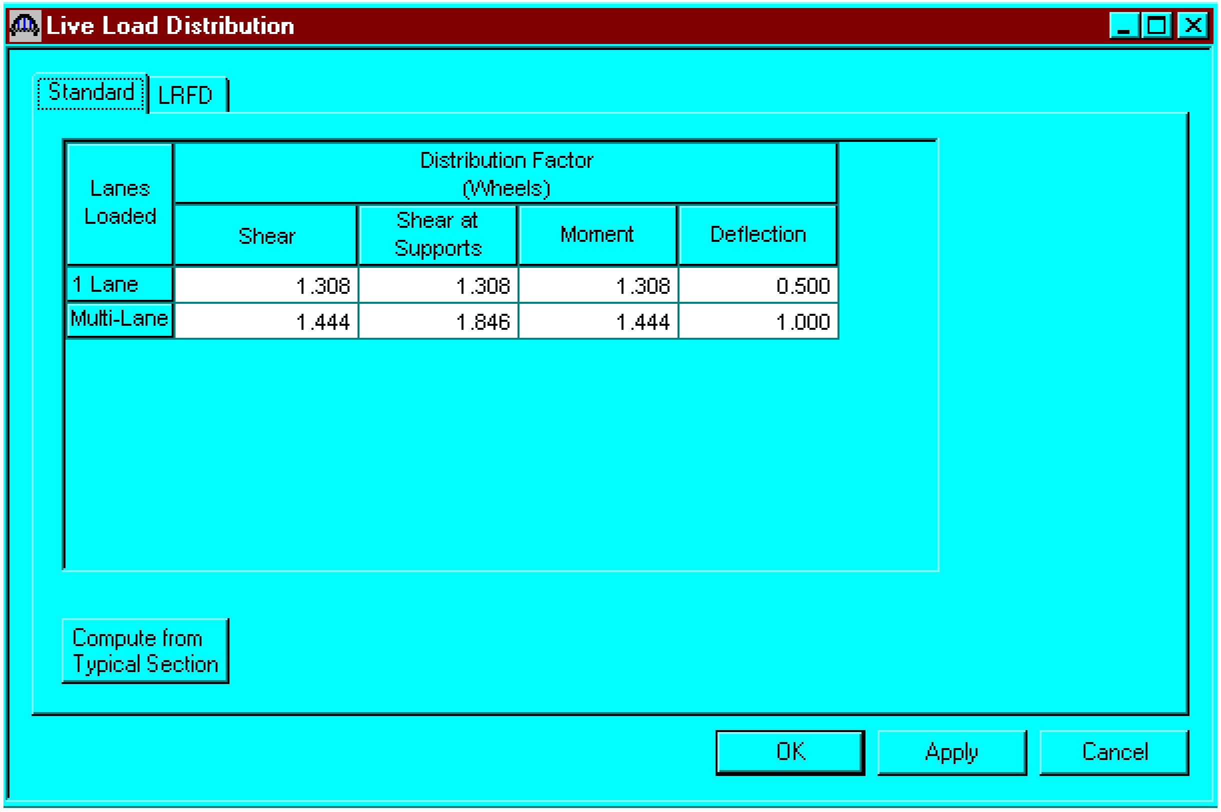
Shear computation method: Check this box if the AASHTO LFD shear specifications should be ignored in the analysis.

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



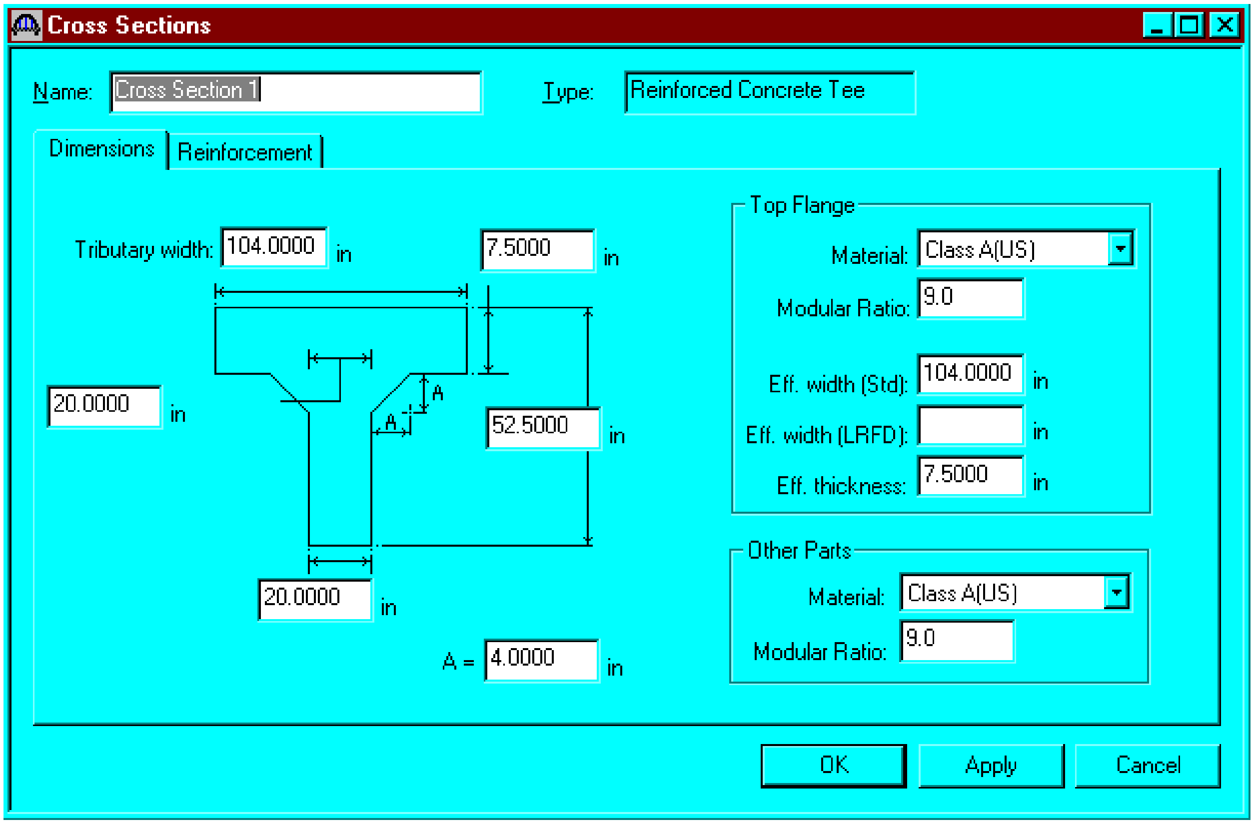
Support Number	Support Type	Translation Constraints		Rotation Constraints
		X	Y	Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐

Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23. Click Apply and then OK to save data to memory and close the window.



Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.308	1.308	1.308	0.500
Multi-Lane	1.444	1.846	1.444	1.000

Double click on Cross Sections in the tree to create the cross section that defines the girder geometry. The Cross Section window is shown below. Define cross section 1 as shown below. Click apply and then the Reinforcement tab.



Name: Cross Section 1

Type: Reinforced Concrete Tee

Tributary width: 104.0000 in

7.5000 in

20.0000 in

52.5000 in

20.0000 in

A = 4.0000 in

Top Flange

Material: Class A(US)

Modular Ratio: 9.0

Eff. width (Std): 104.0000 in

Eff. width (LRFD): in

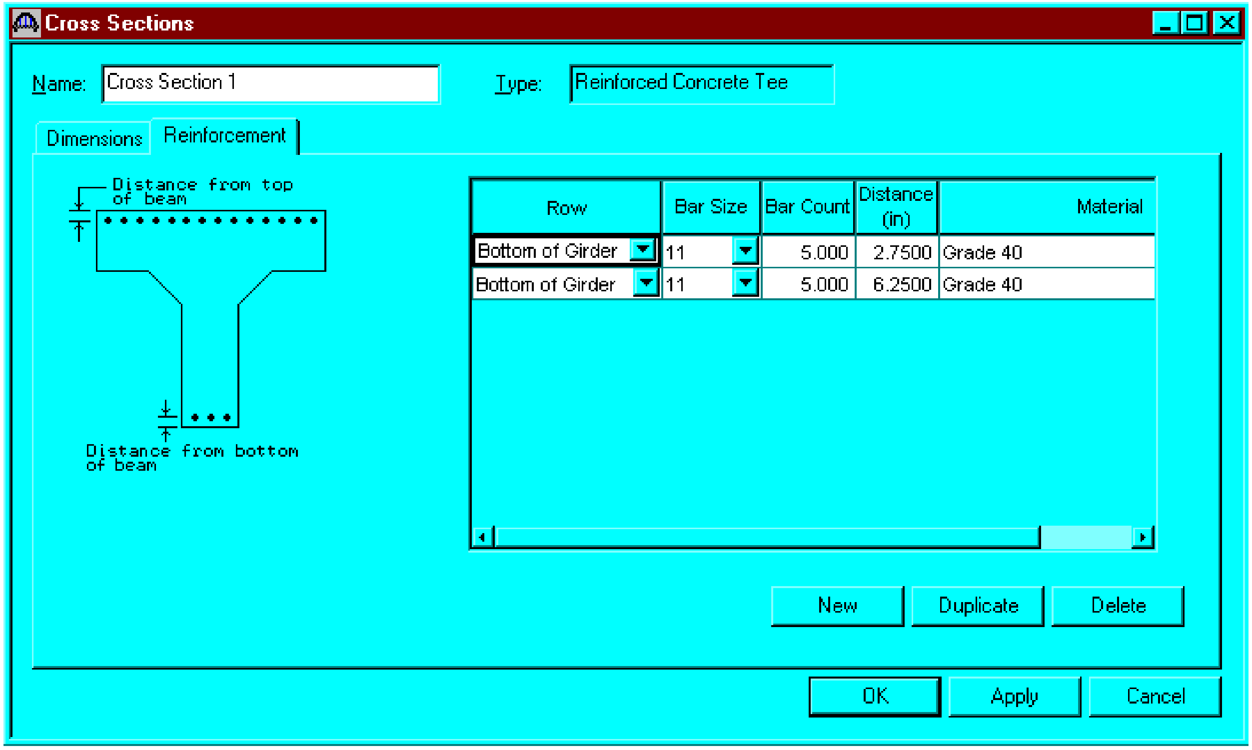
Eff. thickness: 7.5000 in

Other Parts

Material: Class A(US)

Modular Ratio: 9.0

Define reinforcements for Cross Section 1. Click OK to save data to memory and close the window.

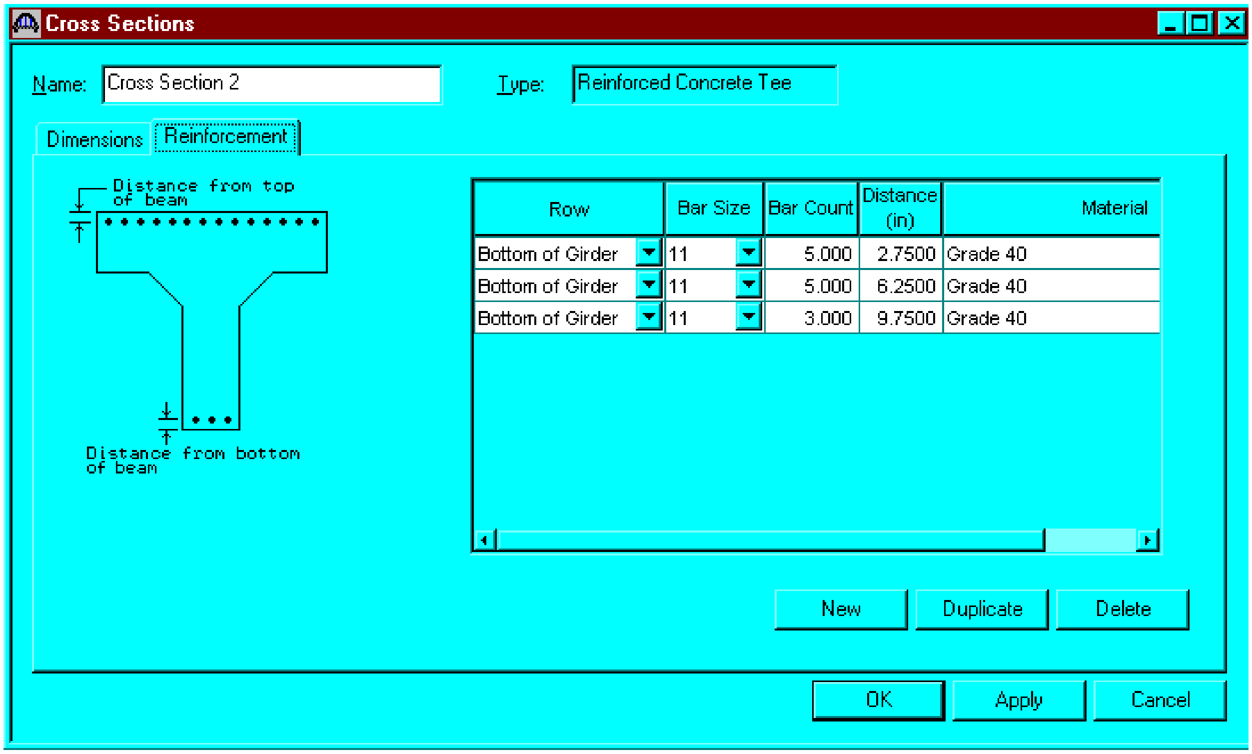


Name: Cross Section 1

Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	5.000	2.7500	Grade 40
Bottom of Girder	11	5.000	6.2500	Grade 40

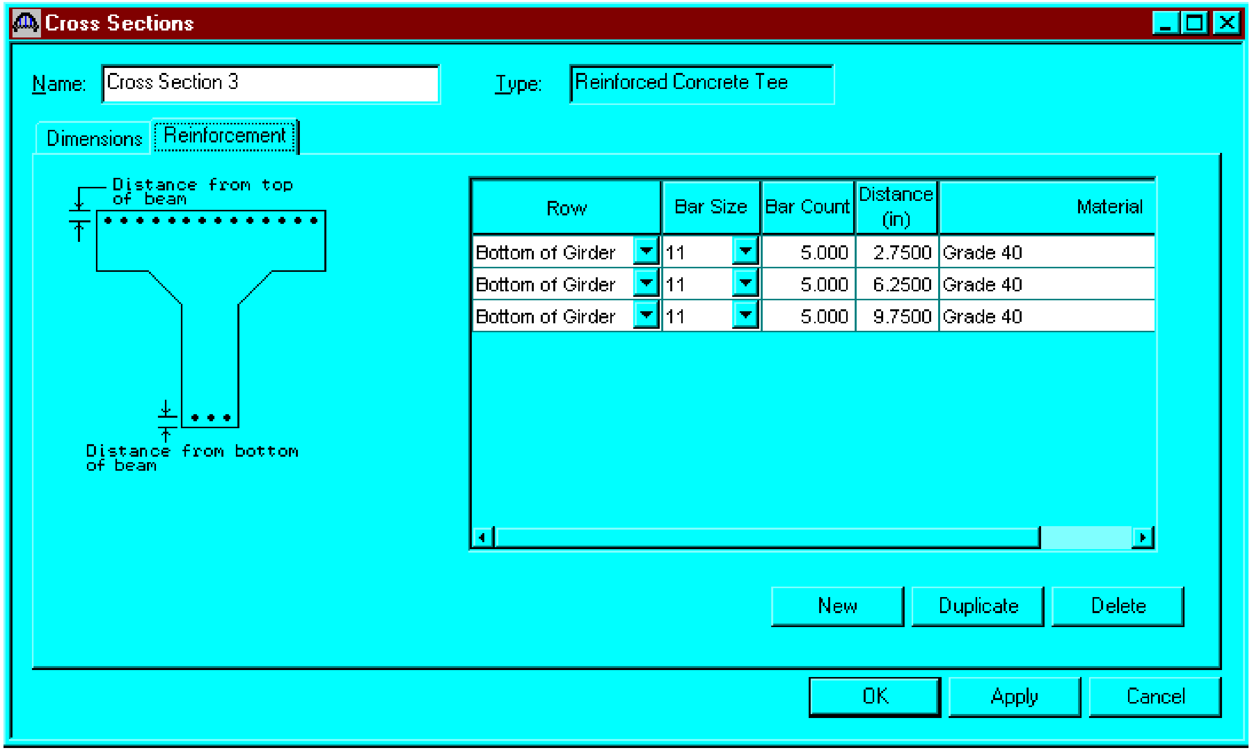
Using the same techniques, create cross section 2, cross-section 3 and define their associated reinforcement patterns.



Name: Cross Section 2

Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	5.000	2.7500	Grade 40
Bottom of Girder	11	5.000	6.2500	Grade 40
Bottom of Girder	11	3.000	9.7500	Grade 40

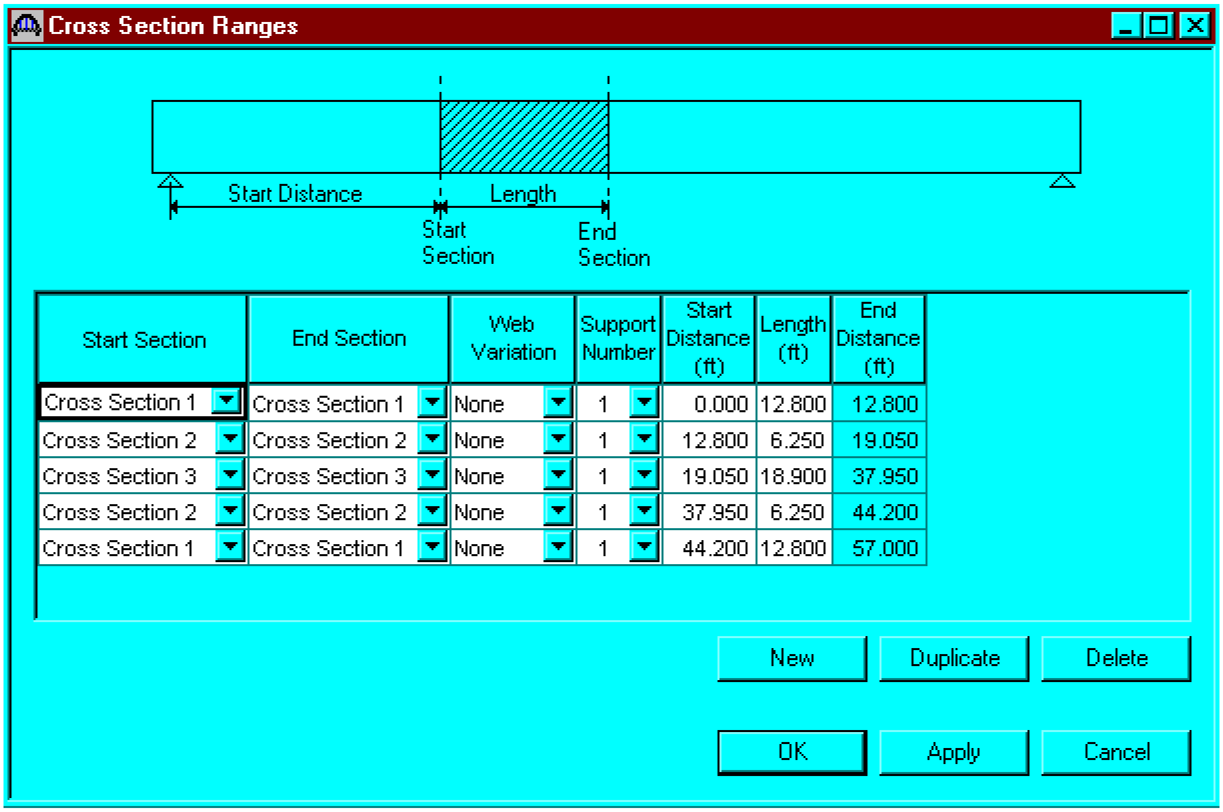


Name: Cross Section 3

Type: Reinforced Concrete Tee

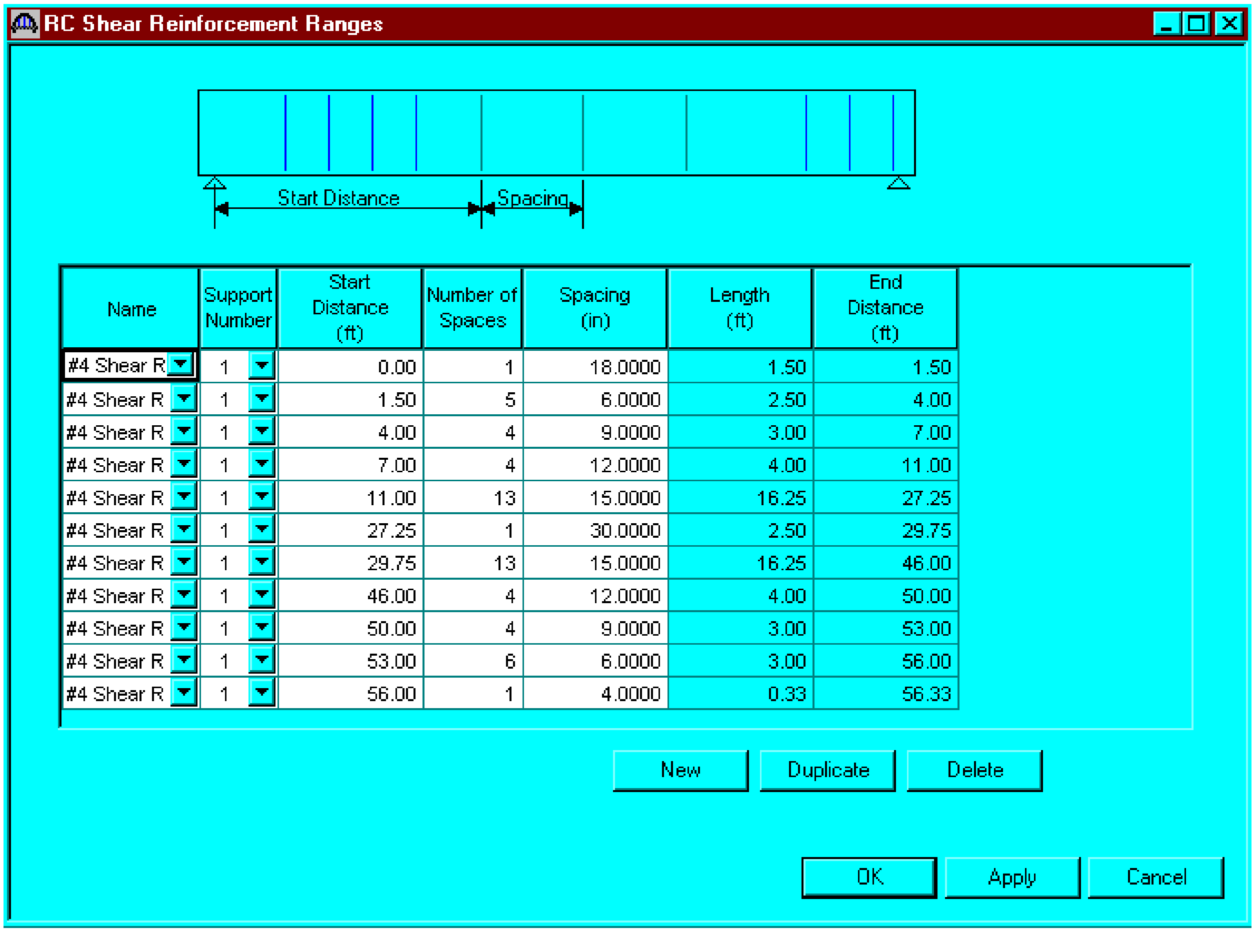
Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	5.000	2.7500	Grade 40
Bottom of Girder	11	5.000	6.2500	Grade 40
Bottom of Girder	11	5.000	9.7500	Grade 40

The Cross Section Ranges window is shown below. Define the ranges over which the cross sections apply.



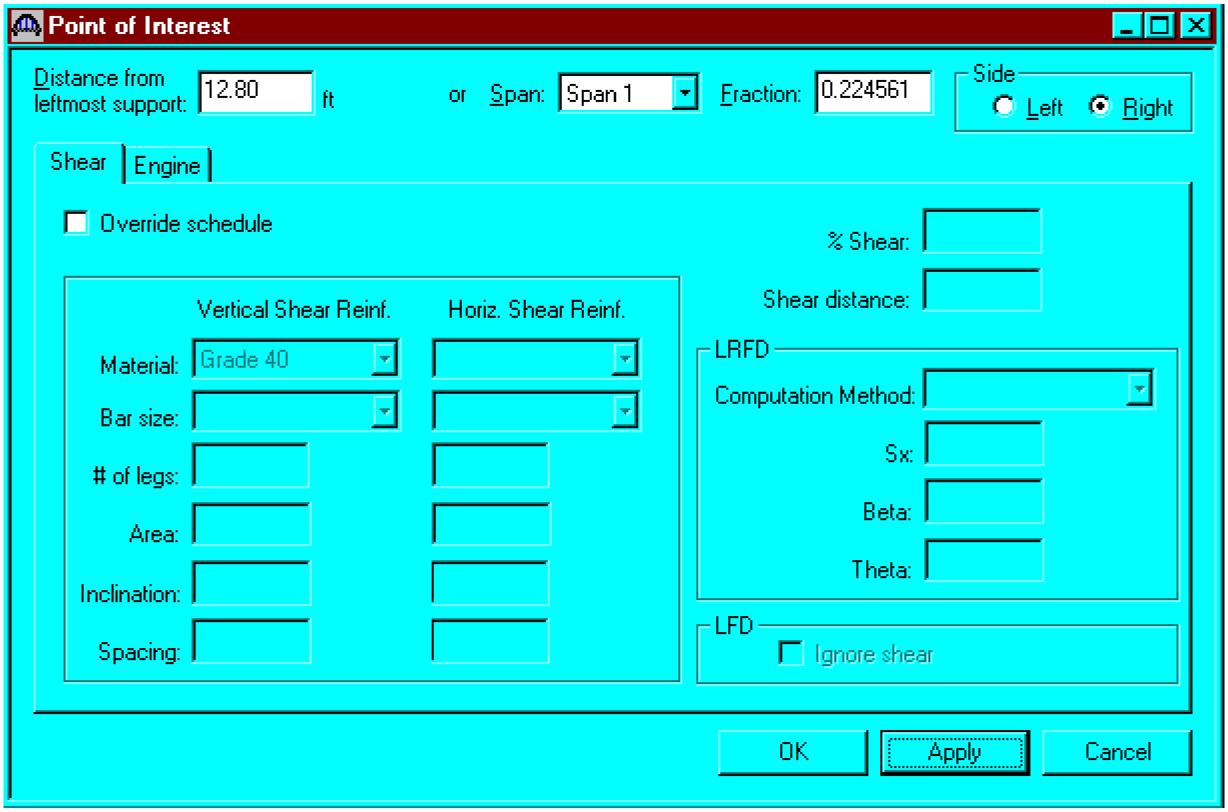
Start Section	End Section	Web Variation	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Cross Section 1	Cross Section 1	None	1	0.000	12.800	12.800
Cross Section 2	Cross Section 2	None	1	12.800	6.250	19.050
Cross Section 3	Cross Section 3	None	1	19.050	18.900	37.950
Cross Section 2	Cross Section 2	None	1	37.950	6.250	44.200
Cross Section 1	Cross Section 1	None	1	44.200	12.800	57.000

Shear reinforcement locations are described using the Shear Reinforcement Ranges window shown below.



Name	Support Number	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
#4 Shear R	1	0.00	1	18.0000	1.50	1.50
#4 Shear R	1	1.50	5	6.0000	2.50	4.00
#4 Shear R	1	4.00	4	9.0000	3.00	7.00
#4 Shear R	1	7.00	4	12.0000	4.00	11.00
#4 Shear R	1	11.00	13	15.0000	16.25	27.25
#4 Shear R	1	27.25	1	30.0000	2.50	29.75
#4 Shear R	1	29.75	13	15.0000	16.25	46.00
#4 Shear R	1	46.00	4	12.0000	4.00	50.00
#4 Shear R	1	50.00	4	9.0000	3.00	53.00
#4 Shear R	1	53.00	6	6.0000	3.00	56.00
#4 Shear R	1	56.00	1	4.0000	0.33	56.33

Define points of interest using the Points of Interest window shown below.



Distance from leftmost support: 12.80 ft

Span: Span 1

Fraction: 0.224561

Side: ○ Left ● Right

☐ Override schedule

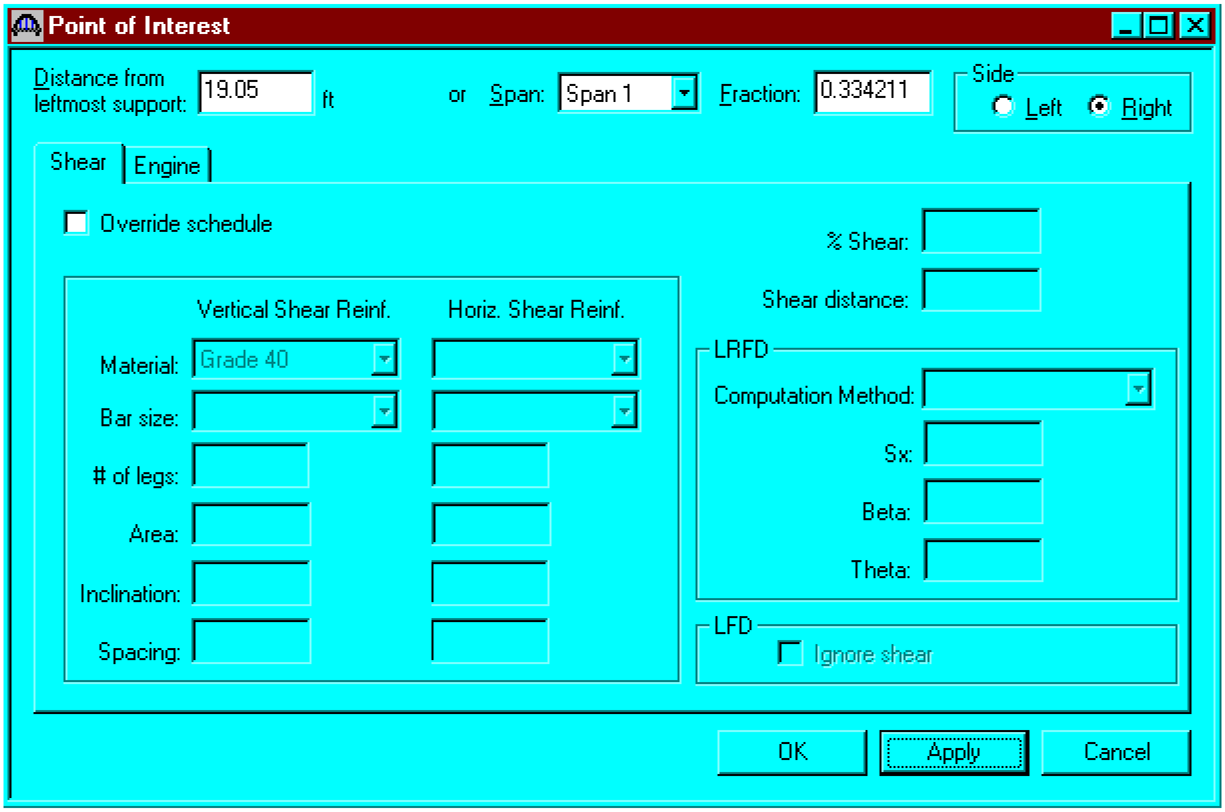
Material: Grade 40

☐ Ignore shear

The Point of Interest window enables the user to enter points of interest in addition to those that are automatically generated by the program.

15 bar diameter = 15*(11/8) = 1.712’
Clear Span/20 = (57-1.83)/20 = 2.75’
Effective Depth = 46.25/12 = 3.85’   Use 3.8’

First rebar cutoff from left support = 12.8’
Second rebar cutoff from left support = 19.05’



Point of Interest

Distance from leftmost support: 19.05 ft

or Span: Span 1

Fraction: 0.334211

Side: ○ Left ● Right

☐ Override schedule

	Vertical Shear Reinf.	Horiz. Shear Reinf.
Material:	Grade 40	
Bar size:		
# of legs:		
Area:		
Inclination:		
Spacing:		

% Shear:

Shear distance:

LRFD

Computation Method:

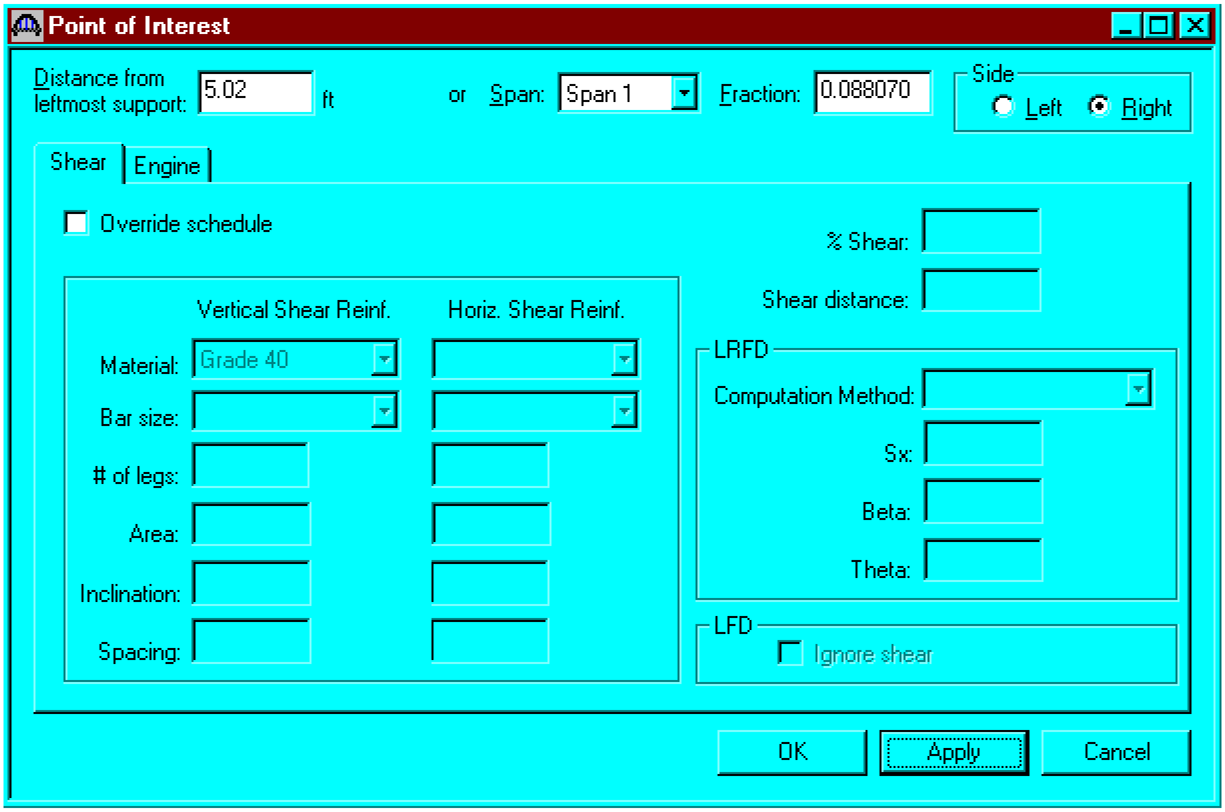
Sx:

Beta:

Theta:

LFD

☐ Ignore shear



Point of Interest

Distance from leftmost support: 5.02 ft or Span: Span 1 Fraction: 0.088070

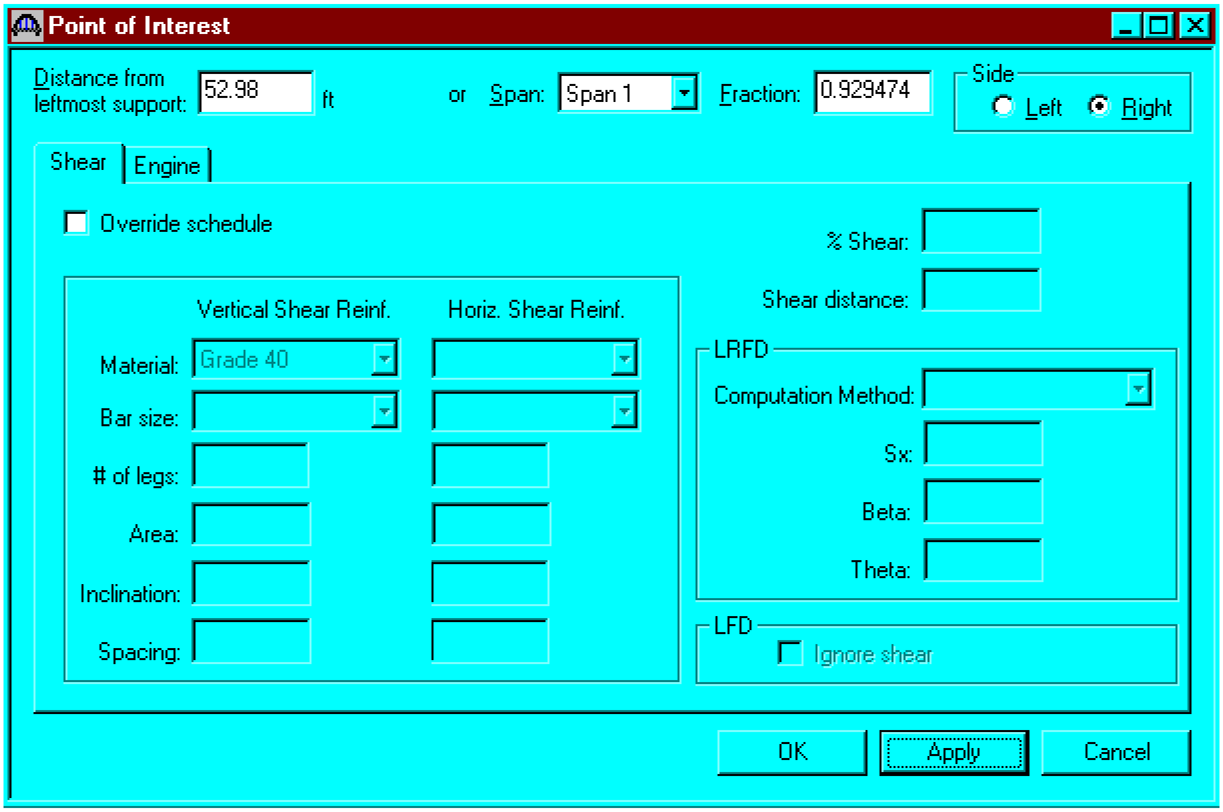
Side: ○ Left ● Right

☐ Override schedule

Material: Grade 40

LFD: ☐ Ignore shear

Shear Check: d = 52.5”-6.25” = 46.25” = 3.85’
Shear at a distance ‘d’ from the free edge of the left support + 1.167’ = 3.85’ + 1.167’ = 5.02’



Point of Interest

Distance from leftmost support: 52.98 ft

or Span: Span 1

Fraction: 0.929474

Side: ○ Left ● Right

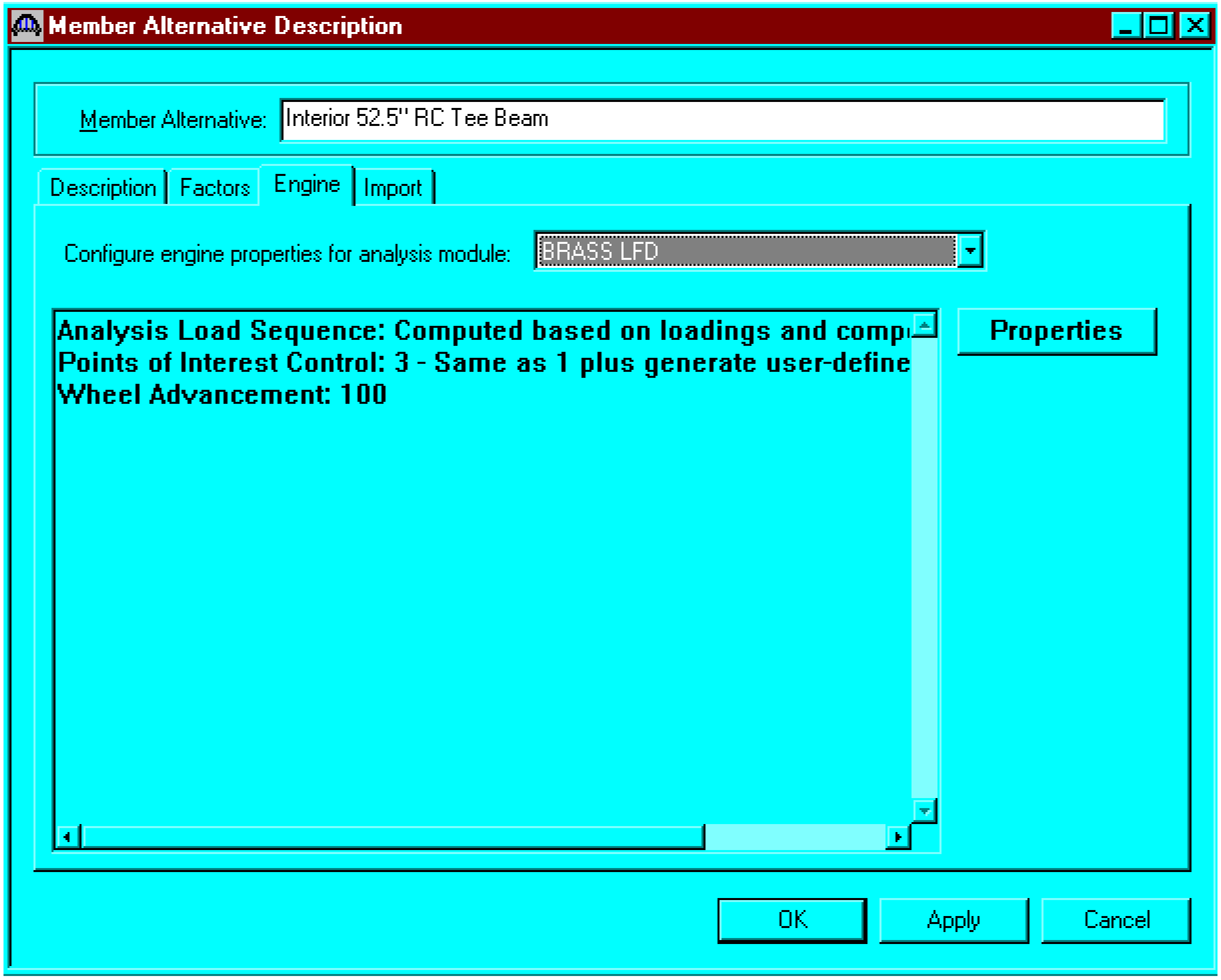
☐ Override schedule

Material: Grade 40

☐ Ignore shear

Shear Check: d = 52.5”-6.25” = 46.25” = 3.85’
Shear at a distance ‘d’ from the free edge of the right support + 0.167’ = 3.85’ + 0.167’ = 4.02’
Therefore, Distance from the left support = 57.0’- 4.04’ = 52.98’

Open the Member Alternative Description window and click the Engine tab as shown below.

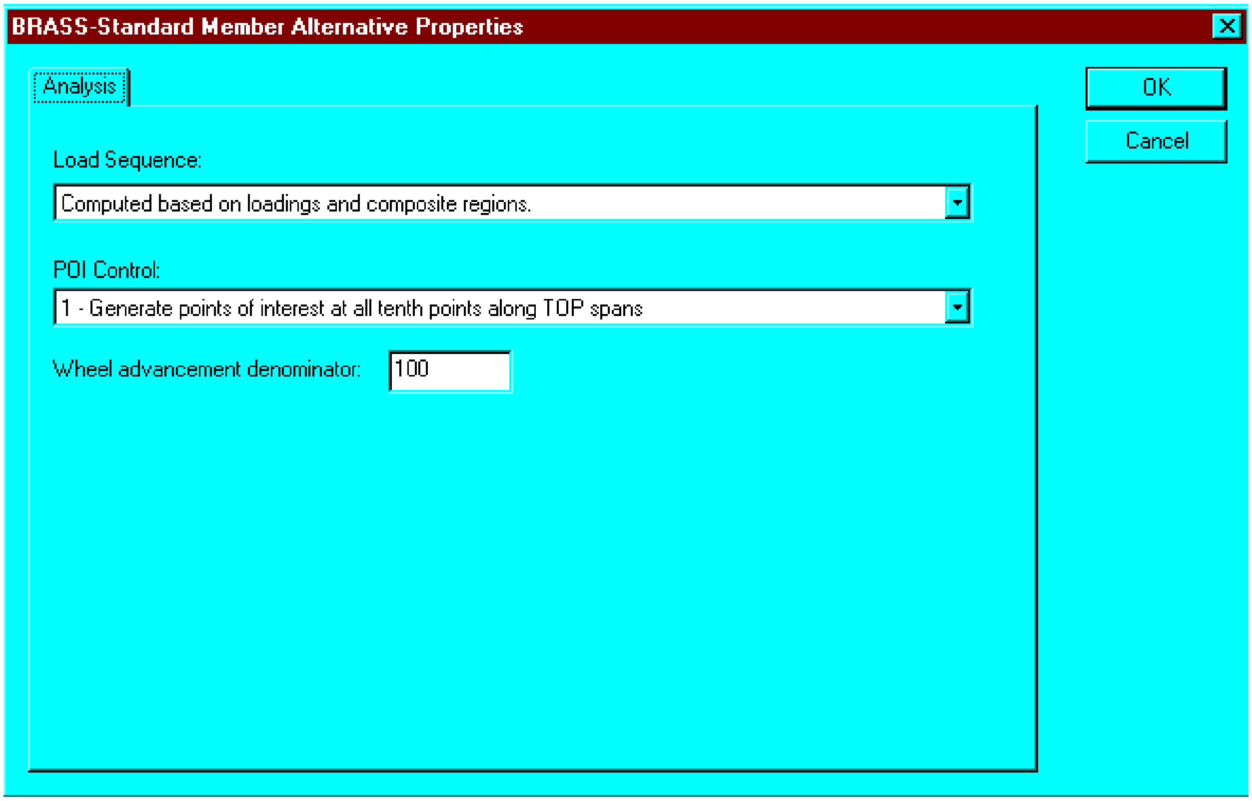


Member Alternative: Interior 52.5" RC Tee Beam

Configure engine properties for analysis module: BRASS LFD

Analysis Load Sequence: Computed based on loadings and comp
Points of Interest Control: 3 - Same as 1 plus generate user-define
Wheel Advancement: 100

Click the Properties button to edit the engine properties for BRASS LFD.

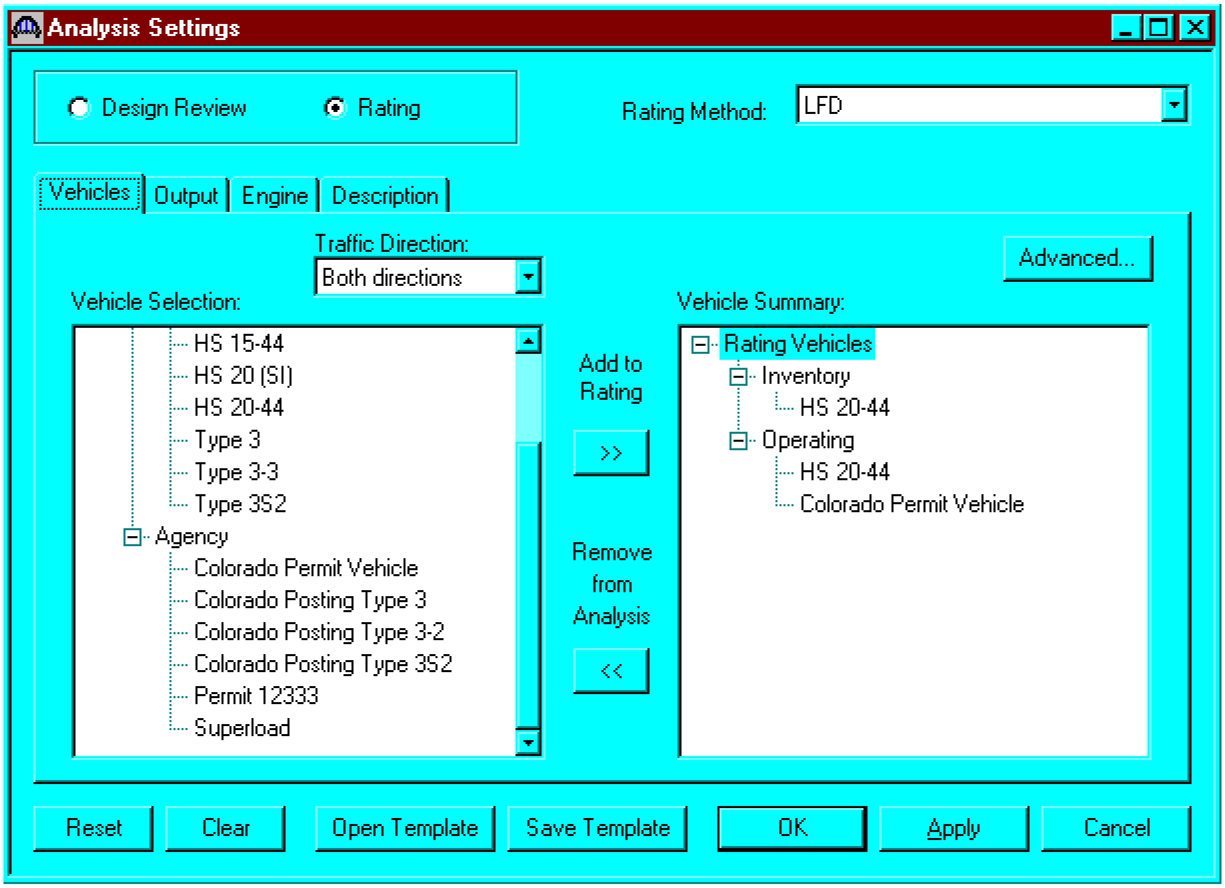


Load Sequence: Computed based on loadings and composite regions.

POI Control: 1 - Generate points of interest at all tenth points along TOP spans

Wheel advancement denominator: 100

To perform a rating, select the View Analysis Settings button on the toolbar to open the window shown below. Select the required vehicles to be used in the rating and click OK.



○ Design Review ● Rating

Rating Method: LFD

Traffic Direction: Both directions

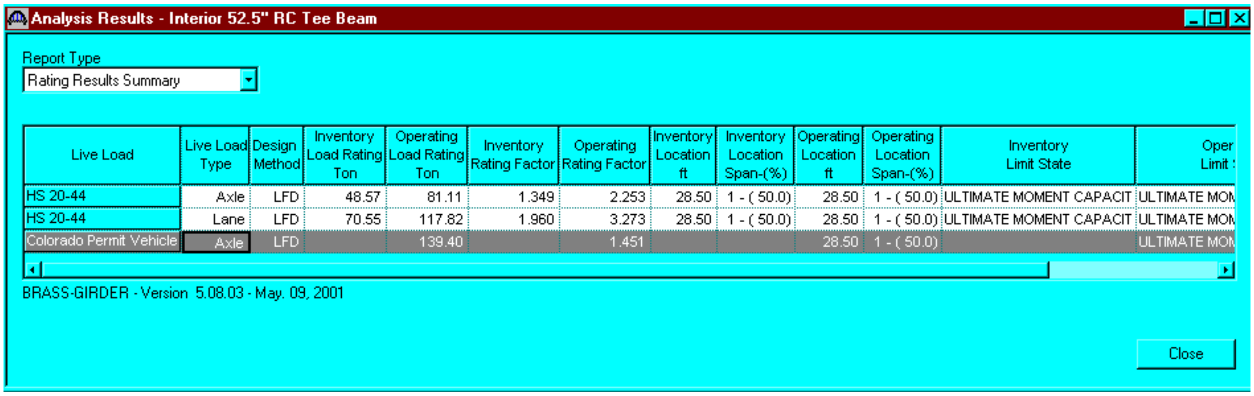
Vehicle Selection:

- HS 15-44
- HS 20 (SI)
- HS 20-44
- Type 3
- Type 3-3
- Type 3S2
- Agency
  - Colorado Permit Vehicle
  - Colorado Posting Type 3
  - Colorado Posting Type 3-2
  - Colorado Posting Type 3S2
  - Permit 12333
  - Superload

Vehicle Summary:

- Rating Vehicles
  - Inventory
    - HS 20-44
  - Operating
    - HS 20-44
    - Colorado Permit Vehicle

The results of the LFD rating analysis are as follows.



Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Oper Limit
HS 20-44	Axle	LFD	48.57	81.11	1.349	2.253	28.50	1 - (50.0)	28.50	1 - (50.0)	ULTIMATE MOMENT CAPACIT	ULTIMATE MON
HS 20-44	Lane	LFD	70.55	117.82	1.960	3.273	28.50	1 - (50.0)	28.50	1 - (50.0)	ULTIMATE MOMENT CAPACIT	ULTIMATE MON
Colorado Permit Vehicle	Axle	LFD		139.40		1.451			28.50	1 - (50.0)		ULTIMATE MON

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

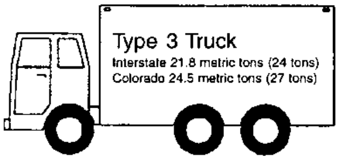
COLORADO DEPARTMENT OF TRANSPORTATION

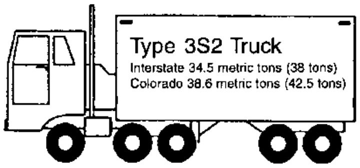
LOAD FACTOR RATING SUMMARY

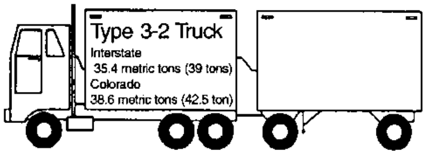
Structure # O-18-BY(S.B.)
State highway # I-25
Batch I.D.
Structure type CSG
Parallel structure # O-18-CD(N.B.)

Rated using
Asphalt thickness: 50 mm (2 in.)
☐ Colorado legal loads
☒ Interstate legal loads

Structural member	INTERIOR GIRDER	SLAB		
	Metric tons (Tons)			
Inventory	43.6 (48)	33.6 (37)	( )	( )
Operating	73.6 (81)	56.4 (62)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	126.3 (139)	( )	( )	( )







____ (____)	____ (____)	____ (____)
Metric tons Tons	Metric tons Tons	Metric tons Tons

Comments

Control Member: Deck; Rated for 2" HBP
Load Capacity: 62 Tons
Girder: Only Interior Girder Rated; Rated for 2" HBP

Color Code: White

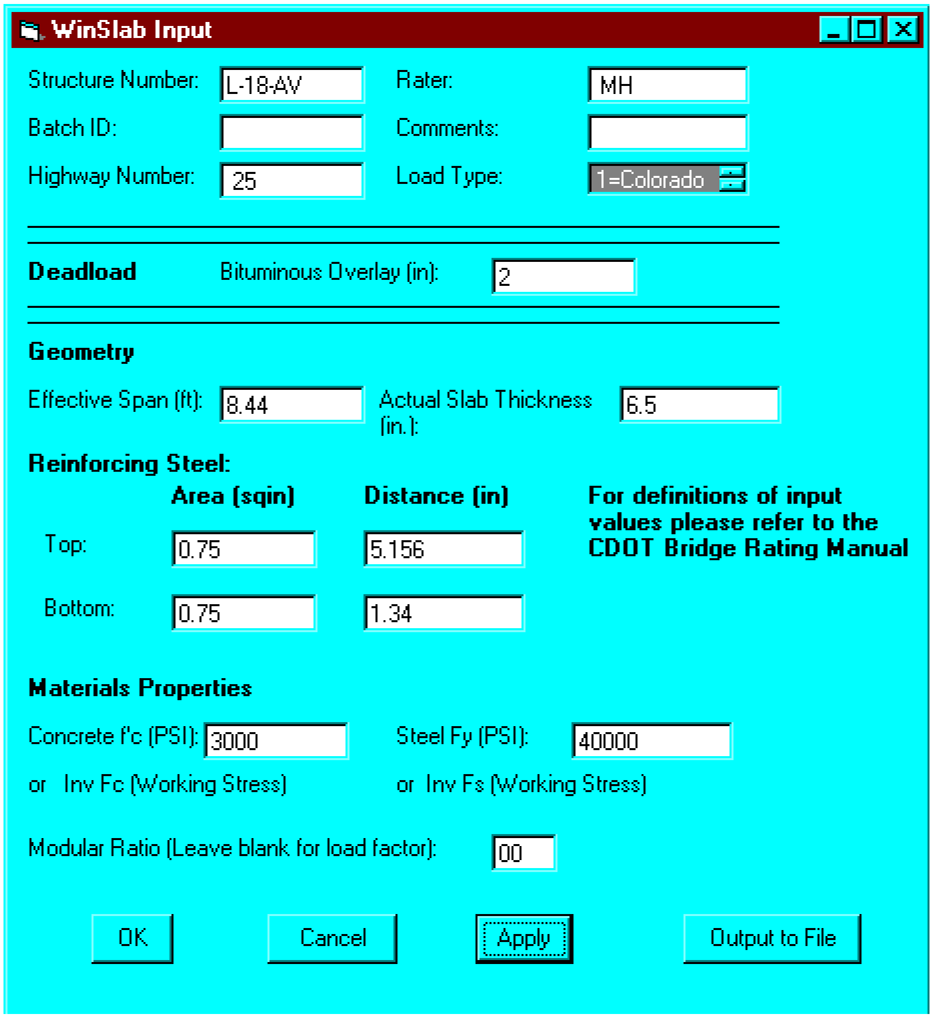
Project No: I-25-1(21)31

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used

CDOT Form #1187a 1/95

Slab Rating Program Input, Structure No. L-18-AV



Structure Number: L-18-AV
Rater: MH
Batch ID:
Comments:
Highway Number: 25
Load Type: 1=Colorado

Deadload Bituminous Overlay (in): 2

Geometry

Effective Span (ft): 8.44
Actual Slab Thickness (in.): 6.5

Reinforcing Steel:

	Area (sqin)	Distance (in)
Top:	0.75	5.156
Bottom:	0.75	1.34

For definitions of input values please refer to the CDOT Bridge Rating Manual

Materials Properties

Concrete f'c (PSI): 3000
or Inv Fc (Working Stress)
Steel Fy (PSI): 40000
or Inv Fs (Working Stress)

Modular Ratio (Leave blank for load factor): 00

Effective Span Length: Per AASHTO Article 3.24.1.2(a)

(Clear span)*1/cos27.3° = (9.00-1.50)*1/cos27.3° = 8.440’

Distance to Top Steel = 5.156”
Distance to Bottom Steel = 1.344”

Top Steel Area: #6 @ 12 = 0.440
#5 @ 12 = 0.310
Σ = 0.750 in*in

Bott. Steel Area: #6 @ 12 = 0.440
#5 @ 12 = 0.310
Σ = 0.750 in*in

Slab Rating Program Output, Structure No. L-18-AV

```
WinSlab Rating Version 1     Date: 1/14/2002

 Structure NO. L-18-AV     Rater:  MH     State HWY NO. =  25
     Batch ID=         Description:

 LOAD FACTOR RATING-COMP STEEL NOT USED

 *** Warning: Slab thickness violates old AASHTO 1.5.40(B)***

 INPUT DATA

       Bituminous Overlay(in)=    2.000
       Eff. Span(ft)=             8.440          Slab Thickness(in)= 6.500
       Top Reinf. (sq.in)=         0.75          Eff. Depth(in) =    5.156
       Bottom Area(sq.in)=         0.75          Bottom Dist.(in)=   1.34
       Conc. Strength(PSI) Inv =   3000          Oper. =             3000
       Steel Yield (PSI)   Inv =  40000          Oper. =             40000
       Modular Ratio =                9

Dead Load Moment   0.75 K-Ft
LL+I Moment        5.43 K-Ft
Gross Weight       36.0 Tons
                                    Inventory     Operating
Actual Concrete Stress      (PSI)    1051.42       1650.22
Actual Reinf. Steel Stress  (PSI)   18660.60      29288.22
Actual Comp. Steel Stress   (PSI)    4307.46       6760.66
Member Capacity             (K-Ft)     10.50         10.50
Member Capacity (LL+I)      (K-Ft)      9.52          9.52
     Rating                 (Tons)     29.15         48.58
```

Virtis Bridge Rating Example, Structure No. L-18-AV

Effective slab width: Per AASHTO Article 8.10.1.1

0.25(L)= 0.25(41*12)= 123”
12t+ Web Thickness = (12*6.5)+ 18 = 96.0”   Controls
C.L. - C.L. of girder= 9.00’= 108”

Dead Load:

Intermediate Diaphragm = (0.67)*(2.00)*(9.00-1.50)*(1/Cos27.3°)*(0.150)
= 1.696 kips   Use 1.7 kips

Abutment Diaphragm = ((4.81)*(1)*(7.5)+(2.1)*(1)*(7.5))*1/Cos27.3°*0.150
= 8.75 kips   Use 9.0 kips

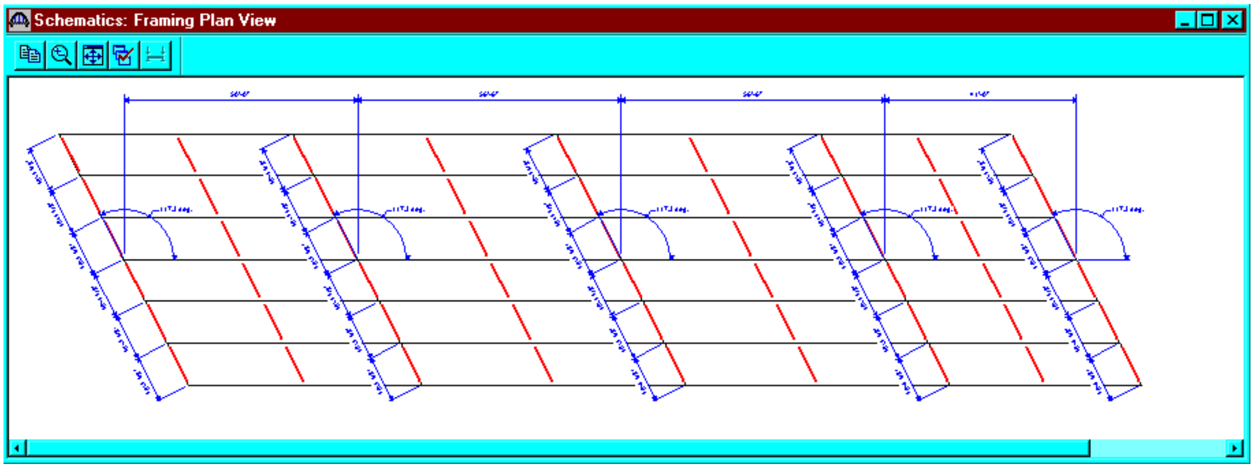
Pier Diaphragm = (2)*(6.5)*(7.5)*(1/Cos27.3°)*(0.15)
= 16.50 kips   Use 16.50 kips

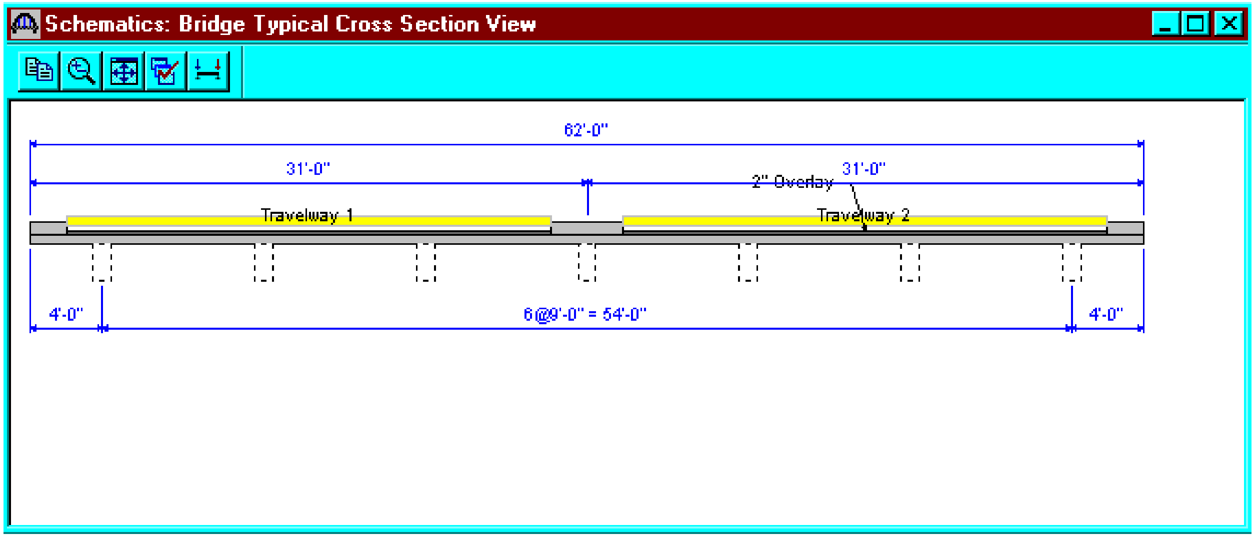
Distribution Factor:

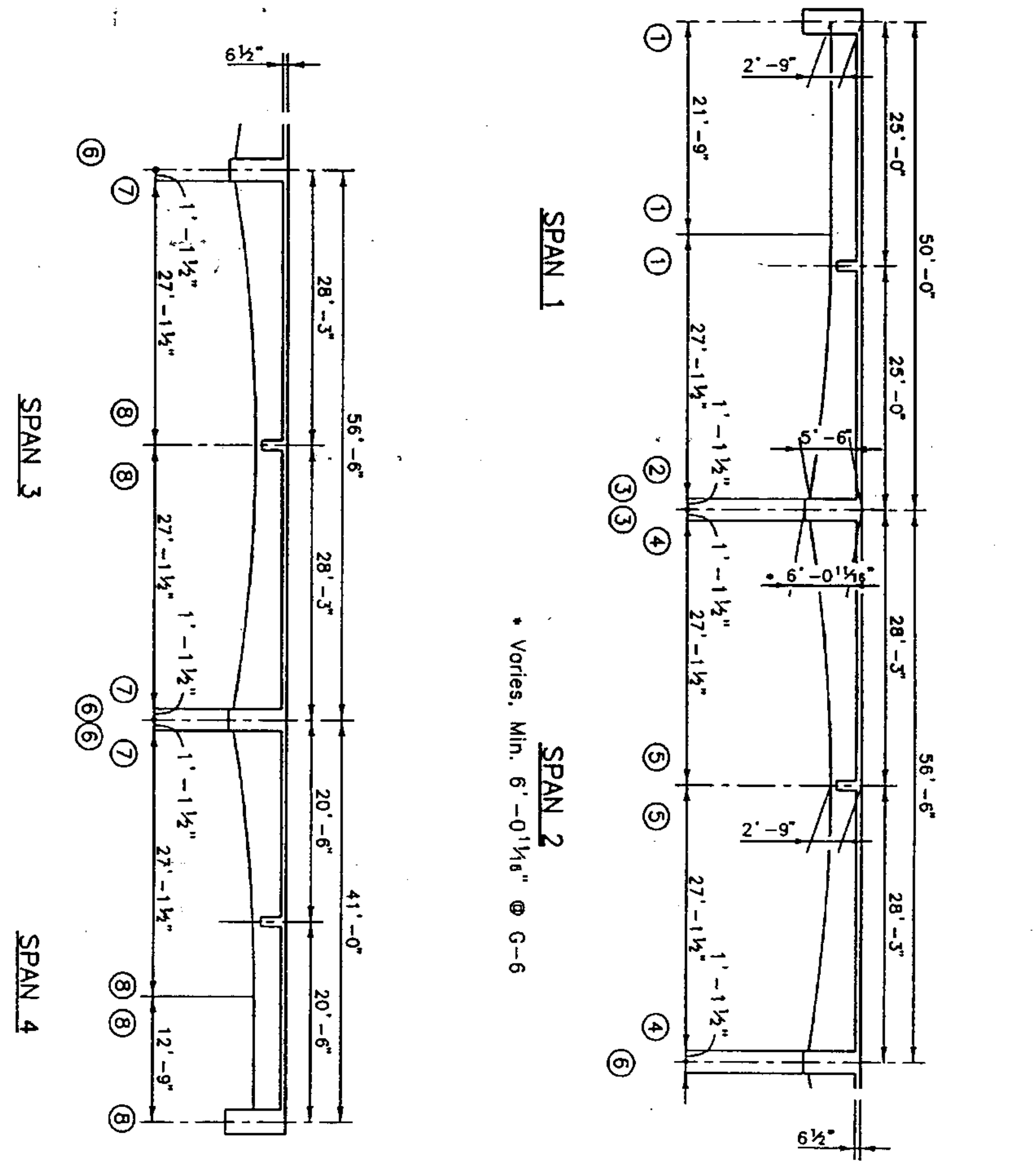
Multi-Lane = S/6 = 9.00/6 = 1.500

Single Lane = 1+ 3.00/9.00 = 1.333

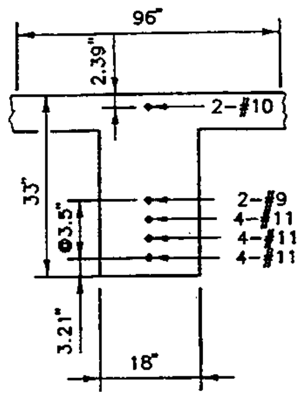
Virtis Bridge Rating Example, Structure No. L-18-AV (contd.)



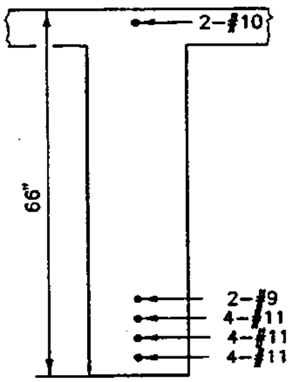




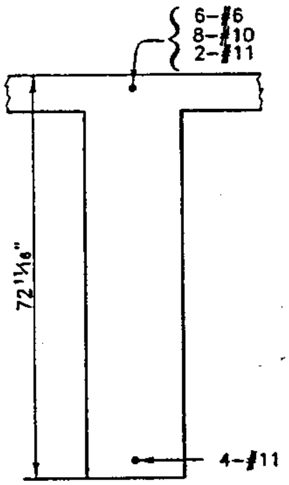
ELEVATION ~ G-6


96"
2.39"
2-#10
33"
2-#9
4-#11
4-#11
4-#11
Φ3.5"
3.21"
18"

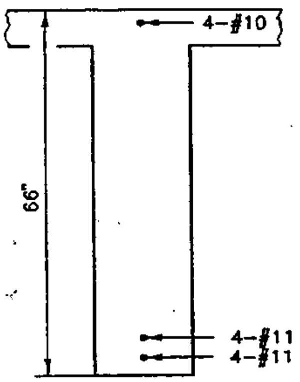
①


2-#10
66"
2-#9
4-#11
4-#11
4-#11

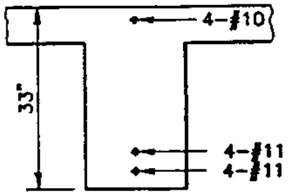
②


6-#6
8-#10
2-#11
72 11/16"
4-#11

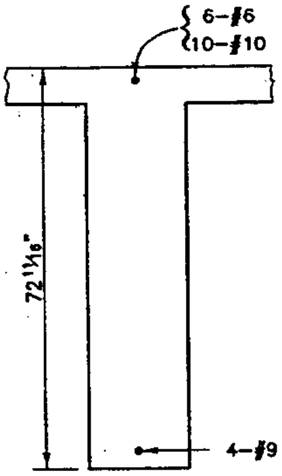
③


4-#10
66"
4-#11
4-#11

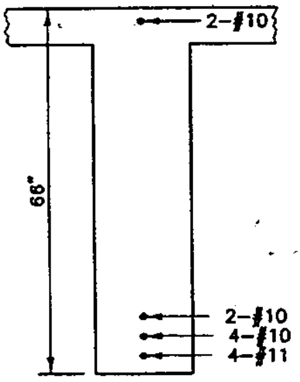
④


4-#10
33"
4-#11
4-#11

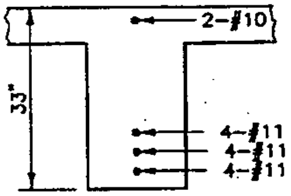
⑤


6-#6
10-#10
72 11/16"
4-#9

⑥

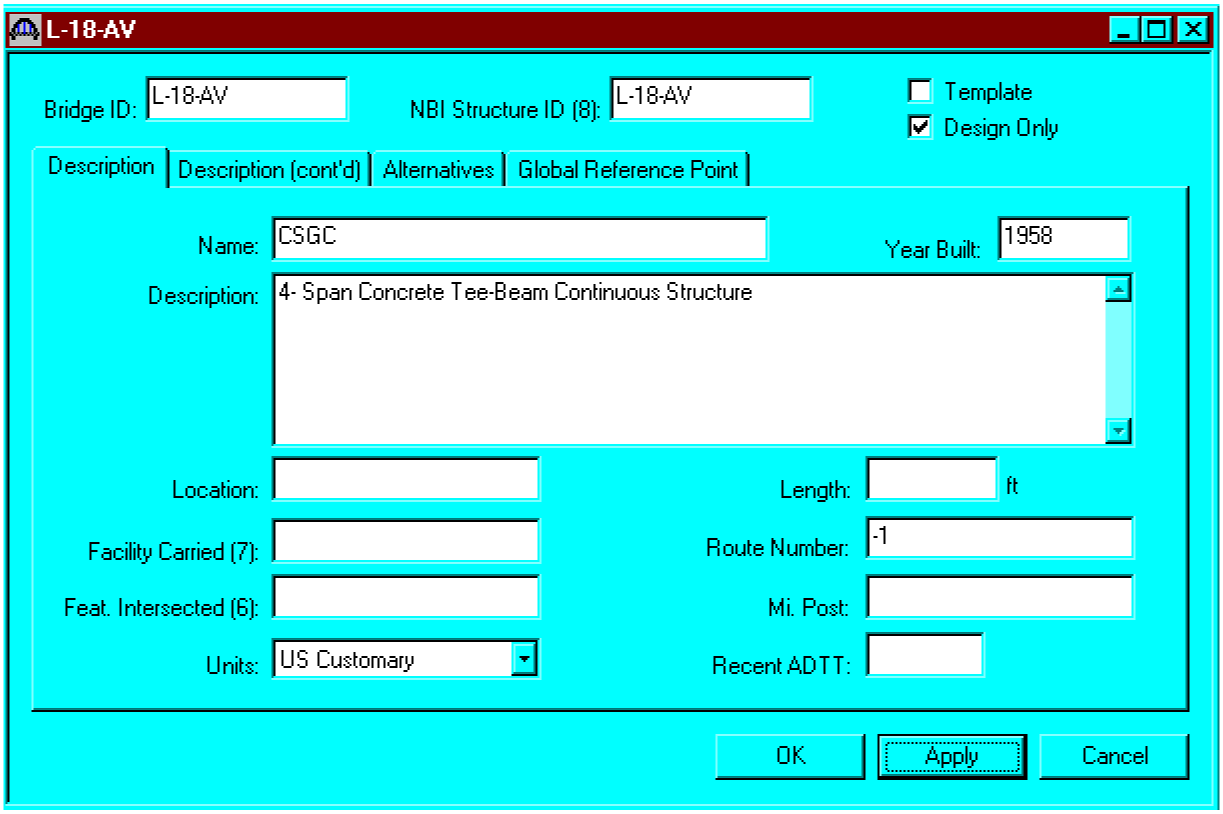

2-#10
66"
2-#10
4-#10
4-#11

⑦


2-#10
33"
4-#11
4-#11
4-#11

⑧

From the bridge explorer, create a new bridge and enter the following information.



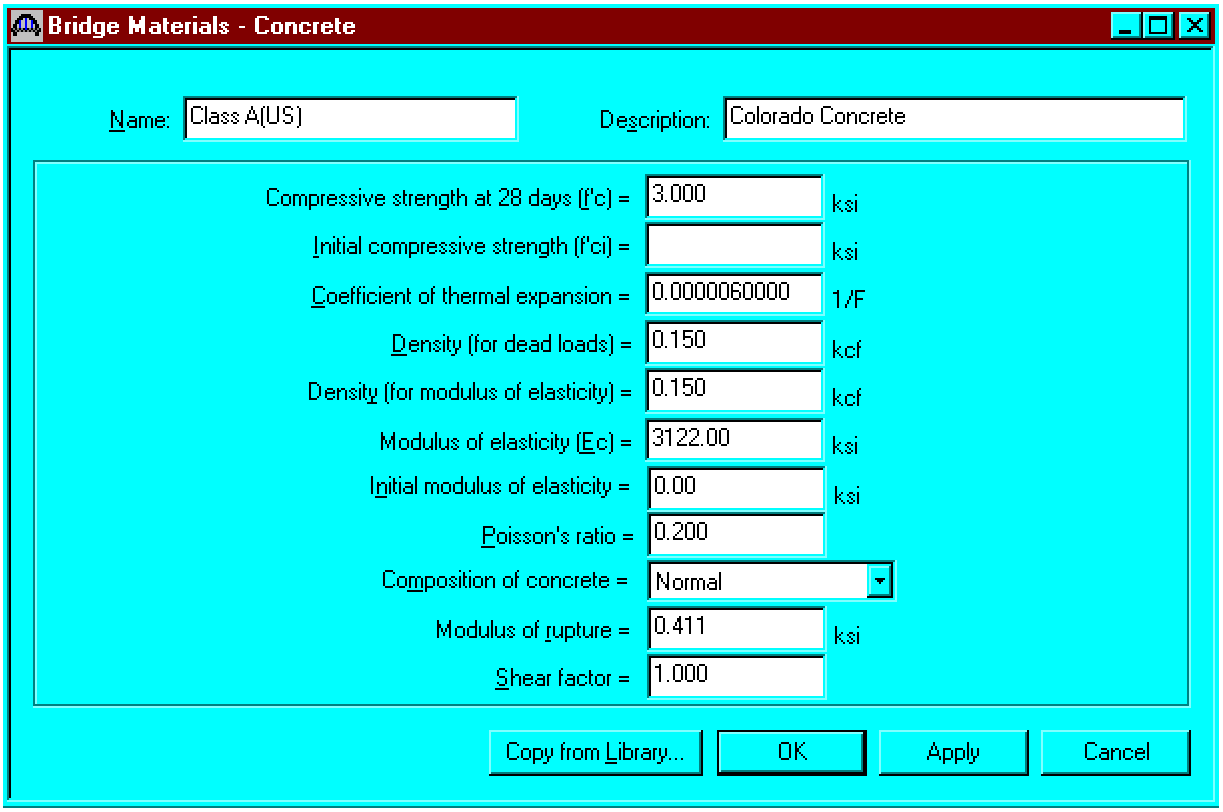
Bridge ID: L-18-AV
NBI Structure ID (8): L-18-AV
☐ Template
☑ Design Only

Name: CSGC
Year Built: 1958
Description: 4- Span Concrete Tee-Beam Continuous Structure
Location:
Length: ft
Facility Carried (7):
Route Number: -1
Feat. Intersected (6):
Mi. Post:
Units: US Customary
Recent ADTT:

Click OK. This saves the data to memory and closes the window.

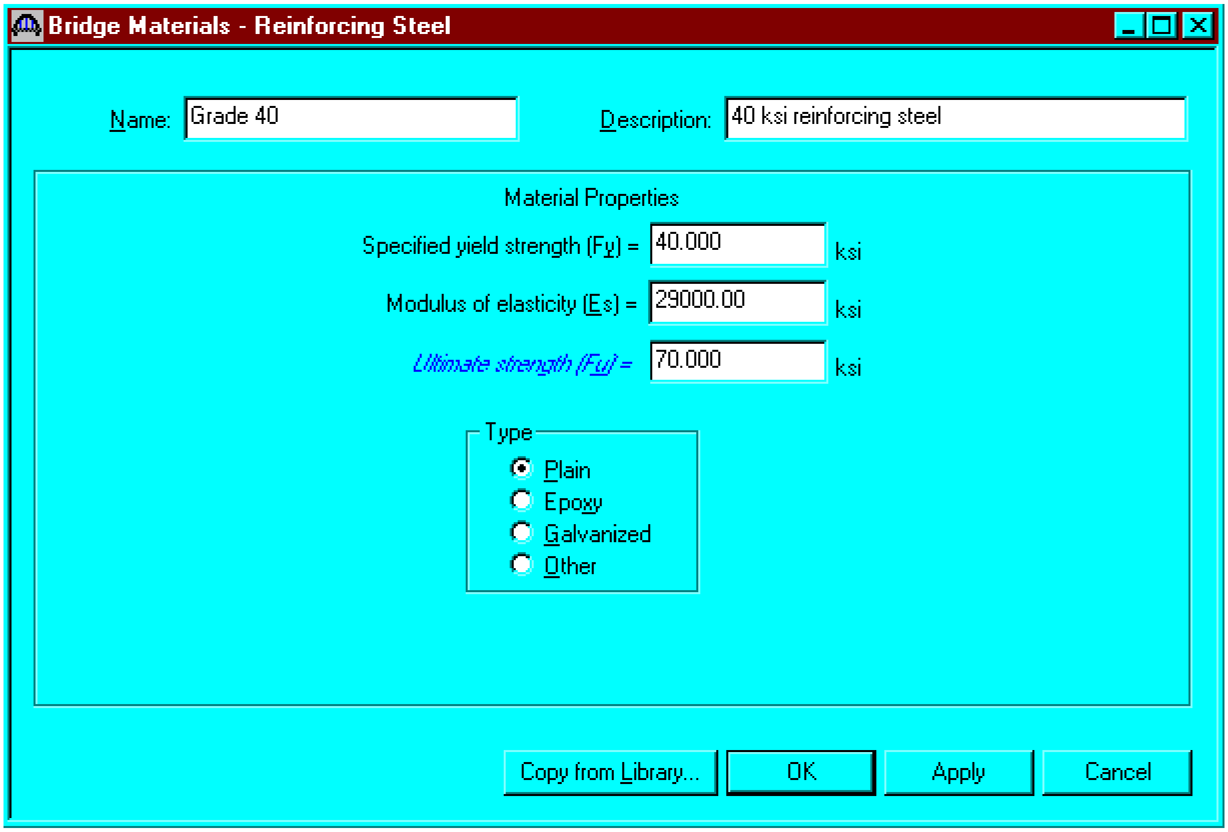
NOTE: Since Virtis uses a common/shared database, it is required that users of this program create a folder from the bridge explorer window **(EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Concrete from the library. Click OK and the following window will open. Click OK to save this concrete material to memory and close the window.



Name: Class A(US)
Description: Colorado Concrete
Compressive strength at 28 days (f'c) = 3.000 ksi
Initial compressive strength (f'ci) = ksi
Coefficient of thermal expansion = 0.0000060000 1/F
Density (for dead loads) = 0.150 kcf
Density (for modulus of elasticity) = 0.150 kcf
Modulus of elasticity (Ec) = 3122.00 ksi
Initial modulus of elasticity = 0.00 ksi
Poisson's ratio = 0.200
Composition of concrete = Normal
Modulus of rupture = 0.411 ksi
Shear factor = 1.000

Using the same techniques, create the following Reinforcing Steel Material to be used for the girder.



Name: Grade 40

Description: 40 ksi reinforcing steel

Material Properties

Specified yield strength (Fy) = 40.000 ksi

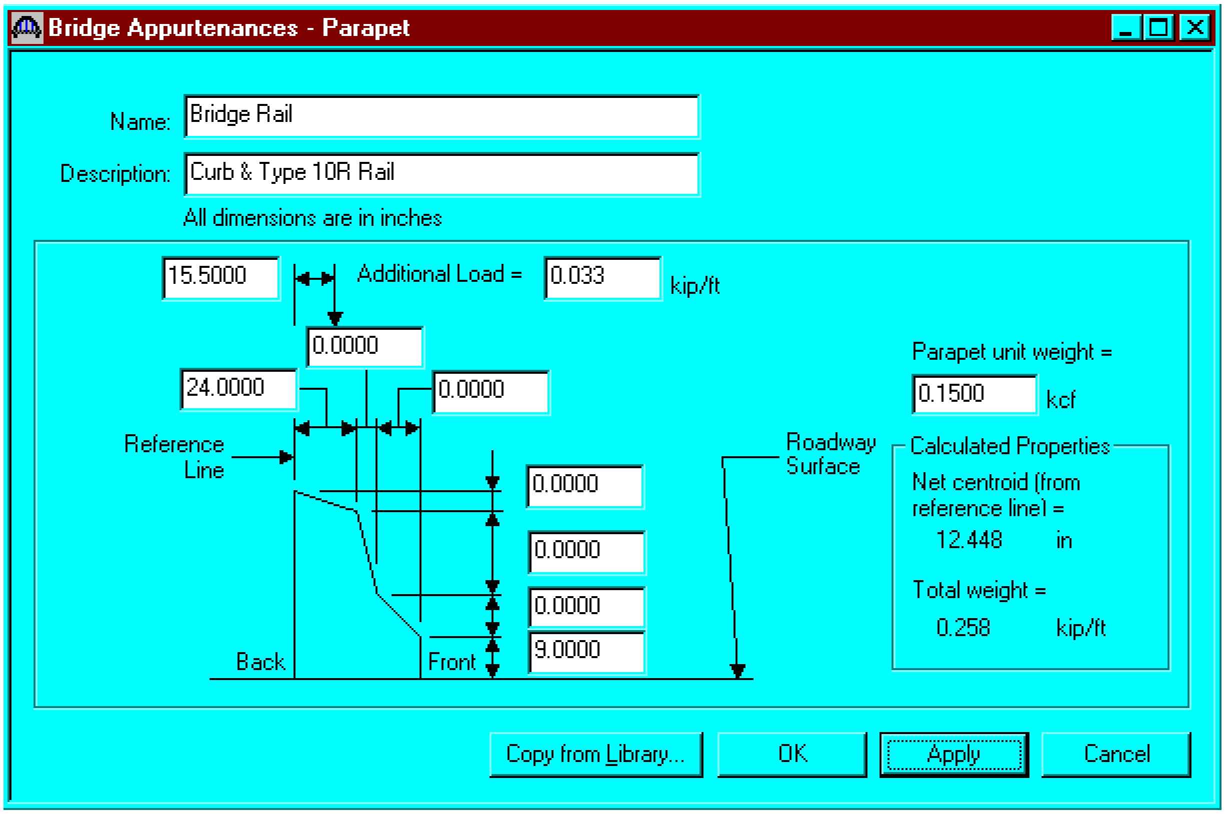
Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 70.000 ksi

Type

● Plain
○ Epoxy
○ Galvanized
○ Other

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, and select New. Fill in the parapet properties as required. Click OK to save the data to memory and close the window.



Bridge Appurtenances - Parapet

Name: Bridge Rail

Description: Curb & Type 10R Rail

All dimensions are in inches

15.5000

Additional Load = 0.033 kip/ft

0.0000

24.0000

0.0000

Parapet unit weight = 0.1500 kcf

0.0000

0.0000

0.0000

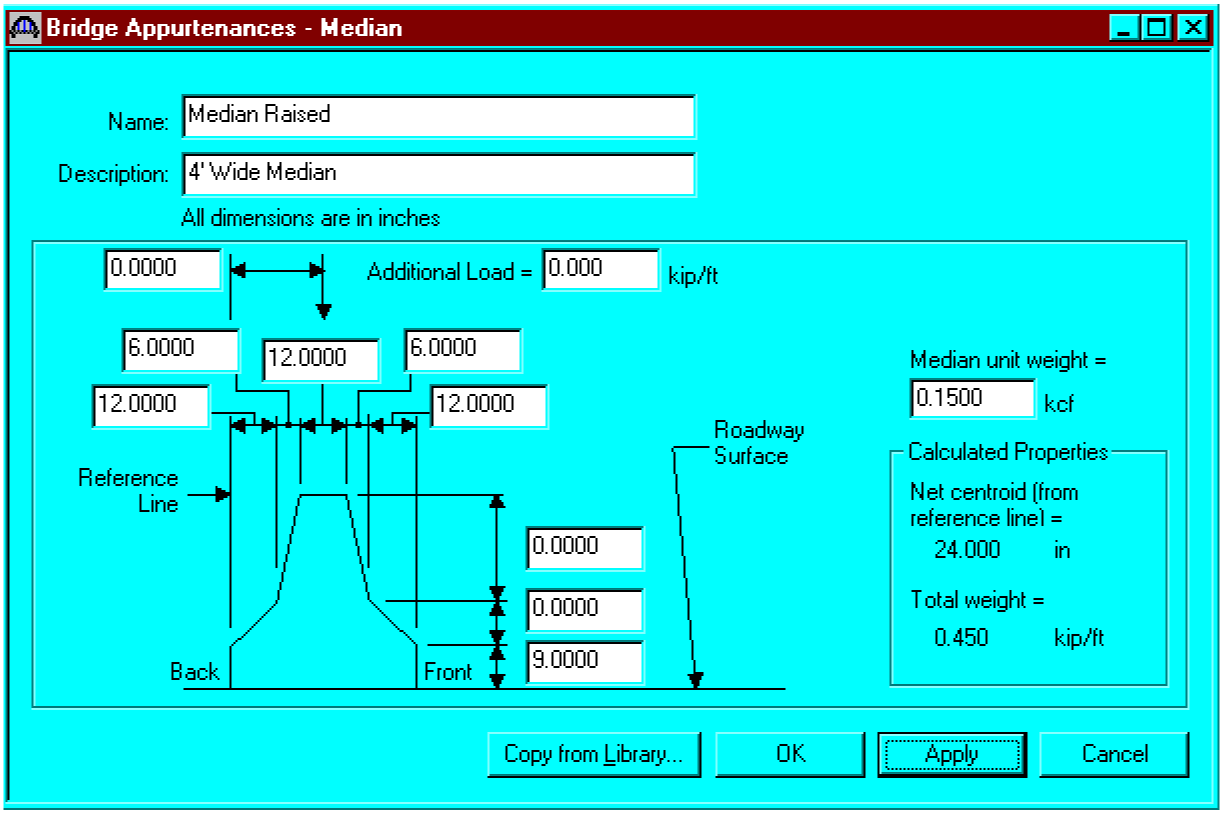
9.0000

Calculated Properties

Net centroid (from reference line) = 12.448 in

Total weight = 0.258 kip/ft

Right mouse click on Median in the tree, and select New. Fill in the median properties as required. Click OK to save the data to memory and close the window.



Bridge Appurtenances - Median

Name: Median Raised

Description: 4' Wide Median

All dimensions are in inches

Additional Load = 0.000 kip/ft

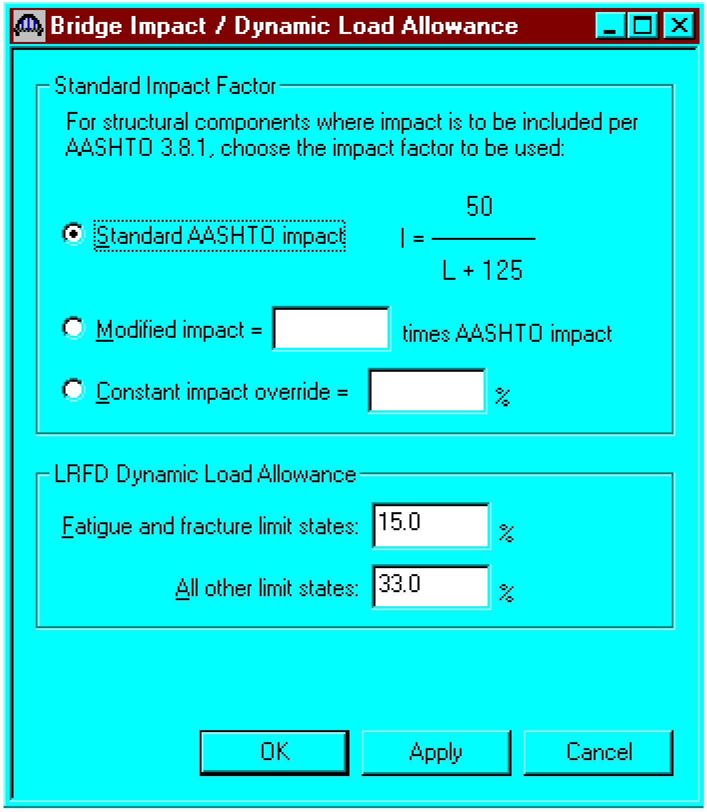
Median unit weight = 0.1500 kcf

Calculated Properties

Net centroid (from reference line) = 24.000 in

Total weight = 0.450 kip/ft

Double click on Impact/Dynamic Load Allowance in the tree. The Bridge Impact window shown below will open. Accept the default values by clicking OK.



Bridge Impact / Dynamic Load Allowance

Standard Impact Factor

For structural components where impact is to be included per AASHTO 3.8.1, choose the impact factor to be used:

● Standard AASHTO impact $I = \frac{50}{L + 125}$

○ Modified impact = ☐ times AASHTO impact

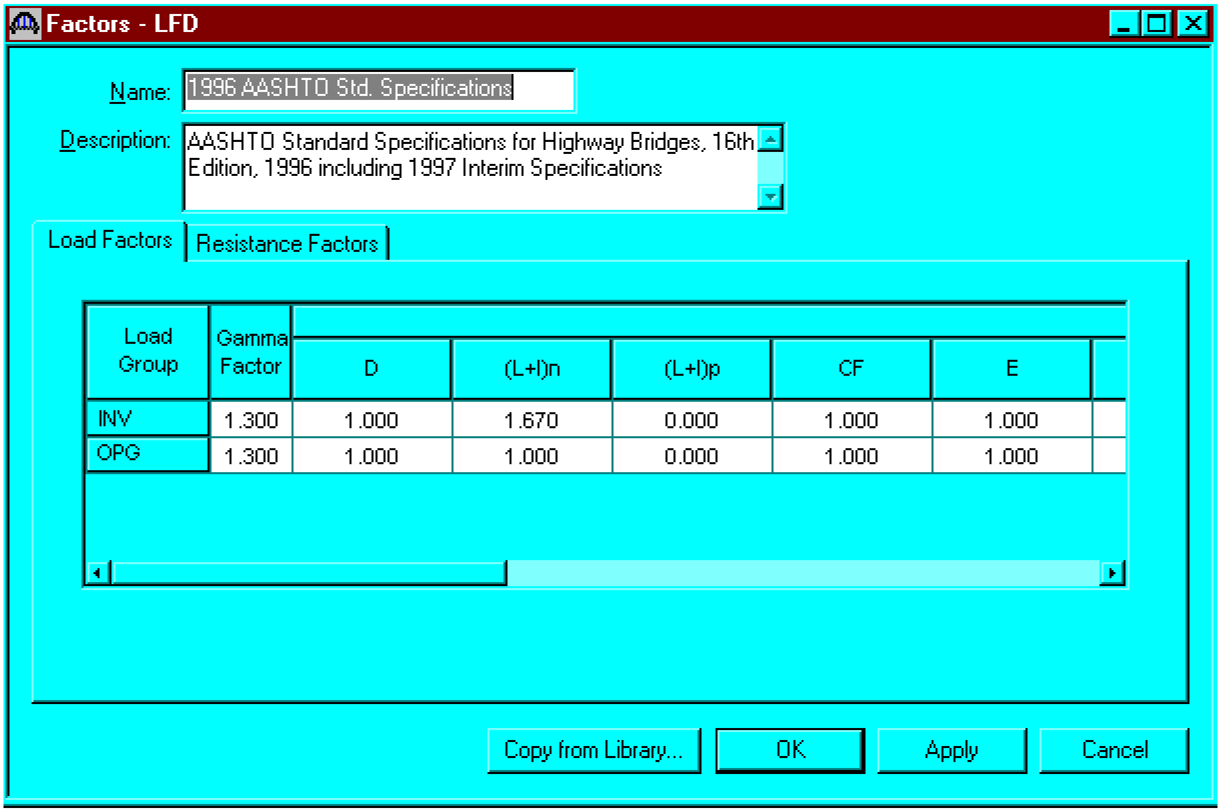
○ Constant impact override = ☐ %

LRFD Dynamic Load Allowance

Fatigue and fracture limit states: 15.0 %

All other limit states: 33.0 %

Click on Factors, right mouse click on LFD and select New. The LFD-Factors window will open. Click the Copy from Library button and select the 1996 AASHTO Standard Specifications from the library. Click Apply and then OK to save data to memory and close the window.



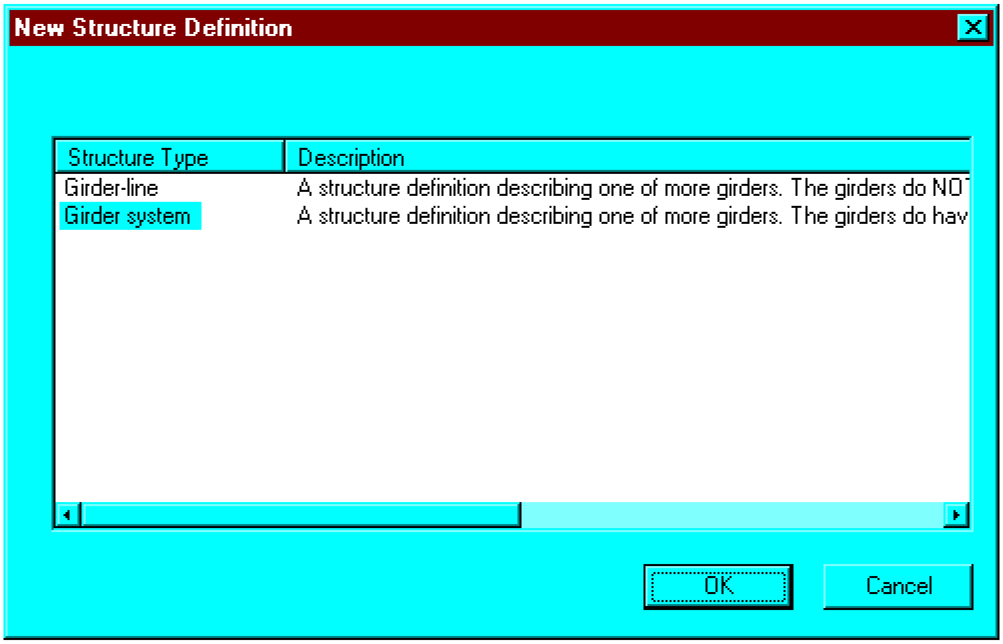
Name: 1996 AASHTO Std. Specifications

Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

Load Group	Gamma Factor	D	(L+I)n	(L+I)p	CF	E
INV	1.300	1.000	1.670	0.000	1.000	1.000
OPG	1.300	1.000	1.000	0.000	1.000	1.000

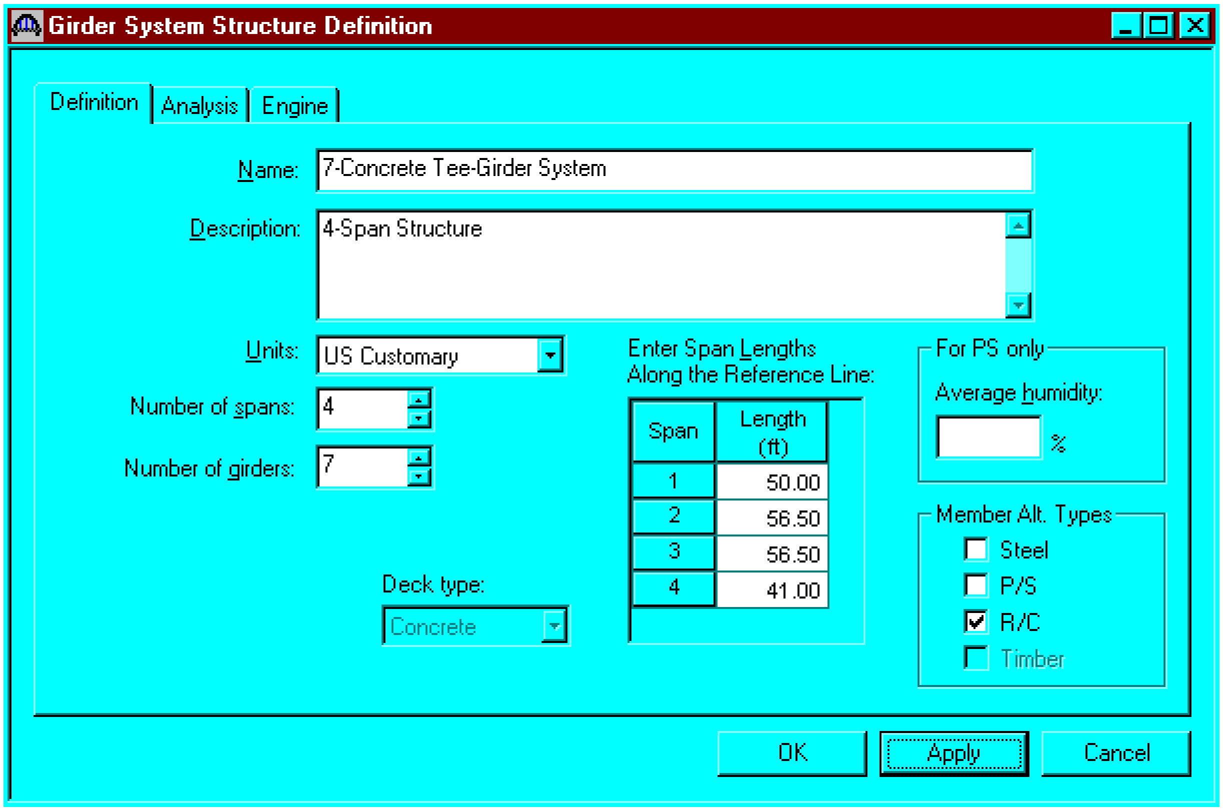
We will now skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



Structure Type	Description
Girder-line	A structure definition describing one of more girders. The girders do NO
Girder system	A structure definition describing one of more girders. The girders do hav

Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



Name: 7-Concrete Tee-Girder System

Description: 4-Span Structure

Units: US Customary

Number of spans: 4

Number of girders: 7

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	50.00
2	56.50
3	56.50
4	41.00

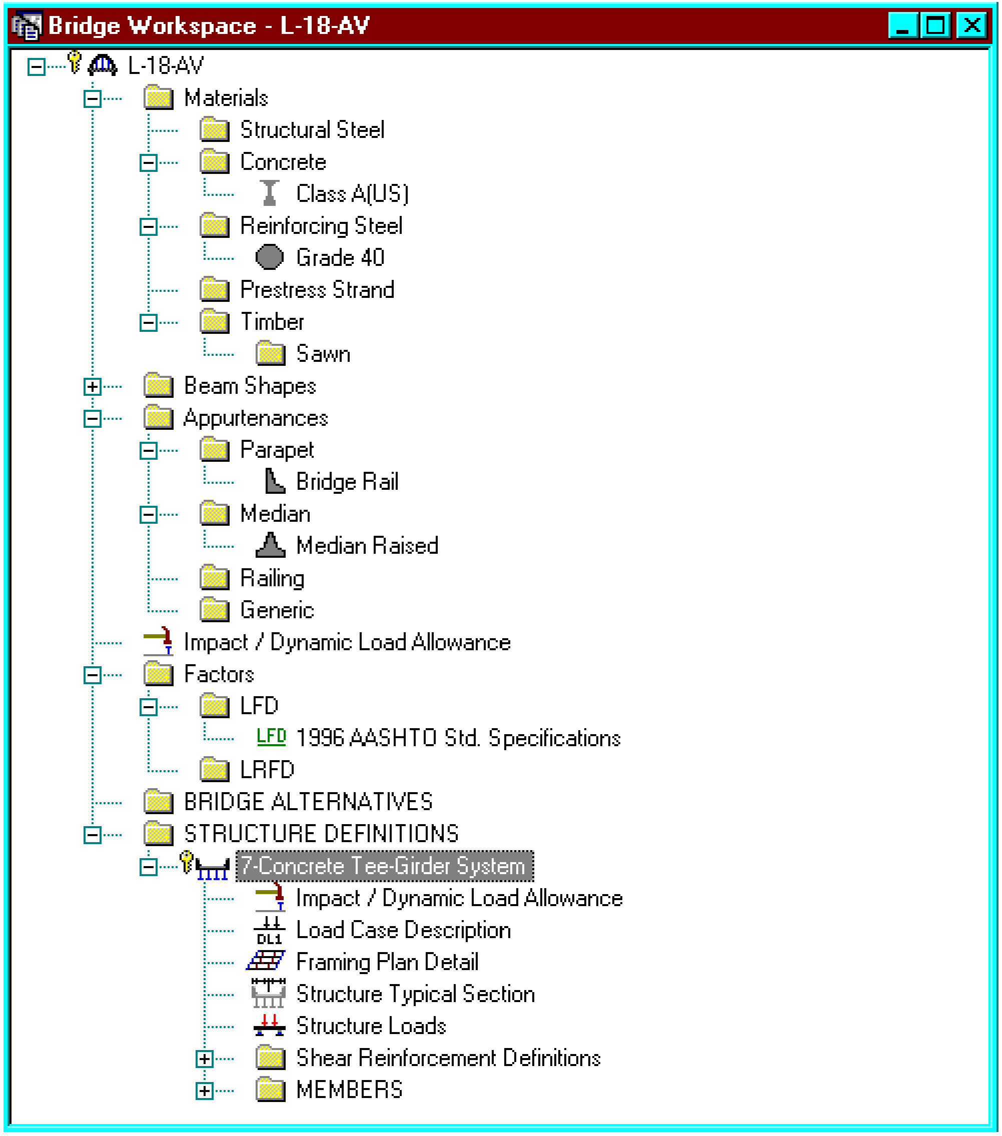
For PS only

Average humidity: %

Member Alt. Types

☐ Steel
☐ P/S
☑ R/C
☐ Timber

The partially expanded Bridge Workspace tree is shown below:

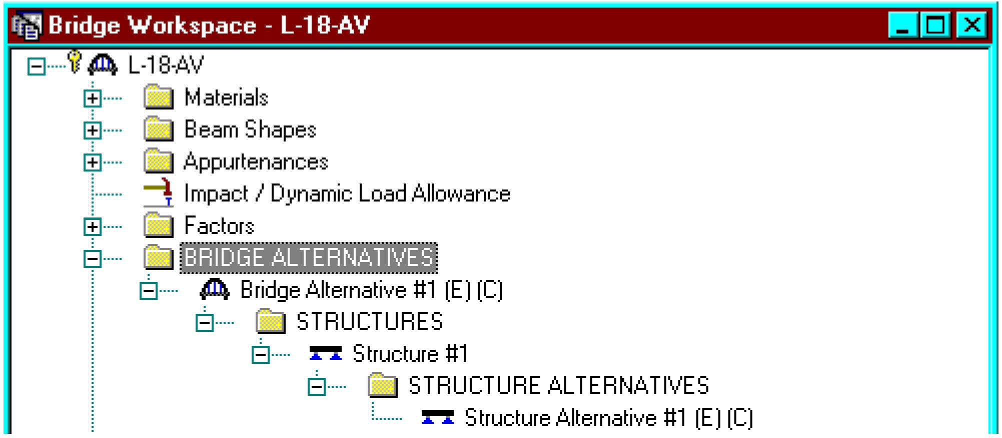


Bridge Workspace - L-18-AV

- L-18-AV
  - Materials
    - Structural Steel
    - Concrete
      - Class A(US)
    - Reinforcing Steel
      - Grade 40
    - Prestress Strand
    - Timber
      - Sawn
  - Beam Shapes
  - Appurtenances
    - Parapet
      - Bridge Rail
    - Median
      - Median Raised
    - Railing
    - Generic
  - Impact / Dynamic Load Allowance
  - Factors
    - LFD
      - LFD 1996 AASHTO Std. Specifications
    - LRFD
  - BRIDGE ALTERNATIVES
  - STRUCTURE DEFINITIONS
    - 7-Concrete Tee-Girder System
      - Impact / Dynamic Load Allowance
      - Load Case Description
      - Framing Plan Detail
      - Structure Typical Section
      - Structure Loads
      - Shear Reinforcement Definitions
      - MEMBERS

We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

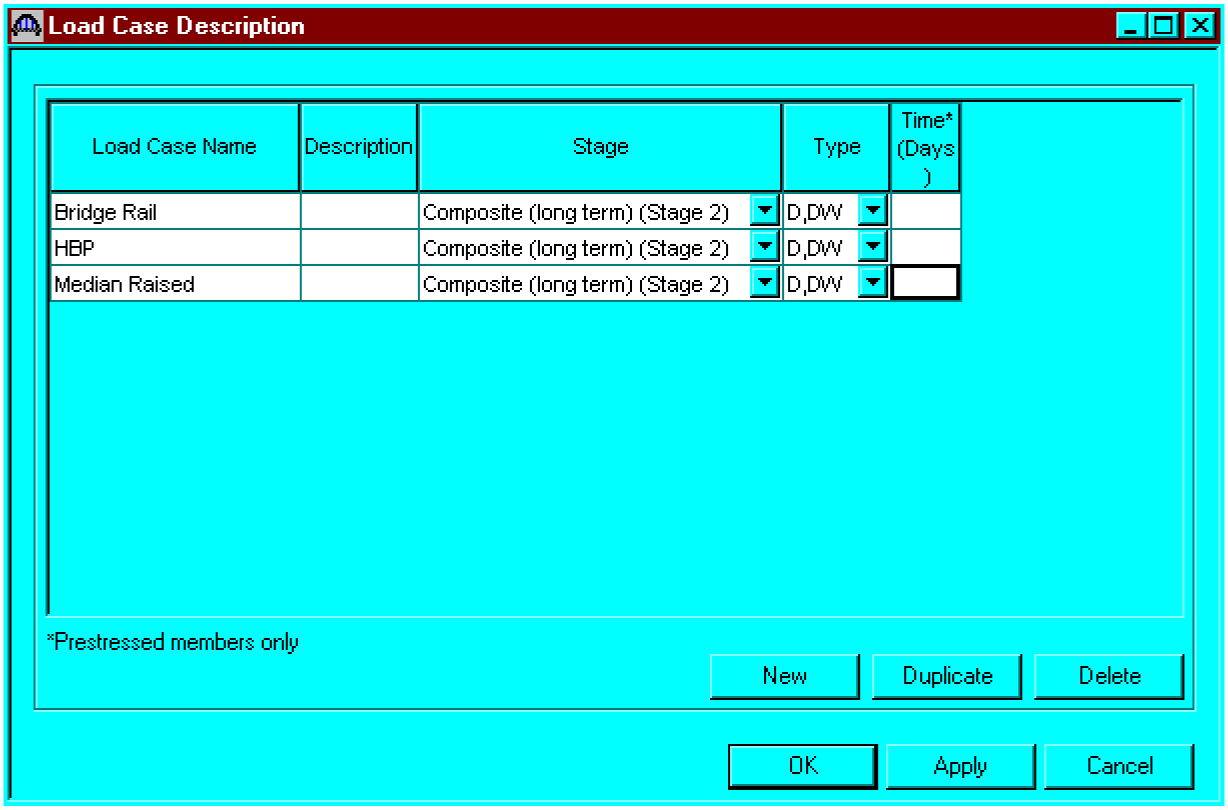
The partially expanded Bridge Workspace tree is shown below:



Bridge Workspace - L-18-AV

- L-18-AV
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
  - BRIDGE ALTERNATIVES
    - Bridge Alternative #1 (E) (C)
      - STRUCTURES
        - Structure #1
          - STRUCTURE ALTERNATIVES
            - Structure Alternative #1 (E) (C)

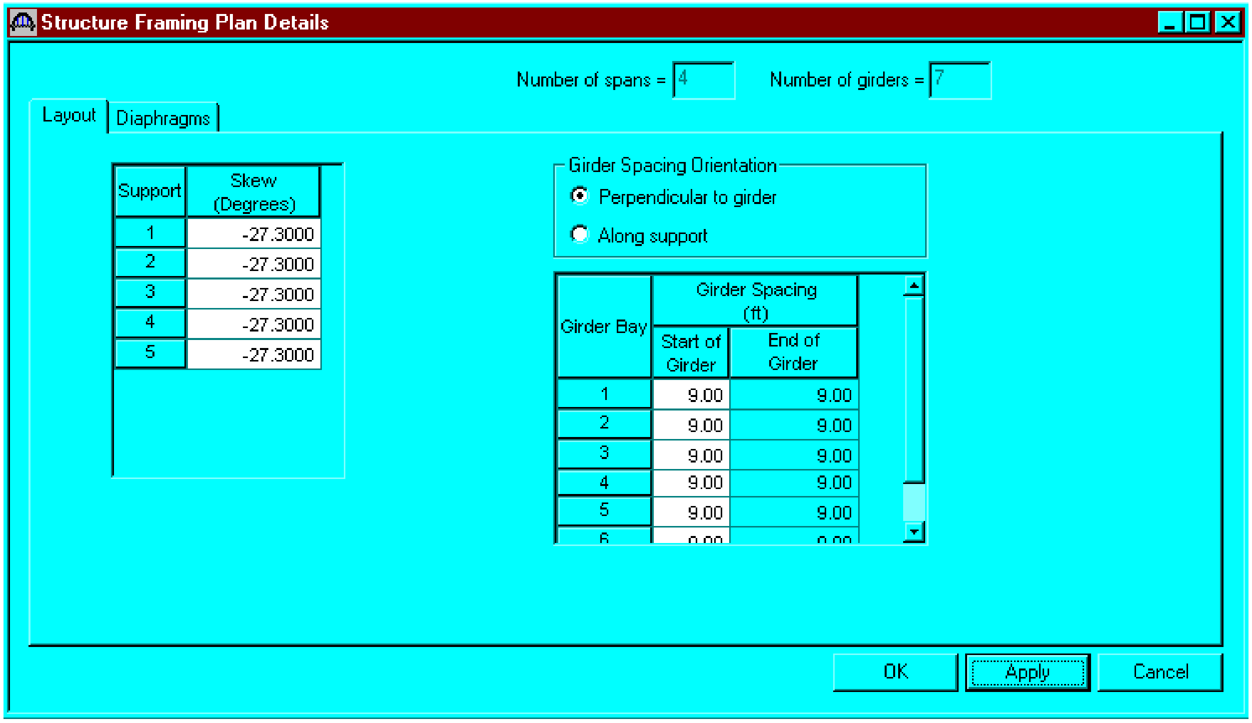
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.



Load Case Name	Description	Stage	Type	Time* (Days)
Bridge Rail		Composite (long term) (Stage 2)	D,DW	
HBP		Composite (long term) (Stage 2)	D,DW	
Median Raised		Composite (long term) (Stage 2)	D,DW	

*Prestressed members only

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



Number of spans = 4

Number of girders = 7

Support	Skew (Degrees)
1	-27.3000
2	-27.3000
3	-27.3000
4	-27.3000
5	-27.3000

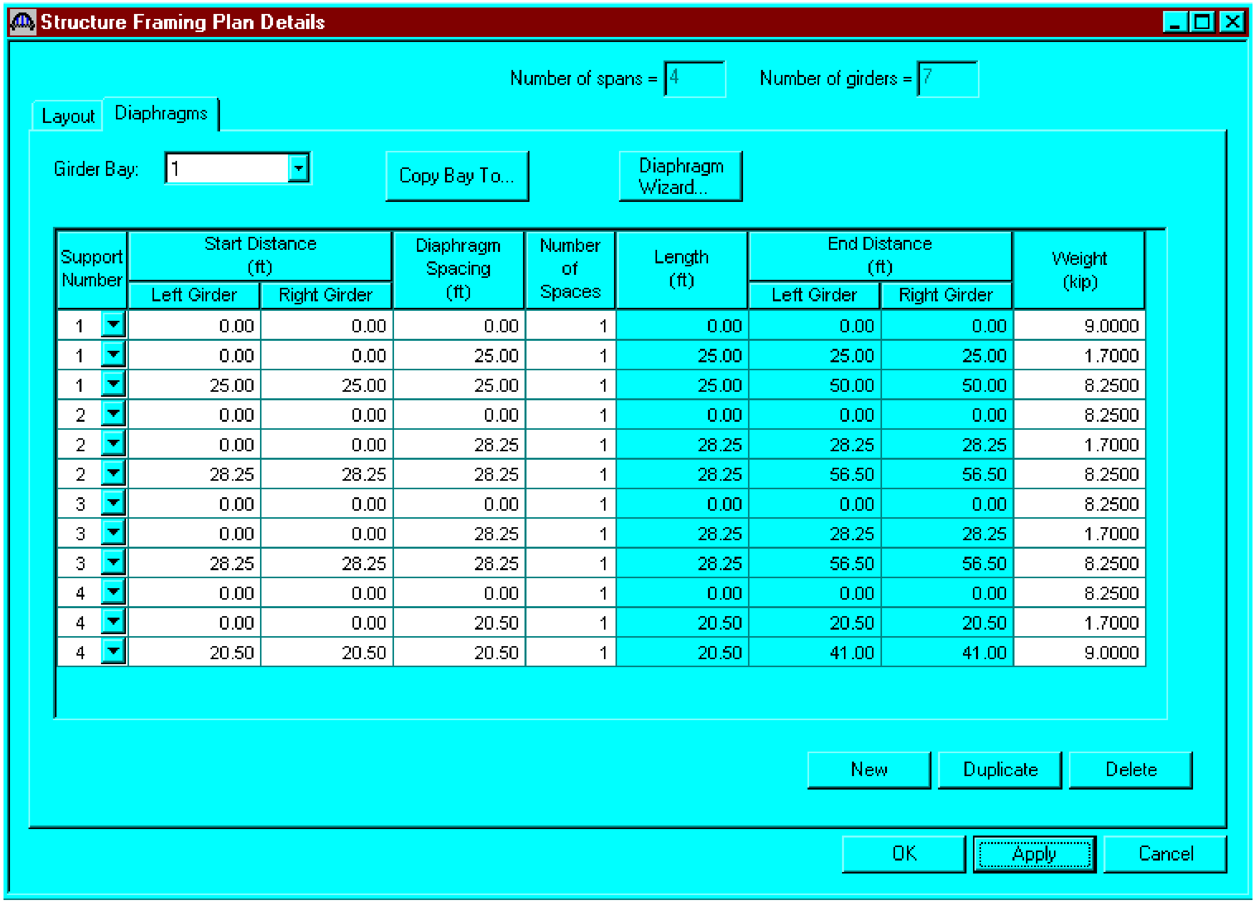
Girder Spacing Orientation

● Perpendicular to girder

○ Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	9.00	9.00
2	9.00	9.00
3	9.00	9.00
4	9.00	9.00
5	9.00	9.00
6		

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.



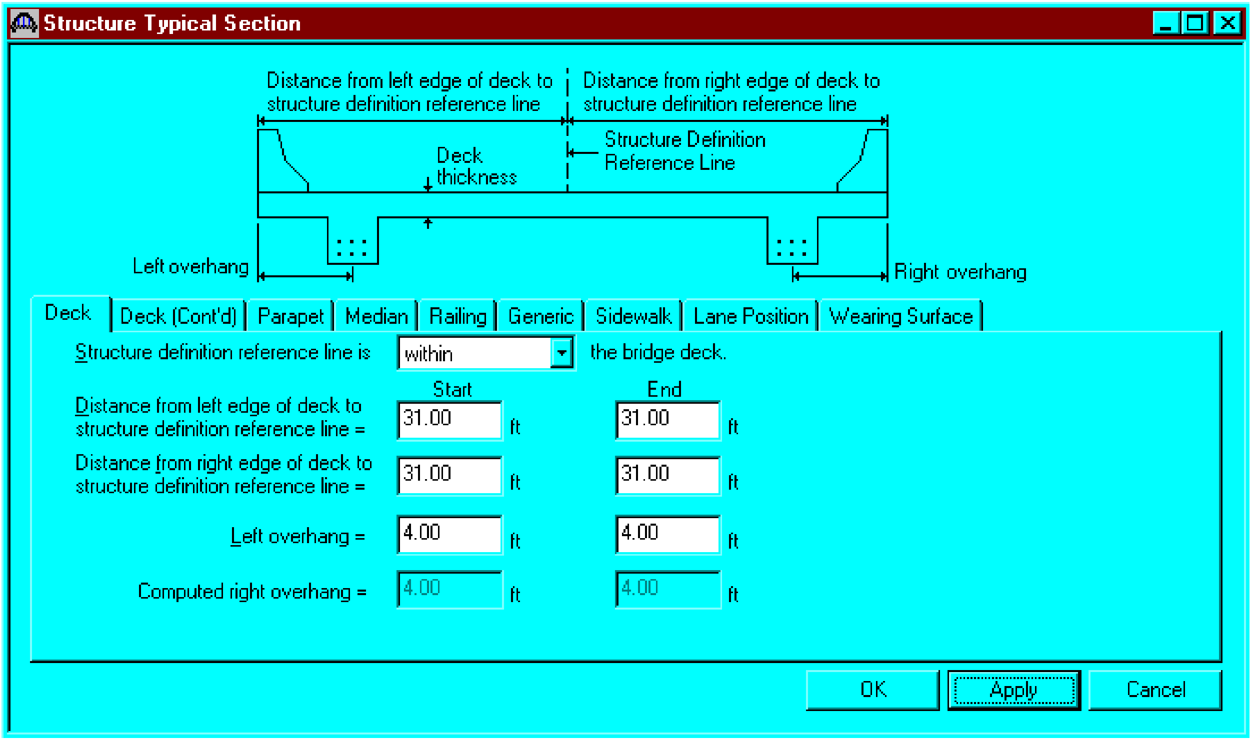
Number of spans = 4

Number of girders = 7

Girder Bay: 1

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	9.0000
1	0.00	0.00	25.00	1	25.00	25.00	25.00	1.7000
1	25.00	25.00	25.00	1	25.00	50.00	50.00	8.2500
2	0.00	0.00	0.00	1	0.00	0.00	0.00	8.2500
2	0.00	0.00	28.25	1	28.25	28.25	28.25	1.7000
2	28.25	28.25	28.25	1	28.25	56.50	56.50	8.2500
3	0.00	0.00	0.00	1	0.00	0.00	0.00	8.2500
3	0.00	0.00	28.25	1	28.25	28.25	28.25	1.7000
3	28.25	28.25	28.25	1	28.25	56.50	56.50	8.2500
4	0.00	0.00	0.00	1	0.00	0.00	0.00	8.2500
4	0.00	0.00	20.50	1	20.50	20.50	20.50	1.7000
4	20.50	20.50	20.50	1	20.50	41.00	41.00	9.0000

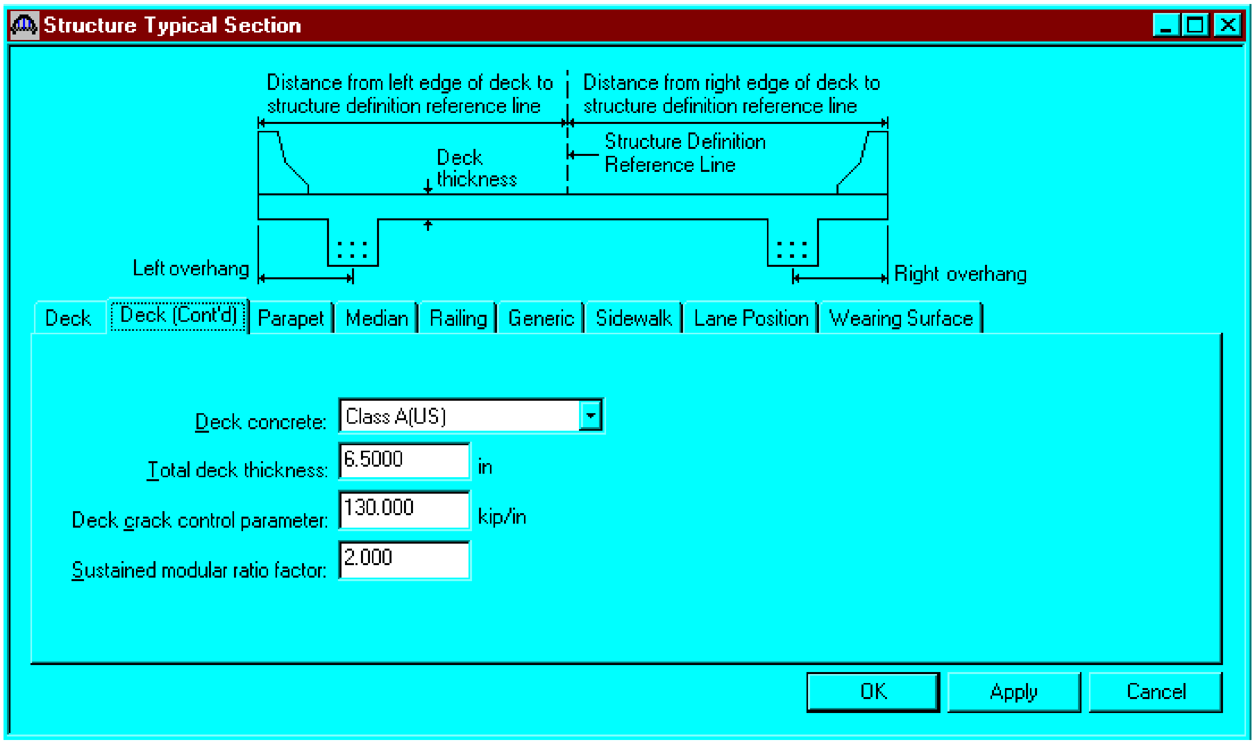
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



Structure definition reference line is within the bridge deck.

	Start		End	
Distance from left edge of deck to structure definition reference line =	31.00	ft	31.00	ft
Distance from right edge of deck to structure definition reference line =	31.00	ft	31.00	ft
Left overhang =	4.00	ft	4.00	ft
Computed right overhang =	4.00	ft	4.00	ft

The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



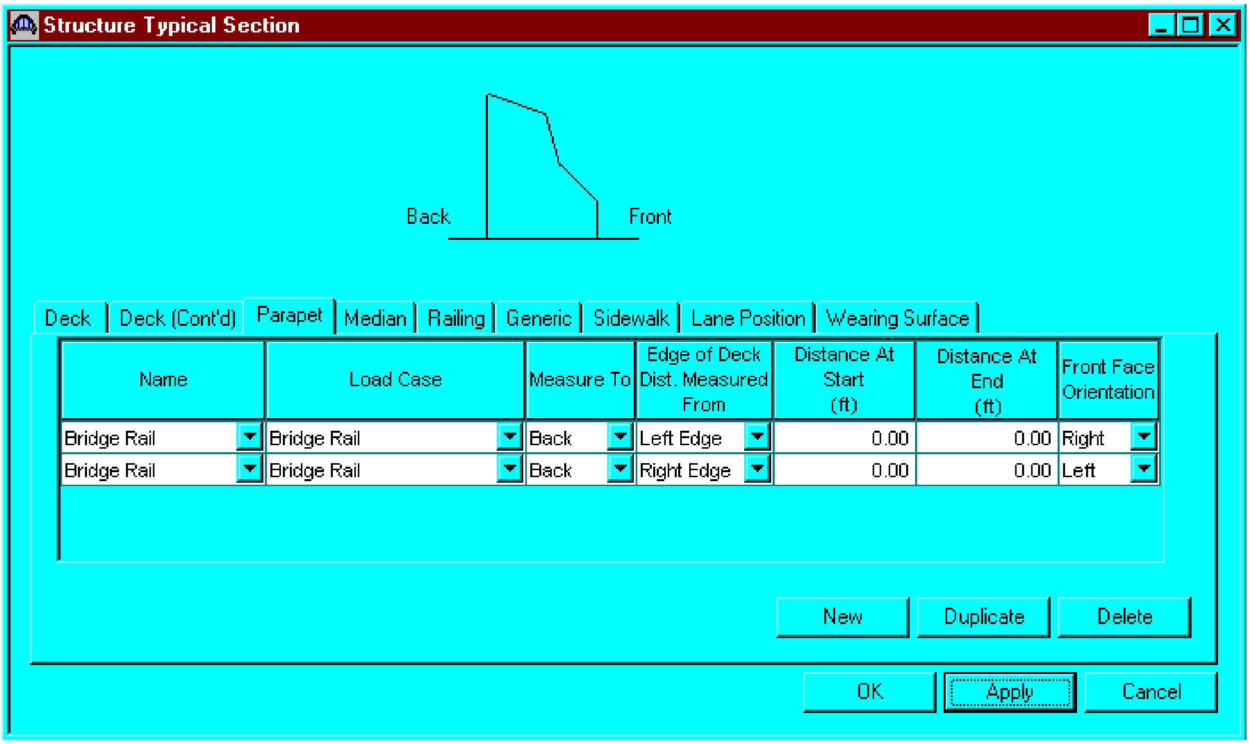
Deck concrete: Class A(US)

Total deck thickness: 6.5000 in

Deck crack control parameter: 130.000 kip/in

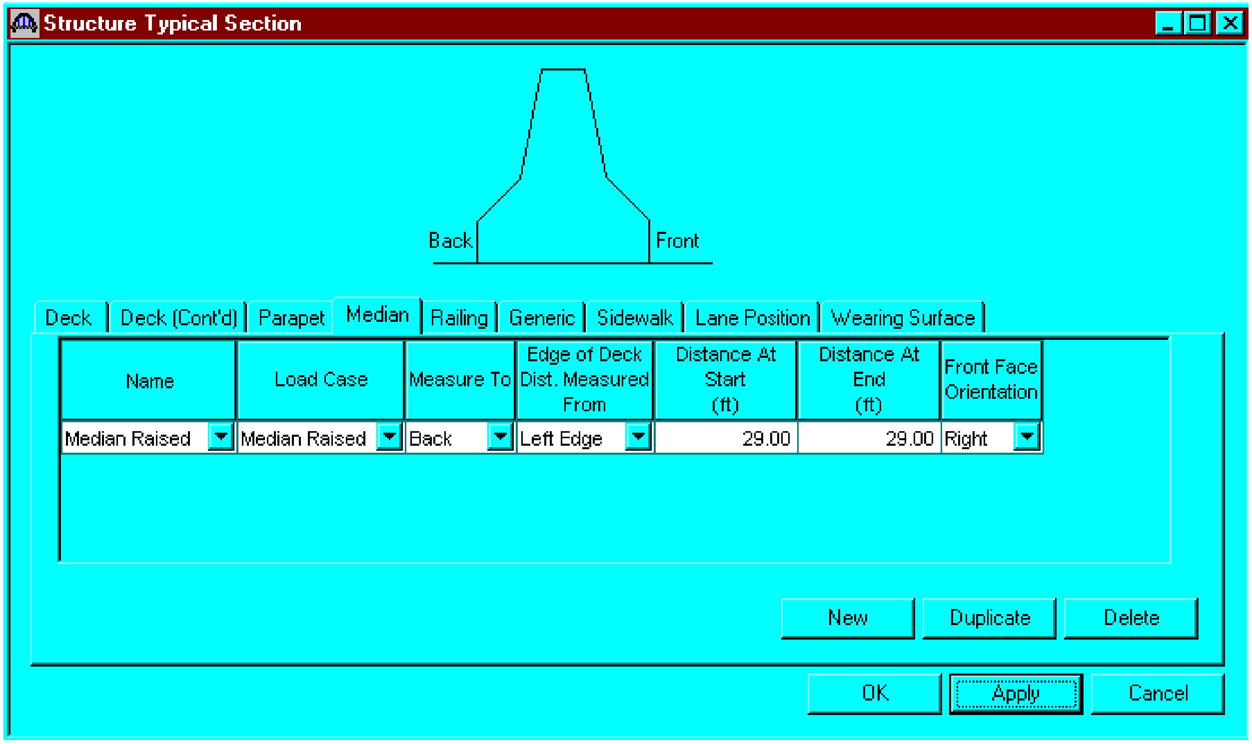
Sustained modular ratio factor: 2.000

Parapets:
Add two parapets as shown below.



Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Bridge Rail	Bridge Rail	Back	Left Edge	0.00	0.00	Right
Bridge Rail	Bridge Rail	Back	Right Edge	0.00	0.00	Left

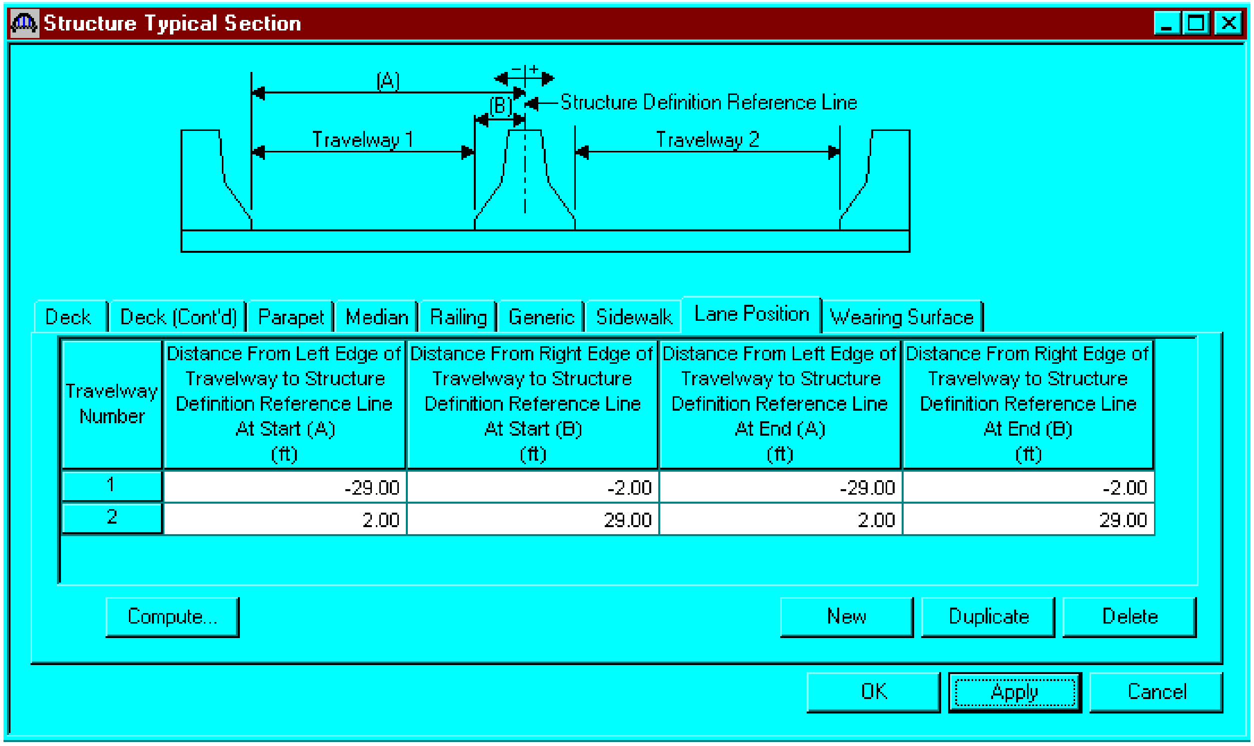
Median:
Add one median as shown below.



Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Median Raised	Median Raised	Back	Left Edge	29.00	29.00	Right

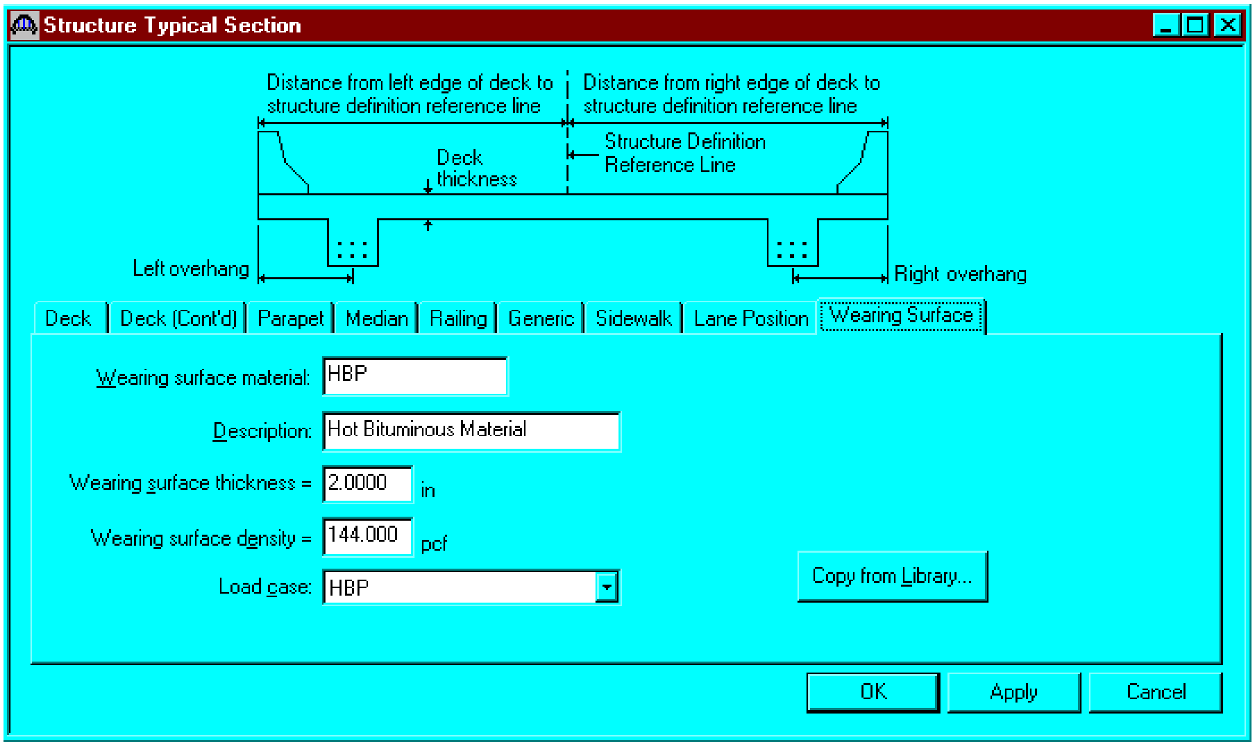
Lane Positions:

Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to apply the computed values. The Lane Position tab is populated as shown below.



Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At End (B) (ft)
1	-29.00	-2.00	-29.00	-2.00
2	2.00	29.00	2.00	29.00

Enter the following wearing surface information on the Wearing Surface tab.



Wearing surface material: HBP

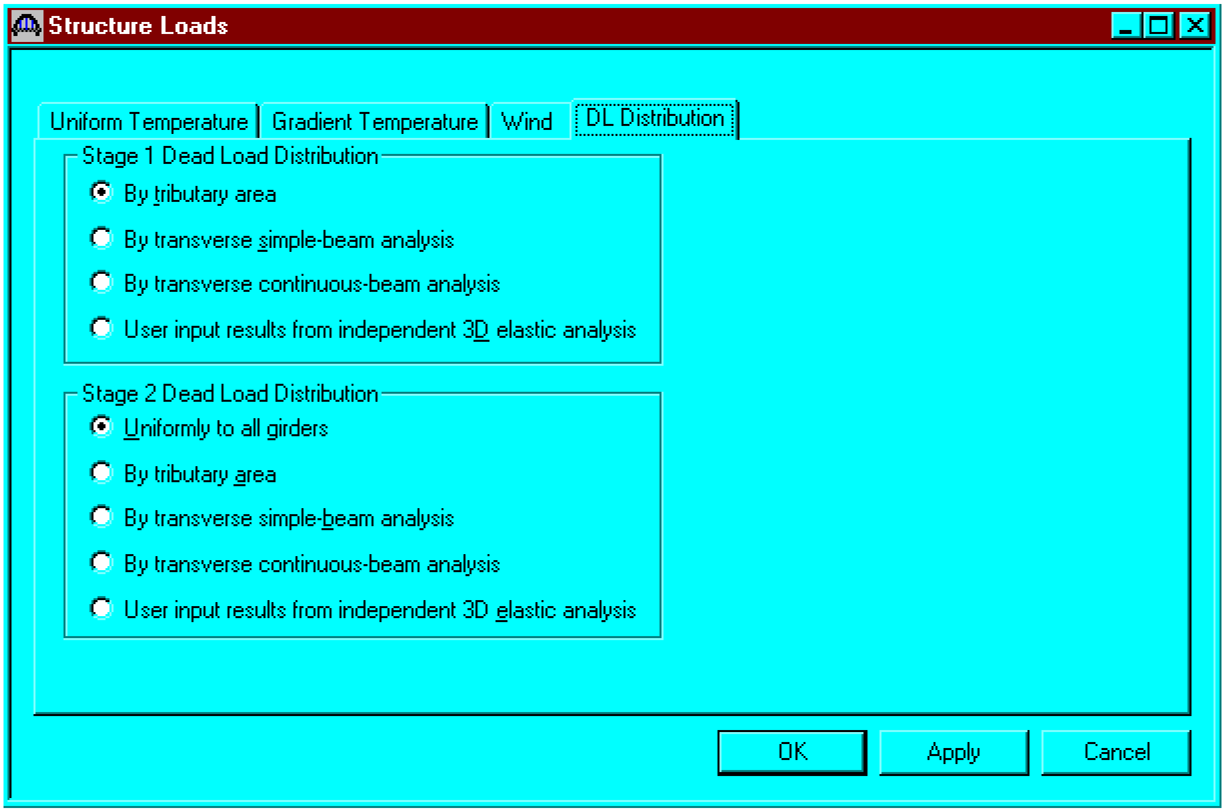
Description: Hot Bituminous Material

Wearing surface thickness = 2.0000 in

Wearing surface density = 144.000 pcf

Load case: HBP

Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



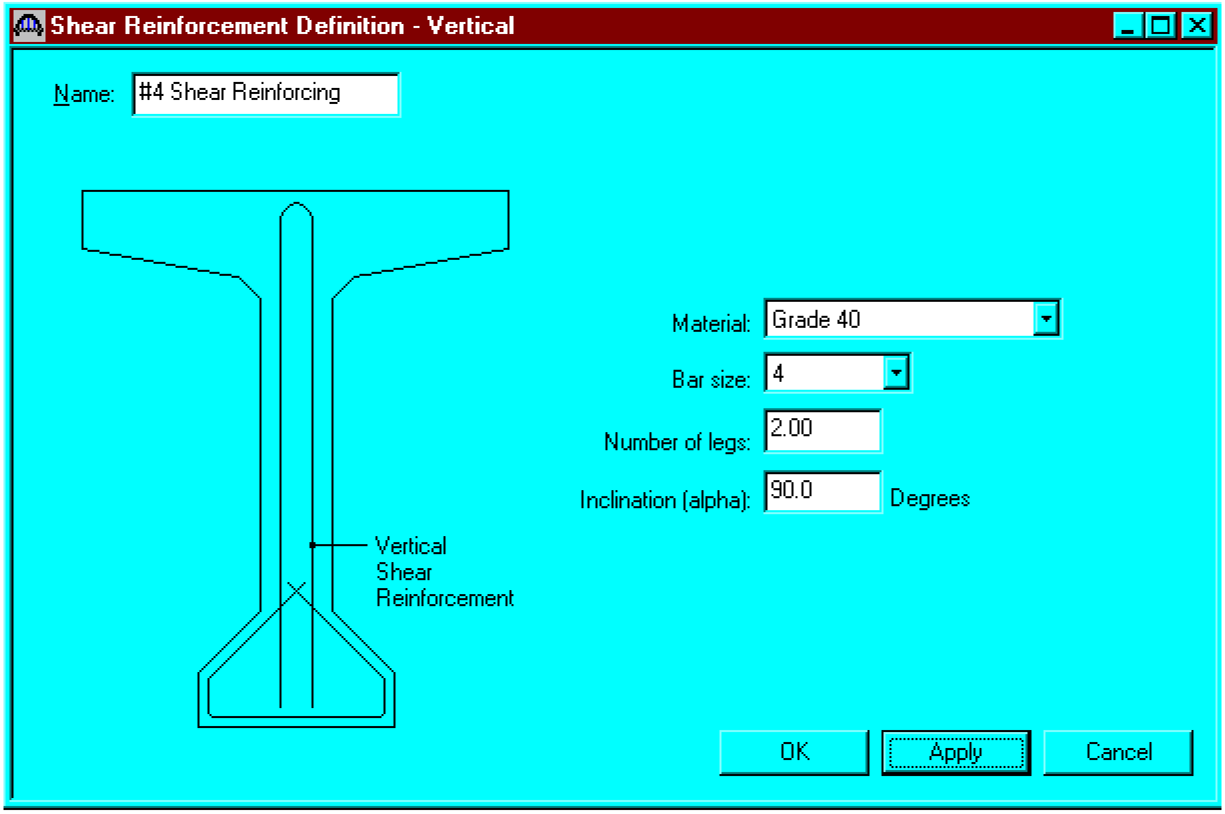
Stage 1 Dead Load Distribution

- ● By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

Stage 2 Dead Load Distribution

- ● Uniformly to all girders
- ○ By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



Name: #4 Shear Reinforcing

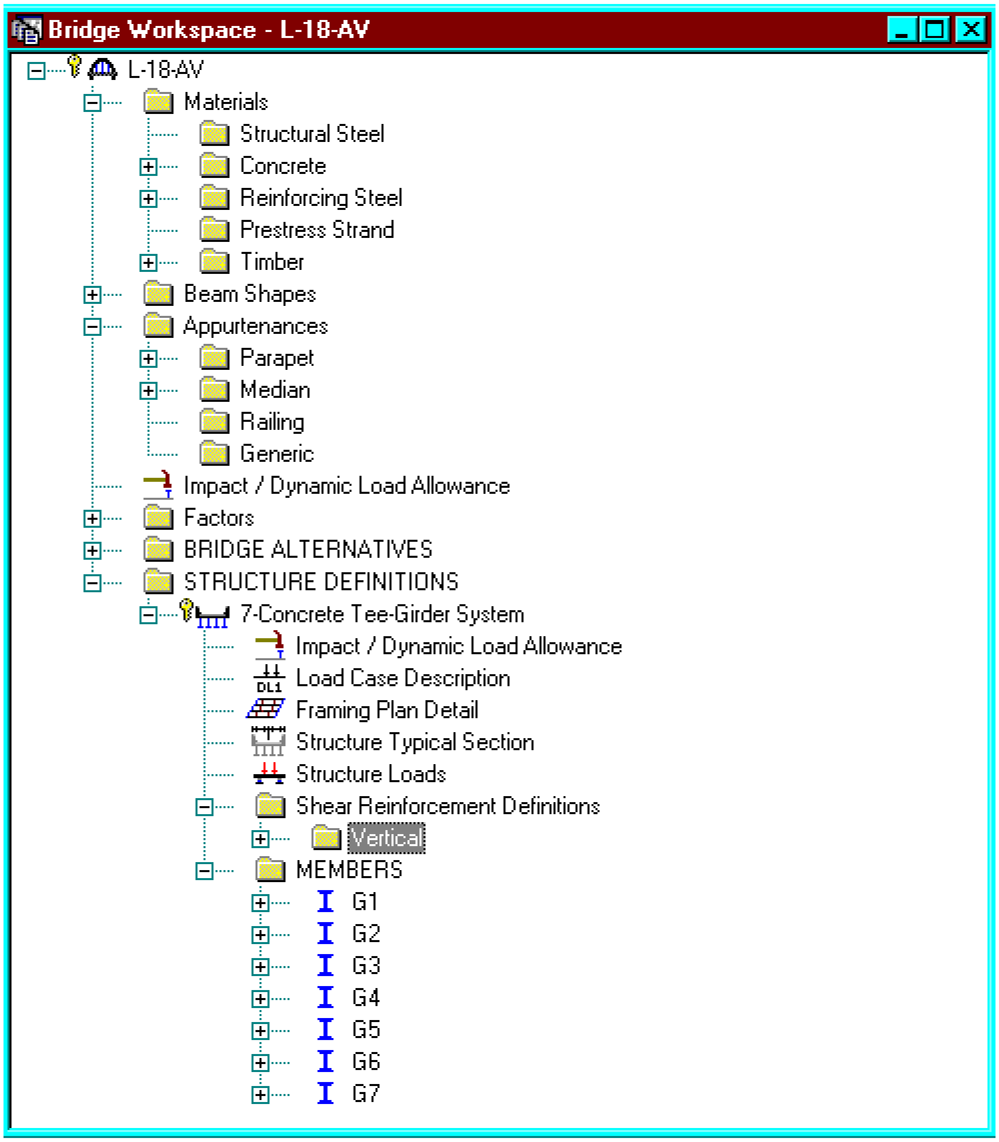
Material: Grade 40

Bar size: 4

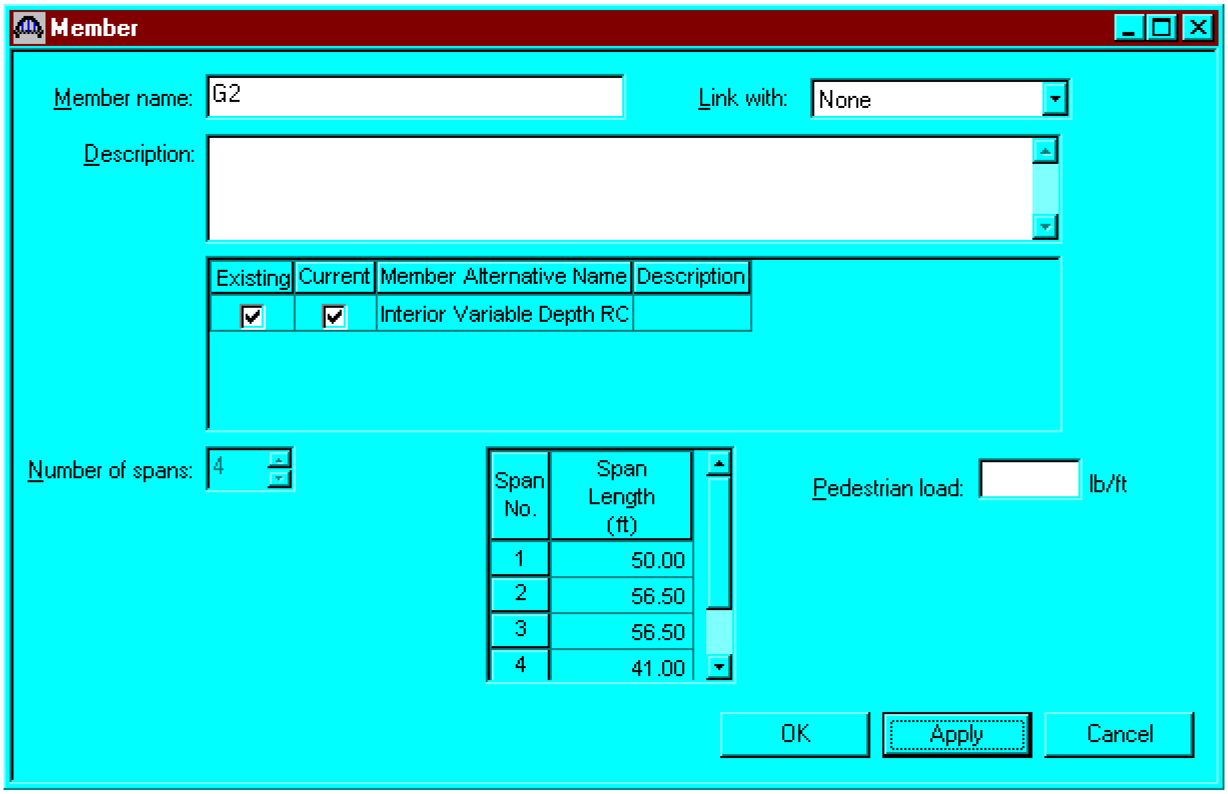
Number of legs: 2.00

Inclination (alpha): 90.0

The partially expanded Bridge Workspace tree is shown below:



Describing a member:
The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.



Member name: G2

Link with: None

Description:

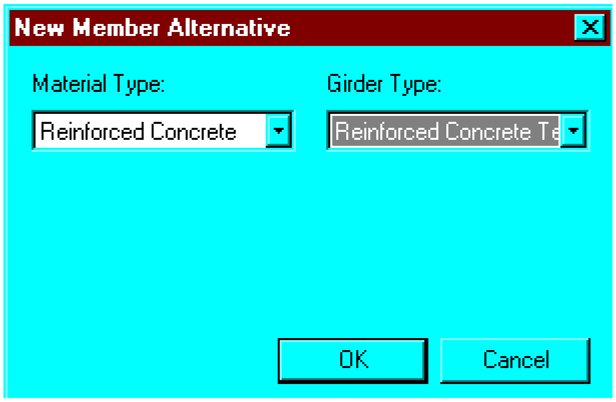
Existing	Current	Member Alternative Name	Description
☑	☑	Interior Variable Depth RC	

Number of spans: 4

Span No.	Span Length (ft)
1	50.00
2	56.50
3	56.50
4	41.00

Pedestrian load: lb/ft

Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Reinforced Concrete for the Material Type and Reinforced Concrete Tee for the Girder Type.

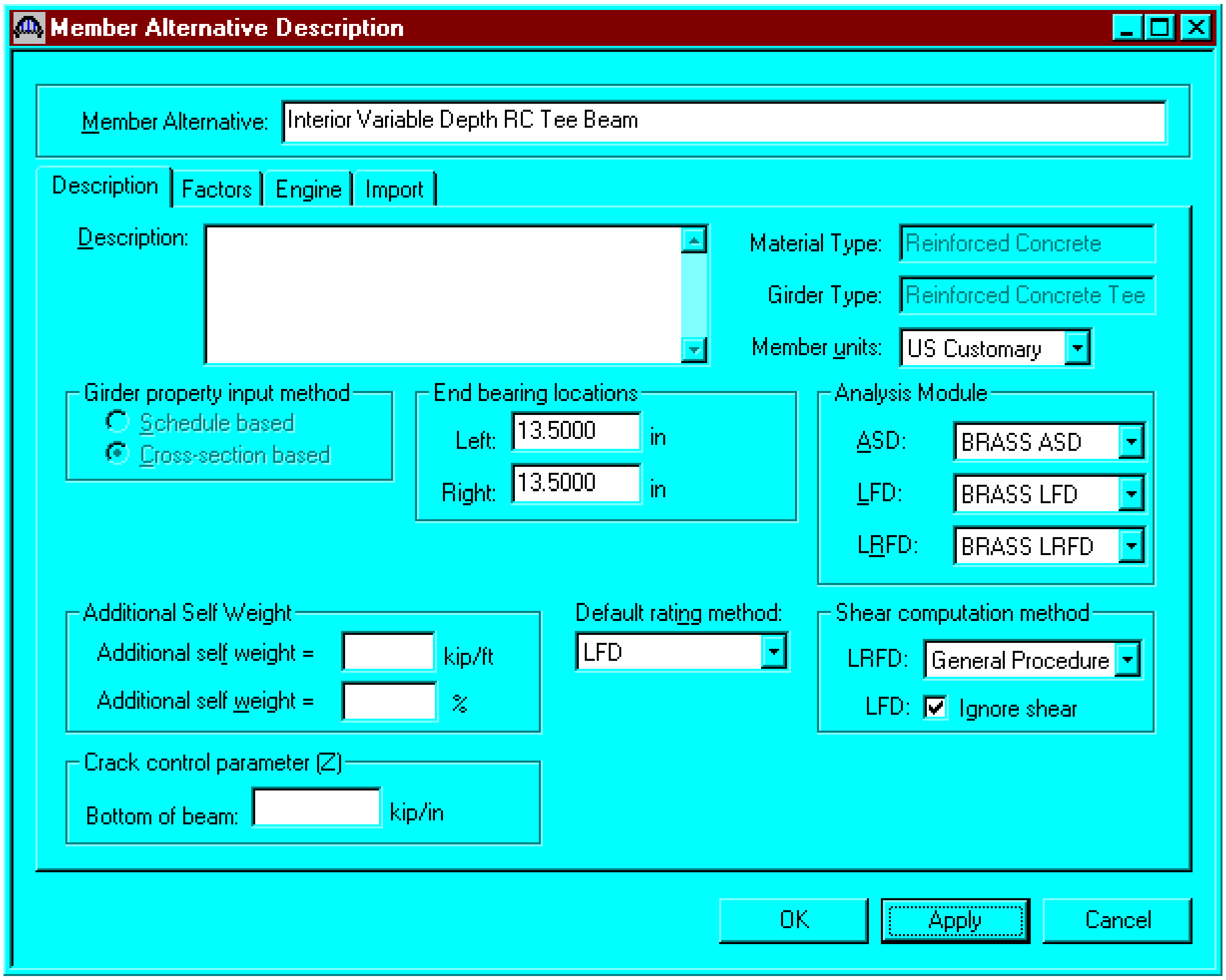


Material Type: Reinforced Concrete

Girder Type: Reinforced Concrete Te

Click OK to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below.



Member Alternative: Interior Variable Depth RC Tee Beam

Description:

Material Type: Reinforced Concrete

Girder Type: Reinforced Concrete Tee

Member units: US Customary

Girder property input method
○ Schedule based
● Cross-section based

End bearing locations
Left: 13.5000 in
Right: 13.5000 in

Analysis Module
ASD: BRASS ASD
LFD: BRASS LFD
LRFD: BRASS LRFD

Additional Self Weight
Additional self weight = kip/ft
Additional self weight = %

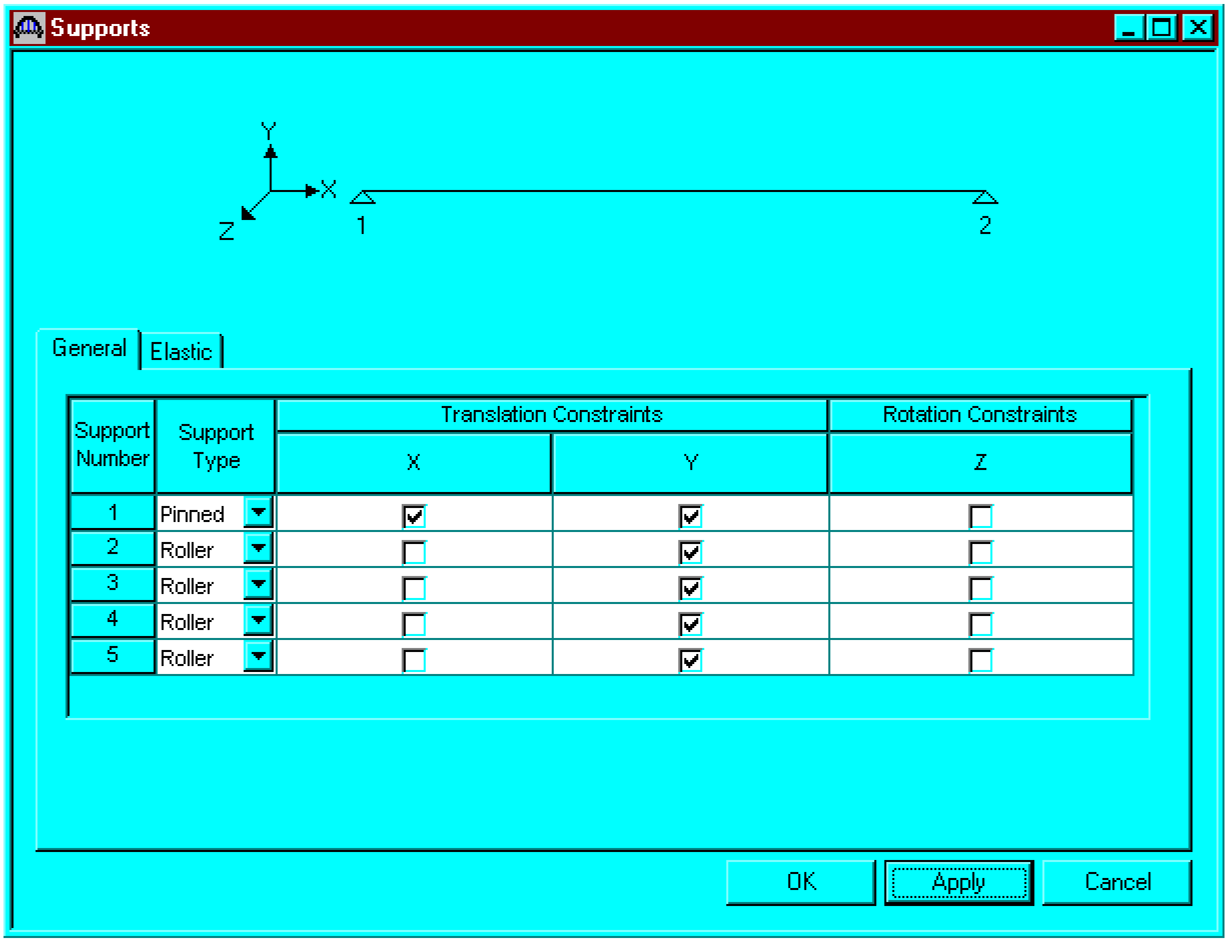
Default rating method: LFD

Shear computation method
LRFD: General Procedure
LFD: ☑ Ignore shear

Crack control parameter (Z)
Bottom of beam: kip/in

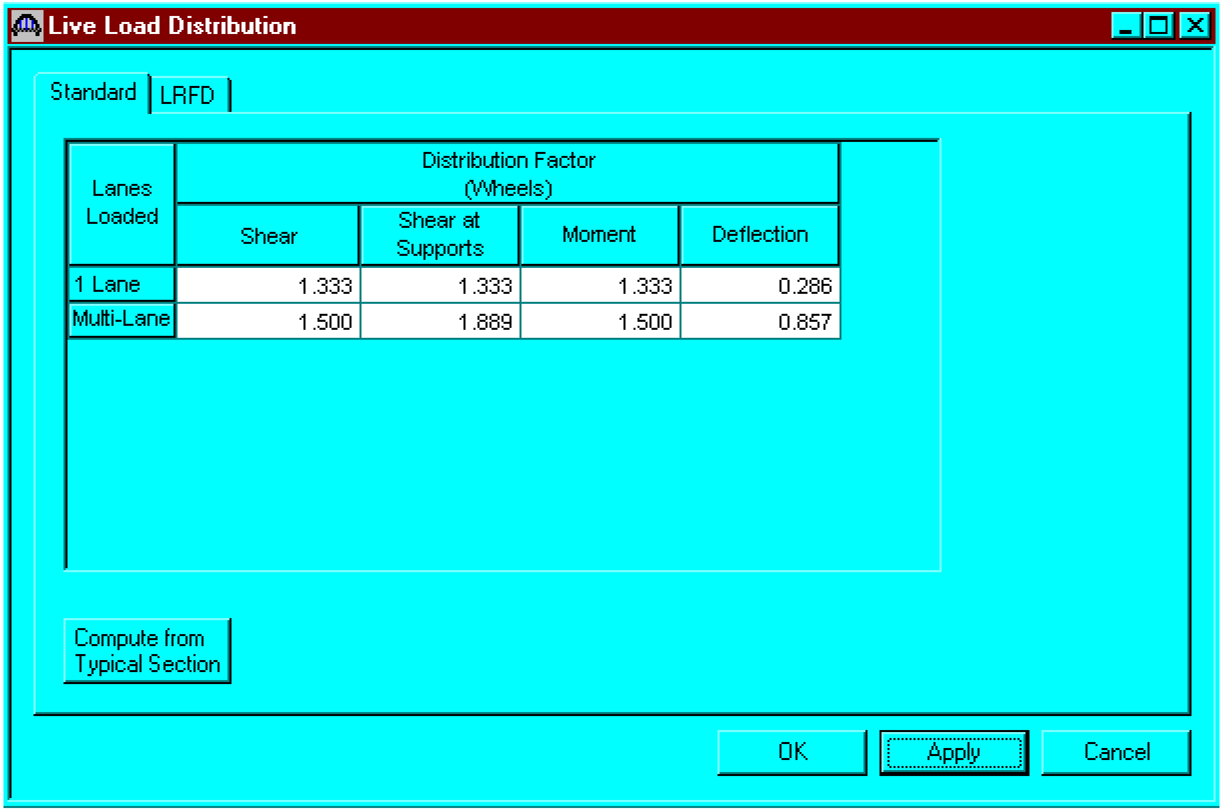
Shear computation method: Check this box if the AASHTO LFD shear specifications should be ignored in the analysis.

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



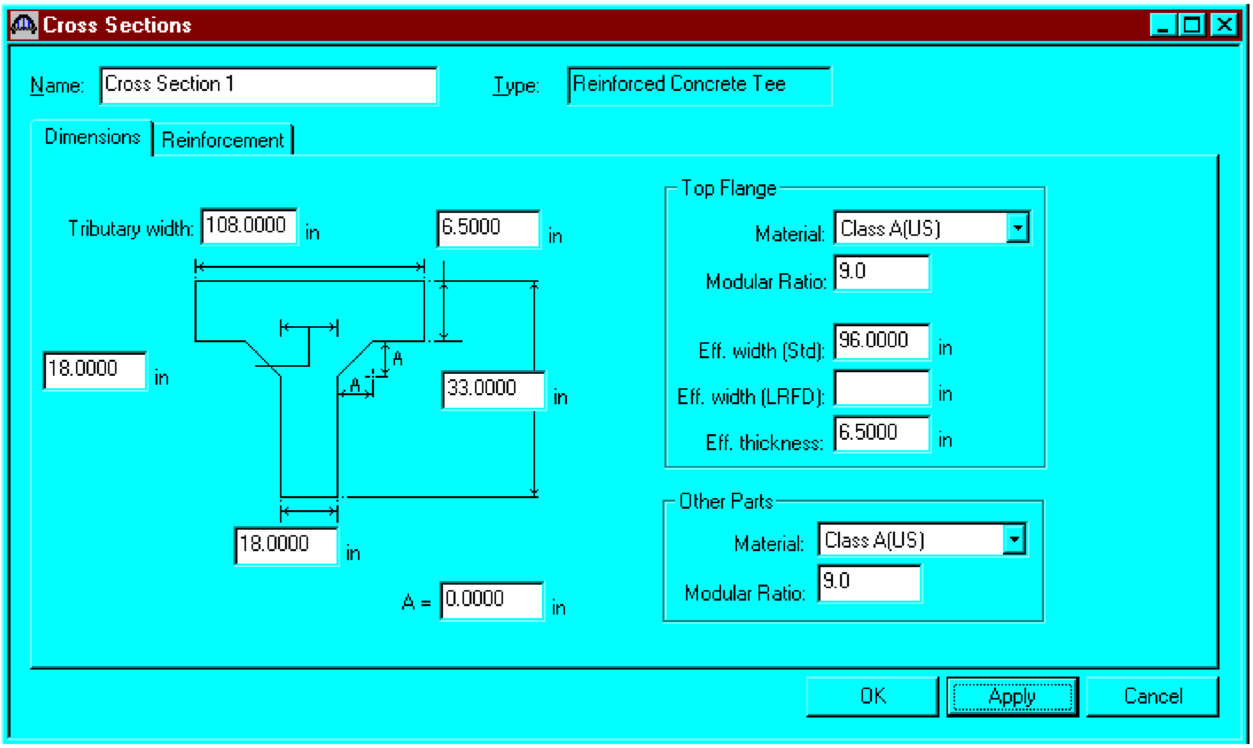
Support Number	Support Type	Translation Constraints		Rotation Constraints
		X	Y	Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐
3	Roller	☐	☑	☐
4	Roller	☐	☑	☐
5	Roller	☐	☑	☐

Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23. Click Apply and then OK to save data to memory and close the window.



Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.333	1.333	1.333	0.286
Multi-Lane	1.500	1.889	1.500	0.857

Double click on Cross Sections in the tree to create the cross section that defines the girder geometry. The Cross Section window is shown below. Define cross section 1 as shown below. Click apply and then the Reinforcement tab.



Name: Cross Section 1

Type: Reinforced Concrete Tee

Tributary width: 108.0000 in

6.5000 in

18.0000 in

33.0000 in

18.0000 in

A = 0.0000 in

Top Flange

Material: Class A(US)

Modular Ratio: 9.0

Eff. width (Std): 96.0000 in

Eff. width (LRFD): in

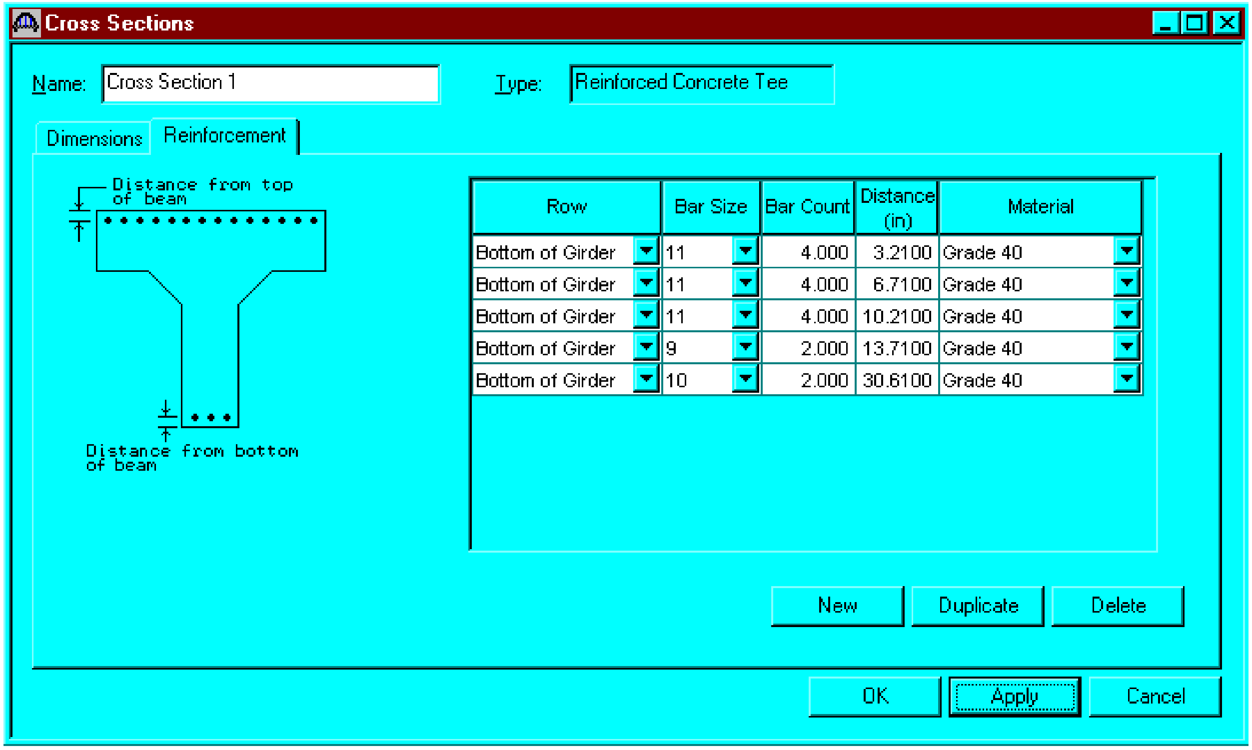
Eff. thickness: 6.5000 in

Other Parts

Material: Class A(US)

Modular Ratio: 9.0

Define reinforcements for Cross Section 1. Click OK to save data to memory and close the window.

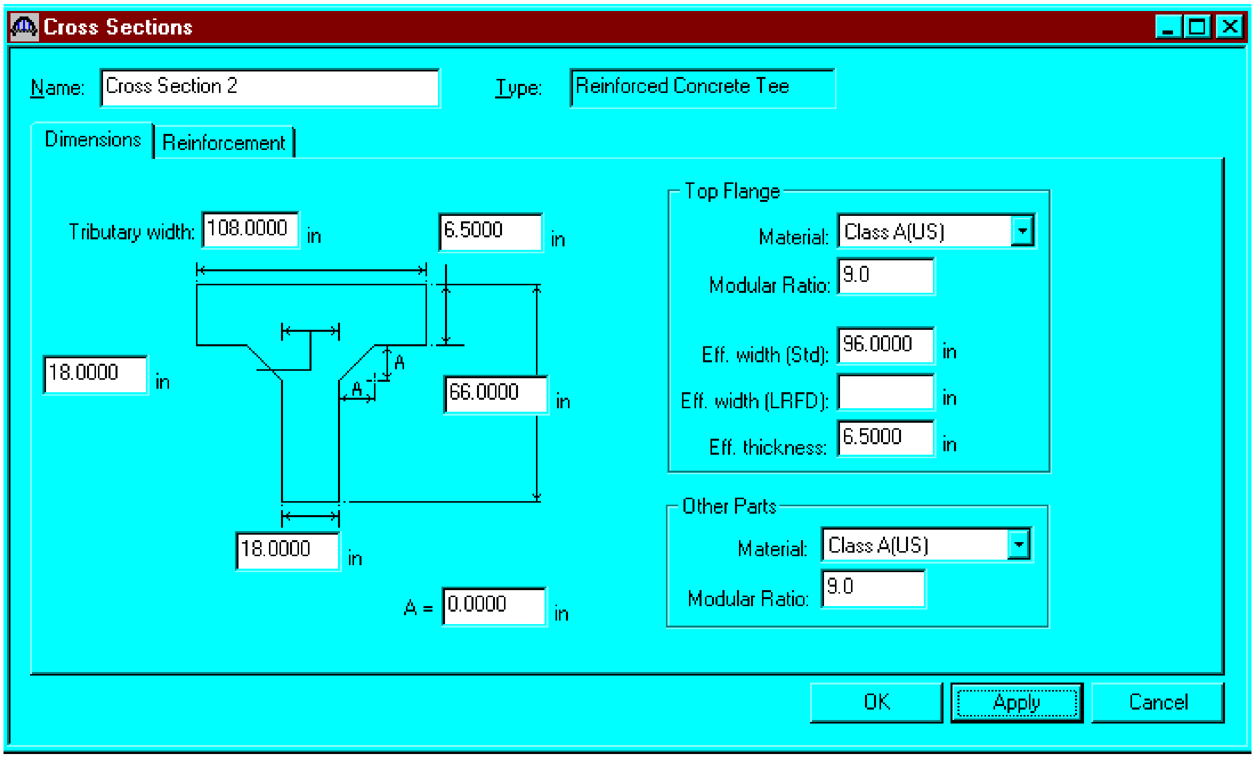


Name: Cross Section 1

Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	11	4.000	10.2100	Grade 40
Bottom of Girder	9	2.000	13.7100	Grade 40
Bottom of Girder	10	2.000	30.6100	Grade 40

Using the same techniques, create cross sections 2 thru 8, and define their associated reinforcement patterns.

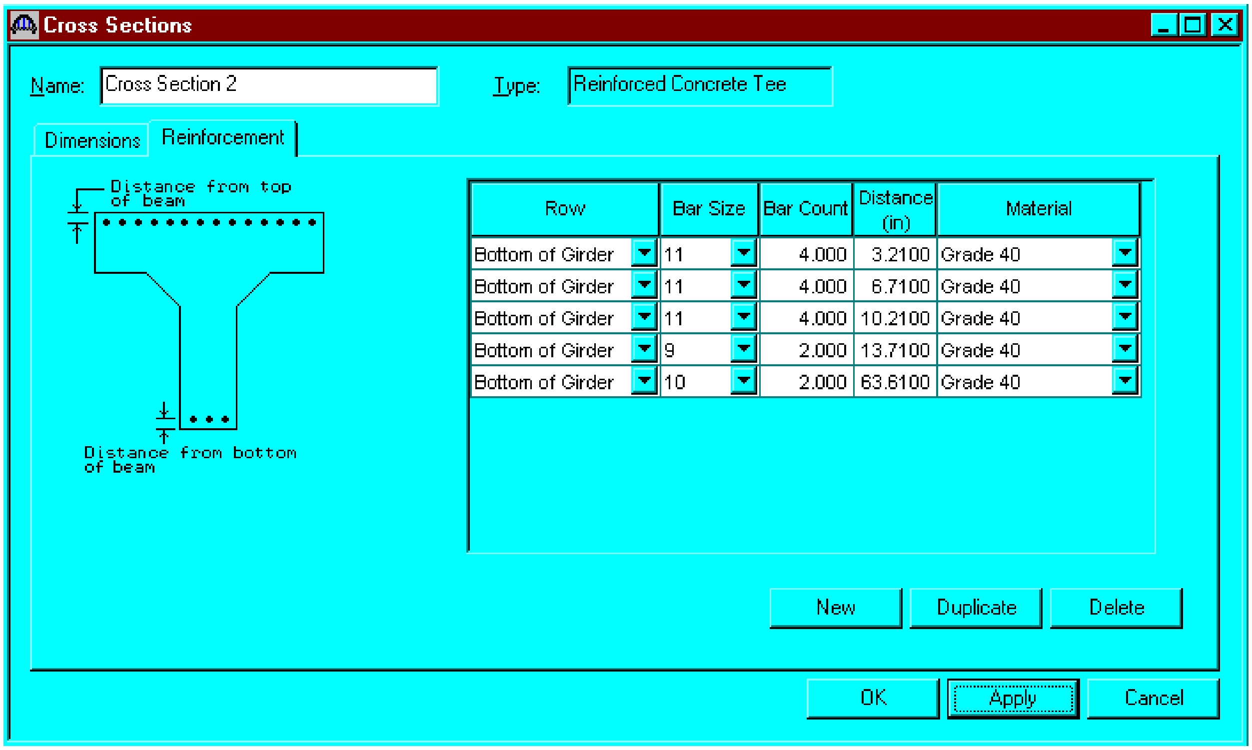


Name: Cross Section 2
Type: Reinforced Concrete Tee

Tributary width: 108.0000 in
6.5000 in
18.0000 in
66.0000 in
18.0000 in
A = 0.0000 in

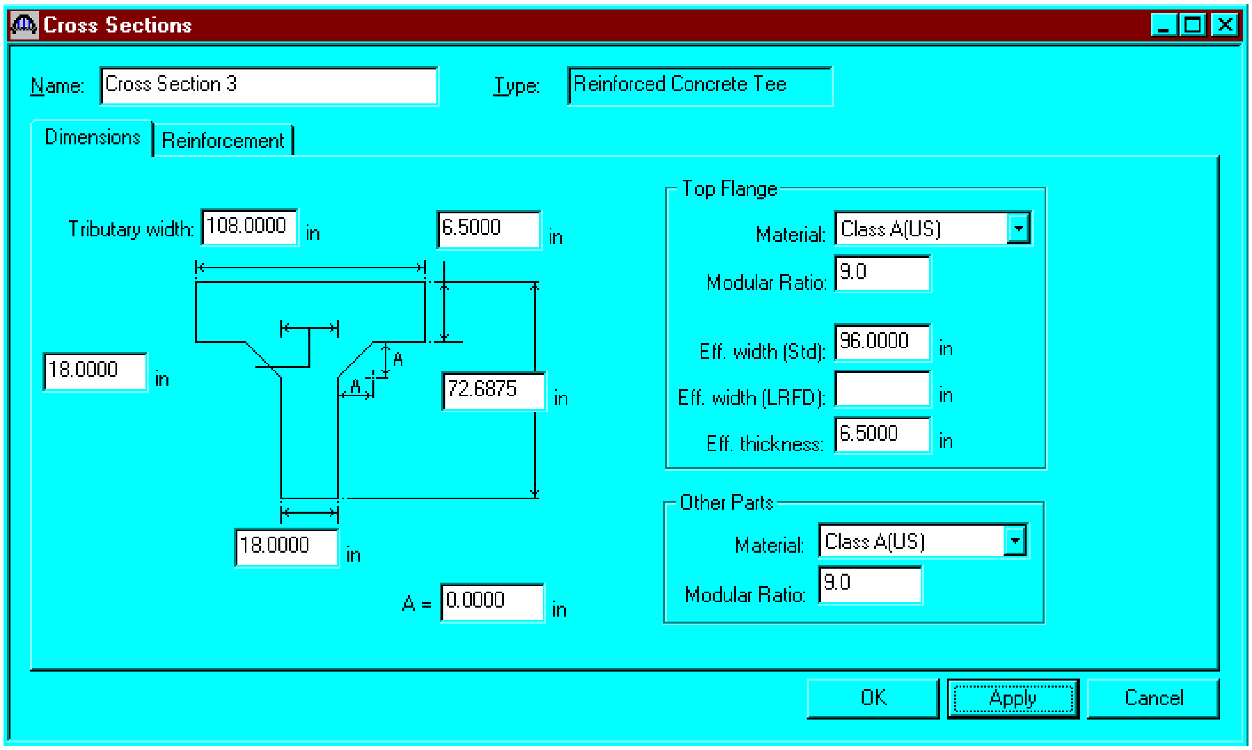
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in

Other Parts
Material: Class A(US)
Modular Ratio: 9.0



Name: Cross Section 2
Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	11	4.000	10.2100	Grade 40
Bottom of Girder	9	2.000	13.7100	Grade 40
Bottom of Girder	10	2.000	63.6100	Grade 40



Name: Cross Section 3

Type: Reinforced Concrete Tee

Tributary width: 108.0000 in

6.5000 in

18.0000 in

72.6875 in

18.0000 in

A = 0.0000 in

Top Flange

Material: Class A(US)

Modular Ratio: 9.0

Eff. width (Std): 96.0000 in

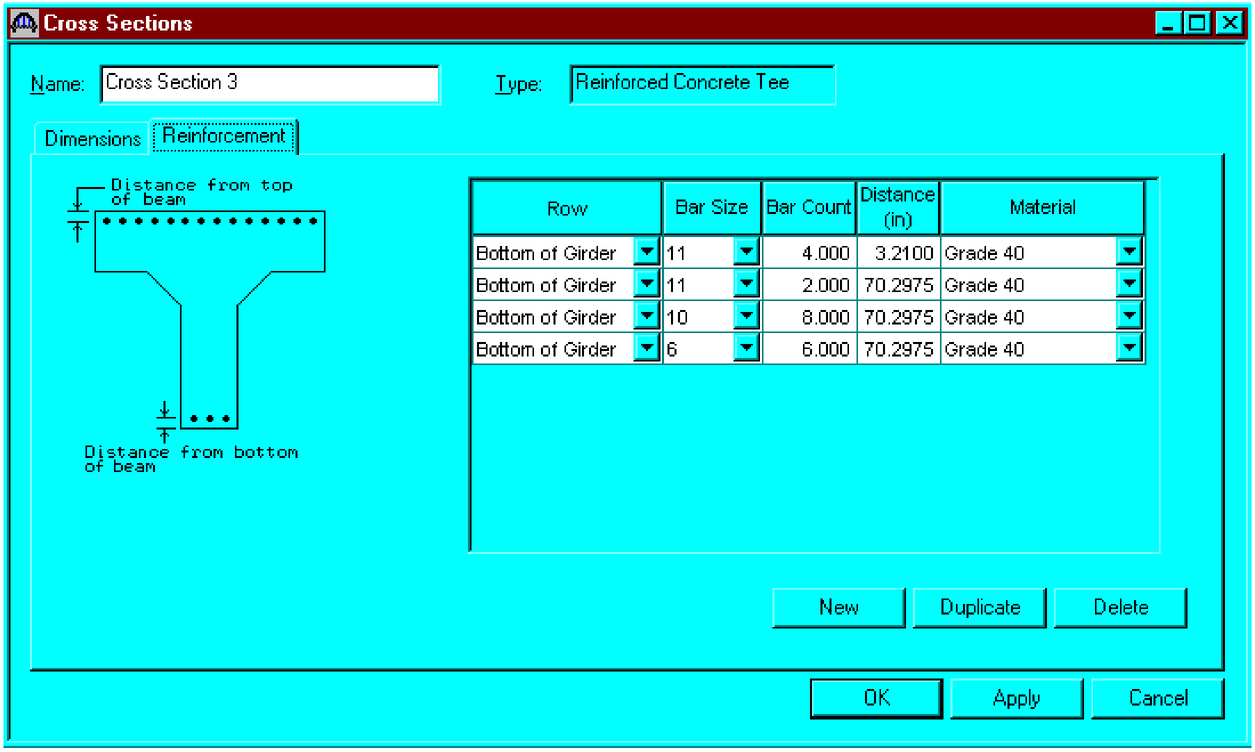
Eff. width (LRFD): in

Eff. thickness: 6.5000 in

Other Parts

Material: Class A(US)

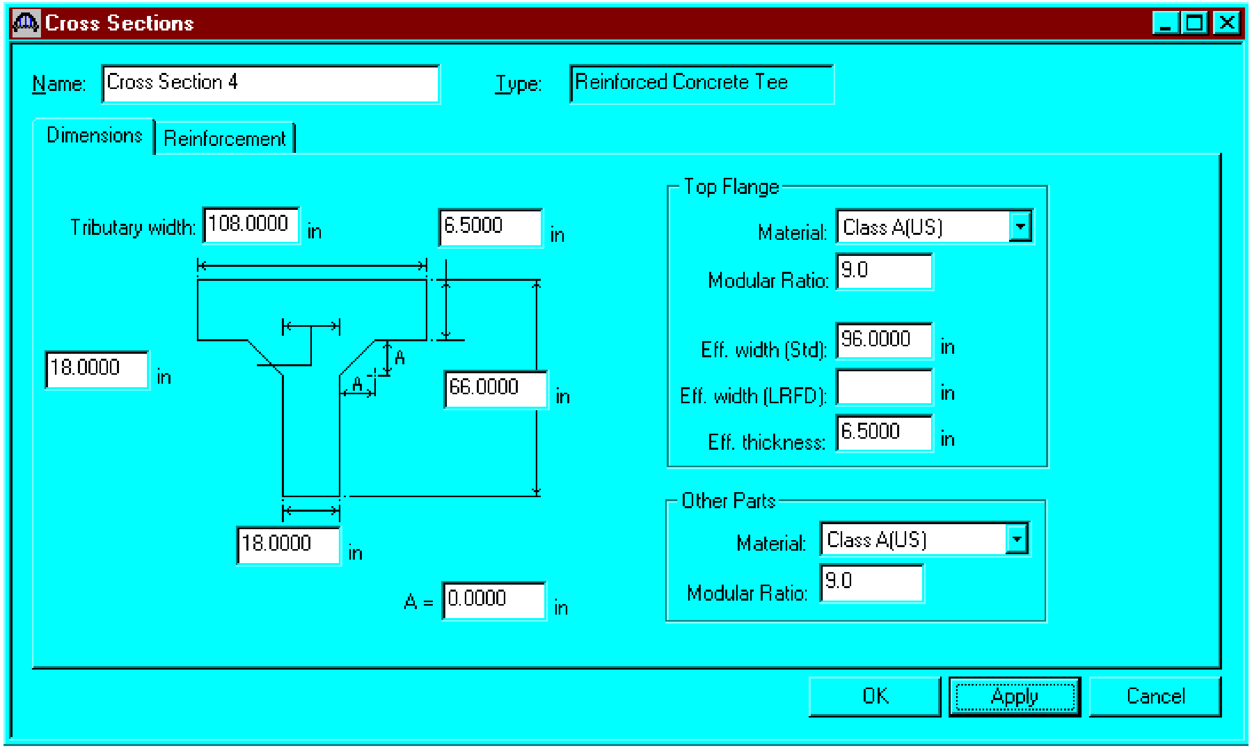
Modular Ratio: 9.0



Name: Cross Section 3

Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	2.000	70.2975	Grade 40
Bottom of Girder	10	8.000	70.2975	Grade 40
Bottom of Girder	6	6.000	70.2975	Grade 40



Name: Cross Section 4

Type: Reinforced Concrete Tee

Tributary width: 108.0000 in

6.5000 in

18.0000 in

66.0000 in

18.0000 in

A = 0.0000 in

Top Flange

Material: Class A(US)

Modular Ratio: 9.0

Eff. width (Std): 96.0000 in

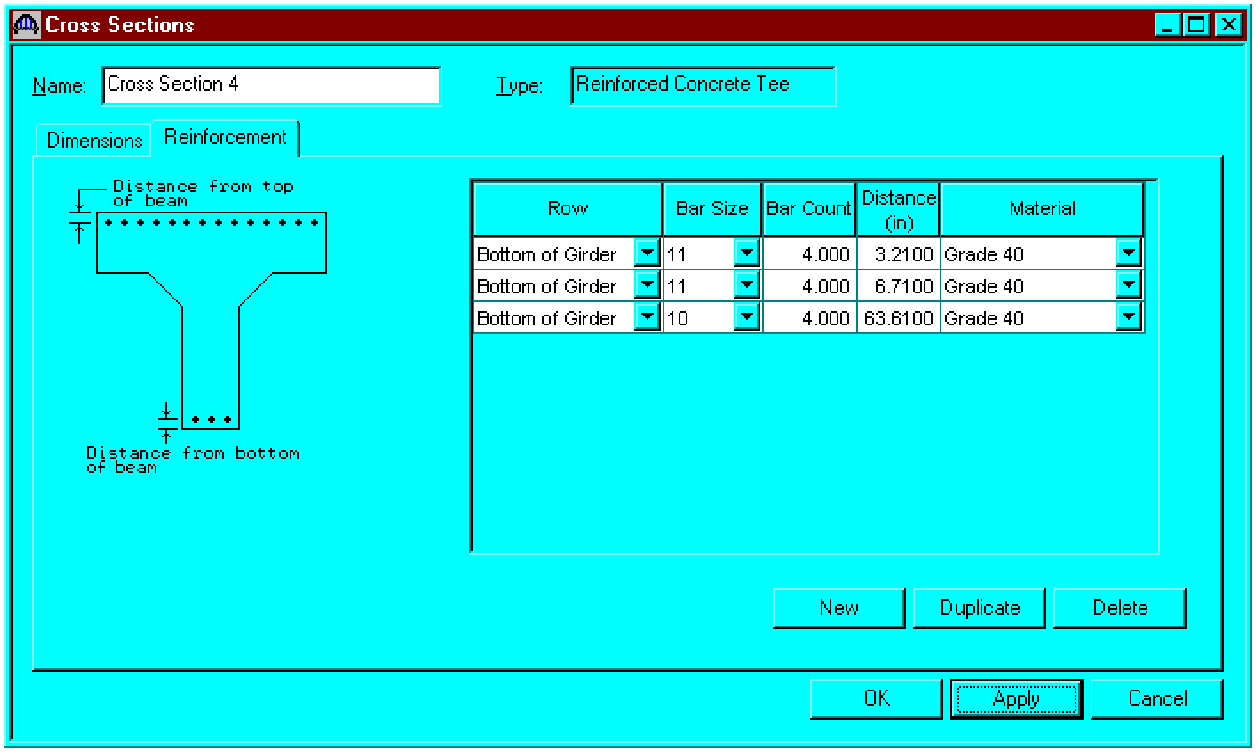
Eff. width (LRFD): in

Eff. thickness: 6.5000 in

Other Parts

Material: Class A(US)

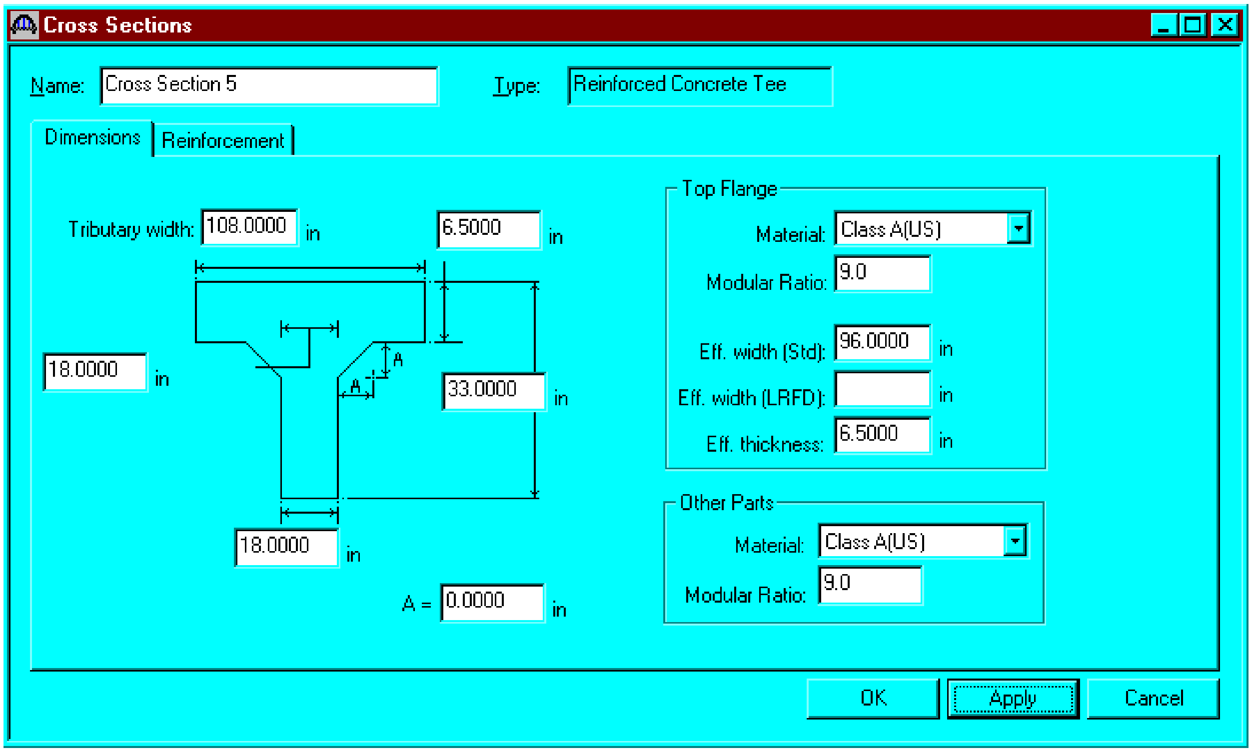
Modular Ratio: 9.0



Name: Cross Section 4

Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	10	4.000	63.6100	Grade 40

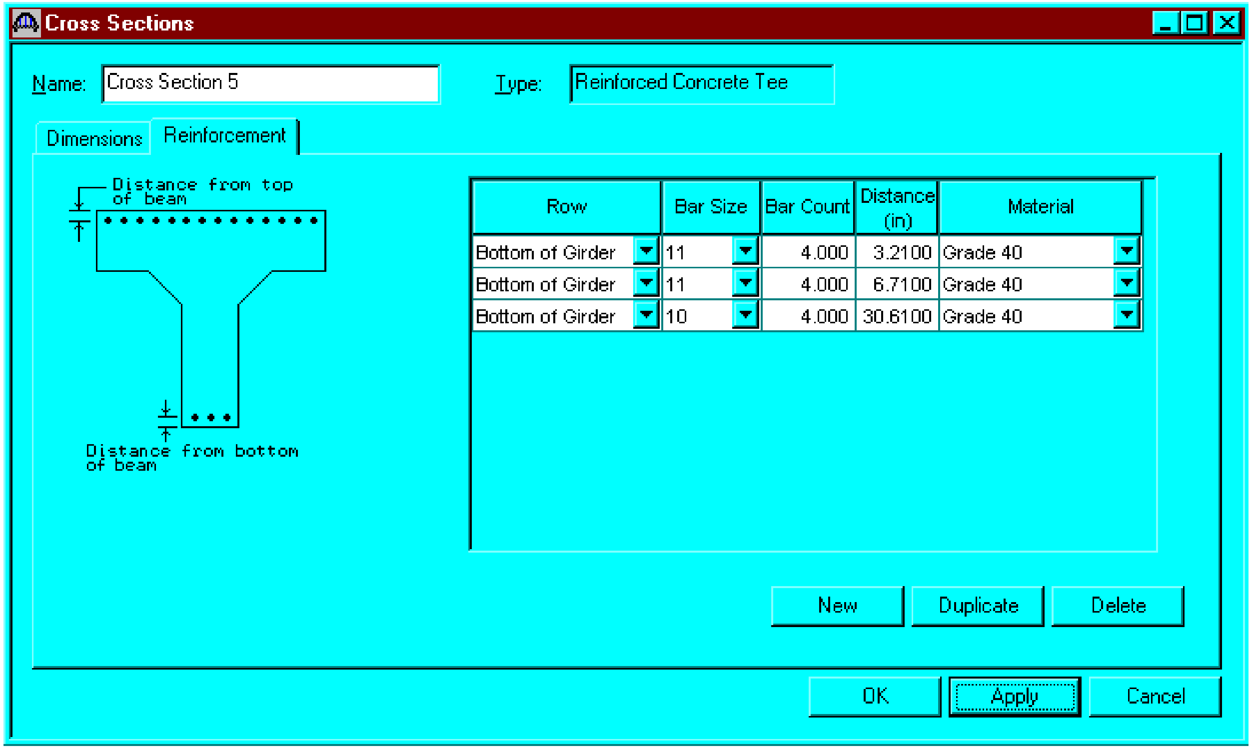


Name: Cross Section 5
Type: Reinforced Concrete Tee

Tributary width: 108.0000 in
6.5000 in
18.0000 in
33.0000 in
18.0000 in
A = 0.0000 in

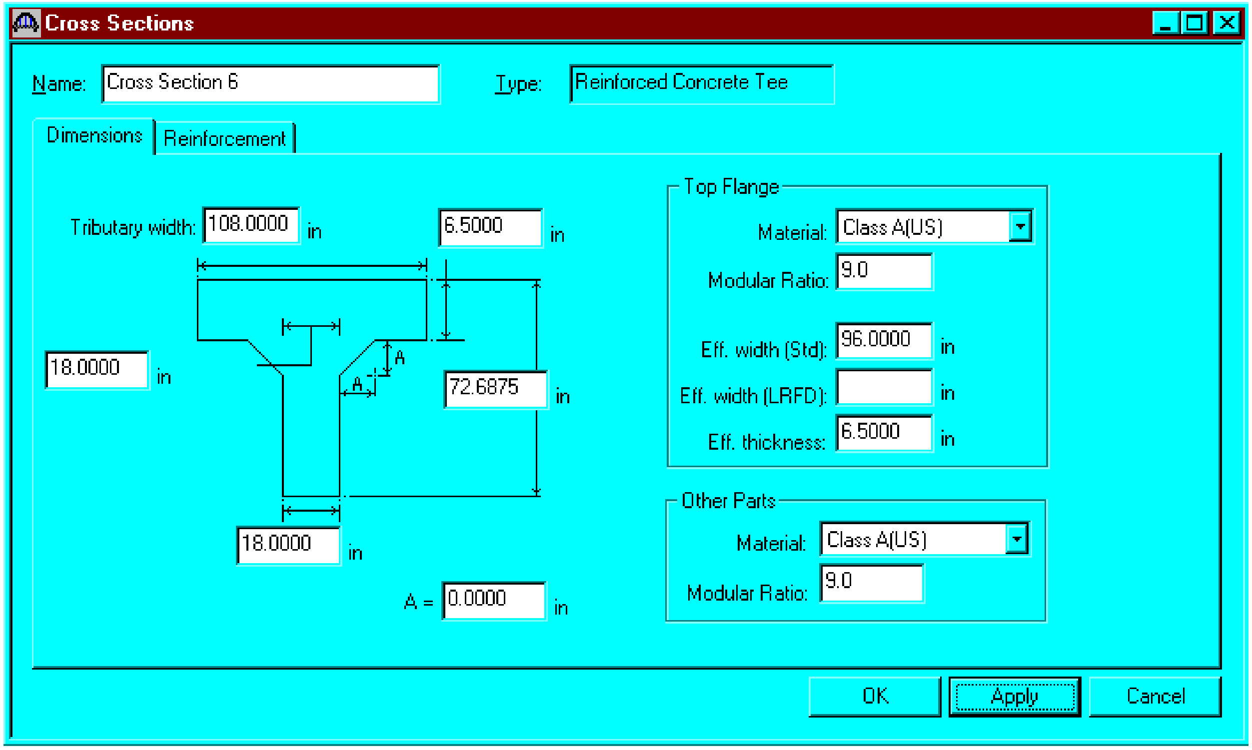
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in

Other Parts
Material: Class A(US)
Modular Ratio: 9.0



Name: Cross Section 5
Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	10	4.000	30.6100	Grade 40



Name: Cross Section 6

Type: Reinforced Concrete Tee

Tributary width: 108.0000 in

6.5000 in

18.0000 in

72.6875 in

18.0000 in

A = 0.0000 in

Top Flange

Material: Class A(US)

Modular Ratio: 9.0

Eff. width (Std): 96.0000 in

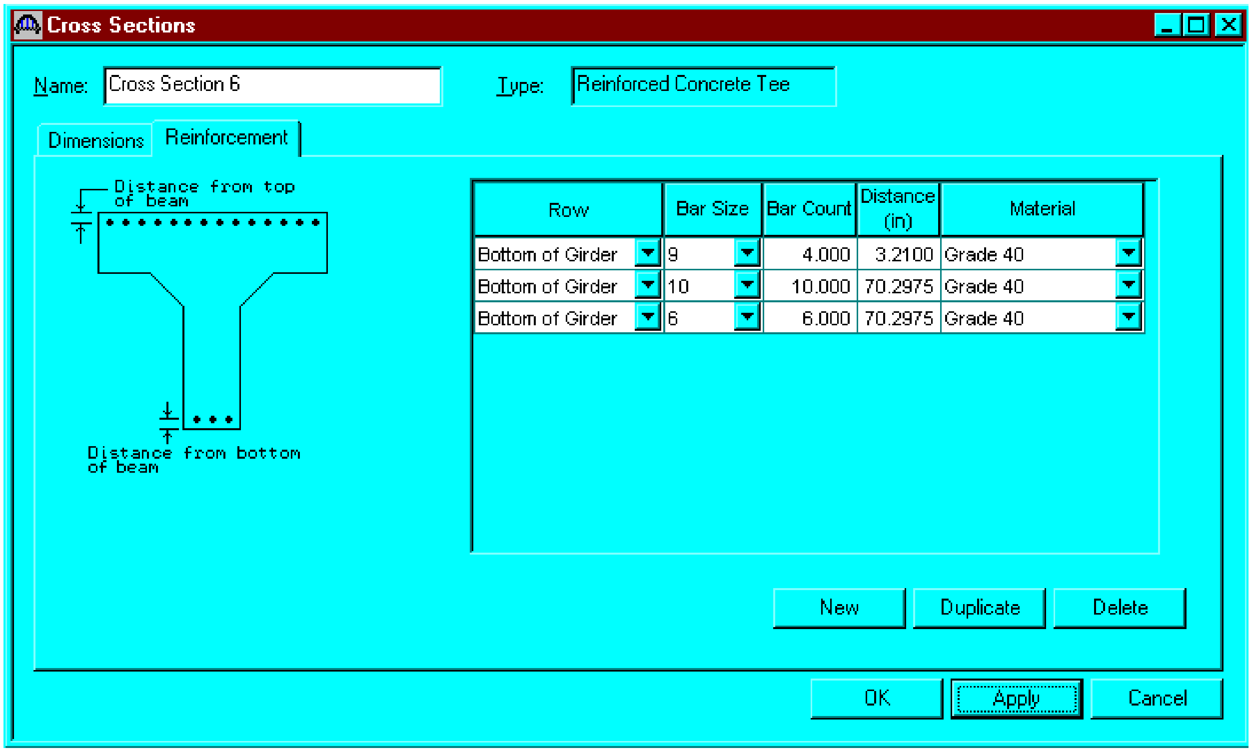
Eff. width (LRFD): in

Eff. thickness: 6.5000 in

Other Parts

Material: Class A(US)

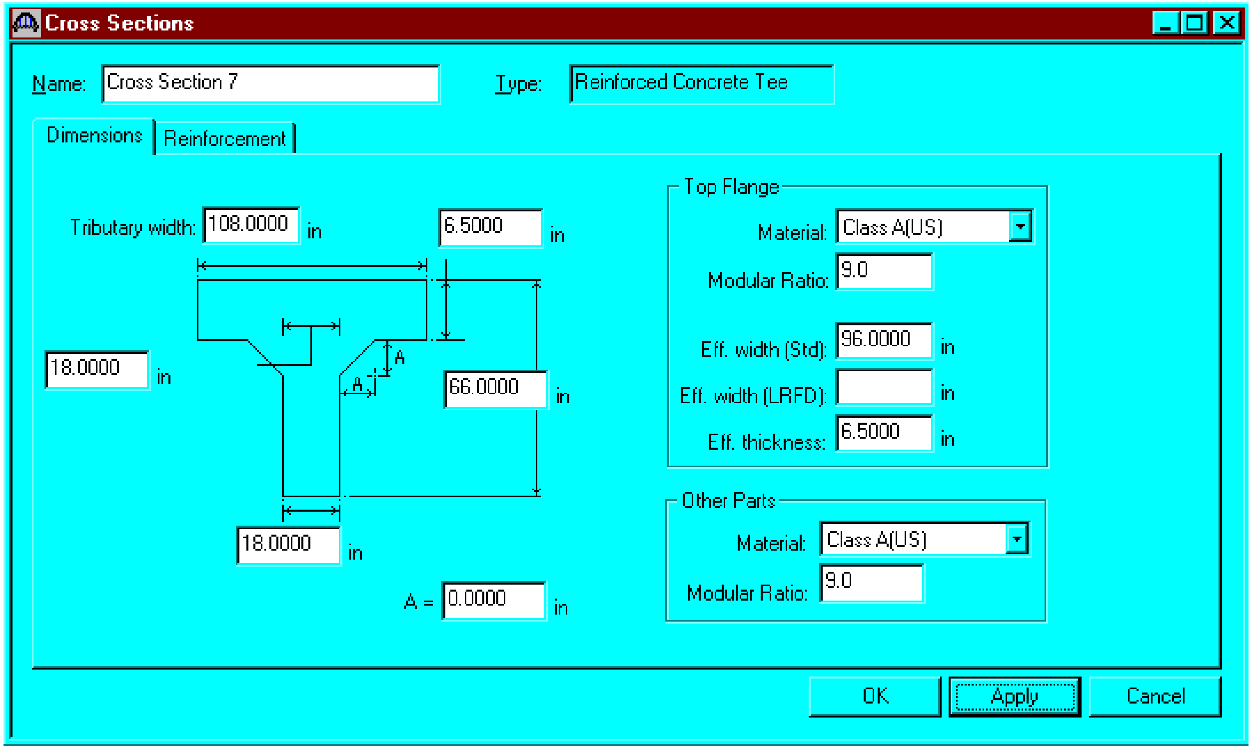
Modular Ratio: 9.0



Name: Cross Section 6

Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	9	4.000	3.2100	Grade 40
Bottom of Girder	10	10.000	70.2975	Grade 40
Bottom of Girder	6	6.000	70.2975	Grade 40



Name: Cross Section 7

Type: Reinforced Concrete Tee

Tributary width: 108.0000 in

6.5000 in

18.0000 in

66.0000 in

18.0000 in

A = 0.0000 in

Top Flange

Material: Class A(US)

Modular Ratio: 9.0

Eff. width (Std): 96.0000 in

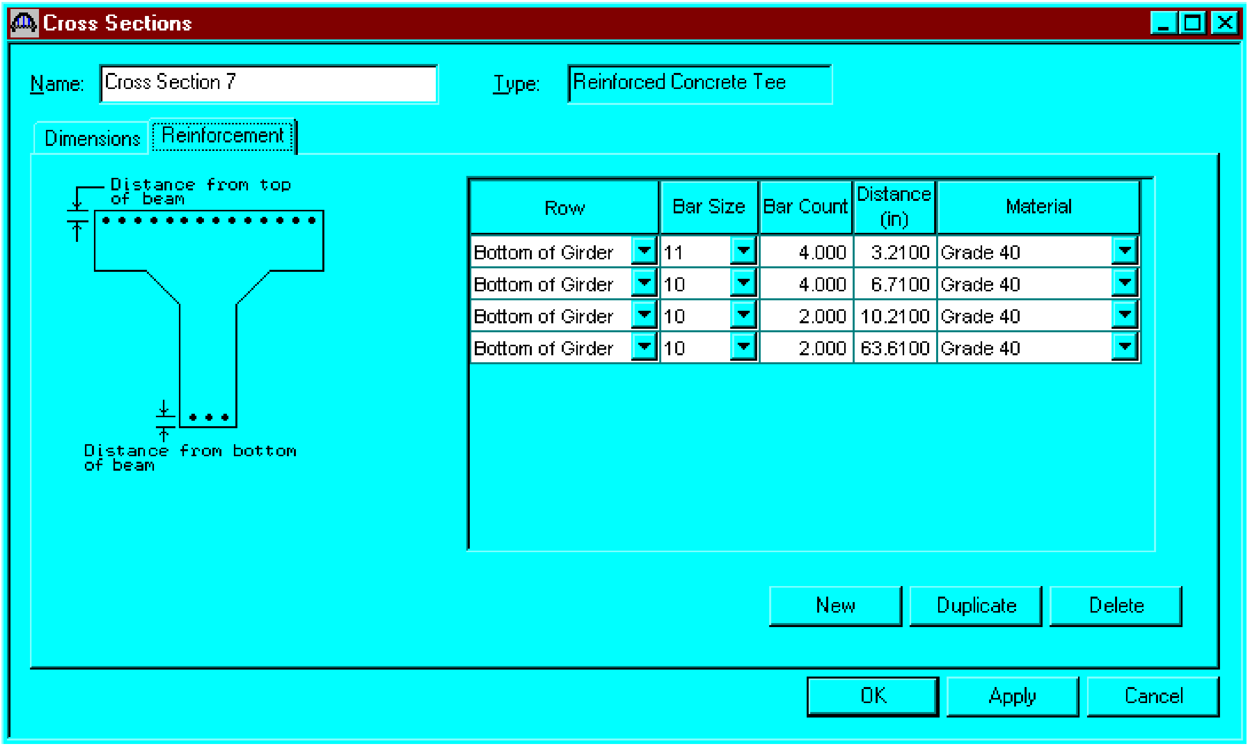
Eff. width (LRFD): in

Eff. thickness: 6.5000 in

Other Parts

Material: Class A(US)

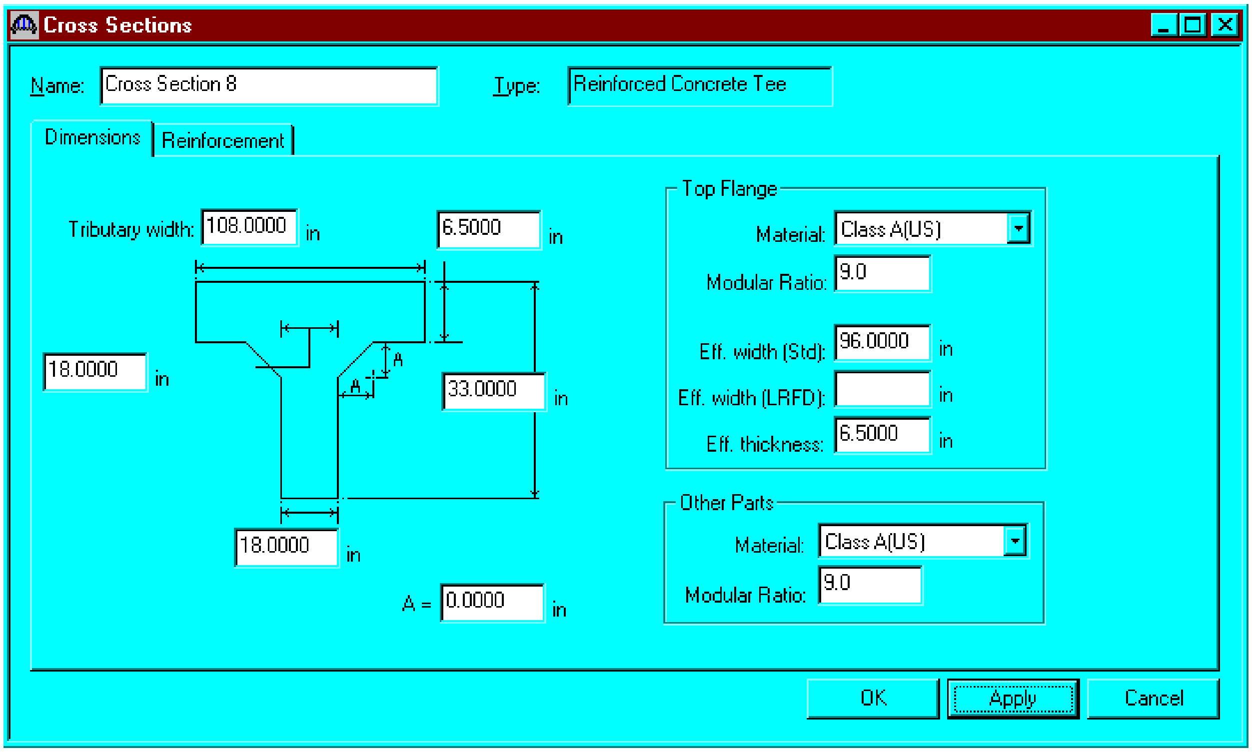
Modular Ratio: 9.0



Name: Cross Section 7

Type: Reinforced Concrete Tee

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	10	4.000	6.7100	Grade 40
Bottom of Girder	10	2.000	10.2100	Grade 40
Bottom of Girder	10	2.000	63.6100	Grade 40

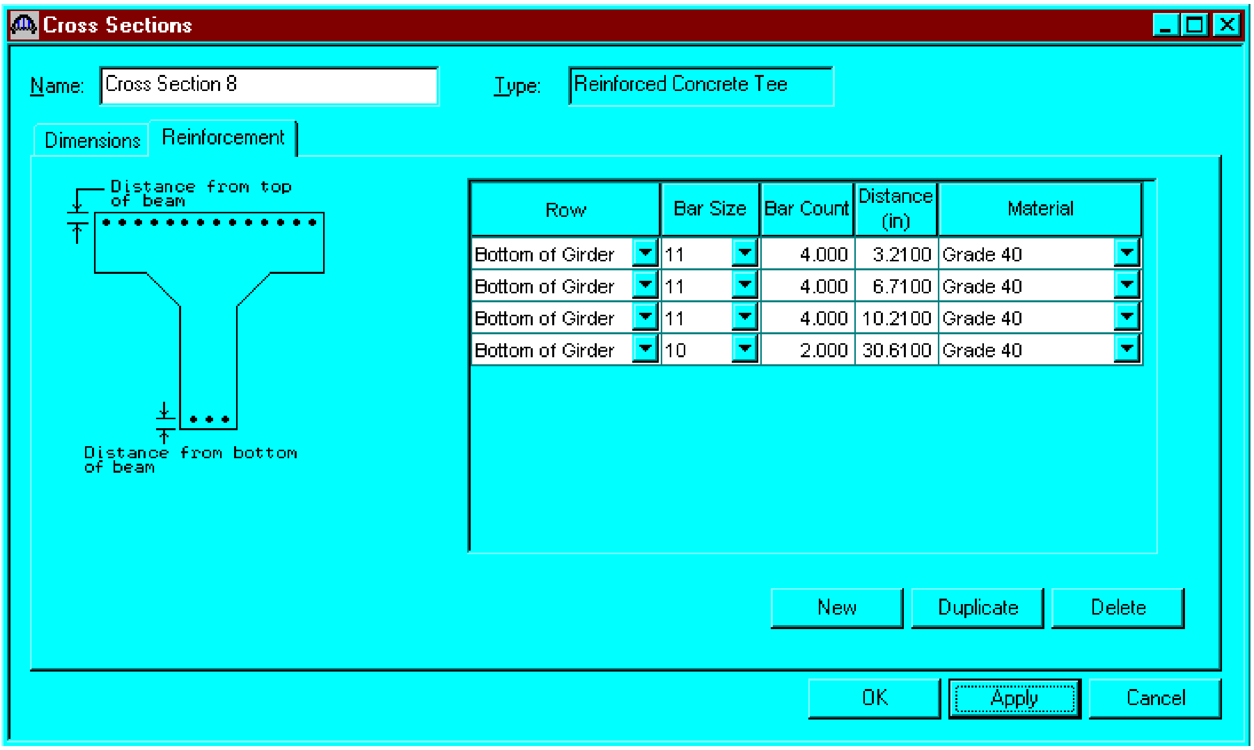


Name: Cross Section 8
Type: Reinforced Concrete Tee

Tributary width: 108.0000 in
6.5000 in
18.0000 in
33.0000 in
18.0000 in
A = 0.0000 in

Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in

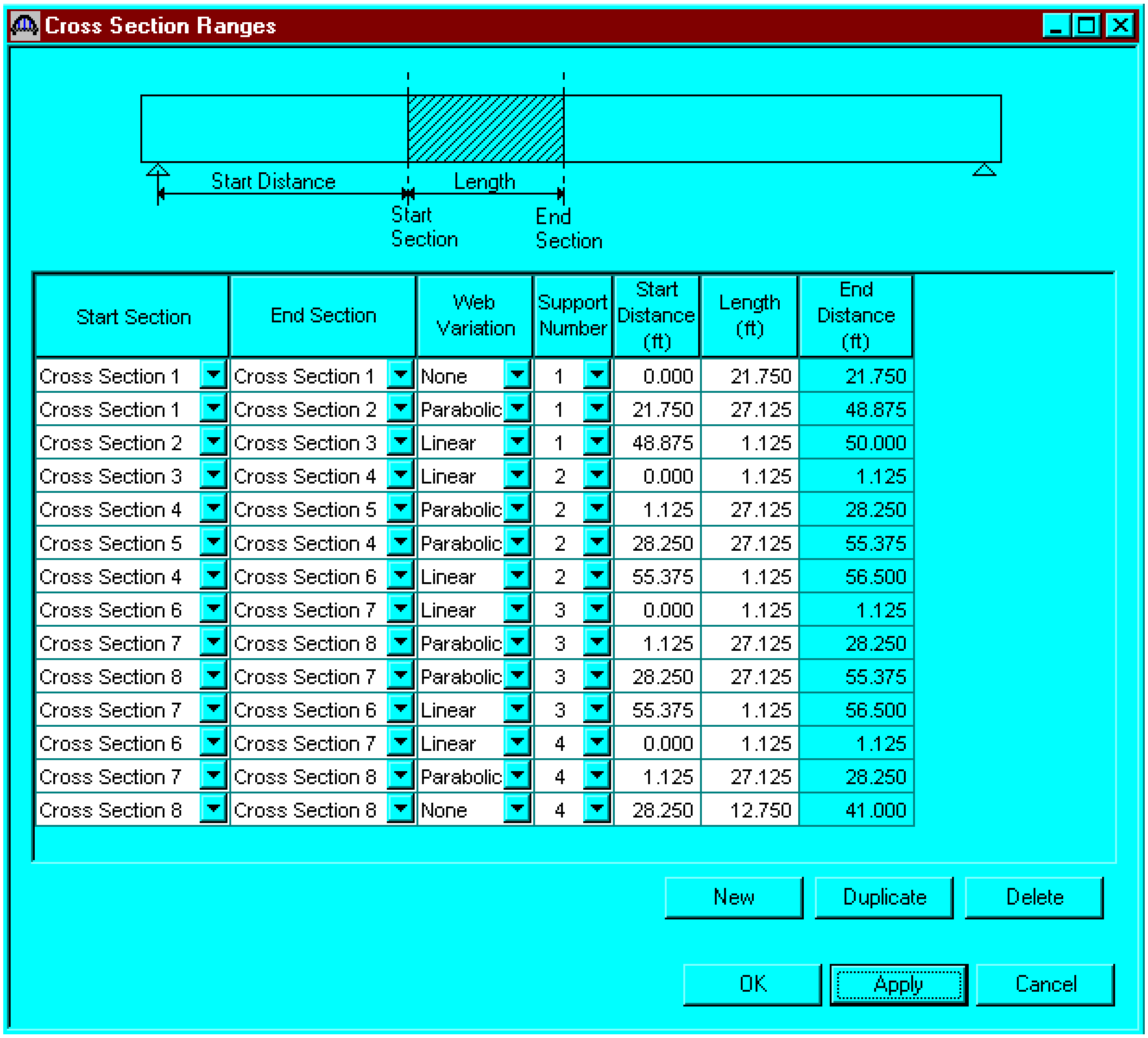
Other Parts
Material: Class A(US)
Modular Ratio: 9.0



Name: Cross Section 8
Type: Reinforced Concrete Tee

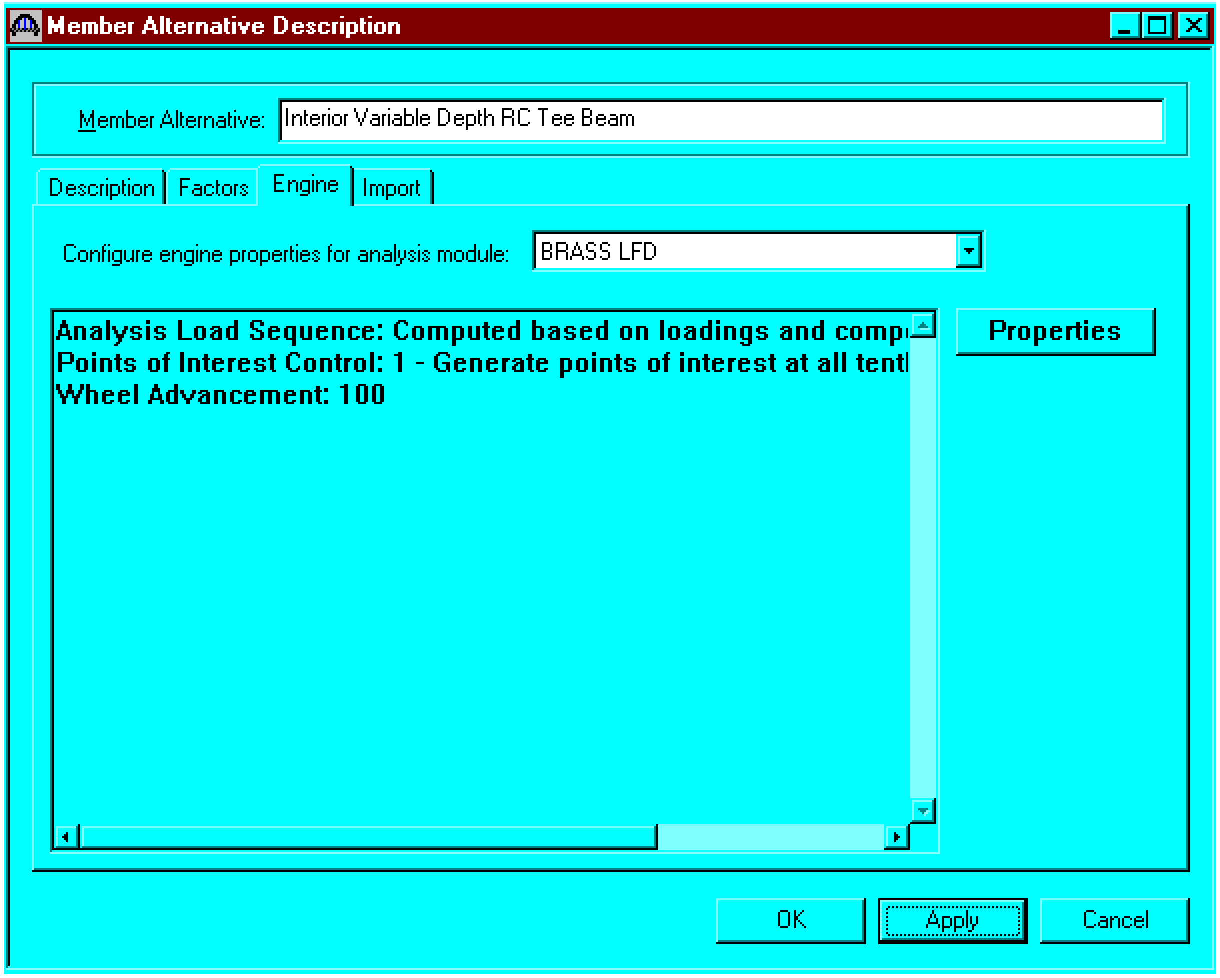
Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	11	4.000	10.2100	Grade 40
Bottom of Girder	10	2.000	30.6100	Grade 40

The Cross Section Ranges window is shown below. Define the ranges over which the cross sections apply.



Start Section	End Section	Web Variation	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Cross Section 1	Cross Section 1	None	1	0.000	21.750	21.750
Cross Section 1	Cross Section 2	Parabolic	1	21.750	27.125	48.875
Cross Section 2	Cross Section 3	Linear	1	48.875	1.125	50.000
Cross Section 3	Cross Section 4	Linear	2	0.000	1.125	1.125
Cross Section 4	Cross Section 5	Parabolic	2	1.125	27.125	28.250
Cross Section 5	Cross Section 4	Parabolic	2	28.250	27.125	55.375
Cross Section 4	Cross Section 6	Linear	2	55.375	1.125	56.500
Cross Section 6	Cross Section 7	Linear	3	0.000	1.125	1.125
Cross Section 7	Cross Section 8	Parabolic	3	1.125	27.125	28.250
Cross Section 8	Cross Section 7	Parabolic	3	28.250	27.125	55.375
Cross Section 7	Cross Section 6	Linear	3	55.375	1.125	56.500
Cross Section 6	Cross Section 7	Linear	4	0.000	1.125	1.125
Cross Section 7	Cross Section 8	Parabolic	4	1.125	27.125	28.250
Cross Section 8	Cross Section 8	None	4	28.250	12.750	41.000

Open the Member Alternative Description window and click the Engine tab as shown below.

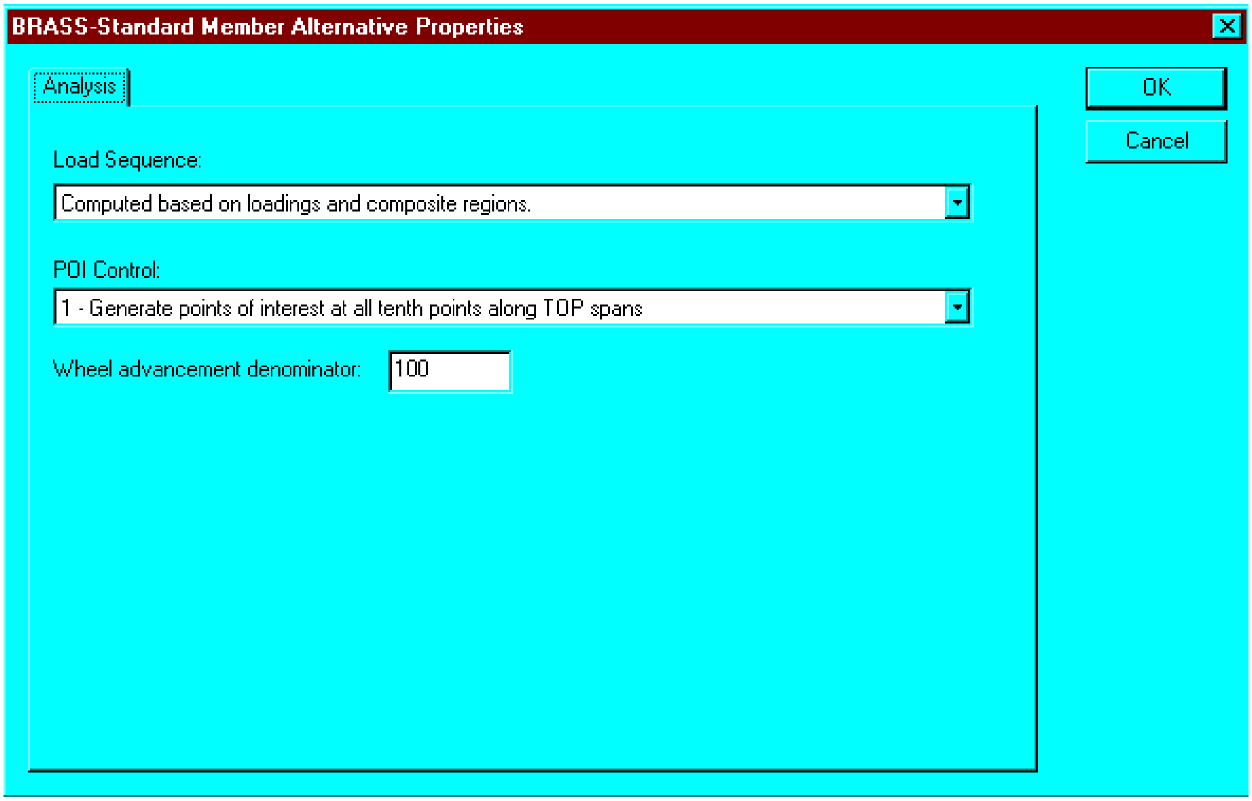


Member Alternative: Interior Variable Depth RC Tee Beam

Configure engine properties for analysis module: BRASS LFD

Analysis Load Sequence: Computed based on loadings and comp
Points of Interest Control: 1 - Generate points of interest at all tent
Wheel Advancement: 100

Click the Properties button to edit the engine properties for BRASS LFD.

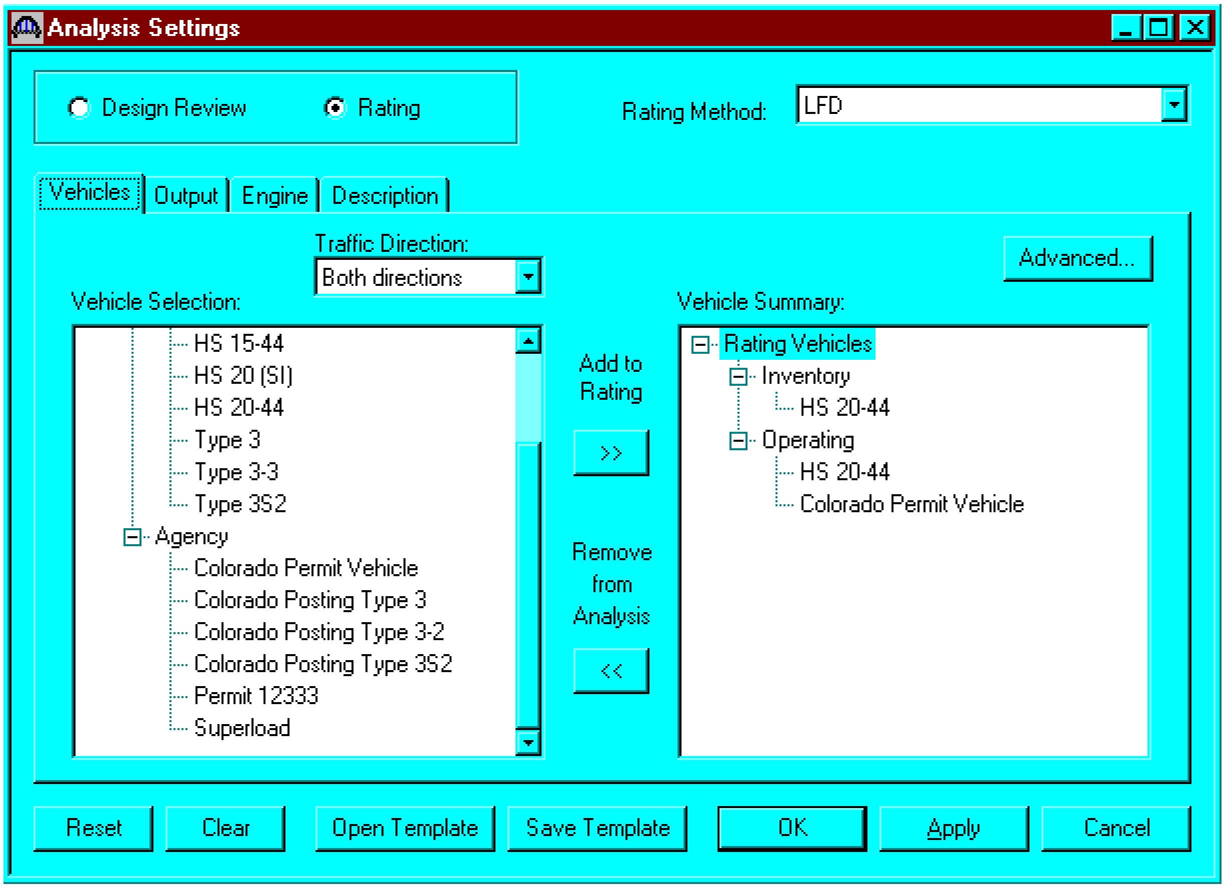


Load Sequence: Computed based on loadings and composite regions.

POI Control: 1 - Generate points of interest at all tenth points along TOP spans

Wheel advancement denominator: 100

To perform a rating, select the View Analysis Settings button on the toolbar to open the window shown below. Select the required vehicles to be used in the rating and click OK.



○ Design Review ● Rating

Rating Method: LFD

Traffic Direction: Both directions

Vehicle Selection:

- HS 15-44
- HS 20 (SI)
- HS 20-44
- Type 3
- Type 3-3
- Type 3S2
- Agency
  - Colorado Permit Vehicle
  - Colorado Posting Type 3
  - Colorado Posting Type 3-2
  - Colorado Posting Type 3S2
  - Permit 12333
  - Superload

Vehicle Summary:

- Rating Vehicles
  - Inventory
    - HS 20-44
  - Operating
    - HS 20-44
    - Colorado Permit Vehicle

The results of the LFD rating analysis are as follows.

```
    Member: G2


  RATING FACTOR REPORT
    ANALYSIS POINT NO.  17:  205.00
    LOAD LEVELS                               TRUCK DESCRIPTION
     1:  1.30(  1.00 * D  +   1.67 * L )        1. Truck: AASHTO H 20-S 16 Loading, 1944 Ed
     2:  1.30(  1.00 * D  +   1.00 * L )        2. Truck: AASHTO H 20-S 16 Loading, 1944 Ed
                                                3. Truck: 96 Tons Vehicle

                        LOAD LEVEL 1 ----- LOAD LEVEL 2 ----- LOAD LEVEL 3 ----- LOAD LEVEL 4
-------------------------------------------------------------------------------------------
   POS. MOMENT
     TRUCK  1              01.23  44.28T      02.05  73.8T       N/A                N/A
     TRUCK  2              01.67              02.80              N/A                N/A
     TRUCK  3              01.09              01.83              N/A                N/A
     CRITICAL              01.09              01.83 175.7T       N/A                N/A
   NEG. MOMENT
     TRUCK  1              01.79              02.99              N/A                N/A
     TRUCK  2              01.49              02.50              N/A                N/A
     TRUCK  3              01.17              01.96              N/A                N/A
     CRITICAL              01.17              01.96              N/A                N/A
   POS. SHEAR
     TRUCK  1               N/A                N/A               N/A                N/A
     TRUCK  2               N/A                N/A               N/A                N/A
     TRUCK  3               N/A                N/A               N/A                N/A
     CRITICAL               N/A                N/A               N/A                N/A
   NEG. SHEAR
     TRUCK  1               N/A                N/A               N/A                N/A
     TRUCK  2               N/A                N/A               N/A                N/A
     TRUCK  3               N/A                N/A               N/A                N/A
     CRITICAL               N/A                N/A               N/A                N/A
-------------------------------------------------------------------------------------------
```

COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

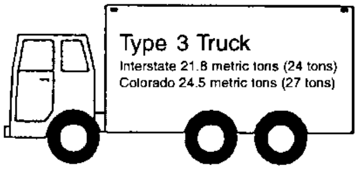
Structure #	L-18-AV
State highway #	I25 Overpass
Batch I.D.	
Structure type	CSGC
Parallel structure #	

Rated using
Asphalt thickness: 50 mm (2 in.)
☒ Colorado legal loads
☐ Interstate legal loads

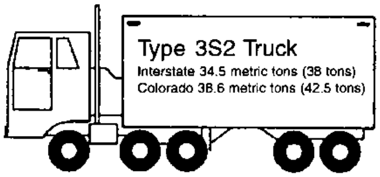
Structural member	INTERIOR GIRDER @ 2.5 PT	SLAB		

Metric tons (Tons)

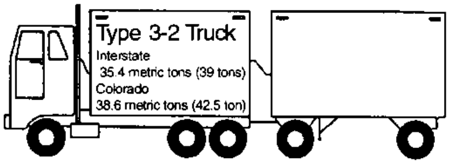
Inventory	40.0 (44)	26.4 (29)	( )	( )
Operating	67.3 (74)	44.5 (49)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	160.0 (176)	( )	( )	( )



______ (______)
Metric tons Tons



______ (______)
Metric tons Tons



______ (______)
Metric tons Tons

Comments

Control Member: Deck; Rated for 2" HBP
Load Capacity: 49 Tons
Girder: Only Interior Girder Rated; Rated for 2" HBP

Color Code: White

Project No: I 002-3(20) Eldorado Street over I-25
IM 0251-141 Rehab/Rail repair

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used

CDOT Form #1187a 1/95

SECTION 9A – PRESTRESSED CONCRETE GIRDER BRIDGES

9A-1 INTRODUCTION TO RATING PRESTRESSED CONCRETE GIRDER BRIDGES

This section together with section 1, presents the policies and guidelines for rating prestressed concrete girders. Policies are itemized in subsection 9A-2, while supporting guidelines are summarized in subsections 9A-2, 3, 4, and 5.

The types of girders covered by this section include precast pretensioned girders as described below:

CPG - Concrete Prestressed Girder
CPGC - Concrete Prestressed Girder Continuous
CDTPG - Concrete Double-Tee Prestressed Girder
CBGP - Concrete Box Girder Prestressed
CBGCP - Concrete Box Girder Continuous Prestressed

9A-2 POLICIES AND GUIDELINES FOR RATING PRESTRESSED CONCRETE GIRDER BRIDGES

I. General

A. Prestressed concrete girders, either simple span, or simple spans made continuous, shall be rated using the VIRTIS computer program. Refer to subsection 9A-3 for information on this program.

B. When the LFD method is used for rating girders, unless a more rational methodology like the modified compression field theory in the AASHTO LRFD code is adopted for use, prestressed girders shall not be rated for shear. However, during the design process, all prestressed girders shall be checked for shear using the appropriate AASHTO code.

C. Double-tee structures without a poured in place composite deck or a full depth diaphragm shall use the live load distribution factor as prescribed in the AASHTO LRFD Specifications. The exterior girder distribution factor shall be calculated using the lever rule.

D. Double-tee structures with a poured in place composite deck or a full depth rigid diaphragm/bracing system with a rotational stiffness roughly equal to a poured in place deck, the live load distribution factor for Concrete T-Girders as prescribed in Table 3.23.1 of the AASHTO Standard Specifications for Highway Bridges, 16th Edition, shall be used.

E. When using the AASHTO LRFD Multi-Beam live load distribution factor and load restrictions are required, a rational method may be used for the live load distribution factor calculation, including the use of the LDFAC program.

F. The rater shall be responsible for determining whether stress-relieved or low-relaxation strands were used in the bridge. If it is not possible to discern what type of strand was used, then the rater shall assume that stress-relieved strands were used prior to December, 1983, and low-relaxation strands thereafter.

G. Prestressed concrete girder bridges with complex geometric alignment i.e., flared girder bridges or girders with a variable overhang, shall be modeled as simple, straight beams on pin or roller supports. The Virtis program output results can then be supplemented by hand calculations to consider any significant influences, as necessary.

H. For effective slab widths, the b in the equation (12t+b) shall be the width of the top flange of the girder, not the web.

II. Girders Requiring Rating

A. Interior Girders - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, number of prestressing strands, differences in loads or moments, concrete strength, etc.

B. Exterior Girders - An exterior girder shall be rated under the following guidelines:

1. When the section used for an exterior girder is different than the section used for an interior girder.

2. When the overhang is greater than S/2.

3. The exterior unit of a multi-beam structure should be rated if it does not have a cast-in-place composite slab. For this case the dead loads due to sidewalks, curbs and railing shall be applied to only the exterior unit.

4. When the rater determines the rating would be advantageous in analyzing the overall condition of a structure.

III. Calculations

A. A set of calculations, separate from computer output, shall be submitted with each rating. These calculations shall include derivations for dead loads, derivations for live load distribution factors, and any other calculations or assumptions used for rating. The rater shall also indicate whether stress-relieved or low-relaxation strands were used in the rating calculations.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the nearest 5 pounds.

2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt, curbs, sidewalks, railing, etc.

3. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as non-composite loads. Examples of this type of dead load are deck slabs, girders and diaphragms.

4. Use 5 psf for the unit weight of formwork when it is likely the formwork will remain in place.

5. The method of applying dead loads due to utilities is left to the rater's discretion.

IV. Simple and Continuous Span Bridges

Simple span prestressed girders shall be rated as simple span members for all loads(i.e. DL1, DL2, LL+I loads). Span length shall be taken as the distance between the centerline of bearing at abutments or supports.

Simple span prestressed girders made continuous for composite dead loads and live load plus impact, shall be rated as continuous members for these loads. Span lengths shall be taken as the distance from centerline of bearing at the abutment to centerline of pier, and centerline of pier to centerline of pier as applicable.

The negative moment analysis at centerline of piers shall be based on the Ultimate Strength (Load Factor) method. The girder’s primary negative moment reinforcement and only the top layer of the slab’s distribution reinforcement, within the effective slab width, shall be used in the analysis.

Prestressed girder end blocks, if present, shall not be used in the analysis.

Simple span prestressed girders made continuous for composite dead loads and live load plus impact, and if the specified compressive strength of concrete (28 days of age) used in the girders changes from span to span, only the girder with the least compressive strength shall be used to model the entire structure.

V. Rating Reporting/Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. The rating package requirements shall be per Section 1-13 of this manual and as amended herein:

Consultant designed projects – Before finalizing the rating package and when VIRTIS is used as the analysis tool, the Rater shall verify with the Staff Bridge Rating Coordinator that the version number of the program being used is identical to CDOT’S version number. Data files created using a lower version of the program shall be rejected. It is required for the CDOT data archive, since the data base management feature inside the program would not work satisfactorily. After the analysis is completed, the rater shall save the data file. When saving is finalized, the rater shall export the data file in *.bbd format (i.e., F-17-IE.bbd format; bbd = BRIDGEWare Bridge Data File) on an IBM- compatible 3.5” PC Disk for delivery with the rating package. Also, the version number used during analysis shall be typed on the diskette label. This ensures proper importation of bridge data archive by the Staff Bridge at a later date.

9A-3 GUIDELINES FOR USING THE VIRTIS RATING PROGRAM

The VIRTIS computer program performs the analysis and rating of simple span and multispan prestressed girder bridges. It uses the BRASS ASD or the BRASS LFD engine for analysis. This program was developed in accordance with the AASHTO STANDARD SPECIFICATIONS, 16TH EDITION AND THE AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES.

A maximum of thirteen (13) spans and twelve (12) girder lines can be modeled using the program. When a structure model is finalized, it can be rated using the ASD or the LFD method. The LRFD rating module is currently being developed and will be available in the future. When a structure model is being generated and before any analysis can be performed, it is recommended that Virtis users save the data to memory periodically. This can be accomplished by using the File and Save feature of this program.

The library explorer can be used to save commonly used items (beam shapes, non standard vehicles, materials, appurtenances etc.) and this eliminates the need for all users to define the same items repeatedly throughout the program. Once a new girder shape is defined or copied from the library, Virtis automatically computes the required section properties and beam constants.

Dead load due to the girder self weight, deck slab and appurtenances (i.e. rails, median barrier etc.) are calculated automatically by the program. Dead load due to the haunch, wearing surface and stiffener weight (for steel bridges) are defined by the user. For a detailed description of the girder loads, refer to the Opis/Virtis Help Menu index item - dead loads. During modeling a structure, help menu can also be activated by using the F1 key when the user requires clarification on a particular item in the GUI window.

In the Live Load Distribution Factor window, when the compute button is used to calculate the DF’s automatically by the program, Virtis users shall verify that these numbers are accurate and are equal to their calculated numbers.

For prestressed girder bridges, in addition to using the BRASS LFD engine for analysis, all serviceability checks/rating per Article 6.6.3.3 of the AASHTO Manual For Condition Evaluation Of Bridges shall be performed using the BRASS ASD engine.

All Colorado BT girder shapes, the Colorado permit vehicle, the Colorado posting trucks and the Interstate posting trucks have been added to the Virtis library explorer and may be copied by the user. The Staff Bridge Rating Coordinator shall be responsible for updating existing information or adding new information (i.e. beam shapes, vehicles etc.) to the library explorer.

The configuration browser provides access to the configuration features of Virtis. It may be employed to provide specific access privileges, i.e. read, write, delete etc., to the users. This feature is extremely powerful, since Virtis/Opis uses and shares bridge data from one common source. Therefore, it is required that users of this program create a folder from the bridge explorer window (**EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

9A-4 RATING PRESTRESSED CONCRETE GIRDER BRIDGES DESIGNED BY LOAD FACTOR METHOD

All ratings should be performed in accordance to the AASHTO Manual For Condition Evaluation of Bridges and the appropriate Articles of AASHTO Bridge Design Specifications. The capacity of prestressed concrete members should be evaluated for strength requirements (at both Inventory and Operating level) stated in the AASHTO Design Specifications Article 9.17. At the Inventory level, Serviceability requirements should also be considered. The basic rating equation (6-1a) of the Manual For Condition Evaluation of Bridges may be used if checking the crack serviceability limit state with $A_1=1.0$, $A_2=1.0$, and $C=M^*_{cr}$. Typically, prestressed concrete members used in bridge structures will meet the minimum reinforcement requirements of Article 9.18.2.1 of the AASHTO Design Specifications. While there is no reduction in the flexural strength of the member in the event that these provisions are not satisfied, an owner, as part of the flexural rating may choose to limit live loads to those that preserve the relationship between ϕM_n and M^*_{cr} by adjusting the capacity value "C" in the rating equation (6-1a). Thus when $\phi M_n < 1.2M^*_{cr}$, the adjusted "C" becomes $(k)(\phi)(M_n)$ where $k= (\phi M_n)/(1.2M^*_{cr})$.
Non Prestressed Reinforcement may be considered as per AASHTO Specifications Article 9.19.

The following equations regarding Load Factor rating of pretensioned and postensioned concrete members are furnished:

INVENTORY RATING

$$RF = \frac{6\sqrt{F'_C} \pm F_D \pm F_P \pm F_S}{F_{LL+I}}$$ Equation (1) Concrete Tension

$$RF = \frac{.6F'_C \pm F_D \pm F_P \pm F_S}{F_{LL+I}}$$ Equation (2) Concrete Compression

$$RF = \frac{.4F'_C \pm 1/2(F_D \pm F_P \pm F_S)}{F_{LL+I}}$$ Equation (3) Concrete Compression

$$RF = \frac{0.8F_Y^* \pm F_D \pm F_P \pm F_S}{F_{LL+I}}$$ Equation (4) Prestressing Steel Tension

$$RF = \frac{\phi R_n \pm 1.3D \pm 1.0S}{2.17L}$$ Equation (5) Flexural & Shear Strength

OPERATING RATING

$$RF = \frac{\phi R_n \pm 1.3D \pm 1.0S}{1.3L}$$ Equation (6) Flexural & Shear Strength

$$RF = \frac{0.9F_Y^* \pm F_D \pm F_P \pm F_S}{F_{LL+I}}$$ Equation (7) Prestressing Steel Tension

RF = Rating Factor

F'_C = Concrete Compressive Strength

F_D = Unfactored dead load stresses

F_P = Unfactored stress due to prestress force after all losses

F_S = Unfactored stress due to secondary prestress forces

F_{LL+I} = Unfactored live load stress including impact

ΦR_n = Nominal strength of section (ϕM_n or ϕV_n) satisfying the ductility limitations of Article 9.18 and Article 9.20 of the AASHTO Standard Specifications. Both moment (ϕM_n) and shear (ϕV_n) should be evaluated.

D = Unfactored dead load moment or shear

S = Unfactored prestress secondary moment or shear

L = Unfactored live load moment or shear including impact

F_Y^* = Prestressing steel yield stress

M^*_{cr} = Cracking Moment per AASHTO article 9.18

NOTE:

Equation (7) can control rating when at least one strand is near the extreme tension fiber and the C.G. of the prestressing is near the neutral axis.

9A-5 RATING PRESTRESSED CONCRETE GIRDER BRIDGES WITHOUT PLANS

When there are no plans or other documentation for a particular prestressed concrete structure, its numerical rating shall be determined by a Professional Engineer Registered in the State of Colorado. This rating shall be based on a complete and comprehensive inspection of the structure and directions from the AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES 1994, Second Edition. If the structure shows no signs of distress due to load, the Engineer can assign it a maximum inventory rating of 36 tons, and operating rating of 40 tons. For all structures in the State Highway System and designed after January 1994, with the exception of LRFD designed bridges, a no distress condition shall have a minimum Inventory rating of 45 tons and an Operating rating of 75 tons. For LRFD designed bridges, i.e., structures designed after January 1998, a no distress condition shall have a minimum permit vehicle operating rating of 105 tons.

When there are signs of capacity-reducing distress or deterioration, an appropriate judgment should be made and ratings proportionally less shall be given to the prestressed concrete structure.

For bridges owned or maintained by the Colorado Department of Transportation, the Staff Bridge Engineer will approve this type of rating. For bridges owned or maintained by a city or county, a recommended rating shall be approved by the City and County Engineer and shown on the Rating Summary Sheet.

The processes and responsibilities of the Rater and Checker will still follow those described in Section 1 with the following two additions. First, as just described, the Staff Bridge Engineer shall, or appropriate city/county official should, review the recommended rating. Secondly, the rating summary sheet shall state that the structure was rated by inspection.

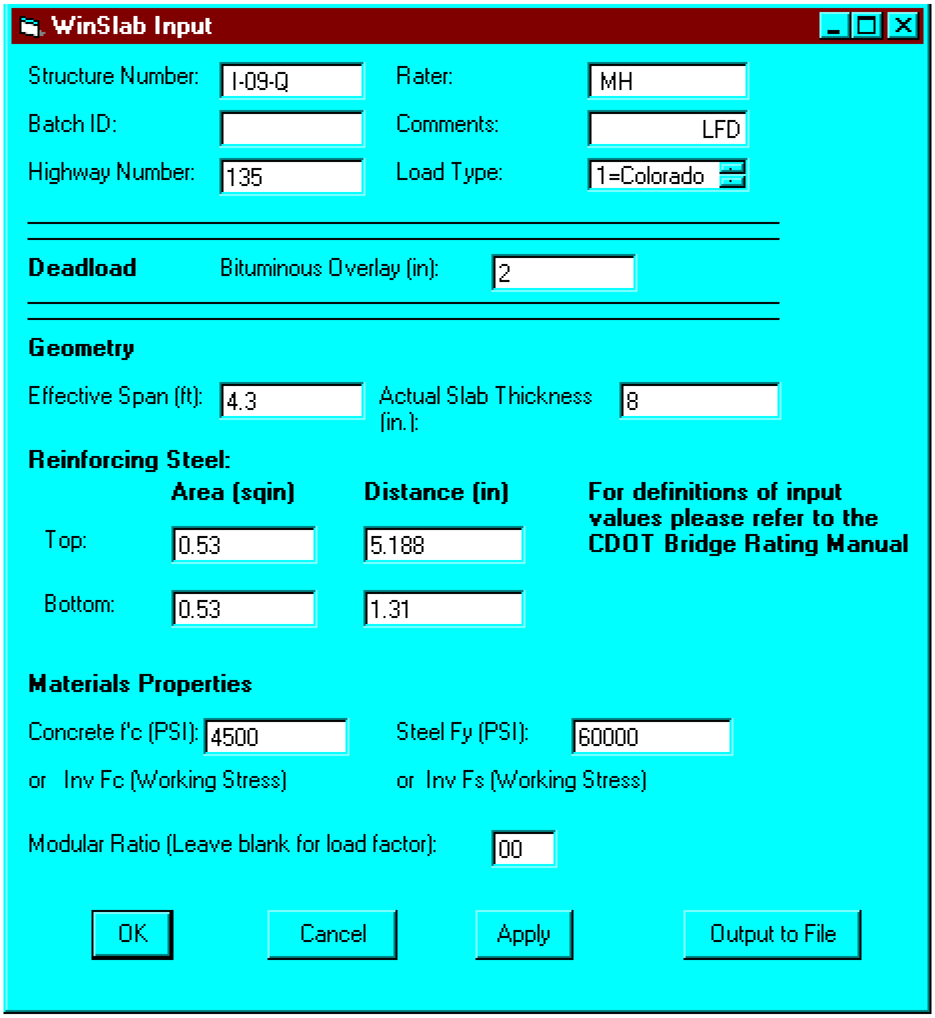
9A-6 PRESTRESSED CONCRETE GIRDER BRIDGE RATING EXAMPLES

Three examples are presented in this section. First, Structure I-09-Q is a simple span composite concrete prestressed girder bridge with a skew of 33° degrees. It has seven (7) BT-72 girders. Only the interior girder has been modeled for this structure. The second structure, F-17-IE, is a 3-span composite concrete prestressed girder bridge with a skew of 52° degrees. It has four (4) G-54 girders. For simplicity, only the interior girder has been modeled for this structure. The third structure, L-26-BR, is a simple span prestressed girder bridge with a skew of 0°. It has no poured in place composite deck. Due to limitations on the number of girders that Virtis can analyze, only twelve (12) girders (i.e., 6 Double-tee girder Units) have been used to model the structure. For modeling simplicity, only half of a Double-tee interior girder has been modeled for this structure.

Colorado BT girder shapes included:

Colorado BT girder shapes included:

Slab Rating Program Input, Structure No. I-09-Q



Structure Number: I-09-Q
Rater: MH
Batch ID:
Comments: LFD
Highway Number: 135
Load Type: 1=Colorado

Deadload Bituminous Overlay (in): 2

Geometry

Effective Span (ft): 4.3
Actual Slab Thickness (in.): 8

Reinforcing Steel:

	Area (sqin)	**Distance (in)**
Top:	0.53	5.188
Bottom:	0.53	1.31

For definitions of input values please refer to the CDOT Bridge Rating Manual

Materials Properties

Concrete f'c (PSI): 4500
Steel Fy (PSI): 60000
or Inv Fc (Working Stress)
or Inv Fs (Working Stress)

Modular Ratio (Leave blank for load factor): 00

Effective Span Length: Per AASHTO Article 3.24.1.2(b)

Clear distance between flanges + 1/2 flange width = 30”+1/2(43)=51.5”
=4.3’

Slab Rating Program Output, Structure No. I-09-Q

```
WinSlab Rating Version 1     Date: 10/12/2001

 Structure NO.  I-09-Q     Rater:  MH     State HWY NO. = 135
     Batch ID=         Description:                   LFD

 LOAD FACTOR RATING-COMP STEEL NOT USED

 INPUT DATA

       Bituminous Overlay(in)=    2.000
       Eff. Span(ft)=             4.300          Slab Thickness(in)= 8.000
       Top Reinf. (sq.in)=         0.53          Eff. Depth(in) =    5.188
       Bottom Area(sq.in)=         0.53          Bottom Dist.(in)=   1.31
       Conc. Strength(PSI) Inv =   4500          Oper. =             4500
       Steel Yield (PSI)   Inv =  60000          Oper. =             60000
       Modular Ratio =                8

Dead Load Moment   0.23 K-Ft
LL+I Moment        3.28 K-Ft
Gross Weight       36.0 Tons
                                    Inventory     Operating
Actual Concrete Stress      (PSI)    1384.70       2268.79
Actual Reinf. Steel Stress  (PSI)   26715.30      43772.27
Actual Comp. Steel Stress   (PSI)    3069.34       5029.03
Member Capacity             (K-Ft)     11.55         11.55
Member Capacity (LL+I)      (K-Ft)     11.25         11.25
     Rating                 (Tons)     57.05         95.09
```

Virtis Bridge Rating Example, Structure No. I-09-Q

Effective slab width: Per AASHTO Article 9.8.1.1

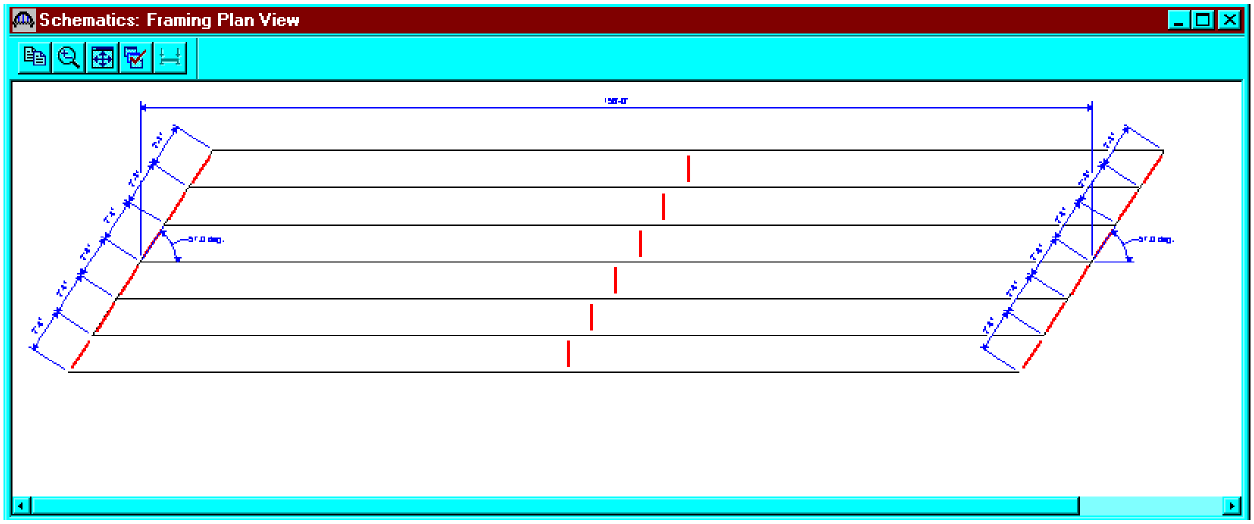
0.25(L)= 0.25(156*12)= 468”
12t+ b = 12*8+ 43= 139”
C.L. - C.L. of girder= 6.0833’=73” Controls

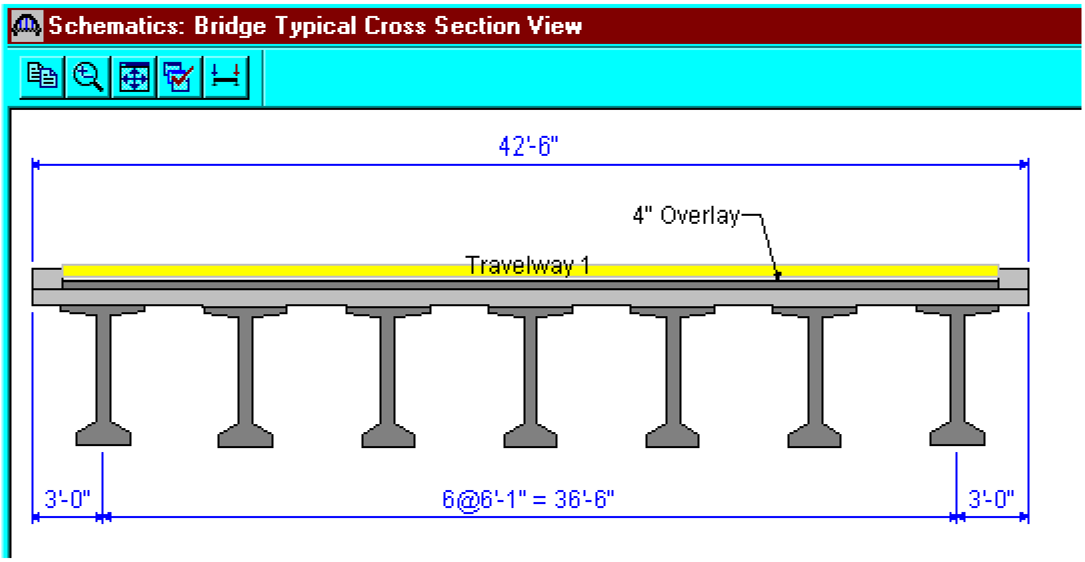
Dead Load:

Intermediate Diaphragm = (26/1000)*(73-7)/12 = 0.143 kip
Use 0.150 kip

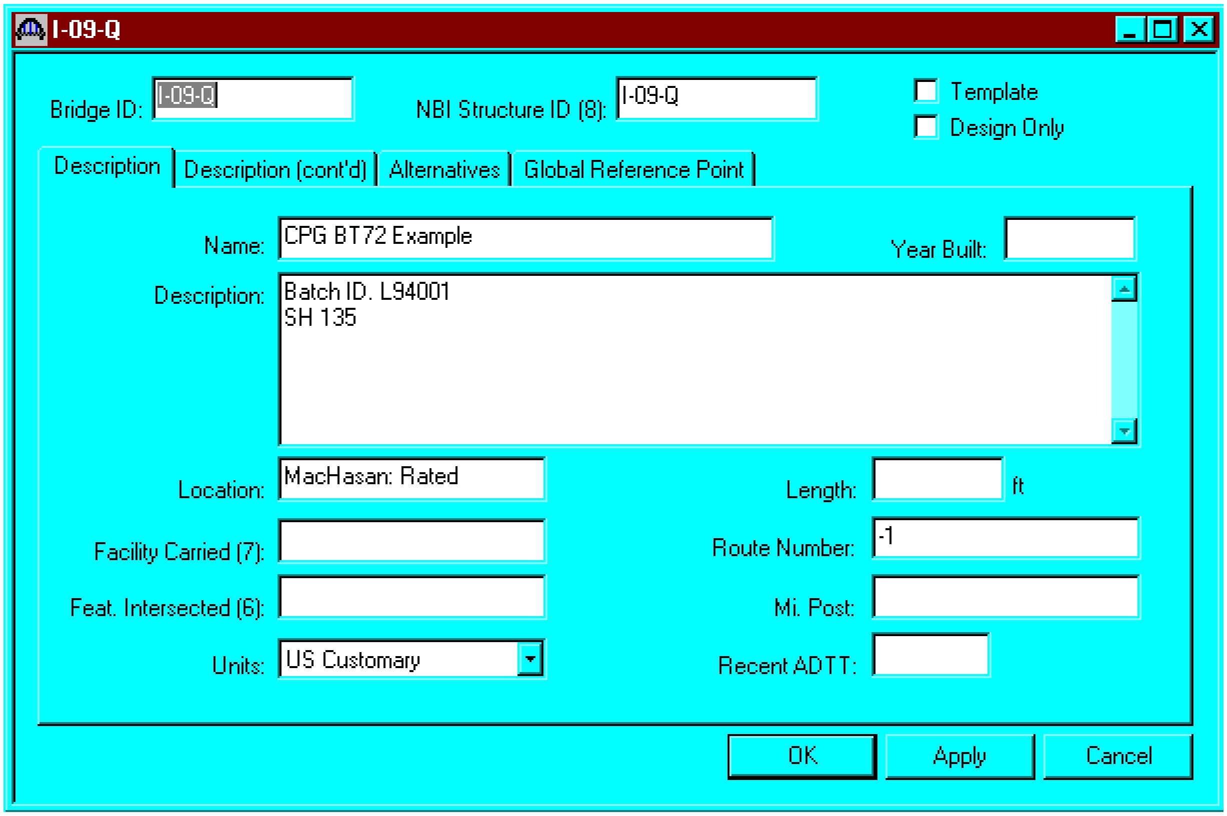
Abutment Diaphragm = ((2.67)*(80.5/12)*6.0833*(1/sin57°) – (864/144)*(21/12)*(1/sin57°))*(0.150)= 17.6 kips
Use 18.0 kips

Virtis Bridge Rating Example, Structure No. I-09-Q (contd.)





From the bridge explorer, create a new bridge and enter the following information.

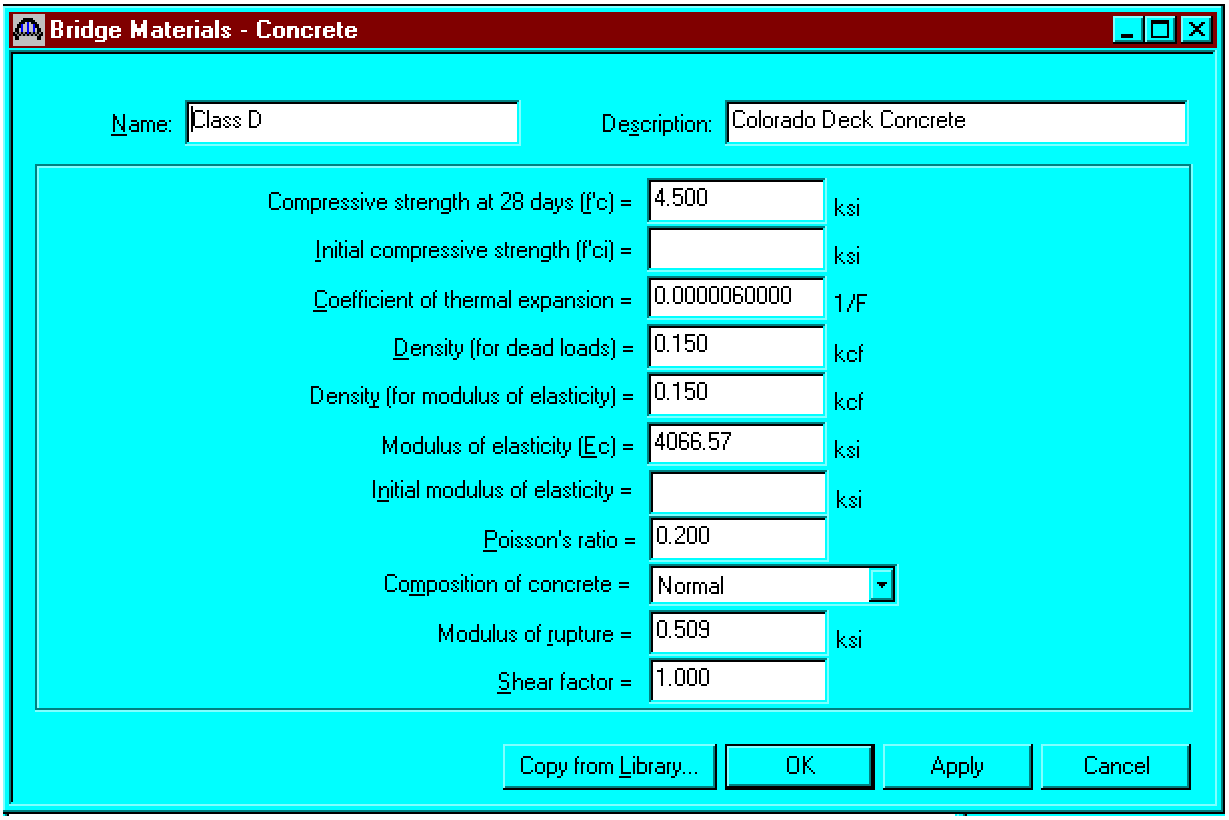


Bridge ID: I-09-Q
NBI Structure ID (8): I-09-Q
☐ Template
☐ Design Only
Name: CPG BT72 Example
Year Built:
Description: Batch ID. L94001
SH 135
Location: MacHasan: Rated
Length: ft
Facility Carried (7):
Route Number: -1
Feat. Intersected (6):
Mi. Post:
Units: US Customary
Recent ADTT:

Click OK. This saves the data to memory and closes the window.

NOTE: Since Virtis uses a common/shared database; it is required that users of this program create a folder from the bridge explorer window **(EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Deck Concrete from the library. Click OK and the following window will open. Click OK to save this deck concrete material to memory and close the window.



Name: Class D

Description: Colorado Deck Concrete

Compressive strength at 28 days (f'c) = 4.500 ksi

Initial compressive strength (f'ci) = ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.150 kcf

Density (for modulus of elasticity) = 0.150 kcf

Modulus of elasticity (Ec) = 4066.57 ksi

Initial modulus of elasticity = ksi

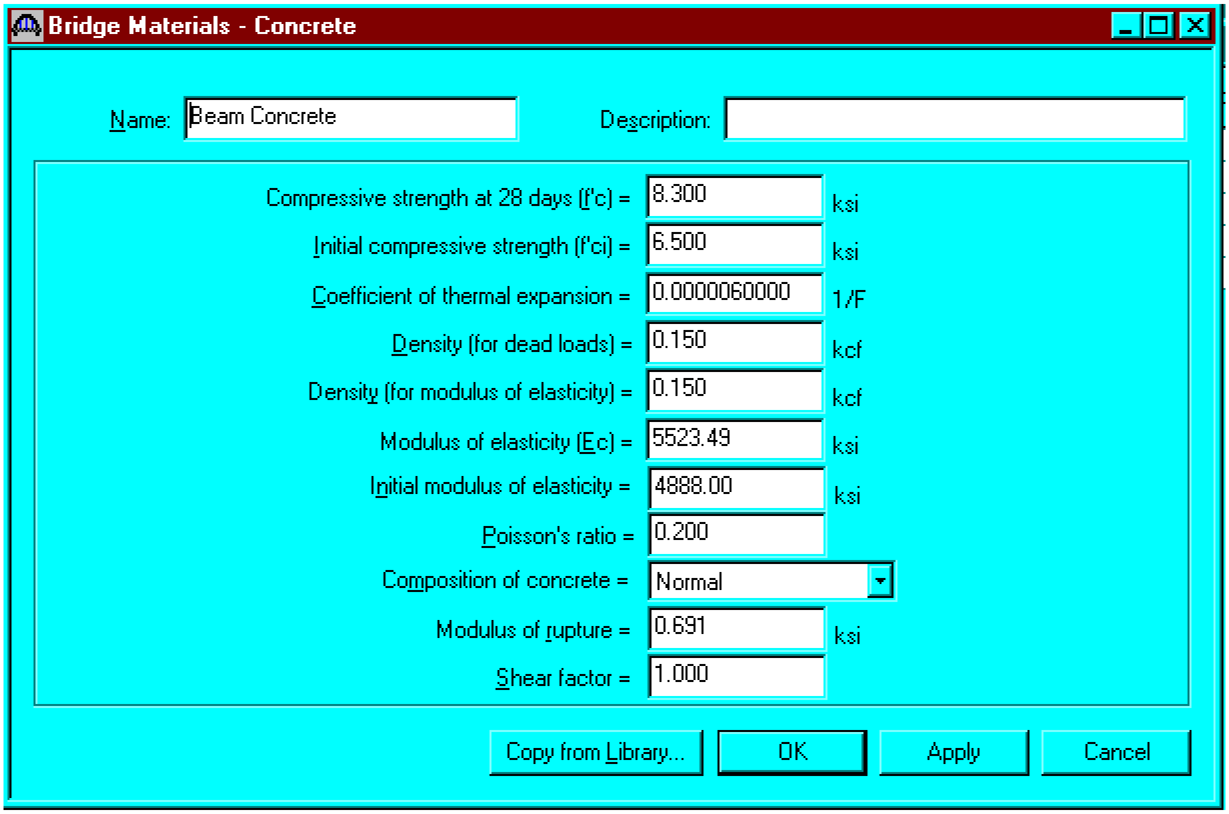
Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.509 ksi

Shear factor = 1.000

Using the same techniques, create a new concrete material to be used for the girder.



Name: Beam Concrete

Description:

Compressive strength at 28 days (f'c) = 8.300 ksi

Initial compressive strength (f'ci) = 6.500 ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.150 kcf

Density (for modulus of elasticity) = 0.150 kcf

Modulus of elasticity (Ec) = 5523.49 ksi

Initial modulus of elasticity = 4888.00 ksi

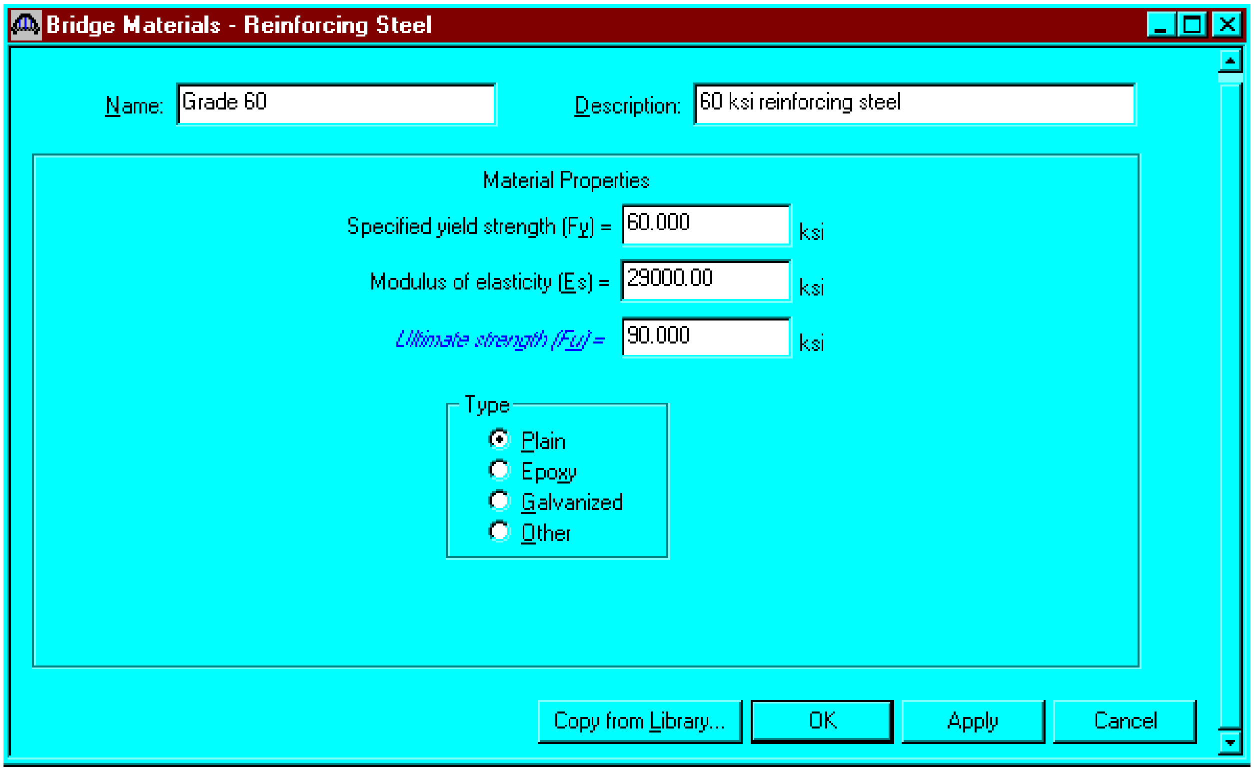
Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.691 ksi

Shear factor = 1.000

Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.



Bridge Materials - Reinforcing Steel

Name: Grade 60

Description: 60 ksi reinforcing steel

Material Properties

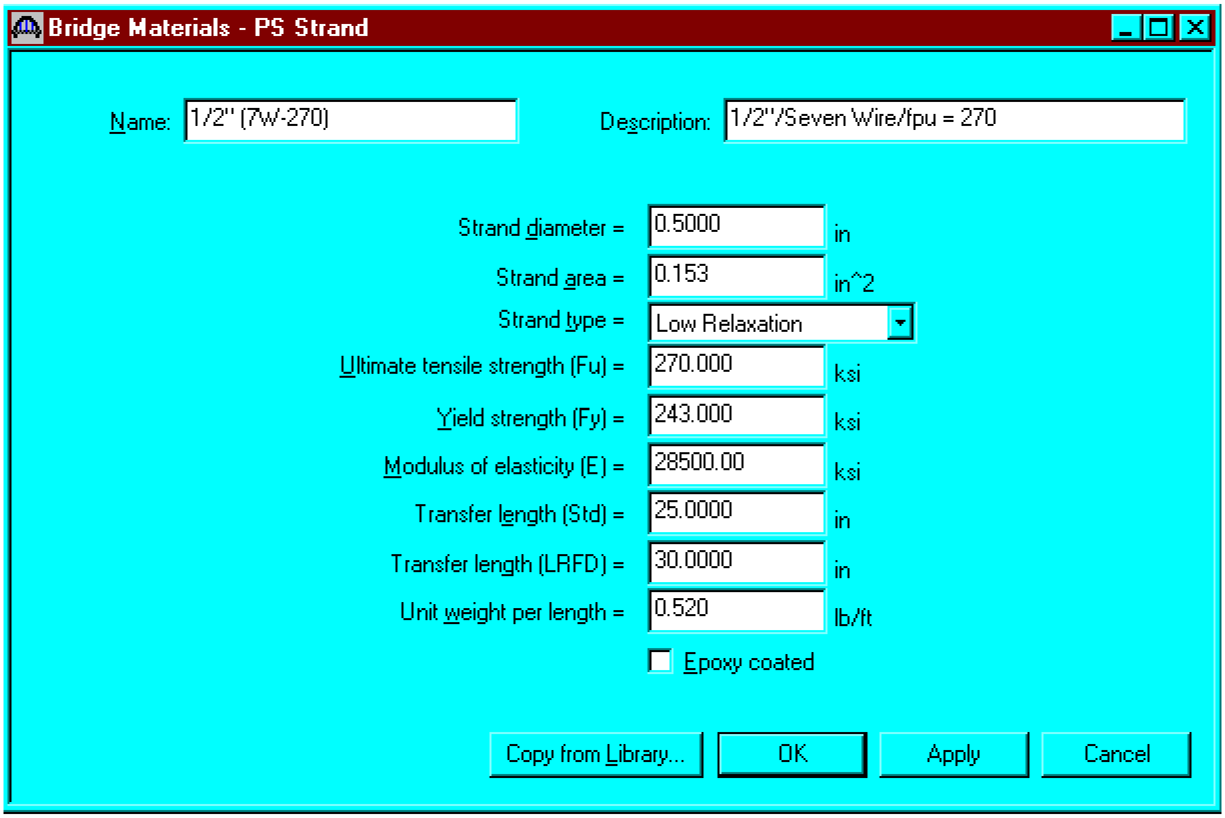
Specified yield strength (Fy) = 60.000 ksi

Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 90.000 ksi

Type

● Plain
○ Epoxy
○ Galvanized
○ Other



Name: 1/2" (7W-270)

Description: 1/2"/Seven Wire/fpu = 270

Strand diameter = 0.5000 in

Strand area = 0.153 in^2

Strand type = Low Relaxation

Ultimate tensile strength (Fu) = 270.000 ksi

Yield strength (Fy) = 243.000 ksi

Modulus of elasticity (E) = 28500.00 ksi

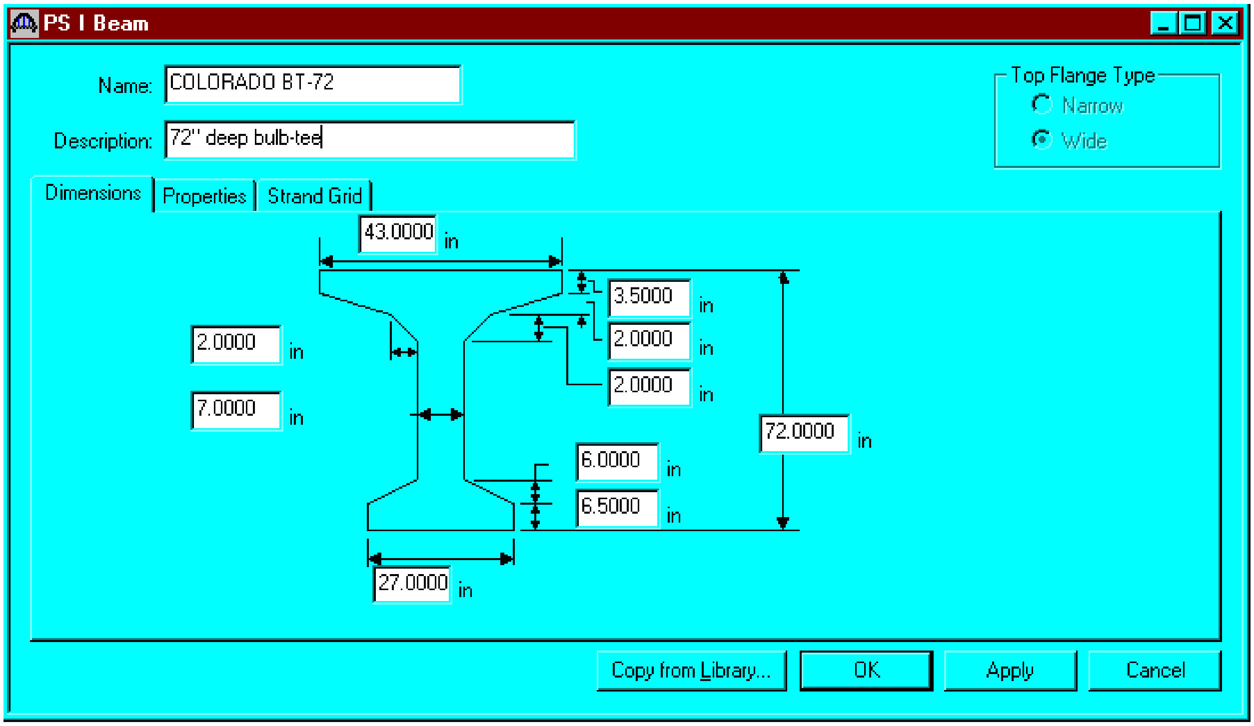
Transfer length (Std) = 25.0000 in

Transfer length (LRFD) = 30.0000 in

Unit weight per length = 0.520 lb/ft

☐ Epoxy coated

Expand the tree labeled Beam Shapes to enter a prestressed beam shape to be used in the analysis. Click on Prestressed Beam Shapes and I Beams in the tree and select File/New from the menu (or right mouse click on I Beam and select New). Click on the copy from library button or fill in the blanks.



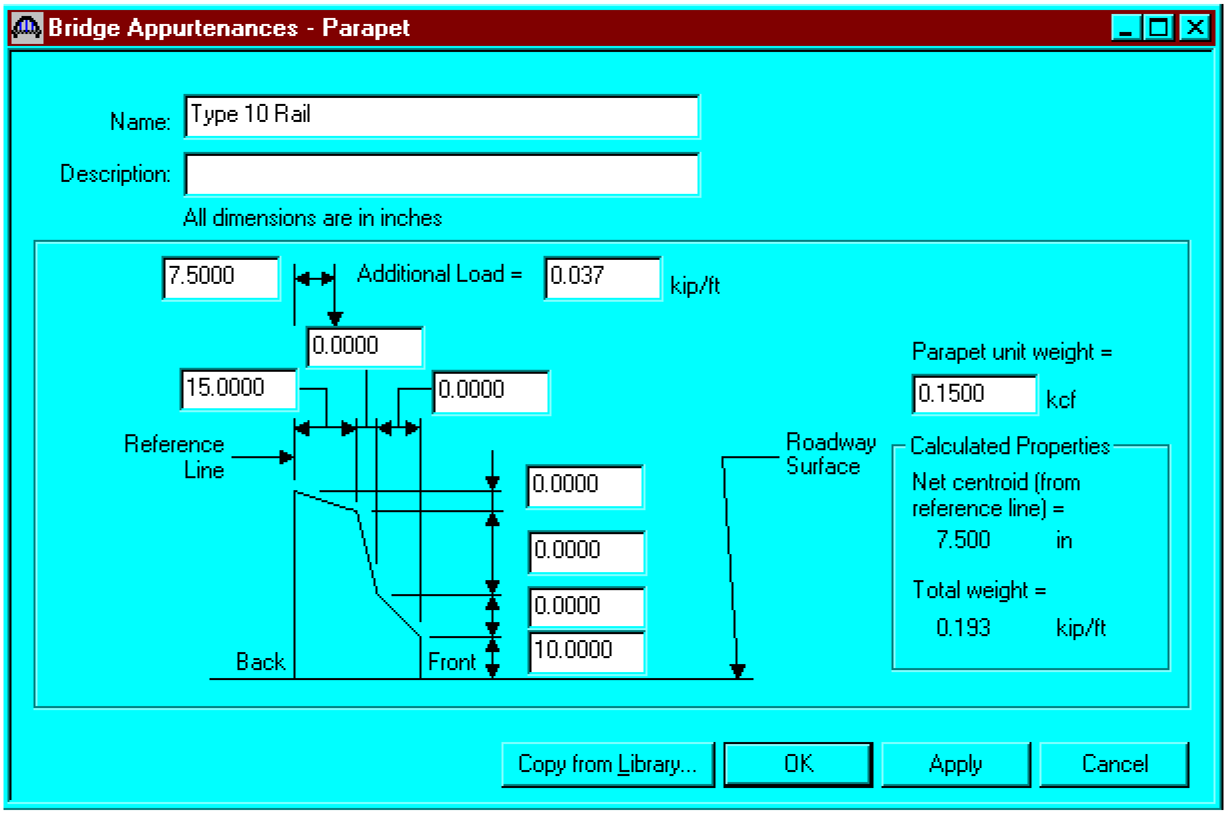
Name: COLORADO BT-72

Description: 72" deep bulb-tee

○ Narrow
● Wide

Click OK to save to the memory and close the window.

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, select New and click copy from Library button. Select the Jersey Barrier and click OK. The parapet properties are copied to parapet window as shown below. Click OK to save the data to memory and close the window.



Name: Type 10 Rail

Description:

All dimensions are in inches

Additional Load = 0.037 kip/ft

Parapet unit weight = 0.1500 kcf

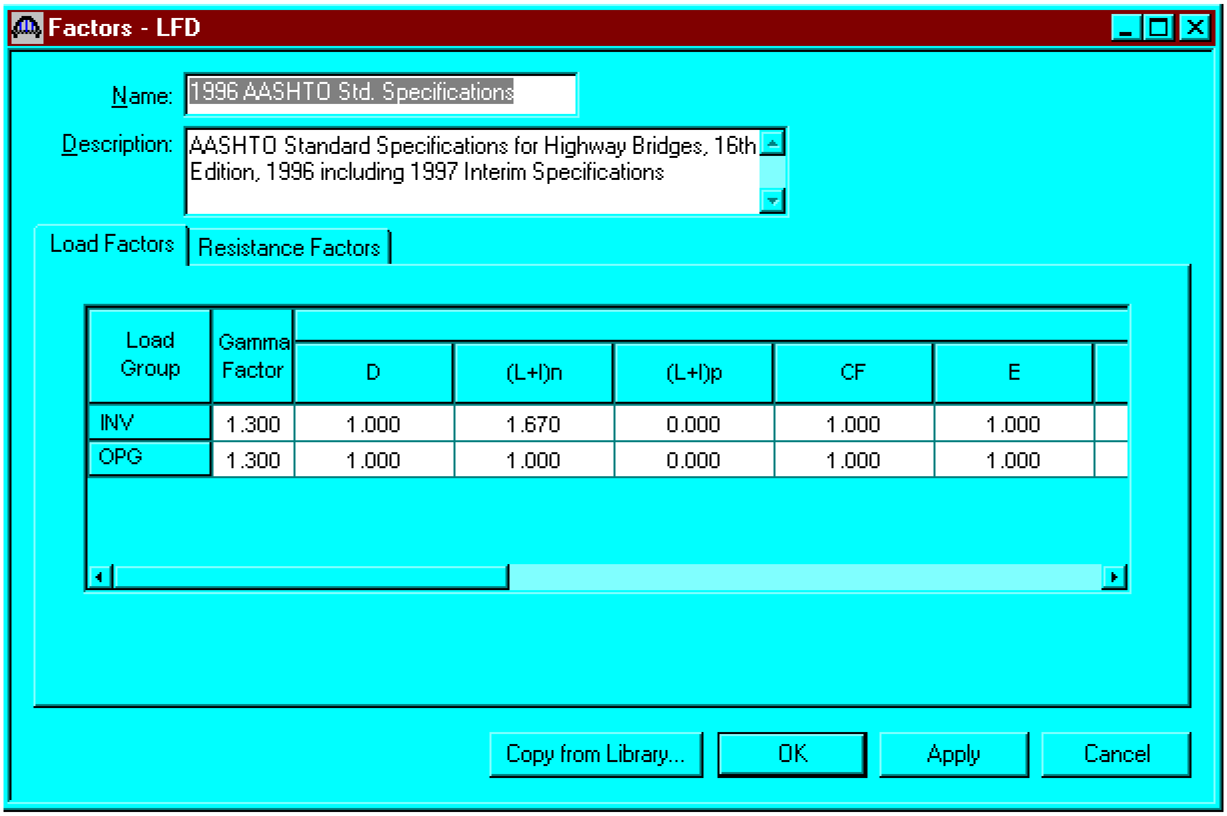
Calculated Properties

Net centroid (from reference line) = 7.500 in

Total weight = 0.193 kip/ft

The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

This window shows the LFD load factors.

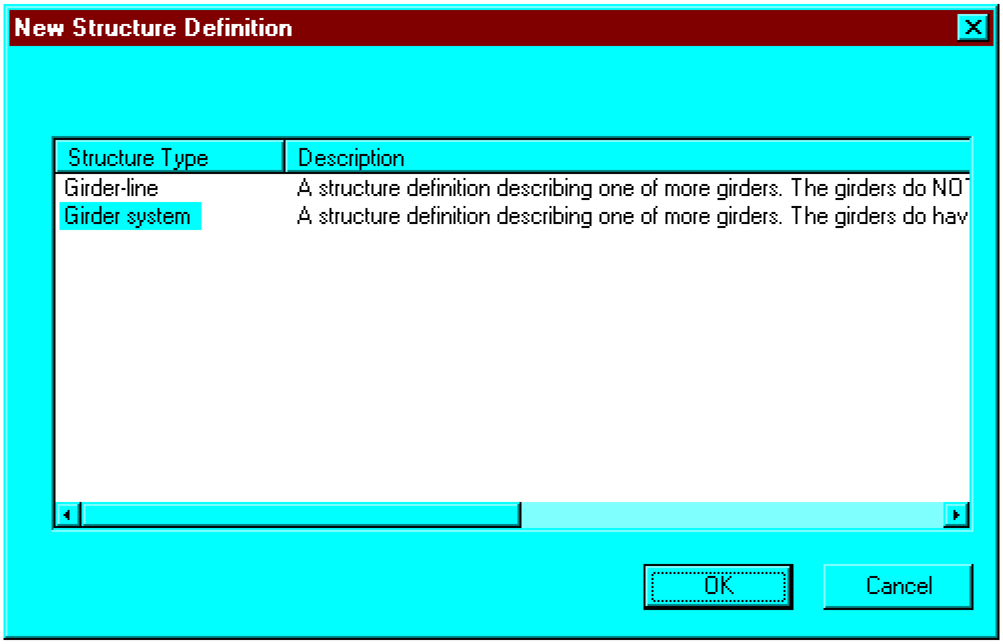


Name: 1996 AASHTO Std. Specifications

Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

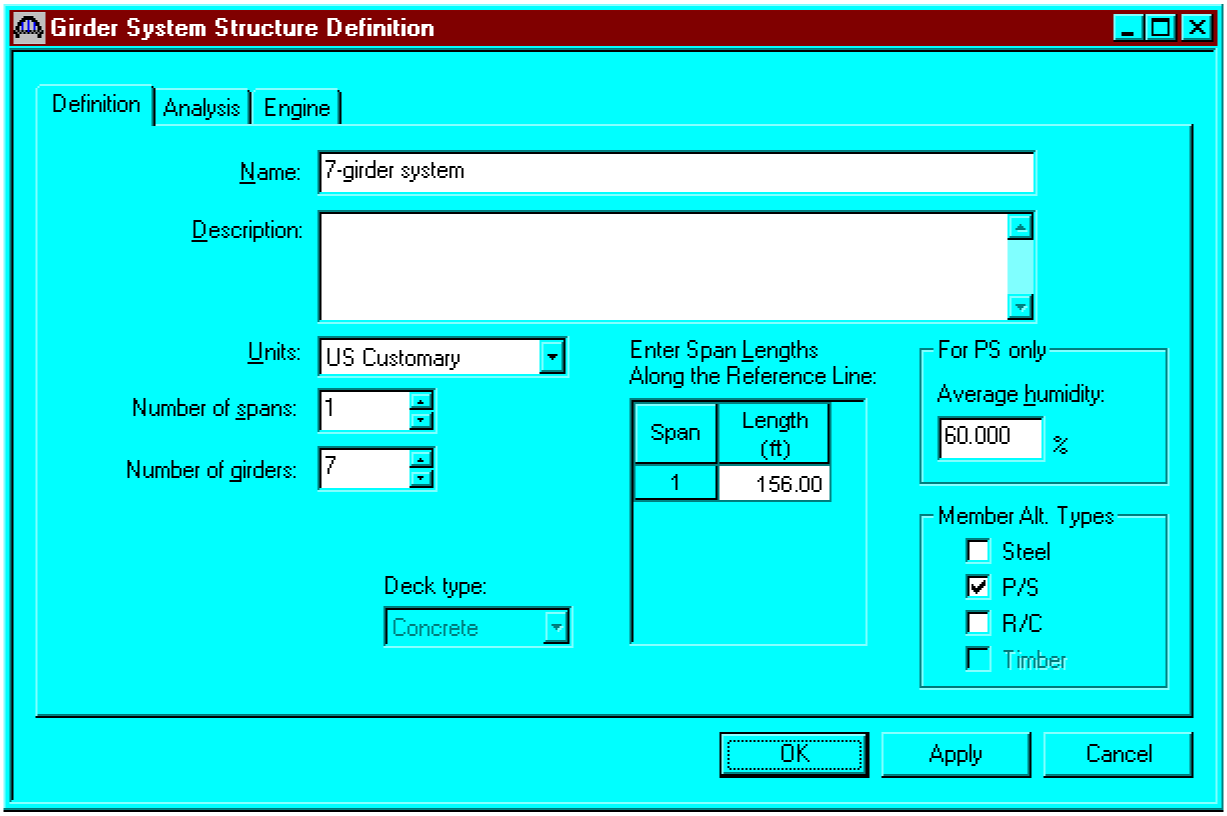
Load Group	Gamma Factor	D	(L+I)n	(L+I)p	CF	E
INV	1.300	1.000	1.670	0.000	1.000	1.000
OPG	1.300	1.000	1.000	0.000	1.000	1.000

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



Structure Type	Description
Girder-line	A structure definition describing one of more girders. The girders do NO
Girder system	A structure definition describing one of more girders. The girders do hav

Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



Name: 7-girder system

Description:

Units: US Customary

Number of spans: 1

Number of girders: 7

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	156.00

For PS only

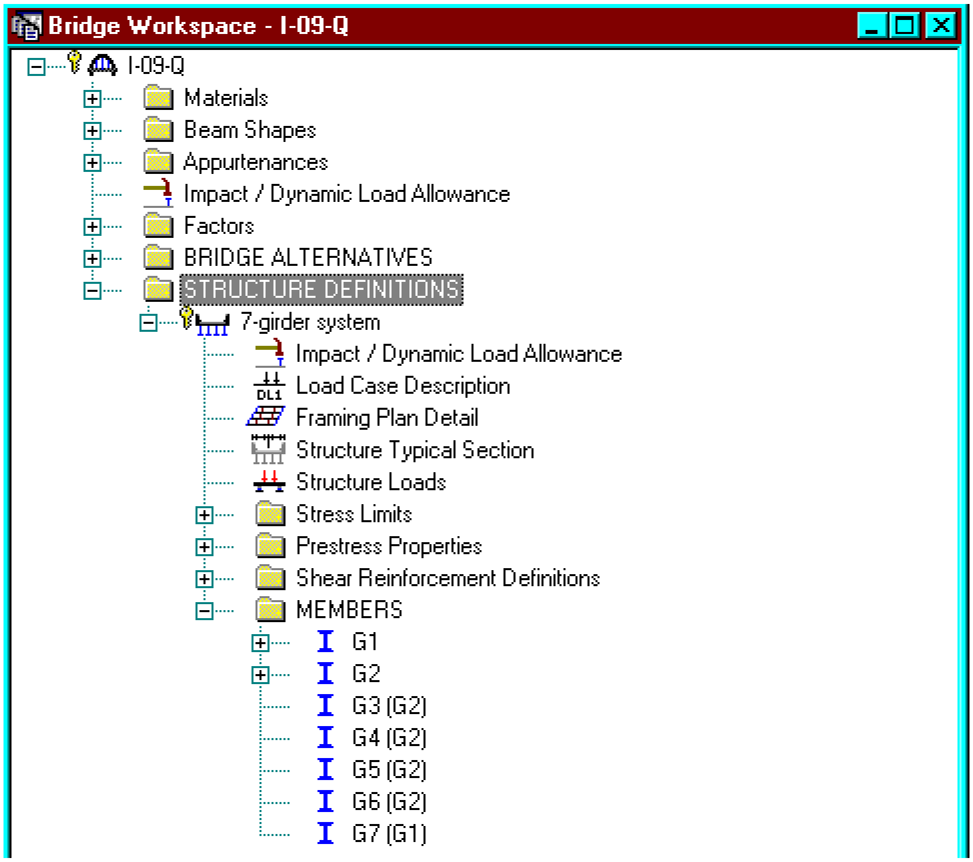
Average humidity: 60.000 %

Member Alt. Types

☐ Steel
☑ P/S
☐ R/C
☐ Timber

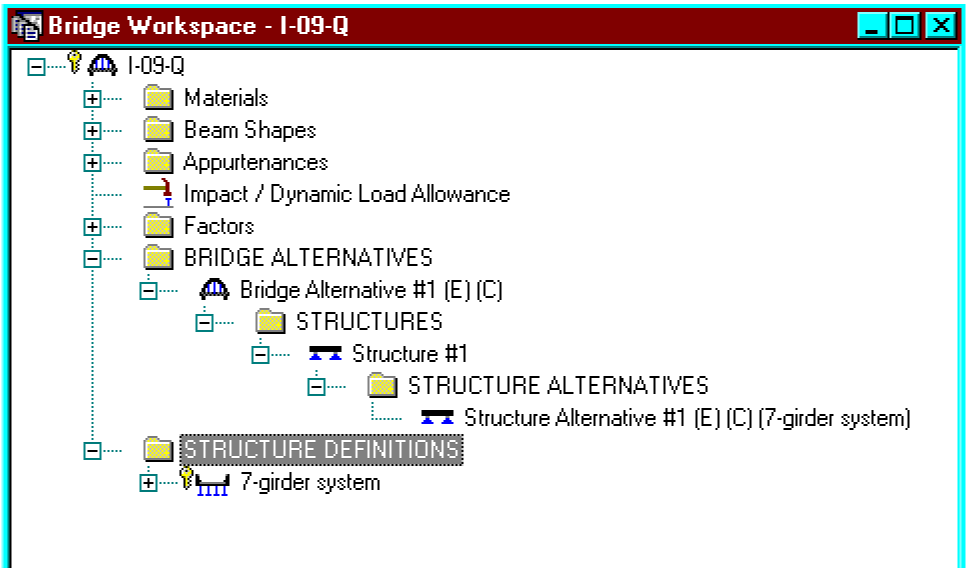
Span length for a simple span prestressed girder structure shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:

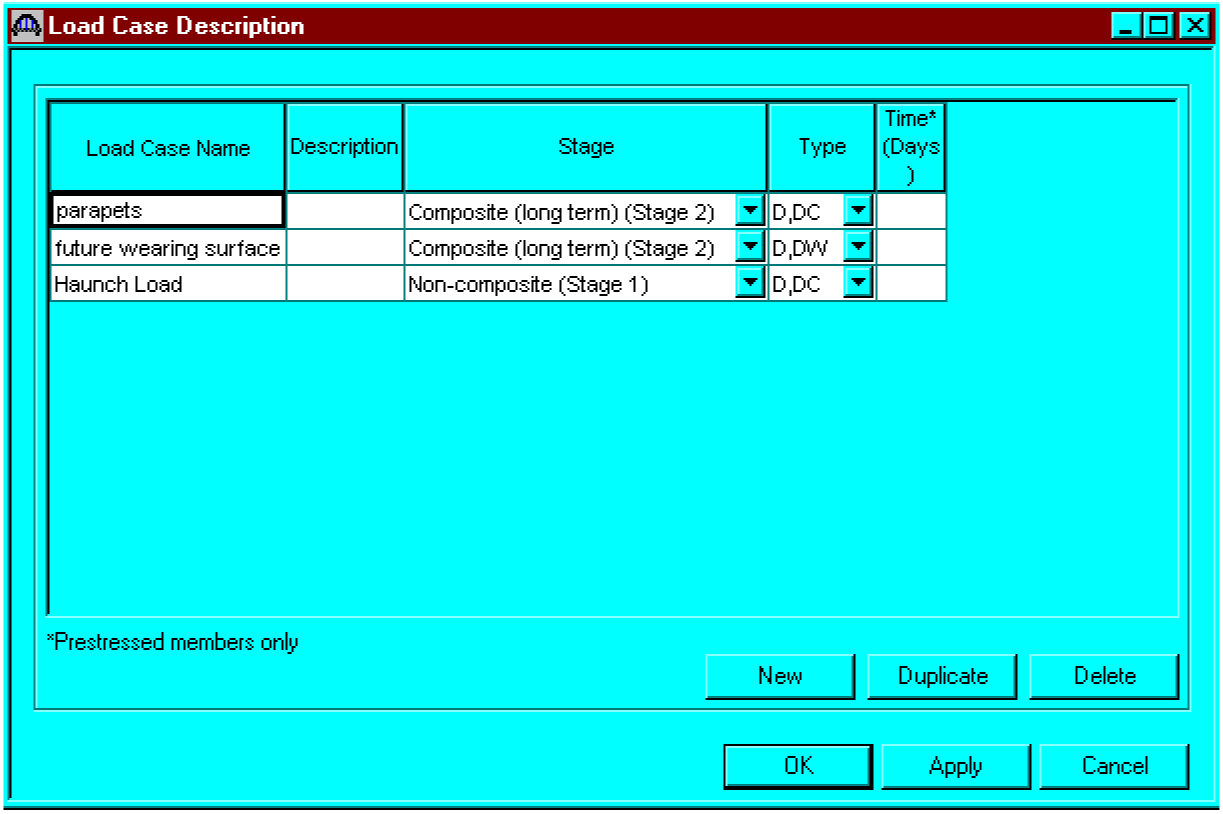


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

The partially expanded Bridge Workspace tree is shown below:



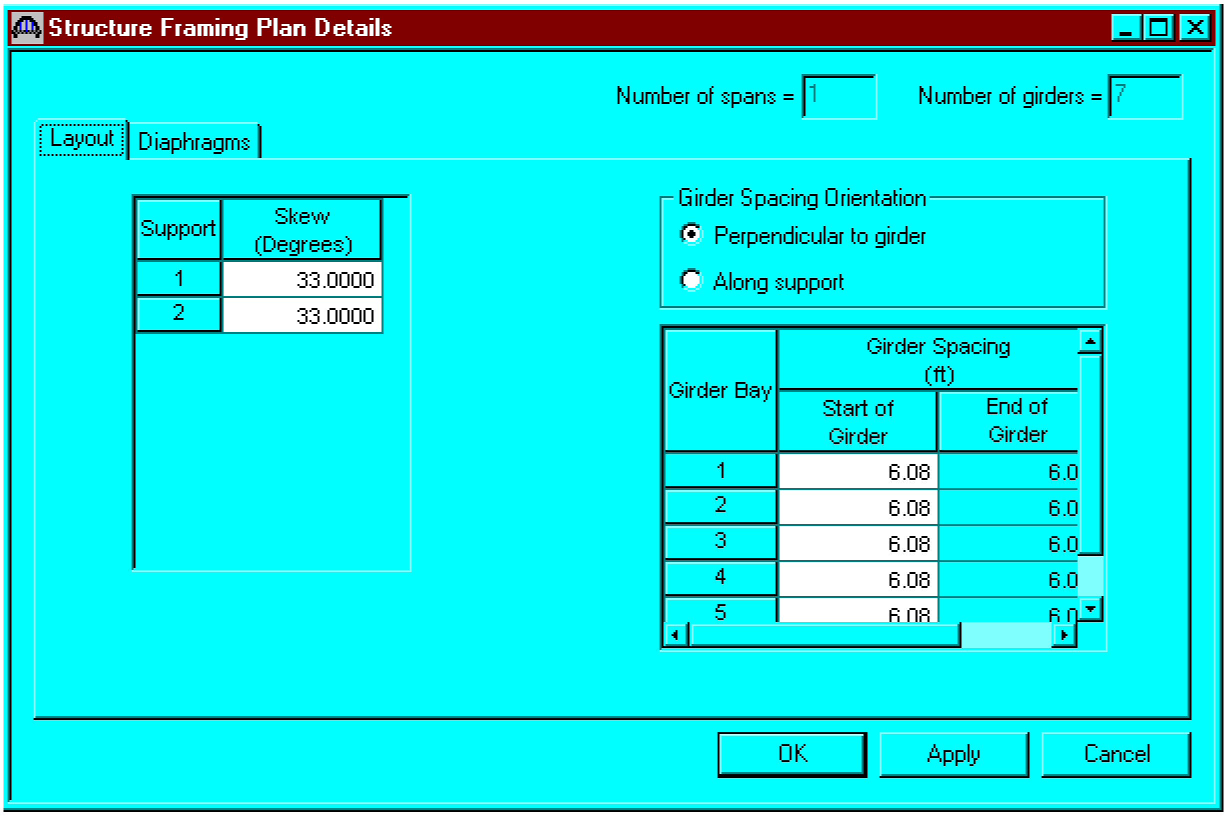
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.



Load Case Name	Description	Stage	Type	Time* (Days)
parapets		Composite (long term) (Stage 2)	D,DC	
future wearing surface		Composite (long term) (Stage 2)	D,DW	
Haunch Load		Non-composite (Stage 1)	D,DC	

*Prestressed members only

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



Number of spans = 1

Number of girders = 7

Support	Skew (Degrees)
1	33.0000
2	33.0000

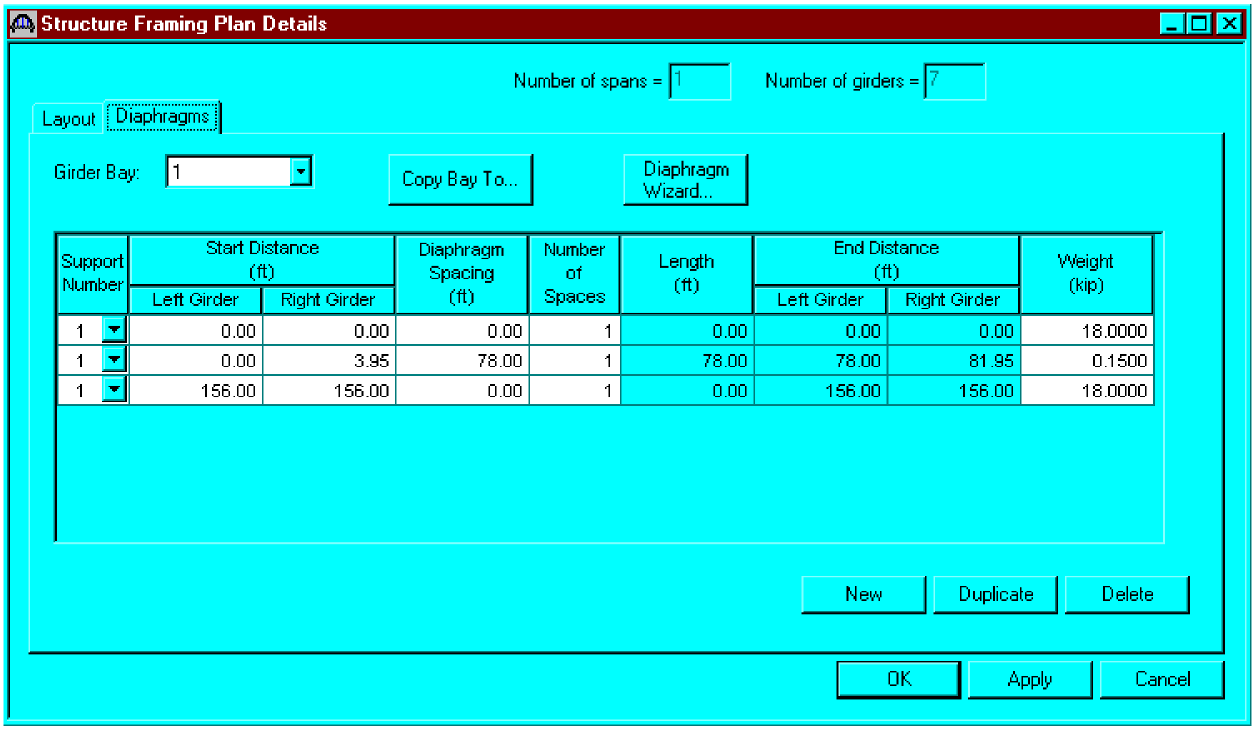
Girder Spacing Orientation

● Perpendicular to girder

○ Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	6.08	6.0
2	6.08	6.0
3	6.08	6.0
4	6.08	6.0
5	6.08	6.0

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.



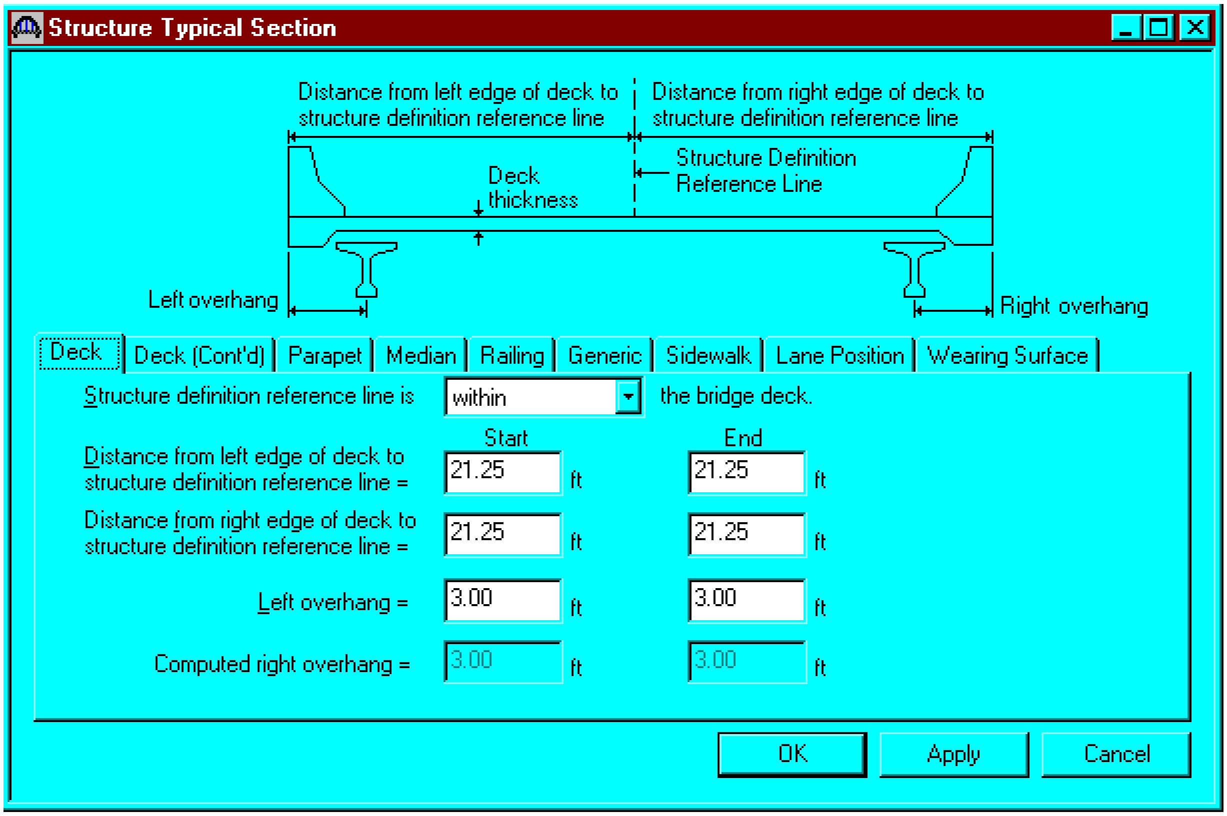
Number of spans = 1

Number of girders = 7

Girder Bay: 1

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	18.0000
1	0.00	3.95	78.00	1	78.00	78.00	81.95	0.1500
1	156.00	156.00	0.00	1	0.00	156.00	156.00	18.0000

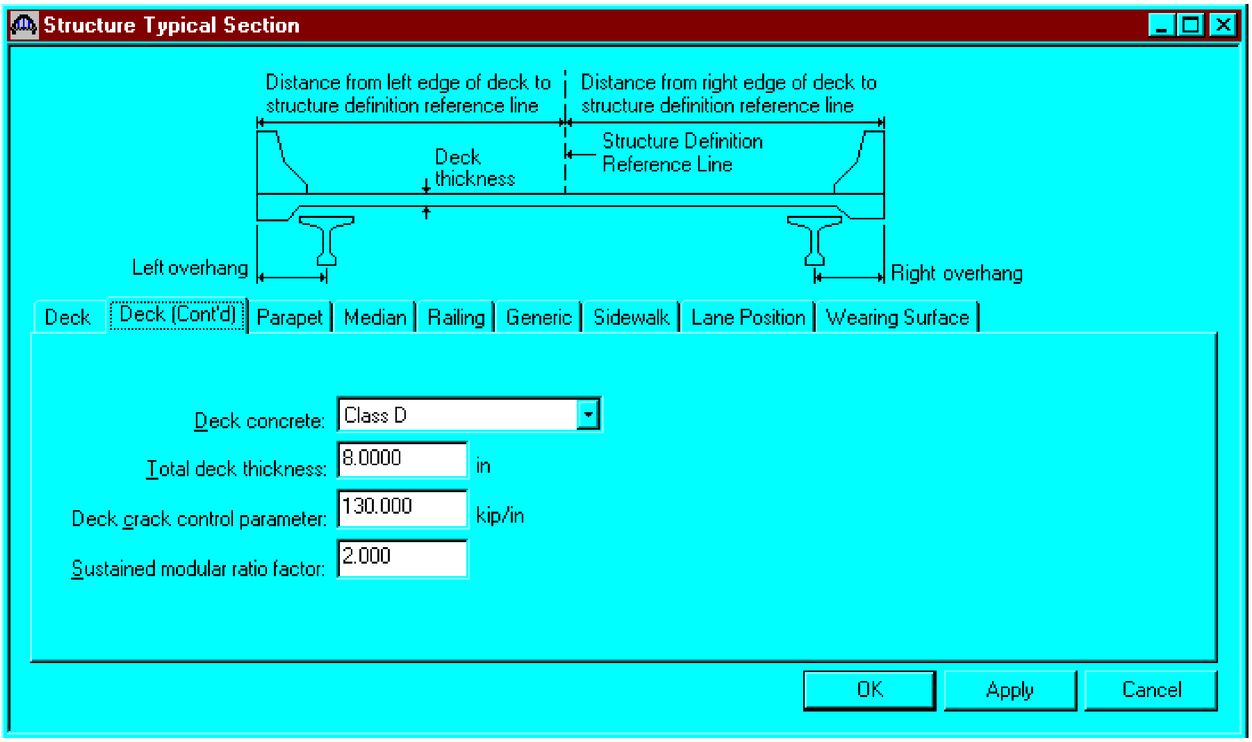
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



Structure definition reference line is within the bridge deck.

	Start		End	
Distance from left edge of deck to structure definition reference line =	21.25	ft	21.25	ft
Distance from right edge of deck to structure definition reference line =	21.25	ft	21.25	ft
Left overhang =	3.00	ft	3.00	ft
Computed right overhang =	3.00	ft	3.00	ft

The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



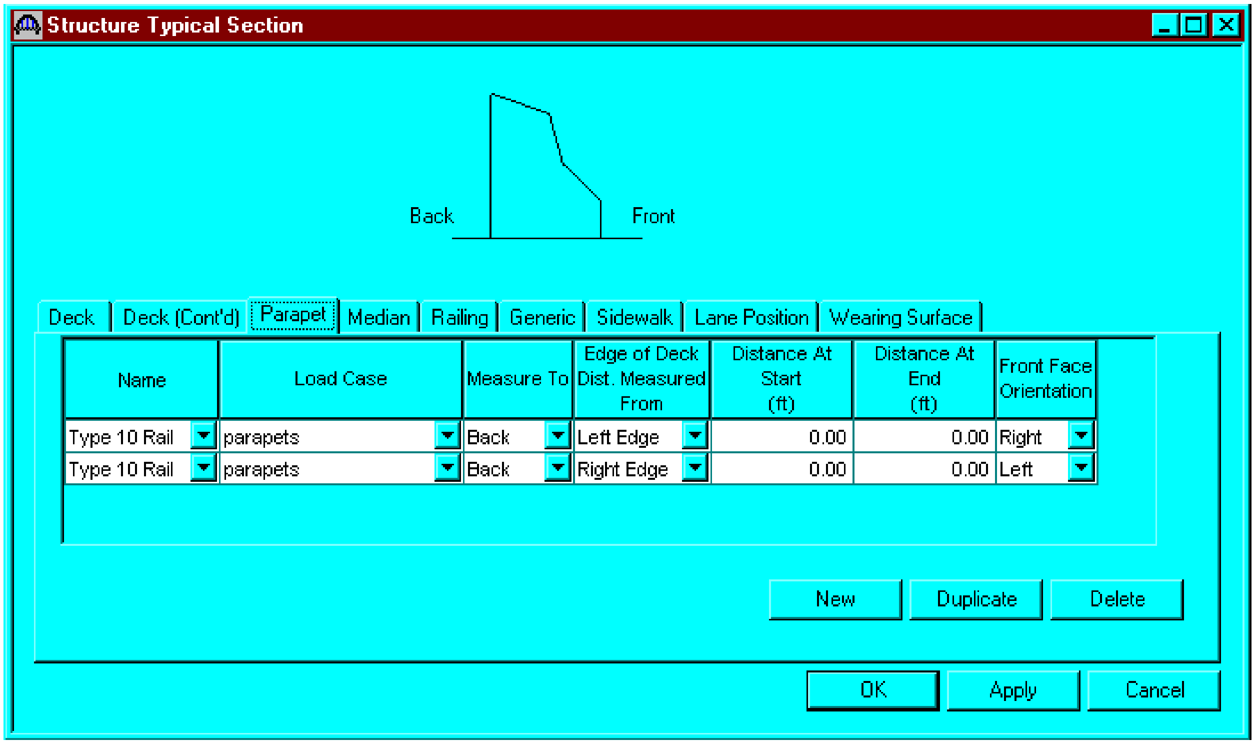
Deck concrete: Class D

Total deck thickness: 8.0000 in

Deck crack control parameter: 130.000 kip/in

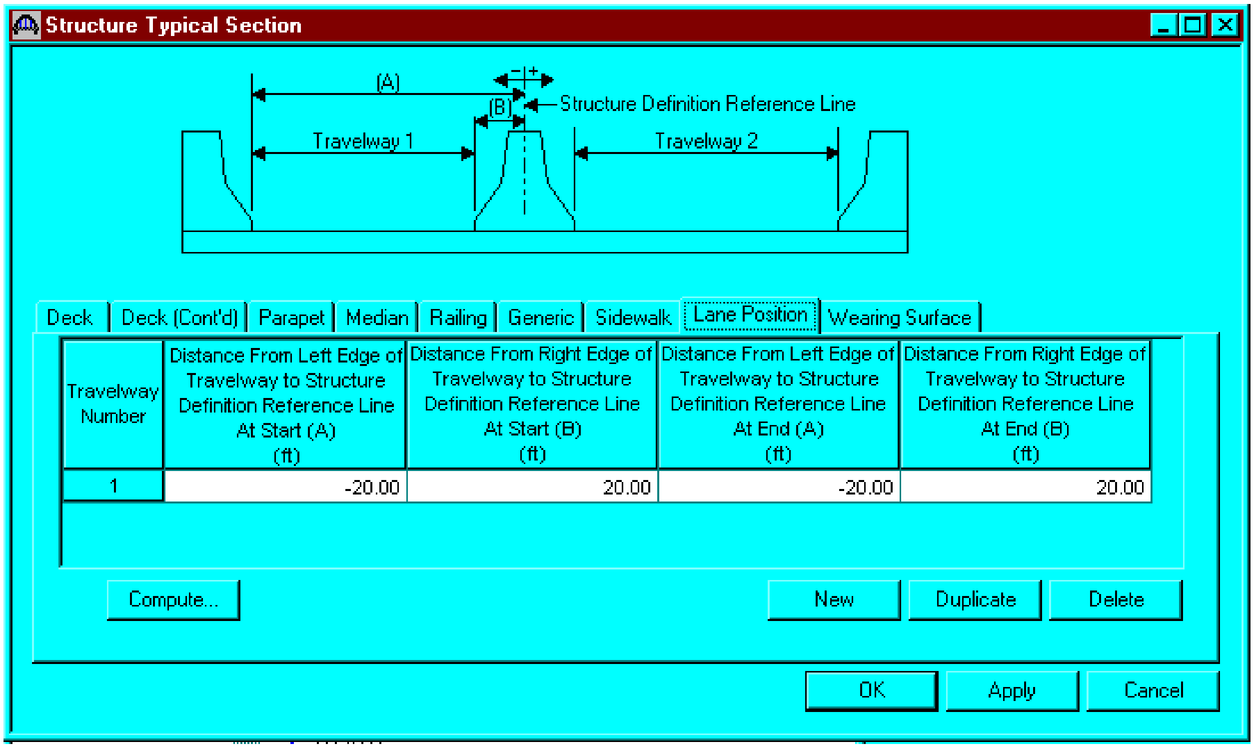
Sustained modular ratio factor: 2.000

Parapets:
Add two parapets as shown below.



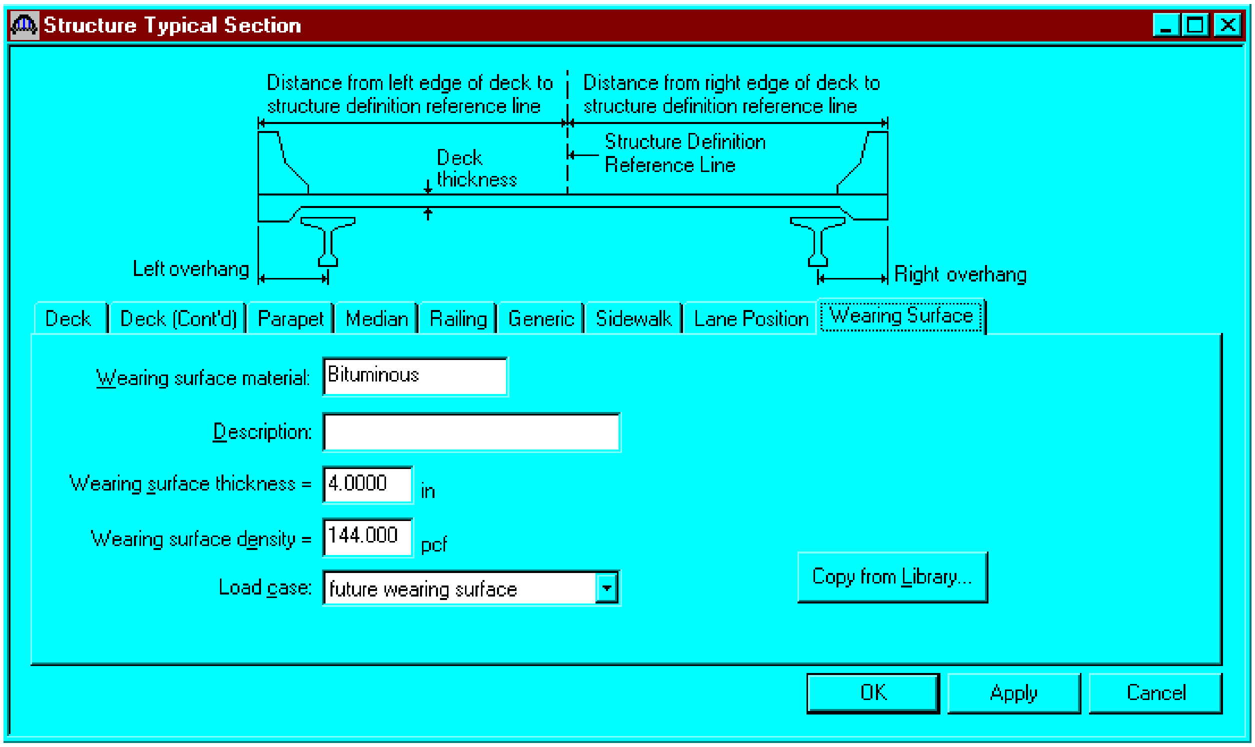
Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Type 10 Rail	parapets	Back	Left Edge	0.00	0.00	Right
Type 10 Rail	parapets	Back	Right Edge	0.00	0.00	Left

Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to accept the computed values. The Lane Position tab is populated as shown below.



Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At End (B) (ft)
1	-20.00	20.00	-20.00	20.00

Enter the following wearing surface information on the Wearing Surface tab.



Wearing surface material: Bituminous

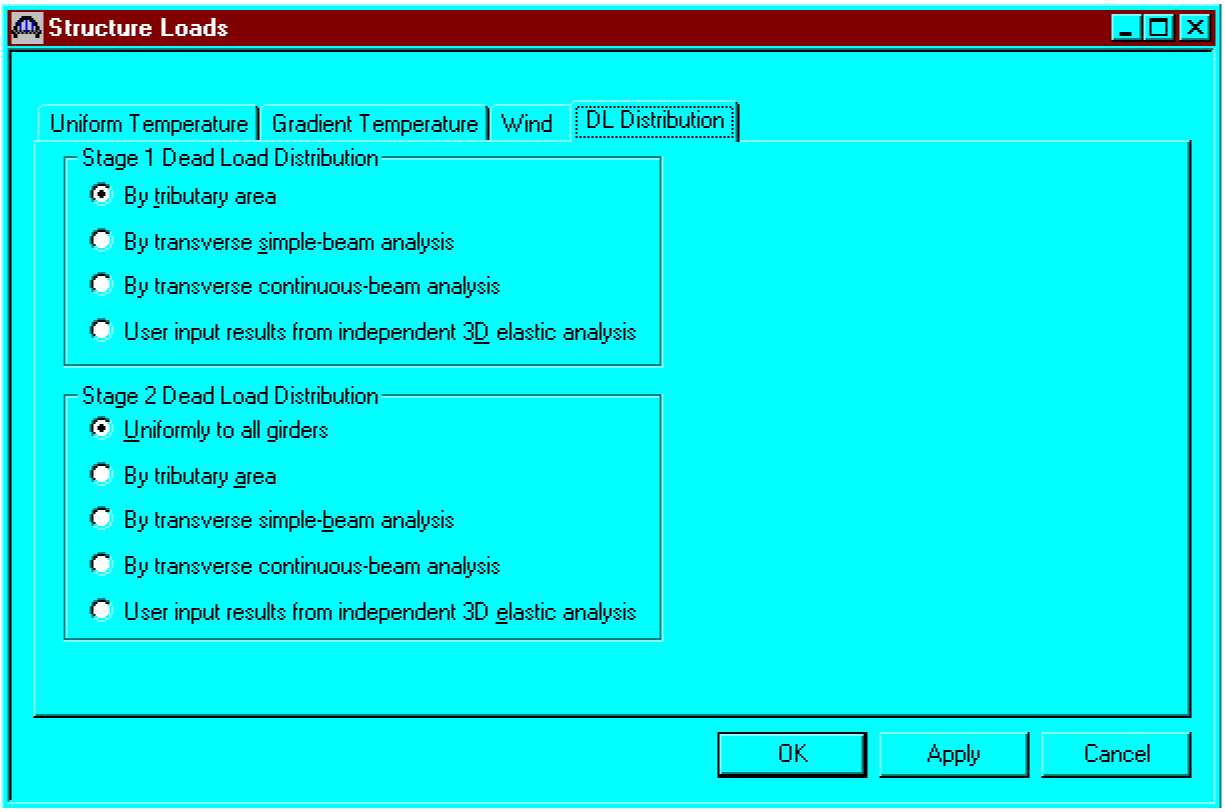
Description:

Wearing surface thickness = 4.0000 in

Wearing surface density = 144.000 pcf

Load case: future wearing surface

Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



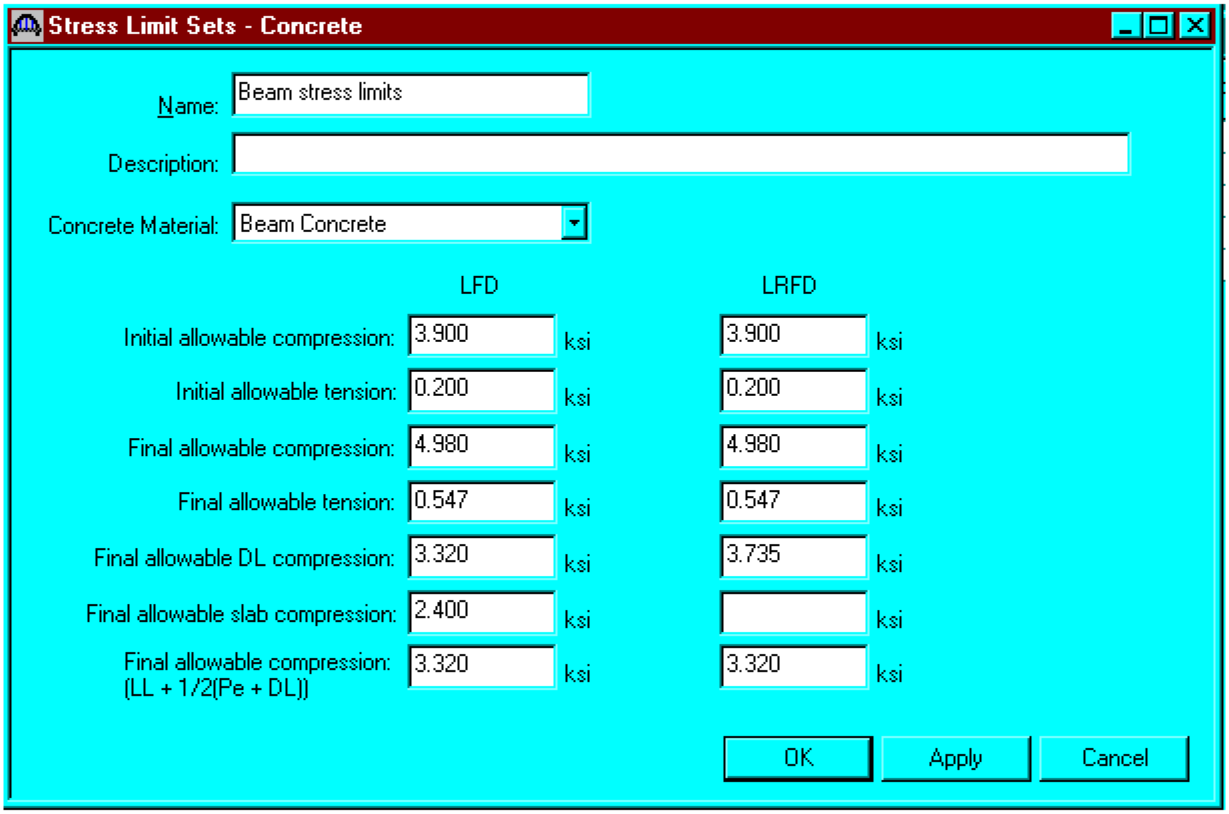
Stage 1 Dead Load Distribution

- ● By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

Stage 2 Dead Load Distribution

- ● Uniformly to all girders
- ○ By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the “Beam Concrete” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.



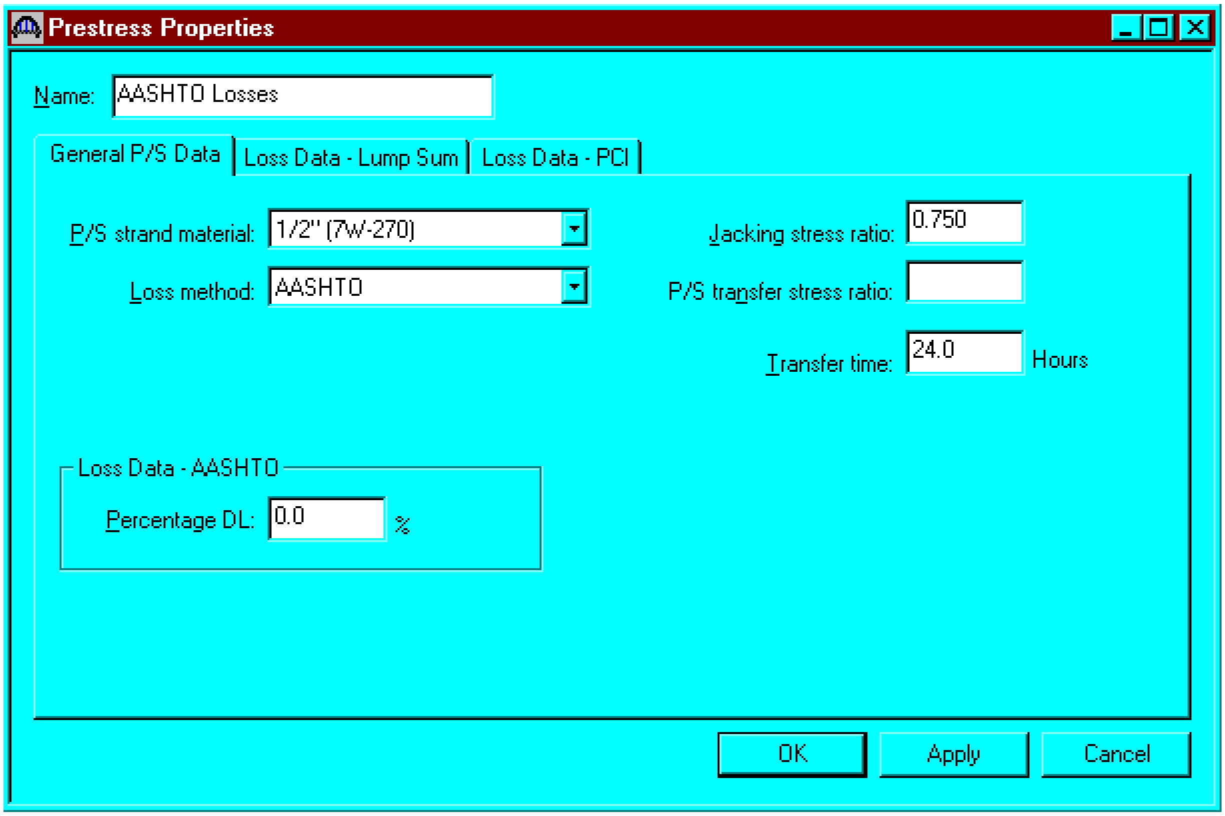
Name: Beam stress limits

Description:

Concrete Material: Beam Concrete

	LFD		LRFD	
Initial allowable compression:	3.900	ksi	3.900	ksi
Initial allowable tension:	0.200	ksi	0.200	ksi
Final allowable compression:	4.980	ksi	4.980	ksi
Final allowable tension:	0.547	ksi	0.547	ksi
Final allowable DL compression:	3.320	ksi	3.735	ksi
Final allowable slab compression:	2.400	ksi		ksi
Final allowable compression: (LL + 1/2(Pe + DL))	3.320	ksi	3.320	ksi

Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the "General P/S Data" tab is required. Click OK to save to memory and close the window.



Name: AASHTO Losses

P/S strand material: 1/2" (7W-270)

Loss method: AASHTO

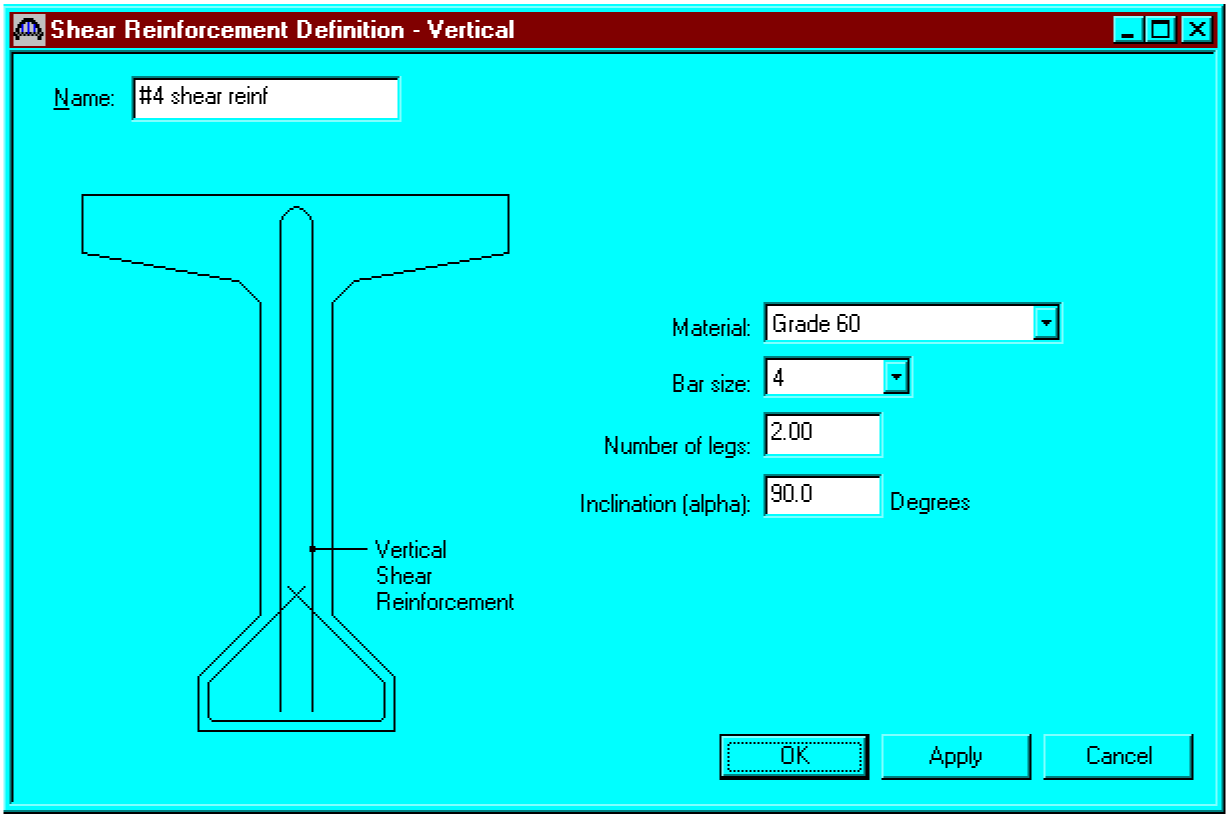
Jacking stress ratio: 0.750

P/S transfer stress ratio:

Transfer time: 24.0 Hours

Percentage DL: 0.0 %

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



Name: #4 shear reinf

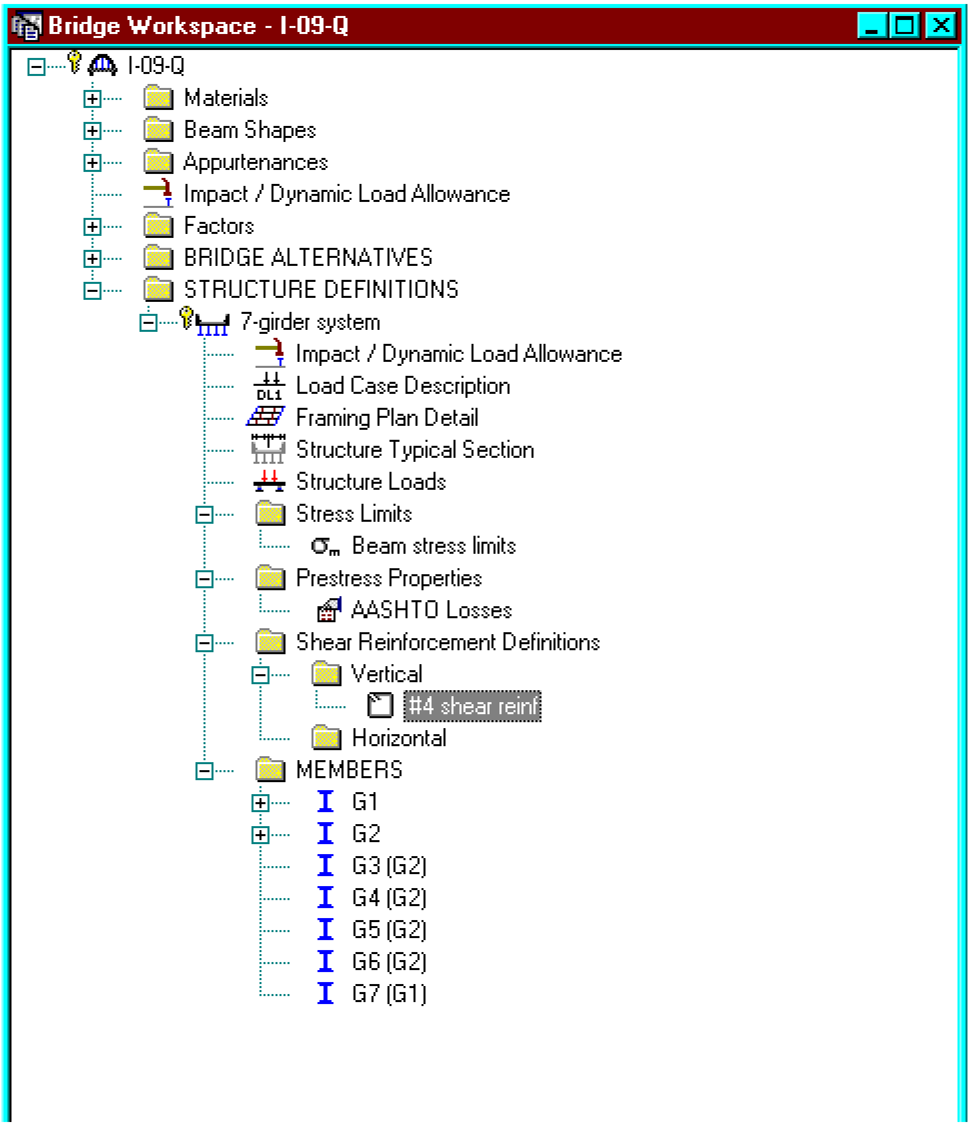
Material: Grade 60

Bar size: 4

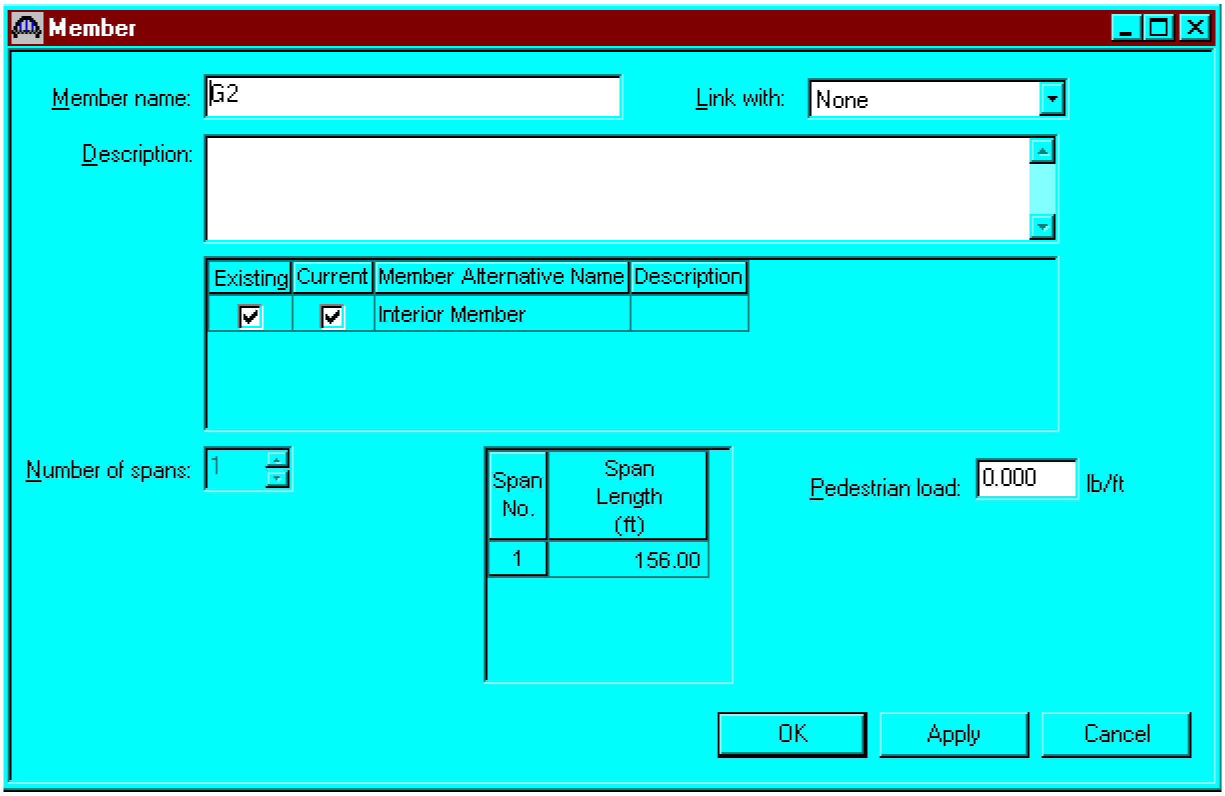
Number of legs: 2.00

Inclination (alpha): 90.0 Degrees

The partially expanded Bridge Workspace tree is shown below:



Describing a member:
The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.



Member name: G2

Link with: None

Description:

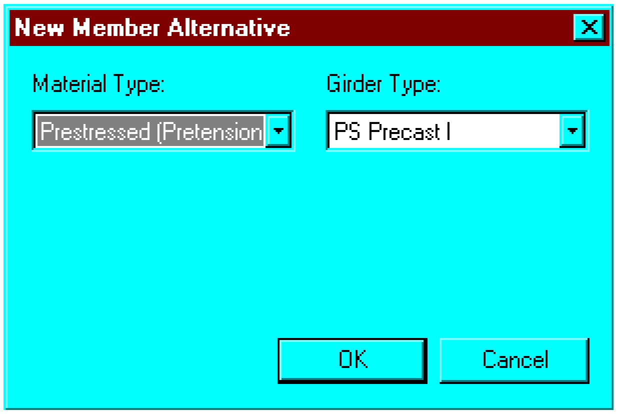
Existing	Current	Member Alternative Name	Description
☑	☑	Interior Member	

Number of spans: 1

Span No.	Span Length (ft)
1	156.00

Pedestrian load: 0.000 lb/ft

Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

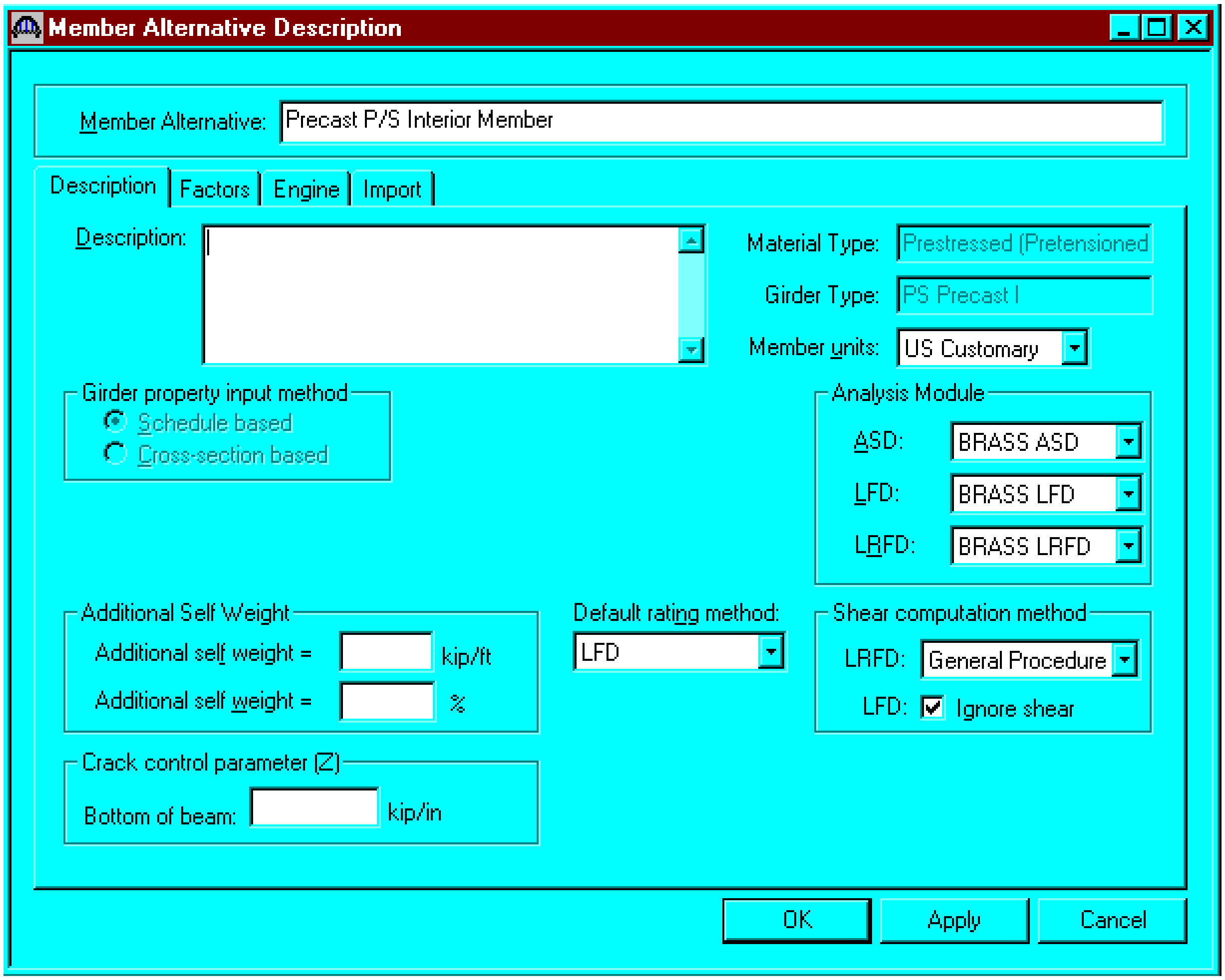


Material Type: Prestressed (Pretension

Girder Type: PS Precast I

Click OK to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam.



Member Alternative: Precast P/S Interior Member

Description:

Material Type: Prestressed (Pretensioned

Girder Type: PS Precast I

Member units: US Customary

Girder property input method
● Schedule based
○ Cross-section based

Analysis Module
ASD: BRASS ASD
LFD: BRASS LFD
LRFD: BRASS LRFD

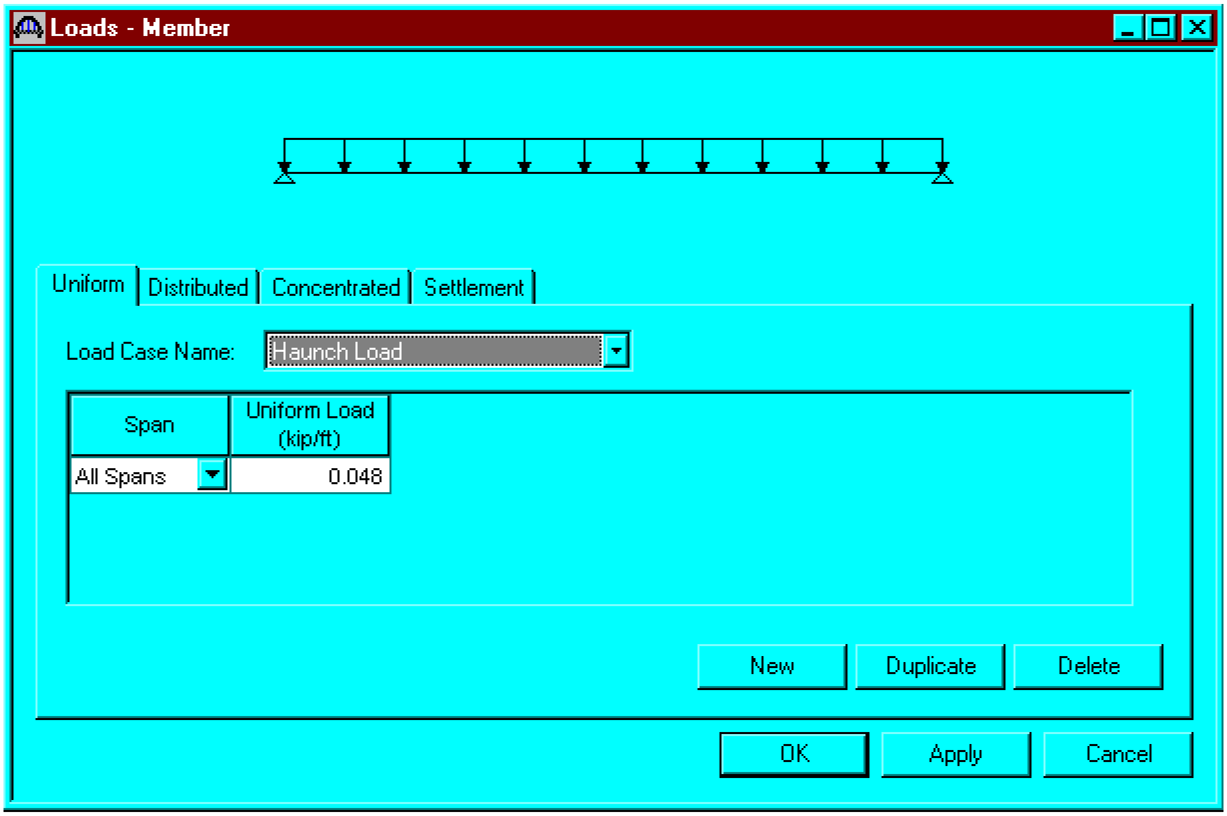
Additional Self Weight
Additional self weight = kip/ft
Additional self weight = %

Default rating method: LFD

Shear computation method
LRFD: General Procedure
LFD: ☑ Ignore shear

Crack control parameter (Z)
Bottom of beam: kip/in

Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to haunch not included in the section properties calculation is entered here.



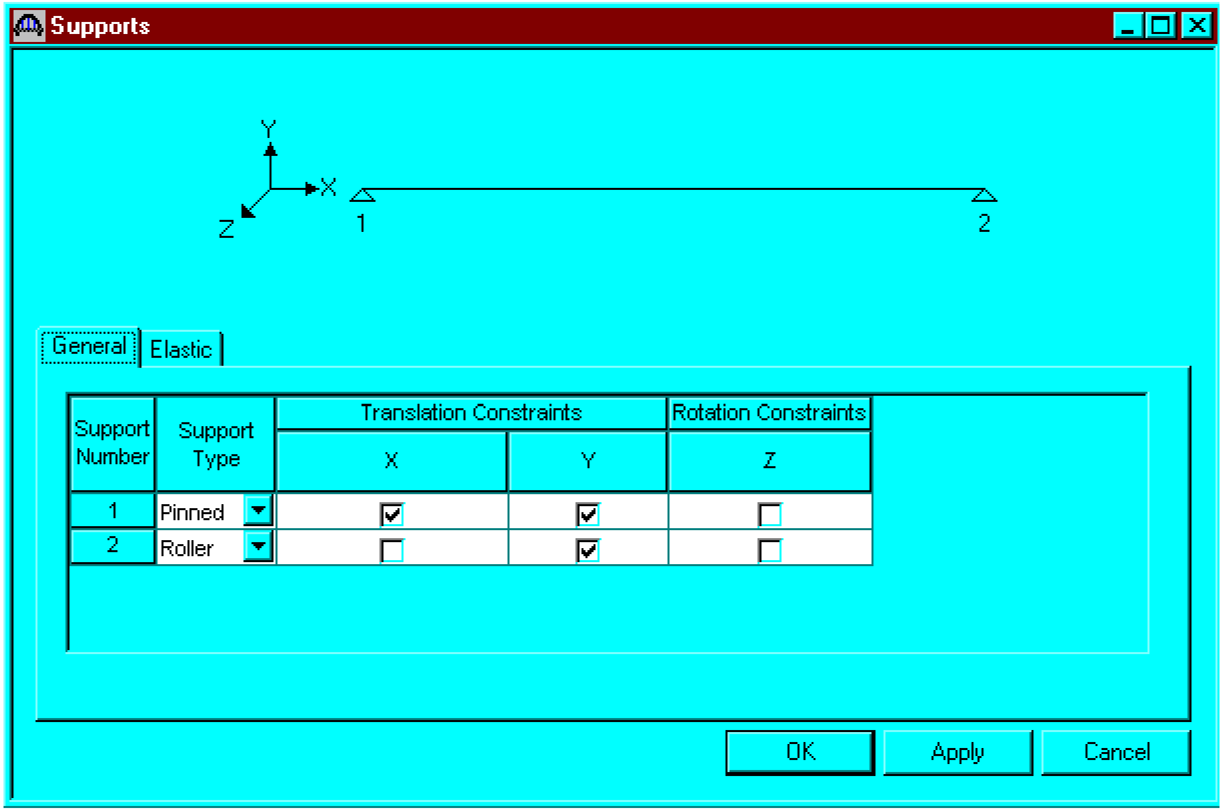
Load Case Name: Haunch Load

Span	Uniform Load (kip/ft)
All Spans	0.048

Calculated average haunch = 2.5”
Haunch used for section properties = 1.43”

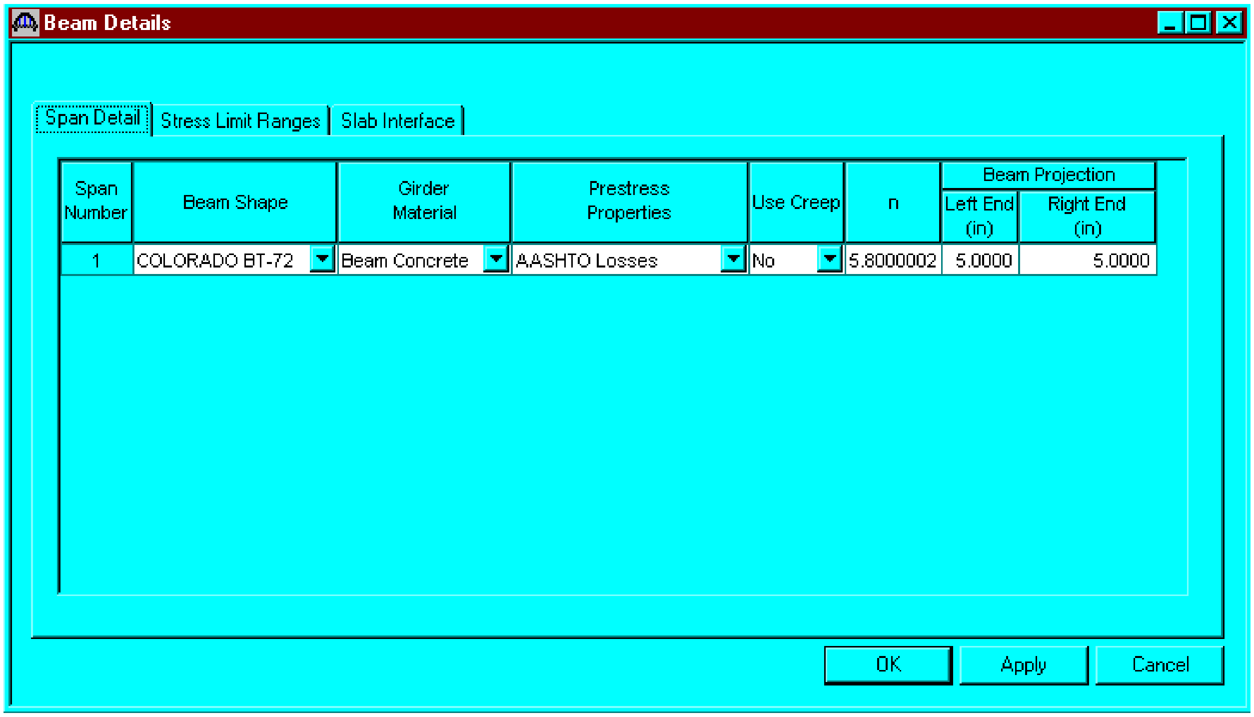
Dead Load/Girder = (2.5-1.43)/12*(43/12)*(0.15) = 0.048 k/ft

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



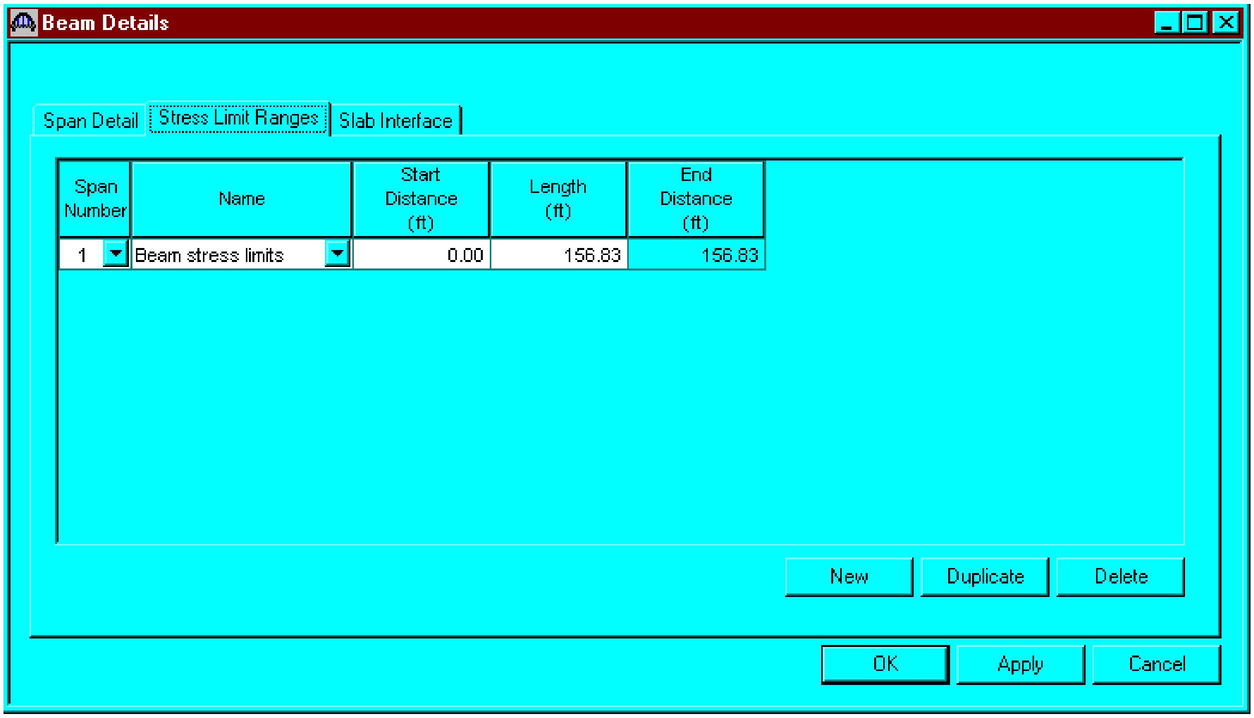
Support Number	Support Type	Translation Constraints		Rotation Constraints
		X	Y	Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐

The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape now in the Beam Details window and then come back to the Live Load Distribution window. Double click on Beam Details in the tree to describe the beam details. Enter the following beam details information.



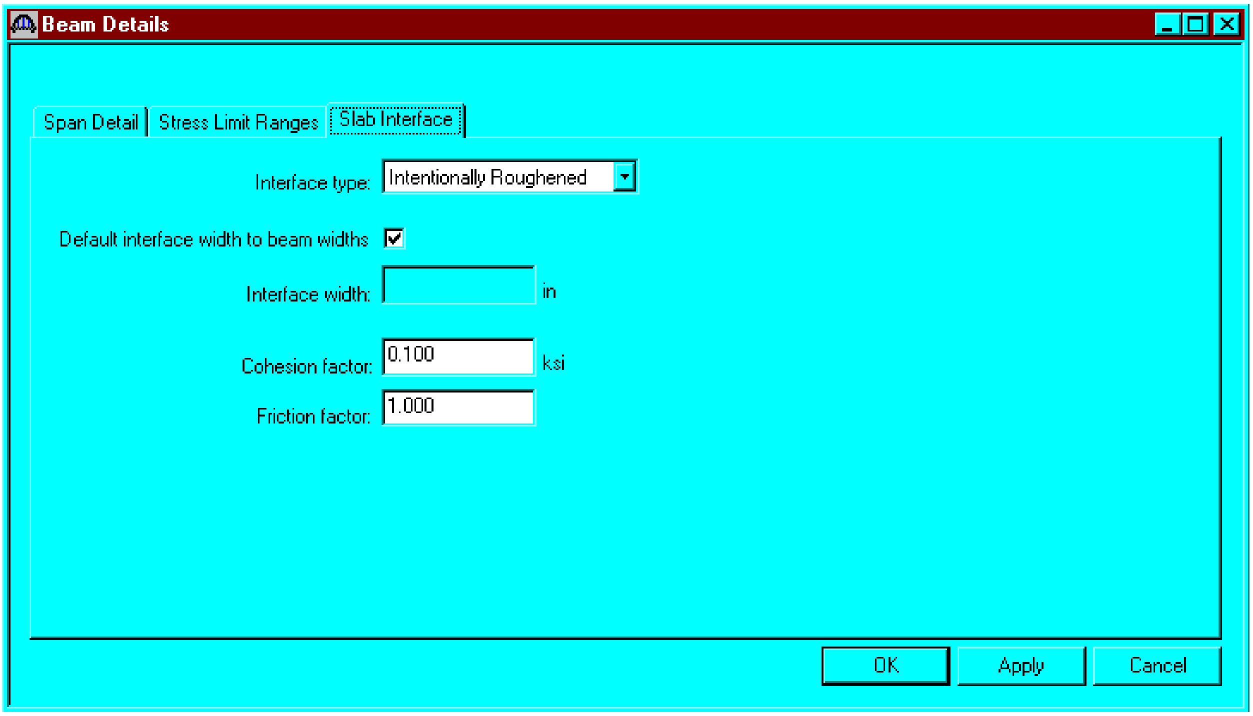
Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	COLORADO BT-72	Beam Concrete	AASHTO Losses	No	5.8000002	5.0000	5.0000

Note that the Stress Limit Ranges are defined over the entire length of the precast beam.



Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	Beam stress limits	0.00	156.83	156.83

The defaults on the Slab Interface tab are shown below and are acceptable.



Interface type: Intentionally Roughened

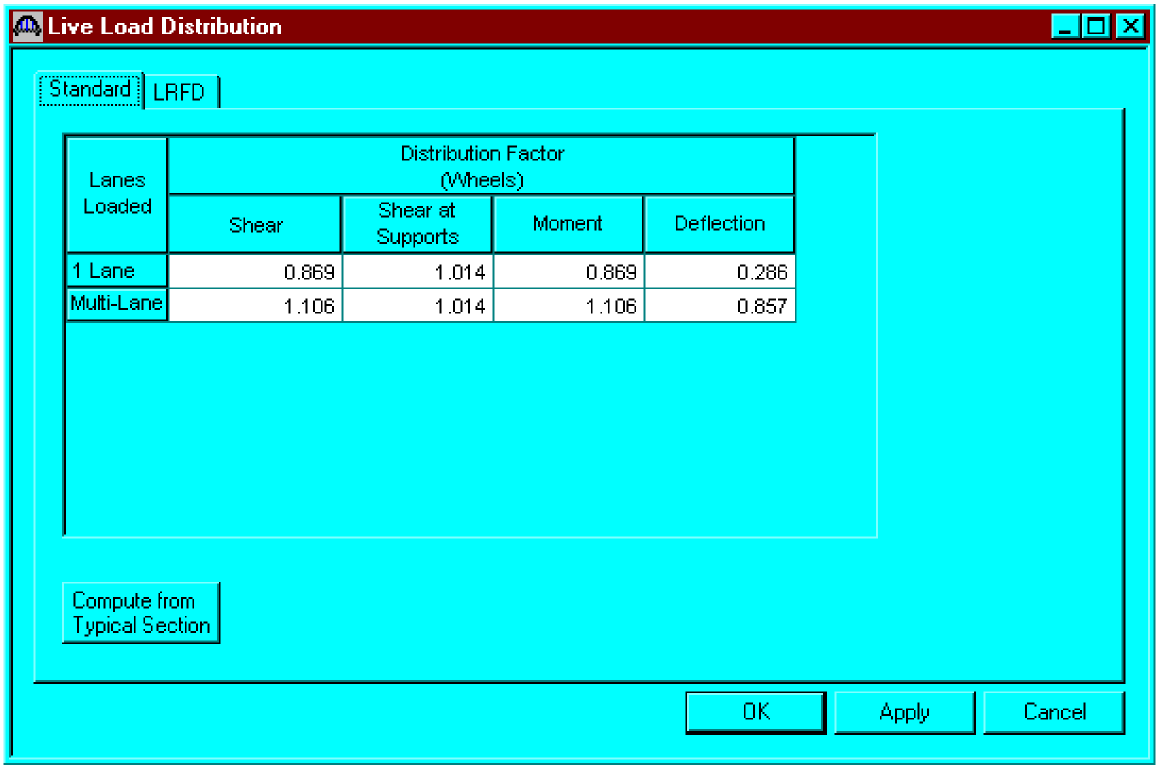
Default interface width to beam widths ☑

Interface width: in

Cohesion factor: 0.100 ksi

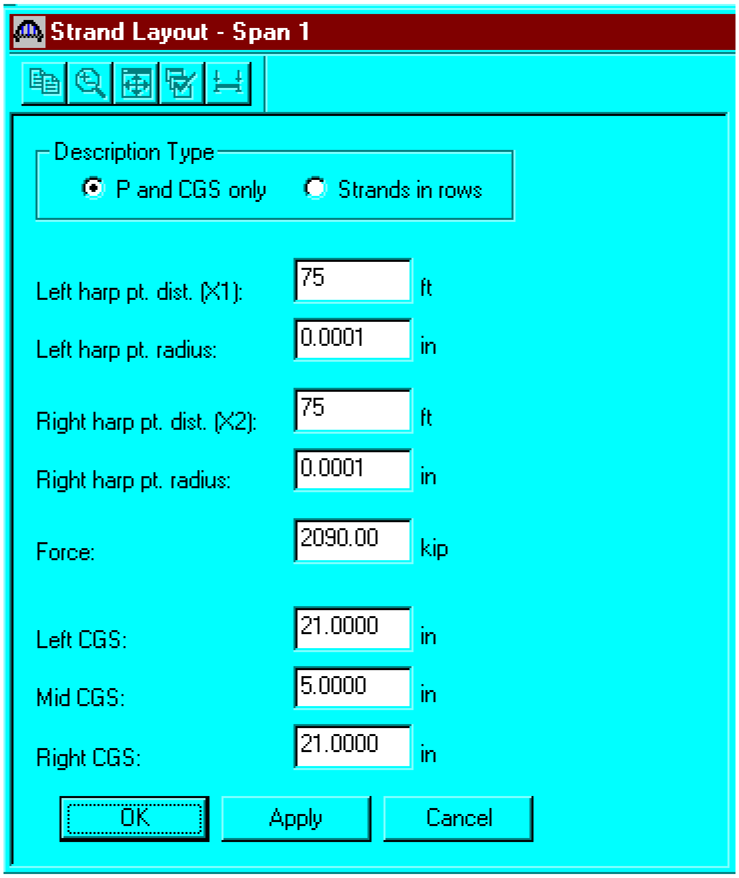
Friction factor: 1.000

Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23 and 3.28. Click Apply and then OK to save data to memory and close the window.



Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	0.869	1.014	0.869	0.286
Multi-Lane	1.106	1.014	1.106	0.857

Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center of gravity) of the group of strands. Select P and CGS only for the Description Type. Enter the following Strand Layout information for Span 1. Press F1 while on this tab to view the strand layout help topic describing the use of this information.

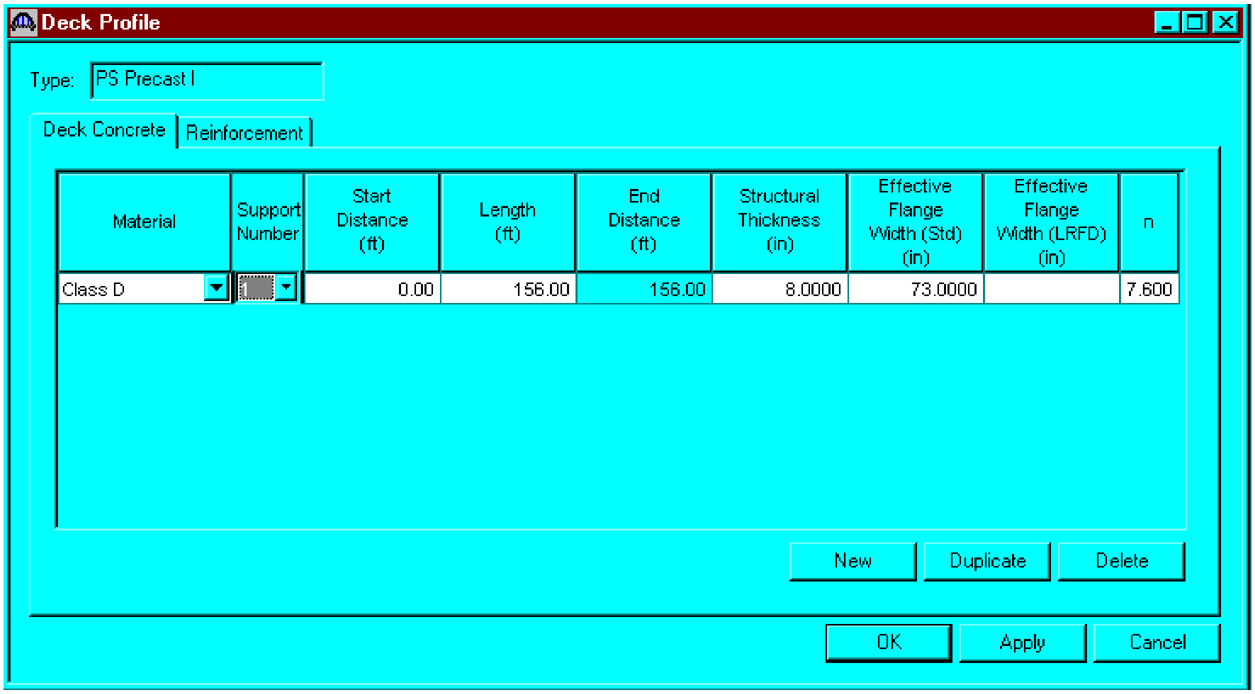


Strand Layout - Span 1

Description Type
● P and CGS only ○ Strands in rows

Left harp pt. dist. (X1): 75 ft
Left harp pt. radius: 0.0001 in
Right harp pt. dist. (X2): 75 ft
Right harp pt. radius: 0.0001 in
Force: 2090.00 kip
Left CGS: 21.0000 in
Mid CGS: 5.0000 in
Right CGS: 21.0000 in

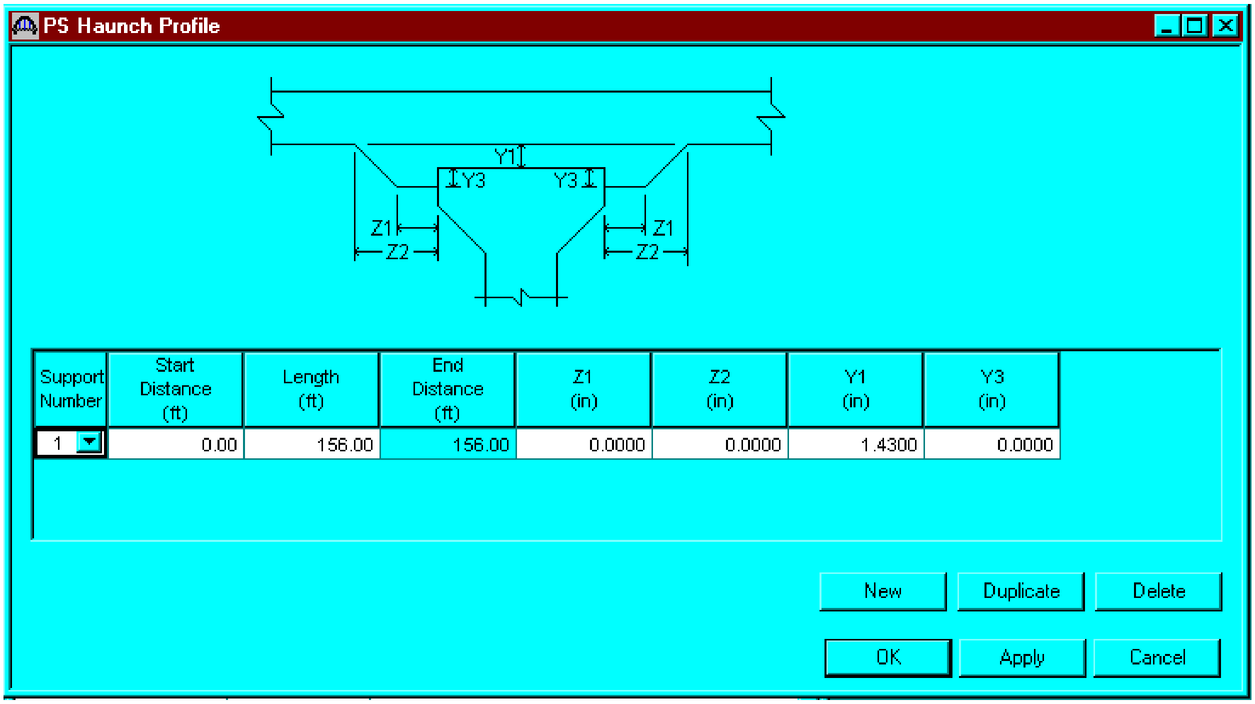
Open the Deck Profile window and enter the date describing the structural properties of the deck.



Type: PS Precast I

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Structural Thickness (in)	Effective Flange Width (Std) (in)	Effective Flange Width (LRFD) (in)	n
Class D	1	0.00	156.00	156.00	8.0000	73.0000		7.600

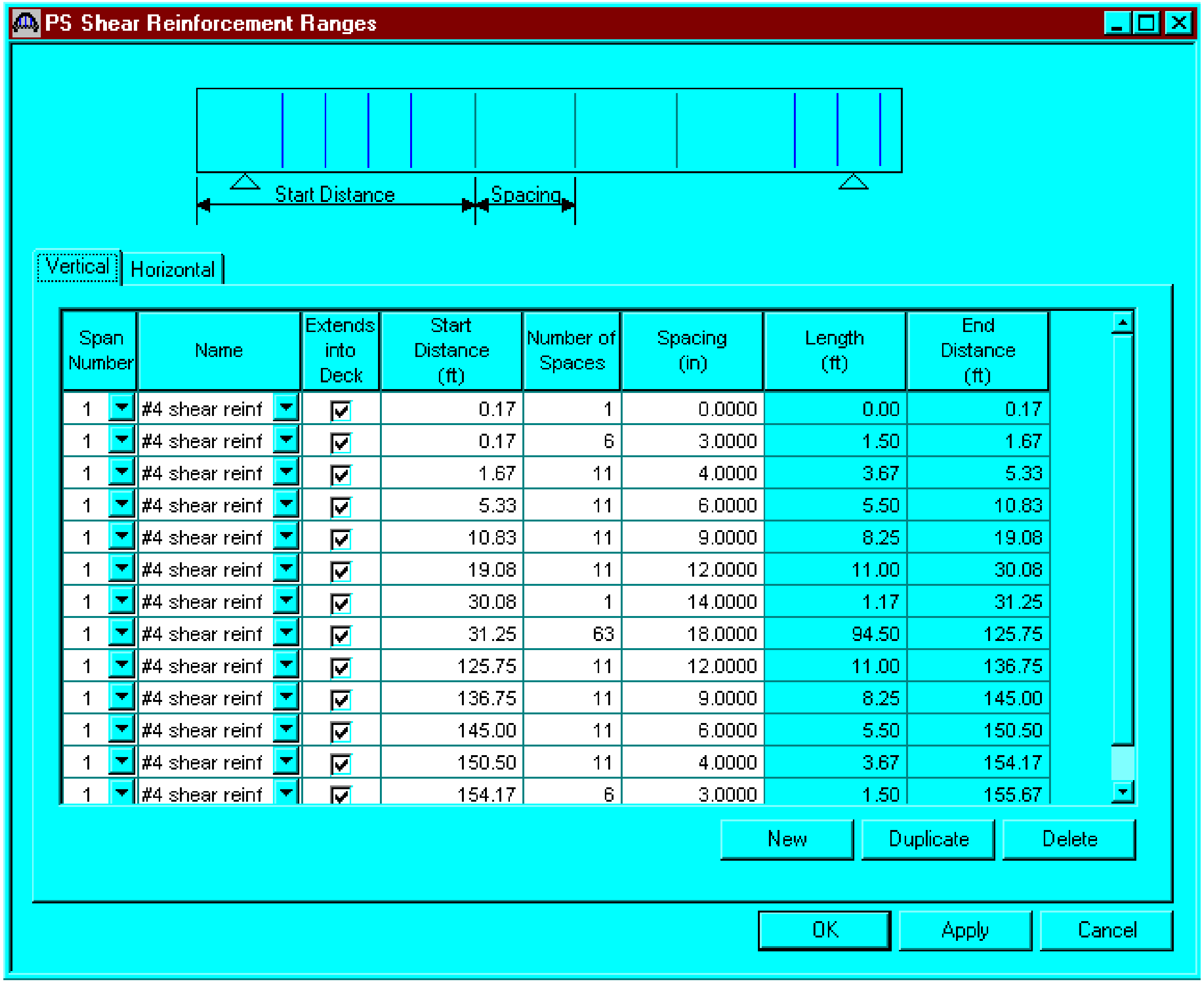
Double click on Haunch Profile in the tree to define the haunch profile for the girder.



Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)	Y3 (in)
1	0.00	156.00	156.00	0.0000	0.0000	1.4300	0.0000

Note: Only the haunch thickness to be used in section properties calculation is input here. The program calculates dead load due to this haunch automatically.

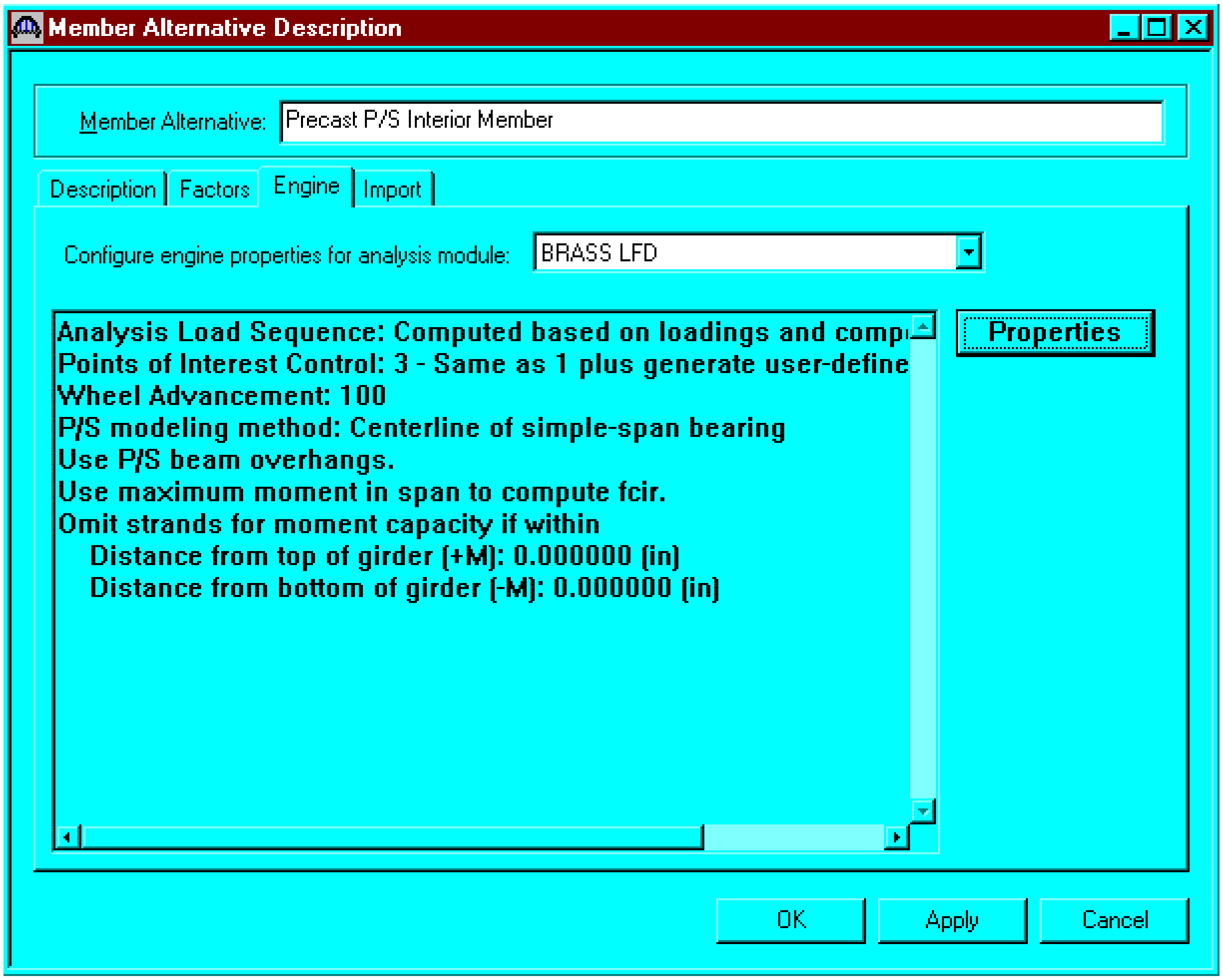
The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on this tab. This ensures composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we have defined that by extending the vertical bars into the deck.



Span Number	Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
1	#4 shear reinf	☑	0.17	1	0.0000	0.00	0.17
1	#4 shear reinf	☑	0.17	6	3.0000	1.50	1.67
1	#4 shear reinf	☑	1.67	11	4.0000	3.67	5.33
1	#4 shear reinf	☑	5.33	11	6.0000	5.50	10.83
1	#4 shear reinf	☑	10.83	11	9.0000	8.25	19.08
1	#4 shear reinf	☑	19.08	11	12.0000	11.00	30.08
1	#4 shear reinf	☑	30.08	1	14.0000	1.17	31.25
1	#4 shear reinf	☑	31.25	63	18.0000	94.50	125.75
1	#4 shear reinf	☑	125.75	11	12.0000	11.00	136.75
1	#4 shear reinf	☑	136.75	11	9.0000	8.25	145.00
1	#4 shear reinf	☑	145.00	11	6.0000	5.50	150.50
1	#4 shear reinf	☑	150.50	11	4.0000	3.67	154.17
1	#4 shear reinf	☑	154.17	6	3.0000	1.50	155.67

The description of an interior beam for this structure definition is complete.

The BRASS LFD engine data for the member alternative is shown below.



Member Alternative: Precast P/S Interior Member

Configure engine properties for analysis module: BRASS LFD

Analysis Load Sequence: Computed based on loadings and comp

Points of Interest Control: 3 - Same as 1 plus generate user-define

Wheel Advancement: 100

P/S modeling method: Centerline of simple-span bearing

Use P/S beam overhangs.

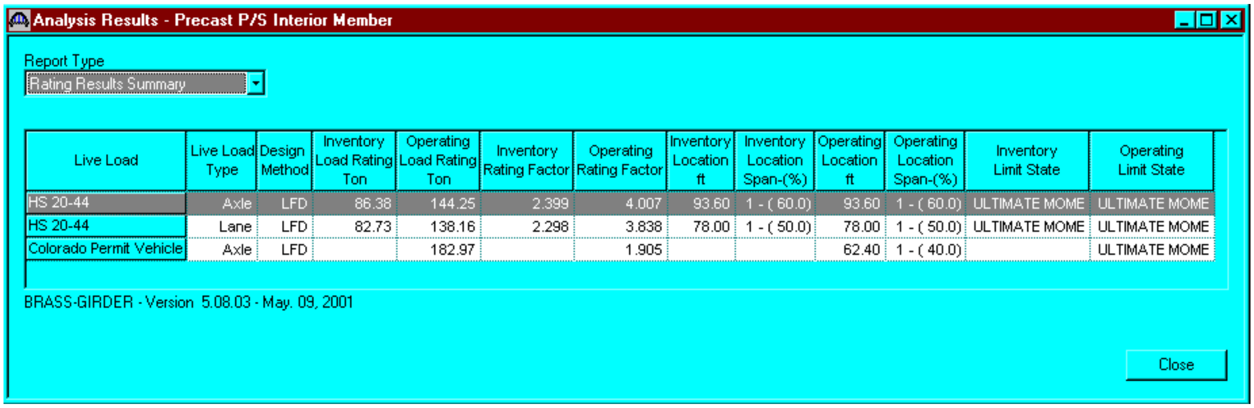
Use maximum moment in span to compute fcir.

Omit strands for moment capacity if within

Distance from top of girder (+M): 0.000000 (in)

Distance from bottom of girder (-M): 0.000000 (in)

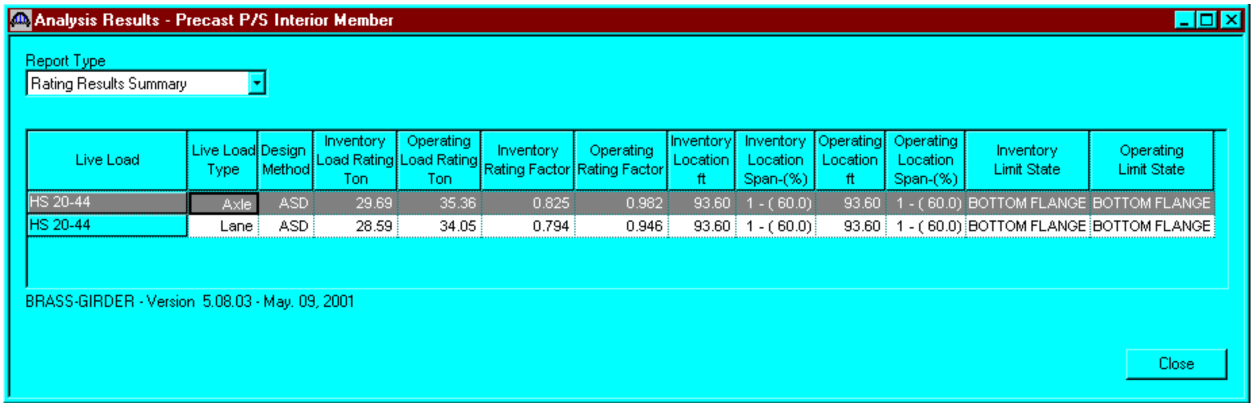
The results of the LFD/ASD rating analysis are as follows:



Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	LFD	86.38	144.25	2.399	4.007	93.60	1 - (60.0)	93.60	1 - (60.0)	ULTIMATE MOME	ULTIMATE MOME
HS 20-44	Lane	LFD	82.73	138.16	2.298	3.838	78.00	1 - (50.0)	78.00	1 - (50.0)	ULTIMATE MOME	ULTIMATE MOME
Colorado Permit Vehicle	Axle	LFD		182.97		1.905			62.40	1 - (40.0)		ULTIMATE MOME

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001



Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	ASD	29.69	35.36	0.825	0.982	93.60	1 - (60.0)	93.60	1 - (60.0)	BOTTOM FLANGE	BOTTOM FLANGE
HS 20-44	Lane	ASD	28.59	34.05	0.794	0.946	93.60	1 - (60.0)	93.60	1 - (60.0)	BOTTOM FLANGE	BOTTOM FLANGE

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

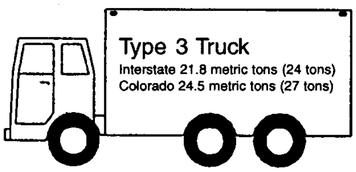
Structure # I-09-Q
State highway # 135
Batch I.D.
Structure type CPG
Parallel structure #

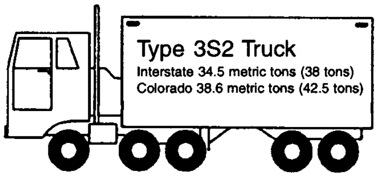
Rated using
Asphalt thickness: 102 mm (4 in.)
☒ Colorado legal loads
☐ Interstate legal loads

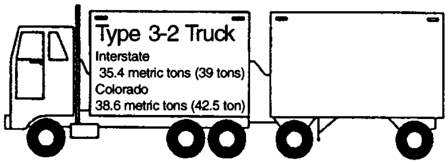
Structural member	INTERIOR GIRDER BT 72	SLAB		

Metric tons (Tons)

Inventory	26.4 (29)	51.8 (57)	( )	( )
Operating	125.4 (138)	86.4 (95)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	166.4 (183)	( )	( )	( )







_______ (_______) Metric tons Tons
_______ (_______) Metric tons Tons
_______ (_______) Metric tons Tons

Comments

Control Member: Deck; Rated for 2" HBP
Load Capacity: 95 Tons
Girder: Only Interior Girder Rated; Haunch included in the section properties calculations;
BT 72 Girders; Rated for 4" HBP

Color Code: White

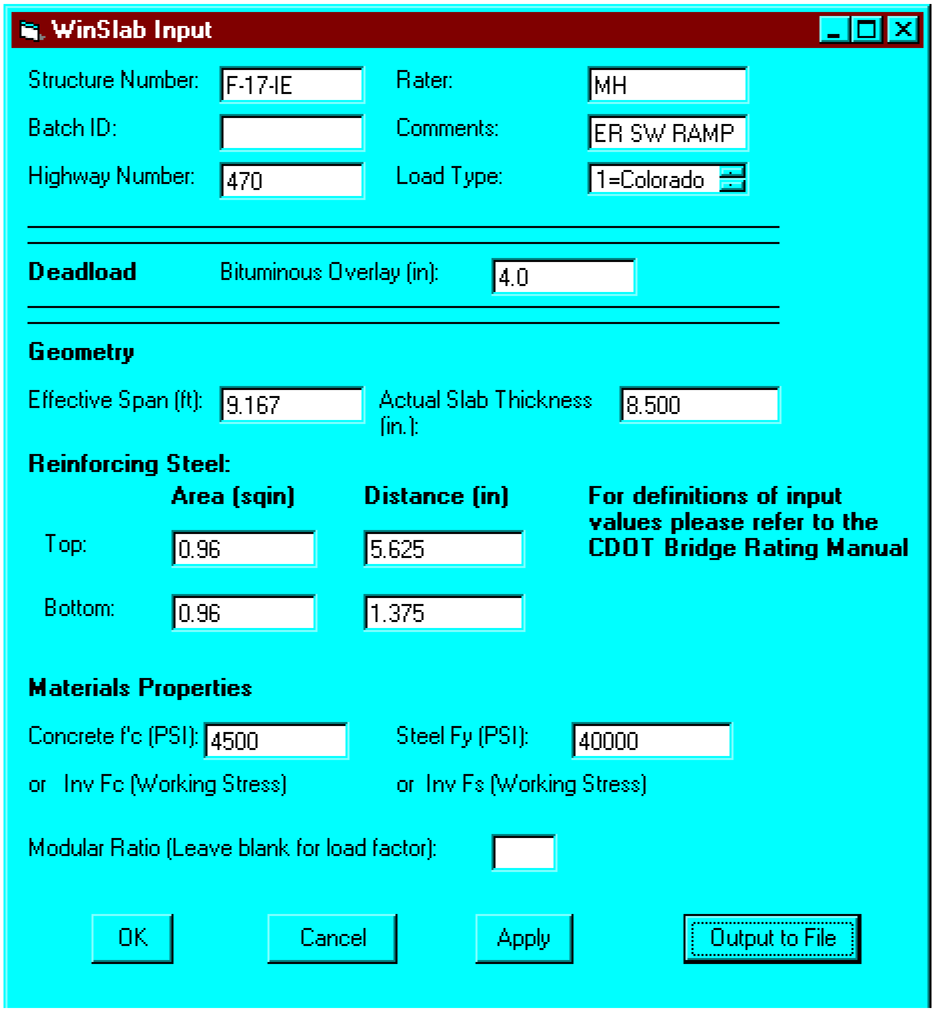
Project No: STR(CX) 0135(14)

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used

CDOT Form #1187a 1/95

Slab Rating Program Input, Structure No. F-17-IE



Structure Number: F-17-IE
Rater: MH
Batch ID:
Comments: ER SW RAMP
Highway Number: 470
Load Type: 1=Colorado

Deadload Bituminous Overlay (in): 4.0

Geometry

Effective Span (ft): 9.167
Actual Slab Thickness (in.): 8.500

Reinforcing Steel:

	Area (sqin)	**Distance (in)**
Top:	0.96	5.625
Bottom:	0.96	1.375

For definitions of input values please refer to the CDOT Bridge Rating Manual

Materials Properties

Concrete f'c (PSI): 4500
Steel Fy (PSI): 40000
or Inv Fc (Working Stress)
or Inv Fs (Working Stress)

Modular Ratio (Leave blank for load factor):

Effective Span Length: Per AASHTO Article 3.24.1.2(a)

Clear distance between flanges = 11.5’-2.333’=9.167’

Slab Rating Program Output, Structure No. F-17-IE

```
  WinSlab Rating Version 1     Date: 9/18/2001

 Structure NO. F-17-IE     Rater: MH      State HWY NO. = 470
     Batch ID=         Description: RAMP A OVER SW RAMP

 LOAD FACTOR RATING-COMP STEEL NOT USED

 INPUT DATA

       Bituminous Overlay(in)=    4.000
       Eff. Span(ft)=             9.167          Slab Thickness(in)= 8.500
       Top Reinf. (sq.in)=         0.96          Eff. Depth(in) =    5.625
       Bottom Area(sq.in)=         0.96          Bottom Dist.(in)=   1.38
       Conc. Strength(PSI) Inv =   4500          Oper. =             4500
       Steel Yield (PSI)   Inv =  40000          Oper. =             40000
       Modular Ratio =                8

Dead Load Moment   1.30 K-Ft
LL+I Moment        5.81 K-Ft
Gross Weight       36.0 Tons
                                    Inventory     Operating
Actual Concrete Stress      (PSI)    1220.64       1892.62
Actual Reinf. Steel Stress  (PSI)   19354.22      30008.88
Actual Comp. Steel Stress   (PSI)    5294.17       8208.66
Member Capacity             (K-Ft)     15.00         15.00
Member Capacity (LL+I)      (K-Ft)     13.31         13.31
     Rating                 (Tons)     38.09         63.48
```

Virtis Bridge Rating Example, Structure No. F-17-IE

Effective slab width: Per AASHTO Article 9.8.1.1

0.25(L)= 0.25(52.72*12)= 158.16”
0.25(L)= 0.25(65.00*12)= 195.00”
0.25(L)= 0.25(49.96*12)= 149.88”
12t+ b = 12*8.5+ 28= 130.00” Controls
C.L. - C.L. of girder= 11.5’=138.00”

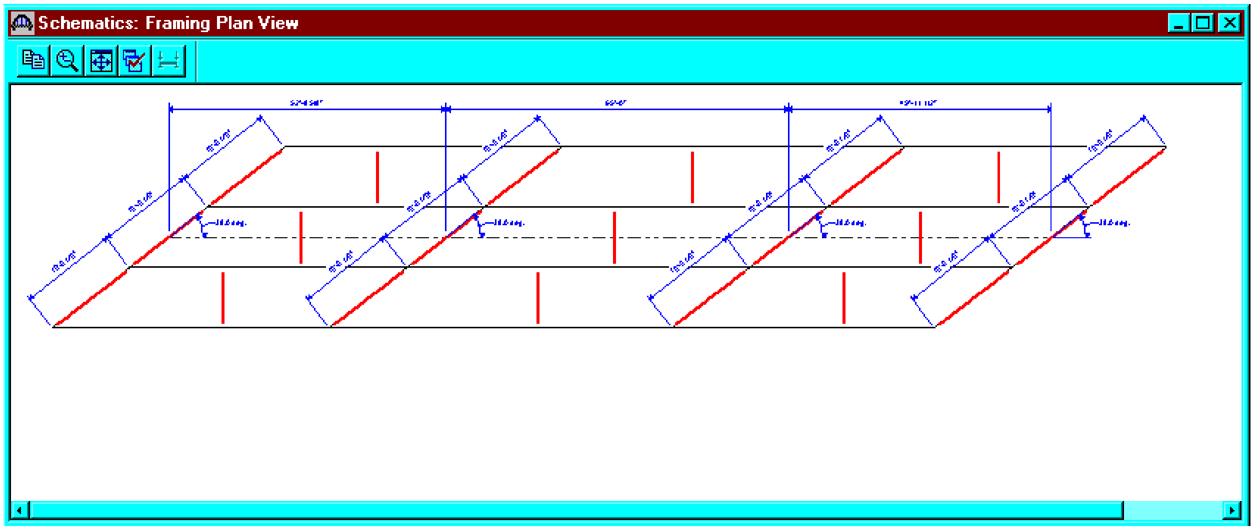
Dead Load:

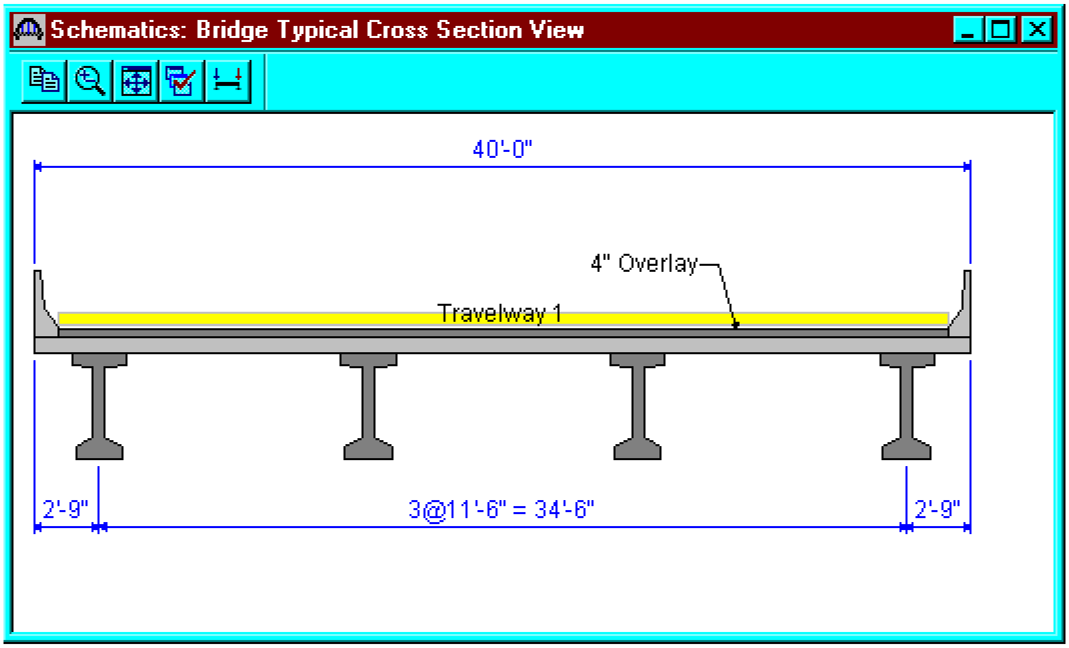
Intermediate Diaphragm = ((2)*(8/12)*(11.5) – (630/2)*(1/144)*(0.67))*(0.15)
= 2.09 kips Use 2.1 kips

Abutment Diaphragm = ((2.58)*(56.5/12)*(11.5)*(1/sin38°) – (630/144)*(18/12)*
(1/sin38°))*(0.150)= 32.4 kips
Use 32.0 kips

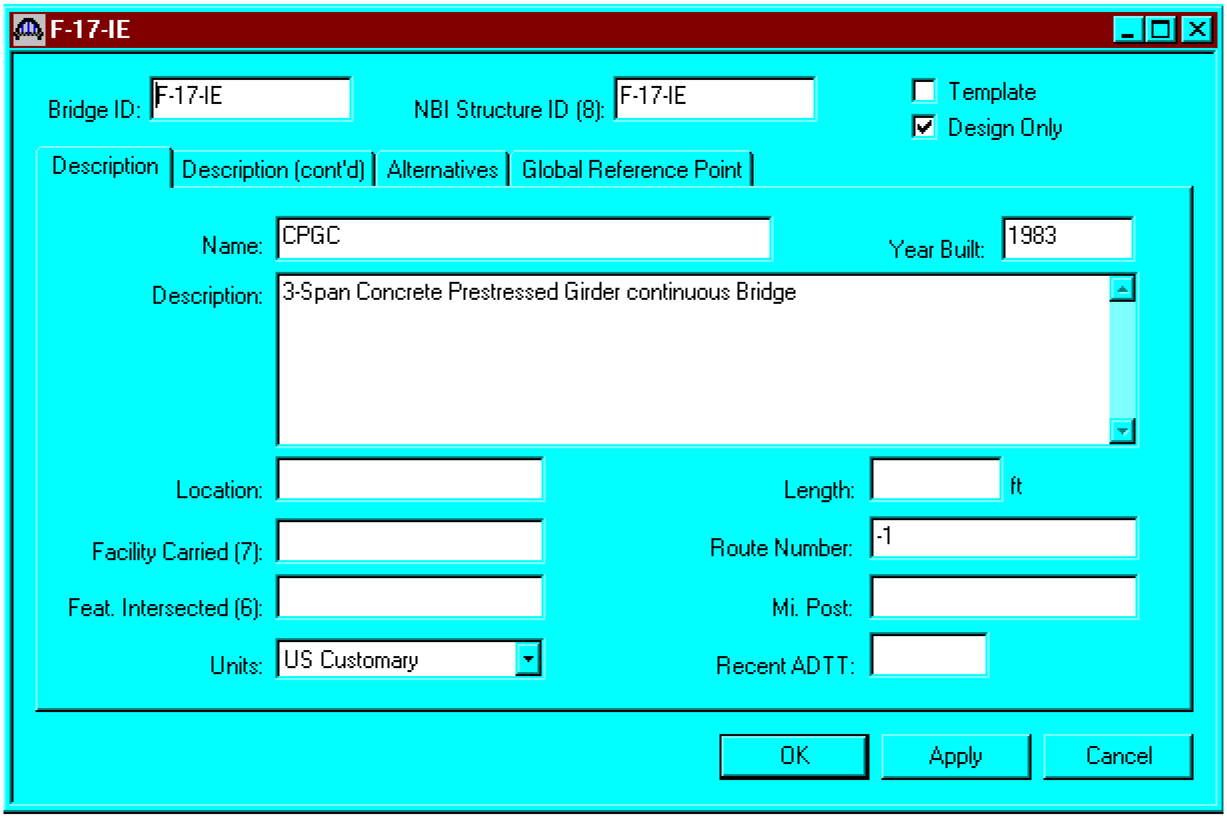
Pier Diaphragm = ((3.50)*(56.5/12)*(11.5)*(1/sin38°) – (630/144)*(29/12)*
(1/sin38°))*(0.150)= 43.6 kips
Use 44.0 kips

Virtis Bridge Rating Example, Structure No. F-17-IE (contd.)





From the bridge explorer, create a new bridge and enter the following information.



Bridge ID: F-17-IE

NBI Structure ID (8): F-17-IE

☐ Template

☑ Design Only

Name: CPGC

Year Built: 1983

Description: 3-Span Concrete Prestressed Girder continuous Bridge

Location:

Length: ft

Facility Carried (7):

Route Number: -1

Feat. Intersected (6):

Mi. Post:

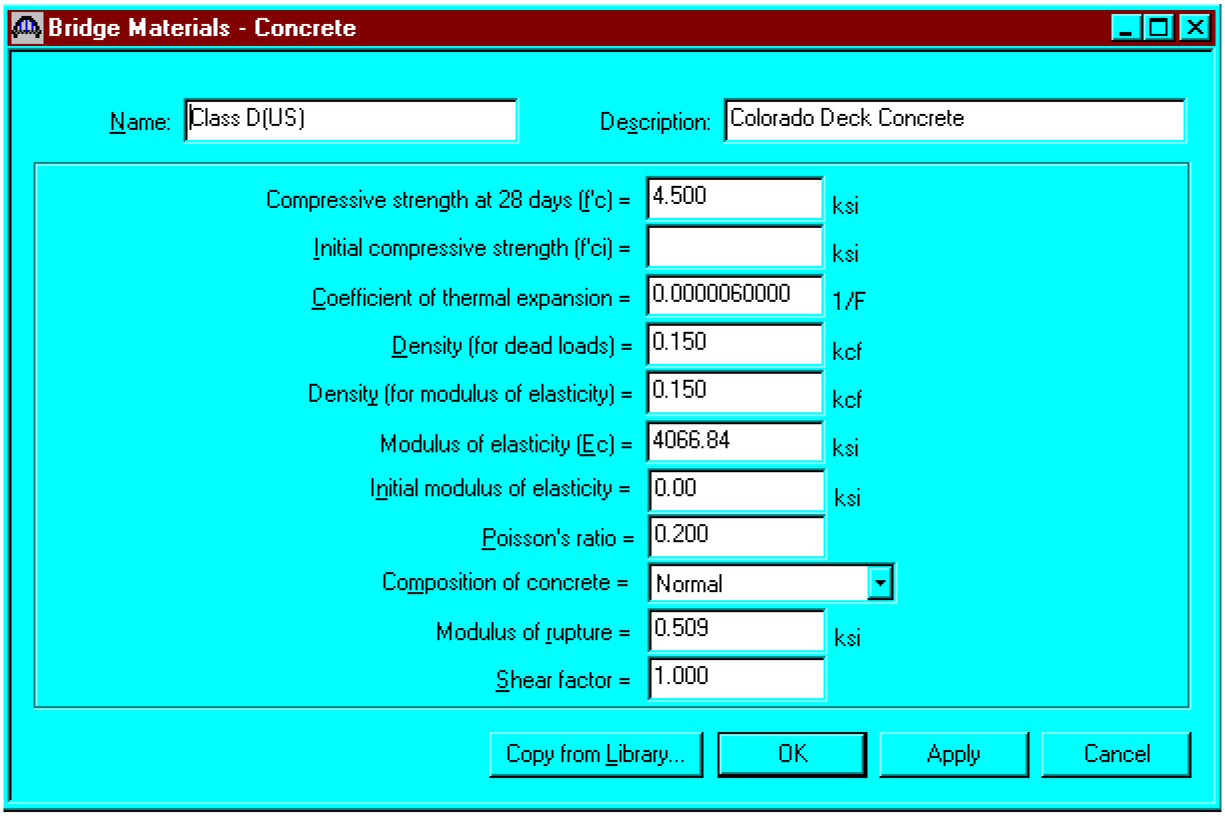
Units: US Customary

Recent ADTT:

Click OK. This saves the data to memory and closes the window.

NOTE: Since Virtis uses a common/shared database; it is required that users of this program create a folder from the bridge explorer window **(EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Deck Concrete from the library. Click OK and the following window will open. Click OK to save this deck concrete material to memory and close the window.



Bridge Materials - Concrete

Name: Class D(US)

Description: Colorado Deck Concrete

Compressive strength at 28 days (f'c) = 4.500 ksi

Initial compressive strength (f'ci) = ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.150 kcf

Density (for modulus of elasticity) = 0.150 kcf

Modulus of elasticity (Ec) = 4066.84 ksi

Initial modulus of elasticity = 0.00 ksi

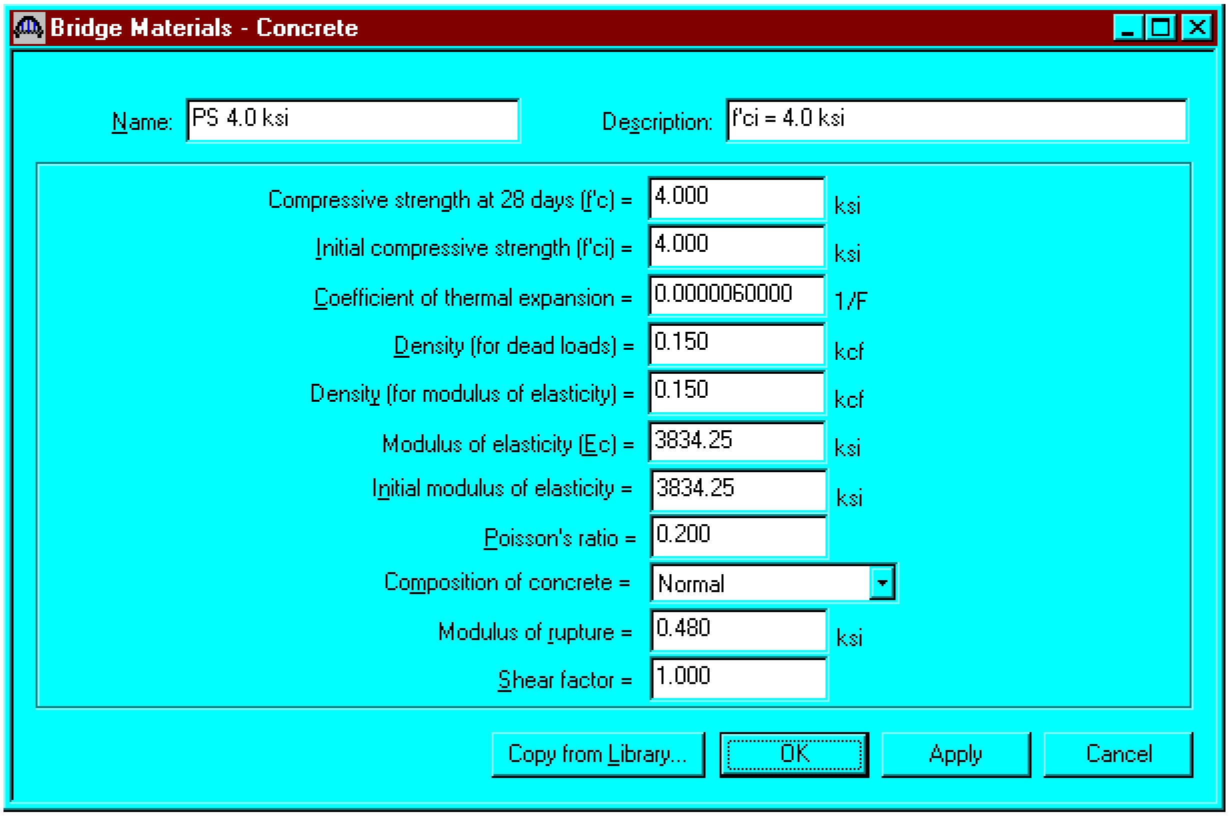
Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.509 ksi

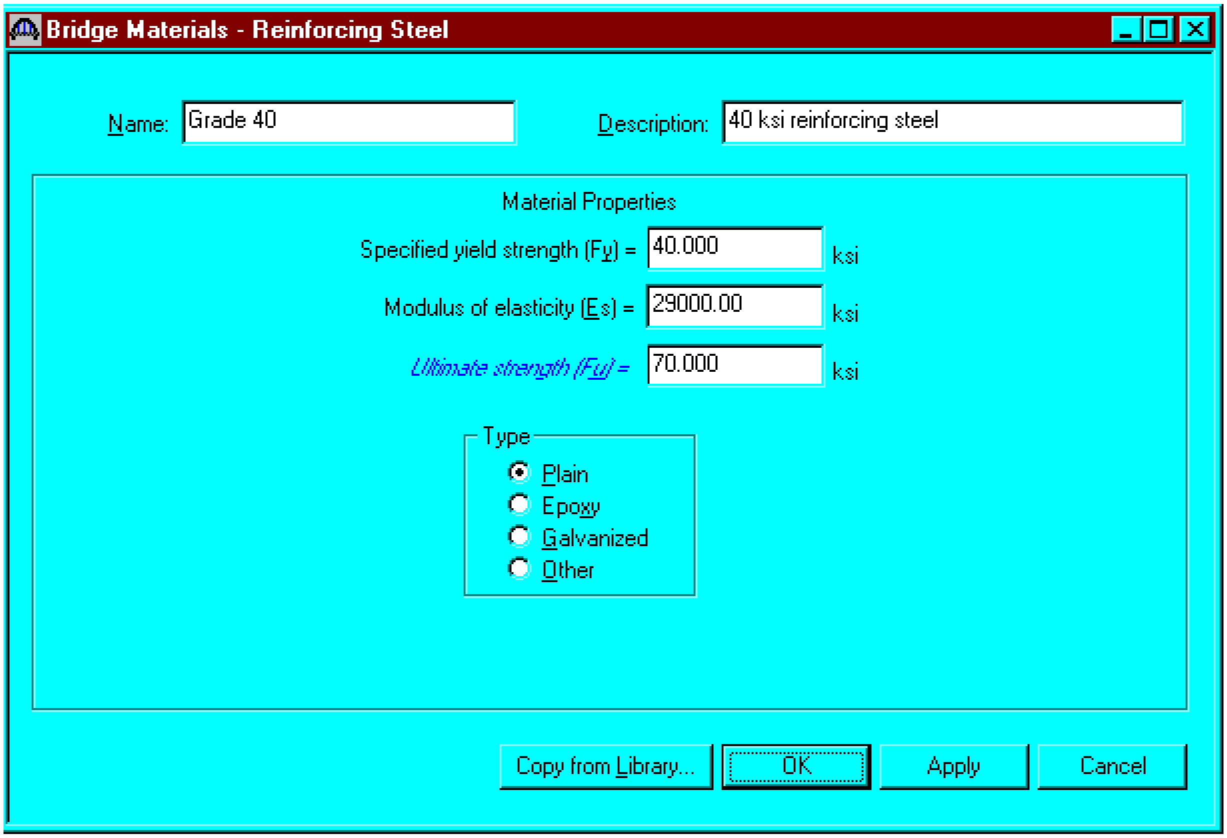
Shear factor = 1.000

Using the same techniques, create a new concrete material to be used for the girder.



Name: PS 4.0 ksi
Description: f'ci = 4.0 ksi
Compressive strength at 28 days (f'c) = 4.000 ksi
Initial compressive strength (f'ci) = 4.000 ksi
Coefficient of thermal expansion = 0.0000060000 1/F
Density (for dead loads) = 0.150 kcf
Density (for modulus of elasticity) = 0.150 kcf
Modulus of elasticity (Ec) = 3834.25 ksi
Initial modulus of elasticity = 3834.25 ksi
Poisson's ratio = 0.200
Composition of concrete = Normal
Modulus of rupture = 0.480 ksi
Shear factor = 1.000

Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.



Name: Grade 40

Description: 40 ksi reinforcing steel

Material Properties

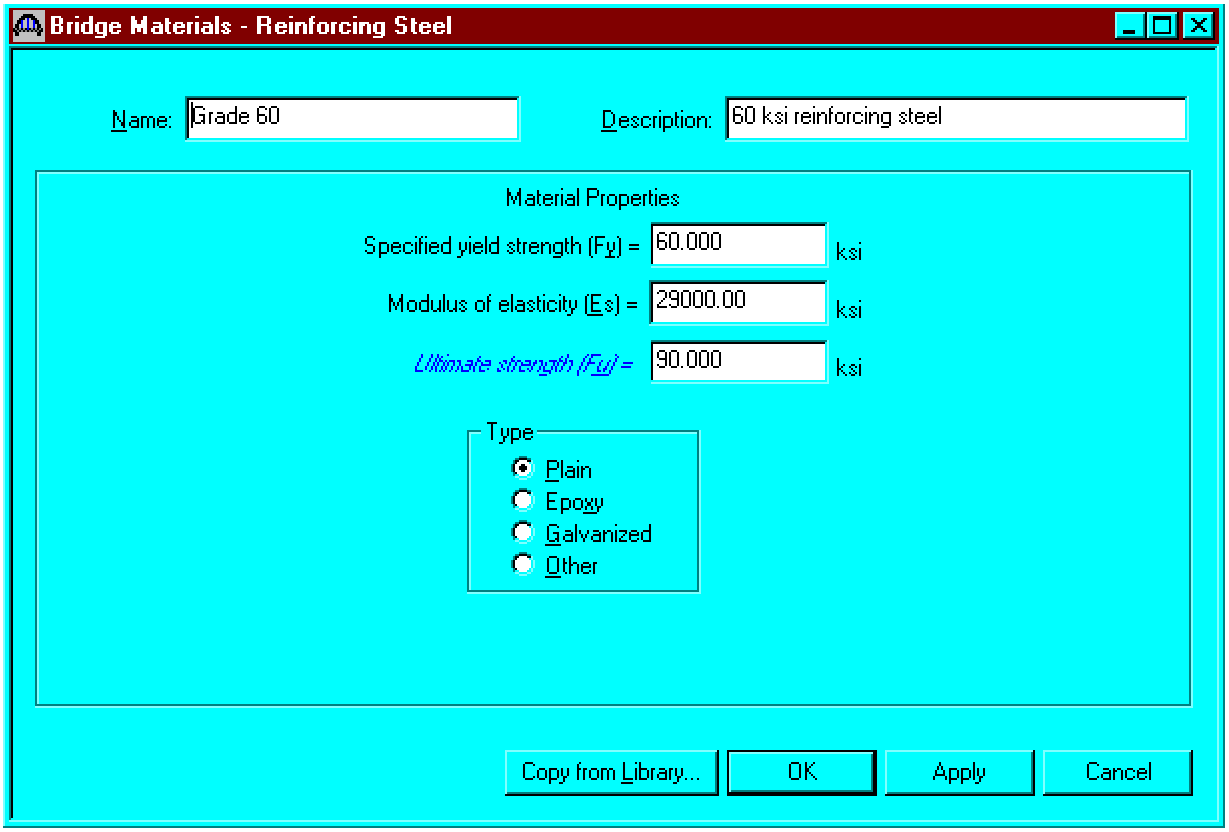
Specified yield strength (Fy) = 40.000 ksi

Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 70.000 ksi

Type

● Plain
○ Epoxy
○ Galvanized
○ Other



Name: Grade 60

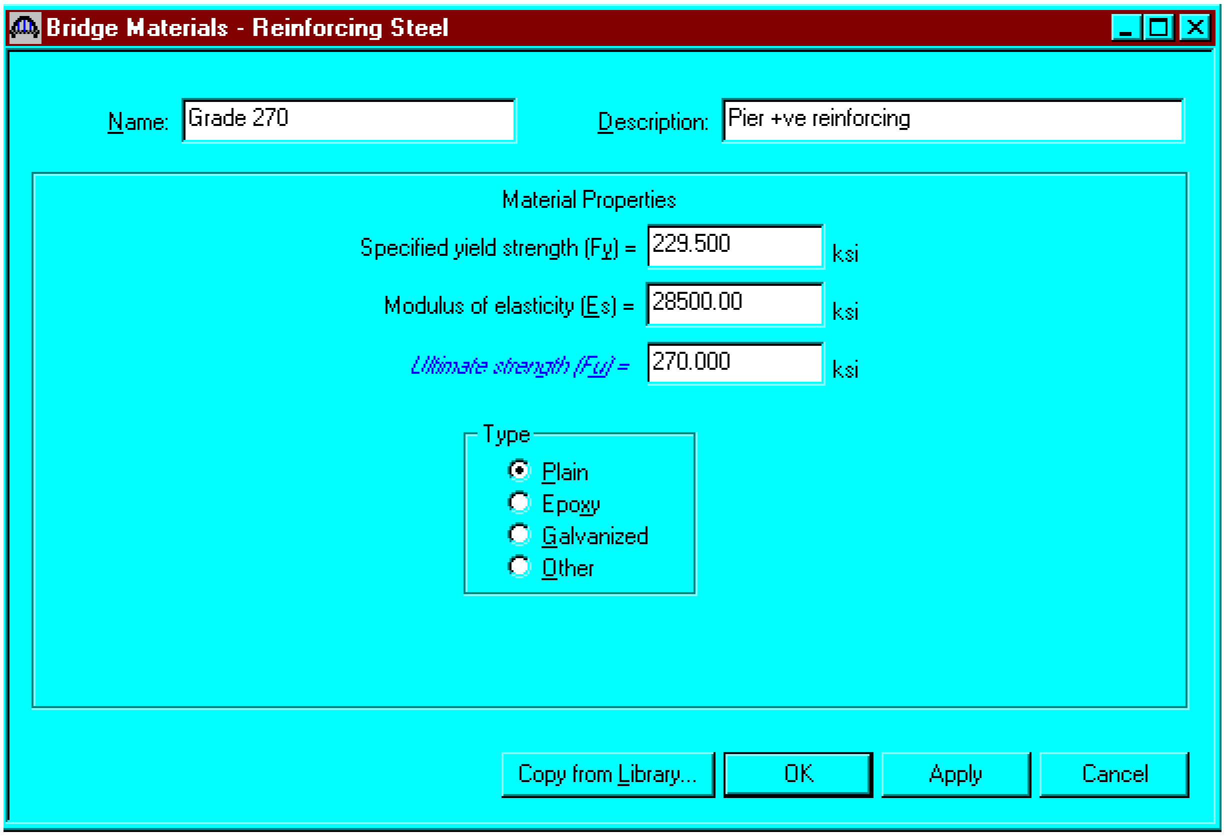
Description: 60 ksi reinforcing steel

Specified yield strength (Fy) = 60.000 ksi

Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 90.000 ksi

Type:
- ● Plain
- ○ Epoxy
- ○ Galvanized
- ○ Other



Name: Grade 270

Description: Pier +ve reinforcing

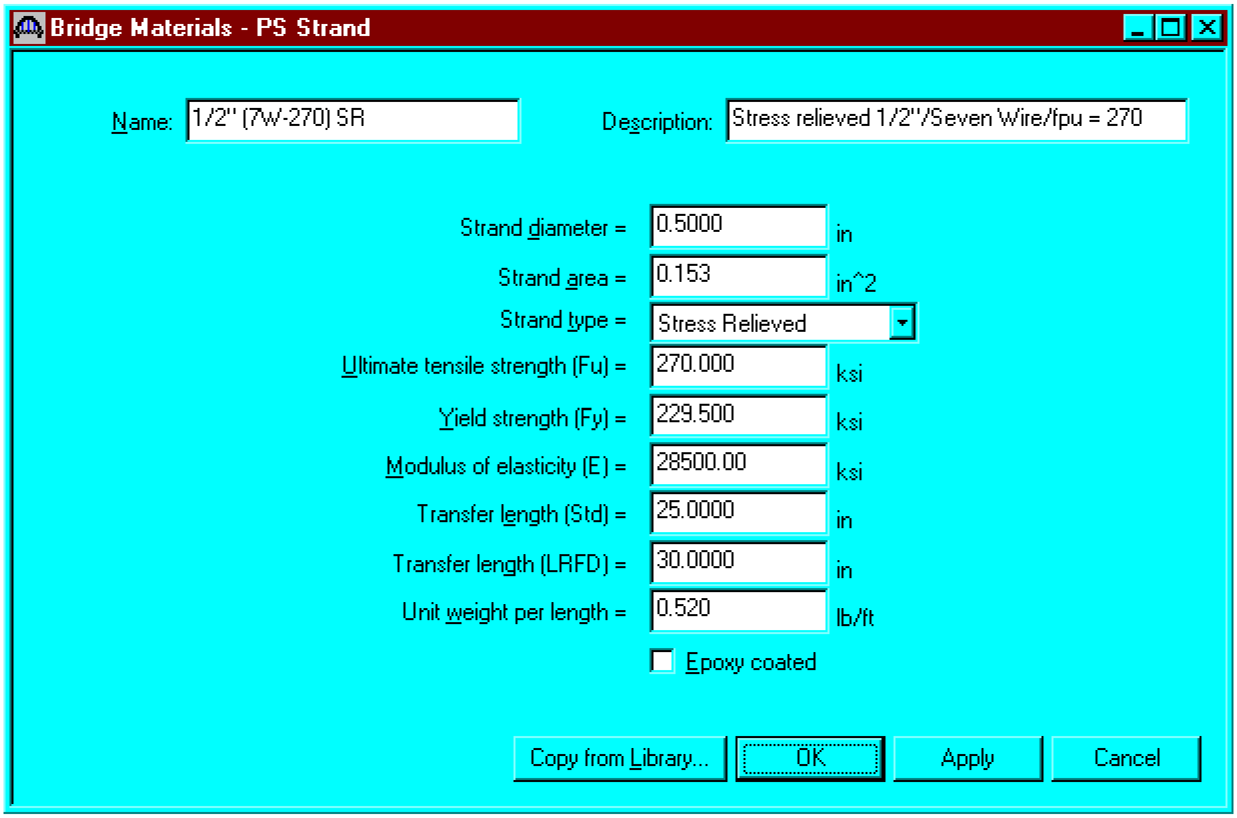
Material Properties

Specified yield strength (Fy) = 229.500 ksi

Modulus of elasticity (Es) = 28500.00 ksi

Ultimate strength (Fu) = 270.000 ksi

Type
- ● Plain
- ○ Epoxy
- ○ Galvanized
- ○ Other



Name: 1/2" (7W-270) SR

Description: Stress relieved 1/2"/Seven Wire/fpu = 270

Strand diameter = 0.5000 in

Strand area = 0.153 in^2

Strand type = Stress Relieved

Ultimate tensile strength (Fu) = 270.000 ksi

Yield strength (Fy) = 229.500 ksi

Modulus of elasticity (E) = 28500.00 ksi

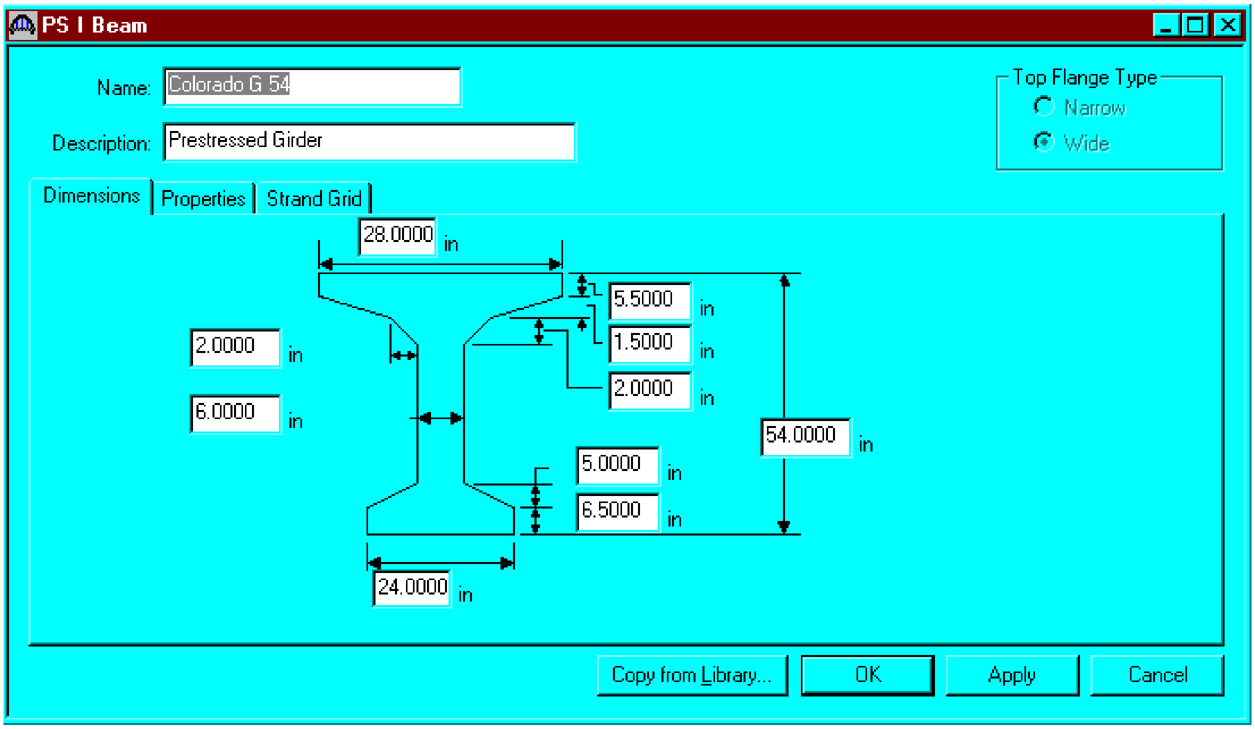
Transfer length (Std) = 25.0000 in

Transfer length (LRFD) = 30.0000 in

Unit weight per length = 0.520 lb/ft

☐ Epoxy coated

Expand the tree labeled Beam Shapes to enter a prestressed beam shape to be used in the analysis. Click on Prestressed Beam Shapes and I Beams in the tree and select File/New from the menu (or right mouse click on I Beam and select New). Click on the copy from library button or fill in the blanks.



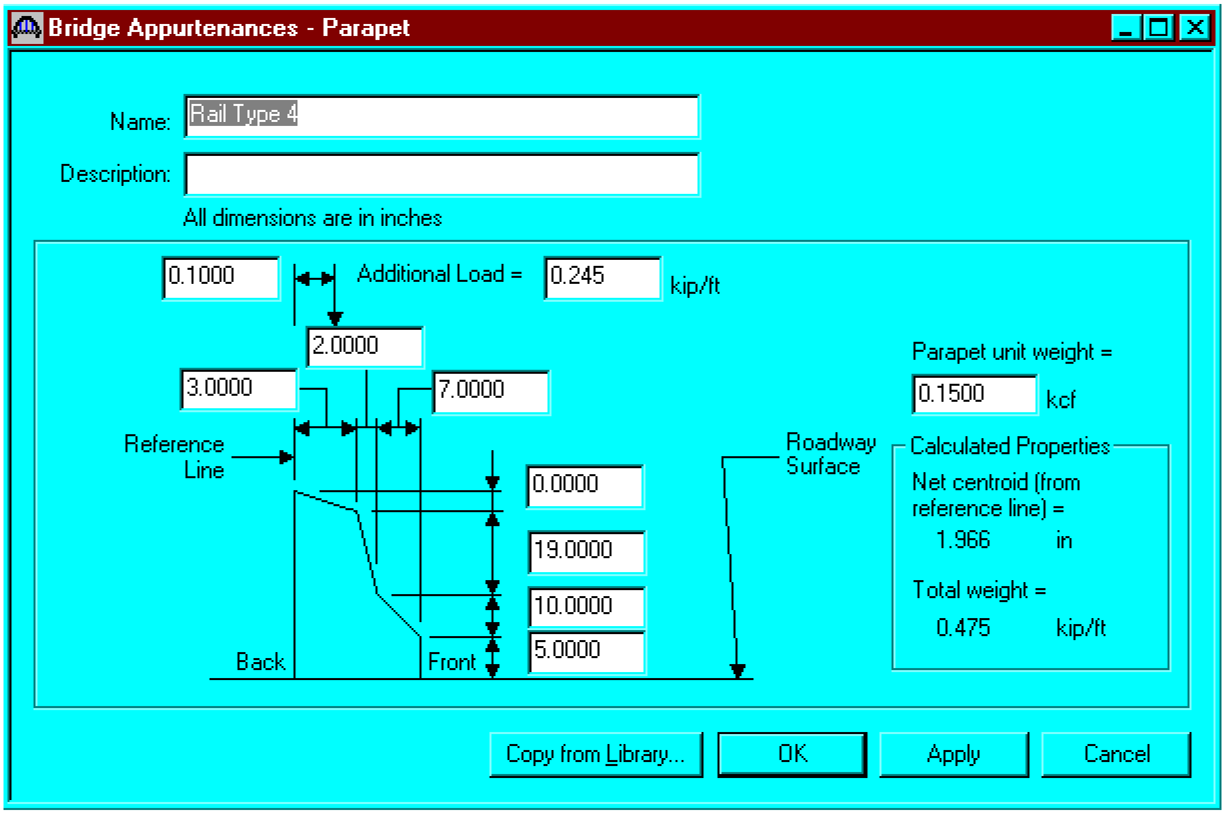
Name: Colorado G 54

Description: Prestressed Girder

Top Flange Type
○ Narrow
● Wide

Click OK to save to the memory and close the window.

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, select New and click copy from Library button. Select the Jersey Barrier and click OK. The parapet properties are copied to parapet window as shown below. Click OK to save the data to memory and close the window.



Name: Rail Type 4

Description:

All dimensions are in inches

0.1000

Additional Load = 0.245 kip/ft

2.0000

3.0000

7.0000

0.0000

19.0000

10.0000

5.0000

Parapet unit weight = 0.1500 kcf

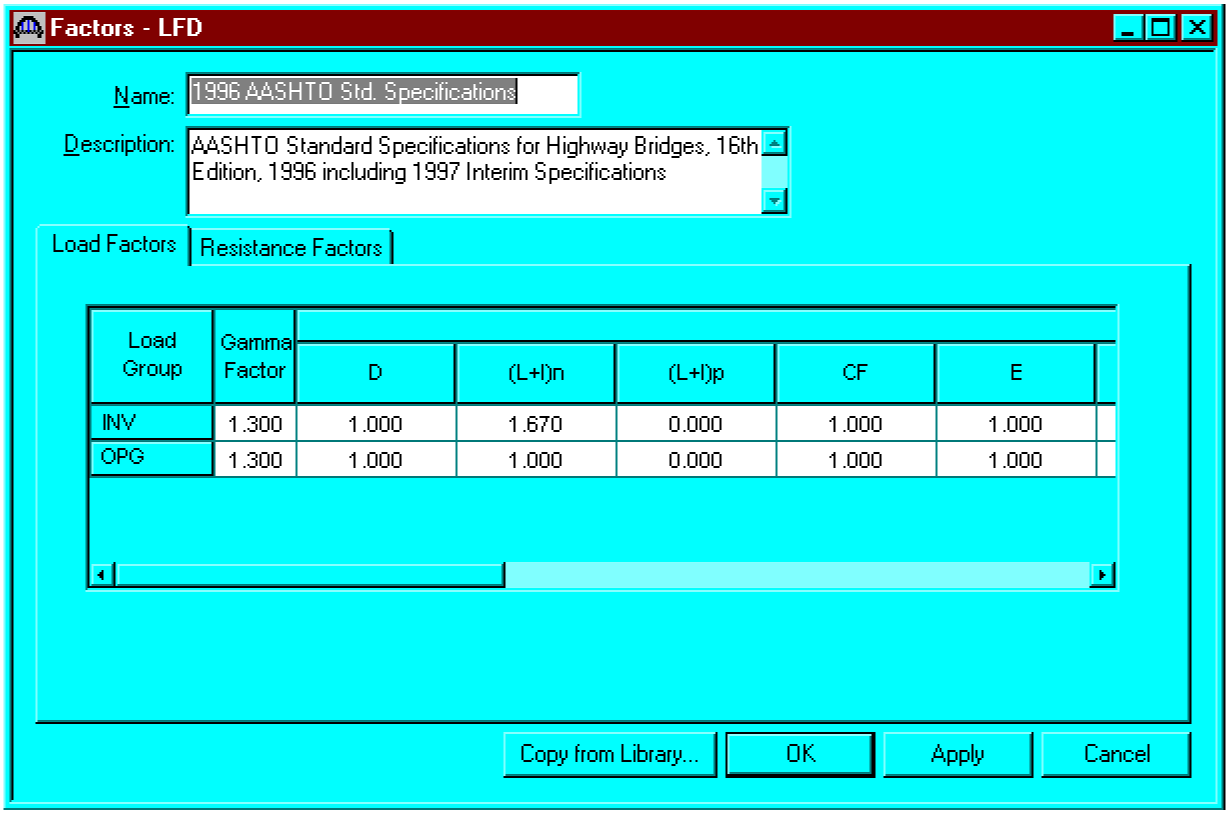
Calculated Properties

Net centroid (from reference line) = 1.966 in

Total weight = 0.475 kip/ft

The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

This window shows the LFD load factors.

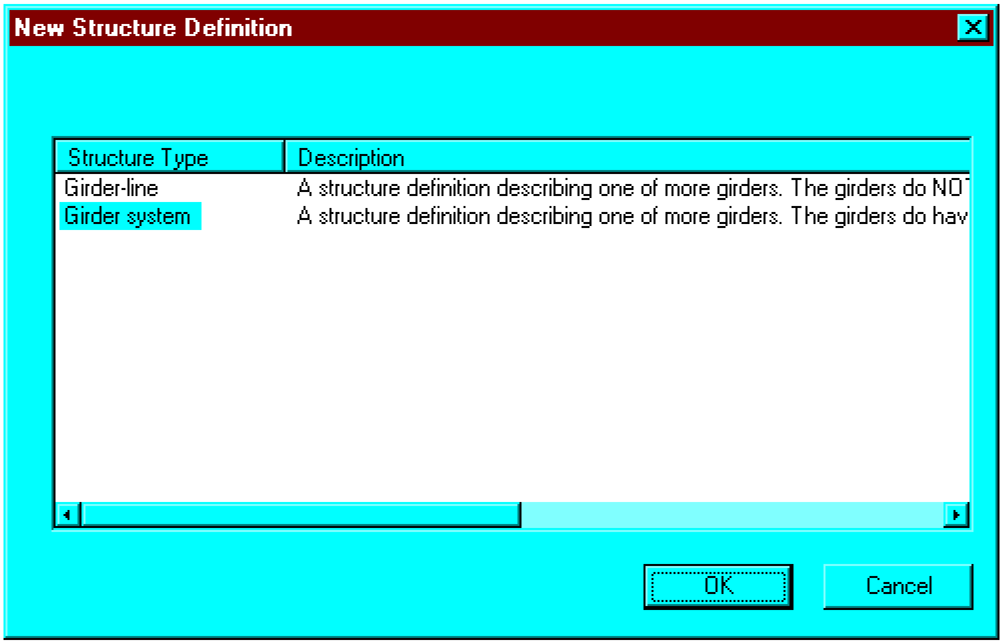


Name: 1996 AASHTO Std. Specifications

Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

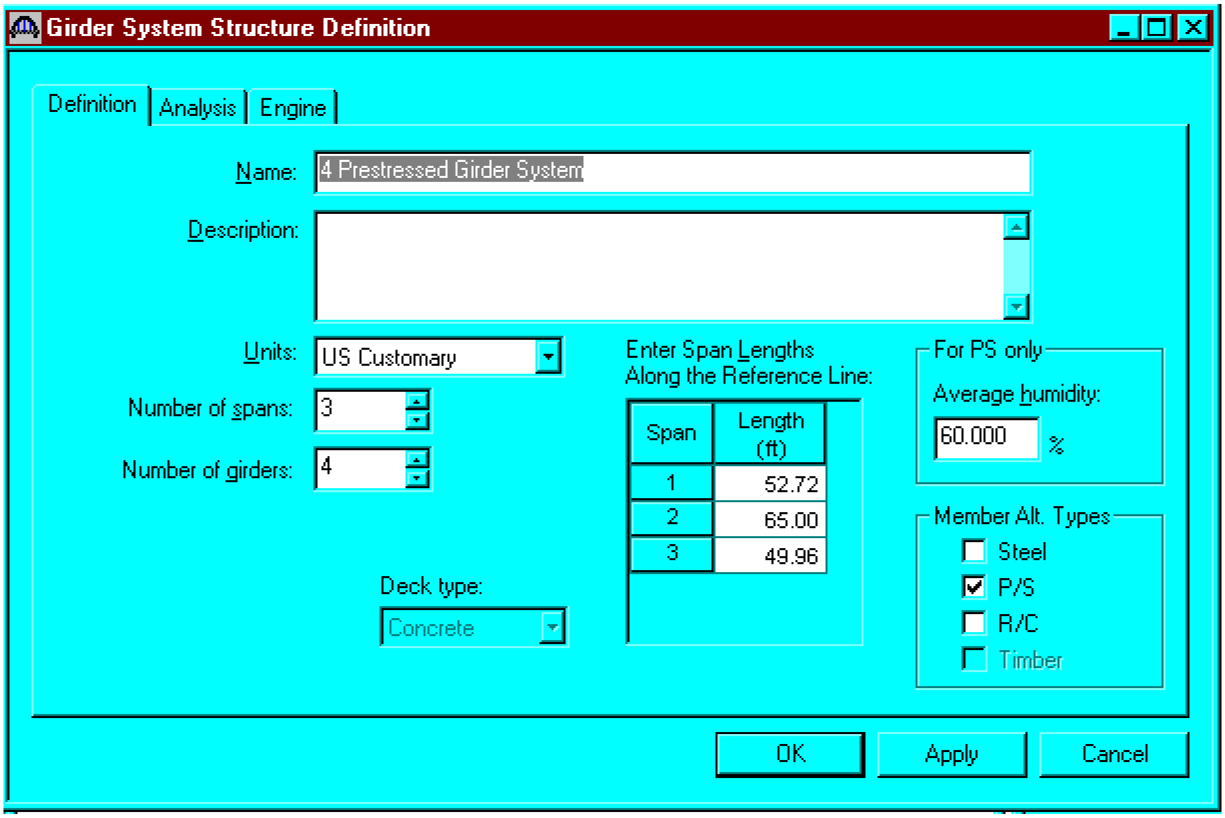
Load Group	Gamma Factor	D	(L+I)n	(L+I)p	CF	E
INV	1.300	1.000	1.670	0.000	1.000	1.000
OPG	1.300	1.000	1.000	0.000	1.000	1.000

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



Structure Type	Description
Girder-line	A structure definition describing one of more girders. The girders do NO
Girder system	A structure definition describing one of more girders. The girders do hav

Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



Name: 4 Prestressed Girder System

Description:

Units: US Customary

Number of spans: 3

Number of girders: 4

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	52.72
2	65.00
3	49.96

For PS only

Average humidity: 60.000 %

Member Alt. Types

☐ Steel

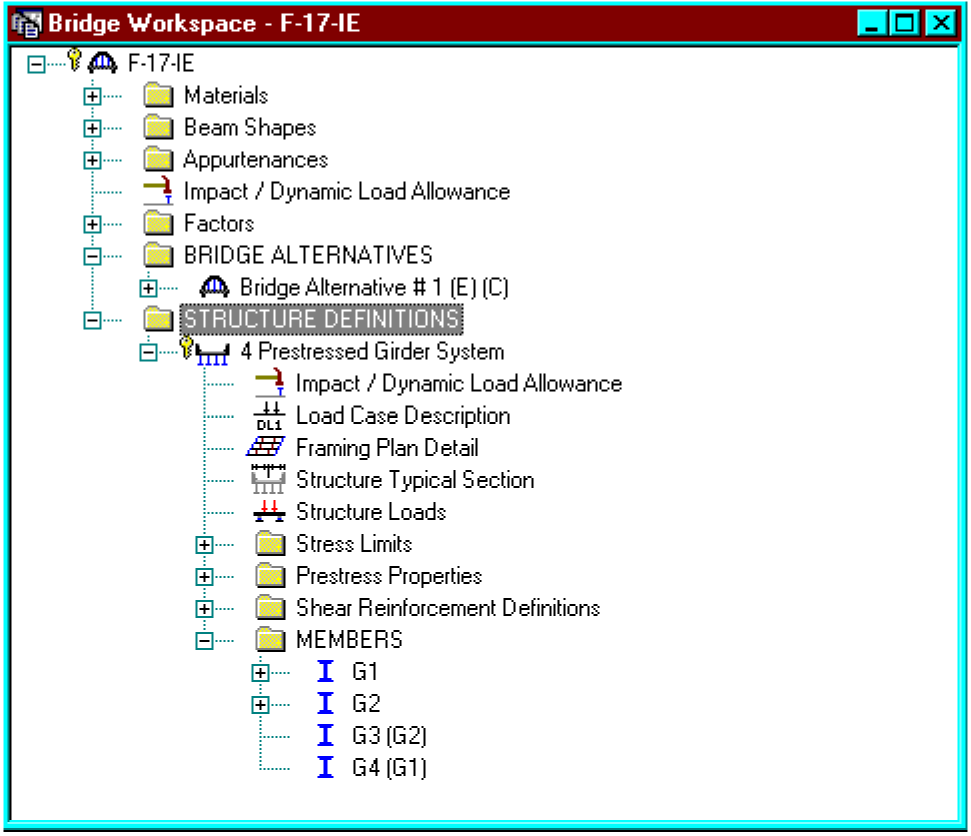
☑ P/S

☐ R/C

☐ Timber

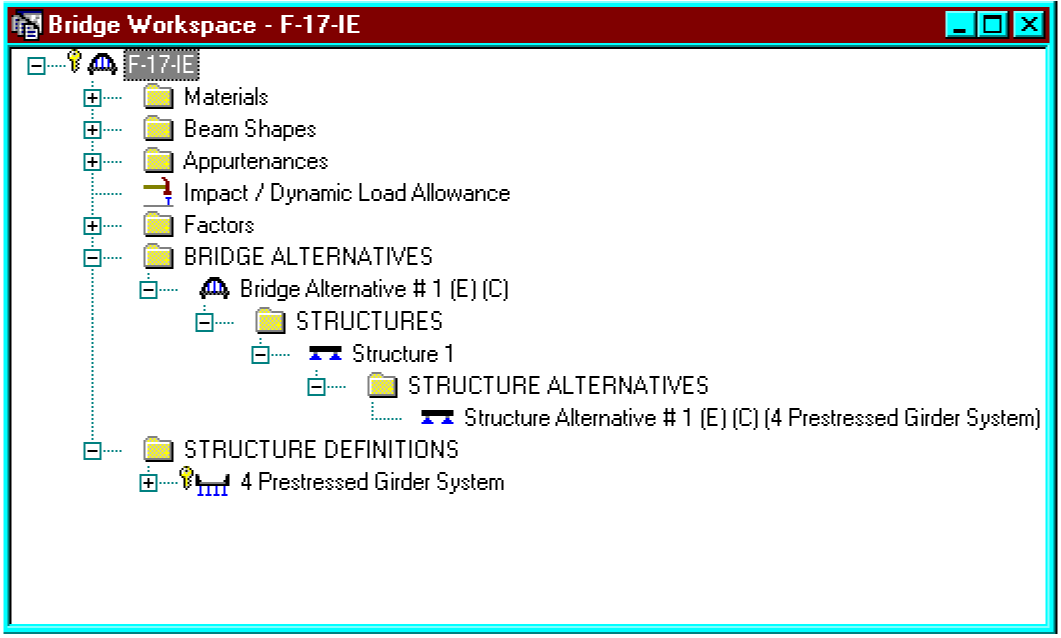
Span lengths for a prestressed girder structure made continuous for live loads shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:

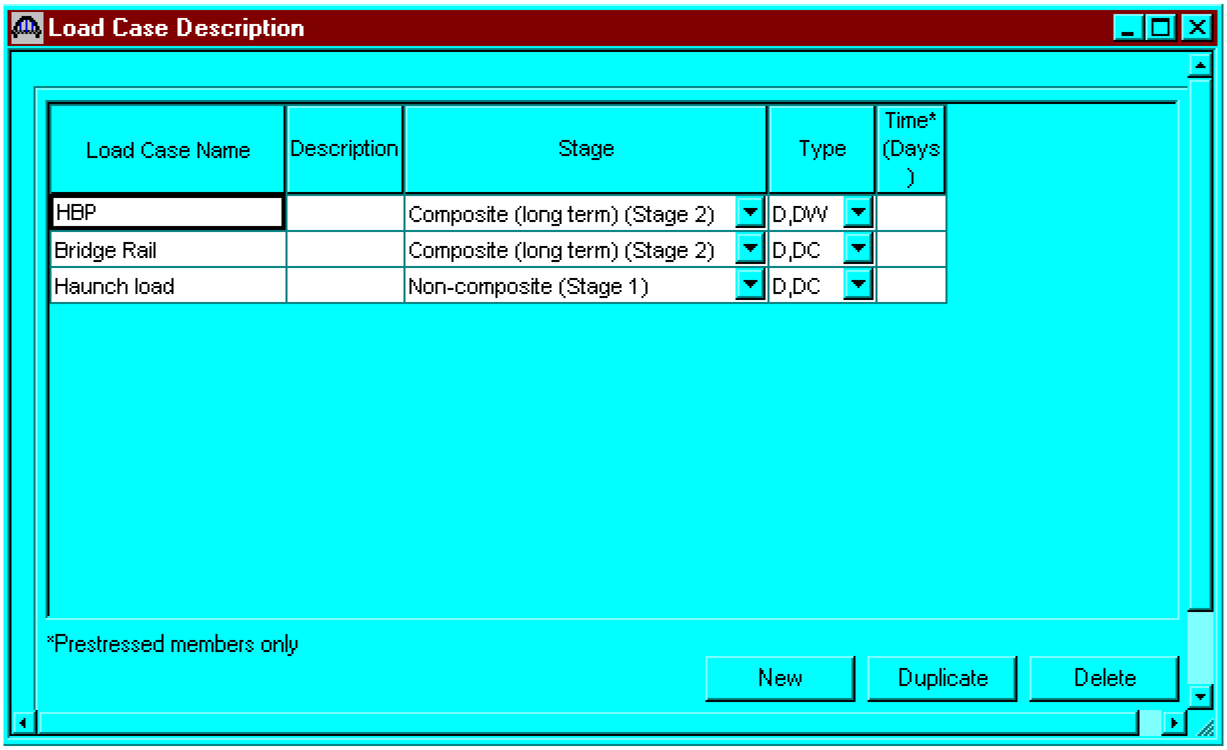


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

The partially expanded Bridge Workspace tree is shown below:



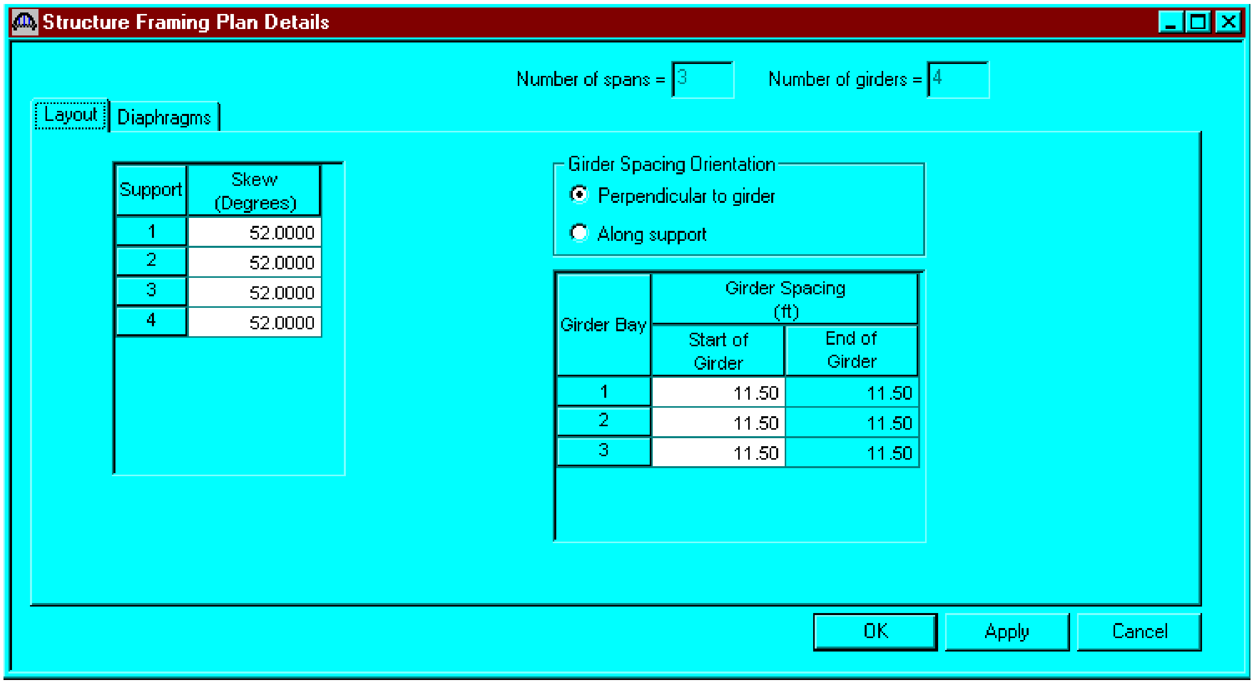
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.



Load Case Name	Description	Stage	Type	Time* (Days)
HBP		Composite (long term) (Stage 2)	D,DW	
Bridge Rail		Composite (long term) (Stage 2)	D,DC	
Haunch load		Non-composite (Stage 1)	D,DC	

*Prestressed members only

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



Number of spans = 3   Number of girders = 4

Support	Skew (Degrees)
1	52.0000
2	52.0000
3	52.0000
4	52.0000

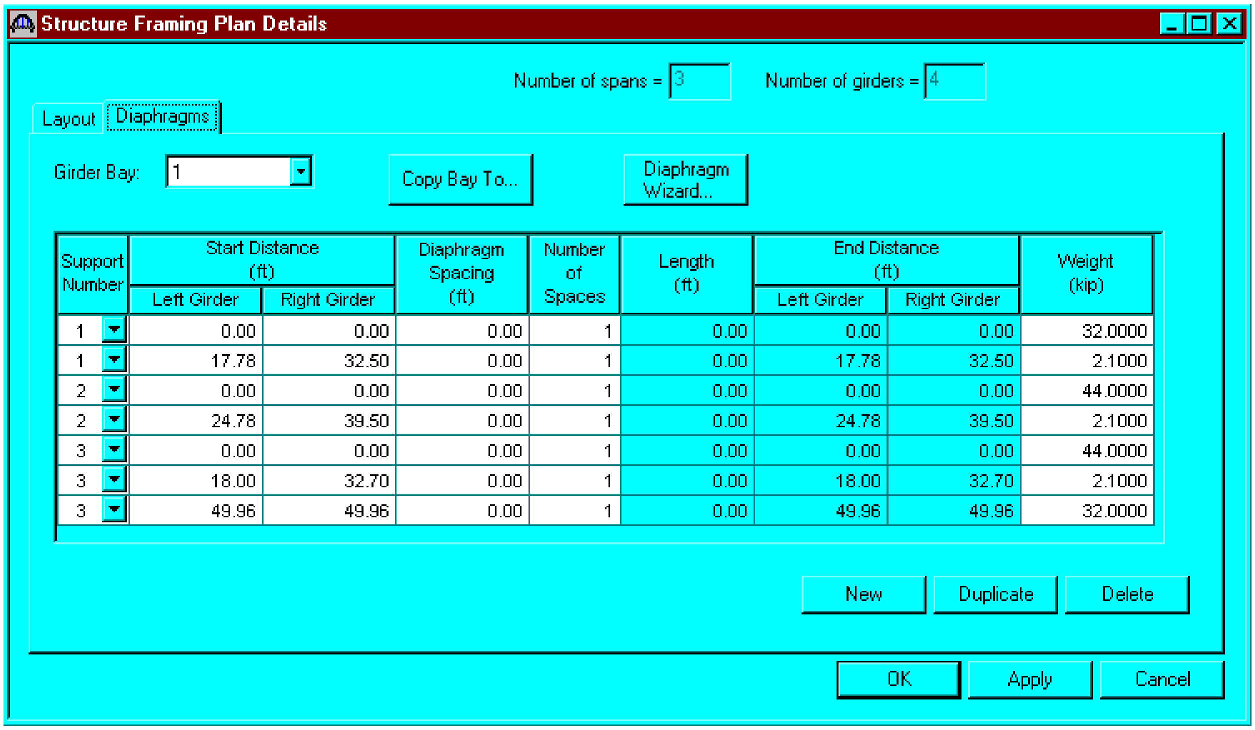
Girder Spacing Orientation

● Perpendicular to girder

○ Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	11.50	11.50
2	11.50	11.50
3	11.50	11.50

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.



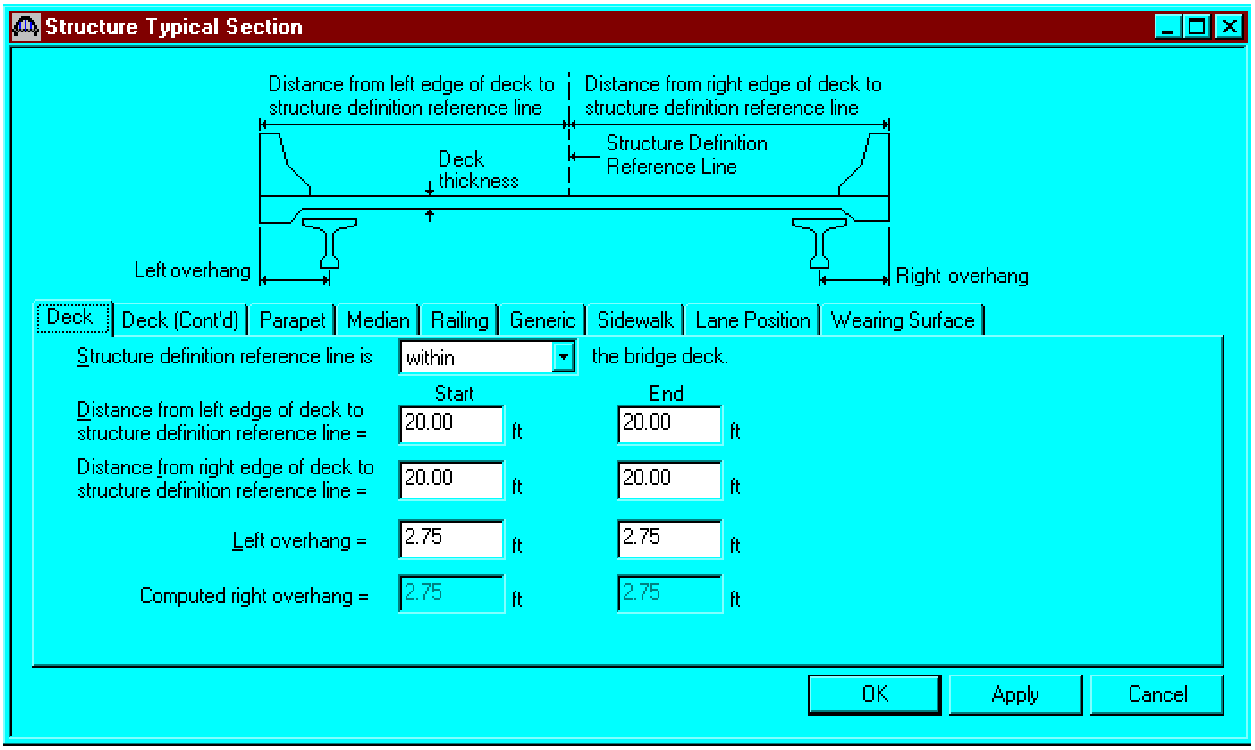
Number of spans = 3

Number of girders = 4

Girder Bay: 1

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	32.0000
1	17.78	32.50	0.00	1	0.00	17.78	32.50	2.1000
2	0.00	0.00	0.00	1	0.00	0.00	0.00	44.0000
2	24.78	39.50	0.00	1	0.00	24.78	39.50	2.1000
3	0.00	0.00	0.00	1	0.00	0.00	0.00	44.0000
3	18.00	32.70	0.00	1	0.00	18.00	32.70	2.1000
3	49.96	49.96	0.00	1	0.00	49.96	49.96	32.0000

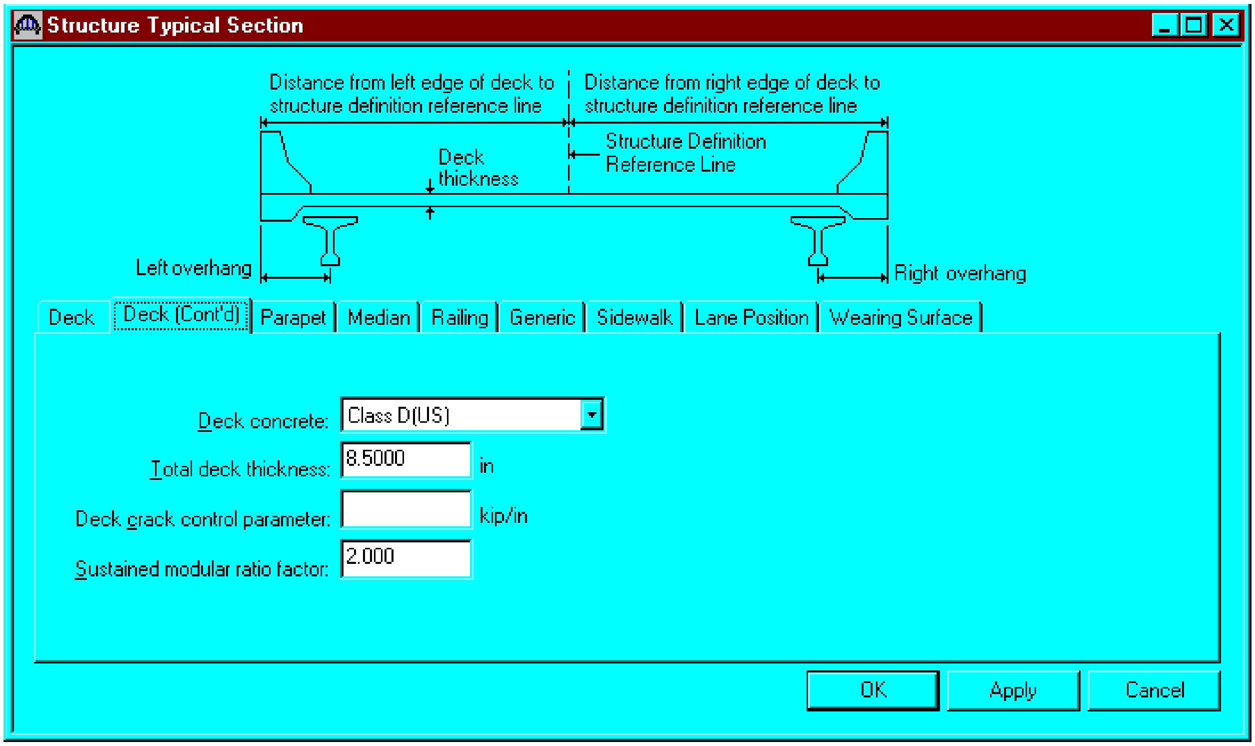
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



Structure definition reference line is within the bridge deck.

	Start		End	
Distance from left edge of deck to structure definition reference line =	20.00	ft	20.00	ft
Distance from right edge of deck to structure definition reference line =	20.00	ft	20.00	ft
Left overhang =	2.75	ft	2.75	ft
Computed right overhang =	2.75	ft	2.75	ft

The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



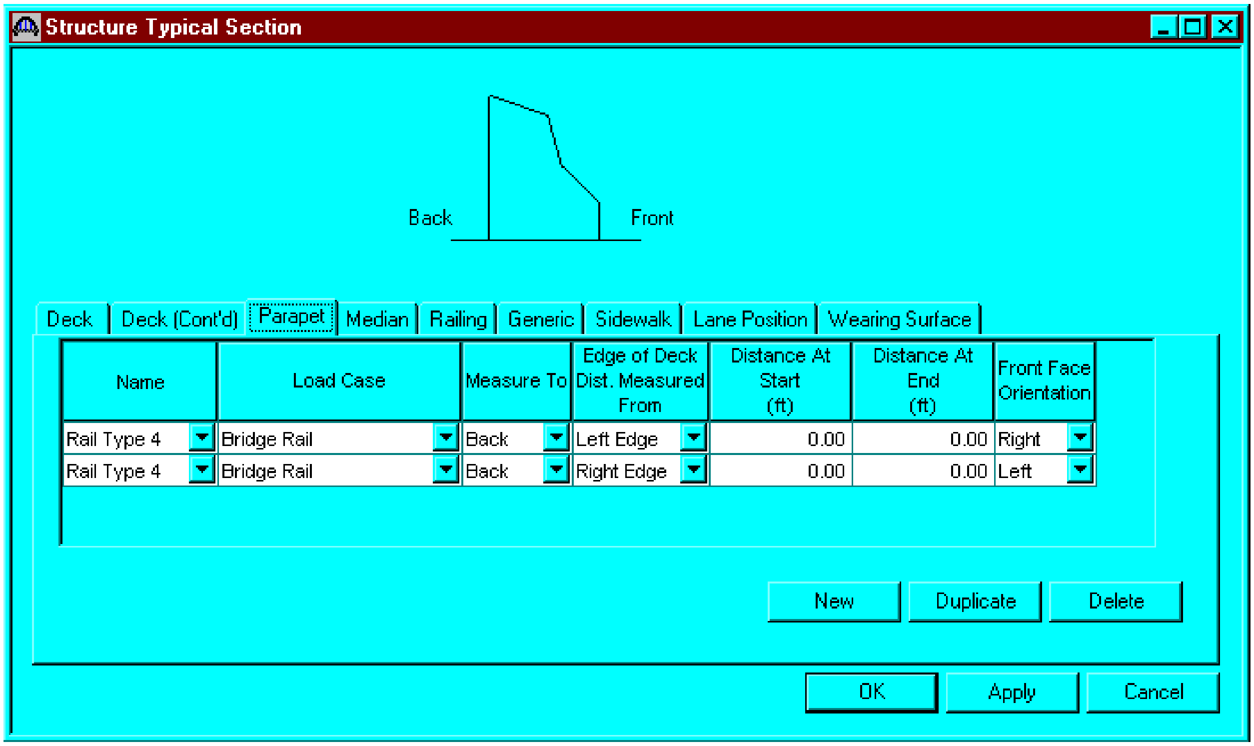
Deck concrete: Class D(US)

Total deck thickness: 8.5000 in

Deck crack control parameter: kip/in

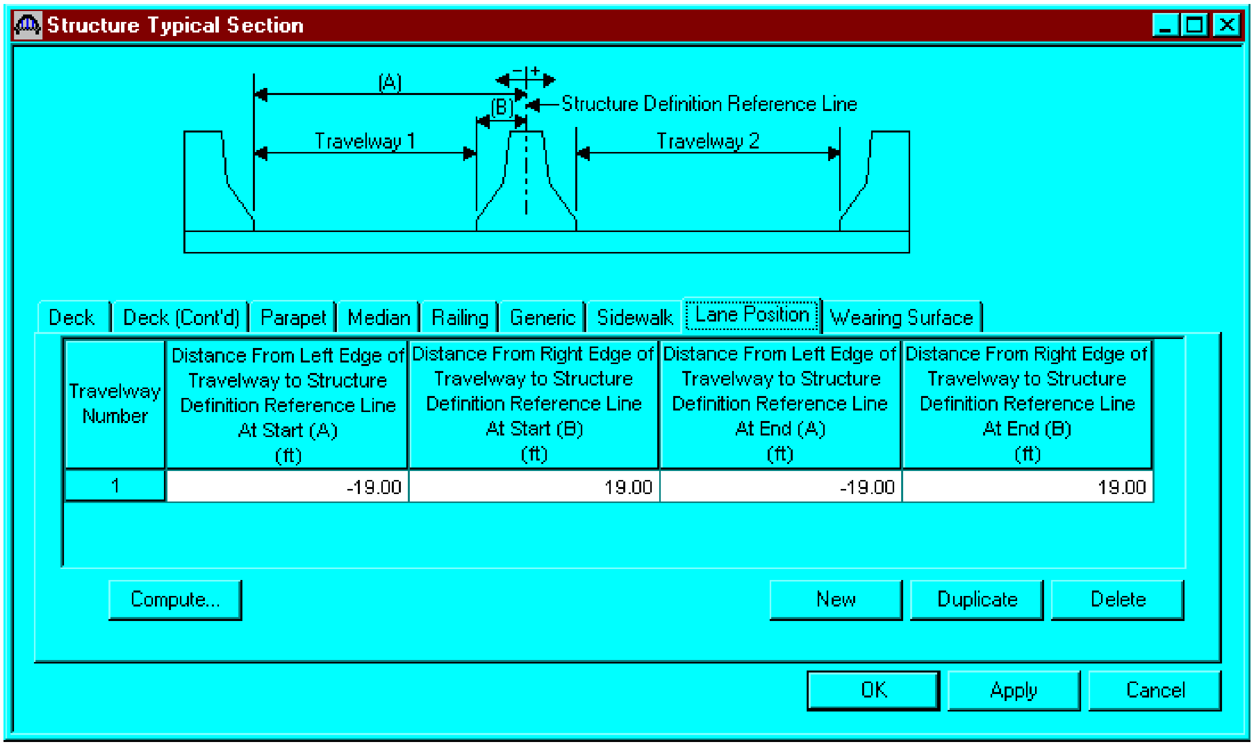
Sustained modular ratio factor: 2.000

Parapets:
Add two parapets as shown below.



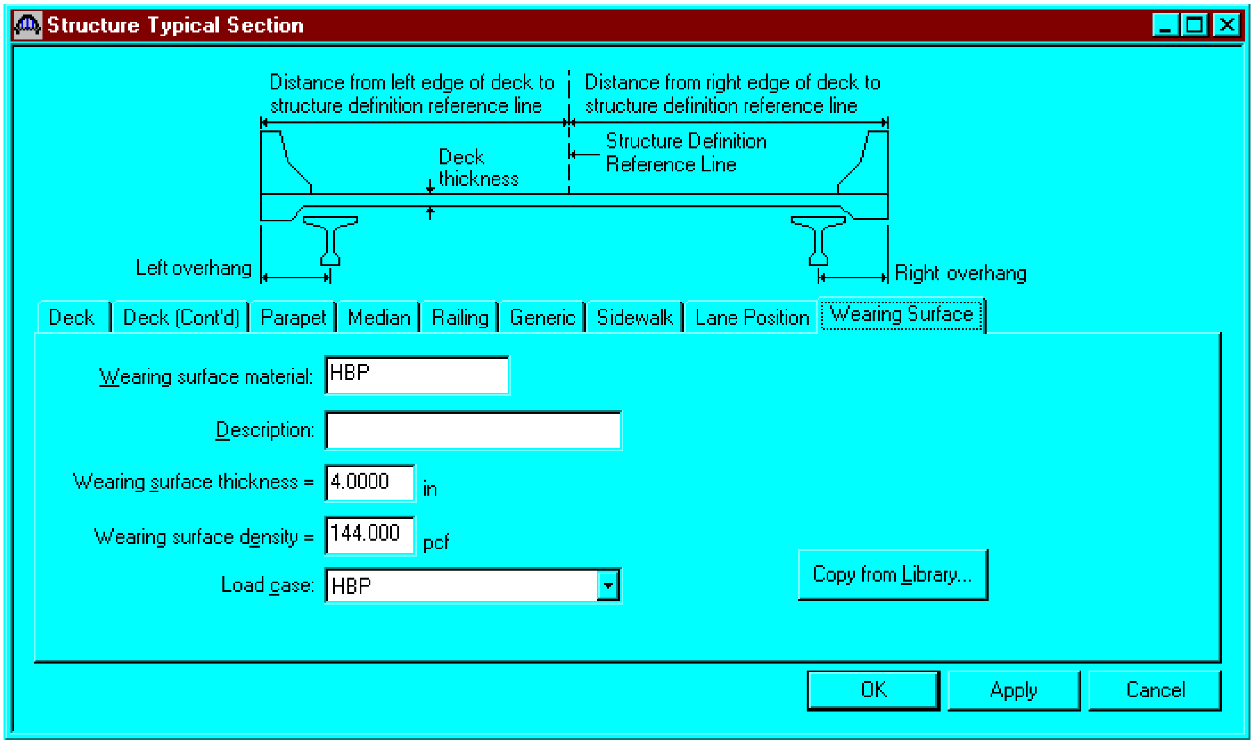
Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Rail Type 4	Bridge Rail	Back	Left Edge	0.00	0.00	Right
Rail Type 4	Bridge Rail	Back	Right Edge	0.00	0.00	Left

Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to accept the computed values. The Lane Position tab is populated as shown below.



Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At End (B) (ft)
1	-19.00	19.00	-19.00	19.00

Enter the following wearing surface information on the Wearing Surface tab.



Wearing surface material: HBP

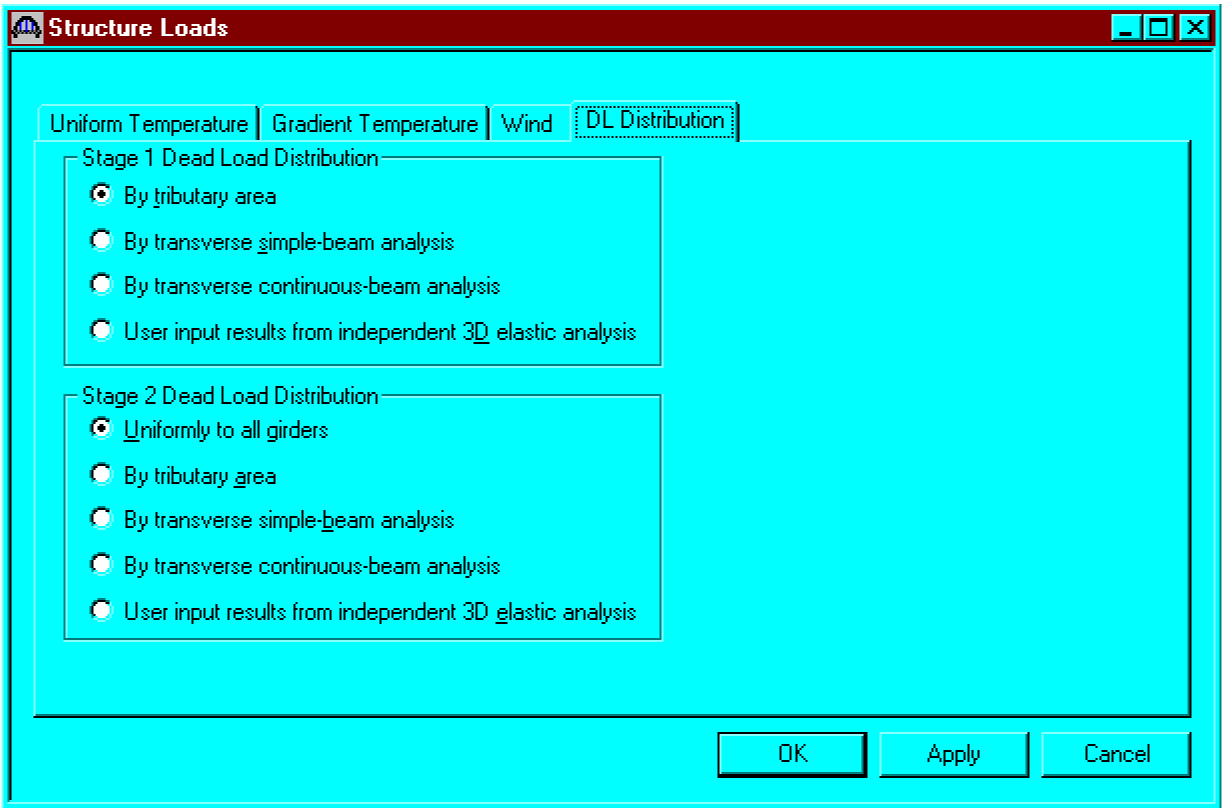
Description:

Wearing surface thickness = 4.0000 in

Wearing surface density = 144.000 pcf

Load case: HBP

Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



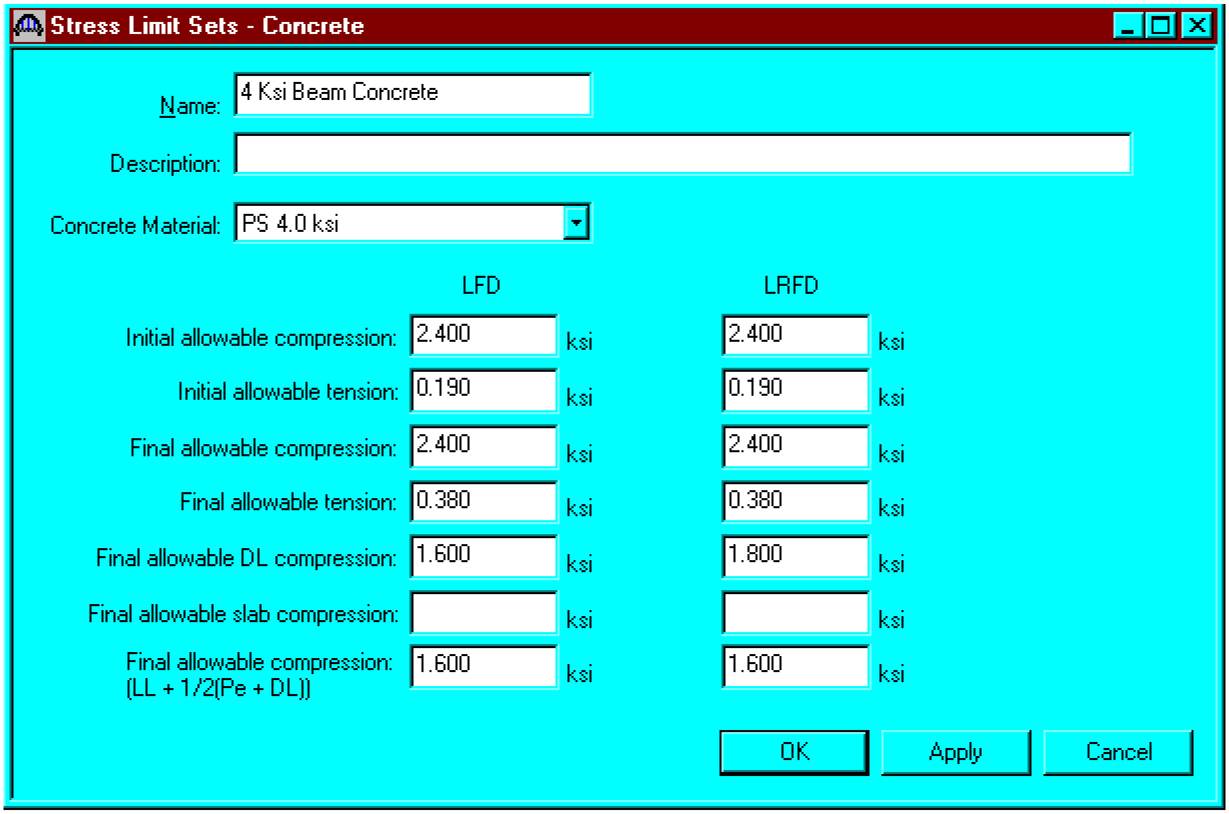
Stage 1 Dead Load Distribution

- ● By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

Stage 2 Dead Load Distribution

- ● Uniformly to all girders
- ○ By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the “PS 4.0 ksi” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.


Stress Limit Sets - Concrete

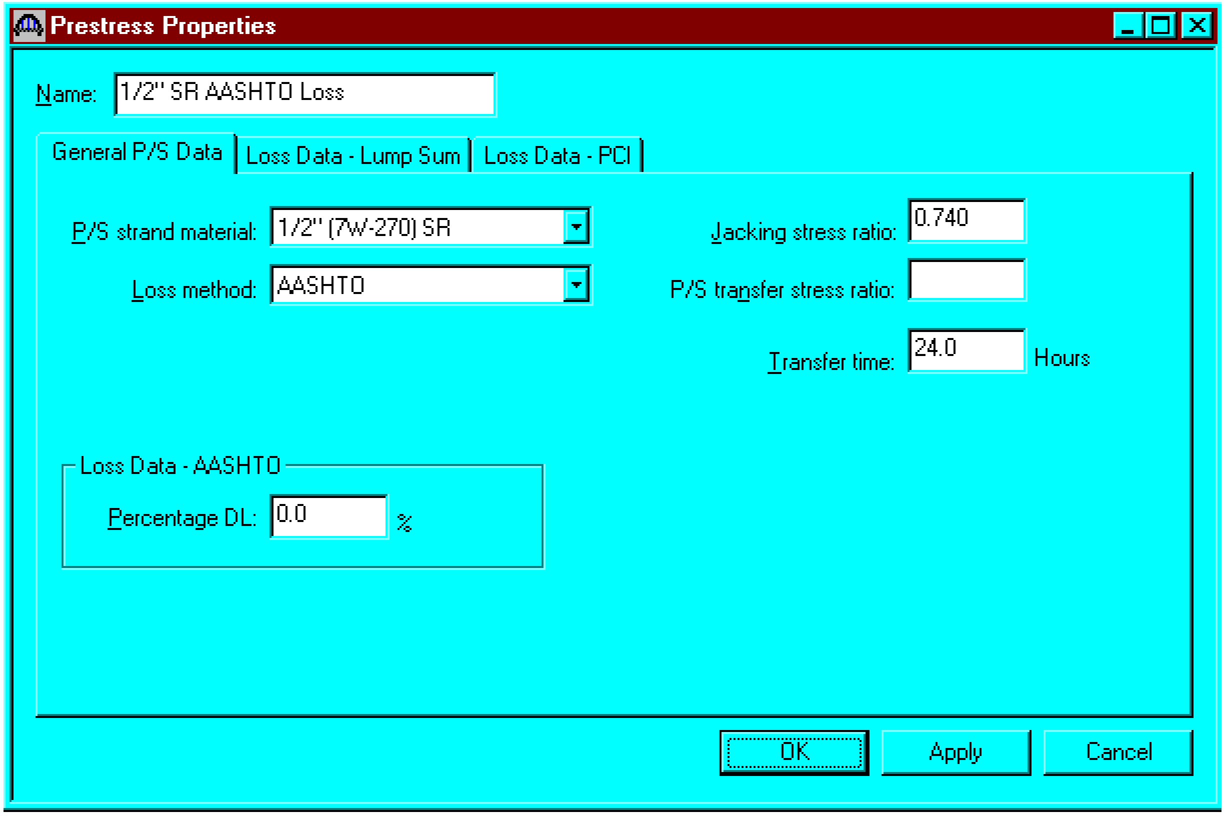
Name: 4 Ksi Beam Concrete

Description:

Concrete Material: PS 4.0 ksi

	LFD		LRFD	
Initial allowable compression:	2.400	ksi	2.400	ksi
Initial allowable tension:	0.190	ksi	0.190	ksi
Final allowable compression:	2.400	ksi	2.400	ksi
Final allowable tension:	0.380	ksi	0.380	ksi
Final allowable DL compression:	1.600	ksi	1.800	ksi
Final allowable slab compression:		ksi		ksi
Final allowable compression: (LL + 1/2(Pe + DL))	1.600	ksi	1.600	ksi

Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the “General P/S Data” tab is required. Click OK to save to memory and close the window.



Name: 1/2" SR AASHTO Loss

P/S strand material: 1/2" (7W-270) SR

Loss method: AASHTO

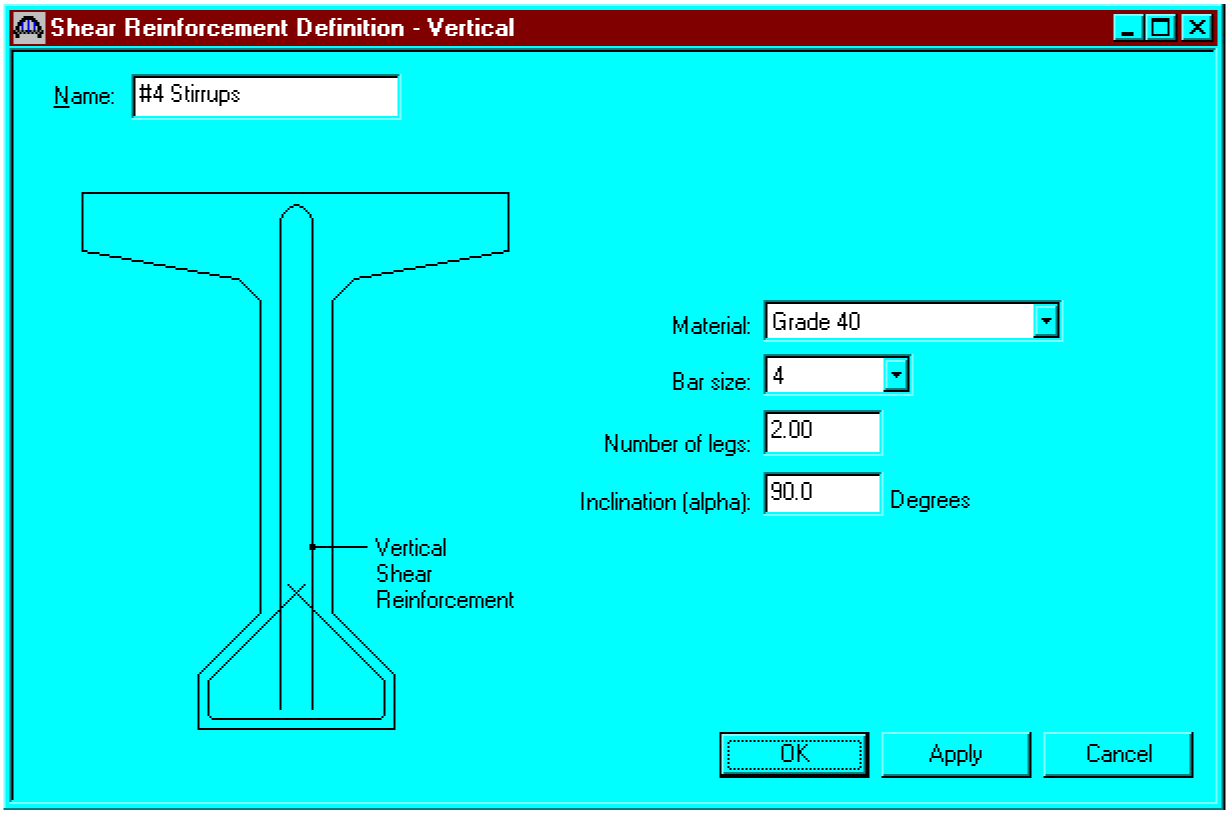
Jacking stress ratio: 0.740

P/S transfer stress ratio:

Transfer time: 24.0 Hours

Percentage DL: 0.0 %

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



Name: #4 Stirrups

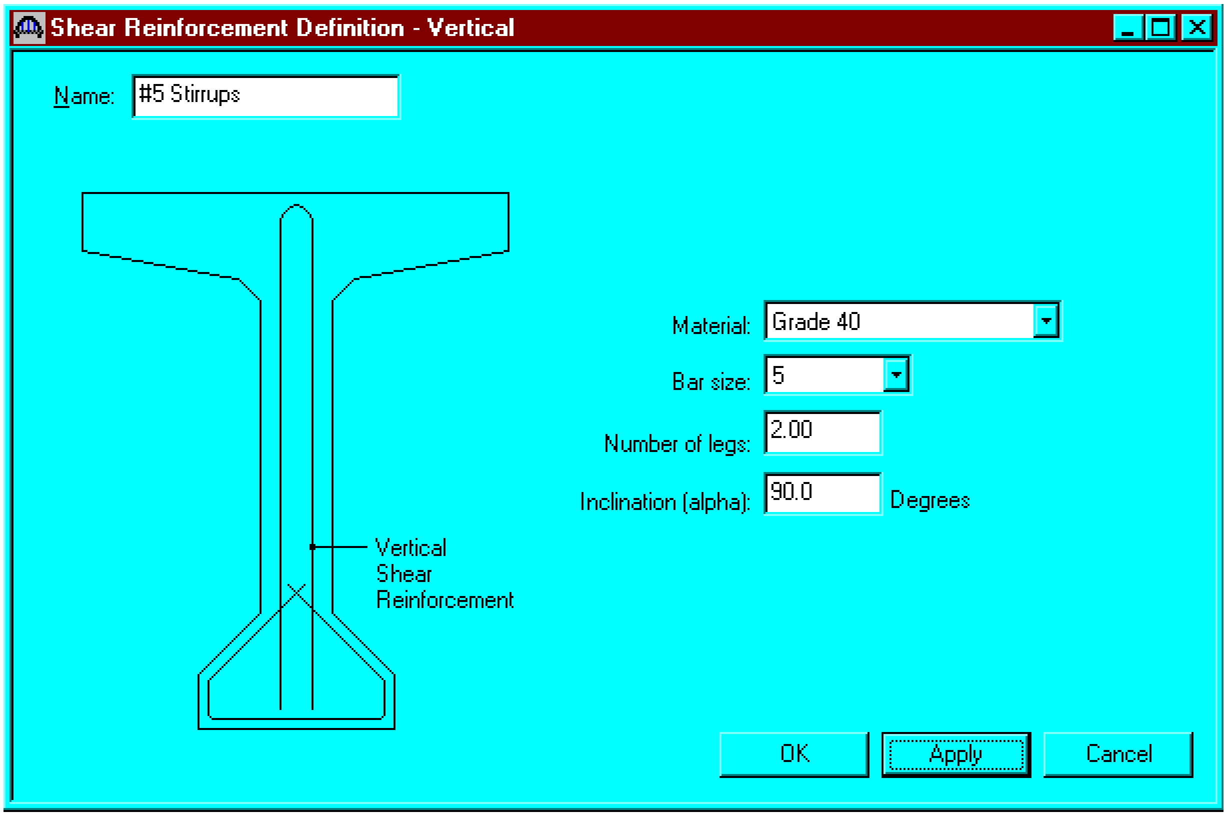
Material: Grade 40

Bar size: 4

Number of legs: 2.00

Inclination (alpha): 90.0 Degrees

Using the same techniques, define another vertical Shear Reinforcement Definition.



Shear Reinforcement Definition - Vertical

Name: #5 Stirrups

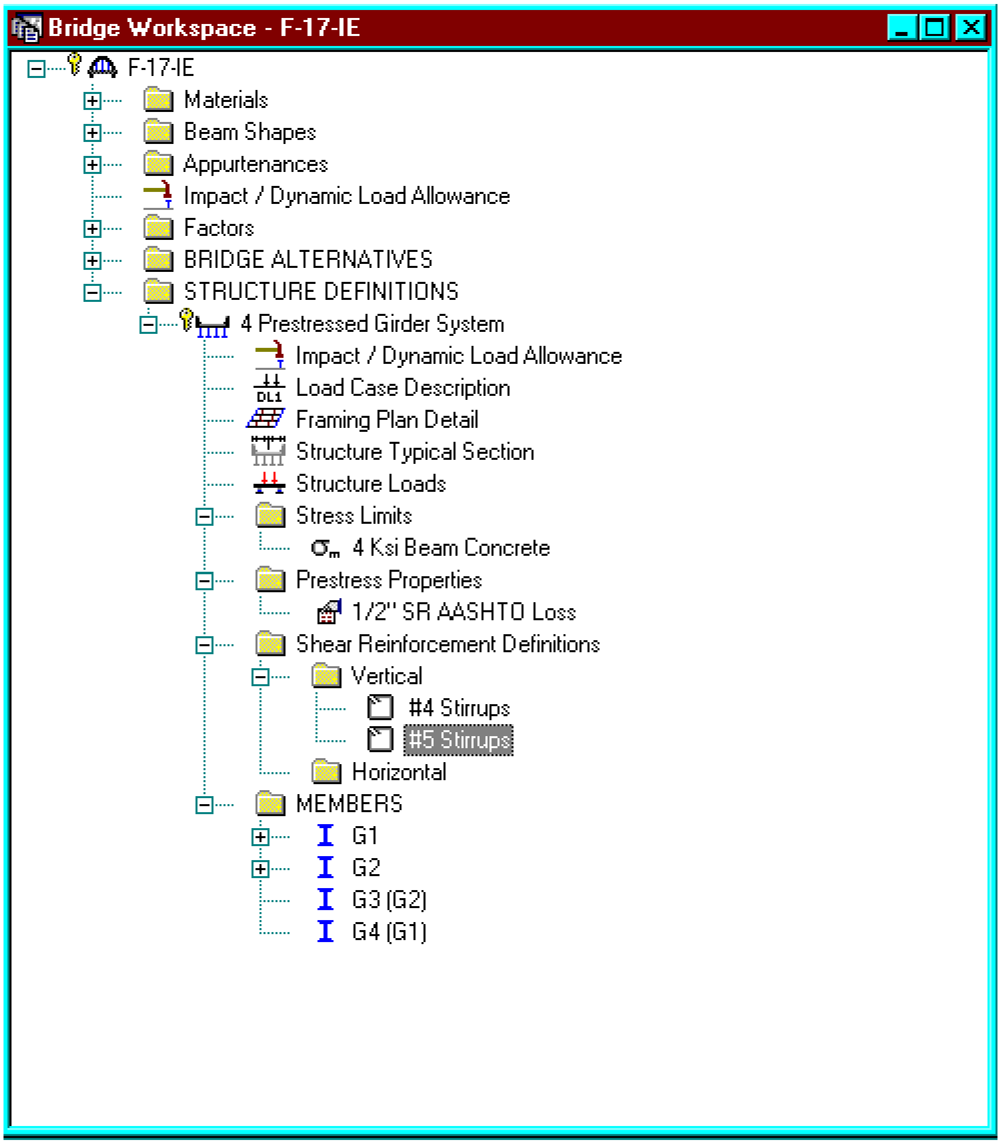
Material: Grade 40

Bar size: 5

Number of legs: 2.00

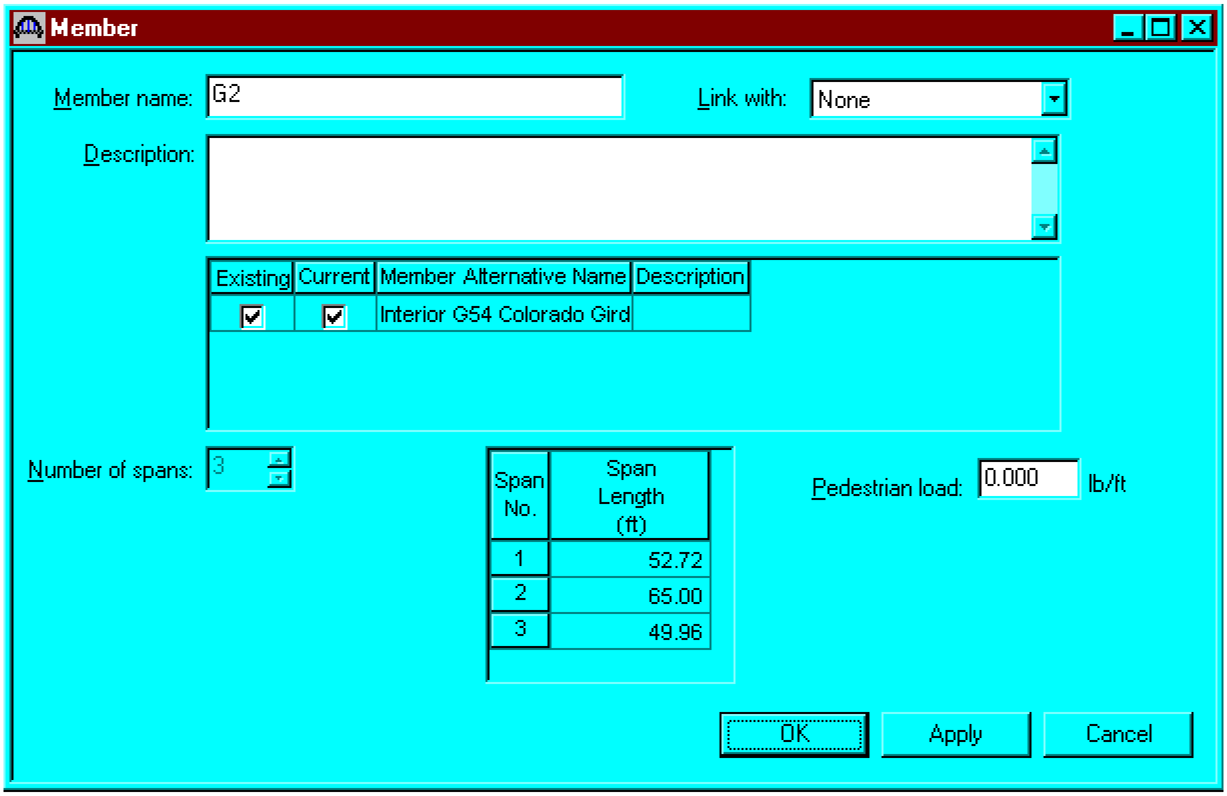
Inclination (alpha): 90.0 Degrees

The partially expanded Bridge Workspace tree is shown below:



- F-17-IE
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
  - BRIDGE ALTERNATIVES
  - STRUCTURE DEFINITIONS
    - 4 Prestressed Girder System
      - Impact / Dynamic Load Allowance
      - Load Case Description
      - Framing Plan Detail
      - Structure Typical Section
      - Structure Loads
      - Stress Limits
        - 4 Ksi Beam Concrete
      - Prestress Properties
        - 1/2" SR AASHTO Loss
      - Shear Reinforcement Definitions
        - Vertical
          - #4 Stirrups
          - #5 Stirrups
        - Horizontal
      - MEMBERS
        - G1
        - G2
        - G3 (G2)
        - G4 (G1)

Describing a member:
The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.



Member name: G2

Link with: None

Description:

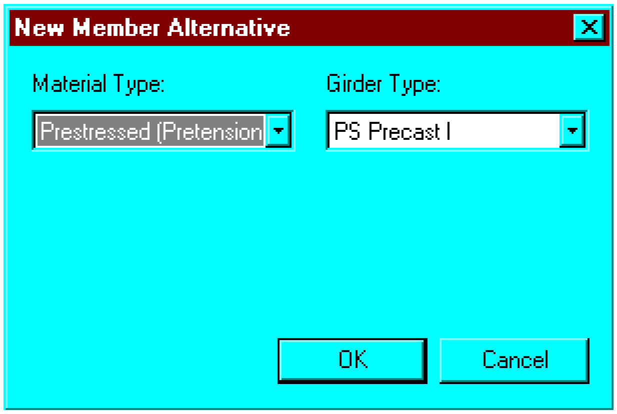
Existing	Current	Member Alternative Name	Description
☑	☑	Interior G54 Colorado Gird	

Number of spans: 3

Span No.	Span Length (ft)
1	52.72
2	65.00
3	49.96

Pedestrian load: 0.000 lb/ft

Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

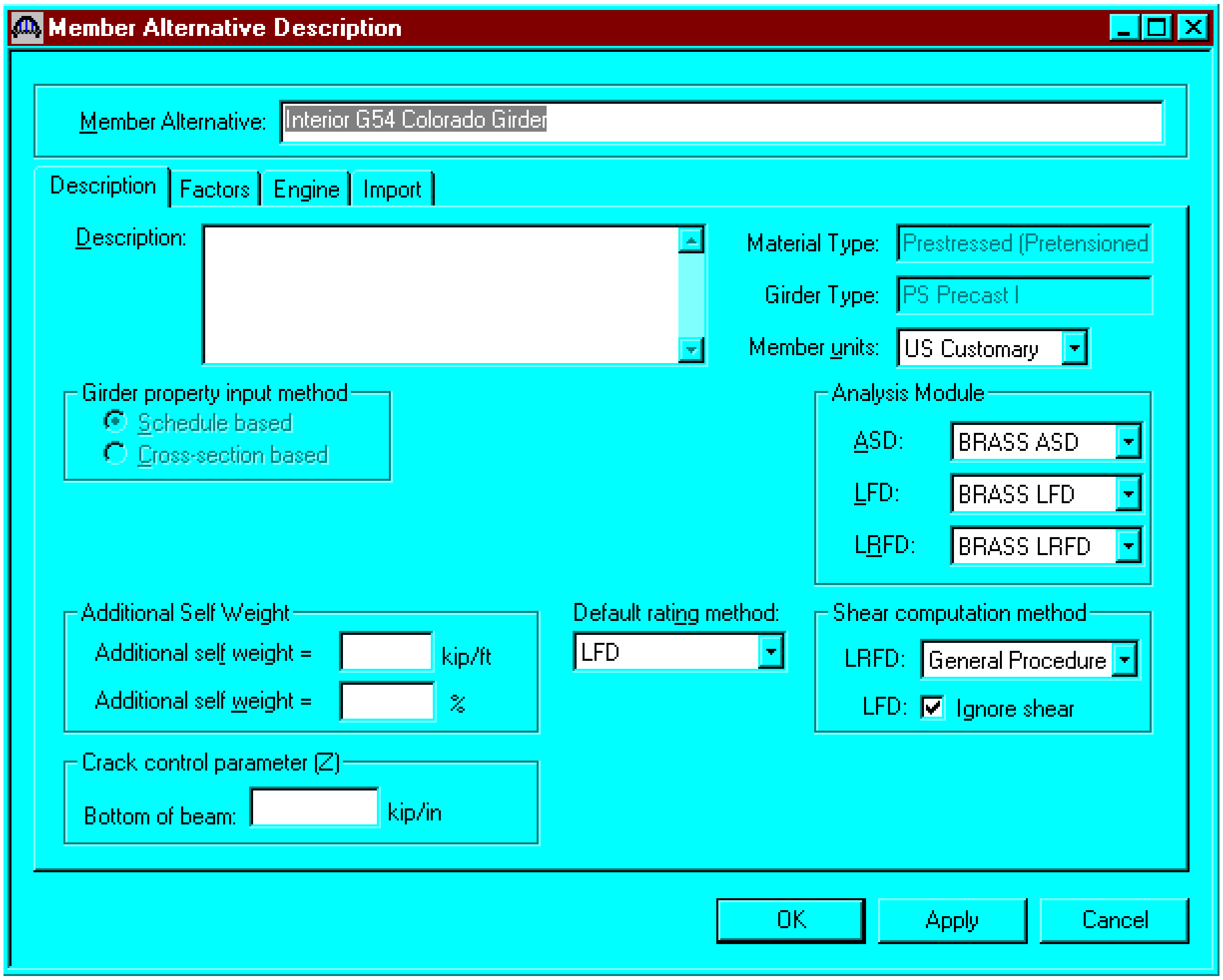


Material Type: Prestressed (Pretension

Girder Type: PS Precast I

Click OK to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam.



Member Alternative: Interior G54 Colorado Girder

Description:

Material Type: Prestressed (Pretensioned

Girder Type: PS Precast I

Member units: US Customary

Girder property input method
● Schedule based
○ Cross-section based

Analysis Module
ASD: BRASS ASD
LFD: BRASS LFD
LRFD: BRASS LRFD

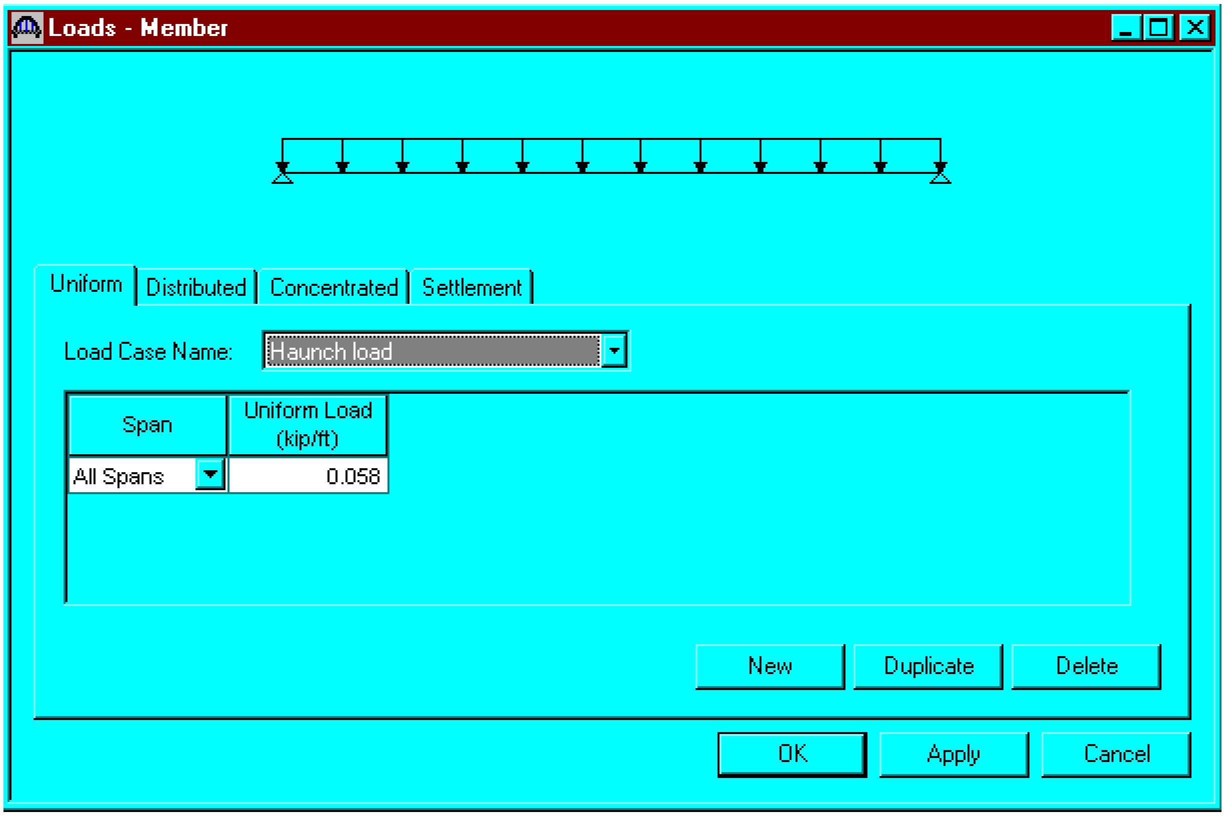
Additional Self Weight
Additional self weight = kip/ft
Additional self weight = %

Default rating method: LFD

Shear computation method
LRFD: General Procedure
LFD: ☑ Ignore shear

Crack control parameter (Z)
Bottom of beam: kip/in

Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to haunch not included in the section properties calculation is entered here.



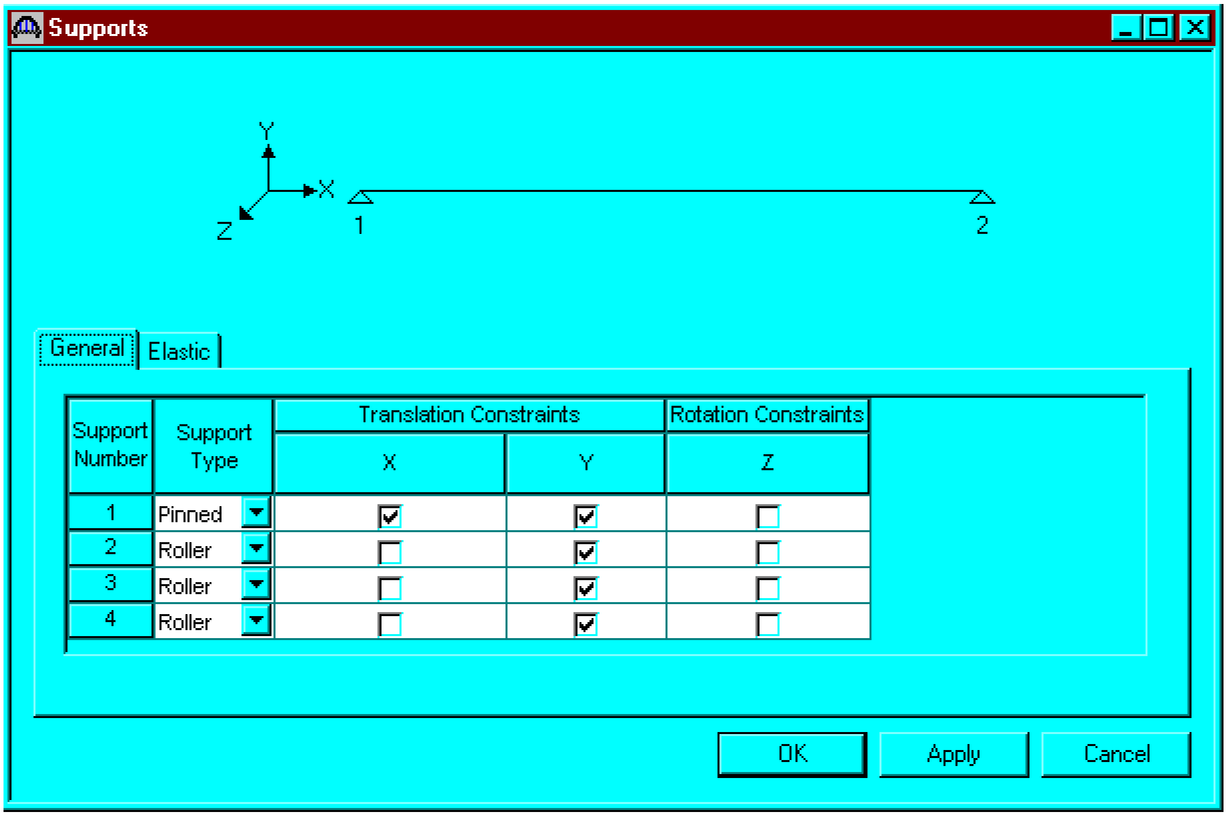
Load Case Name: Haunch load

Span	Uniform Load (kip/ft)
All Spans	0.058

Calculated average haunch = 2.0”
Haunch used for section properties = 0.0”

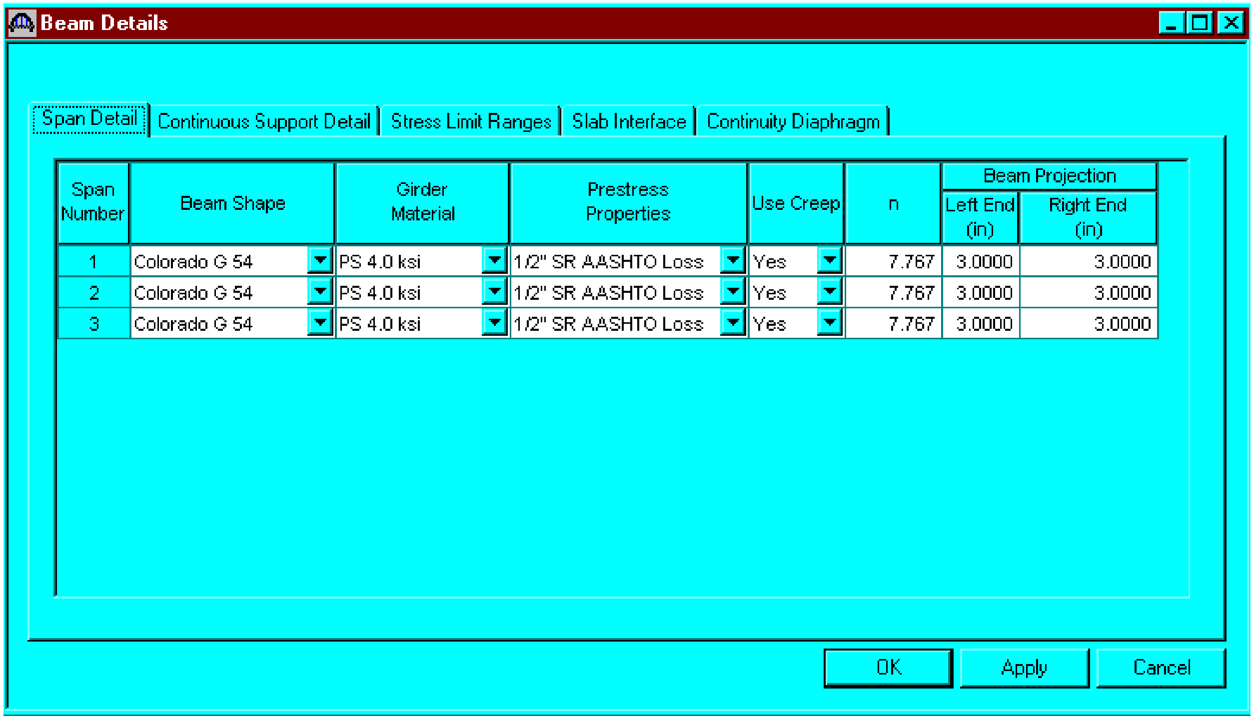
Dead Load/Girder = (2.0-0.0)/12*(28/12)*(0.15) = 0.058 k/ft

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



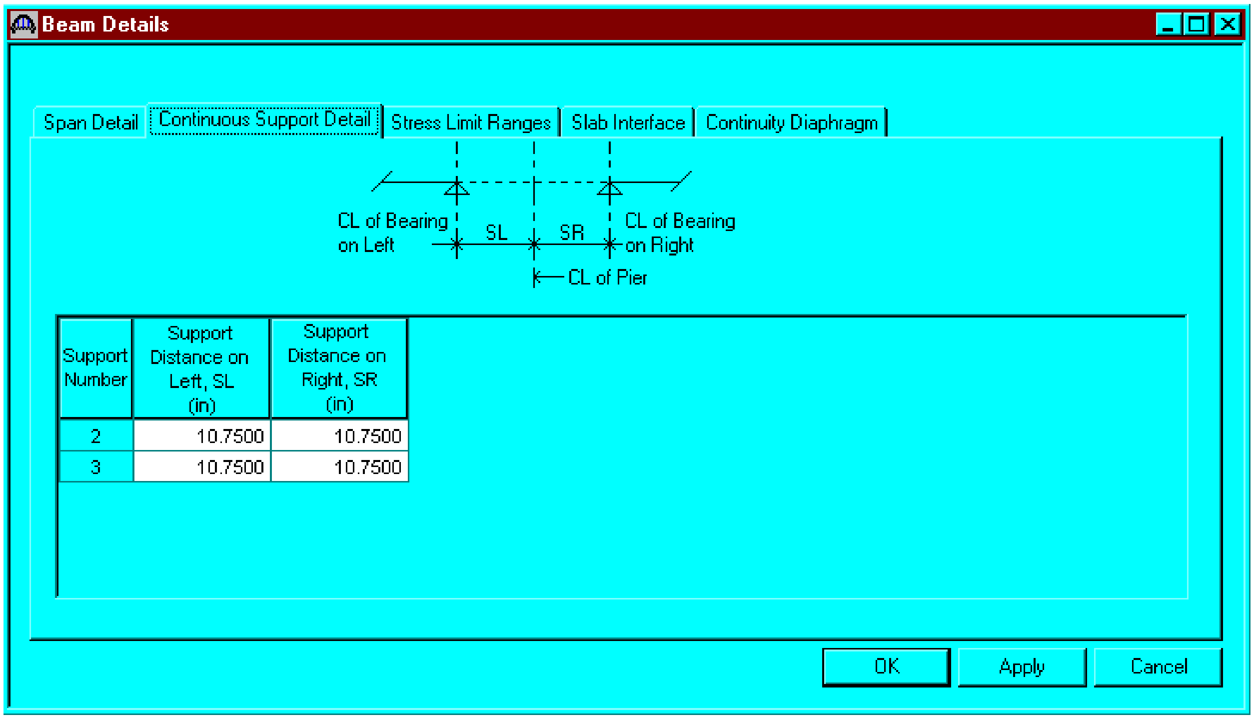
Support Number	Support Type	Translation Constraints X	Translation Constraints Y	Rotation Constraints Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐
3	Roller	☐	☑	☐
4	Roller	☐	☑	☐

The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape now in the Beam Details window and then come back to the Live Load Distribution window. Double click on Beam Details in the tree to describe the beam details. Enter the following beam details information.



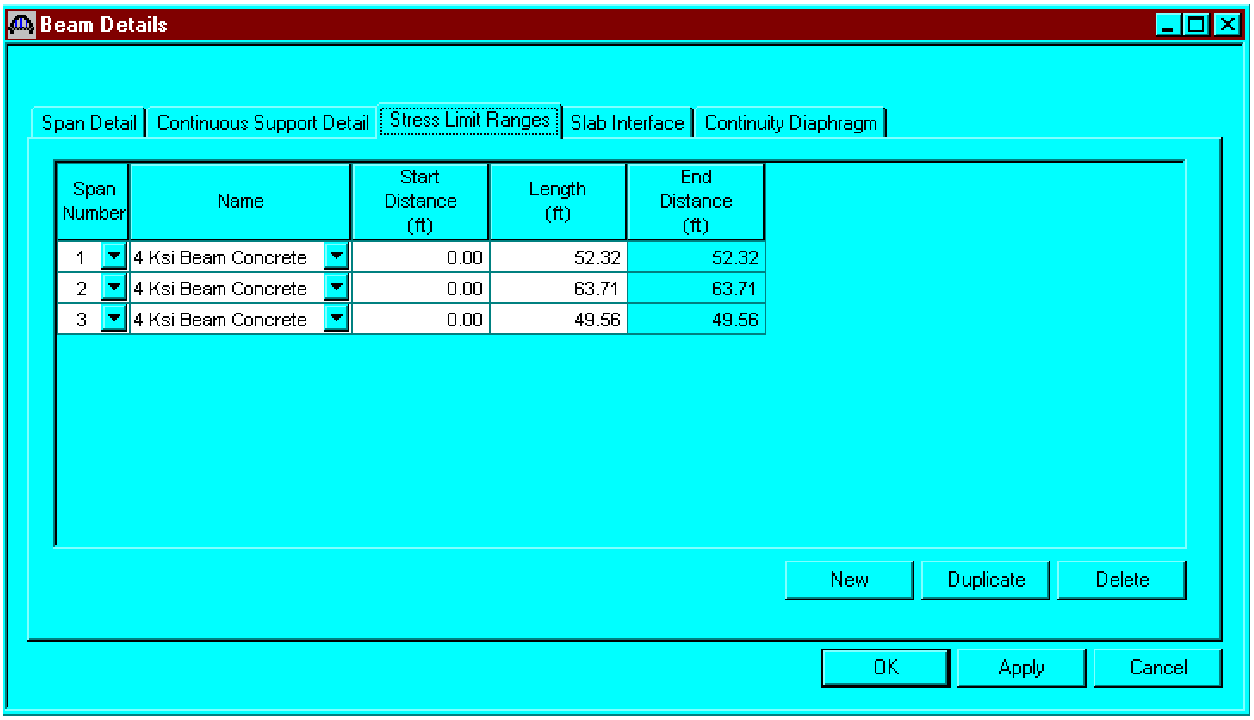
Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	Colorado G 54	PS 4.0 ksi	1/2" SR AASHTO Loss	Yes	7.767	3.0000	3.0000
2	Colorado G 54	PS 4.0 ksi	1/2" SR AASHTO Loss	Yes	7.767	3.0000	3.0000
3	Colorado G 54	PS 4.0 ksi	1/2" SR AASHTO Loss	Yes	7.767	3.0000	3.0000

The Continuous Support Detail tab is only shown for a multi-span structure. The following data describes the distances from the centerlines of bearing to the centerlines of the piers.



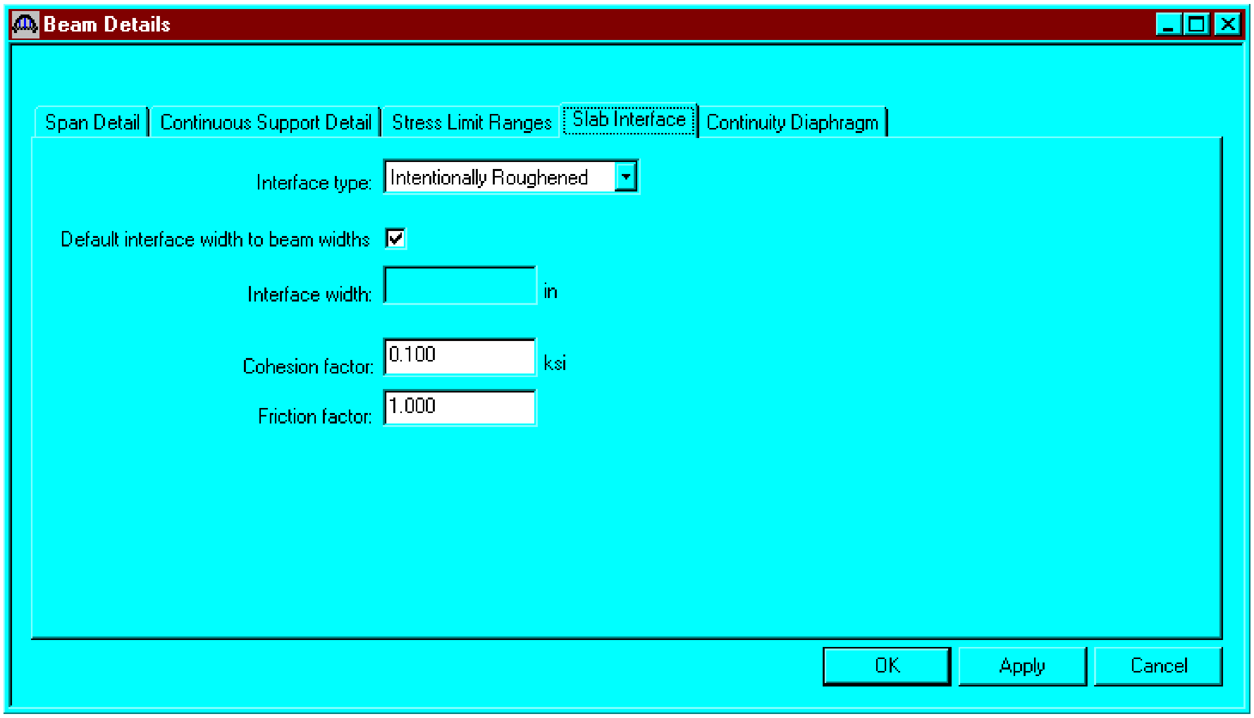
Support Number	Support Distance on Left, SL (in)	Support Distance on Right, SR (in)
2	10.7500	10.7500
3	10.7500	10.7500

Note that the Stress Limit Ranges are defined over the entire length of the precast beam.



Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	4 Ksi Beam Concrete	0.00	52.32	52.32
2	4 Ksi Beam Concrete	0.00	63.71	63.71
3	4 Ksi Beam Concrete	0.00	49.56	49.56

The defaults on the Slab Interface tab are shown below and are acceptable.



Interface type: Intentionally Roughened

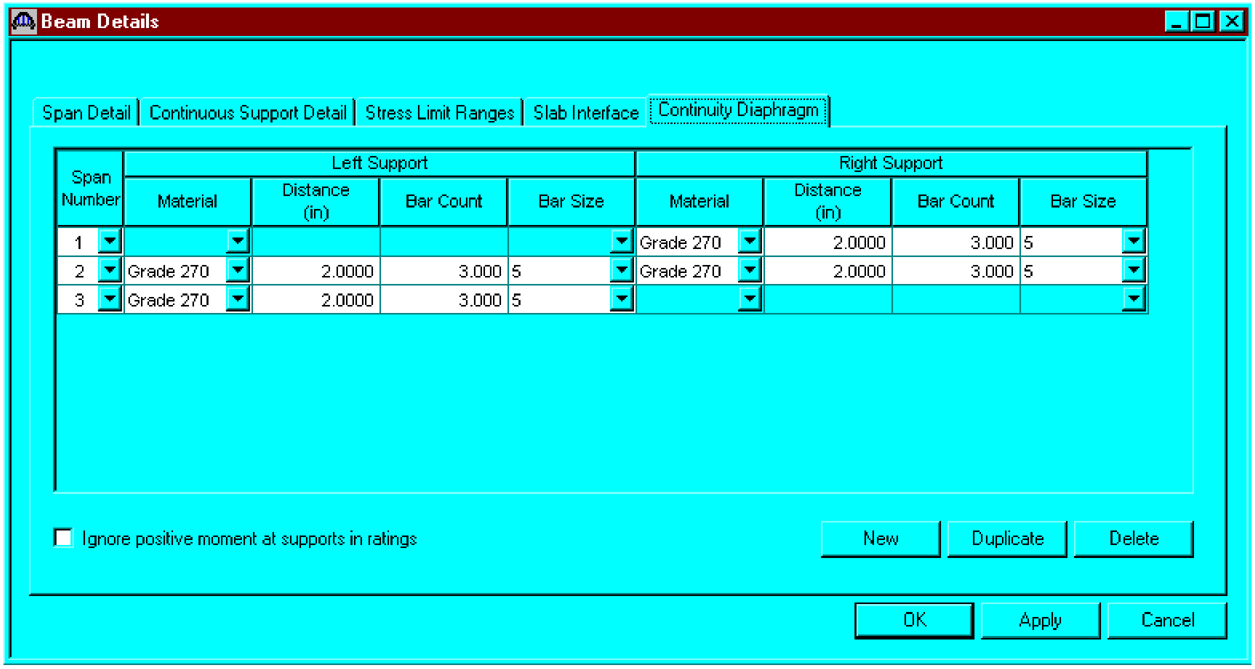
Default interface width to beam widths ☑

Interface width: in

Cohesion factor: 0.100 ksi

Friction factor: 1.000

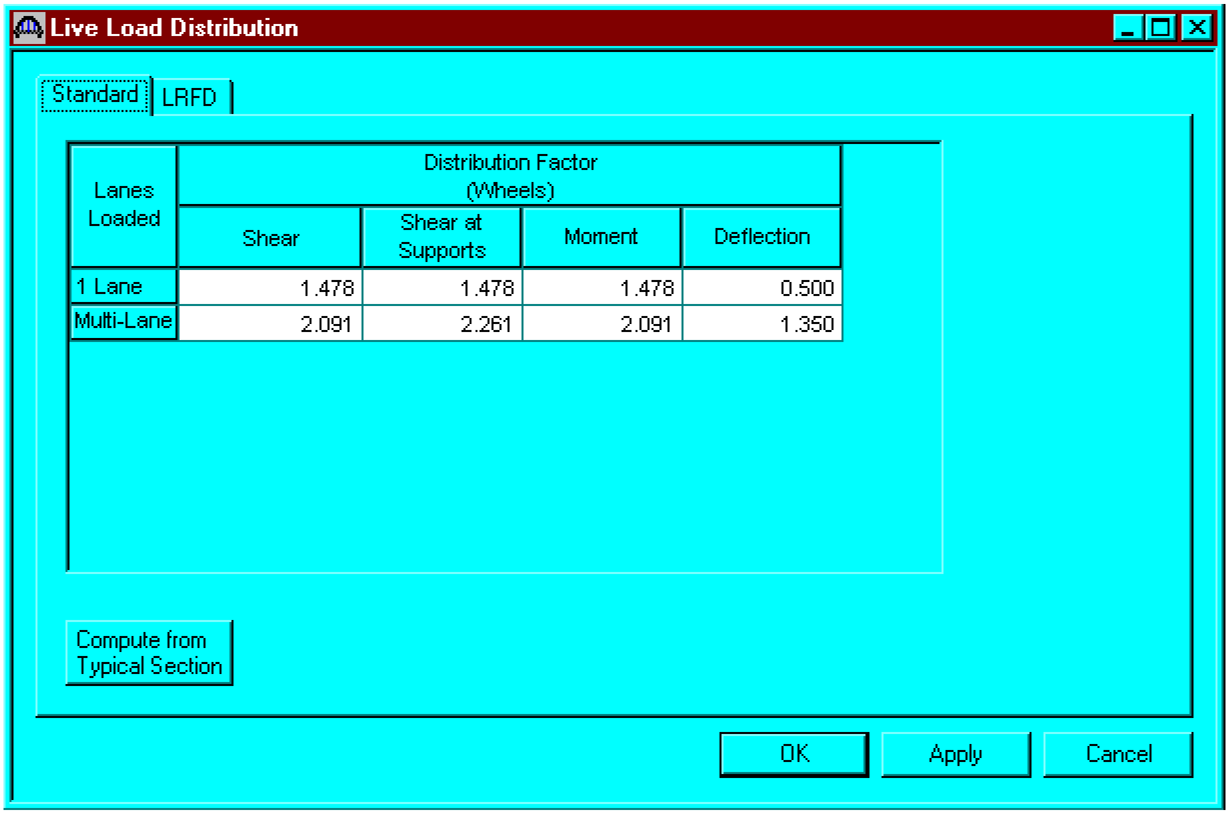
The Continuity Diaphragm tab is only displayed for multi-span structures. The data on this tab defines the cast-in-place diaphragms used to make the structure continuous for live load. Press F1 while on this tab to view the continuity diaphragm help topic describing the use of this information.



Span Number	Left Support				Right Support			
	Material	Distance (in)	Bar Count	Bar Size	Material	Distance (in)	Bar Count	Bar Size
1					Grade 270	2.0000	3.000	5
2	Grade 270	2.0000	3.000	5	Grade 270	2.0000	3.000	5
3	Grade 270	2.0000	3.000	5				

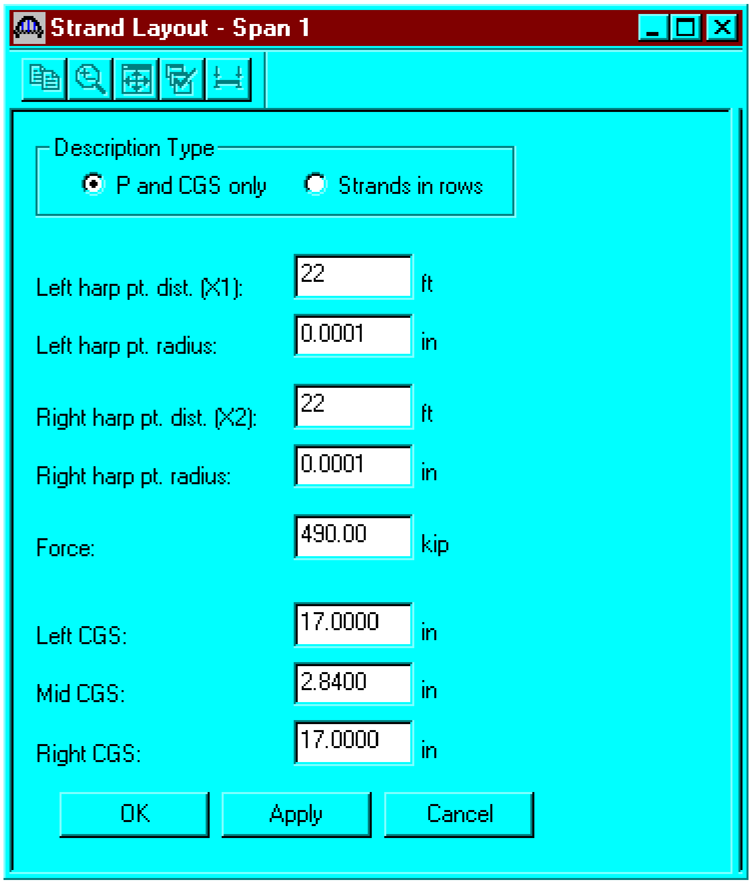
☐ Ignore positive moment at supports in ratings

Now double click on Live Load Distribution in the tree to enter the live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23 and 3.28. Click Apply and then OK to save data to memory and close the window.



Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.478	1.478	1.478	0.500
Multi-Lane	2.091	2.261	2.091	1.350

Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center of gravity) of the group of strands. Select P and CGS only for the Description Type. Enter the following Strand Layout information for Span 1. Press F1 while on this tab to view the strand layout help topic describing the use of this information.



Description Type

● P and CGS only ○ Strands in rows

Left harp pt. dist. (X1): 22 ft

Left harp pt. radius: 0.0001 in

Right harp pt. dist. (X2): 22 ft

Right harp pt. radius: 0.0001 in

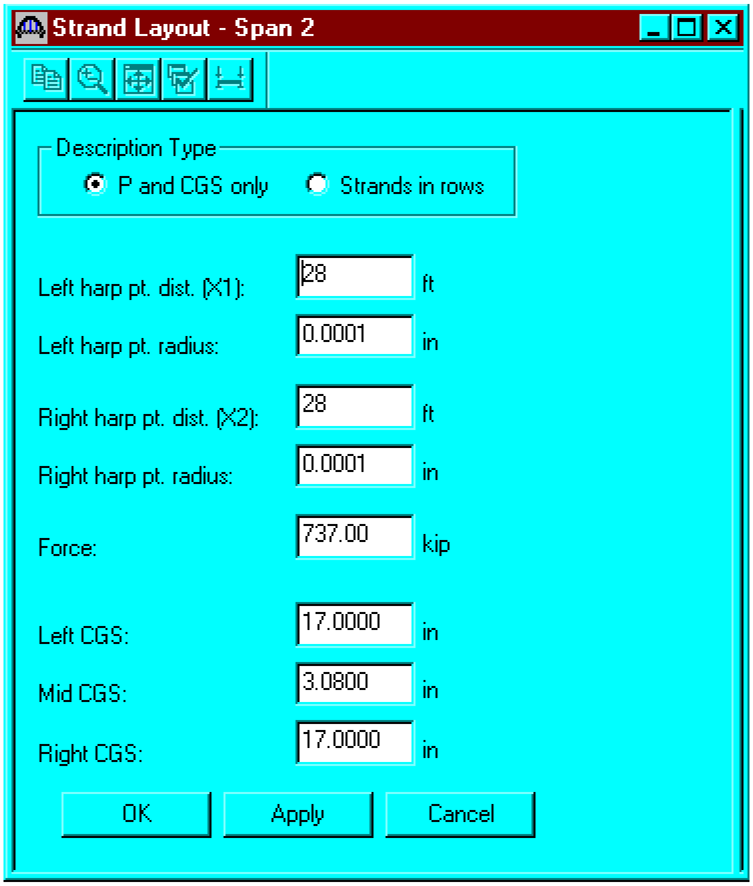
Force: 490.00 kip

Left CGS: 17.0000 in

Mid CGS: 2.8400 in

Right CGS: 17.0000 in

Using the same techniques, define the strand layout for span 2 and span 3.



Description Type
● P and CGS only ○ Strands in rows

Left harp pt. dist. (X1): 28 ft

Left harp pt. radius: 0.0001 in

Right harp pt. dist. (X2): 28 ft

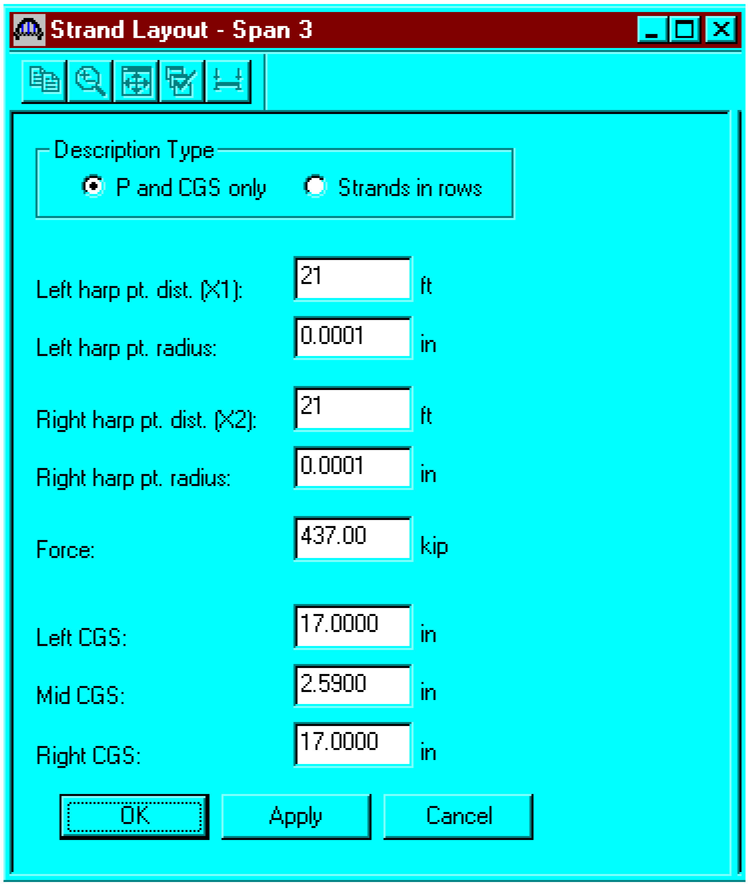
Right harp pt. radius: 0.0001 in

Force: 737.00 kip

Left CGS: 17.0000 in

Mid CGS: 3.0800 in

Right CGS: 17.0000 in



Description Type

● P and CGS only ○ Strands in rows

Left harp pt. dist. (X1): 21 ft

Left harp pt. radius: 0.0001 in

Right harp pt. dist. (X2): 21 ft

Right harp pt. radius: 0.0001 in

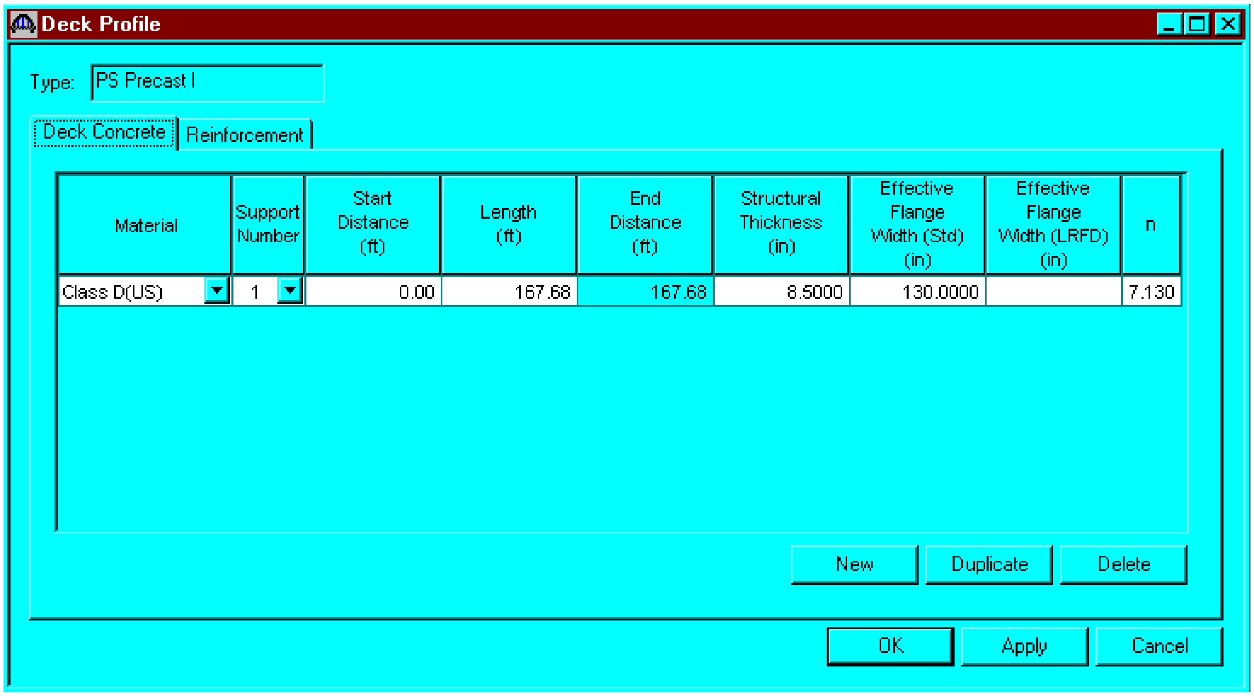
Force: 437.00 kip

Left CGS: 17.0000 in

Mid CGS: 2.5900 in

Right CGS: 17.0000 in

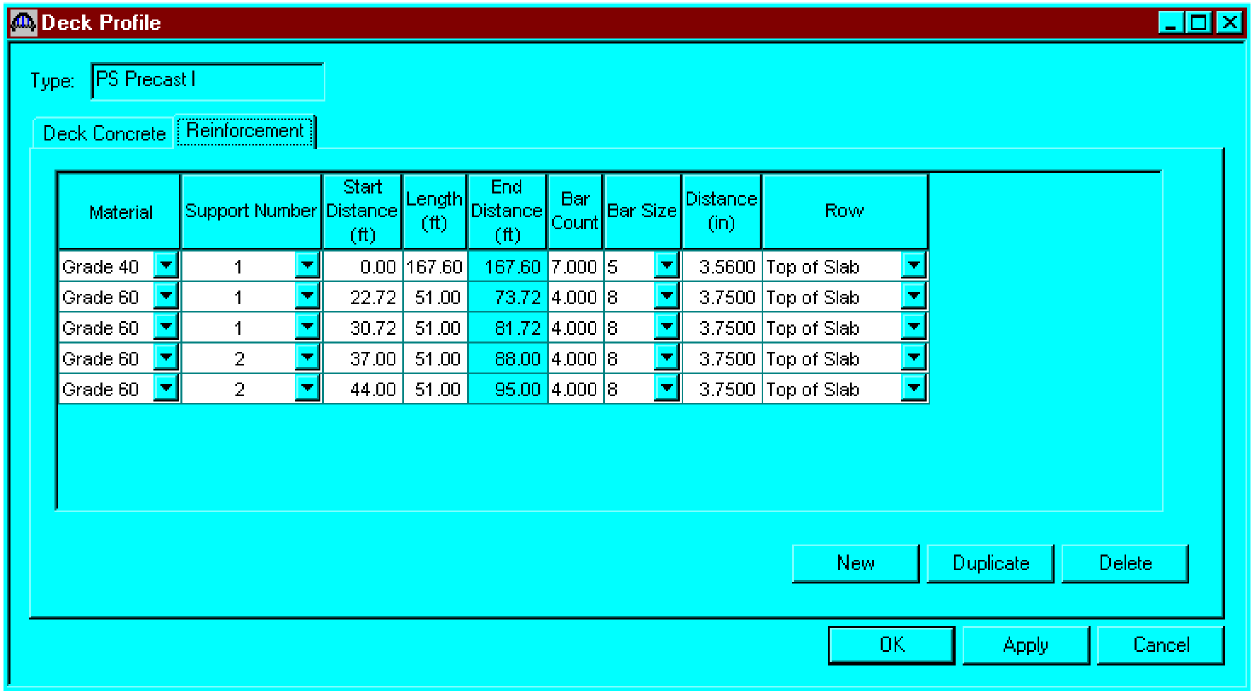
Open the Deck Profile window and enter the date describing the structural properties of the deck.



Type: PS Precast I

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Structural Thickness (in)	Effective Flange Width (Std) (in)	Effective Flange Width (LRFD) (in)	n
Class D(US)	1	0.00	167.68	167.68	8.5000	130.0000		7.130

The deck reinforcement in the negative moment regions is described as follows.

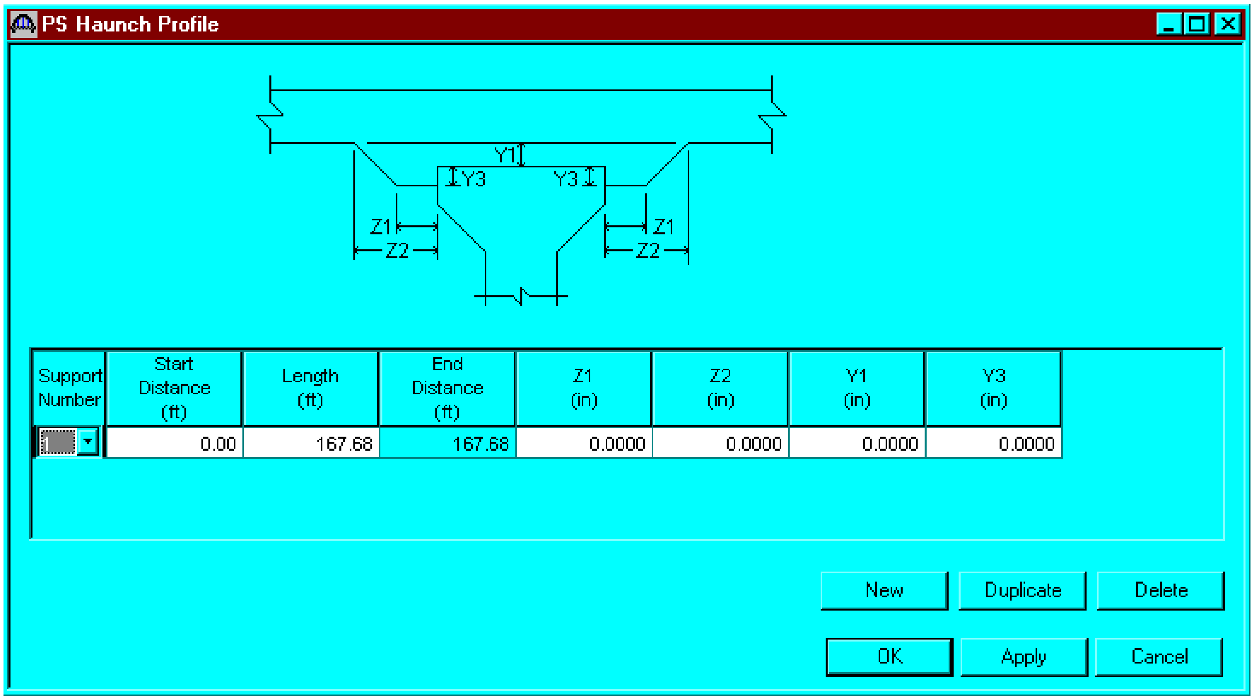


Type: PS Precast I

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Bar Count	Bar Size	Distance (in)	Row
Grade 40	1	0.00	167.60	167.60	7.000	5	3.5600	Top of Slab
Grade 60	1	22.72	51.00	73.72	4.000	8	3.7500	Top of Slab
Grade 60	1	30.72	51.00	81.72	4.000	8	3.7500	Top of Slab
Grade 60	2	37.00	51.00	88.00	4.000	8	3.7500	Top of Slab
Grade 60	2	44.00	51.00	95.00	4.000	8	3.7500	Top of Slab

Note: Only the top layer of the slab’s distribution reinforcement is used in the analysis.

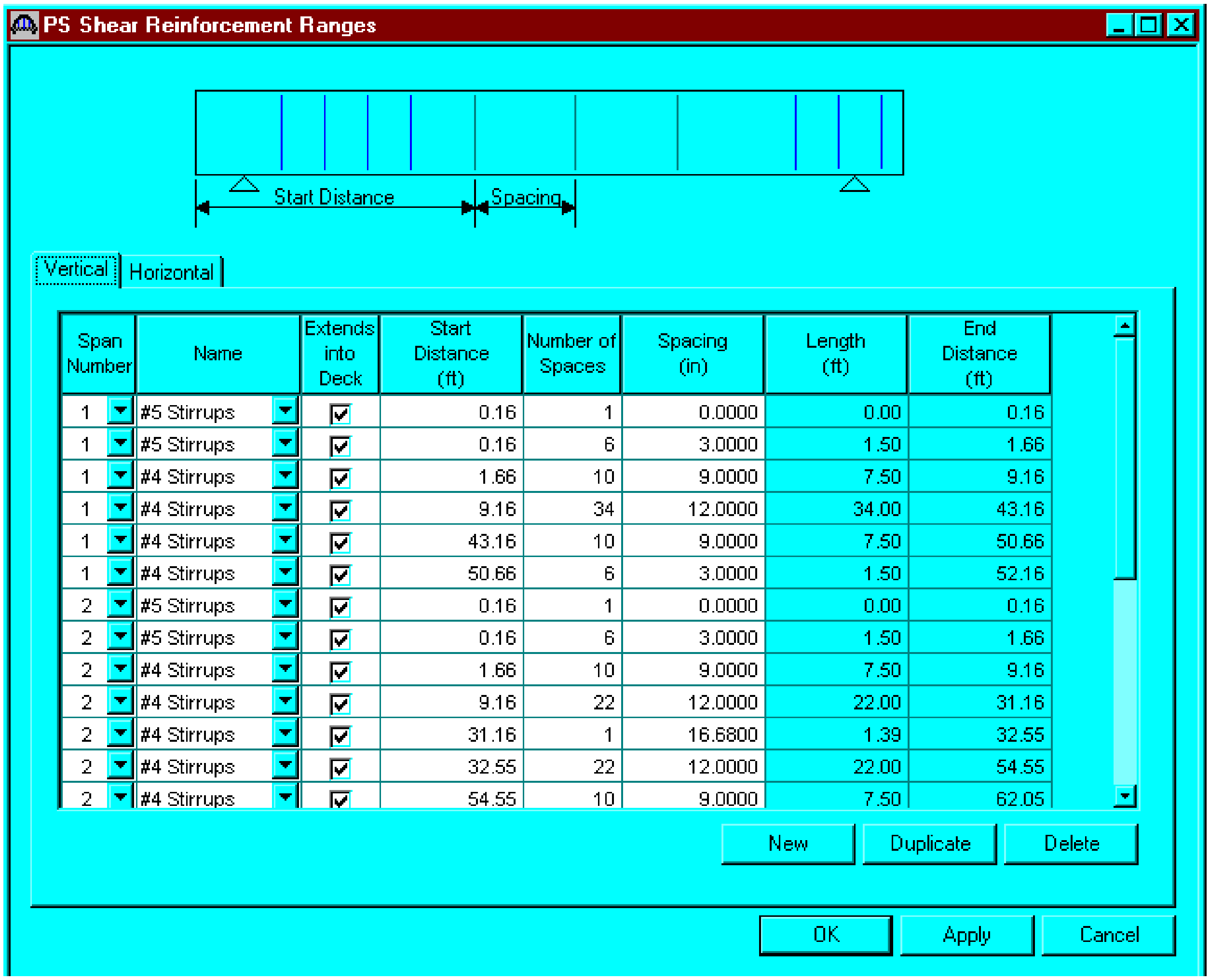
Double click on Haunch Profile in the tree to define the haunch profile for the girder.



Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)	Y3 (in)
1	0.00	167.68	167.68	0.0000	0.0000	0.0000	0.0000

Note: Only the haunch thickness to be used in section properties calculation is input here. The program calculates dead load due to this haunch automatically.

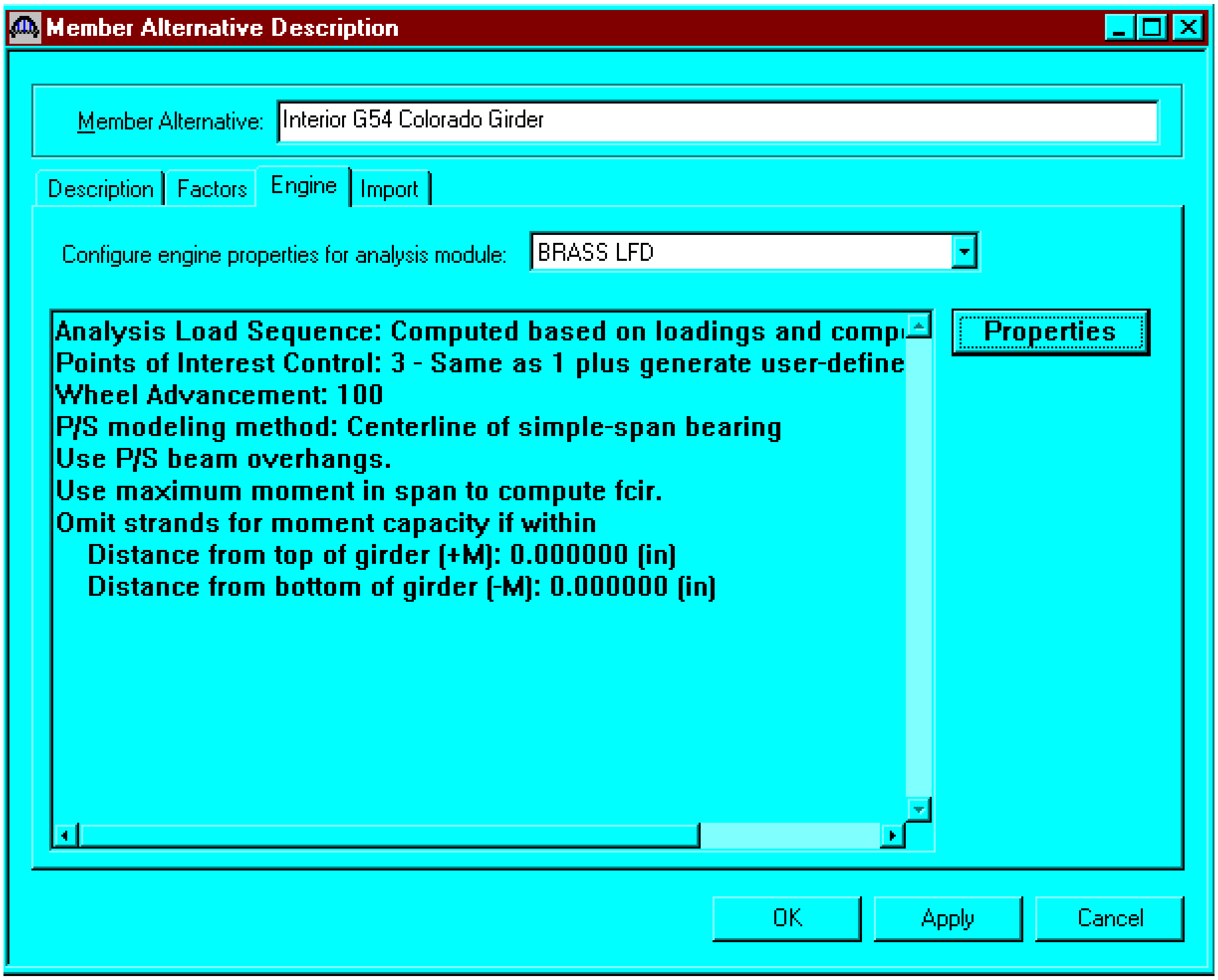
The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on this tab. This ensures composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we have defined that by extending the vertical bars into the deck.



Span Number	Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
1	#5 Stirrups	☑	0.16	1	0.0000	0.00	0.16
1	#5 Stirrups	☑	0.16	6	3.0000	1.50	1.66
1	#4 Stirrups	☑	1.66	10	9.0000	7.50	9.16
1	#4 Stirrups	☑	9.16	34	12.0000	34.00	43.16
1	#4 Stirrups	☑	43.16	10	9.0000	7.50	50.66
1	#4 Stirrups	☑	50.66	6	3.0000	1.50	52.16
2	#5 Stirrups	☑	0.16	1	0.0000	0.00	0.16
2	#5 Stirrups	☑	0.16	6	3.0000	1.50	1.66
2	#4 Stirrups	☑	1.66	10	9.0000	7.50	9.16
2	#4 Stirrups	☑	9.16	22	12.0000	22.00	31.16
2	#4 Stirrups	☑	31.16	1	16.6800	1.39	32.55
2	#4 Stirrups	☑	32.55	22	12.0000	22.00	54.55
2	#4 Stirrups	☑	54.55	10	9.0000	7.50	62.05

The description of an interior beam for this structure definition is complete.

The BRASS LFD engine data for the member alternative is shown below.

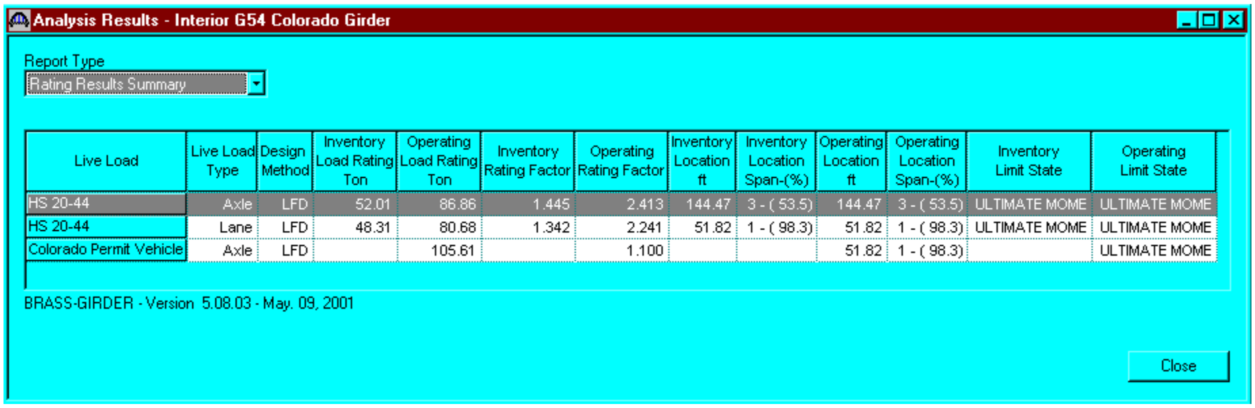


Member Alternative: Interior G54 Colorado Girder

Configure engine properties for analysis module: BRASS LFD

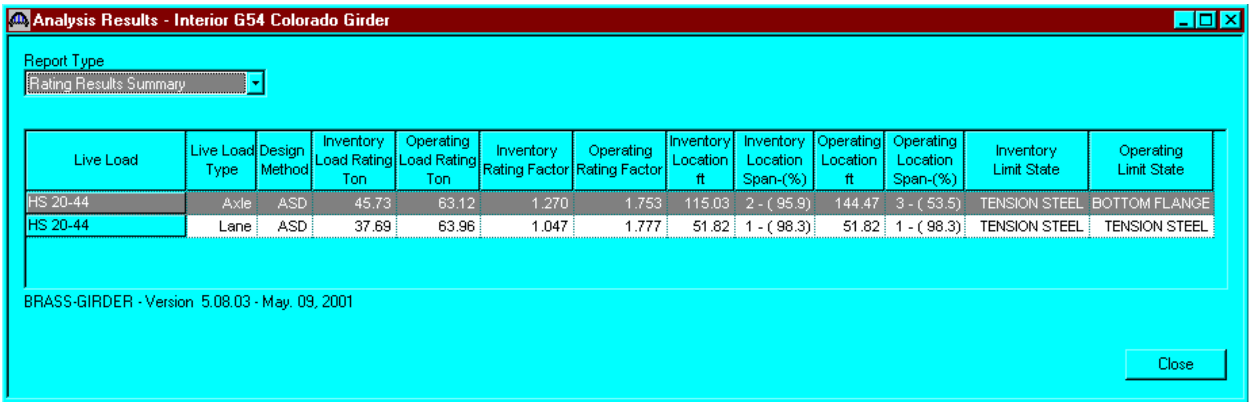
Analysis Load Sequence: Computed based on loadings and comp
Points of Interest Control: 3 - Same as 1 plus generate user-define
Wheel Advancement: 100
P/S modeling method: Centerline of simple-span bearing
Use P/S beam overhangs.
Use maximum moment in span to compute fcir.
Omit strands for moment capacity if within
Distance from top of girder (+M): 0.000000 (in)
Distance from bottom of girder (-M): 0.000000 (in)

The results of the LFD/ASD rating analysis are as follows:



Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	LFD	52.01	86.86	1.445	2.413	144.47	3 - (53.5)	144.47	3 - (53.5)	ULTIMATE MOME	ULTIMATE MOME
HS 20-44	Lane	LFD	48.31	80.68	1.342	2.241	51.82	1 - (98.3)	51.82	1 - (98.3)	ULTIMATE MOME	ULTIMATE MOME
Colorado Permit Vehicle	Axle	LFD		105.61		1.100			51.82	1 - (98.3)		ULTIMATE MOME

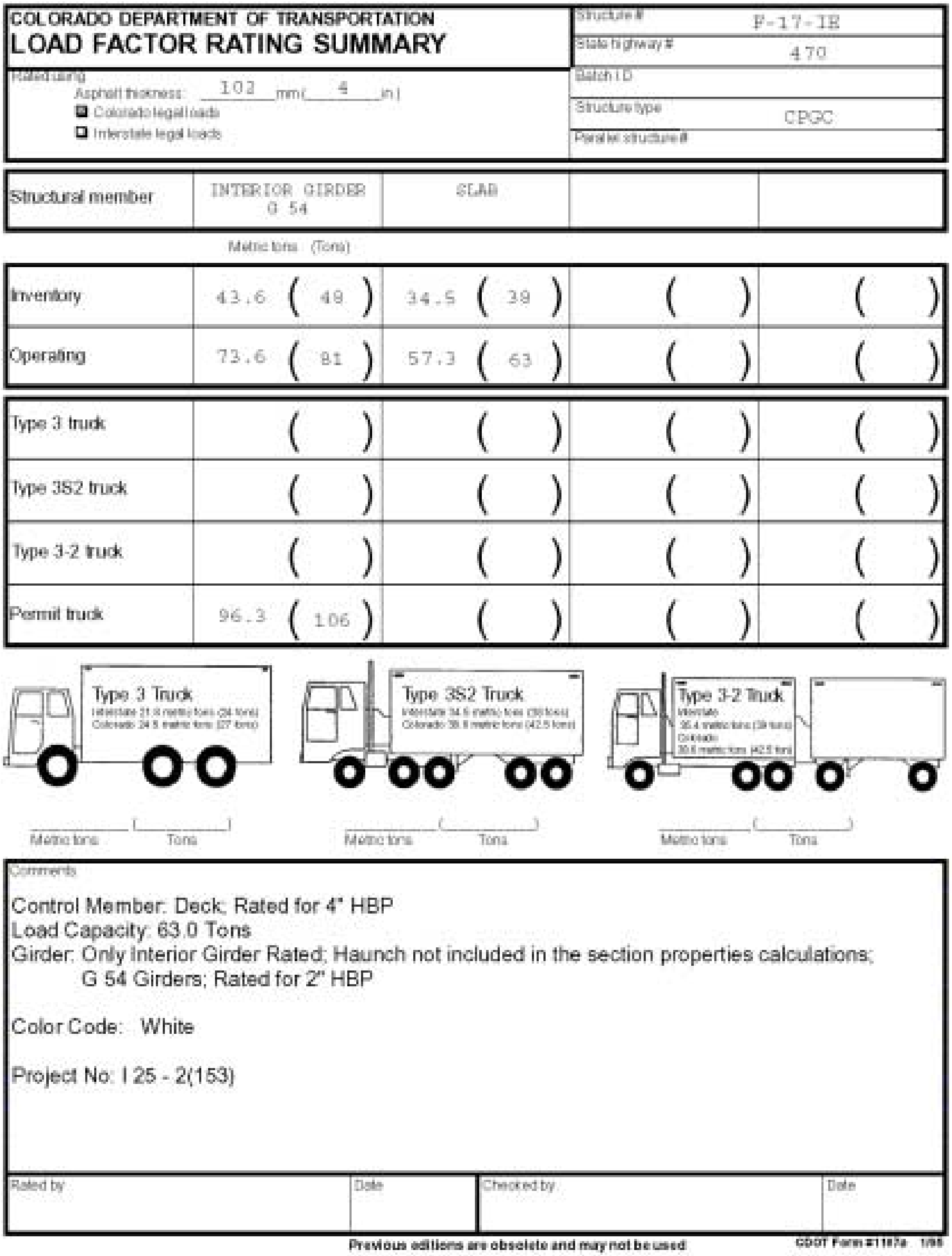
BRASS-GIRDER - Version 5.08.03 - May. 09, 2001



Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	ASD	45.73	63.12	1.270	1.753	115.03	2 - (95.9)	144.47	3 - (53.5)	TENSION STEEL	BOTTOM FLANGE
HS 20-44	Lane	ASD	37.69	63.96	1.047	1.777	51.82	1 - (98.3)	51.82	1 - (98.3)	TENSION STEEL	TENSION STEEL

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

Note: LFD method controls both the Inventory and the Operating rating.



COLORADO DEPARTMENT OF TRANSPORTATION
LOAD FACTOR RATING SUMMARY

Structure # F-17-IE
State highway # 470
Batch I.D.
Structure type CPGC
Parallel structure #

Rated using
Asphalt thickness: 102 mm (4 in.)
☒ Colorado legal loads
☐ Interstate legal loads

Structural member	INTERIOR GIRDER G 54	SLAB		
	Metric tons (Tons)			
Inventory	43.6 (48)	34.5 (39)	( )	( )
Operating	73.6 (81)	57.3 (63)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	96.3 (106)	( )	( )	( )

_______ (_______)
Metric tons Tons

_______ (_______)
Metric tons Tons

_______ (_______)
Metric tons Tons

Comments

Control Member: Deck; Rated for 4" HBP
Load Capacity: 63.0 Tons
Girder: Only Interior Girder Rated; Haunch not included in the section properties calculations;
G 54 Girders; Rated for 2" HBP

Color Code: White

Project No: I 25 - 2(153)

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used

CDOT Form #1187a 1/98

Virtis Bridge Rating Example, Structure No. L-26-BR

Use average web = 6.0”
Girder flange = ½(Total flange width) = ½(86.0) = 43.0”
4x4 ~ W4xW4 WWF, assumed shear reinforcing: #3 single leg bar @ 12” c/c
Dead Load:

Intermediate Diaphragm = 0.150 kip/diaphragm
½(diaphragm) = 0.075 kip

Abutment Diaphragm = ((2.50)*(44.5/12)*(3.5833) – (507.5/144)*(20/12))
*(0.150)= 4.1 kips Use 4.1 kips

Distribution Factors:

- **AASHTO LRFD Table 4.6.2.2.2b-1**

K = √ (1+μ)*I/J= √ (1+0.2)*(90584)/(12345)=2.96

C = K*(W/L) = 2.96*(72/59.5) = 3.58 > K ∴ C = K = 2.96

NL = 6 Lanes Assumed L = 59.5’

D = 11.5 – NL + 1.4*NL*(1-0.2C)*(1-0.2C)

= (11.5 – 6) + 1.4*6*(1-0.2*2.96)*(1-0.2*2.96) = 6.898

S/D = (43/12)/(6.898/2) = 1.039 Wheel Lines

NL = 1 Lane

D = (11.5 – 1) + 1.4*1*(1-0.2*2.96)*(1-0.2*2.96) = 10.733

S/D = (43/12)/(10.733/2) = 0.668 Wheel Lines

- **AASHTO Standard Specifications, Table 3.23.1**

Assumed full depth rigid diaphragm.

Distribution Factor = S/6 = (7.167/2)/6 = 0.597 (Multi Lanes)

Distribution Factor = 0.547 (Single Lane)

- **LDFAC Program**

Assumed 8” poured in place composite deck.

Distribution Factor = 0.673 (Multi Lanes)

Distribution Factor = 0.542 (Single Lane)

```
LDFAC Version 1.0 (Release Version)

Dbl_Tee


 Geometry Data:

      Bridge Type                Beam & Slab
      Width of Curb          [ft]      0.0000
      Element Density                      12
      Number of Spans                       1
      Span Length(s)         [ft]
          59.5000
      Skew Angles      [degrees]
           0.0000      0.0000




 Live Load Generator Data

      Truck Name                             HS20TR
      Multiple Presence Factor - 1 Truck       1.00
      Multiple Presence Factor - 2 Trucks      1.00
      Multiple Presence Factor - 3 Trucks      0.90
      Multiple Presence Factor - 4 Trucks      0.75



 Point-of-Interest Data

          Type     Span #     Span Loc. [ft]     Rel. Span Loc.

           Shr        1           0.00             0.00
          +Mom        1          30.00             0.50
          -Mom        1          60.00             1.00



 Beam and Slab Data:

      Slab Thickness                   [in]       8.0000
      Young' Modulus                  [ksi]    3823.0000
      Poisson's Ratio                             0.2000
      Exterior Girder Area A         [in^2]       507.50
      Exterior Girder Moment I       [in^4]     90584.00
      Exterior Girder Moment J       [in^4]     12345.00
      Exterior Centroidal Offset       [in]      16.2500
      Interior Girder Area A         [in^2]       507.50
      Interior Girder Moment I       [in^4]     90584.00
      Interior Girder Moment J       [in^4]     12345.00
      Interior Centroidal Offset       [in]      16.2500
      Girder Modular Ratio n                      7.0000
      Left  Girder Overhang            [in]      21.5000
      Right Girder Overhang            [in]      21.5000
      Total Number of Girders                         20
```

```
 Girder Spacing Values            [in]
      43.0000     43.0000     43.0000     43.0000     43.0000     43.0000
43.0000     43.0000     43.0000     43.0000     43.0000     43.0000
43.0000     43.0000     43.0000     43.0000     43.0000     43.0000
43.0000


LDFAC Version 1.0 - Release Version
    Out-of-Limits Results for Formula Are Marked With an Asterisk *


1 - Span  Straight Beam & Slab  Bridge with          HS20TR Load

Multi-Lane Load Distribution Results

  Point-of-Interest Data       Analysis Results           Formula Results
  ----------------------     --------------------       --------------------
  No.  Type    Sp#    Sp%      Interior    Exterior       Interior    Exterior

    1   Shr     1      0       0.86074     0.86148        0.97668     0.76099
    2  +Mom     1     50       0.67364     0.71775        0.88385     0.88385
    3  -Mom     1    100        N/A         N/A            N/A         N/A


LDFAC Version 1.0 - Release Version
    Out-of-Limits Results for Formula Are Marked With an Asterisk *

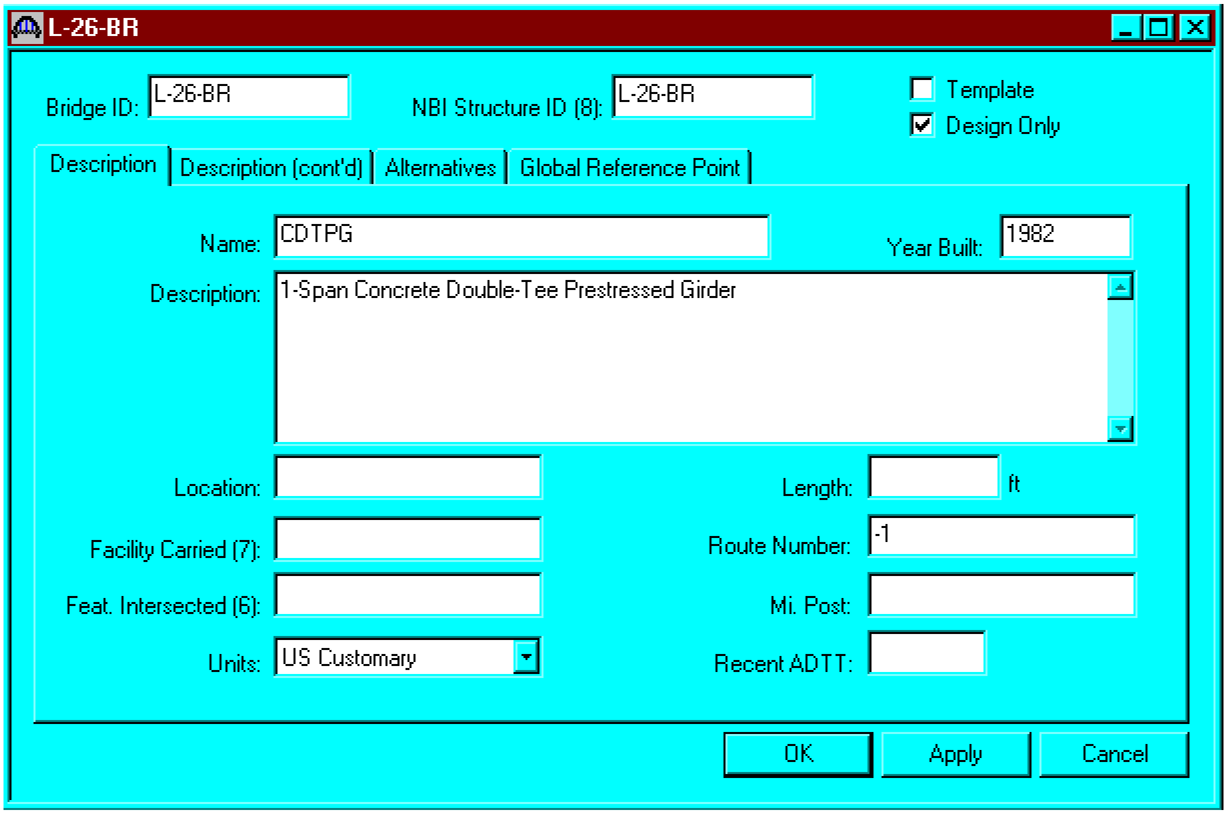

1 - Span  Straight Beam & Slab  Bridge with          HS20TR Load

Single-Lane Load Distribution Results

  Point-of-Interest Data       Analysis Results           Formula Results
  ----------------------     --------------------       --------------------
  No.  Type    Sp#    Sp%      Interior    Exterior       Interior    Exterior

    1   Shr     1      0       0.76917     0.86148        0.83889     1.00000
    2  +Mom     1     50       0.54238     0.68849        0.57662     1.00000
    3  -Mom     1    100        N/A         N/A            N/A         N/A
```

From the bridge explorer, create a new bridge and enter the following information.



Bridge ID: L-26-BR

NBI Structure ID (8): L-26-BR

☐ Template

☑ Design Only

Name: CDTPG

Year Built: 1982

Description: 1-Span Concrete Double-Tee Prestressed Girder

Location:

Length: ft

Facility Carried (7):

Route Number: -1

Feat. Intersected (6):

Mi. Post:

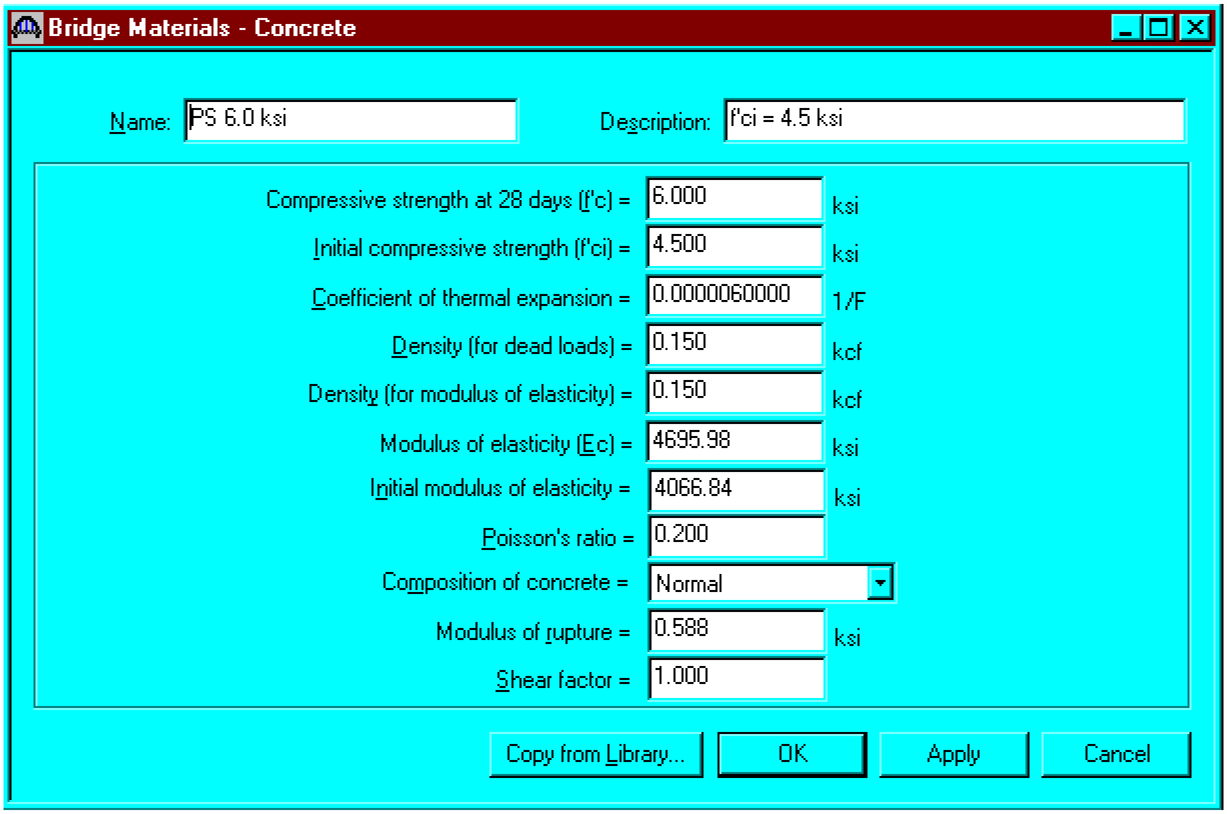
Units: US Customary

Recent ADTT:

Click OK. This saves the data to memory and closes the window.

NOTE: Since Virtis uses a common/shared database; it is required that users of this program create a folder from the bridge explorer window **(EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Fill in the data for the beam concrete material as shown below. Click OK to save this beam concrete material to memory and close the window.



Name: PS 6.0 ksi

Description: f'ci = 4.5 ksi

Compressive strength at 28 days (f'c) = 6.000 ksi

Initial compressive strength (f'ci) = 4.500 ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.150 kcf

Density (for modulus of elasticity) = 0.150 kcf

Modulus of elasticity (Ec) = 4695.98 ksi

Initial modulus of elasticity = 4066.84 ksi

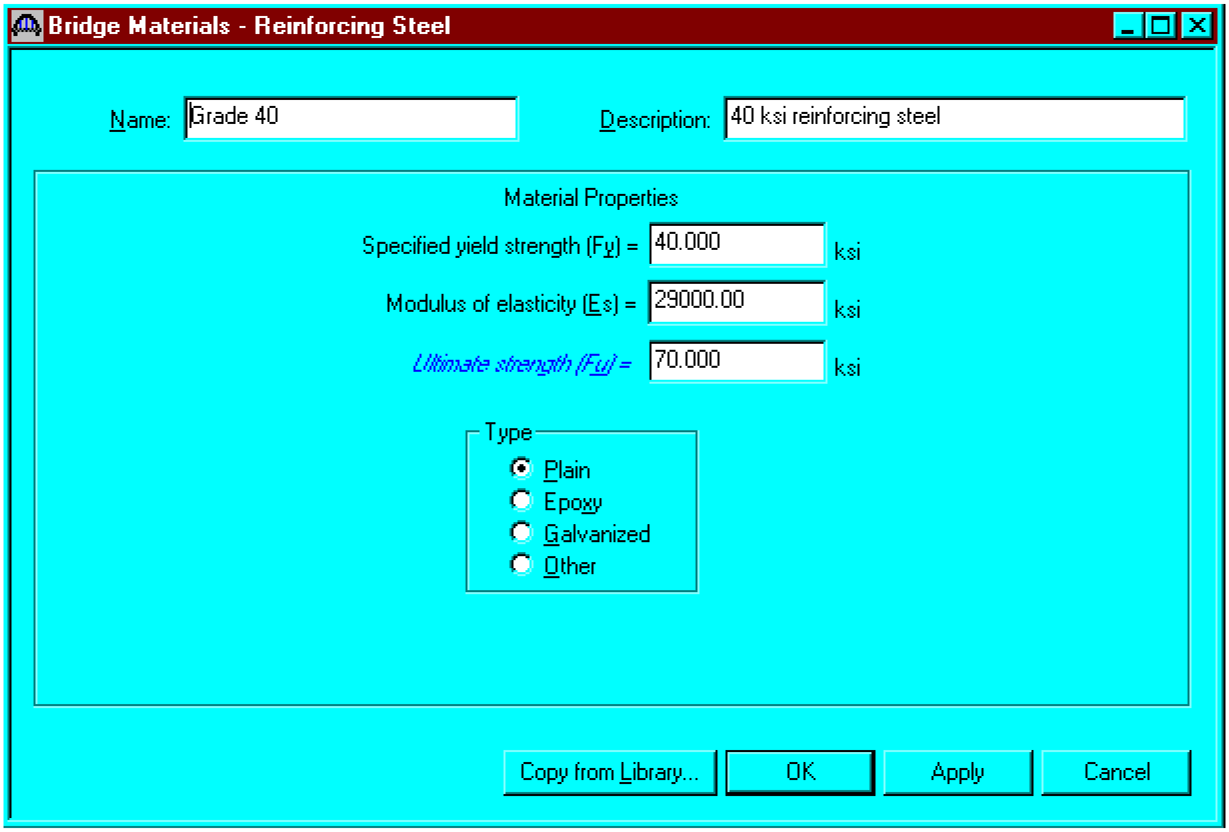
Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.588 ksi

Shear factor = 1.000

Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.



Name: Grade 40

Description: 40 ksi reinforcing steel

Material Properties

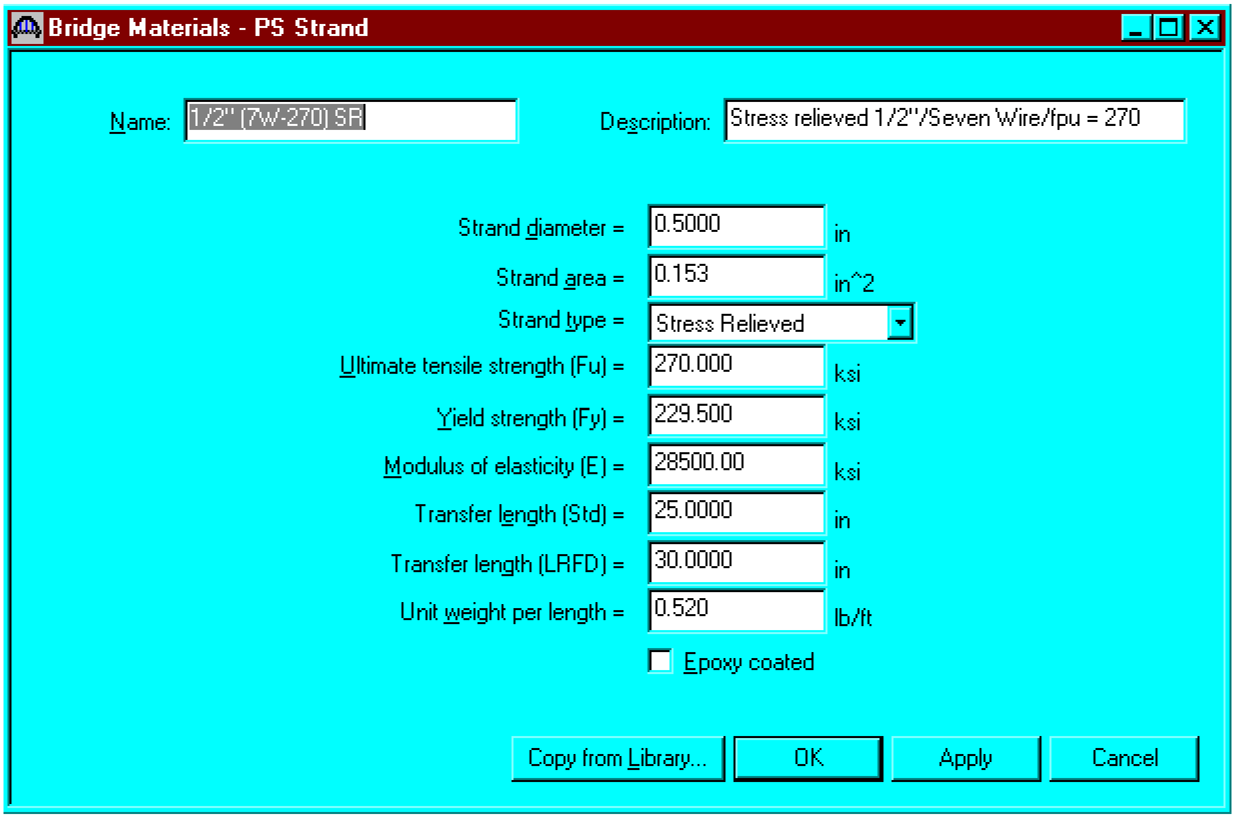
Specified yield strength (Fy) = 40.000 ksi

Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 70.000 ksi

Type

● Plain
○ Epoxy
○ Galvanized
○ Other



Name: 1/2" (7W-270) SR

Description: Stress relieved 1/2"/Seven Wire/fpu = 270

Strand diameter = 0.5000 in

Strand area = 0.153 in^2

Strand type = Stress Relieved

Ultimate tensile strength (Fu) = 270.000 ksi

Yield strength (Fy) = 229.500 ksi

Modulus of elasticity (E) = 28500.00 ksi

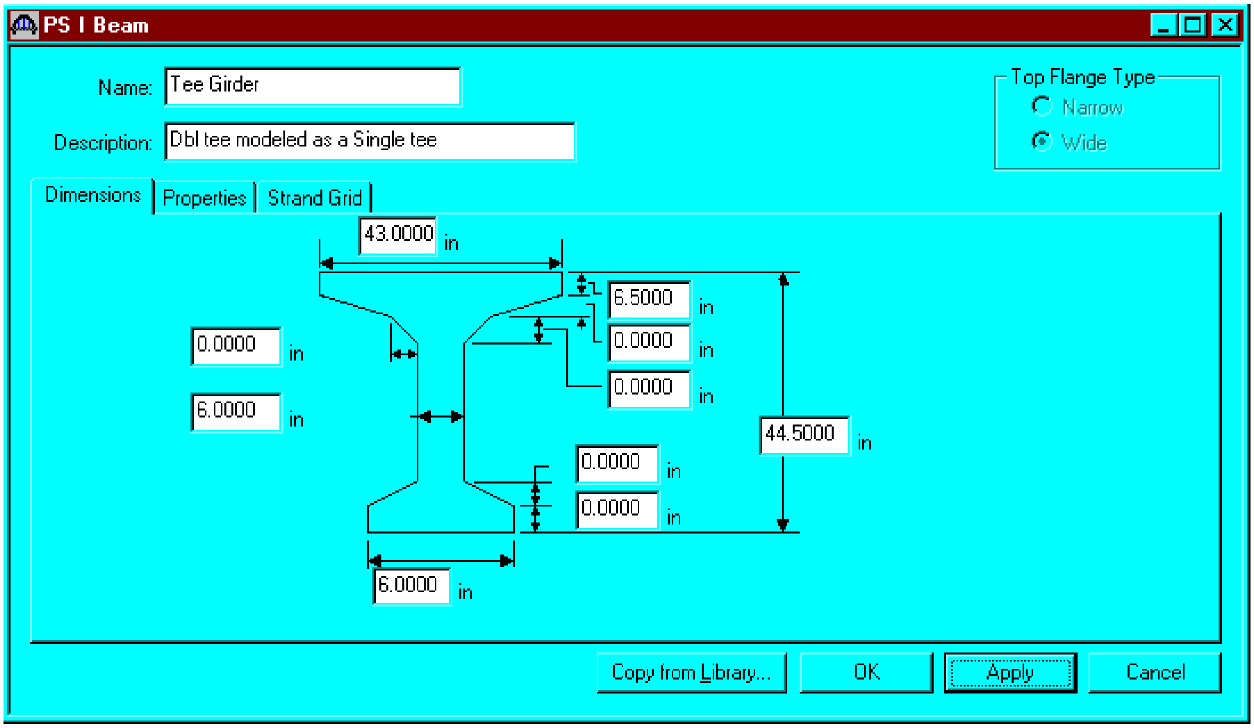
Transfer length (Std) = 25.0000 in

Transfer length (LRFD) = 30.0000 in

Unit weight per length = 0.520 lb/ft

☐ Epoxy coated

Expand the tree labeled Beam Shapes to enter a prestressed beam shape to be used in the analysis. Click on Prestressed Beam Shapes and I Beams in the tree and select File/New from the menu (or right mouse click on I Beam and select New). Fill in the data for the beam (Modeled as a Single-Tee beam). Click the Properties tab, then the compute button and then OK.



PS I Beam

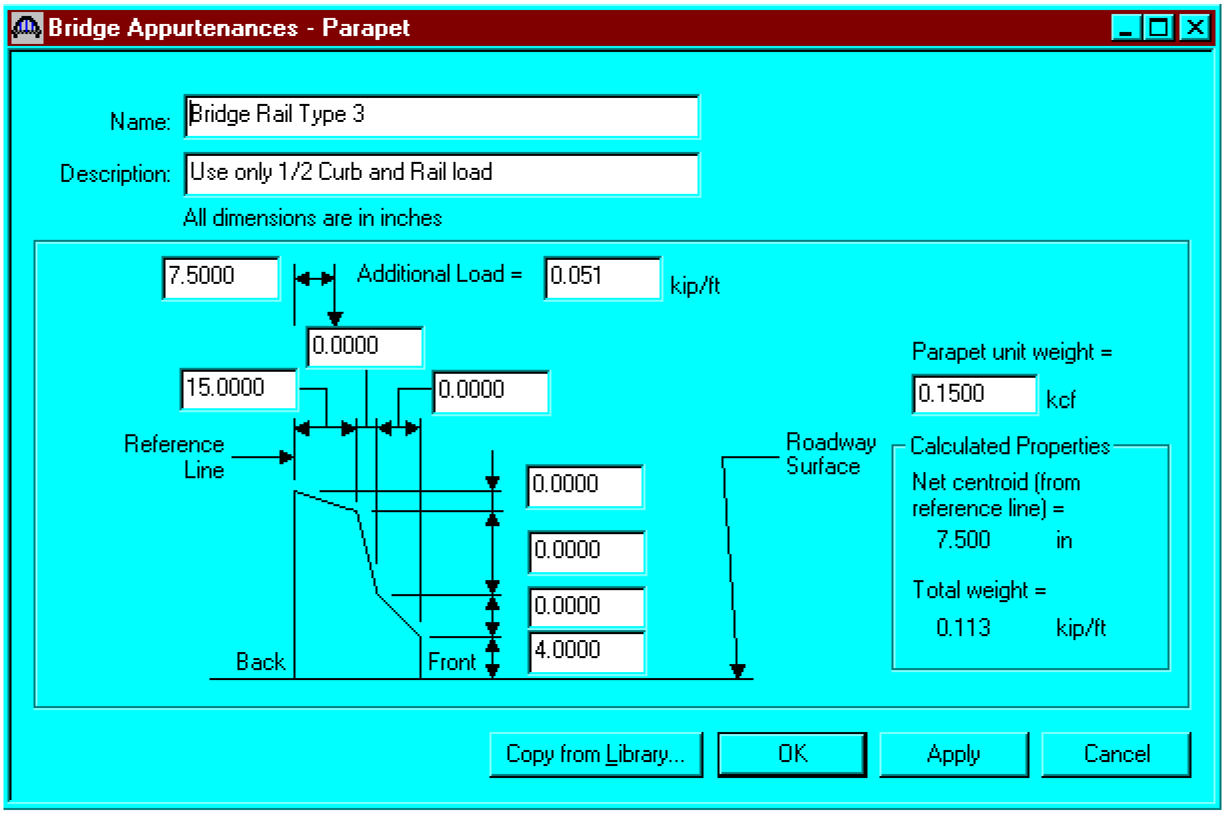
Name: Tee Girder

Description: Dbl tee modeled as a Single tee

Top Flange Type
○ Narrow
● Wide

Click OK to save the data to memory and close the window.

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, select New and fill in the data for the Bridge Rail Type 3 (Note: Since the girder is modeled as a single-Tee, use only ½ the curb and rail load). Click OK to save the data to memory and close the window.



Name: Bridge Rail Type 3

Description: Use only 1/2 Curb and Rail load

All dimensions are in inches

7.5000

Additional Load = 0.051 kip/ft

0.0000

15.0000

0.0000

0.0000

0.0000

0.0000

4.0000

Parapet unit weight = 0.1500 kcf

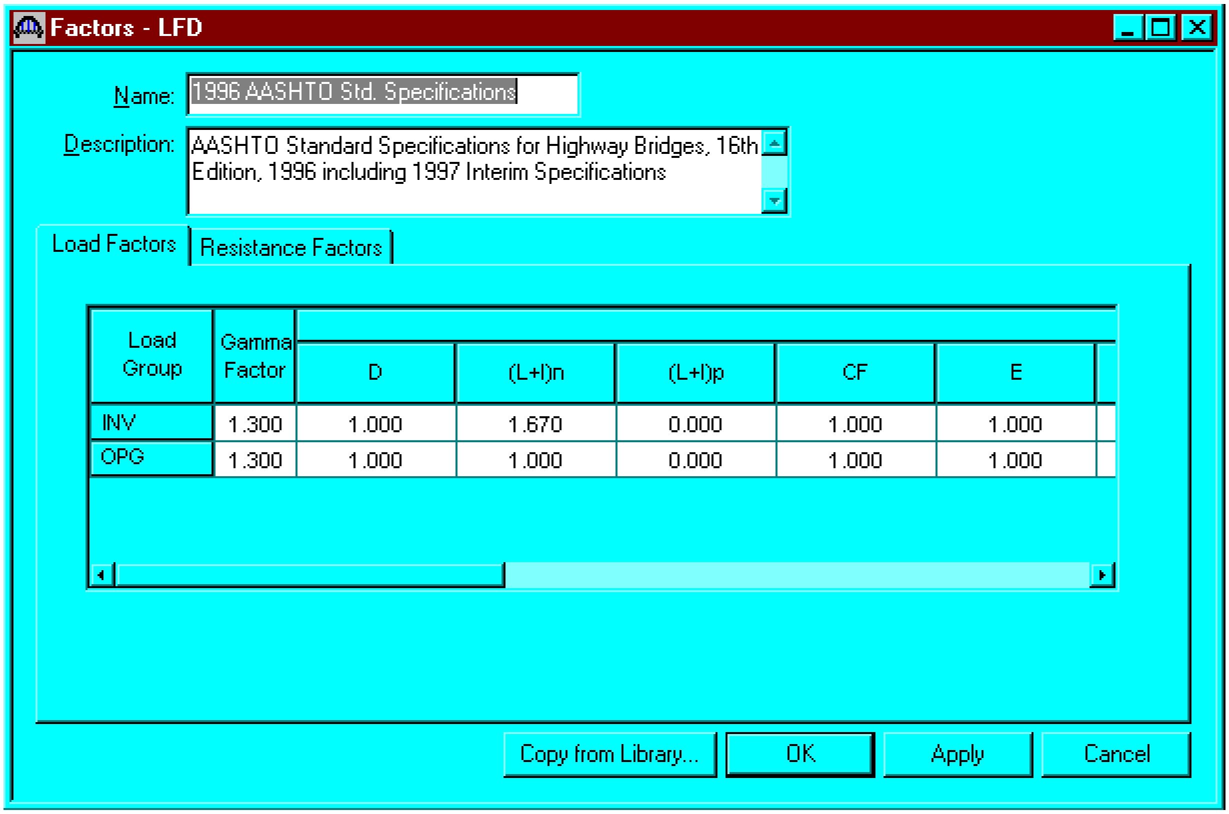
Calculated Properties

Net centroid (from reference line) = 7.500 in

Total weight = 0.113 kip/ft

The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

This window shows the LFD load factors.

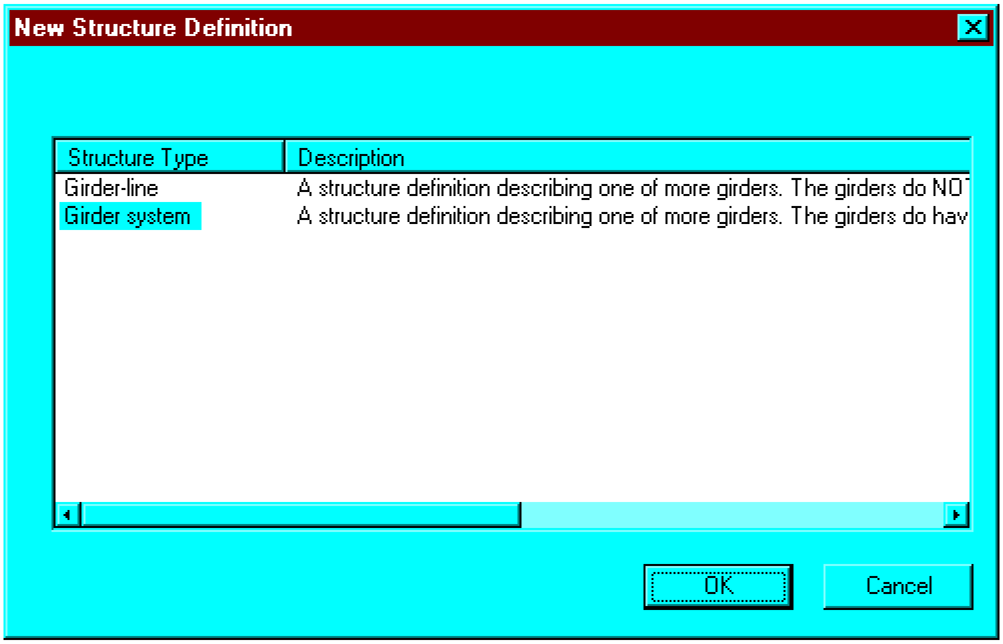


Name: 1996 AASHTO Std. Specifications

Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

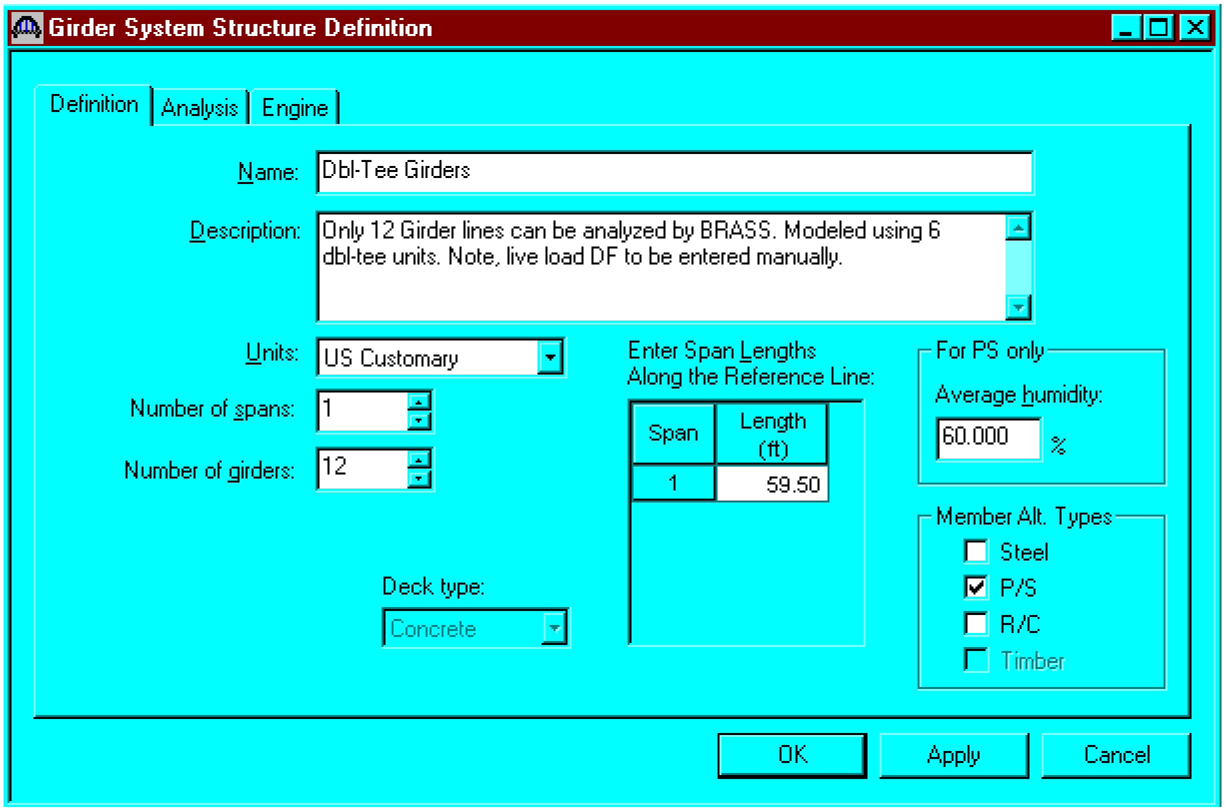
Load Group	Gamma Factor	D	(L+I)n	(L+I)p	CF	E
INV	1.300	1.000	1.670	0.000	1.000	1.000
OPG	1.300	1.000	1.000	0.000	1.000	1.000

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



Structure Type	Description
Girder-line	A structure definition describing one of more girders. The girders do NO
Girder system	A structure definition describing one of more girders. The girders do hav

Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



Name: Dbl-Tee Girders

Description: Only 12 Girder lines can be analyzed by BRASS. Modeled using 6 dbl-tee units. Note, live load DF to be entered manually.

Units: US Customary

Number of spans: 1

Number of girders: 12

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	59.50

For PS only

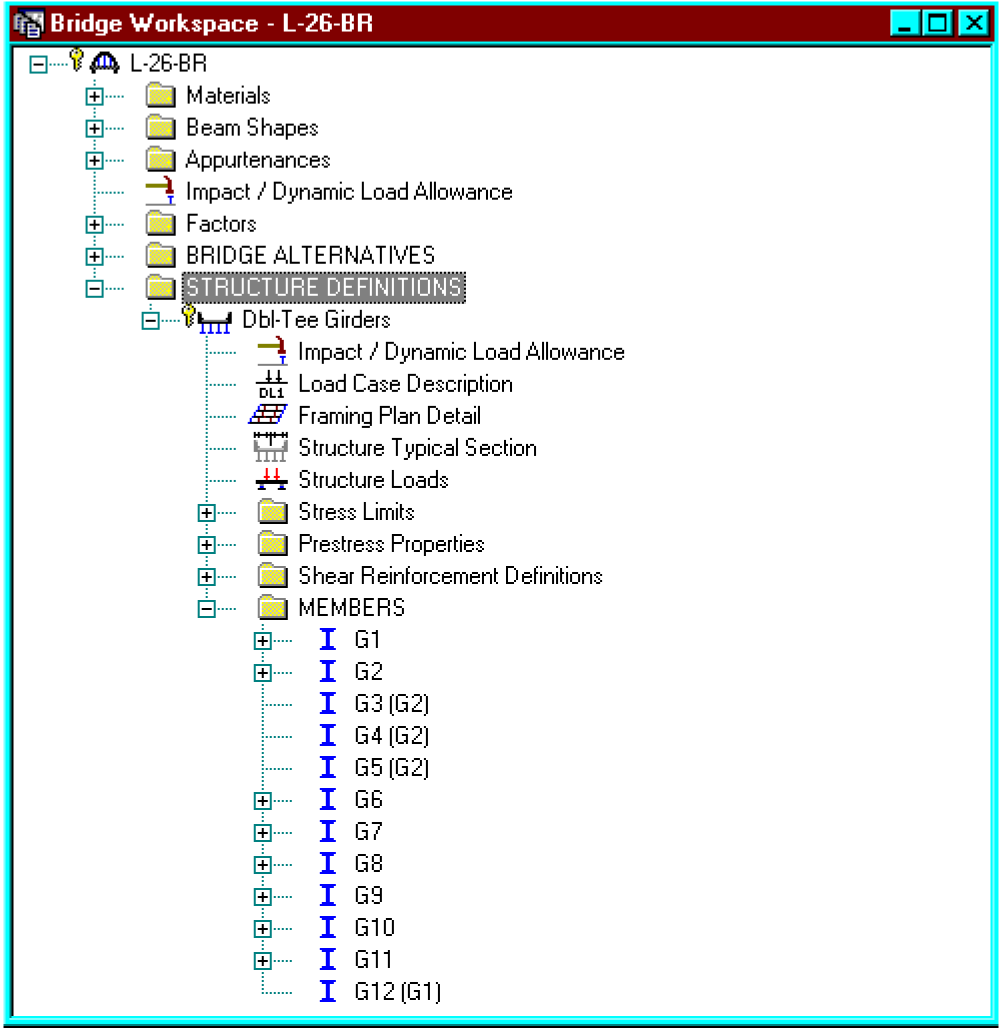
Average humidity: 60.000 %

Member Alt. Types

☐ Steel
☑ P/S
☐ R/C
☐ Timber

Span length for a simple span prestressed girder structure shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:

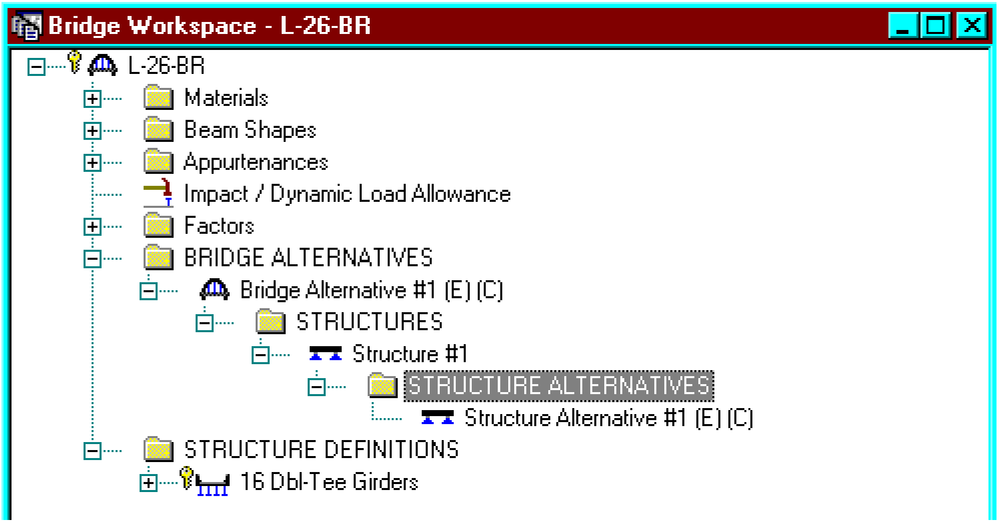


Bridge Workspace - L-26-BR

- L-26-BR
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
  - BRIDGE ALTERNATIVES
  - STRUCTURE DEFINITIONS
    - Dbl-Tee Girders
      - Impact / Dynamic Load Allowance
      - Load Case Description
      - Framing Plan Detail
      - Structure Typical Section
      - Structure Loads
      - Stress Limits
      - Prestress Properties
      - Shear Reinforcement Definitions
      - MEMBERS
        - G1
        - G2
        - G3 (G2)
        - G4 (G2)
        - G5 (G2)
        - G6
        - G7
        - G8
        - G9
        - G10
        - G11
        - G12 (G1)

We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

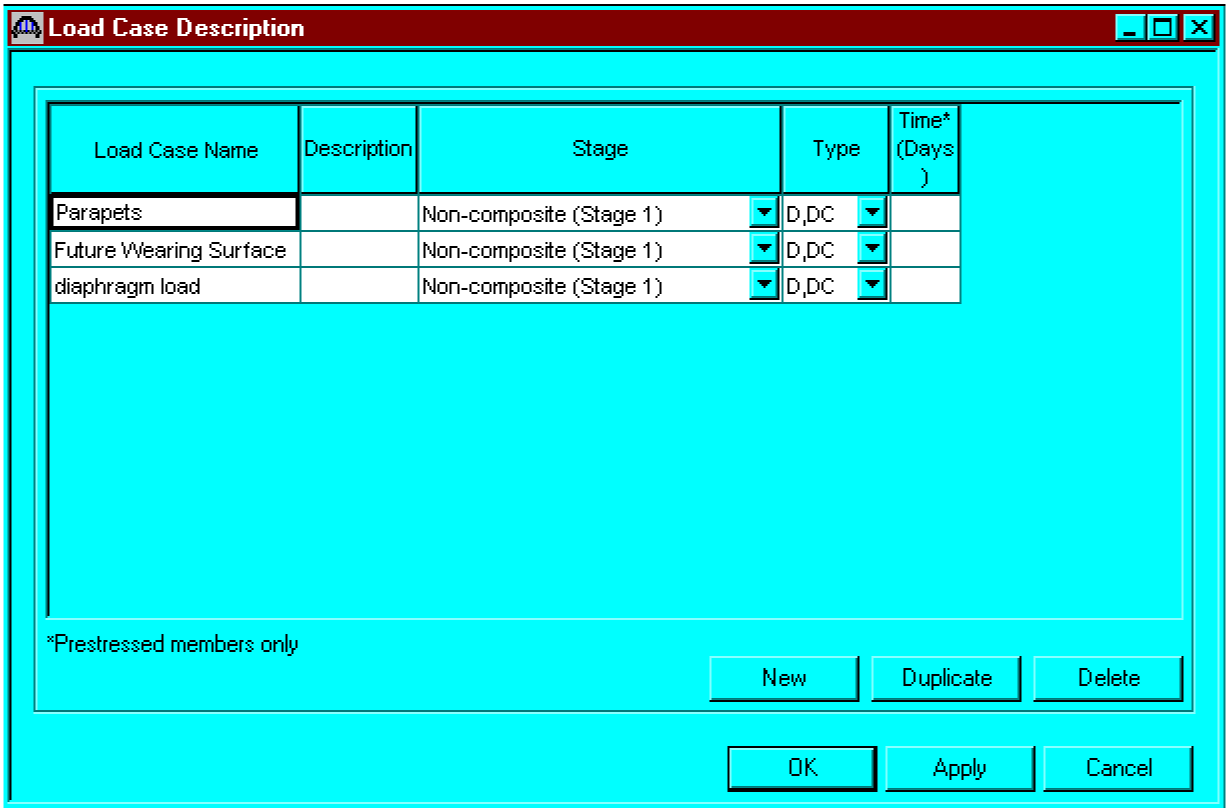
The partially expanded Bridge Workspace tree is shown below:



Bridge Workspace - L-26-BR

- L-26-BR
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
  - BRIDGE ALTERNATIVES
    - Bridge Alternative #1 (E) (C)
      - STRUCTURES
        - Structure #1
          - STRUCTURE ALTERNATIVES
            - Structure Alternative #1 (E) (C)
  - STRUCTURE DEFINITIONS
    - 16 Dbl-Tee Girders

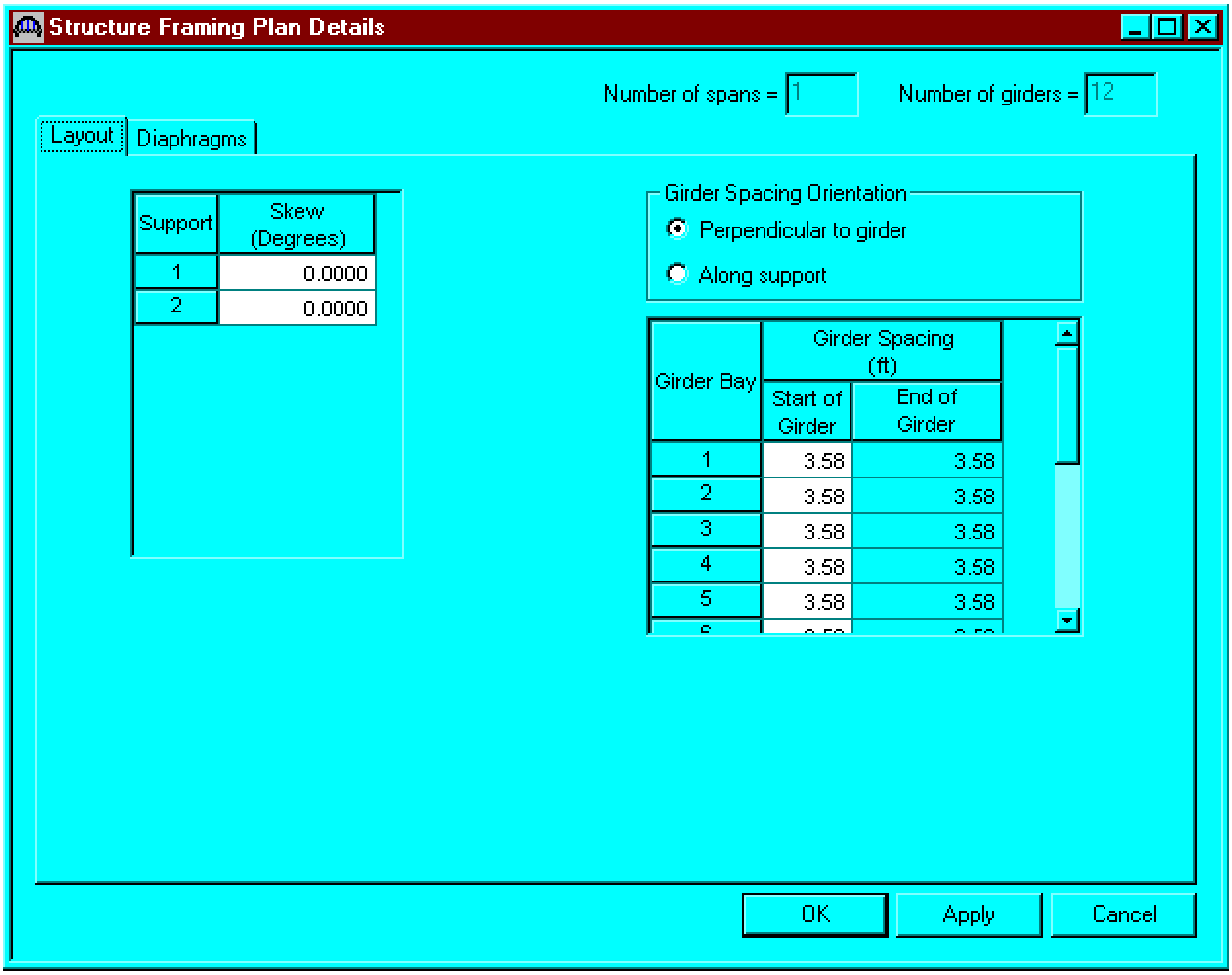
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.



Load Case Name	Description	Stage	Type	Time* (Days)
Parapets		Non-composite (Stage 1)	D,DC	
Future Wearing Surface		Non-composite (Stage 1)	D,DC	
diaphragm load		Non-composite (Stage 1)	D,DC	

*Prestressed members only

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



Number of spans = 1

Number of girders = 12

Support	Skew (Degrees)
1	0.0000
2	0.0000

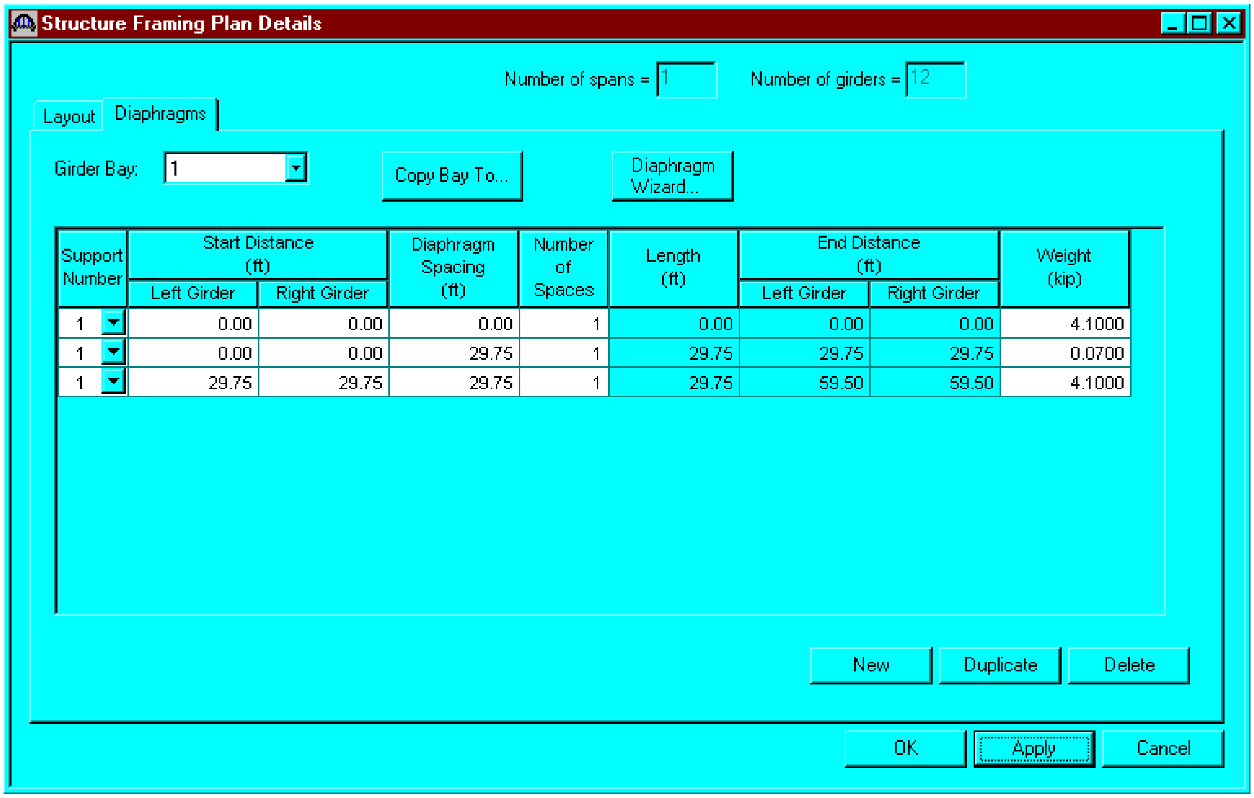
Girder Spacing Orientation

● Perpendicular to girder

○ Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	3.58	3.58
2	3.58	3.58
3	3.58	3.58
4	3.58	3.58
5	3.58	3.58

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.



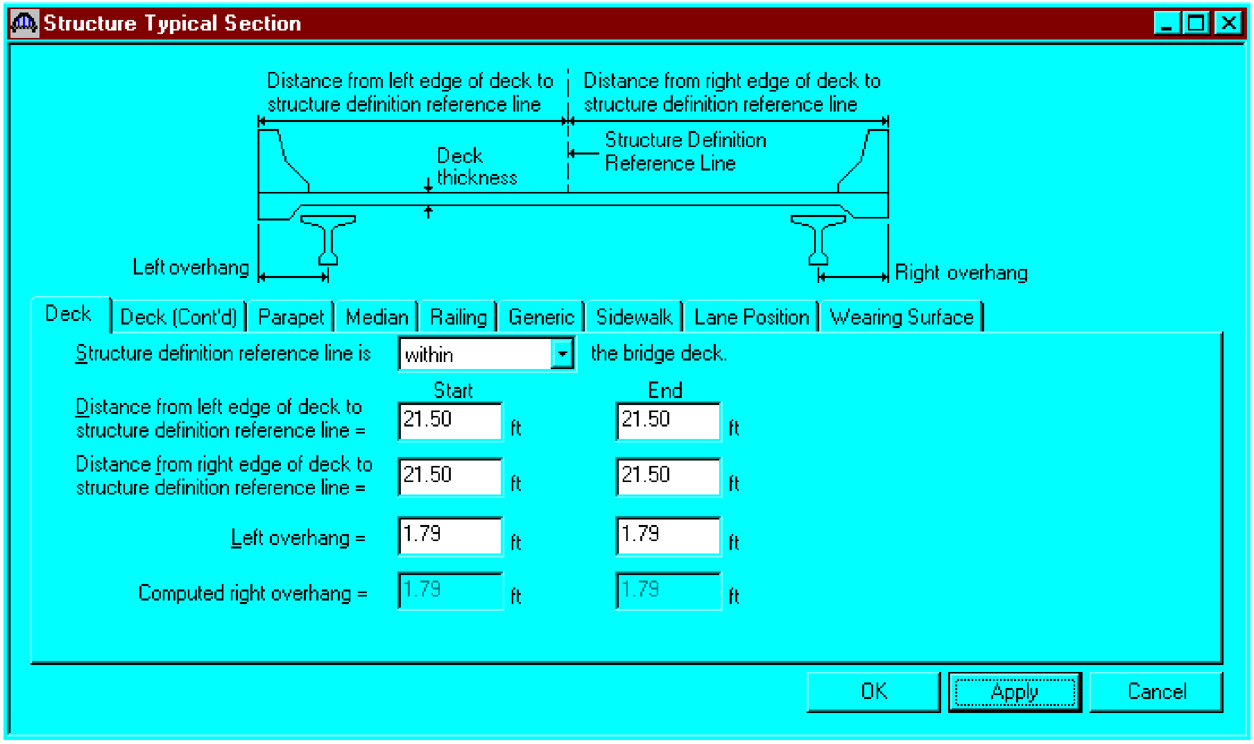
Number of spans = 1

Number of girders = 12

Girder Bay: 1

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	4.1000
1	0.00	0.00	29.75	1	29.75	29.75	29.75	0.0700
1	29.75	29.75	29.75	1	29.75	59.50	59.50	4.1000

Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.

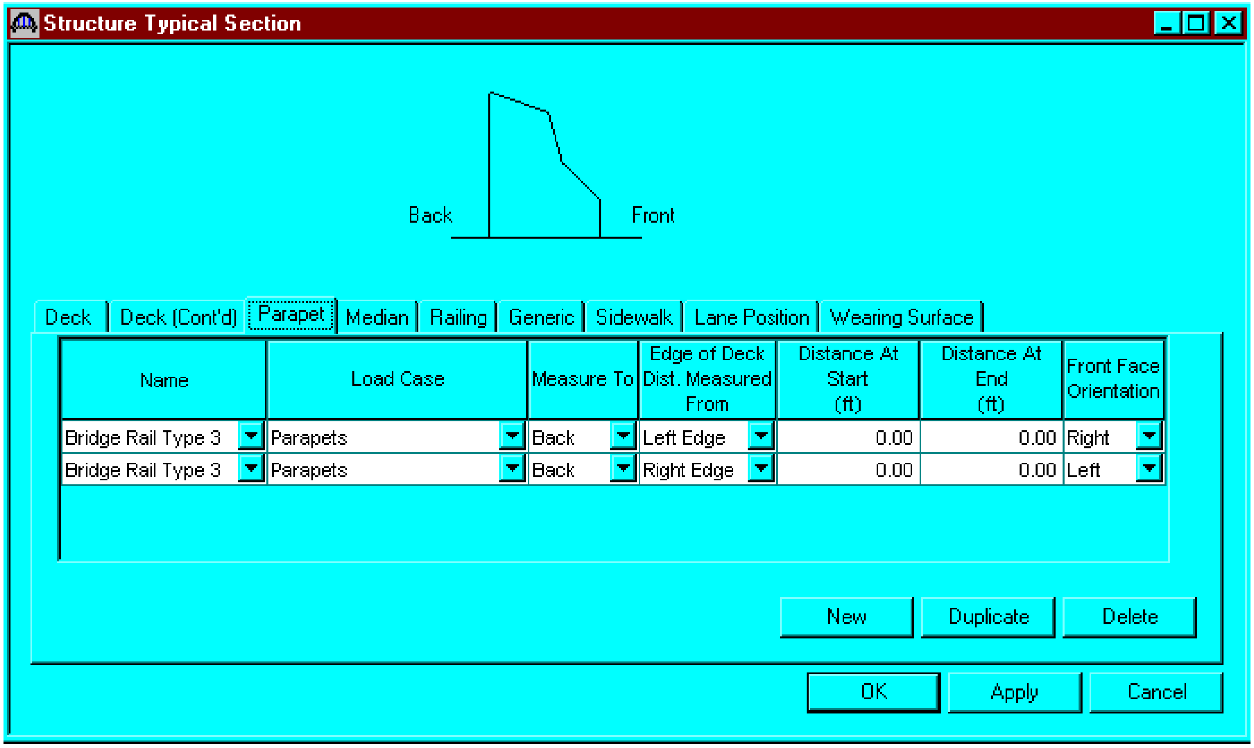


Structure definition reference line is within the bridge deck.

	Start		End	
Distance from left edge of deck to structure definition reference line =	21.50	ft	21.50	ft
Distance from right edge of deck to structure definition reference line =	21.50	ft	21.50	ft
Left overhang =	1.79	ft	1.79	ft
Computed right overhang =	1.79	ft	1.79	ft

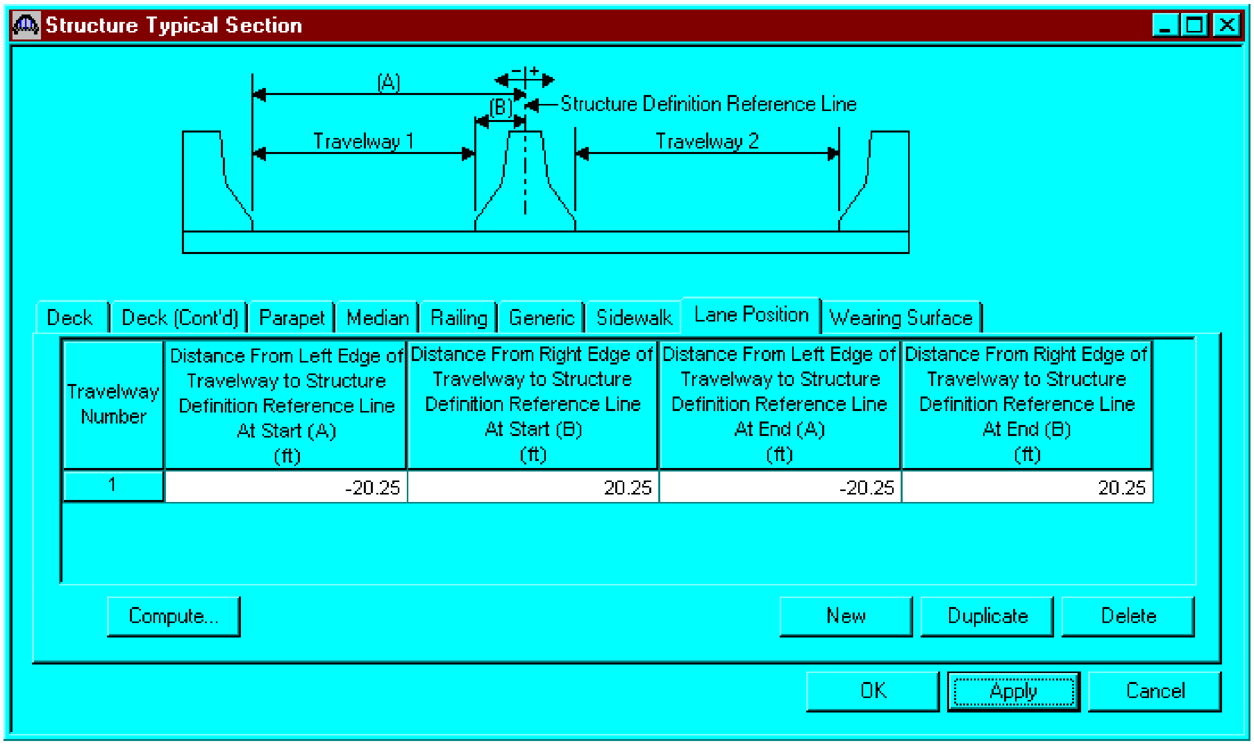
The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. This structure does not have a concrete deck, so leave the information on this tab blank.

Parapets:
Add two parapets as shown below.



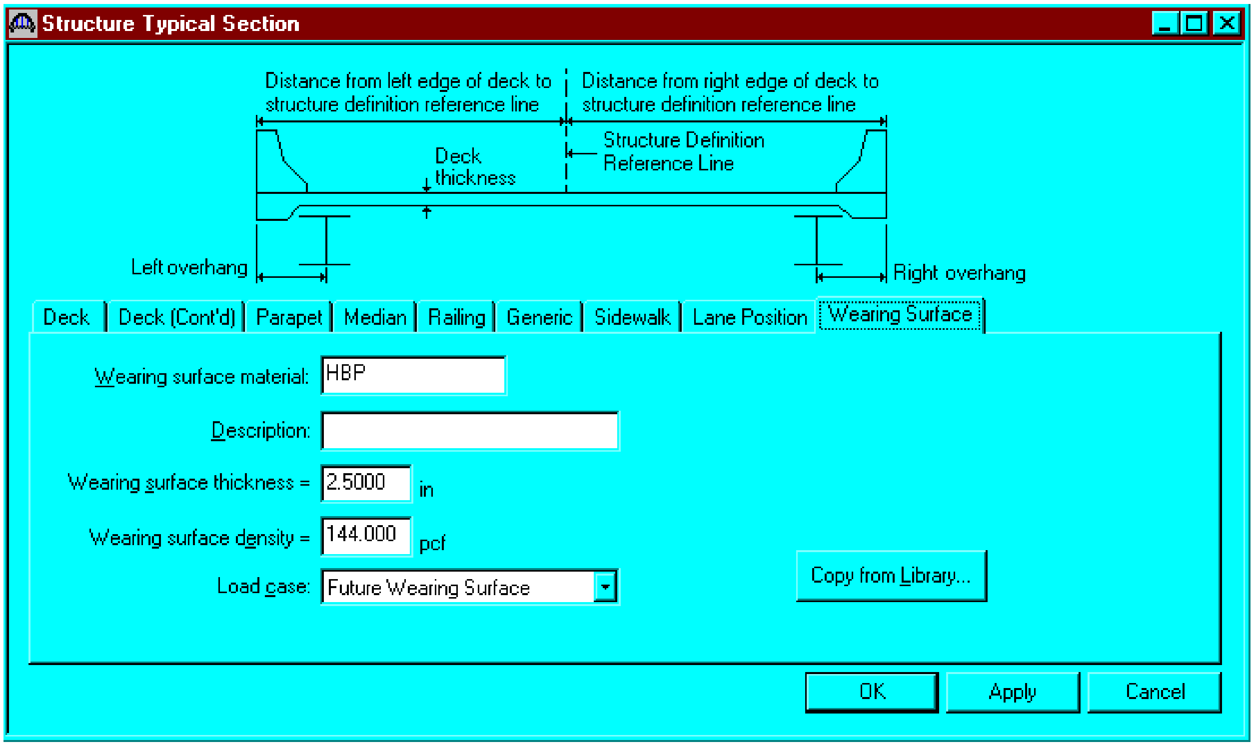
Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Bridge Rail Type 3	Parapets	Back	Left Edge	0.00	0.00	Right
Bridge Rail Type 3	Parapets	Back	Right Edge	0.00	0.00	Left

Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to accept the computed values. The Lane Position tab is populated as shown below.



Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At End (B) (ft)
1	-20.25	20.25	-20.25	20.25

Enter the following wearing surface information on the Wearing Surface tab.



Wearing surface material: HBP

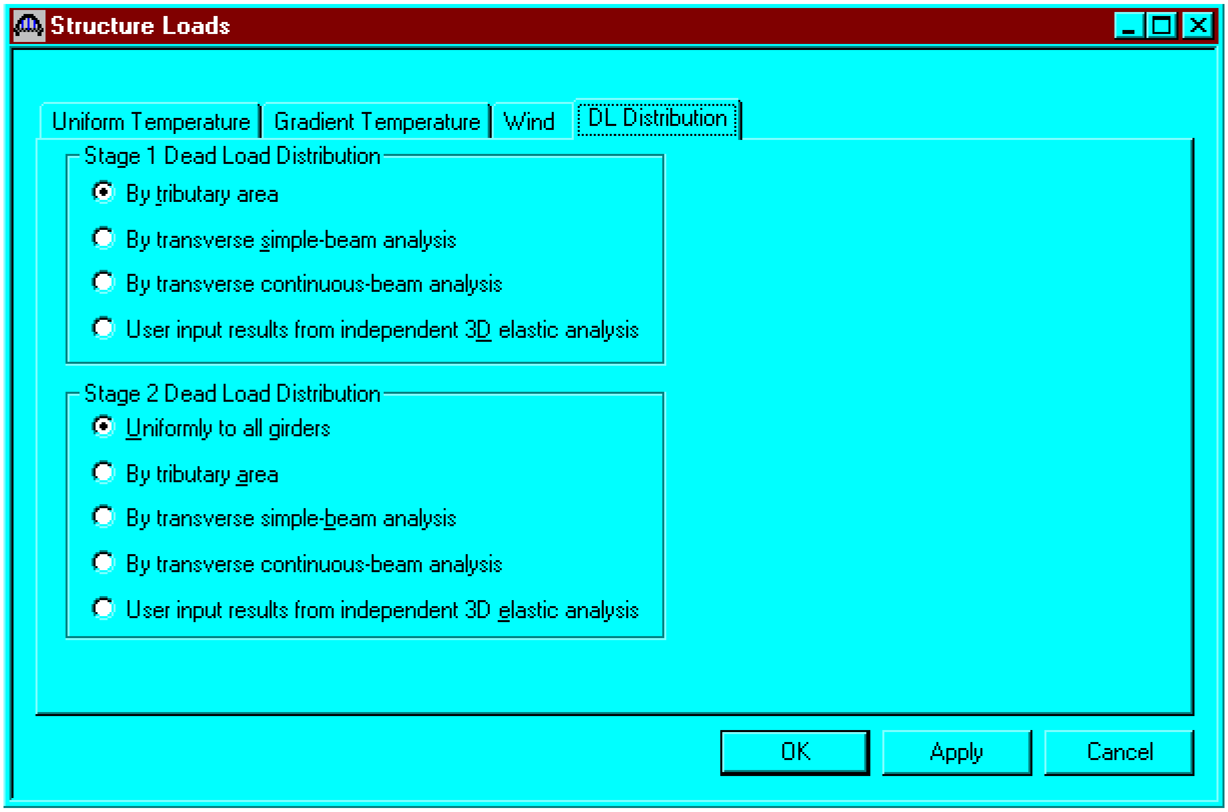
Description:

Wearing surface thickness = 2.5000 in

Wearing surface density = 144.000 pcf

Load case: Future Wearing Surface

Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



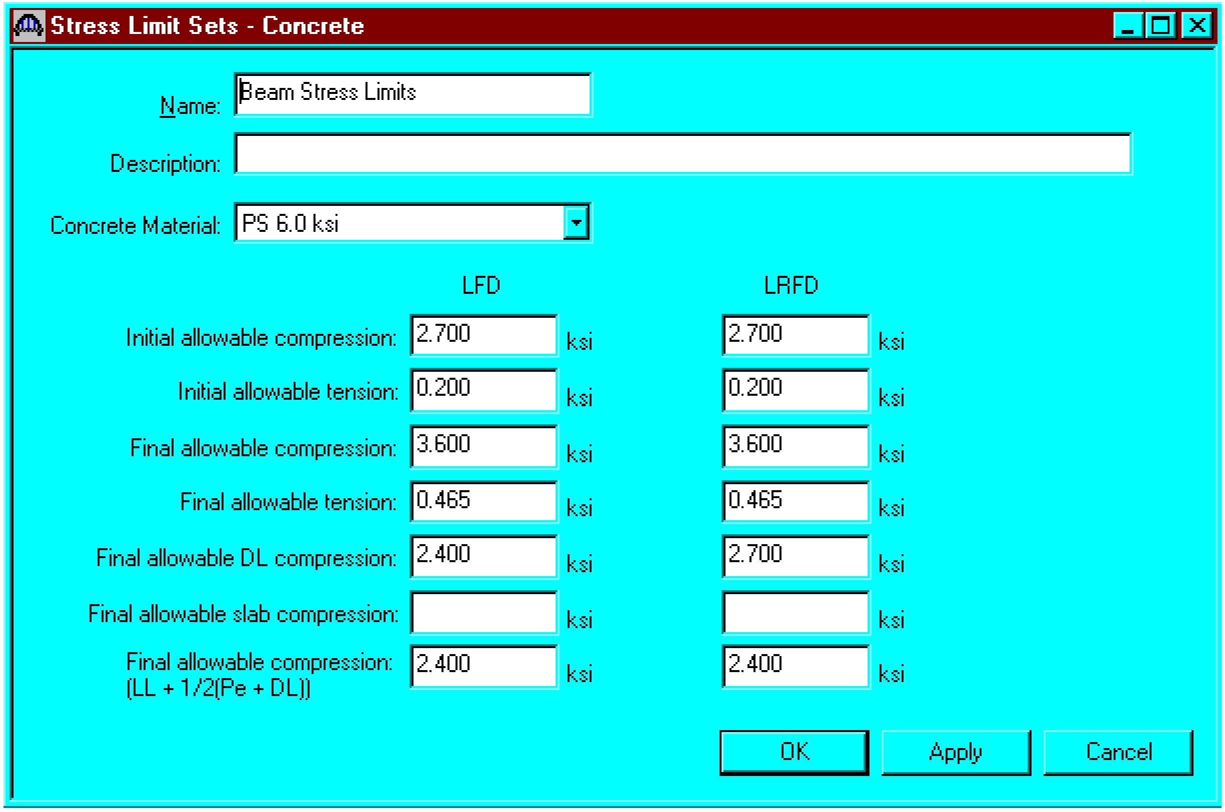
Stage 1 Dead Load Distribution

- ● By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

Stage 2 Dead Load Distribution

- ● Uniformly to all girders
- ○ By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the “PS 6.0 ksi” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.



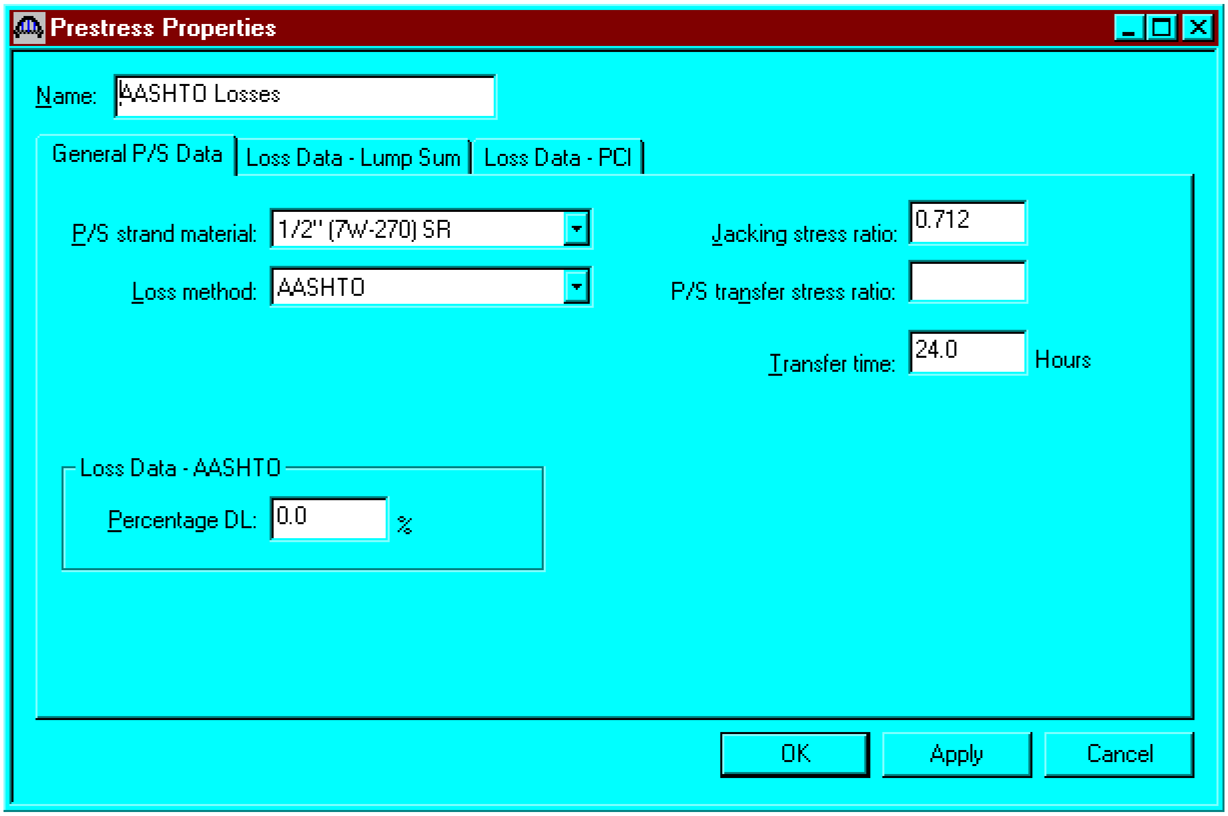
Name: Beam Stress Limits

Description:

Concrete Material: PS 6.0 ksi

	LFD		LRFD	
Initial allowable compression:	2.700	ksi	2.700	ksi
Initial allowable tension:	0.200	ksi	0.200	ksi
Final allowable compression:	3.600	ksi	3.600	ksi
Final allowable tension:	0.465	ksi	0.465	ksi
Final allowable DL compression:	2.400	ksi	2.700	ksi
Final allowable slab compression:		ksi		ksi
Final allowable compression: (LL + 1/2(Pe + DL))	2.400	ksi	2.400	ksi

Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the “General P/S Data” tab is required. Click OK to save to memory and close the window.



Name: AASHTO Losses

P/S strand material: 1/2" (7W-270) SR

Loss method: AASHTO

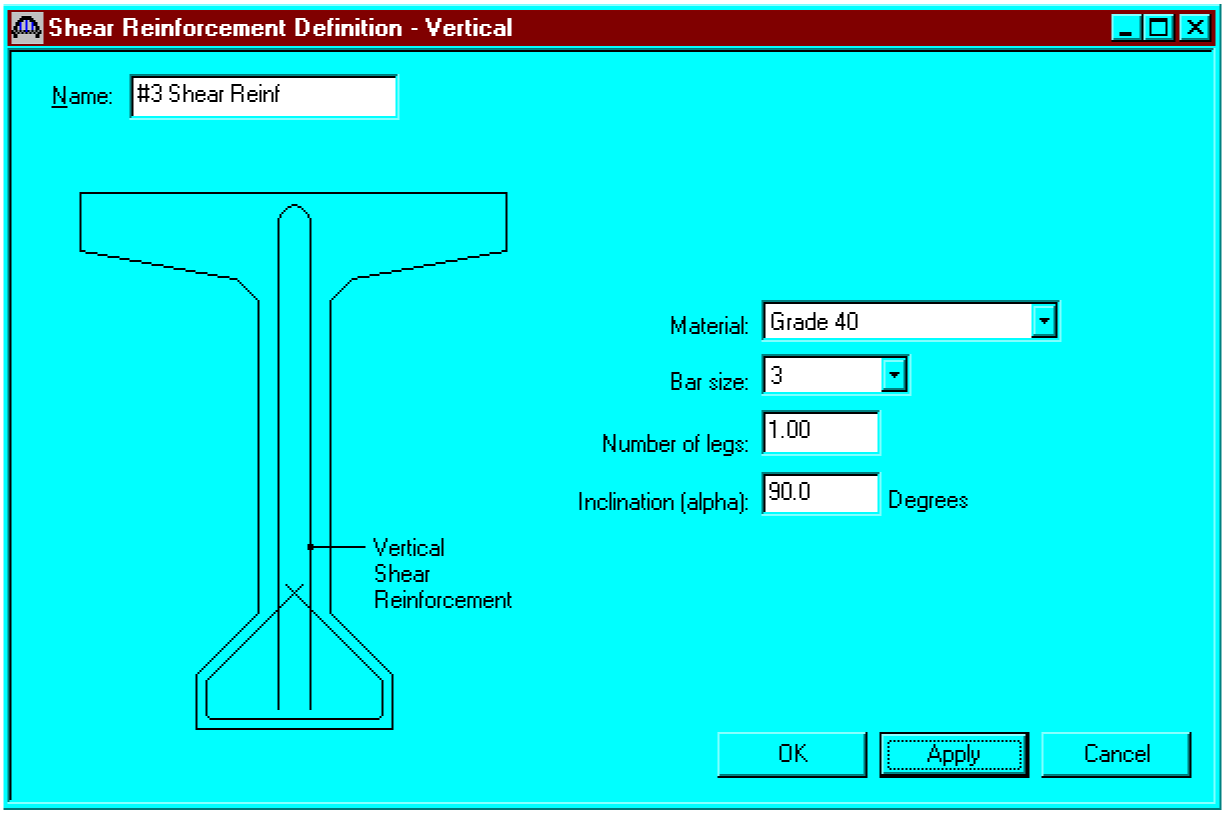
Jacking stress ratio: 0.712

P/S transfer stress ratio:

Transfer time: 24.0 Hours

Percentage DL: 0.0 %

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



Name: #3 Shear Reinf

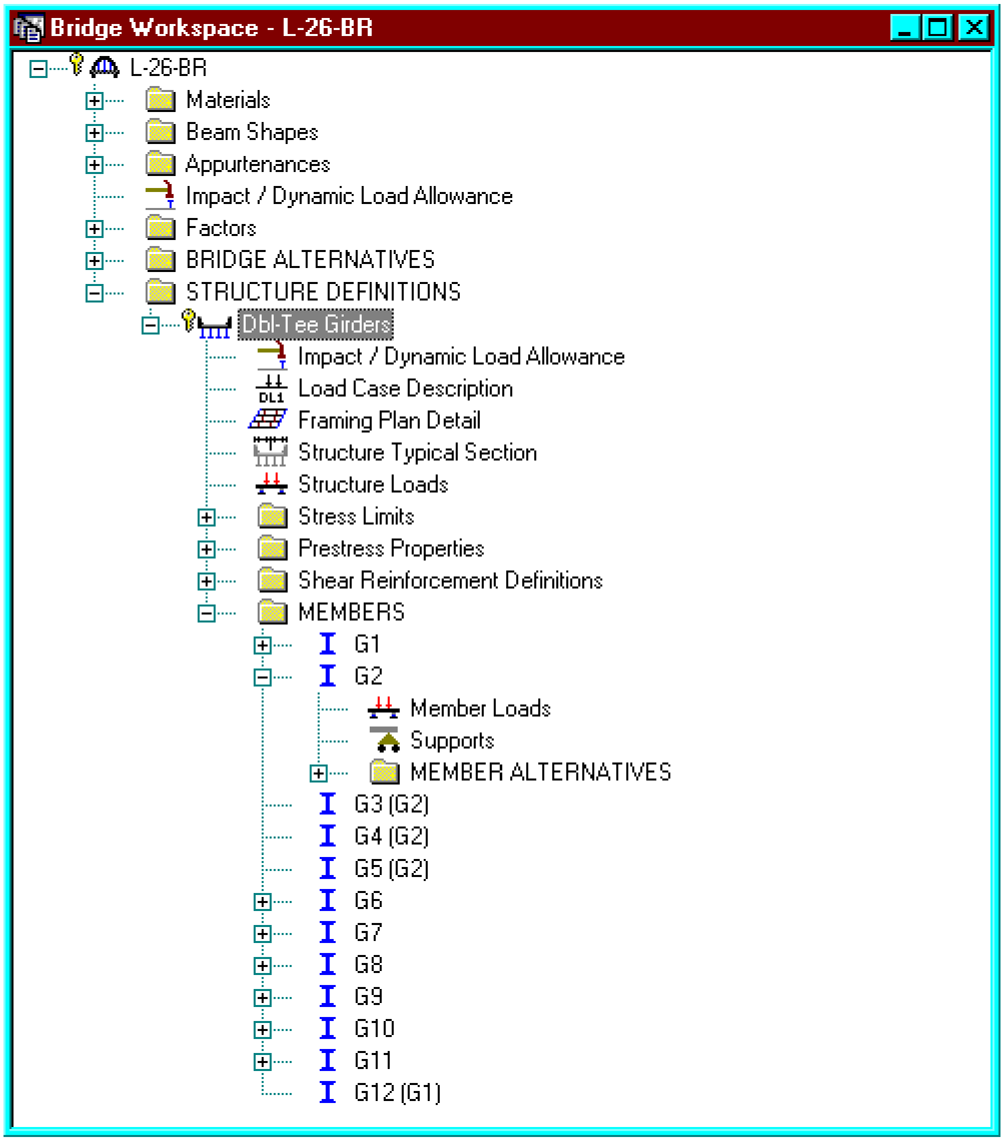
Material: Grade 40

Bar size: 3

Number of legs: 1.00

Inclination (alpha): 90.0 Degrees

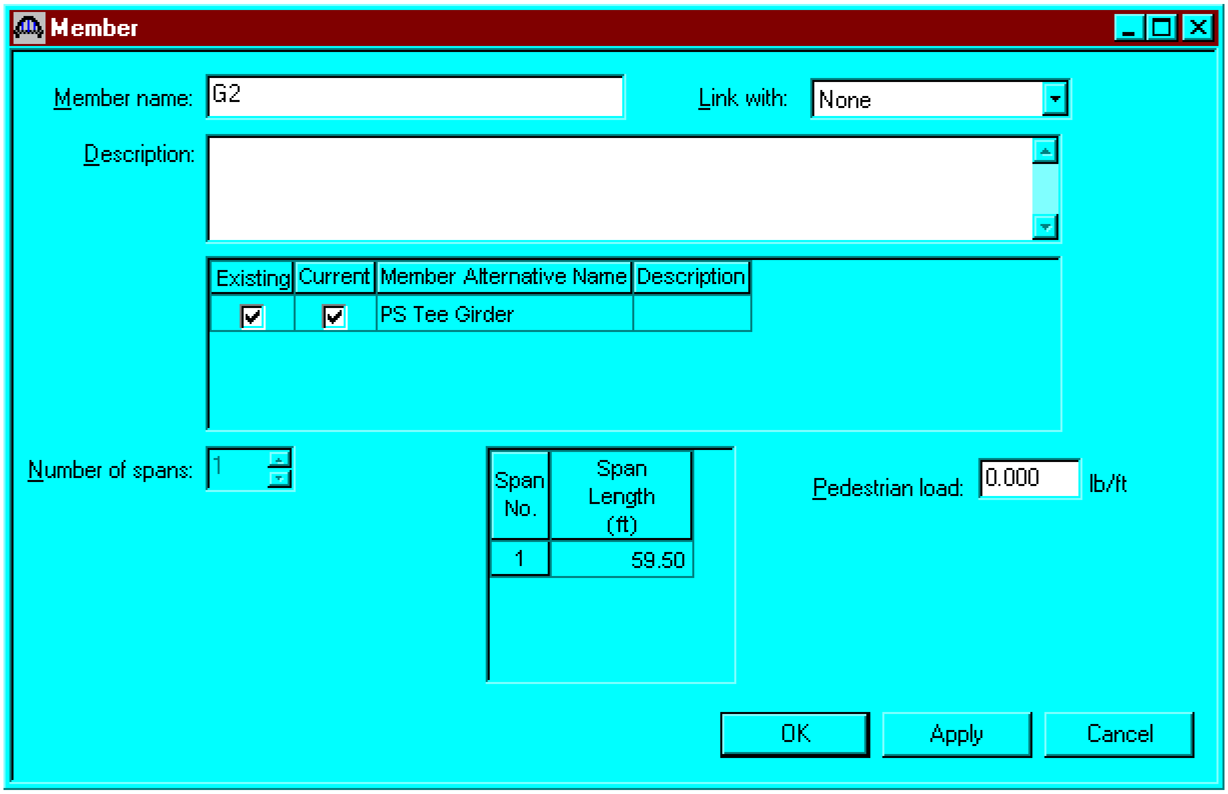
The partially expanded Bridge Workspace tree is shown below:



Bridge Workspace - L-26-BR

- L-26-BR
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
  - BRIDGE ALTERNATIVES
  - STRUCTURE DEFINITIONS
    - Dbl-Tee Girders
      - Impact / Dynamic Load Allowance
      - Load Case Description
      - Framing Plan Detail
      - Structure Typical Section
      - Structure Loads
      - Stress Limits
      - Prestress Properties
      - Shear Reinforcement Definitions
      - MEMBERS
        - G1
        - G2
          - Member Loads
          - Supports
          - MEMBER ALTERNATIVES
        - G3 (G2)
        - G4 (G2)
        - G5 (G2)
        - G6
        - G7
        - G8
        - G9
        - G10
        - G11
        - G12 (G1)

Describing a member:
The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.



Member name: G2

Link with: None

Description:

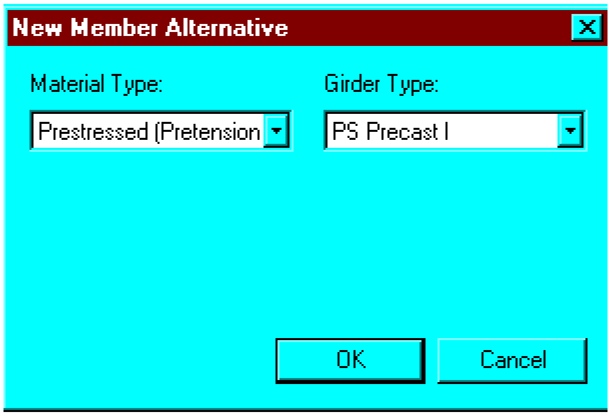
Existing	Current	Member Alternative Name	Description
☑	☑	PS Tee Girder	

Number of spans: 1

Span No.	Span Length (ft)
1	59.50

Pedestrian load: 0.000 lb/ft

Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

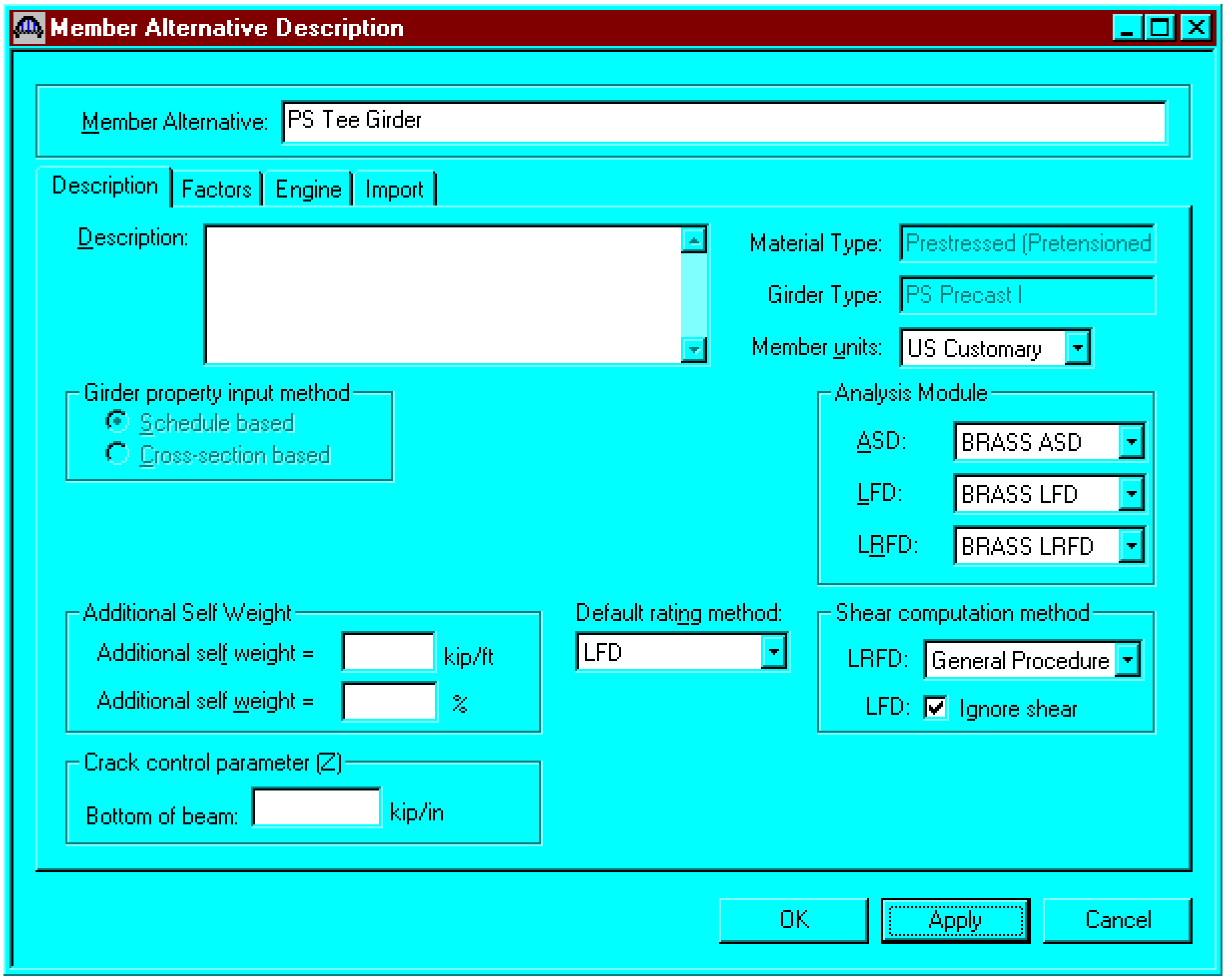


Material Type: Prestressed (Pretension

Girder Type: PS Precast I

Click OK to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam.



Member Alternative: PS Tee Girder

Description:

Material Type: Prestressed (Pretensioned

Girder Type: PS Precast I

Member units: US Customary

Girder property input method
● Schedule based
○ Cross-section based

Analysis Module
ASD: BRASS ASD
LFD: BRASS LFD
LRFD: BRASS LRFD

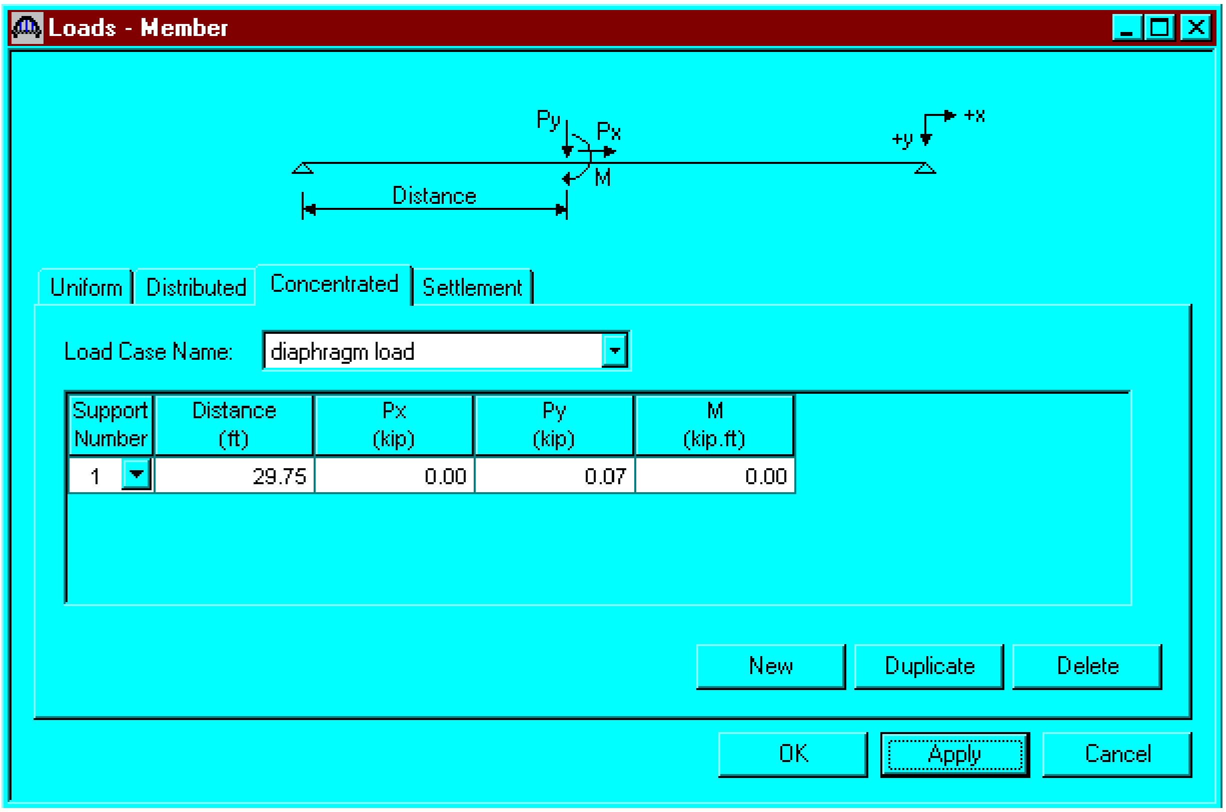
Additional Self Weight
Additional self weight = kip/ft
Additional self weight = %

Default rating method: LFD

Shear computation method
LRFD: General Procedure
LFD: ☑ Ignore shear

Crack control parameter (Z)
Bottom of beam: kip/in

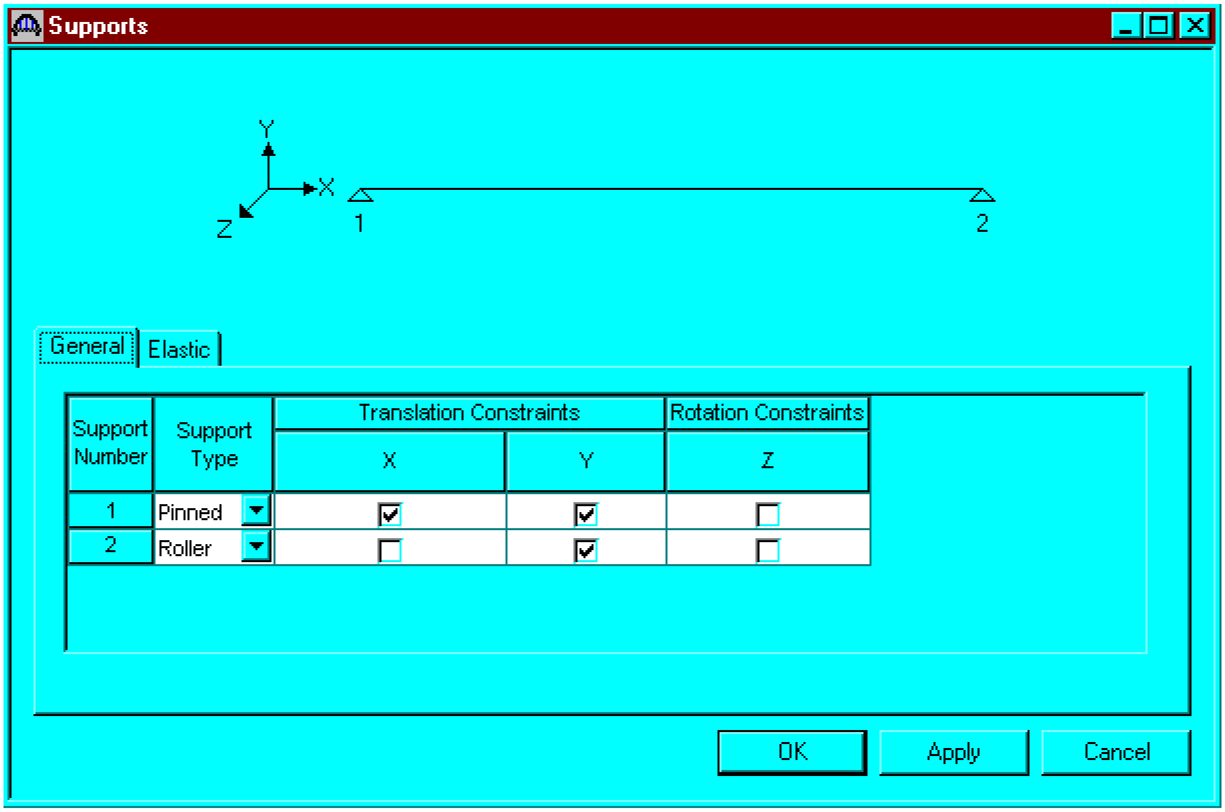
Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to intermediate diaphragm located at centerline of the girder is entered here.



Load Case Name: diaphragm load

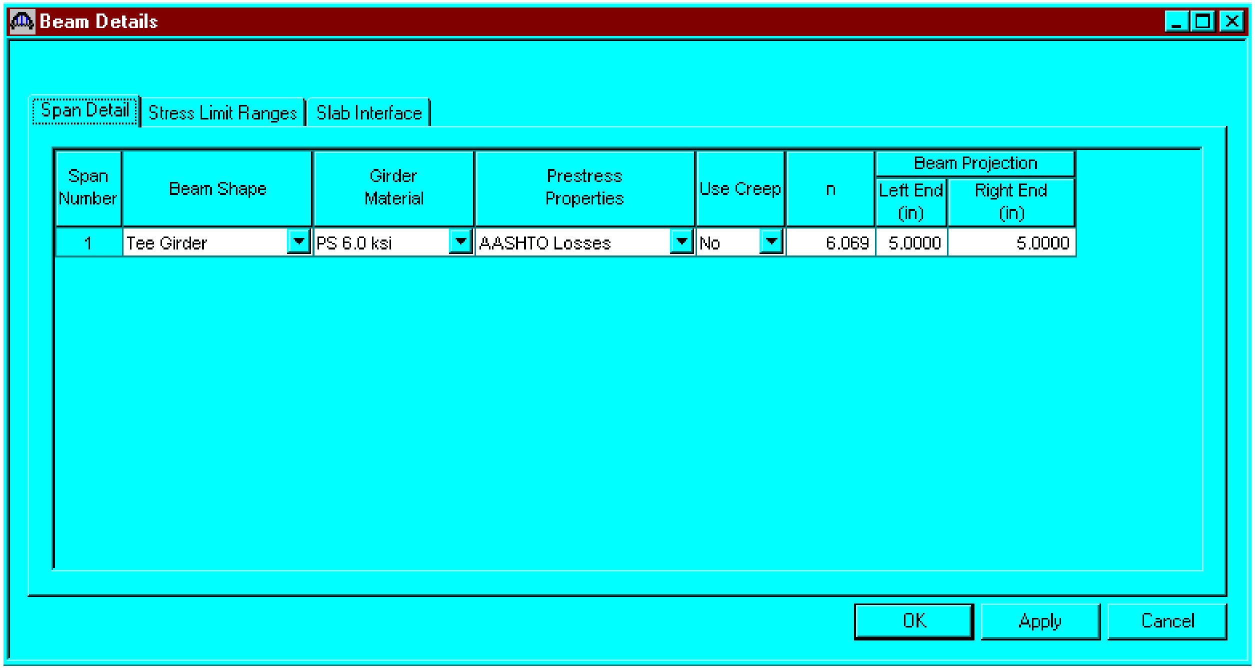
Support Number	Distance (ft)	Px (kip)	Py (kip)	M (kip.ft)
1	29.75	0.00	0.07	0.00

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



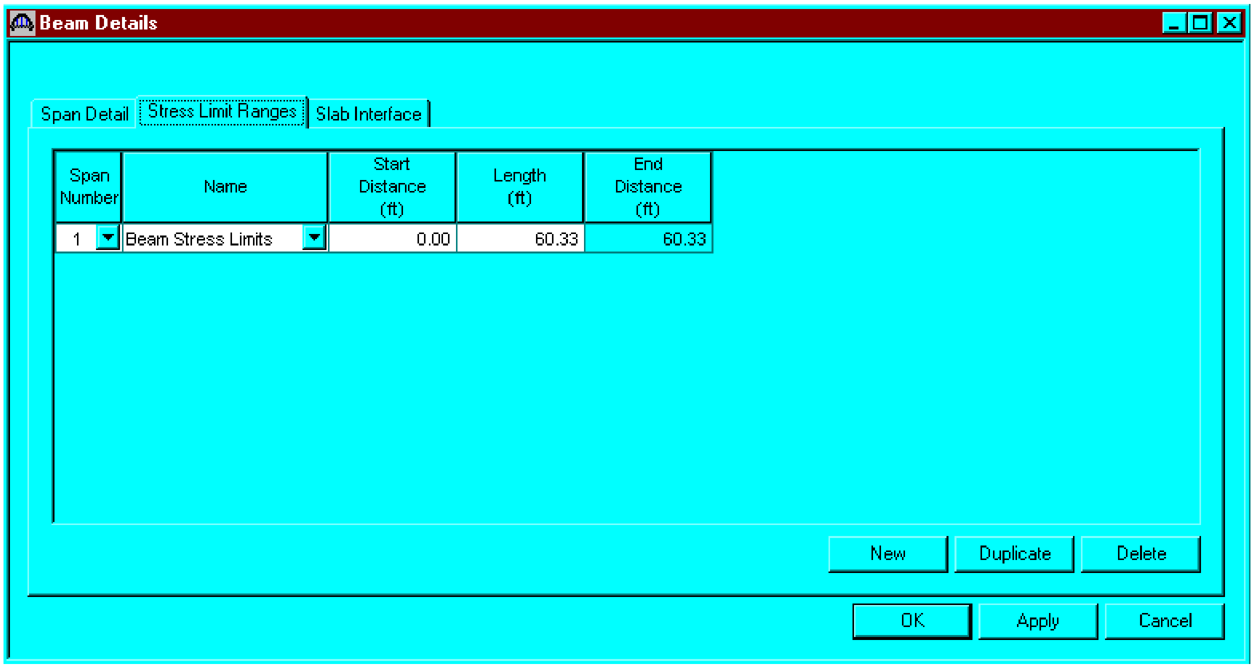
Support Number	Support Type	Translation Constraints		Rotation Constraints
		X	Y	Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐

The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape now in the Beam Details window and then come back to the Live Load Distribution window. Double click on Beam Details in the tree to describe the beam details. Enter the following beam details information.



Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	Tee Girder	PS 6.0 ksi	AASHTO Losses	No	6.069	5.0000	5.0000

Note that the Stress Limit Ranges are defined over the entire length of the precast beam.

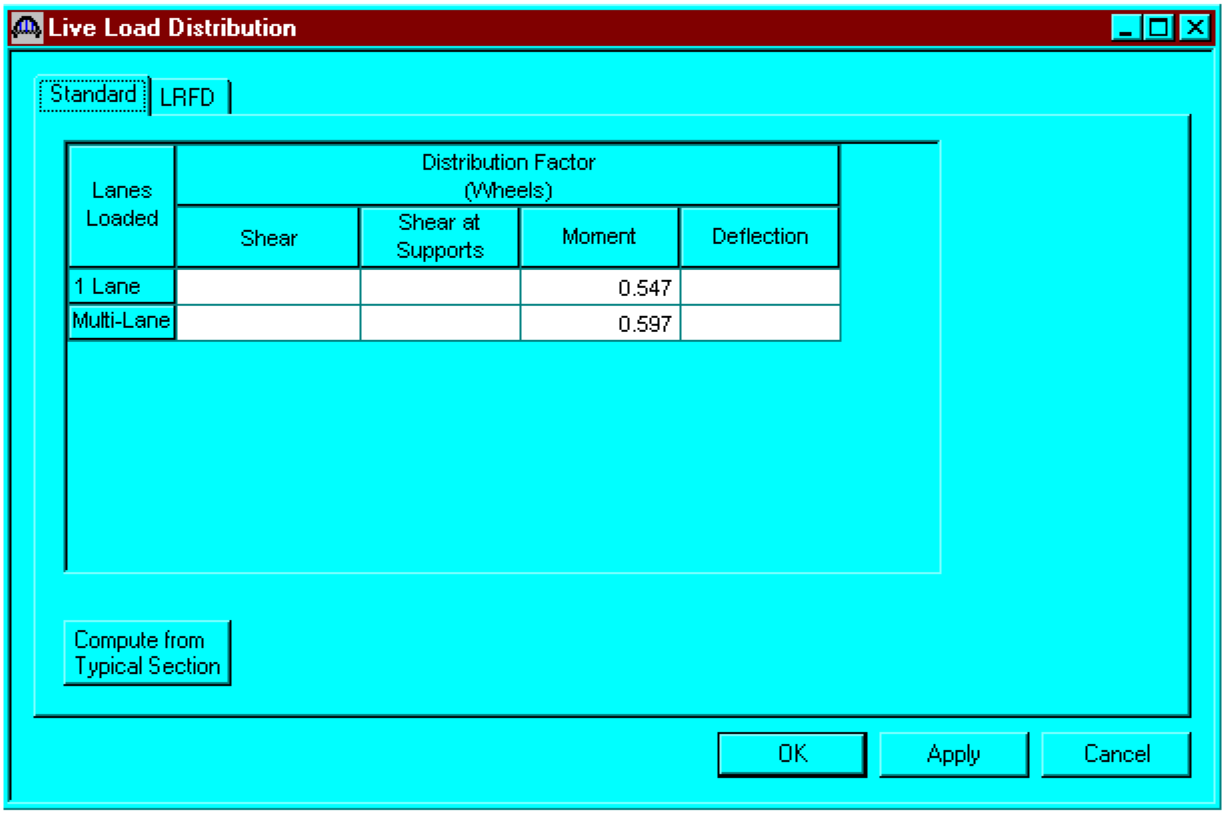


Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	Beam Stress Limits	0.00	60.33	60.33

Since we do not have a concrete deck for this structure definition, we do not need to enter any information on the Slab Interface tab.

Click OK to save the Beam Details data to memory and close the window.

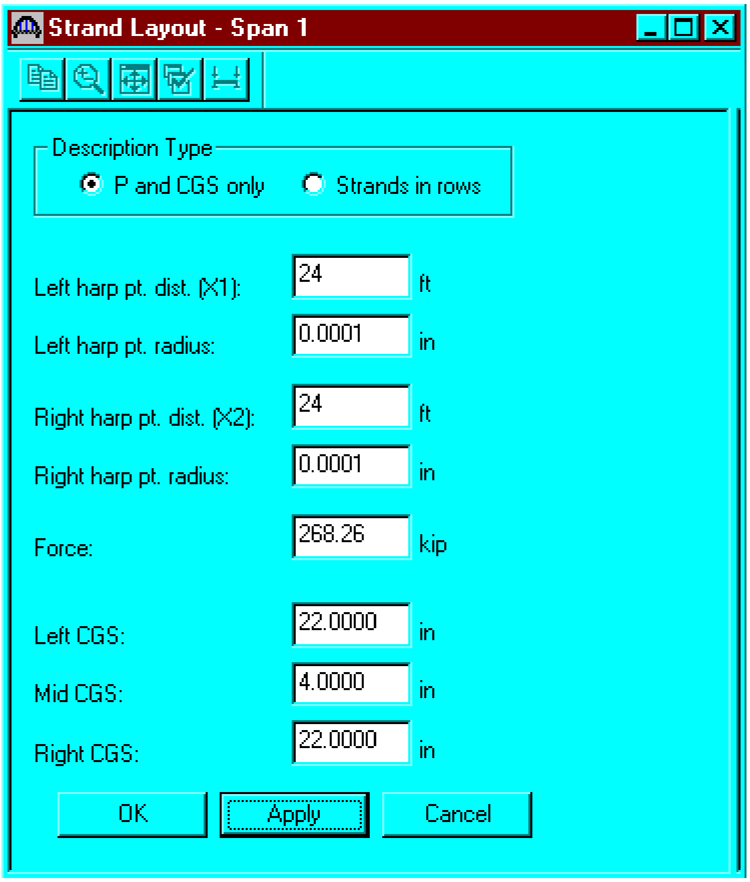
Now double click on Live Load Distribution in the tree to enter the following live load distribution factors. Click OK to save data to memory and close the window.



Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane			0.547	
Multi-Lane			0.597	

Note: The AASHTO live load distribution factor for concrete T-Girder used in the analysis.

Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center of gravity) of the group of strands. Select P and CGS only for the Description Type. Enter the following Strand Layout information for Span 1. Press F1 while on this tab to view the strand layout help topic describing the use of this information.

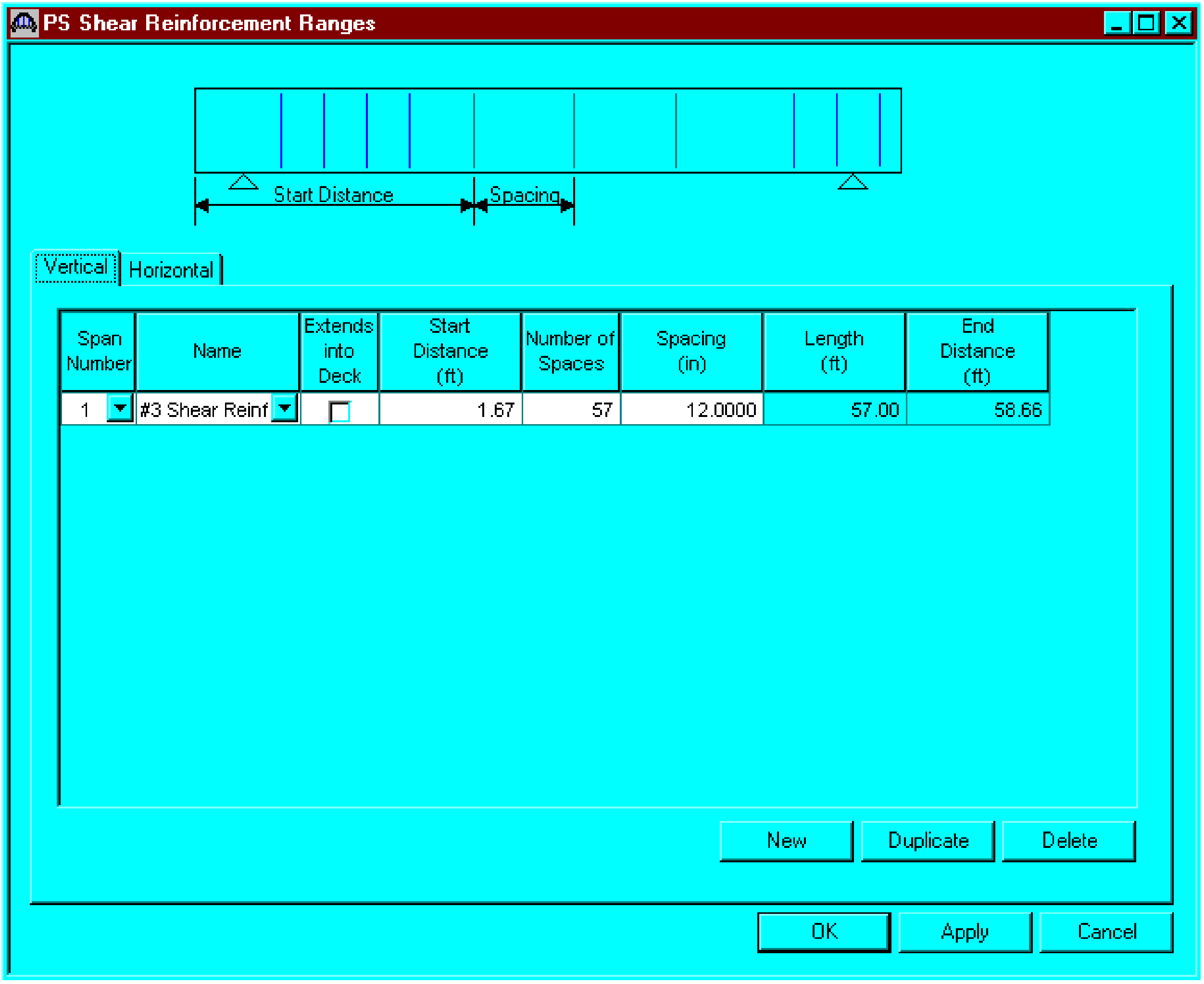


Description Type
● P and CGS only ○ Strands in rows

Left harp pt. dist. (X1): 24 ft
Left harp pt. radius: 0.0001 in
Right harp pt. dist. (X2): 24 ft
Right harp pt. radius: 0.0001 in
Force: 268.26 kip
Left CGS: 22.0000 in
Mid CGS: 4.0000 in
Right CGS: 22.0000 in

Since this structure does not have a cast in place deck, the Deck Profile and the Haunch Profile information is not required.

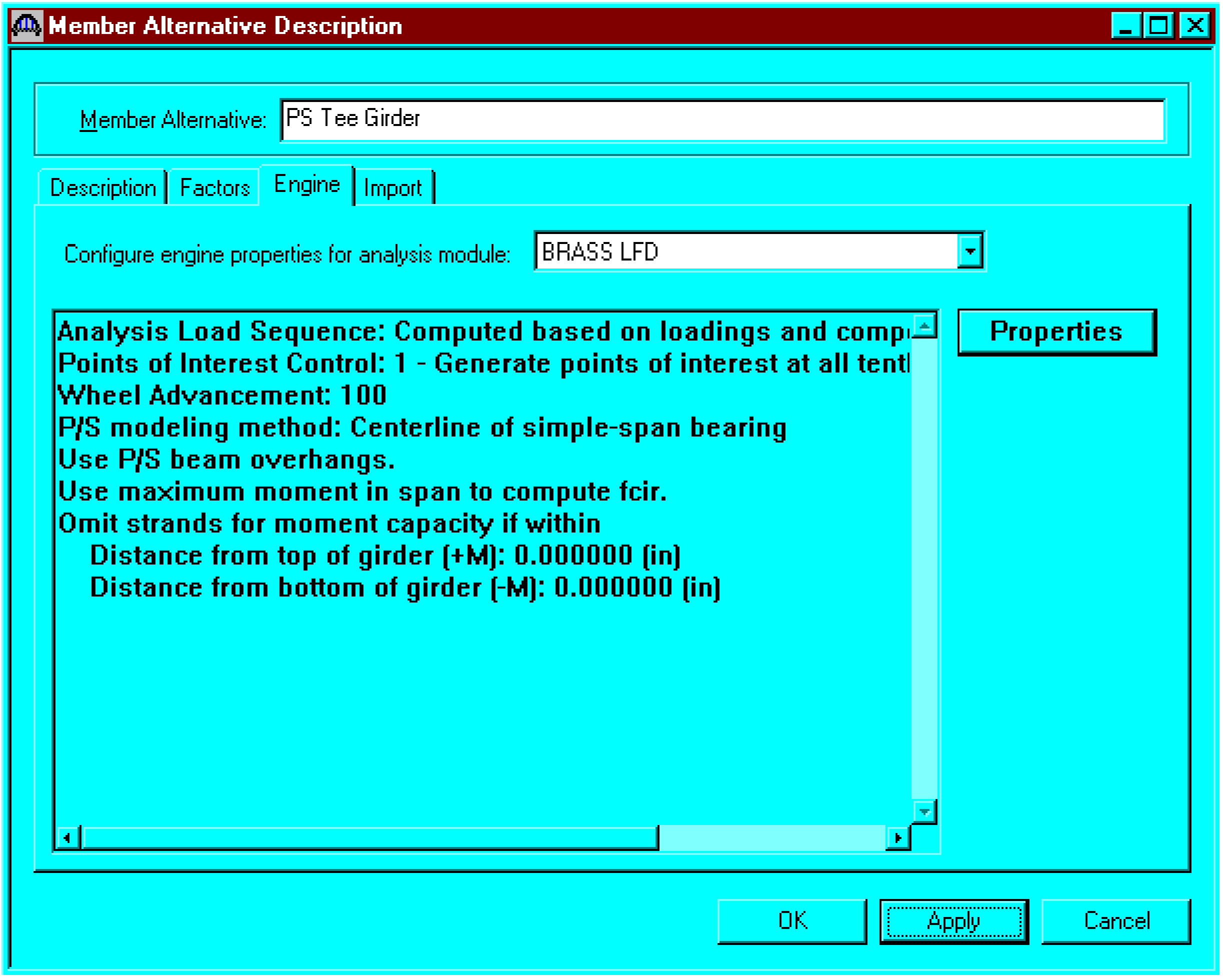
The Shear Reinforcement Ranges are entered as described below.



Span Number	Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
1	#3 Shear Reinf	☐	1.67	57	12.0000	57.00	58.66

The description of an interior beam for this structure definition is complete.

The BRASS LFD engine data for the member alternative is shown below.

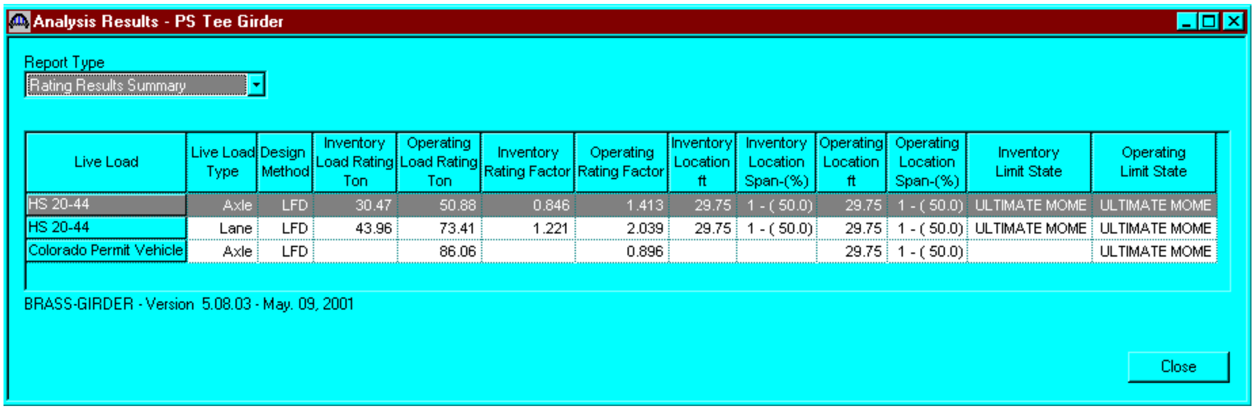


Member Alternative: PS Tee Girder

Configure engine properties for analysis module: BRASS LFD

Analysis Load Sequence: Computed based on loadings and comp
Points of Interest Control: 1 - Generate points of interest at all tent
Wheel Advancement: 100
P/S modeling method: Centerline of simple-span bearing
Use P/S beam overhangs.
Use maximum moment in span to compute fcir.
Omit strands for moment capacity if within
    Distance from top of girder (+M): 0.000000 (in)
    Distance from bottom of girder (-M): 0.000000 (in)

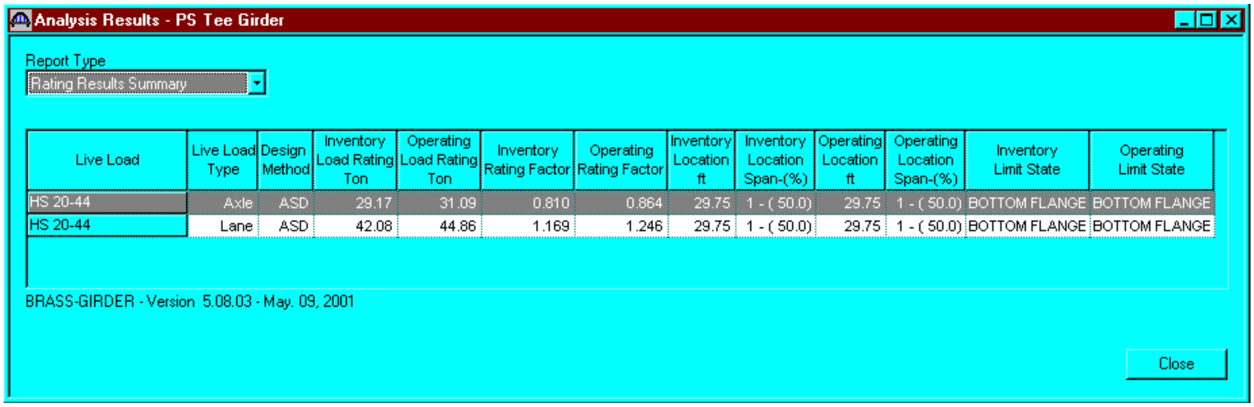
The results of the LFD/ASD rating analysis are as follows:



Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	LFD	30.47	50.88	0.846	1.413	29.75	1 - (50.0)	29.75	1 - (50.0)	ULTIMATE MOME	ULTIMATE MOME
HS 20-44	Lane	LFD	43.96	73.41	1.221	2.039	29.75	1 - (50.0)	29.75	1 - (50.0)	ULTIMATE MOME	ULTIMATE MOME
Colorado Permit Vehicle	Axle	LFD		86.06		0.896			29.75	1 - (50.0)		ULTIMATE MOME

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001



Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	ASD	29.17	31.09	0.810	0.864	29.75	1 - (50.0)	29.75	1 - (50.0)	BOTTOM FLANGE	BOTTOM FLANGE
HS 20-44	Lane	ASD	42.08	44.86	1.169	1.246	29.75	1 - (50.0)	29.75	1 - (50.0)	BOTTOM FLANGE	BOTTOM FLANGE

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

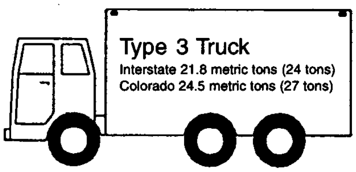
Structure # L-26-BR
State highway # 50
Batch I.D.
Structure type CDTPG
Parallel structure #

Rated using
Asphalt thickness: 51 mm (2 in.)
☒ Colorado legal loads
☐ Interstate legal loads

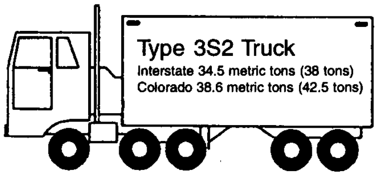
Structural member	INTERIOR GIRDER DBL-TEE			

Metric tons (Tons)

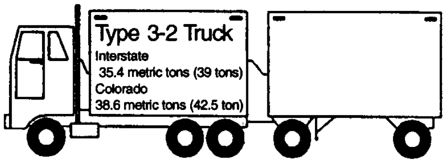
Inventory	26.4 (29)	( )	( )	( )
Operating	46.4 (51)	( )	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	78.2 (86)	( )	( )	( )



_________ (_________)
Metric tons Tons



_________ (_________)
Metric tons Tons



_________ (_________)
Metric tons Tons

Comments

Load Capacity: 51 Tons
Girder: Only Interior Girder Rated

Color Code: Orange

Project No: FC 050 - 5(16)

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used CDOT Form #1187a 1/95

SECTION 9B

POST-TENSIONED CONCRETE GIRDER BRIDGES

SUBJECT. .... Page No.

9B-1 INTRODUCTION TO RATING POST-TENSIONED CONCRETE GIRDER BRIDGES 9B.2

9B-2 POLICIES AND GUIDELINES FOR RATING POST-TENSIONED CONCRETE GIRDER BRIDGES 9B.3

9B-3 GUIDELINES FOR USING STAFF BRIDGE COMPUTER PROGRAMS 9B.5

9B-4 RATING POST-TENSIONED CONCRETE GIRDER BRIDGES DESIGNED BY LOAD FACTOR METHOD 9B.6

9B-5 POST-TENSIONED CONCRETE GIRDER BRIDGE RATING EXAMPLES 9B.7

9B-5a CSGCP EXAMPLE 9B.8

9B-5b. CBGCP EXAMPLE 9B.48

9B-1 INTRODUCTION TO RATING POST-TENSIONED CONCRETE GIRDER BRIDGES

This section, with section 1, presents the policies and guidelines for rating post-tensioned concrete girder bridges.

The types of girders covered by this section include cast-in-place, post-tensioned girders as described below:

A. CBGP - Concrete Box Girder Prestressed
B. CSGCP - Concrete Slab and Girder Continuous Prestressed
C. CSGP - Concrete Slab and Girder Prestressed
D. CBGCP - Concrete Box Girder Continuous Prestressed

9B-2 POLICIES AND GUIDELINES FOR RATING POST-TENSIONED CONCRETE GIRDER BRIDGES

I. GENERAL

A. It is recommended that the rater use the FRAME computer program (CALFRAME) also called BDS to analyze post-tensioned girders. Refer to subsection 9-3 and the FRAME (BDS) users' manual for guidelines on the use of this program.

B. The rater will be responsible for determining whether stress-relieved or low-relaxation strands were used in the bridge. If it is not possible to determine what type of strand was used, then the rater is to assume that stress-relieved strands were used prior to December, 1983, and low-relaxation strands thereafter. Post-tensioned concrete girder bridges with considerable horizontal curvature, skew, or other influences which increases the amount of stress/strain on the structure, may be modeled as simple, straight beams on pin or roller supports. The FRAME program (or BDS)output results can then be supplemented by hand calculations to account for these effects, as necessary.

II. GIRDERS REQUIRING RATING

A. Interior Girders - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, number of post-tensioning strands, differences in loads or moments, etc.

B. Exterior Girders - An exterior girder shall be rated under the following guidelines.

1. When the section used for an exterior girder is different from the section used for an interior girder.

2. When the overhang is greater than S/2.

3. When the rater determines the rating would be advantageous in analyzing the overall condition of a structure.

C. In lieu of rating individual girders, the rater may use the entire superstructure cross-section for the rating analysis.

III. CALCULATIONS

A. A set of calculations, separate from computer output, shall be submitted with each rating. These calculations shall include derivations for dead loads, derivations for live load distribution factors, and any other calculations or assumptions used for rating. The rater may also indicate whether stress-relieved or low-relaxation strands were used in the rating calculations.(may not make much difference except for balanced cantilever segmental).

The examples in Section 9B-5 of this manual show the minimum calculations required to rate a post-tensioned concrete girder bridge. These calculation sheets are to be filed in the structure folder.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.

2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt. curbs. sidewalks. railing. etc.

3. Use 7 psf (or as appropriate per Colo. Standard Specs & Design manual)for the unit weight of formwork for a distance equal to center-to-center of exterior girder measured along the top slab it is for stay in place forms. For closed cell construction, such as cast-in-place concrete box girders. No additional weight will be used for stay-in-place steel deck forms.

4. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as noncomposite loads. Examples of this type of dead load are deck slabs, girders, diaphragms, and fillets. In the case of continuous shoring these dead loads are typically applied at the time of the post-tensioning.

5. The method of applying dead loads due to utilities is left to the rater's discretion.

C. Continuous Bridges

Secondary moment effects due to post-tensioning shall be included in rating calculations.

IV. REPORTING RATINGS

The rater and checker shall complete the rating documentation as described in Section 2, of this manual. The rater shall include the Batch I.D, computer runs and all relevant information for the structure being rated.

9B-3 GUIDELINES FOR USING STAFF BRIDGE COMPUTER PROGRAMS

I. CODING FRAME (CALFRAME “BDS”)

A. Composite dead loads are coded as "Trial 01" loads.

B. Noncomposite dead loads are coded as "Trial 00" loads except that the program will calculate dead load moments due to slabs and girders from the coded structure geometry.

C. When using FRAME and coding prestressed data, the jacking force shown on the plans is to be entered into the P-JACK columns of card type 600 (7315 for the old FRAME program) when rating the entire cross-section. Additionally, a note similar to the following may appear in the plans, P-JACK SPECIFIED AT THE JACKING ENDS INCLUDES FRICTION AND ELASTIC SHORTENING LOSSES AND PROVISIONS FOR AN ADDITIONAL XX KSI IN LONG TERM LOSS IN STRESS". The value XX from this note should be coded into the LOSSES column of card type 600 (7315). For the long term losses, the rater has the option to use AASHTO’s lump sum losses or calculate them based on AASHTO’s loss equations.

NOTE:

Cal-Frame (BDS) program uses your input numbers for sorting purposes, therefore (0.00 is not taken as equal to 00.00 or 6.0 and 6.00 may not be interpreted the same) it may produce errors in the output when a consistent decimal format is not followed. Specific data should be repeated for each member on each input card when it is different from default values.

II. **CONTINUOUS BRIDGES**

When using FRAME, the secondary moment(s) should be calculated using the program output as shown in the examples.

9B.4 RATING POST TENSIONED CONCRETE GIRDER BRIDGES DESIGNED By LOAD FACTOR

All POSTENSIONED structures should be checked for serviceability requirements at the inventory level and checked for strength requirements for both inventory and operating levels, All as stated in the AASHTO Design Specifications (Article 9.17). The inventory rating value shall be the smaller of the serviceability or the strength requirement rating results. The operating shall be 5/3 of the strength requirement rating for all LFD operating ratings When checking the serviceability limit state the DL and the LL are unfactored in the rating equation.

9B-5 POST-TENSIONED CONCRETE GIRDER BRIDGE RATING EXAMPLES

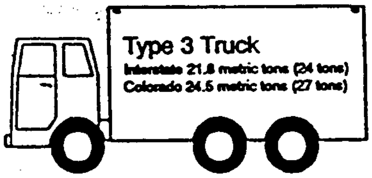
This section includes examples for rating of the Post-Tensioned bridges that are already under service. The examples are structures located on interstate 76 and 70.

9B-5a CSGCP EXAMPLE

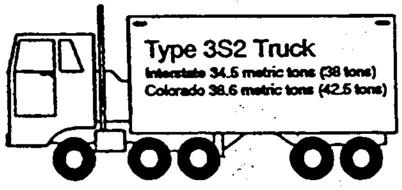
This is a 3 span Concrete Slab Girder Continuous Post-Tensioned structure. It consists of three horizontal members and two vertical members. Members have left and right end joint associated with them and are connected together by specifying the appropriate joint numbers. BDS or the new version of California Frame program is used to model the structure. The Colorado Permit Truck with (8) Axles for a total of 192,000 lbs (96 tons) is utilized for the purpose of Color coding of this structure and as a means to provide an example.

COLORADO DEPARTMENT OF TRANSPORTATION **LOAD FACTOR RATING SUMMARY**	Structure # E-16-IN State highway # 76
Rated using Asphalt thickness: 101.6 mm (4 in.) ☐ Colorado legal loads ☒ Interstate legal loads	Batch I.D. J83005 Structure type CSGCP Parallel structure # E-16-IO

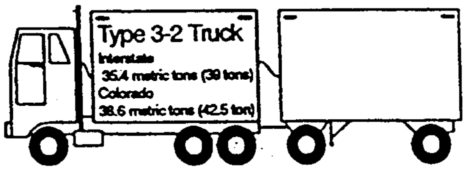
Structural member	GIRDER	SLAB		
	Metric tons (Tons)			
Inventory	34.0 (37.5)	34.4 (37.9)	( )	( )
Operating	59.4 (65.5)	57.4 (63.2)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	87.8 (96.8)	( )	( )	( )



______ Metric tons (______) Tons



______ Metric tons (______) Tons



______ Metric tons (______) Tons

Comments

PROJ I76-1(84)

Designated Color for overload map: WHITE
Based on rating for the permit Truck @ operating.

Rated by	Date	Checked by	Date
Rater's Signature	Date	Checker's Signature	Date

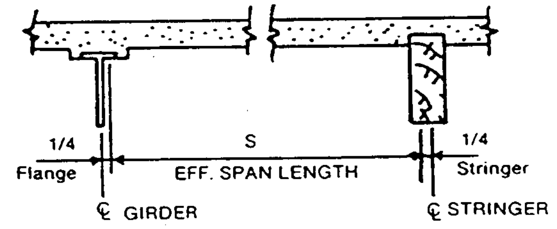
Previous editions are obsolete and may not be used

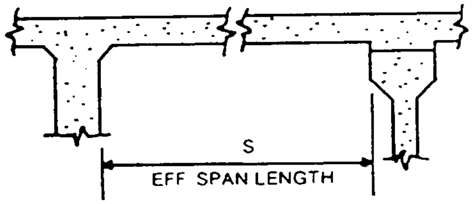
CDOT Form #1187 1/95

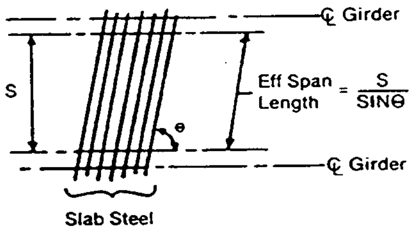
DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form 709
July, 1985

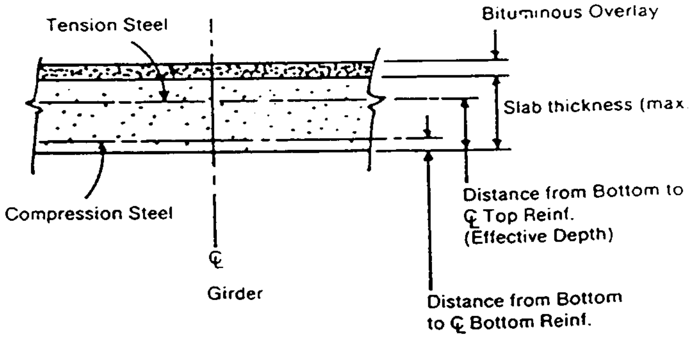
CONCRETE SLAB RATING

DESCRIPTION	INPUT	UNITS	CARD IMAGE COLS.
LOAD TYPE: 1 = Colo. Trucks 2 = Interstate	2		1
STRUCTURE NUMBER:	E-16-IN		2 - 8
RATER:	MM		9 - 11
HIGHWAY NUMBER:	76		12 - 14
BATCH I.D.:	I83005		15 - 20
COMMENTS:	E-16-I0 PAR & SIMILAR		21 - 41
EFFECTIVE SPAN LENGTH:	9.200	FEET	42 - 46
ACTUAL SLAB THICKNESS:	8.500	INCHES	47 - 51
EFFECTIVE DEPTH:	5.625	INCHES	52 - 56
TOP STEEL AREA:	0.96	In2/Ft	57 - 59
ASPHALT OVERLAY:	4.00	INCHES	60 - 63
INV Fc (f'c load factor):	4500	P.S.I.	64 - 67
INV Fs (Fy load factor):	40000	P.S.I.	68 - 72
INV MODULAR RATIO: (load factor method: leave blank)	—	Es/Ec	73 - 74
DEPTH TO BOTT. REIN.:	1.38	INCHES	75 - 77
BOTT . STEEL AREA:	0.96	In2/Ft	78 - 80









```
                    SLAB RATING Version 1.0
                        DATE: 95/02/24

STRUCTURE NO. E-16-IN     RATER: MM      STATE HWY NO. = 76
BATCH ID= I83005  DESCRIPTION: E-16-IO PAR & SIMILAR
LOAD FACTOR RATING-COMP STEEL NOT USED---LOAD FACTOR RATING-COMP STEEL NOT USED

               INPUT DATA
               ----- ----
EFF. SPAN(FT)=  9.200      EFF. DEPTH(INS)=  5.625
REINF.(SQ.IN)=  .96
SLAB TK(IN)=  8.500        WEARING SURFACE(IN)=  4.00
CONC. STRENGTH(PSI)  INV=  4500.     OPER=  4500.
STEEL  YIELD  (PSI)  INV= 40000.     OPER= 40000.
N=   8.
D1= 1.38                 AS1=  .96

DEAD LOAD MOMENT         1.31 K-FT
LL+I MOMENT              5.82 K-FT
GROSS WEIGHT            36.0 TONS

                        INVENTORY     OPERATING
ACTUAL CONCRETE STRESS       (PSI)     1222.95        1895.24
ACTUAL REINF. STEEL STRESS   (PSI)    19365.92       30011.93
ACTUAL COMP. STEEL STRESS    (PSI)     5264.52        8158.58
MEMBER CAPACITY              (K-FT)      15.00          15.00
MEMBER CAPACITY (LL+I)       (K-FT)      13.30          13.30

RATING                  (TONS)      37.94          63.23
```

Rater's Signature
& Date

Checker's Signature
& DATE

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

SUPER STRUCTURE INPUT TO CAL FRAME (BDS)

NON COMPOSITE DEAD LOAD

ASPHALT :

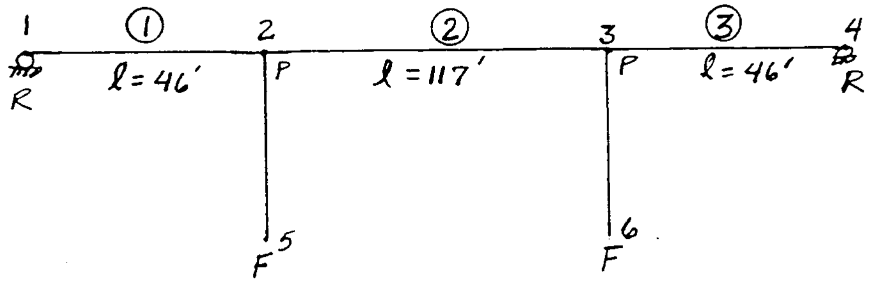
$$(38)\left(\frac{4}{12}\right)(144\ \mathrm{lb}/\mathrm{ft}^3) = 1824\ \mathrm{lb}/\mathrm{ft}$$

RAIL (TYPE 4B) :

$$(2)(0.109\ \mathrm{yd}^3/\mathrm{ft})\left(\frac{3\ \mathrm{ft}}{1\ \mathrm{yd}}\right)^3(150\ \mathrm{lb}/\mathrm{ft}^3) = 882.9\ \mathrm{lb}/\mathrm{ft}$$

TOTAL DL N.C. : $1824 + 882.9 = \underline{\underline{2.707}}$ KLF.

FRAME DESCRIPTION; ★ STRESS RELIEVED STRANDS



$$E_c = w^{1.5} \cdot 33\sqrt{f'_c}$$ AASHTO

$w = 145\ \mathrm{lb}/\mathrm{ft}^3$; $f'_c = 4500$ psi

$E_c = 3865$ KSI ←

LLDF

$$\frac{\#\ GIR * GIR\ SPACING}{12} = 3.33$$ ← CONTROLS

or

$$\frac{CURB - CURB}{12} = \frac{38}{12} = 3.17$$

COLORADO DEPARTMENT OF TRANSPORTATION		Sheet 1 of
By: MM Date 2-95	Project No. I 76-1(84)	J83005
Chk'd: Date	Structure No. E-16-IN, IO	REVISED FOR LFD

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

INVENTORY RATING (STRESSES):

STRESES FROM CALFRAM (BDS) RUN PG. 14, 16, 38, 46

$$\text{RATING} = \frac{\text{CAP} - A_1 \text{DL}}{A_2(\text{LL}+\text{I})} \qquad A_1 = A_2 = 1$$

$$+\text{CAP} = 0.4 f'_c = 0.4(4500) = 1800 \text{ PSI}$$

$$-\text{CAP} = 6\sqrt{f'_c} = 6\sqrt{4500} = -402 \text{ PSI}$$

{AASHTO 9.15.2.2}

			PSI			TON
	POINT	MOM	$LL+I_{HS20}$	DL + P	CAPACITY	RATING INV
TOP	2.5	(+)	+452	+727	+1800	85.5
BOTT.	2.5	(+)	-1255	+904	-402	37.5

$$INV_{TOP} = \frac{1800-727}{452} * 36 = 85.5 \text{ TON.}$$

$$INV_{BOT} = \frac{-402-904}{-1255} * 36 = 37.5 \text{ TON}$$

			PSI			TON
	POINT	MOM	$LL+I_{HS20}$	DL+P	CAPACITY	RATING INV.
TOP	3.0	(−)	-303	+441	-402	100.0
BOTT.	3.0	(−)	+735	+949	+1800	41.7

COLORADO DEPARTMENT OF TRANSPORTATION Sheet 2 of ____

By: MM Date 2/95	Project No. I 76-1 (84)	J 83005
Chk'd: Date	Structure No. E-16-IN, IO	REV. FOR LFD.

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

$$INV_{TOP} = \frac{-402-441}{-303} * 36 = 100.0 \quad \text{TONS.}$$

$$INV_{BOT.} = \frac{1800-949}{735} * 36 = 41.7 \quad \text{TONS.}$$

INVENTORY & OPERATING RATINGS (LOAD FACTOR MOMENTS):

FROM CALFRAME (BDS) PG. 8, 11, 14, 16, 30.

RATING @ 2.5 LOCATION

$A_s^{*} = 33.9 \ in^2$

A_s in bottom half of section $= 7.4 \ in^2$

A_s in top half of section $= 27.3 \ in^2$

$M_s = P_J * $ (DEM's ; from calframe & interpolate for each point)

$M_{s_{2.5}} = 6865 * 0.813 = 5581.2$ k-ft

$M_{s_{3.0}} = 6865 * 0.813 = 5,581.2$ K-ft

COLORADO DEPARTMENT OF TRANSPORTATION Sheet 3 of

By: MM Date 2-95	Project No. I76-1 (84)	J83005
Chk'd: Date	Structure No. E-16-IN,	REVISED FOR LFD

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

	K-ft				in.		TON	
POINT	MDL0	MDL1	$M_{LL+I_{H20}}$	M_S	d	b	INV.	OPR.
2.5	+3831	+1463	+3236	+5581.2	38	492	70.1	116.8
3.0	−8385	−3169	−4716	+5581.2	60	60	38.3	63.8

AT 2.5 Check Point

$$F^*_{su} = f'_s * \left\{1-0.5\left[(A^*_s * f'_s) - (A_{s_{TOP}} - A_{s_{BOT}})\cdot f_y\right] / (f'_c * b * d)\right\}$$

$$F^*_{su} = 270\left\{1-0.5\left(\left[(33.9*270) - (27.3-7.4)*60\right]/(4.5*492*38)\right)\right\}$$

$$F^*_{su} = 257.23 \text{ KSI}$$

$$a = \left[F^*_{su} * A^*_s - (A_{s_{TOP}} - A_{s_{BOT}}) * f_y\right]/(0.85 f'_c b') \leqq (0.3d/\beta = 13.82)$$

$$a = \left[257.23*33.9 - (27.3-7.4)*60\right]/(4.5*8.5*492)$$

$$a = 4.0'' < 8.5'' < 0.3d/\beta = 13.82$$

$$M_n = \left[A^*_s * F^*_{su} + (A_{s_{BOT}} * f_y)\right]\cdot\left[d - \frac{a}{2}\right]$$

$$M_n = \left[(33.9*257.23) + (7.4*60)\right]\cdot\left[38 - 4.0/2\right] \div 12$$

$$M_n = 27,492.3 \text{ K-ft} \longleftarrow$$

	COLORADO DEPARTMENT OF TRANSPORTATION	Sheet 4 of
By MM Date 2-95	Project No. I 76-1(84)	J83005
Chk'd: Date	Structure No. E-16-IN, IO	REV. FOR LFD.

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

$$INV = \frac{0.95 M_n - 1.3\,(MDL\phi + MDL1) \pm 1.0 * M_S}{(2.16667 * M_{LL+I})} * 36$$

$$INV = \frac{0.95 * 27492.3 - 1.3\,(3831 + 1463) - 5581.2}{2.16667 * 3236} * 36$$

$\underline{INV = 70.1 \text{ TON}}$

$\underline{OPR = \frac{5}{3}(INV) = 116.8 \text{ TON}}$

AT 3.0 check point

$$F^{*}_{su} = 270\left\{1 - 0.5\left[(33.9 * 270) + (27.3 - 7.4) * 60\right] / (4.5 * 60 * 60)\right\}$$

$$F^{*}_{su} = 188.3 \text{ KSI}$$

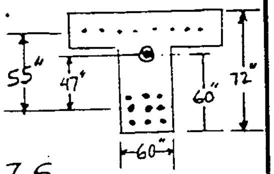
$$a = \left[188.2 * 33.9 + (27.3 - 7.4) * 60\right] / (4.5 * 0.85 * 60)$$

$a = 33.0 > 0.3d/\beta = 21.82$ OVERREINFORCED.

UTILIZING COMP. STEEL & AASHTO Eq 9.22 :

$$M_n = \left[A'_s * f'_y * (d - d')\right] + \left[(0.36\beta_1 - 0.08\beta_1^2)\, f'_c b d^2\right]$$

$$M_n = \left[7.4 * 60 * 55\right] + \left[(0.2425) * 4.5 * 60 * 60^2\right] = 21,677.5 \text{ K-ft}$$



$$INV = \frac{(0.95 * 21,385.6) - 1.3\,(8385 + 3169) + 5581.2}{2.1667 * 4716} * 36$$

$\underline{INV = 39.3 \text{ TON}} \leftarrow$

$\underline{OPR = \frac{5}{3} * INV = 65.5 \text{ TON}} \leftarrow$ CONTROLS

COLORADO DEPARTMENT OF TRANSPORTATION Sheet 5 of

By: MM Date 2-95 | Project No. I76-1 (84) | J83005

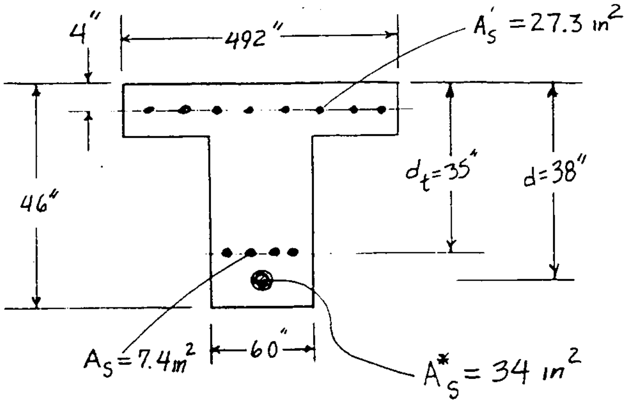
Chk'd: Date | Structure No. E-16-IN, IO | REV. FOR LFD.

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

Rechecking location 2.5 (using AASHTO Sections 9.17, 9.18 and 9.19)
—For flexural strength :



$$\rho^* = \frac{34}{492 * 38} = 0.001819$$

$$\rho = \frac{7.4}{492 * 35} = 0.00043$$

$$\rho' = \frac{27.3}{492 * 34} = 0.001632$$

$f'_c = 4500$ psi

$f_{sy} = f'_y = 60$ ksi

$f'_s = 270$ ksi

$\gamma^* = 0.40$ for stress relieved.

$\beta_1 = 0.85 - 0.05(f'_c - 4.0)$

$\beta_1 = 0.825$, $\Phi = 0.95$

$$F^*_{su} = f'_s\left[1 - \frac{\gamma}{\beta_1}\left(\frac{\rho^* f'_s}{f'_c} + \frac{dt}{d}\rho\frac{f_y}{f'_c}\right)\right] \quad ; \quad (A^*_s f^*_{su} + A_s f_{sy})/(0.85 f'_c b) < t \text{ ok}$$

$$F^*_{su} = 270\left[1 - \frac{0.4}{0.825}\left(\frac{0.001819 * 270}{4.5} + \frac{35}{38} * 0.0043 * \frac{60}{4.5}\right)\right] = 255.0 \text{ ksi}$$

Use non-Prestress reinf. per AASHTO (9-24) :

$$\left\{\left(\frac{\rho f_{sy}}{f'_c}\right)\frac{dt}{d} + \left(\frac{\rho^* f^*_{su}}{f'_c}\right) - \left(\frac{\rho' f'_y}{f'_c}\right) \leqslant 0.36\beta_1 = 0.30\right\} \Rightarrow 0.0879 < 0.3 \text{ ok}$$

$$\phi M_n = \Phi\left\{A^*_s F^*_{su} d\left[1 - 0.6\left(\frac{\rho^* f^*_{su}}{f'_c} + \frac{dt}{d}\cdot\frac{\rho f_{sy}}{f'_c}\right)\right] + A_s f_{sy} d_t\left[1 - 0.6\left(\frac{d}{d_t}\frac{\rho^* f^*_{su}}{f'_c} + \frac{\rho f_{sy}}{f'_c}\right)\right]\right\} \quad \underline{\underline{\text{AASHTO } 9\text{-}13a}}$$

$M_u = \Phi M_n = 25530$ k-ft

@ 2.5 $M_{DL} = 3831 + 1463 = 5294.0$ k-ft

$M_{sec} = 5581.2$ k-ft

$M_{LL+I} = 3236$ k-ft

$$R_{INV} = \frac{25530.0 - 1.3(5294.0) - 5581.2}{2.1667 * 3236} * 36 = \underline{67.0 \text{ TON}}$$

$$R_{OPR} = (67.0) * \frac{5}{3} = \underline{111.8 \text{ TON}}$$

* ANSWERS CLOSE TO THE FIRST RESULTS.

By: MM Date	Project no.	I76-1(84)	Project code (SA#): REV. LFD 95
Chk'd: Date	Structure no.	E-16-IN , IO	Sheet 6 of

CDOT Form #1034 1/95

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

Rating @ 3.6 will similarly be:

$R_{INV} = 47$ TON & $R_{OPR} = 91$ TON

Permit truck Rating: (LL #4 BDS, Calframe run page 29 & 31)

$(LL+I)$ @ 2.5 $= +5266$ k-ft

$(LL+I)$ @ 3.0 $= -9220$ k-ft

@ 2.5

$$R_{OPR} = \frac{25530 - 1.3\,(5294.0) - 5581.2}{1.3 * 5266} * 96 = 180.9 \text{ TON}$$

@ 3.0

$$R_{OPR} = \frac{20{,}593.6 - 1.3\,(11{,}554) + 5581.2}{1.3 * 9220} * 96 = 89.36 \text{ TON}$$

when single lane distribution applied to The permit Load:

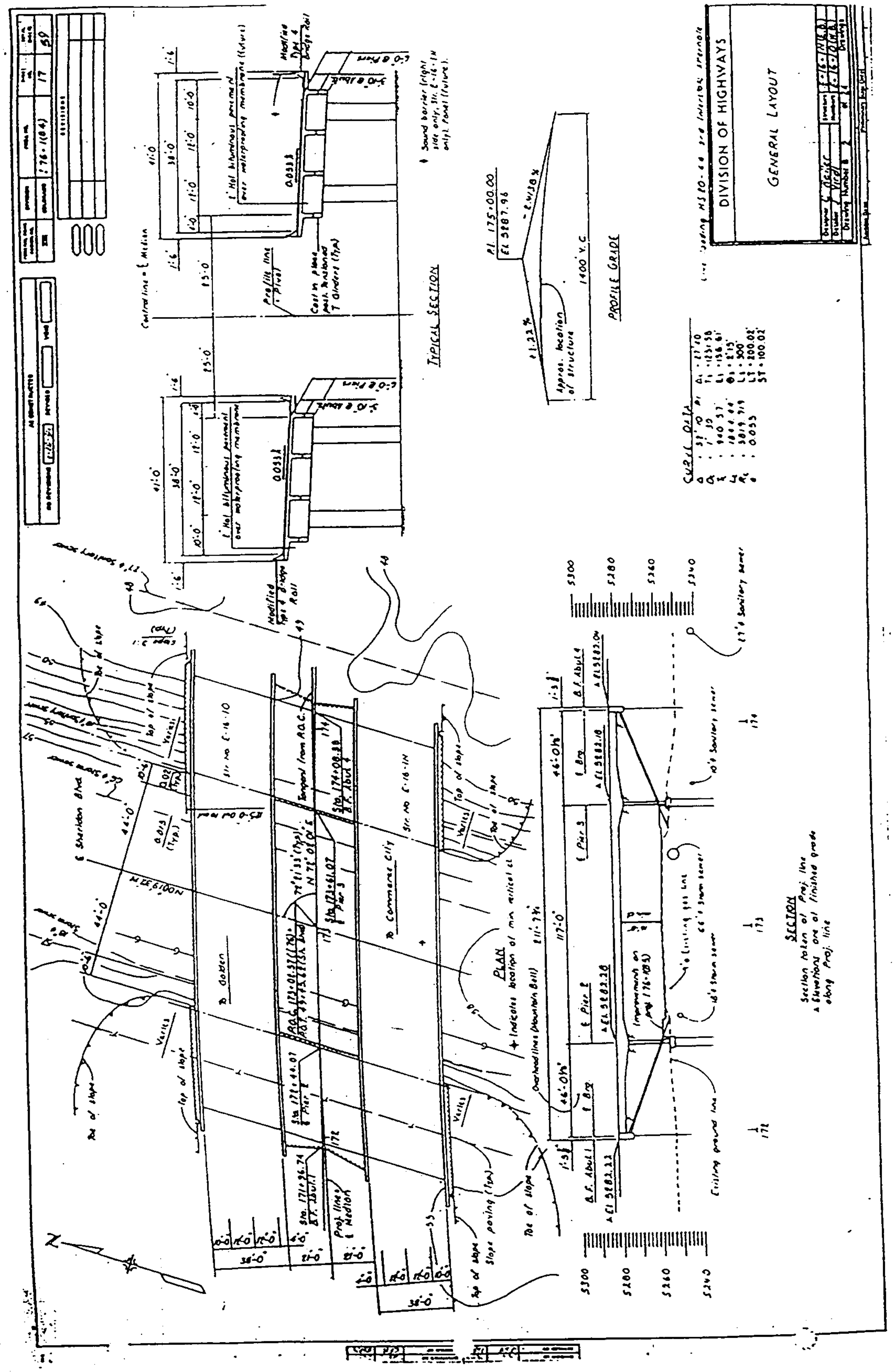
$$R_{OPR} = 89.36 * \frac{6.5}{6.0} = 96.8 \text{ TONS}$$

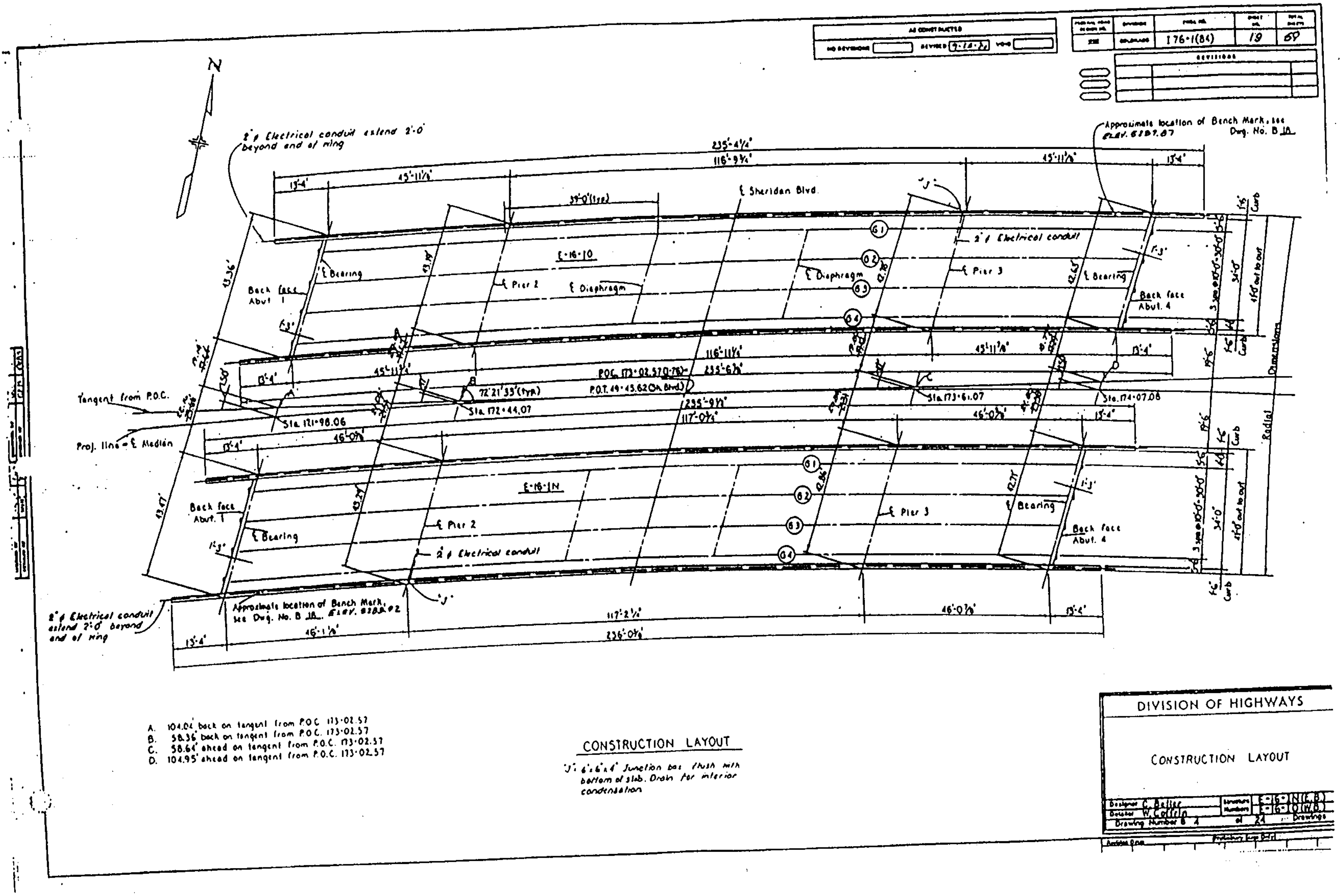
COLOR = WHITE

★ note: Location 3.0 can also be rated similar to procedure used to rate location 2.5 (using AASHTO sections 9.17, 9.18, 9.19). non prestressed steel (only in Compresion) Was added to reflect Actual Conditions & increase rating.

By: MM Date 6-95	Project no. I 76-1(84)	Project code (SA#): JB3005 REV. LFD 95
Chk'd: Date	Structure no. E-16-IN, IO	Sheet 7 of

CDOT Form #1034 1/95


DIVISION OF HIGHWAYS
GENERAL LAYOUT
TYPICAL SECTION
PROFILE GRADE
CURVE DATA
PLAN
SECTION
To Golden
To Commerce City
Sheridan Blvd.



A. 104.04' back on tangent from P.O.C. 173+02.57
B. 58.36' back on tangent from P.O.C. 173+02.57
C. 58.64' ahead on tangent from P.O.C. 173+02.57
D. 104.95' ahead on tangent from P.O.C. 173+02.57

CONSTRUCTION LAYOUT

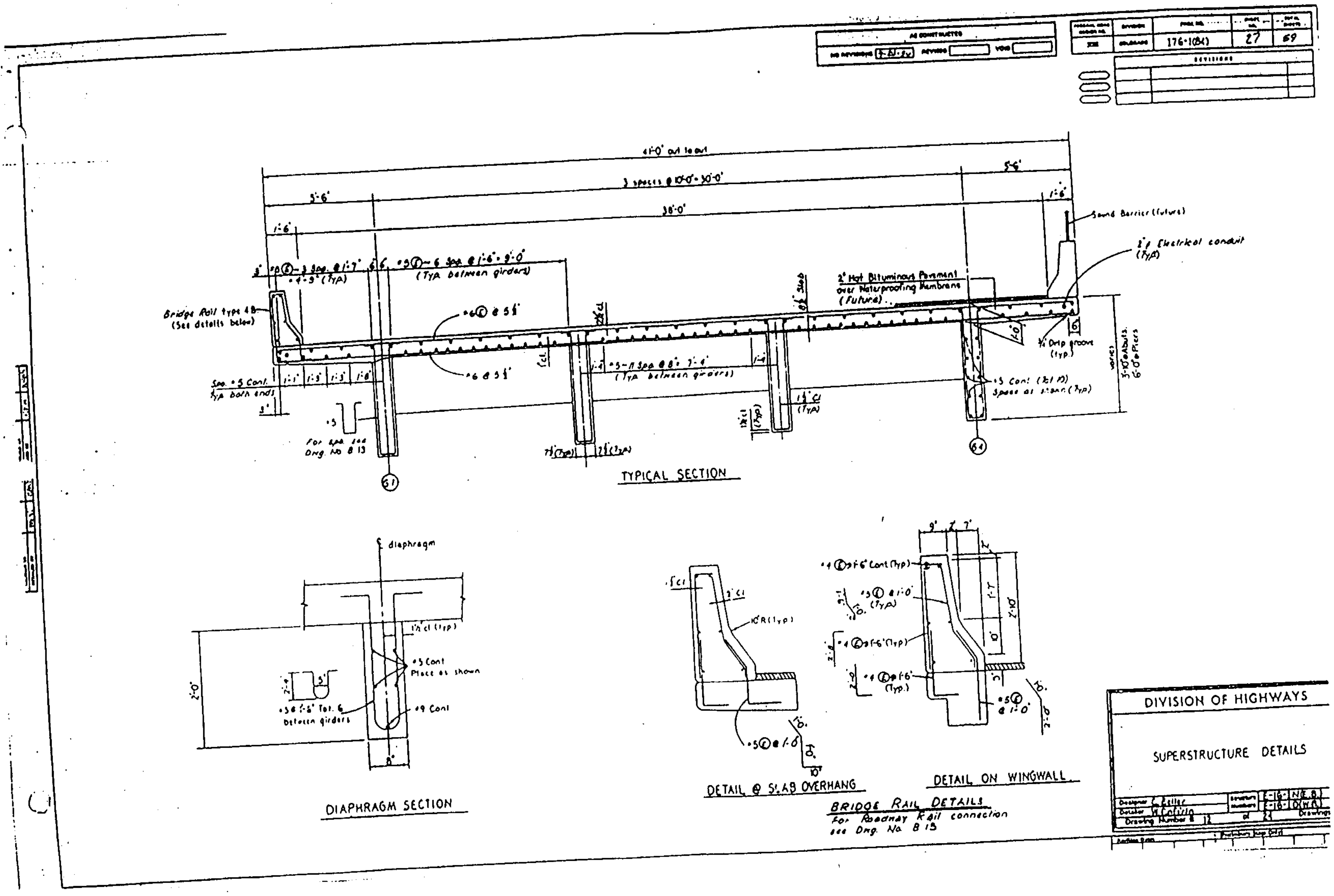
'J': 6"x6"x4" Junction box flush with bottom of slab. Drain for interior condensation

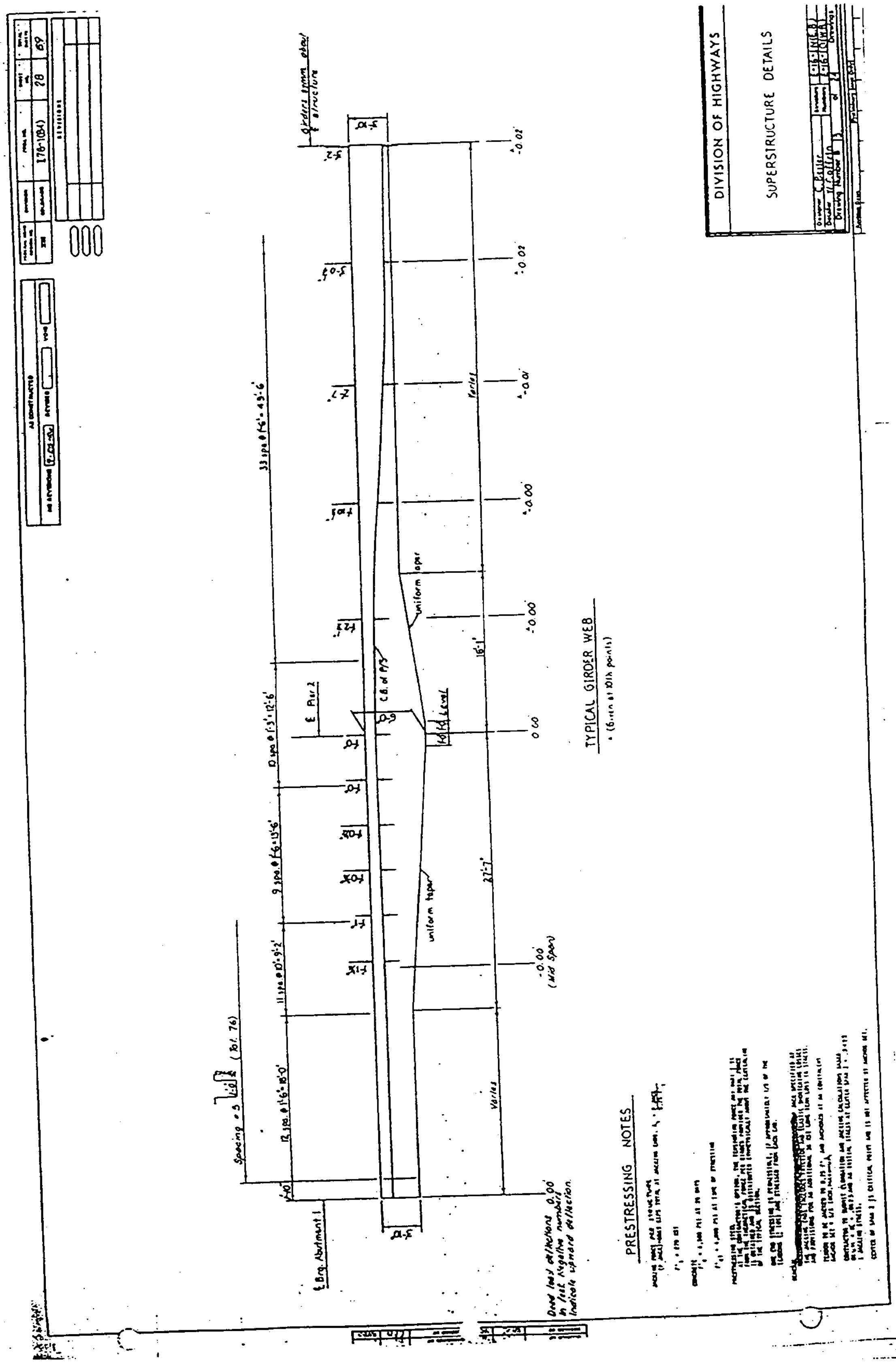
DIVISION OF HIGHWAYS

CONSTRUCTION LAYOUT

Designer C. Beller
Detailer W. Coffelo
Drawing Number B 4 of 24 Drawings
Structure Numbers E-16-IN(E.B.) E-16-IO(W.B.)

176-1(84) 19 69


AS CONSTRUCTED
NO REVISIONS 7-31-74
REVISED
VOID
176-1(84)
27
69
REVISIONS
41'-0" out to out
3 spaces @ 10'-0" = 30'-0"
38'-0"
5'-6"
5'-6"
1'-6"
1'-6"
Sound Barrier (future)
3" ø Electrical conduit (Typ)
#5 ⑥ – 3 Spa. @ 1'-7" = 4'-9" (Typ)
#5 ⑦ – 6 Spa @ 1'-6" = 9'-0" (Typ between girders)
Bridge Rail type 4B (See details below)
#6 ⑥ @ 5½"
#6 @ 5½"
Spa. #5 Cont. Typ both ends
1'-1" 1'-3" 1'-3" 1'-8"
#5
For spa see Dwg. No B 13
#5 – 11 Spa @ 8" = 7'-4" (Typ between girders)
1½" Cl (Typ)
2" Hot Bituminous Pavement over Waterproofing Membrane (Future)
6½" Slab
6
¾" Drip groove (typ.)
#5 Cont (Tot 10) Space as shown (Typ)
varies 3'-10" @ Abuts. 6'-0" @ Piers
G1
G4
TYPICAL SECTION
℄ diaphragm
1½" cl (typ)
#5 Cont Place as shown
#9 Cont
#5 @ 1'-6" Tot. 6 between girders
2'-0"
8"
DIAPHRAGM SECTION
10"R (Typ)
#5 ⑥ @ 1'-6
DETAIL @ SLAB OVERHANG
#4 ⑥ @ 1'-6" Cont (Typ)
#5 ⑥ @ 1'-0" (Typ)
#4 ⑥ @ 1'-6" (Typ)
#4 ⑥ @ 1'-6" (Typ.)
#5 ⑥ @ 1'-0"
9" 2" 7"
1'-7"
2'-10"
2'-0"
DETAIL ON WINGWALL
BRIDGE RAIL DETAILS
For Roadway Rail connection see Dwg. No B 13
DIVISION OF HIGHWAYS
SUPERSTRUCTURE DETAILS
Designer C. Keller
Detailer W. Colisio
Drawing Number B 12 of 21
E-16-NE.B.
E-16-DW.B.


DIVISION OF HIGHWAYS
SUPERSTRUCTURE DETAILS
TYPICAL GIRDER WEB
(Given at 10th points)
PRESTRESSING NOTES
Dead load deflections in feet. Negative numbers indicate upward deflection.
℄ Brg. Abutment 1
℄ Pier 2
Girders symm about ℄ structure
Spacing @ 5
12 spa @ 1'6" = 18'-0"
11 spa @ 10" = 9'-2"
9 spa @ 1'6" = 13'-6"
10 spa @ 1'3" = 12'-6"
33 spa @ 1'6" = 49'-6"
C.G. of P/S
Level
uniform taper
Varies
27'-7"
16'-1"
0.00
-0.00 (Mid Span)
AS CONSTRUCTED

Input Forms

COMMENTS : 000 FORM

ACCOUNT: E-16-1N2

SORT NO.: 000

STRUCTURE E-16-IN ; CSGCP ; SH-76 ; PROJ#I761(84) ; M. MOHSENI 2-95

NOTES:
(1) First line of comments will appear at the top of each page of output
(2) Additional lines may be used if required

FRAME DESCRIPTION : 100 FORM

ACCOUNT E-16-IM2

100

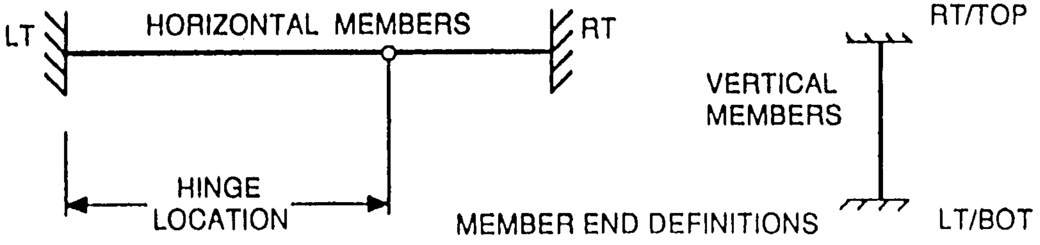
MEMBER NO. (1)	END JOINT NO. LT	END JOINT NO. RT	END CONDITION (2) LT	END CONDITION (2) RT	DIRECTION (3)	LENGTH FT	MIN I_{22} FT	HINGE LOC. OR SUPPORT WIDTH FT	E KSI	DEAD LOAD UNIFORM K/FT	DEAD LOAD UNIT WT PCF	MEMBER PROPERTIES K STIFFNESS FACTOR LT	MEMBER PROPERTIES K STIFFNESS FACTOR RT	MEMBER PROPERTIES C CARRY OVER FACTOR LT	MEMBER PROPERTIES C CARRY OVER FACTOR RT	RECALL MEMBER	RECALL REVERSE R	DL DEFLECTIONS	DL SIDESWAY S	
9 10	11 12	13 14	15	16	17	18 19 20 21	22 23 24 25 26 27	28 29 30 31	32 33 34 35 36	37 38 39 40 41	42 43 44	45 46 47 48	49 50 51 52	53 54 55 56	57 58 59 60	61 62	63	64 65	66	67 68 69 70 71 72 73 74 75 76 77
01	01	02	R		H	460			3865		150									
02	02	03			H	1170					150									
03	03	04		R	H	460					150					01	R			
04	05	02		P		200					150									
05	06	03														04				
9 10	11 12	13 14	15	16	17	18 19 20 21	22 23 24 25 26 27	28 29 30 31	32 33 34 35 36	37 38 39 40 41	42 43 44	45 46 47 48	49 50 51 52	53 54 55 56	57 58 59 60	61 62	63	64 65	66	67 68 69 70 71 72 73 74 75 76 77

NOTES:

(1) Member numbers must be numbered consecutively.

(2) Possible END CONDITIONS are:
[BLANK] = fixed (by default)
P = pinned
R = roller
C = cantilever

(3) DIRECTION Code
G or H = girder or horizontal member



MEMBER END DEFINITIONS

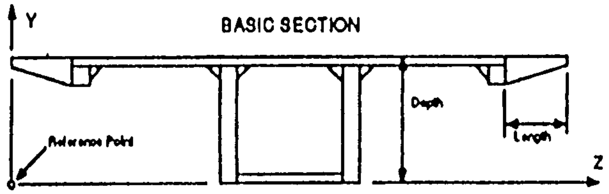
SUPERSTRUCTURE DATA : 200 FORM

ACCOUNT: E-16-IN (01–08)

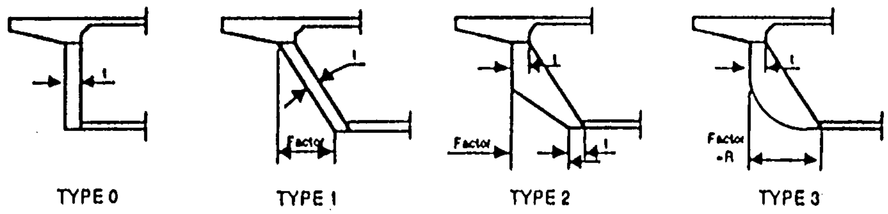
SORT NO.: 200 (78–80)

MEMBER NO.	CROSS SEC. LOC. X (FT)	RECALL	REF. POINT COORD. Z (FT)	REF. POINT COORD. Y (FT)	SS. DATA WIDTH ED-ED (FT)	SS. DATA DEPTH (FT)	SLAB DATA TOP THICK. (IN)	SLAB DATA BOTTOM THICK. (IN)	INT. GIRDERS NUMBER (INT. ONLY)	INT. GIRDERS WEB THICK. (IN)	EXTERIOR GIRDERS LEFT TYPE	EXTERIOR GIRDERS LEFT WEB THICK. (IN)	EXTERIOR GIRDERS LEFT FACTOR (FT)	EXTERIOR GIRDERS RIGHT TYPE	EXTERIOR GIRDERS RIGHT WEB THICK. (IN)	EXTERIOR GIRDERS RIGHT FACTOR (FT)	OVERHANGS LEFT LENGTH (FT)	OVERHANGS LEFT EXT. THICK. (IN)	OVERHANGS LEFT INT. THICK. (IN)	OVERHANGS RIGHT LENGTH (FT)	OVERHANGS RIGHT EXT. THICK. (IN)	OVERHANGS RIGHT INT. THICK. (IN)		STORE SECTION	
9 10	11 12 13 14	15 16	17 18 19	20 21 22	23 24 25 26	27 28 29 30	31 32 33 34	35 36 37 38	39 40	41 42	43	44 45	46 47 48	49	50 51	52 53 54	55 56 57	58 59	60 61	62 63 64	65 66	67 68	69 70 71 72 73	74 75	76 77
01	00				410	38	850	000	2	15	0	15	000	0	15	090	49	9	12	49	9	12	▨	01	▨
01	184	01																					▨		▨
01	450				410	60	850	000	2	15	0	15	000	0	15	000	49	9	12	49	9	12	▨	02	▨
01	460	02																					▨		▨
02	00	02																					▨		▨
02	10	02																					▨		▨
02	161	01																					▨		▨
02	1009	01																					▨		▨
02	1160	02																					▨		▨
02	1170	02																					▨		▨
9 10	11 12 13 14	15 16	17 18 19	20 21 22	23 24 25 26	27 28 29 30	31 32 33 34	35 36 37 38	39 40	41 42	43	44 45	46 47 48	49	50 51	52 53 54	55 56 57	58 59	60 61	62 63 64	65 66	67 68	69 70 71 72 73	74 75	76 77

BASIC SECTION



EXTERIOR GIRDERS



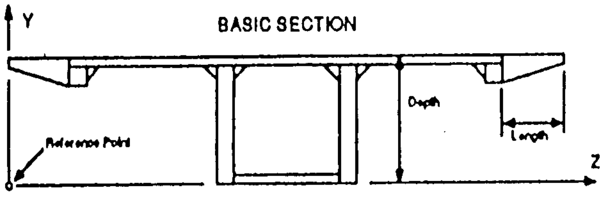
NOTES:
(1) Type 9 means no exterior girder.

SUPERSTRUCTURE DATA : 200 FORM

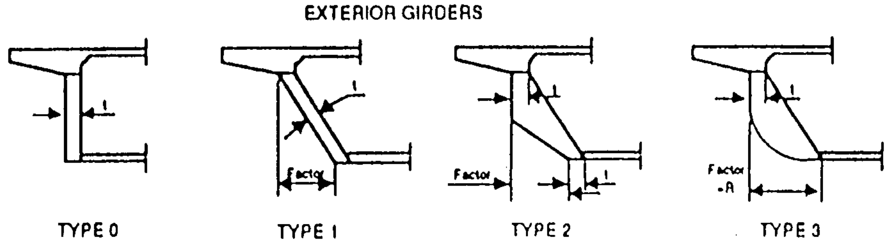
ACCOUNT E-116-11M2 (01 02 03 04 05 06 07 08)

SORT NO. 200 (78 79 80)

MEMBER NO.	CROSS SEC. LOC. X	RECALL	REF. POINT COORD.		SS. DATA		SLAB DATA		INT. GIRDERS		EXTERIOR GIRDERS						OVERHANGS							STORE SECTION	
											LEFT			RIGHT			LEFT			RIGHT					
			Z	Y	WIDTH ED-ED	DEPTH	TOP THICK.	BOTTOM THICK.	NUMBER (INT. ONLY)	WEB THICK.	TYPE	WEB THICK.	FACTOR	TYPE	WEB THICK.	FACTOR	LENGTH	EXT. THICK.	INT. THICK.	LENGTH	EXT. THICK.	INT. THICK.			
	FT		FT	FT	FT	FT	IN	IN		IN		IN	FT		IN	FT	FT	IN	IN	FT	IN	IN			
9 10	11 12 13 14	15 16	17 18 19	20 21 22	23 24 25 26	27 28 29 30	31 32 33 34	35 36 37 38	39 40	41 42	43	44 45	46 47 48	49	50 51	52 53 54	55 56 57	58 59	60 61	62 63 64	65 66	67 68	69 70 71 72 73	74 75	76 77
03	0.0	02																							
03	1.0	02																							
03	27.6	01																							
03	46.0	01																							
9 10	11 12 13 14	15 16	17 18 19	20 21 22	23 24 25 26	27 28 29 30	31 32 33 34	35 36 37 38	39 40	41 42	43	44 45	46 47 48	49	50 51	52 53 54	55 56 57	58 59	60 61	62 63 64	65 66	67 68	69 70 71 72 73	74 75	76 77



NOTES:
(1) Type 9 means no exterior girder.



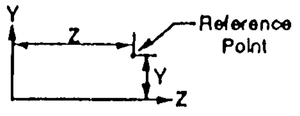
PARTS DATA : 201 FORM

ACCOUNT E-16-IN

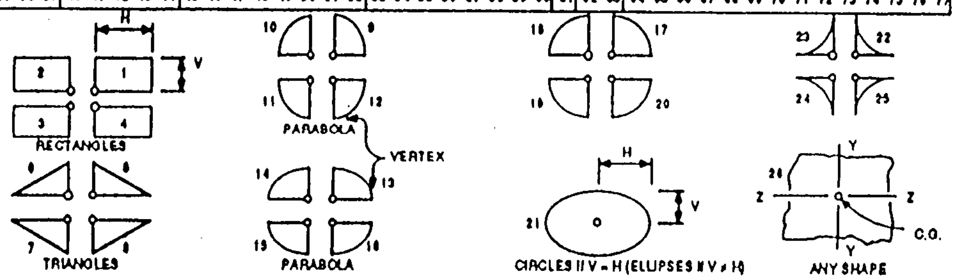
SORT NO. 201

MEMBER NO.	CROSS SEC. LOC. X FT	RECALL	SIGN + OR −	PART CODE	PART DIMENSION (1) VERTICAL V OR DEPTH D FT	PART DIMENSION HORIZ. H FT	REF. PT. COORD. Z FT	REF. PT. COORD. Y FT	ANY SHAPE AREA FT	ANY SHAPE Izz FT	ANY SHAPE E KSI		STORE SECTION	
04	0000		+	1	200	800							06	
04	2000	06												
05	0000	06												
05	2000	06												

NOTES:
(1) Enter total depth of section using part code 27



PART CODES:



LOAD DATA : 300 FORM

ACCOUNT: E-16-IN2 (01 02 03 04 05 06 07 08)

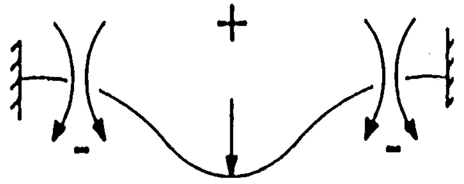
SORT NO.: 300 (78 79 80)

		LOADS				FEM'S (1)				
TRIAL NO.	MEMBER NO.	W or P K/FT or K	CODE (2)	A FT	B FT	LEFT FT · K	RIGHT FT · K	DEFLECTIONS	SIDESWAY S	COMMENTS
9 10	11 12	13 14 15 16 17 18 19	20	21 22 23 24	25 26 27 28	29 30 31 32 33 34 35	36 37 38 39 40 41 42	43 44	45	46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77
00	02	5400	P	390						DIAPHRAGM
00	02	5400	P	780						DIAPHRAGM
01	01	2707	U	00	460					ASPHALT AND RAILS
01	02	2707	U	00	1170					ASPHALT AND RAILS
01	03	2707	U	00	460					ASPHALT AND RAILS
9 10	11 12	13 14 15 16 17 18 19	20	21 22 23 24	25 26 27 28	29 30 31 32 33 34 35	36 37 38 39 40 41 42	43 44	45	46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77

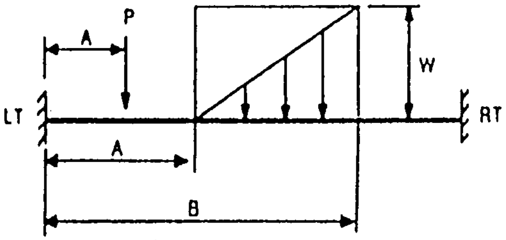
NOTES:

(1) When FEMs are given, they are not calculated for any load on that member.

(2) CODE:
L = Max. W on left
R = Max. W on right
U = Uniform Load
P = Point Load



SIGN CONVENTIONS



DIMENSIONS

LIVE LOAD HS20-44 MEMBER DATA : 400 FORM

ACCOUNT E-1G-IN

01 02 03 04 05 06 07 08

SORT NO. 400

78 79 80

MEMBER NO.	NUMBER OF LIVE LOAD LANES					PLOT DATA				INFLUENCE LINES		COMMENTS
	SUPERSTRUCTURE		SUB-STRUCTURE			RESISTING MOMENT OF UNIT STEEL		MOMENT & SHEAR	SCALE			
	LT END	RT END	LT	RT		POSITIVE	NEGATIVE					
9 10	11 12 13 14 15	16 17 18 19 20	21 22 23	24 25 26	27	28 29 30 31 32	33 34 35 36 37	38	39	40	41	42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77
01	3333	3333	27	27								
02	3333	3333	27	27								
03	3333	3333	27	27								
9 10	11 12 13 14 15	16 17 18 19 20	21 22 23	24 25 26	27	28 29 30 31 32	33 34 35 36 37	38	39	40	41	42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77

NOTES:

(1) FRAME DESCRIPTION data with the horizontal members numbered consecutively starting with 01 must accompany this data.

(2) MEMBER DATA - When the NUMBER OF L.L. LANES is given, it must be given for the left end of Superstructure Member 01. (Substructure Member 01 defaults to 1.0 when left blank). Thereafter, it is assumed to be constant until another entry is made.

(3) INFLUENCE LINES - When a "1" in entered, a plot of the influence lines will be produced along with the printed results.

LIVE LOAD TRUCK AND LANE DATA : 401 FORM

ACCOUNT E-16-IN (01–08)

SORT NO. 401 (78 79 80)

LIVE LOAD NO	TRUCK (1 LANE)					LANE (1 LANE)			NO IMPACT	(2) NUMBER OF LIVE LOAD LANES	COMMENTS
	P_1	D_1	P_2	D_2	P_3	UNIFORM LOAD	MOMENT RIDER	SHEAR RIDER			
	KIPS	FT	KIPS	FT	KIPS	K/FT	KIPS	KIPS			
9	10 11 12 13	14 15 16	17 18 19 20	21 22 23	24 25 26 27	28 29 30 31 32	33 34 35 36	37 38 39 40	41	42 43 44 45 46	47 – 77
1											HS20-44 TRUCK
2	240	40	240								MILITARY LOAD
3	80	140	320	300	320	0640	180	260			HS20-44 VARIABLE AXLE SPACING
9	10 11 12 13	14 15 16	17 18 19 20	21 22 23	24 25 26 27	28 29 30 31 32	33 34 35 36	37 38 39 40	41	42 43 44 45 46	47 – 77

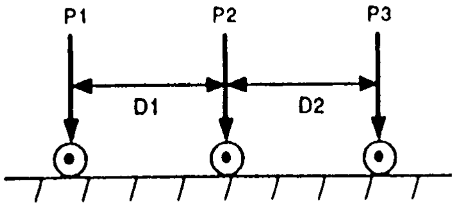
← (CAN BE ADDED)

NOTES:

(1) LIVE LOAD DATA - For AASHTO HS20-44 Loading, leave TRUCK and LANE data blank for L.L. No. 1. When this data is given, it replaces the HS20-44 Loading.

(2) An entry for the NUMBER OF LIVE LOAD LANES overrides that given on MEMBER DATA (400 form).

(3) Data entries for L.L. No.'s 2 and 3 produce separate results in addition to L.L. No. 1



TRUCK AXLE LOADS AND SPACING

LIVE LOAD GENERATOR MEMBER DATA : 500 FORM

ACCOUNT E-16-IN

SORT NO. 500

MEMBER NO.	NUMBER OF LIVE LOAD LANES				IMPACT FACTOR - % (3)	COMMENTS
	SUPERSTRUCTURE		SUB-STRUCTURE			
	LT END	RT END	LT	RT		
9 10	11 12 13 14 15	16 17 18 19 20	21 22 23	24 25 26	27 28	29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77
01	3333	3333	27			LIVE LOAD DISTRIBUTIONS FOR PERMIT TRUCK
02	3333	3333	27			
03	3333	3333	27			

NOTES:

(1) FRAME DESCRIPTION data with the horizontal members numbered consecutively starting with 01 must accompany this data.

(2) When the NUMBER OF LL. LANES is given, it must be given for the left end of Superstructure Member 01. Thereafter, it is assumed to be constant until another entry is made. Substructure Member 01 defaults to 1.0 when left blank.

(3) If a Cooper loading is to be given, % of Impact to be applied to each member must be given. It will be used for Cooper loading only.

LIVE LOAD GENERATOR LIVE LOAD DATA : 501 FORM

ACCOUNT E-16-IN

SORT NO. 501

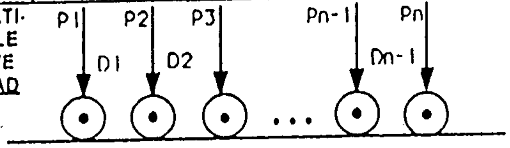
	MULTI-AXLE LIVE LOAD													OVER LOAD					
LIVE LOAD NO. (1)	P1 KIPS	D1 FT	P2 KIPS	D2 FT	P3 KIPS	D3 FT	P4 KIPS	D4 FT	P5 KIPS	D5 FT	P6 KIPS	D6 FT	Pn KIPS	COLOR CODE	NO. OF AXLES	COOPER LOADING	NO IMPACT		LINE NO. (2)
4	270	140	250	40	250	120	250	40	250	350	217	40			08			PERMIT TRUCK	01
	216	40	217																02

NOTES:

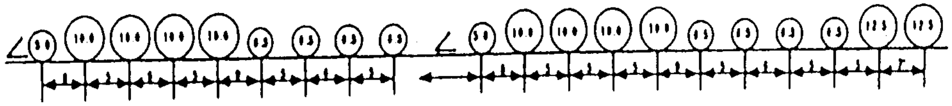
(1) LIVE LOAD DATA - Leave LIVE LOAD NO. 4 blank for 7 axle P-13 truck or simply omit this form using only the 500 form.

(2) Up to 97 axles can be used to describe the live load. The LINE NO. in column 76-77 must be from 1 thru 16.

MULTI-AXLE LIVE LOAD



STEAM RAILROAD LOADING
CLASS E-10 ENGINE LOADING
ONE TRACK OF TWO RAILS



PRESTRESS DATA (1) : 600 FORM

ACCOUNT E-16-IN (01 02 03 04 05 06 07 08)

SORT NO. 600 (78 79 80)

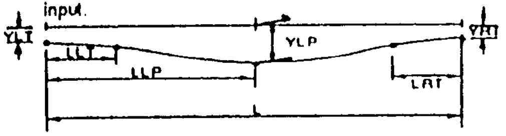
				CABLE PATH								SPECIFICATIONS																	
																	ANCHOR SET		ALL. TENS.										
TRIAL NO.	FRAME NO.	PATH NO.	MEMBER NO.	LLT	LLP	LRT	YLT	YLP	YRT	XLT	XRT	μ	K	f_s	% JACK	JACK END	LT	RT	SPEC		P-JACK	F'c	SHORTENING	LOSSES	RELATIVE HUMIDITY	NO LOW-LAX	PLOT PATHS	PLOT STRESSES	
				%	%	%	FT	FT	FT	FT	FT	X10-3	X10-6	KSI			1/8 IN	1/8 IN		%	KIPS	KSI	%	KSI	%				
9 10	11	12 13	14 15	16 17	18 19	20 21	22 23 24 25	26 27 28 29	30 31 32 33	34 35 36 37	38 39 40 41	42 43	44 45 46	47 48 49	50 51	52	53 54	55 56	57	58 59	60 61 62 63 64	65 66	67	68 69	70 71	72	73	74	75 76 77
01	1	01	01	00	50	25	110	110	100			25	20			B	5	5	1		6865	45	5	38		1			
01	1	01	02	20	50	20	100	317	100			25	20			B	5	5	1		6865	45	5	38		1			
01	1	01	03	25	50	00	100	110	110			25	20			B	5	5	1		6865	45	5	38		1			
9 10	11	12 13	14 15	16 17	18 19	20 21	22 23 24 25	26 27 28 29	30 31 32 33	34 35 36 37	38 39 40 41	42 43	44 45 46	47 48 49	50 51	52	53 54	55 56	57	58 59	60 61 62 63 64	65 66	67	68 69	70 71	72	73	74	75 76 77

NOTES:

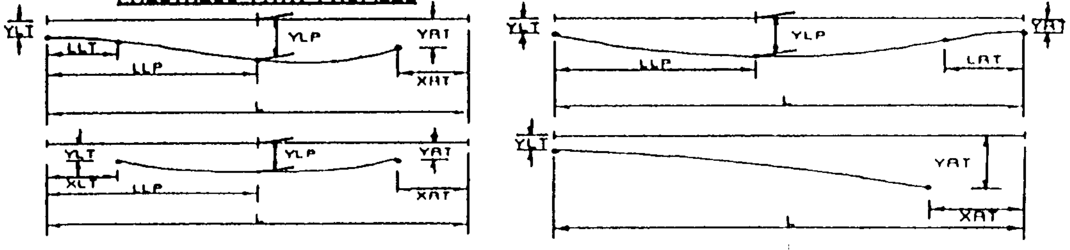
(1) "L" must be the total member length as shown on "FRAME DESCRIPTION".

(2) LLP is always the length from the left end to the low point.

(3) For a straight tendon YLT, YLP and YRT are required input.



PRESTRESS PATH PROFILES



```
       *************************************************************************
       *                            IAI-BDS                                    *
       *                      Bridge Design System                             *
       *                                                                       *
       *                  By: Imbsen and Associates, Inc.                      *
       *                    VERSION 4.0.1    25-AUG-93                         *
       *************************************************************************



       ********************* Licensed to: Colorado DOT **********************
1                                  LISTING OF THE SORTED INPUT FILE
+                                                 ______

  CARD              1         2         3         4         5         6         7         8
 NUMBER    12345678901234567890123456789012345678901234567890123456789012345678901234567890
+______    ________________________________________________________________________________

    1      E-16-IN, Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95  000
    2      E-16-IN,010102R H 460           3865     150                                 100
    3      E-16-IN,020203  H1170           3865     150                                 100
    4      E-16-IN,030304 RH 460           3865     150                01R              100
    5      E-16-IN,040502 P  200                    150                                 100
    6      E-16-IN,050603                           150                04               100
    7      E-16-IN,01  00         410 380 850 000 215015000015000 49 912 49 912     01  200
    8      E-16-IN,01 18401                                                             200
    9      E-16-IN,01 450         410 600 850 000 215015000015000 49 912 49 912     02  200
   10      E-16-IN,01 46002                                                             200
   11      E-16-IN,02  0002                                                             200
   12      E-16-IN,02  1002                                                             200
   13      E-16-IN,02 16101                                                             200
   14      E-16-IN,02100901                                                             200
   15      E-16-IN,02116002                                                             200
   16      E-16-IN,02117002                                                             200
   17      E-16-IN,03  0002                                                             200
   18      E-16-IN,03  1002                                                             200
   19      E-16-IN,03 27601                                                             200
   20      E-16-IN,03 46001                                                             200
   21      E-16-IN,04 000    1  200  800                                06              201
   22      E-16-IN,04 20006                                                             201
   23      E-16-IN,05 00006                                                             201
   24      E-16-IN,05 20006                                                             201
   25      E-16-IN,0002   5400P 390                      DIAPHRAGM                      300
   26      E-16-IN,0002   5400P 780                      DIAPHRAGM                      300
   27      E-16-IN,0101   2707U  00 460                  ASPHALT AND RAILS              300
   28      E-16-IN,0102   2707U  001170                  ASPHALT AND RAILS              300
   29      E-16-IN,0103   2707U  00 460                  ASPHALT AND RAILS              300
   30      E-16-IN,01 3333 3333 27 27                                                   400
   31      E-16-IN,02 3333 3333 27 27                                                   400
   32      E-16-IN,03 3333 3333 27 27                                                   400
   33      E-16-IN,1                                     HS20-44 TRUCK                  401
   34      E-16-IN,2 240 40 240                          MILITARY LOAD                  401
   35      E-16-IN,01 3333 3333 27 27      LIVE LOAD DISTRIBUTIONS FOR PERMIT TRUCK     500
   36      E-16-IN,02 3333 3333 27 27                                                   500
   37      E-16-IN,03 3333 3333 27 27                                                   500
   38      E-16-IN,4 216 40 217                                                       02501
   39      E-16-IN,4 270140 250 40 250120 250 40 250350 217 40     08     COLO PERMIT 01501
   40      E-16-IN,0110101005025 110 110 100        25 20     B 5 51   686545538601     600
   41      E-16-IN,0110102205020 100 317 100        25 20     B 5 51   686545538601     600
   42      E-16-IN,0110103255000 100 110 110        25 20     B 5 51   686545538601     600

+          ________________________________________________________________________________
                    1         2         3         4         5         6         7         8
           12345678901234567890123456789012345678901234567890123456789012345678901234567890
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

16:13:47  Page    1
Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0FRAME DESCRIPTION
                 END                         SUPPORT                                    CARRY 0VER
     MEM  JT.    COND                          OR               DEAD LOAD      K          FACTORS   RECALL
      NO  LT RT LT RT  DIR   SPAN      I      HINGE      E      UNI  SEC    LT    RT    LT     RT    MEM
    /---/ /---/ /---/ /---/ /-----/ /------/ /-----/  /------/ /--------/ /----------/ /----------/ /----/
      1   1  2   R      H     46.0      0.00    0.0    3865.   0.000 .150  0.00  0.00   0.00  0.00
      2   2  3          H    117.0      0.00    0.0    3865.   0.000 .150  0.00  0.00   0.00  0.00
      3   3  4     R    H     46.0      0.00    0.0    3865.   0.000 .150  0.00  0.00   0.00  0.00  01R
      4   5  2     P          20.0      0.00    0.0    3250.   0.000 .150  0.00  0.00   0.00  0.00
      5   6  3                 0.0      0.00    0.0    3250.   0.000 .150  0.00  0.00   0.00  0.00  04
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

16:13:48  Page    2
Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0SECTION PROPERTIES - INPUT
0MEM        RE
  NO  LOC.  CALL Z     Y     W     D   TOP   BOT  NO  W  T  W  FACT T  W  FACT   L  EX  IN    L  EX  IN   E
STORE
```

```
                    +/-  CODE    V/D       H        Z        Y      AREA     IZZ        E     E-STORE  STORE

  1    0.0       0.0  0.0  41.0  3.80  8.50  0.00  2 15. 0 15. 0.00 0 15. 0.00  4.9  9. 12.  4.9  9. 12. 3865.
01
  1   18.4  01          ** RECALL ONLY
  1   45.0       0.0  0.0  41.0  6.00  8.50  0.00  2 15. 0 15. 0.00 0 15. 0.00  4.9  9. 12.  4.9  9. 12. 3865.
02
  1   46.0  02          ** RECALL ONLY
0SECTION PROPERTIES - OUTPUT
0MEM
  NO  LOC.   DEPTH    Z-BAR    Y-BAR    AREA        IZZ         IYY       E
0 1    0.0    3.80     20.50    2.79   46.47         50.04     6523.55   3865.00
0 1   18.4    3.80     20.50    2.79   46.47         50.04     6523.55   3865.00
0 1   45.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0 1   46.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0MEMBER  1 PROPERTIES
0 LENGTH:  46.0  MIN E*I: 0.193E+06  STIFF:  4.686 LT   10.071 RT  C.O.: 0.810 LT   0.377 RT
0SECTION PROPERTIES - INPUT
0MEM        RE
  NO  LOC. CALL  Z     Y     W     D   TOP   BOT  NO  W  T  W  FACT T  W  FACT   L  EX  IN    L  EX  IN   E
STORE

                    +/-  CODE    V/D       H        Z        Y      AREA     IZZ        E     E-STORE  STORE

  2    0.0  02          ** RECALL ONLY
  2    1.0  02          ** RECALL ONLY
  2   16.1  01          ** RECALL ONLY
  2  100.9  01          ** RECALL ONLY
  2  116.0  02          ** RECALL ONLY
  2  117.0  02          ** RECALL ONLY
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

16:13:48  Page    3
Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0SECTION PROPERTIES - OUTPUT
0MEM
  NO  LOC.   DEPTH    Z-BAR    Y-BAR    AREA        IZZ         IYY       E
0 2    0.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0 2    1.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0 2   16.1    3.80     20.50    2.79   46.47         50.04     6523.55   3865.00
0 2  100.9    3.80     20.50    2.79   46.47         50.04     6523.55   3865.00
0 2  116.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0 2  117.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0MEMBER  2 PROPERTIES
0 LENGTH: 117.0  MIN E*I: 0.193E+06  STIFF:  5.814 LT    5.814 RT  C.O.: 0.596 LT   0.596 RT
0SECTION PROPERTIES - INPUT
0MEM        RE
  NO  LOC. CALL  Z     Y     W     D   TOP   BOT  NO  W  T  W  FACT T  W  FACT   L  EX  IN    L  EX  IN   E
STORE

                    +/-  CODE    V/D       H        Z        Y      AREA     IZZ        E     E-STORE  STORE

  3    0.0  02          ** RECALL ONLY
  3    1.0  02          ** RECALL ONLY
  3   27.6  01          ** RECALL ONLY
  3   46.0  01          ** RECALL ONLY
0SECTION PROPERTIES - OUTPUT
0MEM
  NO  LOC.   DEPTH    Z-BAR    Y-BAR    AREA        IZZ         IYY       E
0 3    0.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0 3    1.0    6.00     20.50    4.25   57.47        189.37     7895.40   3865.00
0 3   27.6    3.80     20.50    2.79   46.47         50.04     6523.55   3865.00
0 3   46.0    3.80     20.50    2.79   46.47         50.04     6523.55   3865.00
0MEMBER  3 PROPERTIES
0 LENGTH:  46.0  MIN E*I: 0.193E+06  STIFF: 10.071 LT    4.686 RT  C.O.: 0.377 LT   0.810 RT
0SECTION PROPERTIES - INPUT
0MEM        RE
  NO  LOC. CALL  Z     Y     W     D   TOP   BOT  NO  W  T  W  FACT T  W  FACT   L  EX  IN    L  EX  IN   E
STORE

                    +/-  CODE    V/D       H        Z        Y      AREA     IZZ        E     E-STORE  STORE

  4   0.0               1     2.00     8.00     0.00     0.00    0.00      0.00   3250.00      0      06
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

16:13:48  Page    4
Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0SECTION PROPERTIES - INPUT
0MEM        RE
  NO  LOC. CALL  Z     Y     W     D   TOP   BOT  NO  W  T  W  FACT T  W  FACT   L  EX  IN    L  EX  IN   E
STORE

                    +/-  CODE    V/D       H        Z        Y      AREA     IZZ        E     E-STORE  STORE

  4   20.0  06          ** RECALL ONLY
0SECTION PROPERTIES - OUTPUT
0MEM
  NO  LOC.   DEPTH    Z-BAR    Y-BAR    AREA        IZZ         IYY       E
0 4    0.0    0.00      4.00    1.00   16.00          5.33       85.33   3250.00
0 4   20.0    0.00      4.00    1.00   16.00          5.33       85.33   3250.00
0MEMBER  4 PROPERTIES
```

```
0 LENGTH:  20.0  MIN E*I: 0.173E+05  STIFF:  4.000 LT    4.000 RT  C.O.: 0.500 LT   0.500 RT
0SECTION PROPERTIES - INPUT
0MEM        RE
  NO  LOC. CALL  Z     Y     W     D   TOP   BOT  NO  W  T  W  FACT T  W  FACT   L  EX  IN    L  EX  IN    E
STORE

                    +/-  CODE    V/D       H        Z        Y      AREA     IZZ        E     E-STORE  STORE

  5    0.0  06          ** RECALL ONLY
  5   20.0  06          ** RECALL ONLY
0SECTION PROPERTIES - OUTPUT
0MEM
  NO  LOC.   DEPTH    Z-BAR    Y-BAR    AREA        IZZ         IYY       E
0 5    0.0    0.00     4.00     1.00   16.00          5.33       85.33   3250.00
0 5   20.0    0.00     4.00     1.00   16.00          5.33       85.33   3250.00
0MEMBER  5 PROPERTIES
0 LENGTH:  20.0  MIN E*I: 0.173E+05  STIFF:  4.000 LT    4.000 RT  C.O.: 0.500 LT   0.500 RT
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                              Run time: 07-JUL-95

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Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95

0FRAME PROPERTIES
                 END                              SUPPORT              CARRY OVER        DISTRIBUTION
  MEM     JT     COND                               OR                  FACTORS            FACTORS
  NO    LT  RT    LT RT   DIR    SPAN   MIN E*I    HINGE       E         LT      RT         LT    RT
 /---/ /------/ /-----/ /---/ /-----/ /-------/ /-------/ /-------/ /---------------/  /-------------/
   1     1   2   R       H     46.0  0.1934E+06   0.0       3865.      0.810   0.000    0.000  0.754
   2     2   3           H    117.0  0.1934E+06   0.0       3865.      0.596   0.596    0.246  0.246
   3     3   4       R   H     46.0  0.1934E+06   0.0       3865.      0.000   0.810    0.754  0.000
   4     5   2       P         20.0  0.1733E+05   0.0       3250.      0.000   0.500    0.000  0.000
   5     6   3       P         20.0  0.1733E+05   0.0       3250.      0.000   0.500    0.000  0.000
0***** IF MEMBER IS HORIZONTAL SUPPORT OR HINGE FIELD EQUALS LOCATION OF HINGE FROM LEFT END OF MEMBER *****
 ***** IF MEMBER IS VERTICAL SUPPORT OR HINGE FIELD EQUALS SUPPORT WIDTH USED FOR MOMENT REDUCTION *****
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LOAD DATA  TRIAL  0
                          LOAD                          FIXED END MOMENTS
   LINE MEM    W OR P    CODE       A       B          LEFT      RIGHT  DEFLT    COMMENTS
           2      5.400     P       39.0     0.0         0.         0.         DIAPHRAGM
           2      5.400     P       78.0     0.0         0.         0.         DIAPHRAGM
0FIXED END MOMENTS  TRIAL  0

    MEM     FIXED END MOMENTS          MEM     FIXED END MOMENTS            MEM     FIXED END MOMENTS
     NO      LT          RT             NO       LT          RT              NO       LT          RT

      1          0.    -2650.           2     -9142.     -9142.              3     -2650.         0.
      4          0.       0.            5        0.         0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                              Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0SIDESWAY DIAGNOSTICS

0




 RESULTS OF 1 INCH SWAY TO THE RIGHT

     VERTICAL SHEAR (KIPS)    MOMENTS (FT-KIPS)
     MEMBER                      LT        RT
                                                    BASED ON E = 3250. KSI.
         4           78.0        -1560.        0.
         5           78.0        -1560.        0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                              Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0                            *** FRAME DOES NOT SWAY WITH THIS LOADING ***
 HORIZONTAL MEMBER MOMENTS  TRIAL  0
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT  .7 PT    .8 PT    .9 PT    RIGHT
0 1       0.     -153.    -454.    -902.   -1497.   -2241.   -3139.   -4196.   -5418.   -6813.   -8385.
0 2    -8385.   -3951.    -546.    1902.    3354.    3831.    3354.    1902.    -546.   -3951.   -8385.    ←
0 3    -8385.   -6813.   -5418.   -4196.   -3139.   -2241.   -1497.    -902.    -454.    -153.       0.    ←
0HORIZONTAL MEMBER STRESSES  TRIAL  0    BOTTOM FIBER
0 1       0.       59.     176.     350.     581.     639.     732.     845.     977.    1124.    1306.
0 2    1306.      974.     212.    -738.   -1301.   -1486.   -1301.    -738.     212.     974.    1306.
0 3    1306.     1124.     977.     845.     732.     639.     581.     350.     176.      59.       0.
0HORIZONTAL MEMBER STRESSES  TRIAL  0     TOP FIBER
0 1       0.      -21.     -63.    -126.    -209.    -238.    -280.    -332.    -391.    -458.    -538.
0 2     -538.    -370.     -76.     265.     468.     535.     468.     265.     -76.    -370.    -538.
0 3     -538.    -458.    -391.    -332.    -280.    -238.    -209.    -126.     -63.     -21.       0.
0VERTICAL MEMBER MOMENTS  TRIAL  0
0 4       0.        0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
0 5       0.        0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
```

```
0HORIZONTAL MEMBER SHEARS  TRIAL  0
0 1     -17.2    -49.3    -81.4   -113.4   -145.5   -178.2   -212.2   -247.6   -284.2   -322.2   -361.4
0 2     427.3    332.8    250.0    168.5     81.5      0.0    -81.5   -168.5   -250.0   -332.8   -427.3
0 3     361.4    322.2    284.2    247.6    212.2    178.2    145.5    113.4     81.4     49.3     17.2
0VERTICAL MEMBER SHEARS  TRIAL 0
0 4       0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0 5       0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0VERTICAL MEMBER REACTIONS  TRIAL  0
0MEM        LT                RT              MEMBER
 NO      REACTION           REACTION          WEIGHT

   4       836.7             788.7             48.0
   5       836.7             788.7             48.0
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL  0
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END     SPAN    LT. END     RT. END     SPAN   LT. END     RT. END
0     1    -0.000743    0.001355      2     0.001355   -0.001355      3    -0.001355    0.000743
0     4     0.000000    0.000000      5     0.000000    0.000000
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
0     MEMBER  1    E= 3865.     0.000    -0.008    -0.013    -0.011     0.000
0     MEMBER  2    E= 3865.     0.000     0.070     0.121     0.070     0.000
0     MEMBER  3    E= 3865.     0.000    -0.011    -0.013    -0.008     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  4    E= 3250.     0.000     0.000     0.000     0.000     0.000
0     MEMBER  5    E= 3250.     0.000     0.000     0.000     0.000     0.000
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LOAD DATA  TRIAL  1
                          LOAD                           FIXED END MOMENTS
   LINE MEM    W OR P    CODE       A       B          LEFT      RIGHT  DEFLT    COMMENTS
           1      2.707     U        0.0    46.0         0.         0.         ASPHALT AND RAILS
           2      2.707     U        0.0   117.0         0.         0.         ASPHALT AND RAILS
           3      2.707     U        0.0    46.0         0.         0.         ASPHALT AND RAILS
0FIXED END MOMENTS  TRIAL  1

    MEM     FIXED END MOMENTS         MEM     FIXED END MOMENTS            MEM     FIXED END MOMENTS
     NO      LT         RT             NO       LT         RT               NO       LT         RT

      1         0.     -969.           2     -3459.     -3459.             3      -969.         0.
      4         0.        0.           5        0.         0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0                            *** FRAME DOES NOT SWAY WITH THIS LOADING ***
 HORIZONTAL MEMBER MOMENTS  TRIAL  1
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT  .7 PT    .8 PT    .9 PT    RIGHT
0 1       0.     -59.    -175.    -349.    -580.    -868.   -1214.   -1617.   -2077.   -2594.   -3169.
0 2    -3169.   -1501.    -204.     722.    1278.    1463.    1278.     722.    -204.   -1501.   -3169.    ←
0 3    -3169.   -2594.   -2077.   -1617.   -1214.    -868.    -580.    -349.    -175.     -59.       0.
0HORIZONTAL MEMBER STRESSES  TRIAL  1    BOTTOM FIBER
0 1       0.      23.      68.     135.     225.     248.     283.     326.     374.     428.     494.
0 2     494.     370.      79.    -280.    -496.    -568.    -496.    -280.      79.     370.     494.
0 3     494.     428.     374.     326.     283.     248.     225.     135.      68.      23.       0.
0HORIZONTAL MEMBER STRESSES  TRIAL  1     TOP FIBER
0 1       0.      -8.     -24.     -49.     -81.     -92.    -108.    -128.    -150.    -174.    -203.
0 2    -203.    -141.     -28.     101.     178.     204.     178.     101.     -28.    -141.    -203.
0 3    -203.    -174.    -150.    -128.    -108.     -92.     -81.     -49.     -24.      -8.       0.
0VERTICAL MEMBER MOMENTS  TRIAL  1
0 4       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
0 5       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
0HORIZONTAL MEMBER SHEARS  TRIAL  1
0 1      -6.6    -19.1    -31.5    -44.0    -56.4    -68.9    -81.3    -93.8   -106.2   -118.7   -131.1
0 2     158.4    126.7     95.0     63.3     31.7      0.0    -31.7    -63.3    -95.0   -126.7   -158.4
0 3     131.1    118.7    106.2     93.8     81.3     68.9     56.4     44.0     31.5     19.1      6.6
0VERTICAL MEMBER SHEARS  TRIAL 1
0 4       0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0 5       0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0VERTICAL MEMBER REACTIONS  TRIAL  1
0MEM        LT                RT              MEMBER
 NO      REACTION           REACTION          WEIGHT

   4       289.5             289.5
   5       289.5             289.5
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL  1
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END     SPAN    LT. END     RT. END     SPAN   LT. END     RT. END
0     1    -0.000287    0.000520      2     0.000520   -0.000520      3    -0.000520    0.000287
0     4     0.000000    0.000000      5     0.000000    0.000000
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
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0     MEMBER  1    E= 3865.     0.000    -0.003    -0.005    -0.004     0.000
0     MEMBER  2    E= 3865.     0.000     0.027     0.046     0.027     0.000
0     MEMBER  3    E= 3865.     0.000    -0.004    -0.005    -0.003     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  4    E= 3250.     0.000     0.000     0.000     0.000     0.000
0     MEMBER  5    E= 3250.     0.000     0.000     0.000     0.000     0.000
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LIVE LOAD DIAGNOSTICS

0
0SUPERSTRUCTURE LIVE LOAD
0           NUMBER OF LIVE LOAD LANES          RESISTING MOMENT OF        PLOT   PLOT   INFLU-
 MEM     SUPERSTRUCTURE   SUBSTRUCTURE              UNIT STEEL            M   S SCALE   ENCE
  NO.   LT.END   RT.END   LT.END    RT.END     POSITIVE   NEGATIVE         ENV.         LINES  GEN
 -----------------------------------------------------------------------------------------------

   1      3.333   3.333    2.7       2.7           0.        0.            0      0      NO      NO
   2      3.333   3.333    2.7       2.7           0.        0.
   3      3.333   3.333    2.7       2.7           0.        0.
0LIVE    -----------TRUCK-------------    ---------LANE---------         NO.  LIVE
 LOAD     P1     D1    P2  D2     P3      UNIFORM   MOM.   SHEAR          LL   LOAD
 NO.                                               RIDER  RIDER IMPACT  LNS. SIDESWAY

  1.      8.0   14.0  32.0   14.0   32.0     0.640   18.0   26.0   YES    0.00 NO

          COMMENTS: HS20-44 TRUCK
+                                           WITHOUT ALTERNATIVE


  2.     24.0    4.0  24.0    0.0    0.0     0.000    0.0    0.0   YES    0.00 NO

          COMMENTS: MILITARY LOAD



  IMPACT FACTORS CALCULATED BY PROGRAM
0       MEM       IMPACT
         NO         %


         1          29.
         2          21.
         3          29.
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 1.                    NEGATIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.    -472.    -943.   -1415.   -1887.   -2358.   -2830.   -3301.   -3773.   -4245.   -4716.
 SHEAR     0.0   -102.5   -102.5   -102.5   -102.5   -102.5   -102.5   -102.5   -102.5   -102.5   -102.5
0 2    -4716.   -2514.    -908.    -389.    -284.    -224.    -284.    -389.    -908.   -2514.   -4716.
 SHEAR   201.1    161.4     16.4      9.0      9.0      0.0     -9.0     -9.0    -16.4   -161.4   -201.1
0 3    -4716.   -4245.   -3773.   -3301.   -2830.   -2358.   -1887.   -1415.    -943.    -472.       0.   ←
 SHEAR   102.5    102.5    102.5    102.5    102.5    102.5    102.5    102.5    102.5    102.5      0.0
0HORIZONTAL MEMBER STRESSES LL MAX NEG  BOTTOM FIBER
0 1        0.     183.     366.     549.     732.     673.     660.     665.     680.     700.     735.
0 2      735.     620.     352.     151.     110.      87.     110.     151.     352.     620.     735.
0 3      735.     700.     680.     665.     660.     673.     732.     549.     366.     183.       0.   ←
0HORIZONTAL MEMBER STRESSES LL MAX NEG  TOP FIBER
0 1        0.     -66.    -132.    -197.    -263.    -251.    -253.    -261.    -272.    -285.    -303.
0 2     -303.    -236.    -127.     -54.     -40.     -31.     -40.     -54.    -127.    -236.    -303.
0 3     -303.    -285.    -272.    -261.    -253.    -251.    -263.    -197.    -132.     -66.       0.   ←
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 1.                    DEAD LOAD PLUS NEGATIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.    -625.   -1397.   -2316.   -3384.   -4599.   -5968.   -7497.   -9191.  -11057.  -13101.
0 2   -13101.   -6465.   -1454.    1513.    3070.    3607.    3070.    1513.   -1454.   -6465.  -13101.
0 3   -13101.  -11057.   -9191.   -7497.   -5968.   -4599.   -3384.   -2316.   -1397.    -625.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG BOTTOM FIBER
0 1        0.     242.     542.     898.    1312.    1312.    1391.    1511.    1657.    1825.    2041.
0 2     2041.    1594.     564.    -587.   -1191.   -1399.   -1191.    -587.     564.    1594.    2041.
0 3     2041.    1825.    1657.    1511.    1391.    1312.    1312.     898.     542.     242.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG  TOP FIBER
0 1        0.     -87.    -195.    -323.    -472.    -489.    -533.    -593.    -663.    -743.    -841.
0 2     -841.    -606.    -203.     211.     428.     503.     428.     211.    -203.    -606.    -841.
0 3     -841.    -743.    -663.    -593.    -533.    -489.    -472.    -323.    -195.     -87.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

16:13:50  Page   16
                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
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0LL NO. 1.                   POSITIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.     939.    1572.    1917.    2081.    2032.    1942.    1635.    1166.     479.     347.
 SHEAR     0.0    204.1    170.8    138.9    104.9   -103.4   -135.4   -169.5   -199.8   -228.7      7.5  ←
0 2      347.     344.    1100.    2172.    2985.    3236.    2985.    2172.    1100.     344.     347.
 SHEAR    -9.0     78.1    133.8    176.2    137.2     96.0   -137.2   -176.2   -133.8    -78.1      9.0
0 3      347.     479.    1166.    1635.    1942.    2032.    2081.    1917.    1572.     939.       0.
 SHEAR    -7.5    228.7    199.8    169.5    135.4    103.4   -104.9   -138.9   -170.8   -204.1      0.0
0HORIZONTAL MEMBER STRESSES LL MAX POS  BOTTOM FIBER
0 1        0.    -364.    -610.    -744.    -807.    -580.    -453.    -329.    -210.     -79.     -54.
0 2      -54.     -85.    -427.    -842.   -1158.   -1255.   -1158.    -842.    -427.     -85.     -54.  ←
0 3      -54.     -79.    -210.    -329.    -453.    -580.    -807.    -744.    -610.    -364.       0.
0HORIZONTAL MEMBER STRESSES LL MAX POS  TOP FIBER
0 1        0.     131.     219.     268.     290.     216.     173.     129.      84.      32.      22.
0 2       22.      32.     154.     303.     417.     452.     417.     303.     154.      32.      22.  ←
0 3       22.      32.      84.     129.     173.     216.     290.     268.     219.     131.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 1.                   DEAD LOAD PLUS POSITIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.     786.    1118.    1016.     584.    -209.   -1196.   -2561.   -4252.   -6334.   -8038.
0 2    -8038.   -3607.     554.    4074.    6339.    7068.    6339.    4074.     554.   -3607.   -8038.
0 3    -8038.   -6334.   -4252.   -2561.   -1196.    -209.     584.    1016.    1118.     786.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS BOTTOM FIBER
0 1        0.    -305.    -434.    -394.    -226.      60.     279.     516.     767.    1045.    1252.
0 2     1252.     889.    -215.   -1580.   -2459.   -2741.   -2459.   -1580.    -215.     889.    1252.
0 3     1252.    1045.     767.     516.     279.      60.    -226.    -394.    -434.    -305.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS  TOP FIBER
0 1        0.     110.     156.     142.      81.     -22.    -107.    -202.    -307.    -426.    -516.
0 2     -516.    -338.      77.     568.     885.     986.     885.     568.      77.    -338.    -516.
0 3     -516.    -426.    -307.    -202.    -107.     -22.      81.     142.     156.     110.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO.  1.                      LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   238.5    204.1    170.8    138.9    108.5     79.9     52.8     35.1     22.6     11.8      7.5
 MOM.        0.     939.    1572.    1917.    1997.    1838.    1457.     873.     640.     380.     347.
 NEG. V  -102.5   -102.5   -104.2   -108.9   -126.2   -144.2   -162.8   -182.1   -202.0   -228.7   -256.1
 MOM.        0.    -472.     907.     556.     501.     299.     -56.    -570.   -1250.     479.    -408.
 RANGE    341.0    306.6    275.0    247.8    234.7    224.1    215.6    217.1    224.6    240.4    263.6
0LL NO.  1.                      LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   277.6    258.0    229.6    193.6    153.3    112.3     74.1     42.1     18.7      9.0      9.0
 MOM.    -1749.    -514.     859.    2096.    2891.    3095.    2724.    1953.    1055.     241.     347.
 NEG. V    -9.0     -9.0    -18.7    -42.1    -74.1   -112.3   -153.3   -193.6   -229.6   -258.0   -277.6
 MOM.      347.     241.    1055.    1953.    2724.    3095.    2891.    2096.     859.    -514.   -1749.
 RANGE    286.6    266.9    248.3    235.7    227.4    224.6    227.4    235.7    248.3    266.9    286.6
0LL NO.  1.                      LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  3 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   256.1    228.7    202.0    182.1    162.8    144.2    126.2    108.9    104.2    102.5    102.5
 MOM.     -408.     479.   -1250.    -570.     -56.     299.     501.     556.     907.    -472.       0.
 NEG. V    -7.5    -11.8    -22.6    -35.1    -52.8    -79.9   -108.5   -138.9   -170.8   -204.1   -238.5
 MOM.      347.     488.     833.    1130.    1457.    1838.    1997.    1917.    1572.     939.       0.
 RANGE    263.6    240.4    224.6    217.1    215.6    224.1    234.7    247.8    275.0    306.6    341.0
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 1.                   DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   221.3    154.8     89.5     25.5    -36.9    -98.3   -159.4   -212.5   -261.6   -310.4   -353.9
 NEG. V  -119.8   -151.8   -185.5   -222.3   -271.7   -322.4   -375.0   -429.6   -486.2   -550.9   -617.5
0LL NO. 1.                   DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   704.9    590.7    479.6    362.1    234.8    112.3     -7.4   -126.4   -231.4   -323.8   -418.3
 NEG. V   418.3    323.8    231.4    126.4      7.4   -112.3   -234.8   -362.1   -479.6   -590.7   -704.9
0LL NO. 1.                   DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  3 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   617.5    550.9    486.2    429.6    375.0    322.4    271.7    222.3    185.5    151.8    119.8
 NEG. V   353.9    310.4    261.6    212.5    159.4     98.3     36.9    -25.5    -89.5   -154.8   -221.3
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95

0LL NO. 1.                       LIVE LOAD SUPPORT RESULTS
0                           MAX.  AXIAL  LOAD                MAX. LONGITUDINAL MOMENT
                        AXIAL    ------MOMENT------         AXIAL   ------MOMENT------
                        LOAD       TOP         BOT.         LOAD      TOP         BOT.
0SUPPORT JT.  1
           POSITIVE     193.2         0.          0.          0.0         0.          0.
           NEGATIVE     -83.1         0.          0.          0.0         0.          0.
0MEMBER   4
           POSITIVE     331.8         0.          0.          0.0         0.          0.
```

```
           NEGATIVE     -13.4         0.         0.          0.0        0.         0.
0MEMBER   5
           POSITIVE     331.8         0.         0.          0.0        0.         0.
           NEGATIVE     -13.4         0.         0.          0.0        0.         0.
0SUPPORT JT.  4
           POSITIVE     193.2         0.         0.          0.0        0.         0.
           NEGATIVE     -83.1         0.         0.          0.0        0.         0.
0    THE RATIO OF SUBSTRUCTURE / SUPERSTRUCTURE LOADING IS 0.810
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                           Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 2.                    NEGATIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.    -325.    -650.    -976.   -1301.   -1626.   -1951.   -2276.   -2601.   -2927.   -3252.
 SHEAR     0.0    -70.7    -70.7    -70.7    -70.7    -70.7    -70.7    -70.7    -70.7    -70.7    -70.7
0 2    -3252.   -1767.    -611.    -310.    -226.    -143.    -226.    -310.    -611.   -1767.   -3252.
 SHEAR   145.8    119.7     73.3      7.2      7.2      7.2     -7.2     -7.2    -73.3   -119.7   -145.8
0 3    -3252.   -2927.   -2601.   -2276.   -1951.   -1626.   -1301.    -976.    -650.    -325.       0.
 SHEAR    70.7     70.7     70.7     70.7     70.7     70.7     70.7     70.7     70.7     70.7      0.0
0HORIZONTAL MEMBER STRESSES LL MAX NEG  BOTTOM FIBER
0 1        0.     126.     252.     378.     504.     464.     455.     459.     469.     483.     507.
0 2      507.     436.     237.     120.      88.      55.      88.     120.     237.     436.     507.
0 3      507.     483.     469.     459.     455.     464.     504.     378.     252.     126.       0.
0HORIZONTAL MEMBER STRESSES LL MAX NEG  TOP FIBER
0 1        0.     -45.     -91.    -136.    -182.    -173.    -174.    -180.    -188.    -197.    -209.
0 2     -209.    -166.     -85.     -43.     -32.     -20.     -32.     -43.     -85.    -166.    -209.
0 3     -209.    -197.    -188.    -180.    -174.    -173.    -182.    -136.     -91.     -45.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                           Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 2.                    DEAD LOAD PLUS NEGATIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.    -478.   -1104.   -1877.   -2798.   -3867.   -5090.   -6472.   -8020.   -9739.  -11636.
0 2   -11636.   -5718.   -1157.    1592.    3128.    3689.    3128.    1592.   -1157.   -5718.  -11636.
0 3   -11636.   -9739.   -8020.   -6472.   -5090.   -3867.   -2798.   -1877.   -1104.    -478.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG BOTTOM FIBER
0 1        0.     185.     428.     728.    1085.    1103.    1187.    1304.    1446.    1607.    1813.
0 2     1813.    1410.     449.    -617.   -1213.   -1431.   -1213.    -617.     449.    1410.    1813.
0 3     1813.    1607.    1446.    1304.    1187.    1103.    1085.     728.     428.     185.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG  TOP FIBER
0 1        0.     -67.    -154.    -262.    -390.    -411.    -455.    -512.    -579.    -654.    -747.
0 2     -747.    -536.    -161.     222.     437.     515.     437.     222.    -161.    -536.    -747.
0 3     -747.    -654.    -579.    -512.    -455.    -411.    -390.    -262.    -154.     -67.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                           Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 2.                    POSITIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.     790.    1361.    1723.    1894.    1890.    1782.    1519.    1112.     573.     276.
 SHEAR     0.0     68.4    -58.8    -81.9   -103.8   -124.6   -127.2   -146.7   -165.3   -182.9      6.0
0 2      276.     449.    1100.    1865.    2435.    2629.    2435.    1865.    1100.     449.     276.
 SHEAR    -7.2     89.8     77.1    145.8    119.7    -91.7   -119.7   -145.8   -173.6   -186.3      7.2
0 3      276.     573.    1112.    1519.    1782.    1890.    1894.    1723.    1361.     790.       0.
 SHEAR    -6.0     79.6     61.9    -60.0    -79.6    -82.2   -102.9   -124.9   -147.9   -171.8      0.0
0HORIZONTAL MEMBER STRESSES LL MAX POS  BOTTOM FIBER
0 1        0.    -306.    -528.    -668.    -735.    -539.    -415.    -306.    -200.     -95.     -43.
0 2      -43.    -111.    -426.    -723.    -944.   -1020.    -944.    -723.    -426.    -111.     -43.
0 3      -43.     -95.    -200.    -306.    -415.    -539.    -735.    -668.    -528.    -306.       0.
0HORIZONTAL MEMBER STRESSES LL MAX POS  TOP FIBER
0 1        0.     110.     190.     240.     264.     201.     159.     120.      80.      39.      18.
0 2       18.      42.     153.     260.     340.     367.     340.     260.     153.      42.      18.
0 3       18.      39.      80.     120.     159.     201.     264.     240.     190.     110.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                           Run time: 07-JUL-95

16:13:50  Page   24
                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 2.                    DEAD LOAD PLUS POSITIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.     637.     907.     822.     397.    -351.   -1356.   -2677.   -4306.   -6240.   -8108.
0 2    -8108.   -3502.     553.    3767.    5789.    6461.    5789.    3767.     553.   -3502.   -8108.
0 3    -8108.   -6240.   -4306.   -2677.   -1356.    -351.     397.     822.     907.     637.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS BOTTOM FIBER
0 1        0.    -247.    -352.    -319.    -154.     100.     316.     539.     776.    1030.    1263.
0 2     1263.     864.    -215.   -1461.   -2245.   -2506.   -2245.   -1461.    -215.     864.    1263.
0 3     1263.    1030.     776.     539.     316.     100.    -154.    -319.    -352.    -247.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS  TOP FIBER
0 1        0.      89.     127.     115.      55.     -37.    -121.    -212.    -311.    -419.    -521.
0 2     -521.    -328.      77.     526.     808.     902.     808.     526.      77.    -328.    -521.
0 3     -521.    -419.    -311.    -212.    -121.     -37.      55.     115.     127.      89.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                           Run time: 07-JUL-95


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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
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0LL NO.  2.                          LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   196.1    171.8    147.9    124.9    102.9     82.2     62.5     43.8     26.1      9.2      6.0
 MOM.        0.     790.    1361.    1723.    1894.    1890.    1725.    1411.     960.     382.     276.
 NEG. V   -70.7    -70.7    -70.7    -70.7    -84.8   -106.6   -127.2   -146.7   -165.3   -182.9   -199.7
 MOM.        0.    -325.    -650.    -976.    1830.    1890.    1782.    1519.    1112.     573.     -87.
 RANGE    266.8    242.5    218.6    195.6    187.8    188.8    189.7    190.6    191.4    192.2    205.7
0LL NO.  2.                          LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   191.8    182.7    167.5    145.8    119.7     91.7     64.1     39.2     19.5      7.2      7.2
 MOM.     -290.     308.    1071.    1865.    2435.    2629.    2407.    1837.    1100.     193.     276.
 NEG. V    -7.2     -7.2    -19.5    -39.2    -64.1    -91.7   -119.7   -145.8   -167.5   -182.7   -191.8
 MOM.      276.     193.    1100.    1837.    2407.    2629.    2435.    1865.    1071.     308.    -290.
 RANGE    199.0    189.9    187.0    185.0    183.8    183.4    183.8    185.0    187.0    189.9    199.0
0LL NO.  2.                          LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  3 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   199.7    182.9    165.3    146.7    127.2    106.6     84.8     70.7     70.7     70.7     70.7
 MOM.      -87.     573.    1112.    1519.    1782.    1890.    1830.    -976.    -650.    -325.       0.
 NEG. V    -6.0     -9.2    -26.1    -43.8    -62.5    -82.2   -102.9   -124.9   -147.9   -171.8   -196.1
 MOM.      276.     382.     960.    1411.    1725.    1890.    1894.    1723.    1361.     790.       0.
 RANGE    205.7    192.2    191.4    190.6    189.7    188.8    187.8    195.6    218.6    242.5    266.8
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 2.                       DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   178.9    122.5     66.6     11.5    -42.6    -96.0   -149.7   -203.7   -258.2   -313.0   -355.4
 NEG. V   -87.9   -120.0   -152.0   -184.1   -230.3   -284.8   -339.4   -394.3   -449.5   -505.1   -561.1
0LL NO. 2.                       DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   619.1    515.5    417.6    314.3    201.3     91.7    -17.5   -129.3   -230.6   -325.6   -420.1
 NEG. V   420.1    325.6    230.6    129.3     17.5    -91.7   -201.3   -314.3   -417.6   -515.5   -619.1
0LL NO. 2.                       DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  3 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   561.1    505.1    449.5    394.3    339.4    284.8    230.3    184.1    152.0    120.0     87.9
 NEG. V   355.4    313.0    258.2    203.7    149.7     96.0     42.6    -11.5    -66.6   -122.5   -178.9
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                 Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95

0LL NO. 2.                           LIVE LOAD SUPPORT RESULTS
0                           MAX.  AXIAL  LOAD                MAX. LONGITUDINAL MOMENT
                        AXIAL    ------MOMENT------         AXIAL   ------MOMENT------
                        LOAD       TOP        BOT.          LOAD      TOP        BOT.
0SUPPORT JT.  1
           POSITIVE     158.9         0.         0.          0.0        0.         0.
           NEGATIVE     -57.3         0.         0.          0.0        0.         0.
0MEMBER   4
           POSITIVE     186.0         0.         0.          0.0        0.         0.
           NEGATIVE     -10.7         0.         0.          0.0        0.         0.
0MEMBER   5
           POSITIVE     186.0         0.         0.          0.0        0.         0.
           NEGATIVE     -10.7         0.         0.          0.0        0.         0.
0SUPPORT JT.  4
           POSITIVE     158.9         0.         0.          0.0        0.         0.
           NEGATIVE     -57.3         0.         0.          0.0        0.         0.
0    THE RATIO OF SUBSTRUCTURE / SUPERSTRUCTURE LOADING IS 0.810
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                 Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LIVE LOAD DIAGNOSTICS

0
0LIVE LOAD GENERATOR
0           NUMBER OF LIVE LOAD LANES          RESISTING MOMENT OF        PLOT   PLOT   INFLU-
 MEM     SUPERSTRUCTURE   SUBSTRUCTURE              UNIT STEEL            M   S SCALE   ENCE
  NO.   LT.END   RT.END   LT.END    RT.END     POSITIVE   NEGATIVE         ENV.         LINES  GEN
 --------------------------------------------------------------------------------------------------

   1      3.333  3.333    2.7       2.7           0.        0.            0      0      NO      NO
   2      3.333  3.333    2.7       2.7           0.        0.
   3      3.333  3.333    2.7       2.7           0.        0.
0 LIVE
  LOAD              ----- TRUCK OR TRAIN LOADING   -----                  OVER  RRL IMPACT COMB  CARD
  NO    P1   D1    P2   D2    P3   D3    P4   D4    P5   D5   P6    D6    LOAD                 CONTROL
  4.    27.0 14.0  25.0  4.0  25.0 12.0  25.0  4.0  25.0 35.0  21.7  4.0    8.       YES          01
0       P7   D7    P8   D8    P9   D9    P10  D10   P11  D11  P12   D12
        21.6  4.0  21.7  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0                          02
0       P13  D13   P14  D14   P15  D15   P16  D16   P17  D17  P18   D18
         0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0
0       P19  D19   P20  D20   P21  D21   P22  D22   P23  D23  P24   D24
         0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0
0       P25  D25   P26  D26   P27  D27   P28  D28   P29  D29  P30   D30
         0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0
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  IMPACT FACTORS CALCULATED BY PROGRAM
0       MEM       IMPACT
         NO         %



         1          29.
         2          21.
         3          29.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 4.                    NEGATIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.    -922.   -1844.   -2766.   -3688.   -4610.   -5532.   -6454.   -7376.   -8298.   -9220.
 SHEAR     0.0   -200.4   -200.4   -200.4   -200.4   -200.4   -200.4   -200.4   -200.4   -200.4   -200.4
0 2    -9220.   -4598.   -1320.    -578.    -422.    -266.    -422.    -578.   -1320.   -4598.   -9220.
 SHEAR   426.7    340.1    209.4     13.3     13.3     13.3    -13.3    -13.3   -209.4   -340.1   -426.7
0 3    -9220.   -8298.   -7376.   -6454.   -5532.   -4610.   -3688.   -2766.   -1844.    -922.       0.   ←
 SHEAR   200.4    200.4    200.4    200.4    200.4    200.4    200.4    200.4    200.4    200.4      0.0
0HORIZONTAL MEMBER STRESSES LL MAX NEG  BOTTOM FIBER
0 1        0.     358.     715.    1073.    1430.    1315.    1290.    1300.    1330.    1369.    1437.
0 2     1437.    1134.     512.     224.     164.     103.     164.     224.     512.    1134.    1437.
0 3     1437.    1369.    1330.    1300.    1290.    1315.    1430.    1073.     715.     358.       0.   ←
0HORIZONTAL MEMBER STRESSES LL MAX NEG  TOP FIBER
0 1        0.    -129.    -257.    -386.    -515.    -490.    -494.    -510.    -532.    -558.    -592.
0 2     -592.    -431.    -184.     -81.     -59.     -37.     -59.     -81.    -184.    -431.    -592.
0 3     -592.    -558.    -532.    -510.    -494.    -490.    -515.    -386.    -257.    -129.       0.   ←
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 4.                    DEAD LOAD PLUS NEGATIVE LIVE LOAD MOMENT ENVELOPE
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.   -1075.   -2298.   -3668.   -5185.   -6851.   -8671.  -10650.  -12795.  -15111.  -17605.
0 2   -17605.   -8549.   -1866.    1324.    2932.    3566.    2932.    1324.   -1866.   -8549.  -17605.
0 3   -17605.  -15111.  -12795.  -10650.   -8671.   -6851.   -5185.   -3668.   -2298.   -1075.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG BOTTOM FIBER
0 1        0.     417.     891.    1422.    2011.    1955.    2021.    2146.    2306.    2494.    2743.
0 2     2743.    2108.     724.    -513.   -1137.   -1383.   -1137.    -513.     724.    2108.    2743.
0 3     2743.    2494.    2306.    2146.    2021.    1955.    2011.    1422.     891.     417.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG  TOP FIBER
0 1        0.    -150.    -321.    -512.    -724.    -728.    -774.    -842.    -923.   -1015.   -1130.
0 2    -1130.    -801.    -260.     185.     409.     498.     409.     185.    -260.    -801.   -1130.
0 3    -1130.   -1015.    -923.    -842.    -774.    -728.    -724.    -512.    -321.    -150.       0.
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 4.                    POSITIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.    1337.    2176.    2719.    2836.    3000.    2712.    2148.    1350.     647.     515.
 SHEAR     0.0    290.7    175.7    120.6    102.6    -61.5   -176.4   -230.3   -212.9   -237.3     11.2
0 2      515.     359.    1075.    3279.    4856.    5266.    4856.    3279.    1075.     359.     515.   ←
 SHEAR   -13.3    -13.3    164.6    213.9    127.3    -57.1   -127.3   -213.9   -164.6     13.3     13.3
0 3      515.     647.    1350.    2148.    2712.    3000.    2836.    2719.    2176.    1337.       0.
 SHEAR   -11.2    237.3    212.9    230.3    176.4     61.5   -102.6   -120.6   -175.7   -290.7      0.0
0HORIZONTAL MEMBER STRESSES LL MAX POS  BOTTOM FIBER
0 1        0.    -519.    -844.   -1055.   -1100.    -856.    -632.    -433.    -243.    -107.     -80.
0 2      -80.     -89.    -417.   -1272.   -1883.   -2043.   -1883.   -1272.    -417.     -89.     -80.   ←
0 3      -80.    -107.    -243.    -433.    -632.    -856.   -1100.   -1055.    -844.    -519.       0.
0HORIZONTAL MEMBER STRESSES LL MAX POS  TOP FIBER
0 1        0.     187.     304.     379.     396.     319.     242.     170.      97.      43.      33.
0 2       33.      34.     150.     458.     678.     735.     678.     458.     150.      34.      33.
0 3       33.      43.      97.     170.     242.     319.     396.     379.     304.     187.       0.
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 4.                    DEAD LOAD PLUS POSITIVE LIVE LOAD MOMENT ENVELOPE
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1        0.    1184.    1723.    1817.    1339.     759.    -427.   -2048.   -4069.   -6165.   -7869.
0 2    -7869.   -3592.     528.    5181.    8210.    9098.    8210.    5181.     528.   -3592.   -7869.
0 3    -7869.   -6165.   -4069.   -2048.    -427.     759.    1339.    1817.    1723.    1184.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS BOTTOM FIBER
0 1        0.    -459.    -668.    -705.    -519.    -216.     100.     413.     733.    1017.    1226.
0 2     1226.     886.    -205.   -2009.   -3184.   -3529.   -3184.   -2009.    -205.     886.    1226.
0 3     1226.    1017.     733.     413.     100.    -216.    -519.    -705.    -668.    -459.       0.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS  TOP FIBER
0 1        0.     165.     240.     254.     187.      81.     -38.    -162.    -294.    -414.    -505.
0 2     -505.    -337.      74.     723.    1146.    1270.    1146.     723.      74.    -337.    -505.
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0 3      -505.    -414.    -294.    -162.     -38.      81.     187.     254.     240.     165.       0.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO.  4.                       LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   348.3    290.7    235.3    182.5    132.8     99.7     73.7     48.9     20.4     11.2     11.2
 MOM.        0.    1337.    2165.    2519.    2443.    2294.    2034.    1576.     946.     464.     515.
 NEG. V  -200.4   -200.4   -200.4   -200.4   -235.5   -282.8   -324.0   -358.9   -387.9   -429.0   -482.5
 MOM.        0.    -922.   -1844.   -2766.    -301.   -1185.   -2336.   -3660.   -5090.   -3376.   -5294.
 RANGE    548.8    491.2    435.7    383.0    368.2    382.6    397.7    407.8    408.3    440.2    493.7
0LL NO.  4.                       LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   543.3    462.5    381.1    308.8    227.8    142.6     77.4     38.3     13.3     13.3     13.3
 MOM.    -8208.   -3775.     253.    2783.    4426.    4939.    2813.    1772.     203.     359.     515.
 NEG. V   -13.3    -13.3    -13.3    -38.3    -77.4   -142.6   -227.8   -308.8   -381.1   -462.5   -543.3
 MOM.      515.     359.     203.    1772.    2813.    4939.    4426.    2783.     253.   -3775.   -8208.
 RANGE    556.6    475.9    394.5    347.0    305.2    285.2    305.2    347.0    394.5    475.9    556.6
0LL NO.  4.                       LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEMBER  3 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   482.5    429.0    387.9    358.9    324.0    282.8    235.5    200.4    200.4    200.4    200.4
 MOM.    -5294.   -3376.   -5090.   -3660.   -2336.   -1185.    -301.   -2766.   -1844.    -922.       0.
 NEG. V   -11.2    -11.2    -20.4    -48.9    -73.7    -99.7   -132.8   -182.5   -235.3   -290.7   -348.3
 MOM.      515.     464.     946.    1576.    2034.    2294.    2443.    2519.    2165.    1337.       0.
 RANGE    493.7    440.2    408.3    407.8    397.7    382.6    368.2    383.0    435.7    491.2    548.8
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0LL NO. 4.                    DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   331.1    241.4    153.9     69.1    -12.7    -78.5   -138.5   -198.6   -263.8   -311.0   -350.2
 NEG. V  -217.7   -249.7   -281.8   -313.9   -380.9   -461.0   -536.3   -606.4   -672.1   -751.2   -844.0
0LL NO. 4.                    DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   970.5    795.3    631.2    477.3    309.3    142.6     -4.1   -130.2   -236.7   -319.4   -413.9
 NEG. V   413.9    319.4    236.7    130.2      4.1   -142.6   -309.3   -477.3   -631.2   -795.3   -970.5
0LL NO. 4.                    DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0MEMBER  3 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   844.0    751.2    672.1    606.4    536.3    461.0    380.9    313.9    281.8    249.7    217.7
 NEG. V   350.2    311.0    263.8    198.6    138.5     78.5     12.7    -69.1   -153.9   -241.4   -331.1
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95

                        *** SPECIAL TRUCK WITH    8 AXLES WAS REQUESTED THIS LIVE LOAD ***
0LL NO. 4.                        LIVE LOAD SUPPORT RESULTS
0                           MAX.  AXIAL  LOAD                MAX. LONGITUDINAL MOMENT
                        AXIAL    ------MOMENT------         AXIAL   ------MOMENT------
                        LOAD       TOP        BOT.          LOAD      TOP        BOT.
0SUPPORT JT.  1
           POSITIVE     282.2         0.         0.          0.0         0.         0.
           NEGATIVE    -162.4         0.         0.          0.0         0.         0.
0MEMBER   4
           POSITIVE     611.8         0.         0.          0.0         0.         0.
           NEGATIVE     -19.9         0.         0.          0.0         0.         0.
0MEMBER   5
           POSITIVE     611.8         0.         0.          0.0         0.         0.
           NEGATIVE     -19.9         0.         0.          0.0         0.         0.
0SUPPORT JT.  4
           POSITIVE     282.2         0.         0.          0.0         0.         0.
           NEGATIVE    -162.4         0.         0.          0.0         0.         0.
0    THE RATIO OF SUBSTRUCTURE / SUPERSTRUCTURE LOADING IS 0.810
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0     PRESTRESS COMBINATION DATA

0     NO PRESTRESS COMBINATION DATA GIVEN SO DEFAULTS WERE USED.
0     LIVE LOAD NUMBER '1' RESULTS USED FOR P/S DESIGN AND OTHER LIVE LOADS, IF PRESENTED,
      ALSO WILL BE CHECKED TO DETERMINE THE ULTIMATE MOMENT CAPACITY.


0     THE FOLLOWING VALUES ARE BEING USED IN THE CALCULATION OF MOMENT & SHEAR REQUIREMENTS.
0        D.L. LOAD FACTOR: 1.30

         L.L. LOAD FACTOR: 2.17  OR  1.30

         PHI FACTOR FOR SHEAR : 0.90
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         PHI FACTOR FOR MOMENT: 0.95


0     LL NO. 1     ULTIMATE MOMENT APPLIED = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. MOMENT)
0     LL NO. 2     ULTIMATE MOMENT APPLIED = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. MOMENT)
0     LL NO. 4     ULTIMATE MOMENT APPLIED = 1.30 X (DL+ADL) + 1.30 X (LL+I) + 1.00 X (P/S SEC. MOMENT)
0     LL NO. 1     ULTIMATE SHEAR APPLIED  = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. SHEAR)
0     LL NO. 2     ULTIMATE SHEAR APPLIED  = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. SHEAR)
0     LL NO. 4     ULTIMATE SHEAR APPLIED  = 1.30 X (DL+ADL) + 1.30 X (LL+I) + 1.00 X (P/S SEC. SHEAR)
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0INPUT PRESTRESSED DATA
0TRIAL  1    FRAME 1    PATH 01
0      MEM
       NO.      LLT/X     LLP/Y   LRT/Z       YLT/TYPE   YLP/SLOPE  YRT       U        K
0        1      0.00      0.50     0.25       1.10       1.10       1.00       0.25   0.0002
0        2      0.20      0.50     0.20       1.00       3.17       1.00       0.25   0.0002
0        3      0.25      0.50     0.00       1.00       1.10       1.10       0.25   0.0002

0XLT(FT) =   0.0  XRT(FT) =   0.0  STEEL STRESS(KSI) = 270.  JACKING % = 0.75  JACKING ENDS = B
0ANCHOR SET(IN); LEFT = 0.625  RIGHT = 0.625  CONC. STRENGTH(PSI) = 4500.  ALLOW. TENSION(PSI) = -402.
0P-JACK(KIPS) =   6865.   SHORTENING PERCENT=  50   TOTAL LOSSES(KSI) = 38   RELATIVE HUMIDITY % = 60.
0LOW-LAX = NO    PLOT PATHS = NO    PLOT STRESSES = NO


0CABLE PATH OFFSETS
0MEMBER  LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1      1.10     1.10     1.10     1.10     1.10     1.10     1.09     1.07     1.03     1.01     1.00
0 2      1.00     1.22     1.87     2.59     3.03     3.17     3.03     2.59     1.87     1.22     1.00
0 3      1.00     1.01     1.03     1.07     1.09     1.10     1.10     1.10     1.10     1.10     1.10
0CABLE PATH ECCENTRICITIES
0  1    0.094    0.094    0.094    0.094    0.094   -0.034   -0.171   -0.324   -0.489   -0.642   -0.751
0  2   -0.751   -0.006    0.862    1.586    2.020    2.164    2.020    1.586    0.862   -0.006   -0.751
0  3   -0.751   -0.642   -0.489   -0.324   -0.171   -0.034    0.094    0.094    0.094    0.094    0.094
0FORCE COEFFICIENTS
0  1    0.697    0.698    0.699    0.700    0.701    0.702    0.704    0.705    0.707    0.709    0.710
0  2    0.710    0.721    0.732    0.739    0.747    0.754    0.747    0.739    0.732    0.721    0.710
0  3    0.710    0.709    0.707    0.705    0.704    0.702    0.701    0.700    0.699    0.698    0.697
0THE POINT OF NO MOVEMENT FOR PRESTRESSING IS IN SPAN 2,  58.50 FEET FROM THE LEFT END OF THE SPAN
0THE LEFT ANCHOR SET LENGTH IS 103.99                      THE RIGHT ANCHOR SET LENGTH IS 103.99
0THE FORCE COEF. AT THE LEFT END IS  0.697                 THE FORCE COEF. AT THE RIGHT END IS  0.697

0INITAL FORCE COEFF. AT POINT OF NO MOVEMENT = 0.942
0 ***** CONSIDER ONE END JACKING AS TWO END JACKING IS NOT VERY ECONOMICAL IN THIS PROBLEM. *****
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0SECONDARY MOMENT DUE TO PJACK = 1
0TRIAL  1    FRAME 1    PATH 01
                                  FEM'S DUE TO SECONDARY EFFECTS BEFORE BALANCING

   MEMBER    LEFT END   RIGHT END  MEMBER      LEFT END  RIGHT END   MEMBER    LEFT END   RIGHT END
0     1       0.000     -0.231       2          0.951      0.951     3         -0.231      0.000
0                                 DEM'S DUE TO SECONDARY EFFECTS --- UNIT = K-FT
0     1       0.000      0.813       2          0.813      0.813     3          0.813      0.000       ←
0                                 DEM'S DUE TO SECONDARY EFFECTS IN COLUMN --- UNIT = K-FT
0     4       0.000      0.000       5          0.000      0.000
0P/S MOMENT COEF.
                             *** FRAME DOES NOT SWAY WITH THIS LOADING. ***
                            ADJUSTED FOR LOSSES & SECONDARY MOMENTS BUT NO SHORTENING
 MEM
  NO     LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1  -0.0659   0.0153   0.0965   0.1778   0.2590   0.4307   0.6084   0.7979   0.9963   1.1868   1.3466
0 2   1.3466   0.8172   0.1818  -0.3589  -0.6960  -0.8201  -0.6960  -0.3589   0.1818   0.8172   1.3466
0 3   1.3466   1.1868   0.9963   0.7979   0.6084   0.4307   0.2590   0.1778   0.0965   0.0153  -0.0659
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0FEMS      DELTAS IN COLUMNS DUE TO SHORTENING - PJACK=1
0TRIAL = 1  FRAME =1  PATH =01
0                  MEM          FEM              FEM              DELTA TOP OF COL.
                    NO       LT. END          RT. END          (POSITIVE TO RIGHT) --- UNIT = FT
0                   4       -0.01509158        0.00000000               0.00000161
0                   5        0.01509158        0.00000000              -0.00000161
0***** POINT OF NO MOVEMENT FOR STRUCTURE SHORTENING IS,  58.5 FEET FROM THE LEFT END OF SPAN   2    *****

 ***** INFORMATION PROVIDED ABOVE ALSO CAN BE USED AS AN AID TO DETERMINE THE MOVEMENT RATING "MR".  *****
0P/S MOMENT COEF.
                            ADJUSTED FOR LOSSES & SECONDARY MOMENTS & SHORTENING
 MEM
  NO     LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1  -0.0659   0.0153   0.0965   0.1778   0.2590   0.4307   0.6084   0.7979   0.9963   1.1868   1.3466
0 2   1.3466   0.8172   0.1818  -0.3589  -0.6960  -0.8201  -0.6960  -0.3589   0.1818   0.8172   1.3466
0 3   1.3466   1.1868   0.9963   0.7979   0.6084   0.4307   0.2590   0.1778   0.0965   0.0153  -0.0659
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                               Run time: 07-JUL-95
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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0FEMS      DELTAS IN COLUMNS DUE TO SHORTENING - PJACK=1
0TRIAL = 1  FRAME =1  PATH =01
0                  MEM          FEM               FEM                DELTA TOP OF COL.
                    NO        LT. END           RT. END           (POSITIVE TO RIGHT) --- UNIT = FT
0                    4       -0.01509158          0.00000000              0.00000161
0                    5        0.01509158          0.00000000             -0.00000161
0***** POINT OF NO MOVEMENT FOR STRUCTURE SHORTENING IS,  58.5 FEET FROM THE LEFT END OF SPAN   2    *****

 ***** INFORMATION PROVIDED ABOVE ALSO CAN BE USED AS AN AID TO DETERMINE THE MOVEMENT RATING "MR".  *****
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

16:13:53  Page   41
                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL  1  FRAME 1  PATH 01
0HORIZONTAL MEMBER STRESSES PRESTRESS ONLY BOTTOM FIBER AFTER ALL LOSSES (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1     891.      676.     460.     245.      30.    -152.    -306.    -459.    -610.    -741.    -851.
0 2    -851.     -692.     267.    1714.    2620.    2958.    2620.    1714.     267.    -692.    -851.
0 3    -851.     -741.    -610.    -459.    -306.    -152.      30.     245.     460.     676.     891.
0HORIZONTAL MEMBER STRESSES PRESTRESS ONLY TOP FIBER AFTER ALL LOSSES (PS1)
0 1     652.      731.     810.     889.     967.    1006.    1040.    1077.    1117.    1151.    1183.
0 2    1183.     1217.     925.     414.     100.     -12.     100.     414.     925.    1217.    1183.
0 3    1183.     1151.    1117.    1077.    1040.    1006.     967.     889.     810.     731.     652.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL  1    FRAME 1    PATH 01
0HORIZONTAL MEMBER MOMENTS DUE TO P/S
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    -452.     105.     663.    1220.    1778.    2957.    4177.    5477.    6839.    8147.    9245.
0 2    9245.    5610.    1248.   -2464.   -4778.   -5630.   -4778.   -2464.    1248.    5610.    9245.
0 3    9245.    8147.    6839.    5477.    4177.    2957.    1778.    1220.     663.     105.    -452.
0VERTICAL MEMBER MOMENTS DUE TO P/S
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 4    -104.     -93.     -83.     -73.     -62.     -52.     -41.     -31.     -21.     -10.       0.
0 5     104.      93.      83.      73.      62.      52.      41.      31.      21.      10.       0.
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END     SPAN    LT. END     RT. END     SPAN   LT. END     RT. END
0     1     0.000926   -0.001692      2    -0.001692    0.001692      3     0.001692   -0.000926
0     4    -0.000277    0.000138      5     0.000277   -0.000138
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
0     MEMBER  1    E= 3865.     0.000     0.011     0.017     0.014     0.000
0     MEMBER  2    E= 3865.     0.000    -0.092    -0.165    -0.092     0.000
0     MEMBER  3    E= 3865.     0.000     0.014     0.017     0.011     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  4    E= 3250.     0.000    -0.001    -0.001    -0.001     0.000
0     MEMBER  5    E= 3250.     0.000     0.001     0.001     0.001     0.000
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS BEFORE LOSSES BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    1131.      861.     591.     321.      51.    -180.    -376.    -570.    -760.    -926.   -1065.
0 2   -1065.     -860.     345.    2154.    3277.    3687.    3277.    2154.     345.    -860.   -1065.
0 3   -1065.     -926.    -760.    -570.    -376.    -180.      51.     321.     591.     861.    1131.
0HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS BEFORE LOSSES TOP FIBER (PSI)
0 1     828.      926.    1025.    1123.    1221.    1270.    1313.    1360.    1409.    1452.    1491.
0 2    1491.     1530.    1159.     518.     125.     -12.     125.     518.    1159.    1530.    1491.
0 3    1491.     1452.    1409.    1360.    1313.    1270.    1221.    1123.    1025.     926.     828.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS AFTER ALL LOSSES BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1     891.      676.     460.     245.      30.    -152.    -306.    -459.    -610.    -741.    -851.
0 2    -851.     -692.     267.    1714.    2620.    2958.    2620.    1714.     267.    -692.    -851.
0 3    -851.     -741.    -610.    -459.    -306.    -152.      30.     245.     460.     676.     891.
0 HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS AFTER ALL LOSSES TOP FIBER (PSI)
0 1     652.      731.     810.     889.     967.    1006.    1040.    1077.    1117.    1151.    1183.
0 2    1183.     1217.     925.     414.     100.     -12.     100.     414.     925.    1217.    1183.
0 3    1183.     1151.    1117.    1077.    1040.    1006.     967.     889.     810.     731.     652.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES  DL + P/S BEFORE ALL LOSSESBOTTOM FIBER (PSI)
```

```
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    1131.     920.     767.     671.     632.     459.     355.     275.     216.     198.     241.
0 2     241.     115.     557.    1416.    1976.    2201.    1976.    1416.     557.     115.     241.
0 3     241.     198.     216.     275.     355.     459.     632.     671.     767.     920.    1131.
0HORIZONTAL MEMBER STRESSES  DL + P/S BEFORE ALL LOSSESTOP FIBER (PSI)
0 1     828.     905.     961.     997.    1012.    1032.    1033.    1028.    1018.     994.     953.
0 2     953.    1159.    1082.     783.     593.     523.     593.     783.    1082.    1159.     953.
0 3     953.     994.    1018.    1028.    1033.    1032.    1012.     997.     961.     905.     828.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES  DL + P/S AFTER ALL LOSSES BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1     891.     735.     636.     595.     610.     488.     425.     386.     367.     383.     455.
0 2     455.     283.     479.     976.    1319.    1472.    1319.     976.     479.     283.     455.
0 3     455.     383.     367.     386.     425.     488.     610.     595.     636.     735.     891.
0HORIZONTAL MEMBER STRESSES  DL + P/S AFTER ALL LOSSES TOP FIBER (PSI)
0 1     652.     710.     747.     763.     758.     768.     760.     746.     726.     693.     645.
0 2     645.     847.     849.     680.     568.     523.     568.     680.     849.     847.     645.
0 3     645.     693.     726.     746.     760.     768.     758.     763.     747.     710.     652.
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + P/S AFTER ALL LOSSES BOTTOM FIBER (PSI)
0 1     891.     758.     704.     730.     835.     735.     708.     712.     741.     811.     949.
0 2     949.     653.     558.     696.     823.     904.     823.     696.     558.     653.     949. ←
0 3     949.     811.     741.     712.     708.     735.     835.     730.     704.     758.     891.
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + P/S AFTER ALL LOSSES TOP FIBER (PSI)
0 1     652.     702.     722.     714.     678.     676.     652.     618.     576.     519.     441.
0 2     441.     706.     820.     781.     746.     727.     746.     781.     820.     706.     441. ←
0 3     441.     519.     576.     618.     652.     676.     677.     714.     722.     702.     652.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX POS LL + I + P/S  BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1     891.     394.      95.     -14.      28.     156.     255.     383.     531.     732.     895.
0 2     895.     568.     131.    -146.    -334.    -351.    -334.    -146.     131.     568.     895.
0 3     895.     732.     531.     383.     255.     156.      28.     -14.      95.     394.     891.
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX POS LL + I + P/S  TOP FIBER (PSI)
0 1     652.     833.     941.     982.     968.     892.     825.     747.     660.     551.     463.
0 2     463.     739.     974.    1084.    1163.    1179.    1163.    1084.     974.     739.     463.
0 3     463.     551.     660.     747.     825.     892.     968.     982.     941.     833.     652.
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX NEG LL + I + P/S  BOTTOM FIBER (PSI)
0 1     891.     941.    1070.    1279.    1567.    1408.    1368.    1377.    1422.    1512.    1684.
0 2    1684.    1273.     910.     847.     933.     991.     933.     847.     910.    1273.    1684.
0 3    1684.    1512.    1422.    1377.    1368.    1408.    1567.    1279.    1070.     941.     891.
0HORIZONTAL MEMBER STRESSES  DL + ADDED DL + MAX NEG LL+ I + P/S  FOR TOP FIBER (PSI)
0 1     652.     636.     590.     517.     414.     425.     399.     357.     304.     234.     138.
0 2     138.     471.     694.     726.     707.     696.     707.     726.     694.     471.     138.
0 3     138.     234.     304.     357.     399.     425.     414.     517.     590.     636.     652.


0**** MIN PJACK =    6870. KIPS CONC STRENGTH AT 28 DAYS =   4210. PSI AT STRESSING =   4001. PSI  ****

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TOTAL PE MOMENTS FOR ALL MEMBERS.
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    -452.     105.     663.    1220.    1778.    2957.    4177.    5477.    6839.    8147.    9245.
0 2    9245.    5610.    1248.   -2464.   -4778.   -5630.   -4778.   -2464.    1248.    5610.    9245.
0 3    9245.    8147.    6839.    5477.    4177.    2957.    1778.    1220.     663.     105.    -452.
0 4    -104.     -93.     -83.     -73.     -62.     -52.     -41.     -31.     -21.     -10.       0.
0 5     104.      93.      83.      73.      62.      52.      41.      31.      21.      10.       0.
0TOTAL P/S DEFLECTION FOR TRIAL
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END      SPAN    LT. END      RT. END      SPAN   LT. END     RT. END
0     1    0.000926    -0.001692       2    -0.001692    0.001692       3     0.001692   -0.000926
0     4   -0.000277    0.000138        5     0.000277   -0.000138
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
0     MEMBER  1    E= 3865.     0.000     0.011     0.017     0.014     0.000
0     MEMBER  2    E= 3865.     0.000    -0.092    -0.165    -0.092     0.000
0     MEMBER  3    E= 3865.     0.000     0.014     0.017     0.011     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  4    E= 3250.     0.000    -0.001    -0.001    -0.001     0.000
0     MEMBER  5    E= 3250.     0.000     0.001     0.001     0.001     0.000
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                          Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0TOTAL TOP PF FOR TRIAL
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
```

```
0 1       0.       0.       0.       0.       0.    4819.    4830.    4843.    4853.    4865.    4878.
0 2    4878.    4947.       0.       0.       0.       0.       0.       0.       0.    4947.    4878.
0 3    4878.    4865.    4853.    4843.    4830.    4819.       0.       0.       0.       0.       0.
0TOTAL BOTTOM PF FOR TRIAL
0 1    4787.    4794.    4800.    4806.    4813.       0.       0.       0.       0.       0.       0.
0 2       0.       0.    5025.    5073.    5129.    5180.    5129.    5073.    5025.       0.       0.
0 3       0.       0.       0.       0.       0.       0.    4813.    4806.    4800.    4794.    4787.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0                                                    LONG TERM LOSSES
                                    TOTAL LOSS (KSI) = SH + ES + CRC + CRS
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0   1   32.8      32.8     32.8     32.9     33.0     32.6     32.5     32.3     32.2     32.0     31.7
0   2   31.7      33.7     35.8     40.8     45.8     48.4     45.8     40.8     35.8     33.7     31.7
0   3   31.7      32.0     32.2     32.3     32.5     32.6     33.0     32.9     32.8     32.8     32.8
0                                            SHEAR DESIGN - AASHTO 1980
0              LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 MEMBER:  1
0V-CABLE        0.       0.       0.       0.       0.       1.      17.      34.      34.      17.       2.
 SECONDARY    121.     121.     121.     121.     121.     121.     121.     121.     121.     121.     121.
 VU           608.     475.     345.     344.     447.     568.     682.     789.     891.    1010.    1146.
 VC           984.     698.     950.     857.     734.     817.     862.     892.     915.     932.     937.
 REQD WEB      60.      60.      60.      60.      60.      60.      60.      60.      60.      60.      60.
 AS(IN)/FT    0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.69     1.17

 MEMBER:  2
0V-CABLE       23.     183.     352.     251.     127.       0.     127.     251.     352.     183.      11.
 SECONDARY      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
 VU          1468.    1199.     947.     721.     480.     244.     480.     721.     947.    1199.    1468.
 VC          1337.    1315.     976.     549.     354.     250.     354.     549.     976.    1315.    1337.
 REQD WEB      60.      60.      60.      60.      60.      60.      60.      60.      60.      60.      60.
 AS(IN)/FT    1.02     0.60 *   0.60 *   1.39     0.98     0.60 *   0.98     1.39     0.60 *   0.60 *   1.02

 MEMBER:  3
0V-CABLE        2.      17.      34.      34.      17.       1.       0.       0.       0.       0.       0.
 SECONDARY   -121.    -121.    -121.    -121.    -121.    -121.    -121.    -121.    -121.    -121.    -121.
 VU          1146.    1010.     891.     789.     682.     568.     447.     344.     345.     475.     608.
 VC           937.     932.     915.     892.     862.     817.     734.     857.     950.     698.     984.
 REQD WEB      60.      60.      60.      60.      60.      60.      60.      60.      60.      60.      60.
 AS(IN)/FT    1.17     0.69     0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *   0.60 *

0NOTE:  * AFTER REQD WEB INDICATES ADDITIONAL WEB WIDTH REQD.   * AFTER AS(IN)/FT INDICATES MINIMUM REQD.
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95

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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
                                     AASHTO ULTIMATE MOMENT
0           SECOND   ULT MOM    ULT MOM  AVERAGE   NEUTRAL   MILD STEEL   COMBINED       ULT MOM    ULT MOM
            MOMENT    APPLD     P/S CAP    FSU      AXIS       REQD     REINFORCEMENT   MILD CAP  TOTAL CAP
            (K-FT)   (K-FT)     (K-FT)    (KSI)     (IN)      (SQ.IN)      INDEX          (K-FT)    (K-FT)
0          ***** ULTIMATE MOMENT NOT CALCULATED BECAUSE USER DID NOT USE SUPERSTRUCTURE SECTIONS
                 OR USER DID NOT USE '250' DATA CARD
0                                                    TENDON ELONGATION
0   PATH NO.       P-JACK      % JACK      FY        AS       AVE STRESS     TENDON LENGTH    ELONGATION
                   (KIPS)                (KSI)     (SQ IN)      (KSI)           (FT) *           (IN)
0    01             6870.        75.      270.     33.93       199.39          213.00           18.20
0NOTE: TENDON LENGTH INCLUDES 4 FEET FOR JACKS.
0      MODULUS USED FOR P/S STEEL IS 28000. KSI
1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT                                Run time: 07-JUL-95


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                       Structure E-16-IN ; CSGCP ; SH-76 ; Proj#I-761(84) ;M.MOHSENI 2/95
0                                              'APPROXIMATE QUANTITY'
                                               ====================
0                              *****  CONCRETE SUPER           397 C.Y.  *****

                               *****  CONCRETE SUB              23 C.Y.  *****
0                              *****  P/S TRIAL              24090 LBS.  *****
0                   THE SUPERSTRUCTURE CONCRETE QUANTITY IS BASED ON THE UNIT
                    WEIGHT OF CONCRETE SUPPLIED ON THE FRAME DESCRIPTION CARD.
                    IT ASSUMES THAT ALL THE DEAD LOAD IS GIVEN IN TRIAL 0.

                    THE CONCRETE SUBSTRUCTURE QUANTITY IS BASED ON TRIAL 0 ONLY.

                    THE P/S QUANTITIES FOR STRAND ONLY ARE FOR EACH TRIAL, THAT
                    WAS ENTERED AND IN THAT ORDER.  STRAND USE IS BASED ON THE
                    LENGTH FROM ANCHOR TO ANCHOR.
1END OF JOB - 022086
0                 INCREMENTED CPU TIME (SECONDS)=      1.
                  INCREMENTED CLOCK TIME (SECONDS)=    8.
```

9B-5b CBGCP EXAMPLE

This is a 2 span Concrete Box Girder Continuous Post-Tensioned structure. It consists of two horizontal members and three vertical members. Members have left and right end joint associated with them and are connected together by specifying the appropriate joint numbers. BDS or the new version of California Frame program is used to model the structure.

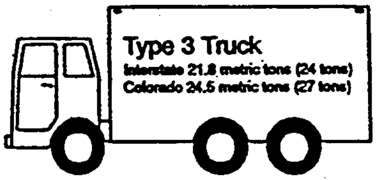
COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

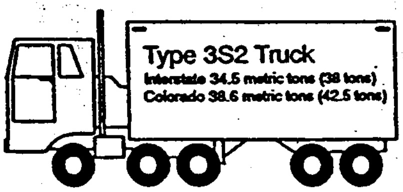
Rated using
Asphalt thickness: 50 mm (2.0 in.)
☒ Colorado legal loads
☐ Interstate legal loads

Structure # G-04-AL
State highway # 70
Batch I.D. C81009
Structure type CBGCP
Parallel structure # ____

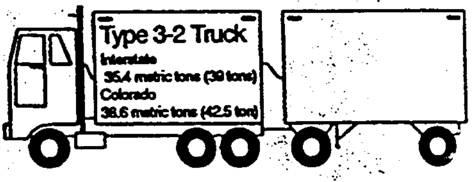
Structural member	GIRDER	SLAB		
	Metric tons (Tons)			
Inventory	34.0 (37.4)	30.36 (33.42)	( )	( )
Operating	60.9 (67.1)	50.6 (55.71)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	148.9 (164.0)	( )	( )	( )



____ (____)
Metric tons Tons



____ (____)
Metric tons Tons



____ (____)
Metric tons Tons

Comments

PROJ I 70-1(75)57

Designated color for overload map: WHITE

Rated by Rater's Signature	Date Date	Checked by checker's Signature	Date Date.

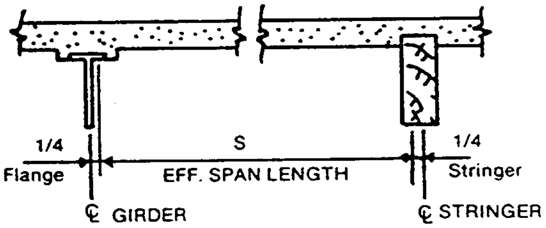
Previous editions are obsolete and may not be used

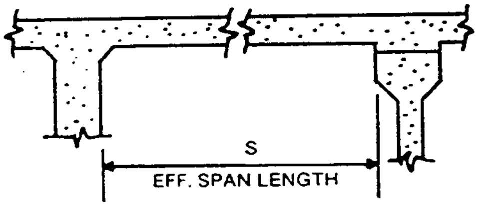
CDOT Form #1187 1/95

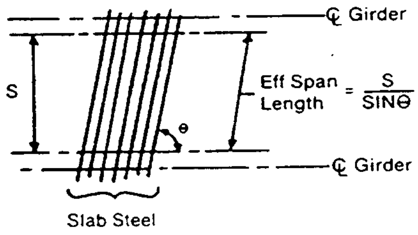
DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form 709
July, 1985

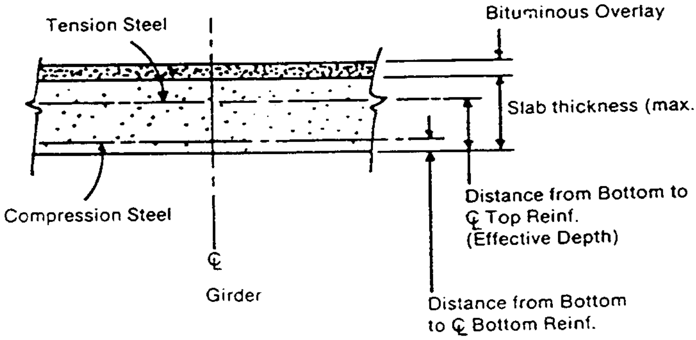
CONCRETE SLAB RATING

DESCRIPTION	INPUT	UNITS	CARD IMAGE COLS.
LOAD TYPE: 1 = Colo. Trucks 2 = Interstate	1		1
STRUCTURE NUMBER:	G-04-AL	-	2 - 8
RATER:	M.M.		9 - 11
HIGHWAY NUMBER:	70		12 - 14
BATCH I.D.:	C81009		15 - 20
COMMENTS:			21 - 41
EFFECTIVE SPAN LENGTH:	7.500	FEET	42 - 46
ACTUAL SLAB THICKNESS:	8.250	INCHES	47 - 51
EFFECTIVE DEPTH:	5.438	INCHES	52 - 56
TOP STEEL AREA:	0.74	In2/Ft	57 - 59
ASPHALT OVERLAY:	3.50	INCHES	60 - 63
INV Fc (f'c load factor):	3000	P.S.I.	64 - 67
INV Fs (Fy load factor):	40000	P.S.I.	68 - 72
INV MODULAR RATIO: (load factor method: leave blank)		Es/Ec	73 - 74
DEPTH TO BOTT. REIN.:	1.31	INCHES	75 - 77
BOTT. STEEL AREA:	0.74	In2/Ft	78 - 80









```
                    SLAB RATING Version 1.0
                      DATE: 95/03/06

   STRUCTURE NO. G-04-AL     RATER: MM      STATE HWY NO. = 70
   BATCH ID= C81009  DESCRIPTION:   RATING
LOAD FACTOR RATING-COMP STEEL NOT USED---LOAD FACTOR RATING-COMP STEEL NOT USED

                   INPUT DATA
                   ----- ----
   EFF. SPAN(FT)=  7.500      EFF. DEPTH(INS)=  5.438
   REINF.(SQ.IN)=   .74
   SLAB TK(IN)=  8.250        WEARING SURFACE(IN)=  3.50
   CONC. STRENGTH(PSI)  INV=  3000.     OPER=  3000.
   STEEL  YIELD  (PSI)  INV= 40000.     OPER= 40000.
   N=   9.
   D1= 1.31               AS1=  .74

   DEAD LOAD MOMENT        .82 K-FT
   LL+I MOMENT            4.94 K-FT
   GROSS WEIGHT           36.0 TONS

                     INVENTORY    OPERATING
   ACTUAL CONCRETE STRESS    (PSI)    1000.54       1566.78
   ACTUAL REINF. STEEL STRESS (PSI)   18721.07      29316.04
   ACTUAL COMP. STEEL STRESS  (PSI)    4651.52       7283.99
   MEMBER CAPACITY           (K-FT)     11.00         11.00
   MEMBER CAPACITY (LL+I)    (K-FT)      9.94          9.94

   RATING                 (TONS)      33.42         55.71
```

Rater's Signature
& Date.

Checker's Signature
& Date

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

INFORMATION FOR RATING From Advanced plans:

Live Load distribution. factor $= \frac{\text{Width}}{7.0} = \frac{34.5}{7} = 4.9286$ wheel lines

Dead Loads

Asphalt	$2''/12 * 32' * 144^{\#}$	$= 768$ PLF (From Design plans)
curbs	$8/12 * 1.25' * 150^{\#} * 2$	$= 250$
Rail	$61.12^{\#} * 2$	$= 122$
		1140 PLF

Diaphragms (intermediate)

$(4'\text{-}8'' - (8\tfrac{1}{4}'' + 4'')) \div 2 = 1.8229'$ $\frac{3}{12} = \frac{x}{21.875''}$ $x = 5.5'' = .4557'$

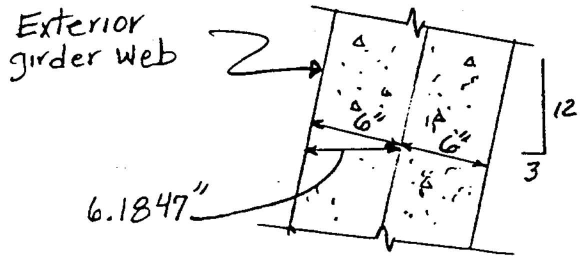
$[8'\text{-}6'' - (6.1847'' + 6'' + 5.5)] * 2 + (8'\text{-}6'' - 1\text{-}0'') = 21.5526'$

$21.5526' * 3.5' * 8/12 = 50.29 \text{ ft}^3.$

fillets $= (7.5' * 4) + (3.5' * 6) + (6.5' * 2) = 64' * (\frac{1}{2} * \frac{3'' * 3''}{144}) = 2.0 \text{ ft}^3/\text{side}$
$* 2$ sides

Weight $= 54.29 * 150 = 8143.5$ lbs. USE 8.14 Kips

Formwork - $7^{\#}/\text{ft}^2 * 8.5' * 3 = 178.5$ PLF $= 0.179$ KLF



COLORADO DEPARTMENT OF TRANSPORTATION Sheet 1 of 9

By: MM Date 3/95 REV.	Project No. I70-1(75)57	C81009
Chk'd: Date	Structure No. G-04-AL REV. LFD	From TCF NOTES 5-81

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

FRAME DESCRIPTION:

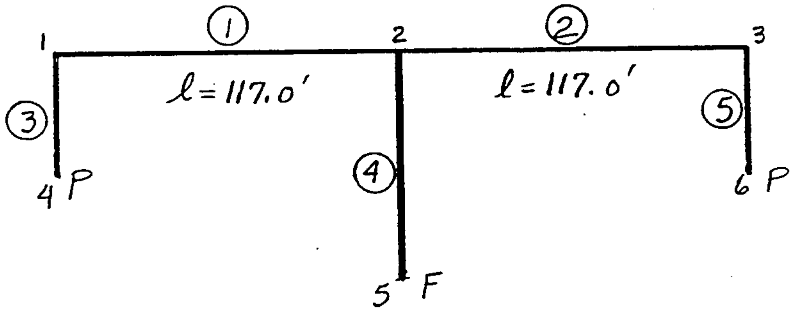
BDS (calframe) IS RUN with abutments coded as vertical members.

Elev. Leftout Abut. 1 back face	4907.6743	9.4743'	use 9.5'
Elev. Bottom of Abut.	4898.2		
Leftout Abut. 3 back face	4908.1448	9.5448'	
Elev. Buttom of Abut.	4898.6		

$y_b = 2.77'$ (From design notes, section property calcs)

$4.6667' - 2.77 = 1.8967'$

$9.5 - (1.8967' + 0.5') = 7.10'$



$I = 34.0(2.5)^3/12 = 44.3\ ft^4$

Live Load input

Live Load lanes $= 34.5'/(7*2) = 2.4643$

COLORADO DEPARTMENT OF TRANSPORTATION		Sheet 2 of 9
By: MM Date REV. 3-95	Project No. I 70-1 (75) 57	C81009
Chk'd: Date	Structure No. G-04-AL REV. LFD	From TCF NOTES 5-81

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION
DESIGN COMPUTATIONS

Frame Description (cont.)

Member 4 length:

Bottom of footing elev.	78.0
- footing depth	2.0
	80.0

Top of column elev. $(0.76 + 0.41)/2 + 103.0 =$ 103.585

Assumed 2.0' for y_b

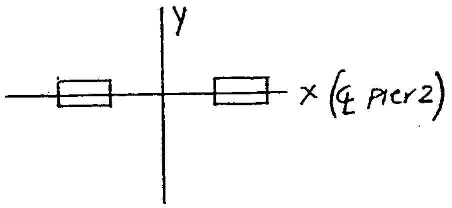
$$\begin{array}{r} 103.585 \\ +\ 2.0 \\ \hline 105.585 \\ -\ 80.0 \\ \hline 25.585' \end{array}$$

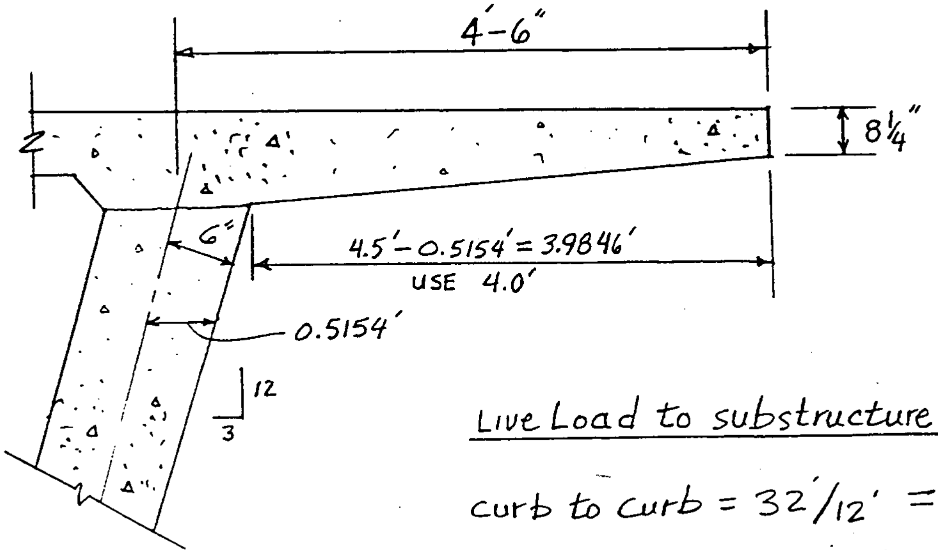
$E = 150^{1.5} \cdot 33\sqrt{4500} = 4066$ KSI SUPERSTRUCTURE.

$E = 150^{1.5}\, 33\sqrt{3000} = 3320$ KSI PIER WALLS (SUBSTRUCTURE)

I_x (PIER WALL)

$4.05 * 2^3/12 * 2 = 5.4\ ft^4$





Live Load to substructure:

curb to curb = 32'/12' = 2.6 use 2 lanes.

2 lanes/2 columns = 1 lane/column

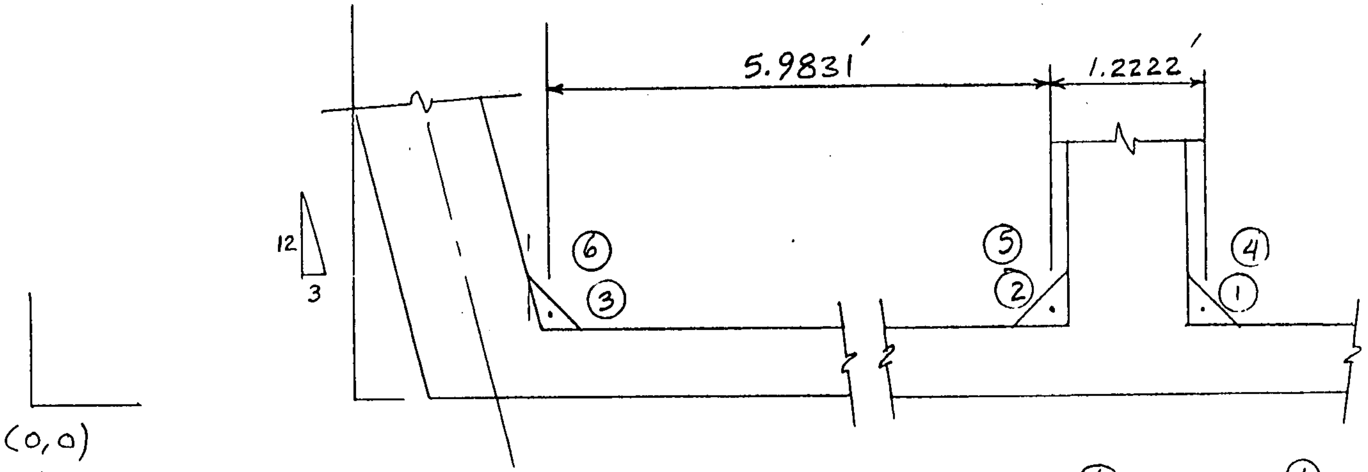
	COLORADO DEPARTMENT OF TRANSPORTATION	Sheet 3 of 9
By: MM Date 3/95 REV.	Project No. I70-1(75)57	C81009
Chk'd: Date	Structure No. G-04-AL REV. LFD	FROM TCF NOTES 5-81

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

Code fillets @ bottom slab: (only coded when requiring more accuracy!)



$\underline{X}$ $34.5/2 = \pm(4.25' - 0.5') = 17.25' \pm 3.75 = \overset{④}{21.0'}$ & $\overset{①}{13.5'}$

$21.0 \quad +1.0\cancel{3} \simeq 22.0'$ ⑤

$13.5 \quad -1.0\cancel{3} \simeq 12.5'$ ②

$4.6667' - [(8\tfrac{1}{4}'' + 4'') + (5\tfrac{3}{4}'')] = 4.6667 - 1.5 = 3.1667'$

$3/12 = x/3.1667 \quad x = 0.7917'$

$\alpha = \tan^{-1} 3/12 \; ; \quad 1'/\cos\alpha = 1.0308' + \overbrace{0.7917}^{x} = 1.8224'$

$8.5 - (1.8224' + 1.0/2) = 6.1776'$

$12.5' - 6.1776' = 6.3224'$ ③

$22.0' + 6.1776' = 28.1776'$ ⑥

$\underline{Y} = 5\tfrac{3}{4}'' = 0.4792'$

COLORADO DEPARTMENT OF TRANSPORTATION Sheet 4 of 9

By: Date 3/95 REV. | Project No. I70-1 (75) 57 | C81009

Chk'd: Date | Structure No. G-04-AL REV. LFD | From TCF NOTES 5-81

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION
DESIGN COMPUTATIONS

INVENTORY RATING

@ 1.0 or 3.0 point:

Bottom Fiber (PSI)			Top Fiber (PSI)
577		DL + ADDED DL + P/S	456
$6\sqrt{f'_c} = 6\sqrt{4500} = -402$		F_b CAP.	$1{,}800 = 0.4(4500)$
$-402 - 577 = -979$		f_b LL CAP	$1344 = 1800 - 456$
-87	$M(+)$	f_b LL (+)	59
11.25		f_b cap. LL / f_b LL	22.8
405.1		* 36 tons	820

$0.4(4500) = 1{,}800$		F_b cap	$-402 = 6\sqrt{4500}$
$1{,}800 - 577 = 1{,}223$		f_b LL cap	$-858 = -402 - 456$
381	$M(-)$	f_b LL (−)	-261
3.21		f_b CAP / f_{LL}	3.29
115.6		* 36 tons	118.3

* Based on the relation of prestress force to stress in the concrete it will not be necessary to rate the 1.0 or 3.0 points for operating capacity.

COLORADO DEPARTMENT OF TRANSPORTATION		Sheet 5 of 9
By: MM Date 2-95	Project No. I 70-1(75)57	C81009
Chk'd: Date	Structure No. G-04-AL	REV. LFD.

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

1.5 or 2.5 POINT INVENTORY RATING:

Bottom Fiber (psi)			Top Fiber (psi)
361		DL + ADDED DL + P/S	655
-402		F_b CAP	1,800
-763		f_b LL CAP	1,145
-380	M(+)	f_b LL (+)	260
2.0		f_b CAP LL / f_b LL	4.4
72.0		* 36 Tons	158.5
1,800		F_b CAP	-402
1,439		f_b LL cap	-1,057
66	M(-)	f_b LL (-)	-45
21.8		f_b cap LL / f_b LL	23.49
—		* 36	—

2.0 POINT INV. RATING

	Bottom Fiber			Top Fiber
	1,189		DL + DLC + P/S	-102
$0.4 f'_c$ =	1800		F_b CAP	-402 $6\sqrt{f'_c}$
1800-1189 =	701		f_b LL CAP	-300 = -402-102
	421	M(-)	f_b LL (-)	-289
	1.66		f_b LL CAP / F_b LL	1.038
	59.9		* 36 tons	$\boxed{37.4}$ ← CONTROLS

COLORADO DEPARTMENT OF TRANSPORTATION Sheet 6 of 9

By: MM Date 2/95	Project No. I 70 -1(75) 57	C81009
Chk'd: Date	Structure No. G-04-AL	

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION
DESIGN COMPUTATIONS

OPERATING RATING & INVENTORY RATING

Rating @ 1.5 or 2.5 Point:

Values from Calframe (BDS) output:

Horizontal member moment (trial 0) = 5,230 K-ft

Horizontal member moment (trial 1) = 735 K-ft

Positive live load + Impact moment = 3,092 K-ft

- Average stress in prestressing steel, F^{*}_{su} = 262.26 Ksi (at ultimate Load)
- ultimate moment P/S capacity, M_n = 24,316 K-ft
- Secondary moment due to P/S, M_S = 3,725 K-ft

Rating

$$OPR = \frac{0.95\ M_n - 1.3\ (M_{DL} + M_{DLC}) - 1.0\ M_S}{1.3\ M_{LL+I}} * 36$$

$$INV = \frac{3}{5}\ OPR$$

$$OPR = \frac{0.95\ (24,316) - 1.3\ (5230 + 735) - 3725}{1.3 * 3092} * 36$$

OPR = 104.1 Tons

INV = $\frac{3}{5} * 104.1$ = 62.4 Tons.

COLORADO DEPARTMENT OF TRANSPORTATION Sheet 7 of 9

By: MM Date 2/95	Project No. 170 - 1 (75) 57	C81009
Chk'd: Date	Structure No. G - 04 - AL	REV. LFD

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

OPERATING & INVENTORY RATING

Rating at 2.0 POINT

From Calframe (BDS) OUTPUT: Pg. 6, 9, 12, 39

Horizontal member moment (trial 0) = −10,458 K-ft

Horizontal member moment (trial 1) = −1469 K-ft

Negative Live Load + impact moment = −3432 K-ft

Average stress in prestressing steel, (at ultimate Load) F^*_{su} = 256.57 ksi

ultimate moment P/S Capacity, M_n = 22,593 K-ft

Secondary moment due to P/S, M_s = 2,355 K-ft

Rating

$$OPR = \frac{0.95 M_n - 1.3 (M_{DL} + M_{DLC}) + 1.0 M_s}{1.3 M_{LL+I}} * 36$$

$$OPR = \frac{0.95 (22,593) - 1.3 (10,458 + 1469) + 2355}{1.3 (3432)} * 36$$

OPR = $\underline{\underline{67.1}}$ TONS. ← CONTROLS

INV = 3/5 (OPR) = $\underline{\underline{40.2}}$ TONS. ←

COLORADO DEPARTMENT OF TRANSPORTATION		Sheet 8 of 9
By: MM Date 3/95	Project No. I70-1(75)57	C81009
Chk'd: Date	Structure No. G-04-AL	REV, LFD.

CDOT Form #1034 1/93

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

Permit truck Rating : (LL No. 4 BDS RUN)

M_{LL+I} @ 1.0 = 5689 k-ft

M_{LL+I} @ 2.0 = 3739 k-ft

M_{LL+I} @ 2.5 = 5123 k-ft

@ 1.5 , 2.5 Location :

$$R_{OPR} = \frac{23,100 - 1.3(5230+735) - 3725}{1.3 * 5123} * 96 = 167.5 \text{ Tons}$$

@ 2.0 Location :

$$R_{OPR} = \frac{21,463.35 - 1.3(11,927) + 2355}{1.3 * 3739} * 96 = 164.0 \text{ Tons}$$

@ 1.0 Location :

$$R_{OPR} = \frac{0.95 * 19309 - 1.3(7816) + 5095}{1.3 * 5689} * 96 = 172.3 \text{ Tons}$$

COLOR = WHITE $R_{OPR\ permit}$ = 164.0 Tons.
@ 2.0

By: MM Date	Project no. I70-1 (75)57	Project code (SA#):
Chk'd: Date	Structure no. G-04-AL	Sheet 9 of 9

CDOT Form #1034 1/95

COMMENTS : 000 FORM

ACCOUNT G 04 AL;

SORT NO. 000

STRUCTURE G-04-AL; CBGCP; SH-70; PROJ#I70-1(75 57; M.M.

NOTES:

(1) First line of comments will appear at the top of each page of output

(2) Additional lines may be used if required

FRAME DESCRIPTION : 100 FORM

ACCOUNT

G-04-AL (01 02 03 04 05 06 07 08)

100 (78 79 80)

MEMBER NO. (1)	END JOINT NO. LT	END JOINT NO. RT	END CONDITION (2) LT	END CONDITION (2) RT	DIRECTION (3)	LENGTH FT	MIN II_{zz} FT	HINGE LOC. OR SUPPORT WIDTH FT	E KSI	DEAD LOAD UNIFORM K/FT	DEAD LOAD UNIT WT PCF	MEMBER PROPERTIES K STIFFNESS FACTOR LT	MEMBER PROPERTIES K STIFFNESS FACTOR RT	MEMBER PROPERTIES C CARRY OVER FACTOR LT	MEMBER PROPERTIES C CARRY OVER FACTOR RT	RECALL MEMBER	RECALL REVERSE R	DL DEFLECTIONS	DL SIDESWAY S	
9 10	11 12	13 14	15	16	17	18 19 20 21	22 23 24 25 26 27	28 29 30 31	32 33 34 35 36	37 38 39 40 41	42 43 44	45 46 47 48	49 50 51 52	53 54 55 56	57 58 59 60	61 62	63	64 65	66	67 68 69 70 71 72 73 74 75 76 77
01	01	02			H	1170			4066		150									▨
02	02	03			H											01	R			▨
03	04	01	P		V	71	4430		3320		150									▨
04	05	02			V	256	540		3320		150									▨
05	06	03			V											03				▨
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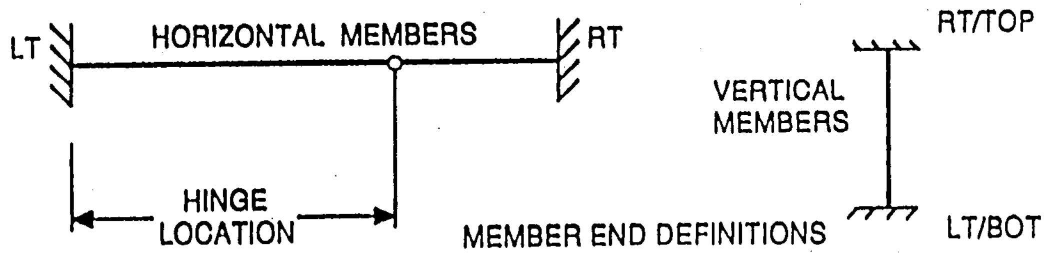
9 10	11 12	13 14	15	16	17	18 19 20 21	22 23 24 25 26 27	28 29 30 31	32 33 34 35 36	37 38 39 40 41	42 43 44	45 46 47 48	49 50 51 52	53 54 55 56	57 58 59 60	61 62	63	64 65	66	67 68 69 70 71 72 73 74 75 76 77

NOTES:
(1) Member numbers must be numbered consecutively.
(2) Possible END CONDITIONS are:
[BLANK] = fixed (by default)
P = pinned
R = roller
C = cantilever
(3) DIRECTION Code
G or H = girder or horizontal member



MEMBER END DEFINITIONS

SUPERSTRUCTURE DATA : 200 FORM

ACCOUNT: G-04-AL (01 02 03 04 05 06 07 08)

SORT NO.: 2 0 0 (78 79 80)

			REF. POINT COORD.		SS. DATA		SLAB DATA		INT. GIRDERS		EXTERIOR GIRDERS						OVERHANGS								
											LEFT			RIGHT			LEFT			RIGHT					
MEMBER NO.	CROSS SEC. LOC. X FT	RECALL	Z FT	Y FT	WIDTH ED-ED FT	DEPTH FT	TOP THICK. IN	BOTTOM THICK. IN	NUMBER (INT. ONLY)	WEB THICK. IN	TYPE	WEB THICK IN	FACTOR FT	TYPE	WEB THICK IN	FACTOR FT	LENGTH FT	EXT. THICK. IN	INT. THICK. IN	LENGTH FT	EXT. THICK. IN	INT. THICK. IN		STORE SECTION	
9 10	11 12 13 14	15 16	17 18 19	20 21 22	23 24 25 26	27 28 29 30	31 32 33 34	35 36 37 38	39 40	41 42	43	44 45	46 47 48	49	50 51	52 53 54	55 56 57	58 59	60 61	62 63 64	65 66	67 68	69 70 71 72 73	74 75	76 77
01	00		00	00	345	467	825	575	2	12	1	12	091	1	12	091	40	8	12	40	8	12	▨		▨
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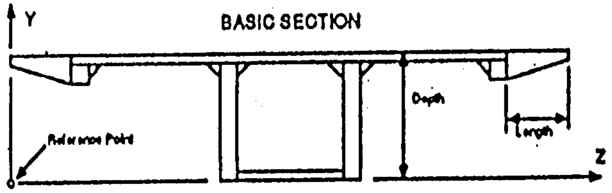
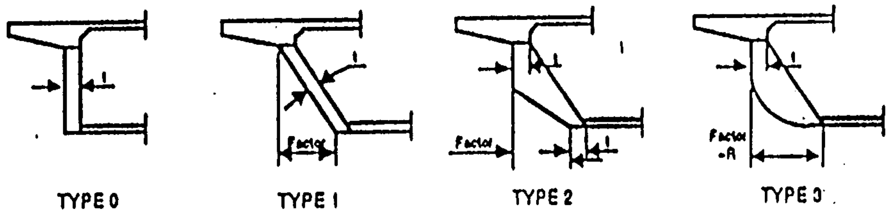
9 10	11 12 13 14	15 16	17 18 19	20 21 22	23 24 25 26	27 28 29 30	31 32 33 34	35 36 37 38	39 40	41 42	43	44 45	46 47 48	49	50 51	52 53 54	55 56 57	58 59	60 61	62 63 64	65 66	67 68	69 70 71 72 73	74 75	76 77

BASIC SECTION



EXTERIOR GIRDERS



NOTES:
(1) Type 9 means no exterior girder.

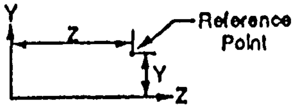
PARTS DATA : 201 FORM

ACCOUNT G-04-AL2

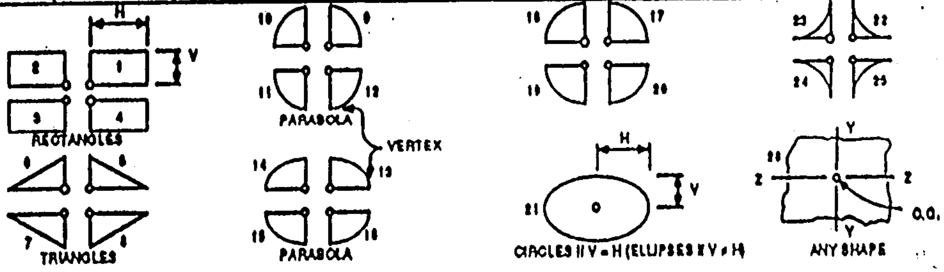
SORT NO. 2 0 1

MEMBER NO.	CROSS SEC. LOC. X FT	RECALL	SIGN + OR —	PART CODE	PART DIMENSION (1) VERTICAL V OR DEPTH D FT	PART DIMENSION HORIZ. H FT	REF. PT. COORD. Z FT	REF. PT. COORD. Y FT	ANY SHAPE AREA FT	ANY SHAPE Izz FT	ANY SHAPE E KSI		STORE SECTION	
9 10	11 12 13 14	15 16	17	18 19	20 21 22 23 24	25 26 27 28 29	30 31 32 33 34	35 36 37 38 39	40 41 42 43 44	45 46 47 48 49 50 51 52	53 54 55 56 57 58 59 60	61	62 63	64 65 66 67 68 69 70 71 72 73 74 75 76 77
01	00		+	5	.3333	.3333	1350	.4792				▨		▨
01	00		+	6	.3333	.3333	1250	.4792				▨		▨
01	00		+	5	.3333	.3333	632	.4792				▨		▨
01	00		+	6	.3333	.3333	2100	.4792				▨		▨
01	00		+	5	.3333	.3333	2200	.4792				▨		▨
01	00		+	6	.3333	.3333	2818	.4792				▨		▨
												▨		▨
												▨		▨
												▨		▨
												▨		▨
9 10	11 12 13 14	15 16	17	18 19	20 21 22 23 24	25 26 27 28 29	30 31 32 33 34	35 36 37 38 39	40 41 42 43 44	45 46 47 48 49 50 51 52	53 54 55 56 57 58 59 60	61	62 63	64 65 66 67 68 69 70 71 72 73 74 75 76 77

NOTES:
(1) · Enter total depth of section using part code 27



PART CODES:



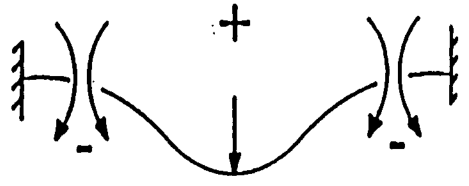
LOAD DATA : 300 FORM

ACCOUNT 51-04-AL

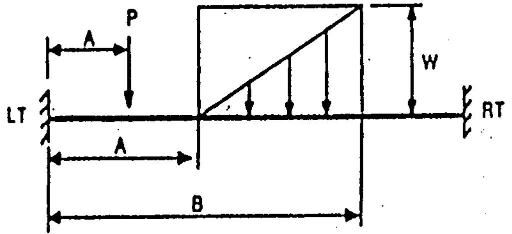
SORT NO. 300

TRIAL NO.	MEMBER NO.	LOADS				FEM'S (1)		DEFLECTIONS	SIDESWAY	COMMENTS
		W or P K/FT or K	CODE (2)	A FT	B FT	LEFT FT • K	RIGHT FT • K			
00	01	814	P	304						DIAPHRAGM
00	01	814	P	778						DIAPHRAGM
00	02	814	P	302						DIAPHRAGM
00	02	814	P	776						DIAPHRAGM
00	01	179	U	00	1170					FORMWORK
00	02	179	U	00	1170					FORMWORK
01	01	114	U	00	1170					ASPHALT; CURBS; RAIL
01	02	114	U	00	1170					ASPHALT; CURBS; RAIL

NOTES:
(1) When FEMs are given, they are not calculated for any load on that member.
(2) CODE:
L = Max. W on left
R = Max. W on right
U = Uniform Load
P = Point Load



SIGN CONVENTIONS



DIMENSIONS

LIVE LOAD HS20-44 MEMBER DATA : 400 FORM

ACCOUNT G-04-AL (columns 01 02 03 04 05 06 07 08)

SORT NO. 400 (columns 78 79 80)

MEMBER NO.	NUMBER OF LIVE LOAD LANES					PLOT DATA						COMMENTS
	SUPERSTRUCTURE		SUB-STRUCTURE			RESISTING MOMENT OF UNIT STEEL		MOMENT & SHEAR	SCALE	INFLUENCE LINES		
	LT END	RT END	LT	RT		POSITIVE	NEGATIVE					
9 10	11 12 13 14 15	16 17 18 19 20	21 22 23	24 25 26	27	28 29 30 31 32	33 34 35 36 37	38	39	40	41	42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77
01	2464	2464	20	20								
02	2464	2464	20	20								
9 10	11 12 13 14 15	16 17 18 19 20	21 22 23	24 25 26	27	28 29 30 31 32	33 34 35 36 37	38	39	40	41	42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77

NOTES:

(1) FRAME DESCRIPTION data with the horizontal members numbered consecutively starting with 01 must accompany this data.

(2) MEMBER DATA - When the NUMBER OF L.L. LANES is given, it must be given for the left end of Superstructure Member 01. (Substructure Member 01 defaults to 1.0 when left blank). Thereafter, it is assumed to be constant until another entry is made.

(3) INFLUENCE LINES - When a "1" in entered, a plot of the influence lines will be produced along with the printed results.

LIVE LOAD TRUCK AND LANE DATA : 401 FORM

ACCOUNT 6-04-AL2 (01 02 03 04 05 06 07 08)

SORT NO. 401 (78 79 80)

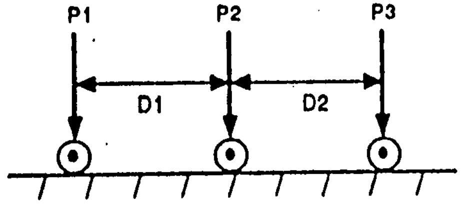
LIVE LOAD NO (9)	TRUCK (1 LANE) P₁ KIPS (10 11 12 13)	D₁ FT (14 15 16)	P₂ KIPS (17 18 19 20)	D₂ FT (21 22 23)	P₃ KIPS (24 25 26 27)	LANE (1 LANE) UNIFORM LOAD K/FT (28 29 30 31 32)	MOMENT RIDER KIPS (33 34 35 36)	SHEAR RIDER KIPS (37 38 39 40)	NO IMPACT (41)	(2) NUMBER OF LIVE LOAD LANES (42 43 44 45 46)	COMMENTS (47–77)
1											HS20-44 TRUCK
2	240	40	240								MILITARY LOAD (ALTERNATE)

NOTES:

(1) LIVE LOAD DATA - For AASHTO HS20-44 Loading, leave TRUCK and LANE data blank for L.L. No. 1. When this data is given, it replaces the HS20-44 Loading.

(2) An entry for the NUMBER OF LIVE LOAD LANES overrides that given on MEMBER DATA (400 form).

(3) Data entries for L.L. No.'s 2 and 3 produce separate results in addition to L.L. No. 1



TRUCK AXLE LOADS AND SPACING

LIVE LOAD GENERATOR MEMBER DATA : 500 FORM

ACCOUNT G-04-AL

SORT NO. 500

MEMBER NO.	NUMBER OF LIVE LOAD LANES				IMPACT FACTOR - % (3)	COMMENTS
	SUPERSTRUCTURE		SUB-STRUCTURE			
	LT END	RT END	LT	RT		
9 10	11 12 13 14 15	16 17 18 19 20	21 22 23	24 25 26	27 28	29 … 77
01	2.464	2.464	2.0			LIVE LOAD DISTRIBUTION FACTOR FOR PERMIT TRUCK
02	2.464	2.464	2.0			

NOTES:

(1) FRAME DESCRIPTION data with the horizontal members numbered consecutively starting with 01 must accompany this data.

(2) When the NUMBER OF LL. LANES is given, it must be given for the left end of Superstructure Member 01. Thereafter, it is assumed to be constant until another entry is made. Substructure Member 01 defaults to 1.0 when left blank.

(3) If a Cooper loading is to be given, % of impact to be applied to each member must be given. It will be used for Cooper loading only.

LIVE LOAD GENERATOR LIVE LOAD DATA : 501 FORM

ACCOUNT: G-04-AL

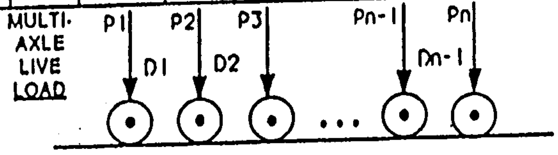
SORT NO.: 501

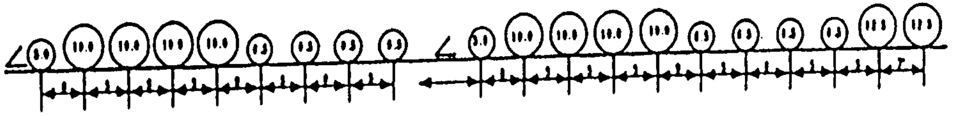
	MULTI-AXLE LIVE LOAD													OVER LOAD					
LIVE LOAD NO.	P1 KIPS	D1 FT	P2 KIPS	D2 FT	P3 KIPS	D3 FT	P4 KIPS	D4 FT	P5 KIPS	D5 FT.	P6 KIPS	D6 FT	Pn KIPS	COLOR CODE	NO. OF AXLES	COOPER LOADING	NO IMPACT		LINE NO.
4	270	140	250	40	250	120	250	40	250	350	217	40			08			PERMIT TRUCK	
	216	40	217																

NOTES:

(1) LIVE LOAD DATA - Leave LIVE LOAD NO. 4 blank for 7 axle P-13 truck or simply omit this form using only the 500 form.

(2) Up to 97 axles can be used to describe the live load. The LINE NO. in column 76-77 must be from 1 thru 16.





STEAM RAILROAD LOADING
CLASS E-10 ENGINE LOADING
ONE TRACK OF TWO RAILS

PRESTRESS DATA (1) : 600 FORM

ACCOUNT G-04-AL9 (01 02 03 04 05 06 07 08)

SORT NO. 600 (78 79 80)

				CABLE PATH								SPECIFICATIONS																	
																	ANCHOR SET		ALL. TENS.										
TRIAL NO.	FRAME NO.	PATH NO.	MEMBER NO.	LLT %	LLP %	LRT %	YLT FT	YLP FT	YRT FT	XLT FT	XRT FT	μ X10-2	K X10-6	f KSI	% JACK	JACK END	LT 1/8 IN	RT 1/8 IN	SPEC	%	P-JACK KIPS	Fo KSI	SHORTENING %	LOSSES KSI	RELATIVE HUMIDITY %	NO LOW-LAX	PLOT PATHS	PLOT STRESSES	
9 10	11	12 13	14 15	16 17	18 19	20 21	22 23 24 25	26 27 28 29	30 31 32 33	34 35 36 37	38 39 40 41	42 43	44 45 46	47 48 49	50 51	52	53 54	55 56	57	58 59	60 61 62 63 64	65 66	67	68 69	70 71	72	73	74	75 76 77
01	1	01	01		40	10	133	408	083			25	20				5	5	1		5902	45	5	27					▨
01	1	01	02	10	60		083	408	133			25	20				5	5	1		5902	45	5	27					▨
																													▨
																													▨
																													▨
																													▨
																													▨
																													▨
																													▨
																													▨
9 10	11	12 13	14 15	16 17	18 19	20 21	22 23 24 25	26 27 28 29	30 31 32 33	34 35 36 37	38 39 40 41	42 43	44 45 46	47 48 49	50 51	52	53 54	55 56	57	58 59	60 61 62 63 64	65 66	67	68 69	70 71	72	73	74	75 76 77

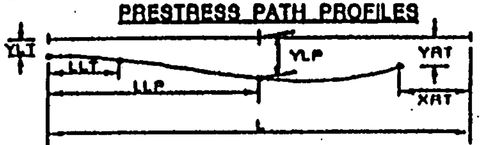
NOTES:

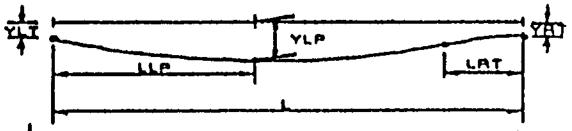
(1) "L" must be the total member length as shown on "FRAME DESCRIPTION".

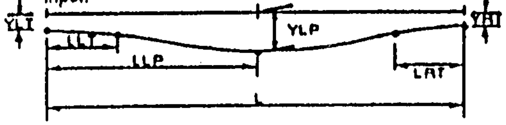
(2) LLP is always the length from the left end to the low point.

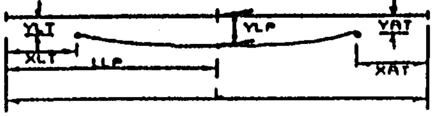
(3) For a straight tendon YLT, YLP and YRT are required input.

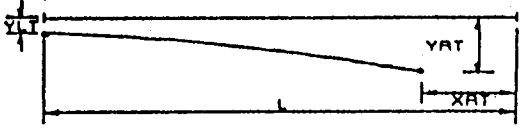
PRESTRESS PATH PROFILES

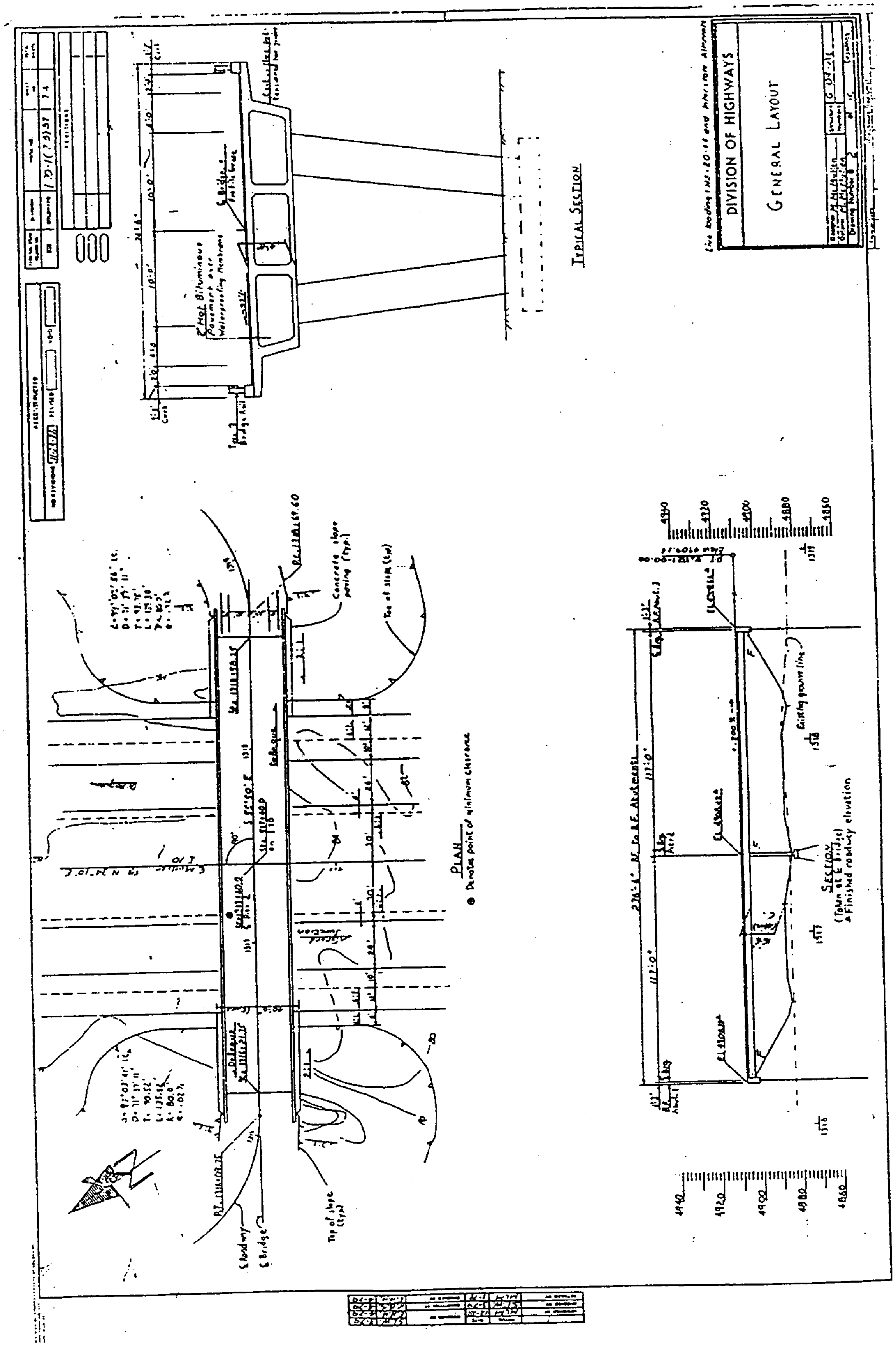


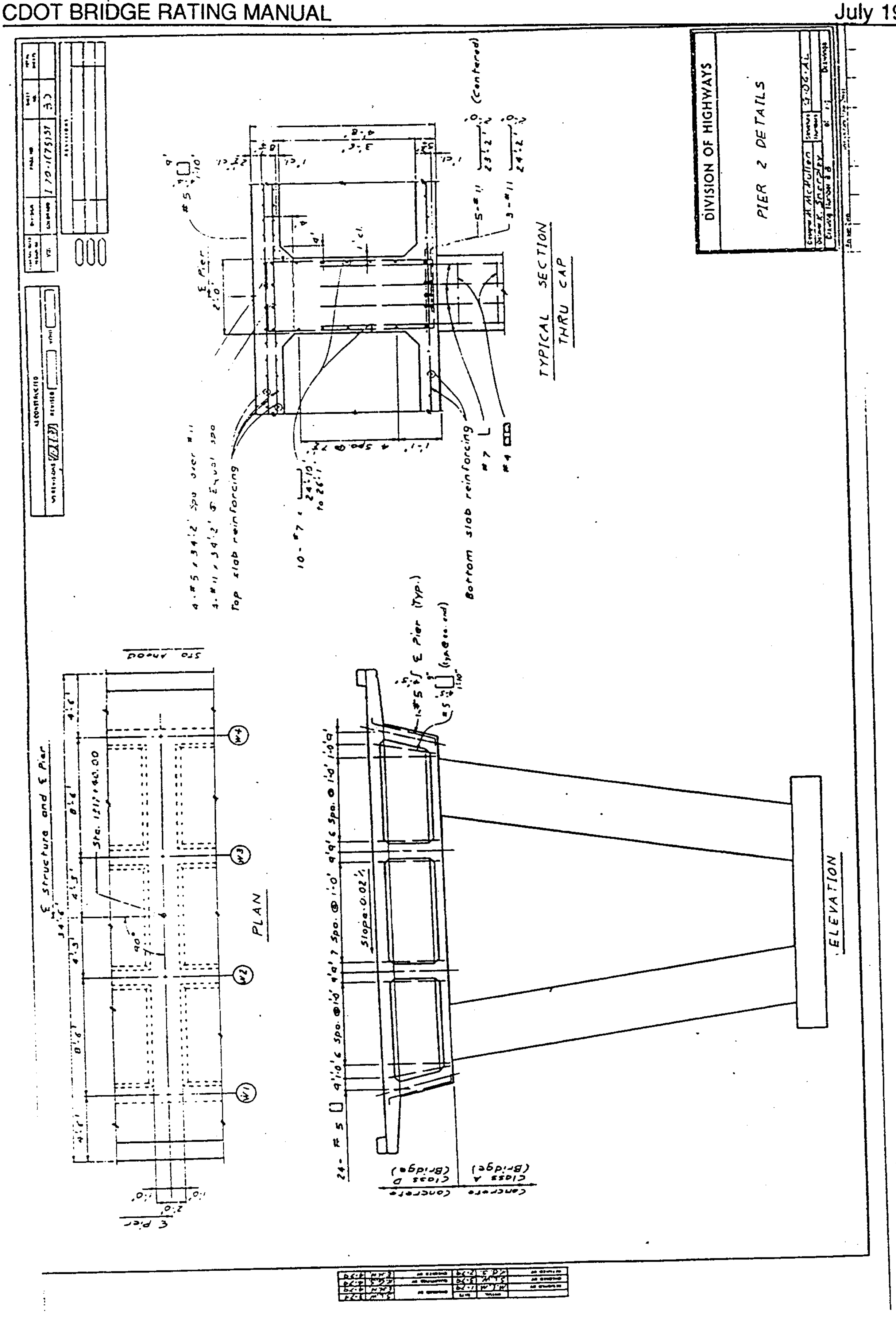


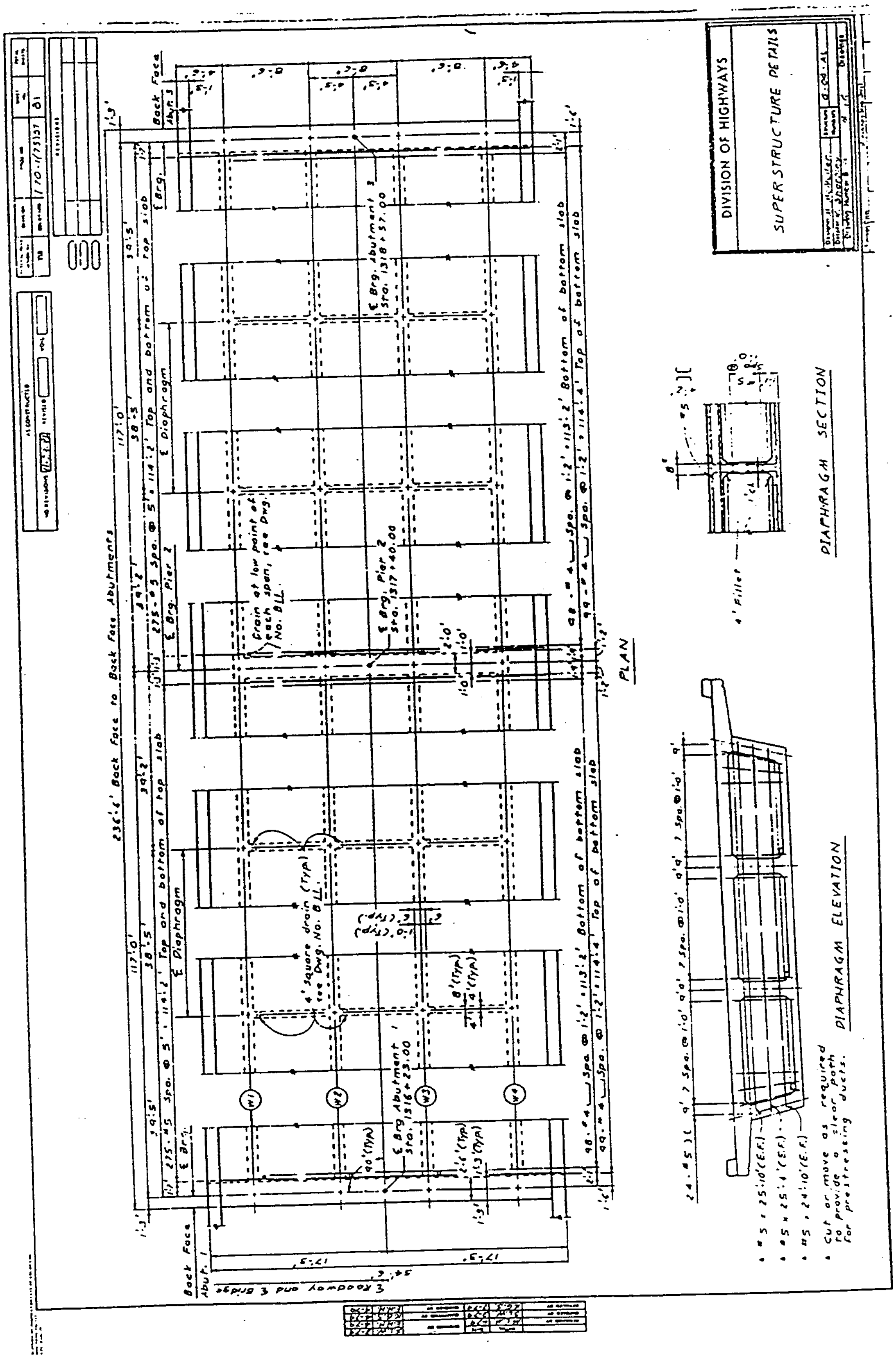


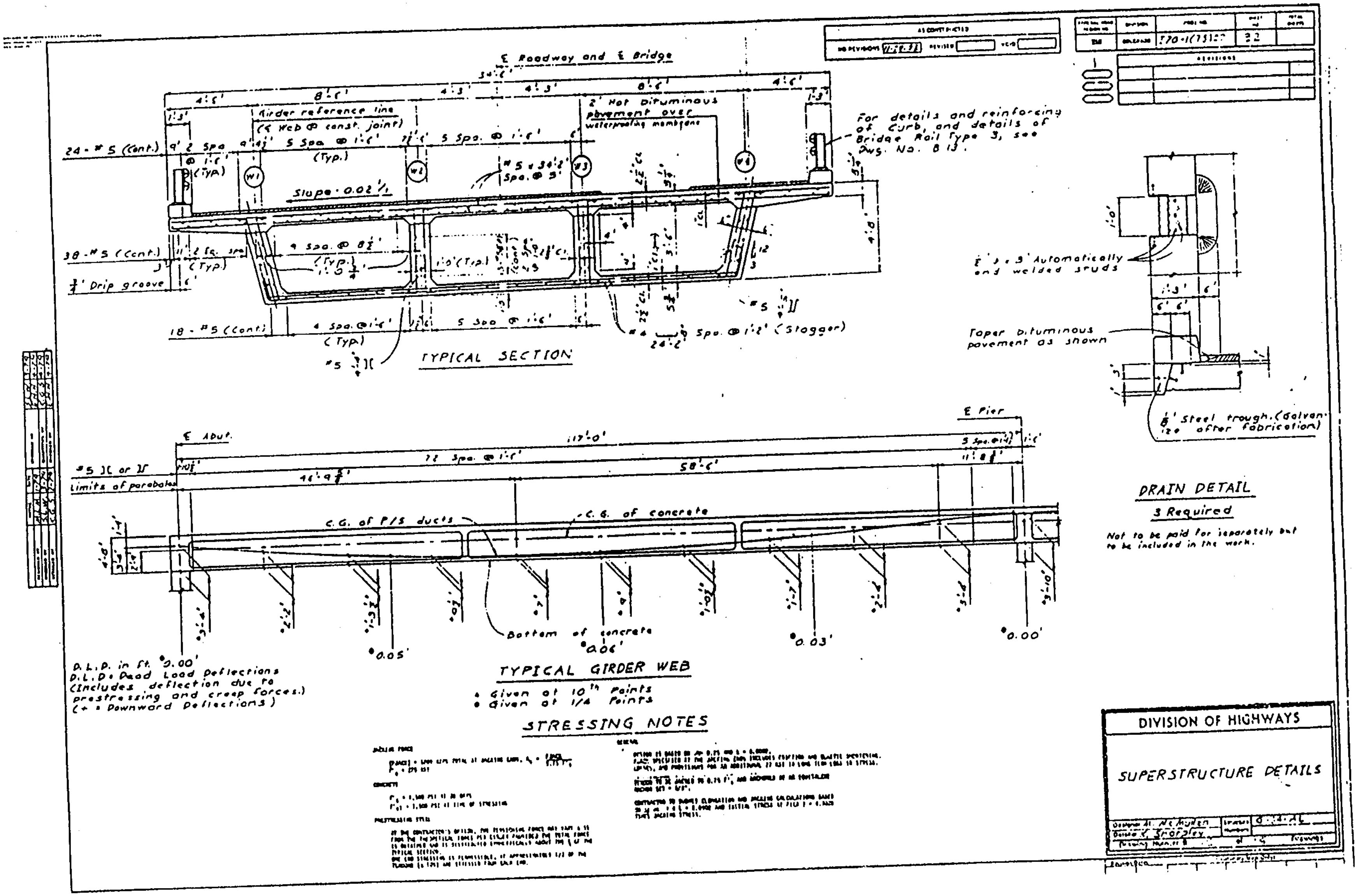





DIVISION OF HIGHWAYS
GENERAL LAYOUT
TYPICAL SECTION
2" Hot Bituminous Pavement over Waterproofing Membrane
℄ Bridge
Type 3 bridge rail
PLAN
Denotes point of minimum clearance
Concrete slope paving (typ.)
Toe of slope (typ.)
Top of slope (typ.)
℄ Roadway
℄ Bridge
SECTION
(Taken at ℄ Bridge)
Finished roadway elevation
Existing ground line
276'-0" Bk to B.F. Abutments
137'-0"
137'-0"
4940
4920
4900
4880
4860


DIVISION OF HIGHWAYS
PIER 2 DETAILS
H. McMullen
K. Snerpley
3-06-AL
I 70-1(75)57
AS CONSTRUCTED
Ȼ Structure and Ȼ Pier
34'-6"
4'-6"
8'-6"
4'-3"
4'-3"
8'-6"
4'-6"
Sta. 1217+40.00
90°
Ȼ Pier
1'-0"
2'-0"
1'-0"
Sta. Ahead
W1
W2
W3
W4
PLAN
24- #5 ⊔ 9", 1'-0", 6 Spa. @ 1'-0", 9", 9", 7 Spa. @ 1'-0", 9", 9", 6 Spa. @ 1'-0", 1'-0", 9"
Slope 0.02'/'
1-#5 ∫ Ȼ Pier (Typ.)
#5 ⊔ 1'-10" (typ @ ea. end)
Concrete Class D (Bridge)
Concrete Class A (Bridge)
ELEVATION
4-#5 x 34'-2" Spa. over #11
3-#11 x 34'-2" & Equal Spa.
Top slab reinforcing
#5 ⊔ 9" 1'-10"
Ȼ Pier
2'-0"
10-#7 x 24'-10" to 26'-1"
4 Spa. @ 7½"
1'-1"
1'-cl.
4"
4"
3'-6"
4'-8"
Bottom slab reinforcing
#7 L
#4 ▭
5-#11 23'-2" 2'-0" (Centered)
3-#11 24'-2" 2'-0"
TYPICAL SECTION THRU CAP


DIVISION OF HIGHWAYS
SUPERSTRUCTURE DETAILS
PLAN
DIAPHRAGM SECTION
DIAPHRAGM ELEVATION
236'-6" Back Face to Back Face Abutments
117'-0"
117'-0"
38'-5"
39'-2"
Top and bottom of top slab
Bottom of bottom slab
Top of bottom slab
℄ Diaphragm
℄ Brg. Abutment 3 Sta. 1318+57.00
℄ Brg. Pier 2 Sta. 1317+40.00
℄ Brg. Abutment 1 Sta. 1316+23.00
Drain at low point of each span, see Dwg. No. B11
4" square drain (Typ) see Dwg. No. B11
Back Face Abut. 1
Back Face Abut. 3
℄ Roadway and ℄ Bridge
17'-3"
17'-3"
34'-6"
W1
W2
W3
W4
4" Fillet
Cut or move as required to provide a clear path for prestressing ducts.


℄ Roadway and ℄ Bridge
34'-0'
4'-0' 8'-0' 4'-3' 4'-3' 8'-0' 4'-0'
1'-3'
Girder reference line (℄ Web @ const. joint)
2' Hot bituminous pavement over waterproofing membrane
24 - #5 (Cont.)
5 Spa. @ 1'-0' (Typ.)
#5 x 34'-2' Spa. @ 5'
Slope - 0.02'/1'
W1 W2 W3 W4
38 - #5 (Cont.)
1/2' Drip groove
18 - #5 (Cont.)
4 Spa. @ 1'-0' (Typ.)
5 Spa. @ 1'-0'
#4 Spa. @ 1'-2' (Stagger)
TYPICAL SECTION
For details and reinforcing of curb, and details of Bridge Rail Type 3, see Dwg. No. B 13.
3/4' x 3' Automatically end welded studs
Taper bituminous pavement as shown
1/8' Steel trough. (Galvanize after fabrication)
DRAIN DETAIL
3 Required
Not to be paid for separately but to be included in the work.
℄ Abut.
℄ Pier
117'-0'
72 Spa. @ 1'-0'
5 Spa. @ 1'-0'
#5][or][
Limits of parabola
46'-9 3/4'
58'-0'
11'-8 1/4'
C.G. of P/S ducts
C.G. of concrete
Bottom of concrete
0.05'
0.06'
0.03'
0.00'
D.L.D. in Ft. 0.00'
D.L.D. = Dead Load Deflections (Includes deflection due to prestressing and creep forces.) (+ = Downward Deflections)
TYPICAL GIRDER WEB
• Given at 10th Points
• Given at 1/4 Points
STRESSING NOTES
DIVISION OF HIGHWAYS
SUPERSTRUCTURE DETAILS
I70-1(73)12
22

```
                       *************************************************************************
                       *                            IAI-BDS                                    *
                       *                      Bridge Design System                             *
                       *                                                                       *
                       *                  By: Imbsen and Associates, Inc.                      *
                       *                    VERSION 4.0.1    25-AUG-93                         *
                       *************************************************************************



                        ********************* Licensed to: Colorado DOT **********************
                      1                                  LISTING OF THE SORTED INPUT FILE
                            +                                                 ______

            CARD              1         2         3         4         5         6         7         8
           NUMBER    12345678901234567890123456789012345678901234567890123456789012345678901234567890
          +_______   ________________________________________________________________________________

               1     G-04-AL,STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.              000
               2     G-O4-AL,010102  H1170           4066     150                                 100
               3     G-04-AL,020203  H                                           01R              100
               4     G-04-AL,030401P V  71  4430     3320     150                                 100
               5     G-04-AL,040502  V 256   540     3320     150                                 100
               6     G-04-AL,050603  V                                           03               100
               7     G-04-AL,01  00   00 00 345 467 825 575 212112091112091 40 812 40 812         200
               8     G-04-AL,01  00  + 5.3333.3333 1350.4792                                      201
               9     G-04-AL,01  00  + 5.3333.3333  632.4792                                      201
              10     G-04-AL,01  00  + 5.3333.3333 2200.4792                                      201
              11     G-04-AL,01  00  + 6.3333.3333 1250.4792                                      201
              12     G-04-AL,01  00  + 6.3333.3333 2100.4792                                      201
              13     G-04-AL,01  00  + 6.3333.3333 2818.4792                                      201
              14     G-04-AL,0001    179U  001170                 FORMWORK                        300
              15     G-04-AL,0001   8140P 394                     DIAPHRAGM                       300
              16     G-04-AL,0001   8140P 778                     DIAPHRAGM                       300
              17     G-04-AL,0002    179U  001170                 FORMWORK                        300
              18     G-04-AL,0002   8140P 392                     DIAPHRAGM                       300
              19     G-04-AL,0002   8140P 776                     DIAPHRAGM                       300
              20     G-04-AL,0101   1140U  001170                 ASPHALT; CURBS; RAIL            300
              21     G-04-AL,0102   1140U  001170                 ASPHALT; CURBS; RAIL            300
              22     G-04-AL,01 2464 2464 20 20                                                   400
              23     G-04-AL,02 2464 2464 20 20                                                   400
              24     G-04-AL,1                                     HS20-44 TRUCK                  401
              25     G-04-AL,2 240 40 240                          MILITARY ALTERNATE LOAD        401
              26     G-04-AL,  216 40 217                                                       02501
              27     G-04-AL,01 2464 2464 20      LIVE LOAD DISTRIBUTION FACTOR FOR PERMIT TRUCK  500
              28     G-04-AL,02 2464 2464 20                                                      500
              29     G-04-AL,4 270140 250 40 250120 250 40 250350 217 40     08    PERMIT TRUCK 01501
              30     G-04-AL,0110101  4010 133 408 083        25 20       5 51   520945527        600
              31     G-04-AL,01101021060   083 408 133        25 20       5 51   520945527        600

          +          ________________________________________________________________________________
                              1         2         3         4         5         6         7         8
                     12345678901234567890123456789012345678901234567890123456789012345678901234567890

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT        Run time: 12-JUL-95 16:18:34   Page    1
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0FRAME DESCRIPTION
                 END                         SUPPORT                                    CARRY 0VER
     MEM  JT.    COND                          OR               DEAD LOAD      K          FACTORS   RECALL
      NO  LT RT LT RT  DIR   SPAN      I      HINGE      E      UNI  SEC   LT     RT    LT    RT     MEM
    /---/ /---/ /---/ /---/ /-----/ /------/ /-----/  /------/ /--------/ /----------/ /----------/ /----/
      1   1  2          H    117.0      0.00    0.0    4066.   0.000 .150  0.00  0.00   0.00  0.00
      2   2  3          H      0.0      0.00    0.0    4066.   0.000 .000  0.00  0.00   0.00  0.00  01R
      3   4  1   P      V      7.1     44.30    0.0    3320.   0.000 .150  0.00  0.00   0.00  0.00
      4   5  2          V     25.6      5.40    0.0    3320.   0.000 .150  0.00  0.00   0.00  0.00
      5   6  3          V      0.0      0.00    0.0    3320.   0.000 .000  0.00  0.00   0.00  0.00  03

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT        Run time: 12-JUL-95 16:18:34   Page    2
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0SECTION PROPERTIES - INPUT
0MEM        RE
  NO  LOC. CALL  Z     Y     W     D   TOP   BOT  NO  W  T  W  FACT T  W  FACT   L  EX  IN    L  EX  IN   E
STORE

                    +/-  CODE    V/D       H        Z        Y      AREA     IZZ        E     E-STORE  STORE

  1    0.0       0.0  0.0  34.5  4.67  8.25  5.75  2 12. 1 12. 0.91 1 12. 0.91  4.0  8. 12.  4.0  8. 12. 4066.
  1    0.0          +     5     0.33     0.33    13.50     0.48    0.00      0.00   4066.00      0
  1    0.0          +     5     0.33     0.33     6.32     0.48    0.00      0.00   4066.00      0
  1    0.0          +     5     0.33     0.33    22.00     0.48    0.00      0.00   4066.00      0
  1    0.0          +     6     0.33     0.33    12.50     0.48    0.00      0.00   4066.00      0
  1    0.0          +     6     0.33     0.33    21.00     0.48    0.00      0.00   4066.00      0
  1    0.0          +     6     0.33     0.33    28.18     0.48    0.00      0.00   4066.00      0
0SECTION PROPERTIES - OUTPUT
0MEM
```

```
  NO  LOC.   DEPTH    Z-BAR    Y-BAR    AREA        IZZ         IYY       E
0 1    0.0    4.67     17.25    2.77   51.66        156.78     4478.44   4066.00
0MEMBER  1 PROPERTIES
0 LENGTH: 117.0  MIN E*I: 0.637E+06  STIFF:  4.000 LT    4.000 RT  C.O.: 0.500 LT   0.500 RT

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT     Run time: 12-JUL-95 16:18:35   Page    3
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0FRAME PROPERTIES
                  END                                SUPPORT                CARRY OVER        DISTRIBUTION
  MEM     JT     COND                                  OR                    FACTORS            FACTORS
  NO    LT  RT   LT RT   DIR    SPAN   MIN E*I     HINGE       E          LT      RT          LT    RT
 /---/ /------/ /-----/ /---/ /-----/ /-------/ /-------/ /-------/ /---------------/  /-------------/
   1     1   2           H    117.0  0.6375E+06   0.0       4066.      0.500   0.500    0.260  0.470
   2     2   3           H    117.0  0.6375E+06   0.0       4066.      0.500   0.500    0.470  0.260
   3     4   1   P       V      7.1  0.1471E+06   0.0       3320.      0.500   0.000    0.000  0.740
   4     5   2           V     25.6  0.1793E+05   0.0       3320.      0.500   0.500    0.000  0.060
   5     6   3   P       V      7.1  0.1471E+06   0.0       3320.      0.500   0.000    0.000  0.740
0***** IF MEMBER IS HORIZONTAL SUPPORT OR HINGE FIELD EQUALS LOCATION OF HINGE FROM LEFT END OF MEMBER *****
 ***** IF MEMBER IS VERTICAL SUPPORT OR HINGE FIELD EQUALS SUPPORT WIDTH USED FOR MOMENT REDUCTION *****

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:35  Page    4
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LOAD DATA  TRIAL  0
                          LOAD                        FIXED END MOMENTS
   LINE MEM    W OR P    CODE       A       B          LEFT      RIGHT  DEFLT    COMMENTS
           1      0.179     U        0.0   117.0         0.         0.        FORMWORK
           1      8.140     P       39.4     0.0         0.         0.        DIAPHRAGM
           1      8.140     P       77.8     0.0         0.         0.        DIAPHRAGM
           2      0.179     U        0.0   117.0         0.         0.        FORMWORK
           2      8.140     P       39.2     0.0         0.         0.        DIAPHRAGM
           2      8.140     P       77.6     0.0         0.         0.        DIAPHRAGM
0FIXED END MOMENTS  TRIAL  0

    MEM     FIXED END MOMENTS         MEM     FIXED END MOMENTS            MEM     FIXED END MOMENTS
     NO      LT          RT            NO       LT          RT              NO       LT          RT

      1      -9256.    -9256.           2     -9257.     -9256.              3         0.         0.
      4          0.        0.           5         0.         0.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:35   Page    5
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0SIDESWAY DIAGNOSTICS

0





 RESULTS OF 1 INCH SWAY TO THE RIGHT

     VERTICAL SHEAR (KIPS)    MOMENTS (FT-KIPS)
     MEMBER                      LT        RT
                                                     BASED ON E = 3320. KSI.
         3         3181.0            0.    22585.
         4          249.2        -2783.     3597.
         5         3181.0            0.    22585.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT   Run time: 12-JUL-95 16:18:35   Page    6
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0                            *** SIDESWAY INCLUDED. ***
 HORIZONTAL MEMBER MOMENTS  TRIAL  0
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT  .7 PT    .8 PT    .9 PT    RIGHT
0 1    -6853.   -2235.    1298.    3746.    5048.    5230.    4327.    2305.    -864.   -5119.  -10458.   ←
0 2   -10458.   -5119.    -864.    2305.    4327.    5230.    5048.    3746.    1298.   -2235.   -6853.   ←
0HORIZONTAL MEMBER STRESSES  TRIAL  0     BOTTOM FIBER
0 1      841.     274.    -159.    -460.    -620.    -642.    -531.    -283.     106.     628.    1284.
0 2     1284.     628.     106.    -283.    -531.    -642.    -620.    -460.    -159.     274.     841.
0HORIZONTAL MEMBER STRESSES  TRIAL  0     TOP FIBER
0 1     -576.    -188.     109.     315.     424.     440.     364.     194.     -73.    -430.    -879.
0 2     -879.    -430.     -73.     194.     364.     440.     424.     315.     109.    -188.    -576.
0VERTICAL MEMBER MOMENTS  TRIAL  0
0 3        0.    -685.   -1371.   -2056.   -2741.   -3426.   -4112.   -4797.   -5482.   -6167.   -6853.
0 4        0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
0 5        0.     685.    1371.    2056.    2741.    3426.    4112.    4797.    5482.    6167.    6853.
0HORIZONTAL MEMBER SHEARS  TRIAL  0
0 1     441.1    348.3    255.6    162.8     61.9    -30.8   -123.6   -224.5   -317.2   -410.0   -502.8
0 2     502.8    410.0    317.2    224.5    123.6     30.8    -61.9   -162.8   -255.6   -348.3   -441.1
0VERTICAL MEMBER SHEARS  TRIAL 0
0 3    -965.2   -965.2   -965.2   -965.2   -965.2   -965.2   -965.2   -965.2   -965.2   -965.2   -965.2
0 4       0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0 5     965.2    965.2    965.2    965.2    965.2    965.2    965.2    965.2    965.2    965.2    965.2
0VERTICAL MEMBER REACTIONS  TRIAL  0
0MEM        LT                RT              MEMBER
 NO      REACTION           REACTION          WEIGHT

   3       441.1             441.1              0.0
   4      1005.5            1005.5              0.0
   5       441.1             441.1              0.0
```

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1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:35  Page    7
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.             0TRIAL  0
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END     SPAN    LT. END     RT. END     SPAN   LT. END     RT. END
0     1     0.000766    0.000000      2     0.000000   -0.000766      3    -0.000383    0.000766
0     4     0.000000    0.000000      5     0.000383   -0.000766
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
0     MEMBER  1     E= 4066.     0.000     0.037     0.054     0.029     0.000
0     MEMBER  2     E= 4066.     0.000     0.029     0.054     0.037     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  3     E= 3320.     0.000    -0.001    -0.001    -0.001     0.000
0     MEMBER  4     E= 3320.     0.000     0.000     0.000     0.000     0.000
0     MEMBER  5     E= 3320.     0.000     0.001     0.001     0.001     0.000

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:35  Page    8
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LOAD DATA  TRIAL  1
                          LOAD                            FIXED END MOMENTS
   LINE MEM    W OR P    CODE       A       B          LEFT      RIGHT  DEFLT    COMMENTS
           1      1.140     U        0.0   117.0         0.          0.        ASPHALT; CURBS; RAIL
           2      1.140     U        0.0   117.0         0.          0.        ASPHALT; CURBS; RAIL
0FIXED END MOMENTS  TRIAL  1

    MEM     FIXED END MOMENTS         MEM     FIXED END MOMENTS           MEM     FIXED END MOMENTS
     NO      LT          RT            NO       LT          RT              NO       LT          RT

      1      -1300.    -1300.           2     -1300.     -1300.              3        0.         0.
      4          0.        0.           5         0.         0.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:35  Page    9
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0                            *** FRAME DOES NOT SWAY WITH THIS LOADING ***
 HORIZONTAL MEMBER MOMENTS  TRIAL  1
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT  .7 PT    .8 PT    .9 PT    RIGHT
0 1     -963.    -311.     184.     524.     707.     735.     606.     321.    -120.    -716.   -1469.   ←
0 2    -1469.    -716.    -120.     321.     606.     735.     707.     524.     184.    -311.    -963.
0HORIZONTAL MEMBER STRESSES  TRIAL  1    BOTTOM FIBER
0 1      118.      38.     -23.     -64.     -87.     -90.     -74.     -39.      15.      88.     180.
0 2      180.      88.      15.     -39.     -74.     -90.     -87.     -64.     -23.      38.     118.
0HORIZONTAL MEMBER STRESSES  TRIAL  1     TOP FIBER
0 1      -81.     -26.      15.      44.      59.      62.      51.      27.     -10.     -60.    -124.
0 2     -124.     -60.     -10.      27.      51.      62.      59.      44.      15.     -26.     -81.
0VERTICAL MEMBER MOMENTS  TRIAL  1
0 3        0.     -96.    -193.    -289.    -385.    -481.    -578.    -674.    -770.    -867.    -963.
0 4        0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
0 5        0.      96.     193.     289.     385.     481.     578.     674.     770.     867.     963.
0HORIZONTAL MEMBER SHEARS  TRIAL  1
0 1      62.4     49.0     35.7     22.3      9.0     -4.3    -17.7    -31.0    -44.3    -57.7    -71.0
0 2      71.0     57.7     44.3     31.0     17.7      4.3     -9.0    -22.3    -35.7    -49.0    -62.4
0VERTICAL MEMBER SHEARS  TRIAL 1
0 3    -135.6   -135.6   -135.6   -135.6   -135.6   -135.6   -135.6   -135.6   -135.6   -135.6   -135.6
0 4       0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0 5     135.6    135.6    135.6    135.6    135.6    135.6    135.6    135.6    135.6    135.6    135.6
0VERTICAL MEMBER REACTIONS  TRIAL  1
0MEM        LT                   RT                 MEMBER
 NO      REACTION            REACTION               WEIGHT

   3        62.4                62.4
   4       142.0               142.0
   5        62.4                62.4

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT    Run time: 12-JUL-95 16:18:35     Page   10
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL  1
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END     SPAN    LT. END     RT. END     SPAN   LT. END     RT. END
0     1     0.000108    0.000000      2     0.000000   -0.000108      3    -0.000054    0.000108
0     4     0.000000    0.000000      5     0.000054   -0.000108
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
0     MEMBER  1     E= 4066.     0.000     0.005     0.008     0.004     0.000
0     MEMBER  2     E= 4066.     0.000     0.004     0.008     0.005     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  3     E= 3320.     0.000     0.000     0.000     0.000     0.000
0     MEMBER  4     E= 3320.     0.000     0.000     0.000     0.000     0.000
0     MEMBER  5     E= 3320.     0.000     0.000     0.000     0.000     0.000

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35  Page   11
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LIVE LOAD DIAGNOSTICS

0
0SUPERSTRUCTURE LIVE LOAD
0           NUMBER OF LIVE LOAD LANES          RESISTING MOMENT OF        PLOT   PLOT   INFLU-
 MEM     SUPERSTRUCTURE   SUBSTRUCTURE             UNIT STEEL            M   S SCALE   ENCE
  NO.   LT.END   RT.END   LT.END    RT.END     POSITIVE   NEGATIVE          ENV.          LINES  GEN
 ----------------------------------------------------------------------------------------------------

   1      2.464   2.464    2.0       2.0          0.        0.             0      0      NO      NO
   2      2.464   2.464    2.0       2.0          0.        0.
0LIVE    -----------TRUCK-------------    ---------LANE---------         NO.  LIVE
```

```
 LOAD     P1     D1    P2  D2     P3      UNIFORM   MOM.   SHEAR          LL   LOAD
 NO.                                                 RIDER  RIDER IMPACT  LNS. SIDESWAY

  1.      8.0   14.0  32.0   14.0   32.0     0.640   18.0   26.0    YES    0.00 NO

         COMMENTS: HS20-44 TRUCK
+                                           WITHOUT ALTERNATIVE


  2.     24.0    4.0  24.0    0.0    0.0     0.000    0.0    0.0    YES    0.00 NO

         COMMENTS: MILITARY ALTERNATE LOAD




  IMPACT FACTORS CALCULATED BY PROGRAM
0      MEM       IMPACT
        NO         %


        1          21.
        2          21.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35   Page   12
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 1.                    NEGATIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1    -3107.   -1542.    -397.     -41.    -290.    -540.    -789.   -1039.   -1289.   -1916.   -3432.
 SHEAR   147.2    121.5     73.6    -21.3    -21.3    -21.3    -21.3    -21.3    -21.3    -45.2   -155.2
0 2    -3432.   -1916.   -1289.   -1039.    -789.    -540.    -290.     -41.    -397.   -1542.   -3107. ←
 SHEAR  155.2     98.7     21.3     21.3     21.3     21.3     21.3     21.3    -73.6   -121.5   -147.2
0HORIZONTAL MEMBER STRESSES LL MAX NEG  BOTTOM FIBER
0 1      381.     189.      49.       5.      36.      66.      97.     128.     158.     235.     421. ←
0 2      421.     235.     158.     128.      97.      66.      36.       5.      49.     189.     381.
0HORIZONTAL MEMBER STRESSES LL MAX NEG  TOP FIBER
0 1     -261.    -130.     -33.      -3.     -24.     -45.     -66.     -87.    -108.    -161.    -289. ←
0 2     -289.    -161.    -108.     -87.     -66.     -45.     -24.      -3.     -33.    -130.    -261.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35   Page   13
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 1.                    DEAD LOAD PLUS NEGATIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1    -9960.   -3777.     901.    3705.    4758.    4690.    3537.    1266.   -2153.   -7035.  -13890.
0 2   -13890.   -7035.   -2153.    1266.    3537.    4690.    4758.    3705.     901.   -3777.   -9960.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG BOTTOM FIBER
0 1     1223.     464.    -111.    -455.    -584.    -576.    -434.    -155.     264.     864.    1706.
0 2     1706.     864.     264.    -155.    -434.    -576.    -584.    -455.    -111.     464.    1223.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG  TOP FIBER
0 1     -837.    -317.      76.     311.     400.     394.     297.     106.    -181.    -591.   -1168.
0 2    -1168.    -591.    -181.     106.     297.     394.     400.     311.      76.    -317.    -837.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35   Page   14
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 1.                    POSITIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1      708.     554.    1143.    2102.    2788.    3092.    3036.    2577.    1726.     588.       0.
 SHEAR  -21.3     50.6    154.9    132.9    108.1     81.6    -90.2   -116.7   -141.8   -164.2      0.0
0 2        0.     588.    1726.    2577.    3036.    3092.    2788.    2102.    1143.     554.     708. ←
 SHEAR    0.0     69.0    141.8    116.7     90.2    -81.6   -108.1   -132.9   -154.9    -50.6     21.3
0HORIZONTAL MEMBER STRESSES LL MAX POS  BOTTOM FIBER
0 1      -87.     -68.    -140.    -258.    -342.    -380.    -373.    -316.    -212.     -72.       0. ←
0 2        0.     -72.    -212.    -316.    -373.    -380.    -342.    -258.    -140.     -68.     -87.
0HORIZONTAL MEMBER STRESSES LL MAX POS  TOP FIBER
0 1       59.      47.      96.     177.     234.     260.     255.     217.     145.      49.       0.
0 2        0.      49.     145.     217.     255.     260.     234.     177.      96.      47.      59. ←

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35   Page   15
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 1.                    DEAD LOAD PLUS POSITIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1    -6145.   -1681.    2441.    5848.    7836.    8322.    7363.    4882.     862.   -4531.  -10458.
0 2   -10458.   -4531.     862.    4882.    7363.    8322.    7836.    5848.    2441.   -1681.   -6145.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS BOTTOM FIBER
0 1      755.     206.    -300.    -718.    -962.   -1022.    -904.    -599.    -106.     556.    1284.
0 2     1284.     556.    -106.    -599.    -904.   -1022.    -962.    -718.    -300.     206.     755.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS  TOP FIBER
0 1     -517.    -141.     205.     492.     659.     700.     619.     410.      72.    -381.    -879.
0 2     -879.    -381.      72.     410.     619.     700.     659.     492.     205.    -141.    -517.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35   Page   16
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO.  1.                       LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   204.6    190.1    170.5    147.2    121.5     94.9     68.5     43.8     22.1      6.9      0.0
 MOM.   -1133.     -54.    1082.    2059.    2724.    2984.    2811.    2239.    1365.     300.       0.
```

```
 NEG. V   -21.6    -22.0    -25.4    -36.7    -52.8    -77.2   -103.4   -130.1   -155.9   -179.6   -199.6
 MOM.     454.    1162.    1174.    1712.    2524.    2932.    2950.    2535.    1710.     558.    -773.
 RANGE    226.2    212.1    195.9    183.9    174.3    172.0    171.9    173.9    178.1    186.4    199.6
0LL NO.  1.                    LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   199.6    179.6    155.9    130.1    103.4     77.2     52.8     36.7     25.4     22.0     21.6
 MOM.    -773.     558.    1710.    2535.    2950.    2932.    2524.     590.     235.    1162.     454.
 NEG. V     0.0     -6.9    -22.1    -43.8    -68.5    -94.9   -121.5   -147.2   -170.5   -190.1   -204.6
 MOM.       0.     696.    1365.    2239.    2811.    2984.    2724.    2059.    1082.     -54.   -1133.
 RANGE    199.6    186.4    178.1    173.9    171.9    172.0    174.3    183.9    195.9    212.1    226.2

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35  Page   17
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 1.                 DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   645.7    538.4    426.1    310.0    183.5     64.0    -55.1   -180.6   -295.1   -403.1   -502.8
 NEG. V   419.5    326.3    230.2    126.1      9.2   -108.0   -227.0   -354.6   -473.2   -589.5   -702.4
0LL NO. 1.                 DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   702.4    589.5    473.2    354.6    227.0    108.0     -9.2   -126.1   -230.2   -326.3   -419.5
 NEG. V   502.8    403.1    295.1    180.6     55.1    -64.0   -183.5   -310.0   -426.1   -538.4   -645.7

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35   Page   18
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.

0LL NO. 1.                          LIVE LOAD SUPPORT RESULTS
0                          MAX.  AXIAL  LOAD                MAX. LONGITUDINAL MOMENT
                       AXIAL    ------MOMENT------         AXIAL   ------MOMENT------
                       LOAD       TOP        BOT.          LOAD      TOP        BOT.
0MEMBER   3
           POSITIVE    166.1      -919.         0.        -17.3       574.         0.
           NEGATIVE    -17.5       581.         0.        119.5     -2522.         0.
0MEMBER   4
           POSITIVE    255.2         0.         0.        127.1       199.      -100.
           NEGATIVE      0.0         0.         0.        127.1      -199.       100.
0MEMBER   5
           POSITIVE    166.1       919.         0.        119.5      2522.         0.
           NEGATIVE    -17.5      -581.         0.        -17.3      -574.         0.
0    THE RATIO OF SUBSTRUCTURE / SUPERSTRUCTURE LOADING IS 0.812

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:35   Page   19
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 2.                 NEGATIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1    -2137.   -1075.    -285.     -28.    -200.    -371.    -543.    -714.    -886.   -1057.   -1398.
 SHEAR    98.0     80.6     44.8    -14.7    -14.7    -14.7    -14.7    -14.7    -14.7    -14.7    -86.3
0 2    -1398.   -1057.    -886.    -714.    -543.    -371.    -200.     -28.    -285.   -1075.   -2137.
 SHEAR    86.3     14.7     14.7     14.7     14.7     14.7     14.7     14.7    -44.8    -80.6    -98.0
0HORIZONTAL MEMBER STRESSES LL MAX NEG  BOTTOM FIBER
0 1      262.     132.      35.       3.      25.      46.      67.      88.     109.     130.     172.
0 2      172.     130.     109.      88.      67.      46.      25.       3.      35.     132.     262.
0HORIZONTAL MEMBER STRESSES LL MAX NEG  TOP FIBER
0 1     -180.     -90.     -24.      -2.     -17.     -31.     -46.     -60.     -74.     -89.    -117.
0 2     -117.     -89.     -74.     -60.     -46.     -31.     -17.      -2.     -24.     -90.    -180.

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 2.                 DEAD LOAD PLUS NEGATIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1    -8990.   -3310.    1013.    3718.    4849.    4859.    3784.    1591.   -1750.   -6176.  -11856.
0 2   -11856.   -6176.   -1750.    1591.    3784.    4859.    4849.    3718.    1013.   -3310.   -8990.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG BOTTOM FIBER
0 1     1104.     406.    -124.    -457.    -595.    -597.    -465.    -195.     215.     758.    1456.
0 2     1456.     758.     215.    -195.    -465.    -597.    -595.    -457.    -124.     406.    1104.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG  TOP FIBER
0 1     -756.    -278.      85.     313.     408.     408.     318.     134.    -147.    -519.    -997.
0 2     -997.    -519.    -147.     134.     318.     408.     408.     313.      85.    -278.    -756.

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 2.                 POSITIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1      486.     419.    1072.    1720.    2196.    2421.    2376.    2048.    1461.     692.       0.
 SHEAR   -14.7     66.1    123.1    108.7     92.2     74.5    -80.1    -97.9   -114.6   -129.3      0.0
0 2        0.     692.    1461.    2048.    2376.    2421.    2196.    1720.    1072.     419.     486.
 SHEAR     0.0     57.9     43.3     97.9    -62.6    -74.5    -92.2   -108.7   -123.1   -137.4     14.7
0HORIZONTAL MEMBER STRESSES LL MAX POS  BOTTOM FIBER
0 1      -60.     -51.    -132.    -211.    -270.    -297.    -292.    -251.    -179.     -85.       0.
0 2        0.     -85.    -179.    -251.    -292.    -297.    -270.    -211.    -132.     -51.     -60.
0HORIZONTAL MEMBER STRESSES LL MAX POS  TOP FIBER
0 1       41.      35.      90.     145.     185.     204.     200.     172.     123.      58.       0.
0 2        0.      58.     123.     172.     200.     204.     185.     145.      90.      35.      41.

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 2.                 DEAD LOAD PLUS POSITIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
```

```
0 1    -6366.   -1816.    2370.    5466.    7244.    7651.    6703.    4352.     597.   -4427.  -10458.
0 2   -10458.   -4427.     597.    4352.    6703.    7651.    7244.    5466.    2370.   -1816.   -6366.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS BOTTOM FIBER
0 1      782.     223.    -291.    -671.    -890.    -939.    -823.    -534.     -73.     544.    1284.
0 2     1284.     544.     -73.    -534.    -823.    -939.    -890.    -671.    -291.     223.     782.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS  TOP FIBER
0 1     -535.    -153.     199.     459.     609.     643.     563.     366.      50.    -372.    -879.
0 2     -879.    -372.      50.     366.     563.     643.     609.     459.     199.    -153.    -535.

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO.  2.                        LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   141.8    134.4    123.1    108.7     92.2     74.5     56.4     38.9     22.8      9.1      0.0
 MOM.    -205.     376.    1072.    1720.    2196.    2421.    2356.    2003.    1408.     656.       0.
 NEG. V   -14.7    -14.7    -15.4    -28.8    -44.7    -62.1    -80.1    -97.9   -114.6   -129.3   -141.0
 MOM.     486.     315.    1056.    1682.    2165.    2413.    2376.    2048.    1461.     692.    -142.
 RANGE    156.5    149.1    138.4    137.5    136.9    136.6    136.5    136.8    137.4    138.3    141.0
0LL NO.  2.                        LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   141.0    129.3    114.6     97.9     80.1     62.1     44.7     28.8     15.4     14.7     14.7
 MOM.    -142.     692.    1461.    2048.    2376.    2413.    2165.    1682.    1056.     315.     486.
 NEG. V     0.0     -9.1    -22.8    -38.9    -56.4    -74.5    -92.2   -108.7   -123.1   -134.4   -141.8
 MOM.       0.     656.    1408.    2003.    2356.    2421.    2196.    1720.    1072.     376.    -205.
 RANGE    141.0    138.3    137.4    136.8    136.5    136.6    136.9    137.5    138.4    149.1    156.5

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 2.                     DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   582.9    482.7    378.6    271.5    154.1     43.7    -67.2   -185.6   -294.4   -400.9   -502.8
 NEG. V   426.4    333.7    240.2    134.0     17.2    -92.9   -203.7   -322.4   -431.9   -539.3   -643.8
0LL NO. 2.                     DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   643.8    539.3    431.9    322.4    203.7     92.9    -17.2   -134.0   -240.2   -333.7   -426.4
 NEG. V   502.8    400.9    294.4    185.6     67.2    -43.7   -154.1   -271.5   -378.6   -482.7   -582.9

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:36   Page   25
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.

0LL NO. 2.                         LIVE LOAD SUPPORT RESULTS
0                           MAX.  AXIAL  LOAD               MAX. LONGITUDINAL MOMENT
                        AXIAL    ------MOMENT------         AXIAL   ------MOMENT------
                        LOAD       TOP       BOT.           LOAD      TOP       BOT.
0MEMBER   3
           POSITIVE     115.1      -167.         0.        -11.9       395.         0.
           NEGATIVE     -11.9       395.         0.         79.6     -1735.         0.
0MEMBER   4
           POSITIVE     115.7        14.        -7.         81.9       137.       -69.
           NEGATIVE       0.0         0.         0.         81.9      -137.        69.
0MEMBER   5
           POSITIVE     115.1       167.         0.         79.6      1735.         0.
           NEGATIVE     -11.9      -395.         0.        -11.9      -395.         0.
0    THE RATIO OF SUBSTRUCTURE / SUPERSTRUCTURE LOADING IS 0.812

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:36   Page   26
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LIVE LOAD DIAGNOSTICS

0
0LIVE LOAD GENERATOR               LIVE LOAD DISTRIBUTION FACT
0          NUMBER OF LIVE LOAD LANES          RESISTING MOMENT OF        PLOT   PLOT   INFLU-
 MEM    SUPERSTRUCTURE   SUBSTRUCTURE            UNIT STEEL              M   S SCALE   ENCE
  NO.   LT.END   RT.END   LT.END    RT.END     POSITIVE   NEGATIVE        ENV.         LINES  GEN
 ---------------------------------------------------------------------------------------------------

   1      2.464   2.464    2.0       2.0          0.        0.            0      0      NO      NO
   2      2.464   2.464    2.0       2.0          0.        0.
0 LIVE
  LOAD             ----- TRUCK OR TRAIN LOADING   -----                  OVER  RRL IMPACT COMB  CARD
  NO    P1   D1    P2   D2    P3   D3    P4   D4    P5   D5   P6    D6    LOAD                  CONTROL
  4.    27.0 14.0  25.0  4.0  25.0 12.0  25.0  4.0  25.0 35.0  21.7  4.0    8.       YES           01
0       P7   D7    P8   D8    P9   D9    P10  D10   P11  D11  P12   D12
         0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0
0       P13  D13   P14  D14   P15  D15   P16  D16   P17  D17  P18   D18
         0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0
0       P19  D19   P20  D20   P21  D21   P22  D22   P23  D23  P24   D24
         0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0
0       P25  D25   P26  D26   P27  D27   P28  D28   P29  D29  P30   D30
         0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0   0.0  0.0



  IMPACT FACTORS CALCULATED BY PROGRAM
0       MEM       IMPACT
         NO         %


         1          21.
         2          21.
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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 4.                    NEGATIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1    -5689.   -2708.   -647.     -74.    -527.    -981.   -1434.   -1887.   -2340.   -2793.   -3739.
 SHEAR   278.4    222.9    131.3    -38.7    -38.7    -38.7    -38.7    -38.7    -38.7    -38.7   -256.1
0 2    -3739.   -2793.   -2340.   -1887.   -1434.    -981.    -527.     -74.    -647.   -2708.   -5689.
 SHEAR   256.1     38.7     38.7     38.7     38.7     38.7     38.7     38.7   -131.3   -222.9   -278.4
0HORIZONTAL MEMBER STRESSES LL MAX NEG  BOTTOM FIBER
0 1      699.     332.      79.       9.      65.     120.     176.     232.     287.     343.     459.
0 2      459.     343.     287.     232.     176.     120.      65.       9.      79.     332.     699.
0HORIZONTAL MEMBER STRESSES LL MAX NEG  TOP FIBER
0 1     -478.    -228.     -54.      -6.     -44.     -82.    -121.    -159.    -197.    -235.    -314.
0 2     -314.    -235.    -197.    -159.    -121.     -82.     -44.      -6.     -54.    -228.    -478.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:36   Page   28
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 4.                    DEAD LOAD PLUS NEGATIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1   -12542.   -4942.     651.    3672.    4521.    4250.    2893.     418.   -3204.   -7912.  -14197.
0 2   -14197.   -7912.   -3204.     418.    2893.    4250.    4521.    3672.     651.   -4942.  -12542.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG BOTTOM FIBER
0 1     1540.     607.     -80.    -451.    -555.    -522.    -355.     -51.     393.     971.    1743.
0 2     1743.     971.     393.     -51.    -355.    -522.    -555.    -451.     -80.     607.    1540.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX NEG  TOP FIBER
0 1    -1054.    -415.      55.     309.     380.     357.     243.      35.    -269.    -665.   -1193.
0 2    -1193.    -665.    -269.      35.     243.     357.     380.     309.      55.    -415.   -1054.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:36   Page   29
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 4.                    POSITIVE LIVE LOAD MOMENT ENVELOPE AND ASSOCIATED SHEARS
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1     1285.     832.    1649.    3329.    4596.    5123.    5044.    4188.    2607.     742.       0. ←
 SHEAR   -38.7    -38.7    169.7    149.7    100.7     49.3    -67.3   -118.8   -193.2   -129.2      0.0
0 2        0.     742.    2607.    4188.    5044.    5123.    4596.    3329.    1649.     832.    1285. ←
 SHEAR     0.0    129.2    193.2    118.8     67.3    -49.3   -100.7   -149.7   -169.7     38.7     38.7
0HORIZONTAL MEMBER STRESSES LL MAX POS  BOTTOM FIBER
0 1     -158.    -102.    -202.    -409.    -564.    -629.    -619.    -514.    -320.     -91.       0.
0 2        0.     -91.    -320.    -514.    -619.    -629.    -564.    -409.    -202.    -102.    -158.
0HORIZONTAL MEMBER STRESSES LL MAX POS  TOP FIBER
0 1      108.      70.     139.     280.     386.     431.     424.     352.     219.      62.       0.
0 2        0.      62.     219.     352.     424.     431.     386.     280.     139.      70.     108.

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 4.                    DEAD LOAD PLUS POSITIVE LIVE LOAD MOMENT ENVELOPE
0MEM    LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 NO
0 1    -5568.   -1403.    2947.    7075.    9645.   10353.    9371.    6493.    1743.   -4377.  -10458.
0 2   -10458.   -4377.    1743.    6493.    9371.   10353.    9645.    7075.    2947.   -1403.   -5568.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS BOTTOM FIBER
0 1      684.     172.    -362.    -869.   -1184.   -1271.   -1151.    -797.    -214.     537.    1284.
0 2     1284.     537.    -214.    -797.   -1151.   -1271.   -1184.    -869.    -362.     172.     684.
0HORIZONTAL MEMBER STRESSES FOR DL+LL MAX POS  TOP FIBER
0 1     -468.    -118.     248.     595.     811.     870.     788.     546.     146.    -368.    -879.
0 2     -879.    -368.     146.     546.     788.     870.     811.     595.     248.    -118.    -468.

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO.  4.                       LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   366.0    325.4    279.9    237.0    191.1    144.6     99.9     59.2     26.4      6.9      0.0
 MOM.   -4262.   -1572.    1318.    3017.    4101.    4450.    4053.    3012.    1627.     500.       0.
 NEG. V   -38.7    -38.7    -38.7    -42.0    -75.3   -115.4   -159.8   -206.2   -255.7   -301.2   -344.2
 MOM.    1285.     832.     379.    2427.    3574.    4319.    4437.    3816.    2246.      56.   -2829.
 RANGE    404.8    364.2    318.6    279.0    266.4    260.0    259.6    265.4    282.1    308.1    344.2
0LL NO.  4.                       LIVE LOAD SHEAR ENVELOPES AND ASSOCIATED MOMENTS
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   344.2    301.2    255.7    206.2    159.8    115.4     75.3     42.0     38.7     38.7     38.7
 MOM.   -2829.      56.    2246.    3816.    4437.    4319.    3574.    2427.     379.     832.    1285.
 NEG. V     0.0     -6.9    -26.4    -59.2    -99.9   -144.6   -191.1   -237.0   -279.9   -325.4   -366.0
 MOM.       0.     500.    1627.    3012.    4053.    4450.    4101.    3017.    1318.   -1572.   -4262.
 RANGE    344.2    308.1    282.1    265.4    259.6    260.0    266.4    279.0    318.6    364.2    404.8

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:36   Page   32
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0LL NO. 4.                    DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  1 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   807.1    673.8    535.5    399.8    253.1    113.8    -23.7   -165.3   -290.8   -403.1   -502.8
 NEG. V   402.4    309.6    216.9    120.9    -13.4   -146.2   -283.4   -430.7   -573.0   -711.2   -847.0
0LL NO. 4.                    DEAD LOAD PLUS LIVE LOAD SHEAR ENVELOPE
0MEMBER  2 LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0POS. V   847.0    711.2    573.0    430.7    283.4    146.2     13.4   -120.9   -216.9   -309.6   -402.4
 NEG. V   502.8    403.1    290.8    165.3     23.7   -113.8   -253.1   -399.8   -535.5   -673.8   -807.1

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                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
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0LL NO. 4.                        LIVE LOAD SUPPORT RESULTS
0                          MAX.  AXIAL  LOAD                MAX. LONGITUDINAL MOMENT
                       AXIAL    ------MOMENT------         AXIAL   ------MOMENT------
                       LOAD       TOP        BOT.          LOAD      TOP        BOT.
0MEMBER   3
           POSITIVE     297.1     -3460.         0.        -31.4      1043.         0.
           NEGATIVE     -31.4      1043.         0.        226.0     -4618.         0.
0MEMBER   4
           POSITIVE     334.2        26.       -13.        239.1       362.      -181.
           NEGATIVE       0.0         0.         0.        239.1      -362.       181.
0MEMBER   5
           POSITIVE     297.1      3460.         0.        226.0      4618.         0.
           NEGATIVE     -31.4     -1043.         0.        -31.4     -1043.         0.
0    THE RATIO OF SUBSTRUCTURE / SUPERSTRUCTURE LOADING IS 0.812

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:36   Page   34
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.


0     PRESTRESS COMBINATION DATA

0     NO PRESTRESS COMBINATION DATA GIVEN SO DEFAULTS WERE USED.
0     LIVE LOAD NUMBER '1' RESULTS USED FOR P/S DESIGN AND OTHER LIVE LOADS, IF PRESENTED,
      ALSO WILL BE CHECKED TO DETERMINE THE ULTIMATE MOMENT CAPACITY.


0     THE FOLLOWING VALUES ARE BEING USED IN THE CALCULATION OF MOMENT & SHEAR REQUIREMENTS.
0        D.L. LOAD FACTOR: 1.30

         L.L. LOAD FACTOR: 2.17  OR  1.30

         PHI FACTOR FOR SHEAR : 0.90

         PHI FACTOR FOR MOMENT: 0.95


0     LL NO. 1     ULTIMATE MOMENT APPLIED = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. MOMENT)
0     LL NO. 2     ULTIMATE MOMENT APPLIED = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. MOMENT)
0     LL NO. 4     ULTIMATE MOMENT APPLIED = 1.30 X (DL+ADL) + 1.30 X (LL+I) + 1.00 X (P/S SEC. MOMENT)
0     LL NO. 1     ULTIMATE SHEAR APPLIED  = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. SHEAR)
0     LL NO. 2     ULTIMATE SHEAR APPLIED  = 1.30 X (DL+ADL) + 2.17 X (LL+I) + 1.00 X (P/S SEC. SHEAR)
0     LL NO. 4     ULTIMATE SHEAR APPLIED  = 1.30 X (DL+ADL) + 1.30 X (LL+I) + 1.00 X (P/S SEC. SHEAR)

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:36   Page   35
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0INPUT PRESTRESSED DATA
0TRIAL  1    FRAME 1    PATH 01
0      MEM
       NO.     LLT/X     LLP/Y   LRT/Z       YLT/TYPE   YLP/SLOPE  YRT       U        K
0        1      0.00      0.40    0.10       1.33       4.08       0.83       0.25   0.0002
0        2      0.10      0.60    0.00       0.83       4.08       1.33       0.25   0.0002

0XLT(FT) =   0.0  XRT(FT) =   0.0  STEEL STRESS(KSI) = 270.  JACKING % = 0.75  JACKING ENDS = B
0ANCHOR SET(IN); LEFT = 0.625  RIGHT = 0.625  CONC. STRENGTH(PSI) = 4500.  ALLOW. TENSION(PSI) = -402.
0P-JACK(KIPS) =   5209.   SHORTENING PERCENT=  50   TOTAL LOSSES(KSI) = 27   RELATIVE HUMIDITY % = 70.
0LOW-LAX = YES   PLOT PATHS = NO    PLOT STRESSES = NO


0CABLE PATH OFFSETS
0MEMBER  LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1      1.33     2.53     3.39     3.91     4.08     3.97     3.65     3.10     2.35     1.37     0.83
0 2      0.83     1.37     2.35     3.10     3.65     3.97     4.08     3.91     3.39     2.53     1.33
0CABLE PATH ECCENTRICITIES
0  1   -0.568    0.635    1.495    2.010    2.182    2.074    1.749    1.207    0.449   -0.526   -1.068
0  2   -1.068   -0.526    0.449    1.207    1.749    2.074    2.182    2.010    1.495    0.635   -0.568
0FORCE COEFFICIENTS
0  1    0.722    0.731    0.741    0.750    0.760    0.765    0.772    0.779    0.785    0.792    0.776
0  2    0.776    0.792    0.785    0.779    0.772    0.765    0.760    0.750    0.741    0.731    0.722
0THE POINT OF NO MOVEMENT FOR PRESTRESSING IS IN SPAN 1, 117.00 FEET FROM THE LEFT END OF THE SPAN
0THE LEFT ANCHOR SET LENGTH IS 107.90                      THE RIGHT ANCHOR SET LENGTH IS 107.90
0THE FORCE COEF. AT THE LEFT END IS  0.722                 THE FORCE COEF. AT THE RIGHT END IS  0.722

0INITAL FORCE COEFF. AT POINT OF NO MOVEMENT = 0.910

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:37   Page   36
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0SECONDARY MOMENT DUE TO PJACK = 1
0TRIAL  1    FRAME 1    PATH 01
                                  FEM'S DUE TO SECONDARY EFFECTS BEFORE BALANCING

   MEMBER    LEFT END   RIGHT END  MEMBER      LEFT END  RIGHT END   MEMBER    LEFT END   RIGHT END
0     1        1.321      0.281       2          0.281      1.321
0                                 DEM'S DUE TO SECONDARY EFFECTS --- UNIT = K-FT
0     1        0.978      0.452       2          0.452      0.978
0                                 DEM'S DUE TO SECONDARY EFFECTS IN COLUMN --- UNIT = K-FT
0     3        0.000      0.978       4          0.000      0.000     5          0.000     -0.978
0P/S MOMENT COEF.
                             *** SIDESWAY INCLUDED. DEAD LOAD WAS SWAYED. ***
                            ADJUSTED FOR LOSSES & SECONDARY MOMENTS BUT NO SHORTENING
 MEM
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  NO    LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1   1.3878    0.4610  -0.2342  -0.6877  -0.8897  -0.8722  -0.6877  -0.3300   0.2049   0.9213   1.2810
0 2   1.2810    0.9213   0.2049  -0.3300  -0.6877  -0.8722  -0.8897  -0.6877  -0.2342   0.4610   1.3878
0***** WARNING - THIS FRAME WILL NOT SHORTEN SO COEFF. WILL NOT BE ADJUSTED FOR SHORTENING. *****
0***** WARNING - THIS FRAME WILL NOT SHORTEN SO COEFF. WILL NOT BE ADJUSTED FOR SHORTENING. *****

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page   37
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL  1  FRAME 1  PATH 01
0HORIZONTAL MEMBER STRESSES PRESTRESS ONLY BOTTOM FIBER AFTER ALL LOSSES (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    -382.      217.     668.     965.    1101.    1094.     980.     756.     419.     -35.    -276.
0 2    -276.      -35.     419.     756.     980.    1094.    1101.     965.     668.     217.    -382.
0HORIZONTAL MEMBER STRESSES PRESTRESS ONLY TOP FIBER AFTER ALL LOSSES (PS1)
0 1    1113.      714.     416.     224.     142.     154.     240.     401.     640.     958.    1104.
0 2    1104.      958.     640.     401.     240.     154.     142.     224.     416.     714.    1113.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page   38
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL  1    FRAME 1    PATH 01
0HORIZONTAL MEMBER MOMENTS DUE TO P/S
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    7229.    2401.   -1220.   -3582.   -4634.   -4543.   -3582.   -1719.    1067.    4799.    6673.
0 2    6673.    4799.    1067.   -1719.   -3582.   -4543.   -4634.   -3582.   -1220.    2401.    7229.
0VERTICAL MEMBER MOMENTS DUE TO P/S
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 3       0.     509.    1019.    1528.    2038.    2547.    3057.    3566.    4076.    4585.    5095.
0 4       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
0 5       0.    -509.   -1019.   -1528.   -2038.   -2547.   -3057.   -3566.   -4076.   -4585.   -5095.
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END     SPAN    LT. END     RT. END     SPAN   LT. END     RT. END
0     1    -0.000569    0.000000      2     0.000000    0.000569      3     0.000285   -0.000569
0     4     0.000000    0.000000      5    -0.000285    0.000569
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
0     MEMBER  1    E= 4066.     0.000    -0.032    -0.047    -0.023     0.000
0     MEMBER  2    E= 4066.     0.000    -0.023    -0.047    -0.032     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  3    E= 3320.     0.000     0.000     0.001     0.001     0.000
0     MEMBER  4    E= 3320.     0.000     0.000     0.000     0.000     0.000
0     MEMBER  5    E= 3320.     0.000     0.000    -0.001    -0.001     0.000

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page   39
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS BEFORE LOSSES BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    -448.      260.     791.    1137.    1294.    1284.    1149.     884.     488.     -43.    -324.
0 2    -324.      -43.     488.     884.    1149.    1284.    1294.    1137.     791.     260.    -448.
0HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS BEFORE LOSSES TOP FIBER (PSI)
0 1    1315.      842.     490.     264.     167.     181.     282.     470.     749.    1120.    1295.
0 2    1295.     1120.     749.     470.     282.     181.     167.     264.     490.     842.    1315.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page   40
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS AFTER ALL LOSSES BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    -382.      217.     668.     965.    1101.    1094.     980.     756.     419.     -35.    -276.
0 2    -276.      -35.     419.     756.     980.    1094.    1101.     965.     668.     217.    -382.
0 HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS AFTER ALL LOSSES TOP FIBER (PSI)
0 1    1113.      714.     416.     224.     142.     154.     240.     401.     640.     958.    1104.
0 2    1104.      958.     640.     401.     240.     154.     142.     224.     416.     714.    1113.
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1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:37   Page   41
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES  DL + P/S BEFORE ALL LOSSESBOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1     393.      534.     631.     677.     674.     641.     617.     601.     594.     586.     960.
0 2     960.      586.     594.     601.     617.     641.     674.     677.     631.     534.     393.
0HORIZONTAL MEMBER STRESSES  DL + P/S BEFORE ALL LOSSESTOP FIBER (PSI)
0 1     739.      654.     599.     578.     592.     621.     645.     664.     677.     690.     415.
0 2     415.      690.     677.     664.     645.     621.     592.     578.     599.     654.     739.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:37   Page   42
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES  DL + P/S AFTER ALL LOSSES BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1     459.      491.     509.     505.     481.     452.     449.     473.     525.     594.    1008.
0 2    1008.      594.     525.     473.     449.     452.     481.     505.     509.     491.     459.
0HORIZONTAL MEMBER STRESSES  DL + P/S AFTER ALL LOSSES TOP FIBER (PSI)
0 1     537.      526.     525.     539.     567.     594.     603.     594.     567.     528.     225.
0 2     225.      528.     567.     594.     603.     594.     567.     539.     525.     526.     537.
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + P/S AFTER ALL LOSSES BOTTOM FIBER (PSI)
0 1     577.      530.     486.     441.     394.     361.     375.     434.     540.     682.    1189.
0 2    1189.      682.     540.     434.     375.     361.     394.     441.     486.     530.     577. ←
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + P/S AFTER ALL LOSSES TOP FIBER (PSI)
0 1     456.      500.     541.     583.     626.     655.     654.     621.     557.     467.     102.
0 2     102.      467.     557.     621.     654.     655.     626.     583.     541.     500.     456. ←

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:37   Page   43
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TRIAL   1   FRAME  1
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX POS LL + I + P/S  BOTTOM FIBER (PSI)
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1     490.      462.     346.     183.      52.     -18.       2.     117.     328.     609.    1189.
0 2    1189.      609.     328.     117.       2.     -18.      52.     183.     346.     462.     490.
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX POS LL + I + P/S  TOP FIBER (PSI)
0 1     515.      546.     637.     760.     860.     915.     909.     838.     702.     517.     102.
0 2     102.      517.     702.     838.     909.     915.     860.     760.     637.     546.     515.
0HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX NEG LL + I + P/S  BOTTOM FIBER (PSI)
0 1     959.      719.     535.     446.     430.     428.     472.     561.     698.     917.    1610.
0 2    1610.      917.     698.     561.     472.     428.     430.     446.     535.     719.     959.
0HORIZONTAL MEMBER STRESSES  DL + ADDED DL + MAX NEG LL+ I + P/S  FOR TOP FIBER (PSI)
0 1     195.      370.     507.     580.     602.     610.     588.     534.     449.     306.    -187.
0 2    -187.      306.     449.     534.     588.     610.     602.     580.     507.     370.     195.


0**** MIN PJACK =    5210. KIPS CONC STRENGTH AT 28 DAYS =   4025. PSI AT STRESSING =   1833. PSI  ****


1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:37   Page   44
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TOTAL PE MOMENTS FOR ALL MEMBERS.
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    7229.     2401.   -1220.   -3582.   -4634.   -4543.   -3582.   -1719.    1067.    4799.    6673.
0 2    6673.     4799.    1067.   -1719.   -3582.   -4543.   -4634.   -3582.   -1220.    2401.    7229.
0 3       0.      509.    1019.    1528.    2038.    2547.    3057.    3566.    4076.    4585.    5095.
0 4       0.        0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
0 5       0.     -509.   -1019.   -1528.   -2038.   -2547.   -3057.   -3566.   -4076.   -4585.   -5095.
0TOTAL P/S DEFLECTION FOR TRIAL
0TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE
    SPAN    LT. END     RT. END     SPAN    LT. END     RT. END     SPAN   LT. END     RT. END
0     1    -0.000569    0.000000      2     0.000000    0.000569      3     0.000285   -0.000569
0     4     0.000000    0.000000      5    -0.000285    0.000569
0HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE
0     MEMBER  1    E= 4066.     0.000    -0.032    -0.047    -0.023     0.000
0     MEMBER  2    E= 4066.     0.000    -0.023    -0.047    -0.032     0.000
0VERTICAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END.
0     MEMBER  3    E= 3320.     0.000     0.000     0.001     0.001     0.000
0     MEMBER  4    E= 3320.     0.000     0.000     0.000     0.000     0.000
0     MEMBER  5    E= 3320.     0.000     0.000    -0.001    -0.001     0.000

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT      Run time: 12-JUL-95 16:18:37   Page   45
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0TOTAL TOP PF FOR TRIAL
 MEM
  NO   LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0 1    3758.        0.       0.       0.       0.       0.       0.       0.       0.    4124.    4043.
0 2    4043.     4124.       0.       0.       0.       0.       0.       0.       0.       0.    3758.
0TOTAL BOTTOM PF FOR TRIAL
0 1       0.     3809.    3858.    3908.    3956.    3987.    4022.    4056.    4090.       0.       0.
0 2       0.        0.    4090.    4056.    4022.    3987.    3956.    3908.    3858.    3809.       0.
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1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page    46
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0                                                  LONG TERM LOSSES
                                    TOTAL LOSS (KSI) = SH + ES + CRC + CRS
 MEM
  NO    LEFT     .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
0   1   17.5      17.8     18.7     19.3     19.3     18.9     18.8     18.9     19.1     19.1     16.2
0   2   16.2      19.1     19.1     18.9     18.8     18.9     19.3     19.3     18.7     17.8     17.5
0                                          SHEAR DESIGN - AASHTO 1980
0            LEFT    .1 PT    .2 PT    .3 PT    .4 PT    .5 PT    .6 PT    .7 PT    .8 PT    .9 PT    RIGHT
 MEMBER:  1
0V-CABLE      425.     334.     226.     115.       3.      74.     149.     225.     302.     352.      47.
 SECONDARY    -23.     -23.     -23.     -23.     -23.     -23.     -23.     -23.     -23.     -23.     -23.
 VU          1107.     916.     725.     537.     333.     237.     431.     638.     832.    1023.    1217.
 VC          1100.    1170.    1066.     697.     403.     273.     416.     659.     751.     873.     903.
 REQD WEB      48.      48.      48.      48.      48.      48.      48.      48.      48.      48.      48.
 AS(IN)/FT    0.58     0.48 *   0.48 *   0.48 *   0.48 *   0.48 *   0.48 *   0.48 *   0.77     1.18     2.00

 MEMBER:  2
0V-CABLE       47.     352.     302.     225.     149.      74.       3.     115.     226.     334.     425.
 SECONDARY     23.      23.      23.      23.      23.      23.      23.      23.      23.      23.      23.
 VU          1217.    1023.     832.     638.     431.     237.     333.     537.     725.     916.    1107.
 VC           903.    1125.     751.     659.     416.     273.     403.     697.    1066.    1170.    1100.
 REQD WEB      48.      48.      48.      48.      48.      48.      48.      48.      48.      48.      48.
 AS(IN)/FT    2.00     0.48 *   0.77     0.48 *   0.48 *   0.48 *   0.48 *   0.48 *   0.48 *   0.48 *   0.58

0NOTE:  * AFTER REQD WEB INDICATES ADDITIONAL WEB WIDTH REQD.   * AFTER AS(IN)/FT INDICATES MINIMUM REQD.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page    47
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
                                 AASHTO ULTIMATE MOMENT
0           SECOND    ULT MOM    ULT MOM  AVERAGE    NEUTRAL    MILD STEEL    COMBINED        ULT MOM   ULT MOM
            MOMENT     APPLD     P/S CAP    FSU       AXIS        REQD     REINFORCEMENT     MILD CAP  TOTAL CAP
            (K-FT)    (K-FT)     (K-FT)    (KSI)      (IN)      (SQ.IN)       INDEX           (K-FT)    (K-FT)
0MEMBER:  1
0 0.0 PT.     5095.    12461.    19309.  254.61      6.88       0.00         0.123             0.    19309.
0 0.1 PT.     4821.     2713.    14754.  255.39      4.92       0.00         0.116             0.    14754.
0 0.2 PT.     4547.     8955.    20394.  259.43      5.11       0.00         0.088             0.    20394.
0 0.3 PT.     4273.    14385.    23882.  261.95      5.16       0.00         0.077             0.    23882.
0 0.4 PT.     3999.    17531.    25058.  262.79      5.18       0.00         0.074             0.    25058.
0 0.5 PT.     3725.    18189.    24316.  262.26      5.16       0.00         0.076             0.    24316.  ←
0 0.6 PT.     3451.    16453.    22106.  260.68      5.13       0.00         0.082             0.    22106.
0 0.7 PT.     3177.    12183.    18476.  258.00      5.08       0.00         0.096             0.    18476.
0 0.8 PT.     2903.     5371.    13535.  254.37      4.92       0.00         0.125             0.    13535.
0 0.9 PT.     2629.     9115.    19038.  254.44      6.88       0.00         0.124             0.    19038.
0 1.0 PT.     2355.    20598.    22593.  256.57      6.88       0.00         0.107             0.    22593.
0MEMBER:  2
0 0.0 PT.     2355.    20598.    22593.  256.57      6.88       0.00         0.107             0.    22593.
0 0.1 PT.     2629.     9115.    19038.  254.44      6.88       0.00         0.124             0.    19038.
0 0.2 PT.     2903.     5371.    13535.  254.37      4.92       0.00         0.125             0.    13535.
0 0.3 PT.     3177.    12183.    18476.  258.00      5.08       0.00         0.096             0.    18476.
0 0.4 PT.     3451.    16453.    22106.  260.68      5.13       0.00         0.082             0.    22106.
0 0.5 PT.     3725.    18189.    24316.  262.26      5.16       0.00         0.076             0.    24316.  ←
0 0.6 PT.     3999.    17531.    25058.  262.79      5.18       0.00         0.074             0.    25058.
0 0.7 PT.     4273.    14385.    23882.  261.95      5.16       0.00         0.077             0.    23882.
0 0.8 PT.     4547.     8955.    20394.  259.43      5.11       0.00         0.088             0.    20394.
0 0.9 PT.     4821.     2713.    14754.  255.39      4.92       0.00         0.116             0.    14754.
0 1.0 PT.     5095.    12461.    19309.  254.61      6.88       0.00         0.123             0.    19309.

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page    48
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0                                                  TENDON ELONGATION
0   PATH NO.       P-JACK      % JACK      FY        AS       AVE STRESS     TENDON LENGTH    ELONGATION
                   (KIPS)                 (KSI)    (SQ IN)      (KSI)           (FT) *          (IN)
0     01           5210.         75.      270.     25.73       193.82          238.00          19.77
0NOTE: TENDON LENGTH INCLUDES 4 FEET FOR JACKS.
0      MODULUS USED FOR P/S STEEL IS 28000. KSI

1IAI-BDS      Version 4.0.13      Licensed to: Colorado DOT       Run time: 12-JUL-95 16:18:37   Page    49
                      STRUCTURE G-04-AL; SH-70; CBGCP; PROJ#I70-1(75)57; M.M.
0                                             'APPROXIMATE QUANTITY'
                                               ====================
0                              *****  CONCRETE SUPER            465 C.Y.  *****

                               *****  CONCRETE SUB                0 C.Y.  *****
0                              *****  P/S TRIAL               20465 LBS.  *****
0                     THE SUPERSTRUCTURE CONCRETE QUANTITY IS BASED ON THE UNIT
                      WEIGHT OF CONCRETE SUPPLIED ON THE FRAME DESCRIPTION CARD.
                      IT ASSUMES THAT ALL THE DEAD LOAD IS GIVEN IN TRIAL 0.

                      THE CONCRETE SUBSTRUCTURE QUANTITY IS BASED ON TRIAL 0 ONLY.

                      THE P/S QUANTITIES FOR STRAND ONLY ARE FOR EACH TRIAL, THAT
                      WAS ENTERED AND IN THAT ORDER.  STRAND USE IS BASED ON THE
                      LENGTH FROM ANCHOR TO ANCHOR.
1END OF JOB - 022086
0                   INCREMENTED CPU TIME (SECONDS)=      1. INCREMENTED CLOCK TIME (SECONDS)=    5.
```

SECTION 10 – STEEL BRIDGES

10-1 INTRODUCTION TO RATING STEEL BRIDGES

This section together with Section 1, presents the policies and guidelines for rating steel girders. Policies are covered in subsection 10-2, while supporting guidelines are presented in subsections 10-2, 3, and 4.

The types of girders covered by this section are:

CI	Concrete on I-Beam
CIC	Concrete on I-Beam Continuous
CIK	Concrete on I-Beam Composite
CICK	Concrete on I-Beam Continuous and Composite
SBG	Steel Box Girder
SBGC	Steel Box Girder Continuous
SDG	Steel Deck Girder
SDGC	Steel Deck Girder Continuous
SSD	Steel Stringer - Concrete Deck
SSE	Steel Stringer - Earth Filled
SSM	Steel Stringer - Metal Plank Floor
SSMC	Steel Stringer Continuous - Metal Plank Floor
SSS	Steel Stringer - Timber Floor
SSSC	Steel Stringer Continuous - Timber Floor
STG	Steel Through Girder
WG	Welded Girder
WGC	Welded Girder Continuous
WGK	Welded Girder Composite
WGCK	Welded Girder Continuous and Composite

10-2 POLICIES AND GUIDELINES FOR RATING STEEL BRIDGES

I. General

A. All steel girders (except for girders in Truss Bridges) shall be rated by the VIRTIS program or one acceptable to the CDOT Bridge Branch.

B. Steel girders with considerable stress/strain effects due to horizontal curvature, skew, temperature, or other influences shall be modeled as simple, straight beams on pin or roller supports. The VIRTIS output results can then be supplemented with hand calculations to consider any of these significant influences, as necessary. *Also, when appropriate, steel girders having or lacking horizontal curvature effects and depending on the type of girder to be analyzed, DESCUS I or DESCUS II may also be used to perform the rating.*

C. All steel bridges shall be rated by the load factor method.

D. Use the minimum design yield strength value (Fy) and the minimum compressive strength of concrete (F'c) from plans.

E. For SSE, SSM and SSS structure types, it is acceptable to disregard AASHTO's allowable stress reduction formula for unsupported compression flanges. If the condition of the girder indicates that full yield strength should not be used, the rating stresses should be reduced as appropriate.

F. Steel box girder template has not been incorporated in the current version of Virtis 4.0.4. However, steel box girders can be rated using ½ the single-girder parameters in the analysis. The live load distribution factor and the dead load shall be adjusted accordingly.

II. Girders Requiring Rating

A. Interior Girders - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, differences in loads or moments, grade of structural steel, etc.

B. Exterior Girders - An exterior girder shall be rated under the following guidelines.

1. When the section used for an exterior girder is different than the section used for an interior girder.

2. When the overhang is greater than S/2.

3. When the plans indicate that the curb and floor slab were poured monolithically, the live load distribution factor for the exterior girder should be calculated and compared to the live load distribution factor (LLDF) for the interior girders. If the LLDF for the exterior girder is equal to or greater than 75% of the LLDF for the interior girders, the exterior girder shall be rated.

4. When the rater determines the rating would be advantageous in analyzing the overall condition of a structure.

III. Calculations

A. A set of calculations, separate from computer output shall be prepared and submitted with each rating. These calculations shall include derivations for dead loads, derivations for live load distribution factors, and any other calculations or assumptions used for rating.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.

2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt, curbs, sidewalks, railing, etc.

3. Use 5 psf for the unit weight of permanent steel bridge deck forms.

4. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as non-composite loads. Examples of this type of dead load are deck slabs, girders, stiffeners, splices and diaphragms. The weight of diaphragms may be treated as point loads or as an equivalent uniform dead load for the span under consideration.

EXAMPLE: For two diaphragms (P) at 1/3 points

$(PL)/3 = M = (wL \times L)/8$

Equivalent uniform load . . . $w = (8P)/3L$

5. The method of applying dead loads due to utilities is left to the rater's discretion.

IV. Rating Reporting/Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. Additionally, yield strength (Fy) of structural steel used in the analysis and any variation from the original design assumptions shall be added to the Rating Summary Sheet. The rating package requirements shall be per Section 1-13 of this manual and as amended herein:

Consultant designed projects – Before finalizing the rating package and when VIRTIS is used as the analysis tool, the Rater shall verify with the Staff Bridge Rating Coordinator that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower version of the program shall be rejected. It is required for the CDOT data archive, since the data base management feature inside the program would not work satisfactorily. After the analysis is completed, the rater shall save the data file. When saving is finalized, the rater shall export the data file in *.bbd format (i.e., F-17-IE.bbd format; bbd = BRIDGEWare Bridge Data File) on an IBM- compatible 3.5" PC Disk for delivery with the rating package. Also, the version number used during analysis shall be written on the diskette label. This ensures proper importation of bridge data archive by Staff Bridge at a later date.

10-3 GUIDELINES FOR USING THE VIRTIS RATING PROGRAM

The VIRTIS computer program performs the analysis and rating of simple span and multi-span steel girder bridges. It uses the BRASS ASD or the BRASS LFD engine for analysis. This program was developed in accordance with the AASHTO STANDARD SPECIFICATIONS, 16TH EDITION AND THE AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES.

A maximum of thirteen (13) spans can be modeled using the program. Linear or parabolic girder web depth variation over the length of a defined cross-section can be modeled using Virtis. When a structure model is finalized, it can be rated using the ASD or the LFD method. The LRFD rating module is currently being developed and will be available in the future. When a structure model is being generated and before any analysis can be performed, it is recommended that Virtis users save the data to memory periodically. This can be accomplished by using the File and Save feature of this program.

The library explorer can be used to save commonly used items (beam shapes, non standard vehicles, materials, appurtenances etc.) and this eliminates the need for all users to define the same items repeatedly throughout the program. Once a new girder shape is defined or copied from the library, Virtis automatically computes the required section properties and beam constants.

Dead load from the girder self weight, deck slab and appurtenances (i.e. rails, median barrier etc.) are calculated automatically by the program. Dead load from the haunch, wearing surface and stiffener weight (for steel bridges) is defined by the user. For a detailed description of the girder loads, refer to the Opis/Virtis Help Menu index item - dead loads. When a structure is being modeled, the help menu can be activated by using the F1 key if the user requires clarification on a particular item in the GUI window.

In the Live Load Distribution Factor window, when the compute button is used to calculate the DF’s automatically by the program, Virtis users shall verify that these numbers are accurate and matches their calculated numbers.

All Colorado BT girder shapes, W-beam shapes, the Colorado permit vehicle, the Colorado posting trucks, and the Interstate posting trucks have been added to the Virtis library explorer and may be copied by the user. The Staff Bridge Rating Coordinator shall be responsible for updating existing information or adding new information (i.e. beam shapes, vehicles, etc.) to the library explorer.

The configuration browser provides access to the configuration features of Virtis. It may be employed to provide specific access privileges, i.e. read, write, delete etc., to the users. This feature is extremely powerful, since Virtis/Opis uses and shares the bridge data from one common source. Therefore, it is required that users of this program create a folder from the bridge explorer window (**EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

10-4 RATING STEEL BRIDGES WITHOUT PLANS

It is possible that the only information a rater may have to rate an old steel bridge is field measurements of the members and the directions of the AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES 1994, Second Edition. A convenient source of beam information is the book titled “Historical Record-Dimensions and Properties-Iron and Steel Beams 1873 to 1952”, published by the American Institute of Steel Construction (AISC). This book can help the rater determine the approximate year the beams were rolled. The rater can then determine the section properties and the allowable stresses to be used to rate the steel beams.

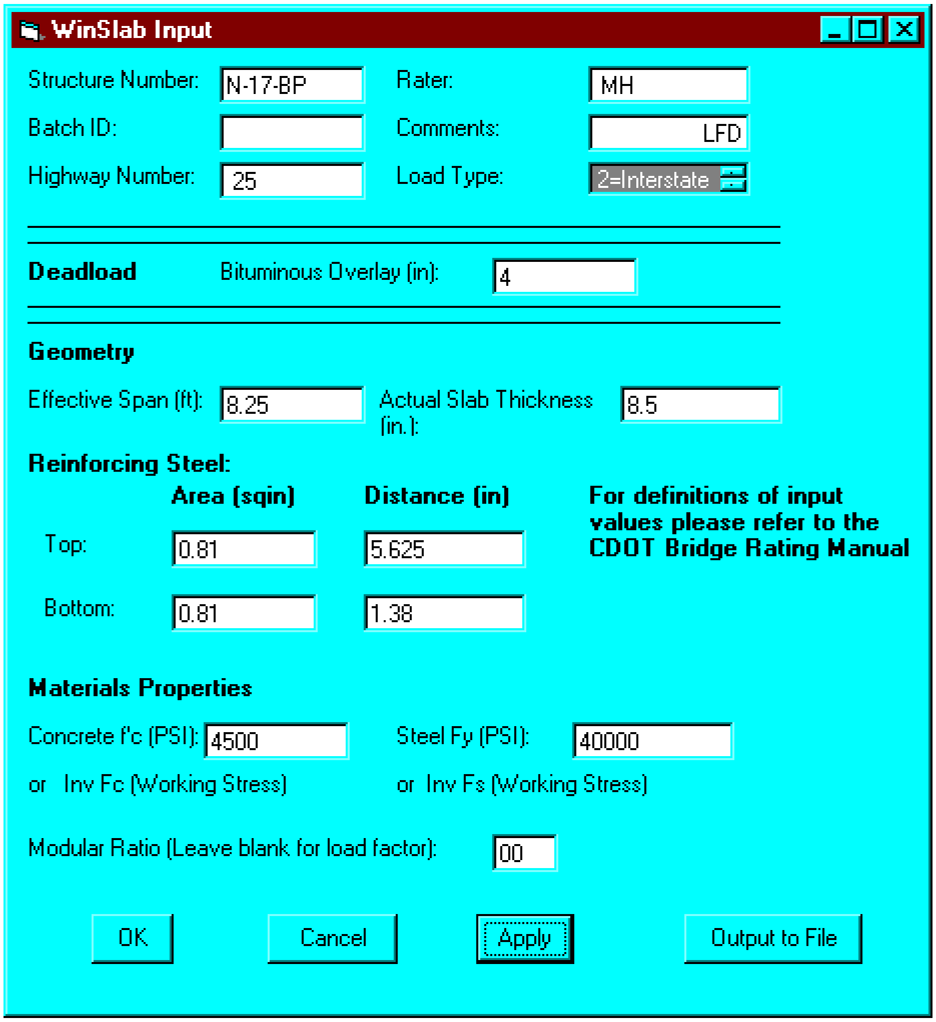
10-5 STEEL GIRDER BRIDGE RATING EXAMPLE

One example is presented in this section. Structure N-17-BP is a two (2) span continuous composite welded girder bridge with a skew of 0° degrees. Note that the girder web varies linearly near the pier. For simplicity, only the interior girder has been modeled for this structure.

One curved welded girder example using Descus-I will be presented at a later date.

Also, one curved welded box girder example using Descus-II will be presented at a later date.

Slab Rating Program Input, Structure No. N-17-BP



Structure Number: N-17-BP
Rater: MH
Batch ID:
Comments: LFD
Highway Number: 25
Load Type: 2=Interstate

Deadload
Bituminous Overlay (in): 4

Geometry
Effective Span (ft): 8.25
Actual Slab Thickness (in.): 8.5

Reinforcing Steel:

	Area (sqin)	**Distance (in)**
Top:	0.81	5.625
Bottom:	0.81	1.38

For definitions of input values please refer to the CDOT Bridge Rating Manual

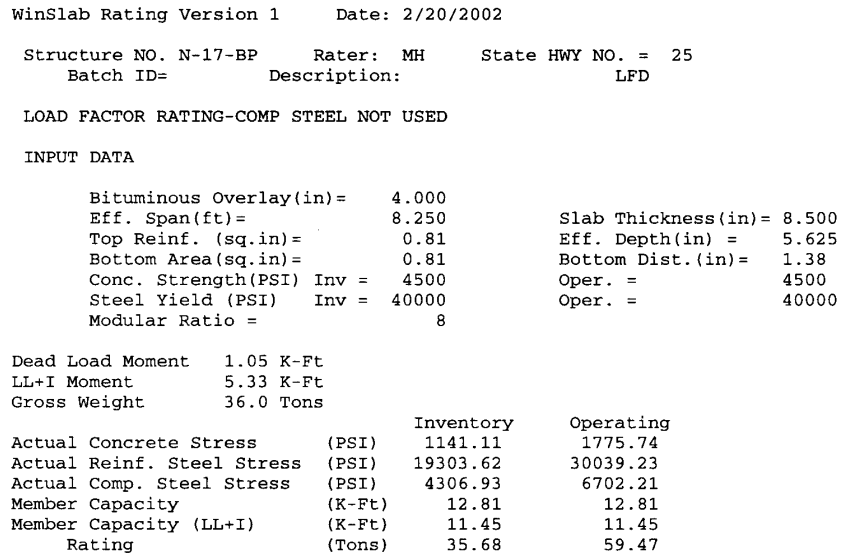
Materials Properties
Concrete f'c (PSI): 4500
Steel Fy (PSI): 40000
or Inv Fc (Working Stress)
or Inv Fs (Working Stress)

Modular Ratio (Leave blank for load factor): 00

Effective Span Length: Per AASHTO Article 3.24.1.2(b)

Clear distance between flanges + 1/2 flange width = (105-12)+1/2(12)=93.0”
=8.25’

Slab Rating Program Output, Structure No. N-17-BP



```
WinSlab Rating Version 1     Date: 2/20/2002

 Structure NO. N-17-BP     Rater:  MH     State HWY NO. =  25
     Batch ID=         Description:                   LFD

 LOAD FACTOR RATING-COMP STEEL NOT USED

 INPUT DATA

       Bituminous Overlay(in)=    4.000
       Eff. Span(ft)=             8.250          Slab Thickness(in)= 8.500
       Top Reinf. (sq.in)=         0.81          Eff. Depth(in) =    5.625
       Bottom Area(sq.in)=         0.81          Bottom Dist.(in)=   1.38
       Conc. Strength(PSI) Inv =   4500          Oper. =             4500
       Steel Yield (PSI)   Inv =  40000          Oper. =             40000
       Modular Ratio =                8

Dead Load Moment   1.05 K-Ft
LL+I Moment        5.33 K-Ft
Gross Weight       36.0 Tons
                                      Inventory     Operating
Actual Concrete Stress      (PSI)     1141.11        1775.74
Actual Reinf. Steel Stress  (PSI)    19303.62       30039.23
Actual Comp. Steel Stress   (PSI)     4306.93        6702.21
Member Capacity             (K-Ft)      12.81          12.81
Member Capacity (LL+I)      (K-Ft)      11.45          11.45
     Rating                 (Tons)      35.68          59.47
```

Virtis Bridge Rating Example, Structure No. N-17-BP

Effective slab width: Per AASHTO Article 10.38.3.1

0.25(L)= 0.25(114.167*12)= 342.5”
12*(t) = (12*8.5)= 102”   Controls
C.L. - C.L. of girder= 8.75’= 105”

Distribution Factor:

Interior Girder (Multi-Lane) = S/5.5 = 8.75/5.5 = 1.591

Interior Girder (Single-Lane) = S/7.0 = 8.75/7.0 = 1.250

Exterior Girder = [(8.75+0.5)+3.25]/8.75 = 1.428

Dead Load:

HBP = 4”

Curb = (8/12)*(1.25)*(150) = 125 lb/ft

Rail:
Assumed 38 Posts @ 70.55 Lbs each
Posts = 38*(70.55)/228.33 = 11.74 Lb/ft
Channel = 40.68 Lb/ft
3A Rail = 7.81 Lb/ft

$\sum$ = 60.23 Lb/ft ~ 0.060 Kip/ft

Interior (D-2 on plan sheet) Diaphragms:

Angles L3x3x5/16 @ 6.1 lb/ft Length = 2(8.75)+2(5.71)=28.92’
Weight = (28.92)*(6.1) = 176.41 Lbs
Stiffener Plate 5x5/16x4.5’
Weight = 2(5.32)(4.5) = 47.88 Lbs
∑ = 224.29 Lbs ~ 0.225 Kips

Pier (D-2 on plan sheet) Diaphragm:

Angles L3x3x5/16 @ 6.1 lb/ft Length = 2(8.75)+2(5.71)=28.92’
Weight = (28.92)*(6.1) = 176.41 Lbs
Stiffener Plate 9x1x7.135’
Weight = 2(30.625)(7.135) = 437.04 Lbs
∑ = 613.40 Lbs ~ 0.614 Kips

End (D-1 on plan sheet) Diaphragms:

Angles L3.5x3.5x5/16 @ 7.2 lb/ft   Length = 2(9.839)=19.68’
Weight = (19.68)*(7.2) = 141.70 Lbs
Stiffener Plate 6.5x5/8x4.5’
Weight = 2(13.817)(4.5) = 124.3 Lbs
∑ = 266.0 Lbs ~ 0.266 Kips

Intermediate Stiffeners:

Assumed length = depth of web = 54”; Neglect longer stiffeners in girder taper
Stiffener Plate 5x5/16x4.5’ @ 5.32Lbs/ft = 23.94 Lbs each
21 Stiffeners/Span = 21*(23.94)/114.167 = 4.4 Lbs/ft

Longitudinal Stiffeners:

Stiffener Plate 4.5x5/16 = 4.79 Lbs/ft
Stiffener Plate 3.5x5/16 = 3.72 Lbs/ft
Average Weight = 4.2 Lbs/ft
∑ Transverse + Longitudinal Stiffeners = 4.4+4.2 = 8.6 Lbs/ft ~ 0.009 Kip/ft

1

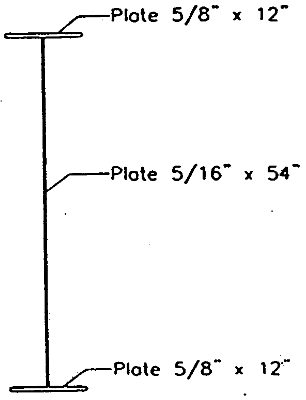


Plate 5/8" x 12"
Plate 5/16" x 54"
Plate 5/8" x 12"

2

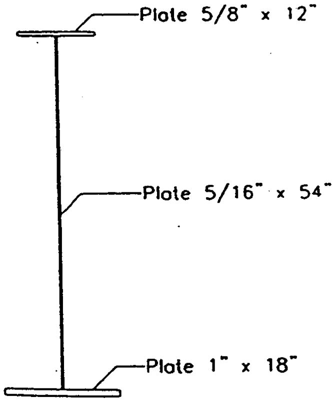


Plate 5/8" x 12"
Plate 5/16" x 54"
Plate 1" x 18"

3

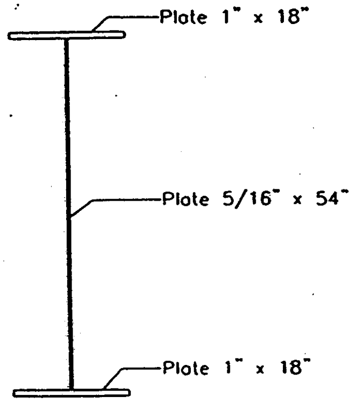


Plate 1" x 18"
Plate 5/16" x 54"
Plate 1" x 18"

4

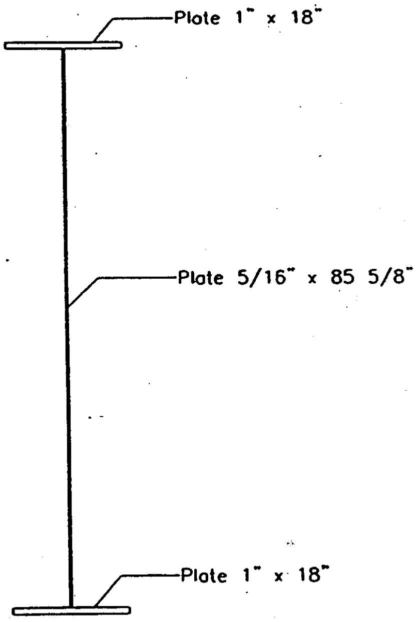
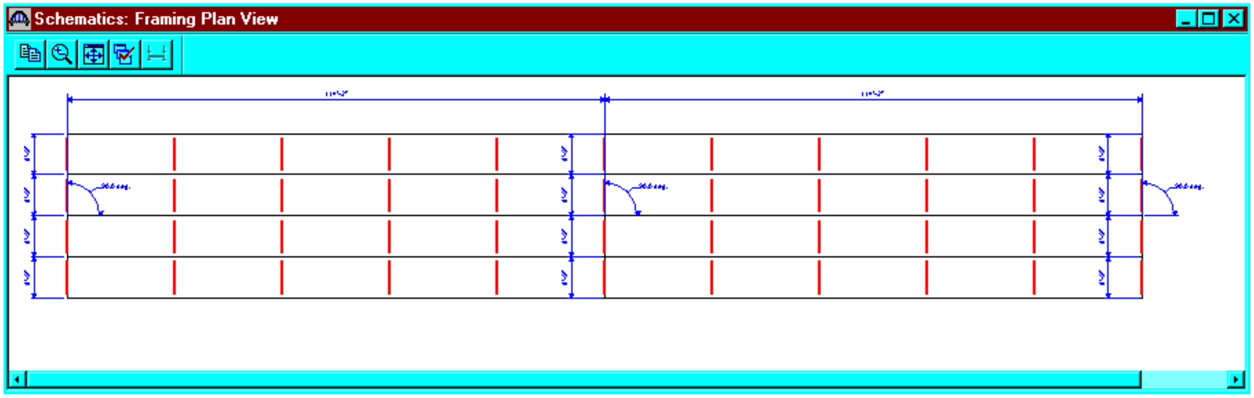
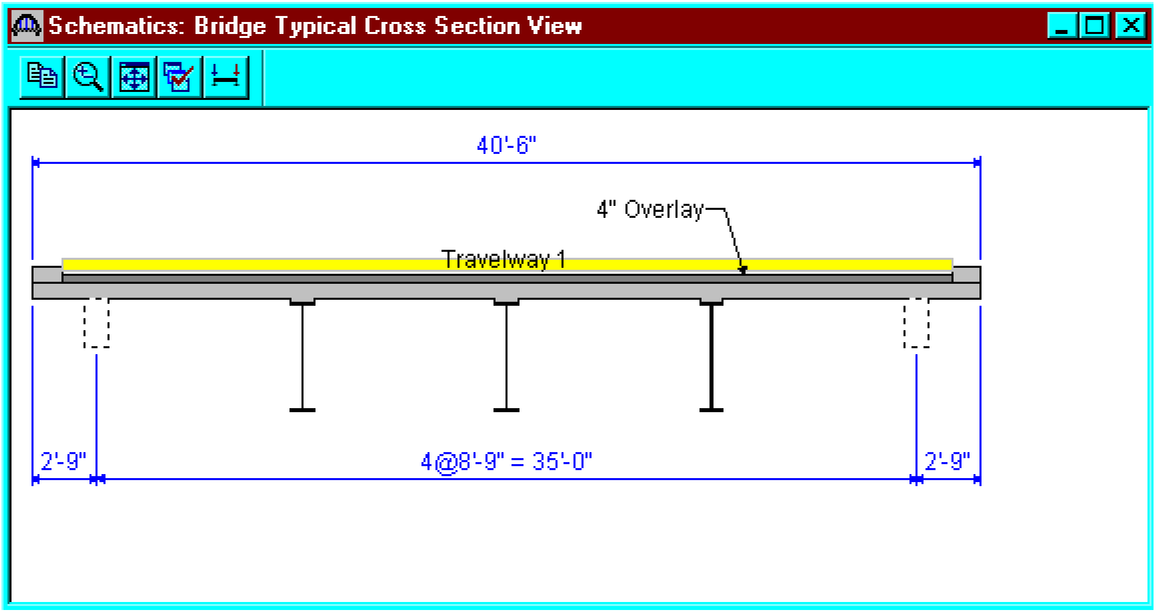


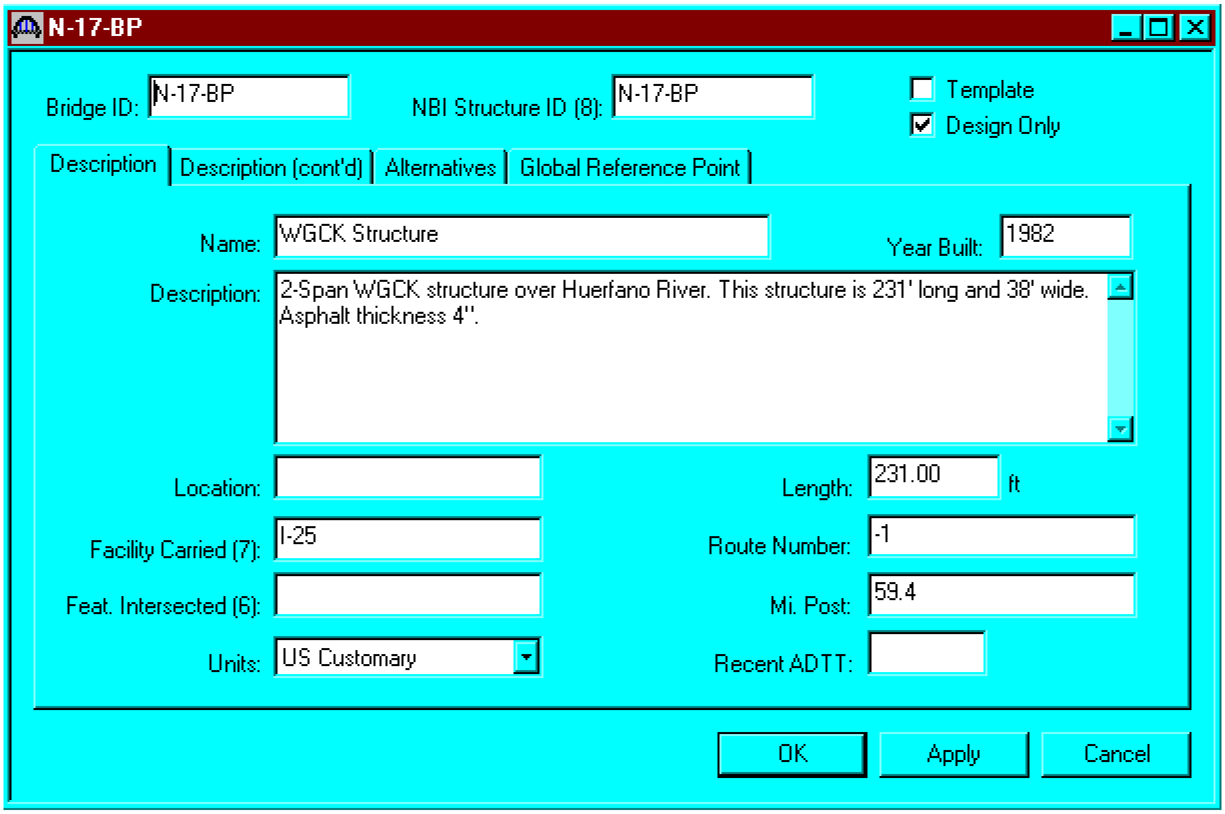
Plate 1" x 18"
Plate 5/16" x 85 5/8"
Plate 1" x 18"

Virtis Bridge Rating Example, Structure No. N-17-BP (contd.)





From the bridge explorer, create a new bridge and enter the following information.

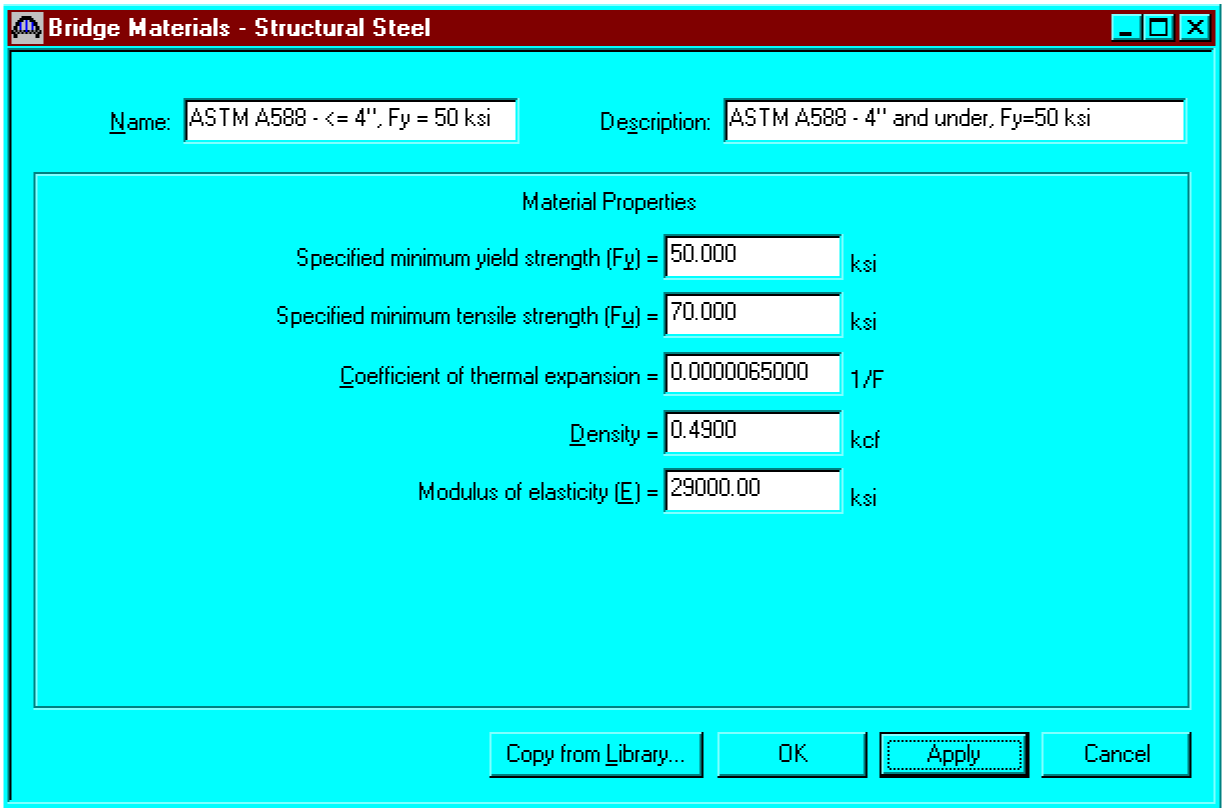


Bridge ID: N-17-BP
NBI Structure ID (8): N-17-BP
☐ Template
☑ Design Only
Name: WGCK Structure
Year Built: 1982
Description: 2-Span WGCK structure over Huerfano River. This structure is 231' long and 38' wide. Asphalt thickness 4".
Location:
Length: 231.00 ft
Facility Carried (7): I-25
Route Number: -1
Feat. Intersected (6):
Mi. Post: 59.4
Units: US Customary
Recent ADTT:

Click OK. This saves the data to memory and closes the window.

NOTE: Since Virtis uses a common/shared database, it is required that users of this program create a folder from the bridge explorer window **(EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

To add a new structural steel material, click on Materials, Structural Steel, in the tree and select File/New from the menu (or right click on Structural Steel and select New). Click Copy from Library button and select the appropriate structural steel from the library. Click OK and the following window will open. Click OK to save this structural steel material to memory and close the window.



Name: ASTM A588 - <= 4", Fy = 50 ksi

Description: ASTM A588 - 4" and under, Fy=50 ksi

Material Properties

Specified minimum yield strength (Fy) = 50.000 ksi

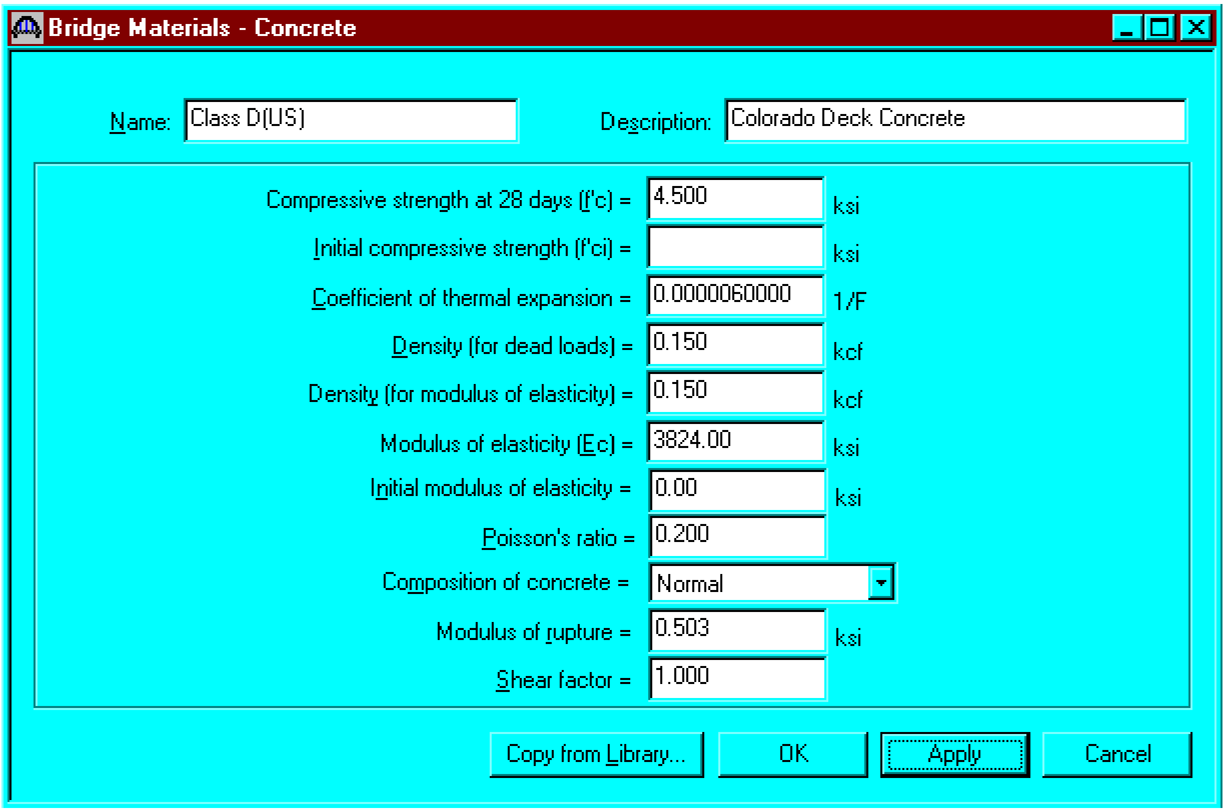
Specified minimum tensile strength (Fu) = 70.000 ksi

Coefficient of thermal expansion = 0.0000065000 1/F

Density = 0.4900 kcf

Modulus of elasticity (E) = 29000.00 ksi

Using the same techniques, create the following Concrete Materials and Reinforcing Steel Materials. The windows are shown in the following page.



Bridge Materials - Concrete

Name: Class D(US)

Description: Colorado Deck Concrete

Compressive strength at 28 days (f'c) = 4.500 ksi

Initial compressive strength (f'ci) = ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.150 kcf

Density (for modulus of elasticity) = 0.150 kcf

Modulus of elasticity (Ec) = 3824.00 ksi

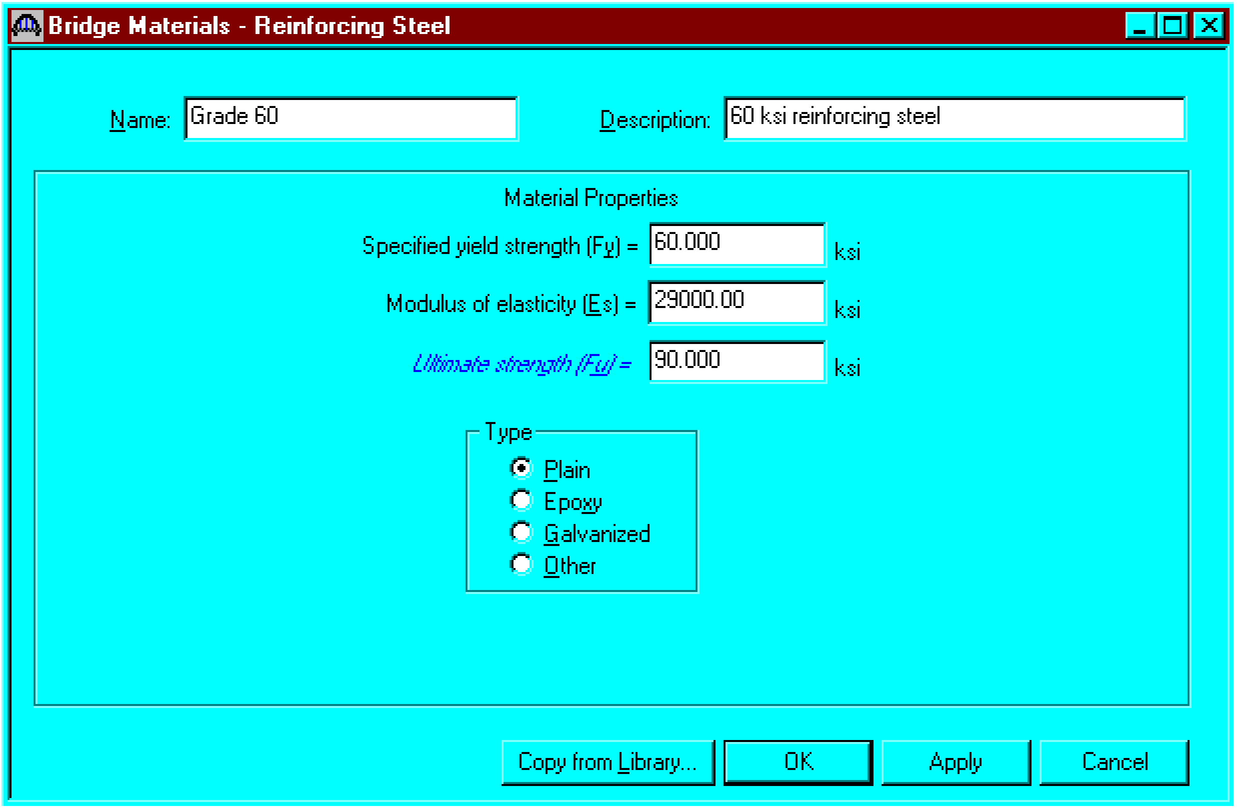
Initial modulus of elasticity = 0.00 ksi

Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.503 ksi

Shear factor = 1.000



Bridge Materials - Reinforcing Steel

Name: Grade 60

Description: 60 ksi reinforcing steel

Material Properties

Specified yield strength (Fy) = 60.000 ksi

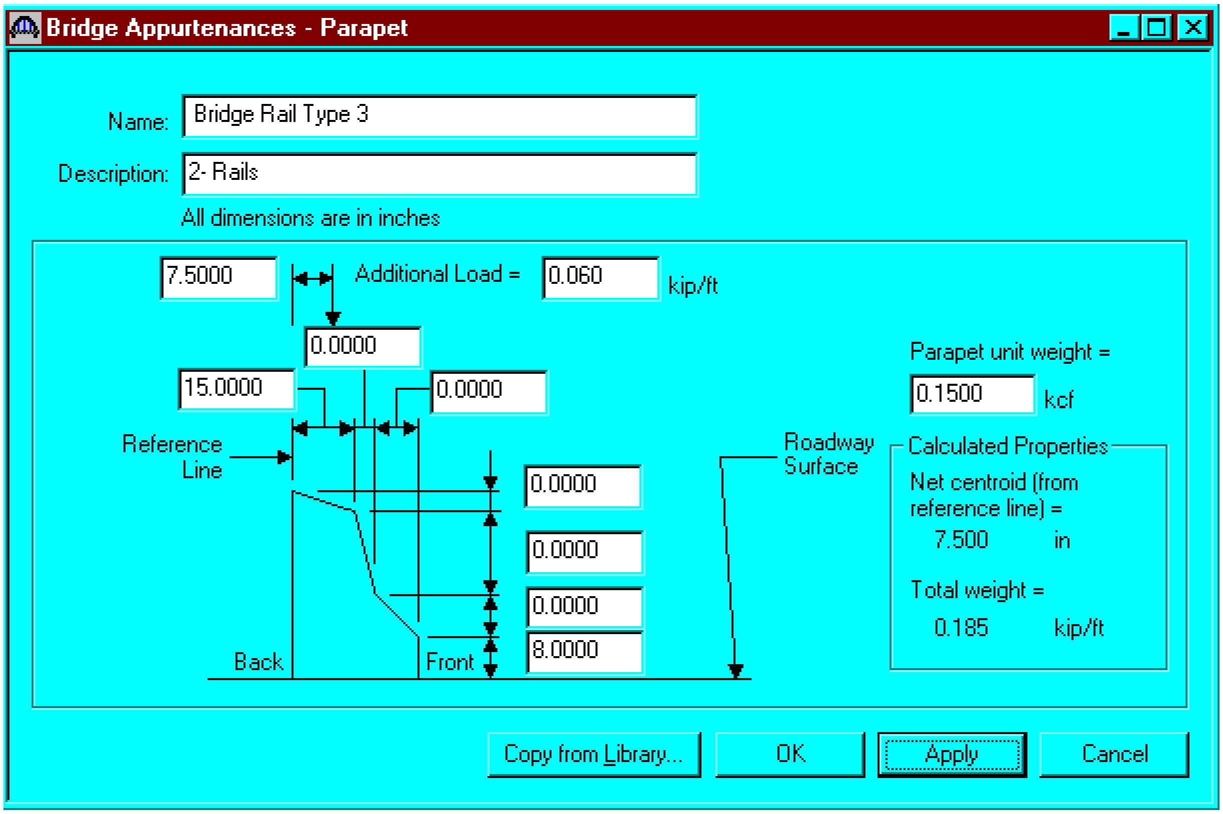
Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 90.000 ksi

Type

● Plain
○ Epoxy
○ Galvanized
○ Other

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, and select New. Fill in the parapet properties as required. Click OK to save the data to memory and close the window.



Name: Bridge Rail Type 3

Description: 2- Rails

All dimensions are in inches

7.5000

Additional Load = 0.060 kip/ft

0.0000

15.0000

0.0000

0.0000

0.0000

0.0000

8.0000

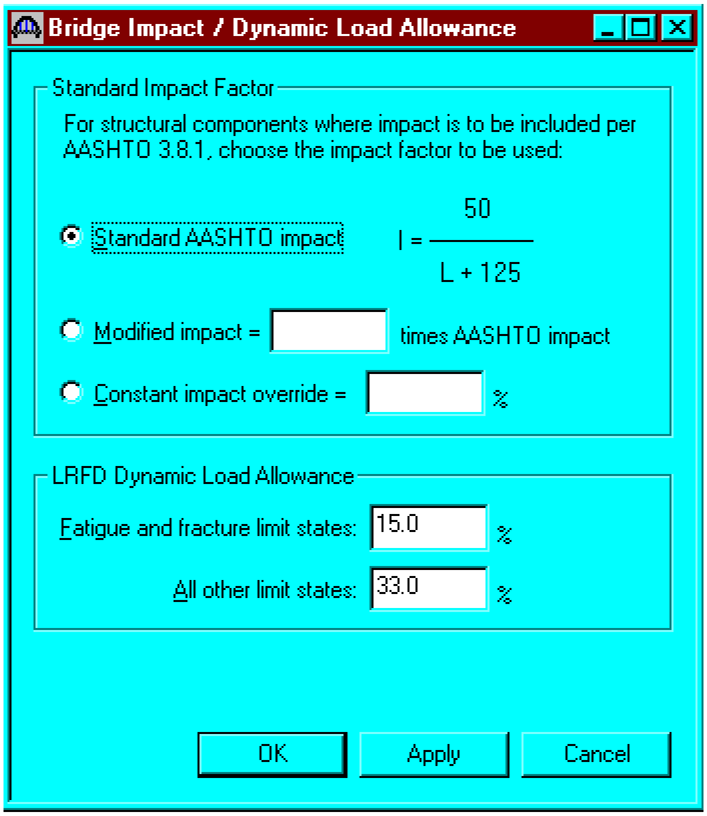
Parapet unit weight = 0.1500 kcf

Calculated Properties

Net centroid (from reference line) = 7.500 in

Total weight = 0.185 kip/ft

Double click on Impact/Dynamic Load Allowance in the tree. The Bridge Impact window shown below will open. Accept the default values by clicking OK.



Standard Impact Factor

For structural components where impact is to be included per AASHTO 3.8.1, choose the impact factor to be used:

● Standard AASHTO impact $I = \frac{50}{L + 125}$

○ Modified impact = times AASHTO impact

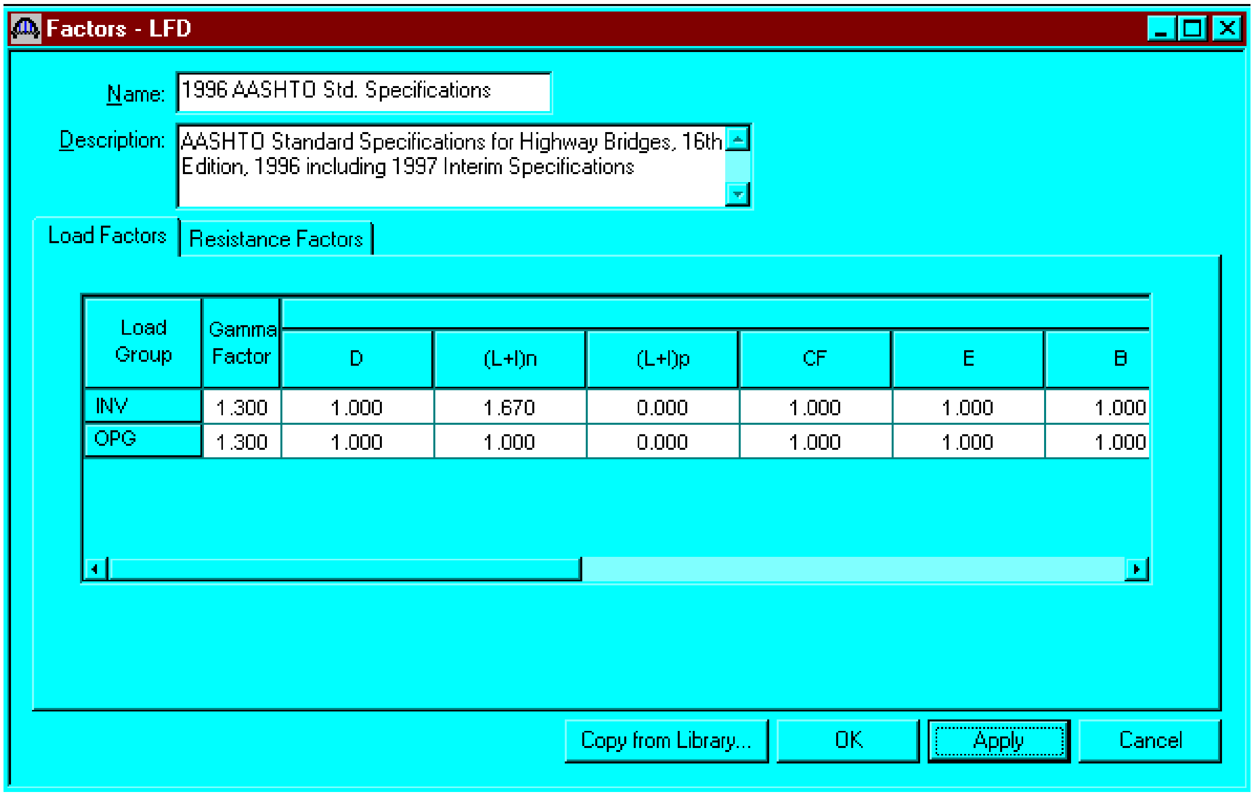
○ Constant impact override = %

LRFD Dynamic Load Allowance

Fatigue and fracture limit states: 15.0 %

All other limit states: 33.0 %

Click on Factors, right mouse click on LFD and select New. The LFD-Factors window will open. Click the Copy from Library button and select the 1996 AASHTO Standard Specifications from the library. Click Apply and then OK to save data to memory and close the window.

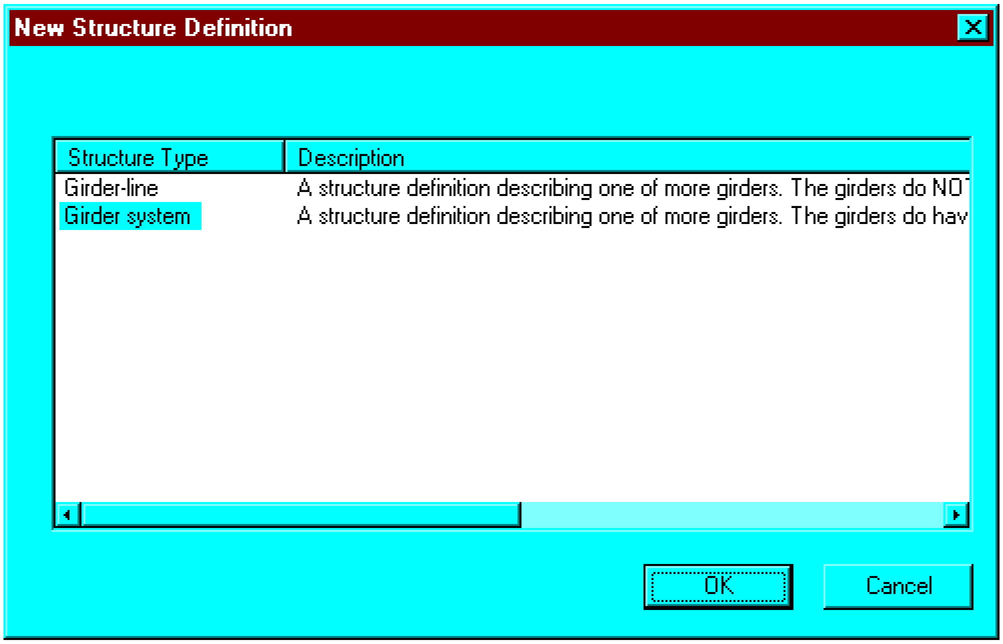


Name: 1996 AASHTO Std. Specifications

Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

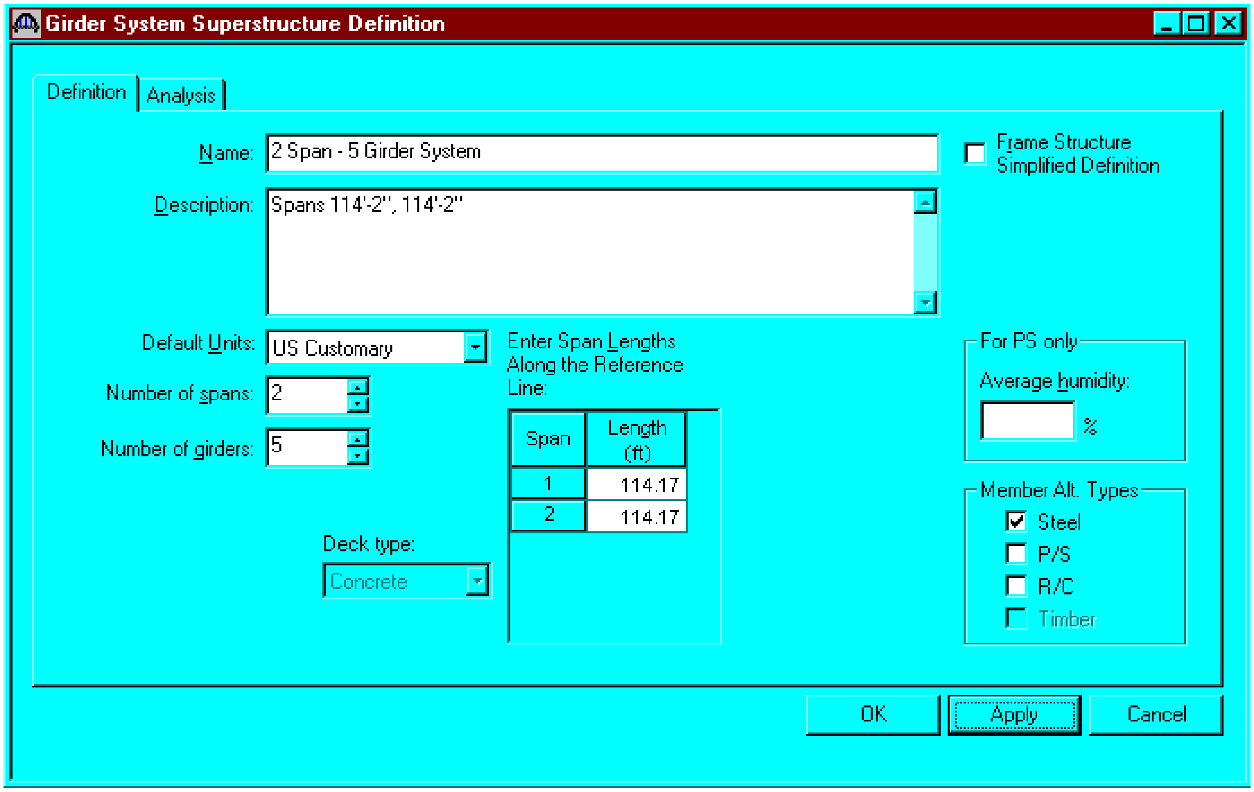
Load Group	Gamma Factor	D	(L+I)n	(L+I)p	CF	E	B
INV	1.300	1.000	1.670	0.000	1.000	1.000	1.000
OPG	1.300	1.000	1.000	0.000	1.000	1.000	1.000

Double click on SUPERSTRUCTURE DEFINITION (or click on SUPERSTRUCTURE DEFINITION and select File/New from the menu or right mouse click on SUPERSTRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



Structure Type	Description
Girder-line	A structure definition describing one of more girders. The girders do NO
Girder system	A structure definition describing one of more girders. The girders do hav

Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



Name: 2 Span - 5 Girder System

Description: Spans 114'-2", 114'-2"

☐ Frame Structure Simplified Definition

Default Units: US Customary

Number of spans: 2

Number of girders: 5

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	114.17
2	114.17

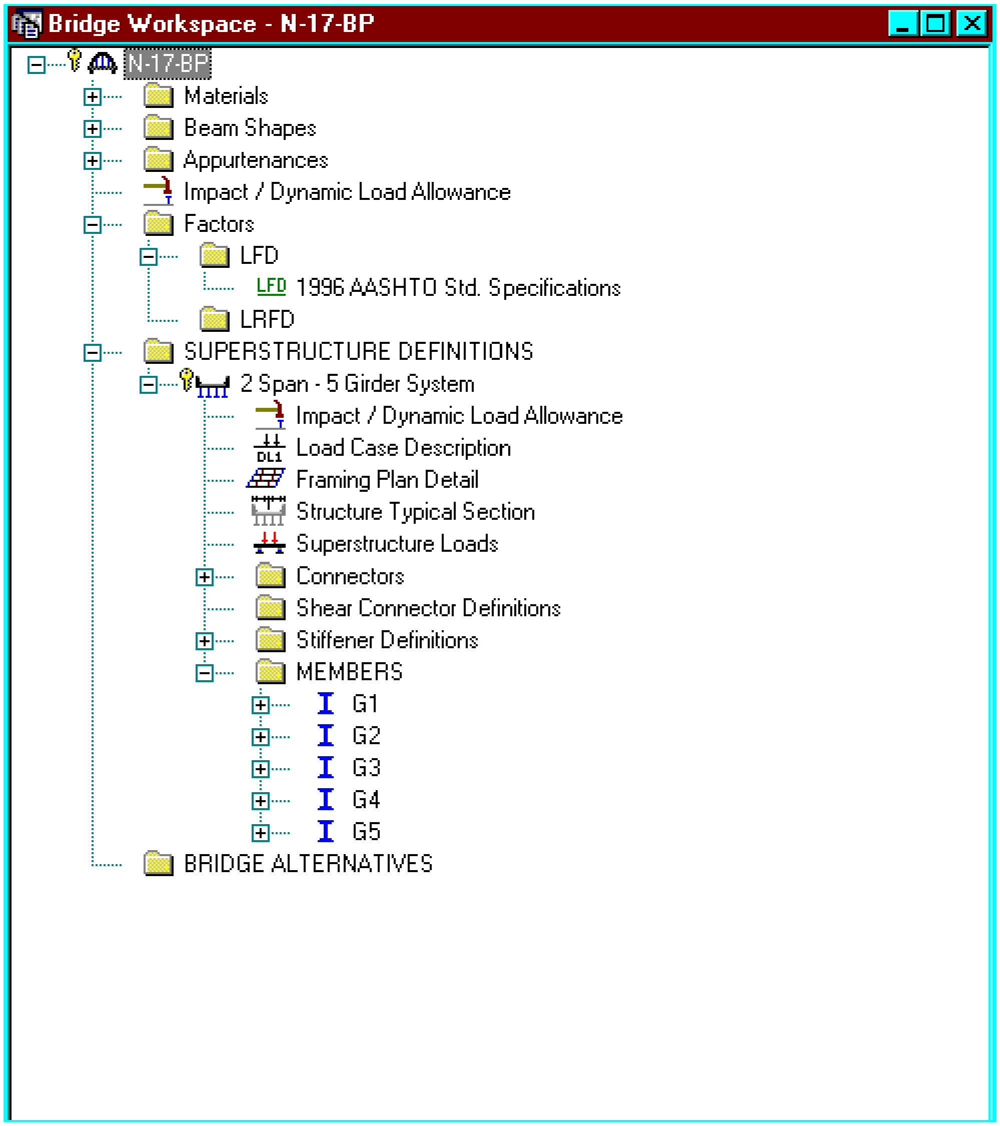
For PS only

Average humidity: %

Member Alt. Types

☑ Steel
☐ P/S
☐ R/C
☐ Timber

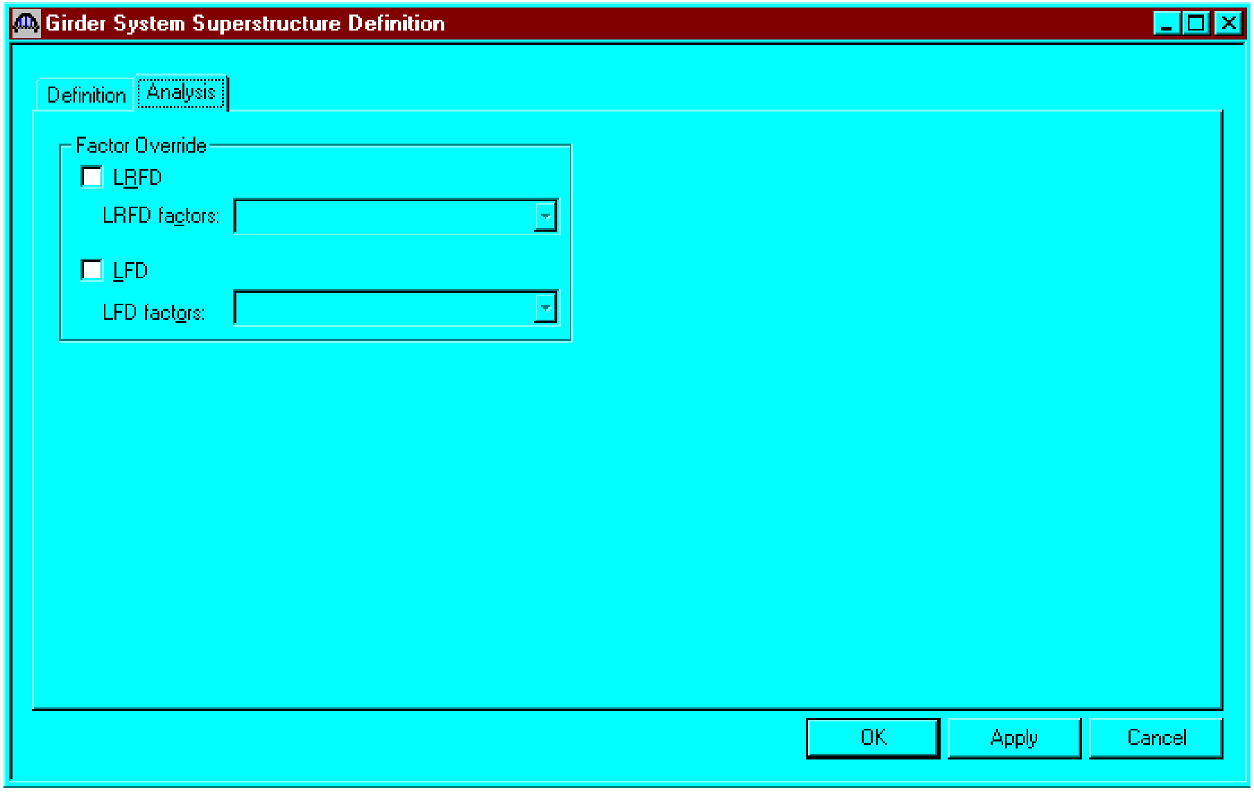
The partially expanded Bridge Workspace tree is shown below:



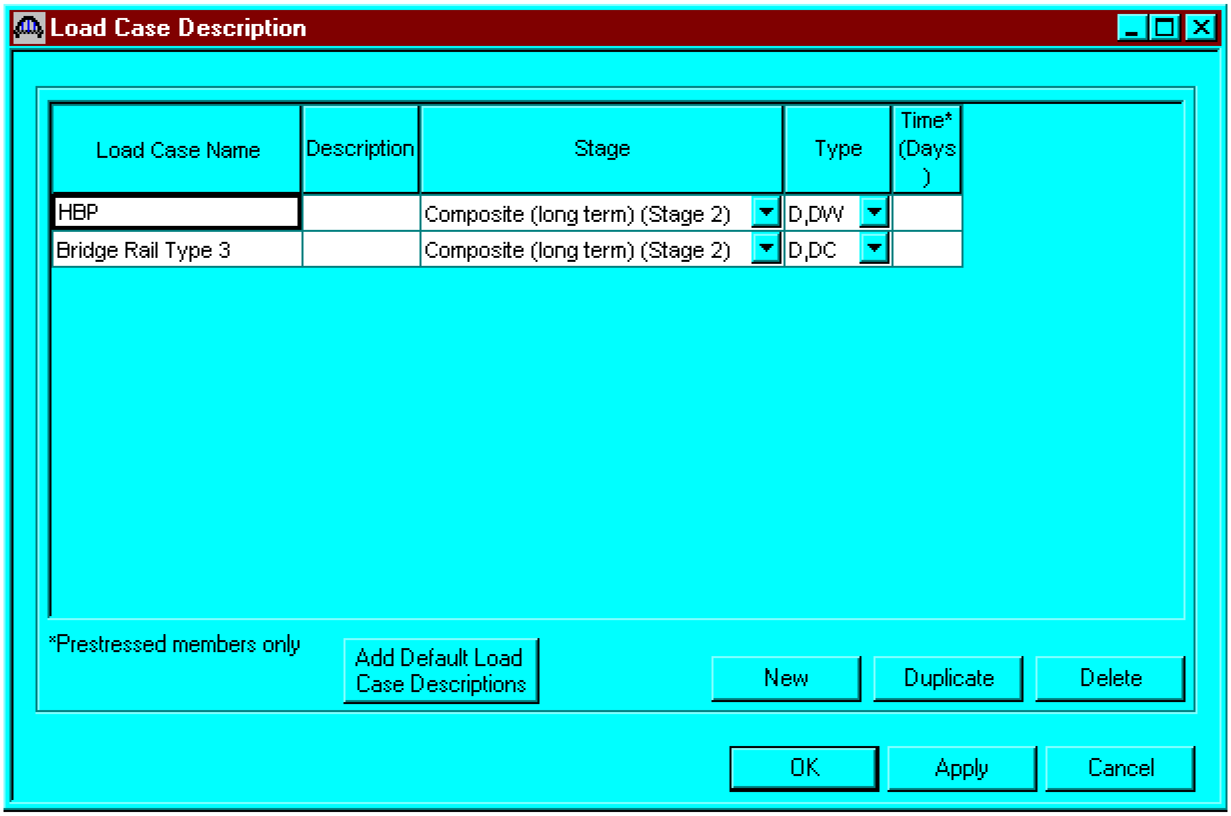
Bridge Workspace - N-17-BP

- N-17-BP
  - Materials
  - Beam Shapes
  - Appurtenances
  - Impact / Dynamic Load Allowance
  - Factors
    - LFD
      - 1996 AASHTO Std. Specifications
    - LRFD
  - SUPERSTRUCTURE DEFINITIONS
    - 2 Span - 5 Girder System
      - Impact / Dynamic Load Allowance
      - Load Case Description
      - Framing Plan Detail
      - Structure Typical Section
      - Superstructure Loads
      - Connectors
      - Shear Connector Definitions
      - Stiffener Definitions
      - MEMBERS
        - G1
        - G2
        - G3
        - G4
        - G5
  - BRIDGE ALTERNATIVES

The Analysis tab in the Girder System Superstructure Definition window is used to override system default factors. Since default factors are used here, click OK to save the data to memory and close the window.



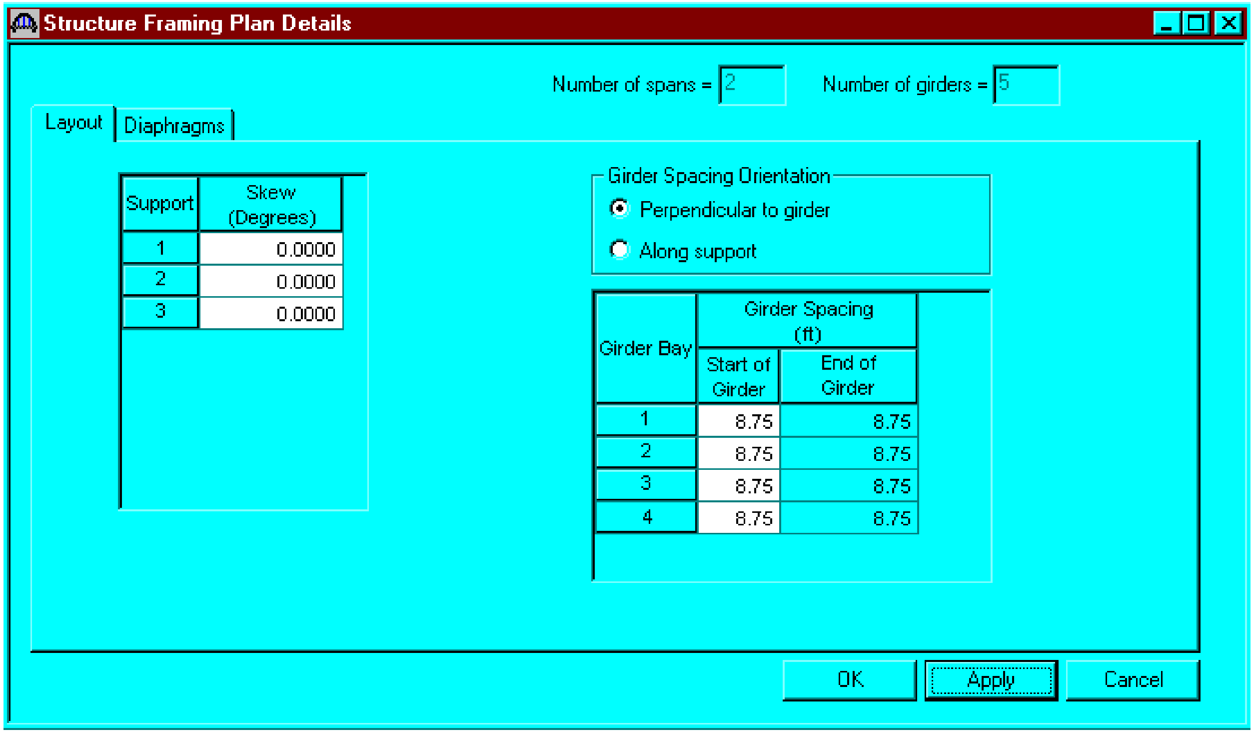
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.



Load Case Name	Description	Stage	Type	Time* (Days)
HBP		Composite (long term) (Stage 2)	D,DW	
Bridge Rail Type 3		Composite (long term) (Stage 2)	D,DC	

*Prestressed members only

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



Number of spans = 2

Number of girders = 5

Support	Skew (Degrees)
1	0.0000
2	0.0000
3	0.0000

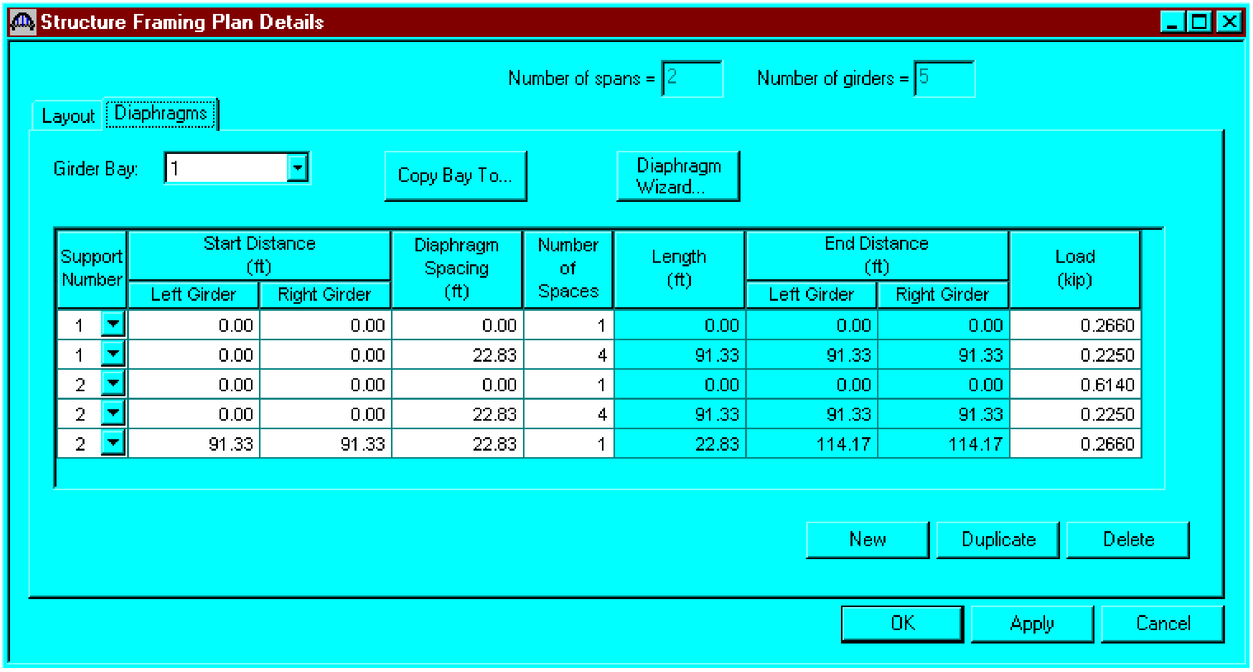
Girder Spacing Orientation

● Perpendicular to girder

○ Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	8.75	8.75
2	8.75	8.75
3	8.75	8.75
4	8.75	8.75

Switch to the Diaphragms tab to enter diaphragm spacing. Enter the following diaphragms data for Girder Bay 1:



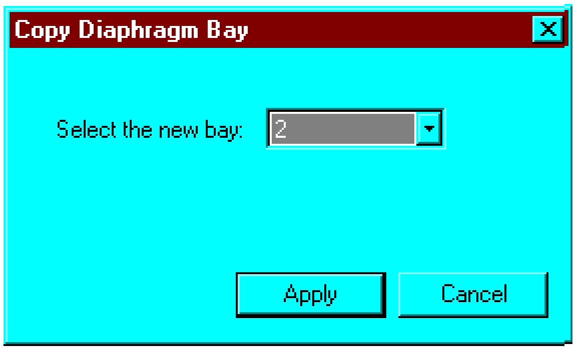
Number of spans = 2

Number of girders = 5

Girder Bay: 1

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Load (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	0.2660
1	0.00	0.00	22.83	4	91.33	91.33	91.33	0.2250
2	0.00	0.00	0.00	1	0.00	0.00	0.00	0.6140
2	0.00	0.00	22.83	4	91.33	91.33	91.33	0.2250
2	91.33	91.33	22.83	1	22.83	114.17	114.17	0.2660

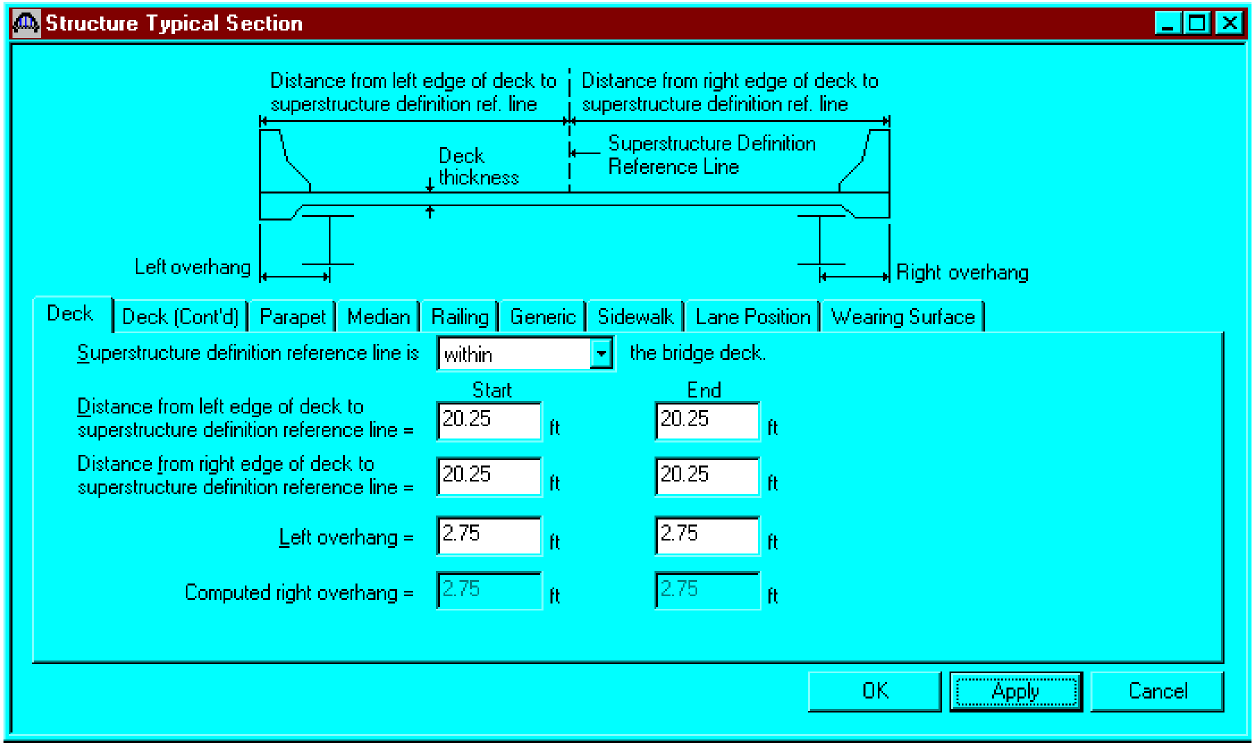
Click the Copy Bay To button to copy the diaphragms entered for Bay to the other bays. The following dialog box will appear. Click Apply to copy the diaphragms to girder bay 2. Repeat the same techniques for girder bay 3 and 4.



Select the new bay: 2

Select OK to close Structure Framing Plan Details window.

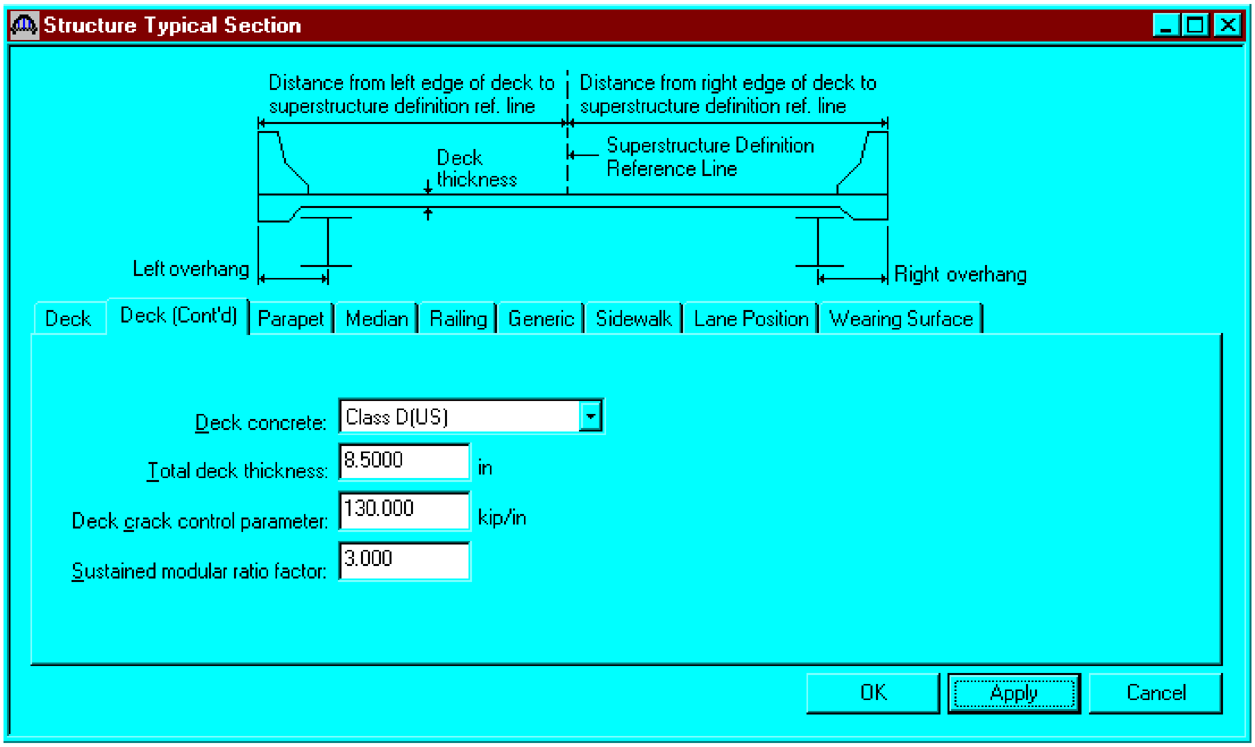
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



Superstructure definition reference line is within the bridge deck.

	Start		End	
Distance from left edge of deck to superstructure definition reference line =	20.25	ft	20.25	ft
Distance from right edge of deck to superstructure definition reference line =	20.25	ft	20.25	ft
Left overhang =	2.75	ft	2.75	ft
Computed right overhang =	2.75	ft	2.75	ft

The Deck (Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



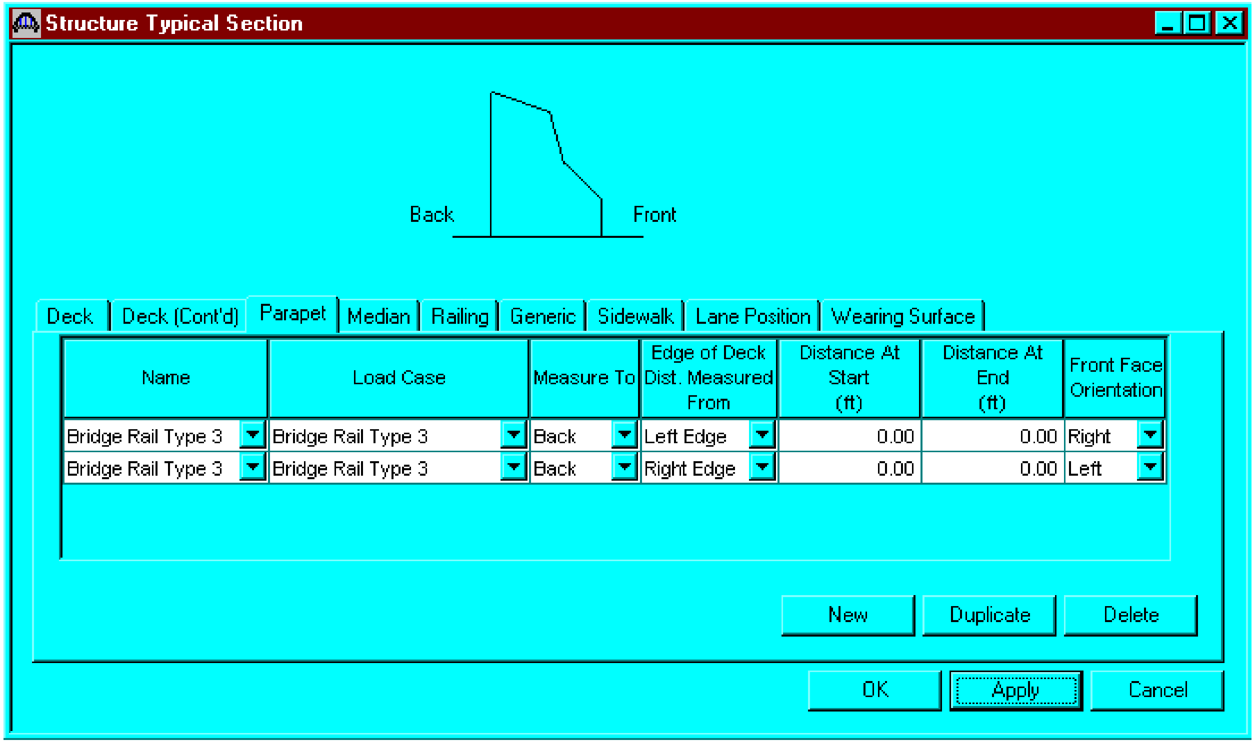
Deck concrete: Class D(US)

Total deck thickness: 8.5000 in

Deck crack control parameter: 130.000 kip/in

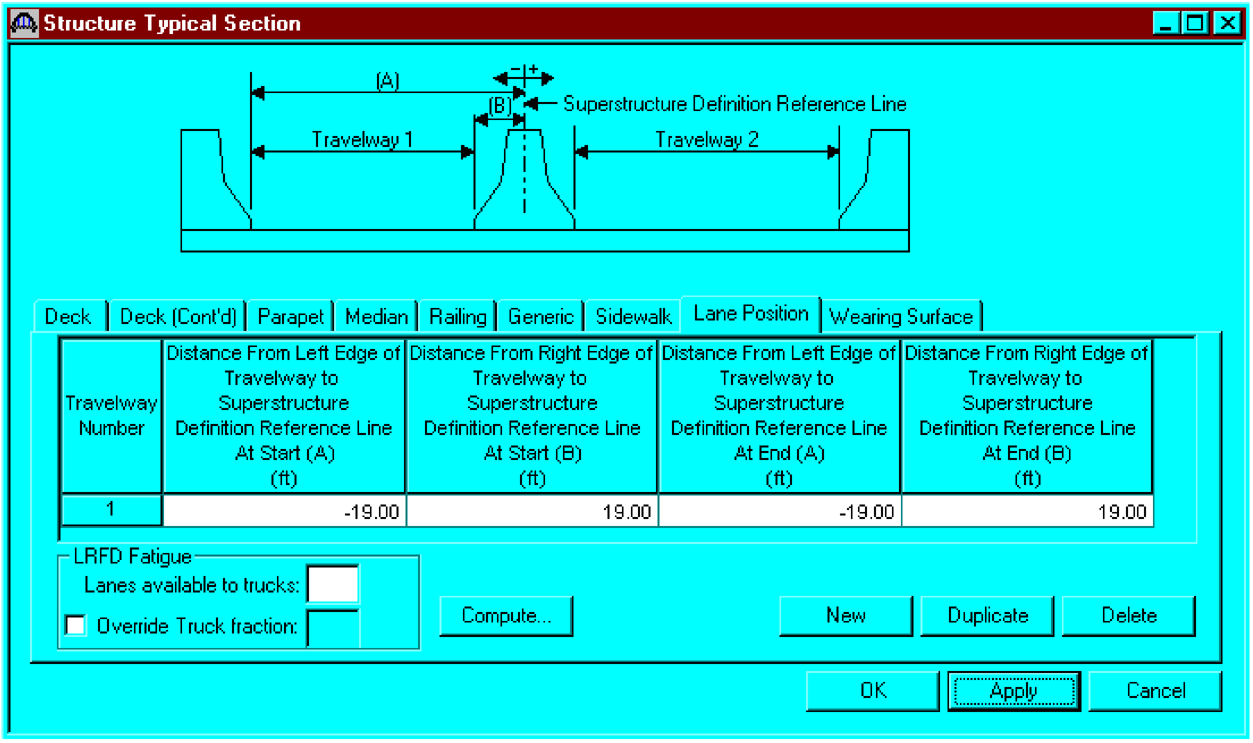
Sustained modular ratio factor: 3.000

Parapets:
Add two parapets as shown below.



Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Bridge Rail Type 3	Bridge Rail Type 3	Back	Left Edge	0.00	0.00	Right
Bridge Rail Type 3	Bridge Rail Type 3	Back	Right Edge	0.00	0.00	Left

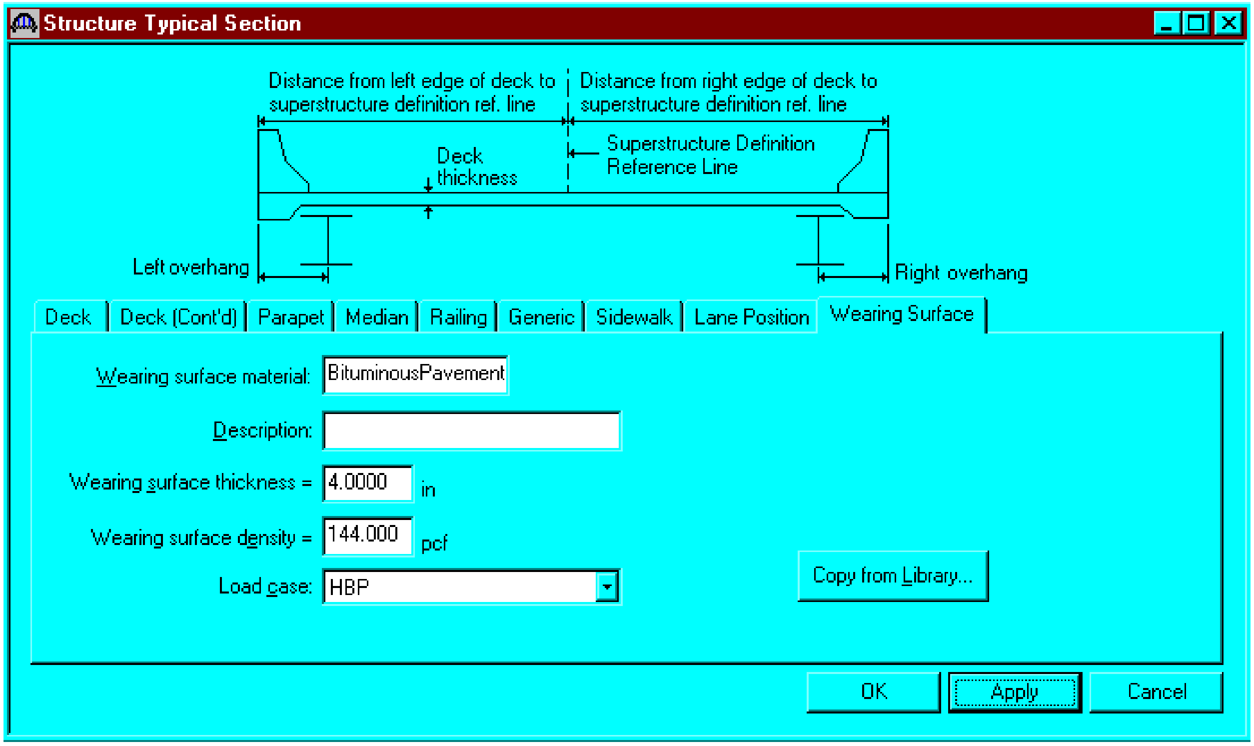
Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click Apply to accept the computed values. The Lane Position tab is populated as shown below.



Travelway Number	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At End (B) (ft)
1	-19.00	19.00	-19.00	19.00

LRFD Fatigue
Lanes available to trucks:
☐ Override Truck fraction:

Enter the following wearing surface information on the Wearing Surface tab.



Wearing surface material: BituminousPavement

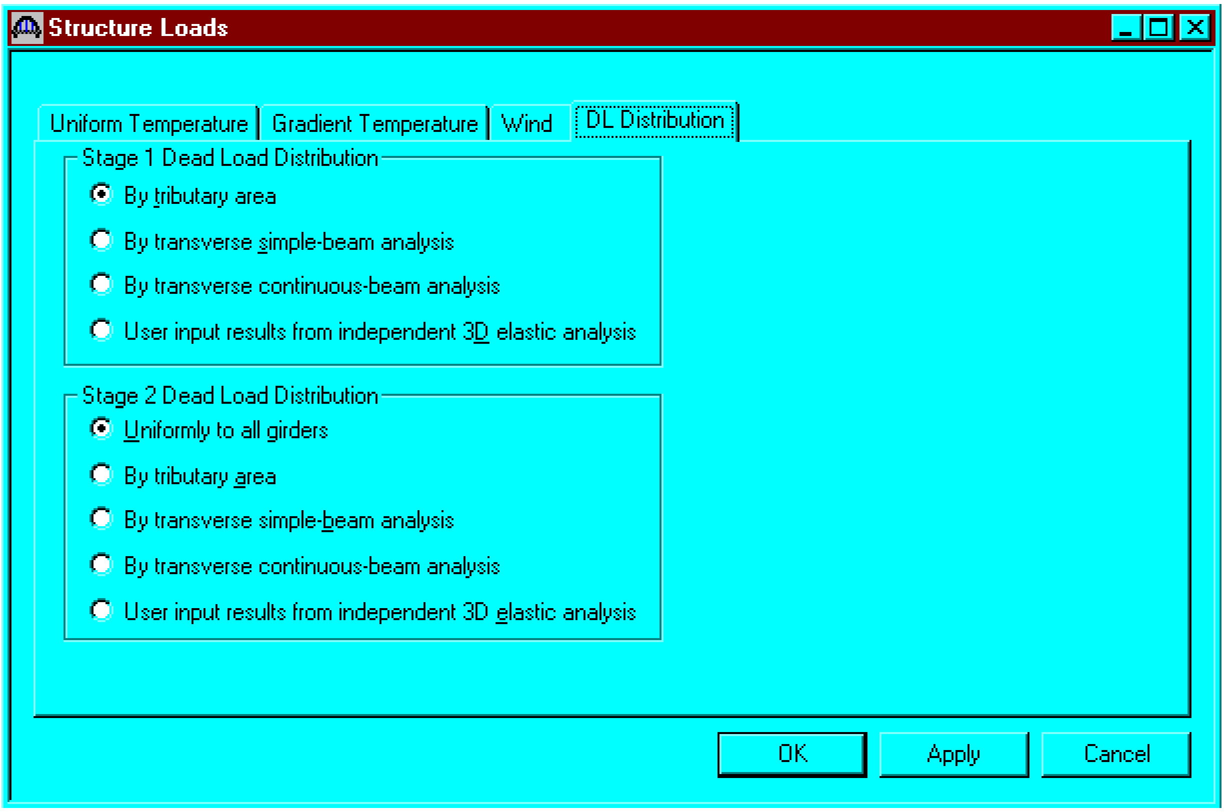
Description:

Wearing surface thickness = 4.0000 in

Wearing surface density = 144.000 pcf

Load case: HBP

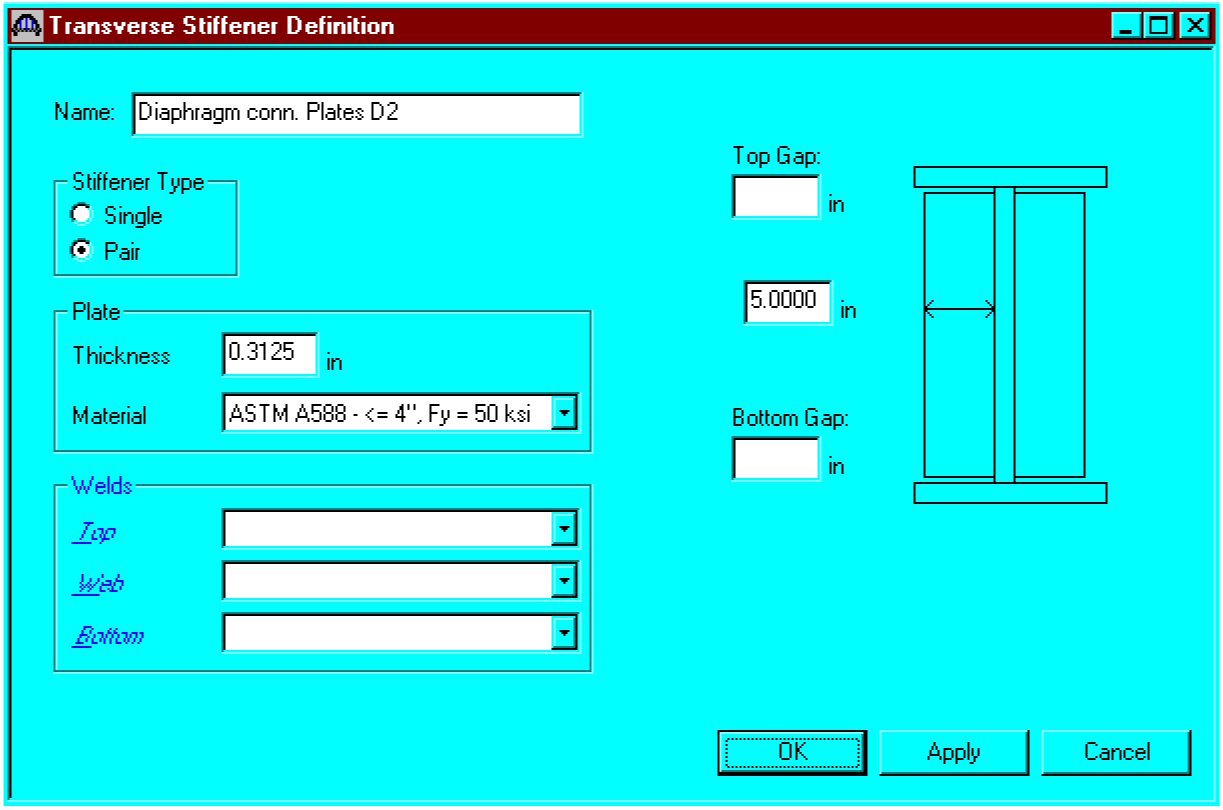
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



Stage 1 Dead Load Distribution
- ● By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

Stage 2 Dead Load Distribution
- ● Uniformly to all girders
- ○ By tributary area
- ○ By transverse simple-beam analysis
- ○ By transverse continuous-beam analysis
- ○ User input results from independent 3D elastic analysis

Expand the Stiffener Definitions tree item and double click on Transverse. Define the stiffener as shown below. Click OK to save to memory and close the window.



Transverse Stiffener Definition

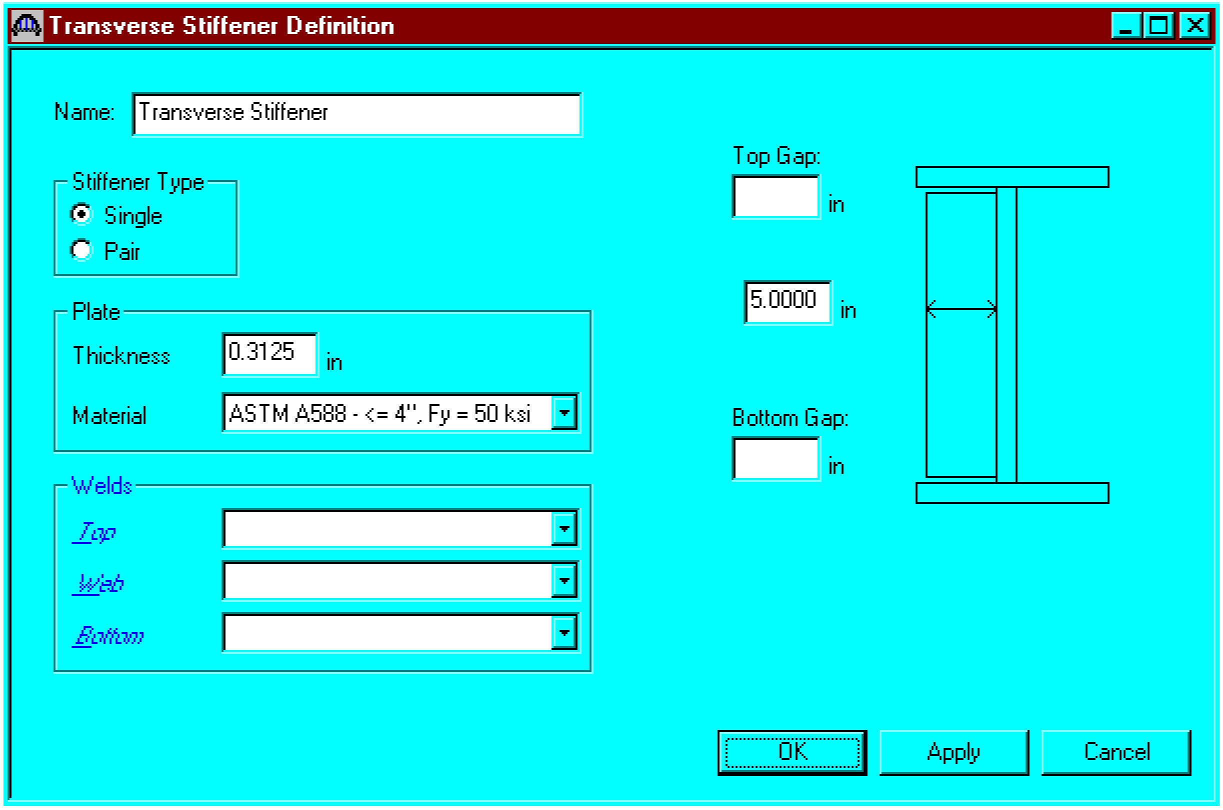
Name: Diaphragm conn. Plates D2

Stiffener Type
○ Single
● Pair

Plate
Thickness 0.3125 in
Material ASTM A588 - <= 4", Fy = 50 ksi

Welds
Top
Web
Bottom

Top Gap: in
5.0000 in
Bottom Gap: in



Name: Transverse Stiffener

Stiffener Type

● Single

○ Pair

Plate

Thickness 0.3125 in

Material ASTM A588 - <= 4", Fy = 50 ksi

Welds

Top

Web

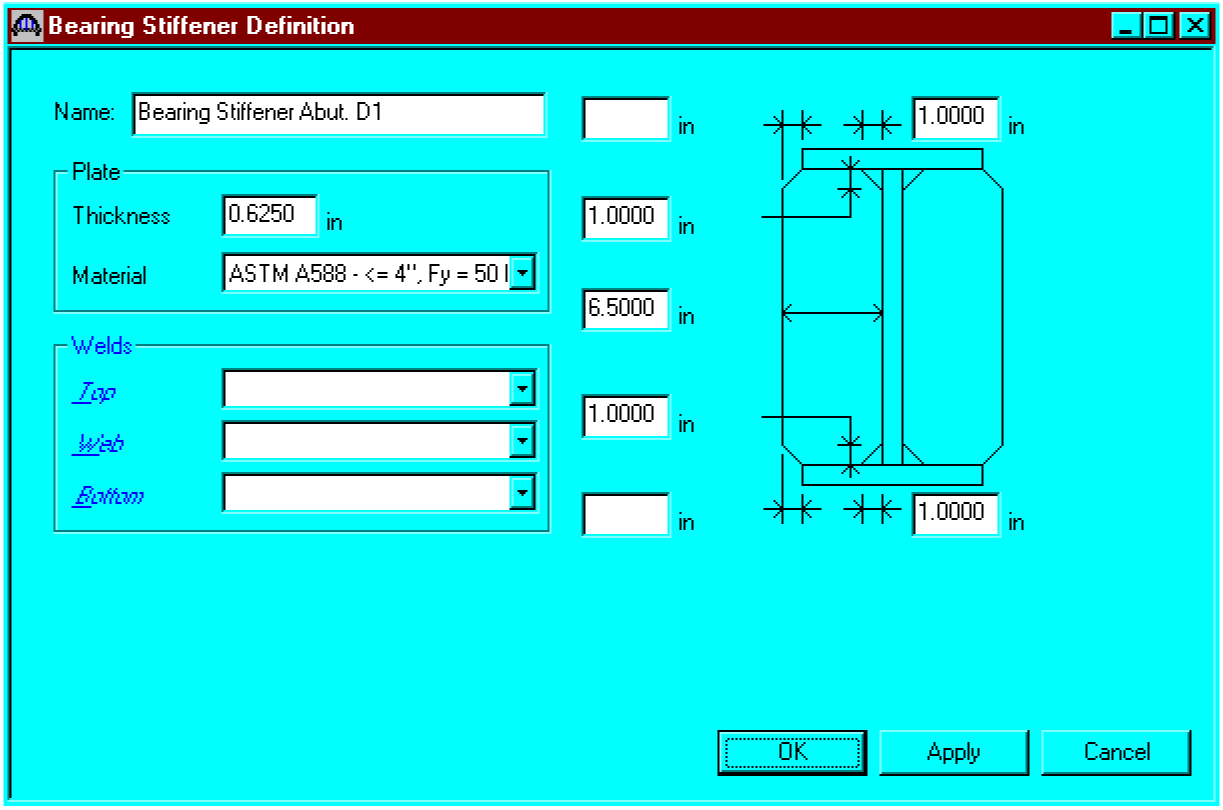
Bottom

Top Gap: in

5.0000 in

Bottom Gap: in

Similarly, define bearing stiffeners by double clicking on Bearing in the tree. Click OK to save to memory and close the window.



Name: Bearing Stiffener Abut. D1

Thickness 0.6250 in

Material ASTM A588 - <= 4", Fy = 50 I

in

1.0000 in

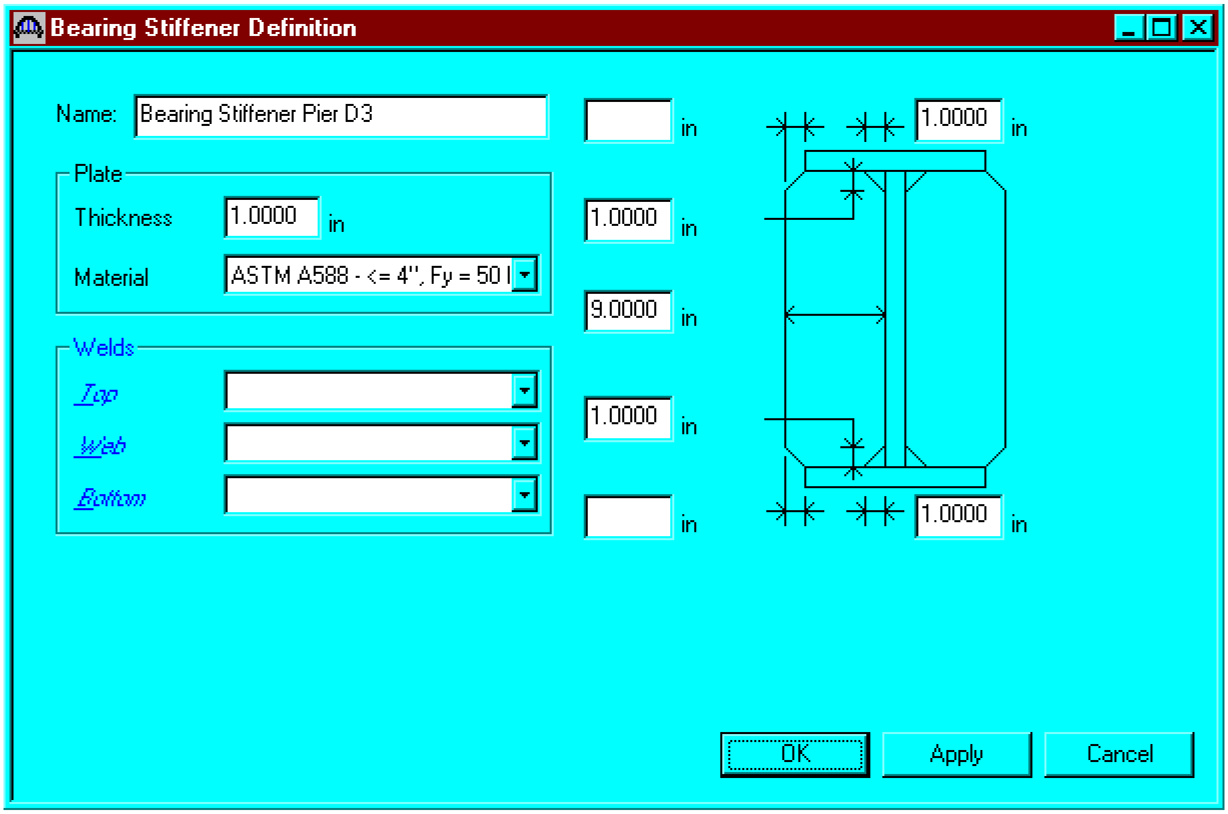
6.5000 in

1.0000 in

in

1.0000 in

1.0000 in



Name: Bearing Stiffener Pier D3

Thickness 1.0000 in

Material ASTM A588 - <= 4", Fy = 50 I

in

1.0000 in

9.0000 in

1.0000 in

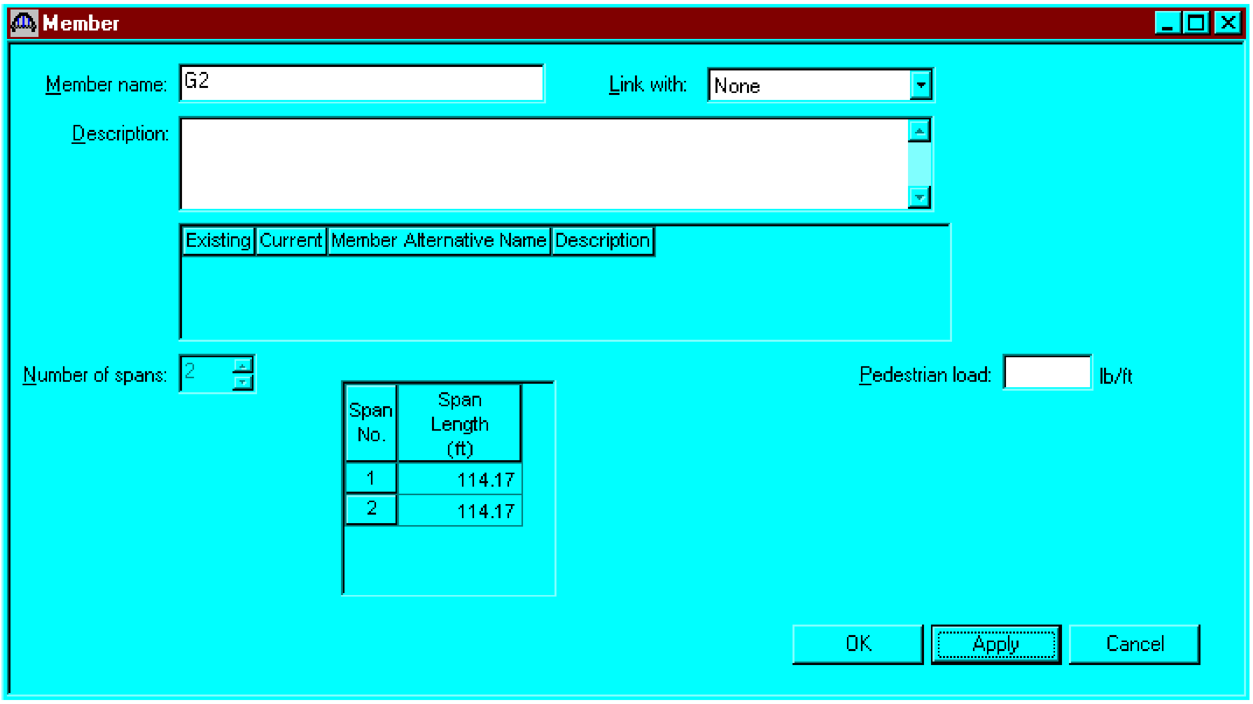
in

1.0000 in

1.0000 in

Describing a member:

The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.



Member name: G2

Link with: None

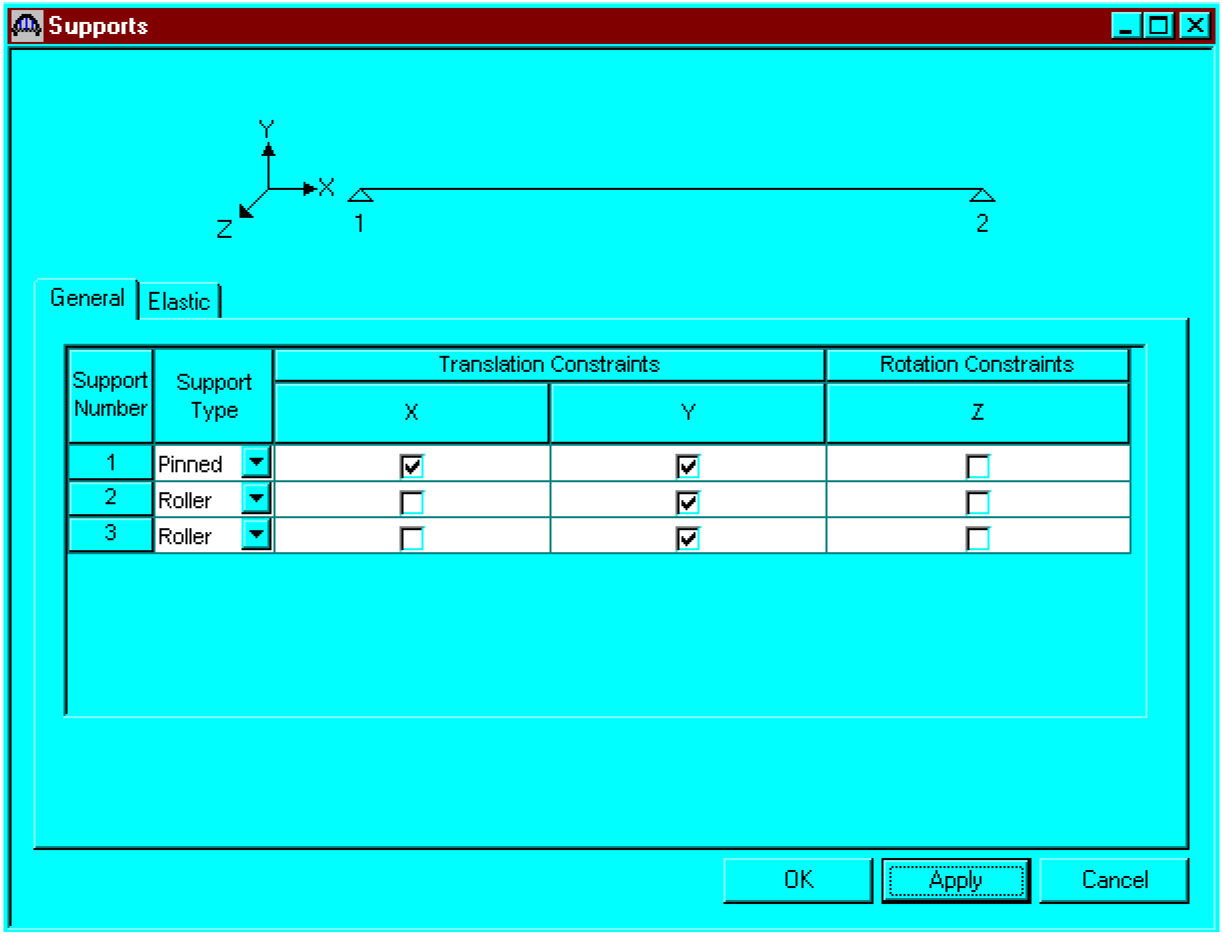
Description:

Number of spans: 2

Pedestrian load: lb/ft

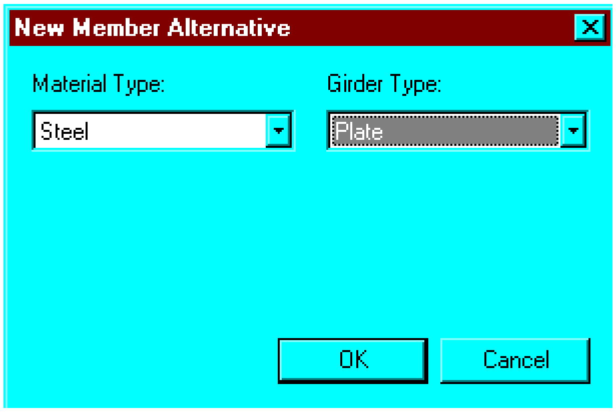
Span No.	Span Length (ft)
1	114.17
2	114.17

Double click on Supports to define support constraints for the girder. Support constraints were generated when the structure definition was created and are shown below. Click OK to save data to memory and close the window.



Support Number	Support Type	Translation Constraints		Rotation Constraints
		X	Y	Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐
3	Roller	☐	☑	☐

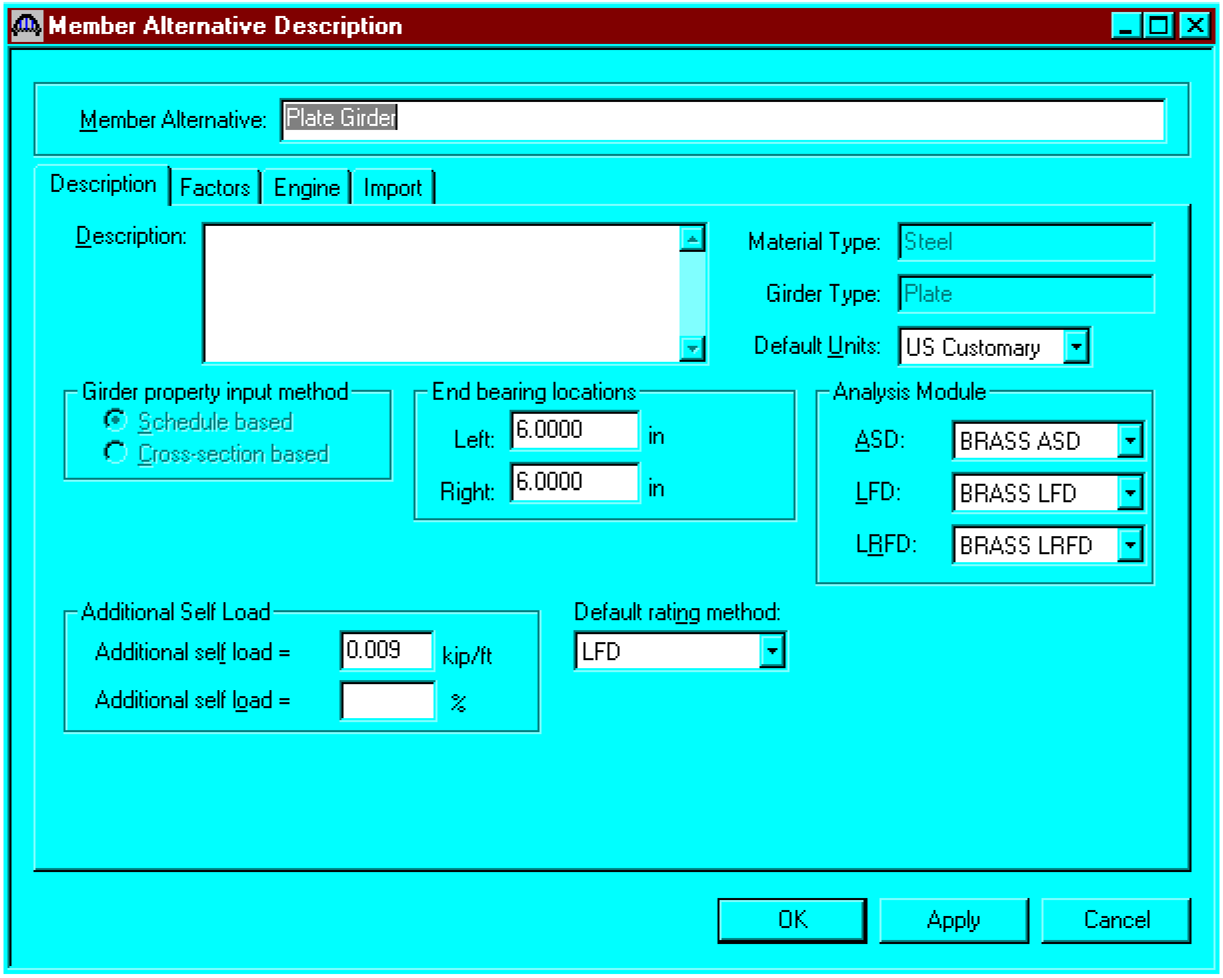
Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select steel for the Material Type and Plate for the Girder Type.



Material Type: Steel

Girder Type: Plate

Click OK to close the dialog and create a new member alternative.



Member Alternative: Plate Girder

Description:

Material Type: Steel

Girder Type: Plate

Default Units: US Customary

Girder property input method
● Schedule based
○ Cross-section based

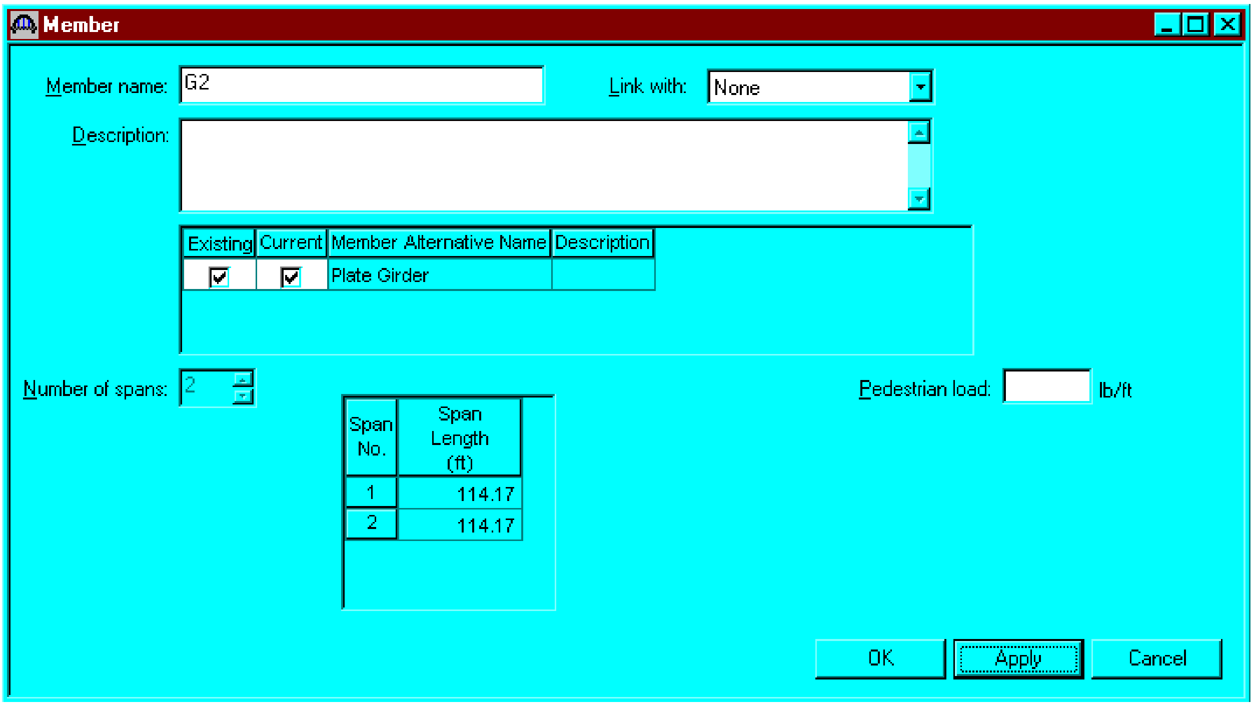
End bearing locations
Left: 6.0000 in
Right: 6.0000 in

Analysis Module
ASD: BRASS ASD
LFD: BRASS LFD
LRFD: BRASS LRFD

Additional Self Load
Additional self load = 0.009 kip/ft
Additional self load = %

Default rating method: LFD

Now re-open the Member G2 window, we will see this Member Alternative designated as the existing and current member alternative for this Member.



Member name: G2

Link with: None

Description:

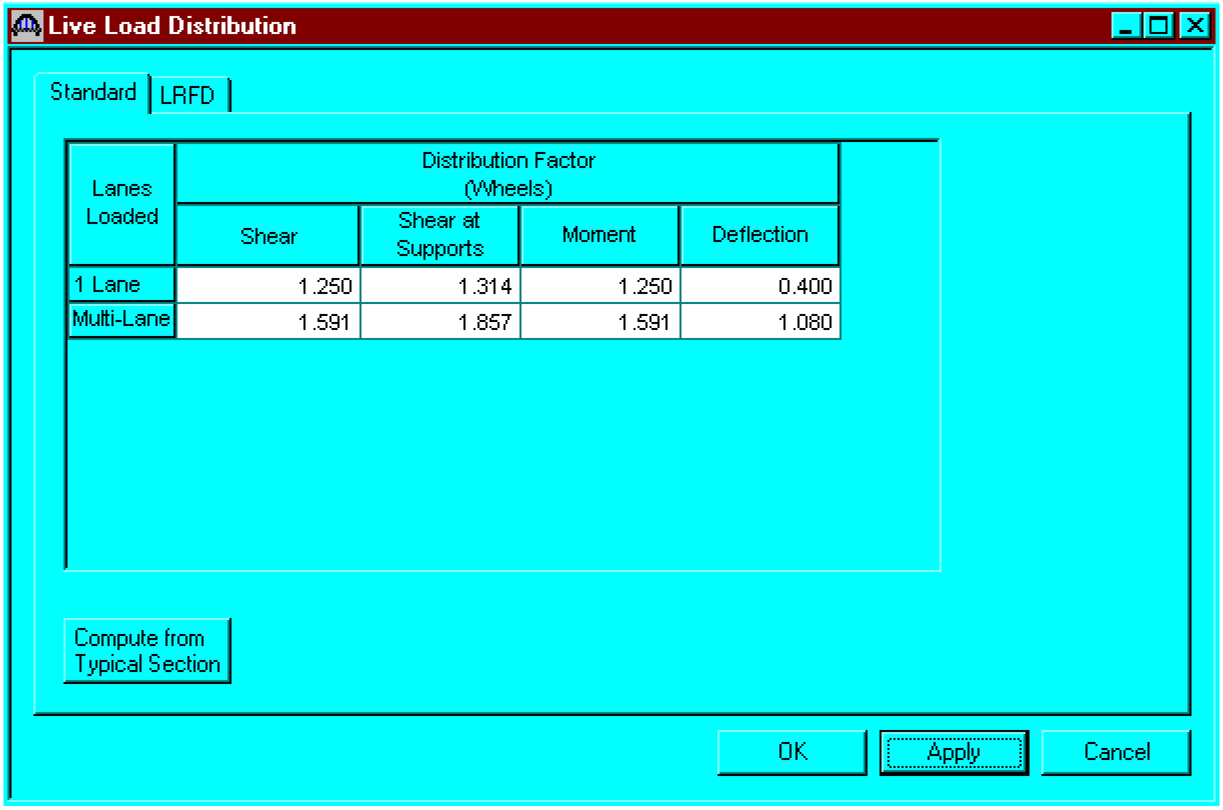
Existing	Current	Member Alternative Name	Description
☑	☑	Plate Girder	

Number of spans: 2

Span No.	Span Length (ft)
1	114.17
2	114.17

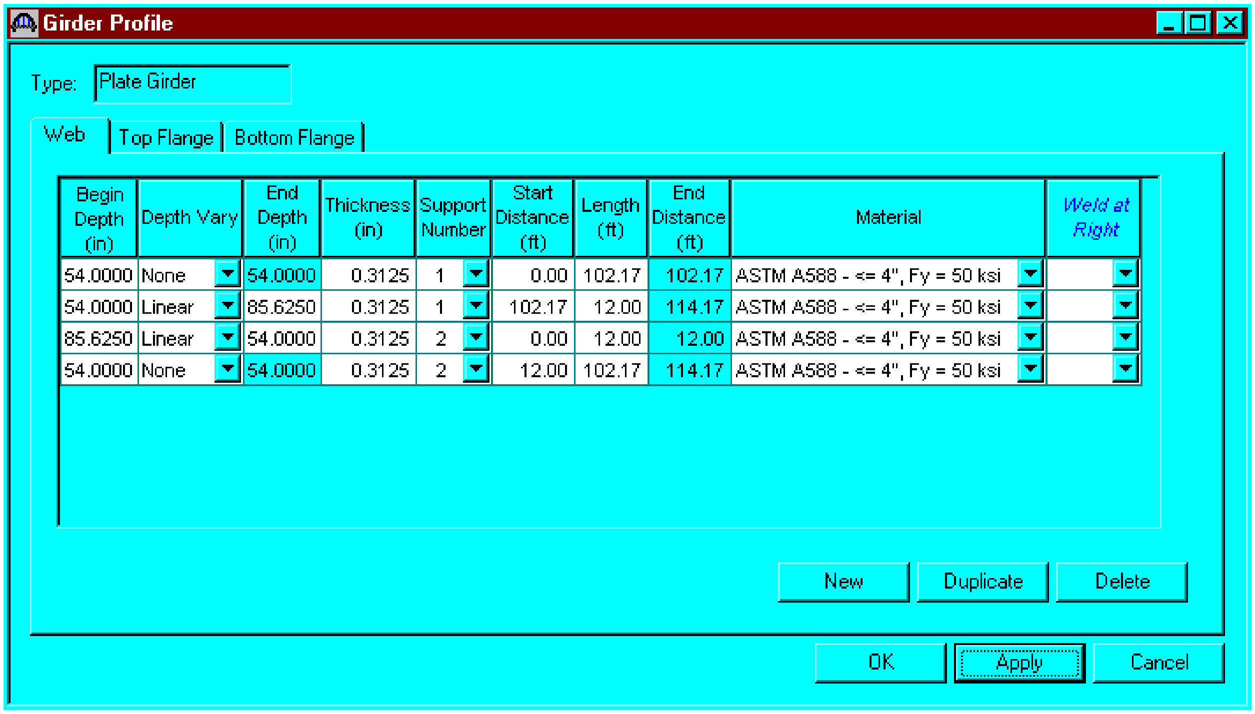
Pedestrian load: lb/ft

Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23. Click Apply and then OK to save data to memory and close the window.



Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.250	1.314	1.250	0.400
Multi-Lane	1.591	1.857	1.591	1.080

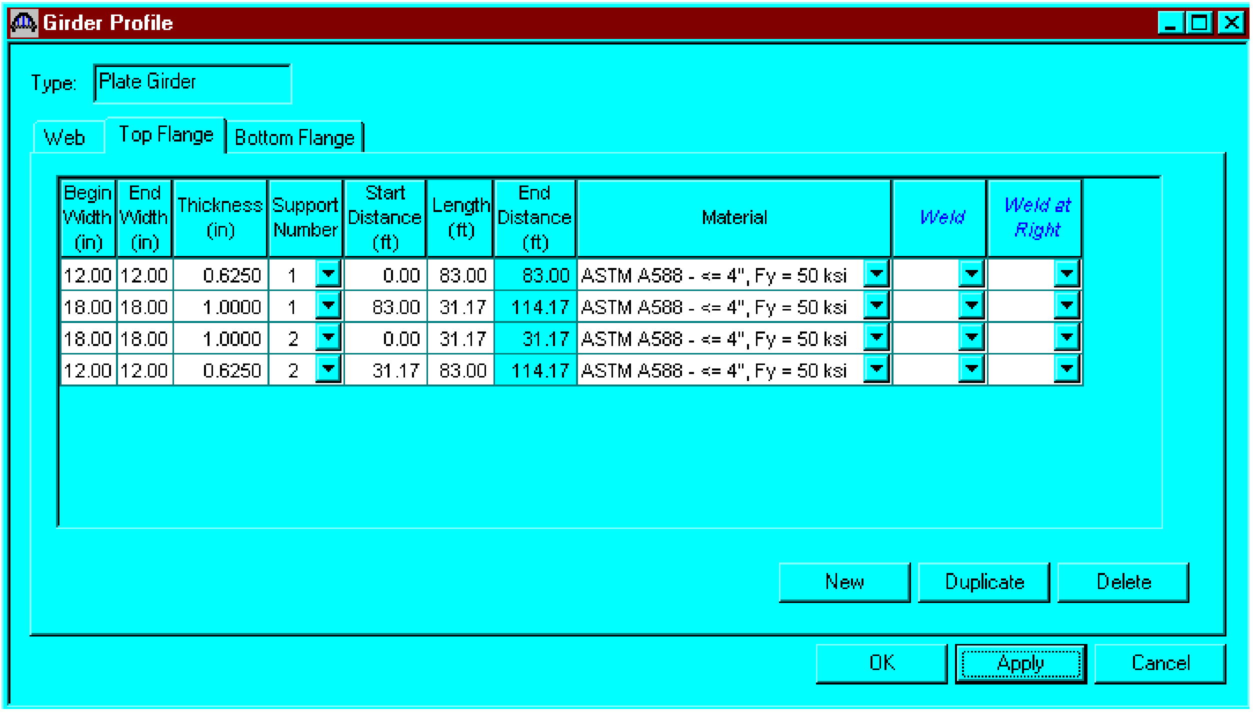
Double click on Girder Profile in the tree to describe the girder profile. The window is shown below with the data describing the web.



Type: Plate Girder

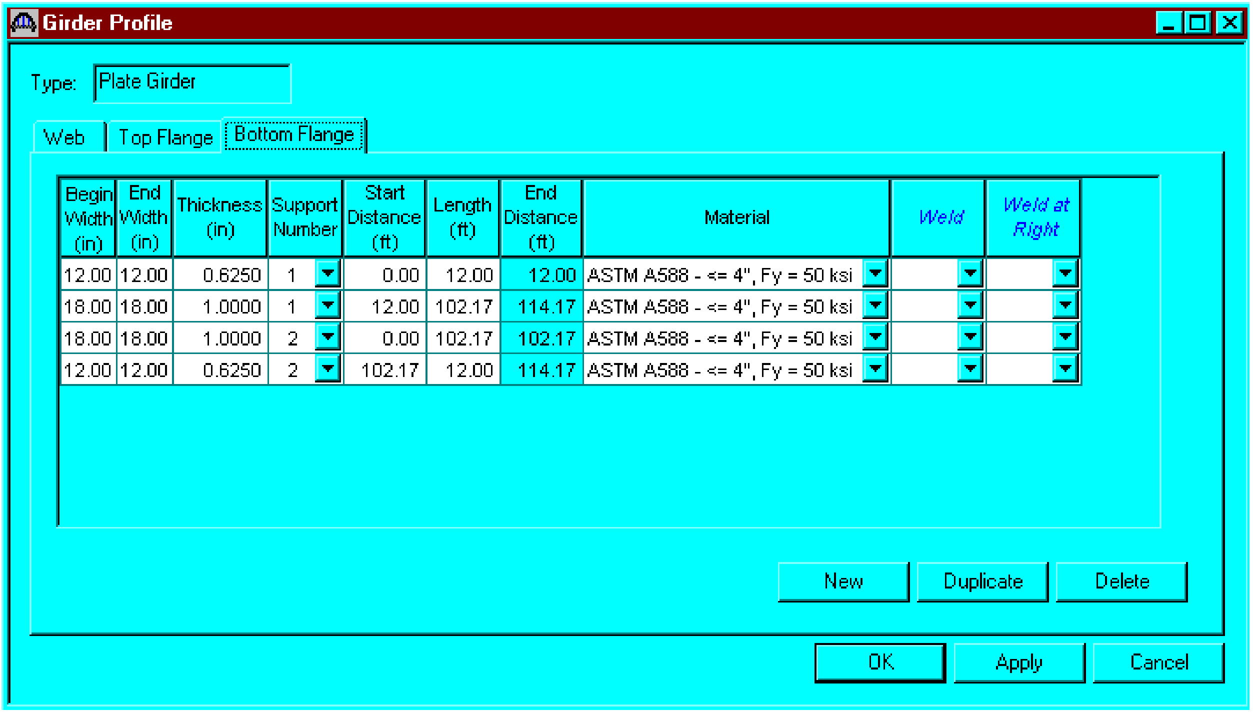
Begin Depth (in)	Depth Vary	End Depth (in)	Thickness (in)	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld at Right
54.0000	None	54.0000	0.3125	1	0.00	102.17	102.17	ASTM A588 - <= 4", Fy = 50 ksi	
54.0000	Linear	85.6250	0.3125	1	102.17	12.00	114.17	ASTM A588 - <= 4", Fy = 50 ksi	
85.6250	Linear	54.0000	0.3125	2	0.00	12.00	12.00	ASTM A588 - <= 4", Fy = 50 ksi	
54.0000	None	54.0000	0.3125	2	12.00	102.17	114.17	ASTM A588 - <= 4", Fy = 50 ksi	

Describe the flanges as shown below.



Type: Plate Girder

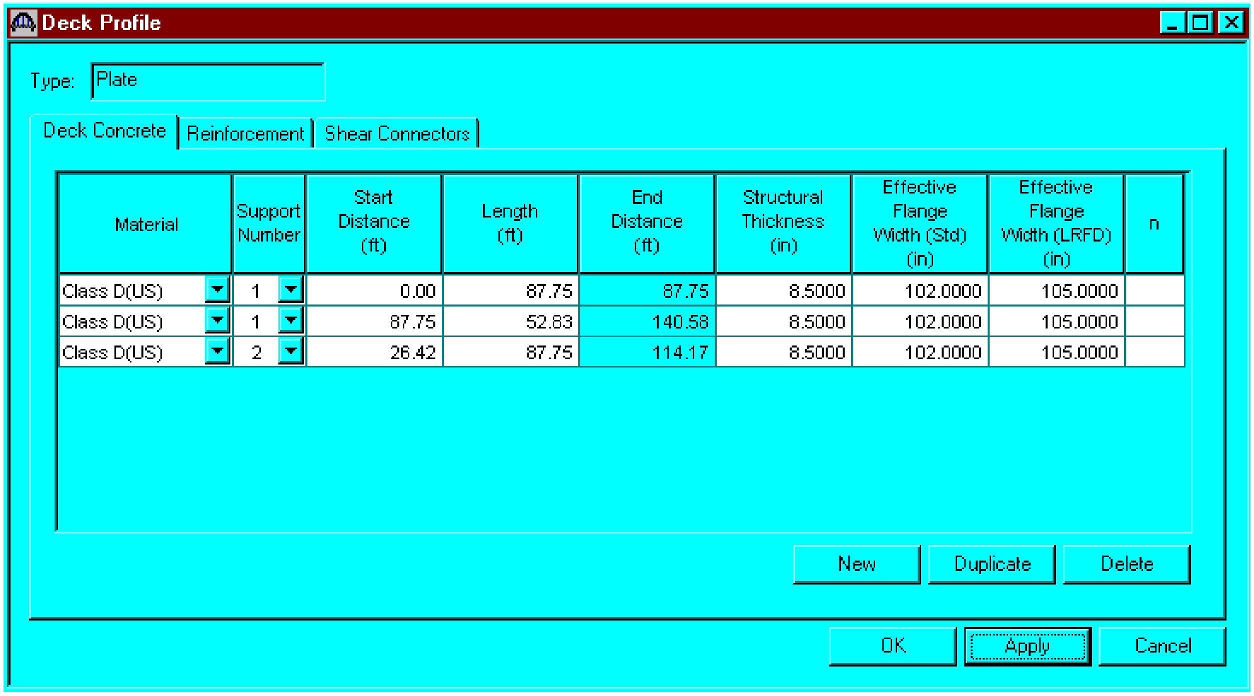
Begin Width (in)	End Width (in)	Thickness (in)	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld	Weld at Right
12.00	12.00	0.6250	1	0.00	83.00	83.00	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	1	83.00	31.17	114.17	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	2	0.00	31.17	31.17	ASTM A588 - <= 4", Fy = 50 ksi		
12.00	12.00	0.6250	2	31.17	83.00	114.17	ASTM A588 - <= 4", Fy = 50 ksi		



Type: Plate Girder

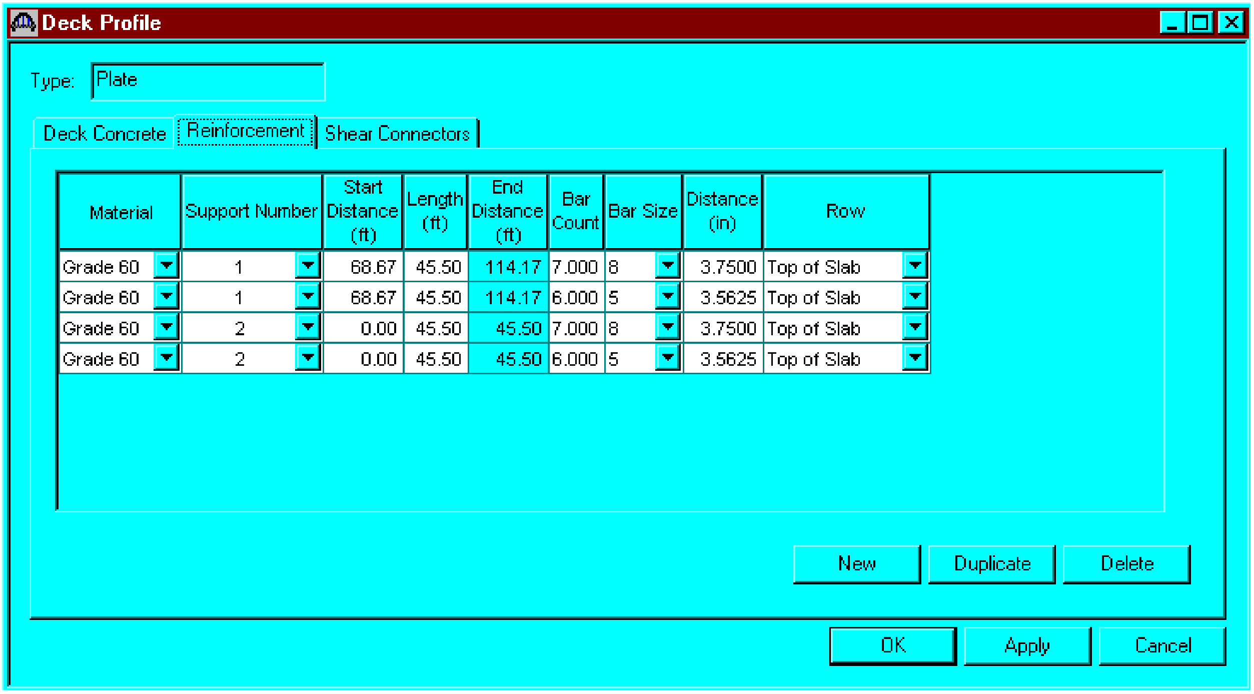
Begin Width (in)	End Width (in)	Thickness (in)	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld	Weld at Right
12.00	12.00	0.6250	1	0.00	12.00	12.00	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	1	12.00	102.17	114.17	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	2	0.00	102.17	102.17	ASTM A588 - <= 4", Fy = 50 ksi		
12.00	12.00	0.6250	2	102.17	12.00	114.17	ASTM A588 - <= 4", Fy = 50 ksi		

Double click on Deck Profile and enter data describing the structural properties of the deck. The deck concrete and reinforcement windows are shown below.



Type: Plate

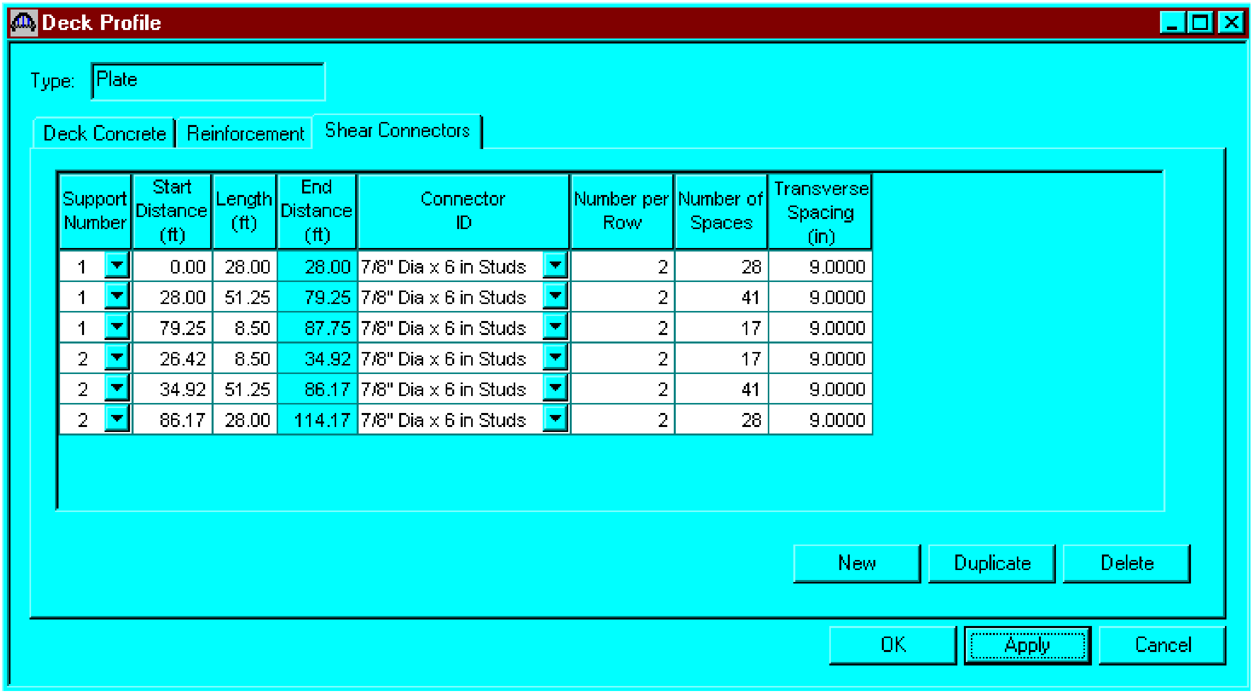
Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Structural Thickness (in)	Effective Flange Width (Std) (in)	Effective Flange Width (LRFD) (in)	n
Class D(US)	1	0.00	87.75	87.75	8.5000	102.0000	105.0000	
Class D(US)	1	87.75	52.83	140.58	8.5000	102.0000	105.0000	
Class D(US)	2	26.42	87.75	114.17	8.5000	102.0000	105.0000	



Type: Plate

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Bar Count	Bar Size	Distance (in)	Row
Grade 60	1	68.67	45.50	114.17	7.000	8	3.7500	Top of Slab
Grade 60	1	68.67	45.50	114.17	6.000	5	3.5625	Top of Slab
Grade 60	2	0.00	45.50	45.50	7.000	8	3.7500	Top of Slab
Grade 60	2	0.00	45.50	45.50	6.000	5	3.5625	Top of Slab

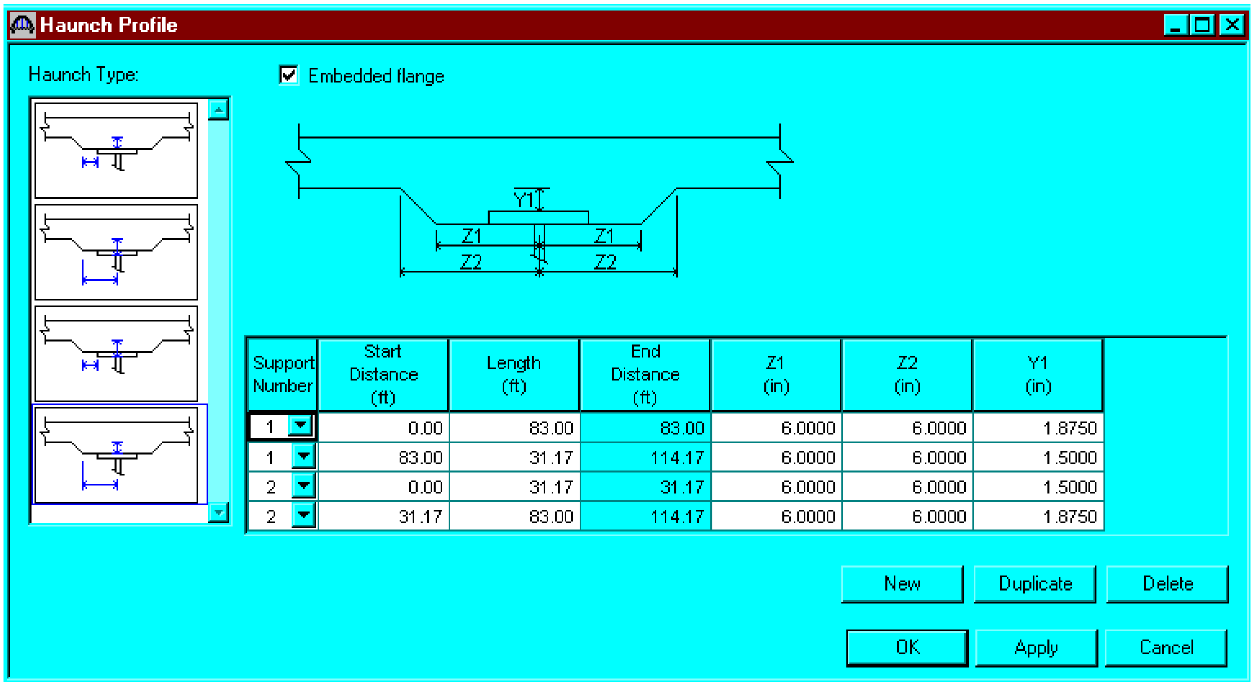
Composite regions are described using the Shear Connectors tab as shown below.



Type: Plate

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Connector ID	Number per Row	Number of Spaces	Transverse Spacing (in)
1	0.00	28.00	28.00	7/8" Dia x 6 in Studs	2	28	9.0000
1	28.00	51.25	79.25	7/8" Dia x 6 in Studs	2	41	9.0000
1	79.25	8.50	87.75	7/8" Dia x 6 in Studs	2	17	9.0000
2	26.42	8.50	34.92	7/8" Dia x 6 in Studs	2	17	9.0000
2	34.92	51.25	86.17	7/8" Dia x 6 in Studs	2	41	9.0000
2	86.17	28.00	114.17	7/8" Dia x 6 in Studs	2	28	9.0000

Double click on Haunch Profile in the tree to define the haunch profile. Check the box ‘embedded flange’ if the top flanges of the girder is embedded in the concrete haunch.



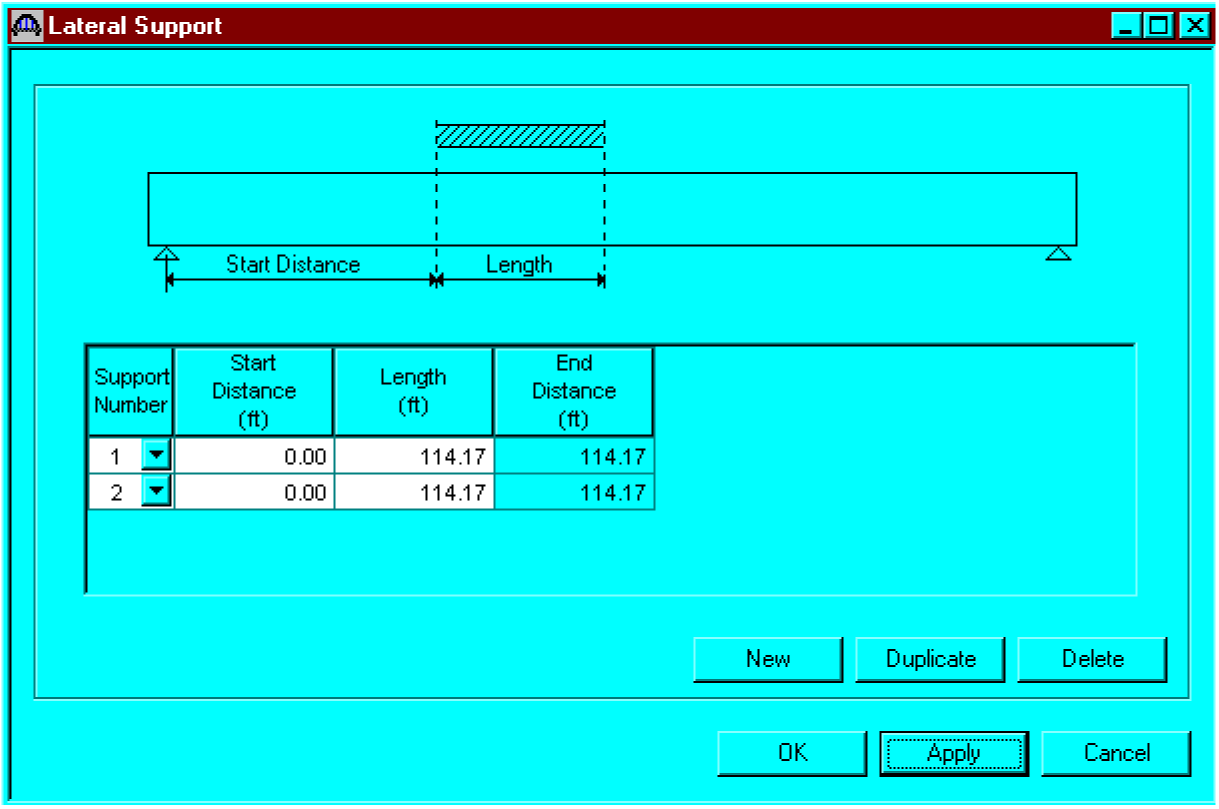
Haunch Profile

Haunch Type:

☑ Embedded flange

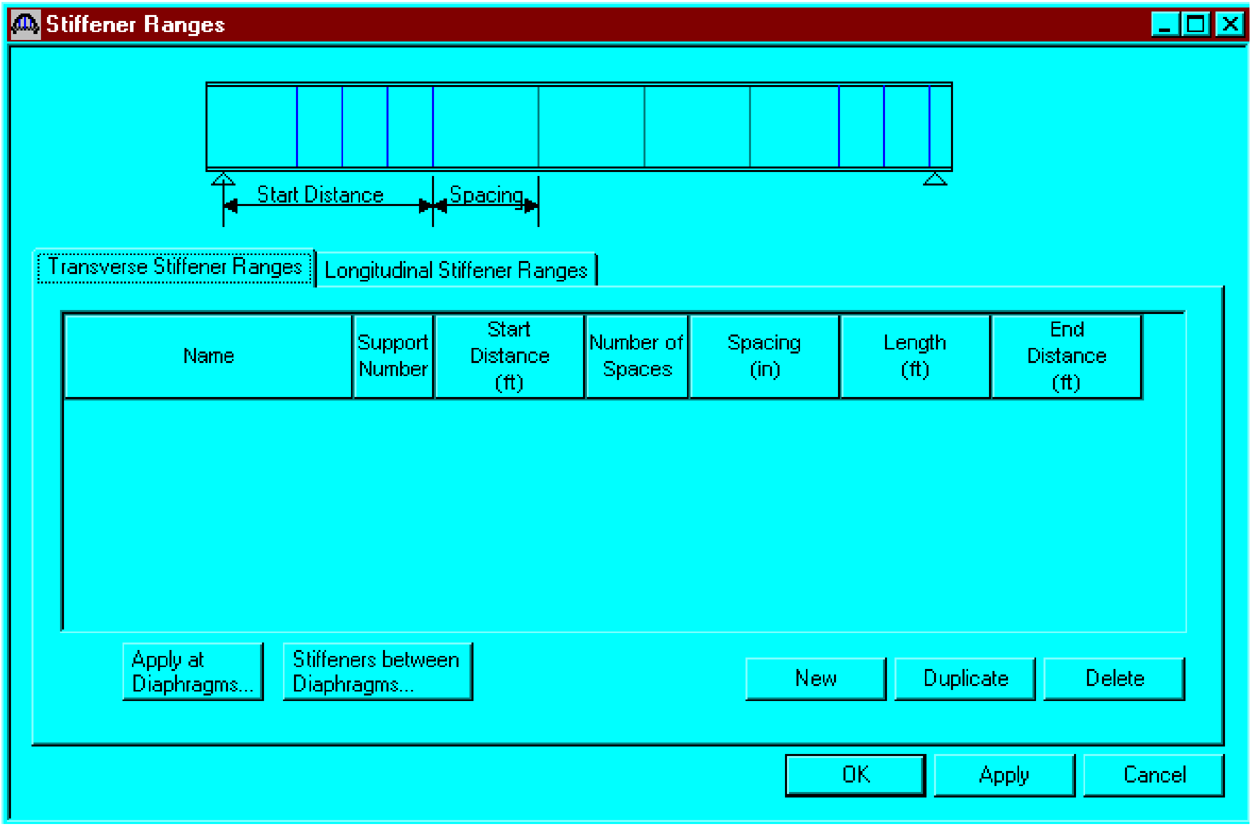
Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)
1	0.00	83.00	83.00	6.0000	6.0000	1.8750
1	83.00	31.17	114.17	6.0000	6.0000	1.5000
2	0.00	31.17	31.17	6.0000	6.0000	1.5000
2	31.17	83.00	114.17	6.0000	6.0000	1.8750

Regions where the hardened concrete deck slab is considered to provide lateral support for the top flange are defined using the Lateral Support window.



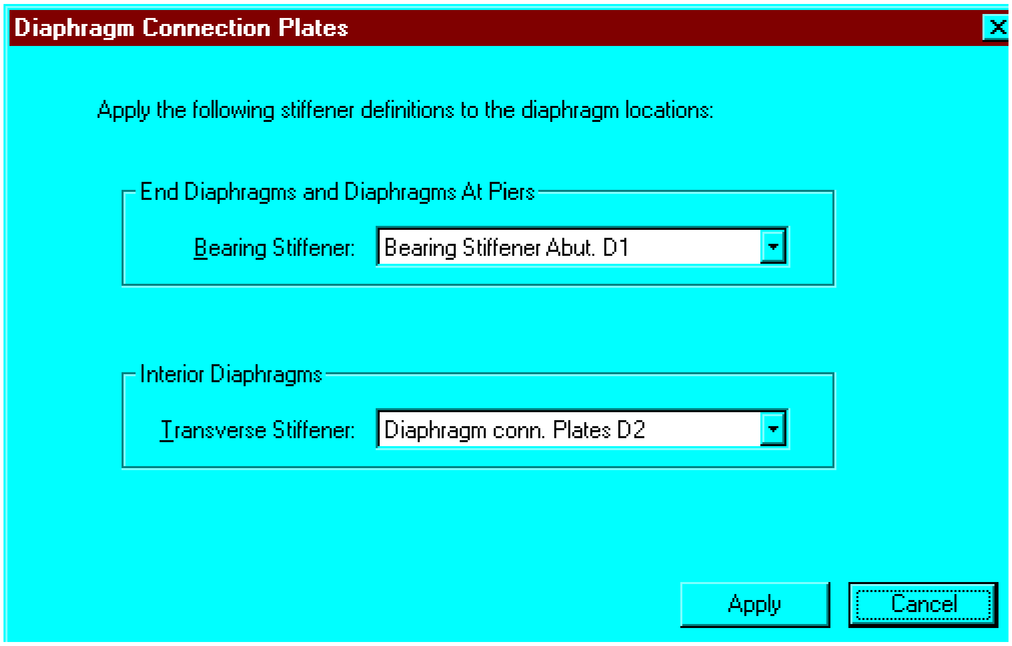
Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
1	0.00	114.17	114.17
2	0.00	114.17	114.17

Define stiffener locations using the Stiffener Ranges window shown below.



Name	Support Number	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)

Click on the Apply at Diaphragms... to open the following dialog box. Select the Diaphragm connection Plates D2 as the stiffener to be applied at interior diaphragms.



Diaphragm Connection Plates

Apply the following stiffener definitions to the diaphragm locations:

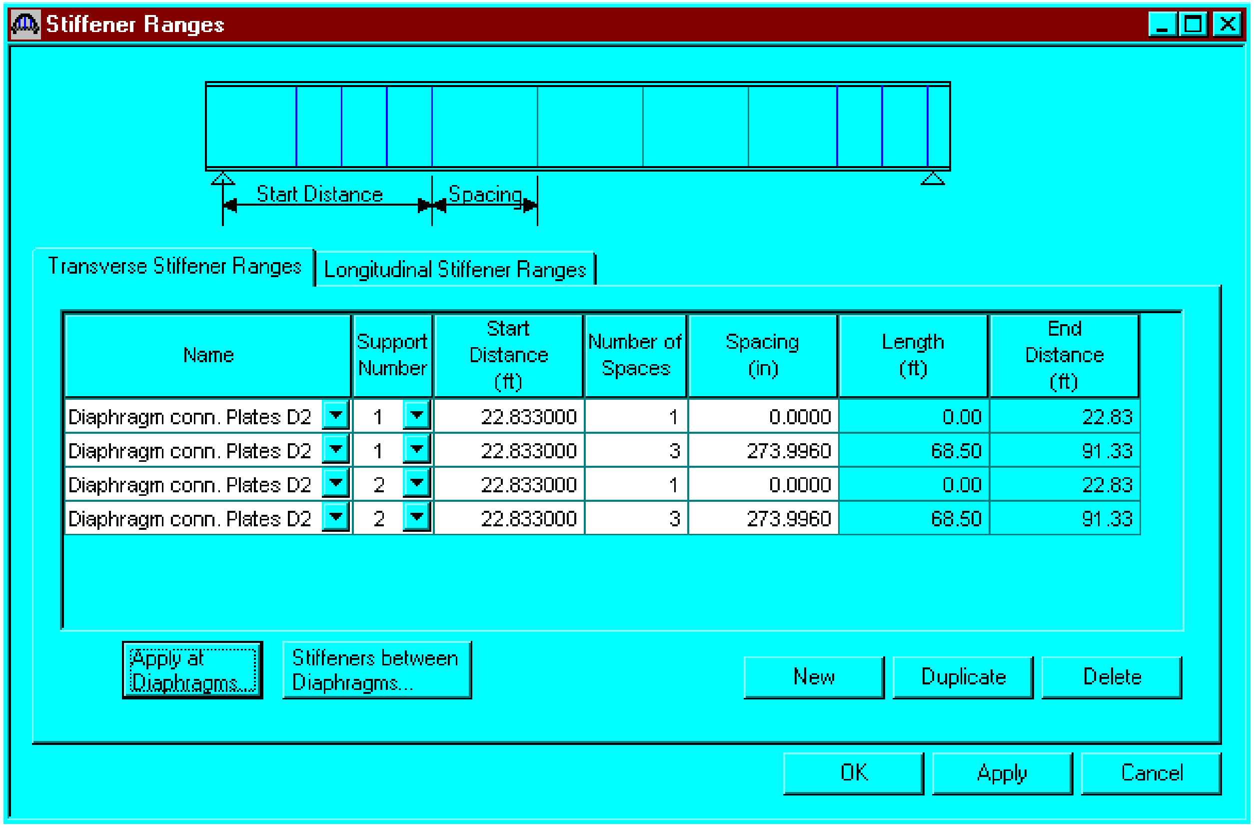
End Diaphragms and Diaphragms At Piers

Bearing Stiffener: Bearing Stiffener Abut. D1

Interior Diaphragms

Transverse Stiffener: Diaphragm conn. Plates D2

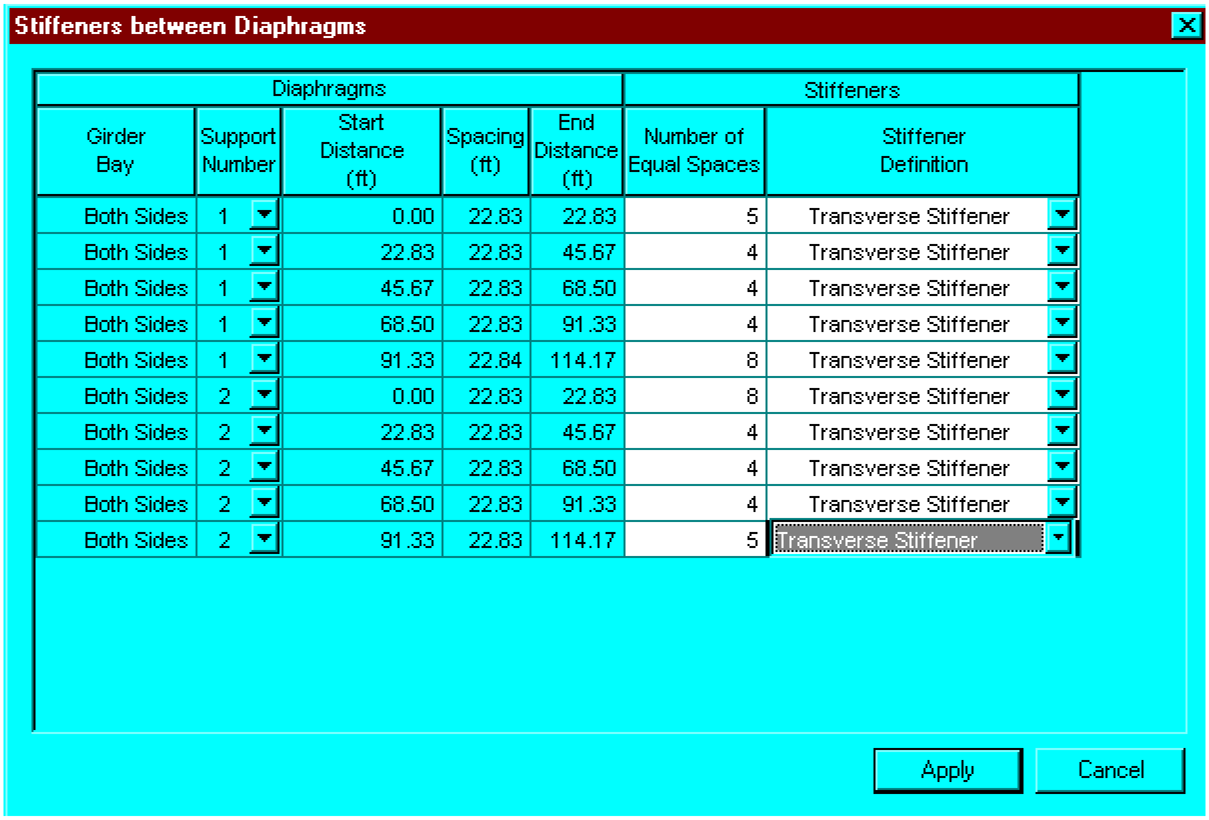
Selecting Apply button will create the following transverse stiffener locations.



Name	Support Number	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
Diaphragm conn. Plates D2	1	22.833000	1	0.0000	0.00	22.83
Diaphragm conn. Plates D2	1	22.833000	3	273.9960	68.50	91.33
Diaphragm conn. Plates D2	2	22.833000	1	0.0000	0.00	22.83
Diaphragm conn. Plates D2	2	22.833000	3	273.9960	68.50	91.33

This structure has intermediate transverse stiffeners between diaphragms. Click on the Stiffeners between Diaphragms... button to open the following window.

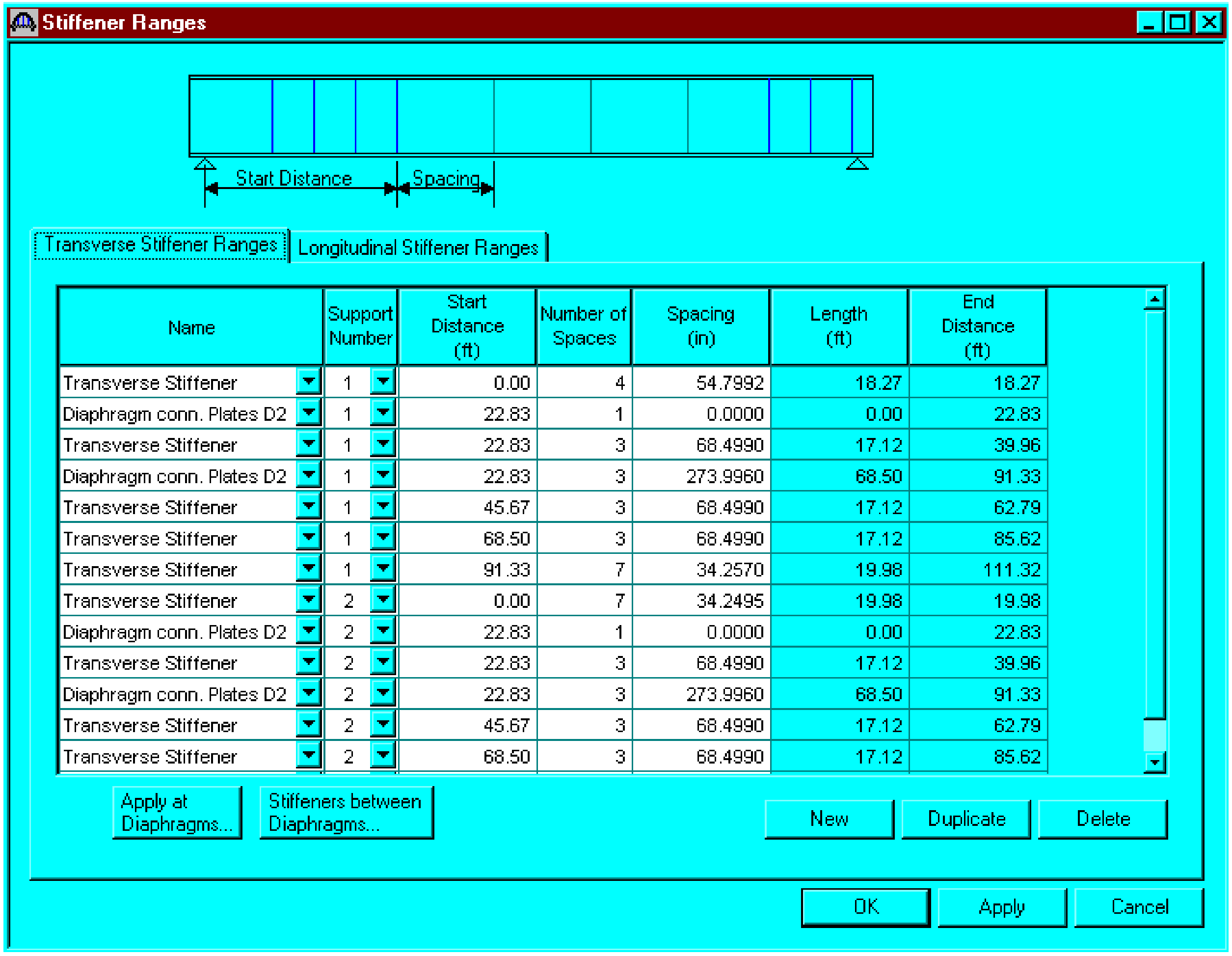
Enter the appropriate stiffener data i.e., the number of equal spaces between diaphragms and the stiffener definition.



Diaphragms					Stiffeners	
Girder Bay	Support Number	Start Distance (ft)	Spacing (ft)	End Distance (ft)	Number of Equal Spaces	Stiffener Definition
Both Sides	1	0.00	22.83	22.83	5	Transverse Stiffener
Both Sides	1	22.83	22.83	45.67	4	Transverse Stiffener
Both Sides	1	45.67	22.83	68.50	4	Transverse Stiffener
Both Sides	1	68.50	22.83	91.33	4	Transverse Stiffener
Both Sides	1	91.33	22.84	114.17	8	Transverse Stiffener
Both Sides	2	0.00	22.83	22.83	8	Transverse Stiffener
Both Sides	2	22.83	22.83	45.67	4	Transverse Stiffener
Both Sides	2	45.67	22.83	68.50	4	Transverse Stiffener
Both Sides	2	68.50	22.83	91.33	4	Transverse Stiffener
Both Sides	2	91.33	22.83	114.17	5	Transverse Stiffener

Click the Apply button.

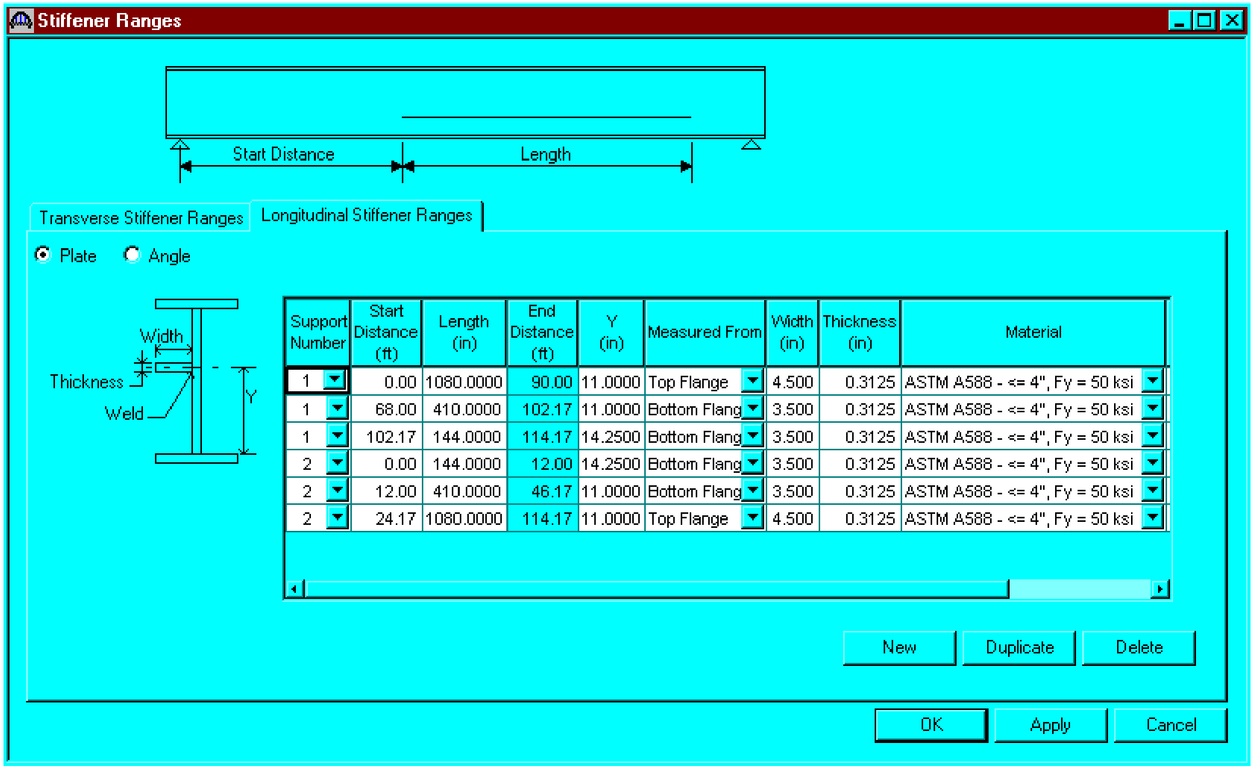
The populated Transverse Stiffener Ranges window is shown below. Click on the Apply button to save the data to memory.



Name	Support Number	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
Transverse Stiffener	1	0.00	4	54.7992	18.27	18.27
Diaphragm conn. Plates D2	1	22.83	1	0.0000	0.00	22.83
Transverse Stiffener	1	22.83	3	68.4990	17.12	39.96
Diaphragm conn. Plates D2	1	22.83	3	273.9960	68.50	91.33
Transverse Stiffener	1	45.67	3	68.4990	17.12	62.79
Transverse Stiffener	1	68.50	3	68.4990	17.12	85.62
Transverse Stiffener	1	91.33	7	34.2570	19.98	111.32
Transverse Stiffener	2	0.00	7	34.2495	19.98	19.98
Diaphragm conn. Plates D2	2	22.83	1	0.0000	0.00	22.83
Transverse Stiffener	2	22.83	3	68.4990	17.12	39.96
Diaphragm conn. Plates D2	2	22.83	3	273.9960	68.50	91.33
Transverse Stiffener	2	45.67	3	68.4990	17.12	62.79
Transverse Stiffener	2	68.50	3	68.4990	17.12	85.62

Click on the Longitudinal Stiffener Ranges tab to define the limits of longitudinal stiffeners.

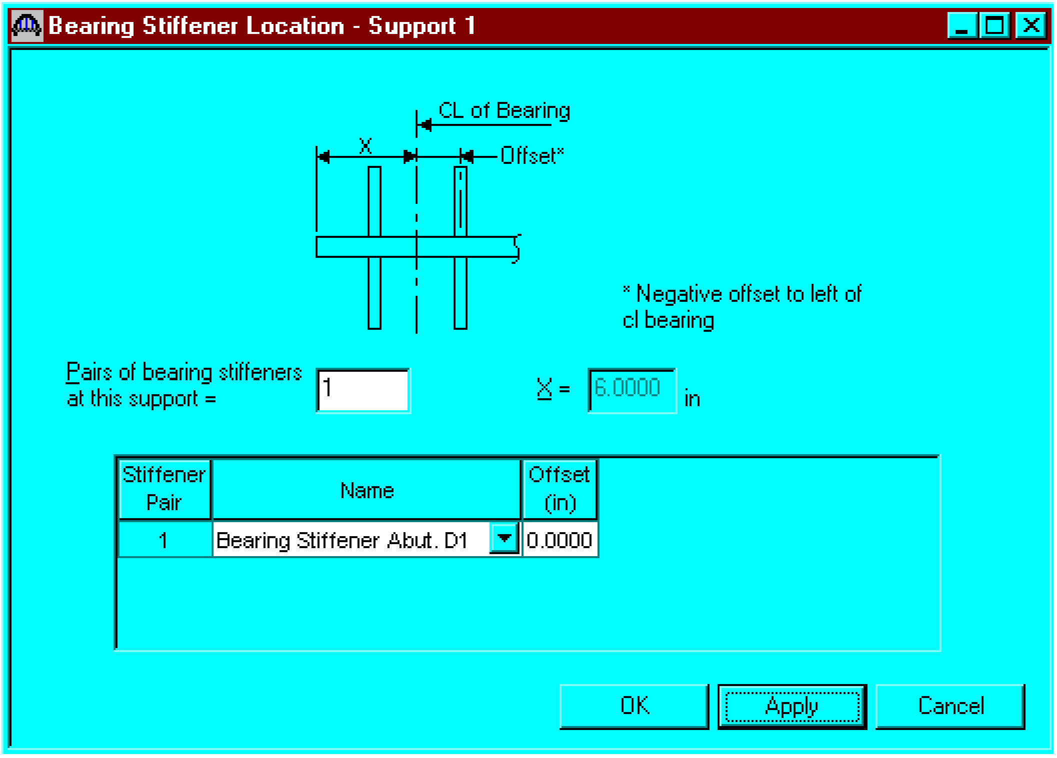
Enter the appropriate stiffener data and click the Apply button to save the data to memory and close the window.



● Plate ○ Angle

Support Number	Start Distance (ft)	Length (in)	End Distance (ft)	Y (in)	Measured From	Width (in)	Thickness (in)	Material
1	0.00	1080.0000	90.00	11.0000	Top Flange	4.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
1	68.00	410.0000	102.17	11.0000	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
1	102.17	144.0000	114.17	14.2500	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
2	0.00	144.0000	12.00	14.2500	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
2	12.00	410.0000	46.17	11.0000	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
2	24.17	1080.0000	114.17	11.0000	Top Flange	4.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi

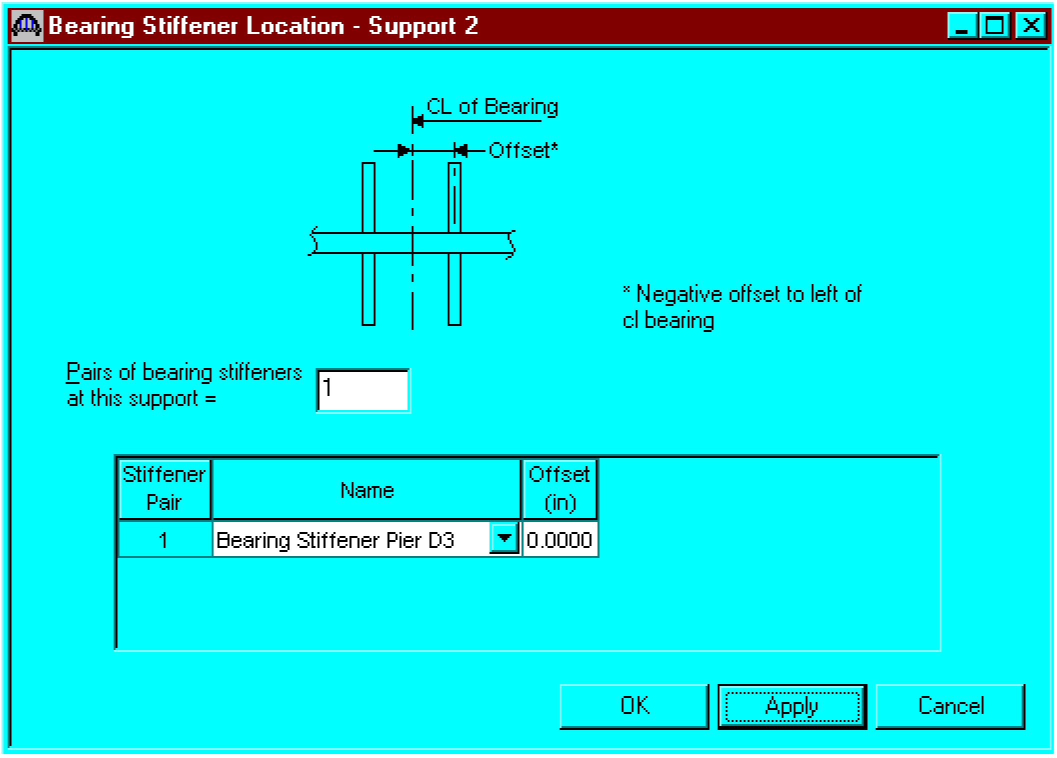
Bearing stiffener definitions were assigned to locations when we used the Apply at Diaphragms... button on the Transverse Stiffener Ranges window. Open the window by expanding the Bearing Stiffener Locations branch in the tree and double clicking on each support. The assignment for support 1, 2 and 3 are shown below.



Pairs of bearing stiffeners at this support = 1

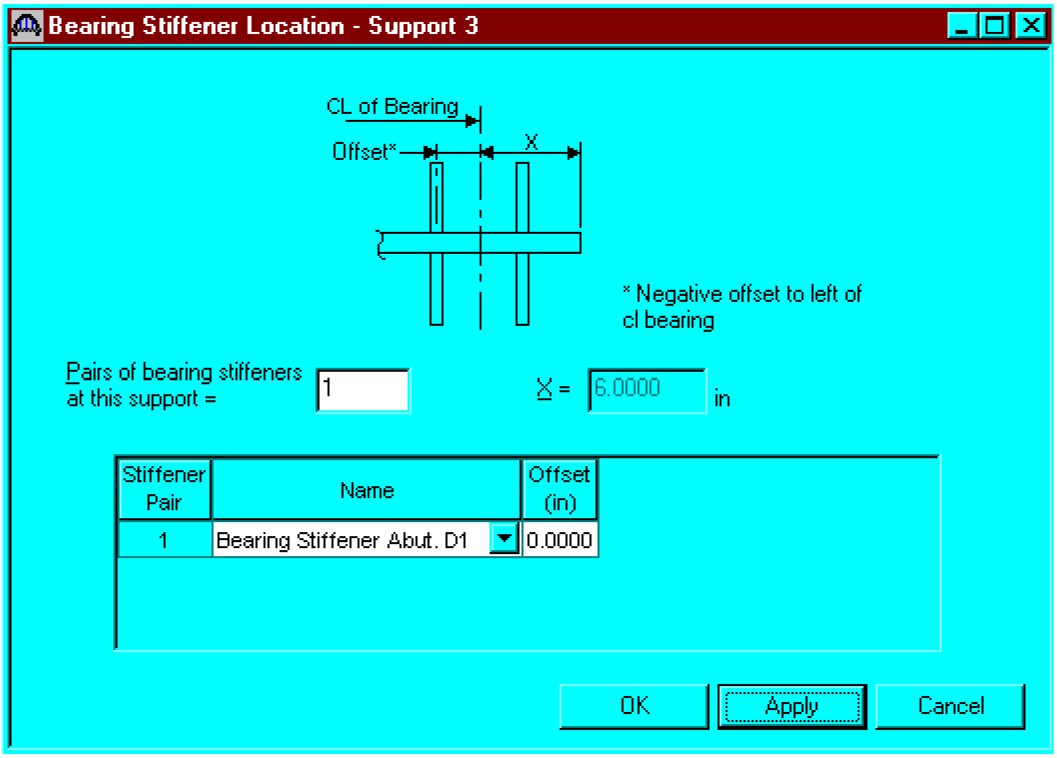
X = 6.0000 in

Stiffener Pair	Name	Offset (in)
1	Bearing Stiffener Abut. D1	0.0000



Pairs of bearing stiffeners at this support = 1

Stiffener Pair	Name	Offset (in)
1	Bearing Stiffener Pier D3	0.0000



Bearing Stiffener Location - Support 3

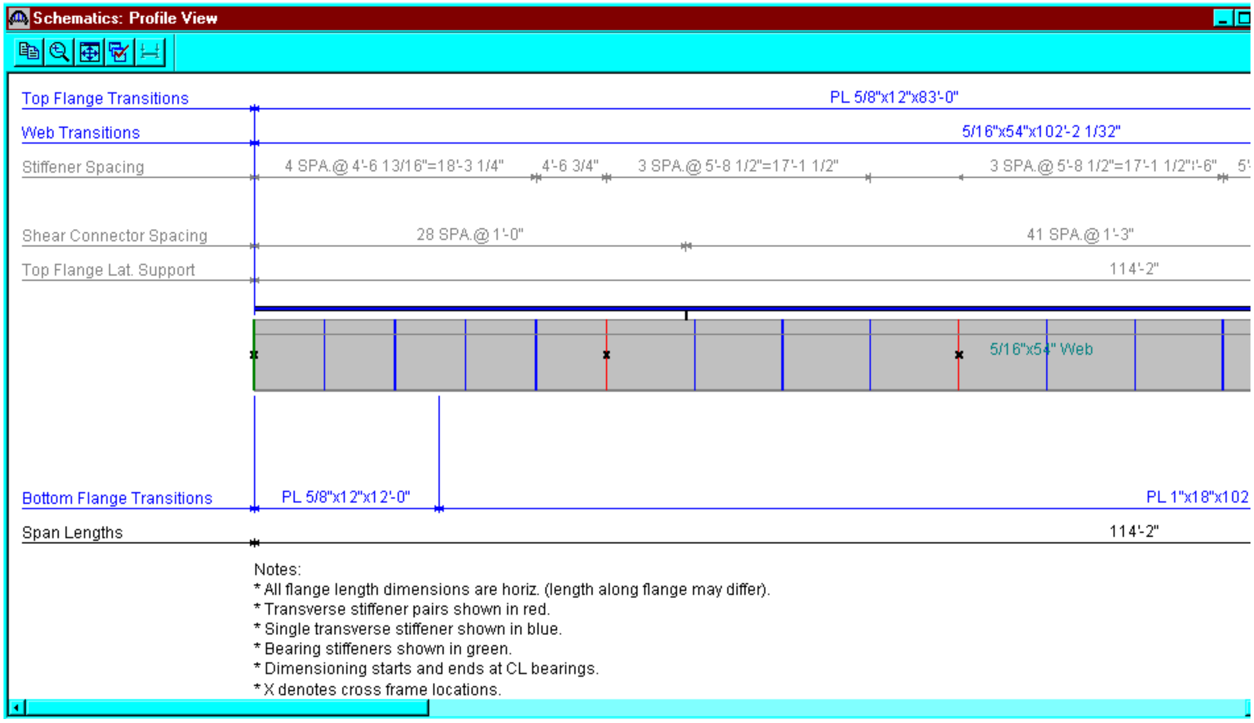
* Negative offset to left of cl bearing

Pairs of bearing stiffeners at this support = 1

X = 6.0000 in

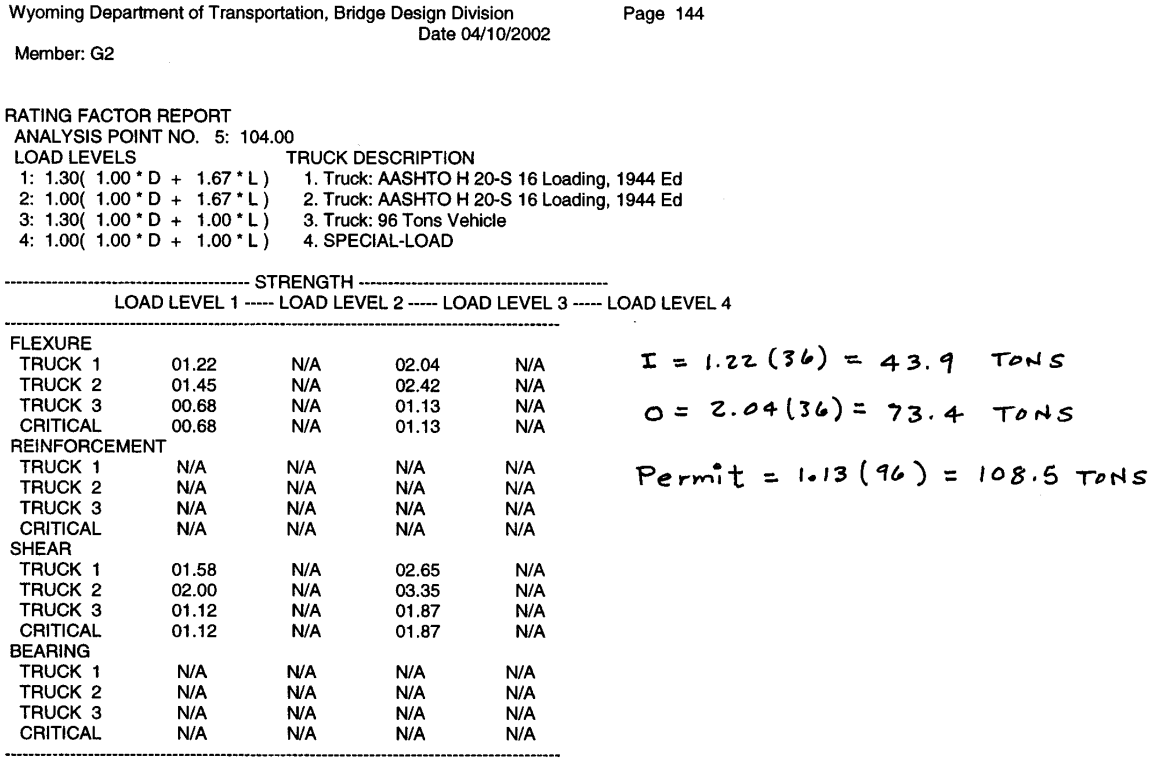
Stiffener Pair	Name	Offset (in)
1	Bearing Stiffener Abut. D1	0.0000

Select Plate Girder (E)(C) in the Bridge Workspace tree; open the schematic for the girder profile by selecting the View Schematic toolbar button or the Bridge/Schematic from the menu.



Notes:
* All flange length dimensions are horiz. (length along flange may differ).
* Transverse stiffener pairs shown in red.
* Single transverse stiffener shown in blue.
* Bearing stiffeners shown in green.
* Dimensioning starts and ends at CL bearings.
* X denotes cross frame locations.

The results of the control LFD rating analysis are as follows:



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                                                   Date 04/10/2002
 Member: G2


RATING FACTOR REPORT
 ANALYSIS POINT NO.  5:  104.00
 LOAD LEVELS                    TRUCK DESCRIPTION
  1:  1.30(  1.00 * D  +  1.67 * L )    1. Truck: AASHTO H 20-S 16 Loading, 1944 Ed
  2:  1.00(  1.00 * D  +  1.67 * L )    2. Truck: AASHTO H 20-S 16 Loading, 1944 Ed
  3:  1.30(  1.00 * D  +  1.00 * L )    3. Truck: 96 Tons Vehicle
  4:  1.00(  1.00 * D  +  1.00 * L )    4. SPECIAL-LOAD

------------------------------------------ STRENGTH ------------------------------------------
               LOAD LEVEL 1 ----- LOAD LEVEL 2 ----- LOAD LEVEL 3 ----- LOAD LEVEL 4
-----------------------------------------------------------------------------------------------
 FLEXURE
  TRUCK  1         01.22          N/A          02.04          N/A
  TRUCK  2         01.45          N/A          02.42          N/A
  TRUCK  3         00.68          N/A          01.13          N/A
  CRITICAL         00.68          N/A          01.13          N/A
 REINFORCEMENT
  TRUCK  1          N/A           N/A           N/A           N/A
  TRUCK  2          N/A           N/A           N/A           N/A
  TRUCK  3          N/A           N/A           N/A           N/A
  CRITICAL          N/A           N/A           N/A           N/A
 SHEAR
  TRUCK  1         01.58          N/A          02.65          N/A
  TRUCK  2         02.00          N/A          03.35          N/A
  TRUCK  3         01.12          N/A          01.87          N/A
  CRITICAL         01.12          N/A          01.87          N/A
 BEARING
  TRUCK  1          N/A           N/A           N/A           N/A
  TRUCK  2          N/A           N/A           N/A           N/A
  TRUCK  3          N/A           N/A           N/A           N/A
  CRITICAL          N/A           N/A           N/A           N/A
-----------------------------------------------------------------------------------------------
```

I = 1.22 (36) = 43.9 TONS

O = 2.04 (36) = 73.4 TONS

Permit = 1.13 (96) = 108.5 TONS

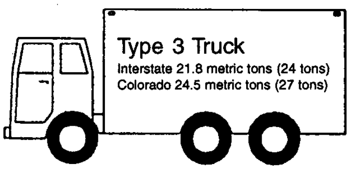
COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

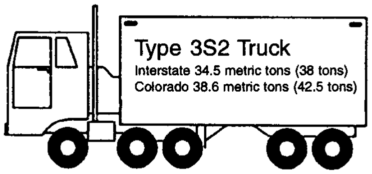
Structure #	N-17-BP(N.B.)
State highway #	I-25
Batch I.D.	
Structure type	WGCK
Parallel structure #	N-17-AM(S.B.)

Rated using
Asphalt thickness: 100 mm (4 in.)
☐ Colorado legal loads
☒ Interstate legal loads

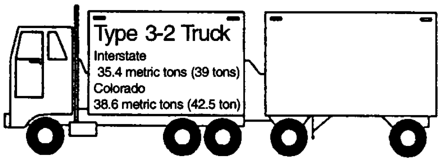
Structural member	INTERIOR GIRDER	SLAB		
	Metric tons (Tons)			
Inventory	40.0 (44)	32.7 (36)	( )	( )
Operating	66.4 (73)	53.6 (59)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	98.2 (108)	( )	( )	( )



______ (______)
Metric tons Tons



______ (______)
Metric tons Tons



______ (______)
Metric tons Tons

Comments

Control Member: Deck; Rated for 4" HBP
Load Capacity: 59 Tons
Girder: Only Interior Girder Rated; Rated for 4" HBP

Color Code: White

Project No: I25-1(88)
Note: Although Virtis performs the required flexure, shear and bearing capacity check during analysis, shear check has been omitted in the determination of girder load capacity.

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used **CDOT Form #1187a 1/95**

SECTION 10A

TRUSS BRIDGES

SUBJECT. PAGE NO.

10A-1 INTRODUCTION TO RATING TRUSS BRIDGES....................................10A.2
10A-2 POLICIES AND GUIDELINES FOR RATING TRUSS BRIDGES..........10A.3
10A-3 GUIDELINES FOR USING THE BARS RATING PROGRAM...............10A.5
10A-4 TRUSS BRIDGE RATING EXAMPLES...10A.9
10A-5 SLT EXAMPLE 10A.11

10A-1 INTRODUCTION TO RATING TRUSS BRIDGES

This section covers the general policies and guidelines for rating all truss bridges. Due to the fact that the majority of truss bridges are structural steel, this section also covers the details necessary to rate steel truss bridges .

Steel truss members shall be rated using the policy and guidelines in subsections 10A-2 and 10A-3.

Steel stringer and floor beam members shall be rated using the policy and guidelines in subsections 10A-2 and 10A-3, along with the applicable policy and guidelines in Section 10.

Timber truss bridges shall be rated using the pertinent policies and guidelines in this section and Section 13.

Bridge decks shall be rated in accordance with Section 3.

Subsections 10A-3 and 10A-4 give guidelines and examples for rating steel truss bridges with the BARS computer program.

The types of bridges covered in detail by this section are:

A. SDT - Steel D Deck Truss
B. SLT - Steel Low Truss
C. STT - Steel Through Truss

10A-2 POLICIES AND GUIDELINES FOR RATING TRUSS BRIDGES

I. GENERAL

A. All truss bridge ratings shall be performed in accordance with Sections 1 of this manual, and the AASHTO code except where amended within this manual.

B. All structural steel members (truss members, floor beams, and stringers) shall be rated with the BARS computer program.

C. Treated timber members shall be rated using the applicable portions of this section and Section 13. Hand computations will be acceptable for rating timber truss members and timber floor beams.

D. Structural steel stringers and floor beams shall be rated using the applicable portions of this section and Section 10.

E Members designed by the working stress method shall be rated by the working stress method.

F. When design plans are available, giving design stresses, use the applicable inventory and operating stresses. Otherwise, the default values used in the BARS program for the applicable year of construction may be used. It is possible that the year of construction and the year of steel member fabrication are not coincident; e.g., when salvaged members have been utilized. In this case, the year of steel fabrication shall be used in determining allowable stresses.

G. Truss members shall be identified on all rating material using the standard notation as shown in the BARS Users' Manual and in the AASHTO MANUAL FOR MAINTENANCE INSPECTION OF BRIDGES.

H. The reduction in capacity of steel compression members with batten plate construction, as stipulated in the AASHTO MANUAL FOR MAINTENANCE INSPECTION OF BRIDGES, shall be used. However, this reduction does not need to be used due to the presence of lacing, perforated plates, or tie plates when lacing connects the flanges between the tie Plates.

II. MEMBERS REQUIRING RATING

A. Truss Members - A rating is required for all members that make up a truss, even though only the critical truss member is recorded on the Rating Summary Sheet. When a truss is symmetrical about its midspan centerline, then all the members on only one side of the centerline require a rating. A rating is not required for portal, or sway bracing, members.

B. Interior Floor Beams - A rating is required for the critical interior floor beam. In order to determine the critical floor beam, more than one interior floor beam may require analysis due to variations in cross-sectional size, grade of material, loads. or any other determining factor.

C. End Floor Beams - A rating is required for an end floor beam when its cross-sectional size is different from that used for the interior floor beams, or when it will give a lower rating value than an interior floor beam.

D. Interior Stringers - A rating is required for the critical interior stringer. In order to determine the critical stringer, more than one interior stringer may require analysis due to variations in cross-sectional size, grade of material, span length. loads, or any other determining factor.

E. Exterior Stringers - A rating is required for an exterior stringer when its cross-sectional size is different from that used for the interior stringers, or when it will give a lower rating value than interior stringer.

III. CALCULATIONS

A. A set of calculations, separate from computer output, shall be submitted with each rating. These calculations shall include: a diagram of the truss as modeled for analysis, with members labeled; derivations for member section properties, with supporting sketches; derivation of dead loads; derivation of live load distribution factors; and any other calculations or assumptions used for rating.

B. Live load distribution factors shall be calculated using the vehicle placement guidelines stipulated in Section 1.

C. Dead Loads

1. S

The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.

2. Dead loads supported by stringers, and applied after a cast-in-place concrete deck has cured, shall be distributed equally to all stringers. Possible examples include asphalt and curbs.

3. Dead loads supported by stringers, and applied before a cast-in-place concrete deck has cured (or applied when the deck is not cast-in-place concrete), shall be distributed to the applicable individual supporting stringer. Examples include stringer weight and deck, but not necessarily overlay. weight.

4. The method for applying dead loads due to utilities is left to the rater's discretion.

IV. REPORTING RATINGS

A. The rater and checker shall complete the rating documentation as described in Section 1 of this manual. In addition to Section 1, the following items shall be observed when filling out the Rating Summary Sheet.

1. Comment on the allowable stress used for inventory if different from the AASHTO allowable.

2. In the truss portion of the rating summary sheet the rating for only the most critical truss member shall be recorded. The critical truss member for one rating value (inventory, operating, posting, or color code) may be different from the truss member that is critical for another rating value. Therefore, the rater shall designate the most critical member and its rating, as appropriate, for each truss rating value entered on the Rating Summary Sheet.

10A-3GUIDELINES FOR USING THE BARS RATING PROGRAM

To effectively use BARS the rater must become familiar with the Data Preparation Instructions Manual, hereafter referred to as the BARS Manual. The following information for coding the BARS input forms is meant only to supplement the BARS Manual. The discussion for data input is arranged in the order which each card type should appear in the input file.

I. BARS INPUT

A. When creating a BARS input file all references to member descriptions, section codes, and span lengths shall be consistent amongst all card types.

l. For member descriptions and section codes, 01 (zero one) is not the same as bl (blank one). For example, if a member is identified as LOlUOl on card type 64, this designation (LOlUOl) must be used on all other applicable card types, whereas the designations LblUbl, LlbUOl, or any other combination inconsistent with LOlUOl, are not to be used.

2. For a given span length, the method used to input feet and inches must be consistent so that the decimal portion of the length is exactly the same on all card types in which the span length is referenced.

B. Card Type 01 - One card type 01 is required for each BATCH I.D. Leave columns 3 through 8 blank. Columns 9 through 14 CANNOT be left blank.

C. Card Type 03 - Got required for all ratings

1. Card type 03 is required when an Interstate structure requires a posting analysis. In this case, the Interstate posting vehicles shall be coded on card type 03 and referred to as "I3", "I3S2", and "I3-2" in columns l0 13. These load names must also be coded in columns 46 57 of card tome 01.

2. Card type 03 is ignored if the operating rating for all bridge members being rated is greater than or equal to 36.0 tons (the HS 20 gross weight), unless this program decision is overridden on card type 01.

D. Card Type 02 - Structure Header and Description

1. The year of construction defines the allowable stresses the program will use. Code in a value that produces the appropriate allowable stresses. If this value is different than the actual year of construction, note the actual year on card type 06.

2. The width entered in columns 59-68 is actual roadway width and may not be greater than the span length of any floor beam member which is being rated.

3. Columns 71-80 should be ignored if the HS 20 vehicle is used for determining the inventory and operating ratings.

E. Card Type 05 - Structure Location and Permanent Identification Factors.

1. Fill in columns 3 - 20.

2. Columns 66 - 73 shall contain the highway number.

3. Columns 74 - 80 shall contain the direction of traffic carried by the bridge if traffic is going in only one direction.

F. Card Type 06 - Comments. This card is used for comments and the following information is required. (see Rating Examples).

   1. Project number and feature intersected.

   2 Thickness and type of surfacing on deck. Note which legal loading applies. Colorado or Interstate Loading.

   3. If a new bridge is being rated, note the structure number of the bridge being replaced; nearest city or town; parallel structure number, and note "SIMILAR" if the parallel structure is identical insofar as the rating for one structure is identical to the rating of the parallel structure .

   4. Identify stringer and beam members chosen for rating; e.g., "BO1 = INT. BEAM (W36x150)". Truss members do not need to be identified. Note if yield stresses used were other than those built into the program. Note the actual year of construction if different from the year entered on card type 02.

G. Card Type 08 through Card Type 12 - Flexural Members

   1. Designate floor beams and stringers by coding in column 9 a "B" or an "S", respectively. Stringers may not be coded as continuous members.

   2. On card type 08, when entering data for a floor beam, code in the center-to-center spacing of floor beams for the value of "S" in columns 61 - 65. If it is an end floor beam, code an "X" in column 66. For stringers, code the distribution factor-as computed from the AASHTO manual for the value of "E" in columns 61 - 65.

   3. For more information on card types 08 through 12, see subsection 10-3.

H. Card Type 60 - General Specifications For Truss Analysis

   1. In some cases, it may be necessary to use columns 10 - 19 to override the allowable stresses designated by the date on card type 02. If so, the BARS rating output shall contain the correct operating allowable stresses. This output does not need to be corrected for the true inventory allowable stresses. However, the inventory stresses used in this case shall be noted on the Rating Summary Sheet under the comments section.

   2. Do not enter the center-to-center truss spacing to allow the program to compute the truss live load distribution factor. Instead, calculate the distribution factor (E) as shown in subsection 1-3 and enter it directly in columns 30 _ 34.
   3. Formally a rating is required for all truss members, even though only the critical member is recorded on the Rating Summary Sheet. When a truss is symmetrical about its midspan centerline, then all the members on only one side of the centerline require a rating.

I. Card Type 61 - Truss Geometry

   1. For the purposes of column 14, a through truss is any truss where the bottom chord directly supports the bridge deck, and a deck truss is any truss where the top chord directly supports the bridge deck.

2. To prevent errors in processing, be certain that the sum of the panel lengths is exactly equal to the overall span length (or one-half overall span for a symmetrical truss) entered on card type 61. without any rounding errors.

J. Card Type 63 and 64 - Truss Member Section Properties

1. Card type 63 is used when the overall section properties of all truss members are known. Card type 64 is used when the overall section properties are not known, and the rater decides to have the program compute them. The input data for section properties shall be shown on the hand calculation sheets submitted with the rating.

2. The reduction of section properties due to bolt and rivet holes must be taken into account when analyzing members subject to tensile stresses. Therefore. the effective area of bolt and rivet holes, as computed according to AASHTO Specifications, shall be used when calculating a member's net area on card type 63, or shall be entered as one of the member's cross sectional elements on card type 64. bolt and rivet holes do not effect gross sectional properties. Consequently, they do not reduce a member's capacity for compression.

3. Defects, or reductions in a member's cross-section, usually due to corrosion or collision damage, reduce both gross and net section properties. Therefore, the affect of defects shall be taken into account for all members in which they occur. The section properties of defects shall be used when computing all of the member's section properties shown on card type 63. Or, on card type 64, the defects shall be entered as elements of the member's cross-section.

4. The BARS program considers all members to have pinned end conditions for- all calculations, except when determining the effective length factor (K). The entry in column 49 and 60 on card types 63 and 64, respectively, will only be used for determining "K". If the end of a member is restrained by only pin friction, then enter an "X" in column 49 or 60, and "K" will be set equal to 0.875. If the end of a member is partially restrained by a bolted or riveted connection, leave column 49 or 60 blank, and "K" will be set equal to 0.75. See Appendix of AASHTO Standard Specifications for Highway Bridges for columns.

5. The value of "F" is used to take into account the reduced strength of batten plate columns (see AASHTO Manual for Maintenance Inspection of Bridges - Formulas For Steel Columns). It only applies when members are subject to compressive forces. The governing center-to-center spacing of the batten plates, i.e. tie plates, on one or both sides of a member should be used in determining "F". It is not necessary to apply this reduction due to the presence of lacing bars, perforated plates, or the tie plates which have lacing between them. In these cases, the value of "F" should be left blank.

K. Card Type 65 - Superimposed Dead Loads on Trusses

1. When the unloaded chords (the chords that are not directly supporting the deck) of the trusses on each side of the bridge are not interconnected with portals, or sway bracing, it is acceptable to apply all of the bridge's dead load as point loads at the panel points on the loaded chord.

II. BARS OUTPUT

A. The impact values for tension and compression assigned to a truss member are the result of the program applying the appropriate portion of the span length, as determined from the member's influence diagram, into the AASHT0 impact formula. When LC is the length of the influence diagram that applies to compression, and LT is the length of the influence diagram that applies to tension, LC plus LT equal the total span length of the truss. LC is used in the impact formula for determining the value of impact for compression, and LT is used for determining the impact for tension.

B. The HS 20 inventory and operating rating values assigned to structural members on the BARS output are the result of the program multiplying the rating factors by 20 to give ratings relative to the HS 20 designation. The rating values to be entered on the Rating Summary Sheet must be in tons. Therefore, the HS 20 ratings reported by the program must be multiplied by 1.8 (where 36/20 = 1.8 and 36 = gross weight of HS 20 vehicle in tons) to obtain the corresponding ratings in tons; i.e., (HS 20 rating) X 1.8 = (rating in tons).

10A-4 TRUSS BRIDGE RATING EXAMPLE (**SLT**)

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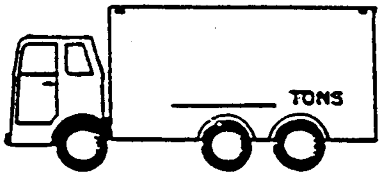
STAFF BRIDGE DESIGN
WORK SHEET (01200) 30
REV JULY, 1981

PARALLEL STRUCTURE NUMBER ——
STRUCTURE TYPE SLT

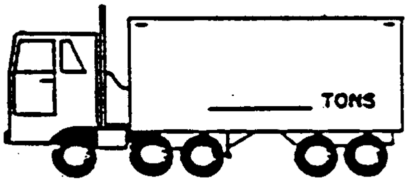
STATE HWY NO. 69
STRUCTURE NO. N-16-L
BATCH I.D. D75-085

COLORADO LEGAL LOADS
RATING SUMMARY (TONS)

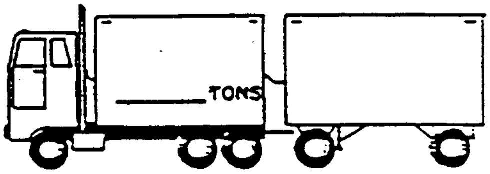
	TRUSS	30 WF 108 INT. FLOOR BEAM	12 I 31.8 INT. STRINGER ~~OR~~ ~~GIRDER~~	STEEL PLANK SLAB
HS 20 (36 TONS) INVENTORY	L2-L3 20.4	37.1	42.7	34.6
HS 20 (36 TONS) OPERATING	L2-L3 38.0	55.0	67.3	46.8
TYPE 3 (27 TONS) OPERATING				
TYPE 3S2 (42.5 TONS) OPERATING				
TYPE 3-2 (42.5 TONS) OPERATING				
OVERLOAD COLOR CODE	see Subsection 200-6	see Subsection 200-6	see Subsection 200-6	



TYPE 3



TYPE 3S2



TYPE 3-2

COMMENTS: 5" ASPHALT OVERLAY

PROJECT NO. S-0038(10) Date Checker's Signature

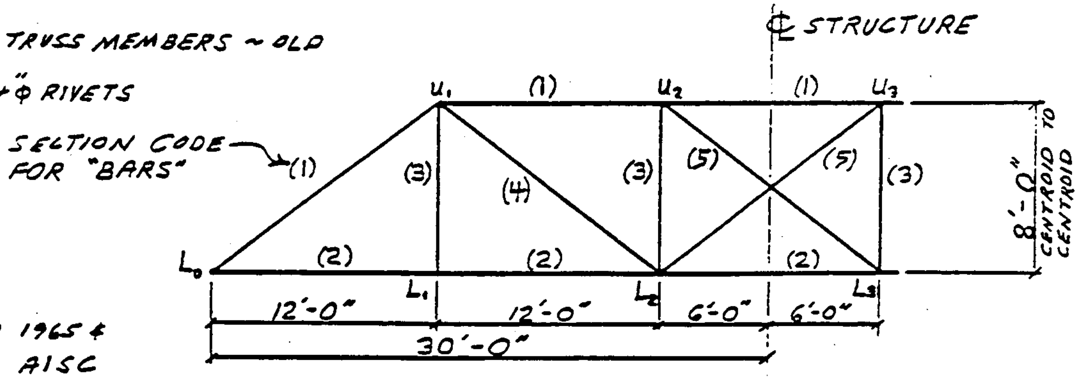
DATE: Date RATER: Rater's Signature

Bridge Work Sheet
(01200)1 October 1982

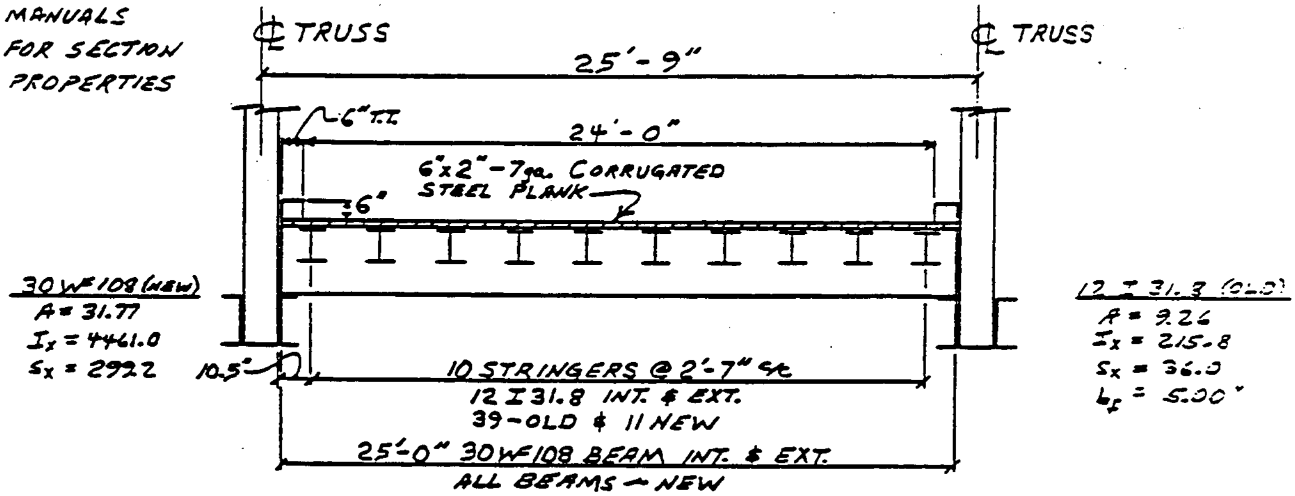
DESIGN COMPUTATIONS

ALL TRUSS MEMBERS ~ OLD

3/4" φ RIVETS



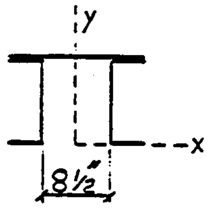
USED 1965 & 1920 AISC MANUALS FOR SECTION PROPERTIES



USED PROJECT #S-0038(10) AS-CONSTRUCTED PLANS - 1965. NEW MEMBERS PER PROJECT #S-0038 (10). OLD MEMBERS SALVAGED - COULD NOT FIND ANY PLANS. THEREFORE, TRUSS DATA FROM FIELD SURVEY - 10/2/85 CONDUCTED BY RON AKIN AND MARK LEONARD.

BARS ENTRY DATA - CARD TYPE 64

SECTION (1)



H = 10 5/16
= 10.31"

2 - C10X20 : $A = 5.86^{IN^2}$ $I_x = 78.5^{IN^4}$ $I_y = 2.8^{IN^4}$

DISTANCE FROM OUTSIDE WEB TO CENTROID = 0.61"

$D_x = 8.5/2 + 0.61 = \pm 4.86''$

$D_y = 10/2 = 5''$

14" x 5/16" ℞ : $A = 4.37^{IN^2}$ $I_x = 14(5/16)^3/12 = 0.036^{IN^4}$

$D_x = 0$ $I_y = \frac{5}{16}(14)^3/12 = 71.46^{IN^4}$

$D_y = 10 + 5/32 = 10.16''$

AREA REDUCTION: NO NEED FOR ~ COMPRESSION MEMBER

BOTTOM FLANGES CONNECTED W/ LACING

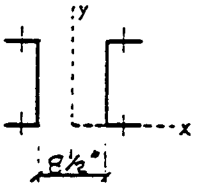
STAFF BRIDGE DESIGN	COLORADO DIVISION OF HIGHWAYS	Sheet 1 of 3
By: ML Date 10/29/84	Project No. S-0038 (10) RATING	
Chk'd: VGC Date 11-2-85	Structure No. N-16-L	075-085

Bridge Work Sheet
(01200)1 October 1982

DESIGN COMPUTATIONS

BARS ENTRY DATA - CARD TYPE 64 (CONT.)

SECTION (2)

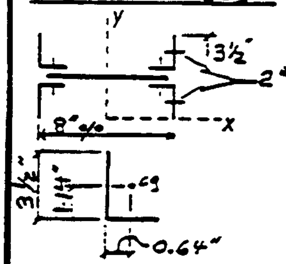


2 - C10X20 : SAME AS SECTION (1)
EXCEPT $H = 10''$

AREA REDCT'N: $4_{HOLES}(3/4 + 1/8)_{\phi}\ 7/16 = 1.53\ IN^2$
$7/16'' = t_f$ @ GAGE

14" x 5/16" BATTEN PL's - No Reduction Required - TENSION MEMBER

SECTION (3)



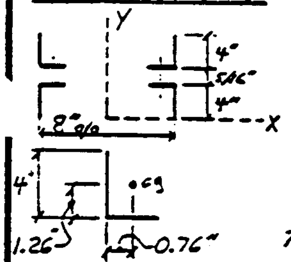
4- L 3½" x 2½" x 5/16" : $A = 1.78$ $I_x = 2.2$ $I_y = 0.94$
$D_x = 8.0/2 - 0.64 = \pm 3.36''$
$D_y = 3.5 - 1.14 = 2.36''$ (OR) $3.5 + 5/16 + 1.14 = 4.95$

7½" x 5/16" PL : $A = 2.34$ $I_x = 7.5(5/16)^3/12 = 0.019$ $I_y = \frac{5}{16}(7.5)^3/12 = 10.99$
$D_x = 0$ $D_y = 3.5 + 5/32 = 3.66''$

AREA REDCT'N : $8_{HOLES}(3/4 + 1/8)_{\phi}\ 5/16 = 2.19\ IN^2$

$H = 2(3.5) + 5/16 = 7.31''$

SECTION (4)

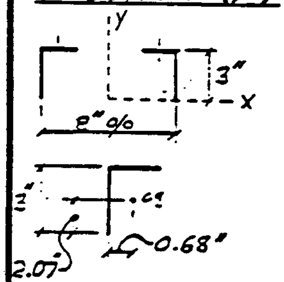


4- L 4" x 3" x 5/16" : $A = 2.09$ $I_x = 3.4$ $I_y = 1.7$
$D_x = 8.0/2 - 0.76 = \pm 3.24''$
$D_y = 4 - 1.26 = 2.74''$
$= 4 + 5/16 + 1.26 = 5.57''$
$H = 4 + 5/16 + 4 = 8.31''$

AREA REDUCT'N: $4_{HOLES}(3/4 + 1/8)_{\phi}\ 5/16 = 1.09\ IN^2$

7½" x 5/16" x 1'-0"
BATTEN PL's SPA. @ 3' ⇒ 3(12)/8.31 ⇒ 4.33H = SPA. ∴ F = 6

SECTION (5)



2- L 3" x 2½" x 5/16" : $A = 1.62$ $I_x = 1.42$ $I_y = 0.9$
$D_x = 8.0/2 - 0.68 = \pm 3.32''$
$D_y = 3 - 0.93 = 2.07''$
$H = 3''$

AREA REDUCTION: $2_{HOLES}(3/4 + 1/8)_{\phi}\ 5/16 = 0.55\ IN^2$
EITHER IN FLANGE OR WEB

7½ x 5/16 x 1'-0" BATTEN PL - No REDUCTION REQUIRED - TENSION MEMBER

ALLOWABLE STRESSES :

TRUSS & OLD STRINGERS — UNKNOWN. PLAQUE ON TRUSS DATED 1920 - FROM FIELD SURVEY. ∴ ASSUME 1920 - DATE OF FABRICATION. FROM BARS STRESS TABLE : ALLW STEEL STRESS = 16.0 KSI INV. & 22.5 KSI OPR.

BEAMS — STEEL 18 KSI INV (from S0038(10) PLANS) & 24.5 KSI OPR

STAFF BRIDGE DESIGN	COLORADO DIVISION OF HIGHWAYS		Sheet 2 of 3
By: ML Date 10/29/84	Project No.	RATING S-0038(10)	
Chk'd: VGC Date 11-2-85	Structure No.	N-16-L	D75-035

Bridge Work Sheet
(01200)1 October 1982

DESIGN COMPUTATIONS

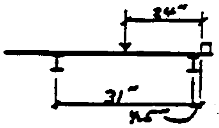
SUPERIMPOSED DEAD LOAD (NOTE: GUARD RAIL ON TRUSSES) (5" ASPHALT OVERLAY)

DECK: 6"x2" 7ga. Corrg. Steel Plank = 10.7^{PSF} (PER ARMCO CATALOG)
ASPHALT FILLER = $144(1")_{ave.}/12 = 12^{PSF}$
PLANK + FILLER = 22.7 psF

INT. STRINGER: 12 I 31.8
OVERLAY = (5/12)(31/12) 144 = 155
DECK = 22.7 (31/12) = 59
214^{PLF}

L.L. D.F. = 31/(12)(4.5) = 0.574
SWAY BRACING SUPPORTED @ MID-SPAN BY STRINGERS E & F; HOWEVER, RESULTING POINT LOAD IS NEGLIGIBLE.

EXT. STRINGER: 12 I 31.8



OVERLAY = (5/12)(31/2(12) + 4.5/12) 144 = 100
DECK = 22.7(31/2(12) + 10.5/12) = 49.2
CURB = 6(6) 50/144 = 12.5
162^{PLF}

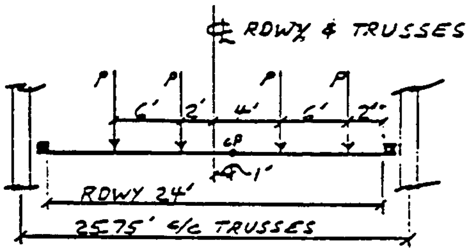
L.L. D.F. = (31-19.5)/31 = 0.371
INT & EXT STRINGER — SAME SIZE. INT. STRINGER CONTROLS.
∴ NO NEED TO RATE EXT. STRINGER.

INT. BEAM: 30 WF 108
P = $(214 + 31.8)^{PLF}$ 12' = 2.9^{K} / INT. STRINGER
= (162 + 31.8) 12 = 2.3^{K} / EXT. STRINGER

EXT. BEAM: 30 WF 108
SAME SIZE AS INT. BEAM. INT BEAM CONTROLS.
∴ NO NEED TO RATE EXT. BEAM.

TRUSS:
INT. STRINGERS = 214^{PLF} (12') 4 STRINGERS 5 BAYS = 51.4^{K}
EXT. STRINGERS = 162^{PLF} (12') 1 STRINGER 5 BAYS = 9.7
PER S0038(10) PLANS { SALVAGED STEEL = 43530/2 = 21.8
NEW STEEL = 26330/2 = 13.2
96.1^{K} /TRUSS
96.1/5 = 19.2^{K} / INT. PANEL POINT

P = WHEEL LOAD
CP = CENTROID OF WHEEL LOADS
L.L. D.F. = $4\left(\frac{25.75}{2} + 1.0\right)/25.75$
= 2.155

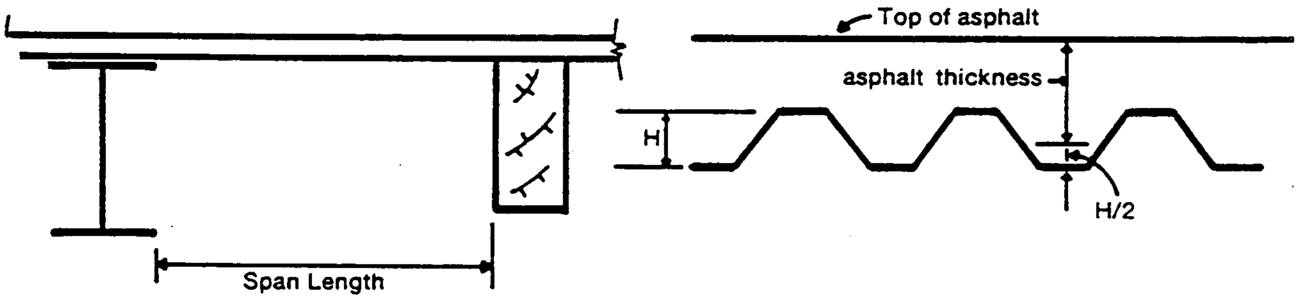


STAFF BRIDGE DESIGN	COLORADO DIVISION OF HIGHWAYS	Sheet 3 of 3
By: ML Date 10/29/84	Project No. RATING S0032 (10)	
Chk'd: VGc Date 11-2-85	Structure No. N-16-L	D75-085

DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS
STATE OF COLORADO
DOH Form 711
July, 1985

CORRUGATED STEEL PLANK RATING

DESCRIPTION	INPUT	UNITS	CARD IMAGE COLS.
STRUCTURE NUMBER	N-16-L		1 - 7
RATER	MAL		8 - 10
STATE HIGHWAY NUMBER	69		11 - 13
BATCH I. D.	D75085		14 - 19
COMMENTS	OVER TURKEY CREEK		20 - 40
SPAN LENGTH	216.00	IN	41 - 44
SECTION MODULUS	.162	IN3/IN	45 - 48
WEIGHT OF PLANK	10.7	PSF	49 - 51
INVENTORY STRESS	20.0	KSI	52 - 54
OPERATING STRESS	27.0	KSI	55 - 57
ASPHALT THICKNESS	6.00	IN	58 - 61



```
                    STEEL BRIDGE PLANK RATING

DATE:  85/03/14.

STRUCTURE NO: N-16-L
RATER: MAL
BATCH ID: D75085
STATE HWY NO:  69
COMMENT: OVER TURKEY CREEK

NET SPAN LENGTH (IN) = 26.00
SECTION MODULUS (IN3/IN) =  .162
PLANK WEIGHT (PSF) = 10.7
INVENTORY STRESS (KSI) = 20.0
OPERATING STRESS (KSI) = 27.0
ASPHALT THICKNESS (IN) =  6.00

LL+I MOMENT (IN-K) =  3.328
(LL MOMENT BASED ON A WHEELPRINT 20IN X 20IN)
DL MOMENT (IN-K) =   .039
INVENTORY LL+I MOMENT CAPACITY (IN-K) = 3.201
OPERATING LL+I MOMENT CAPACITY (IN-K) = 4.335

INVENTORY RATING (TONS) = 34.63

OPERATING RATING (TONS) = 46.89
```

Rater's Signature & Date
Checker's Signature & Date

DOH FORM NO. 399
REV. APRIL, 1974

BRIDGE RATING SYSTEM

BATCH SPECIFICATIONS

CARD TYPE		DATE			RATING ANALYST IDENTIFICATION	RATING TYPE EXCEPTIONS			INV. LOAD NAME	OPER. LOAD NAME	OPER. ALLOW. STRESS RATIO F/F (INV.)	POSTING			ALLOWABLE STRESS RATIO F/F (INV.)	SPEC. ALLOW. STRESS RATIO F/F (INV.)	FILE REQUESTS AND OUTPUT DATA EXCEPTIONS
		D	M	Y		I	O	P				VEH.1 LOAD NAME	VEH.2 LOAD NAME	VEH.3 LOAD NAME			
1	3	9	11	13	15	31	32	33	34	38	42	46	50	54	58	62	66 77
01		10	26	84	MARK LEONARD												

NON-STANDARD LIVE LOAD TRUCK DESCRIPTION

CARD TYPE		SEQUENCE	LOAD NAME	NO. AXLE LOADS	AXLE LOAD AND SPACING																							
					AXLE LOADS 1,5,9,13,17 (KIPS)	SPACING					AXLE LOADS 2,6,10,14,18 (KIPS)	SPACING					AXLE LOADS 3,7,11,15,19 (KIPS)	SPACING					AXLE LOADS 4,8,12,16,20 (KIPS)	SPACING				
						F	I	FEET	IN.	1/16		F	I	FEET	IN.	1/16		F	I	FEET	IN.	1/16		F	I	FEET	IN.	1/16
1	3	9	10	14	16	20	21	22	26	28	30	34	35	36	40	42	44	48	49	50	54	56	58	62	63	64	68	70 71
03																												
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DOH FORM NO. 321
FEBRUARY, 1973

BRIDGE RATING SYSTEM

STRUCTURE HEADER AND DESCRIPTION

CARD TYPE	BATCH ID	STRUCTURE, BATCH SERIAL NUMBER	RATING ANALYST IDENTIFICATION	ENGR. ATTN.	STRUCTURE RATING EXCEPTIONS			OVERRULE FILE REQUESTS AND OUTPUT DATA EXCEPTIONS	STRUCTURE TYPE	YEAR OF CONSTRUCTION	STRUCTURE LENGTH					ROADWAY WIDTH					NUMBER OF SPANS	SP. LOAD MULT.	LIVE LOAD TRUCK DESIGNATION		
					I	O	P				F	I	FEET	IN.	1/16	F	I	FEET	IN.	1/16			INV.	OPER.	
1	1	6	9	25	26	27	28	29	41	47	49	50	51	55	57	59	60	61	65	67	69	71	72	76	80
02	075	085	MARK LEONARD						SLT	20			61	10				24			1				

STRUCTURE LOCATION AND PERMANENT IDENTIFICATION FACTORS

CARD TYPE	BATCH ID	STRUCTURE BATCH SER NUMBER	STRUCTURE NUMBER	DISTRICT	COUNTY	CONSTRUCTION			MICROFILM REEL NO.			KEY ROUTE ID.	MARKED ROUTE
						ROUTE	SECTION	STATION	DESIGN PLANS	COMPUTATIONS	CORRESPONDENCE		
1	3	6	9	17	18	21	29	37	45	52	59	66	74 80
05	075	085	N-16-L	2	055							SH-69	

COMMENTS

CARD TYPE	BATCH ID	BATCH SERIAL NUMBER	SEQ	ANALYST REMARKS TO BE DUPLICATED ON SUMMARY OF RATING
1	3	6	9	10 80
06	075	085	1	PROJECT NO. S-0038(10), ACTUAL YEAR OF CONSTRUCTION 1965
06	075	085	2	TRUSSES AND MOST STRINGERS SALVAGED FROM BEAVER CREEK
06	075	085	3	ASSUME SALVAGED STEEL FABRICATED 1920 FOR ALLW. STRESSES
06	075	085	4	STRINGER S01 INT. I12x31.8 (REUSED), FLOOR BEAM B01 INT. W30x108 (NEW)
06	075	085	5	RATED WITH 5 INCHES ASPHALT OVERLAY AND COLORADO TRUCKS
06	075	085	6	OVER TURKEY CREEK NEAR FARISITA

DOH FORM NO. 363
FEBRUARY, 1973

BRIDGE RATING SYSTEM

MEMBER DESCRIPTION SPECS. - GIRDER, STRINGER, FLOOR BEAM

CARD TYPE	BATCH ID	STRUCTURE BATCH SER NUMBER	MEMBER ID		CONTINUE	TOTAL NO. OF SPANS		SYMMETRICAL?	SPAN LENGTHS															SS AC CSC PSC CPS	ALLOWABLE STRESS		LIVE LOAD DISTR. FACTOR E OR S	END FLOOR BEAM	I / b	MAXIMUM IMPACT FACTOR XX %			
									SPAN 1 4					SPAN 2 5					SPAN 3 6						FY, f'_s	F^b_s, F'_c, F''_o							
			G S B	NO					F	I	FEET	IN.	1/10	F	I	FEET	IN.	1/10	F	I	FEET	IN.	1/10		Lbs/sq.in.	Lbs/sq. in.							
1	3	6	9	10	12	13	15	17	18	19	20	24	26	28	29	30	34	36	38	39	40	44	46	48	51	56	61	66	67	68	70	72	74
08	D75	0852	B	01		01					25													SS	32667		12 0						
08	D75	0852	S	01		01					12													SS			574						
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DOH FORM NO. 367
FEBRUARY, 1971

BRIDGE RATING SYSTEM

SUPERIMPOSED DEAD LOADS - GIRDERS, STRINGERS, FLOOR BEAMS

CARD TYPE	BATCH ID	STRUCTURE BATCH SER NUMBER	GSB	MEMBER ID NØ	SYMMETRICAL ?	SPAN NØ.		DISTANCE FROM LEFT SUPPORT IN SPAN F	I	FEET	IN.	1/16		LOAD TYPE P W V	DISTRIBUTED ØR CONCENTRATED LØAD 'P' IN KIPS 'W' IN LBS./FT. P ØR H_L	H_R	LENGTH (DISTRIBUTED) F	I	FEET	IN.	1/16
1	3	6	9	10	12	13	15	22	23	24	28	30	32	33	34	39	44	45	46	50	52 53
10	D.75	085	B	0.1		0.1					1.0	08		P	2.3						
10	D.75	0.8.5	B	0.1		0.1				3	0.5	0.8		P	2.9						
10	D.7.5	0.8.5	B	0.1		0.1				6	00	0.8		P	2.9						
10	D.75	0.8.5	B	0.1		0.1				8	0.7	0.8		P	2.9						
10	D.75	0.8.5	B	0.1		0.1				1.1	0.2	0.8		P	2.9						
10	D.75	085	B	0.1		0.1				13	09	08		P	2.9						
10	D.7.5	0.8.5	B	0.1		0.1				16	0.4	0.8		P	2.9						
10	D.7.5	0.8.5	B	0.1		0.1				18	1.1	0.8		P	2.9						
10	D.75	0.8.5	B	0.1		0.1				2.1	06	0.8		P	2.9						
10	D.7.5	0.8.5	B	0.1		0.1				24	0.1	0.8		P	2.3						
10	D.75	0.8.5	S	0.1		0.1								W	2.1.4.				1.2		

DOH FORM NO. 360
FEBRUARY, 1973

BRIDGE RATING SYSTEM

[illegible]	BATCH	STRUCTURE NUMBER	MEMBER CODE		SYMMETRICAL ?	SPAN NØ.	SECTION RANGE SPECIFICATIONS																				
							SECTION RANGE										HINGE LOCATION										
							RANGE NØ.	RANGE LENGTH					SEC NØ.		SEC VAR		HINGE CODE	FIRST HINGE DISTANCE FROM LEFT					SECOND HINGE DISTANCE FROM LEFT				
			G S B	NØ				F	I	FEET	IN.	1/10	LT	RT	SPT	IB		F	I	FEET	IN.	1/10	F	I	FEET	IN.	1/10
1	3	6	9	10	12	13	15	17	18	19	23	25	27	29	31	32	33	34	35	36	10	12	14	15	16	50	52 53
11	D75	085	B	01		01	01			25			01														
11	D75	085	S	01		01	01			12			01														

DOH FORM NO. 369
FEBRUARY, 1973

BRIDGE RATING SYSTEM

SECTION PROPERTIES(STEEL) - GIRDERS, STRINGERS, FLOOR BEAMS

CARD TYPE	BATCH ID	STRUCTURE BATCH SER NUMBER	MEMBER ID G S B	MEMBER ID NO		NON-DETAILED DESCRIPTION SECTION NO.	NON-DETAILED DESCRIPTION A in.^{2}	NON-DETAILED DESCRIPTION I in.^{4}	NON-DETAILED DESCRIPTION S in.^{3}		DETAILED DESCRIPTION SECTION NO.	DETAILED DESCRIPTION SAME AS EXCEPT	DETAILED DESCRIPTION ADA	DETAILED DESCRIPTION h in.	DETAILED DESCRIPTION t	DETAILED DESCRIPTION A' in.^{2}	DETAILED DESCRIPTION D=A	DETAILED DESCRIPTION I'_x in.^{4}	DETAILED DESCRIPTION d'_y in.	DETAILED DESCRIPTION d'_x in.
							xxx.xx	xxxxx.x	xxxxx.x					xxx.xx		xx.xx		xxx.xx	xxx.xx	xx.xx
1	3	6	9	10	12	14	16	22	29	36	39	41	43	44	50	52	57	58	64	70 74
12	075	085	B	01		01	91.77	4461.0	299.2											
12	075	085	S	01		01	9.26	215.8	36.0											
12																				
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DOH FORM NO. 373
FEBRUARY, 1973

BRIDGE RATING SYSTEM

GENERAL SPECIFICATIONS FOR TRUSS ANALYSIS

CARD TYPE	BATCH ID	STRUCTURE BATCH SERIAL NUMBER	TRUSS ID	YIELD- ALLOWABLE STRESS		LIVE LOAD DISTRIBUTION							MEMS TO BE RATED			CONTINUATION	EXCEPTED OR SELECTED MEMBERS																							
				F_y	f_s^t	C - C TRUSSES					FACTOR		ALL	EXCEPTIONS	SELECTED		MEMBER ID.				MEMBER ID.				MEMBER ID.				MEMBER ID.				MEMBER ID.				MEMBER ID.			
				Lbs./Sq.in.	Lbs./Sq.in.	F	I	FEET	IN.	1/16	x.xxx						P.P.		P.P.		P.P.		P.P.		P.P.		P.P.		P.P.		P.P.		P.P.		P.P.		P.P.		P.P.	
																	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO	U L M	NO
1	3	6	9	10	15	20	21	22	26	28	30	35	36	37	38	39	40	41	43	44	46	47	49	50	52	53	55	56	58	59	61	62	64	65	67	68	70	71	73	74 75
60	D75	085	1								2.155		X																											
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DOH FORM NO. 374
FEBRUARY, 1973

BRIDGE RATING SYSTEM

TRUSS GEØMETRY

CARD TYPE	BATCH ID.	STRUCTURE BATCH SERIAL NUMBER	TRUSS ID.	PANEL NUMBER	PANEL CØDE	T D	TØTAL NØ. PANELS	SYMMETRY	SPAN LENGTH L					END PØST HGT. h_o					FULL PANEL LGT. P_i					SUBD. PANEL LGT. P'_i					VERTICAL HGT. h_i				
1	3	6	9	10	12	14	15	17	F 18	I 19	FEET 20	IN. 24	1/16 26	F 28	I 29	FEET 30	IN. 34	1/16 36	F 38	I 39	FEET 40	IN. 44	1/16 46	F 48	I 49	FEET 50	IN. 54	1/16 56	F 58	I 59	FEET 60	IN. 64	1/16 66 67
61	075	085	1	01	07	T	05	X			60										12										8		
61	075	085	1	02	02																12										8		
61	075	085	1	03	04																12										8		
61				04																													
61				05																													
61				06																													
61				07																													
61				08																													
61				09																													
61				10																													
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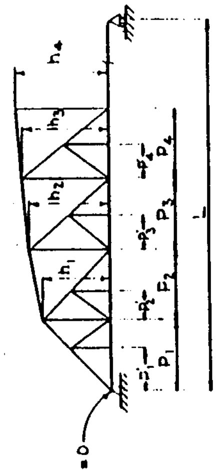
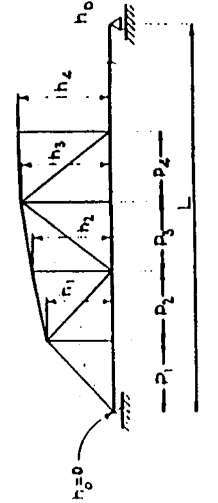
61				17																													
61				18																													
61				19																													
61				20																													



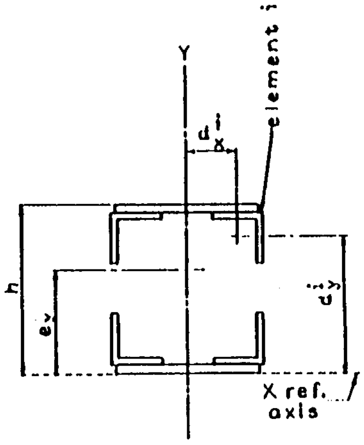


DOH FORM NO. 377
FEBRUARY, 1973

BRIDGE RATING SYSTEM

SECTION PROPERTIES - STRUCTURAL STEEL TRUSS MEMBERS
DETAILED DESCRIPTION

CARD TYPE	BATCH ID.	STRUCTURE BATCH SERIAL NUMBER	TRUSS ID.	MEMBER ID P.P.		MEMBER ID P.P.		SECTION CODE	SAME AS CODE	h	MEMBER ELEMENT NO.	A^i	D H A	I_x^i	I_y^i	d_x^i	d_y^i	e_y	PINNED ENDS ?	F
				U L H	NO	U L H	NO			in.	i	in.^{2}		in.^{4}	in.^{4}	in.	in.	in.		
										x x x . x x		x x x . x		x x x x . x	x x x x . x	x x . x x	x x . x x	x . x x		
1	3	8	9	10	11	13	14	16	18	20	26	28	33	34	40	46	51	56	60	61 62
61	075	085	1	L	00	U	01	01		10.31	01	4.37		00.04	71.46	0.00	10.16			
61	075	085	1	L	00	U	01	01			02	5.86		78.50	2.80	4.86	5.00			
61	075	085	1	L	00	U	01	01			03	5.86		78.50	2.80	-4.86	5.00			
61	075	085	1	U	01	U	02		01											
61	075	085	1	U	02	U	03		01											
61	075	085	1	L	00	L	01	02		10.00	01	5.86		78.50	2.80	4.86	5.00			
61	075	085	1	L	00	L	01	02			02	5.86		78.50	2.80	-4.86	5.00			
61	075	085	1	L	00	L	01	02			03	1.53	H				5.00			
61	075	085	1	L	01	L	02		02											
61	075	085	1	L	02	L	03		02											
61	075	085	1	U	01	L	01	03		7.31	01	1.78		2.20	0.94	3.36	4.95			
61	075	085	1	U	01	L	01	03			02	1.78		2.20	0.94	-3.36	4.95			
61	075	085	1	U	01	L	01	03			03	1.78		2.20	0.94	3.36	2.36			
61	075	085	1	U	01	L	01	03			04	1.78		2.20	0.94	-3.36	2.36			
61	075	085	1	U	01	L	01	03			05	2.34		0.02	10.99		3.66			
61	075	085	1	U	01	L	01	03			06	2.19	H				3.66			
61	075	085	1	U	02	L	02		03											
61	075	085	1	U	03	L	03		03											
61																				
61																				



Properties of ith element

A^i = Area i

I_x^i = Inertia about x

I_y^i = Inertia about y

DØH FØRM NØ. 377
FEBRUARY, 1973

BRIDGE RATING SYSTEM

SECTIØN PRØPERTIES - STRUCTURAL STEEL TRUSS MEMBERS
DETAILED DESCRIPTIØN

CARD TYPE	BATCH ID.	STRUCTURE BATCH SERIAL NUMBER	TRUSS ID.	MEMBER ID				SECTIØN CØDE	SAME AS CØDE	h	MEMBER ELEMENT NØ.	A^i	D H A	I^i_x	I^i_y	d^i_x	d^i_y	e_y	PINNED ENDS ?	F
				P.P.		P.P.														
				U L H	NØ	U L H	NØ			in. x x x . x x	i	in.² x x x . x		in.⁴ x x x x . x	in.⁴ x x x x . x	in. x x . x x	in. x x . x x	in. x . x x		
1	3	6	9	10	11	13	14	16	18	20	26	28	33	34	40	46	51	56	60	61 62
64	D75	085	1	U	01	L	02	04		8.31	01	2.09		3.40	1.70	3.24	5.57			06
64	D75	085	1	U	01	L	02	04			02	2.09		3.40	1.70	-3.24	5.57			
64	D75	085	1	U	01	L	02	04			03	2.09		3.40	1.70	3.24	2.74			
64	D75	085	1	U	01	L	02	04			04	2.09		3.4C	1.70	-3.24	2.74			
64	D75	085	1	U	01	L	02	04			05	1.09	H				2.74			
64	D75	085	1	L	02	U	03	05		3.00	01	1.62		1.42	0.90	3.32	2.07			
64	D75	085	1	L	02	U	03	05			02	1.62		1.42	0.90	-3.32	2.07			
64	D75	085	1	L	02	U	03	05			03	0.55	H				2.07			
64	D75	085	1	U	02	L	03		05											
64																				
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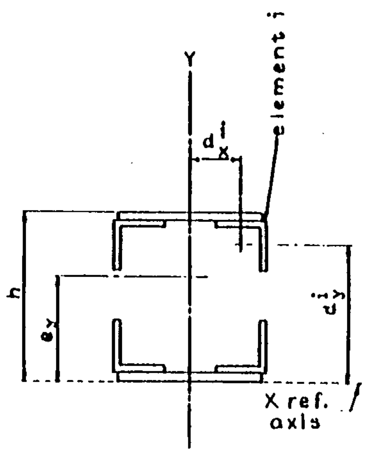

Properties of i^{th} element

A^i = Area i

I^i_x = Inertia about x

I^i_y = Inertia about y

DOH FORM NO. 378
REV. MARCH, 1974

BRIDGE RATING SYSTEM

SUPERIMPOSED DEAD LOAD - TRUSS

CARD TYPE	BATCH ID.	STRUCTURE BATCH SERIAL NUMBER	TRUSS ID.	NORMAL LOAD			ADDED LOAD	@ P.P.	
				UNIFORM LOAD LBS/FT	TO LOADED CHORD %	CONC LOAD KIPS	CONC LOAD KIPS	U L	NO
1	3	6	9	10	15	17	22	27	28 29
65	075	085	1			19.2			
65									
65									
65									
65									
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65									

DØH FØRM NØ. 322
REV. APRIL, 1974

BRIDGE RATING SYSTEM

CØNTRØL CARDS FØR DATA UPDATING AND ANALYSIS INITIATIØN

CARD TYPE	BATCH ID.	STRUCTURE BATCH SERIAL NUMBER	AA UPDATE ØR NEW DD RECØRD NUMBER		DELETE (AA) TRANSFR (DD)					
			99 BATCH ID.	STRUCTURE BATCH SER NUMBER		AA ØNLY				
						ADD	SELT	PERM FILE	LIST	
AA DD 99					X b	X b	X b	ØLD NEW b	b T P B	
1	3	6	9	12	15	16	17	18	21	22 … 80
22	075	085								

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*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*
A                                                                                                                      A
A                                                                                                                      A
S                                                                                                                      S
H                                                                                                                      H
T                                                                                                                      T
O                                                                                                                      O
*                                                                                                                      *
A                                                                                                                      A
A                                        AMERICAN ASSOCIATION OF STATE HIGHWAY                                         A
S                                             AND TRANSPORTATION OFFICIALS                                             S
H                                                                                                                      H
T                                       A PROPRIETARY COMPUTER SOFTWARE PRODUCT                                        T
T                                                                                                                      T
O                                                                                                                      O
*                                                                                                                      *
A                                                                                                                      A
A                                                                                                                      A
S                                                                                                                      S
H                                                                                                                      H
T                                                                                                                      T
O                                                                                                                      O
*                                                                                                                      *
A                                                                                                                      A
A   AASHTOWAREtm   BBBBBBBBBBBB               AAAAAAA             RRRRRRRRRRR              SSSSSSSSSSSSS               A
S                  BBBBBBBBBBBBB             AAAAAAAAA            RRRRRRRRRRRR            SSSSSSSSSSSSSSS              S
H                  BBB        BBB           AA       AA           RRR       RRR          SSSS         SSSS             H
T                  BBB        BBB          AAA       AAA          RRR       RRR          SSS                           T
O                  BBB        BBB          AAA       AAA          RRR       RRR          SSSS                          O
*                  BBBBBBBBBBBB            AAA       AAA          RRRRRRRRRRRR            SSSSSSSSSSSSSS               *
A                  BBBBBBBBBBBBB           AAA       AAA          RRRRRRRRRR               SSSSSSSSSSSSSS              A
A                  BBB        BBB          AAAAAAAAAAAAA          RRR    RRR                          SSSS             A
S                  BBB        BBB          AAAAAAAAAAAAA          RRR     RRR                          SSS             S
H                  BBB        BBB          AAA       AAA          RRR      RRR           SSSS         SSSS             H
T                  BBBBBBBBBBBBB           AAA       AAA          RRR       RRR           SSSSSSSSSSSSSSS              T
O                  BBBBBBBBBBBB            AAA       AAA          RRR        RRR           SSSSSSSSSSSSS               O
*                                                                                                                      *
A                                                                                                                      A
A                                                                                                                      A
S                                                                                                                      S
H                                                                                                                      H
T                                                                                                                      T
O                                                                                                                      O
*                                                                                                                      *
A                                                                                                                      A
A                                         BRIDGE ANALYSIS AND RATING SYSTEM                                            A
S                                                                                                                      S
H                               (C) COPYRIGHT 1994 BY THE AMERICAN ASSOCIATION OF STATE                               H
T                               HIGHWAY AND TRANSPORTATION OFFICIALS, INC.                                             T
O                               444 NORTH CAPITOL STREET, N.W., SUITE 249                                              O
*                               WASHINGTON, D.C. 20001 U.S.A.                                                          *
A                               (202) 624-5800                                                                         A
A                                                                                                                      A
S                                              RELEASE 5.5  -  MOD 2.0                                                 S
H                                                                                                                      H
T                                                  NOVEMBER 11, 1994                                                   T
O                                                                                                                      O
*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*AASHTO*
                                     RECORD                                            REC.NO.
  01      080795MOHSENIM                                                                   100
  02D75085MARK LEONARD                       SLT20    611000    24    01                   100
  05D75085N-16-L  2055                                             SH-69                   200
  06D750851PROJECT NO. S-0038(10), ACTUAL YEAR OF CONSTRUCTION 1965                        300
  06D750852TRUSSES AND MOST STRINGERS SALVAGED FROM BEAVER CREEK                           400
  06D750853ASSUME SALVAGED STEEL FABRICATED 1920 FOR ALLW. STRESSES                        500
  06D750854STRINGER 1 INT. I12X31.8 (REUSED), FLOOR BEAM B01 W30X108 (NEW)                 600
  06D750855RATED WITH 6 INCHES ASPHALT OVERLAY AND COLORADO TRUCKS                         700
  06D750856OVER TURKEY CREEK NEAR FARISITA                                                 800
  08D75085B01 01       250000                     SS32667     12.00                        900
  08D75085S01 01       120000                     SS          0.574                       1000
  10D75085B01 01             10 8 P  2.3                                                  1100
  10D75085B01 01            3 5 8 P  3.3                                                  1200
  10D75085B01 01            6   8 P  3.3                                                  1300
  10D75085B01 01            8 7 8 P  3.3                                                  1400
  10D75085B01 01           11 2 8 P  3.3                                                  1500
  10D75085B01 01           13 9 8 P  3.3                                                  1600
  10D75085B01 01           16 4 8 P  3.3                                                  1700
  10D75085B01 01           1811 8 P  3.3                                                  1800
  10D75085B01 01           21 6 8 P  3.3                                                  1900
  10D75085B01 01           24 1 8 P  2.3                                                  2000
  10D75085S01 01                  W 276.         120000                                   2100
  11D75085B01 0101    25000001                                                            2200
  11D75085S01 0101    12000001                                                            2300
  12D75085B01  01 31.77 4461.0  299.2                                                     2400
  12D75085S01  01  9.26  215.8   36.0                                                     2500
  60D750851                    2.155 X                                                    2600
  61D7508510107T05X    600000              120000               80000                     2700
  61D7508510202                            120000               80000                     2800
  61D7508510304                            120000               80000                     2900
  64D750851L00L0102   10.0001 5.86   78.5  2.80 4.86  5.0                                 3000
  64D750851L00L0102        02 5.86   78.5  2.80-4.86  5.0                                 3100
  64D750851L00L0102        03 1.53H                   5.0                                 3200
  64D750851L00U0101   10.3101 4.37   .036 71.46     10.16                                 3300
  64D750851L00U0101        02 5.86   78.5  2.8  4.86 5.00                                 3400
  64D750851L00U0101        03 5.86   78.5  2.8 -4.86 5.00                                 3500
  64D750851L01L02  02                                                                     3600
  64D750851L02L03  02                                                                     3700
  64D750851L02U0104    8.3101 2.09    3.4   1.7 3.24 5.57      6                          3800
  64D750851L02U0104        02 2.09    3.4   1.7-3.24 5.57                                 3900
  64D750851L02U0104        03 2.09    3.4   1.7 3.24 2.74                                 4000
  64D750851L02U0104        04 2.09    3.4   1.7-3.24 2.74                                 4100
  64D750851L02U0104        05 1.09H                  2.74                                 4200
  64D750851L02U0305    3.0001 1.62   1.42  0.90 3.32 2.07                                 4300
  64D750851L02U0305        02 1.62   1.42  0.90-3.32 2.07                                 4400
  64D750851L02U0305        03 0.55H                  2.07                                 4500
  64D750851L03U02  05                                                                     4600
  64D750851U01L0103    7.3101 1.78   2.20   .94 3.36 4.95                                 4700
  64D750851U01L0103        02 1.78   2.20   .94-3.36 4.95                                 4800
```

```
  64D750851U01L0103        03 1.78   2.20   .94 3.36 2.36                                    4900
  64D750851U01L0103        04 1.78   2.20   .94-3.36 2.36                                    5000
                                     RECORD                                               REC.NO.
  64D750851U01L0103        05 2.34   .019 10.99      3.66                                    5100
  64D750851U01L0103        06 2.19H                  3.66                                    5200
  64D750851U01U02  01                                                                        5300

  64D750851U02L02  03                                                                        5400
  64D750851U02U03  01                                                                        5500
  64D750851U03L03  03                                                                        5600
  65D750851        19.2                                                                      5700
  THE FOLLOWING STRUCTURES WERE SELECTED

  D75085
1


 MAIN -- NEW STRUCTURE I.D.= D75-085



0*** ERROR 2500700 ***  STRUCTURE ID  D75-085
                        TRUSS ID     1       TRUSS MEMBER ID  U 2U 3

   ERROR OPENING UNIT 51.  IT IS THE
           UNFORMATTED BINARY FILE HOLDING THE ERROR MESSAGE
           TEXT.

0*** WARNING  4404500 ***  STRUCTURE ID  D75-085
                         MEMBER ID        B 1
0*** WARNING  4404500 ***  STRUCTURE ID  D75-085
                         MEMBER ID        S 1
1

                    STRUCTURE I.D. = D75-085
```

```
*********************************************************************************************************************************
*                                               STRUCTURE HEADER AND DESCRIPTION                                                *
*********************************************************************************************************************************

   100-- 2    MARK LEONARD      EA/I/O/P =              FILE REQUESTS AND OUTPUT DATA EXCEPTIONS
                      TYPE =     SLT   YEAR =   20  LEN =   61.83 FT.      WIDTH =   24.00 FT.      1 SPANS SP.LOAD =
                      INV.LL.TRK.=       OP.LL.TRK.=


*********************************************************************************************************************************
*                                  STRUCTURE LOCATION AND PERMANENT IDENTIFICATION FACTORS                                      *
*********************************************************************************************************************************

   200-- 5    BRIDGE=N-16-L     DIST./CO.= 2   055  CONST. ROUTE =           CONST. SECT.=           CONST. STA.=   0+  .
              MICROFILM REEL NO.   DESIGN PLANS=          COMPUTATIONS=           CORRESPONDENCE=
                  ROUTE I.D.= SH-69      MARKED ROUTE =


*********************************************************************************************************************************
*                                                           COMMENTS                                                            *
*********************************************************************************************************************************

   300-- 6    1  PROJECT NO. S-0038(10), ACTUAL YEAR OF CONSTRUCTION 1965
   400-- 6    2  TRUSSES AND MOST STRINGERS SALVAGED FROM BEAVER CREEK
   500-- 6    3  ASSUME SALVAGED STEEL FABRICATED 1920 FOR ALLW. STRESSES
   600-- 6    4  STRINGER 1 INT. I12X31.8 (REUSED), FLOOR BEAM B01 W30X108 (NEW)
   700-- 6    5  RATED WITH 6 INCHES ASPHALT OVERLAY AND COLORADO TRUCKS
   800-- 6    6  OVER TURKEY CREEK NEAR FARISITA


*********************************************************************************************************************************
*                          MEMBER SPECIFICATIONS AND REQUIRED ANALYSIS-GIRDER,STRINGER AND FLOOR BEAM                           *
*********************************************************************************************************************************

          MEMBER SPANS  STIFF. SPAN 1     SPAN 2     SPAN 3   MATL  ALLOWABLE STRESS   LL DIST.  END  THRU  MAX  IMPACT  FACTOR
           ID      SYMM CODE (SPAN 4)    (SPAN 5)   (SPAN 6)  CODE    FY   FB FC* FC**  FACTOR  FL.BM DECK  INV  OP.  POST  SPEC

   900-- 8   B 1 `  1           25.000      0.000      0.000    SS 32667.00      0.00   12.000              .00  .00  .00   .00
  1000-- 8   S 1 `  1           12.000      0.000      0.000    SS     0.00      0.00    0.574              .00  .00  .00   .00


*********************************************************************************************************************************
*                                  SUPERIMPOSED DEAD LOADS-GIRDERS,STRINGERS AND FLOOR BEAMS                                    *
*********************************************************************************************************************************

             MEMBER SYMM. SPAN   DISTANCE FR. LOAD          LOAD            LENGTH
               ID          NO.    LEFT SUPP.  TYPE  P OR W(L)     W(R)

  1100--10    B 1          1         0.875FT.   P        2.3      0.0         0.000FT.
  1200--10    B 1          1         3.458FT.   P        3.3      0.0         0.000FT.
  1300--10    B 1          1         6.042FT.   P        3.3      0.0         0.000FT.
  1400--10    B 1          1         8.625FT.   P        3.3      0.0         0.000FT.
  1500--10    B 1          1        11.208FT.   P        3.3      0.0         0.000FT.
  1600--10    B 1          1        13.792FT.   P        3.3      0.0         0.000FT.
  1700--10    B 1          1        16.375FT.   P        3.3      0.0         0.000FT.
  1800--10    B 1          1        18.958FT.   P        3.3      0.0         0.000FT.
  1900--10    B 1          1        21.542FT.   P        3.3      0.0         0.000FT.
  2000--10    B 1          1        24.125FT.   P        2.3      0.0         0.000FT.
  2100--10    S 1          1         0.000FT.   W      276.0      0.0        12.000FT.


*********************************************************************************************************************************
*                                                   SECTION RANGE SPECIFICATIONS                                                *
*********************************************************************************************************************************

             MEMBER SYMM. SPAN  RANGE   RANGE     SECTION NO. SEC. VAR. HINGE   HINGE 1    HINGE 2        HYBRID GIRDER
               ID          NO.   NO.    LENGTH    LEFT RIGHT            CODE    DIST.      DIST.    CODE   FY    CODE   FY

  2200--11    B 1          1     1     25.000FT.   1    0                     0.000FT.   0.000FT.          0.           0.
  2300--11    S 1          1     1     12.000FT.   1    0                     0.000FT.   0.000FT.          0.           0.


*********************************************************************************************************************************
*                         SECTION PROPERTIES (STEEL OR TIMBER) - GIRDERS STRINGERS, FLOOR BEAMS                               *
*********************************************************************************************************************************

             MEMBER -- NON-DETAILED DESCRIPTION ---------------------- DETAILED DESCRIPTION -------------------
               ID   SEC.    A         I        S    CODE  SAME ADR     H   ELE     A         IX        DY        DX

  2400--12    B 1     1   31.77    4461.0     299.2        0    0    0.00   0   0.00         0.0       0.0       0.0
  2500--12    S 1     1    9.26     215.8      36.0        0    0    0.00   0   0.00         0.0       0.0       0.0


*********************************************************************************************************************************
*                                          GENERAL SPECIFICATIONS FOR TRUSS ANALYSIS                                            *
*********************************************************************************************************************************

                                                     LIVE LOAD DISTRIBUTION
                                ALLOWABLE STRESS         C-C TRUSSES   E"   TO BE RATED

  2600--60    TRUSS I.D.=1    FY=    0.  FS=    0.         0.000FT.    2.155     ALL

                                             *** EXCEPTED OR SELECTED MEMBERS ***
               MEMBER I.D.      MEMBER I.D.      MEMBER I.D.      MEMBER I.D.      MEMBER I.D.      MEMBER I.D.

  2600--60        0-  0            0-  0            0-  0            0-  0            0-  0            0-  0
```

```
 *********************************************************************************************************************************
 *                                                        TRUSS GEOMETRY                                                         *
 *********************************************************************************************************************************

              TRUSS PANEL PANEL   P          P"          H        T/D  TOTAL  SYMMETRY    L           HO
               I.D.  NO.   CODE                                        PANELS
                                                                    T      5    X       60.000FT.     0.000FT.
+  2700--61     1    1     7     12.00FT.     0.00FT.     8.00FT.

+  2800--61     1    2     2     12.00FT.     0.00FT.     8.00FT.

+  2900--61     1    3     4     12.00FT.     0.00FT.     8.00FT.



 *********************************************************************************************************************************
 *                            SECTION PROPERTIES-STRUCTURAL STEEL TRUSS MEMBERS DETAILED DESCRIPTION                            *
 *********************************************************************************************************************************

               TRUSS     MEMBER    SECTION SAME      H     I     A     D     IX       IY       DX      DY     EY  PINNED F
                 I.D.    I.D.       CODE    AS                         H                                           ENDS


   5300--64      1       U 1-U 2        0     1       0.00   0    0.00         0.00     0.00    0.00    0.00   0.00        0
   4700--64      1       U 1-L 1        3     0       7.31   1    1.78         2.20     0.94    3.36    4.95   0.00        0
   4800--64      1       U 1-L 1        3     0       0.00   2    1.78         2.20     0.94   -3.36    4.95   0.00        0
   4900--64      1       U 1-L 1        3     0       0.00   3    1.78         2.20     0.94    3.36    2.36   0.00        0
   5000--64      1       U 1-L 1        3     0       0.00   4    1.78         2.20     0.94   -3.36    2.36   0.00        0
   5100--64      1       U 1-L 1        3     0       0.00   5    2.34         0.02    10.99    0.00    3.66   0.00        0
   5200--64      1       U 1-L 1        3     0       0.00   6    2.19  H      0.00     0.00    0.00    3.66   0.00        0
   3800--64      1       U 1-L 2        4     0       8.31   1    2.09         3.40     1.70    3.24    5.57   0.00        6
   3900--64      1       U 1-L 2        4     0       0.00   2    2.09         3.40     1.70   -3.24    5.57   0.00        0
   4000--64      1       U 1-L 2        4     0       0.00   3    2.09         3.40     1.70    3.24    2.74   0.00        0
   4100--64      1       U 1-L 2        4     0       0.00   4    2.09         3.40     1.70   -3.24    2.74   0.00        0
   4200--64      1       U 1-L 2        4     0       0.00   5    1.09  H      0.00     0.00    0.00    2.74   0.00        0
   5500--64      1       U 2-U 3        0     1       0.00   0    0.00         0.00     0.00    0.00    0.00   0.00        0
   5400--64      1       U 2-L 2        0     3       0.00   0    0.00         0.00     0.00    0.00    0.00   0.00        0
   4600--64      1       U 2-L 3        0     5       0.00   0    0.00         0.00     0.00    0.00    0.00   0.00        0
   5600--64      1       U 3-L 3        0     3       0.00   0    0.00         0.00     0.00    0.00    0.00   0.00        0
   3300--64      1       L 0-U 1        1     0      10.31   1    4.37         0.04    71.46    0.00   10.16   0.00        0
   3400--64      1       L 0-U 1        1     0       0.00   2    5.86        78.50     2.80    4.86    5.00   0.00        0
   3500--64      1       L 0-U 1        1     0       0.00   3    5.86        78.50     2.80   -4.86    5.00   0.00        0
   3000--64      1       L 0-L 1        2     0      10.00   1    5.86        78.50     2.80    4.86    5.00   0.00        0
   3100--64      1       L 0-L 1        2     0       0.00   2    5.86        78.50     2.80   -4.86    5.00   0.00        0
   3200--64      1       L 0-L 1        2     0       0.00   3    1.53  H      0.00     0.00    0.00    5.00   0.00        0
   3600--64      1       L 1-L 2        0     2       0.00   0    0.00         0.00     0.00    0.00    0.00   0.00        0
   4300--64      1       L 2-U 3        5     0       3.00   1    1.62         1.42     0.90    3.32    2.07   0.00        0
   4400--64      1       L 2-U 3        5     0       0.00   2    1.62         1.42     0.90   -3.32    2.07   0.00        0
   4500--64      1       L 2-U 3        5     0       0.00   3    0.55  H      0.00     0.00    0.00    2.07   0.00        0
   3700--64      1       L 2-L 3        0     2       0.00   0    0.00         0.00     0.00    0.00    0.00   0.00        0


 *********************************************************************************************************************************
 *                                                SUPERIMPOSED DEAD LOAD - TRUSS                                                 *
 *********************************************************************************************************************************

   5700--65 I.D.=1   W=   0.0 * TO CHORD= 0.00 NOR.P=  19.2 ADD.P=   0.0 P.P.I.D.=   0
1
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1                                       SUMMARY OF RATING CALCULATIONS------STRUCTURE MEMBERL    2      BARS RELEASE 5.5
                                                  INVENTORY AND/OR OPERATING ANALYSIS

        INPUT CODING --                                     STRUCTURE N-16-L                            D/P STR. I.D.--  D75-085

            DATE  8/ 7/95
+                                           INVENTORY                         OPERATING                  BY    MARK LEONARD


+                                         LIVE LOAD    RATING               LIVE LOAD    RATING



+                                          HS20      HS  11.34               HS20      HS  21.13





        STRUCTURE DESCRIPTION --                            LOCATION --                               MICROFILM REEL NUMBERS --
0           IDENTIFICATION    N-16-L                        DISTRICT        2                             DESIGN PLANS
            TYPE                 SLT                        COUNTY          055                           COMPUTATIONS
            YEAR OF CONSTR.   1920                          CONSTR. RTE.                                  CORRESPONDENCE
            LENGTH              61.83 FEET                  CONSTR. SEC.
            ROADWAY WIDTH       24.00 FEET                  CONSTR. STA.        0+  .
            NUMBER OF SPANS      1                          KEY RTE.        SH-69
                                                            MARKED RTE.
0
                              ANALYST REMARKS --

                                               PROJECT NO. S-0038(10), ACTUAL YEAR OF CONSTRUCTION 1965
                                               TRUSSES AND MOST STRINGERS SALVAGED FROM BEAVER CREEK
                                               ASSUME SALVAGED STEEL FABRICATED 1920 FOR ALLW. STRESSES
                                               STRINGER 1 INT. I12X31.8 (REUSED), FLOOR BEAM B01 W30X108 (NEW)
                                               RATED WITH 6 INCHES ASPHALT OVERLAY AND COLORADO TRUCKS
                                               OVER TURKEY CREEK NEAR FARISITA

+    INVENTORY RATING SUMMARY --
+                                                                                            OPERATING RATING SUMMARY --
0

+      TRUSS ID.               1                                                             TRUSS ID.               1


+      CRITICAL MEMBER ID.    L 2 L 3                                                          CRITICAL MEMBER ID.    L 2 L 3


+      LIVE LOAD DESIGNATION  HS20                                                             LIVE LOAD DESIGNATION  HS20

0
+                         AXIAL FORCE                                                                          AXIAL FORCE


+                               (KIPS)                                                                               (KIPS)

+      MEMBER CAPACITY          163.0                                                         MEMBER CAPACITY          229.3


+      DL EFFECT                 86.4                                                         DL EFFECT                 86.4

0
+      CAPACITY FOR (LL+I)       76.6                                                         CAPACITY FOR (LL+I)      142.9


+      ACTUAL (LL+I)            135.2                                                         ACTUAL (LL+I)            135.2



+      INVENTORY RATING      HS 11.34                                                         OPERATING RATING      HS 21.13
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1                                      SUMMARY OF RATING CALCULATIONS------STRUCTURE MEMBER   B 1      BARS RELEASE 5.5
                                                INVENTORY AND/OR OPERATING ANALYSIS


        INPUT CODING --                                    STRUCTURE N-16-L                            D/P STR. I.D.--  D75-085

            DATE  8/ 7/95
+                                            INVENTORY                          OPERATING

            BY    MARK LEONARD             LIVE LOAD    RATING              LIVE LOAD    RATING


+                                            HS20      HS  20.59              HS20      HS  30.44





        STRUCTURE DESCRIPTION --                        LOCATION --                                    MICROFILM REEL NUMBERS --
0           IDENTIFICATION    N-16-L                        DISTRICT        2                             DESIGN PLANS
            TYPE                 SLT                        COUNTY          055                           COMPUTATIONS
            YEAR OF CONSTR.   1920                          CONSTR. RTE.                                  CORRESPONDENCE
            LENGTH              61.83 FEET                  CONSTR. SEC.
            ROADWAY WIDTH       24.00 FEET                  CONSTR. STA.        0+  .
            NUMBER OF SPANS      1                          KEY RTE.        SH-69
                                                            MARKED RTE.
0
                              ANALYST REMARKS --

                                               PROJECT NO. S-0038(10), ACTUAL YEAR OF CONSTRUCTION 1965
                                               TRUSSES AND MOST STRINGERS SALVAGED FROM BEAVER CREEK
                                               ASSUME SALVAGED STEEL FABRICATED 1920 FOR ALLW. STRESSES
                                               STRINGER 1 INT. I12X31.8 (REUSED), FLOOR BEAM B01 W30X108 (NEW)
                                               RATED WITH 6 INCHES ASPHALT OVERLAY AND COLORADO TRUCKS
                                               OVER TURKEY CREEK NEAR FARISITA

+    INVENTORY RATING SUMMARY -                                                            OPERATING RATING SUMMARY
0
+      MEMBER ID.             B 1                                                           MEMBER ID.             B 1


+      SPAN                    1                                                            1 SPAN                  1

+
 +     CRITICAL C.P. DIST.    11.8 FEET                                                    CRITICAL C.P. DIST.    11.8 FEET


+      LIVE LOAD DESIGNATION  HS20.                                                        LIVE LOAD DESIGNATION  HS20


0
                                SHEAR                                                                               SHEAR

                                (KIPS)                                                                              (KIPS)


+      MEMBER CAPACITY          448.0                                                      MEMBER CAPACITY          610.9



+      DL EFFECT                107.2                                                      DL EFFECT                107.2


0
+      CAPACITY FOR (LL+I)      340.7                                                      CAPACITY FOR (LL+I)      503.6


+      ACTUAL (LL+I)            330.9                                                      ACTUAL (LL+I)            330.9


0
+      INVENTORY RATING      HS 20.59                                                      OPERATING RATING      HS 30.44
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1                                       SUMMARY OF RATING CALCULATIONS------STRUCTURE MEMBER   S 1      BARS RELEASE 5.5
                                                  INVENTORY AND/OR OPERATING ANALYSIS


        INPUT CODING --                                     STRUCTURE N-16-L                           D/P STR. I.D.--  D75-085

            DATE  8/ 7/95
+                                            INVENTORY                          OPERATING
            BY    MARK LEONARD
+                                         LIVE LOAD    RATING                LIVE LOAD    RATING


+                                           HS20      HS  23.71             HS20      HS  34.60




        STRUCTURE DESCRIPTION --                            LOCATION --                               MICROFILM REEL NUMBERS --
0           IDENTIFICATION    N-16-L                        DISTRICT        2                            DESIGN PLANS
            TYPE                 SLT                        COUNTY          055                          COMPUTATIONS
            YEAR OF CONSTR.   1920                          CONSTR. RTE.                                 CORRESPONDENCE
            LENGTH              61.83 FEET                  CONSTR. SEC.
            ROADWAY WIDTH       24.00 FEET                  CONSTR. STA.        0+  .
            NUMBER OF SPANS      1                          KEY RTE.        SH-69
                                                            MARKED RTE.
0
                              ANALYST REMARKS --

                                               PROJECT NO. S-0038(10), ACTUAL YEAR OF CONSTRUCTION 1965
                                               TRUSSES AND MOST STRINGERS SALVAGED FROM BEAVER CREEK
                                               ASSUME SALVAGED STEEL FABRICATED 1920 FOR ALLW. STRESSES
                                               STRINGER 1 INT. I12X31.8 (REUSED), FLOOR BEAM B01 W30X108 (NEW)
                                               RATED WITH 6 INCHES ASPHALT OVERLAY AND COLORADO TRUCKS
                                               OVER TURKEY CREEK NEAR FARISITA

+    INVENTORY RATING SUMMARY --                                                                   OPERATING RATING SUMMARY --
0

+      MEMBER ID.             S 1                                                                  MEMBER ID.             S 1

+      SPAN                    1                                                                   SPAN                    1

+      CRITICAL C.P. DIST.     6.0 FEET                                                            CRITICAL C.P. DIST.     6.0 FEET

+      LIVE LOAD DESIGNATION  HS20                                                                 LIVE LOAD DESIGNATION  HS20

0
+                               SHEAR                                                                                       SHEAR

+                               (KIPS)                                                                                      (KIPS)

+      MEMBER CAPACITY           48.                                                                MEMBER CAPACITY           67.5

+      DL EFFECT                  5.5                                                               DL EFFECT                  5.5

0
+      CAPACITY FOR (LL+I)       42.5                                                               CAPACITY FOR (LL+I)       62.0

+      ACTUAL (LL+I)             35.8                                                               ACTUAL (LL+I)             35.8

0
+      INVENTORY RATING      HS 23.71                                                                OPERATING RATING      HS 34.60
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1                              *** FINAL SUMMARY OF RATING RESULTS FOR --- STRUCTURE ID. D75-085    BARS RELEASE 5.5
                                                  INVENTORY AND/OR OPERATING ANALYSIS
            INPUT CODING--                                  STRUCTURE N-16-L                         D/P STR. ID--  D75-085

+                                            INVENTORY                     OPERATING
           DATE   8/ 7/95
+                                       LIVE LOAD    RATING                LIVE LOAD    RATING

+                                         HS20    HS  11.3                 HS20    HS  21.1

+          BY    MARK LEONARD


       STRUCTURE DESCRIPTION--                        LOCATION--                                    MICROFILM REEL NUMBERS--

           IDENTIFICATION    N-16-L                       DISTRICT         2                            DESIGN PLANS
           TYPE                   SLT                     COUNTY           055                          COMPUTATIONS
           YEAR OF CONSTR.    1920                        CONSTR. RTE.                                  CORRESPONDENCE
           LENGTH               61.83 FEET                CONSTR. SEC.
           ROADWAY WIDTH        24.00 FEET                CONSTR. STA.        0+  .
           NUMBER OF SPANS       1                        KEY RTE.          SH-69
                                                          MARKED RTE.

                             ANALYST REMARKS--

                               PROJECT NO. S-0038(10), ACTUAL YEAR OF CONSTRUCTION 1965
                               TRUSSES AND MOST STRINGERS SALVAGED FROM BEAVER CREEK
                               ASSUME SALVAGED STEEL FABRICATED 1920 FOR ALLW. STRESSES
                               STRINGER 1 INT. I12X31.8 (REUSED), FLOOR BEAM B01 W30X108 (NEW)
                               RATED WITH 6 INCHES ASPHALT OVERLAY AND COLORADO TRUCKS
                               OVER TURKEY CREEK NEAR FARISITA



+      INVENTORY RATING SUMMARY                                                               OPERATING RATING SUMMARY


+      CRITICAL MEMBER ID      L 2L 3                                                         CRITICAL MEMBER ID      L 2L 3

+      LIVE LOAD DESIGNATION    HS20                                                           LIVE LOAD DESIGNATION    HS20


+                         AXIAL FORCE                                                                         AXIAL FORCE

+                               (KIPS)                                                                                (KIPS)

+      MEMBER CAPACITY          163.0                                                         MEMBER CAPACITY          229.3

+      DL EFFECT                 86.4                                                         DL EFFECT                 86.4

+      CAPACITY FOR (LL+I)       76.6                                                         CAPACITY FOR (LL+I)      142.9

+      ACTUAL (LL+I)            135.2                                                          ACTUAL (LL+I)            135.2

+      INVENTORY RATING      HS  11.34                                                         OPERATING RATING      HS  21.13
```

```
1
                                                         DETAIL TRUSS DATA


     DATE 08/07/95                                                                                 D/P STRUCTURE I.D.  D75-085
                                                                                                   TRUSS I.D.   1
     SPAN LENGTH (FT.)    60.000                                            C-C TRUSS =   0.000 FT.  LL DIST. FACT. =  2.155


                        TRUSS GEOMETRY                                     UNIFORM DEAD LOAD
                                                                                 UPPER CHORD =     0.0 LBS/FT.
                                                                                 UPPER CHORD =     0.0 LBS/FT.
                   ------LENGTH------   -------HEIGHT-------   DEAD LOADS APPLIED TO PANEL POINTS
     PANEL  PANEL  TOTAL  LEFT SUBDIV.   TOTAL      TOTAL       LOWER CHORD          UPPER CHORD
      NO.   CODE   PANEL      PANEL     VERTICAL  K-VERTICAL      X        P          X        P
                    FT.        FT.        FT.        FT.         FT.      KIPS        FT.      KIPS
       0                                 0.000                  0.000    9.601                                    L00L01    L00U01
       1      7    12.000      0.000     8.000      0.000      12.000   19.200                                    U01L01    U01U02
       2      2    12.000      0.000     8.000      0.000      24.000   19.200                                    L01L02    U01L02
       3      4    12.000      0.000     8.000      0.000      36.000   19.200                                    U02L02    L02L03
       4      1    12.000      0.000     8.000      0.000      48.000   19.200                                    U02U03    U02L03
       5      5    12.000      0.000     0.000      0.000      60.000    9.600                                    L02U03    U03L03
       0




     TRUCK LOAD USED FOR --

        INVENTORY HS20


1
                                                     DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                 D/P STRUCTURE I.D.  D75-085
                                                                                                   TRUSS I.D.   1
                                                                                                   TRUSS MEMBER I.D.   L00L01
 ***** MEMBER PROPERTIES
                             -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY      DY     RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                  COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

  12.000  12.000  10.00   11.72      157      282   5.00   3.66   4.91    10.19      156      282   5.00    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)     0.00   12.00   60.00                           POS AREA    36.00
 LOWER CHORD      Y-ORDINATE       0.00    1.20    0.00                           NEG AREA     0.00

 LOAD  ON         X-DIST (FT.)     0.00   12.00   60.00                           POS AREA    36.00
 UPPER CHORD      Y-ORDINATE       0.00    1.20    0.00                           NEG AREA     0.00

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
             TENS      COMP       TENS     COMP                  TENS     COMP                                   TENS     COMP
             PSI       PSI        KIPS     KIPS                  KIPS     KIPS                                    KIPS     KIPS
 INVENTORY    16000.   12938.      163.0    151.6                  57.6                                          105.4    209.2
 OPERATING    22500.   15875.      229.3    186.1                                                                171.7    243.7


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.000 (COMP.)  = 0.270 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL          LOC.NO.  DIR     LL+IMP     LL          LOC CONC            RATING  SAFE LOAD  RATING
         LOAD                           1 WHEEL                                   LOAD              FACT.   CAPACITY  VALUE
                   KIPS    KIPS           FT.             KIPS     KIPS            FT.                        TONS

 INV     HS20 T     95.3    75.0         40.000   R       61.1     48.1          12.000              1.107     39.8    HS 22.1
              C      0.0     0.0          0.000   `        0.0      0.0           0.000

 OPER    HS20 T     95.3    75.0         40.000   R       61.1     48.1          12.000              1.802     64.9    HS 36.0
              C      0.0     0.0          0.000   `        0.0      0.0           0.000
1

                                                     DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                 D/P STRUCTURE I.D.  D75-085
                                                                                                   TRUSS I.D.   1
                                                                                                   TRUSS MEMBER I.D.   L00U01
 ***** MEMBER PROPERTIES
                             -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY      DY     RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                  COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

  14.422  14.422  10.31   16.09      241      353   3.91   3.88   4.69    16.09      241      353   3.91    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)     0.00   12.00   60.00                           POS AREA     0.00
 LOWER CHORD      Y-ORDINATE       0.00   -1.44    0.00                           NEG AREA    43.27

 LOAD  ON         X-DIST (FT.)     0.00   12.00   60.00                           POS AREA     0.00
 UPPER CHORD      Y-ORDINATE       0.00   -1.44    0.00                           NEG AREA    43.27

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
             TENS      COMP       TENS     COMP                  TENS     COMP                                   TENS     COMP
             PSI       PSI        KIPS     KIPS                  KIPS     KIPS                                   KIPS     KIPS
 INVENTORY    16000.   12875.      257.4    207.2                           69.2                                 326.7    137.9
 OPERATING    22500.   15813.      362.0    254.4                                                                431.3    185.2


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.270 (COMP.)  = 0.000 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
```

```
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL           LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                    LOAD              FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS             FT.                       TONS

 INV     HS20 T     0.0     0.0            0.000   `         0.0     0.0             0.000
              C   114.5    90.1           40.000   R        89.2    70.2            12.000             1.205     43.4    HS 24.1
 OPER    HS20 T     0.0     0.0            0.000   `         0.0     0.0             0.000
              C   114.5    90.1           40.000   R        89.2    70.2            12.000             1.618     58.2    HS 32.4

                                                      DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   L01L02
 ***** MEMBER PROPERTIES
                          -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY      DY     RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                  COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

  12.000  12.000  10.00   11.72      157      282   5.00   3.66   4.91    10.19      156      282   5.00    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   12.00   60.00                           POS AREA    36.00
 LOWER CHORD      Y-ORDINATE      0.00    1.20    0.00                           NEG AREA     0.00

 LOAD  ON         X-DIST (FT.)    0.00   12.00   60.00                           POS AREA    36.00
 UPPER CHORD      Y-ORDINATE      0.00    1.20    0.00                           NEG AREA     0.00

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.   12938.      163.0    151.6                   57.6                                   105.4    209.2
 OPERATING    22500.   15875.      229.3    186.1                                                          171.7    243.7


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.000 (COMP.)  = 0.270 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL           LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                    LOAD              FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS             FT.                       TONS

 INV     HS20 T    95.3    75.0           40.000   R        61.1    48.1            12.000             1.107     39.8    HS 22.1
              C     0.0     0.0            0.000   `         0.0     0.0             0.000

 OPER    HS20 T    95.3    75.0           40.000   R        61.1    48.1            12.000             1.802     64.9    HS 36.0
              C     0.0     0.0            0.000   `         0.0     0.0             0.000
1

                                                      DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   L02L03
 ***** MEMBER PROPERTIES
                          -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY      DY     RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                  COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

  12.000  12.000  10.00   11.72      157      282   5.00   3.66   4.91    10.19      156      282   5.00    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   24.00   60.00                           POS AREA    54.00
 LOWER CHORD      Y-ORDINATE      0.00    1.80    0.00                           NEG AREA     0.00

 LOAD  ON         X-DIST (FT.)    0.00   24.00   60.00                           POS AREA    54.00
 UPPER CHORD      Y-ORDINATE      0.00    1.80    0.00                           NEG AREA     0.00

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.   12938.      163.0    151.6                   86.4                                    76.6    238.0
 OPERATING    22500.   15875.      229.3    186.1                                                          142.9    272.5


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.000 (COMP.)  = 0.270 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL           LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                    LOAD              FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS             FT.                       TONS

 INV     HS20 T   135.2   106.5           10.001   L        91.6    72.1            24.000             0.567     20.4    HS 11.3
              C     0.0     0.0            0.000   `         0.0     0.0             0.000

 OPER    HS20 T   135.2   106.5           10.001   L        91.6    72.1            24.000             1.057     38.0    HS 21.1
              C     0.0     0.0            0.000   `         0.0     0.0             0.000
1

                                                      DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   L02U03
 ***** MEMBER PROPERTIES
                          -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY      DY     RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                  COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

  14.422  14.422   3.00    3.24        2       37   0.93   0.94   3.40     2.69        2       37   0.93    0.00    R    0.8
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 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   24.00   36.00   60.00                   POS AREA    10.82
 LOWER CHORD      Y-ORDINATE      0.00    0.72   -0.72    0.00                   NEG AREA    10.82

 LOAD  ON         X-DIST (FT.)    0.00   24.00   36.00   60.00                   POS AREA    10.82
 UPPER CHORD      Y-ORDINATE      0.00    0.72   -0.72    0.00                   NEG AREA    10.82

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.       0.       43.0      0.0                             0.0                           43.0      0.0
 OPERATING    22500.       0.       60.5      0.0                                                           60.5      0.0


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.000 (COMP.)  = 0.300 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL           LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                    LOAD              FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS             FT.                       TONS



 INV     HS20 T    45.8    35.2           -4.000   L        36.0    27.7           24.000             0.940     33.8    HS 18.8
              C     0.0     0.0            0.000   `         0.0     0.0            0.000

 OPER    HS20 T    45.8    35.2           -4.000   L        36.0    27.7           24.000             1.322     47.6    HS 26.4
              C     0.0     0.0            0.000   `         0.0     0.0            0.000
1

                                                      DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   U01L01
 ***** MEMBER PROPERTIES
                          -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY     DY     RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

   8.000   8.000   7.31    9.46       20       95   3.65   1.48   3.17     7.27       20       95   3.65    0.00    R    0.8

 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00    0.00   12.00   24.00   60.00           POS AREA    12.00
 LOWER CHORD      Y-ORDINATE      0.00    0.00    1.00    0.00    0.00           NEG AREA     0.00

 LOAD  ON         X-DIST (FT.)    0.00   60.00                                   POS AREA     0.00
 UPPER CHORD      Y-ORDINATE      0.00    0.00                                   NEG AREA     0.00

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.   12500.      116.3    118.3                   19.2                                    97.1    137.4
 OPERATING    22500.   15375.      163.6    145.4                                                          144.4    164.6

 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.000 (COMP.)  = 0.300 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL           LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                    LOAD              FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS             FT.                       TONS

 INV     HS20 T    44.8    34.5          -16.000   L        47.2    36.3           12.000             2.059     74.1    HS 41.2
              C     0.0     0.0            0.000   `         0.0     0.0            0.000

 OPER    HS20 T    44.8    34.5          -16.000   L        47.2    36.3           12.000             3.060    110.2    HS 61.2
              C     0.0     0.0            0.000   `         0.0     0.0            0.000
1

                                                      DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   U01L02
 ***** MEMBER PROPERTIES
                          -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY     DY     RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

  14.422  14.422   8.31    8.36       30       94   4.16   1.90   3.36     7.27       27       94   3.94    0.00    R    0.8

 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   12.00   24.00   60.00                   POS AREA    24.34
 LOWER CHORD      Y-ORDINATE      0.00   -0.36    1.08    0.00                   NEG AREA     2.70

 LOAD  ON         X-DIST (FT.)    0.00   12.00   24.00   60.00                   POS AREA    24.34
 UPPER CHORD      Y-ORDINATE      0.00   -0.36    1.08    0.00                   NEG AREA     2.70

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.   10375.      116.3     86.7                   34.6                                    81.7    121.3
 OPERATING    22500.   12750.      163.6    106.6                                                          129.0    141.2

 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.300 (COMP.)  = 0.294 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
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         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL          LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                   LOAD             FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS            FT.                       TONS

 INV     HS20 T    80.4    62.2          52.000   R       60.9    47.1          24.000            1.016     36.6    HS 20.3
              C    16.2    12.4         -16.000   L       15.6    12.0          12.000

 OPER    HS20 T    80.4    62.2          52.000   R       60.9    47.1          24.000            1.603     57.7    HS 32.1
              C    16.2    12.4         -16.000   L       15.6    12.0          12.000
1


                                                     DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   U01U02
 ***** MEMBER PROPERTIES
                  -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA     IX       IY     DY     RX     RY     AREA     IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                               COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.    SQ.IN.  IN**4    IN**4    IN.     IN.

  12.000  12.000  10.31   16.09      241      353   3.91   3.88   4.69   16.09      241      353   3.91    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   24.00   60.00                          POS AREA     0.00
 LOWER CHORD      Y-ORDINATE      0.00   -1.80    0.00                          NEG AREA    54.00

 LOAD  ON         X-DIST (FT.)    0.00   24.00   60.00                          POS AREA     0.00
 UPPER CHORD      Y-ORDINATE      0.00   -1.80    0.00                          NEG AREA    54.00

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
             TENS      COMP       TENS     COMP                  TENS     COMP                          TENS     COMP
             PSI       PSI        KIPS     KIPS                  KIPS     KIPS                          KIPS     KIPS
 INVENTORY   16000.   13000.      257.4    209.2                           86.4                         343.8    122.8
 OPERATING   22500.   15938.      362.0    256.4                                                        448.4    170.0


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.270 (COMP.)  = 0.000 (TENS.)
                  ----------- TRUCK LOAD -----------      ----------LANE LOAD-----------          --------- RATING --------
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL          LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                   LOAD             FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS            FT.                       TONS

 INV     HS20 T     0.0     0.0           0.000   `        0.0     0.0           0.000
              C   135.2   106.5          10.001   L       91.6    72.1          24.000            0.908     32.7    HS 18.2

 OPER    HS20 T     0.0     0.0           0.000   `        0.0     0.0           0.000
              C   135.2   106.5          10.001   L       91.6    72.1          24.000            1.257     45.3    HS 25.1


1
                                                     DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   U02L02
 ***** MEMBER PROPERTIES
                  -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA     IX       IY     DY     RX     RY     AREA     IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                               COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.    SQ.IN.  IN**4    IN**4    IN.     IN.

   8.000   8.000   7.31    9.46       20       95   3.65   1.48   3.17    7.27       20       95   3.65    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   24.00   36.00   60.00                  POS AREA     6.00
 LOWER CHORD      Y-ORDINATE      0.00    0.40   -0.40    0.00                  NEG AREA     6.00

 LOAD  ON         X-DIST (FT.)    0.00   12.00   24.00   60.00                  POS AREA     1.50
 UPPER CHORD      Y-ORDINATE      0.00    0.20   -0.60    0.00                  NEG AREA    13.50

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
             TENS      COMP       TENS     COMP                  TENS     COMP                          TENS     COMP
             PSI       PSI        KIPS     KIPS                  KIPS     KIPS                          KIPS     KIPS
 INVENTORY   16000.   12500.      116.3    118.3                            0.0                         116.3    118.3
 OPERATING   22500.   15375.      163.6    145.4                                                        163.6    145.4


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.300 (COMP.)  = 0.000 (TENS.)
                  ----------- TRUCK LOAD -----------      ----------LANE LOAD-----------          --------- RATING --------
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL          LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                   LOAD             FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS            FT.                       TONS

 INV     HS20 T    25.4    19.5          -4.000   L       19.9    15.3          24.000            4.581    164.9    HS 91.6
              C    25.4    19.5          64.000   R       19.9    15.3          36.000

 OPER    HS20 T    25.4    19.5          -4.000   L       19.9    15.3          24.000
              C    25.4    19.5          64.000   R       19.9    15.3          36.000            5.726    206.1    HS114.5


1
                                                     DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   U02L03
 ***** MEMBER PROPERTIES
                  -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA     IX       IY     DY     RX     RY     AREA     IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                               COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.    SQ.IN.  IN**4    IN**4    IN.     IN.
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  14.422  14.422   3.00    3.24        2       37   0.93   0.94   3.40     2.69        2       37   0.93    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   24.00   36.00   60.00                   POS AREA    10.82
 LOWER CHORD      Y-ORDINATE      0.00   -0.72    0.72    0.00                   NEG AREA    10.82

 LOAD  ON         X-DIST (FT.)    0.00   24.00   36.00   60.00                   POS AREA    10.82
 UPPER CHORD      Y-ORDINATE      0.00   -0.72    0.72    0.00                   NEG AREA    10.82

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.       0.       43.0      0.0                          0.0                            43.0      0.0
 OPERATING    22500.       0.       60.5      0.0                                                         60.5      0.0


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.000 (COMP.)  = 0.300 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL          LOC.NO.  DIR     LL+IMP     LL          LOC CONC          RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                     LOAD            FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS              FT.                       TONS

 INV     HS20 T    45.8    35.2          64.000   R       36.0    27.7           36.000           0.940     33.8    HS 18.8
              C     0.0     0.0           0.000   `        0.0     0.0            0.000

 OPER    HS20 T    45.8    35.2          64.000   R       36.0    27.7           36.000           1.322     47.6    HS 26.4
              C     0.0     0.0           0.000   `        0.0     0.0            0.000


1


                                                      DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   U02U03
 ***** MEMBER PROPERTIES
                          -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY     DY      RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                  COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

  12.000  12.000  10.31   16.09      241      353   3.91   3.88   4.69    16.09      241      353   3.91    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   36.00   60.00                           POS AREA     0.00
 LOWER CHORD      Y-ORDINATE      0.00   -1.80    0.00                           NEG AREA    54.00

 LOAD  ON         X-DIST (FT.)    0.00   36.00   60.00                           POS AREA     0.00
 UPPER CHORD      Y-ORDINATE      0.00   -1.80    0.00                           NEG AREA    54.00


 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.   13000.      257.4    209.2                         86.4                          343.8    122.8
 OPERATING    22500.   15938.      362.0    256.4                                                       448.4    170.0


 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.270 (COMP.)  = 0.000 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL          LOC.NO.  DIR     LL+IMP     LL          LOC CONC          RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                     LOAD            FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS              FT.                       TONS

 INV     HS20 T     0.0     0.0           0.000   `        0.0     0.0            0.000
              C   134.2   105.6          50.560   R       91.6    72.1           36.000           0.915     32.9    HS 18.3

 OPER    HS20 T     0.0     0.0           0.000   `        0.0     0.0            0.000
              C   134.2   105.6          50.560   R       91.6    72.1           36.000           1.267     45.6    HS 25.3


1
                                                      DETAIL TRUSS MEMBER DATA
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                    TRUSS I.D.   1
                                                                                                    TRUSS MEMBER I.D.   U03L03
 ***** MEMBER PROPERTIES
                          -------------- GROSS SECTION ---------------      ------- NET SECTION ------
  EFFECT  EFFECT    H     AREA      IX       IY     DY      RX     RY      AREA      IX       IY     DY      E(Y)   END   FACT.
  LEN.-X  LEN.-Y                                                                                                  COND.
    FT.     FT.    IN.    SQ.IN.  IN**4    IN**4    IN.    IN.    IN.     SQ.IN.  IN**4    IN**4    IN.      IN.

   8.000   8.000   7.31    9.46       20       95   3.65   1.48   3.17     7.27       20       95   3.65    0.00    R    0.8


 ***** MEMBER INFLUENCE LINES

 LOAD  ON         X-DIST (FT.)    0.00   24.00   36.00   60.00                   POS AREA     6.00
 LOWER CHORD      Y-ORDINATE      0.00   -0.40    0.40    0.00                   NEG AREA     6.00

 LOAD  ON         X-DIST (FT.)    0.00   36.00   48.00   60.00                   POS AREA     1.50
 UPPER CHORD      Y-ORDINATE      0.00   -0.60    0.20    0.00                   NEG AREA    13.50

 *****       ALLOWABLE STRESS  /  MEMBER CAPACITY  /  AXIAL FORCE ON MEMBER DUE TO DEAD LOAD  /  AVAILABLE CAPACITY FOR LL+IMPACT
---
              TENS      COMP       TENS     COMP                   TENS     COMP                           TENS     COMP
              PSI       PSI        KIPS     KIPS                   KIPS     KIPS                           KIPS     KIPS
 INVENTORY    16000.   12500.      116.3    118.3                          0.0                          116.3    118.2
 OPERATING    22500.   15375.      163.6    145.4                                                       163.6    145.4
```

```
 ***** LIVE LOAD AND RATING CALCULATIONS--IMPACT FACTOR = 0.300 (COMP.)  = 0.300 (TENS.)
                  ----------- TRUCK LOAD -----------       ----------LANE LOAD-----------            --------- RATING --------
         LIVE     LL+IMP    LL           LOC.NO.  DIR     LL+IMP     LL           LOC CONC           RATING  SAFE LOAD  RATING
         LOAD                            1 WHEEL                                    LOAD              FACT.   CAPACITY  VALUE
                   KIPS    KIPS            FT.             KIPS     KIPS             FT.                       TONS

 INV     HS20 T    25.4    19.5           64.000   R        19.9    15.3           36.000             4.579    164.9    HS 91.6
              C    25.4    19.5           -4.000   L        19.9    15.3           24.000

 OPER    HS20 T    25.4    19.5           64.000   R        19.9    15.3           36.000             6.440    231.8    HS128.8
              C    25.4    19.5           -4.000   L        19.9    15.3           24.000
1
                                                   DETAIL DATA FOR FLEXURAL MEMBER

     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085
                                                                                                   MEMBER I.D.--B01
       NO. SPANS =  1                                                                                MATERIAL--SS
     NOT SYMMETRICAL                                                                                 LL DIST. FACT. = 12.000
                                  VAR                    SUPERIMPOSED DISTRIBUTED DL(S)          SUPERIMPOSED CONCENTRATED DL(S)
                                 CODE    DL DUE TO         LENGTH DISTRIBUTED***************       DIST. FROM LT SUPPORT****
                                  S     MEM. WEIGHT        DIST. FROM LT SUPPORT***        *                               *
 SPAN LENGTH RNG. LENGTH  SEC.NO. T T  W(LT)   W(RT)    SPAN   W(LT)   W(RT)     *        *              SPAN     P       *
  NO.  FT.   NO.    FT.   LT  RT  P B  LBS/FT  LBS/FT     NO.  LBS/FT  LBS/FT    FT.      FT.              NO.   KIPS     FT.
  1   25.000  1   25.000  01  01       108.1   108.1                                                       1      2.3    0.875
                                                                                                            1      3.3    3.458
                                                                                                            1      3.3    6.042
                                                                                                            1      3.3    8.625
                                                                                                            1      3.3   11.208
                                                                                                            1      3.3   13.792
                                                                                                            1      3.3   16.375
                                                                                                            1      3.3   18.958
                                                                                                            1      3.3   21.542
                                                                                                            1      2.3   24.125
CHECK POINTS RATED--
                                                       SPAN DIS FRM  FUNC     SPAN DIS FRM  FUNC
                                                        NO. LT SPRT  M VL VR   NO. LT SPRT  M VL VR
                                                              FT.                    FT.
                                                         1    0.000        X
                                                         1   11.750  X
                                                         1   25.000     X
```

```
1
                                                   DETAIL DATA FOR FLEXURAL MEMBER

     DATE 08/07/95                                                                                   D/P STRUCTURE I.D.  D75-085
                                                                                                    MEMBER I.D.--S01
       NO. SPANS =  1                                                                                 MATERIAL--SS


     NOT SYMMETRICAL                                                                                  LL DIST. FACT. =  0.574
                                  VAR                     SUPERIMPOSED DISTRIBUTED DL(S)         SUPERIMPOSED CONCENTRATED DL(S)
                                 CODE    DL DUE TO          LENGTH DISTRIBUTED***************      DIST. FROM LT SUPPORT****
                                  S     MEM. WEIGHT         DIST. FROM LT SUPPORT***        *                             *
 SPAN LENGTH RNG. LENGTH  SEC.NO. T T   W(LT)  W(RT)     SPAN   W(LT)   W(RT)     *        *              SPAN     P       *
  NO.  FT.   NO.    FT.    LT  RT  P B  LBS/FT  LBS/FT     NO.  LBS/FT  LBS/FT     FT.      FT.             NO.   KIPS     FT.
  1   12.000  1   12.000  01  01          31.5    31.5      1    276.0   276.0    0.000   12.000

CHECK POINTS RATED--
                                                       SPAN DIS FRM  FUNC      SPAN DIS FRM  FUNC
                                                        NO. LT SPRT  M VL VR    NO. LT SPRT  M VL VR
                                                              FT.                     FT.

                                                         1    0.000        X
                                                         1    6.000  X
                                                         1   12.000     X




1
                                                 DETAIL DATA AT MOMENT CHECK POINT FOR             BARS RELEASE 5.5
                                                   STRUCTURAL STEEL FLEXURAL MEMBER
     DATE 08/07/95                                                                                   D/P STRUCTURE I.D.  D75-085
                                                                                                     MEMBER I.D.--B01
                                                                                                     C.P. LOCATION
1.47
 *****  SECTION PROPERTIES IN RANGE  1 OF SPAN  1
                              ---NET AREA---                                  -----------SECTION  MODULUS-----------
                     GROSS      +       -         IX         IX      C        TOP       TOP      BOTTOM    BOTTOM
               H     AREA      BEND    BEND      + BEND     - BEND   (BOT)   + BEND    - BEND    + BEND    - BEND
              IN.   SQ.IN.    SQ.IN.  SQ.IN.     IN**4      IN**4    IN.      IN**3     IN**3     IN**3     IN**3
              0.00   31.77     31.77   31.77     4461.0     4461.0   14.91     299.2     299.2     299.2     299.2

 *****  INFLUENCE LINE (SIMPLE SPAN)                                      *****  ALLOWABLE  *****  MOMENT CAPACITY
                                                                                  STRESS               TOP     TOP    BOTTOM  BOTTOM
       X-DIST (FT.)     0.000    11.750    25.000   POS AREA =                                       + BEND  - BEND  + BEND  - BEND
       Y-ORDINATE       0.000     1.000     0.000                                   PSI           FT-KIPS   FT-KIPS FT-KIPS FT-KIPS
`
                                                                         INVENTORY  17966.8          448.0   448.0   448.0   448.0
 *****  ORDINATES OF AND AREAS UNDER INFLUENCE LINE (CONTINUOUS SPAN)  OPERATING  24500.3          610.9   610.9   610.9   610.9
              SPAN     SPAN     SPAN     SPAN     SPAN     SPAN        POST VEH1      0.0            0.0     0.0     0.0     0.0
      T 0                                                              POST VEH2      0.0            0.0     0.0     0.0     0.0
      E 1                                                              POST VEH3      0.0            0.0     0.0     0.0     0.0
      N 2                                                              POST SPEC      0.0            0.0     0.0     0.0     0.0
      T 3
      H 4                                                              *****  TOTAL DL        *****  AVAIL.CAPAC.FOR LL+IMPACT
        5                                                                   MOMENT EFFECT              TOP     TOP     BOT
BOT
      P 6                                                                                             +BEND   -BEND   +BEND   -
BEND
      O 7                                                                     FT-KIPS                 F-KPS   F-KPS   F-KPS   F-
KPS
      I 8                                                                       107.2      INVENTORY   340.7   555.2   340.7
555.2
      N 9                                                                                  OPERATING   503.6   718.1   503.6
718.1
      T 0                                                           AREA                   VEH. 1       0.0     0.0     0.0
0.0
                                                                   TOTALS                  VEH. 2       0.0     0.0     0.0
0.0
   POS AREA      0.0      0.0      0.0      0.0      0.0      0.0      0.0                 VEH. 3       0.0     0.0     0.0
0.0
   NEG AREA      0.0      0.0      0.0      0.0      0.0      0.0      0.0                 SPECIAL      0.0     0.0     0.0
0.0

 *****  LIVE LOAD AND RATING CALCULATIONS (IMPACT FACTOR = 0.300 FOR +BEND AND = 0.000 FOR -BEND)
                  ---------TRUCK LOAD----------------   -------LANE LOAD-------
      LIVE        LL+IMP   LL     LOC.NO.  DIR  AXLE   LL+IMP    LL     LOC.CONC  LOC.CONC         RATING  SAFE LOAD  RATING
      LOAD                        1 WHEEL       SPACE                    LOAD      LOAD 2           FACT.   CAPACITY   VALUE
                 FT-KIPS FT-KIPS    FT.          FT.   FT-KIPS FT-KIPS    FT.       FT.                       TONS
 INV  HS20 +BEND   330.9   254.6    0.000   R   0.0      0.0     0.0    0.000                      1.030      37.1   HS 20.6
`
           -BEND     0.0     0.0    0.000   R   0.0      0.0     0.0    0.000      0.000

 OPER HS20 +BEND   330.9   254.6    0.000   R   0.0      0.0     0.0    0.000                      1.522      54.8   HS 30.4
`
           -BEND     0.0     0.0    0.000   R   0.0      0.0     0.0    0.000      0.000

 POST      +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000

 POST      +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000

 POST      +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000

 POST SPEC +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000
1

                                                 DETAIL DATA AT MOMENT CHECK POINT FOR             BARS RELEASE 5.5
                                                   STRUCTURAL STEEL FLEXURAL MEMBER
     DATE 08/07/95                                                                                   D/P STRUCTURE I.D.  D75-085
                                                                                                     MEMBER I.D.--S01
```

```
                                                                                                    C.P. LOCATION
1.50
 *****  SECTION PROPERTIES IN RANGE  1 OF SPAN  1
                              ---NET AREA---                                 -----------SECTION  MODULUS-----------
                     GROSS      +       -           IX         IX      C       TOP       TOP     BOTTOM    BOTTOM
               H     AREA      BEND    BEND      + BEND     - BEND   (BOT)   + BEND    - BEND    + BEND    - BEND
              IN.   SQ.IN.    SQ.IN.  SQ.IN.      IN**4      IN**4    IN.     IN**3     IN**3     IN**3     IN**3
              0.00    9.26      9.26    9.26      215.8      215.8    5.99      36.0      36.0      36.0      36.0

 *****  INFLUENCE LINE (SIMPLE SPAN)                                   *****  ALLOWABLE  *****  MOMENT CAPACITY
                                                                                 STRESS             TOP     TOP    BOTTOM  BOTTOM
       X-DIST (FT.)    0.000     6.000    12.000   POS AREA =                                      + BEND  - BEND  + BEND  - BEND
       Y-ORDINATE      0.000     3.000     0.000                                 PSI           FT-KIPS   FT-KIPS FT-KIPS FT-KIPS
`
                                                                       INVENTORY  16000.0            48.0    48.0    48.0    48.0
 *****  ORDINATES OF AND AREAS UNDER INFLUENCE LINE (CONTINUOUS SPAN)  OPERATING  22500.0            67.5    67.5    67.5    67.5
              SPAN     SPAN     SPAN     SPAN     SPAN     SPAN        POST VEH1      0.0             0.0     0.0     0.0     0.0
      T 0                                                              POST VEH2      0.0             0.0     0.0     0.0     0.0
      E 1                                                              POST VEH3      0.0             0.0     0.0     0.0     0.0
      N 2                                                              POST SPEC      0.0             0.0     0.0     0.0     0.0
      T 3


      H 4                                                              *****  TOTAL DL        *****  AVAIL.CAPAC.FOR LL+IMPACT
        5                                                                   MOMENT EFFECT              TOP     TOP     BOT
BOT
      P 6                                                                                             +BEND   -BEND   +BEND   -
BEND
      O 7                                                                     FT-KIPS                 F-KPS   F-KPS   F-KPS   F-
KPS
      I 8                                                                         5.5      INVENTORY    42.5    53.5    42.5
53.5
      N 9                                                                                  OPERATING    62.0    73.0    62.0
73.0
      T 0                                                           AREA                   VEH. 1        0.0     0.0     0.0
0.0
                                                                   TOTALS                  VEH. 2        0.0     0.0     0.0
0.0
   POS AREA      0.0      0.0      0.0      0.0      0.0      0.0      0.0                 VEH. 3        0.0     0.0     0.0
0.0
   NEG AREA      0.0      0.0      0.0      0.0      0.0      0.0      0.0                 SPECIAL       0.0     0.0     0.0
0.0

 *****  LIVE LOAD AND RATING CALCULATIONS (IMPACT FACTOR = 0.300 FOR +BEND AND = 0.300 FOR -BEND)
                  ---------TRUCK LOAD----------------   -------LANE LOAD-------
      LIVE        LL+IMP   LL     LOC.NO.  DIR   AXLE   LL+IMP    LL    LOC.CONC  LOC.CONC         RATING  SAFE LOAD  RATING
      LOAD                        1 WHEEL       SPACE                    LOAD      LOAD 2           FACT.   CAPACITY   VALUE
                 FT-KIPS FT-KIPS    FT.           FT.   FT-KIPS FT-KIPS   FT.        FT.                      TONS
 INV  HS20 +BEND    35.8    27.6   -8.000   L    0.0     24.4    18.8    6.000                     1.186      42.7   HS 23.7
`
           -BEND     0.0     0.0    0.000   L    0.0      0.0     0.0    0.000      0.000

 OPER HS20 +BEND    35.8    27.6   -8.000   L    0.0     24.4    18.8    6.000                     1.730      62.3   HS 34.6
`
           -BEND     0.0     0.0    0.000   L    0.0      0.0     0.0    0.000      0.000

 POST      +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000

 POST      +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000

 POST      +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000

 POST SPEC +BEND     0.0     0.0    0.000                                                          0.000       0.0
           -BEND     0.0     0.0    0.000
1
                                                      SUMMARY OF SHEAR ANALYSIS
     DATE 08/07/95                                                                                  D/P STRUCTURE I.D.  D75-085

                                        ---INVENTORY---  ---OPERATING---  --VEH. 1 --  --VEH. 2 --  --VEH. 3 --  --SPECIAL--
 MEMB.     SPAN DIS FRM L   DL    SDL    LL+I T  LL+I T   LL+I T  LL+I T   LL+I  LL+I   LL+I  LL+I   LL+I  LL+I   LL+I  LL+I
  ID  MATL  NO. LT SPRT R  SHEAR SHEAR  MAX.V L MIN.V L  MAX.V L MIN.V L  MAX.V MIN.V  MAX.V MIN.V  MAX.V MIN.V  MAX.V MIN.V
                  FT.      KIPS  KIPS    KIPS    KIPS     KIPS    KIPS     KIPS  KIPS   KIPS  KIPS   KIPS  KIPS   KIPS  KIPS

  B01  SS    1    0.000 R    1.4  15.5   51.6 T   0.0 T   51.6 T   0.0 T
             1   25.000 L   -1.4 -15.5    0.0 T -51.6 T    0.0 T -51.6 T

  S01  SS    1    0.000 L    0.2   1.7   11.9 T   0.0 T   11.9 T   0.0 T
             1    6.000 L    0.0   0.0    6.0 T   6.0 T    6.0 T   6.0 T
             1   12.000 L    0.2   1.7    0.0 T  12.1 T    0.0 T  12.1 T
```

SECTION 13
TIMBER STRUCTURE

13.1 INTRODUCTION TO RATING TIMBER BRIDGES RATINGS

This section covers the rating of timber stringers and decks. All timber members will be rated using the policies and guidelines in Section 1.

All timber stringers shall be rated using the AASHTOWare Bridge Rating program BrR. The timber decks shall be rated with CDOT Timber Bridge Rating program that is available from the Staff Bridge Branch Software Library.

All other types of timber stringers and decks will be rated in compliance with the applicable guidelines within this manual and the AASHTO codes.

Examples are presented for the three-stringer types listed below, as well as transverse nail laminated timber decks, and transverse plank timber decks.

Timber structures are repaired with the sister beam method using guidelines in Subsection 13.8.

For rating non-timber decks, see Section 3.

An important aspect of rating timber bridges is that the rating should reflect the actual condition of the members, as reported from field inspections. The guidelines for evaluating and accounting for the condition of timber members are shown in Subsection 13-3.

The types of stringers covered by this section are:

TS	- Timber Stringer - Timber Deck
TTD	- Treated Timber Stringer - Concrete Deck
TTS	- Treated Timber Stringer - Timber Deck

13.2 POLICIES AND GUIDELINES FOR RATING TIMBER STRINGERS

13.2.1 General

A) Allowable stress method shall be used to rate timber structures.
B) Timber stringers shall be rated using the BrR program. Nail laminated and plank decks shall be rated using the TIMBER computer program as mentioned in Subsection 13.6.
C) When plans are not available, timber stringers may be rated with BrR software using field dimension in accordance Section 1.7.1.

D) When plans are not available, the allowable stress values in Section 1.5 Table 1-3 for Douglas Fir-Larch Select Structural can be used.

E) The allowable stress value for shear may be increased by a modification factor of 1.33. This factor will always be used for stringers without splits and in good condition. If a beam or stringer is split horizontally, the increase factor is not allowed; see Subsection 13.3.

F) Adjustment factors for timber deck and stringer may be defaulted by using the BrR compute button.

G) For structures constructed after year 1960, the allowable stresses shall be modified according to the AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES.

H) For existing timber bridges, CDOT used lumber that has not been dressed / surfaced. The stringers may be considered as the full-sawn lumber sizes. The stringer sizes as presented in the design plans, or CARDEX may be used for ratings rather than dry dimensions, except the actual dimensions are verified by the inspectors.

Commentary: The full-sawn lumber is the same size as the stated nominal size. (Timber Bridges Design, page 3-40, Construction, Inspection, and Maintenance, 1990 – Michael A. Ritter, United States Department of Agriculture, Forest Service).

I) The rater shall evaluate and account for the condition of timber members as specified in Subsection 13.3.

13.2.2 Stringers Requiring Rating

A) Interior Stringers - A rating is required for the critically loaded interior stringer combined with the worst condition. Factors that influence condition are splits, broken, and repaired stringers, and wood condition. More than one interior stringer may require an analysis due to variation in span length, stringer size, stringer spacing, differences in loads or moments, etc.

B) Exterior Stringers - An exterior stringer shall be rated when the section used is different than the section used for an interior stringer.

13.2.3 Dead Loads

A) When rating timber bridges with timber decks use the maximum asphalt thickness obtained along a transverse cross section taken at midspan, rather than the average thickness, for dead load calculations.

B) For timber or metal plank decks, dead loads due to railing curbs, and wheel guards shall not be distributed to all stringers, but shall be considered to be carried by the exterior stringer.

C) The method of applying dead loads due to utilities is left to the rater's discretion.

13.2.4 Rating Reporting / Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. Any variation from the original design assumptions shall be added to the Rating Summary Sheet as applicable. The rating package requirements shall be per Section 1.13 of this manual and as amended herein:

Consultant designed projects – Before finalizing the rating package and when BrR is used as the analysis tool, the Rater shall verify with the Staff Bridge Rating Coordinator that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower, or higher version of the program shall be rejected, except if approved in advance by the Bridge Rating Engineer. It is required for the CDOT data archive, since the data base management feature inside the program would not work satisfactorily. After the analysis is completed, the rater shall save the data file. When saving is finalized, the rater shall export the data file in *.xml format (i.e., O-18-BY.xml format).

13.3 EVALUATING CONDITION OF TIMBER MEMBERS

13.3.1 Broken Stringers

A) In a broken stringer the wood is completely separated. The separation must extend a distance equal to or greater than one-fourth the depth of the stringer.

B) For a broken stringer, the rater shall assume that the stringer is not there. Use stringer spacing equal to 1.5 times the actual spacing for dead load and live load distribution calculations.

13.3.2 Cracked Stringers

A) A cracked stringer is similar to a broken stringer. A cracked stringer must be separated completely through the stringer in a lateral or transverse direction (at or nearly at 90 degrees to the longitudinal axis of the stringer); however, the separation must not extend vertically into the stringer more than one-fourth the depth of the stringer.

B) The rater will evaluate the crack as follows, depending upon its location in the stringer:

1. In the 1/4 span closest to the support the rater shall use the allowable shear stress values given in AASHTO without the shear increase factor from subsection 13.2.
2. In the center-half of the span, the rater shall calculate the effective or reduced section depth, corresponding to the crack location on the beam, in order for the TIMBER computer program to determine the bending moment capacity.

13.3.3 Split Stringers

A) To be a split, it must penetrate completely through the stringer and may or may not extend the full length of the stringer.

B) A split will not reduce a member's bending capacity.

C) For stringers that are split the allowable shear stress values given in AASHTO shall be used without the shear increase factor from Subsection 13-2.

13.3.4 Checked Stringers

A) A check is a separation of the wood along the fiber direction resulting from stresses set up in wood during seasoning, and usually extends across the rings of annual growth.
B) Checks in a stringer may be on either or both sides.
C) A check will not be considered to reduce the load carrying capacity of a timber member.

13.3.5 Shaked Stringers

A) A shake is the result of the growth in the tree and may easily be mistaken as a check.
B) A shake will not be considered to reduce the load carrying capacity of a timber member.

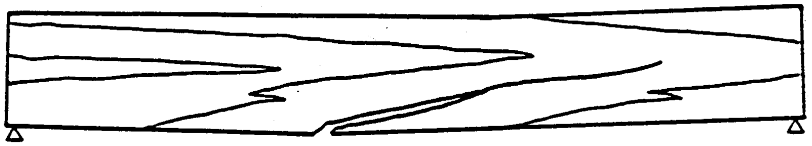
13.3.6 Decay

A) Decay can reduce a member's load capacity.
B) A reduced section will be rated for shear or bending strength depending on the location.

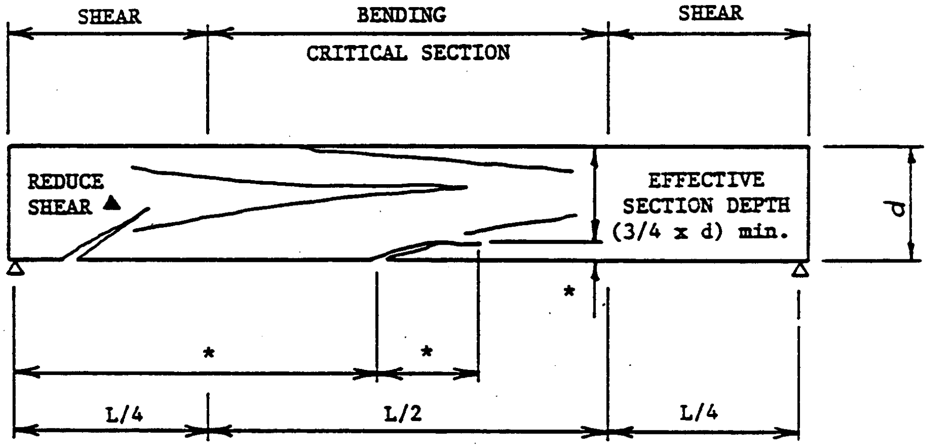
13.3.7 Aging

A) No adjustment in the allowable stresses for timber is necessary for reasons of aging alone. This is in accordance with ASTM D 245, April 10, 2000.

EVALUATING CONDITION OF TIMBER MEMBERS

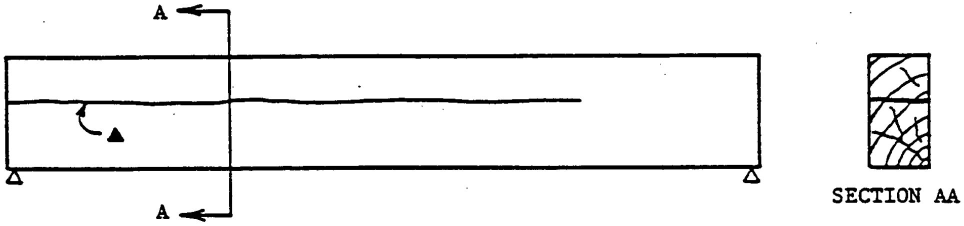


BROKEN STRINGER



* REQUIRES DIMENSION

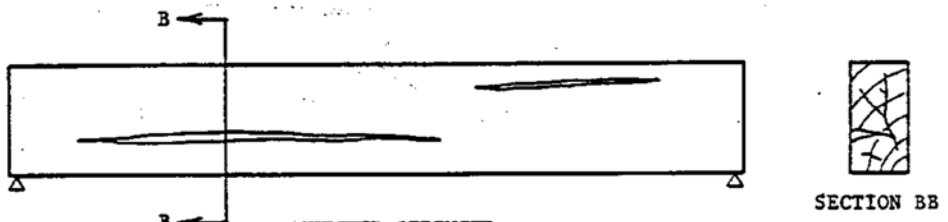
CRACKED STRINGER



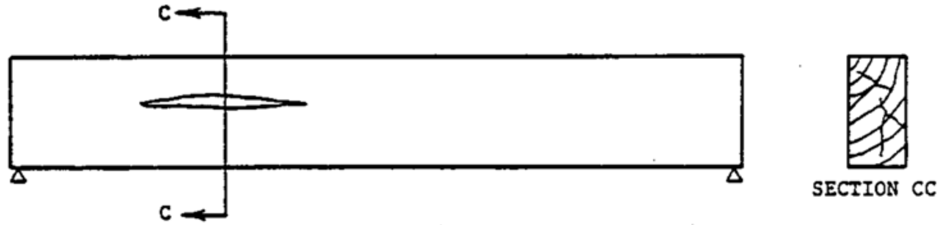
SPLIT STRINGER

▲ Use allowable shear value (F_v) without 1.33 increase in these areas.

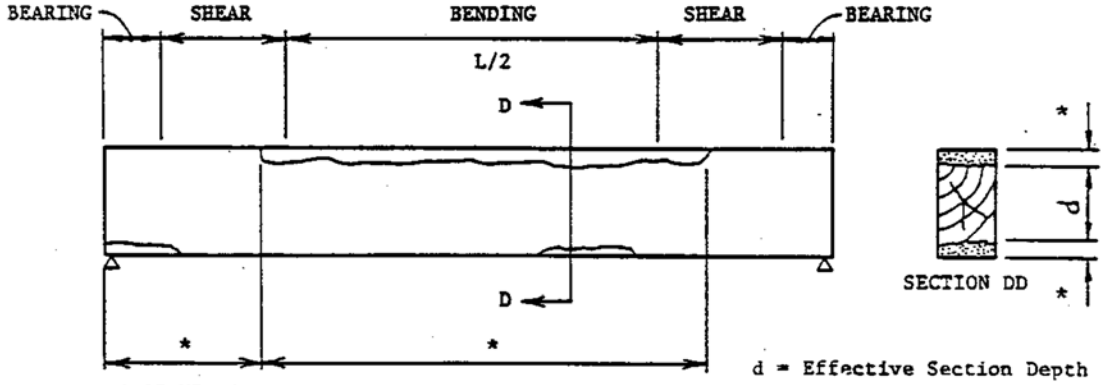
EVALUATING CONDITION OF TIMBER MEMBERS



CHECKED STRINGER



SHAKED STRINGER



d = Effective Section Depth

* REQUIRES DIMENSION

DECAYED STRINGER

13.4 GUIDELINES FOR USING THE BrR RATING PROGRAM

The BrR computer program performs the analysis and rating of simple span timber bridges. BrR uses the Madero ASD analysis engine. This program was developed in accordance with the AASHTO STANDARD SPECIFICATIONS and the AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES.

The program will not rate sawn timber decks, glue laminated stringers, glue laminated flooring, flooring placed longitudinally, splined or doweled flooring, multiple layered decks, nor nontimber decks. For required modification to the allowable stresses, see Subsection 13.2 and 13.3.

The library explorer can be used to save commonly used items (beam shapes, non standard vehicles, materials, appurtenances etc.) and this eliminates the need for all users to define the same items repeatedly throughout the program. Once a new girder shape is defined or copied from the library, BrR automatically computes the required section properties and beam constants.

The program does consider uniform dead loads other than those caused by the stringers, deck, and overlay. In the case where other dead loads are present that would substantially affect the rating, they shall be accounted for during the analysis.

In the Live Load Distribution Factor window, when the compute button is used to calculate the DF’s automatically by the program, BrR users shall verify that these numbers are accurate and matches their calculated numbers.

Timber structures should rate using ASD for three stringer conditions (**no split stringer, split stringer, and repaired split stringer**) based on updated section 1 in CDOT BRM, as shown below:

A) For no split stringer (more than 75% of the total number of stringers have NO splits or shear cracks) should use inventory bending stress 1600 psi and 113 psi for inventory parallel shear stress.

B) For split stringers (more than 25% of the total number of the stringers are not repaired or have shear cracks) should use inventory bending stress 1600 psi and inventory parallel shear stress 85.0 psi.

C) For repaired split stringer by lag bolts (more than 25% of the total number of stringers are repaired) should use inventory bending stress 1600 psi and 98 psi for inventory parallel shear stress.

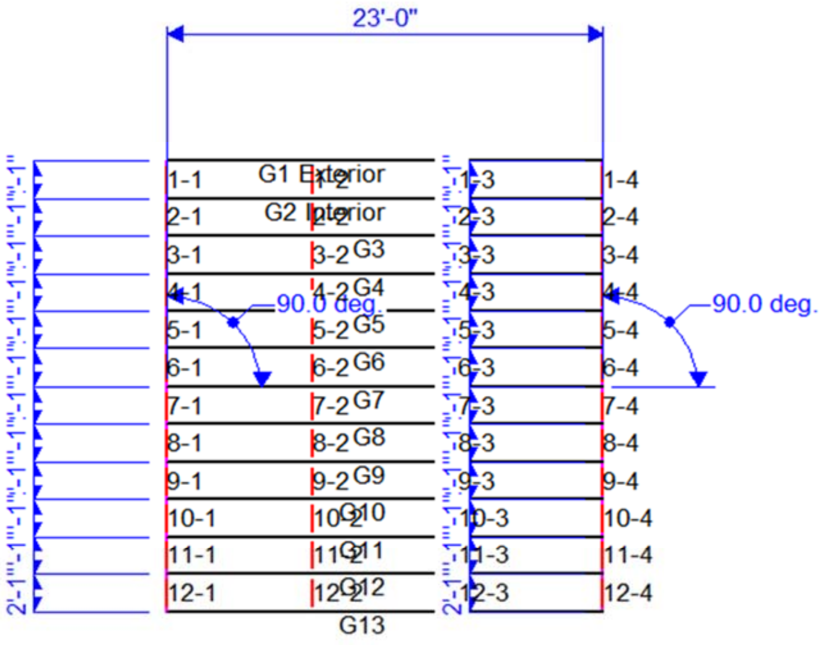
In rating summary sheet rater should report all interior stringer capacity for three above condition, with referring for current stringer condition split/no split or repaired.

One example is presented for structure A-27-A, a two span bridge having treated timber stringers with timber decks. For simplicity, only one span has been modeled using the above conditions of the members as reported in the field inspection report.

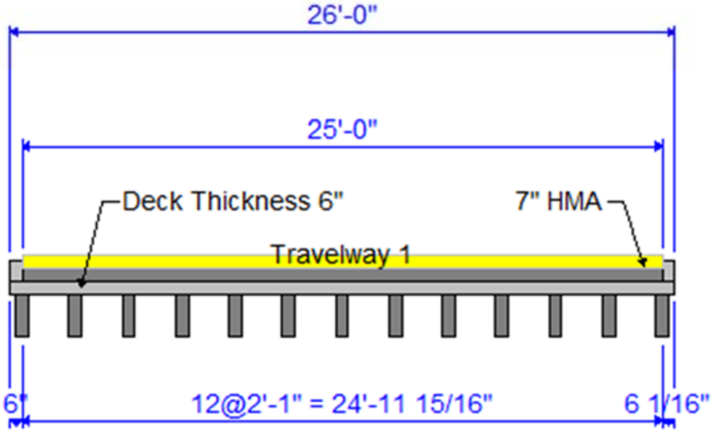
13.5 BRIDGE RATING EXAMPLE

TIMBER STRUCTURE EXAMPLE, STRUCTURE NO. A-27-A

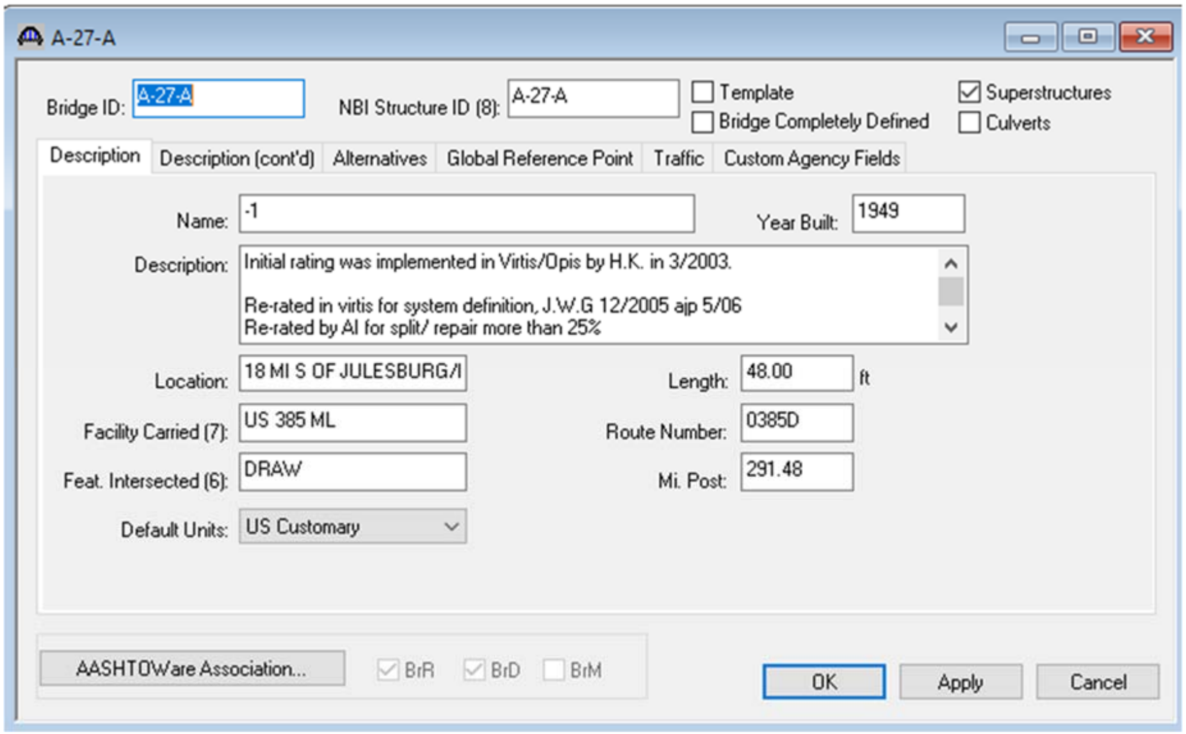
A-27-A
-1 - No split Structure Definition # 1
US 385 ML / DRAW
06/24/19



A-27-A
-1 - No split Structure Definition # 1
US 385 ML / DRAW
06/24/19



From the bridge explorer, create a new bridge and enter the following information.



Bridge ID: A-27-A

NBI Structure ID (8): A-27-A

☐ Template

☐ Bridge Completely Defined

☑ Superstructures

☐ Culverts

Name: -1

Year Built: 1949

Description: Initial rating was implemented in Virtis/Opis by H.K. in 3/2003.

Re-rated in virtis for system definition, J.W.G 12/2005 ajp 5/06
Re-rated by Al for split/ repair more than 25%

Location: 18 MI S OF JULESBURG/I

Length: 48.00 ft

Facility Carried (7): US 385 ML

Route Number: 0385D

Feat. Intersected (6): DRAW

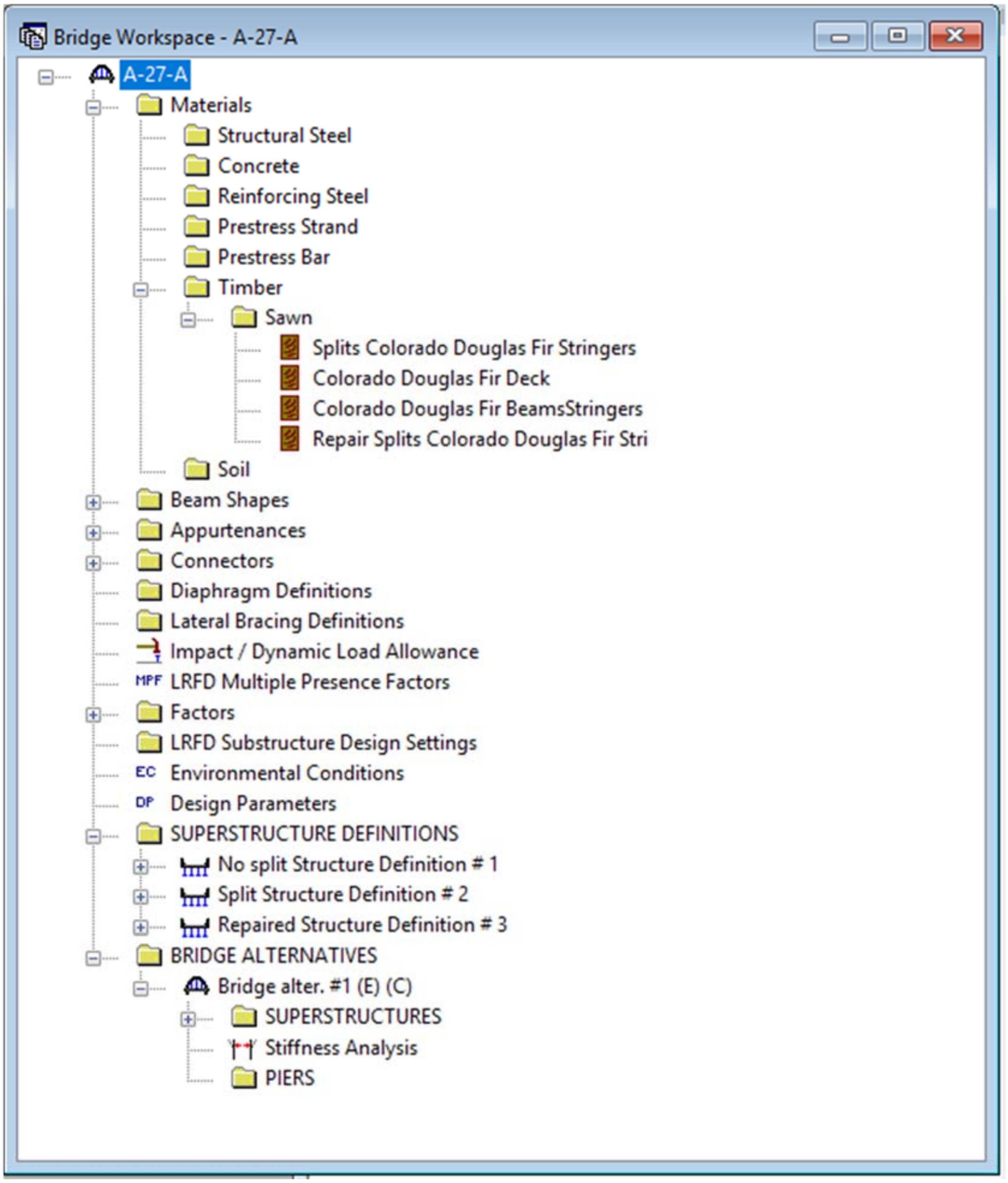
Mi. Post: 291.48

Default Units: US Customary

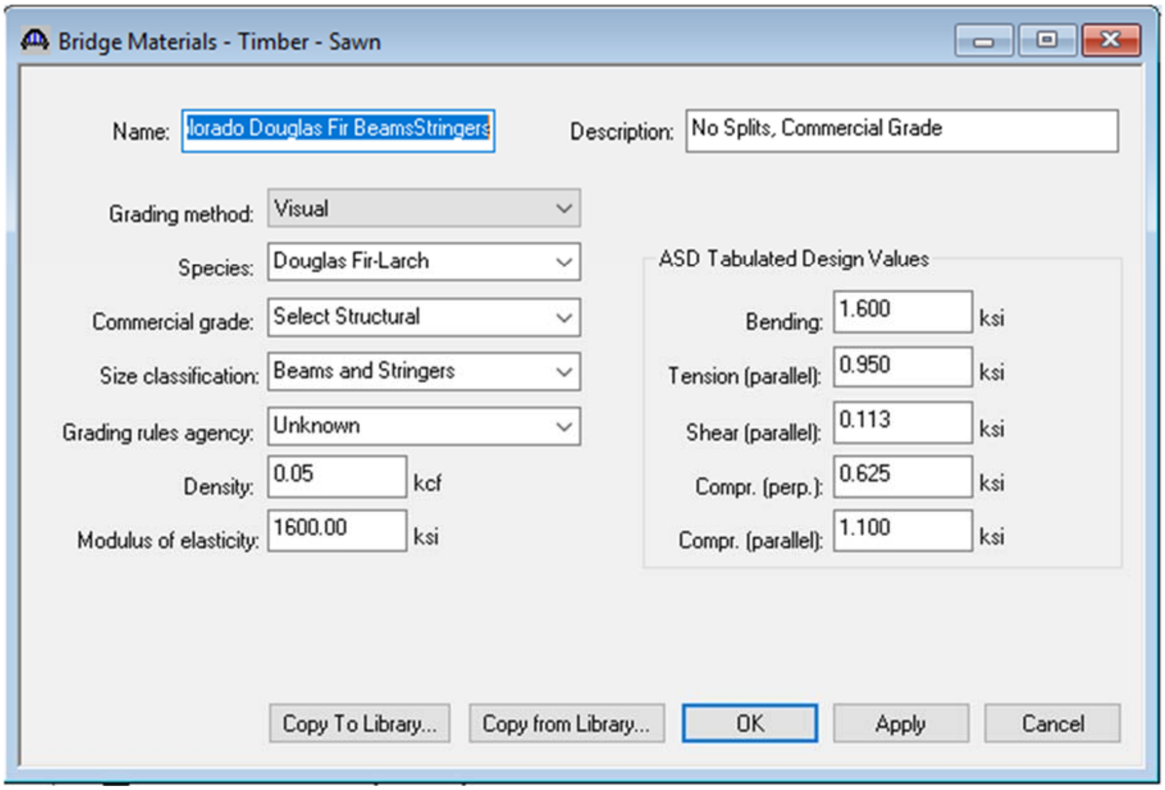
☑ BrR ☑ BrD ☐ BrM

Click OK. This saves the data to memory and closes the window.

To add three a new timber material, click on Materials, Timber, and Sawn in the tree and select File/New from the menu (or right click on Sawn and select New). Click the Copy from Library button and select the Colorado Douglas Fir Beams Stringers from the library. Click OK and the following window will open. The ASD Tabulated Design Values in this window are based on dry conditions and do not include any adjustment factors based on usage conditions. Make necessary corrections to the allowable bending and shear stress values for No Split, Split and Repaired conditions. Click OK to save these timber materials to memory and close the window.



For No split stringer condition materials properties



Name: lorado Douglas Fir BeamsStringers

Description: No Splits, Commercial Grade

Grading method: Visual

Species: Douglas Fir-Larch

Commercial grade: Select Structural

Size classification: Beams and Stringers

Grading rules agency: Unknown

Density: 0.05 kcf

Modulus of elasticity: 1600.00 ksi

ASD Tabulated Design Values

Bending: 1.600 ksi

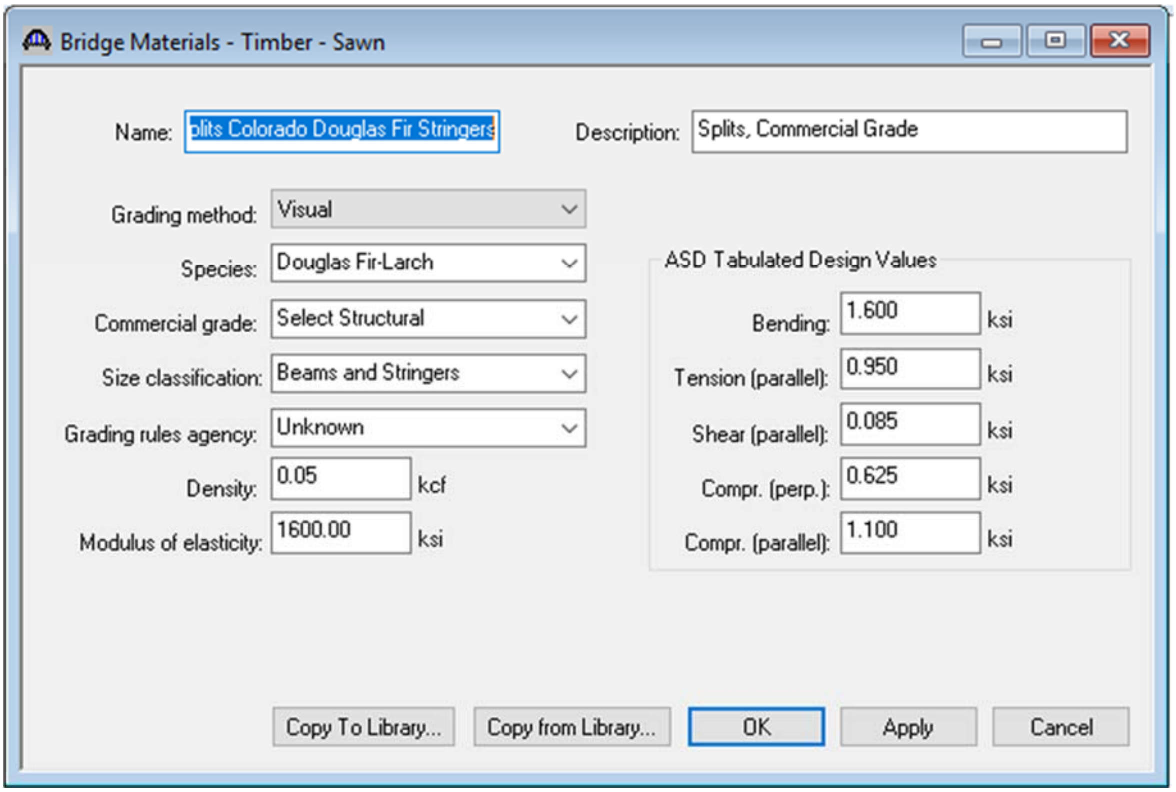
Tension (parallel): 0.950 ksi

Shear (parallel): 0.113 ksi

Compr. (perp.): 0.625 ksi

Compr. (parallel): 1.100 ksi

For split stringer condition materials properties



Name: plits Colorado Douglas Fir Stringers

Description: Splits, Commercial Grade

Grading method: Visual

Species: Douglas Fir-Larch

Commercial grade: Select Structural

Size classification: Beams and Stringers

Grading rules agency: Unknown

Density: 0.05 kcf

Modulus of elasticity: 1600.00 ksi

ASD Tabulated Design Values

Bending: 1.600 ksi

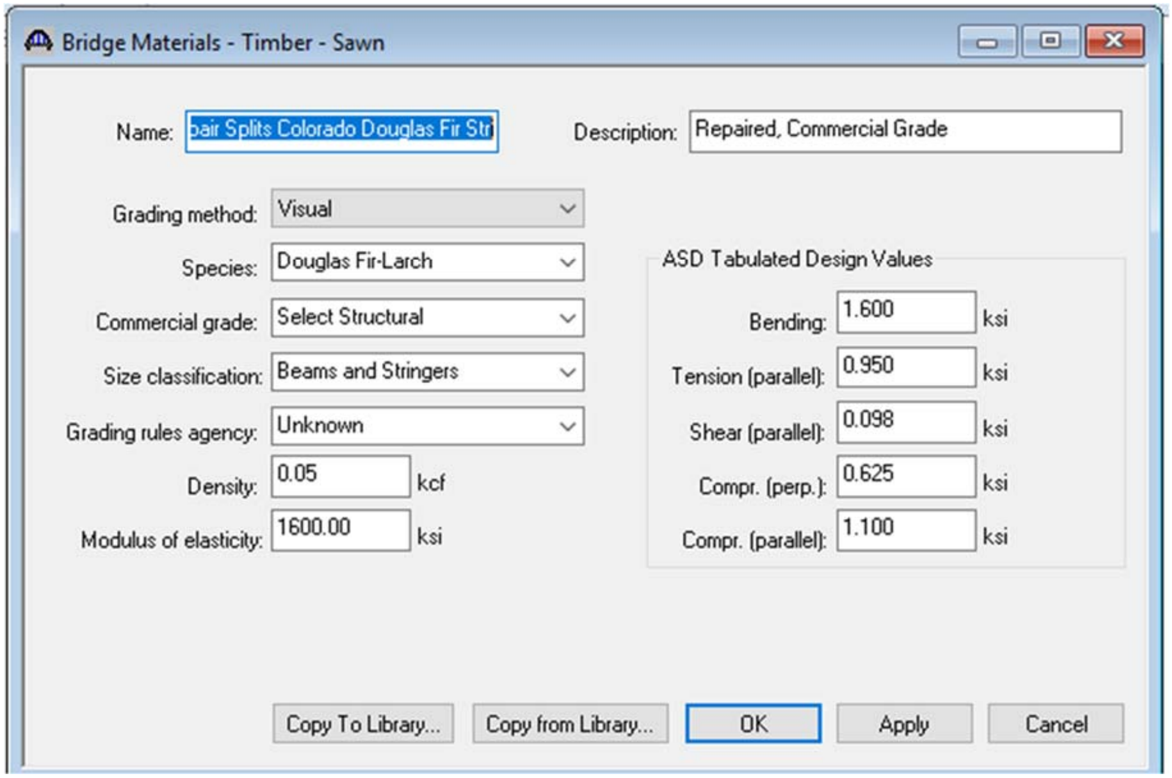
Tension (parallel): 0.950 ksi

Shear (parallel): 0.085 ksi

Compr. (perp.): 0.625 ksi

Compr. (parallel): 1.100 ksi

For repaired split stringer condition materials properties


Bridge Materials - Timber - Sawn

Name: pair Splits Colorado Douglas Fir Stri

Description: Repaired, Commercial Grade

Grading method: Visual

Species: Douglas Fir-Larch

Commercial grade: Select Structural

Size classification: Beams and Stringers

Grading rules agency: Unknown

Density: 0.05 kcf

Modulus of elasticity: 1600.00 ksi

ASD Tabulated Design Values

Bending: 1.600 ksi

Tension (parallel): 0.950 ksi

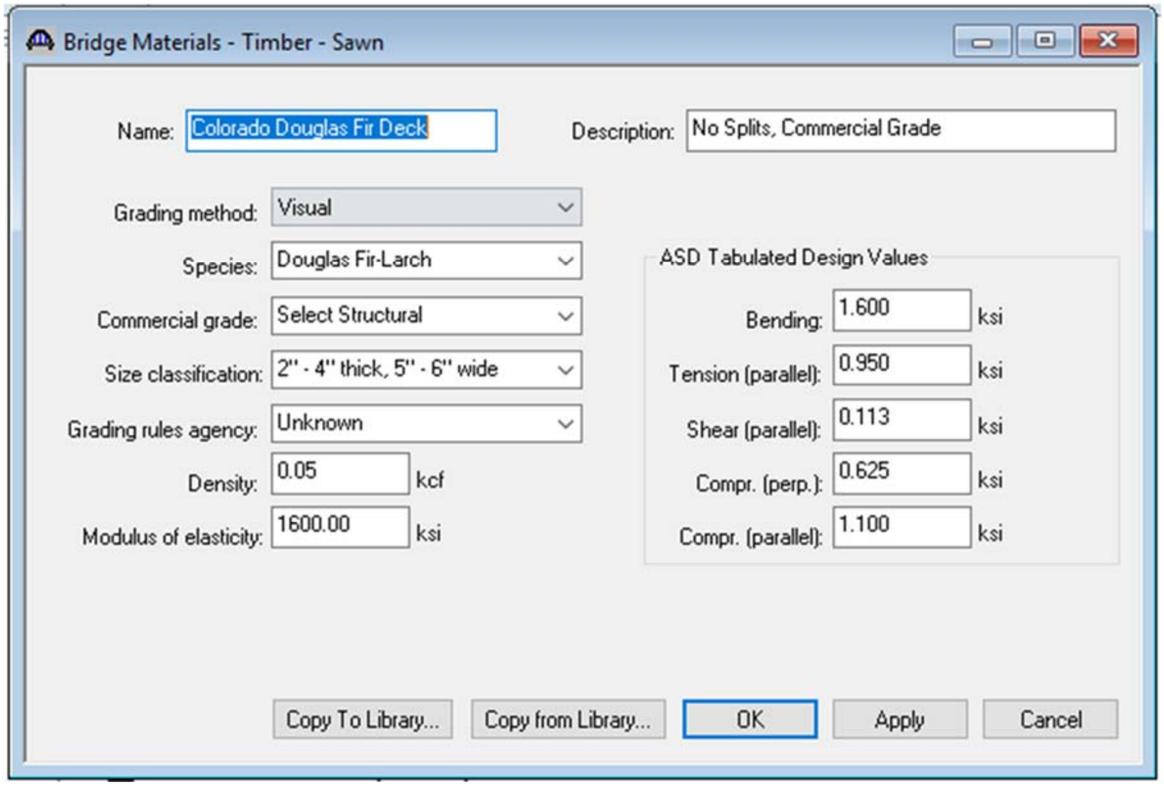
Shear (parallel): 0.098 ksi

Compr. (perp.): 0.625 ksi

Compr. (parallel): 1.100 ksi

Inventory shear stress for repaired split stringer = *130 / 1.33 = 98 psi
(* see Section 1, Table 1-3)

Follow the same procedure to copy from the Materials library. Change the name of material and size classification. Click OK to save this timber deck material to memory and close the window.



Bridge Materials - Timber - Sawn

Name: Colorado Douglas Fir Deck

Description: No Splits, Commercial Grade

Grading method: Visual

Species: Douglas Fir-Larch

Commercial grade: Select Structural

Size classification: 2" - 4" thick, 5" - 6" wide

Grading rules agency: Unknown

Density: 0.05 kcf

Modulus of elasticity: 1600.00 ksi

ASD Tabulated Design Values

Bending: 1.600 ksi

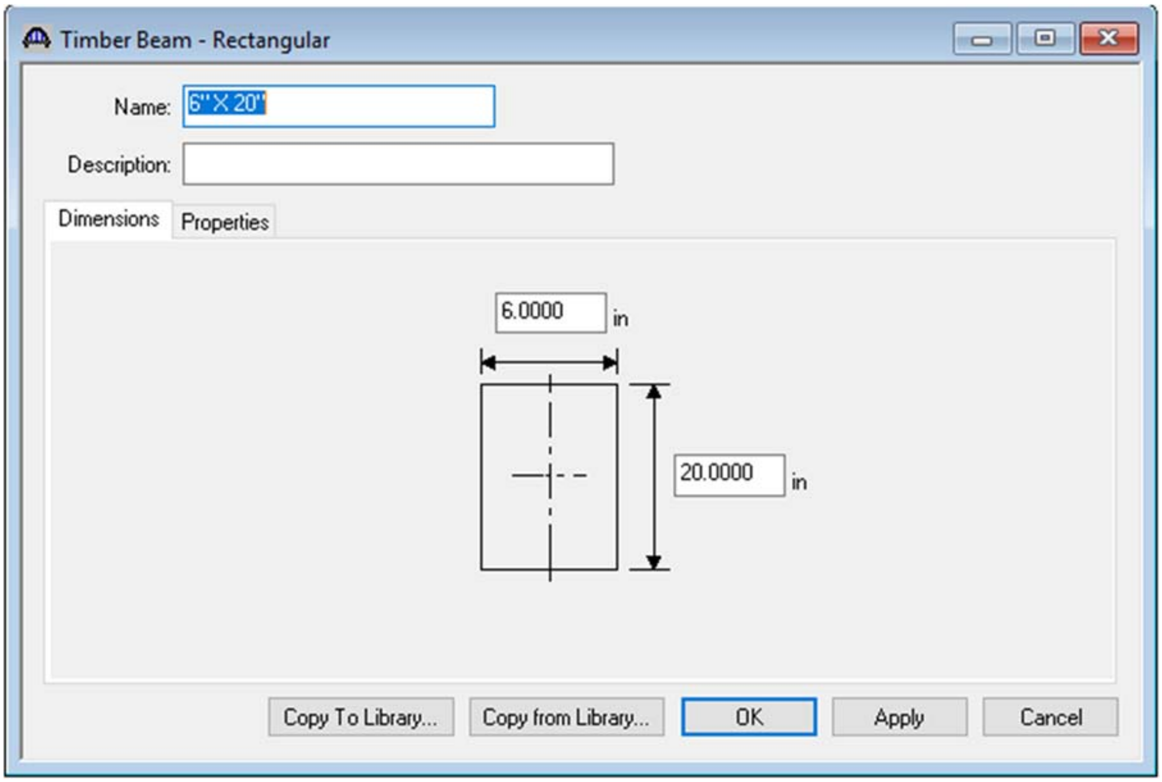
Tension (parallel): 0.950 ksi

Shear (parallel): 0.113 ksi

Compr. (perp.): 0.625 ksi

Compr. (parallel): 1.100 ksi

Add a new timber beam shape by clicking on Beam Shapes, Timber, and Rectangular in the tree and selecting File/New from the menu (or double clicking on Rectangular). Enter the final beam dimensions to be used to calculate section properties on the dimensions tab. Dressed dimensions shall not be used. Click OK to save the data to memory and close the window.



Timber Beam - Rectangular

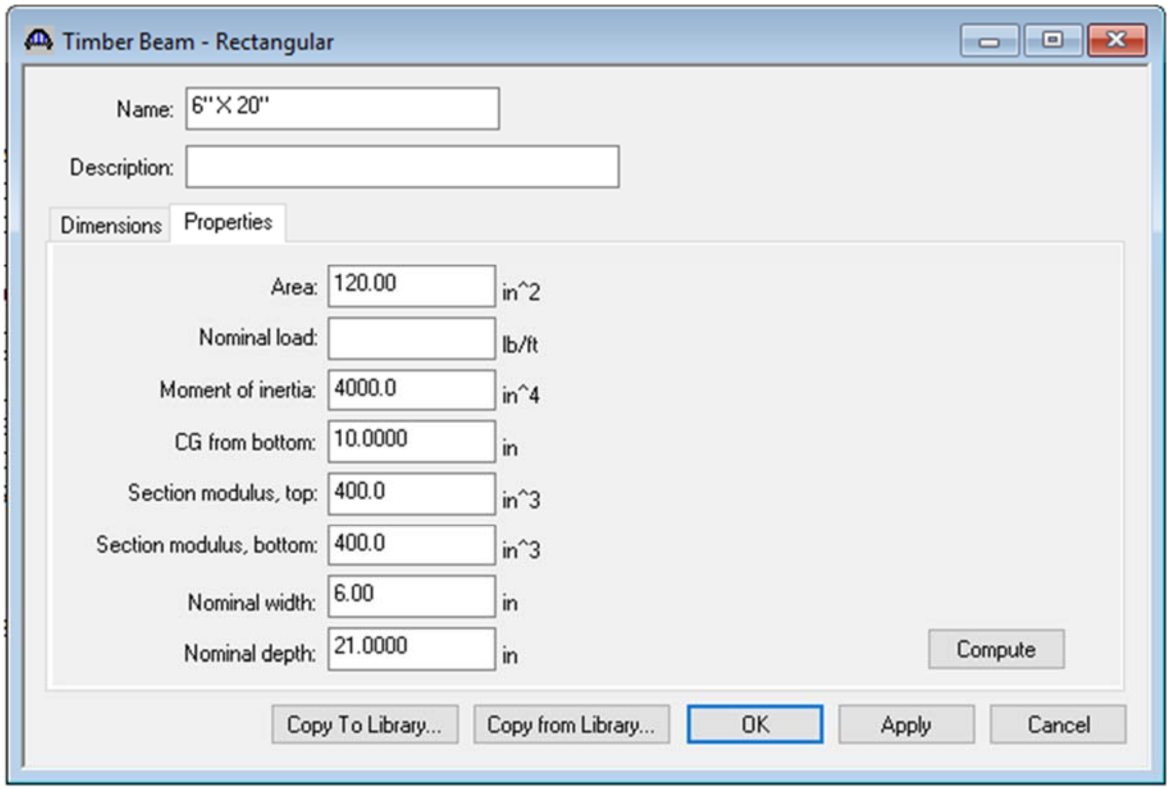
Name: 6" X 20"

Description:

6.0000 in

20.0000 in

Click the Properties tab, and then Compute. Click OK to save the data to memory and close the window.



Timber Beam - Rectangular

Name: 6" X 20"

Description:

Area: 120.00 in^2

Nominal load: lb/ft

Moment of inertia: 4000.0 in^4

CG from bottom: 10.0000 in

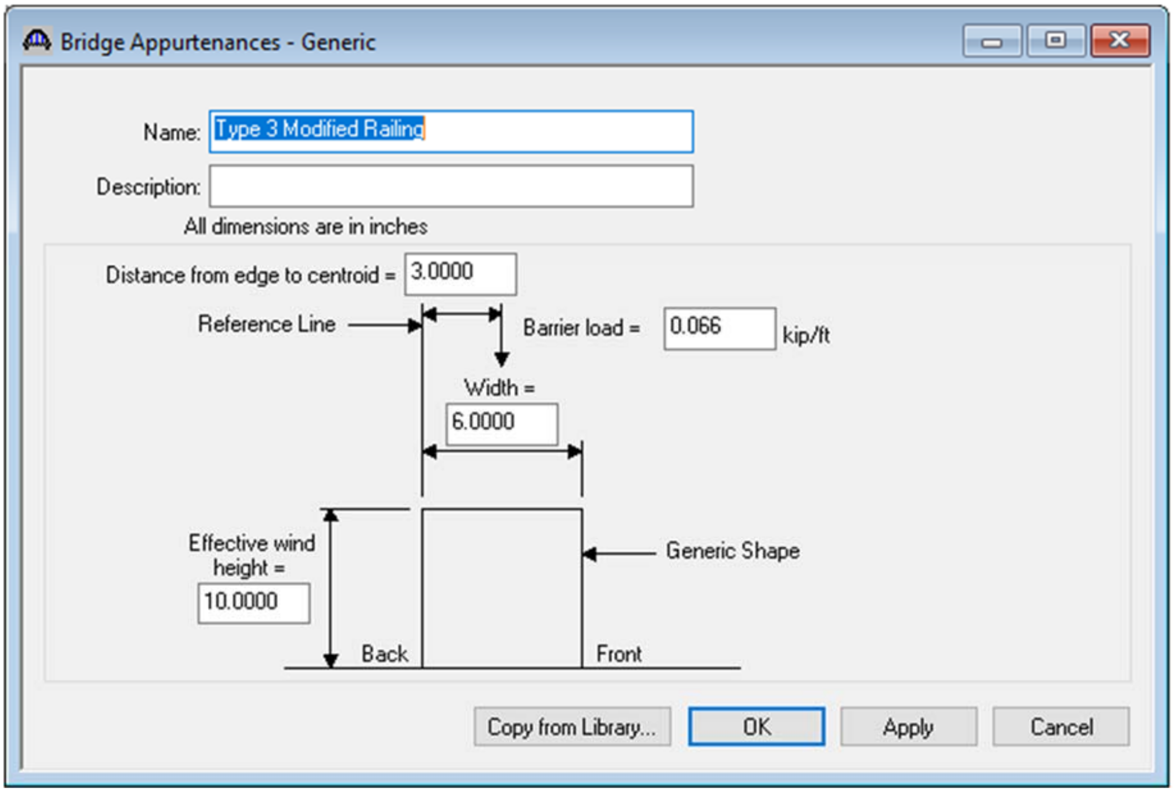
Section modulus, top: 400.0 in^3

Section modulus, bottom: 400.0 in^3

Nominal width: 6.00 in

Nominal depth: 21.0000 in

Expand the tree labeled Appurtenances to enter the bridge appurtenances information to be used in the analysis. To define a generic railing, double click on Generic in the tree and input the generic railing dimensions. Click OK to save date to memory and close the window.



Name: Type 3 Modified Railing

Description:

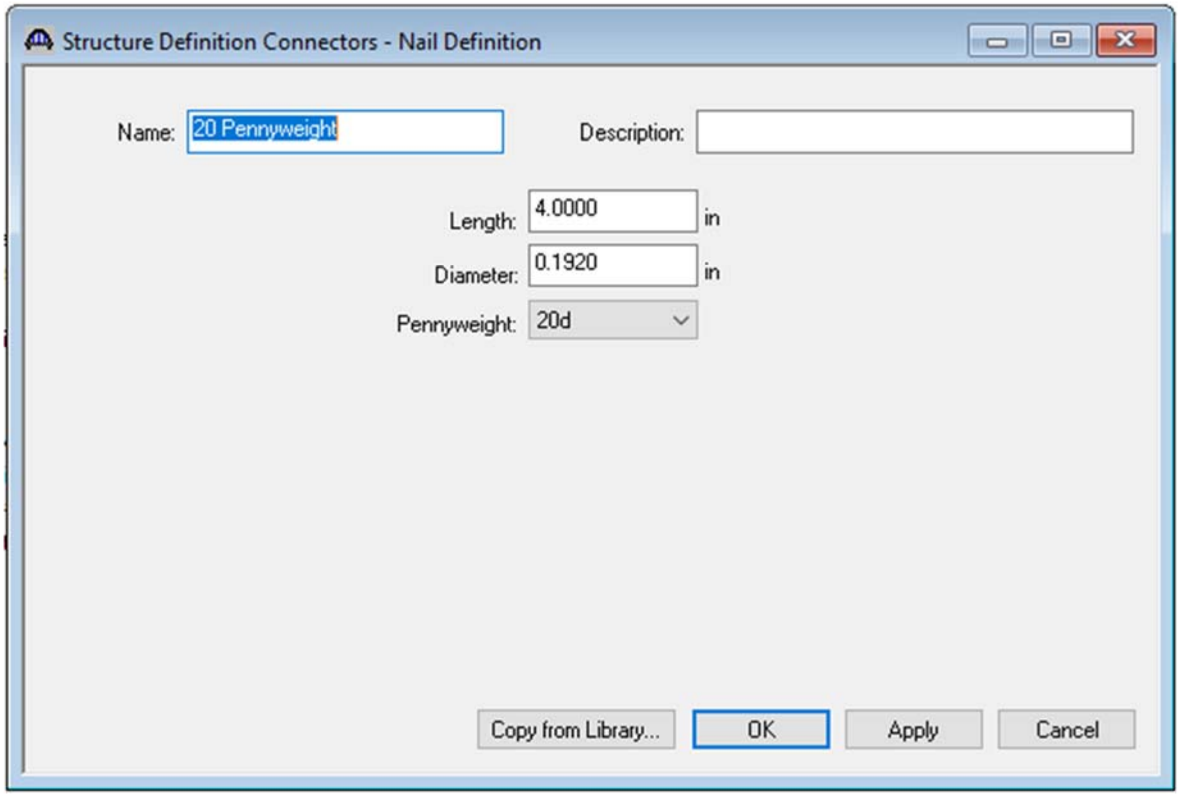
Distance from edge to centroid = 3.0000

Barrier load = 0.066 kip/ft

Width = 6.0000

Effective wind height = 10.0000

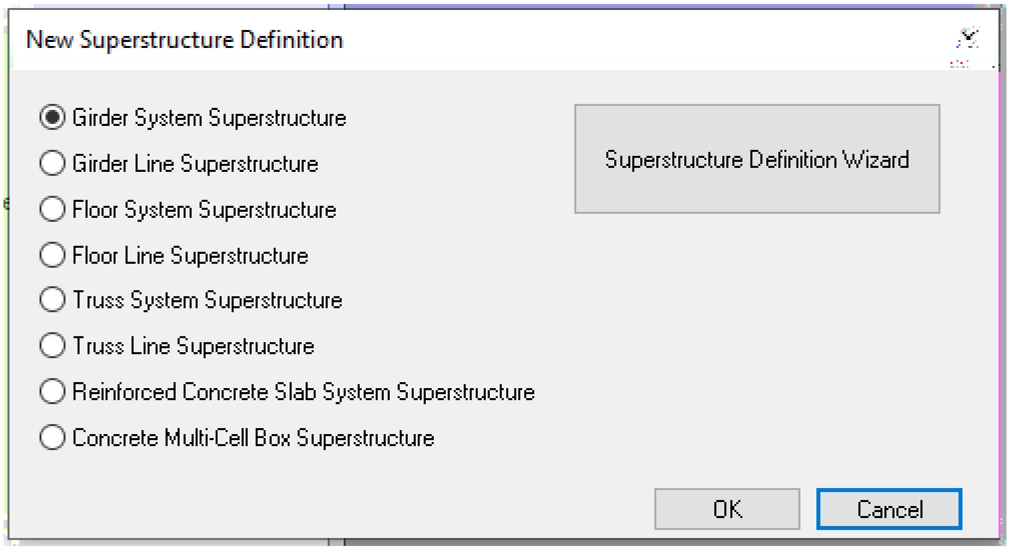
Expand the Connectors tree item to create a nail definition. Double click on Nail. Define the nail and click OK to save to memory.



Name: 20 Pennyweight
Description:
Length: 4.0000 in
Diameter: 0.1920 in
Pennyweight: 20d

Now that we have created a nail definition, this can be applied to nails in the deck. Reopen the Structure Typical Section: Deck (cont'd) tab. Select the 20 Pennyweight nail definition as the nail on that tab. Click OK to save to memory and close the window.

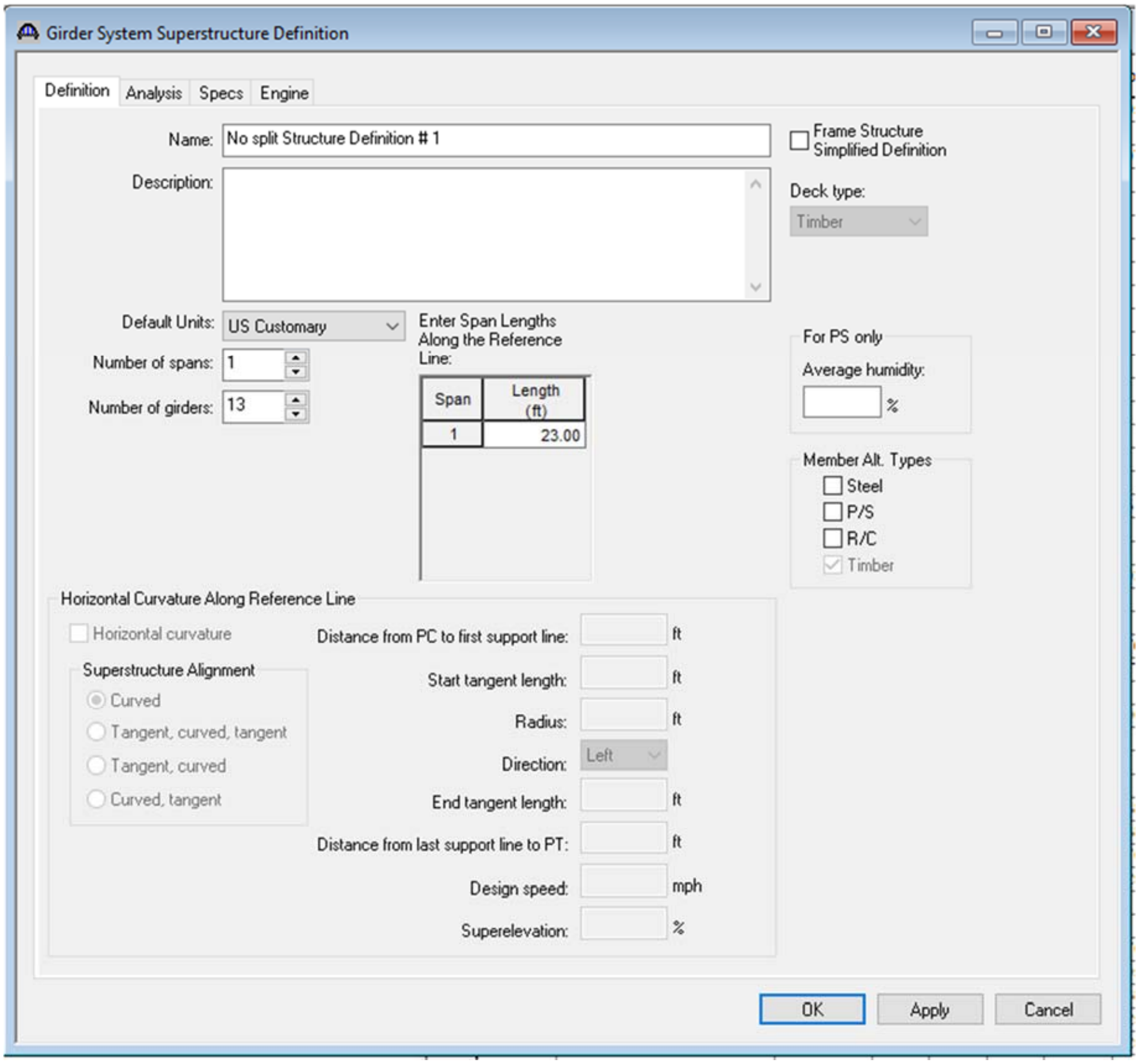
Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



New Superstructure Definition

● Girder System Superstructure
○ Girder Line Superstructure
○ Floor System Superstructure
○ Floor Line Superstructure
○ Truss System Superstructure
○ Truss Line Superstructure
○ Reinforced Concrete Slab System Superstructure
○ Concrete Multi-Cell Box Superstructure

Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below.



Girder System Superstructure Definition

Definition | Analysis | Specs | Engine

Name: No split Structure Definition # 1

Description:

☐ Frame Structure Simplified Definition

Deck type: Timber

Default Units: US Customary

Number of spans: 1

Number of girders: 13

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	23.00

For PS only

Average humidity: %

Member Alt. Types

☐ Steel
☐ P/S
☐ R/C
☑ Timber

Horizontal Curvature Along Reference Line

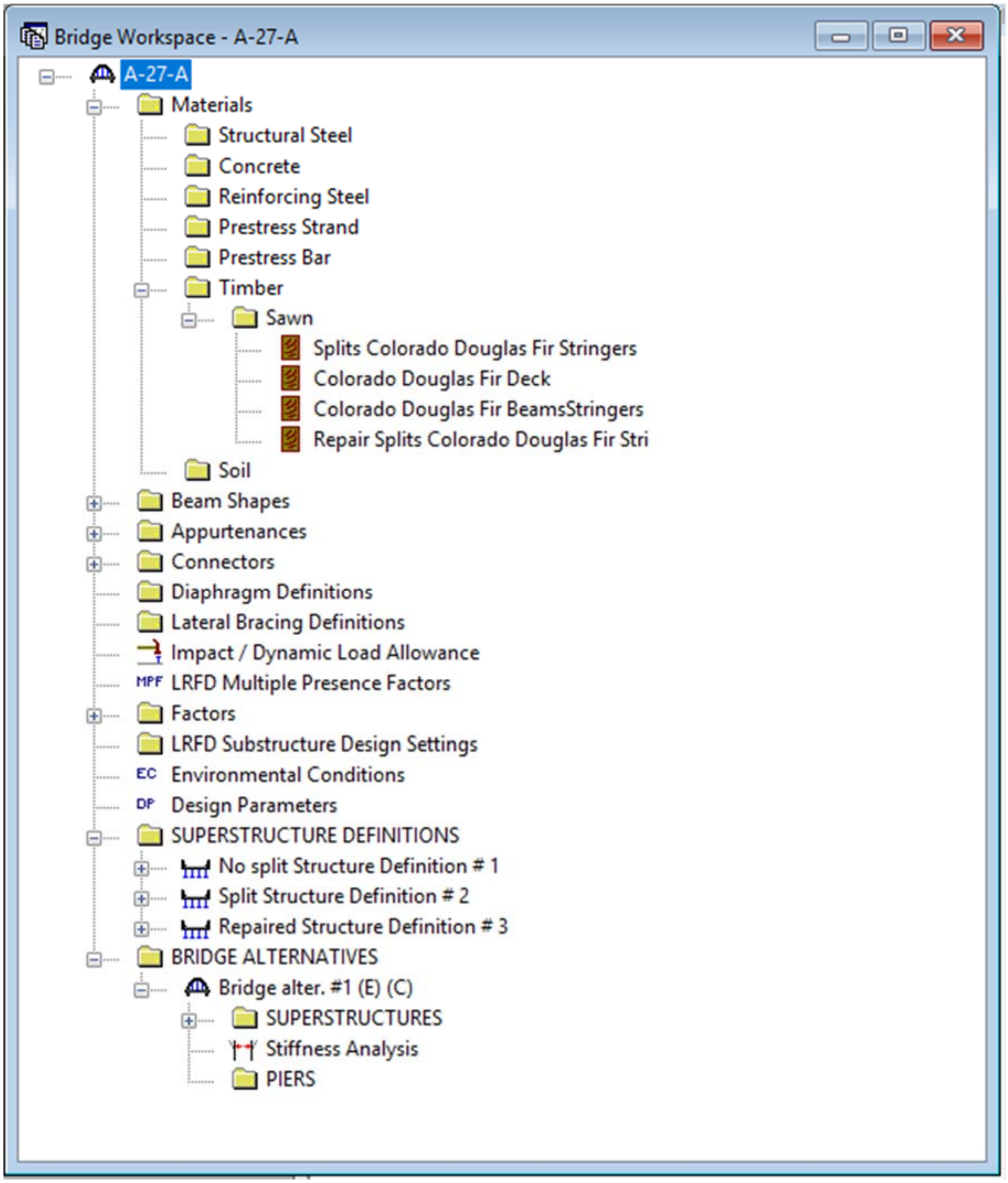
☐ Horizontal curvature

Superstructure Alignment

● Curved
○ Tangent, curved, tangent
○ Tangent, curved
○ Curved, tangent

Distance from PC to first support line: ft
Start tangent length: ft
Radius: ft
Direction: Left
End tangent length: ft
Distance from last support line to PT: ft
Design speed: mph
Superelevation: %

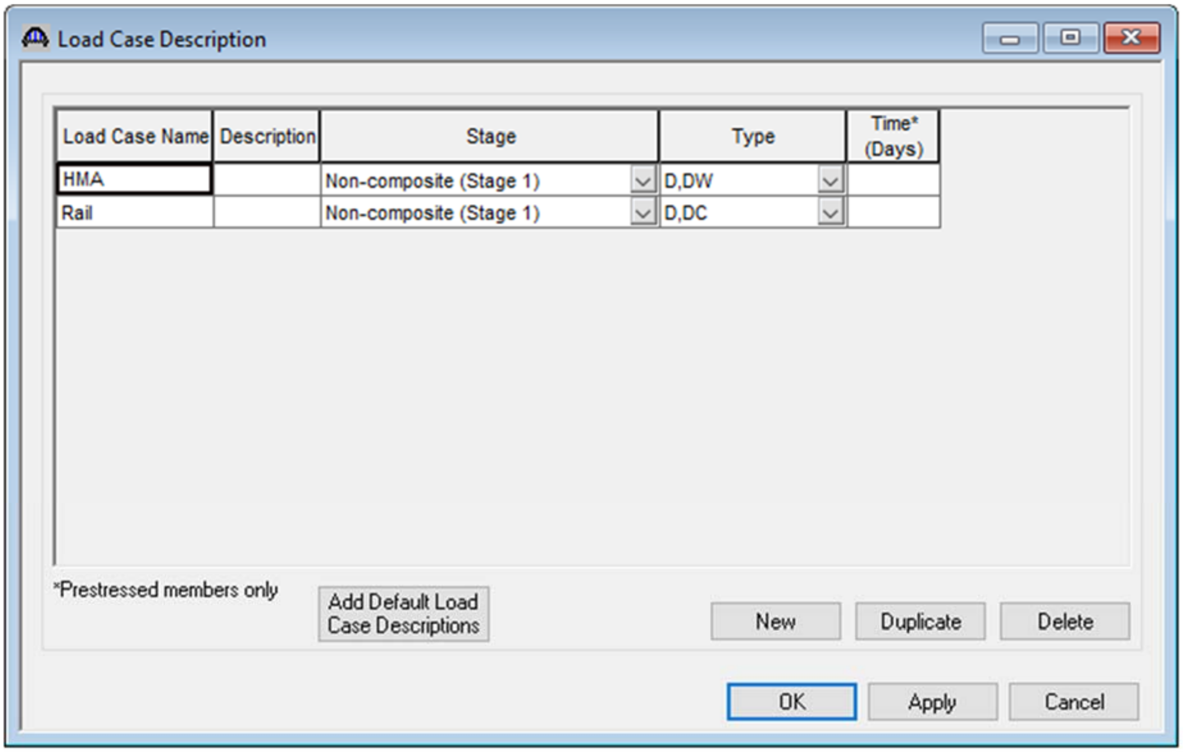
Following is the partially expanded Bridge Workspace tree:



Bridge Workspace - A-27-A

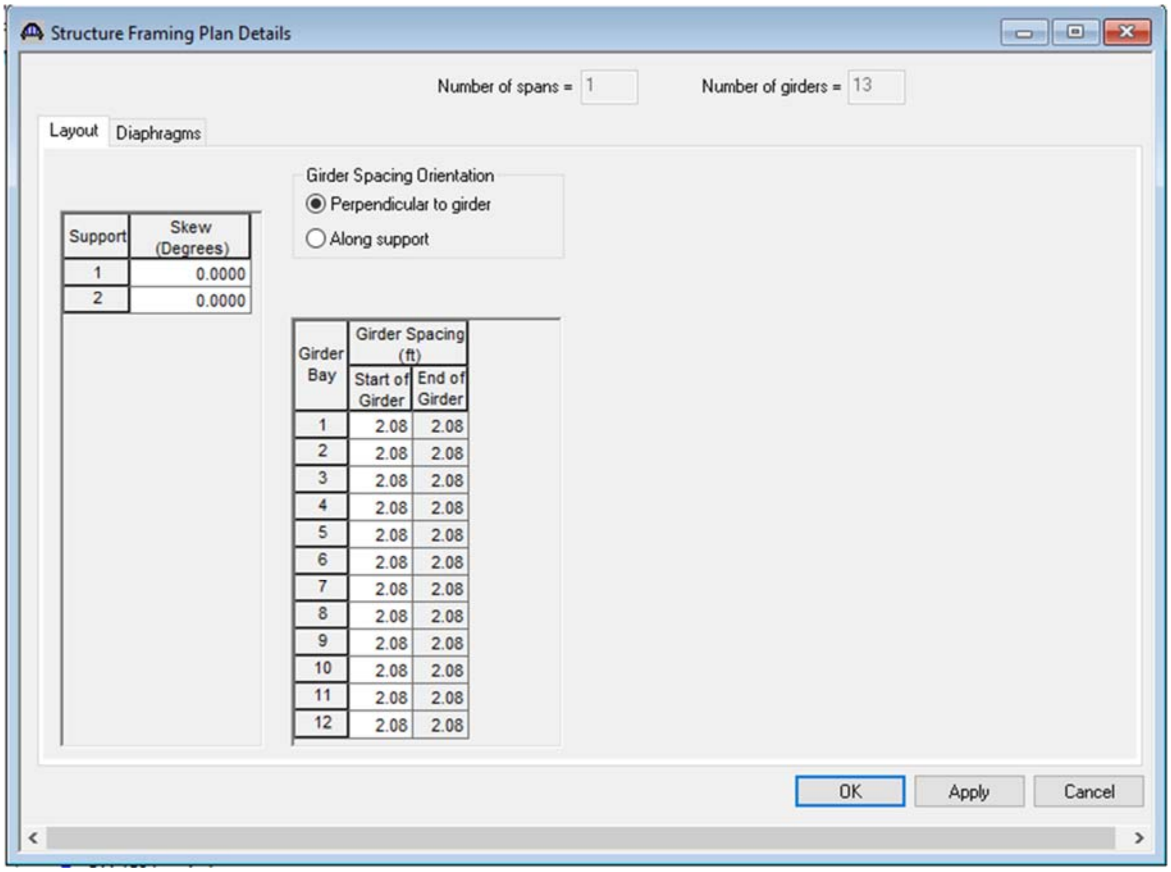
- A-27-A
  - Materials
    - Structural Steel
    - Concrete
    - Reinforcing Steel
    - Prestress Strand
    - Prestress Bar
    - Timber
      - Sawn
        - Splits Colorado Douglas Fir Stringers
        - Colorado Douglas Fir Deck
        - Colorado Douglas Fir BeamsStringers
        - Repair Splits Colorado Douglas Fir Stri
    - Soil
  - Beam Shapes
  - Appurtenances
  - Connectors
  - Diaphragm Definitions
  - Lateral Bracing Definitions
  - Impact / Dynamic Load Allowance
  - MPF LRFD Multiple Presence Factors
  - Factors
  - LRFD Substructure Design Settings
  - EC Environmental Conditions
  - DP Design Parameters
  - SUPERSTRUCTURE DEFINITIONS
    - No split Structure Definition # 1
    - Split Structure Definition # 2
    - Repaired Structure Definition # 3
  - BRIDGE ALTERNATIVES
    - Bridge alter. #1 (E) (C)
      - SUPERSTRUCTURES
      - Stiffness Analysis
      - PIERS

Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to LFD design and the second type applies to LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.



Load Case Name	Description	Stage	Type	Time* (Days)
HMA		Non-composite (Stage 1)	D,DW	
Rail		Non-composite (Stage 1)	D,DC	

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan. If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.



Number of spans = 1

Number of girders = 13

Girder Spacing Orientation

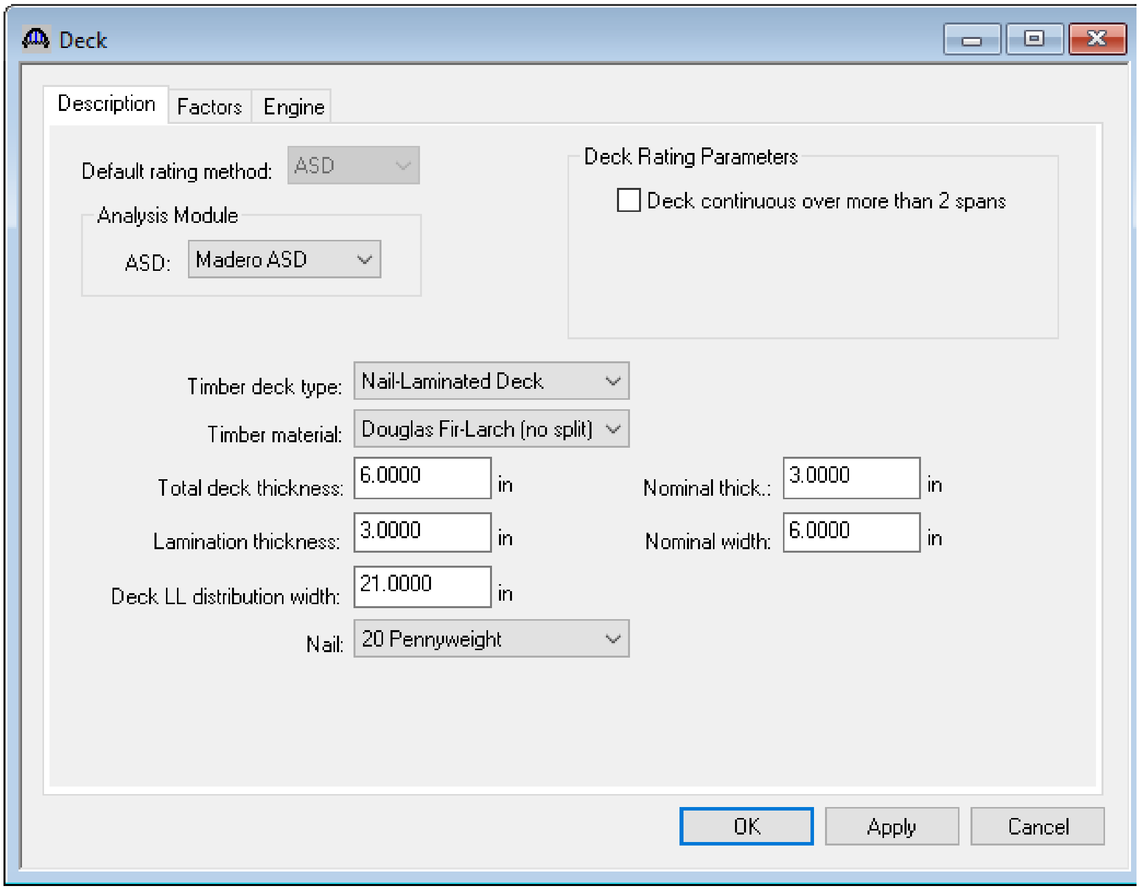
● Perpendicular to girder

○ Along support

Support	Skew (Degrees)
1	0.0000
2	0.0000

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	2.08	2.08
2	2.08	2.08
3	2.08	2.08
4	2.08	2.08
5	2.08	2.08
6	2.08	2.08
7	2.08	2.08
8	2.08	2.08
9	2.08	2.08
10	2.08	2.08
11	2.08	2.08
12	2.08	2.08

The Deck tab is used to enter information about the deck. BrR only supports transverse timber decks. Select the type of deck as Nail-Laminated. The timber material to be used for the deck is selected from the list of bridge materials described above. A Nail definition has not been created yet, so leave the field blank for now. The Deck LL distribution width in the direction normal to the flooring span shall be per AASHTO Standard Specifications, Article 3.25.1.1. For this structure, this value is equal to 21.0 inches (15 inches plus thickness of floor).



Default rating method: ASD

ASD: Madero ASD

☐ Deck continuous over more than 2 spans

Timber deck type: Nail-Laminated Deck

Timber material: Douglas Fir-Larch (no split)

Total deck thickness: 6.0000 in

Nominal thick.: 3.0000 in

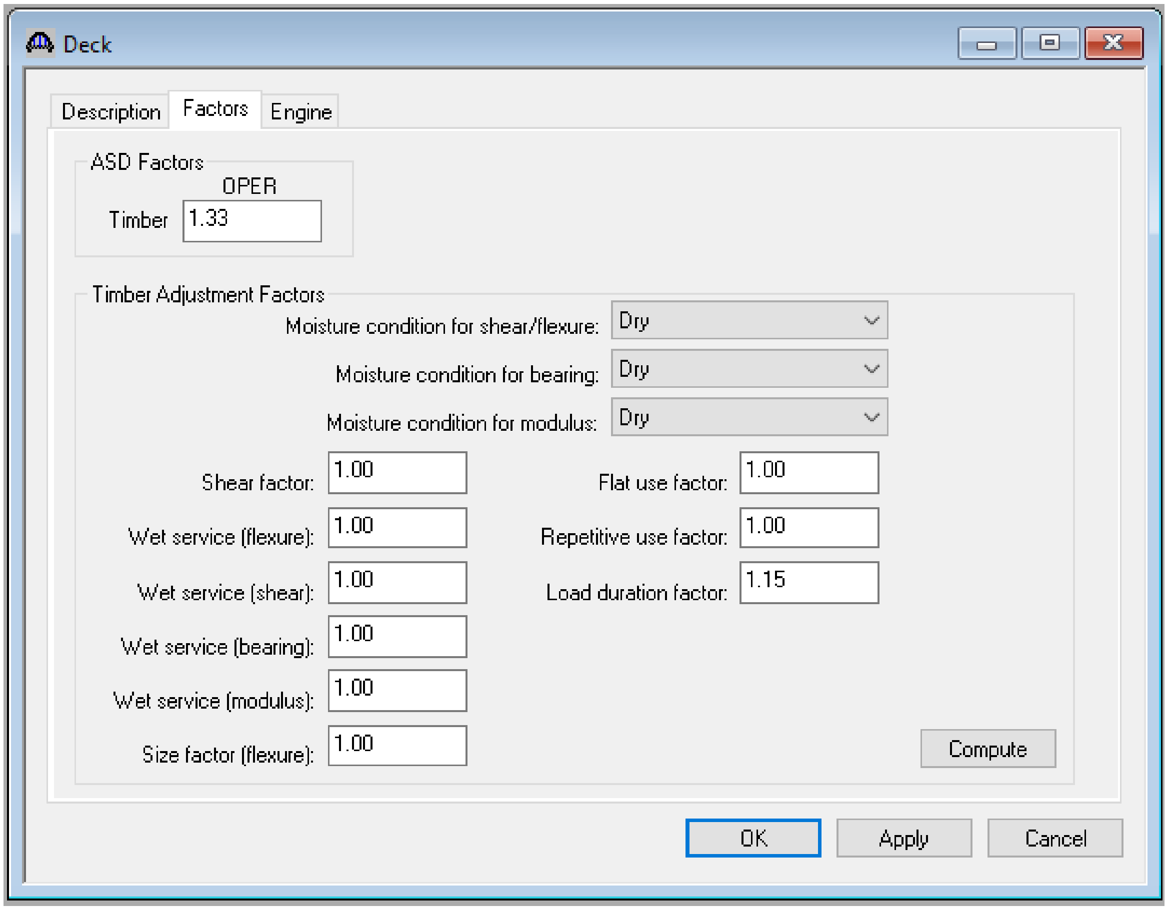
Lamination thickness: 3.0000 in

Nominal width: 6.0000 in

Deck LL distribution width: 21.0000 in

Nail: 20 Pennyweight

For the Factors tab of the Deck window, factors may be defaulted by using the BrR compute button. In Colorado, dry moisture condition is used.



Timber: 1.33

Moisture condition for shear/flexure: Dry

Moisture condition for bearing: Dry

Moisture condition for modulus: Dry

Shear factor: 1.00

Wet service (flexure): 1.00

Wet service (shear): 1.00

Wet service (bearing): 1.00

Wet service (modulus): 1.00

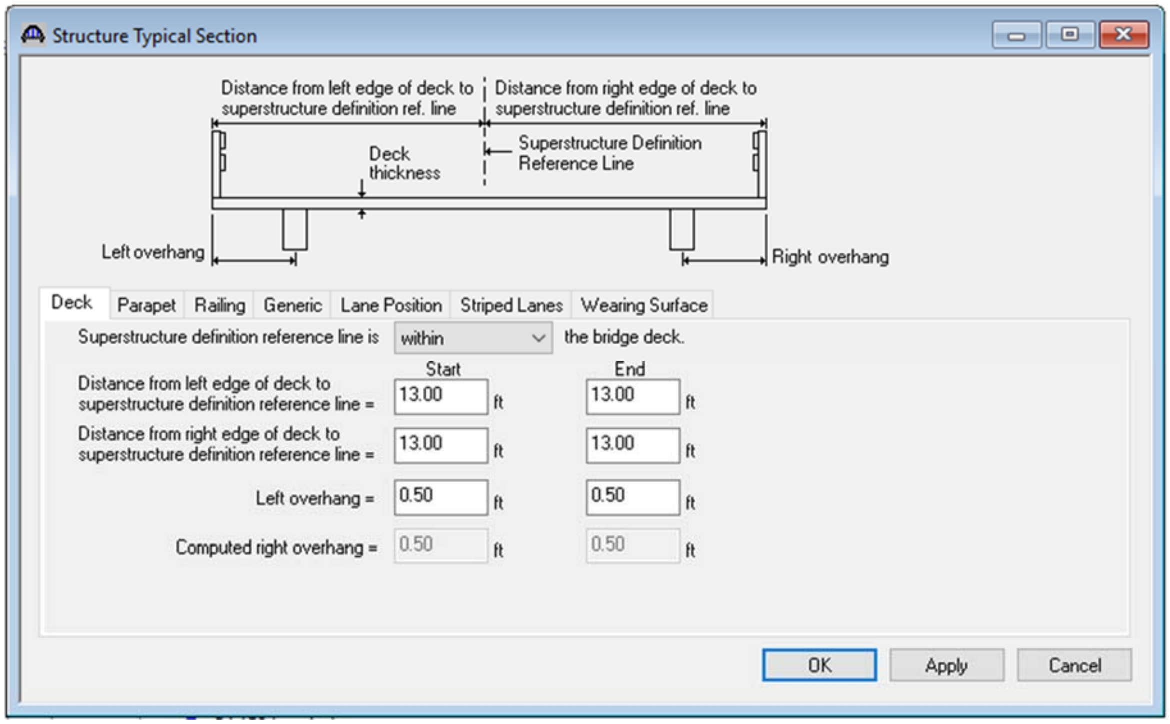
Size factor (flexure): 1.00

Flat use factor: 1.00

Repetitive use factor: 1.00

Load duration factor: 1.15

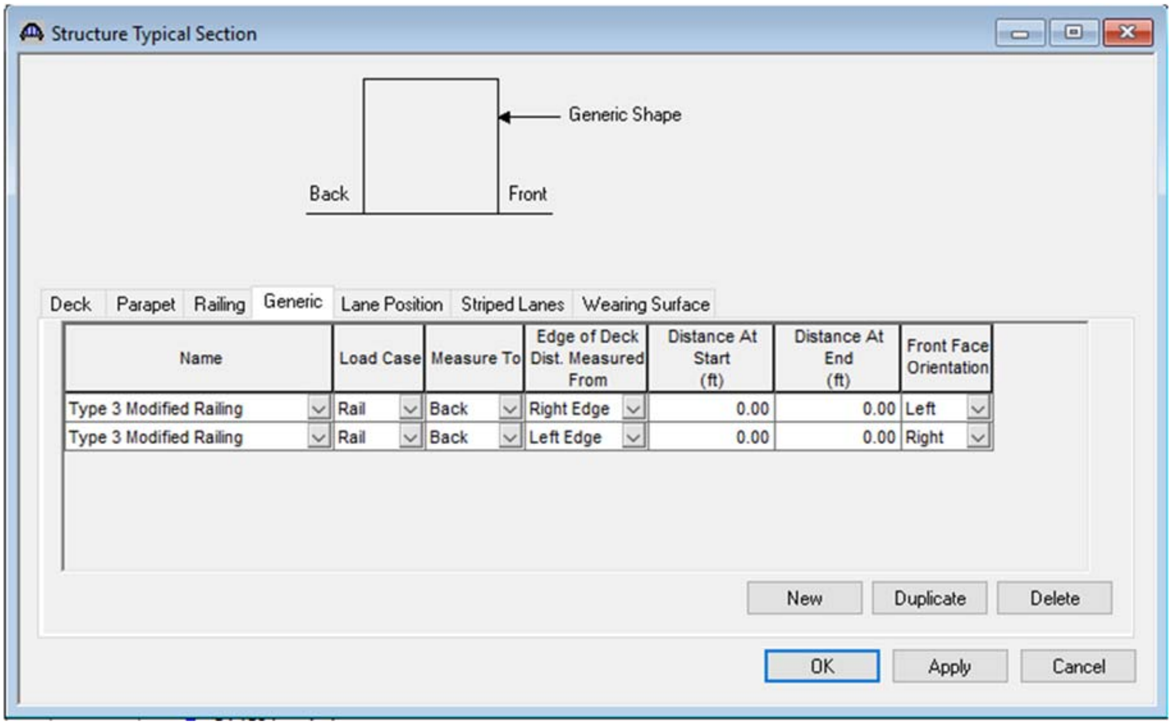
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



Superstructure definition reference line is within the bridge deck.

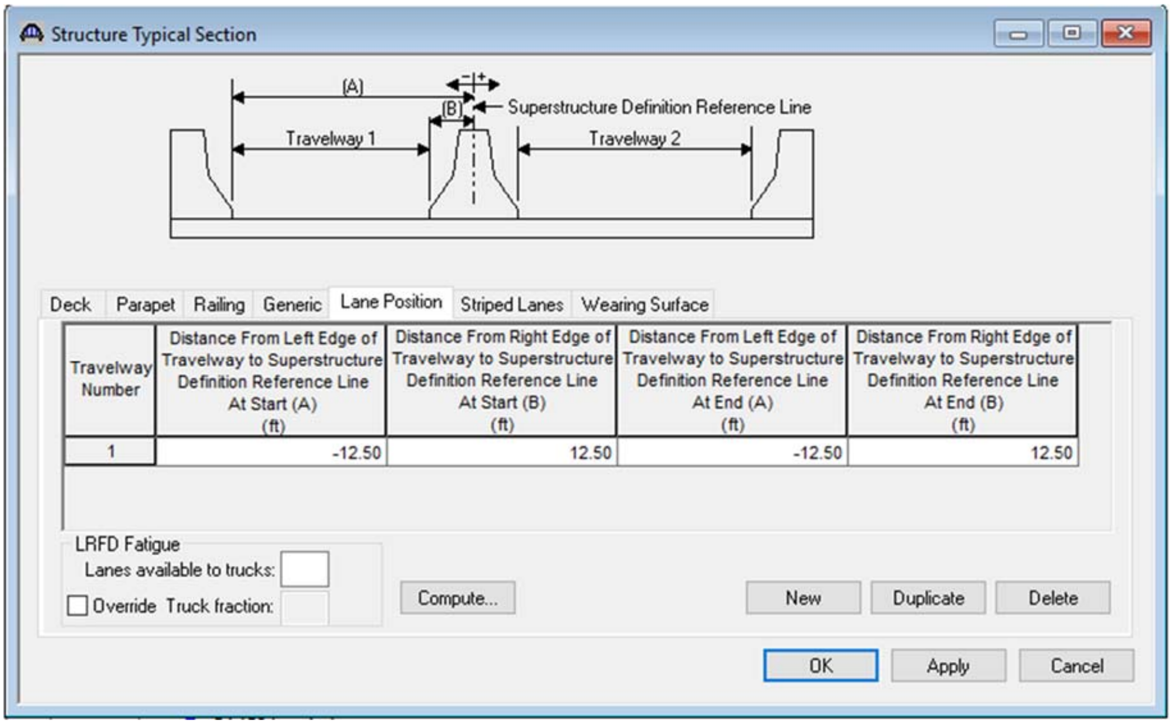
	Start		End	
Distance from left edge of deck to superstructure definition reference line =	13.00	ft	13.00	ft
Distance from right edge of deck to superstructure definition reference line =	13.00	ft	13.00	ft
Left overhang =	0.50	ft	0.50	ft
Computed right overhang =	0.50	ft	0.50	ft

The Generic tab is used to enter information about the appurtenances. Click New to add a row to the table. Enter the following data.



Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Type 3 Modified Railing	Rail	Back	Right Edge	0.00	0.00	Left
Type 3 Modified Railing	Rail	Back	Left Edge	0.00	0.00	Right

Select the Lane Position tab. Enter the values shown below or click the Compute...button to automatically compute the lane positions. A dialog box showing the results of the computation opens. Click the apply button to apply the computed values.



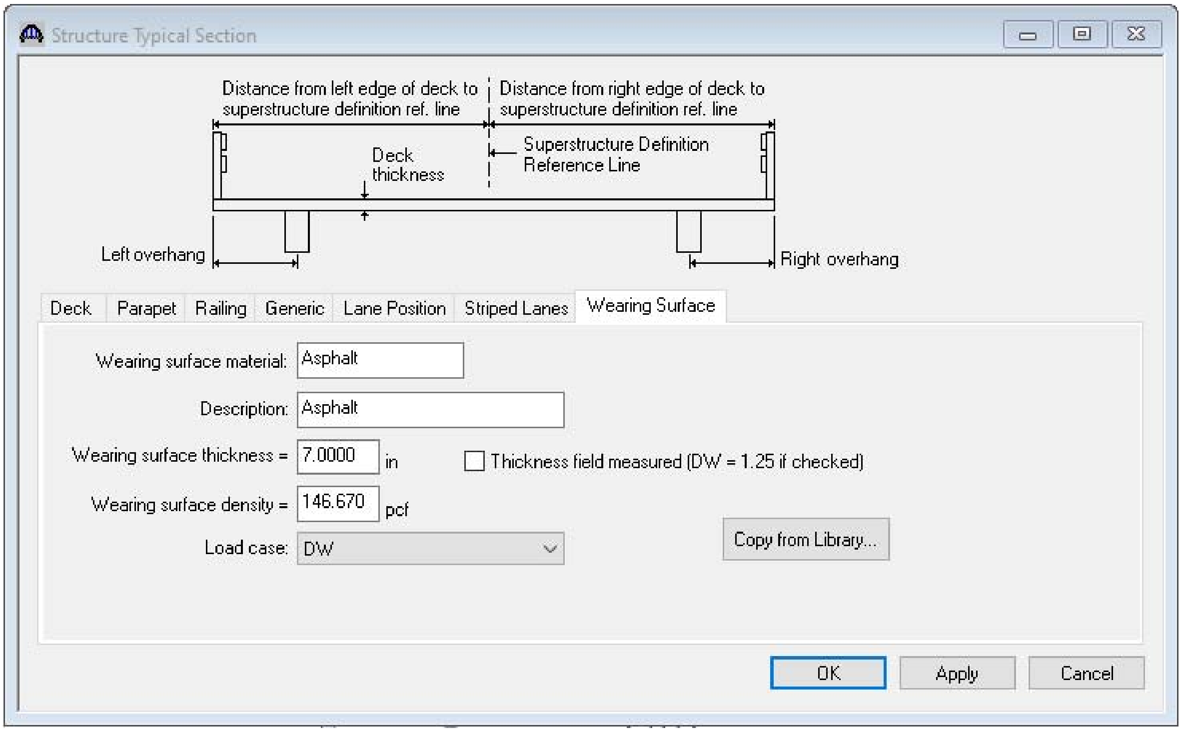
Travelway Number	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At End (B) (ft)
1	-12.50	12.50	-12.50	12.50

LRFD Fatigue

Lanes available to trucks:

☐ Override Truck fraction:

Enter the following wearing surface information and click OK to save to memory and close the window.



Wearing surface material: Asphalt

Description: Asphalt

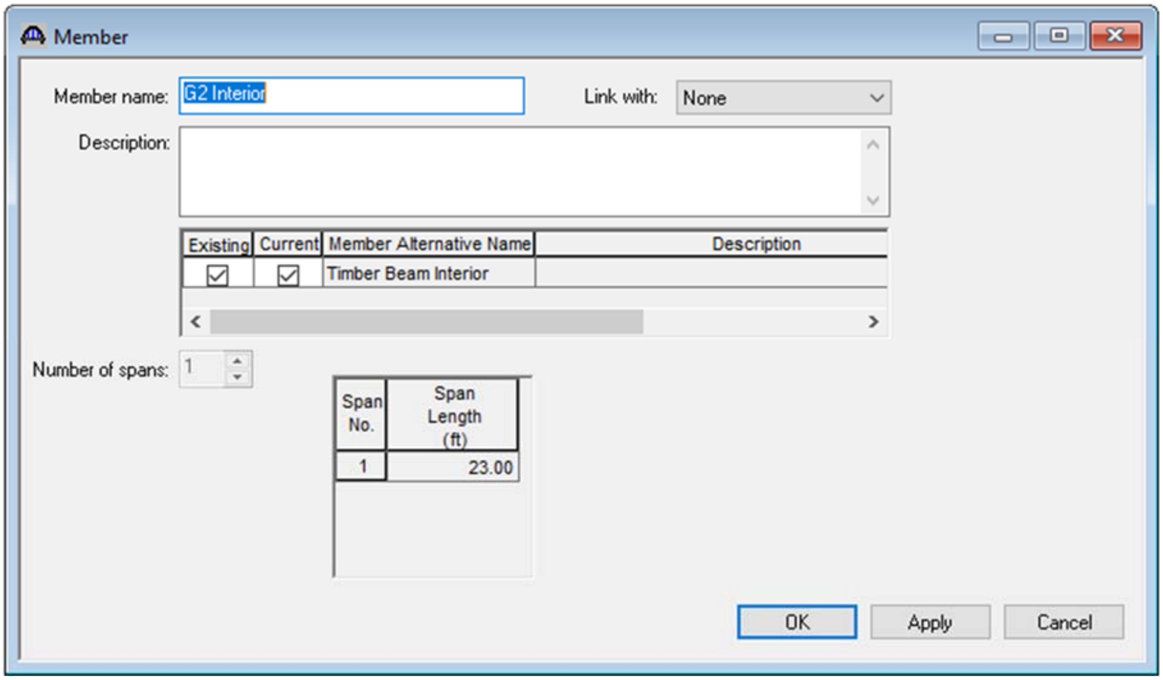
Wearing surface thickness = 7.0000 in

☐ Thickness field measured (DW = 1.25 if checked)

Wearing surface density = 146.670 pcf

Load case: DW

Describing a member:
The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.



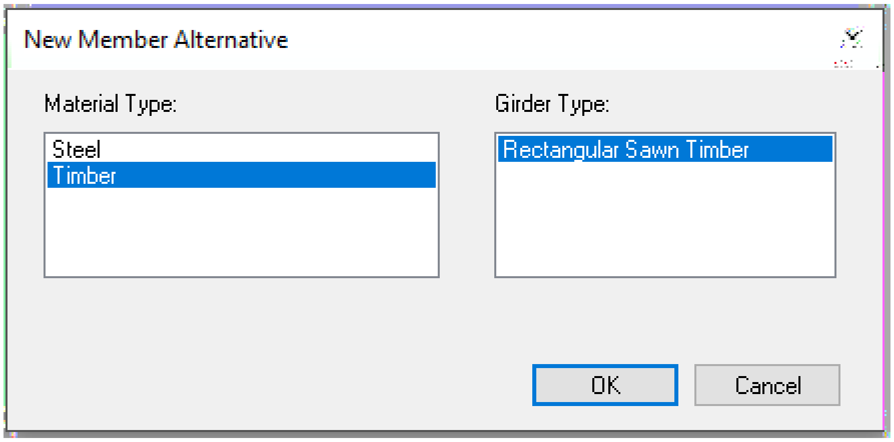
Member name: G2 Interior
Link with: None
Description:

Existing	Current	Member Alternative Name	Description
☑	☑	Timber Beam Interior	

Number of spans: 1

Span No.	Span Length (ft)
1	23.00

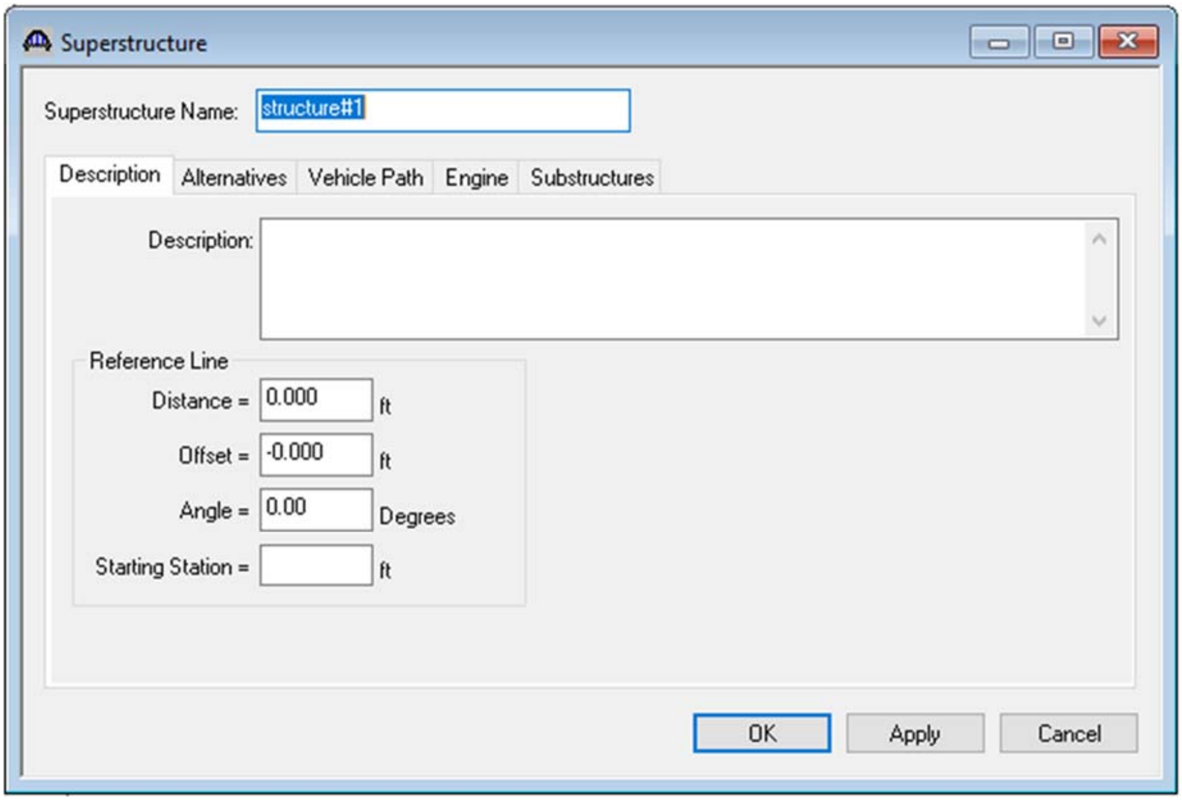
Defining a Member Alternative: Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog will open. Select Timber for the Material Type and Rectangular Sawn Timber for the Girder Type. Only Timber is available for the Material Type since a timber deck type was selected on the Structure Definition window. Timber decks are limited to timber beams in BrR.



Material Type:
Steel
Timber

Girder Type:
Rectangular Sawn Timber

Enter the following data for the Member Alternative. Click OK to save to memory and close the window.



Superstructure Name: structure#1

Description:

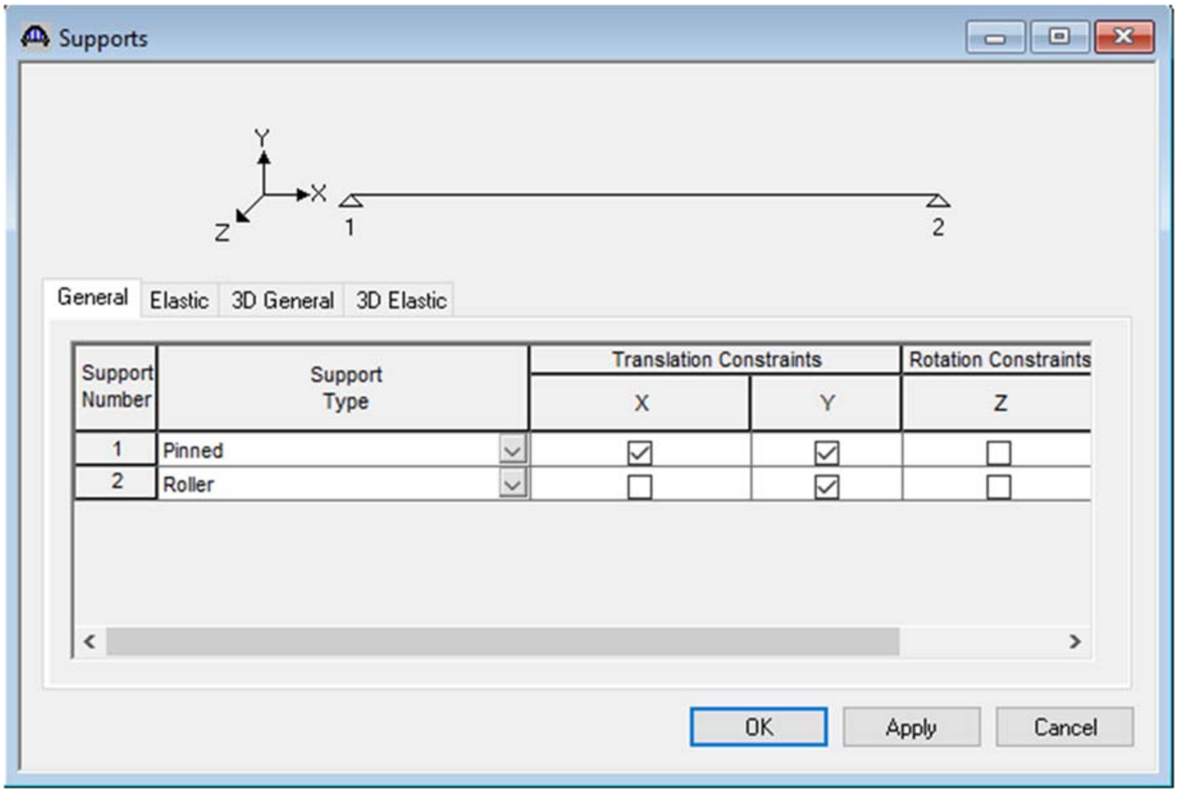
Distance = 0.000 ft

Offset = -0.000 ft

Angle = 0.00 Degrees

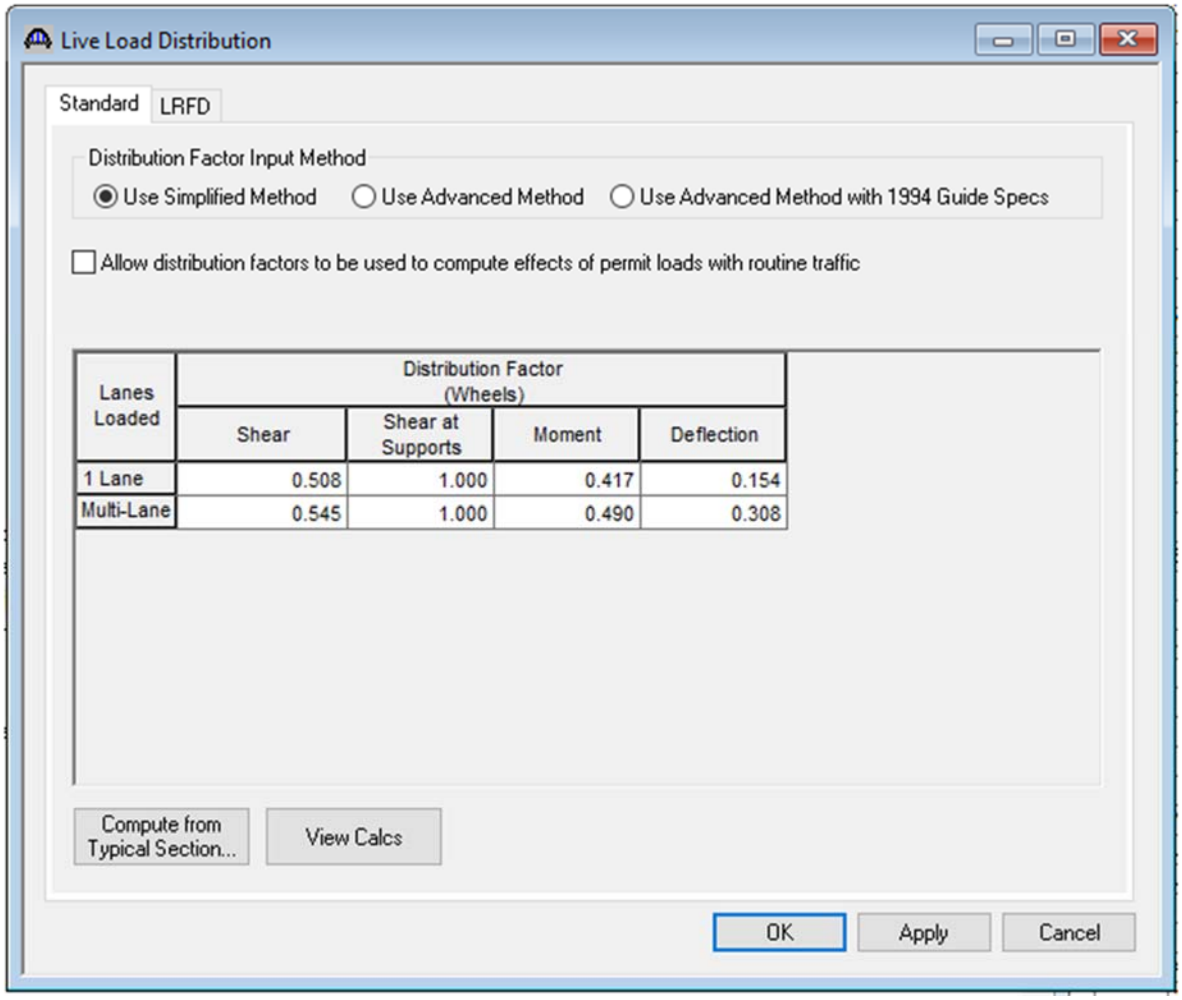
Starting Station = ft

Support constraints were generated when the structure definition was created and are shown below.



Support Number	Support Type	Translation Constraints		Rotation Constraints
		X	Y	Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐

Use the Compute from Typical Section button to compute the live load distribution factors. Refer to AASHTO Table 3.23.1, Article 3.23.1.2 and Article 13.6.5.2.



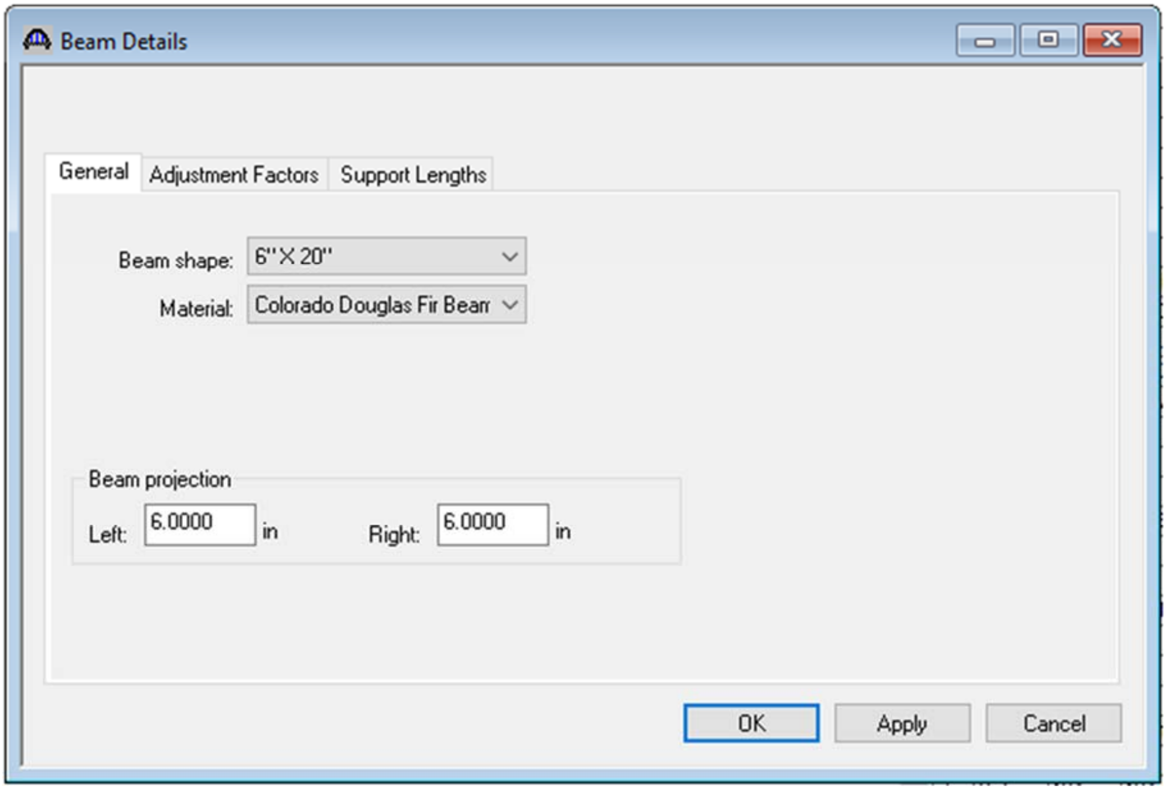
Distribution Factor Input Method

● Use Simplified Method ○ Use Advanced Method ○ Use Advanced Method with 1994 Guide Specs

☐ Allow distribution factors to be used to compute effects of permit loads with routine traffic

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	0.508	1.000	0.417	0.154
Multi-Lane	0.545	1.000	0.490	0.308

Open the Beam Details window by double clicking on Beam Details in the Bridge Workspace tree. The Beam Details window is shown below.



Beam shape: 6"X 20"

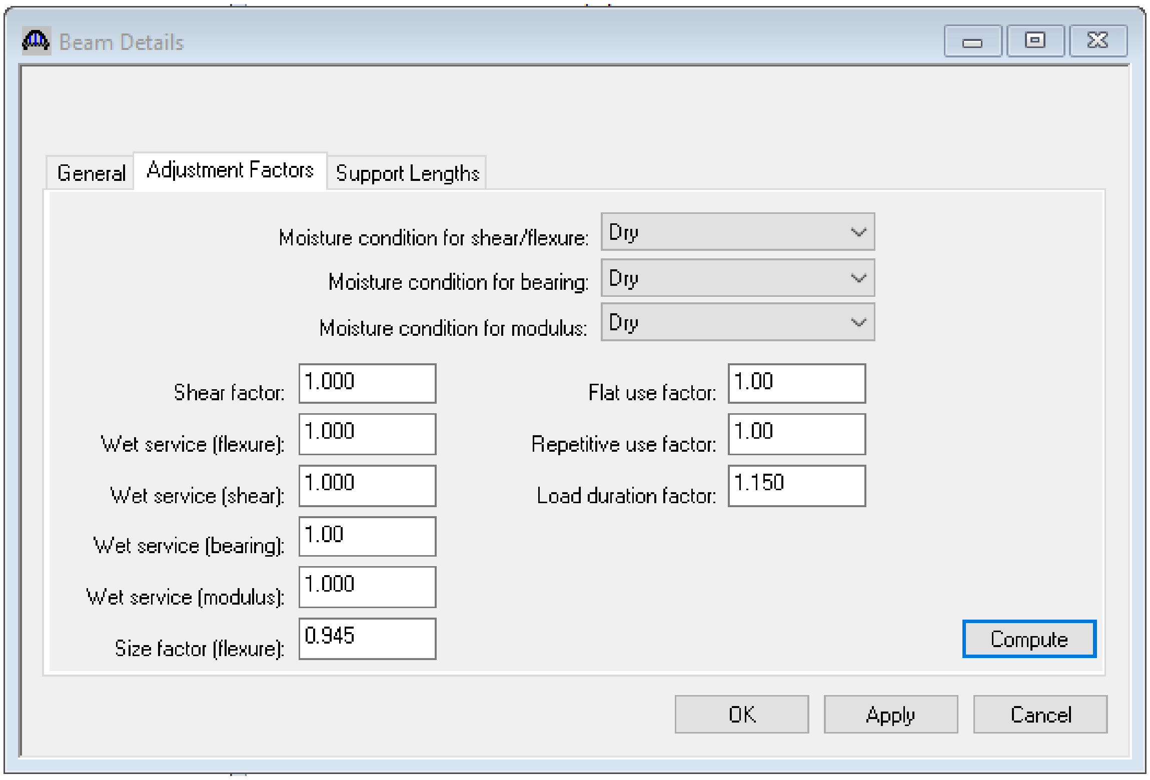
Material: Colorado Douglas Fir Bear

Beam projection

Left: 6.0000 in

Right: 6.0000 in

The Adjustment Factors tab of the Beam Details window allows you to enter adjustment factors to modify the tabulated design values entered on the Bridge Materials – Timber – Sawn window. The tabulated design values modified by these adjustment factors produce the design allowable stresses. In Colorado, dry moisture condition is used. Adjustment factors may be defaulted by using the BrR compute button.



Moisture condition for shear/flexure: Dry

Moisture condition for bearing: Dry

Moisture condition for modulus: Dry

Shear factor: 1.000

Wet service (flexure): 1.000

Wet service (shear): 1.000

Wet service (bearing): 1.00

Wet service (modulus): 1.000

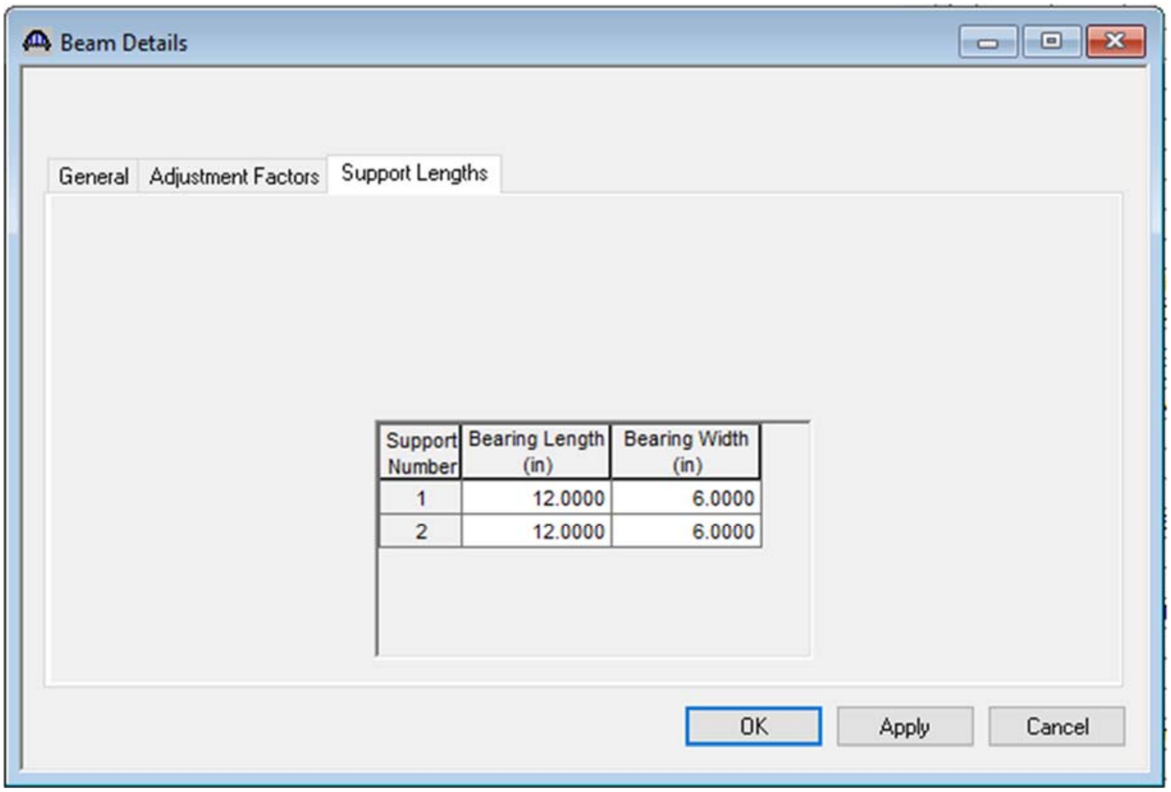
Size factor (flexure): 0.945

Flat use factor: 1.00

Repetitive use factor: 1.00

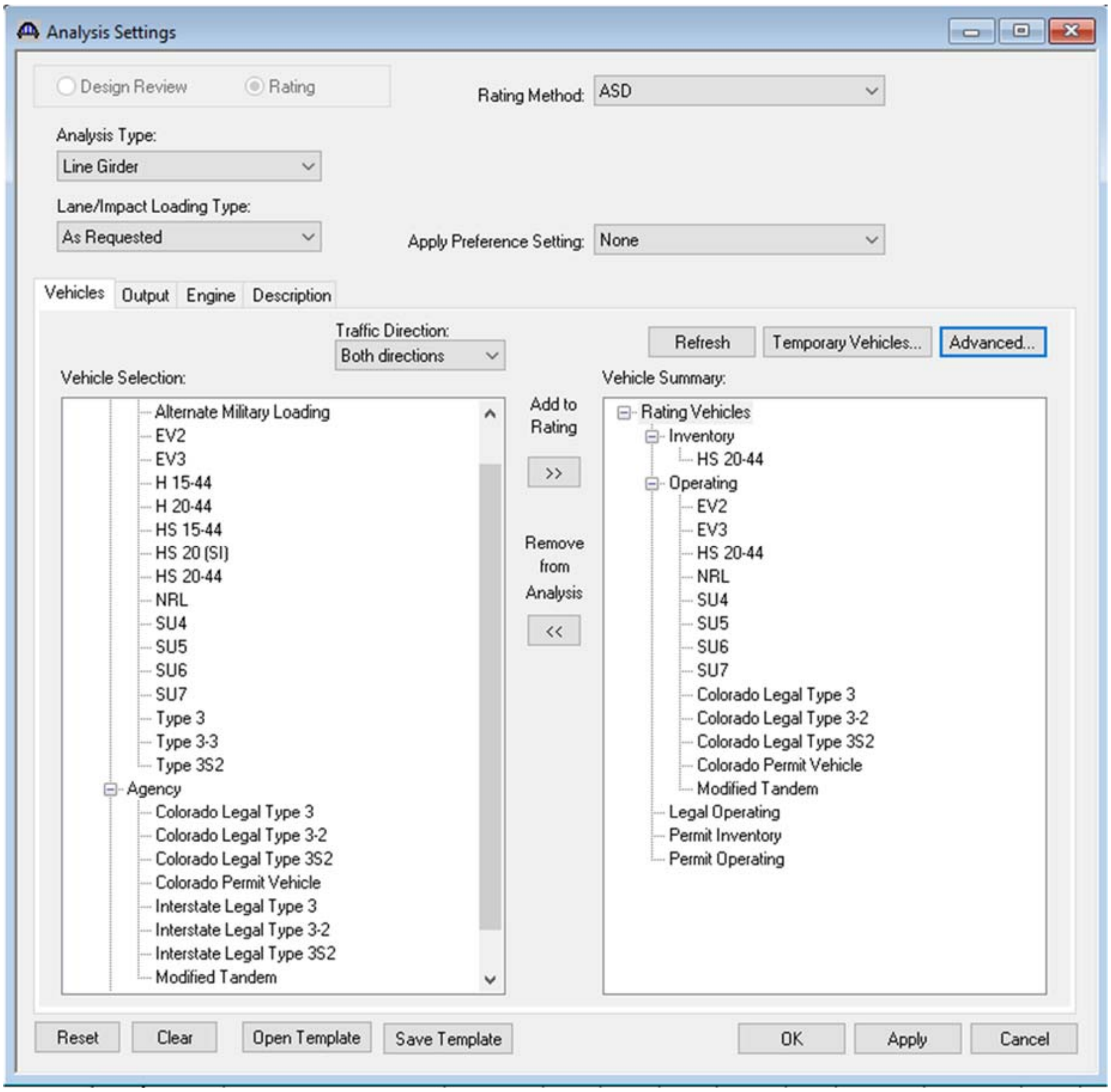
Load duration factor: 1.150

Enter the following data for the Support Lengths tab. Click OK to save to memory and close the window.



Support Number	Bearing Length (in)	Bearing Width (in)
1	12.0000	6.0000
2	12.0000	6.0000

To perform a rating analysis, select the Bridge Analysis Settings button on the toolbar to open the window shown below. Select ASD as the Rating Method, select HS 20-44 vehicle or other vehicles to be used in the rating and click OK.



Rating Method: ASD

Analysis Type: Line Girder

Lane/Impact Loading Type: As Requested

Apply Preference Setting: None

Traffic Direction: Both directions

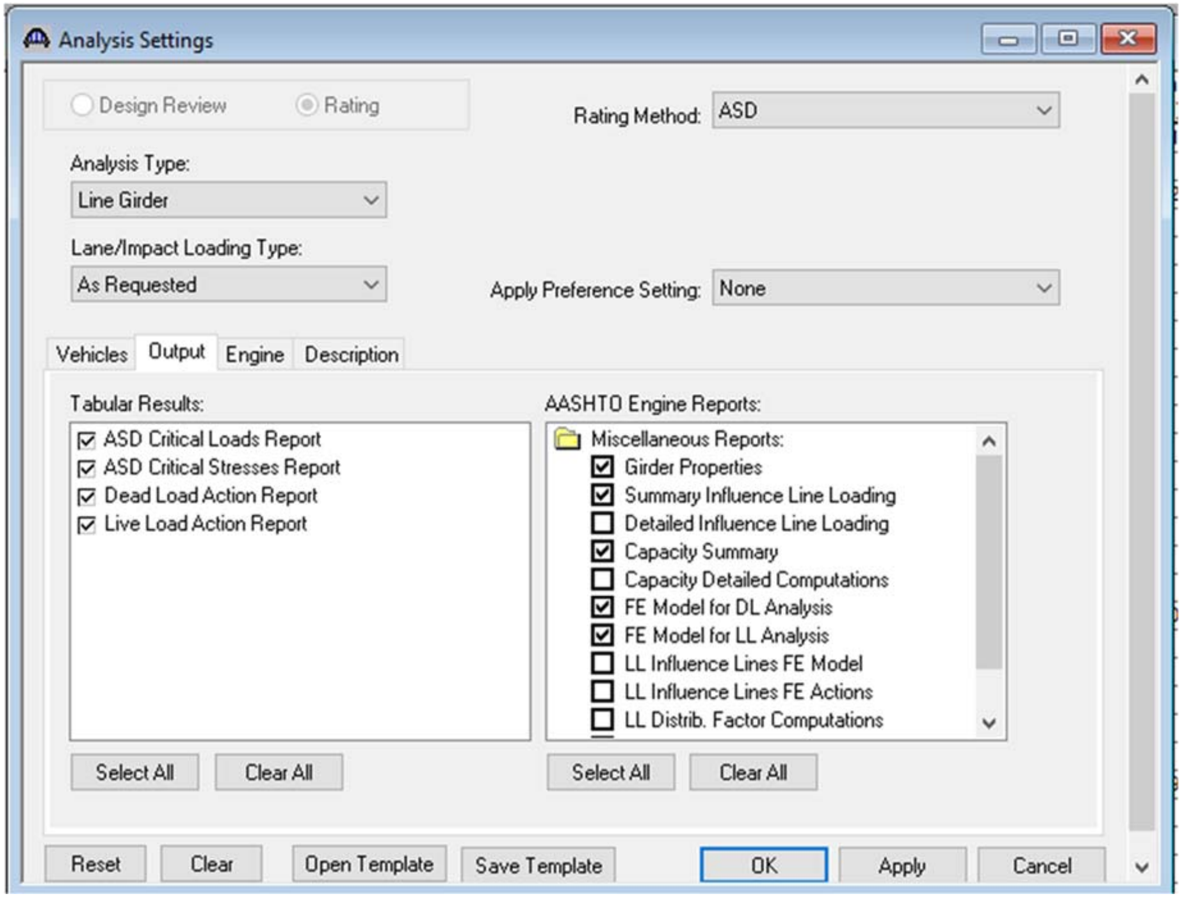
Vehicle Selection:

- Alternate Military Loading
- EV2
- EV3
- H 15-44
- H 20-44
- HS 15-44
- HS 20 (SI)
- HS 20-44
- NRL
- SU4
- SU5
- SU6
- SU7
- Type 3
- Type 3-3
- Type 3S2
- Agency
  - Colorado Legal Type 3
  - Colorado Legal Type 3-2
  - Colorado Legal Type 3S2
  - Colorado Permit Vehicle
  - Interstate Legal Type 3
  - Interstate Legal Type 3-2
  - Interstate Legal Type 3S2
  - Modified Tandem

Vehicle Summary:

- Rating Vehicles
  - Inventory
    - HS 20-44
  - Operating
    - EV2
    - EV3
    - HS 20-44
    - NRL
    - SU4
    - SU5
    - SU6
    - SU7
    - Colorado Legal Type 3
    - Colorado Legal Type 3-2
    - Colorado Legal Type 3S2
    - Colorado Permit Vehicle
    - Modified Tandem
  - Legal Operating
  - Permit Inventory
  - Permit Operating

Select the output tab of the Analysis Settings window. Check specific boxes next to the desired output report and click the Engine tab.



Analysis Settings

○ Design Review ● Rating

Rating Method: ASD

Analysis Type: Line Girder

Lane/Impact Loading Type: As Requested

Apply Preference Setting: None

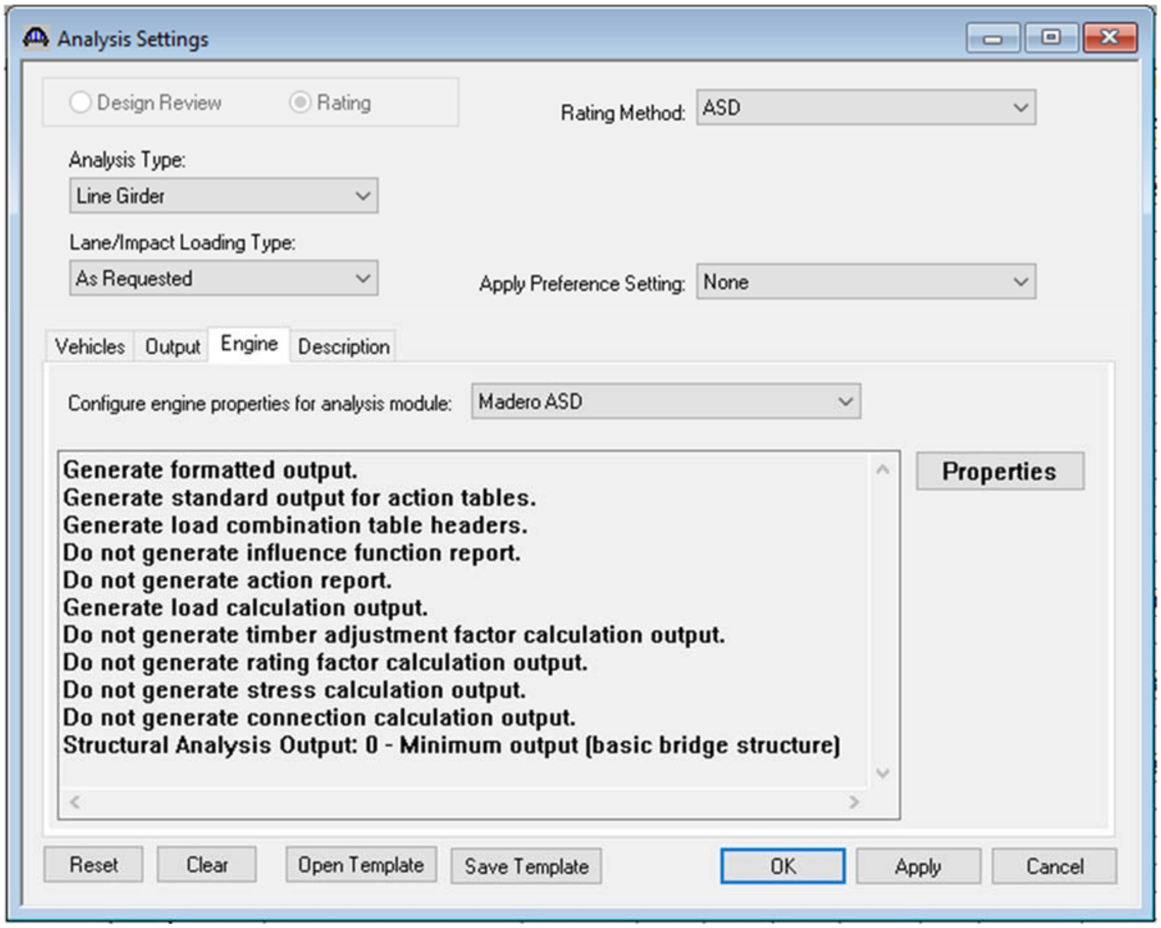
Tabular Results:

- ☑ ASD Critical Loads Report
- ☑ ASD Critical Stresses Report
- ☑ Dead Load Action Report
- ☑ Live Load Action Report

AASHTO Engine Reports:

- Miscellaneous Reports:
  - ☑ Girder Properties
  - ☑ Summary Influence Line Loading
  - ☐ Detailed Influence Line Loading
  - ☑ Capacity Summary
  - ☐ Capacity Detailed Computations
  - ☑ FE Model for DL Analysis
  - ☑ FE Model for LL Analysis
  - ☐ LL Influence Lines FE Model
  - ☐ LL Influence Lines FE Actions
  - ☐ LL Distrib. Factor Computations

Select the analysis engine and click the Properties tab.



Rating Method: ASD

Analysis Type: Line Girder

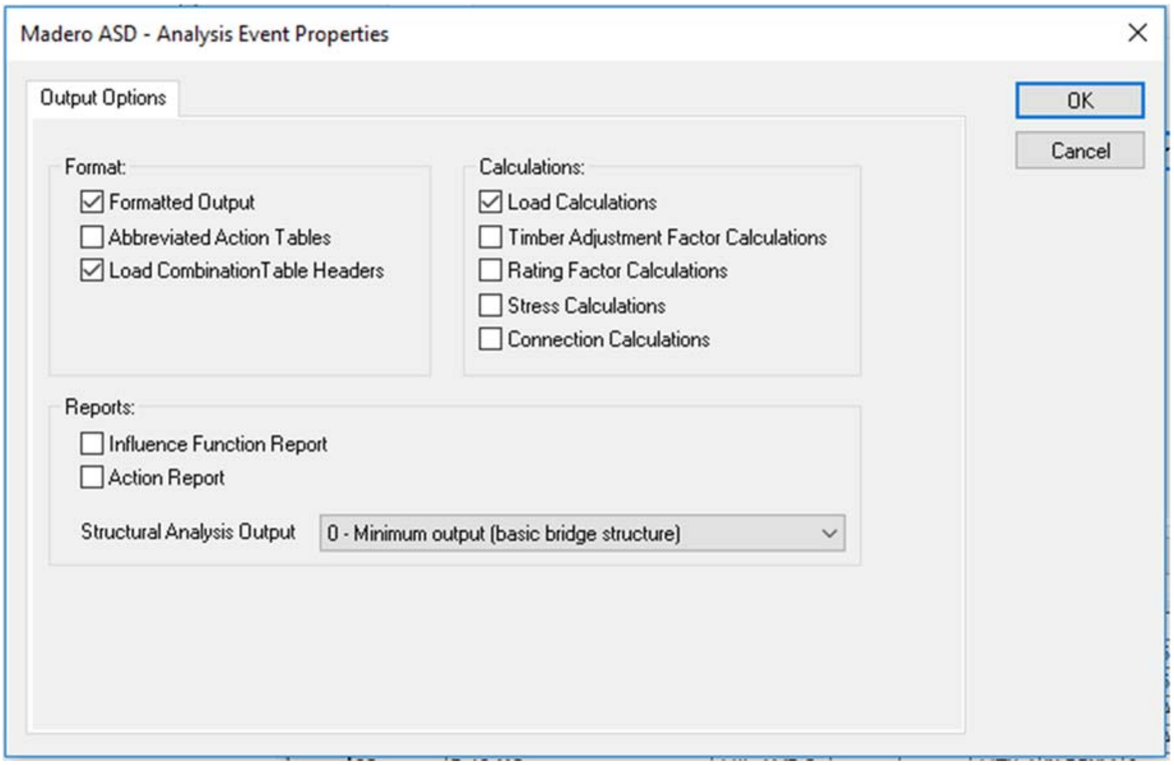
Lane/Impact Loading Type: As Requested

Apply Preference Setting: None

Configure engine properties for analysis module: Madero ASD

Generate formatted output.
Generate standard output for action tables.
Generate load combination table headers.
Do not generate influence function report.
Do not generate action report.
Generate load calculation output.
Do not generate timber adjustment factor calculation output.
Do not generate rating factor calculation output.
Do not generate stress calculation output.
Do not generate connection calculation output.
Structural Analysis Output: 0 - Minimum output (basic bridge structure)

Select the desired Output Options and click OK.



Format:

- ☑ Formatted Output
- ☐ Abbreviated Action Tables
- ☑ Load CombinationTable Headers

Calculations:

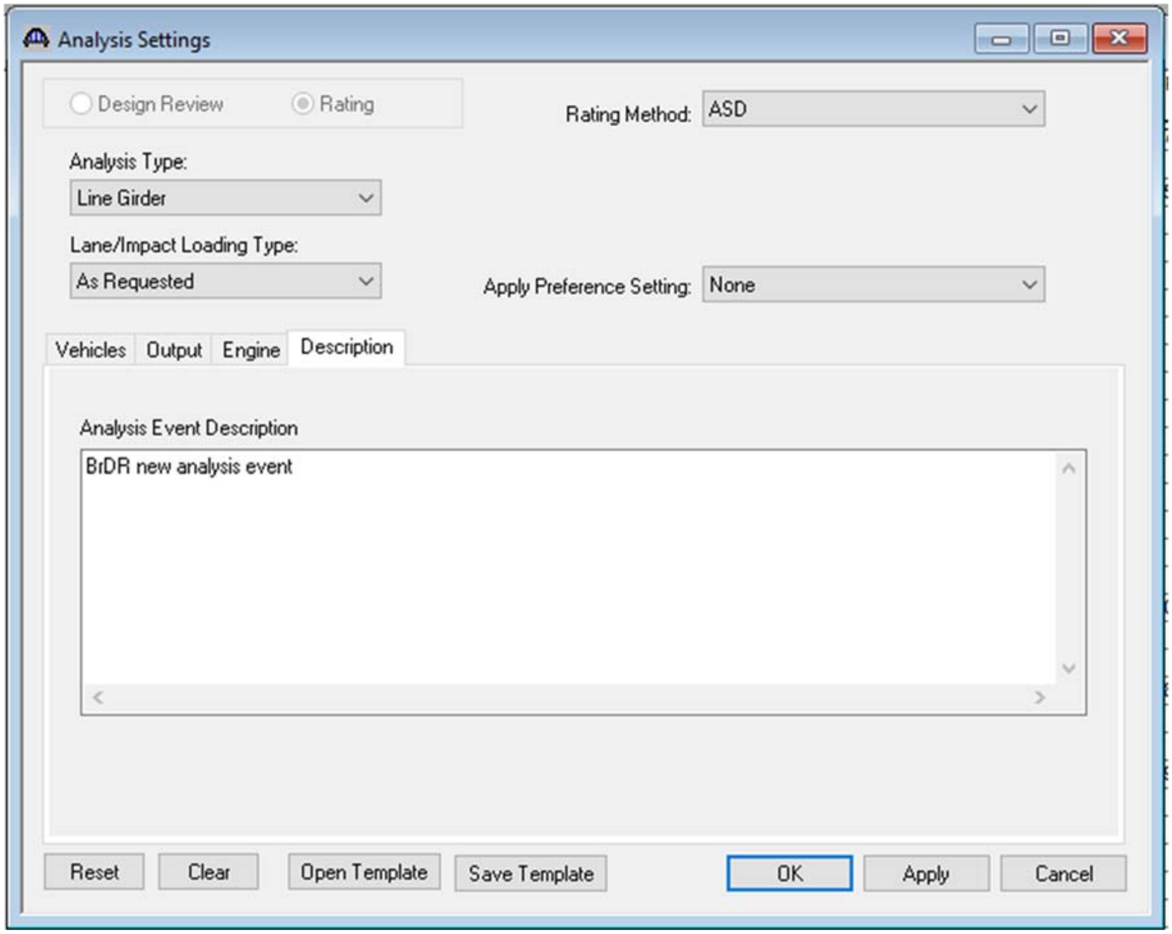
- ☑ Load Calculations
- ☐ Timber Adjustment Factor Calculations
- ☐ Rating Factor Calculations
- ☐ Stress Calculations
- ☐ Connection Calculations

Reports:

- ☐ Influence Function Report
- ☐ Action Report

Structural Analysis Output: 0 - Minimum output (basic bridge structure)

Click the Description tab, provide a general narrative description of the analysis event and click OK.



Analysis Settings

○ Design Review ● Rating

Rating Method: ASD

Analysis Type: Line Girder

Lane/Impact Loading Type: As Requested

Apply Preference Setting: None

Analysis Event Description: BrDR new analysis event

13.6 CDOT BRIDGE TIMBER RATING PROGRAM DESCRIPTION

The TIMBER computer program performs the complete analysis and rating of simple span timber bridges. The program was developed in accordance with the AASHTO Standard Specifications and the AASHTO Manual for Condition Evaluation of Bridges.

The program will not rate flooring placed longitudinally, splined or doweled flooring, multiple layered decks, nor nontimber decks. In accordance with subsection 13.2, the program does not modify the user input values for allowable stresses.

The program does not consider dead loads other than those caused by the stringers, deck, and overlay. In the case where other dead loads are present that would substantially affect the rating, they shall be accounted for during the analysis.

In the TIMBER program, the nail laminated and plank timber decks shall be rated for non-continuous between stringers while the BrR program rates for continuous. Conventionally, the TIMBER program shall be used for conservative.

The asphalt overlay depth is used to compute the dead load, using the asphalt unit weight of 146.67 pcf. When the timber bridge has gravel overlay (unit weight = 120 pcf) the depth entered should be the equivalent depth of asphalt to gravel. This is done by taking the actual depth of gravel, dividing it by 1.2, and entering the result into the required depth column. The actual depth of gravel shall be shown on the Rating Summary Sheet.

The following information appears as output from the program.

13.6.1 Stringer (For Information Only)

The Bridge Rating Program shall not use for stringer rating. The BrR program shall be used for timber stringer ratings.

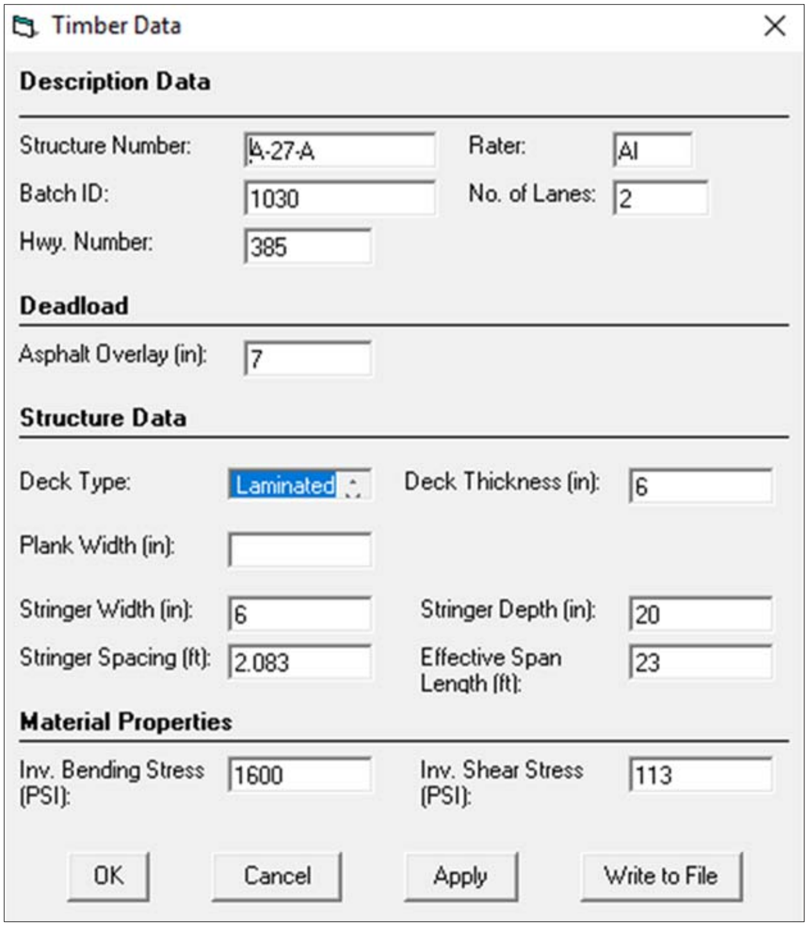
A) Total dead load moment and shear for the stringer being rated.
B) Live load moment and shear due to HS 20 truck.
C) Stringer rating for bending and shear for Inventory and Operating stress levels.
D) Live load moment and shear due to all three Colorado posting trucks.
E) Posting ratings for bending and shear for all three Colorado posting trucks. If all posting rating values are greater than the respective posting truck weights, and the operating rating is greater than or equal to 36 tons, then the posting ratings are not printed.
F) The Overload Color Code Rating for the stringer being rated is based on either shear or bending, depending on which controls.

13.6.2 Decking

A) Deck rating for nail laminated and plank floors at Inventory and Operating stress levels. Only design vehicle deck load ratings shall be reported in the RSS.
B) Posting ratings for all three Colorado posting trucks do not need to report in the RSS.
C) The Overload Color Code Rating is not a function of the deck rating.

13.7 TIMBER BRIDGE DECK RATING EXAMPLES

Timber Rating Program Input:



Description Data

Structure Number: A-27-A
Rater: AI
Batch ID: 1030
No. of Lanes: 2
Hwy. Number: 385

Deadload

Asphalt Overlay (in): 7

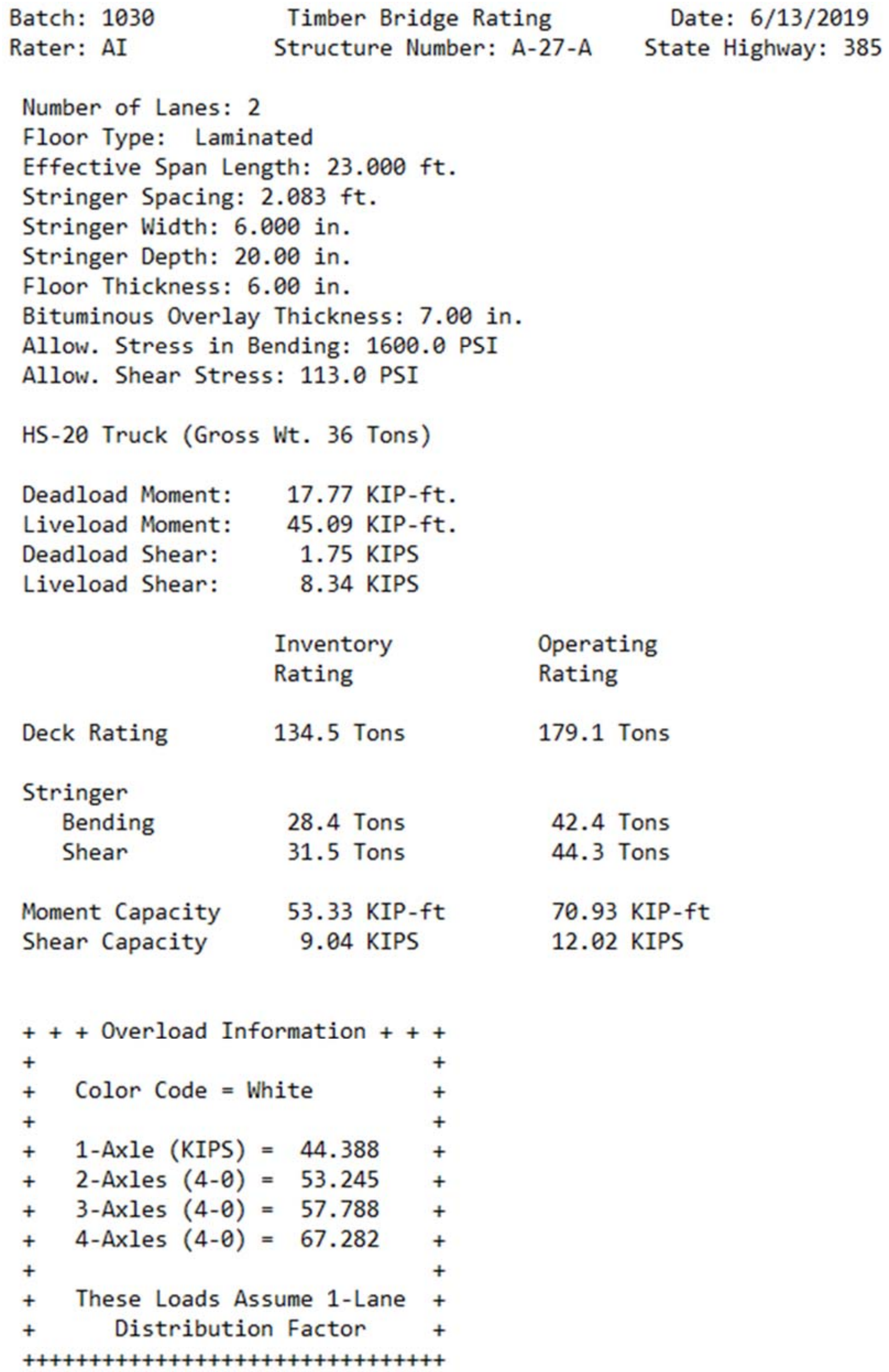
Structure Data

Deck Type: Laminated
Deck Thickness (in): 6
Plank Width (in):
Stringer Width (in): 6
Stringer Depth (in): 20
Stringer Spacing (ft): 2.083
Effective Span Length (ft): 23

Material Properties

Inv. Bending Stress (PSI): 1600
Inv. Shear Stress (PSI): 113

Timber Rating Program Output:



```
Batch: 1030          Timber Bridge Rating         Date: 6/13/2019
Rater: AI           Structure Number: A-27-A    State Highway: 385

 Number of Lanes: 2
 Floor Type:  Laminated
 Effective Span Length: 23.000 ft.
 Stringer Spacing: 2.083 ft.
 Stringer Width: 6.000 in.
 Stringer Depth: 20.00 in.
 Floor Thickness: 6.00 in.
 Bituminous Overlay Thickness: 7.00 in.
 Allow. Stress in Bending: 1600.0 PSI
 Allow. Shear Stress: 113.0 PSI

 HS-20 Truck (Gross Wt. 36 Tons)

 Deadload Moment:    17.77 KIP-ft.
 Liveload Moment:    45.09 KIP-ft.
 Deadload Shear:      1.75 KIPS
 Liveload Shear:      8.34 KIPS

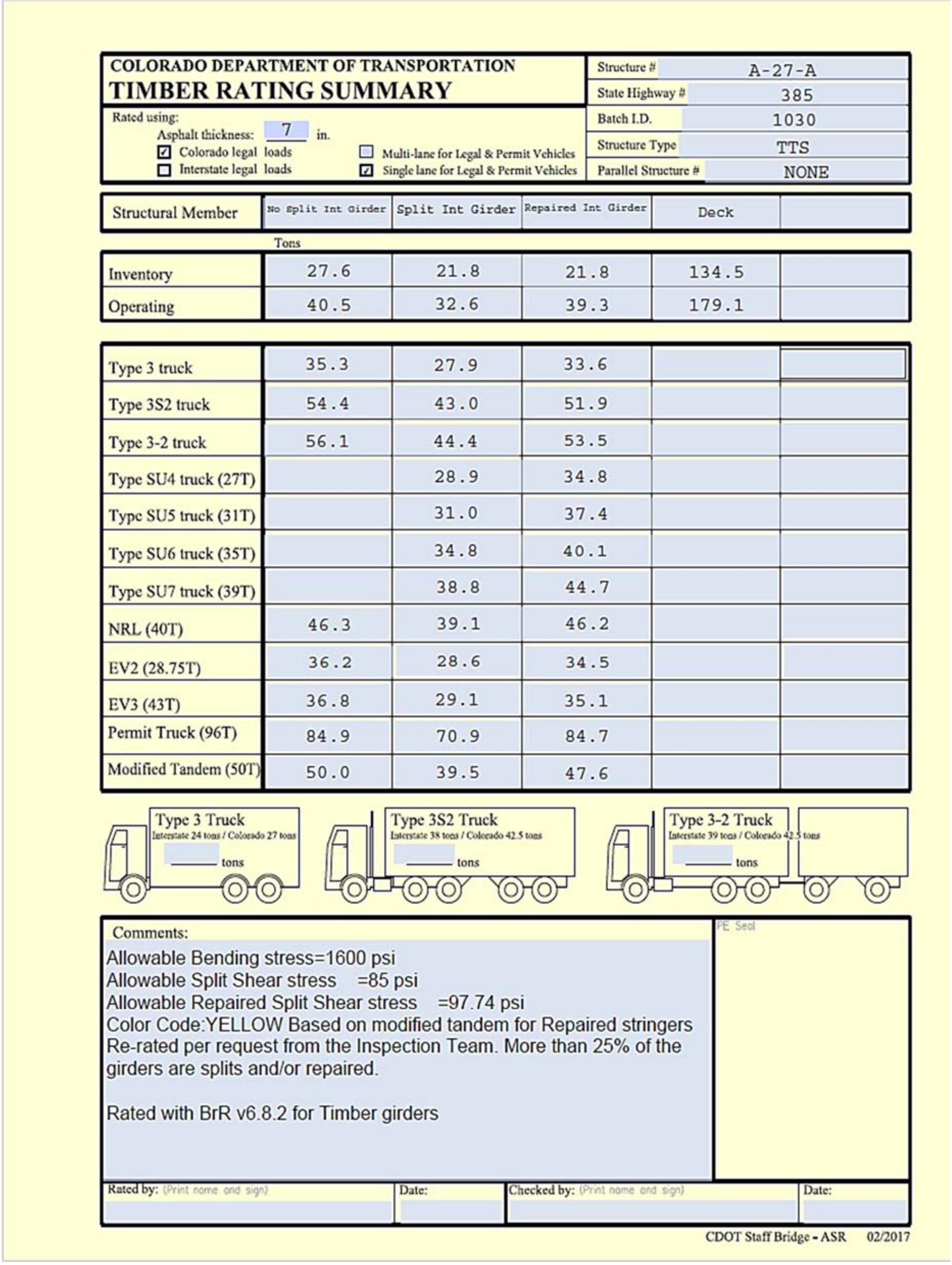
                    Inventory           Operating
                    Rating              Rating

 Deck Rating        134.5 Tons          179.1 Tons

 Stringer
    Bending          28.4 Tons           42.4 Tons
    Shear            31.5 Tons           44.3 Tons

 Moment Capacity     53.33 KIP-ft        70.93 KIP-ft
 Shear Capacity       9.04 KIPS          12.02 KIPS


 + + + Overload Information + + +
 +                              +
 +   Color Code = White         +
 +                              +
 +   1-Axle (KIPS) =  44.388    +
 +   2-Axles (4-0) =  53.245    +
 +   3-Axles (4-0) =  57.788    +
 +   4-Axles (4-0) =  67.282    +
 +                              +
 +   These Loads Assume 1-Lane  +
 +      Distribution Factor     +
 ++++++++++++++++++++++++++++++++
```



COLORADO DEPARTMENT OF TRANSPORTATION
TIMBER RATING SUMMARY

Structure # A-27-A
State Highway # 385
Batch I.D. 1030
Structure Type TTS
Parallel Structure # NONE

Rated using:
Asphalt thickness: 7 in.
☑ Colorado legal loads
☐ Interstate legal loads
☐ Multi-lane for Legal & Permit Vehicles
☑ Single lane for Legal & Permit Vehicles

Tons

Structural Member	No Split Int Girder	Split Int Girder	Repaired Int Girder	Deck	
Inventory	27.6	21.8	21.8	134.5	
Operating	40.5	32.6	39.3	179.1	

Type 3 truck	35.3	27.9	33.6		
Type 3S2 truck	54.4	43.0	51.9		
Type 3-2 truck	56.1	44.4	53.5		
Type SU4 truck (27T)		28.9	34.8		
Type SU5 truck (31T)		31.0	37.4		
Type SU6 truck (35T)		34.8	40.1		
Type SU7 truck (39T)		38.8	44.7		
NRL (40T)	46.3	39.1	46.2		
EV2 (28.75T)	36.2	28.6	34.5		
EV3 (43T)	36.8	29.1	35.1		
Permit Truck (96T)	84.9	70.9	84.7		
Modified Tandem (50T)	50.0	39.5	47.6		

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
_____ tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
_____ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
_____ tons

Comments:

Allowable Bending stress=1600 psi
Allowable Split Shear stress =85 psi
Allowable Repaired Split Shear stress =97.74 psi
Color Code:YELLOW Based on modified tandem for Repaired stringers
Re-rated per request from the Inspection Team. More than 25% of the girders are splits and/or repaired.

Rated with BrR v6.8.2 for Timber girders

PE Seal

Rated by: (Print name and sign)
Date:
Checked by: (Print name and sign)
Date:

CDOT Staff Bridge - ASR 02/2017

13.8 GUIDELINES FOR SISTER BEAM RATING

The term “Sister Beam” is used when a new steel beam/section or a new timber stringer is added to an existing timber structure, and placed adjacent to or side-by-side an existing damaged or deteriorated timber stringer, to add structural capacity or carry the existing stringer load.

Adding a Sister-Beam to an existing structure is a major rehabilitation and should be designed and rated using LRFD and LRFR methods respectively.

AASHTOWare BrR software should be used for the rating.

The existing timber stringers shall be rated using ASD method with single lane loaded for Legal Load vehicles and Colorado Permit vehicles. The new sister-beam/s shall be rated using LRFR method with single lane loaded for Legal Load vehicles and Colorado Permit vehicles. The Live Load Impact shall be considered for the sister-beam, but not for the timber stringer. The entire structure should be rated in both ASD and LRFR for the existing stringers and new sister-beam/s respectively.

Substructure does not need to be rated except as requested by the Bridge Inspection Engineer.

The Rating Summary sheet shall show both the existing stringers and the new sister-beam ratings and denote the controlling one.

Major and Minor timber structures with sister-beam/s should be rated the in same manner in accordance with this section.

Damaged / Deteriorated stringer covers stringers that have been evaluated as broken, checked, cracked, split, or decayed stringer. Existing timber stringers condition evaluation should follow Subsection 13-3 and 13-4.

The rater and checker shall complete the rating documentation as described in Section 1 of the Bridge Rating Manual. Any variation from the original design assumptions shall be added to the Rating Summary Sheet as applicable. The rating package requirements shall be per Section 1.13 and Section 1.14 of the Bridge Rating Manual and as amended herein.

The Designer should review the superstructure rating to make sure it meets the design’s load path and assumptions.

13.8.1 LIVE LOAD DISTRIBUTION

Matching the existing stringers deflection, stiffens, and load path should be considered when adding a structural support or a sister beam. To maintain the existing structure behavior and load path, the new sister beam is usually designed to match the existing stringers deflection, stiffness, depth, etc.

The load sharing between the new sister-beam and the damaged / deteriorated existing stringer can be calculated in different way. Different load sharing calculation could result in different LLDF between the new and other existing stringers. The designer should be consulted in verifying the intent of the design, the LLDF calculation methodology, and the final load distribution factors.

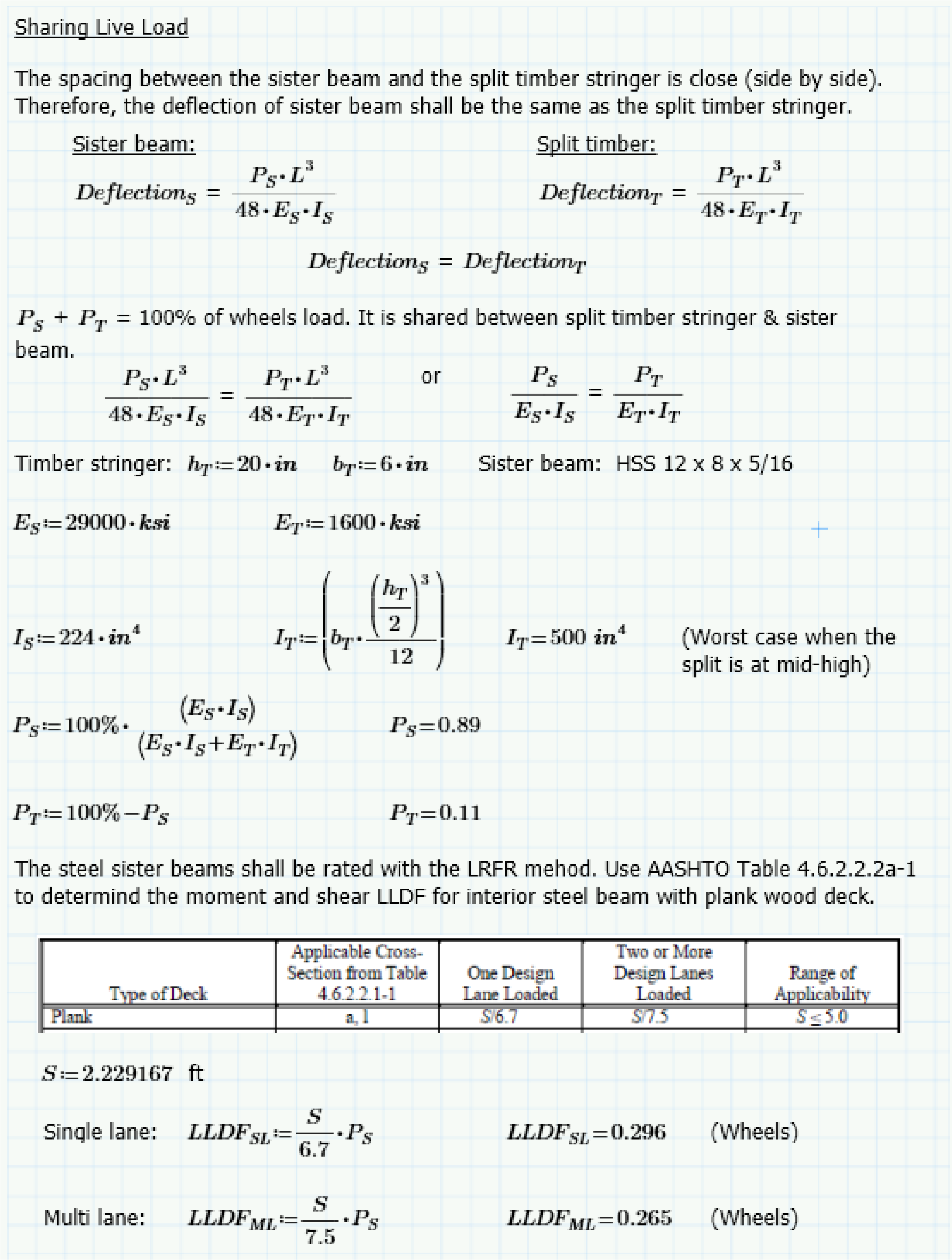
Based on the provided load sharing example in this section and other load sharing calculations, in most cases, the damaged/deteriorated stringer carries about 10% to 20% of the load while the new sister-beam carries the rest. On the long term, the damaged/deteriorated stringer might continue to lose its capacity and the new sister-beam may be required to carry all the dead and live load. To minimize repetitive ratings, the new rating should ignore any capacity of the damaged/deteriorated stringer and apply all the load to the new beam, unless otherwise approved in advance by CDOT Staff Bridge Rating Engineer.

For consistency among ratings and for simplification purposes, distribution factors should be calculated based on average girder spacing since the spacing can differ. (In reality, the spacing might have not changed much considering the damaged/deteriorated timber stringer still exist).

The existing sound timber stringers should be the controlling stringers in the rating. The design should be re-evaluated if otherwise.

Service-II Limit State is intended to control the yielding of steel and slip-critical connections. It is considered to be midway between Service-I and Strength-I Limit States. Service-II usually does not control non-composite, non-compact steel sections. Accordingly, Service-II rating maybe ignored when rating steel sister-beam structures, (Reference AASHTO LRFD 9th edition and MBE 3 Edition).

Below is an example calculation of live load sharing between a split timber stringer and a new steel sister-beam. The rater and designer should convene to insure consistency between the rating and the design intent.



Sharing Live Load

The spacing between the sister beam and the split timber stringer is close (side by side). Therefore, the deflection of sister beam shall be the same as the split timber stringer.

Sister beam:

$$Deflection_S = \frac{P_S \cdot L^3}{48 \cdot E_S \cdot I_S}$$

Split timber:

$$Deflection_T = \frac{P_T \cdot L^3}{48 \cdot E_T \cdot I_T}$$

$$Deflection_S = Deflection_T$$

$P_S + P_T$ = 100% of wheels load. It is shared between split timber stringer & sister beam.

$$\frac{P_S \cdot L^3}{48 \cdot E_S \cdot I_S} = \frac{P_T \cdot L^3}{48 \cdot E_T \cdot I_T} \quad \text{or} \quad \frac{P_S}{E_S \cdot I_S} = \frac{P_T}{E_T \cdot I_T}$$

Timber stringer: $h_T := 20 \cdot in$ $b_T := 6 \cdot in$ Sister beam: HSS 12 x 8 x 5/16

$E_S := 29000 \cdot ksi$ $E_T := 1600 \cdot ksi$

$I_S := 224 \cdot in^4$ $I_T := \left(b_T \cdot \frac{\left(\frac{h_T}{2}\right)^3}{12} \right)$ $I_T = 500\ in^4$ (Worst case when the split is at mid-high)

$P_S := 100\% \cdot \frac{(E_S \cdot I_S)}{(E_S \cdot I_S + E_T \cdot I_T)}$ $P_S = 0.89$

$P_T := 100\% - P_S$ $P_T = 0.11$

The steel sister beams shall be rated with the LRFR mehod. Use AASHTO Table 4.6.2.2.2a-1 to determind the moment and shear LLDF for interior steel beam with plank wood deck.

Type of Deck	Applicable Cross-Section from Table 4.6.2.2.1-1	One Design Lane Loaded	Two or More Design Lanes Loaded	Range of Applicability
Plank	a, l	S/6.7	S/7.5	$S \leq 5.0$

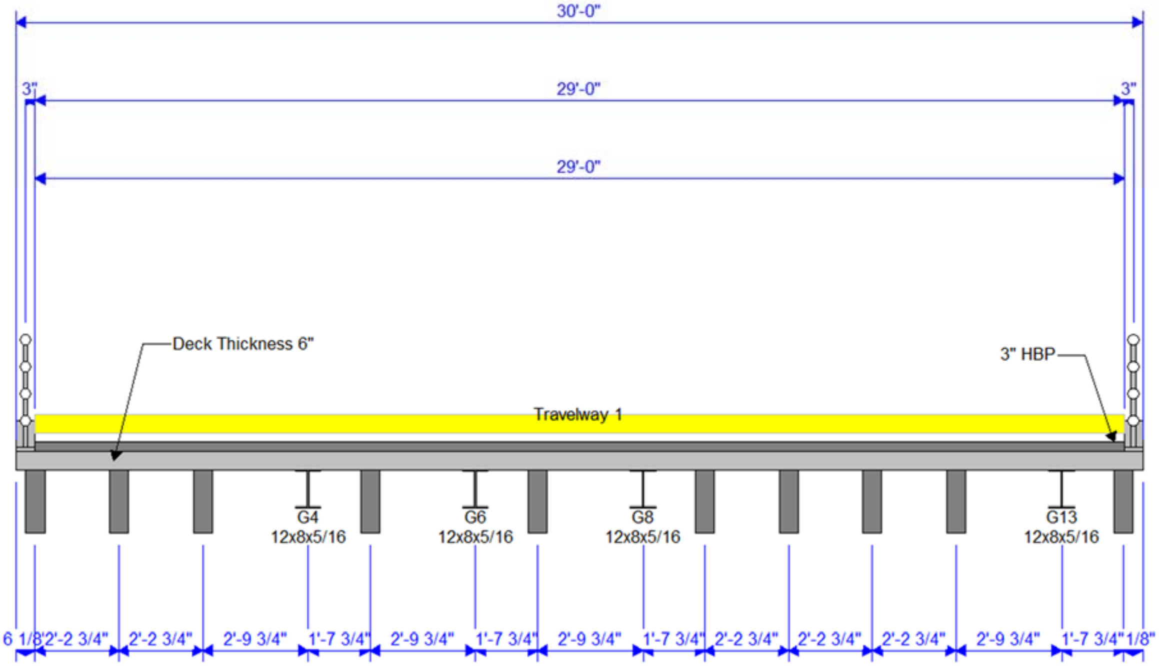
$S := 2.229167$ ft

Single lane: $LLDF_{SL} := \frac{S}{6.7} \cdot P_S$ $LLDF_{SL} = 0.296$ (Wheels)

Multi lane: $LLDF_{ML} := \frac{S}{7.5} \cdot P_S$ $LLDF_{ML} = 0.265$ (Wheels)

13.9 SISTER BEAM RATING EXAMPLE, STRUCTURE X-XX-X.

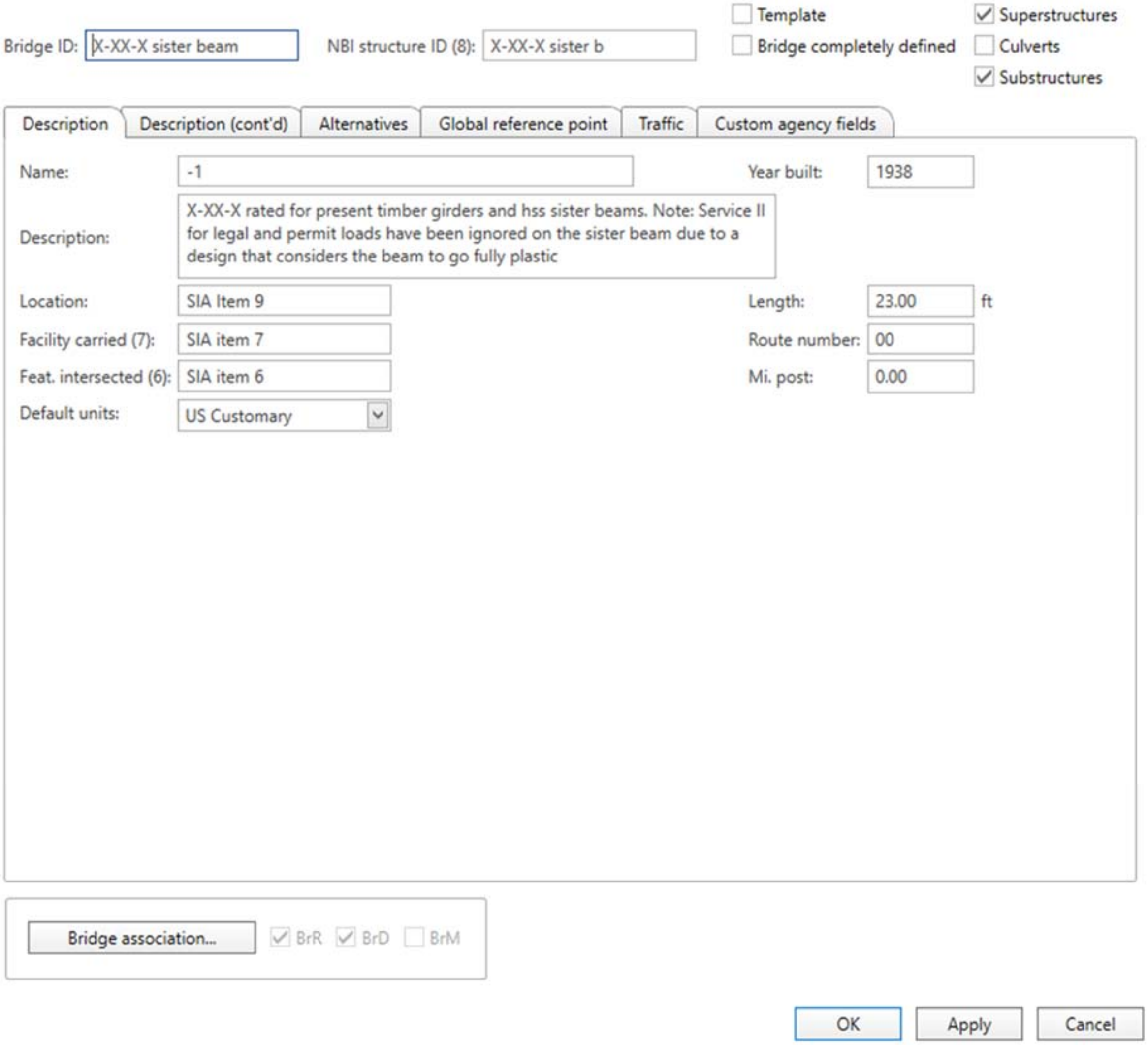
Structure X-XX-X AASHTOWare BrR Rating is presented below as an example. This structure is a 1-Span 23’-0” c-c timber stringer with steel sister beam for Girder number 4, 6, 8, and 13. The structure is 30’-0” out-to-out with original stringer spacing of 2’-2 ¾” c-c. The existing timber stringers are 6” wide x 20” deep Colorado Douglas Fir. The new Sister beam is 12x8x5/16 HSS steel section placed adjacent (side-by-side) the existing damaged or deteriorated stringer with spacing of 7” c-c. The damaged/deteriorated timber stringers are not modeled since it is assumed that the new sister-beam is carrying 100% of the load. Distribution factors should be calculated based on average girder spacing since the spacing can differ. The Live Load Impact shall be considered for the sister-beam, but not for the timber stringer. See Section 13.5 Example for more information



Structure X-XX-X Typical Section

AASHTOWARE BrR (VERSION 7.2) INPUT

From the bridge explorer, create a new bridge and complete the bridge name and information tabulation.



Bridge ID: X-XX-X sister beam

NBI structure ID (8): X-XX-X sister b

☐ Template

☐ Bridge completely defined

☑ Superstructures

☐ Culverts

☑ Substructures

Name: -1

Year built: 1938

Description: X-XX-X rated for present timber girders and hss sister beams. Note: Service II for legal and permit loads have been ignored on the sister beam due to a design that considers the beam to go fully plastic

Location: SIA Item 9

Length: 23.00 ft

Facility carried (7): SIA item 7

Route number: 00

Feat. intersected (6): SIA item 6

Mi. post: 0.00

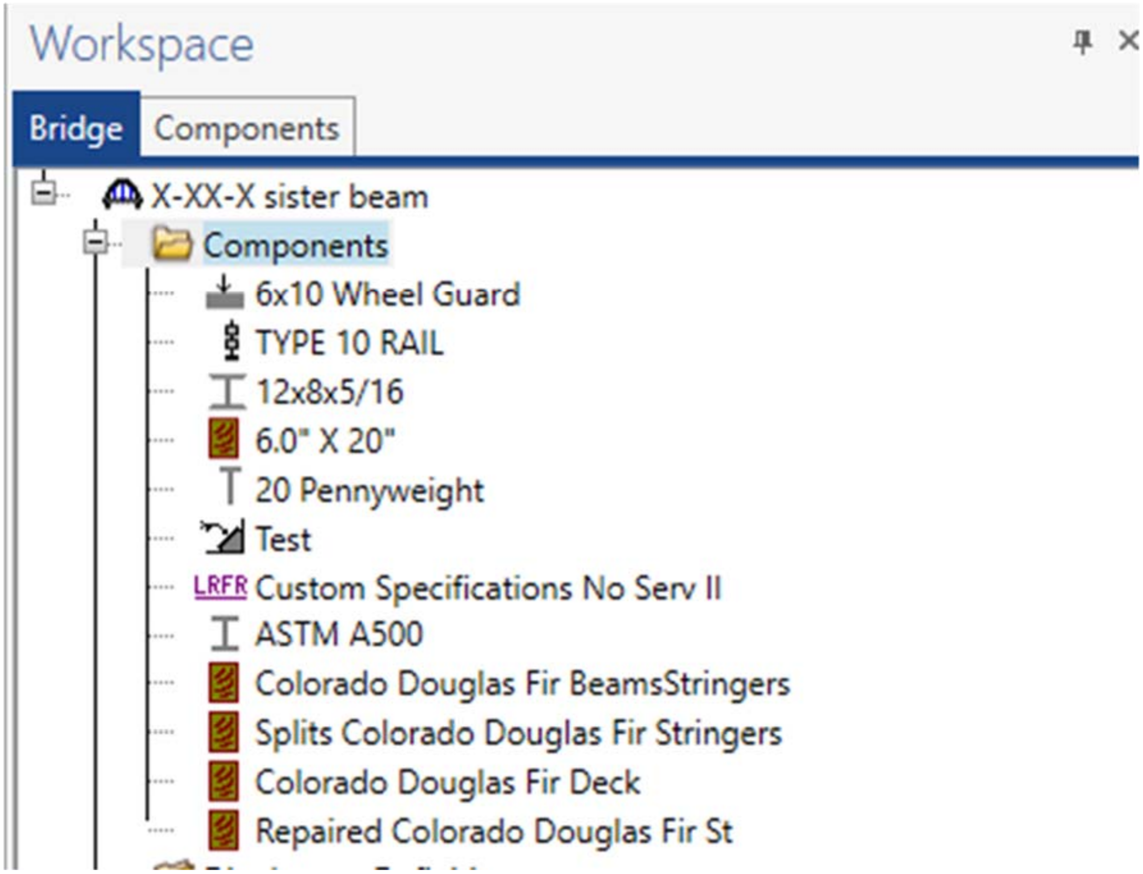
Default units: US Customary

☑ BrR ☑ BrD ☐ BrM

The Description should include CDOT/the Consultant company’s name, the rater and checker initials, and date of completion.

The fields under the “Global reference point” and “Traffic” tabs should be completed matching the latest structure inspection and appraisal (SIA) report information.

The Components folder contains bridge components that are applicable to the entire bridge like appurtenances, beam shapes, specifications, and materials properties, see capture below:

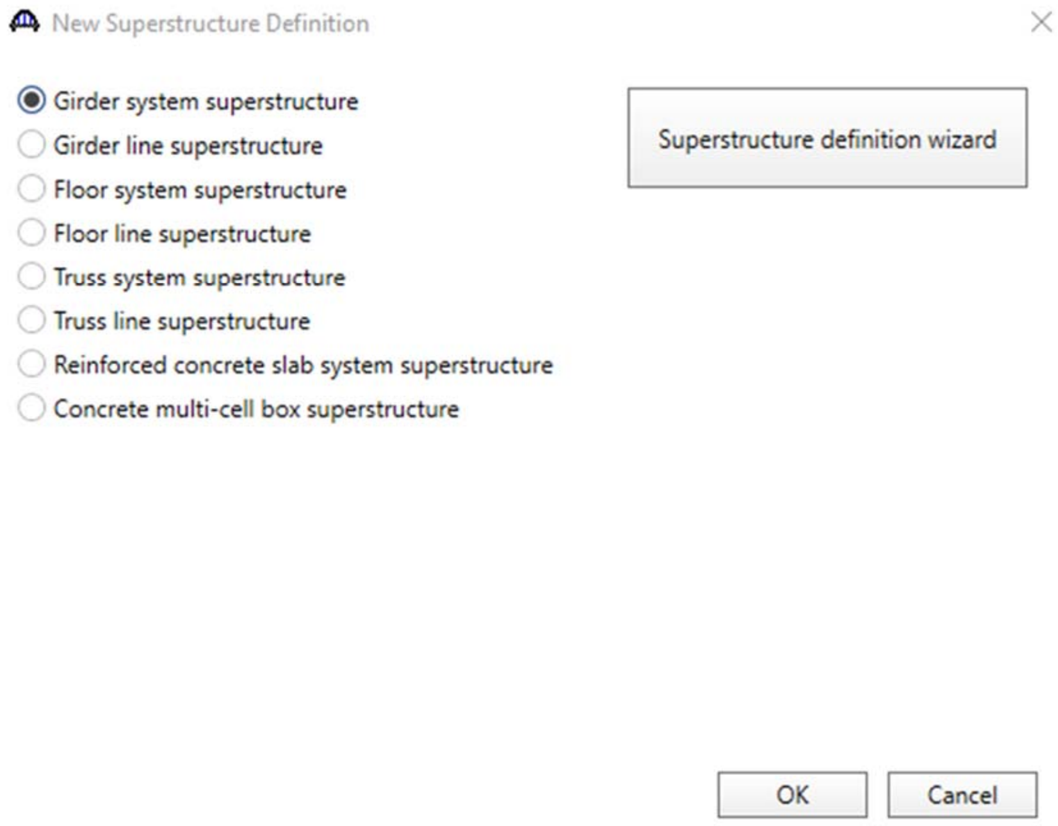


Workspace

Bridge Components

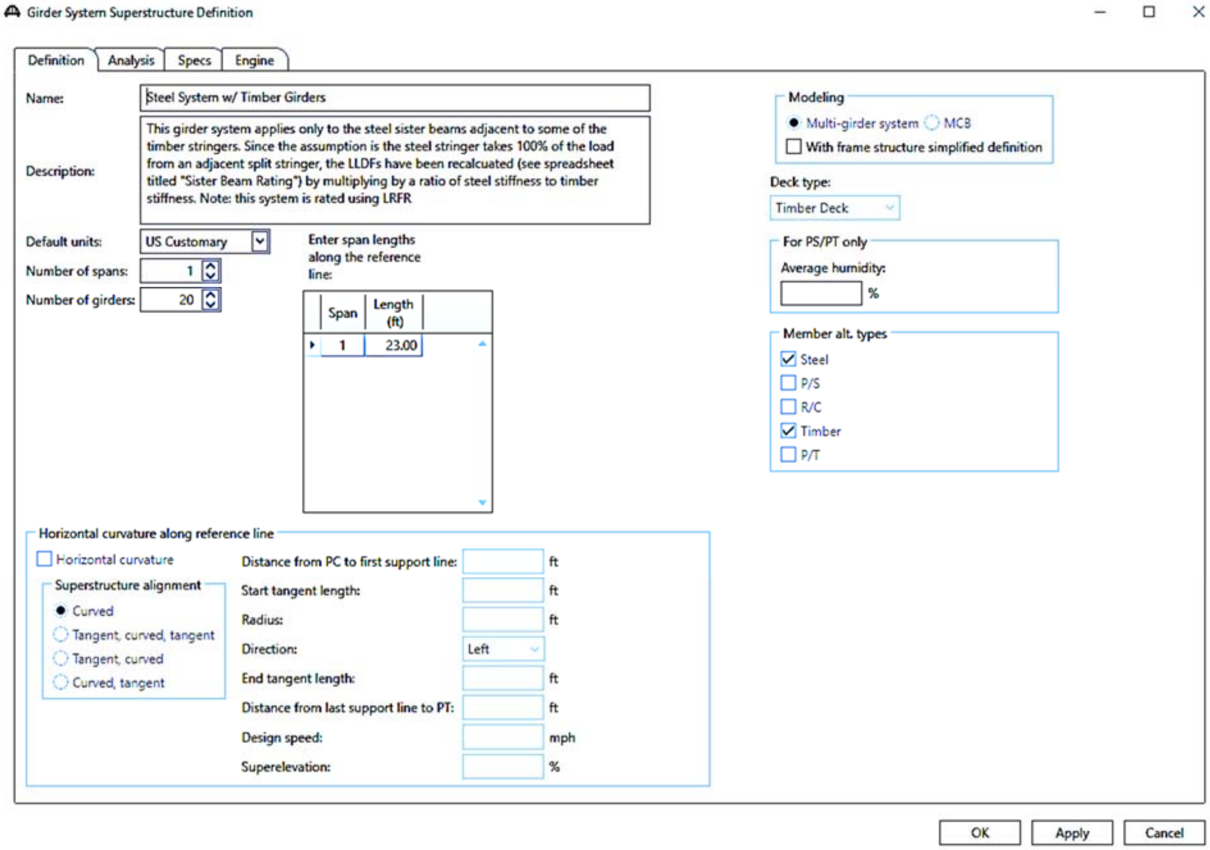
- X-XX-X sister beam
  - Components
    - 6x10 Wheel Guard
    - TYPE 10 RAIL
    - 12x8x5/16
    - 6.0" X 20"
    - 20 Pennyweight
    - Test
    - LRFR Custom Specifications No Serv II
    - ASTM A500
    - Colorado Douglas Fir BeamsStringers
    - Splits Colorado Douglas Fir Stringers
    - Colorado Douglas Fir Deck
    - Repaired Colorado Douglas Fir St

A Girder System superstructure is selected to create a new Superstructure Definition.



Complete the new Girder System Superstructure Definition information:

Two superstructure definitions should be created, one for the ASD Timber stringer rating, and the other for the LRFD Steel beam rating. The information below is shown for the steel beam rating only.



Name: Steel System w/ Timber Girders

Description: This girder system applies only to the steel sister beams adjacent to some of the timber stringers. Since the assumption is the steel stringer takes 100% of the load from an adjacent split stringer, the LLDFs have been recalcuated (see spreadsheet titled "Sister Beam Rating") by multiplying by a ratio of steel stiffness to timber stiffness. Note: this system is rated using LRFR

Default units: US Customary

Number of spans: 1

Number of girders: 20

Enter span lengths along the reference line:

Span	Length (ft)
1	23.00

Modeling

● Multi-girder system ○ MCB

☐ With frame structure simplified definition

Deck type: Timber Deck

For PS/PT only

Average humidity: %

Member alt. types

☑ Steel

☐ P/S

☐ R/C

☑ Timber

☐ P/T

Horizontal curvature along reference line

☐ Horizontal curvature

Superstructure alignment

● Curved

○ Tangent, curved, tangent

○ Tangent, curved

○ Curved, tangent

Distance from PC to first support line: ft

Start tangent length: ft

Radius: ft

Direction: Left

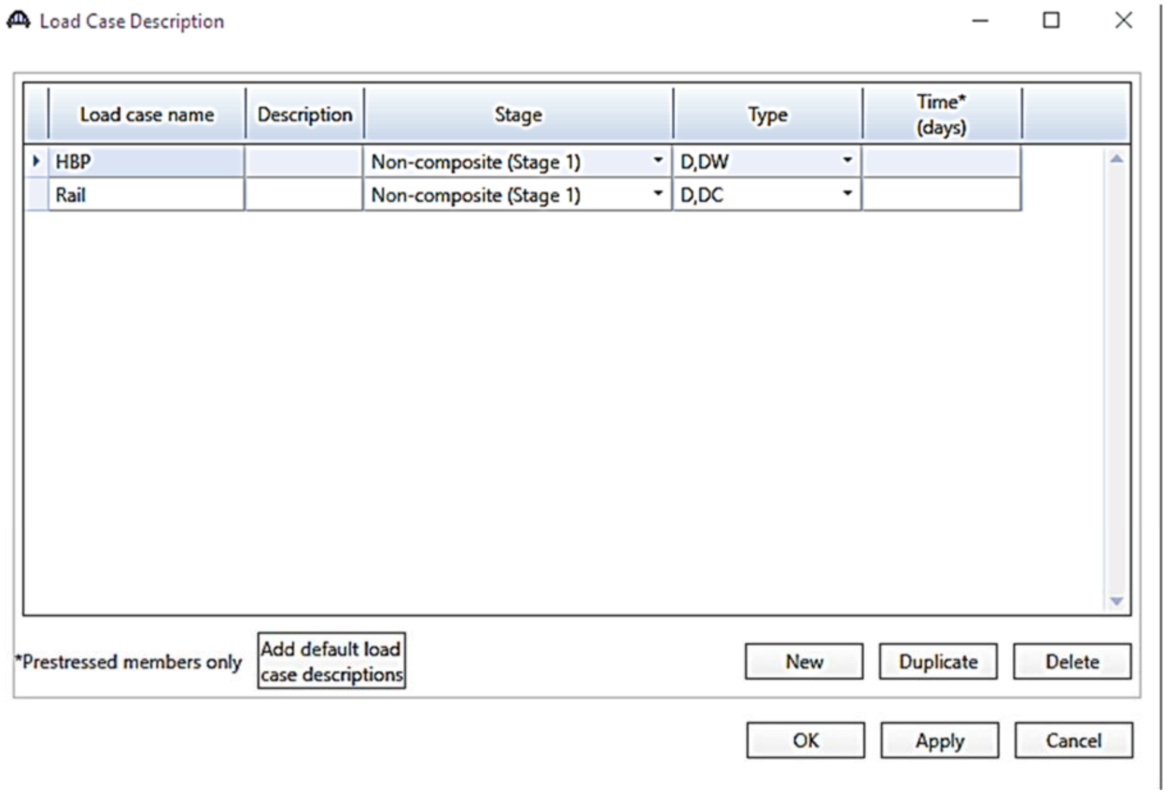
End tangent length: ft

Distance from last support line to PT: ft

Design speed: mph

Superelevation: %

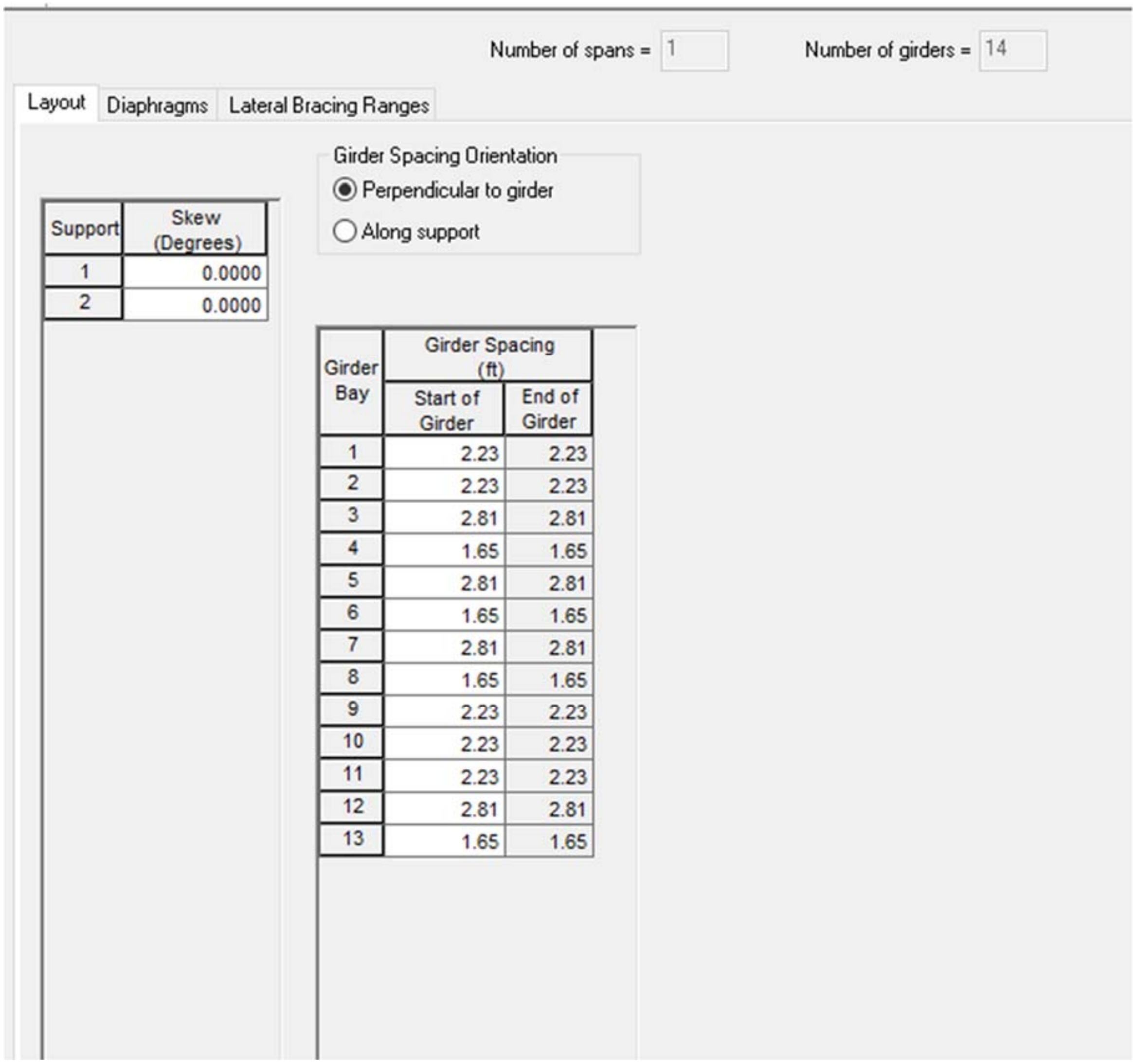
Complete the Load Case Description:



Load case name	Description	Stage	Type	Time* (days)
HBP		Non-composite (Stage 1)	D,DW	
Rail		Non-composite (Stage 1)	D,DC	

*Prestressed members only

Complete Structure Framing Plan Details:



Number of spans = 1   Number of girders = 14

Girder Spacing Orientation

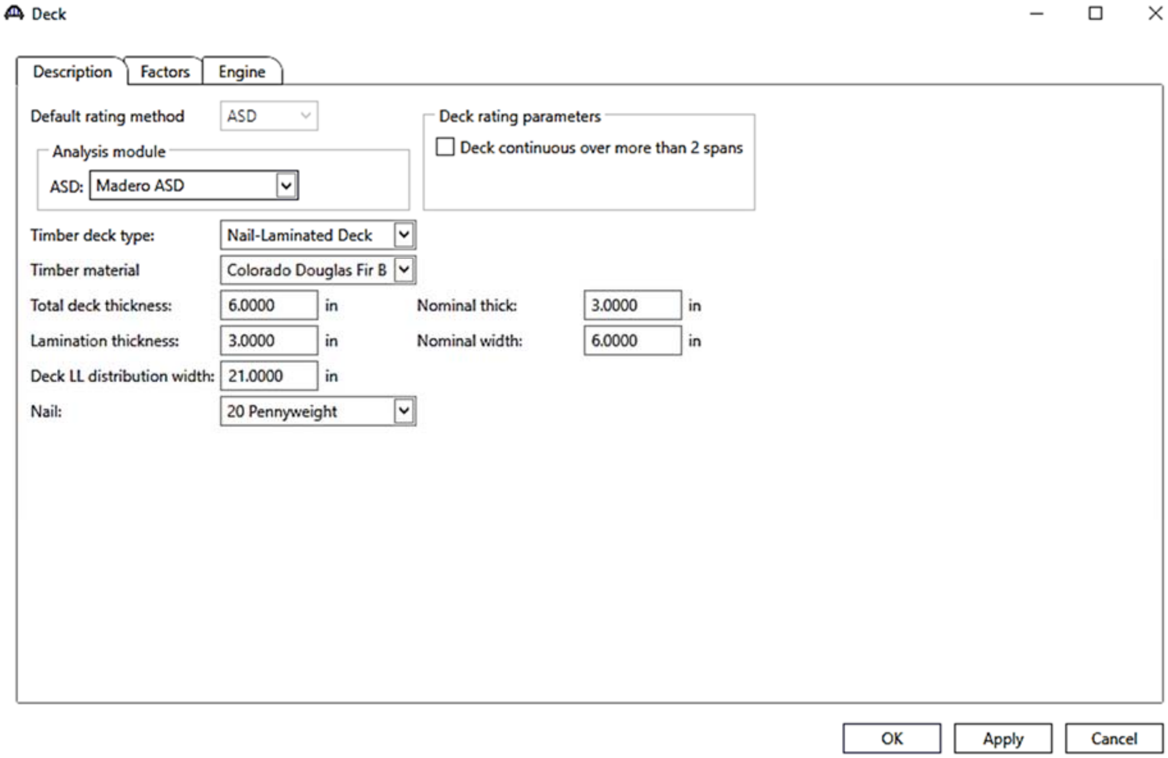
● Perpendicular to girder

○ Along support

Support	Skew (Degrees)
1	0.0000
2	0.0000

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	2.23	2.23
2	2.23	2.23
3	2.81	2.81
4	1.65	1.65
5	2.81	2.81
6	1.65	1.65
7	2.81	2.81
8	1.65	1.65
9	2.23	2.23
10	2.23	2.23
11	2.23	2.23
12	2.81	2.81
13	1.65	1.65

Complete the Deck folder information:



Default rating method: ASD

Analysis module

ASD: Madero ASD

Deck rating parameters

☐ Deck continuous over more than 2 spans

Timber deck type: Nail-Laminated Deck

Timber material: Colorado Douglas Fir B

Total deck thickness: 6.0000 in

Nominal thick: 3.0000 in

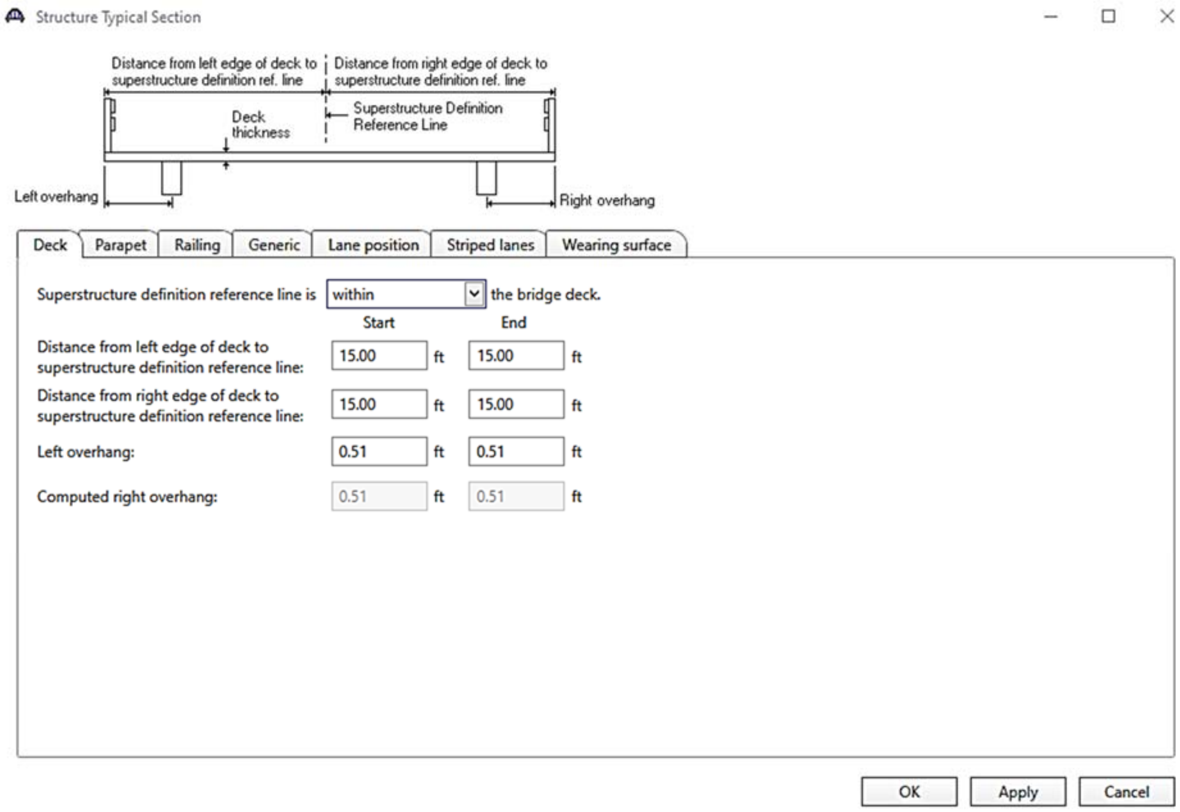
Lamination thickness: 3.0000 in

Nominal width: 6.0000 in

Deck LL distribution width: 21.0000 in

Nail: 20 Pennyweight

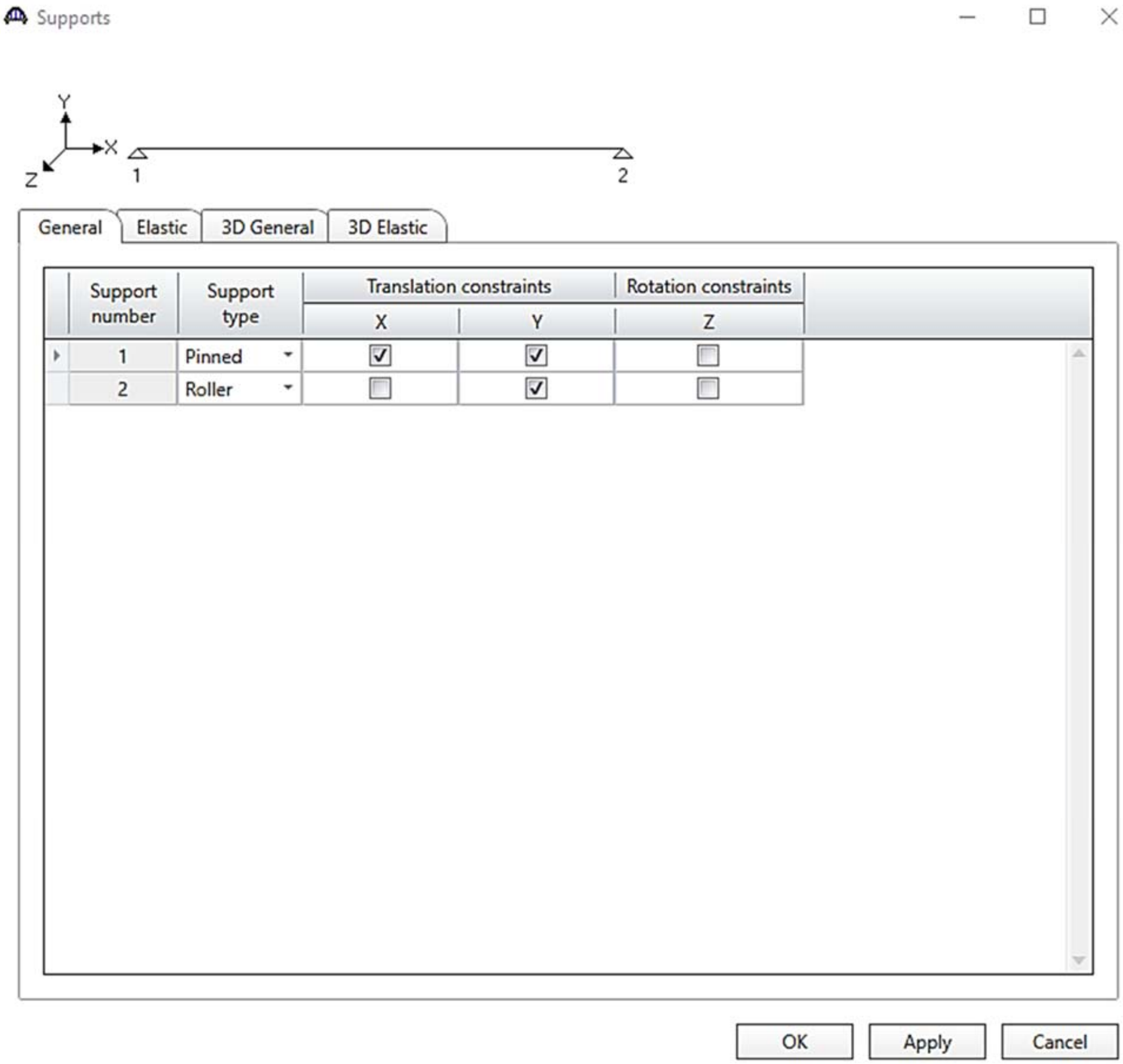
Complete Structure Typical Section information:



Superstructure definition reference line is within the bridge deck.

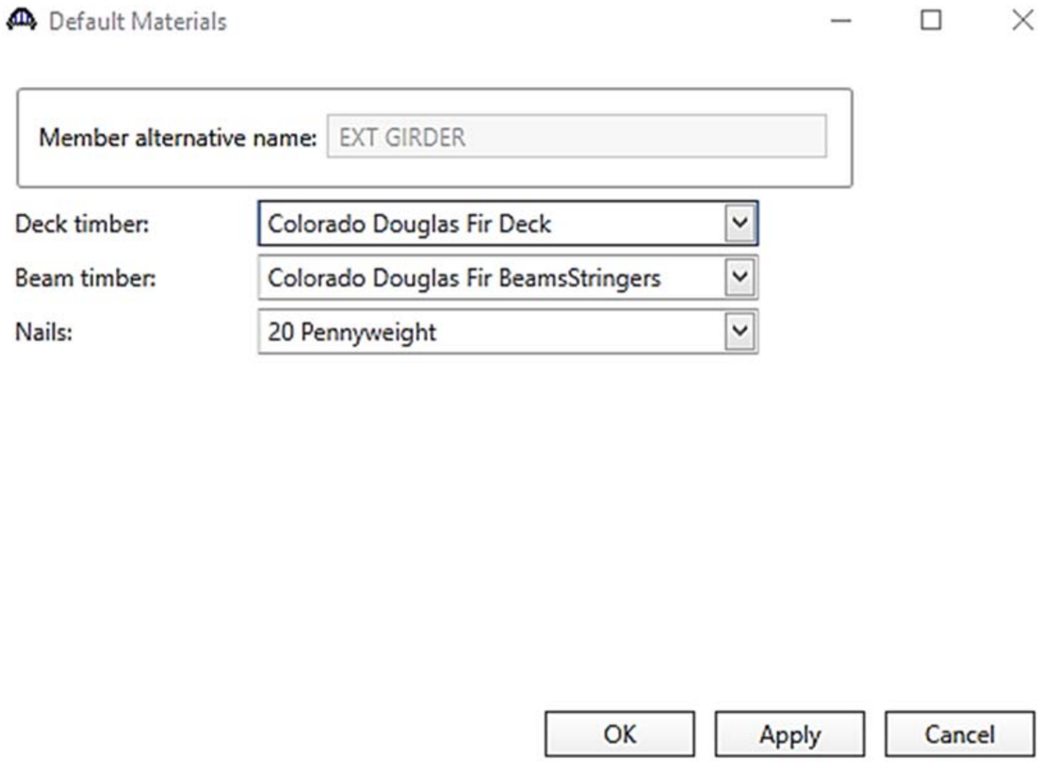
	Start		End	
Distance from left edge of deck to superstructure definition reference line:	15.00	ft	15.00	ft
Distance from right edge of deck to superstructure definition reference line:	15.00	ft	15.00	ft
Left overhang:	0.51	ft	0.51	ft
Computed right overhang:	0.51	ft	0.51	ft

Complete each girder Supports information:



Support number	Support type	Translation constraints X	Translation constraints Y	Rotation constraints Z
1	Pinned	☑	☑	☐
2	Roller	☐	☑	☐

Complete Girders Default Material:



Member alternative name: EXT GIRDER

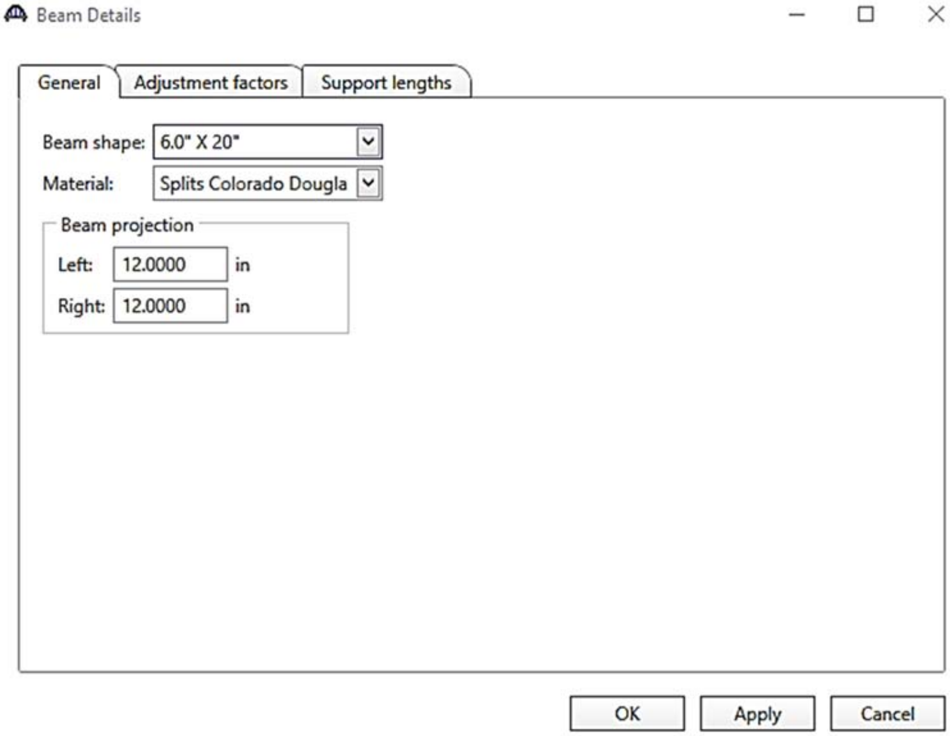
Deck timber: Colorado Douglas Fir Deck

Beam timber: Colorado Douglas Fir BeamsStringers

Nails: 20 Pennyweight

Complete the Beam Details information under each girder:

For Existing Timber Stringers:



Beam shape: 6.0" X 20"

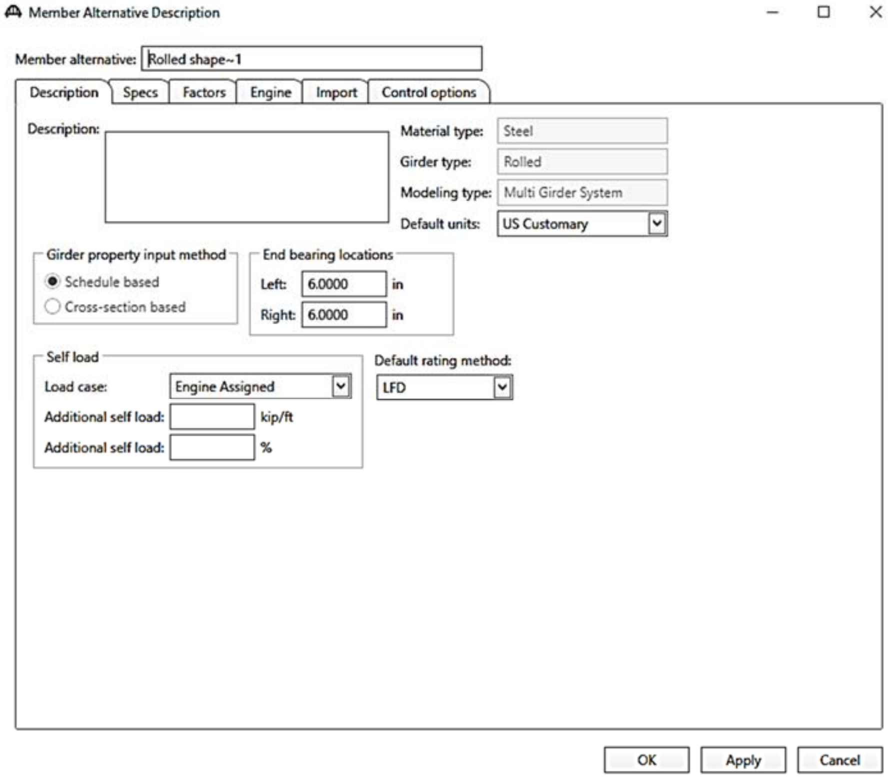
Material: Splits Colorado Dougla

Beam projection

Left: 12.0000 in

Right: 12.0000 in

For New Steel Sister-Beams:



Member alternative: Rolled shape~1

Description:

Material type: Steel

Girder type: Rolled

Modeling type: Multi Girder System

Default units: US Customary

Girder property input method

● Schedule based

○ Cross-section based

End bearing locations

Left: 6.0000 in

Right: 6.0000 in

Self load

Load case: Engine Assigned

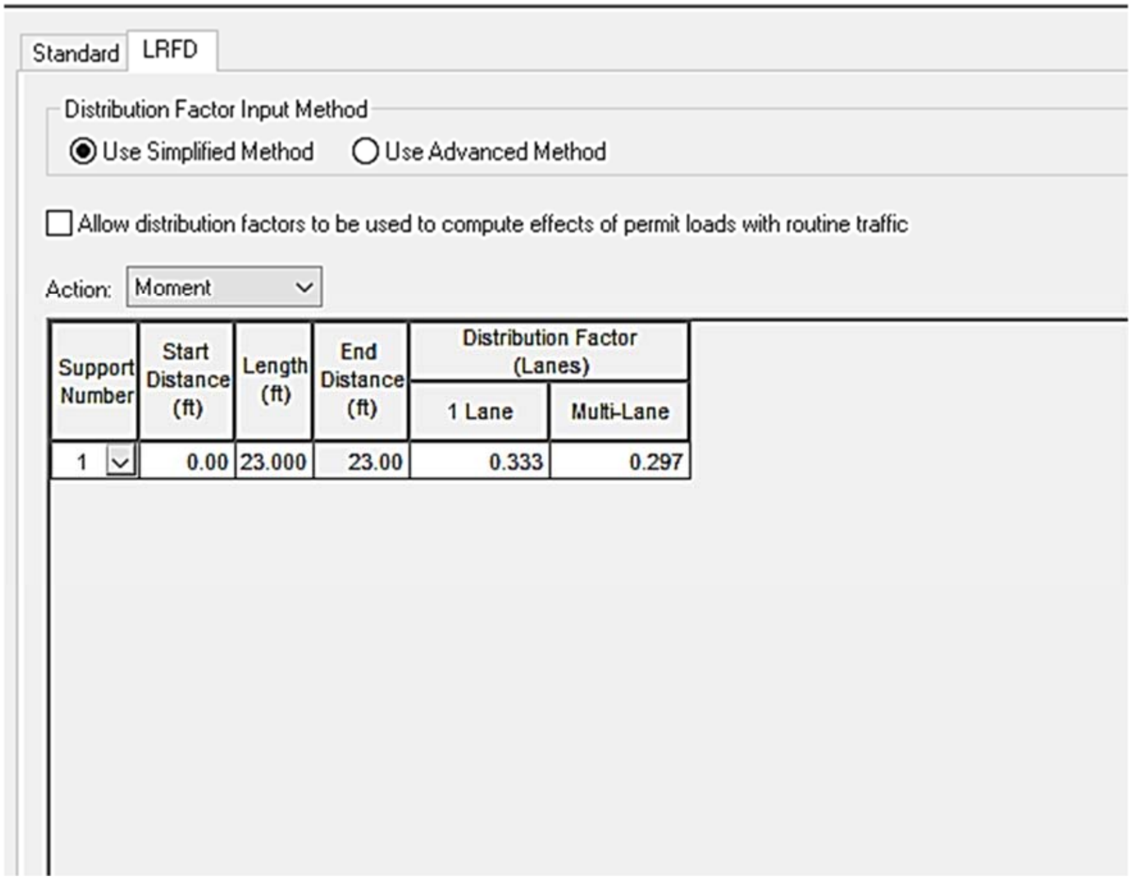
Additional self load: kip/ft

Additional self load: %

Default rating method: LFD

:

Complete the Live Load Distribution factors tabulation as per the design, hand calculation, or use the “Compute from typical section” button as appropriate.



Distribution Factor Input Method

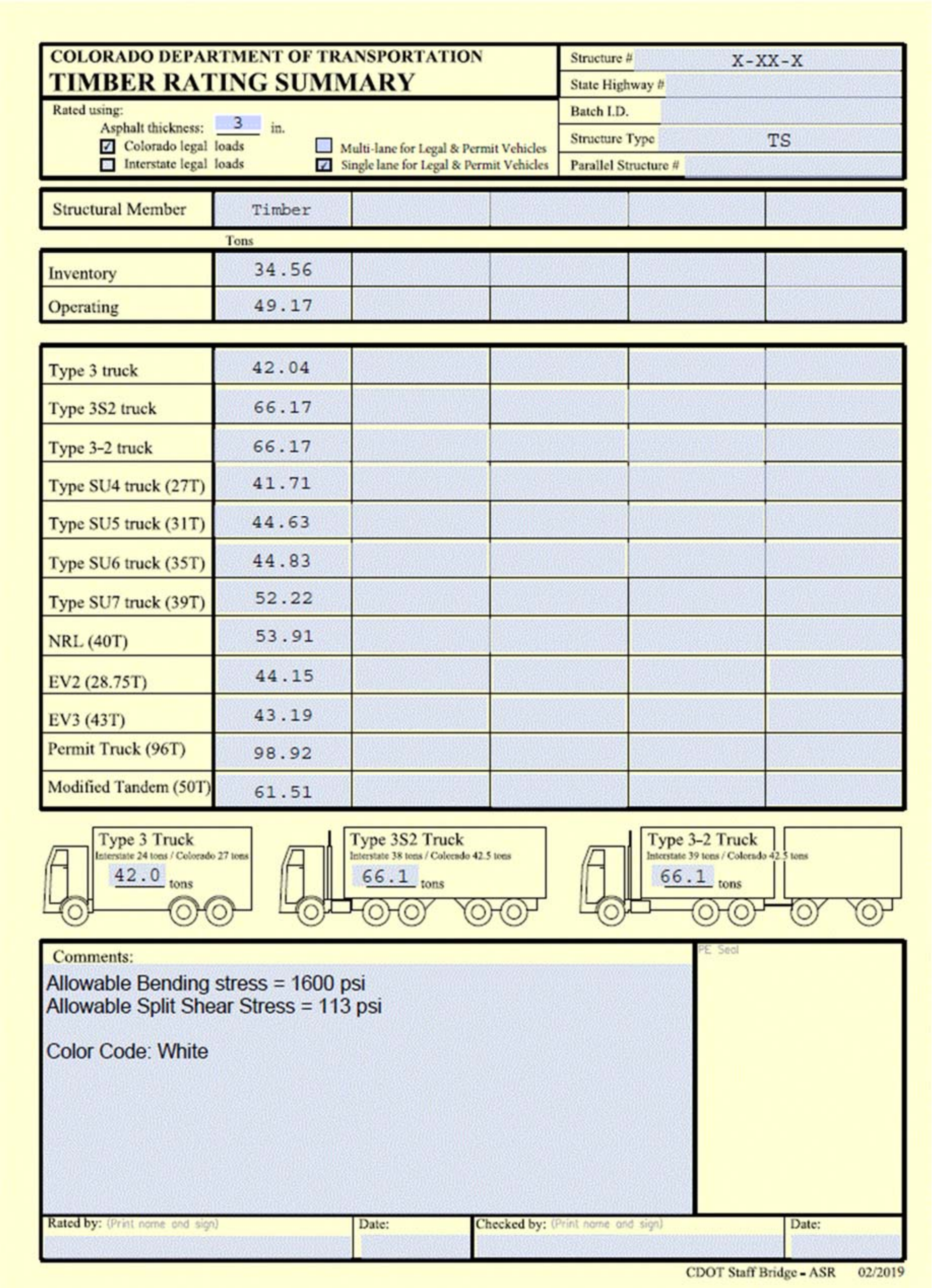
● Use Simplified Method ○ Use Advanced Method

☐ Allow distribution factors to be used to compute effects of permit loads with routine traffic

Action: Moment

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Distribution Factor (Lanes)	
				1 Lane	Multi-Lane
1	0.00	23.000	23.00	0.333	0.297

Rating results are shown below for the existing sound timber stringers in ASD and the new sister-beam in LRFR.



COLORADO DEPARTMENT OF TRANSPORTATION

TIMBER RATING SUMMARY

Structure # X-XX-X
State Highway #
Batch I.D.
Structure Type TS
Parallel Structure #

Rated using:
Asphalt thickness: 3 in.
☑ Colorado legal loads
☐ Interstate legal loads
☐ Multi-lane for Legal & Permit Vehicles
☑ Single lane for Legal & Permit Vehicles

Structural Member	Timber				

Tons

Inventory	34.56				
Operating	49.17				

Type 3 truck	42.04				
Type 3S2 truck	66.17				
Type 3-2 truck	66.17				
Type SU4 truck (27T)	41.71				
Type SU5 truck (31T)	44.63				
Type SU6 truck (35T)	44.83				
Type SU7 truck (39T)	52.22				
NRL (40T)	53.91				
EV2 (28.75T)	44.15				
EV3 (43T)	43.19				
Permit Truck (96T)	98.92				
Modified Tandem (50T)	61.51				

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
42.0 tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
66.1 tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
66.1 tons

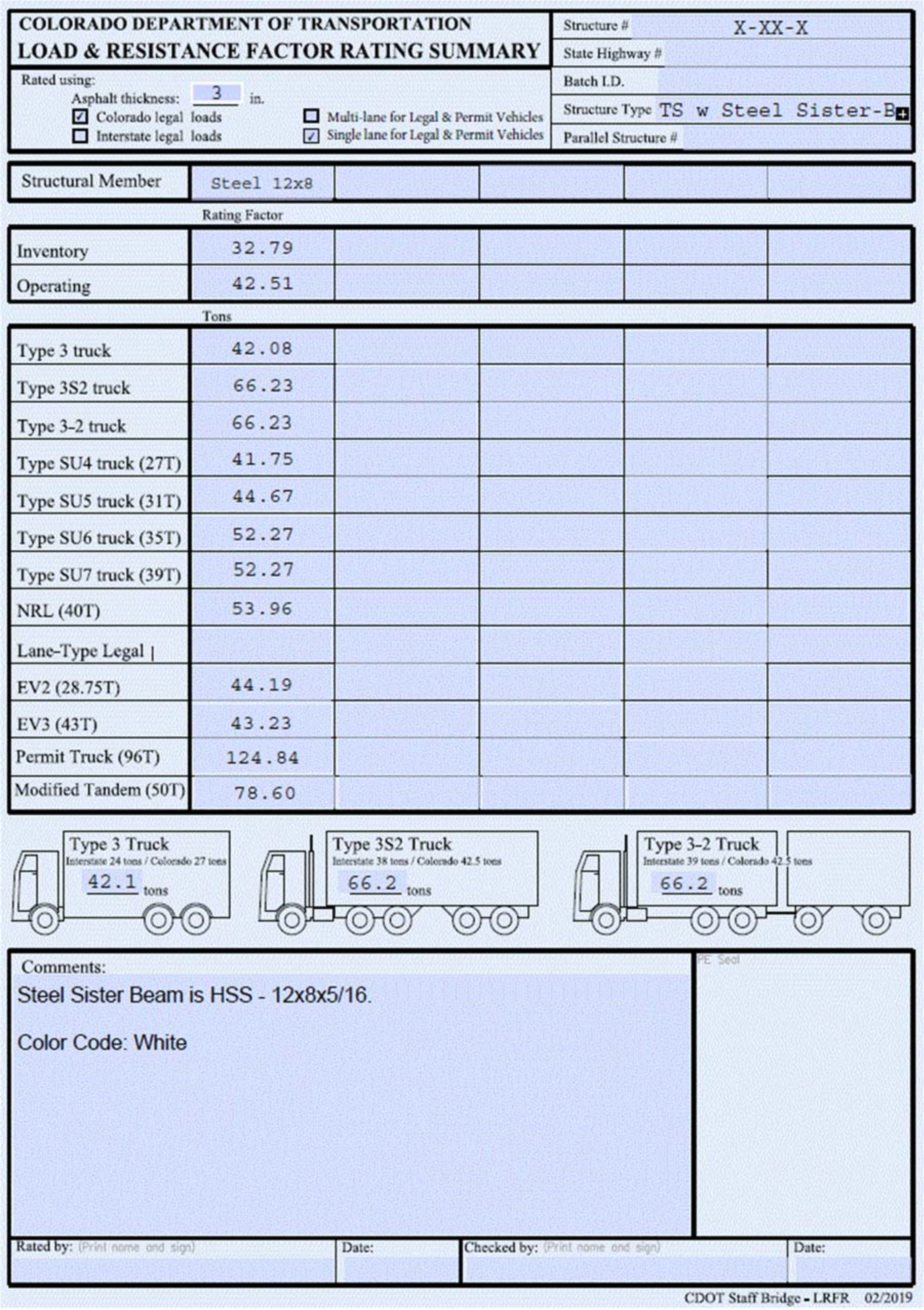
Comments:
Allowable Bending stress = 1600 psi
Allowable Split Shear Stress = 113 psi

Color Code: White

PE Seal

Rated by: (Print name and sign)
Date:
Checked by: (Print name and sign)
Date:

CDOT Staff Bridge - ASR 02/2019



COLORADO DEPARTMENT OF TRANSPORTATION
LOAD & RESISTANCE FACTOR RATING SUMMARY

Structure # X-XX-X
State Highway #
Batch I.D.
Structure Type TS w Steel Sister-B
Parallel Structure #

Rated using:
Asphalt thickness: 3 in.
☑ Colorado legal loads
☐ Interstate legal loads
☐ Multi-lane for Legal & Permit Vehicles
☑ Single lane for Legal & Permit Vehicles

Structural Member	Steel 12x8				
	Rating Factor				
Inventory	32.79				
Operating	42.51				
	Tons				
Type 3 truck	42.08				
Type 3S2 truck	66.23				
Type 3-2 truck	66.23				
Type SU4 truck (27T)	41.75				
Type SU5 truck (31T)	44.67				
Type SU6 truck (35T)	52.27				
Type SU7 truck (39T)	52.27				
NRL (40T)	53.96				
Lane-Type Legal						
EV2 (28.75T)	44.19				
EV3 (43T)	43.23				
Permit Truck (96T)	124.84				
Modified Tandem (50T)	78.60				

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
42.1 tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
66.2 tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
66.2 tons

Comments:
Steel Sister Beam is HSS - 12x8x5/16.

Color Code: White

PE Seal

Rated by: (Print name and sign)
Date:
Checked by: (Print name and sign)
Date:

CDOT Staff Bridge - LRFR 02/2019

SECTION 14
CONCRETE BOX CULVERT

14.1 INTRODUCTION TO RATING CONCRETE BOX CULVERTS

This section covers the rating of cast-in-place (CIP) concrete and pre- cast box culverts. All concrete box culverts are to be rated using the policies and guidelines of the Bridge Rating Manual, Section 1 and Subsections 14-2 and 14-3.

The rating of other culverts is discussed in Section 14A.

When there are no plans available for the concrete box culverts being rated, the requirements in Subsection 1.7, and 14.2 (III) shall be used.

For CBC extension projects, the rating process shall follow the CDOT Bridge Rating Manual, Section 1-17.

The types of rigid culverts covered by this section are:

CBC	- Concrete Box Culvert
PCBC	- Concrete Box Culvert, Pre-Cast

The types of culverts not covered by this section are:

AAC	- Aluminum Arch Culvert
CAC	- Concrete Arch Culvert
RCPC	- Reinforced Concrete Pipe Culvert
RAC	- Rubble Arch Culvert
SAC	- Steel Arch Culvert
TBC	- Timber Box Culvert
TTC	- Timber Culvert
CMP	- Corrugated Metal Pipe

14.2 POLICIES AND GUIDELINES FOR RATING CONCRETE BOX CULVERTS

14.2.1 General

A. All existing ASD & LFD CBCs shall be rated or rerated with LFR or LRFR methods, All LRFD CBCs shall be rated with LRFR method

B. All major concrete box culverts (i.e. length greater than 20' between inside faces of outside walls) shall be rated by the AASHTOWARE BrR program. The Rater shall verify with the Staff Bridge Rating Coordinator that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower, or higher version of the program shall be rejected, except if approved by the Bridge Rating Engineer. Programs other than AASHTOWARE BrR must be approved in advance by the Bridge Rating Engineer. If CDOT standard plans (i.e. M-601-1, M-601-2 and M-601-3) are used in the design, the BrR xml files for each type and size of CBC are available and can be provided by Staff Bridge if requested.

C. Inventory and operating Design Load Rating levels shall be performed for the HS20-44 loading when LFR method is used and the HL93 loading when LRFR method is used. Also, the Legal Load Rating and Permit Load Rating levels shall comply with BRM subsection 1.2.

> Note: For LFR live load distribution factors refer to "The AASHTO Standard Specifications", "The AASHTO Manual for Bridge Evaluation", and the "AASHTO LRFD/LRFR/LFD Culvert Method of Solution Manual."
>
> For LRFR live load distribution factors refer to "The AASHTO LRFD Specifications", "The AASHTO Manual for Bridge Evaluation", the "AASHTO LRFD/LRFR/LFD Culvert Method of Solution Manual."

D. When the depth of the fill exceeds 8.0 feet and exceeds the clear span for a single-cell culvert or exceeds the distance between interior faces of the outer walls for a multiple-cell culvert, live load analysis is not required. For how to report the load ratings, see the BRM subsection 1.14, but an xml file still required. The controlling depth of fill shall be recorded on the Rating Summary Sheet with the notation "live load is negligible".

14.2.2 Calculations

A. A set of calculations, separate from computer output, shall be submitted with each rating package. These calculations shall include derivations for dead loads and any other calculations or assumptions used for rating.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.
2. Dead loads include fill, curbs, sidewalks, railing, etc.

C. Use the minimum design yield strength value Fy and the minimum compressive strength of concrete F'c from plans if not shown refer to Section 1.5.

14.2.3 Guidelines for using Engineering Judgement / Visual Rating

When performing visual ratings, either the Rating Engineer or the Rating Checker shall be a Colorado Registered Professional Engineer.

The following provides guidelines for visual ratings:

Step 1: Pull the structure folder.

Step 2: Look for plans in the folder that are sufficient to perform the rating analysis. If the folder has plans that completely detail the reinforcement as well as notes that call out a specific design fill height together with all corresponding sheets from the M-Standard (if the culvert was designed using the CDOT M-Standard); the structure shall be rated using the AASHTOWARE BrR (formerly Virtis, preferred software), Brass Culvert or other approved program.

Step 3: Look at the fill height, item 66T on the SIA Sheet, and inspection sketch. Live load contribution through fill will be assumed as per the Bridge Rating Manual section 14.2.1(D).

Step 4: Look at the condition state, item 62 on the SIA sheet. In general NBI condition rating of 6 and above will not require a reduction in live load carrying capacity.

Step 5: Review the inspection notes and photos. Look for signs of live load deterioration such as:

- Essential repairs with any load restrictions.
- Transverse cracking that is breaking up, delaminating or spalling. Transverse cracking is cracking normal to the culvert span. These cracks could indicate a reduced shear or flexural capacity.
- Guidance on crack width will be taken from the Pontis coding guide. The Pontis coding guides states a crack width 3/32” or less will not significantly reduce strength. Cracks greater than 3/32” will warrant further analysis. Cracking longitudinal to the culvert span is typically due to shrinkage and differential settlement. Cracking longitudinal to the culvert span will not warrant further investigation.
- Pending essential repairs that affect the structural integrity.
- Exposed rebar located in high moment and shear regions.
- Spalling not caused by debris impact.
- Spalling caused by debris impact in a high shear or high moment region.
- Excessive deflection noted in top/bottom slab and walls during inspection.
- Essential repairs with severe scour and settlement.

If clarification of inspection notes is necessary, the Rater or Rating Checker shall meet with the inspector to clear up any questions.

Step 6: If no live load carrying capacity reduction is warranted, fill out and sign the rating summary sheet. The numerical value will be based on section 1.7.2(B).
The following notes should appear on the rating summary sheet.

- Total structure length (Inside face to inside face of exterior walls).
- Fill height (shown in tenth of feet).
- Plans availability (yes, no or partial).

- Describe any load induced damage (if none, state none).List any pending essential repairs (if none, state none).
- NBI condition state coding for Item 62.
- Describe any damage that has a direct effect on load rating capacity (if none, state none). Also note the inspection date the distress as first identified.
- Color Code assignment.
- When Fill Height controls live load rating, use this note “Live load is negligible per section 14-2 of the CDOT Bridge Rating Manual.”
- “Visually Rated” will be noted in the Comments section of the Rating Summary Sheet.

Step 7: If live load reduction is required based the criteria in Step 5, the rater shall assign a reduced load rating as described in the Step 6. The rater shall document a color code recommendation along with the fill height, location and magnitude of distress. For on-system structures, this documentation shall be submitted to the Staff Bridge Rating Unit. The Staff Bridge Rating Unit will coordinate a review panel. At a minimum, this review panel shall consist of the Staff Bridge Engineer, Staff Bridge Rating Engineer and Staff Bridge Inspection Engineer. This panel will make the final decision on any live load restrictions.

Step 8: Turn the structure folder and rating summary sheet over to the checker for review. The checker shall verify compliance with steps 2 through 6 above. If satisfactory and in agreement, the checker shall sign the summary sheet. If it is not satisfactory, the checker will send comments to the rater and find agreement prior to signing.

Step 9: The checker shall follow the CDOT Bridge Rating Archiving Policy Memo before submitting the rating package to the Bridge Rating Unit.
The foregoing applies to off-system structures except for the review panel in step 7, the color code in step 6 and step 9.

14.3 RATING REPORTING AND PACKAGING REQUIREMENTS

14.3.1 Rating Reporting / Package Requirements

A. A copy of the AASHTOWare BrR reinforcement schematic drawing showing the elevation and applied loads shall be included with the rating package.

B. The rater and checker shall complete the rating documentation (i.e. the rating QA checklist) as described in Section 1 of the Bridge Rating Manual. Any variation from the original design assumptions shall be added to the Rating Summary Sheet as applicable. The rating package requirements shall be per Section 1.13 of the Bridge Rating Manual and as amended here.

14.3.2 Consultant Requirements

A. Consultant designed projects – Before finalizing the rating package and when AASHTOWare BrR is used as the analysis tool, the Rater shall verify with the Staff Bridge that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower, or higher version of the program shall be rejected, except if approved by the Bridge Rating Engineer.

B. When the rating is finalized, the rater shall save the input files in ".xml" format. The file name shall include the structure number of the rated CBC (i.e., O-14-BY.xml). The rating package including input program file, Rating Summary Sheet and necessary computations in pdf shall be transmitted electronically to Staff Bridge for archiving.

14.4 CONCRETE BOX CULVERT RATING EXAMPLES

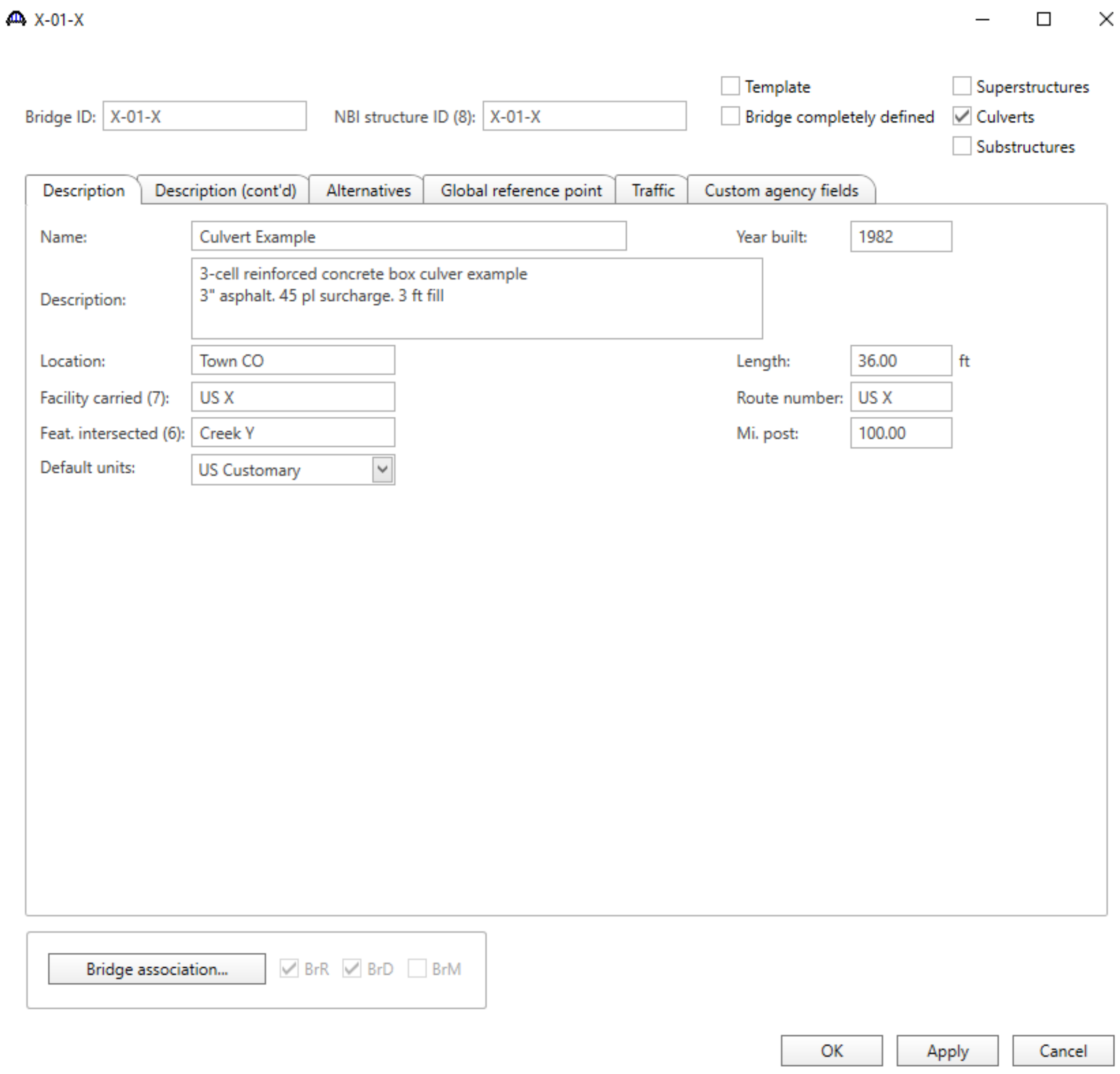
Two examples are presented in this section. First, Structure X-01-X is a 3-cell culvert with 3 feet of asphalt and fill. The structure has a 6 inch asphalt overlay. This structure is rated using a HS20-44 truck and lane live load, Colorado Permit Vehicle, Colorado Legal Type 3, 3S2, 3-2 vehicles, NRL, SU4 thru SU7 and EVs vehicles.

The second structure, X-02-X, is a single-cell culvert with a skew of 10° degrees. The culvert has 6 feet of fill. It also carries a 4 inch asphalt roadway. This structure is rated using a HL-93 truck and lane live load, Colorado Permit Vehicle, Colorado Legal Type 3, 3S2, 3-2 vehicles, NRL, SU4 thru SU7 and EVs vehicles.

14.4.1 AASHTOWare BrR Program - Version 7.2

Example 1 (LFR) – Structure No. X-01-X

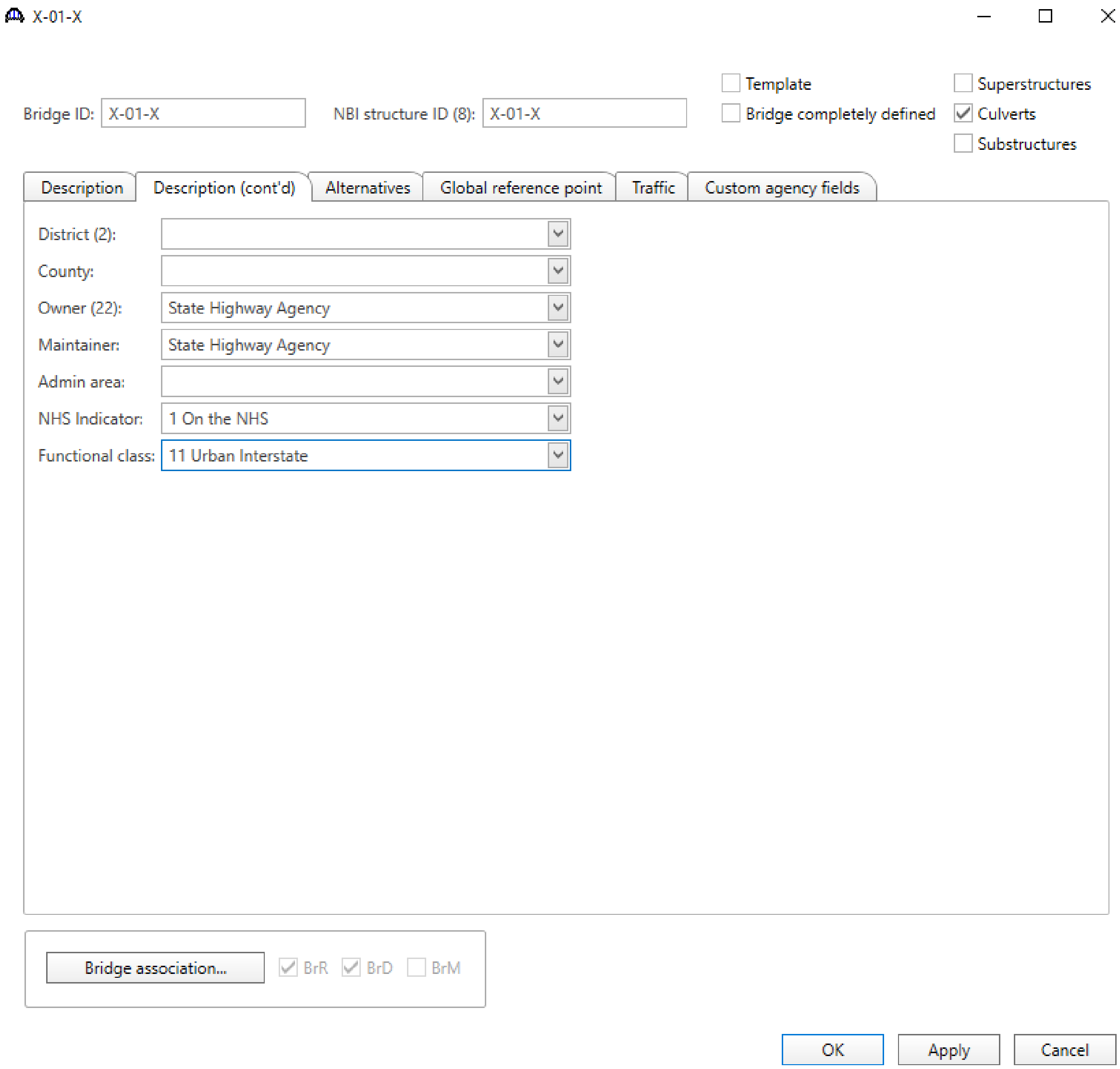
From the Bridge Explorer, select File | New | New Bridge to create a new bridge and then enter the following description information.



Bridge ID: X-01-X
NBI structure ID (8): X-01-X
☐ Template
☐ Bridge completely defined
☐ Superstructures
☑ Culverts
☐ Substructures

Name: Culvert Example
Year built: 1982
Description: 3-cell reinforced concrete box culver example
3" asphalt. 45 pl surcharge. 3 ft fill
Location: Town CO
Length: 36.00 ft
Facility carried (7): US X
Route number: US X
Feat. intersected (6): Creek Y
Mi. post: 100.00
Default units: US Customary

☑ BrR ☑ BrD ☐ BrM



X-01-X

Bridge ID: X-01-X

NBI structure ID (8): X-01-X

☐ Template

☐ Bridge completely defined

☐ Superstructures

☑ Culverts

☐ Substructures

District (2):

County:

Owner (22): State Highway Agency

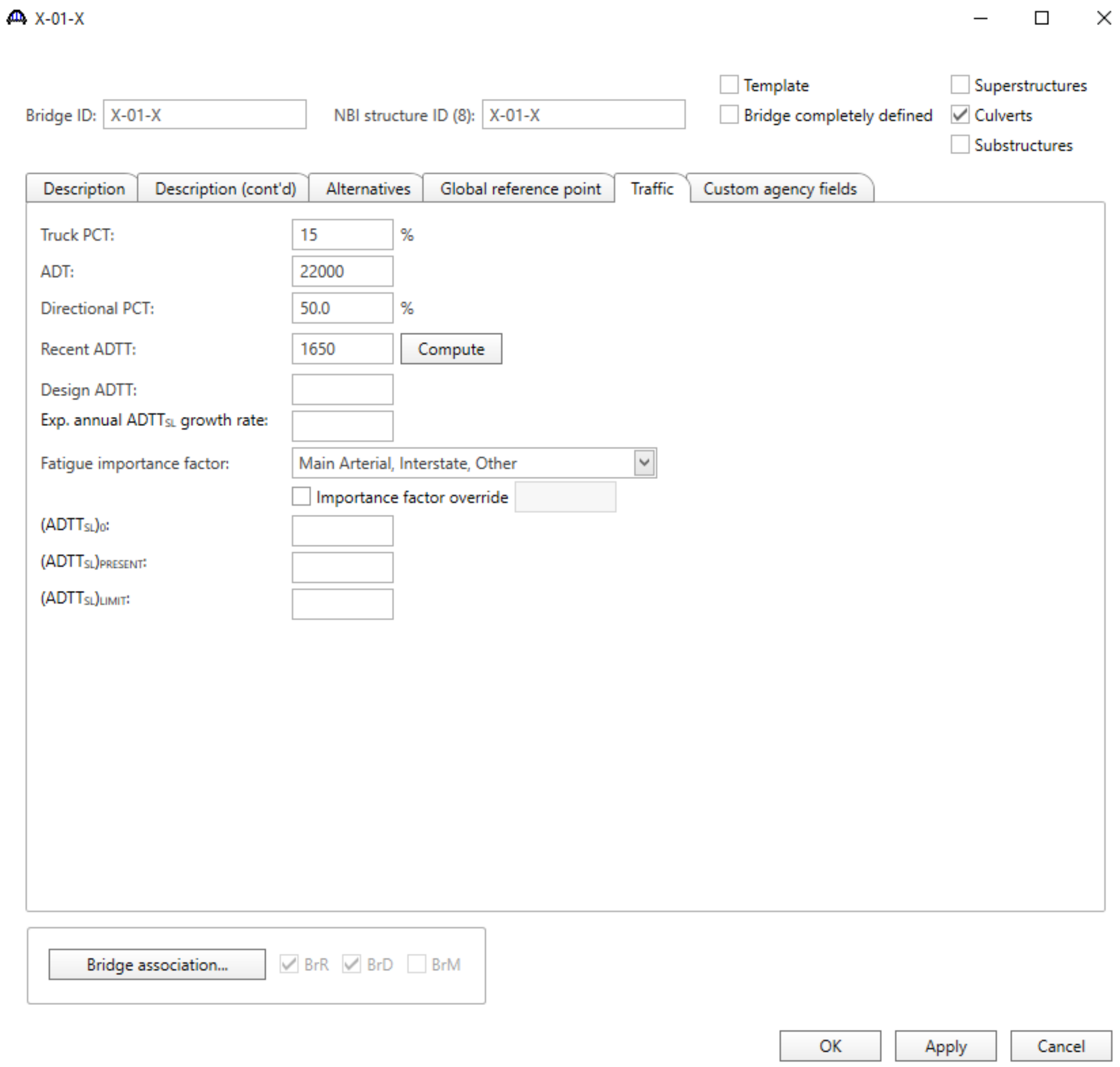
Maintainer: State Highway Agency

Admin area:

NHS Indicator: 1 On the NHS

Functional class: 11 Urban Interstate

☑ BrR ☑ BrD ☐ BrM



Bridge ID: X-01-X

NBI structure ID (8): X-01-X

☐ Template

☐ Bridge completely defined

☐ Superstructures

☑ Culverts

☐ Substructures

Truck PCT: 15 %

ADT: 22000

Directional PCT: 50.0 %

Recent ADTT: 1650

Design ADTT:

Exp. annual ADTT$_{SL}$ growth rate:

Fatigue importance factor: Main Arterial, Interstate, Other

☐ Importance factor override

(ADTT$_{SL}$)$_{0}$:

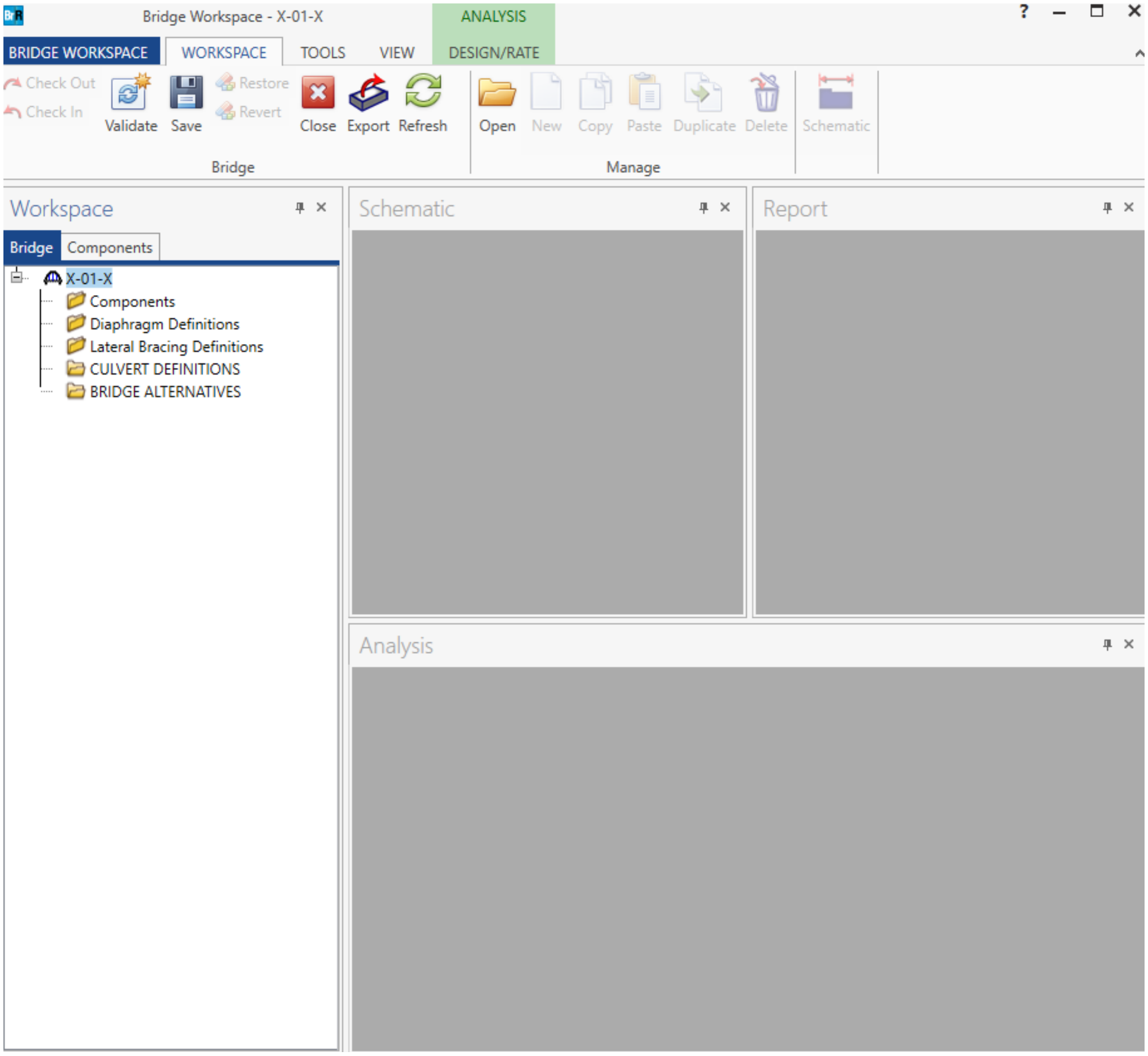
(ADTT$_{SL}$)$_{PRESENT}$:

(ADTT$_{SL}$)$_{LIMIT}$:

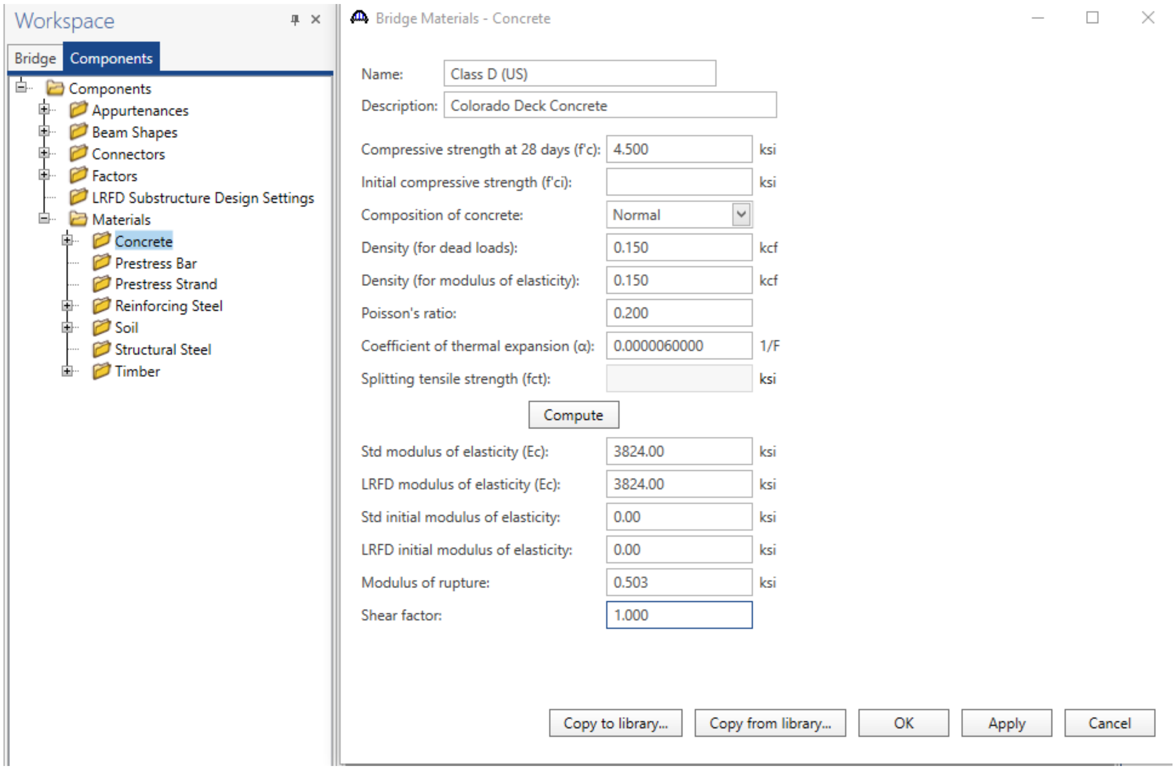
☑ BrR ☑ BrD ☐ BrM

Close the window by clicking OK. This saves the data to memory and closes the window.

The Bridge Workspace tree after the bridge is created is shown below:



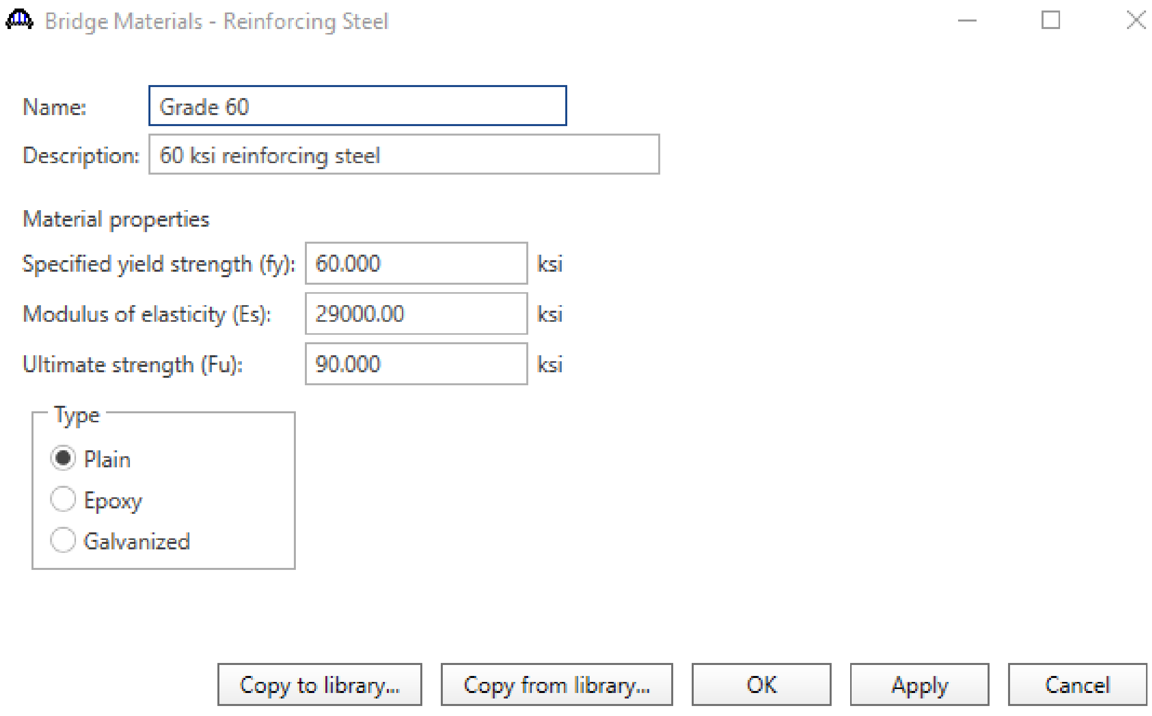
To enter the materials for the culvert, click on the Components and expand the tree for Materials. Double-click on the Concrete folder to create a new concrete material. Enter the following values.



Name: Class D (US)
Description: Colorado Deck Concrete
Compressive strength at 28 days (f'c): 4.500 ksi
Initial compressive strength (f'ci): ksi
Composition of concrete: Normal
Density (for dead loads): 0.150 kcf
Density (for modulus of elasticity): 0.150 kcf
Poisson's ratio: 0.200
Coefficient of thermal expansion (α): 0.0000060000 1/F
Splitting tensile strength (fct): ksi
Std modulus of elasticity (Ec): 3824.00 ksi
LRFD modulus of elasticity (Ec): 3824.00 ksi
Std initial modulus of elasticity: 0.00 ksi
LRFD initial modulus of elasticity: 0.00 ksi
Modulus of rupture: 0.503 ksi
Shear factor: 1.000

When plans are available, use the minimum concrete strength and yield strength values given in the plans. If plan values are not known, values given in Section 1 of the Bridge Rating Manual for the applicable year of construction may be followed.

Double-click on the Reinforcing Steel folder to create a new reinforcement material. Click on the Copy from Library button to copy the Grade 60 reinforcement material to the bridge.



Name: Grade 60

Description: 60 ksi reinforcing steel

Material properties

Specified yield strength (fy): 60.000 ksi

Modulus of elasticity (Es): 29000.00 ksi

Ultimate strength (Fu): 90.000 ksi

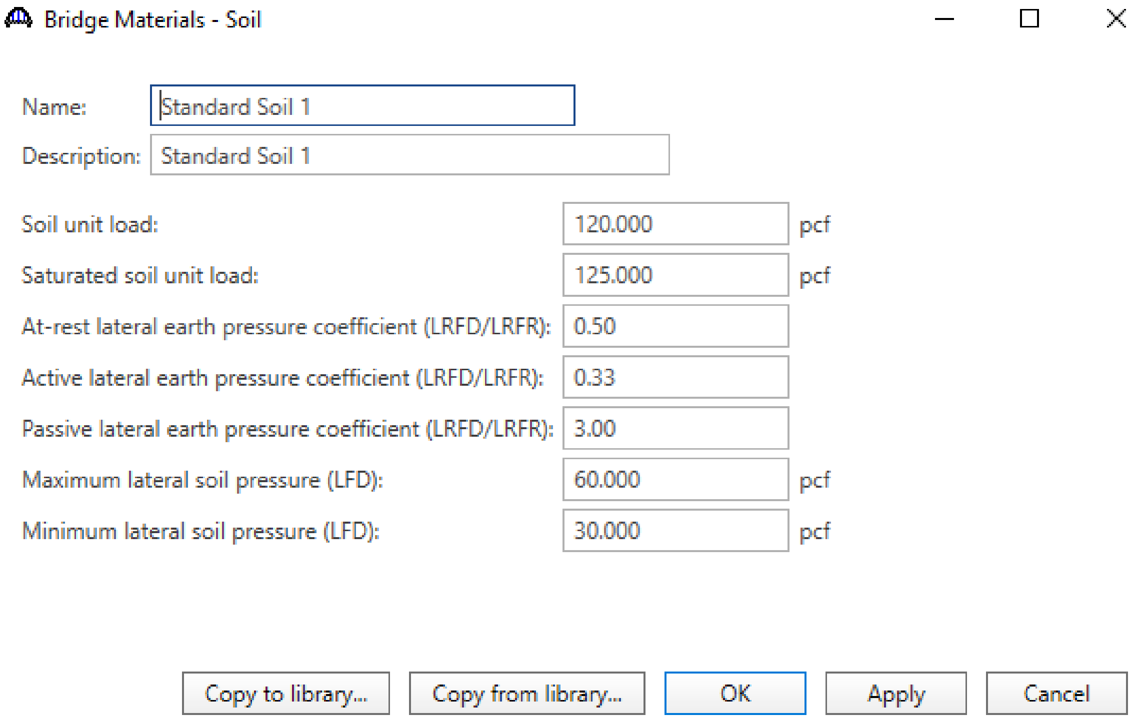
Type

● Plain

○ Epoxy

○ Galvanized

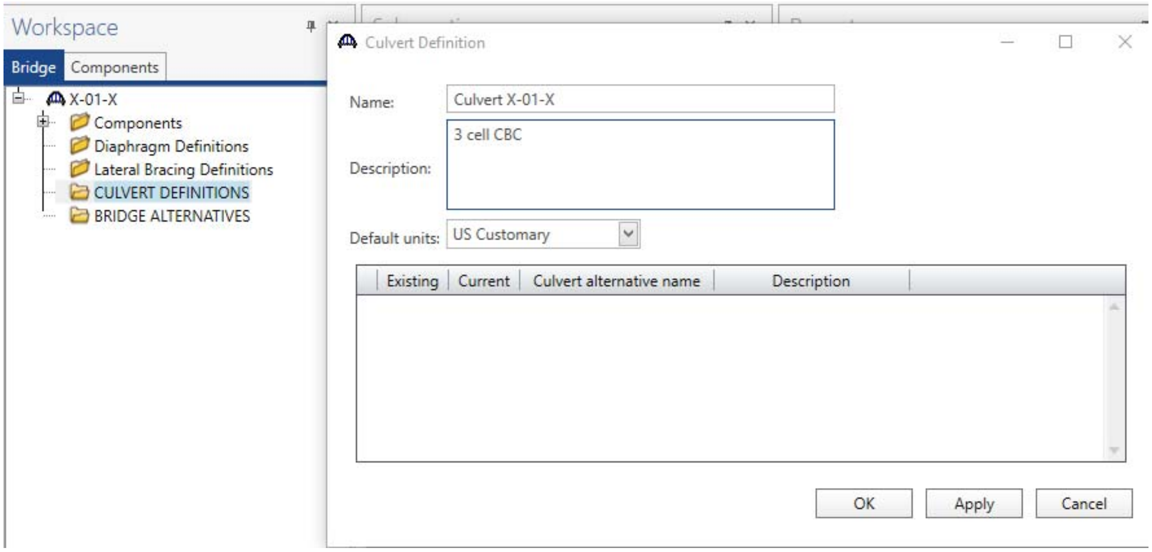
Double-click on the Soil folder to create a new soil material. Click on the Copy from Library button to copy the Standard Soil 1 material to the bridge (see Table 1-1 for Soil Material to use).



Name: Standard Soil 1
Description: Standard Soil 1
Soil unit load: 120.000 pcf
Saturated soil unit load: 125.000 pcf
At-rest lateral earth pressure coefficient (LRFD/LRFR): 0.50
Active lateral earth pressure coefficient (LRFD/LRFR): 0.33
Passive lateral earth pressure coefficient (LRFD/LRFR): 3.00
Maximum lateral soil pressure (LFD): 60.000 pcf
Minimum lateral soil pressure (LFD): 30.000 pcf

Standard Soil 1 uses for LFD and LRFD Specifications.
Standard Soil 2 uses for ASD Specification.

Double-click on the CULVERT DEFINITIONS folder to create a new culvert definition. Enter the Culvert Definition name as show below. The first Culvert Alternative that we create will automatically be assigned as the Existing and Current Culvert Alternative for this Culvert Definition.



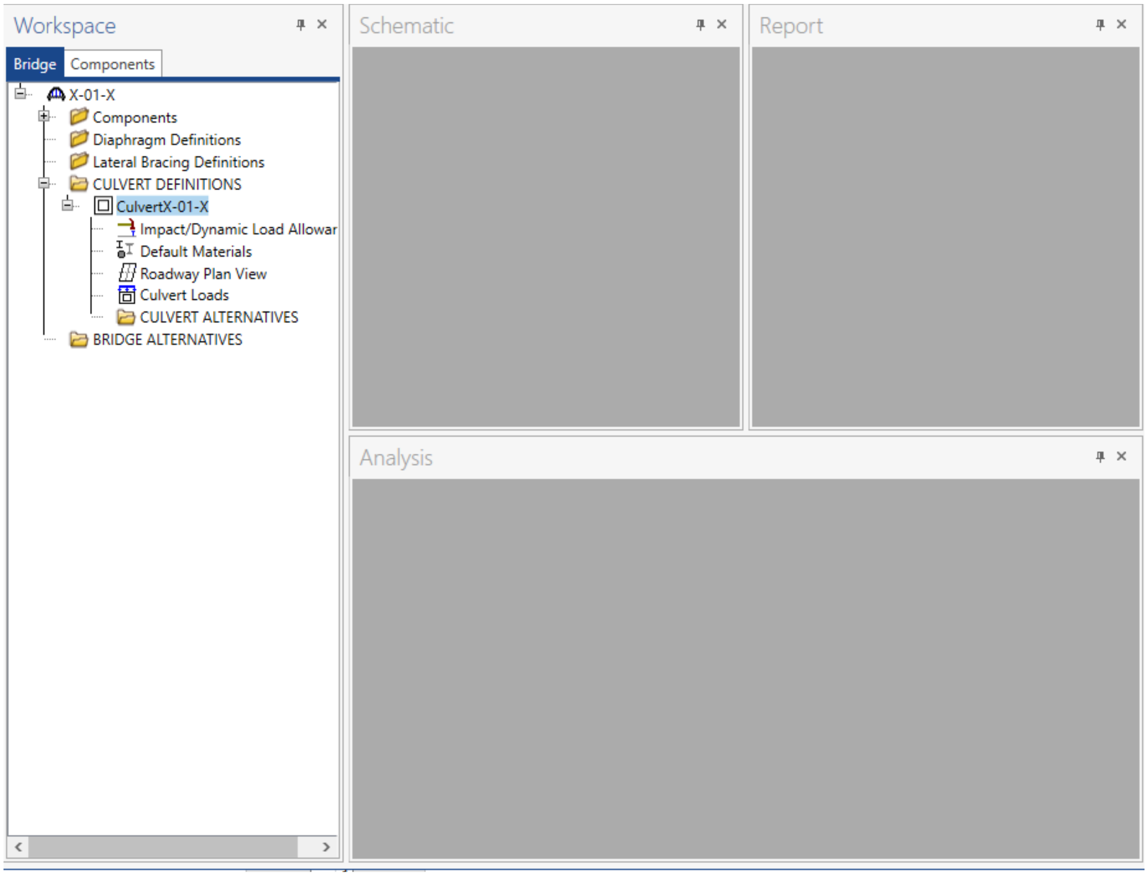
Name: Culvert X-01-X

Description: 3 cell CBC

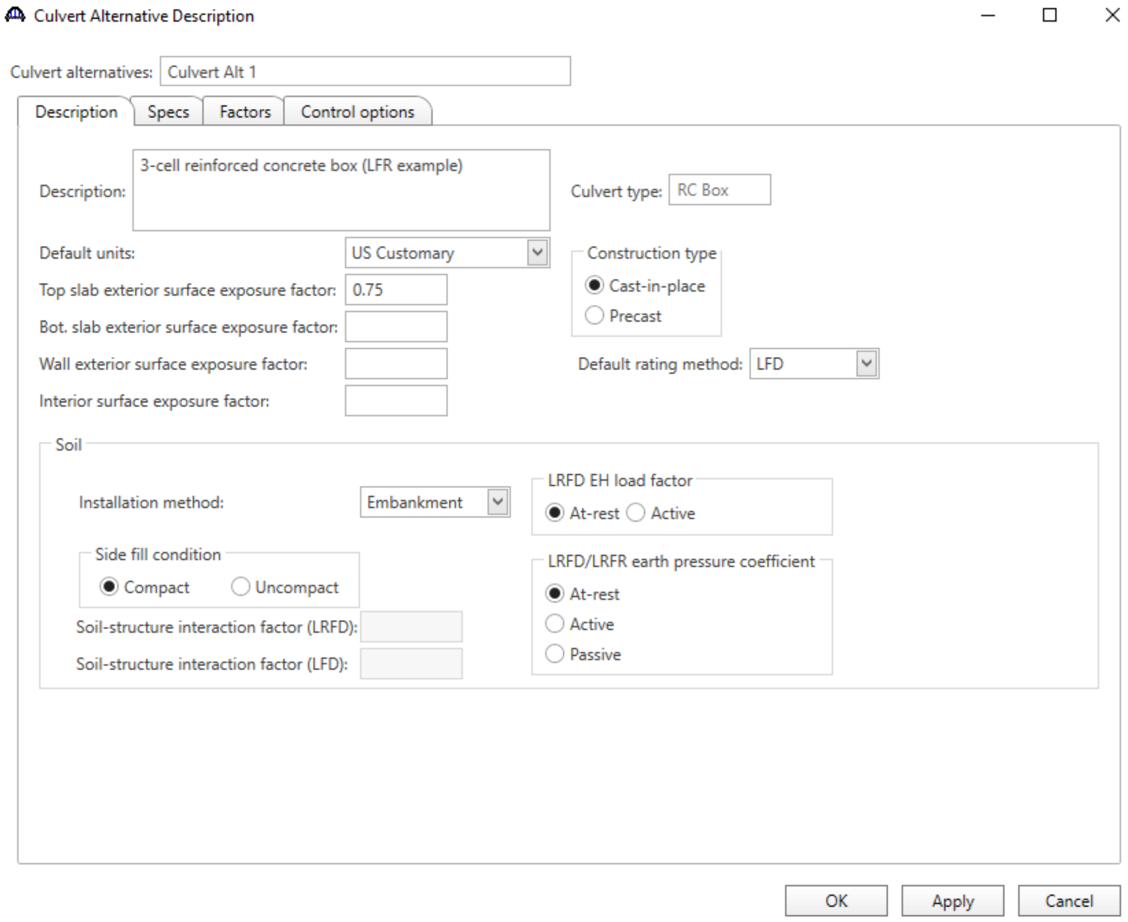
Default units: US Customary

Existing	Current	Culvert alternative name	Description

Expand the tree for Culvert Definition X-01-X.



Double-click on the CULVERT ALTERNATIVES folder to create a new culvert alternative for Culvert X-01-X. Enter the data as show below.



Culvert alternatives: Culvert Alt 1

Description: 3-cell reinforced concrete box (LFR example)

Culvert type: RC Box

Default units: US Customary

Top slab exterior surface exposure factor: 0.75

Bot. slab exterior surface exposure factor:

Wall exterior surface exposure factor:

Interior surface exposure factor:

Construction type

● Cast-in-place

○ Precast

Default rating method: LFD

Soil

Installation method: Embankment

LRFD EH load factor

● At-rest ○ Active

Side fill condition

● Compact ○ Uncompact

LRFD/LRFR earth pressure coefficient

● At-rest

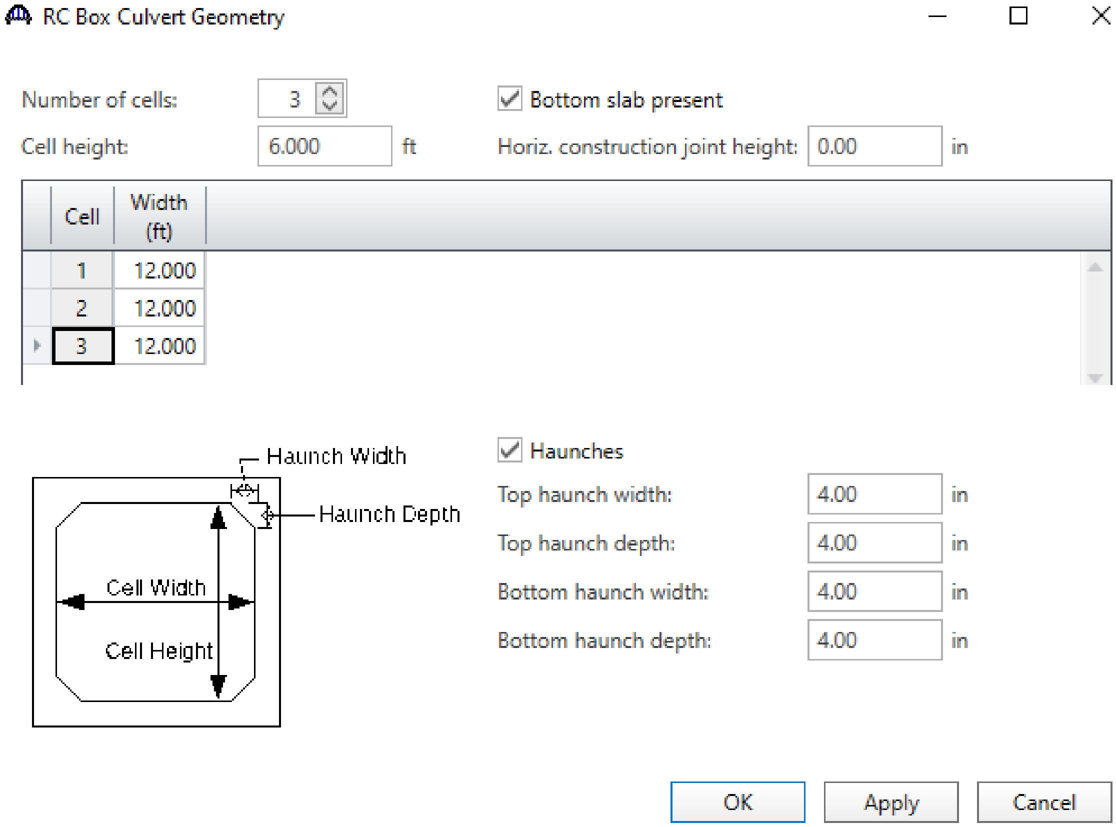
○ Active

○ Passive

Soil-structure interaction factor (LRFD):

Soil-structure interaction factor (LFD):

Expand the tree for Culvert Alt 1.
Double-click on RC Box Culvert Geometry in the tree. Enter the data as shown below.
Click Ok to save the data to memory and close the window.



RC Box Culvert Geometry

Number of cells: 3

☑ Bottom slab present

Cell height: 6.000 ft

Horiz. construction joint height: 0.00 in

Cell	Width (ft)
1	12.000
2	12.000
3	12.000

☑ Haunches

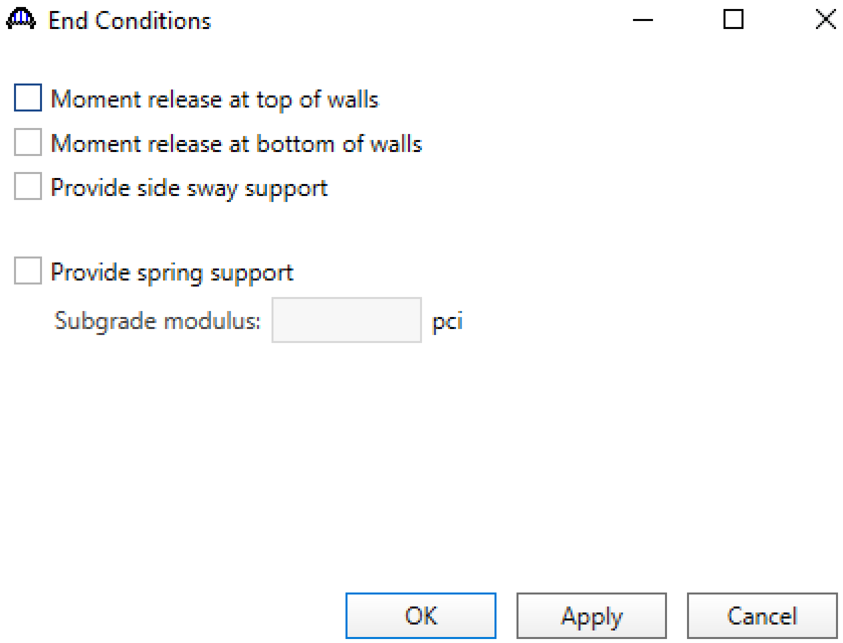
Top haunch width: 4.00 in

Top haunch depth: 4.00 in

Bottom haunch width: 4.00 in

Bottom haunch depth: 4.00 in

Double-click on End Conditions. Leave uncheck box if reinforcement is rigid. Spring support may be used if subgrade modulus is known. Click Ok to save the data to memory and close the window


End Conditions

☐ Moment release at top of walls

☐ Moment release at bottom of walls

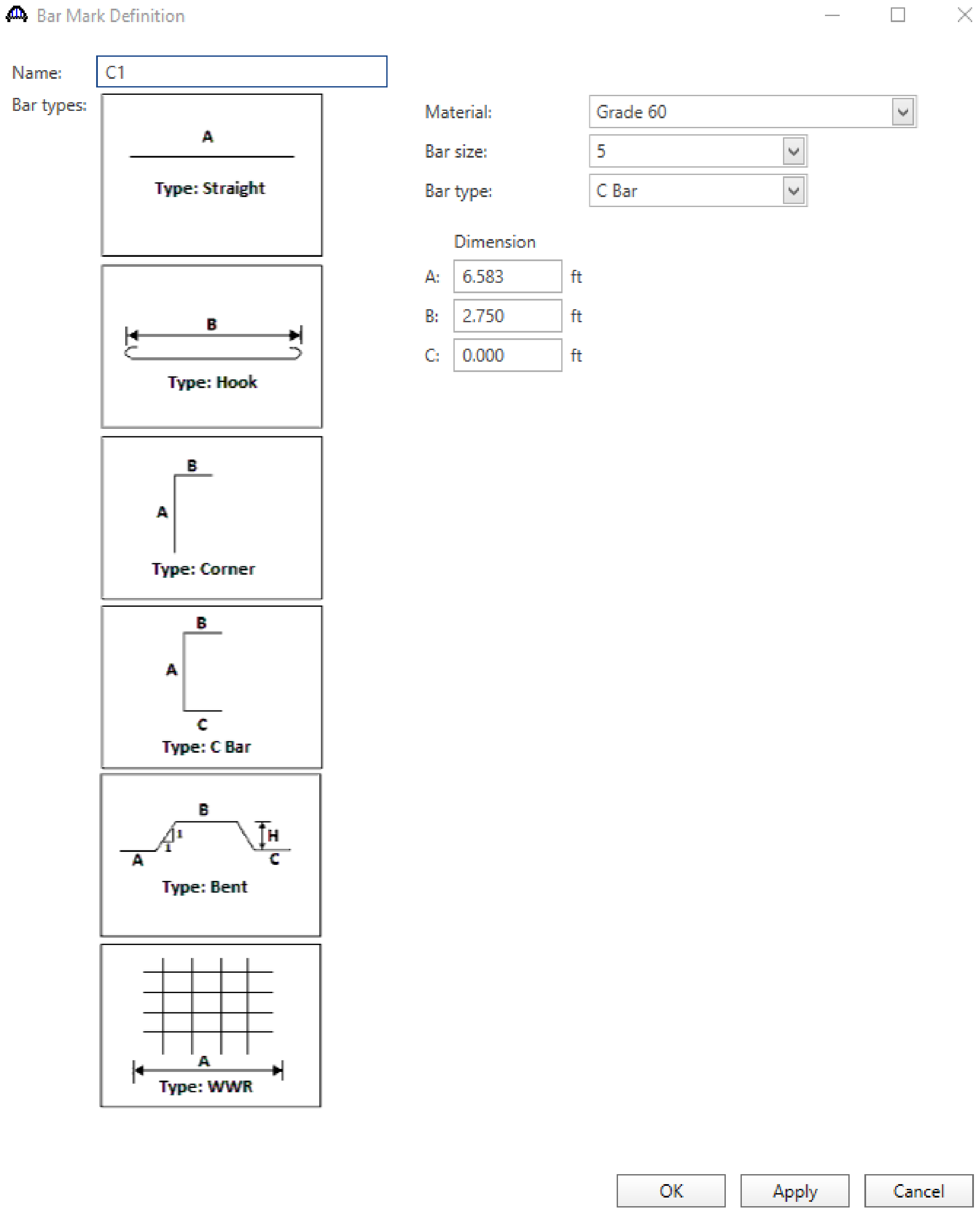
☐ Provide side sway support

☐ Provide spring support

Subgrade modulus: pci

Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

Enter the data for C1 as shown below. Click Ok to save the data to memory and close the window. Repeat the process for all bars (C2, W1, W2, W3, W4, B1, B2, T1, and T2) as shown.



Name: C1

Material: Grade 60

Bar size: 5

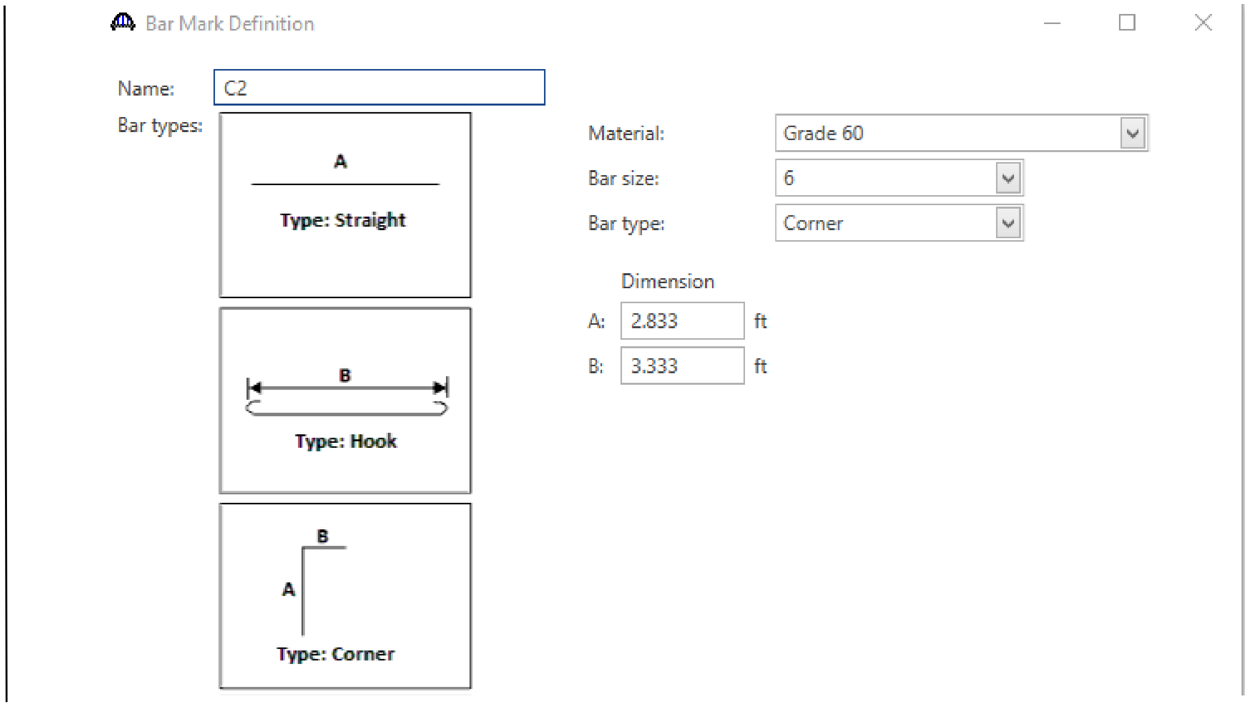
Bar type: C Bar

Dimension

A: 6.583 ft

B: 2.750 ft

C: 0.000 ft



Bar Mark Definition

Name: C2

Material: Grade 60

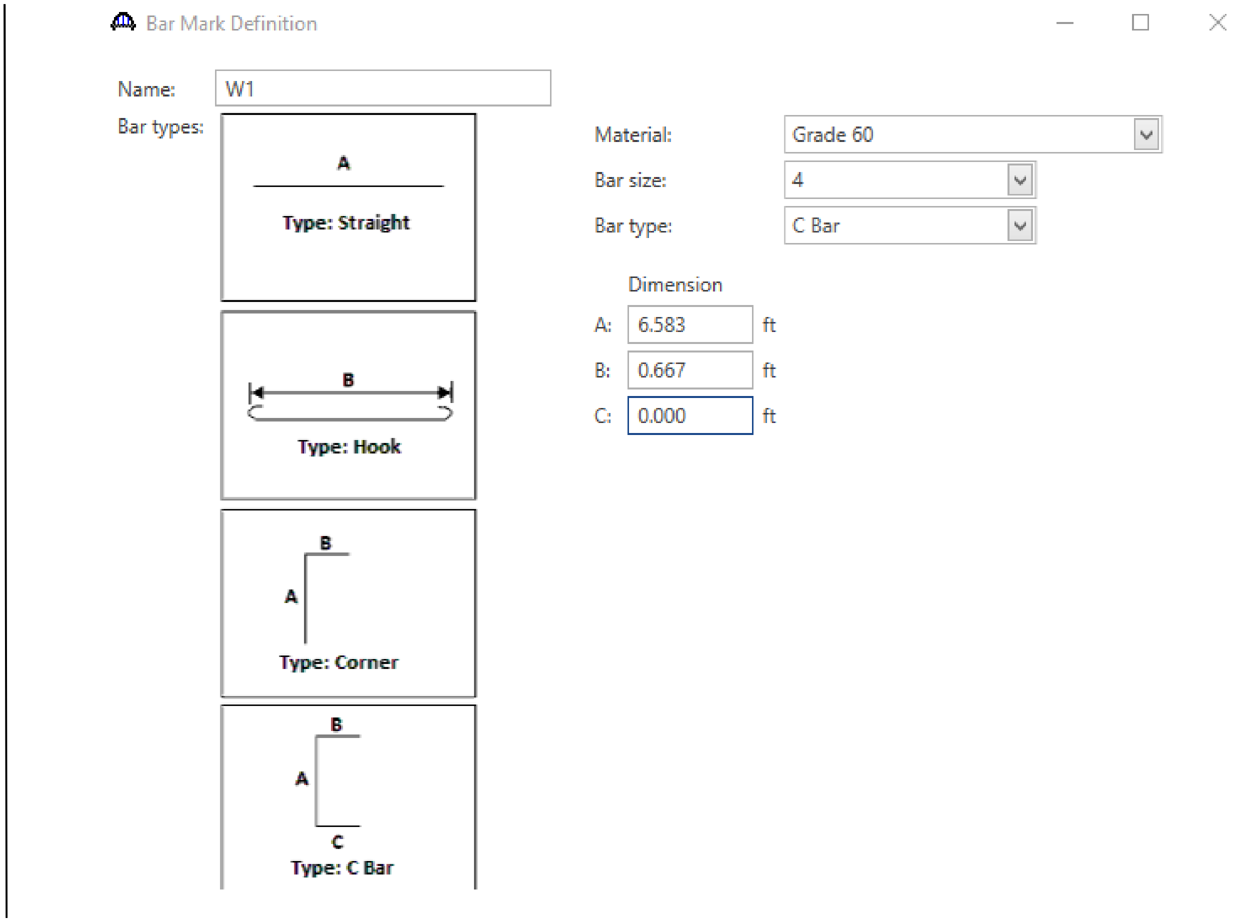
Bar size: 6

Bar type: Corner

Dimension

A: 2.833 ft

B: 3.333 ft



Bar Mark Definition

Name: W1

Material: Grade 60

Bar size: 4

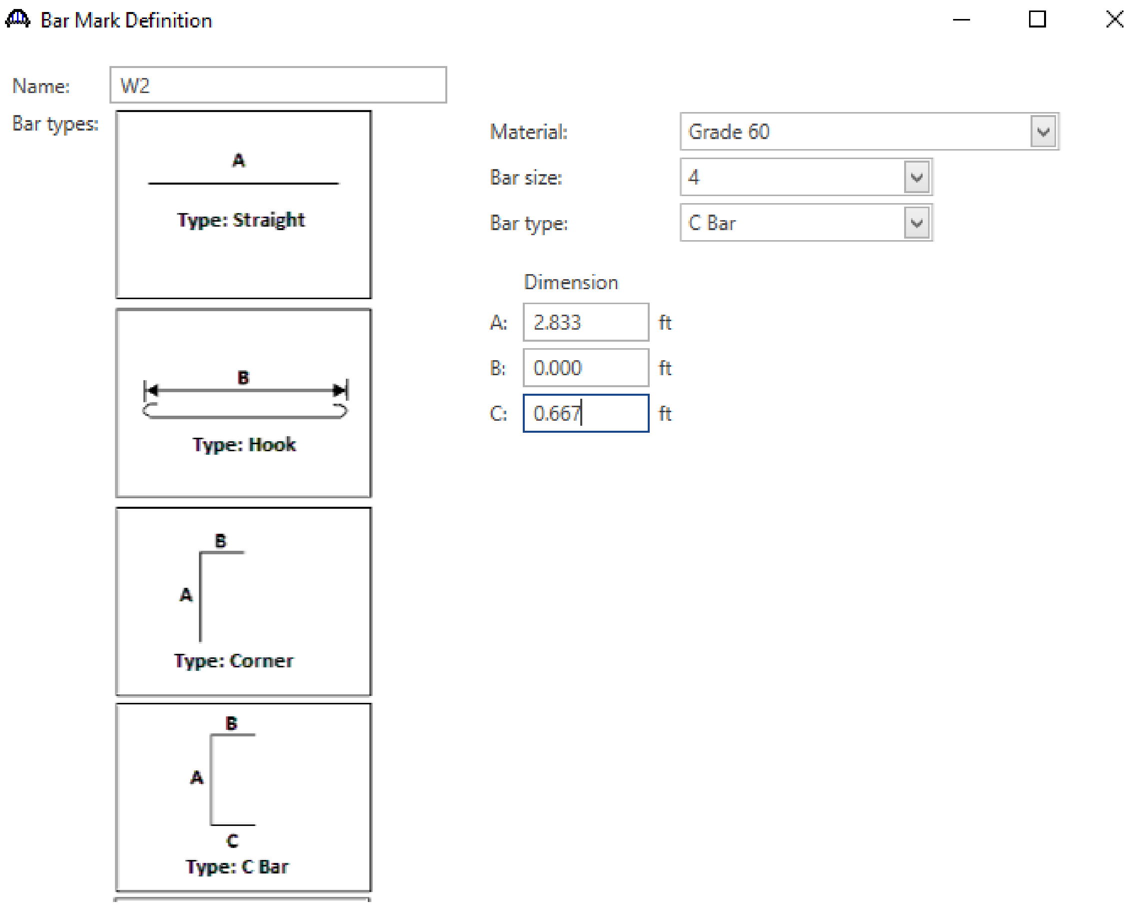
Bar type: C Bar

Dimension

A: 6.583 ft

B: 0.667 ft

C: 0.000 ft



Name: W2

Material: Grade 60

Bar size: 4

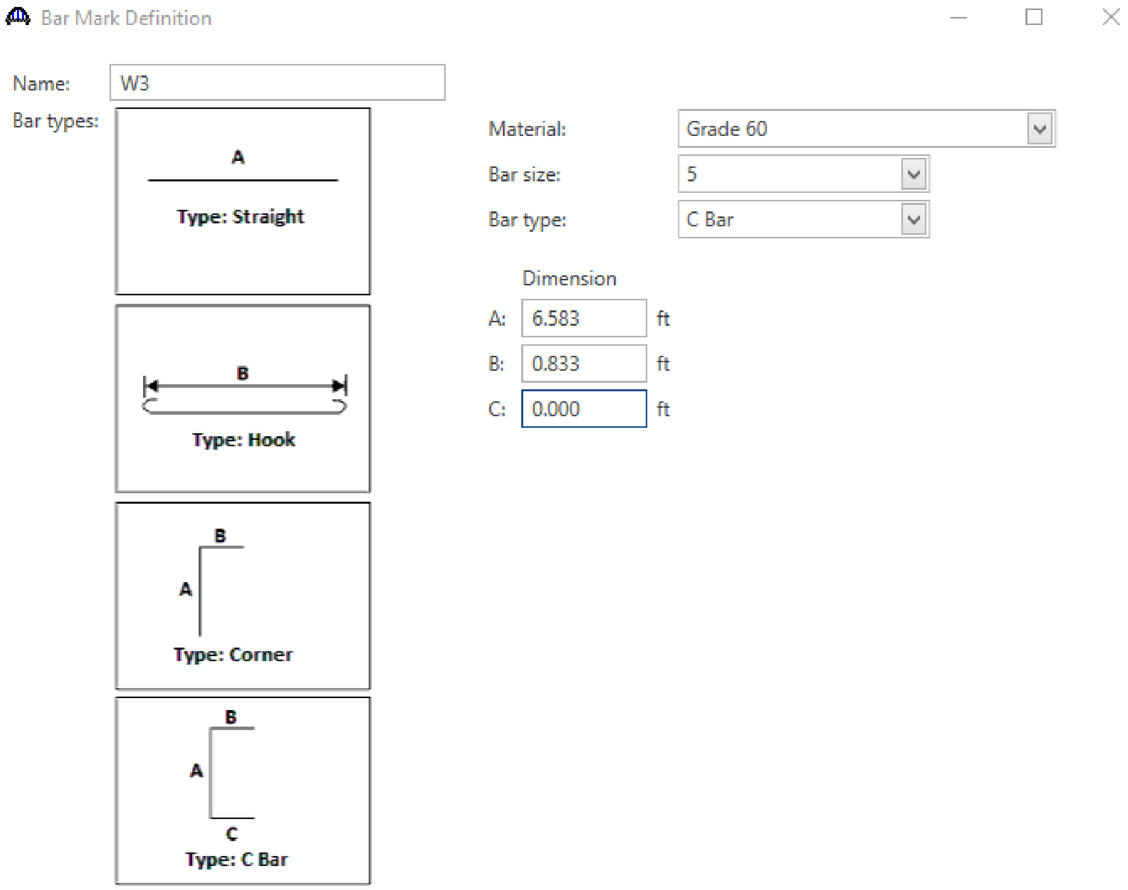
Bar type: C Bar

Dimension

A: 2.833 ft

B: 0.000 ft

C: 0.667 ft



Name: W3

Material: Grade 60

Bar size: 5

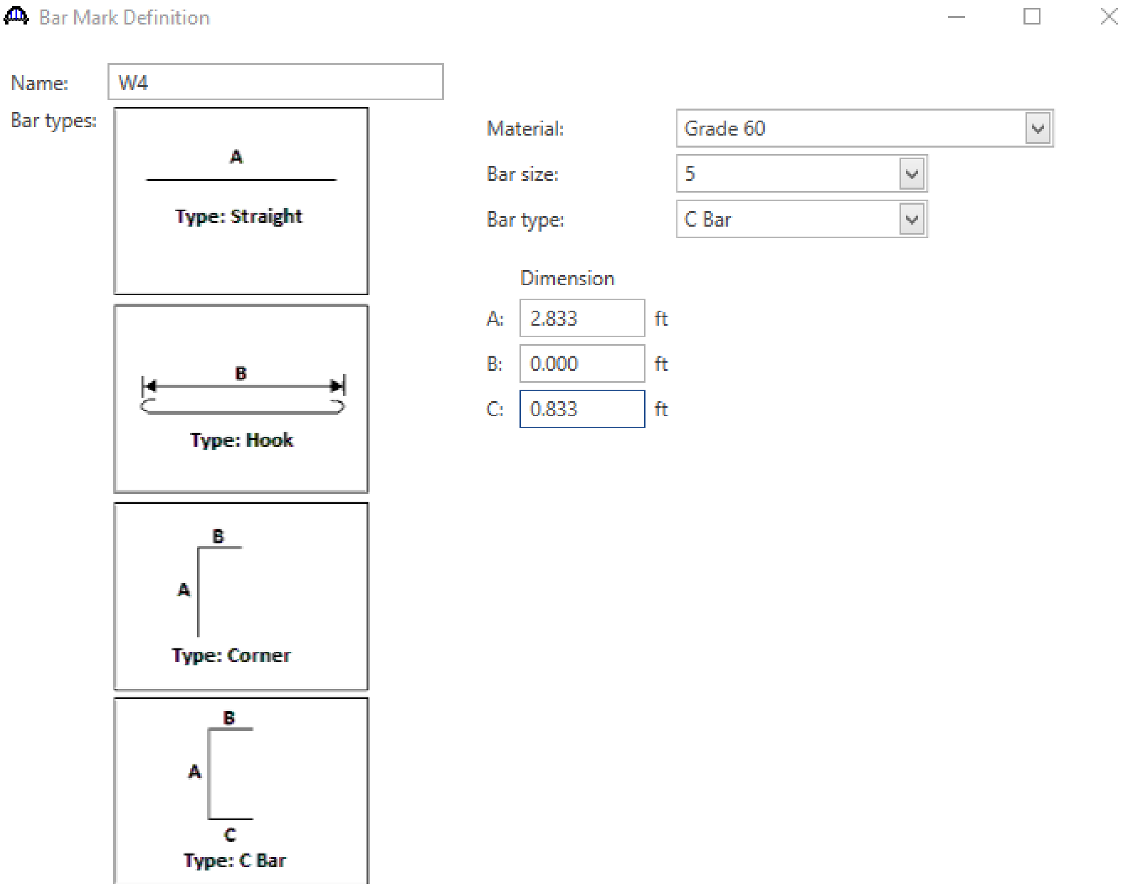
Bar type: C Bar

Dimension

A: 6.583 ft

B: 0.833 ft

C: 0.000 ft



Name: W4

Bar types:

Material: Grade 60

Bar size: 5

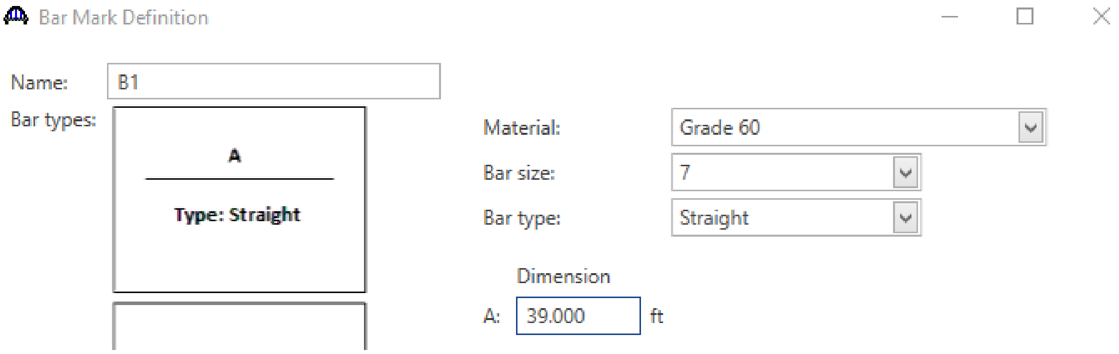
Bar type: C Bar

Dimension

A: 2.833 ft

B: 0.000 ft

C: 0.833 ft



Name: B1

Bar types:

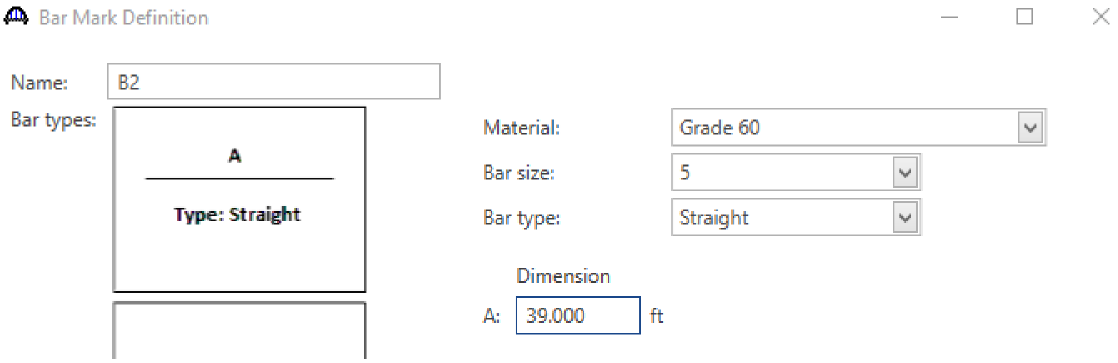
Material: Grade 60

Bar size: 7

Bar type: Straight

Dimension

A: 39.000 ft



Name: B2

Bar types:

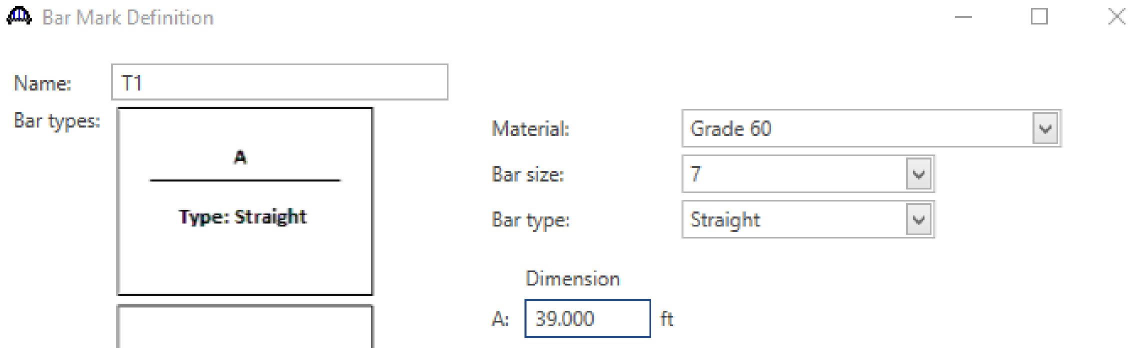
Material: Grade 60

Bar size: 5

Bar type: Straight

Dimension

A: 39.000 ft



Name: T1

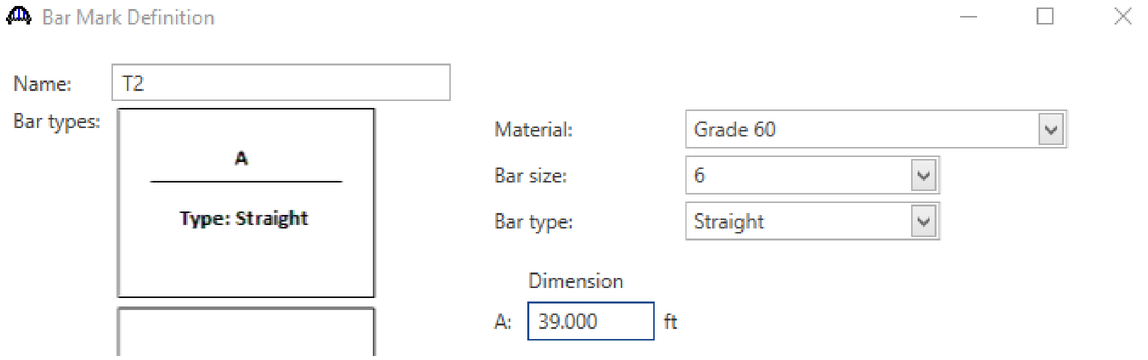
Bar types:

Material: Grade 60

Bar size: 7

Bar type: Straight

A: 39.000 ft



Name: T2

Bar types:

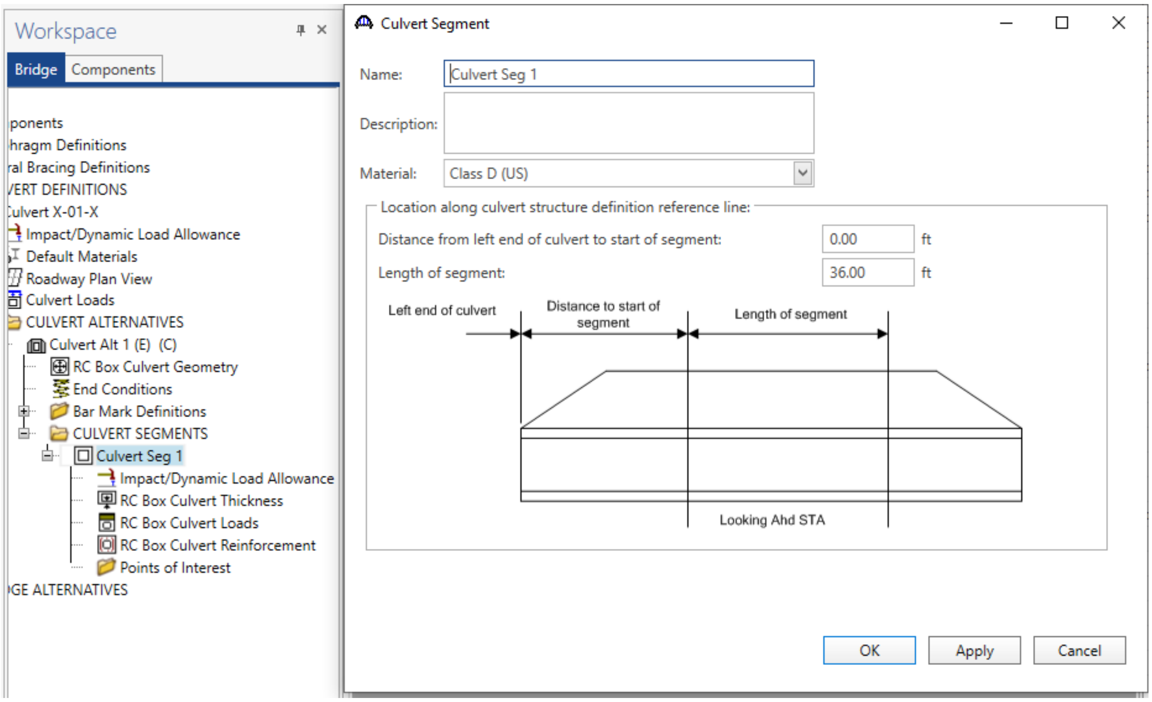
Material: Grade 60

Bar size: 6

Bar type: Straight

A: 39.000 ft

Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as shown below.


Name: Culvert Seg 1

Description:

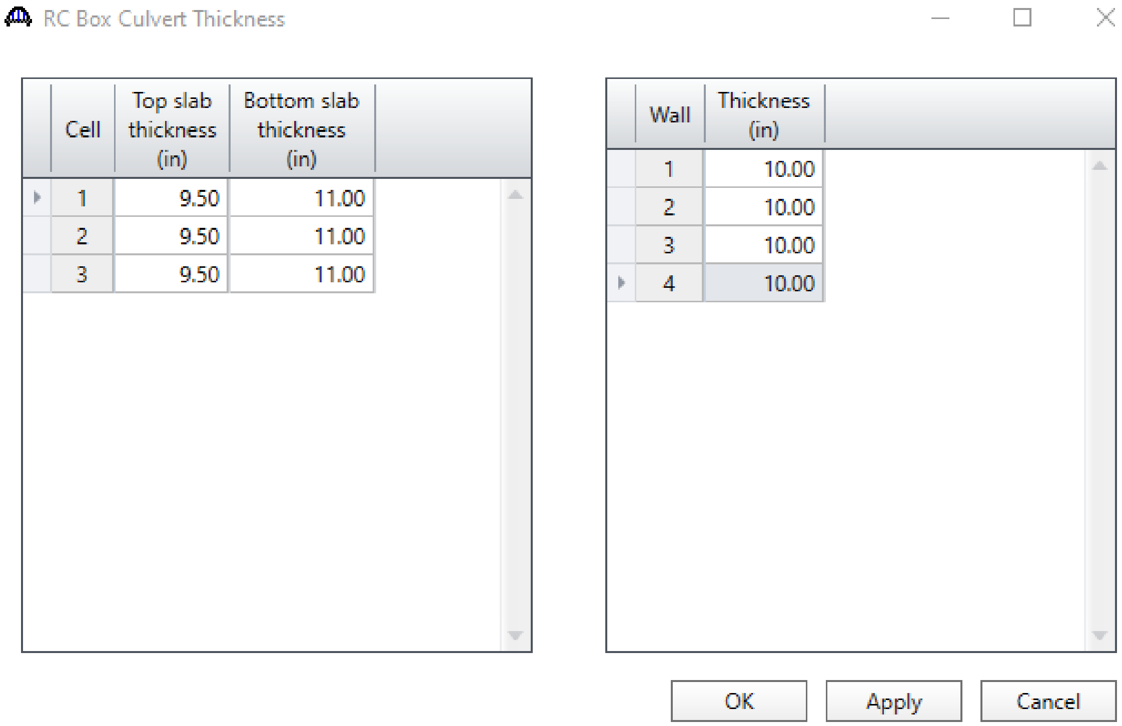
Material: Class D (US)

Location along culvert structure definition reference line:

Distance from left end of culvert to start of segment: 0.00 ft

Length of segment: 36.00 ft

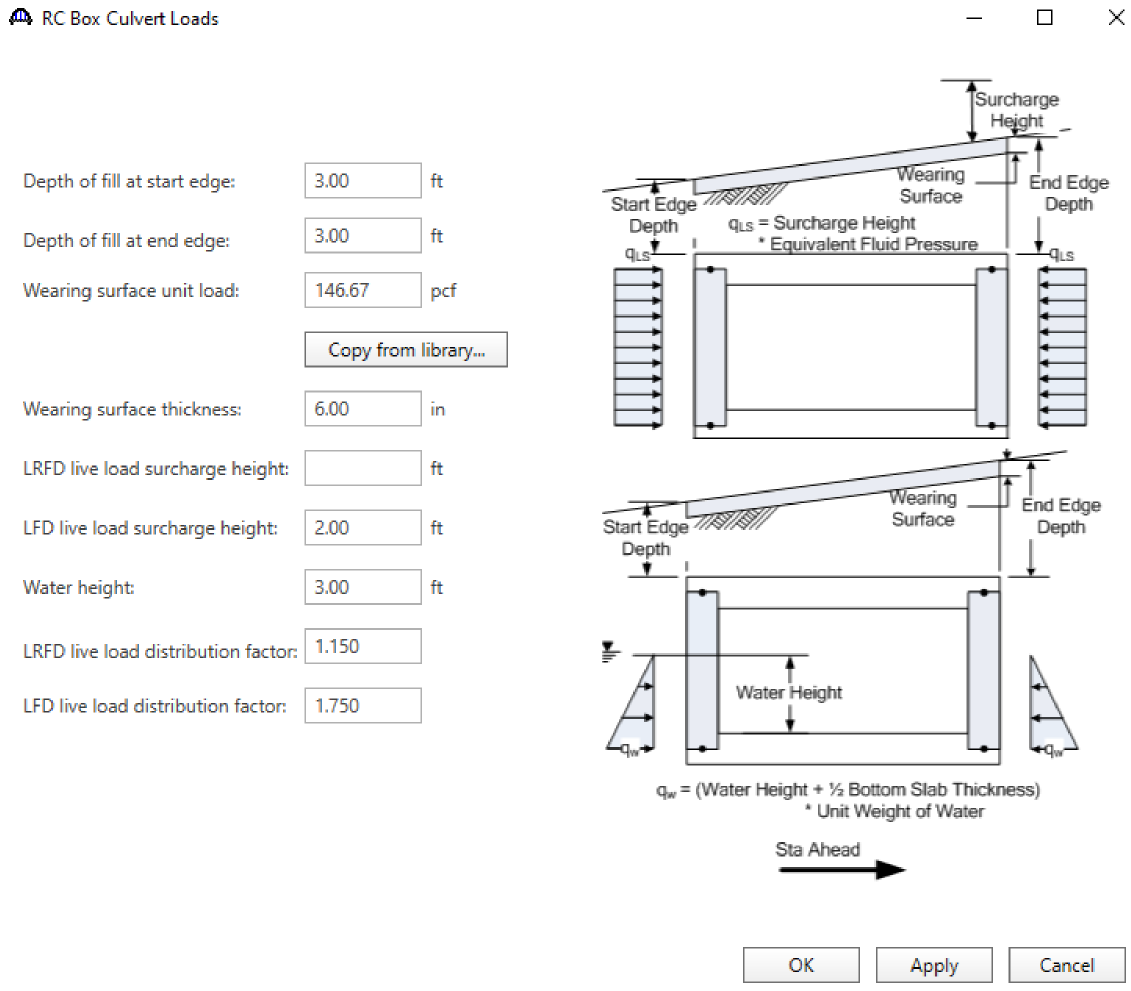
Expand the tree for Culvert Seg 1. Double-click on RC Box Culvert Thickness in the tree. Enter the slab and wall thicknesses as shown below. Click OK to save the data to memory and close the window.



Cell	Top slab thickness (in)	Bottom slab thickness (in)
1	9.50	11.00
2	9.50	11.00
3	9.50	11.00

Wall	Thickness (in)
1	10.00
2	10.00
3	10.00
4	10.00

Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. The wearing surface thickness includes the equivalent for the rail dead load. Click OK to save the data to memory and close the window.



RC Box Culvert Loads

Depth of fill at start edge: 3.00 ft

Depth of fill at end edge: 3.00 ft

Wearing surface unit load: 146.67 pcf

Wearing surface thickness: 6.00 in

LRFD live load surcharge height: ft

LFD live load surcharge height: 2.00 ft

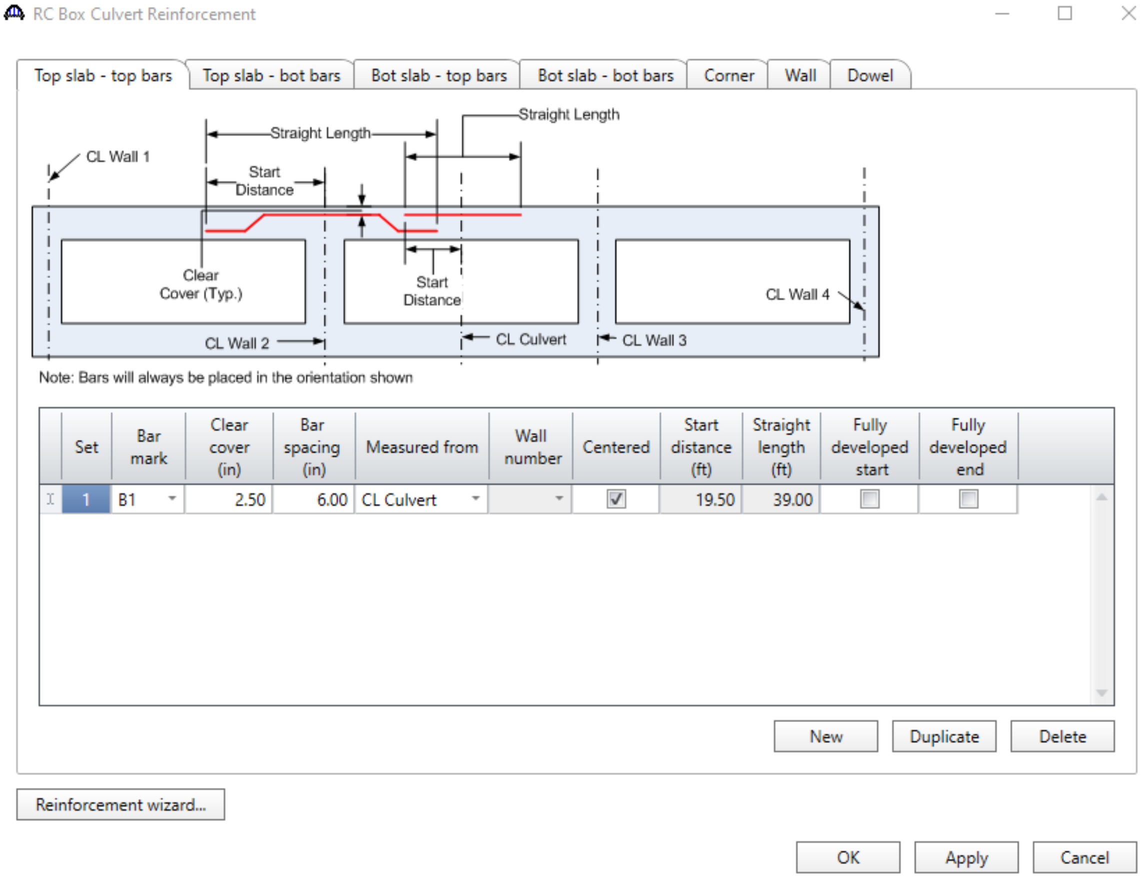
Water height: 3.00 ft

LRFD live load distribution factor: 1.150

LFD live load distribution factor: 1.750

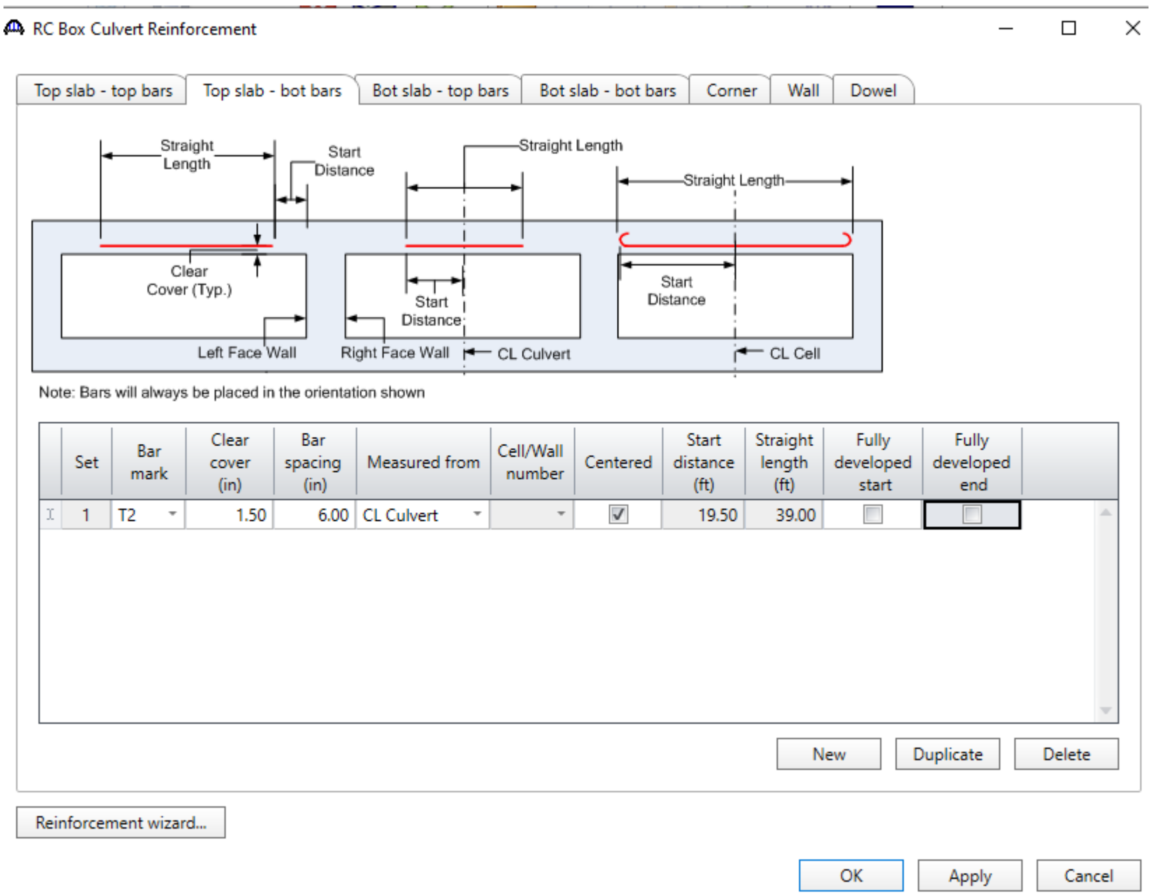
Use water height half the rise of the culvert.

Double-click on RC Box Culvert Reinforcement in the tree. Enter the reinforcement data as shown below for each location. Click Ok to save the data to memory and close the window.



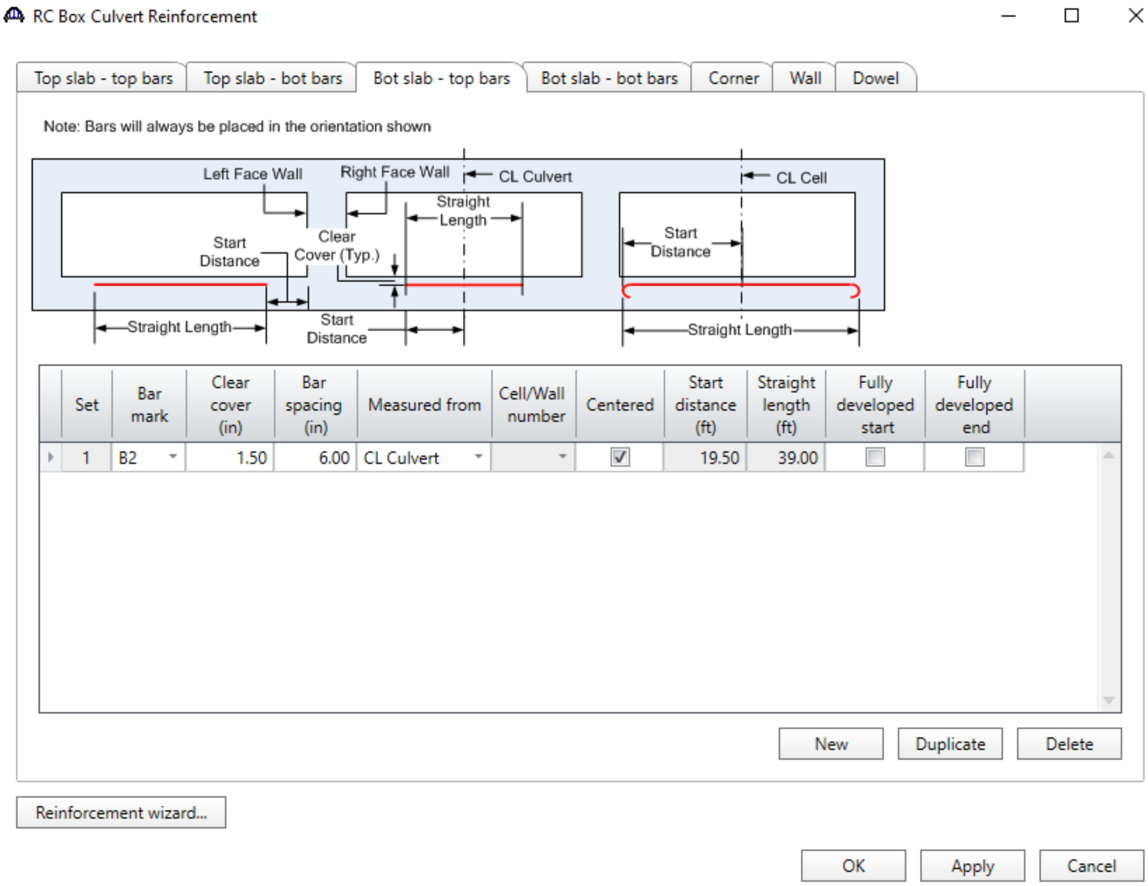
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	B1	2.50	6.00	CL Culvert		☑	19.50	39.00	☐	☐



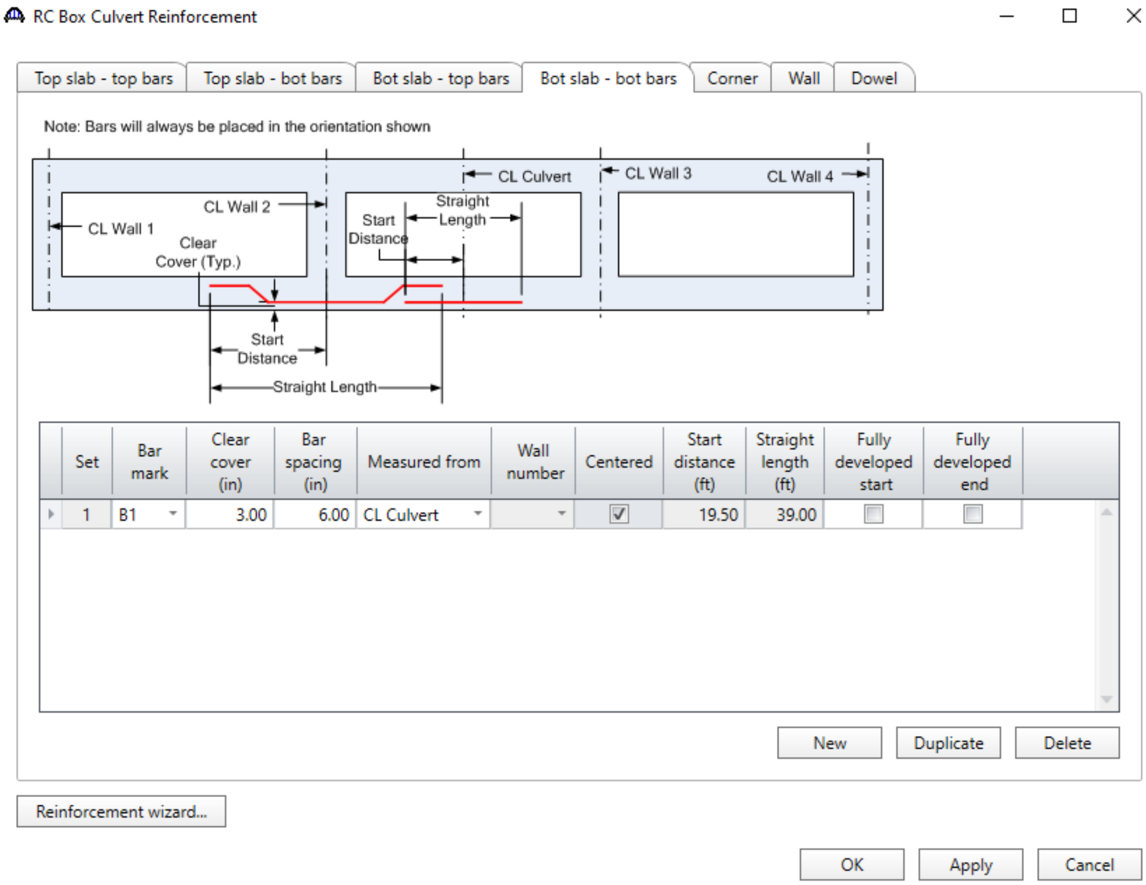
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Cell/Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	T2	1.50	6.00	CL Culvert		☑	19.50	39.00	☐	☐



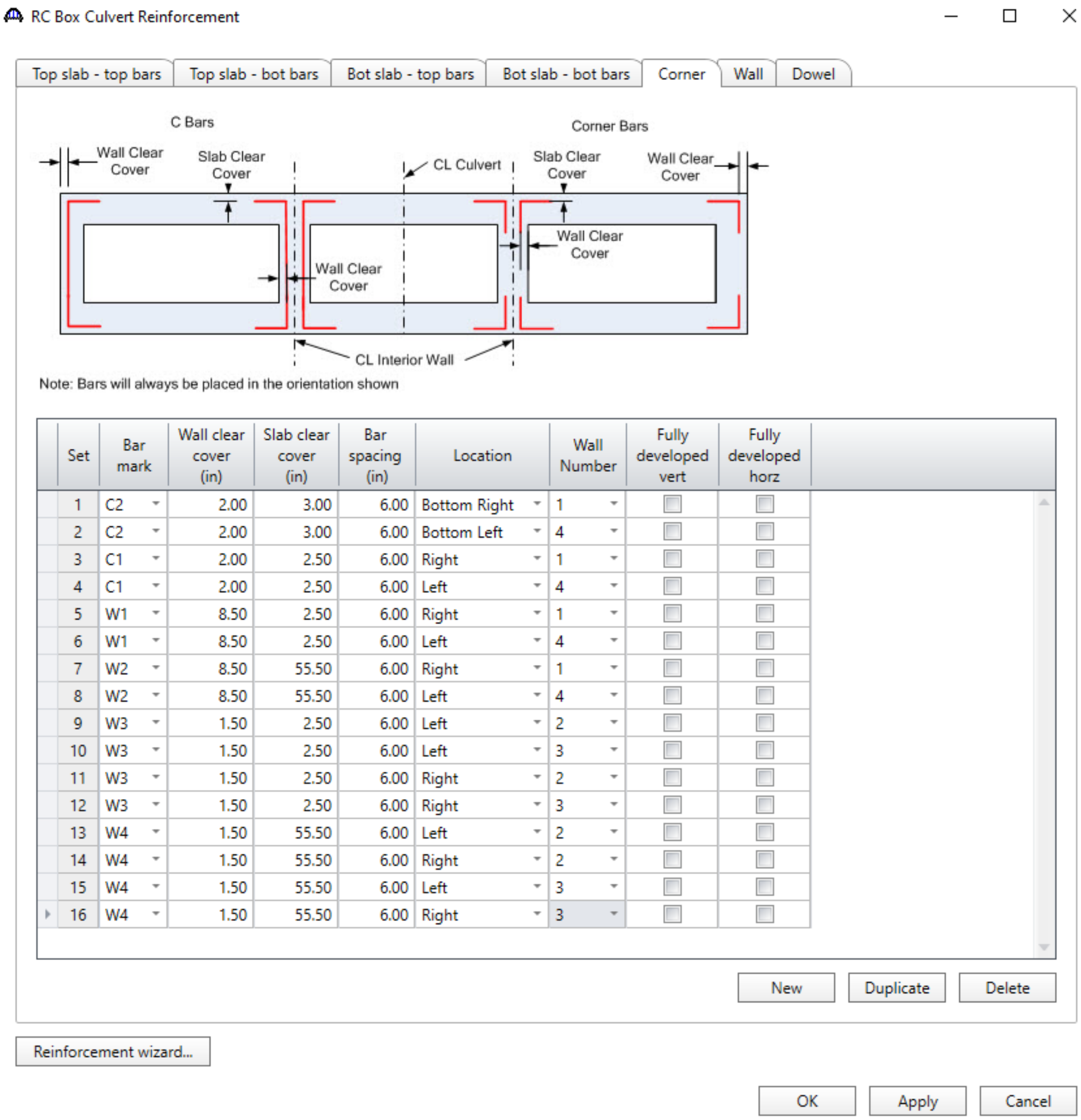
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Cell/Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	B2	1.50	6.00	CL Culvert		☑	19.50	39.00	☐	☐



Note: Bars will always be placed in the orientation shown

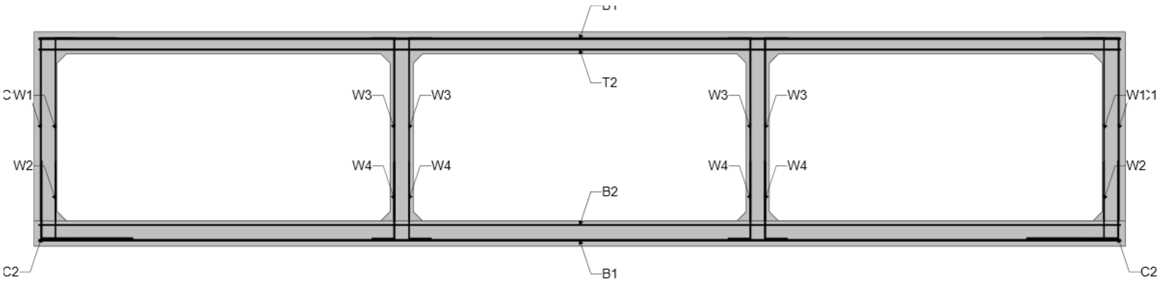
Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	B1	3.00	6.00	CL Culvert		☑	19.50	39.00	☐	☐



Note: Bars will always be placed in the orientation shown

Set	Bar mark	Wall clear cover (in)	Slab clear cover (in)	Bar spacing (in)	Location	Wall Number	Fully developed vert	Fully developed horz
1	C2	2.00	3.00	6.00	Bottom Right	1	☐	☐
2	C2	2.00	3.00	6.00	Bottom Left	4	☐	☐
3	C1	2.00	2.50	6.00	Right	1	☐	☐
4	C1	2.00	2.50	6.00	Left	4	☐	☐
5	W1	8.50	2.50	6.00	Right	1	☐	☐
6	W1	8.50	2.50	6.00	Left	4	☐	☐
7	W2	8.50	55.50	6.00	Right	1	☐	☐
8	W2	8.50	55.50	6.00	Left	4	☐	☐
9	W3	1.50	2.50	6.00	Left	2	☐	☐
10	W3	1.50	2.50	6.00	Left	3	☐	☐
11	W3	1.50	2.50	6.00	Right	2	☐	☐
12	W3	1.50	2.50	6.00	Right	3	☐	☐
13	W4	1.50	55.50	6.00	Left	2	☐	☐
14	W4	1.50	55.50	6.00	Right	2	☐	☐
15	W4	1.50	55.50	6.00	Left	3	☐	☐
16	W4	1.50	55.50	6.00	Right	3	☐	☐

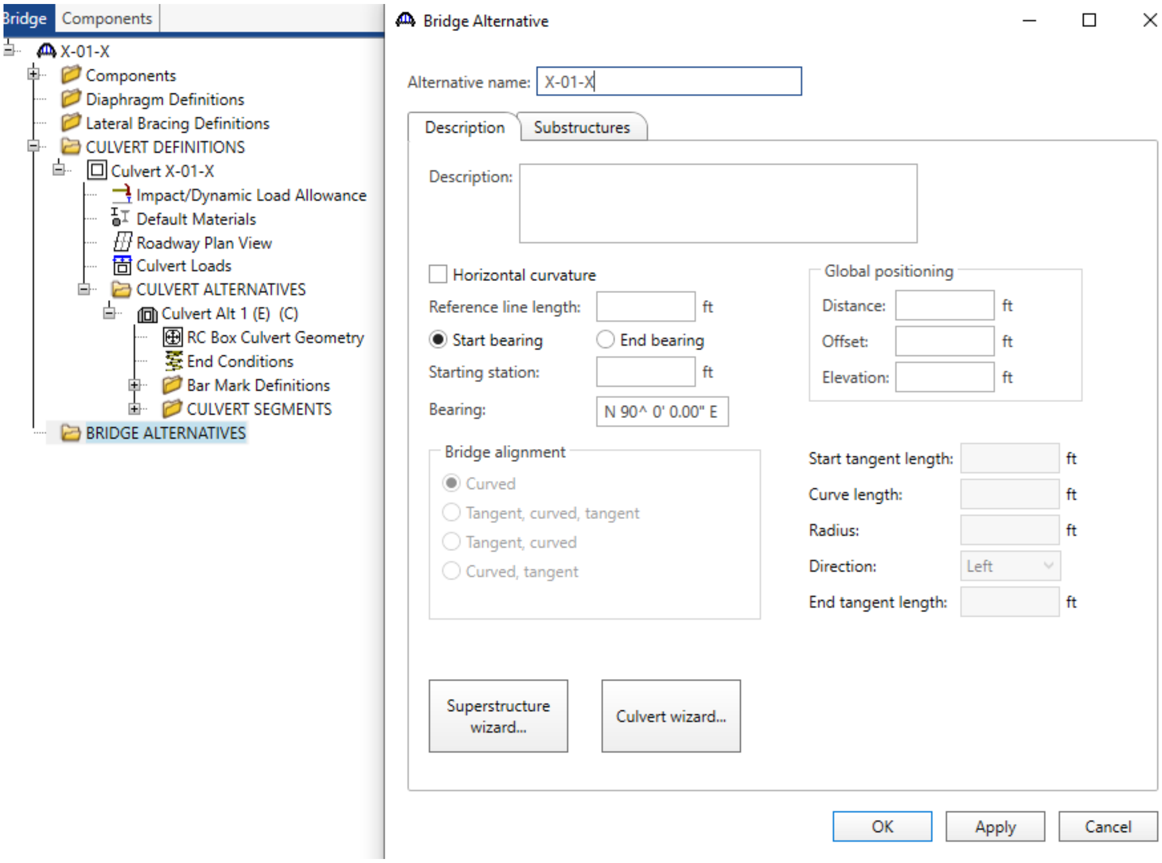
Select Bridge | Schematic to review the reinforcement data.



The description of the three-cell reinforced concrete box culvert is now complete.

Select File | Save to save the file in BrR.

Double-click on Bridge Alternatives to create a Bridge Alternative name. Enter the Alternative name as show below.



Alternative name: X-01-X

Description:

☐ Horizontal curvature

Reference line length: ft

● Start bearing ○ End bearing

Starting station: ft

Bearing: N 90^ 0' 0.00" E

Global positioning

Distance: ft

Offset: ft

Elevation: ft

Bridge alignment

● Curved

○ Tangent, curved, tangent

○ Tangent, curved

○ Curved, tangent

Start tangent length: ft

Curve length: ft

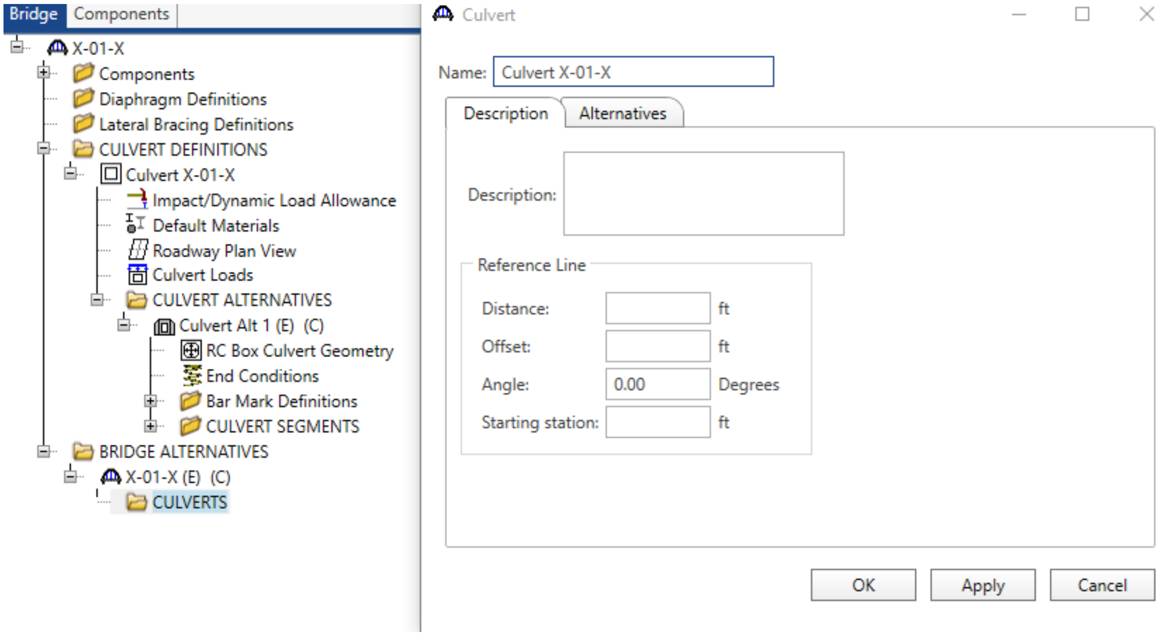
Radius: ft

Direction: Left

End tangent length: ft

Click Ok to save the data to memory and close the window.

Double-click on Culverts to create a culvert name. Enter the Culvert name as show below.

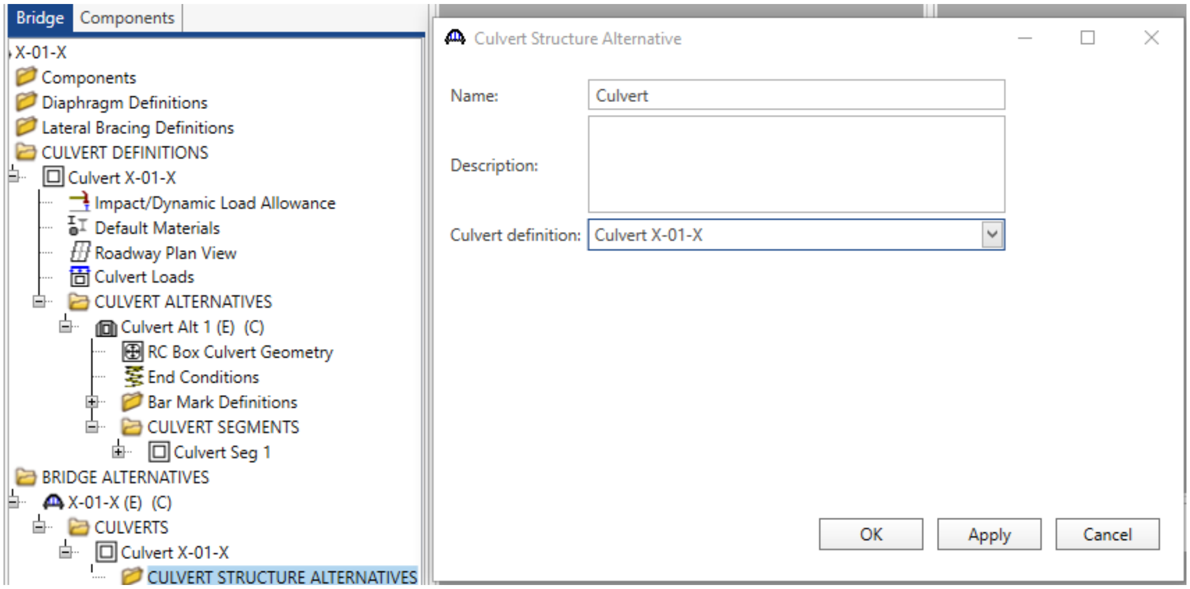


Name: Culvert X-01-X

Angle: 0.00 Degrees

Click Ok to save the data to memory and close the window.

Double-click on Culvert Structure Alternatives to create a culvert name. Enter the Culvert Structure Alternative name as show below.

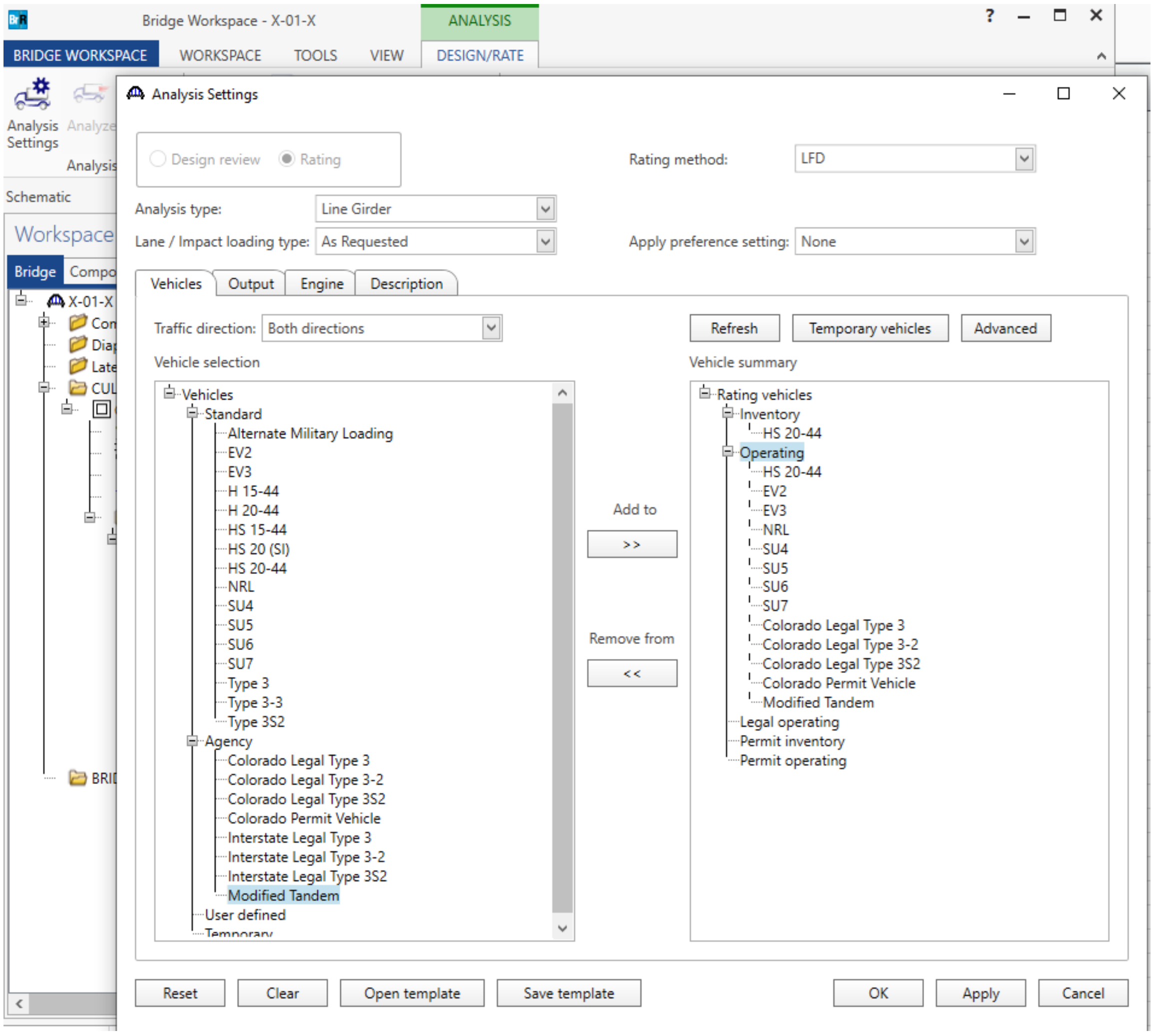


Name: Culvert

Culvert definition: Culvert X-01-X

Click Ok to save the data to memory and close the window.

To perform LFD Design Load Rating, open the Analysis setting window by selecting Bridge│Analysis Settings. Select LFD as the Rating Method and specify the vehicles. Under Vehicles → Advanced.. select Single Lane Loaded for Colorado Permit Vehicle and Modified Tandem.



○ Design review ● Rating

Rating method: LFD

Analysis type: Line Girder

Lane / Impact loading type: As Requested

Apply preference setting: None

Traffic direction: Both directions

Vehicle selection

- Vehicles
  - Standard
    - Alternate Military Loading
    - EV2
    - EV3
    - H 15-44
    - H 20-44
    - HS 15-44
    - HS 20 (SI)
    - HS 20-44
    - NRL
    - SU4
    - SU5
    - SU6
    - SU7
    - Type 3
    - Type 3-3
    - Type 3S2
  - Agency
    - Colorado Legal Type 3
    - Colorado Legal Type 3-2
    - Colorado Legal Type 3S2
    - Colorado Permit Vehicle
    - Interstate Legal Type 3
    - Interstate Legal Type 3-2
    - Interstate Legal Type 3S2
    - Modified Tandem
  - User defined
  - Temporary

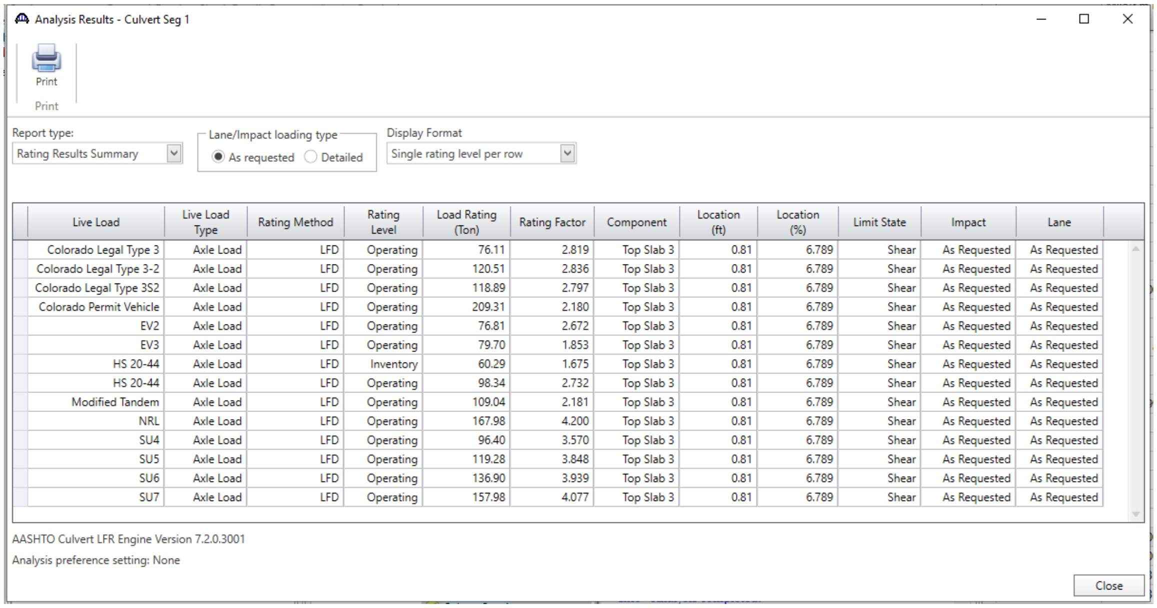
Vehicle summary

- Rating vehicles
  - Inventory
    - HS 20-44
  - Operating
    - HS 20-44
    - EV2
    - EV3
    - NRL
    - SU4
    - SU5
    - SU6
    - SU7
    - Colorado Legal Type 3
    - Colorado Legal Type 3-2
    - Colorado Legal Type 3S2
    - Colorado Permit Vehicle
    - Modified Tandem
  - Legal operating
  - Permit inventory
  - Permit operating

Click Ok to save the analysis settings to memory and close the window.

Select Culvert Seg 1 in the tree. Select Bridge | Analyze to start the rating process. Click Ok to close the Analysis Progress window after the analysis is completed.

Select Bridge | Tabular Report to open the Analysis Results window.



Report type: Rating Results Summary

Lane/Impact loading type: ● As requested ○ Detailed

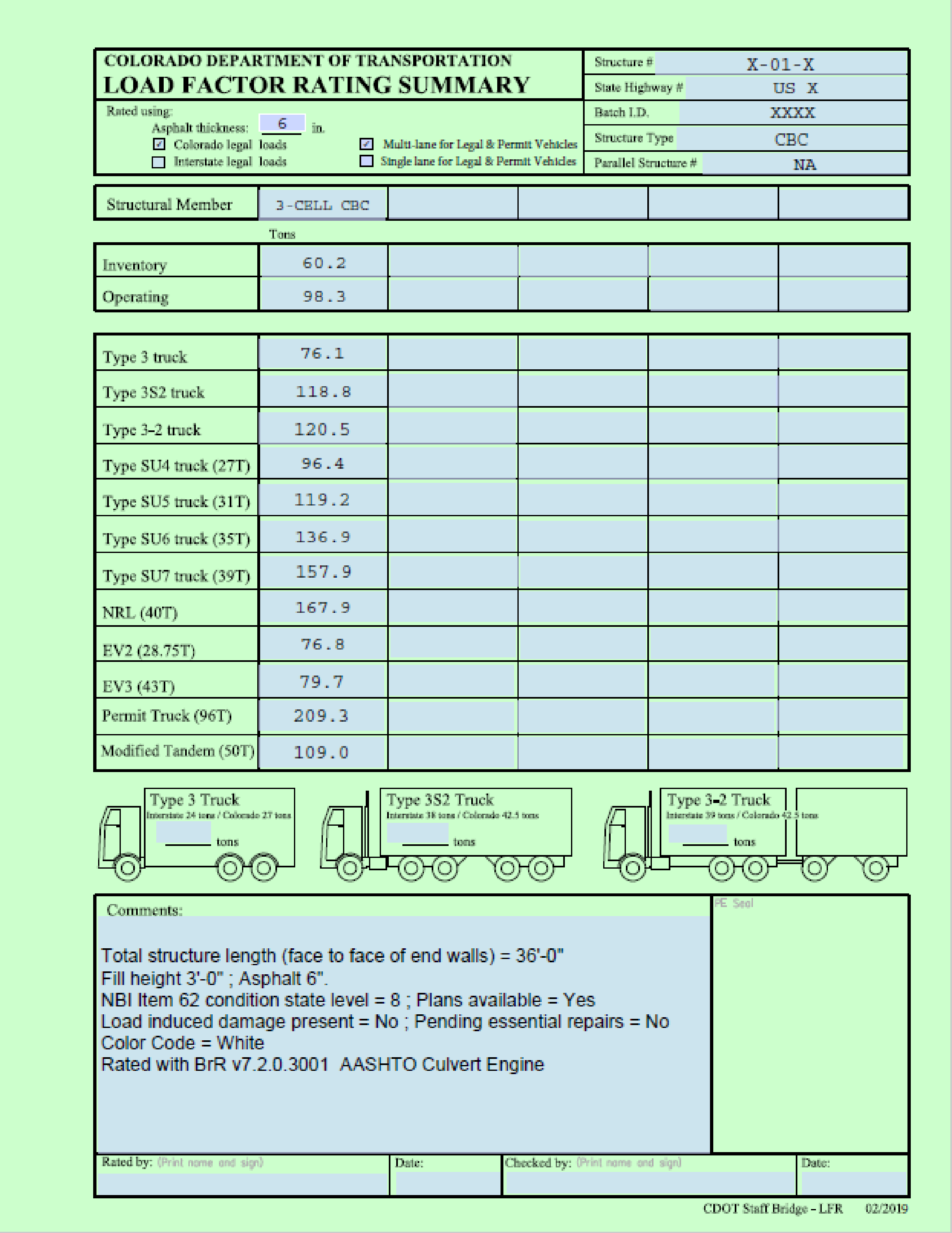
Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Component	Location (ft)	Location (%)	Limit State	Impact	Lane
Colorado Legal Type 3	Axle Load	LFD	Operating	76.11	2.819	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Legal Type 3-2	Axle Load	LFD	Operating	120.51	2.836	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Legal Type 3S2	Axle Load	LFD	Operating	118.89	2.797	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Permit Vehicle	Axle Load	LFD	Operating	209.31	2.180	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
EV2	Axle Load	LFD	Operating	76.81	2.672	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
EV3	Axle Load	LFD	Operating	79.70	1.853	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
HS 20-44	Axle Load	LFD	Inventory	60.29	1.675	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	98.34	2.732	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Modified Tandem	Axle Load	LFD	Operating	109.04	2.181	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
NRL	Axle Load	LFD	Operating	167.98	4.200	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU4	Axle Load	LFD	Operating	96.40	3.570	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU5	Axle Load	LFD	Operating	119.28	3.848	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU6	Axle Load	LFD	Operating	136.90	3.939	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU7	Axle Load	LFD	Operating	157.98	4.077	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested

AASHTO Culvert LFR Engine Version 7.2.0.3001

Analysis preference setting: None

Fill out the Rating Summary Sheet using policies and guidelines in the Bridge Rating Manual, Section 1. The results of the LFD rating analysis are as follows.



COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

Structure # X-01-X
State Highway # US X
Batch I.D. XXXX
Structure Type CBC
Parallel Structure # NA

Rated using:
Asphalt thickness: 6 in.
☑ Colorado legal loads
☐ Interstate legal loads
☑ Multi-lane for Legal & Permit Vehicles
☐ Single lane for Legal & Permit Vehicles

Structural Member	3-CELL CBC				
	Tons				
Inventory	60.2				
Operating	98.3				
Type 3 truck	76.1				
Type 3S2 truck	118.8				
Type 3-2 truck	120.5				
Type SU4 truck (27T)	96.4				
Type SU5 truck (31T)	119.2				
Type SU6 truck (35T)	136.9				
Type SU7 truck (39T)	157.9				
NRL (40T)	167.9				
EV2 (28.75T)	76.8				
EV3 (43T)	79.7				
Permit Truck (96T)	209.3				
Modified Tandem (50T)	109.0				

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
______ tons

Type 3S2 Truck
Interstate 36 tons / Colorado 42.5 tons
______ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
______ tons

Comments:

Total structure length (face to face of end walls) = 36'-0"
Fill height 3'-0" ; Asphalt 6".
NBI Item 62 condition state level = 8 ; Plans available = Yes
Load induced damage present = No ; Pending essential repairs = No
Color Code = White
Rated with BrR v7.2.0.3001 AASHTO Culvert Engine

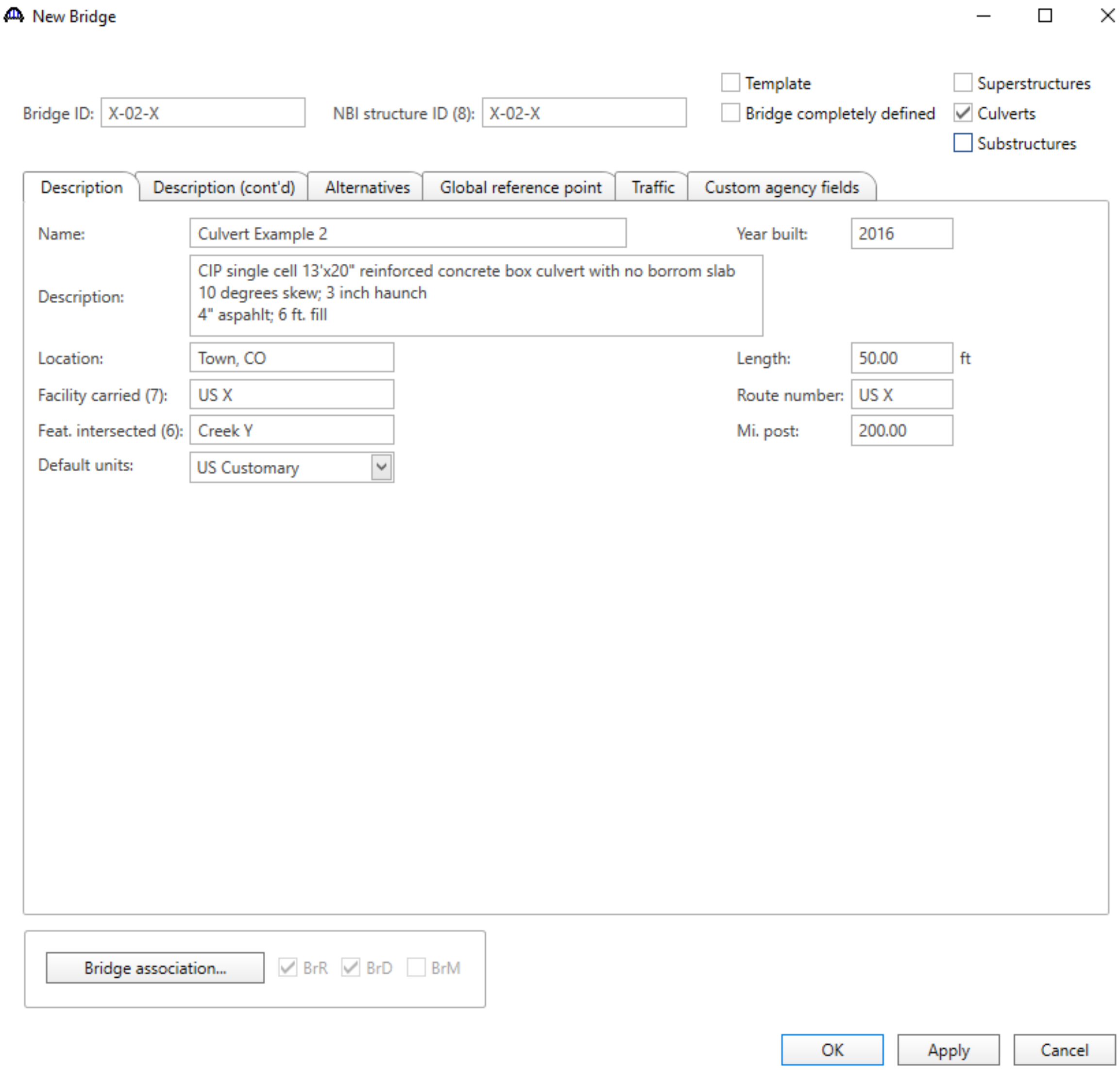
PE Seal

Rated by: (Print name and sign)
Date:
Checked by: (Print name and sign)
Date:

CDOT Staff Bridge - LFR 02/2019

14.4.2 **AASHTOWare** BrR Program, Example 2 (LRFR) – Structure No. X-02-X

From the Bridge Explorer, select File│ New│ New Bridge to create a new bridge and then enter the following description information.



☐ Template
☐ Bridge completely defined
☐ Superstructures
☑ Culverts
☐ Substructures

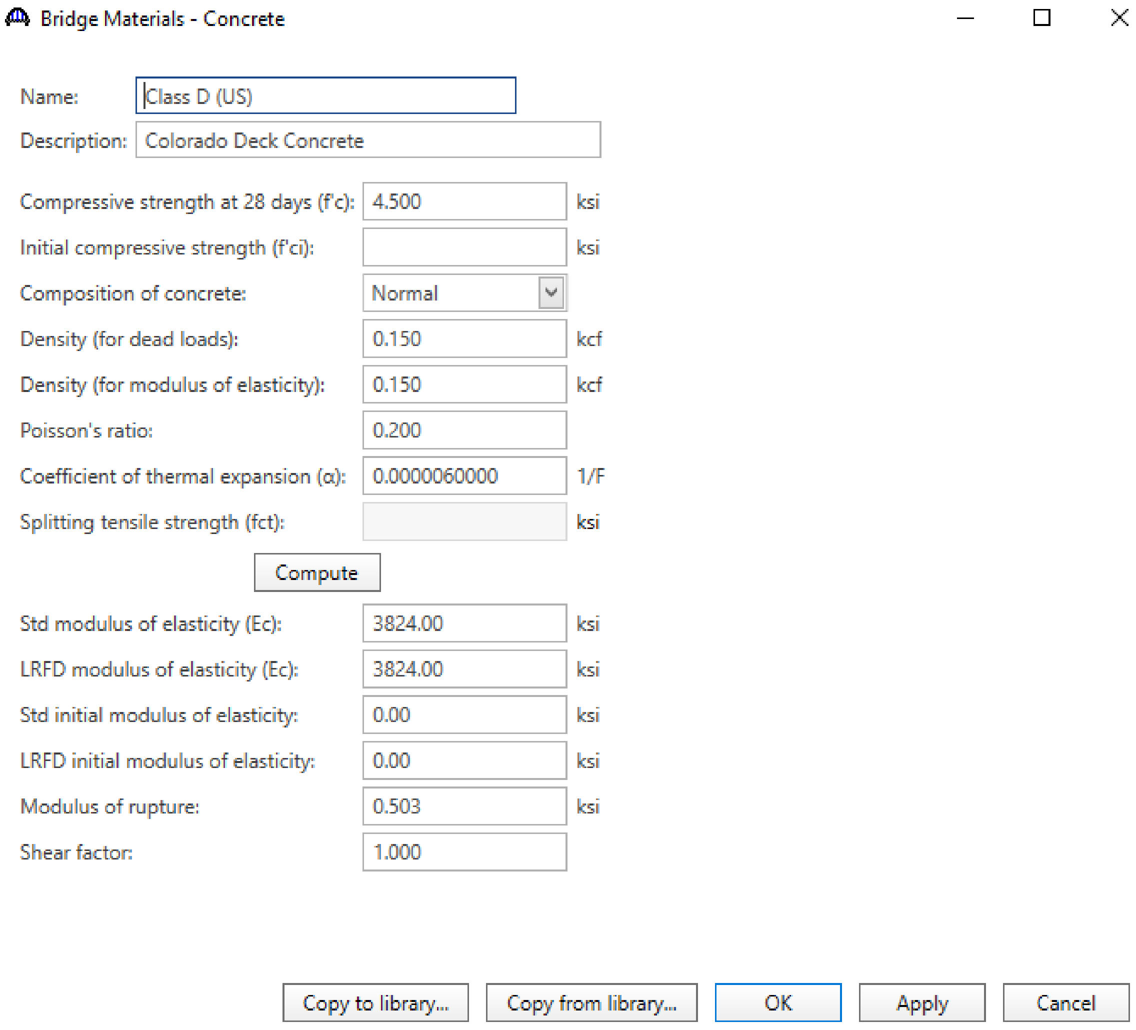
Bridge ID: X-02-X
NBI structure ID (8): X-02-X

Name: Culvert Example 2
Year built: 2016
Description: CIP single cell 13'x20" reinforced concrete box culvert with no borrom slab
10 degrees skew; 3 inch haunch
4" aspahlt; 6 ft. fill
Location: Town, CO
Length: 50.00 ft
Facility carried (7): US X
Route number: US X
Feat. intersected (6): Creek Y
Mi. post: 200.00
Default units: US Customary

☑ BrR ☑ BrD ☐ BrM

Close the window by clicking OK. This saves the data to memory and closes the window.

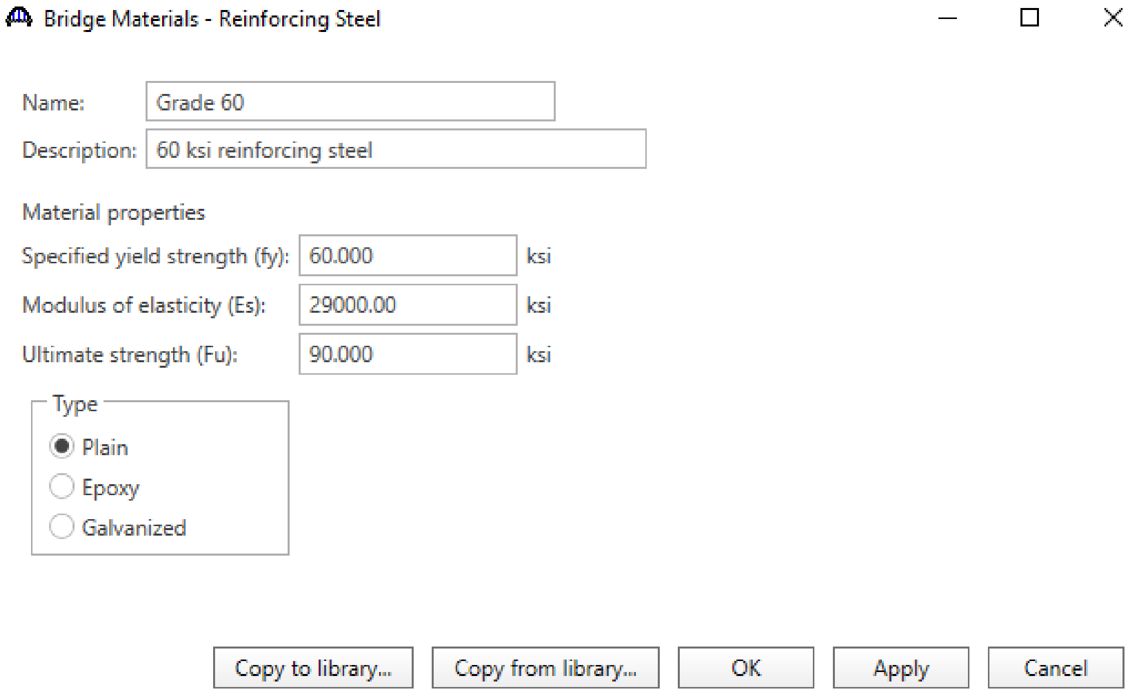
To enter the materials for the culvert, expand the tree for Materials.
Double-click on the Concrete folder to create a new concrete material. Enter the following values.



Name: Class D (US)
Description: Colorado Deck Concrete
Compressive strength at 28 days (f'c): 4.500 ksi
Initial compressive strength (f'ci): ksi
Composition of concrete: Normal
Density (for dead loads): 0.150 kcf
Density (for modulus of elasticity): 0.150 kcf
Poisson's ratio: 0.200
Coefficient of thermal expansion (α): 0.0000060000 1/F
Splitting tensile strength (fct): ksi
Std modulus of elasticity (Ec): 3824.00 ksi
LRFD modulus of elasticity (Ec): 3824.00 ksi
Std initial modulus of elasticity: 0.00 ksi
LRFD initial modulus of elasticity: 0.00 ksi
Modulus of rupture: 0.503 ksi
Shear factor: 1.000

When plans are available, use the minimum concrete strength and yield strength values given in the plans. If plan values are not known, values given in Section 1 of the Bridge Rating Manual for the applicable year of construction may be followed.

Double-click on the Reinforcing Steel folder to create a new reinforcement material. Click on the Copy from Library button to copy the Grade 60 reinforcement material to the bridge.



Bridge Materials - Reinforcing Steel

Name: Grade 60

Description: 60 ksi reinforcing steel

Material properties

Specified yield strength (fy): 60.000 ksi

Modulus of elasticity (Es): 29000.00 ksi

Ultimate strength (Fu): 90.000 ksi

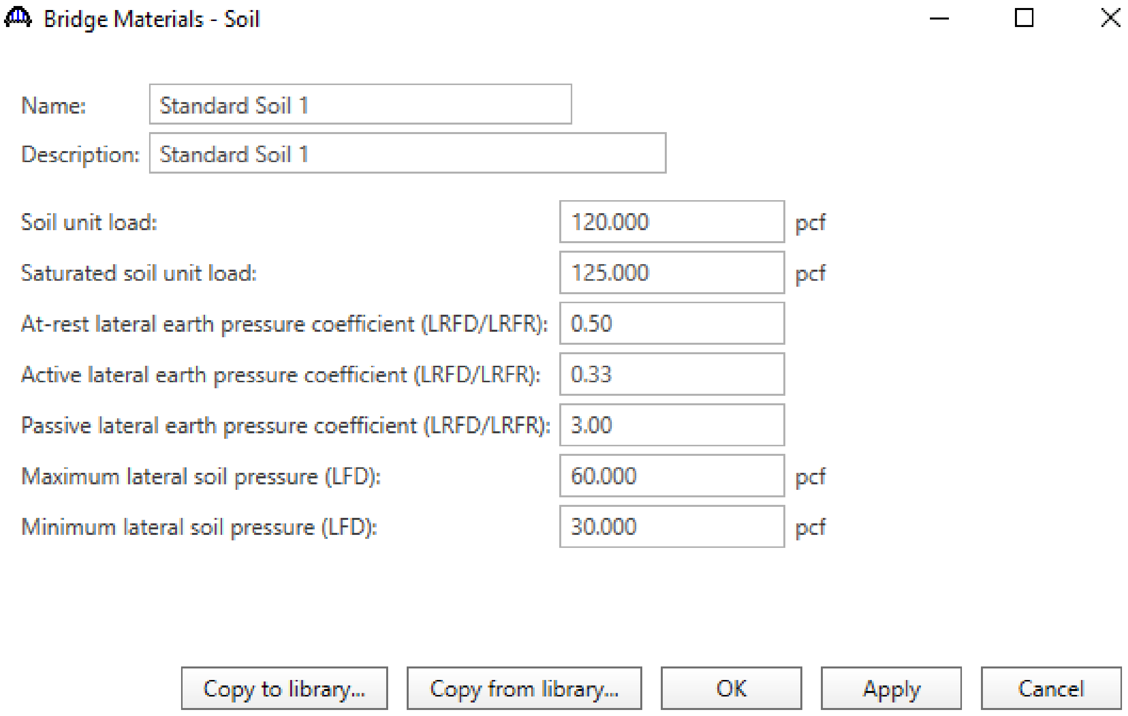
Type

● Plain

○ Epoxy

○ Galvanized

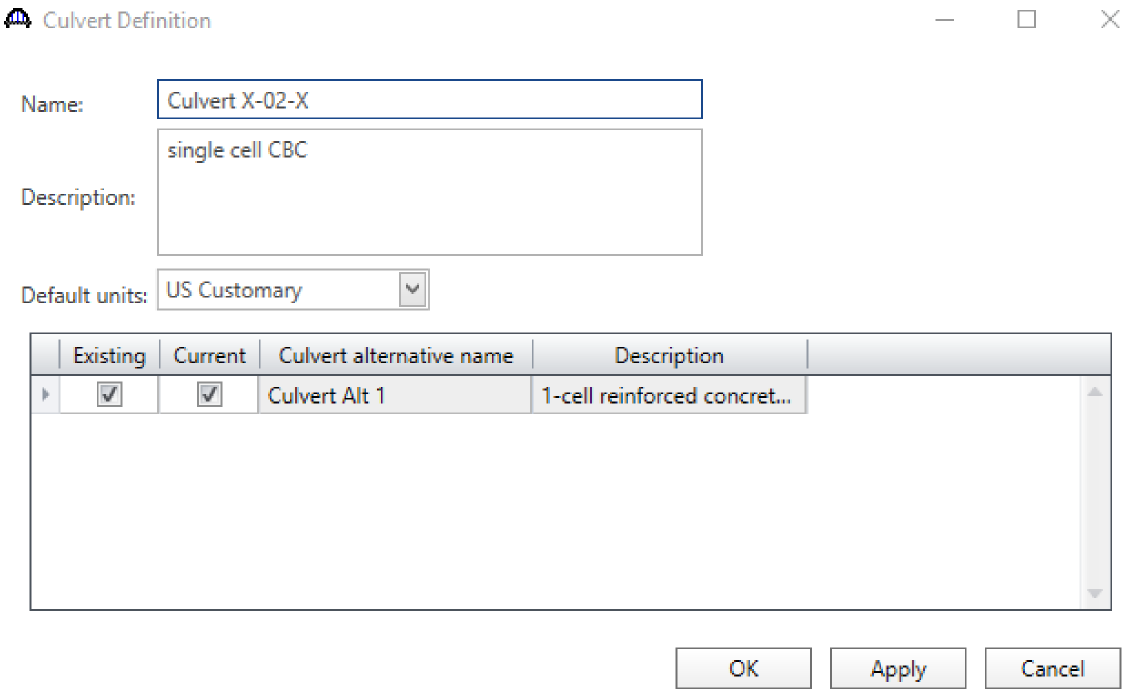
Double-click on the Soil folder to create a new soil material. Click on the Copy from Library button to copy the Standard Soil 1 material to the bridge.



Name: Standard Soil 1
Description: Standard Soil 1
Soil unit load: 120.000 pcf
Saturated soil unit load: 125.000 pcf
At-rest lateral earth pressure coefficient (LRFD/LRFR): 0.50
Active lateral earth pressure coefficient (LRFD/LRFR): 0.33
Passive lateral earth pressure coefficient (LRFD/LRFR): 3.00
Maximum lateral soil pressure (LFD): 60.000 pcf
Minimum lateral soil pressure (LFD): 30.000 pcf

Standard Soil 1 for LFD and LRFD Specification.
Standard Soil 2 for ASD Specification.

Double-click on the CULVERT DEFINITIONS folder to create a new culvert definition. Enter the Culvert Definition name as show below. The first Culvert Alternative that we create will automatically be assigned as the Existing and Current Culvert Alternative for this Culvert Definition.



Name: Culvert X-02-X

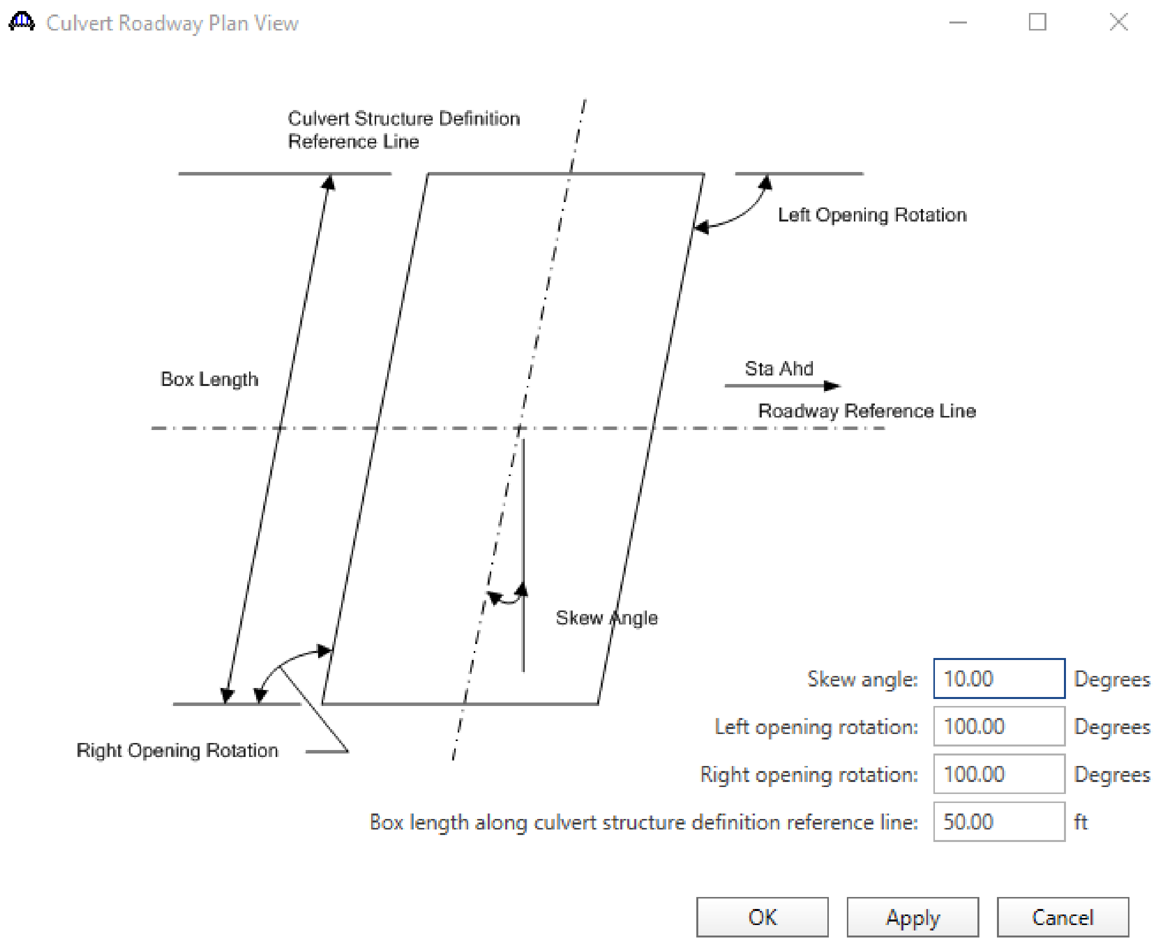
Description: single cell CBC

Default units: US Customary

Existing	Current	Culvert alternative name	Description
☑	☑	Culvert Alt 1	1-cell reinforced concret...

Expand the tree for Culvert Definition X-02-X.

Double-click on the Roadway Plan View to enter the skew angles as shown below.



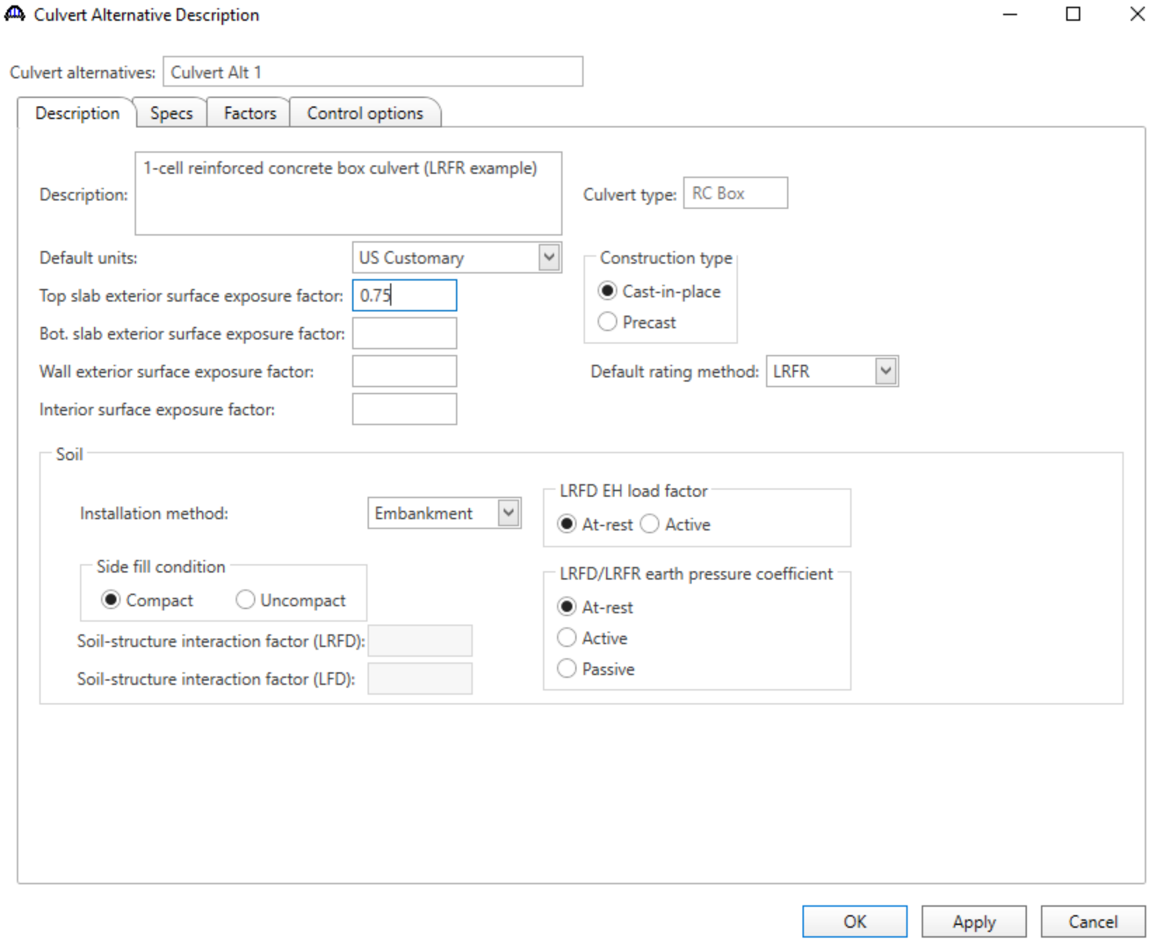
Skew angle: 10.00 Degrees

Left opening rotation: 100.00 Degrees

Right opening rotation: 100.00 Degrees

Box length along culvert structure definition reference line: 50.00 ft

Double-click on the CULVERT ALTERNATIVES folder to create a new culvert alternative for Culvert X-02-X. Enter the data as shown below.



Culvert Alternative Description

Culvert alternatives: Culvert Alt 1

Description: 1-cell reinforced concrete box culvert (LRFR example)

Culvert type: RC Box

Default units: US Customary

Top slab exterior surface exposure factor: 0.75

Bot. slab exterior surface exposure factor:

Wall exterior surface exposure factor:

Interior surface exposure factor:

Construction type: ● Cast-in-place ○ Precast

Default rating method: LRFR

Soil

Installation method: Embankment

Side fill condition: ● Compact ○ Uncompact

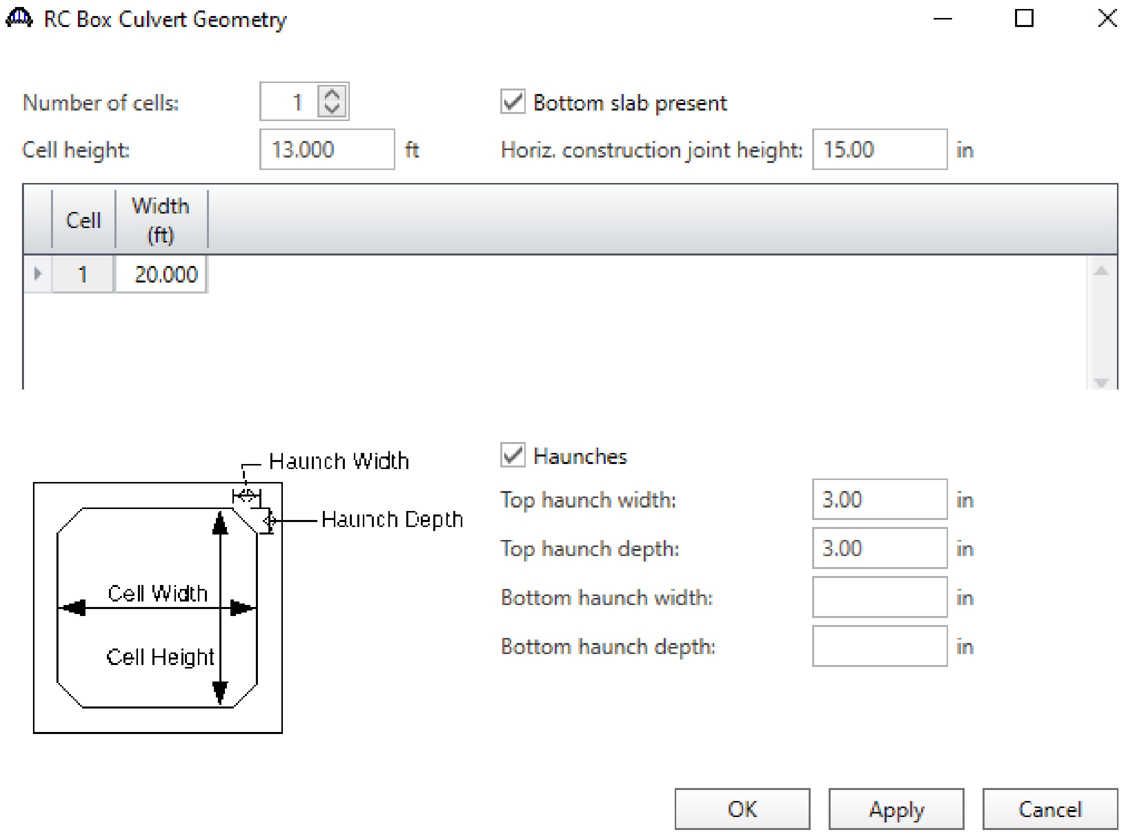
Soil-structure interaction factor (LRFD):

Soil-structure interaction factor (LFD):

LRFD EH load factor: ● At-rest ○ Active

LRFD/LRFR earth pressure coefficient: ● At-rest ○ Active ○ Passive

Expand the tree for Culvert Alt 1.
Double-click on RC Box Culvert Geometry in the tree. Enter the data as shown below.
Click Ok to save the data to memory and close the window.



RC Box Culvert Geometry

Number of cells: 1

☑ Bottom slab present

Cell height: 13.000 ft

Horiz. construction joint height: 15.00 in

Cell	Width (ft)
1	20.000

☑ Haunches

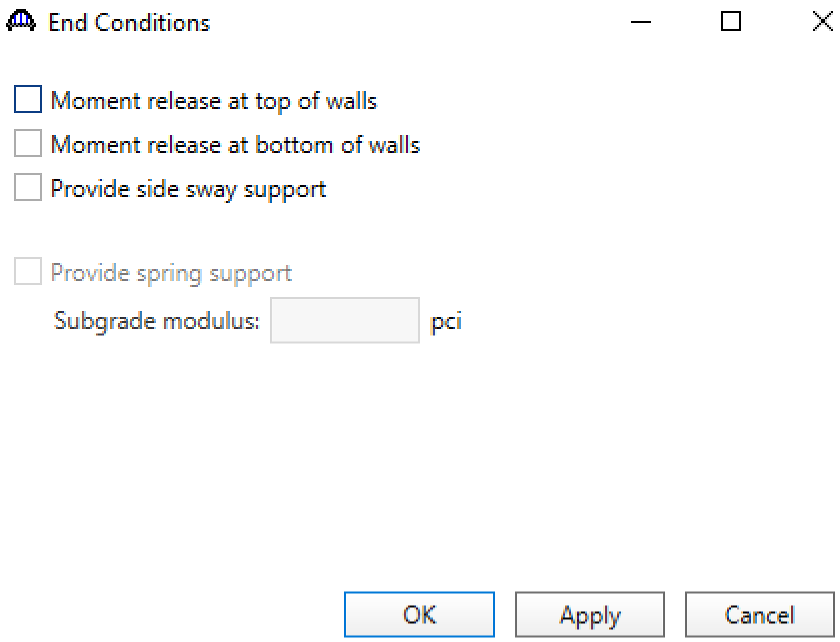
Top haunch width: 3.00 in

Top haunch depth: 3.00 in

Bottom haunch width: in

Bottom haunch depth: in

Double-click on End Conditions. Leave uncheck box if reinforcement is rigid. Spring support may be used if subgrade modulus is known. Click Ok to save the data to memory and close the window.



End Conditions

☐ Moment release at top of walls

☐ Moment release at bottom of walls

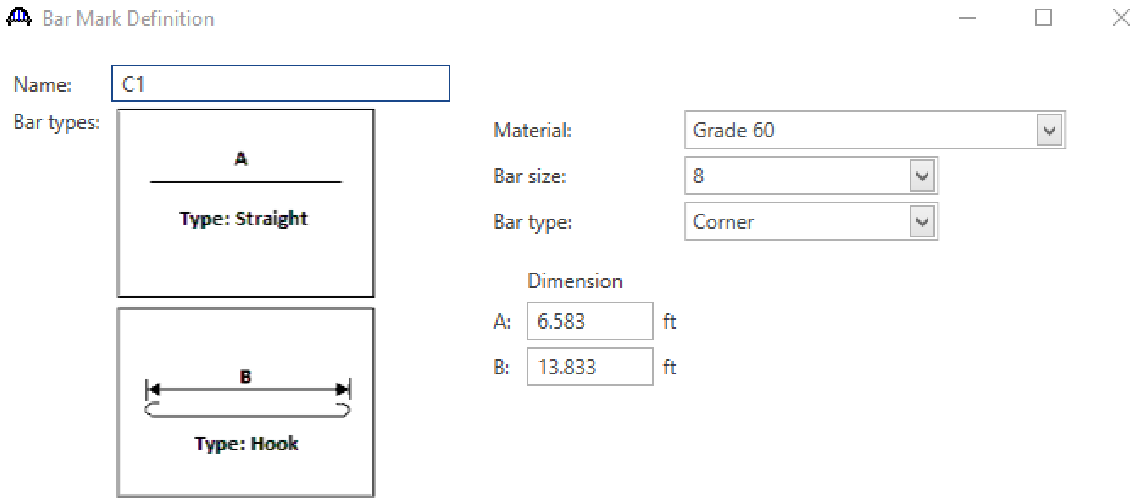
☐ Provide side sway support

☐ Provide spring support

Subgrade modulus: pci

Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

Enter the data for C1 as shown below. Click Ok to save the data to memory and close the window. Repeat the process for all bars (W1, W2, T1, and T2) as shown.



Name: C1

Material: Grade 60

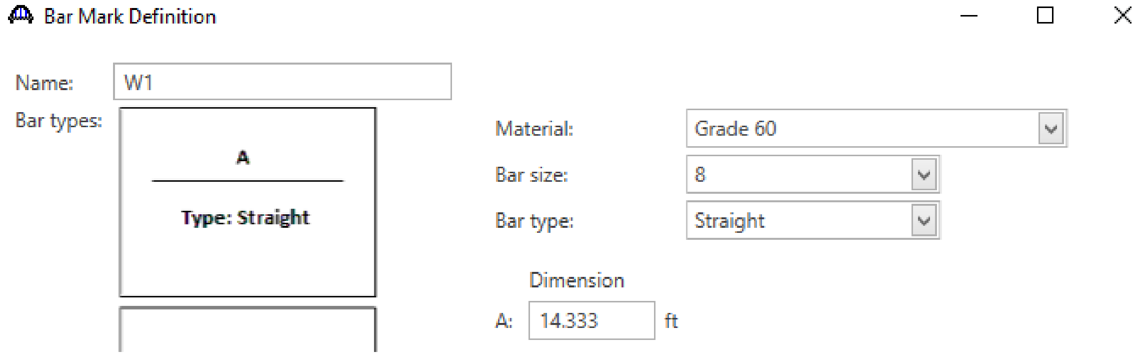
Bar size: 8

Bar type: Corner

Dimension

A: 6.583 ft

B: 13.833 ft



Name: W1

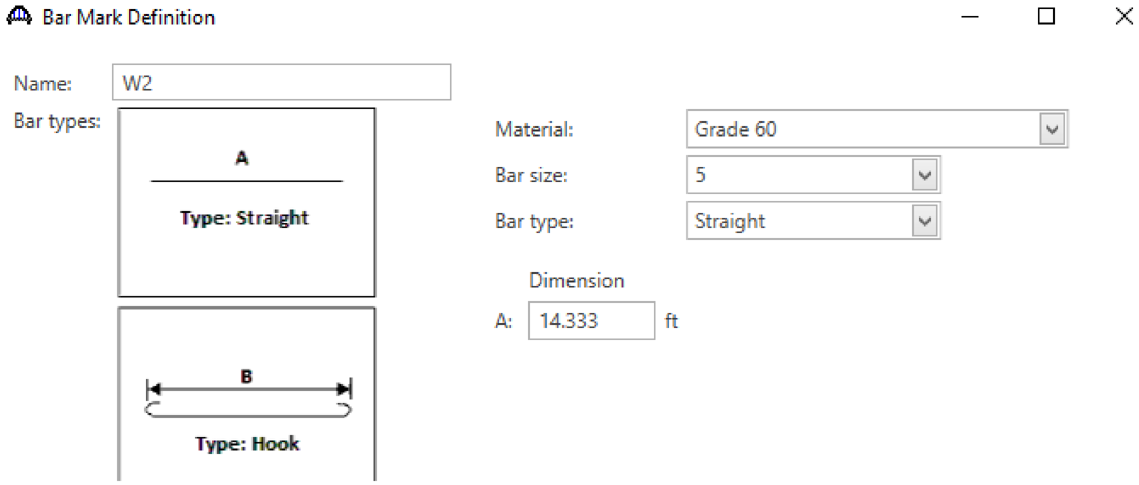
Material: Grade 60

Bar size: 8

Bar type: Straight

Dimension

A: 14.333 ft



Name: W2

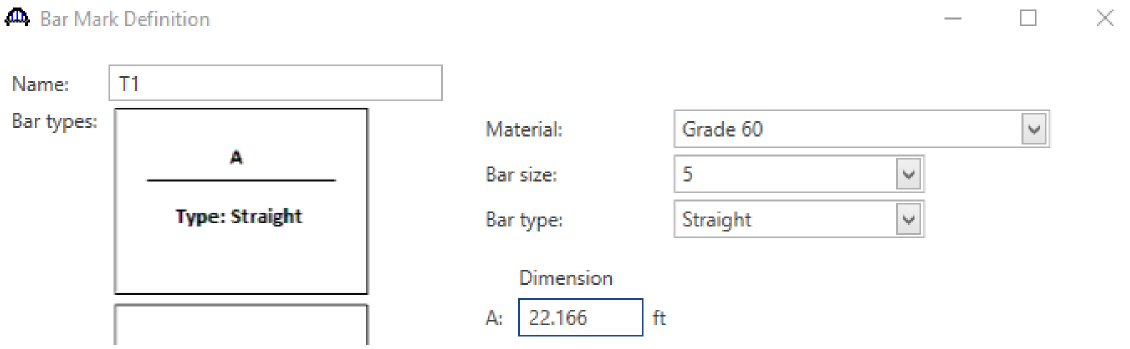
Material: Grade 60

Bar size: 5

Bar type: Straight

Dimension

A: 14.333 ft



Name: T1

Bar types:

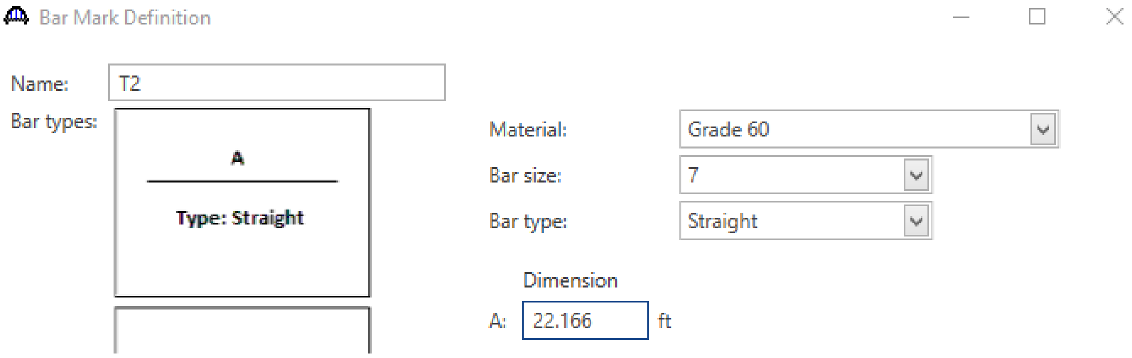
Material: Grade 60

Bar size: 5

Bar type: Straight

Dimension

A: 22.166 ft



Name: T2

Bar types:

Material: Grade 60

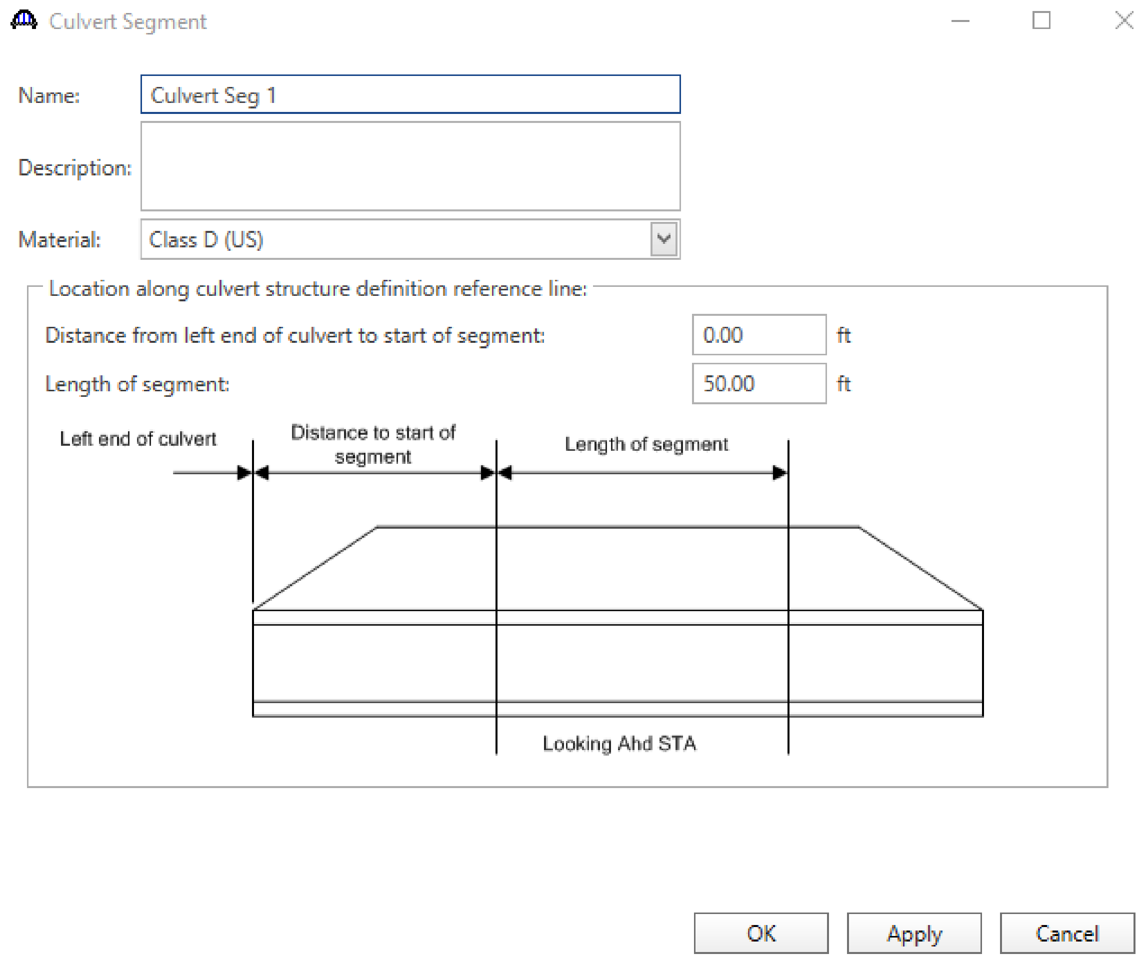
Bar size: 7

Bar type: Straight

Dimension

A: 22.166 ft

Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as show below.



Culvert Segment

Name: Culvert Seg 1

Description:

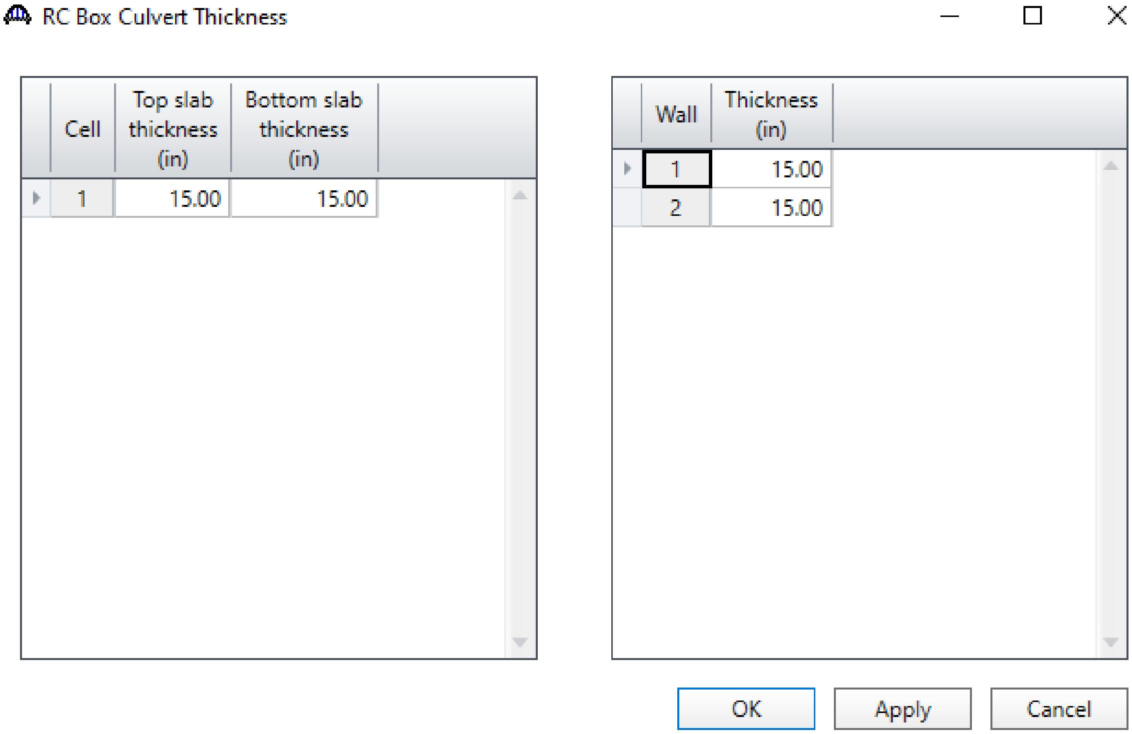
Material: Class D (US)

Location along culvert structure definition reference line:

Distance from left end of culvert to start of segment: 0.00 ft

Length of segment: 50.00 ft

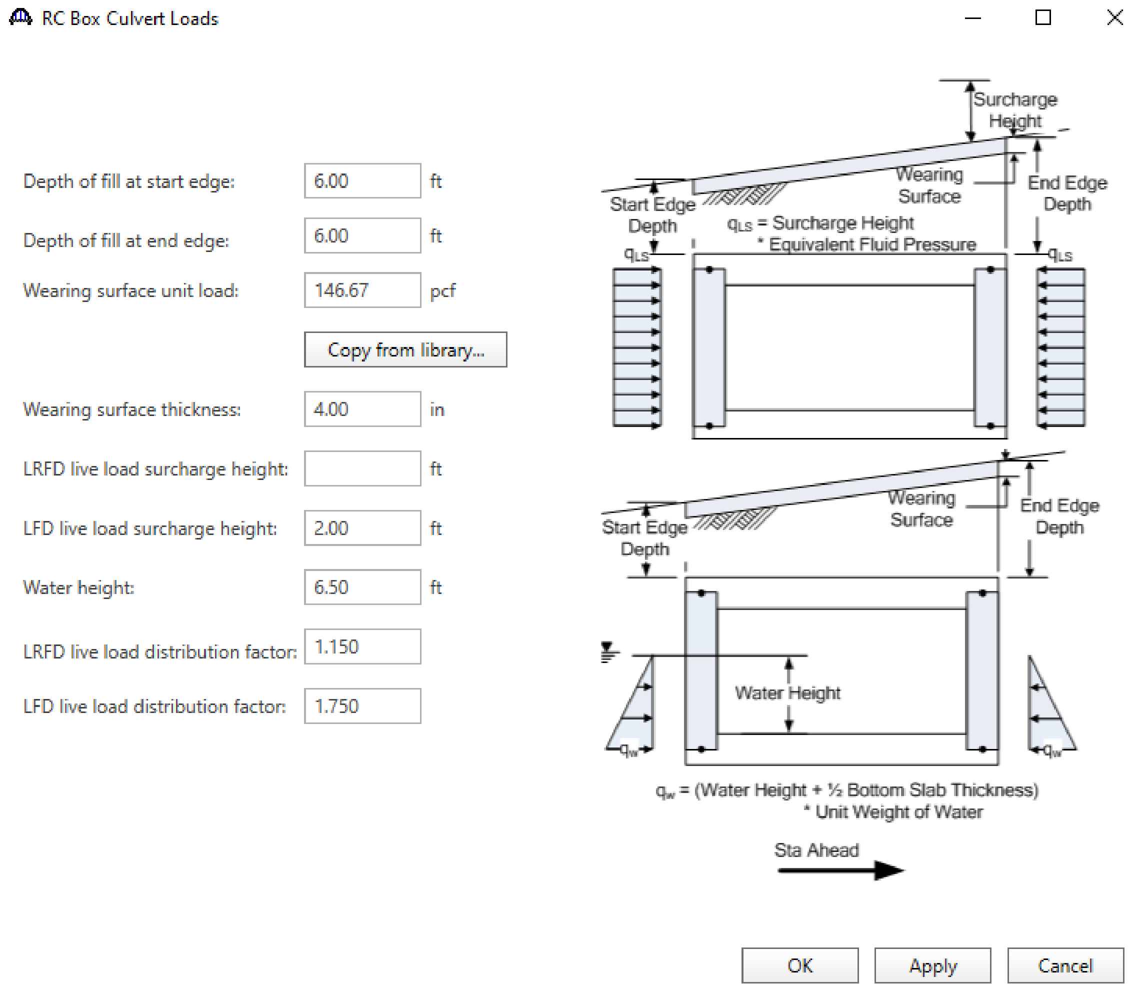
Expand the tree for Culvert Seg 1. Double-click on RC Box Culvert Thickness in the tree. Enter the slab and wall thicknesses as shown below. Click OK to save the data to memory and close the window.



Cell	Top slab thickness (in)	Bottom slab thickness (in)
1	15.00	15.00

Wall	Thickness (in)
1	15.00
2	15.00

Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. The wearing surface thickness includes the equivalent for the rail dead load. Click OK to save the data to memory and close the window.



RC Box Culvert Loads

Depth of fill at start edge: 6.00 ft

Depth of fill at end edge: 6.00 ft

Wearing surface unit load: 146.67 pcf

Wearing surface thickness: 4.00 in

LRFD live load surcharge height: ft

LFD live load surcharge height: 2.00 ft

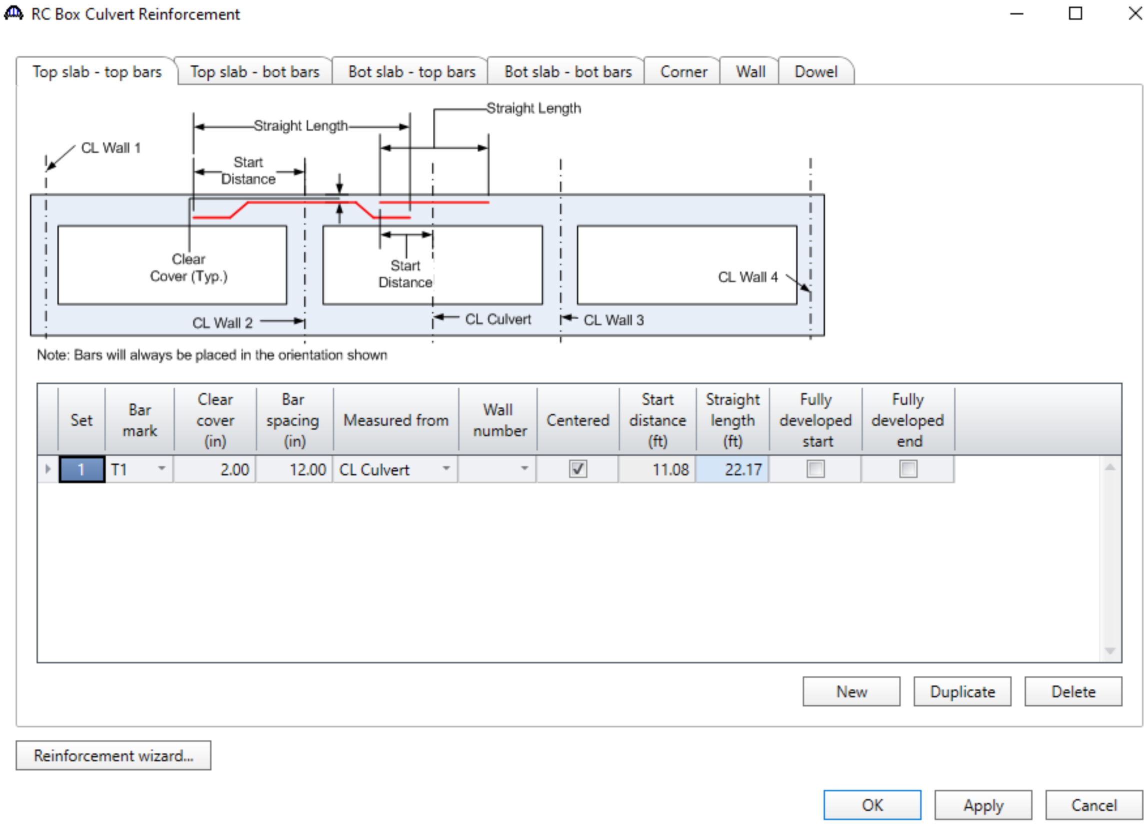
Water height: 6.50 ft

LRFD live load distribution factor: 1.150

LFD live load distribution factor: 1.750

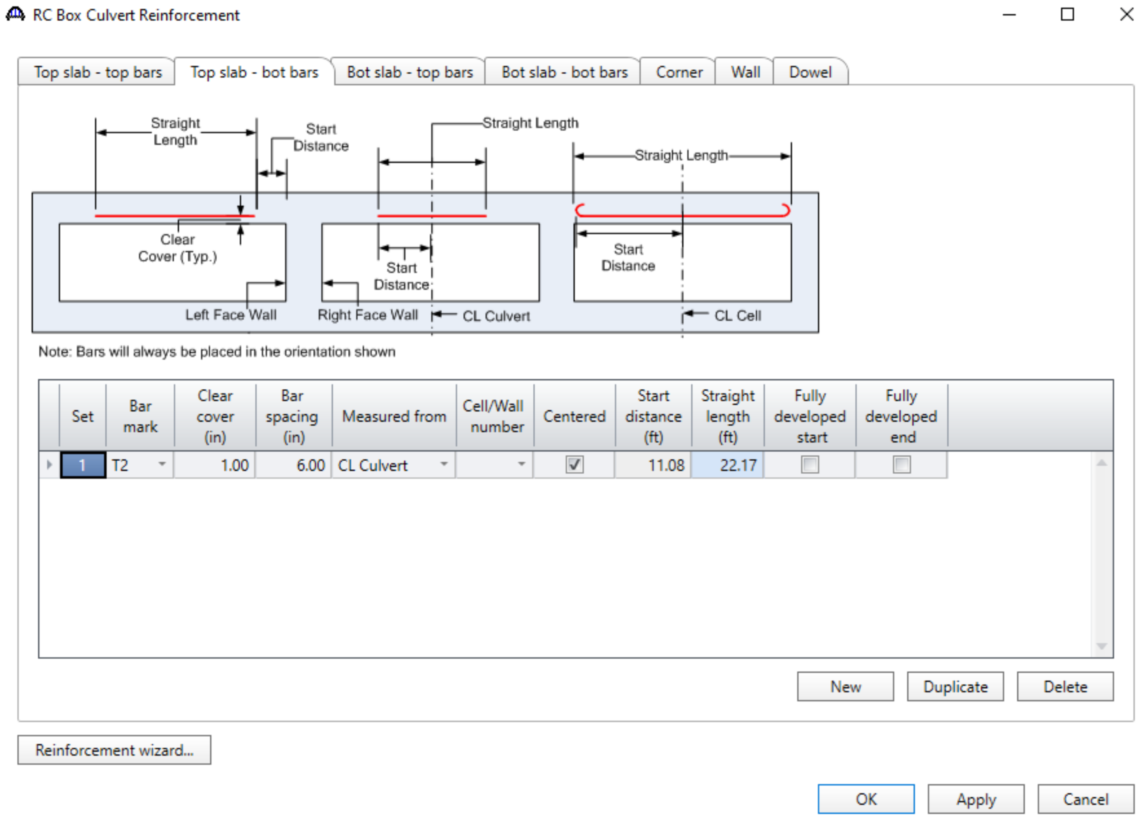
Use water height half the rise of the culvert.

Double-click on RC Box Culvert Reinforcement in the tree. Enter the reinforcement data as shown below for each location. Click Ok to save the data to memory and close the window.



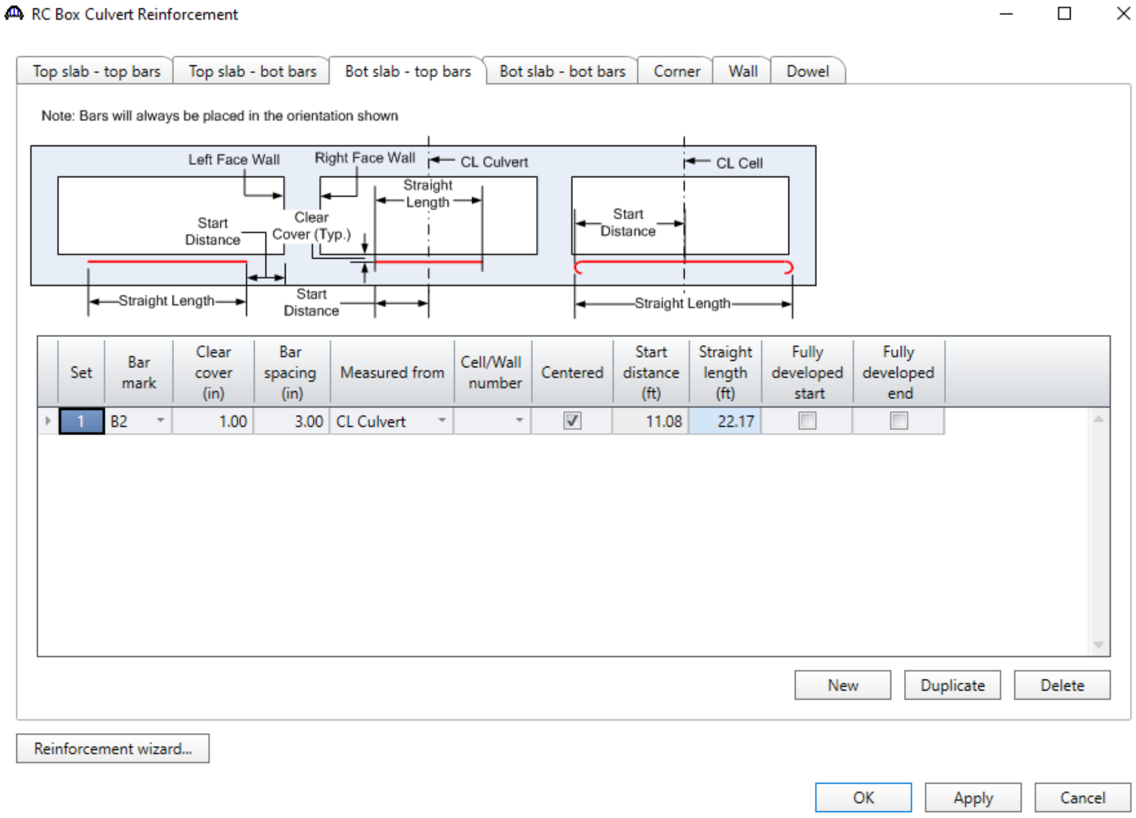
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	T1	2.00	12.00	CL Culvert		☑	11.08	22.17	☐	☐



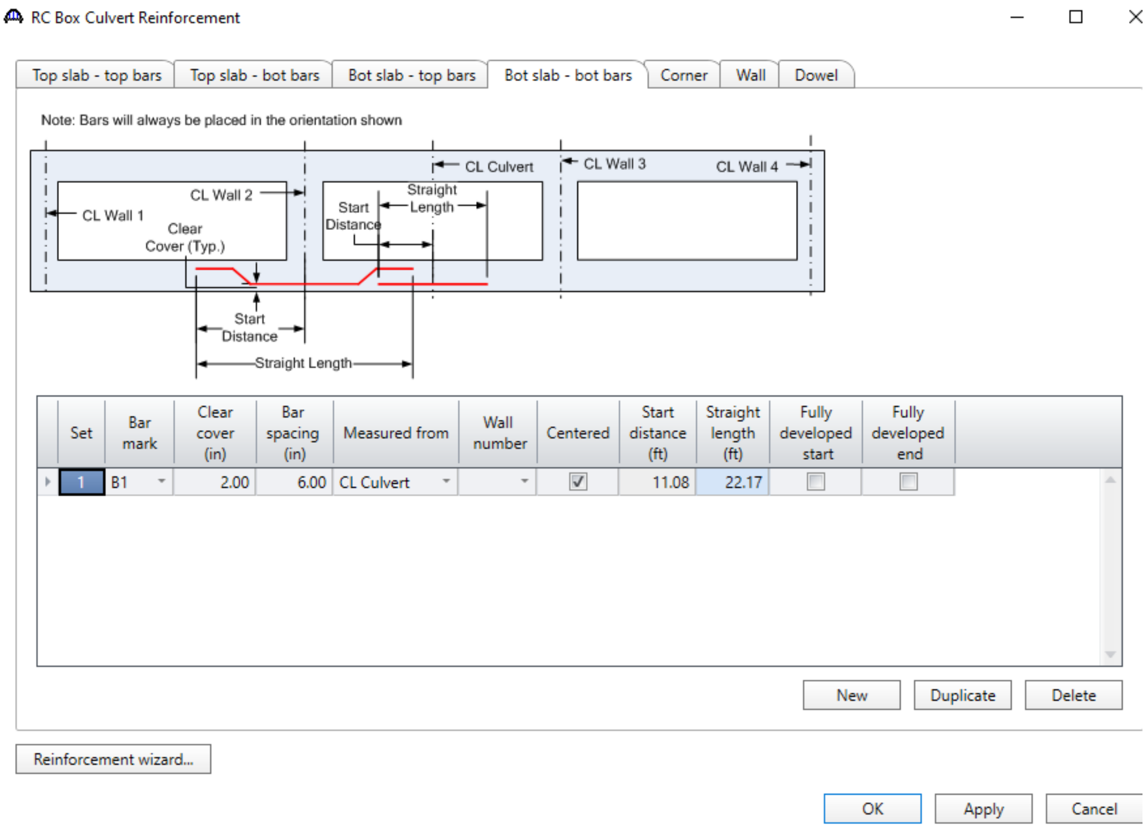
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Cell/Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	T2	1.00	6.00	CL Culvert		☑	11.08	22.17	☐	☐



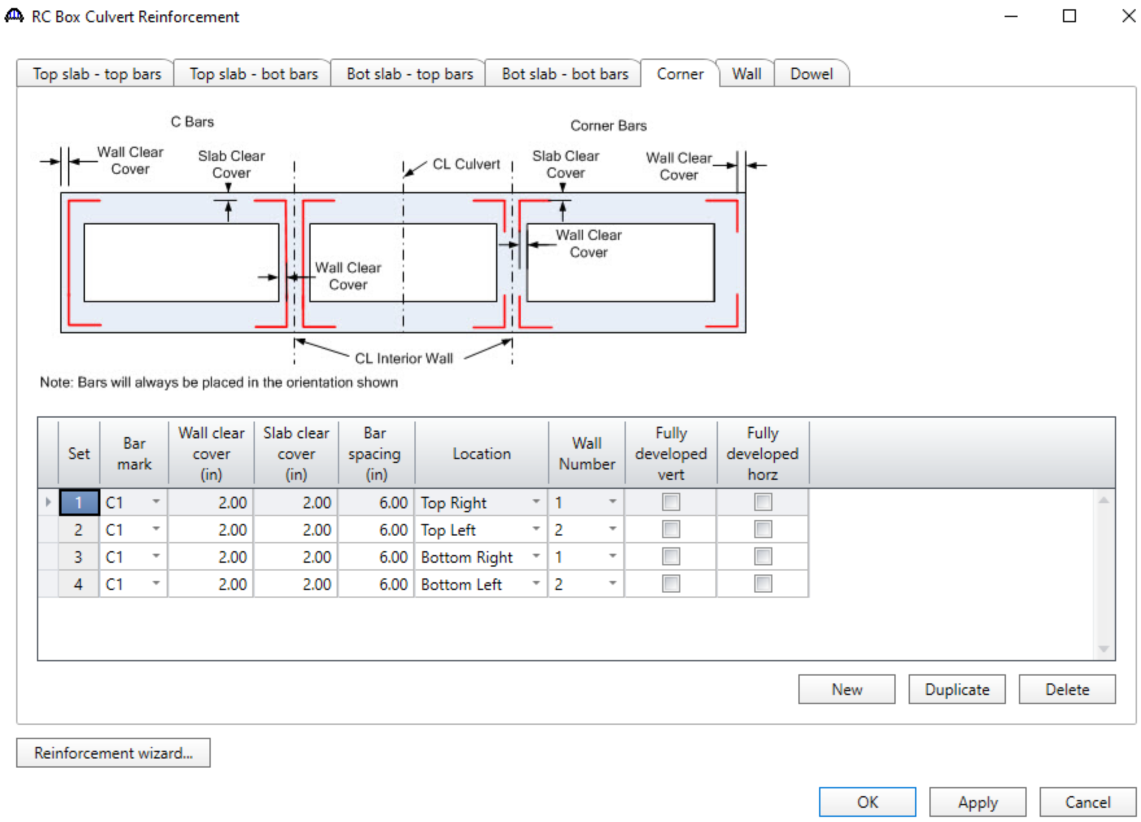
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Cell/Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	B2	1.00	3.00	CL Culvert		☑	11.08	22.17	☐	☐



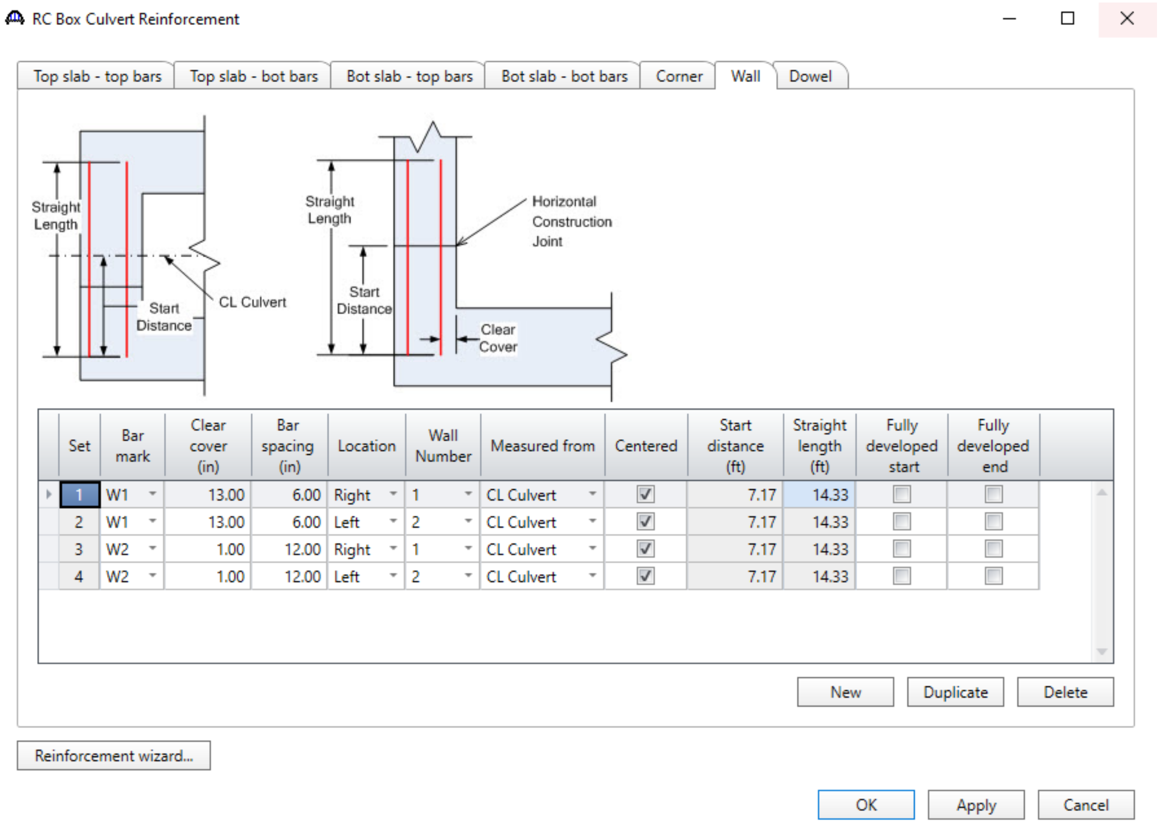
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Clear cover (in)	Bar spacing (in)	Measured from	Wall number	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	B1	2.00	6.00	CL Culvert		☑	11.08	22.17	☐	☐



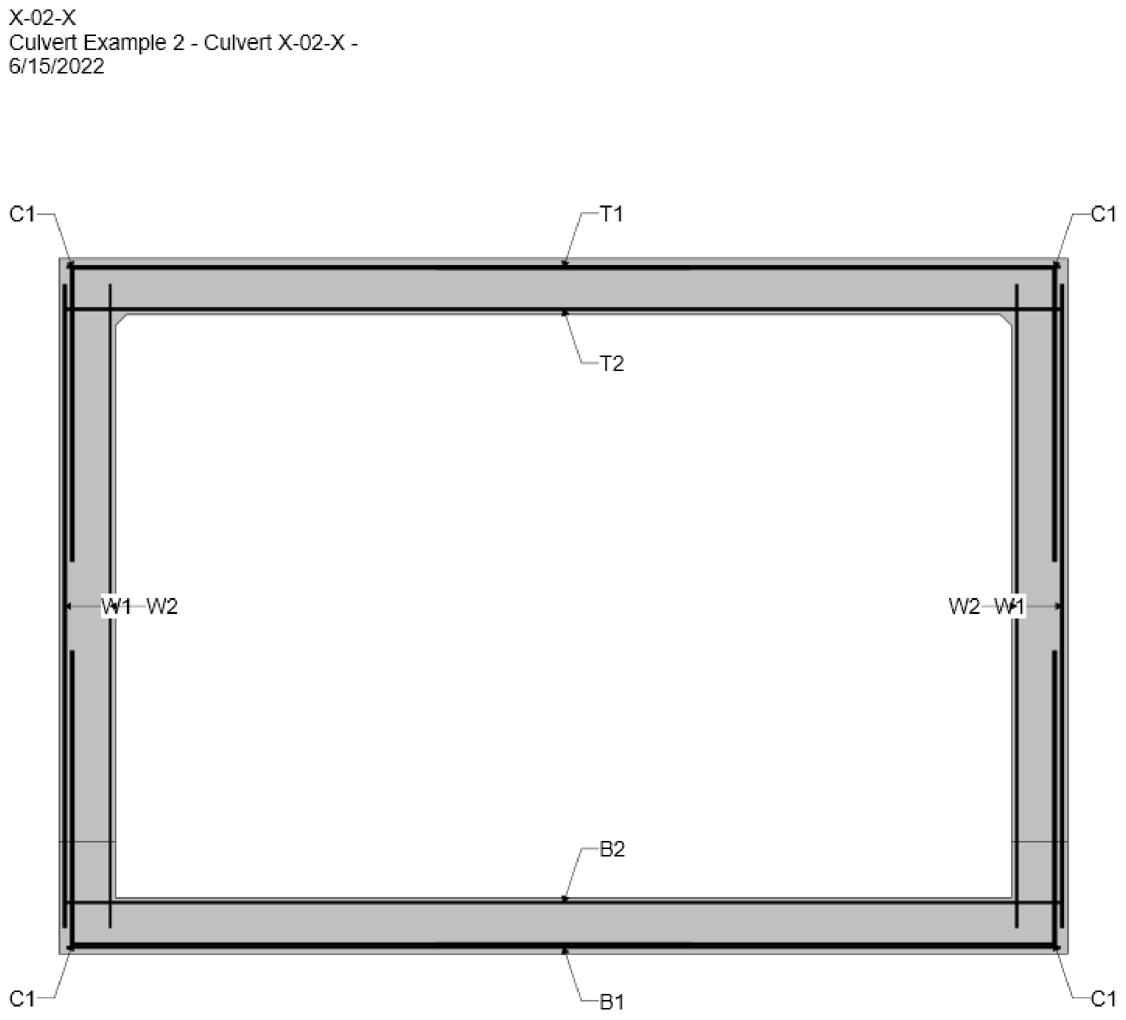
Note: Bars will always be placed in the orientation shown

Set	Bar mark	Wall clear cover (in)	Slab clear cover (in)	Bar spacing (in)	Location	Wall Number	Fully developed vert	Fully developed horz
1	C1	2.00	2.00	6.00	Top Right	1	☐	☐
2	C1	2.00	2.00	6.00	Top Left	2	☐	☐
3	C1	2.00	2.00	6.00	Bottom Right	1	☐	☐
4	C1	2.00	2.00	6.00	Bottom Left	2	☐	☐



Set	Bar mark	Clear cover (in)	Bar spacing (in)	Location	Wall Number	Measured from	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	W1	13.00	6.00	Right	1	CL Culvert	☑	7.17	14.33	☐	☐
2	W1	13.00	6.00	Left	2	CL Culvert	☑	7.17	14.33	☐	☐
3	W2	1.00	12.00	Right	1	CL Culvert	☑	7.17	14.33	☐	☐
4	W2	1.00	12.00	Left	2	CL Culvert	☑	7.17	14.33	☐	☐

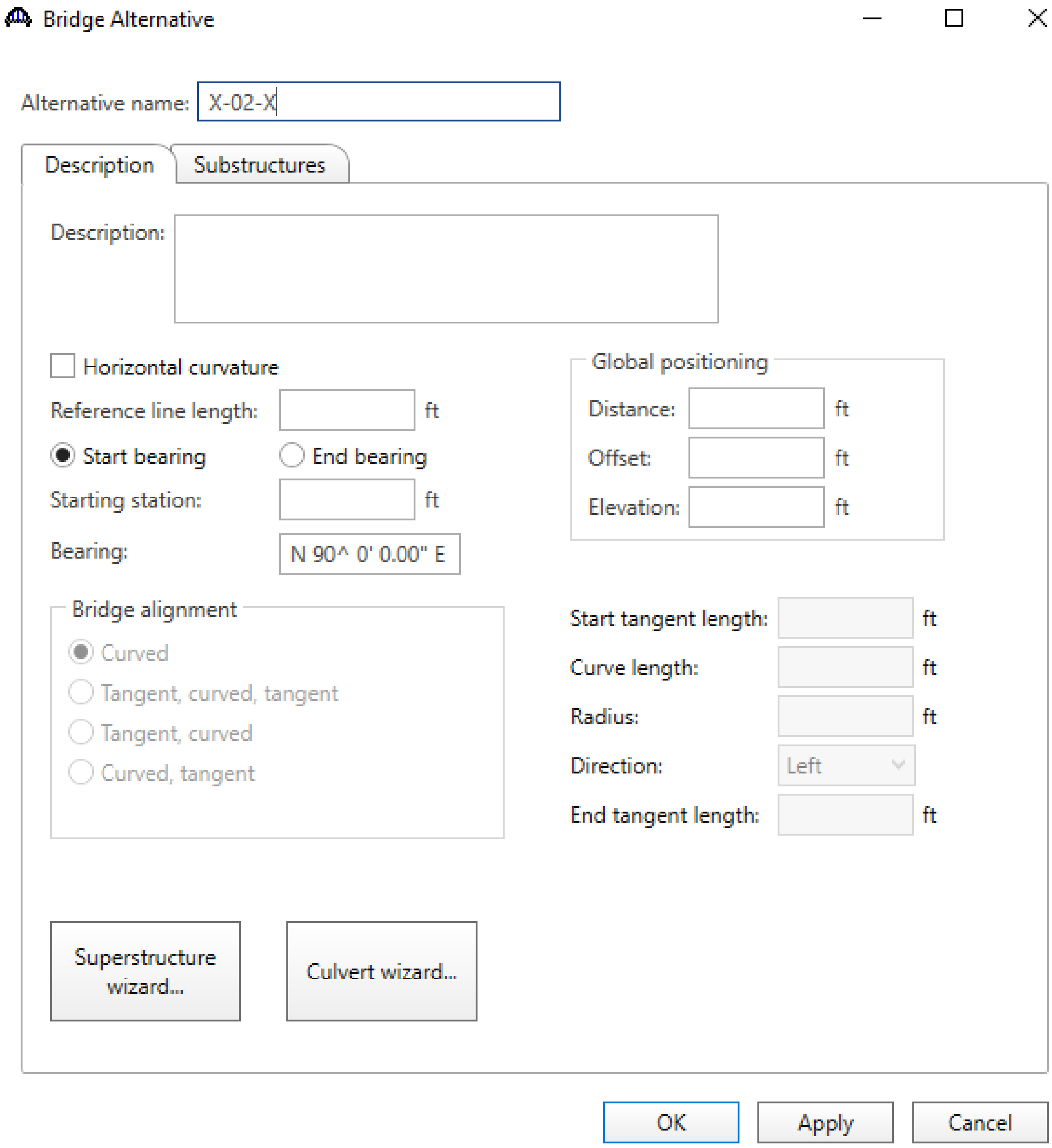
Select Bridge│Schematic to review the reinforcement data.


X-02-X
Culvert Example 2 - Culvert X-02-X -
6/15/2022

The description of the single-cell reinforced concrete box culvert is now complete.

Select File│Save to save the file in BrR.

Double-click on Bridge Alternatives to create an Alternative name. Enter the Bridge Alternative name as show below.



Alternative name: X-02-X

☐ Horizontal curvature

● Start bearing ○ End bearing

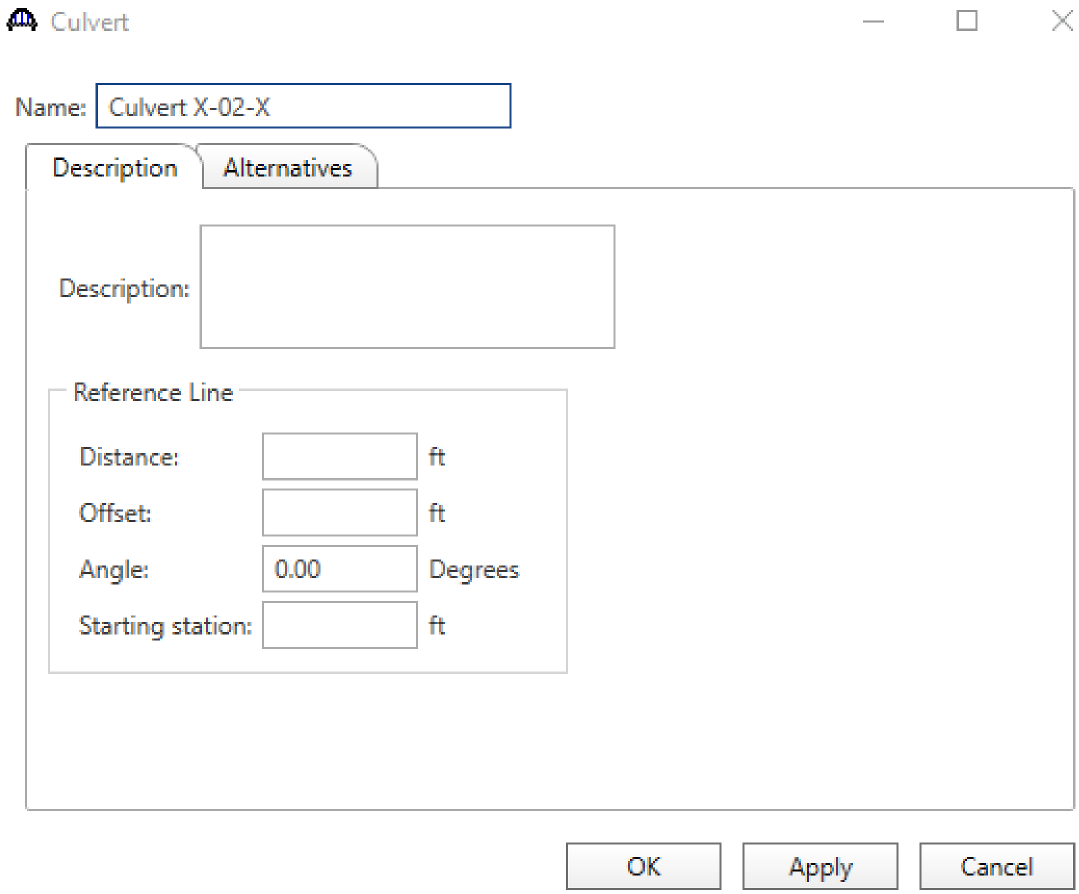
Bearing: N 90^ 0' 0.00" E

Bridge alignment: ● Curved ○ Tangent, curved, tangent ○ Tangent, curved ○ Curved, tangent

Direction: Left

Click Ok to save the data to memory and close the window.

Double-click on Culverts to create a culvert name. Enter the Culvert name as show below.

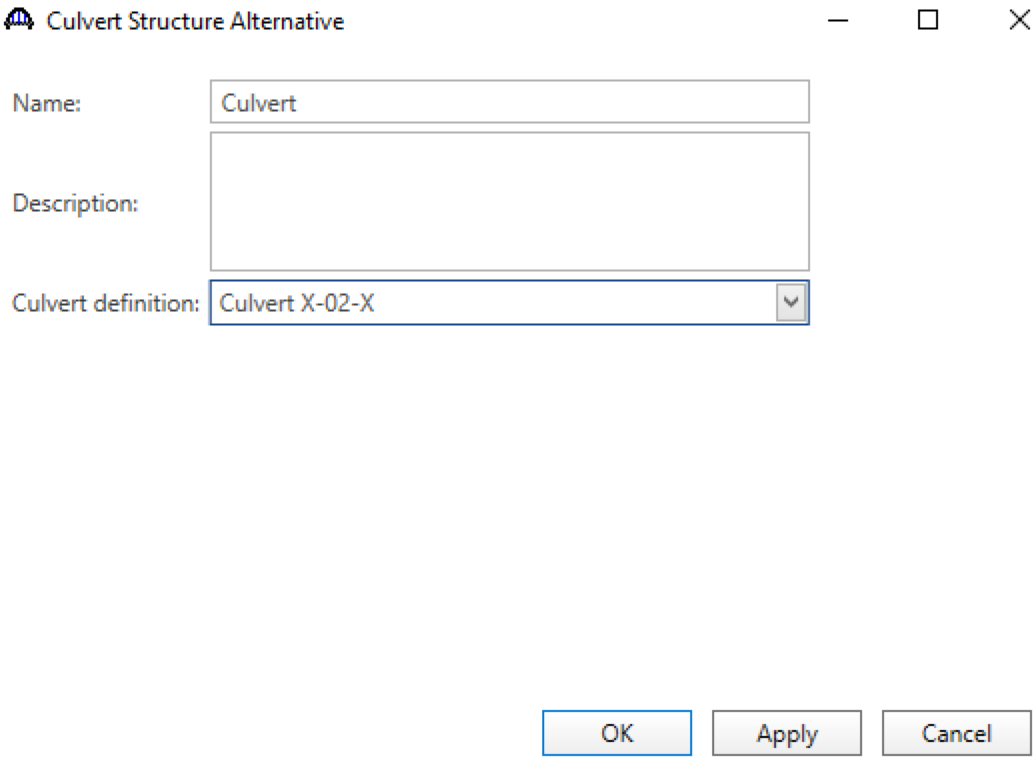


Name: Culvert X-02-X

Angle: 0.00 Degrees

Click Ok to save the data to memory and close the window.

Double-click on Culvert Structure Alternative a name. Enter the Culvert Structure Alternative name as show below.

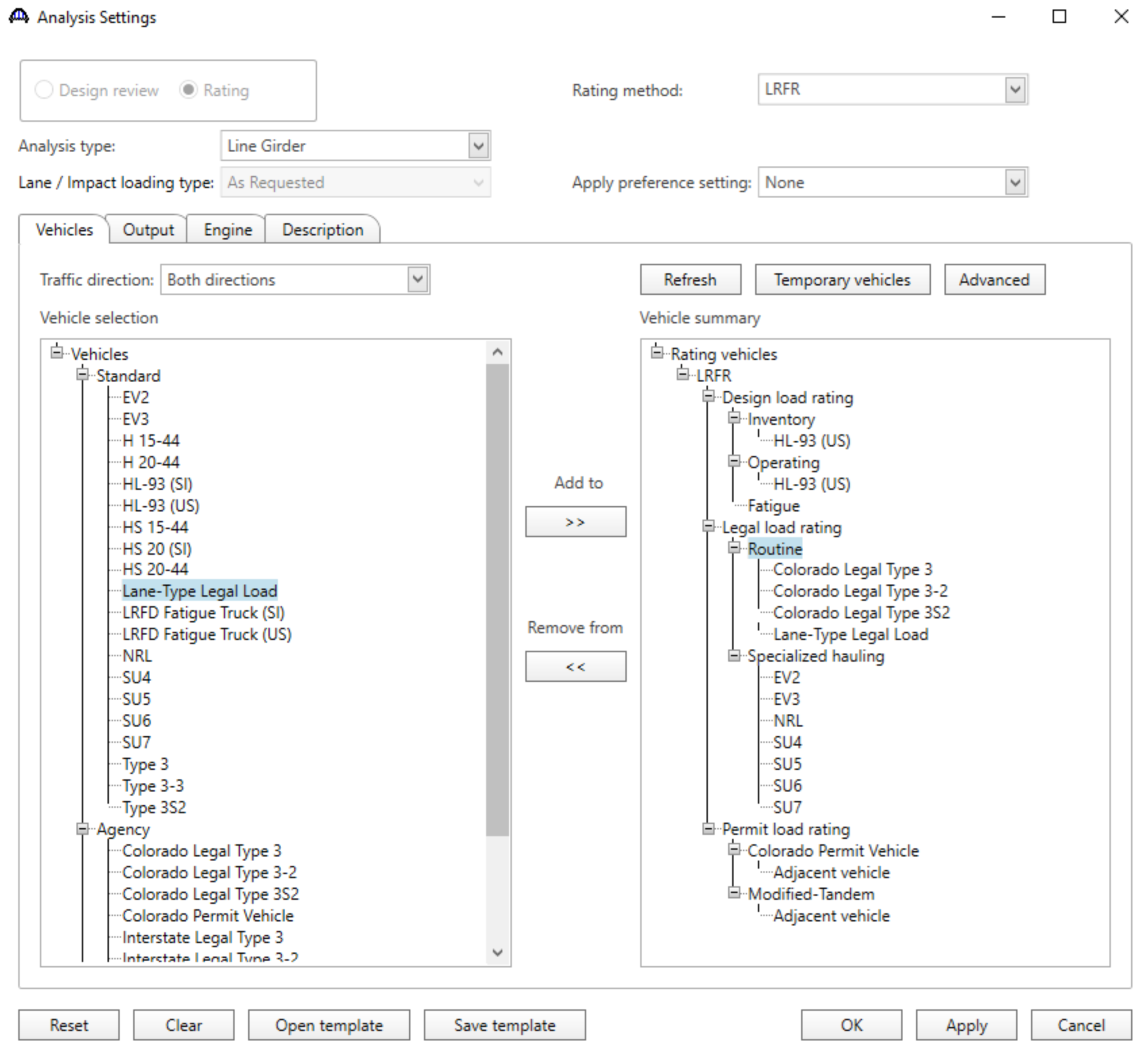


Name: Culvert

Description:

Culvert definition: Culvert X-02-X

To perform LRFR Design Load Rating, open the Analysis setting window by selecting Bridge│Analysis Settings. Select LRFR as the Rating Method and specify the vehicles.



Rating method: LRFR

Analysis type: Line Girder

Lane / Impact loading type: As Requested

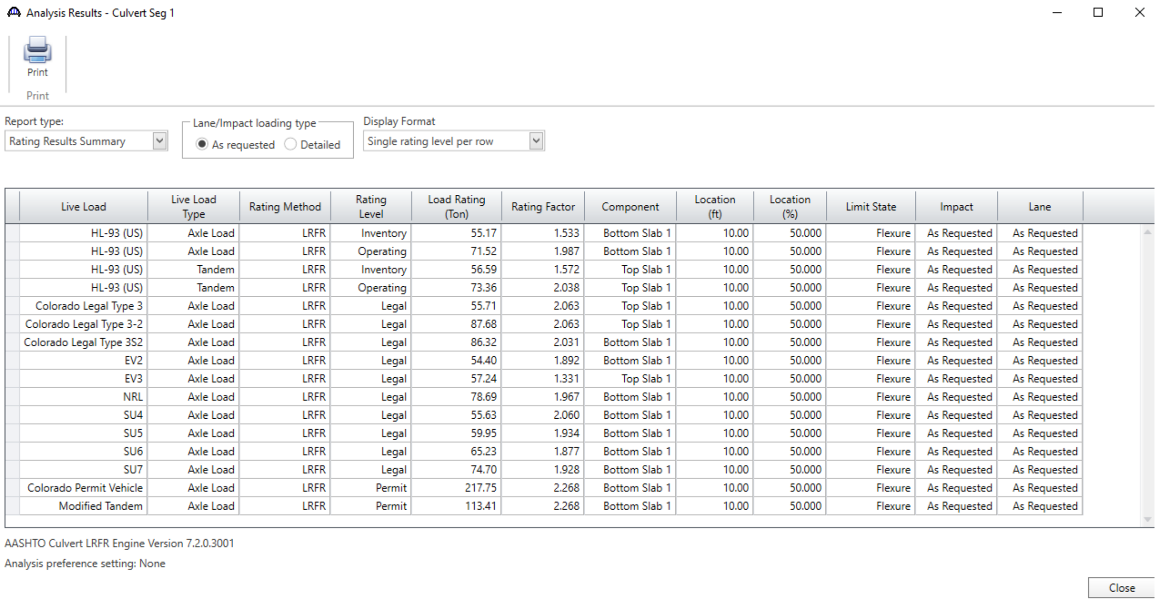
Apply preference setting: None

Traffic direction: Both directions

Click Ok to save the analysis settings to memory and close the window.

Select Culvert Seg 1 in the tree. Select Bridge | Analyze to start the rating process. Click Ok to close the Analysis Progress window after the analysis is completed.

Select Bridge | Tabular Report to open the Analysis Results window.



Report type: Rating Results Summary

Lane/Impact loading type: ● As requested ○ Detailed

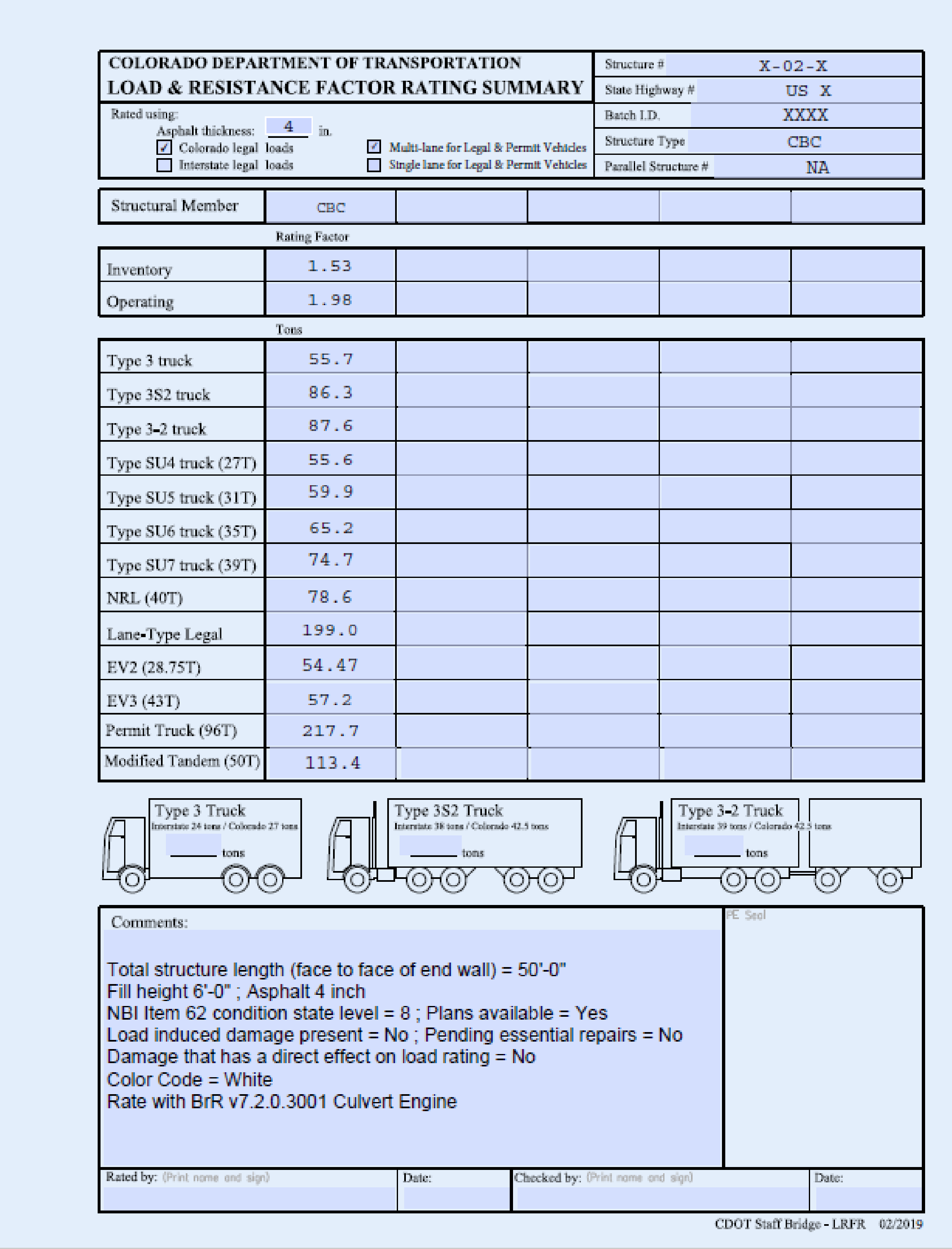
Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Component	Location (ft)	Location (%)	Limit State	Impact	Lane
HL-93 (US)	Axle Load	LRFR	Inventory	55.17	1.533	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Axle Load	LRFR	Operating	71.52	1.987	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Inventory	56.59	1.572	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Operating	73.36	2.038	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3	Axle Load	LRFR	Legal	55.71	2.063	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3-2	Axle Load	LRFR	Legal	87.68	2.063	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3S2	Axle Load	LRFR	Legal	86.32	2.031	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
EV2	Axle Load	LRFR	Legal	54.40	1.892	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
EV3	Axle Load	LRFR	Legal	57.24	1.331	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
NRL	Axle Load	LRFR	Legal	78.69	1.967	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU4	Axle Load	LRFR	Legal	55.63	2.060	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU5	Axle Load	LRFR	Legal	59.95	1.934	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU6	Axle Load	LRFR	Legal	65.23	1.877	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU7	Axle Load	LRFR	Legal	74.70	1.928	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Permit Vehicle	Axle Load	LRFR	Permit	217.75	2.268	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Modified Tandem	Axle Load	LRFR	Permit	113.41	2.268	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested

AASHTO Culvert LRFR Engine Version 7.2.0.3001

Analysis preference setting: None

Fill out the Rating Summary Sheet using the policies and guidelines in the Bridge Rating Manual, Section 1.



COLORADO DEPARTMENT OF TRANSPORTATION
LOAD & RESISTANCE FACTOR RATING SUMMARY

Structure #	X-02-X
State Highway #	US X
Batch I.D.	XXXX
Structure Type	CBC
Parallel Structure #	NA

Rated using:
Asphalt thickness: 4 in.
☑ Colorado legal loads
☐ Interstate legal loads
☑ Multi-lane for Legal & Permit Vehicles
☐ Single lane for Legal & Permit Vehicles

Structural Member	CBC				
	Rating Factor				
Inventory	1.53				
Operating	1.98				
	Tons				
Type 3 truck	55.7				
Type 3S2 truck	86.3				
Type 3-2 truck	87.6				
Type SU4 truck (27T)	55.6				
Type SU5 truck (31T)	59.9				
Type SU6 truck (35T)	65.2				
Type SU7 truck (39T)	74.7				
NRL (40T)	78.6				
Lane-Type Legal	199.0				
EV2 (28.75T)	54.47				
EV3 (43T)	57.2				
Permit Truck (96T)	217.7				
Modified Tandem (50T)	113.4				

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
_____ tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
_____ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
_____ tons

Comments:

Total structure length (face to face of end wall) = 50'-0"
Fill height 6'-0" ; Asphalt 4 inch
NBI Item 62 condition state level = 8 ; Plans available = Yes
Load induced damage present = No ; Pending essential repairs = No
Damage that has a direct effect on load rating = No
Color Code = White
Rate with BrR v7.2.0.3001 Culvert Engine

PE Seal

Rated by: (Print name and sign)
Date:
Checked by: (Print name and sign)
Date:

CDOT Staff Bridge - LRFR 02/2019

SECTION 14A
CULVERTS

14A.1 INTRODUCTION TO RATING CULVERTS

This section covers the load rating of culverts, flexible and rigid other than concrete box culverts. Culverts include, but are not limited to: metal pipe, metal plate pipe, pipe arch, long span plate structure, thermoplastic pipe, steel reinforced thermoplastic pipe, and fiberglass pipe. This section also covers rigid pipes such as concrete pipes. Culverts are to be rated using the policies and guidelines of the Bridge Rating Manual, Section 1 and Subsections 14A.2 and 14A.3.
The load rating of concrete box culverts is covered in section 14.

When there are no plans available for the culverts, the requirements in Subsection 1.5 of CDOT Bridge Rating Manual, CDOT M&S Standards, or AASHTO Specifications may be used if proven to be representative of the culvert. Field measurements may also be used.

The types of flexible culverts covered by this section are:
AAC - Aluminum Arch Culvert
CMP - Corrugated Metal Pipe (Steel/Aluminum)
CPP - Corrugated Plastic Pipe
SAC - Steel Arch Culvert/Multiplate Arch Culvert
SPP - Smooth Plastic Pipe

The other types of rigid culverts also covered by this section are:
RCPC - Reinforced Concrete Pipe Culvert
CAC - Concrete Arch Culvert

14A.2 POLICIES AND GUIDELINES FOR RATING CULVERTS

14A.2.1 General

A) A culvert shall be rated or re-rated based on AASHTO Load and Resistance Factor Rating (LRFR) using latest version on CANDE (Culvert Analysis and Design) software. Programs other than CANDE must be approved in advance by the CDOT Bridge Rating Engineer.

B) A major culvert is defined as a culvert or a group of culverts that have a span length of greater than 20 feet measured parallel to the centerline of roadway from outside of the first pipe to the outside of the last pipe. A group of culverts are culverts with distance between them of less than or equal to the radius of the smallest culvert in the group.

C) A minor culvert is defined as a culvert or a group of culverts that have a span length of less than or equal 20 feet but greater than or equal to 4 feet measured parallel to the centerline of roadway from outside of the first pipe to the outside of the last pipe.

D) Inventory and operating ratings shall be performed for HL-93 as applicable. Additionally, an operating rating shall be performed for appropriate Legal Loads (Colorado or Interstate Type 3, 3-2, and 3S2), NRL, EVs, Colorado Permit Vehicle, and Modified Tandem. Rating for SHVs shall be performed if the rating factor (RF) for the NRL vehicle is less than 1.0. Truck configurations for the legal loads, NRL, SHVs, EVs, Colorado Permit Vehicle, and Modified Tandem can be obtained from Chapter 1 of the CDOT Rating Manual.

E) For live load~~s~~ and impact factors refer to AASHTO Specifications, AASHTO Manual for Bridge Evaluation, and CDOT Bridge Rating Manual Section 1.

F) “For single-span culverts, the effects of live load may be neglected where the depth of fill is more than 8.0 ft. and exceeds the span length. For multiple span culverts, the effects may be neglected where the depth of fill exceeds the distance between inside faces of end walls.” AASHTO LRFD 8th edition, section 3.6.1.2.6. When these conditions are met, the capacity adequacy shall be verified for dead load and other superimposed loads. The rater shall also verify and document that the fill height meets CDOT M&S Standard fill height limitations.

G) The structure Inspection and appraisal report shall be investigated for the culvert condition. Reducing section properties due to loss of cross section or damage shall be investigated and accounted for by a professional engineer. Findings and recommendation shall be discussed with the Staff Bridge contact and the Bridge Rating engineer prior to finalizing the rating. If approved, the findings and recommendation shall be clearly documented in the rating package.

H) Refined analysis and/or soil interaction analysis may be used if rating shows that posting or color coding per section 1.15 or 1.16 is required. Geotechnical engineering may be required to provide soil interaction properties.

I) For multiple lines of buried pipe structure that meets the minimum spacing between pipes per AASHTO LRFD, Section 12.6.7, a single pipe instead of multi-pipe may be modeled for load rating analysis.

14A.2.2 Calculations

A) A set of calculations, separate from computer output, shall be submitted with each rating package. These calculations shall include derivations for dead loads, derivation of live load, and any other calculations or assumptions used for the rating.

B) Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.
2. Dead loads shall include fill, pavement, curbs, sidewalks, railing, etc.
3. Fill Dead loads shall be calculated based on 125 lb/ft³.

C) Use the minimum design yield strength value F_y from plans or AASHTO Specifications.

14A.3 RATING REPORTING AND PACKAGING REQUIREMENTS

14A.3.1 Rating Reporting/Package Requirements

A) A copy of the schematic drawing or sketch showing the elevation and applied loads shall be included with the rating package. Rating procedure shall be per section 1.11 or 1.12 as applicable.

B) The rater and checker shall complete the rating documentation as described in Section 1 of the Bridge Rating Manual. Any variation from the original design assumptions shall be added to the Rating Summary Sheet as applicable. The rating package requirements shall be per Section 1.13 and Section 1.14 of the Bridge Rating Manual and as amended herein.

14A.3.2 Consultant Submittal Requirements

A) Consultant designed/rated culverts: Before finalizing the rating package and when a computer program is used as the analysis tool, the rater shall verify with Staff Bridge that the program being used is acceptable to CDOT. Unapproved program data files may be rejected.

B) When the rating is finalized, the rater shall save the input and output files. The files name shall include the structure number of the rated culvert. The rating package including the program input and output files, the rating summary sheet, and necessary computations shall be transmitted electronically (.xlsx, .xml, etc.) and in PDF format to Staff Bridge for review and archiving.

14A.4 INTRODUCTION TO CANDE SOFTWARE

CANDE is a public domain 2D finite element software for analysis and design of culverts and buried structures (corrugated metal, reinforced concrete, and thermoplastics). CANDE can rate or design buried structures by Load Resistance Factor Design (LRFD) or Allowable Stress Design (ASD) methodologies.

There are three levels for analysis: Level 1, 2 and 3 as shown in Fig 14A-1. CANDE will generate a mesh automatically for half of the culvert then by using the Tool Box application can convert to a level 3 mesh (full culvert).

CANDE analyzes different types of culverts (steel, concrete, and plastic) for various design criteria as shown in Table 14A-1.

Culvert properties such as: (culvert type, soil types, culvert wall thickness, fill materials density, thickness, etc.) must be defined in CANDE but to receive a rating for the culvert, the user must use the Tool Box attached to CANDE software.

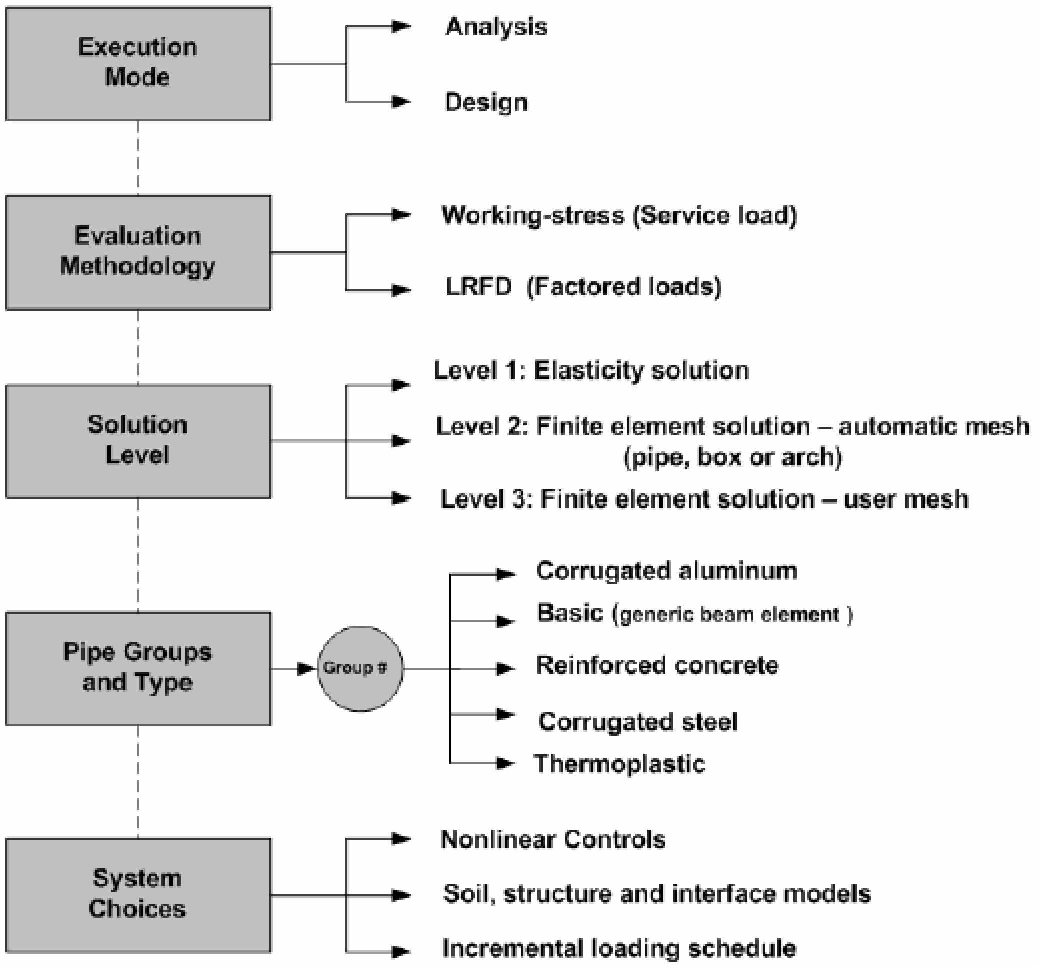
14A.5 INTRODUCTION TO CANDE TOOL BOX SOFTWARE

The CANDE Tool Box is an application that supplements the CANDE software to rate culverts. It has the ability to define wearing surface thickness, convert analysis level, define design, legal and permit trucks with varies load factors, and to obtaining rating factors.

Table 14A-1: Design/Analysis CANDE criteria

Buried structure Type	**Analysis/Design Criteria**
Corrugated Metal	• Thrust Yielding • Buckling • Seam Failure • Plastic hinging
Reinforced Concrete	• Steel Yielding • Concrete Crush • Shear failure • Radial Tension
Plastic	• Thrust Yielding • Bucking • Combined Strain • Tension Strain

Figure 14A-1 CANDE Analysis/Design procedure (as outlined in tha CANDE-2019 Manual)



The following information was obtained from CDOT standards and AASHTO Standard Specification Section 12:

Table 14A-2: Materials Specifications

Pavement Unit weight	146.67	pcf
Soil Unit Weight	125	pcf
Soil Stiffness factor K	0.22	
Steel Pipe material Modulus of Elasticity, E_m	29,000,000	psi
Pipe material Min. Tensile Strength, f_u	45,000	psi
Pipe material Min. Yield Point, F_y	33,000	psi
Capacity Modification Factor for Wall Area and Buckling, Φ_b	1.0	
Capacity Modification Factor for Seam Strength, Φ_s	0.67	
Elastic Young modulus for steel	29,000,000	psi
Poisson's ratio for steel	0.3	
Yield stress for steel	33,000	psi
Steel Density	490	pcf
Elastic Young modulus for aluminum	10,000,000	psi
Poisson's ratio for Aluminum	0.33	
Yield stress for Aluminum	24,000	psi
Aluminum Density	170	pcf
Compressive Strength of Concrete, $f'c$	Based on the actual grade	ksi
Concrete Density	150	pcf
Poisson's ratio for concrete	0.17	
Elastic Young modulus for concrete	$120 * (Density)^2$	psi
Plastic Elastic Young modulus for short-term loading	See attached table	
Plastic Ultimate stress limit for short-term loading	See attached table	
Plastic Elastic Young modulus for long-term loading	See attached table	
Plastic Ultimate stress limit for long-term loading	See attached table	
Poisson's ratio for plastic	0.3	

Table 14A-3: Plastic Materials Specifications

Type of plastic	Effective Young's Modulus (PE)		Ultimate strength (PU)	
	Short-Term (ksi)	Long-term (ksi)	Short-Term (ksi)	Long-term (ksi)
HDPE –High Density Polyethylene	110	22	3	0.9
PVC –Polyvinyl Chloride	400	140	6	2.6
PP –Polypropylene	135	31	3.1	1

Table 14A-4: Section Properties for Standard Steel Corrugation Sizes

Corrugation Profile	Section Properties	Corrugation thickness (in)						
		0.040	**0.052**	**0.064**	**0.079**	**0.109**	**0.138**	**0.168**
1-1/2 x 1/4	$PA\ in^2/in$	0.03800	0.05070	0.06340	0.07920	0.11090	0.14270	0.17480
	$PI\ \ in^4/in$	0.00025	0.00034	0.00044	0.00057	0.00086	0.00121	0.00164
	$PS\ \ in^3/in$	0.00172	0.00225	0.00280	0.00347	0.00479	0.00624	0.00785
2-2/3 x 1/2	$PA\ in^2/in$	0.03880	0.05160	0.06460	0.08070	0.11300	0.14530	0.17780
	$PI\ \ in^4/in$	0.00112	0.00150	0.00189	0.00239	0.00342	0.00453	0.00573
	$PS\ \ in^3/in$	0.00415	0.00543	0.00670	0.00826	0.01123	0.01420	0.01716
3 x 1	$PA\ in^2/in$	0.04450	0.05930	0.07420	0.09280	0.13000	0.16730	0.20480
	$PI\ \ in^4/in$	0.00515	0.00689	0.00866	0.01088	0.01546	0.02018	0.02509
	$PS\ \ in^3/in$	0.00990	0.01310	0.01628	0.02017	0.02788	0.03547	0.04296
5 x 1	$PA\ in^2/in$	0.00000	0.00000	0.06620	0.82670	0.11580	0.14900	0.18220
	$PI\ \ in^4/in$	0.00000	0.00000	0.00885	0.01109	0.01565	0.02032	0.02509
	$PS\ \ in^3/in$	0.00000	0.00000	0.01664	0.02056	0.02822	0.03571	0.04296

Corrugation Profile	Section Properties	Corrugation thickness (in)						
		0.110	**0.140**	**0.170**	**0.188**	**0.218**	**0.249**	**0.280**
6 x 2	$PA\ \ in^2/in$	0.12970	0.16690	0.20410	0.22830	0.26660	0.30420	0.34330
	$PI\ \ in^4/in$	0.06041	0.07816	0.09616	0.10800	0.12691	0.14616	0.16583
	$PS\ \ in^3/in$	0.05726	0.07305	0.08863	0.09872	0.11444	0.12998	0.14546

Corrugation Profile	Section Properties	Corrugation thickness (in)	
		0.318	**0.380**
6 x 2	$PA\ \ in^2/in$	0.38930	0.46780
	$PI\ \ in^4/in$	0.19000	0.23200
	$PS\ \ in^3/in$	0.16393	0.19496

Table 14A-5: Section Properties for Standard Aluminum Corrugation Sizes

Corrugation Profile	Section Properties	Corrugation thickness (in)					
		0.048	**0.060**	**0.075**	**0.105**	**0.135**	**0.164**
1-1/2 x 1/4	$PA\ \ in^2/in$	0.05070	0.06342	0	0	0	0
	$PI\ \ in^4/in$	0.00034	0.00035	0	0	0	0
	$PS\ \ in^3/in$	0.00228	0.00226	0	0	0	0
2-2/3 x 1/2	$PA\ \ in^2/in$	0	0.06458	0.08067	0.11300	0.14533	0.17775
	$PI\ \ in^4/in$	0	0.00189	0.00239	0.00342	0.00453	0.00573
	$PS\ \ in^3/in$	0	0.00675	0.00831	0.01131	0.01427	0.01726
3 x 1	$PA\ \ in^2/in$	0	0.07416	0.09317	0.1300	0.17400	0.20483
	$PI\ \ in^4/in$	0	0.00866	0.01088	0.01545	0.02017	0.02508
	$PS\ \ in^3/in$	0	0.01634	0.02024	0.02796	0.03554	0.04309
6 x 1	$PA\ \ in^2/in$	0	0.0646	0.08067	0.11300	0.14533	0.17775
	$PI\ \ in^4/in$	0	0.00850	0.01060	0.01490	0.01910	0.02340
	$PS\ \ in^3/in$	0	0.01604	0.01972	0.02697	0.03366	0.04021

Corrugation Profile	Section Properties	Corrugation thickness (in)					
		0.100	**0.125**	**0.150**	**0.175**	**0.200**	**0.225**
9 x 2 ½	$PA\ \ in^2/in$	0.11700	0.14583	0.17500	0.20408	0.23325	0.26242
	$PI\ \ in^4/in$	0.08310	0.10400	0.12490	0.14590	0.16700	0.18820
	$PS\ \ in^3/in$	0.06392	0.07924	0.09426	0.10908	0.12370	0.13813

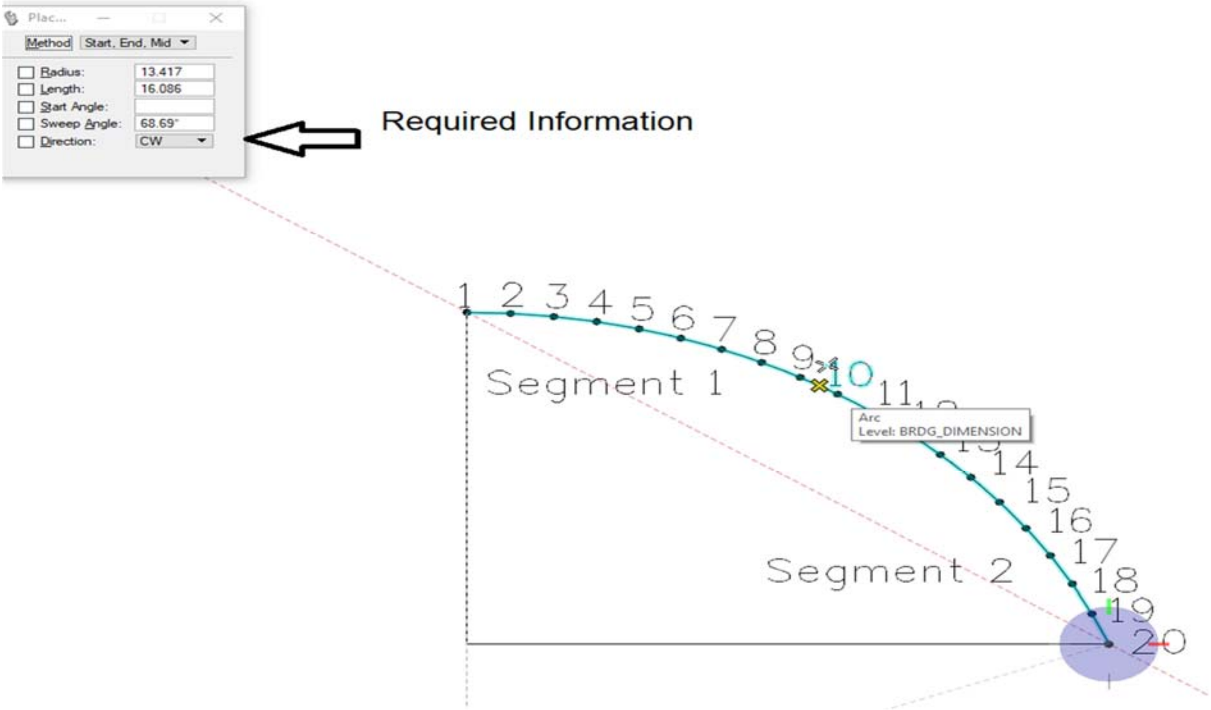
Corrugation Profile	Section Properties	Corrugation thickness (in)
		0.250
9 x 2 ½	$PA\ \ in^2/in$	0.29175
	$PI\ \ in^4/in$	0.20940
	$PS\ \ in^3/in$	0.15229

14A.6 ARCH GEOMETRIC DATA DEFINITION PROCEDURE IN CANDE

14A.6-1: Two Segment Arch Definition

1. Draw a horizontal line in MicroStation with length S (Pipe Span Length) as detailed in the Culvert Field Measurement Form
2. From the center of that line, draw a vertical line with length R (Pipe Rise)
3. Create an arc using the “Start, End, Mid” method and make sure the arc’s radius centers on the drew vertical line.
4. Record the radius and sweep angle from the “Place arc” command box
5. In the “Arch Segments and Angles” section of CANDE, input the value of the radius previously recorded in the “R1” and “R2” fields. Divide the sweeping angle by 2 and record those values in “Angle for R1 segment” and “Angle for R2 segment”.
6. Go to Material Definition 4 (Interface 1) and input 90° and change the coefficient of friction to 0.3 (the minimum value)
7. Go to Material Definition 5 (Interface 2) under the Material Control Parameters change the Material Name to “Interface #19” and change the Material ID to 19. This is the last interface of the nodes generated by CANDE. The program will calculate all the interface angles in between. Using the equation $\theta(i) = 90 - (i-1) * \frac{\Delta}{m-1}$ where i = 1, 2, …, m and m= total number of nodes (should always be 20 for a two-segmented arch) and delta = sweep angle, calculate the interface angle at the 20th node. Input this value into the “Angle from x-axis to normal interface” field of Material Definition 5 and change the coefficient of friction to 0.3.

Figure 14A-2: Two Segmented Arch

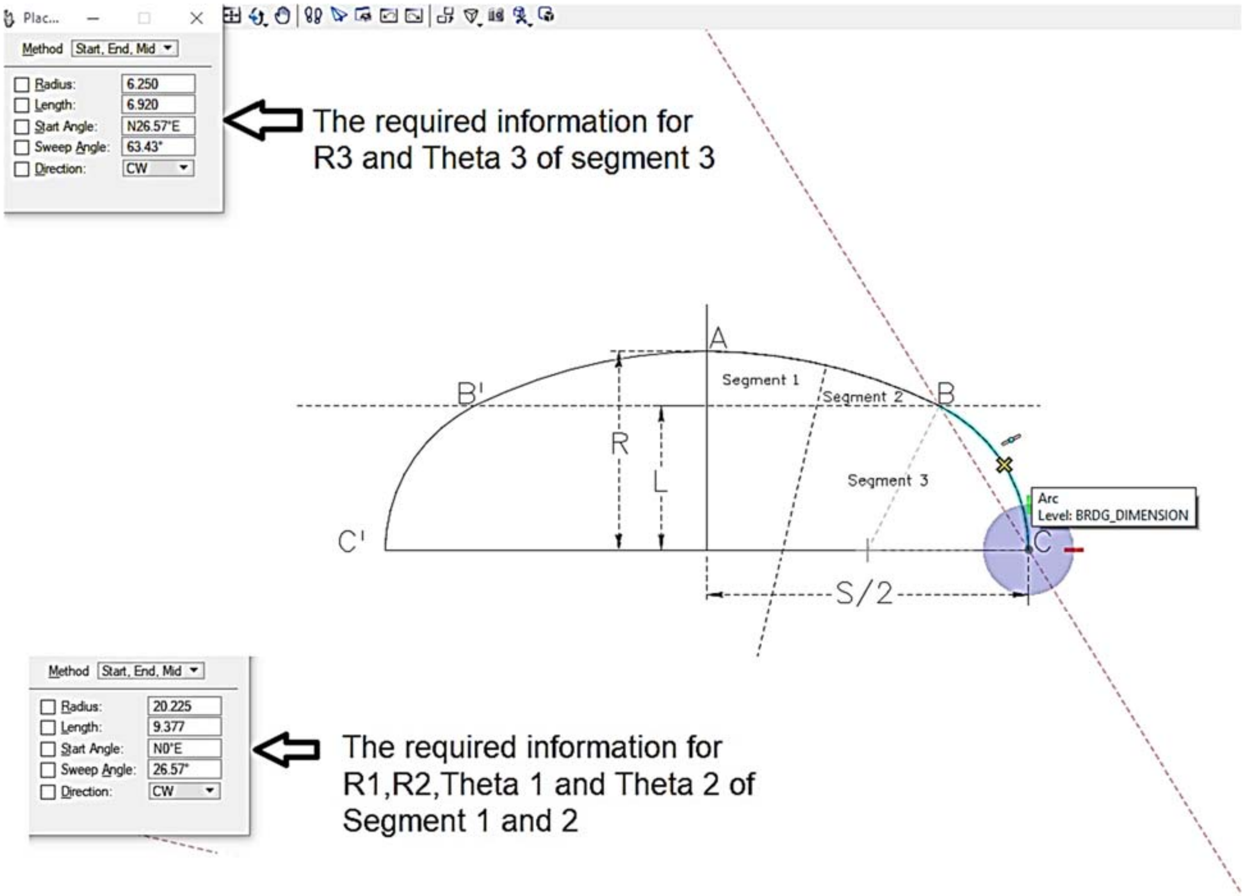


Method: Start, End, Mid
☐ Radius: 13.417
☐ Length: 16.086
☐ Start Angle:
☐ Sweep Angle: 68.69°
☐ Direction: CW

14A.6-2: Three Segment Arch Definition

1. Draw a horizontal line in MicroStation with length S (Pipe Span Length) as detailed in the Culvert Field Measurement Form
2. From the center of that line, draw a vertical line with length R (Pipe Rise)
3. From the center of that line, draw another vertical line with length L (Vertical rise of side segment)
4. Create an arc for segment 1 and 2 using the “Start, End, Mid” method and make sure the arc’s start from B’ to B point (as shown in the attached drawing).
5. Record the radius and sweep angle from the “Place arc” command box for Arch of segment 1 and 2
6. In the “Arch Segments and Angles” section of CANDE, input the value of the radius previously recorded in the “R1” and “R2” fields. Divide the sweeping angle by 2 and record those values in “Angle for R1 segment” and “Angle for R2 segment”.
7. Create an arc using the “Start, End, Mid” method and make sure the arcs from point B to point C.
8. Record the radius and sweep angle from the “Place arc” command box.
9. In the “Arch Segments and Angles” section of CANDE, input the value of the radius previously recorded in the “R3” and sweeping angle. Record those values in “Angle for R3 segment” and “Angle for R3 segment”.
10. To activate R3 and Theta 3 values define “vertical rise of side segment” in “Arch and footing dimension definition” equal to “L” length.
11. Go to Material Definition 4 (Interface 1) and input 90° and change the coefficient of friction to 0.3 (the minimum value)
12. Go to Material Definition 5 (Interface 2) under the Material Control Parameters change the Material Name to “Interface #19” and change the Material ID to 19. This is the last interface of the nodes generated by CANDE. The program will calculate all the interface angles in between. Using the equation where i = 1, 2, …, m and m= total number of nodes (should always be 20 for a two-segmented arch) and delta = sweep angle, calculate the interface angle at the 20th node. Input this value into the “Angle from the x-axis to normal interface” field of Material Definition 5 and change the coefficient of friction to 0.3.

Figure 14A-3: Three Segmented Arch



Plac...

Method: Start, End, Mid

☐ Radius: 6.250
☐ Length: 6.920
☐ Start Angle: N26.57°E
☐ Sweep Angle: 63.43°
☐ Direction: CW

The required information for R3 and Theta 3 of segment 3

Method: Start, End, Mid

☐ Radius: 20.225
☐ Length: 9.377
☐ Start Angle: N0°E
☐ Sweep Angle: 26.57°
☐ Direction: CW

The required information for R1,R2,Theta 1 and Theta 2 of Segment 1 and 2

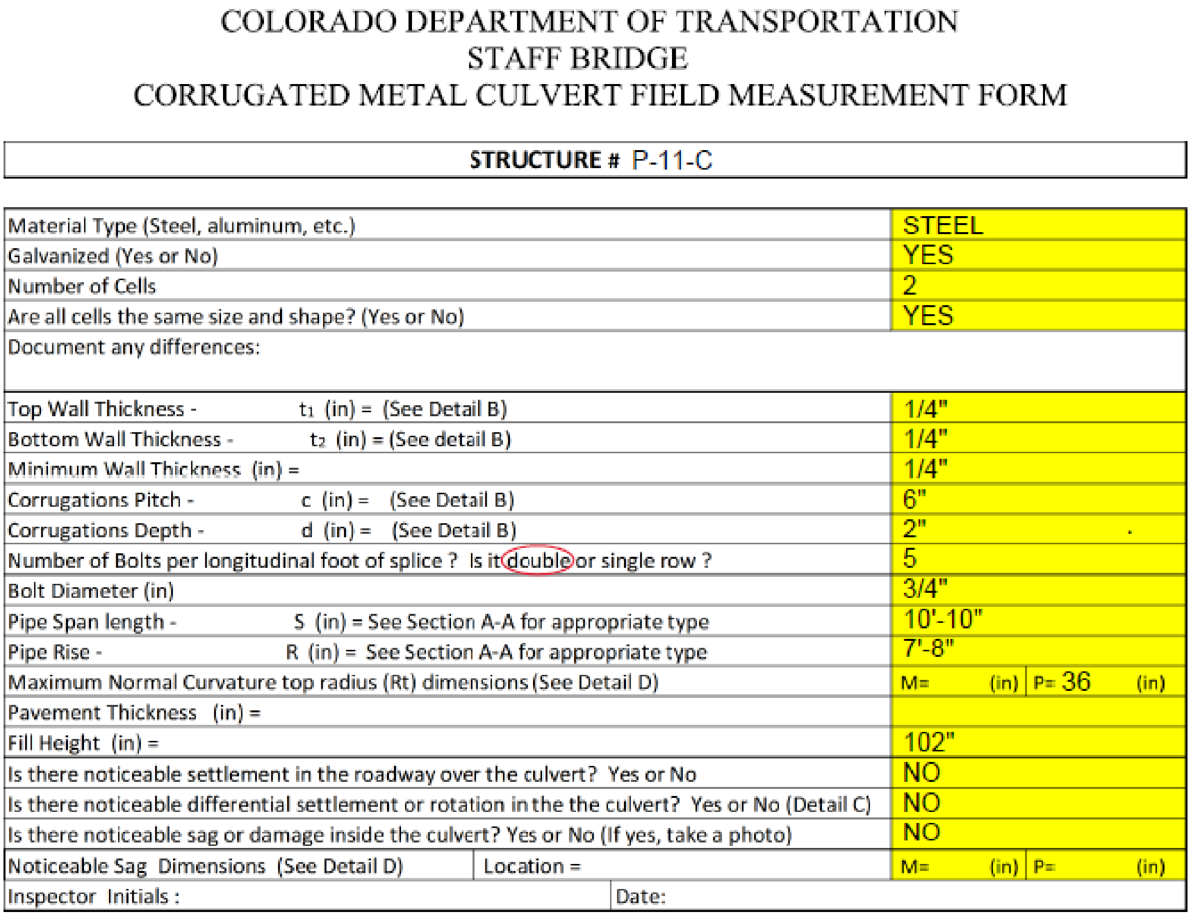
14A.7 CULVERT RATING EXAMPLES

14A.7.1 Example 1: Corrugated Metal Pipe (CMP)

The example presented in this section is based on LRFR method. The rating is for Structure P-11-C, 2-Cells Corrugated Metal Pipe (CMP) pictured below.

CANDE has two options for pipe rating, first option pipe only and second option pipe with soil interface. It is recommend to rate pipe without soil interface being more conservative.

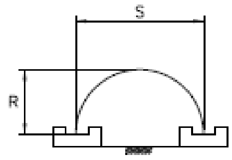
The following information is provided by the inspector:



COLORADO DEPARTMENT OF TRANSPORTATION
STAFF BRIDGE
CORRUGATED METAL CULVERT FIELD MEASUREMENT FORM

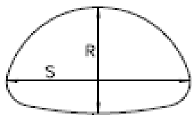
STRUCTURE # P-11-C

Material Type (Steel, aluminum, etc.)	STEEL
Galvanized (Yes or No)	YES
Number of Cells	2
Are all cells the same size and shape? (Yes or No)	YES
Document any differences:	
Top Wall Thickness - t_1 (in) = (See Detail B)	1/4"
Bottom Wall Thickness - t_2 (in) = (See detail B)	1/4"
Minimum Wall Thickness (in) =	1/4"
Corrugations Pitch - c (in) = (See Detail B)	6"
Corrugations Depth - d (in) = (See Detail B)	2"
Number of Bolts per longitudinal foot of splice ? Is it [✓ double] or single row ?	5
Bolt Diameter (in)	3/4"
Pipe Span length - S (in) = See Section A-A for appropriate type	10'-10"
Pipe Rise - R (in) = See Section A-A for appropriate type	7'-8"
Maximum Normal Curvature top radius (Rt) dimensions (See Detail D)	M= (in) P= 36 (in)
Pavement Thickness (in) =	
Fill Height (in) =	102"
Is there noticeable settlement in the roadway over the culvert? Yes or No	NO
Is there noticeable differential settlement or rotation in the the culvert? Yes or No (Detail C)	NO
Is there noticeable sag or damage inside the culvert? Yes or No (If yes, take a photo)	NO
Noticeable Sag Dimensions (See Detail D) Location =	M= (in) P= (in)
Inspector Initials : Date:	

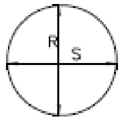


No t_2 values exist for this section

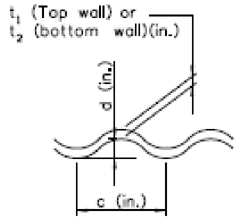
SECTION A-A
(ARCH)



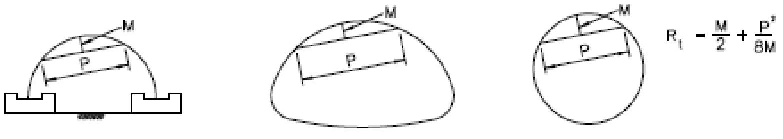
SECTION A-A
(PIPE ARCH)



SECTION A-A
(CIRCULAR)



DETAIL B
(METAL CORRUGATION & GAGE INFORMATION)

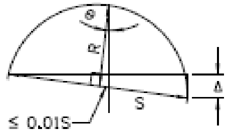


$R_t = \frac{M}{2} + \frac{P^2}{8M}$

(ARCH) (PIPE ARCH) (CIRCULAR)

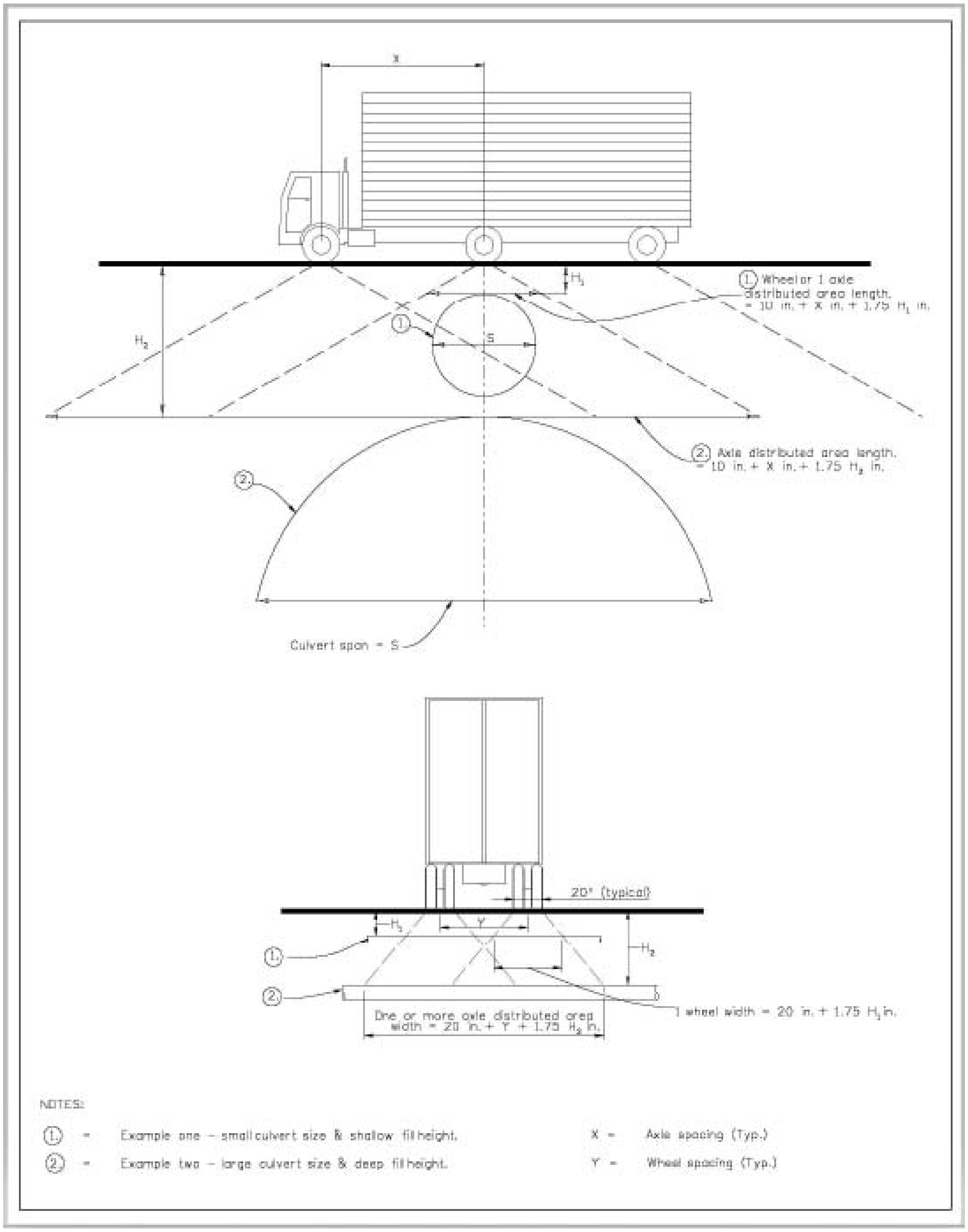
Calculate maximum existing normal curvature top radius (R_t) by taking measurments around the upper periphery of the culvert using a ruler of length "P" to obtain value of "M". This should be done at selected stations along length of culvert (particularly at locations with normal curvature and at location with noticeable sag)

DETAIL D
Top Radius Rt



The rotation of the structure, θ, may be determined as: $\theta = \tan^{-1}(\frac{\Delta}{S})$

DETAIL C
DIFFERENTIAL SETTLEMENT



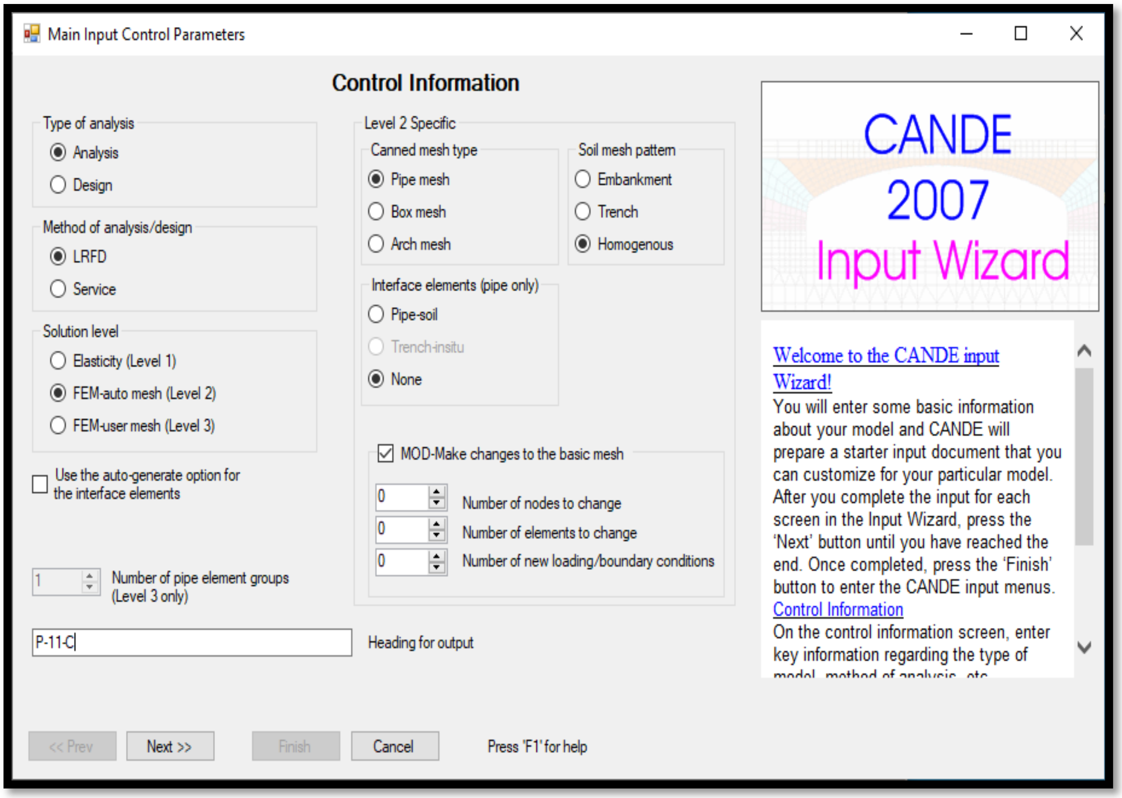
NOTES:

① = Example one – small culvert size & shallow fill height.

② = Example two – large culvert size & deep fill height.

X = Axle spacing (Typ.)

Y = Wheel spacing (Typ.)



Main Input Control Parameters

Control Information

Type of analysis
● Analysis
○ Design

Method of analysis/design
● LRFD
○ Service

Solution level
○ Elasticity (Level 1)
● FEM-auto mesh (Level 2)
○ FEM-user mesh (Level 3)

☐ Use the auto-generate option for the interface elements

1 Number of pipe element groups (Level 3 only)

Level 2 Specific

Canned mesh type
● Pipe mesh
○ Box mesh
○ Arch mesh

Soil mesh pattern
○ Embankment
○ Trench
● Homogenous

Interface elements (pipe only)
○ Pipe-soil
○ Trench-insitu
● None

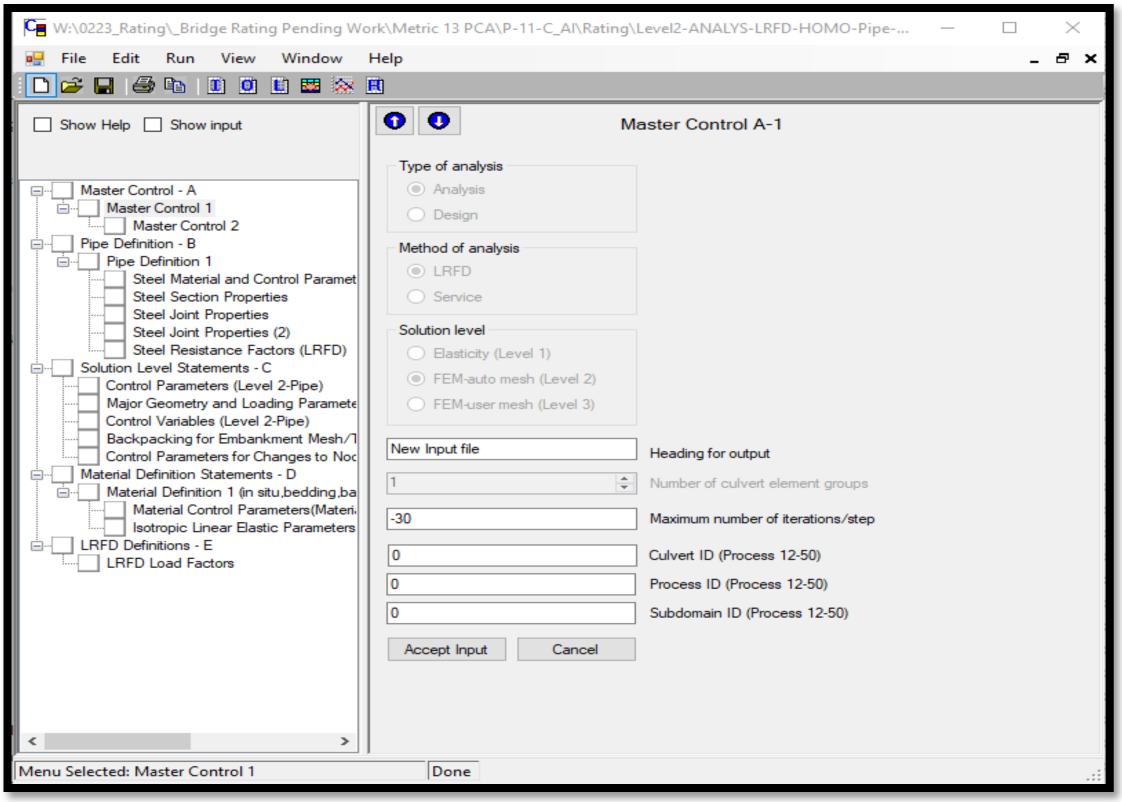
☑ MOD-Make changes to the basic mesh
0 Number of nodes to change
0 Number of elements to change
0 Number of new loading/boundary conditions

Heading for output: P-11-C

Welcome to the CANDE input Wizard!
You will enter some basic information about your model and CANDE will prepare a starter input document that you can customize for your particular model. After you complete the input for each screen in the Input Wizard, press the 'Next' button until you have reached the end. Once completed, press the 'Finish' button to enter the CANDE input menus.
Control Information
On the control information screen, enter key information regarding the type of

Press 'F1' for help

- In Main input control parameter: Interface element “None” soil interface neglected, if soil information available rater may use “pipe-soil” option.
- Solution level used “level 2” and converted to “level 3” by Tool Box.
- LRFD analysis type used per section 1.6-B.



Master Control A-1

Type of analysis
● Analysis
○ Design

Method of analysis
● LRFD
○ Service

Solution level
○ Elasticity (Level 1)
● FEM-auto mesh (Level 2)
○ FEM-user mesh (Level 3)

New Input file — Heading for output

1 — Number of culvert element groups

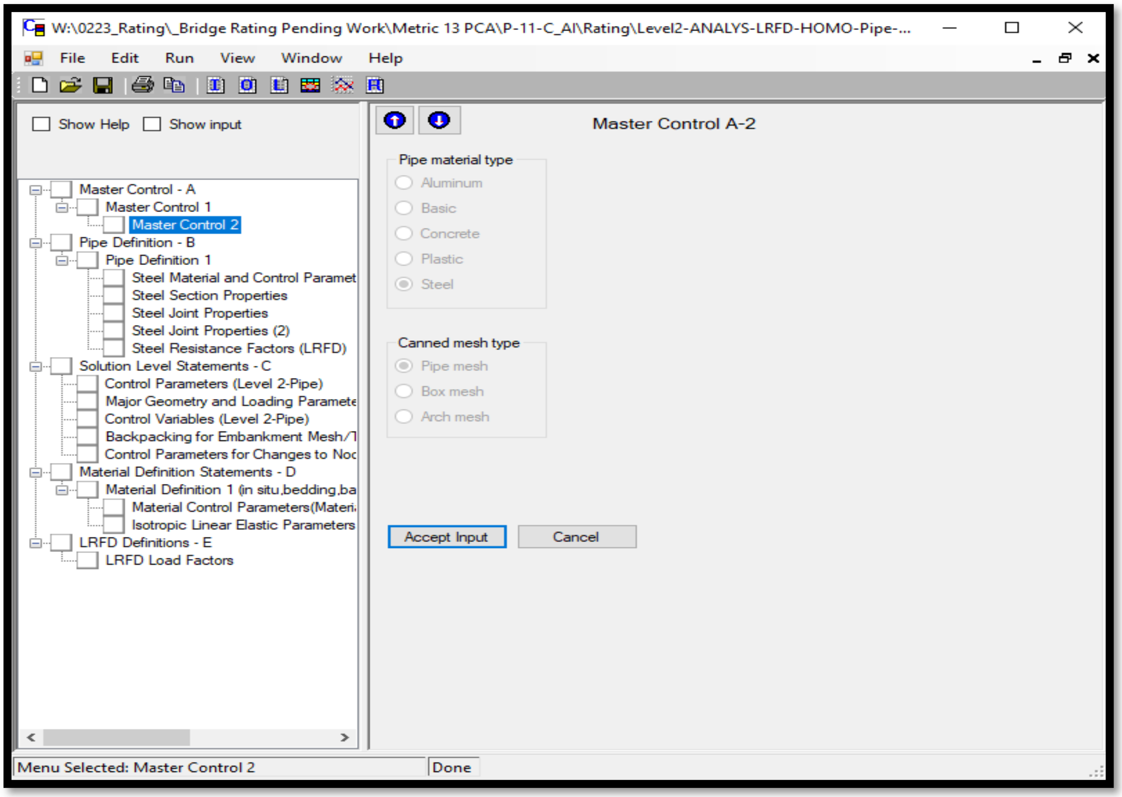
-30 — Maximum number of iterations/step

0 — Culvert ID (Process 12-50)

0 — Process ID (Process 12-50)

0 — Subdomain ID (Process 12-50)

Menu Selected: Master Control 1

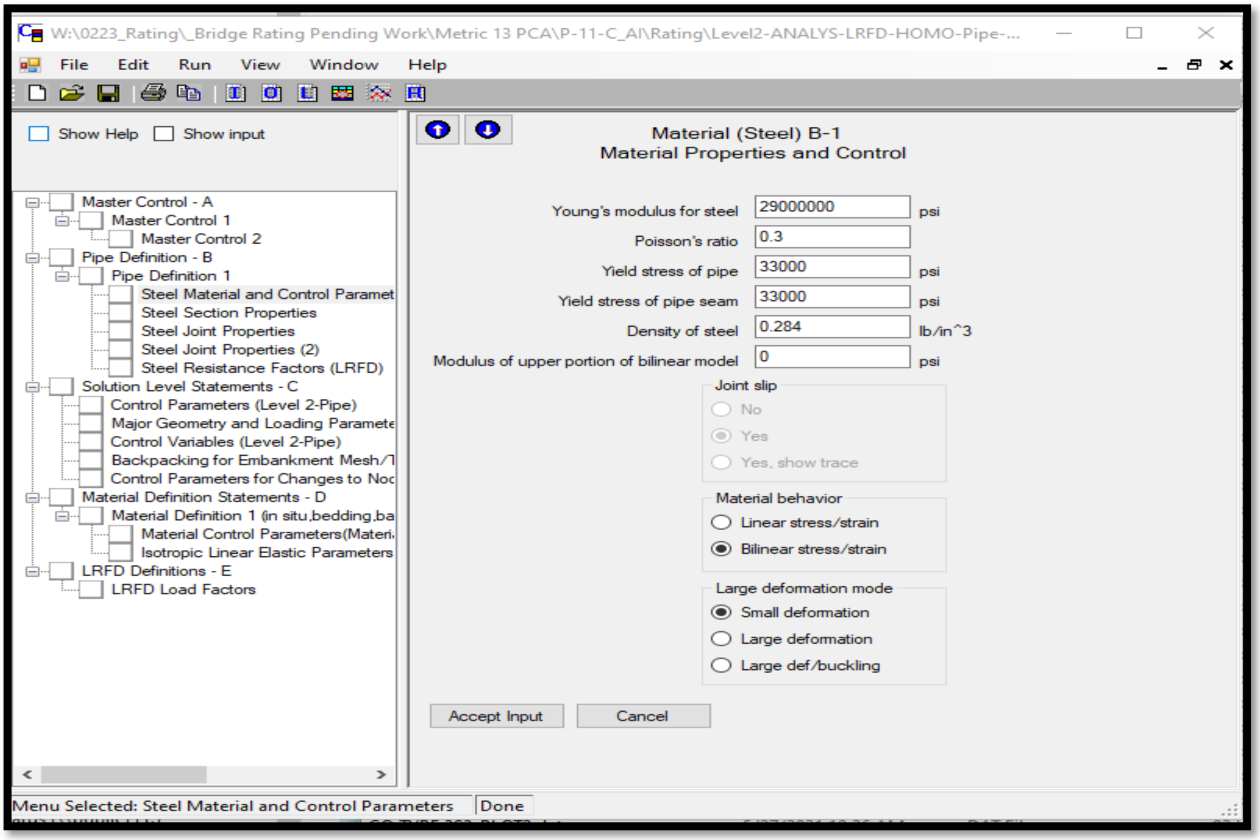


Master Control A-2

Pipe material type
○ Aluminum
○ Basic
○ Concrete
○ Plastic
● Steel

Canned mesh type
● Pipe mesh
○ Box mesh
○ Arch mesh

Menu Selected: Master Control 2



Material (Steel) B-1
Material Properties and Control

Young's modulus for steel 29000000 psi
Poisson's ratio 0.3
Yield stress of pipe 33000 psi
Yield stress of pipe seam 33000 psi
Density of steel 0.284 lb/in^3
Modulus of upper portion of bilinear model 0 psi

Joint slip
○ No
● Yes
○ Yes, show trace

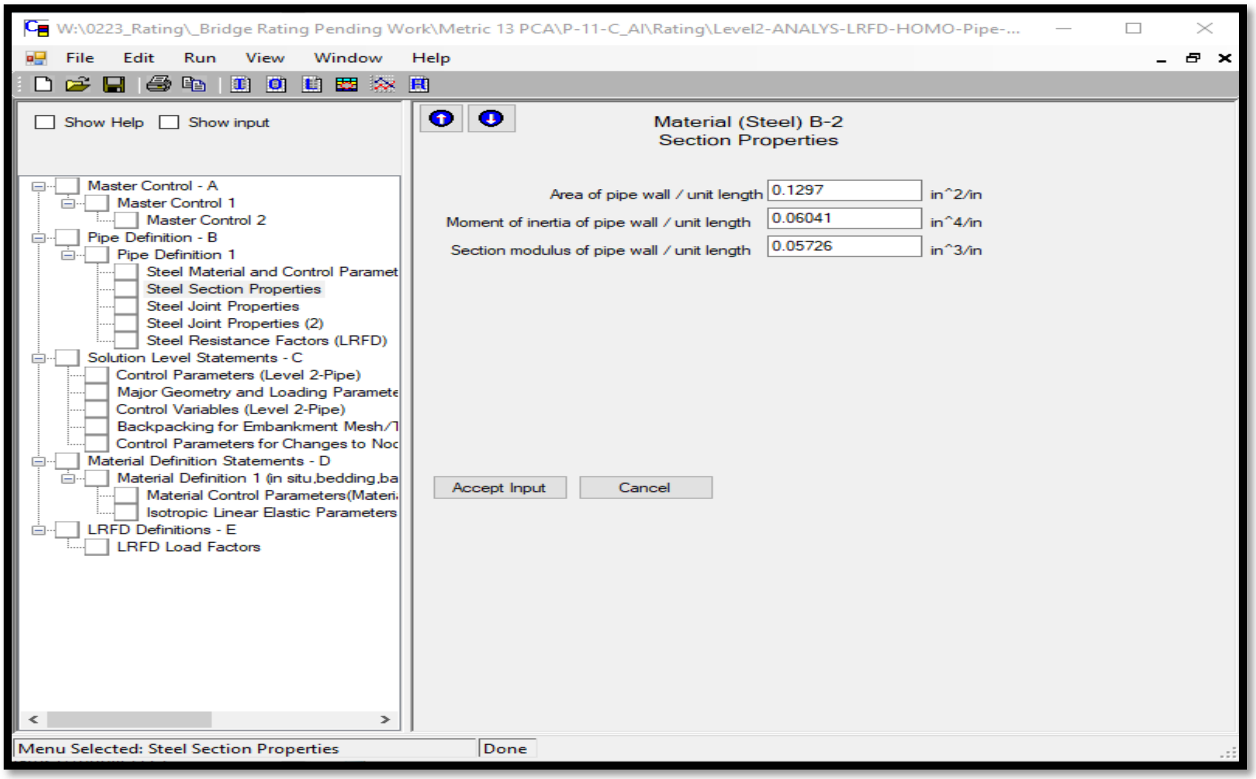
Material behavior
○ Linear stress/strain
● Bilinear stress/strain

Large deformation mode
● Small deformation
○ Large deformation
○ Large def/buckling

Menu Selected: Steel Material and Control Parameters

Material properties (Young Modulus, passion ratio, yield stress and steam stress of pipe) values exist by default in CANDE software help menu, rater may modify these inputs.

Detail of deformation modes available in “CANDE solution methods” for this example “small deformation mode” has been used.

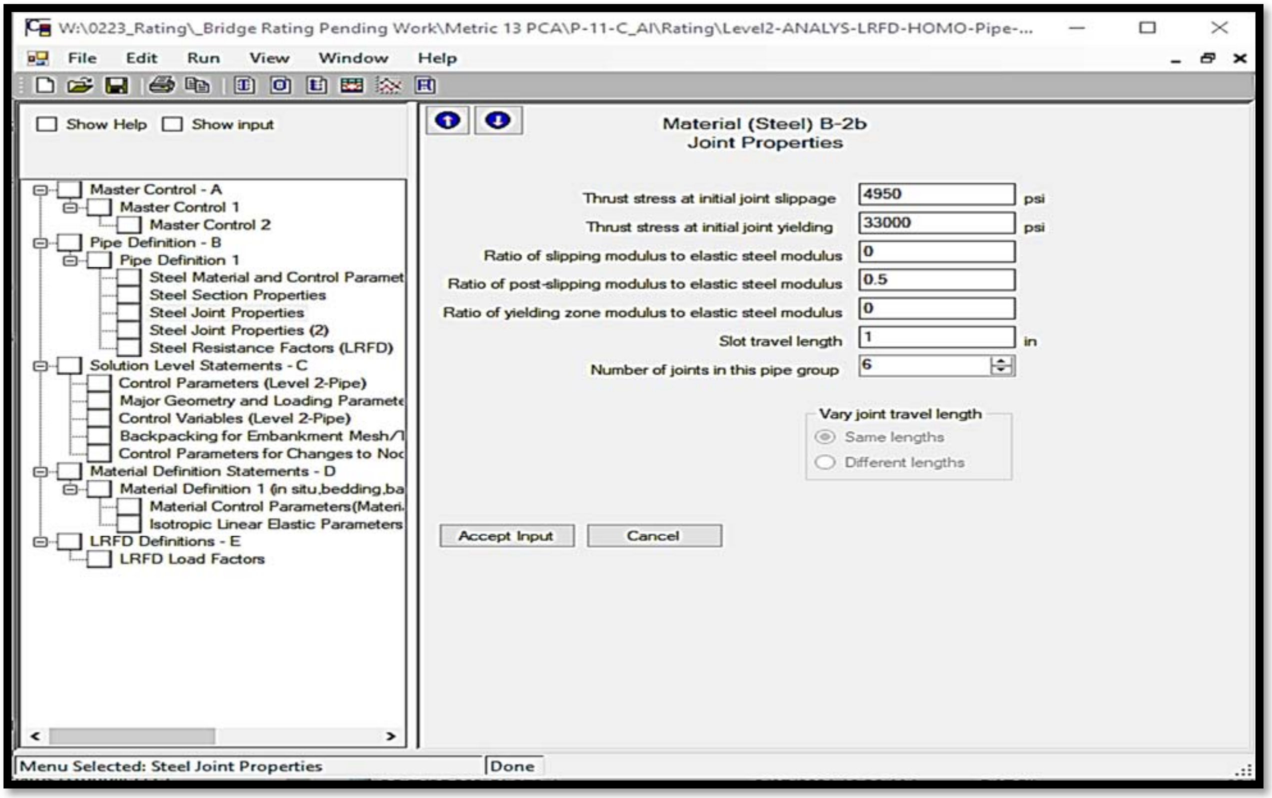


Material (Steel) B-2
Section Properties

Area of pipe wall / unit length 0.1297 in^2/in
Moment of inertia of pipe wall / unit length 0.06041 in^4/in
Section modulus of pipe wall / unit length 0.05726 in^3/in

Menu Selected: Steel Section Properties

Area of Pipe wall, Moment of Inertia and section modulus inputs available in help menu (Table 14A-5).Based on material types (Steel or Aluminum) and pipe Corrugation pitch and depth from field measurement form.

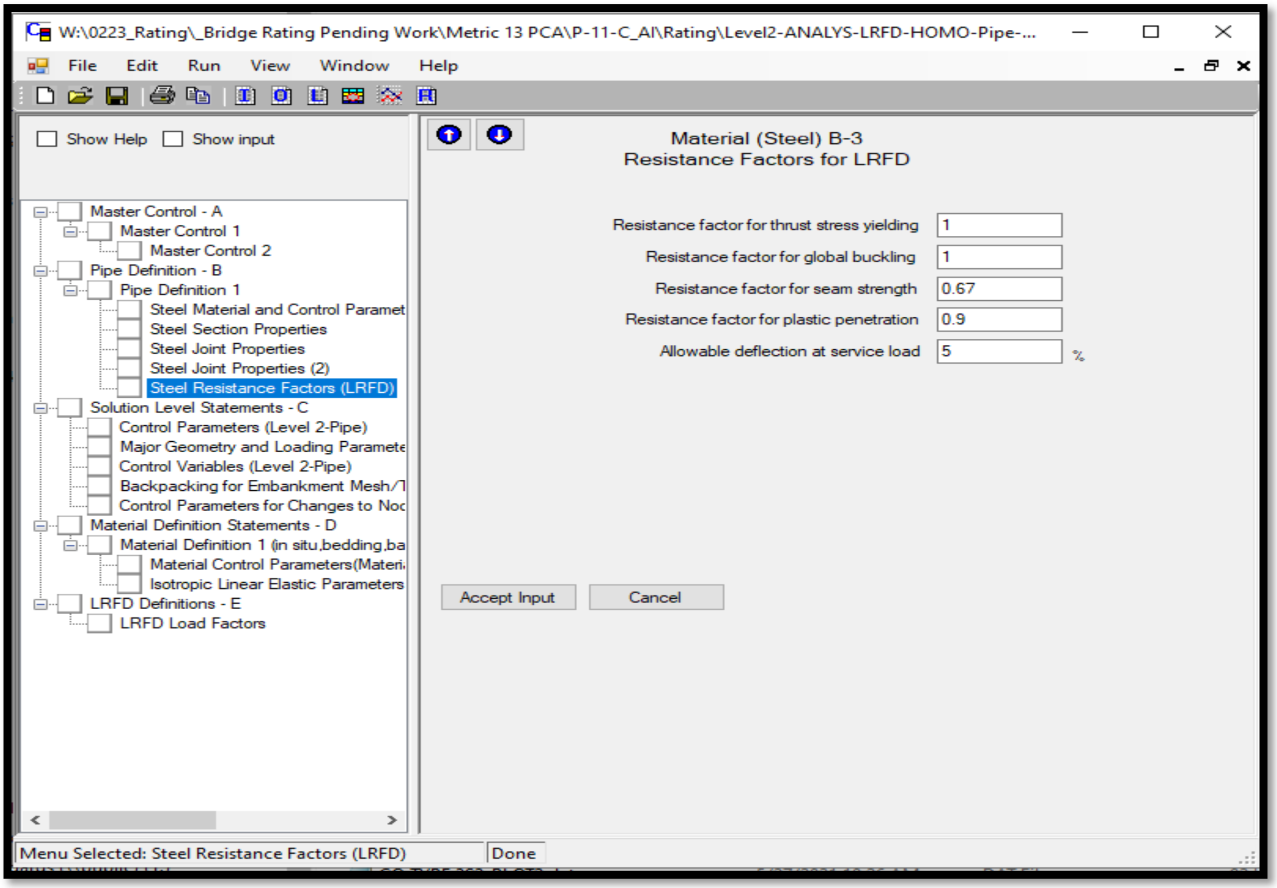


Material (Steel) B-2b
Joint Properties

Thrust stress at initial joint slippage: 4950 psi
Thrust stress at initial joint yielding: 33000 psi
Ratio of slipping modulus to elastic steel modulus: 0
Ratio of post-slipping modulus to elastic steel modulus: 0.5
Ratio of yielding zone modulus to elastic steel modulus: 0
Slot travel length: 1 in
Number of joints in this pipe group: 6

Vary joint travel length
● Same lengths
○ Different lengths

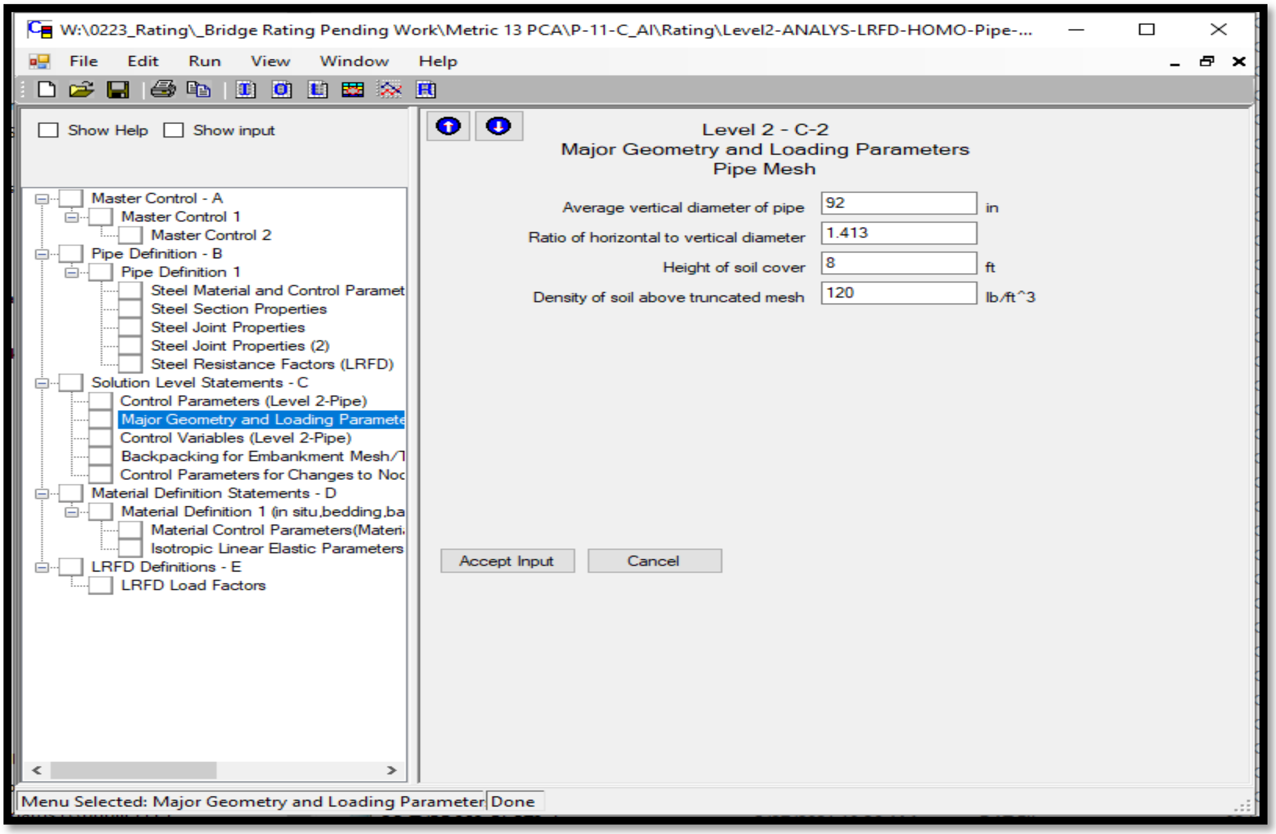
Menu Selected: Steel Joint Properties



Material (Steel) B-3
Resistance Factors for LRFD

Resistance factor for thrust stress yielding: 1
Resistance factor for global buckling: 1
Resistance factor for seam strength: 0.67
Resistance factor for plastic penetration: 0.9
Allowable deflection at service load: 5 %

Menu Selected: Steel Resistance Factors (LRFD)



Level 2 - C-2
Major Geometry and Loading Parameters
Pipe Mesh

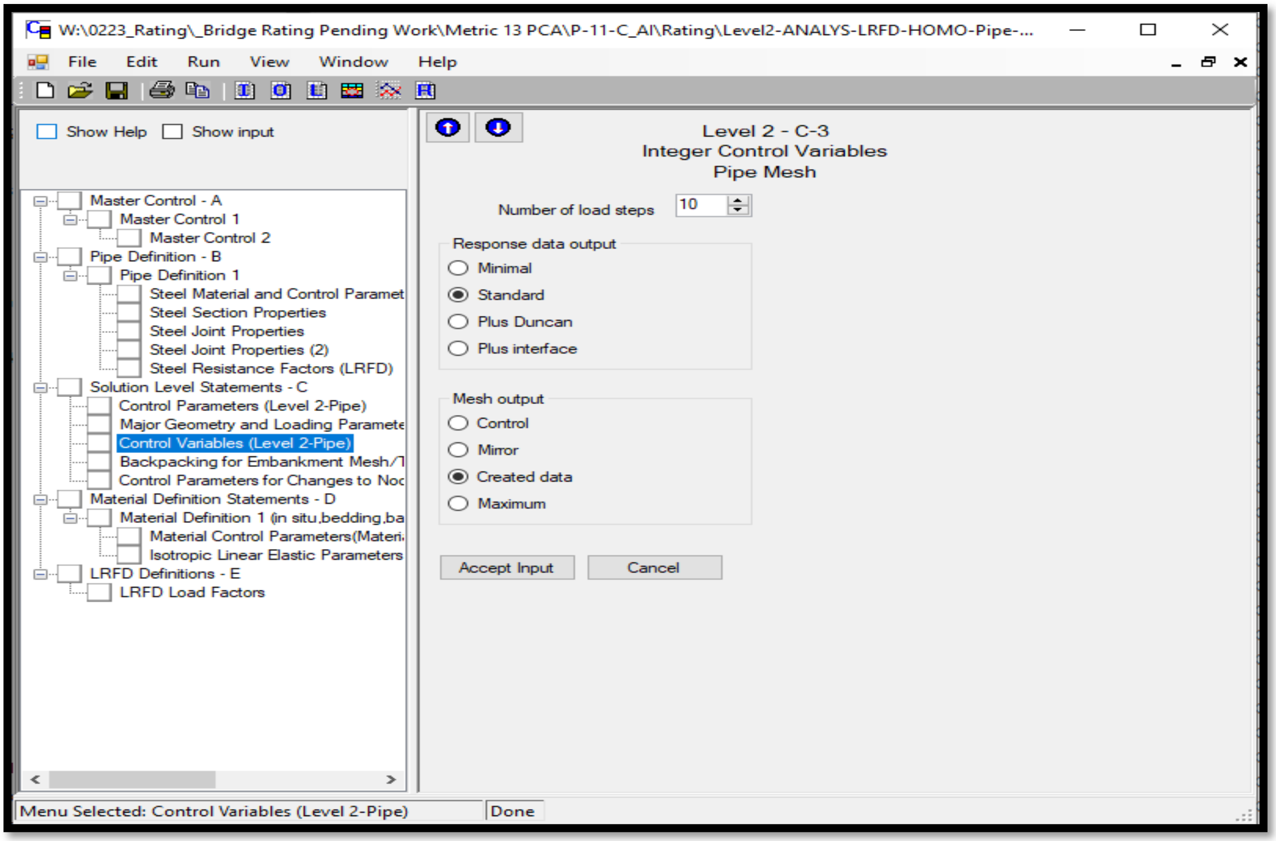
Average vertical diameter of pipe: 92 in

Ratio of horizontal to vertical diameter: 1.413

Height of soil cover: 8 ft

Density of soil above truncated mesh: 120 lb/ft^3

Menu Selected: Major Geometry and Loading Parameter Done



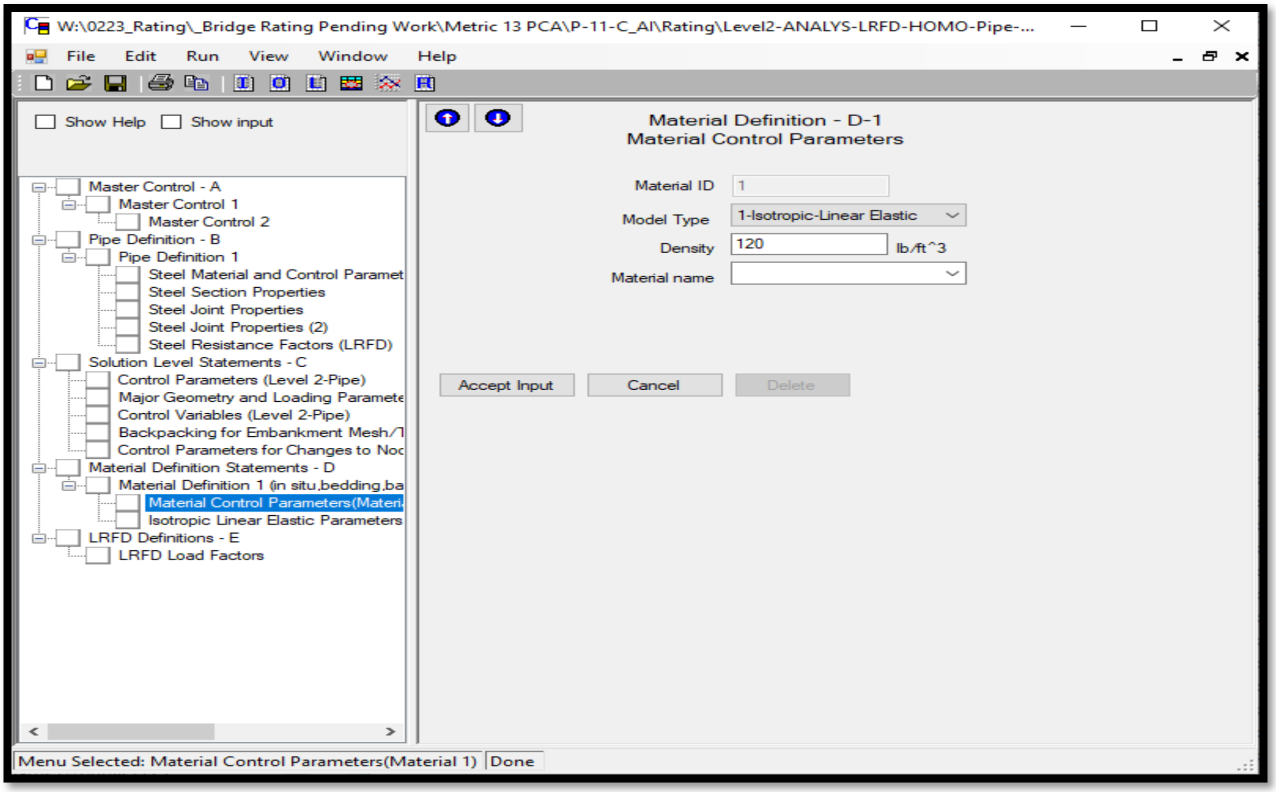
Level 2 - C-3
Integer Control Variables
Pipe Mesh

Number of load steps: 10

Response data output
○ Minimal
● Standard
○ Plus Duncan
○ Plus interface

Mesh output
○ Control
○ Mirror
● Created data
○ Maximum

Menu Selected: Control Variables (Level 2-Pipe) Done

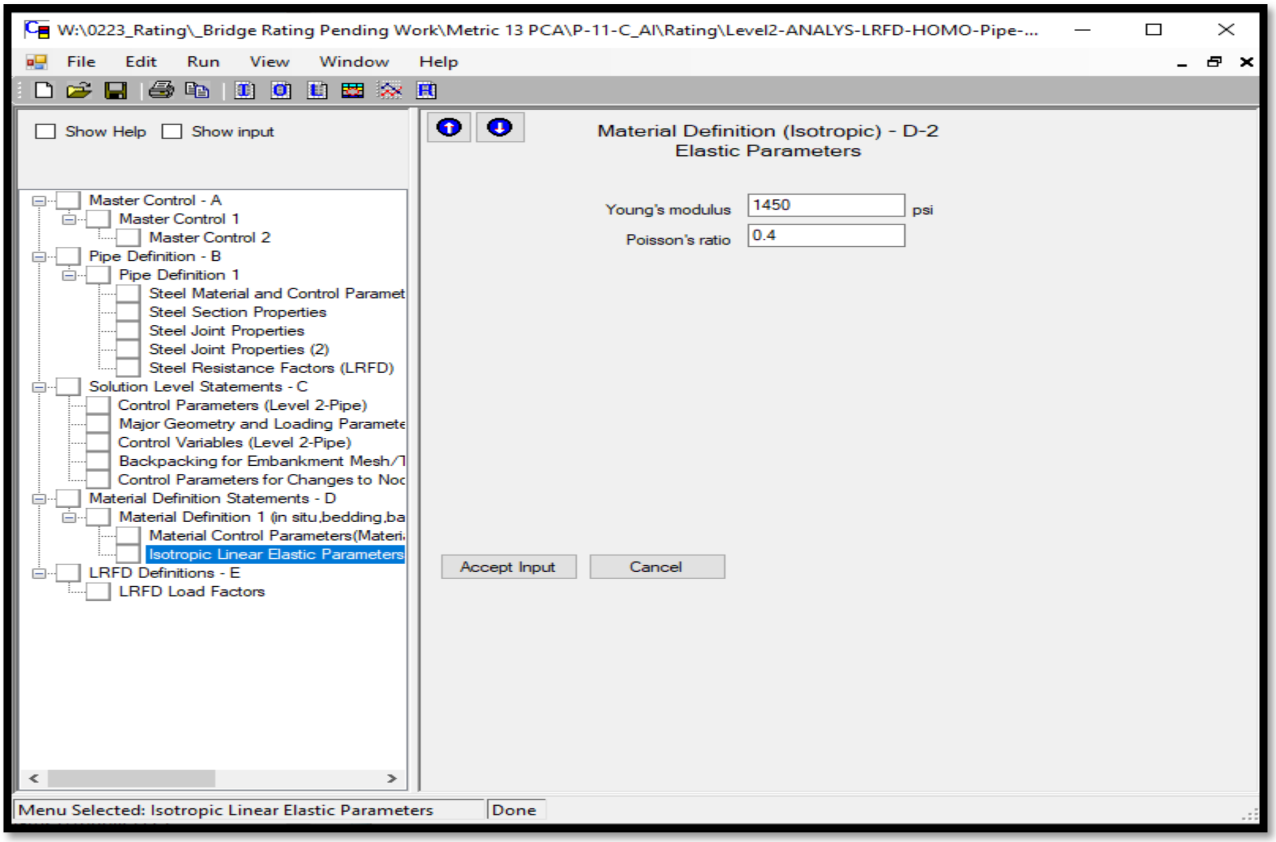


W:\0223_Rating_Bridge Rating Pending Work\Metric 13 PCA\P-11-C_AI\Rating\Level2-ANALYS-LRFD-HOMO-Pipe-...

Material Definition - D-1
Material Control Parameters

Material ID 1
Model Type 1-Isotropic-Linear Elastic
Density 120 lb/ft^3
Material name

Menu Selected: Material Control Parameters(Material 1) Done

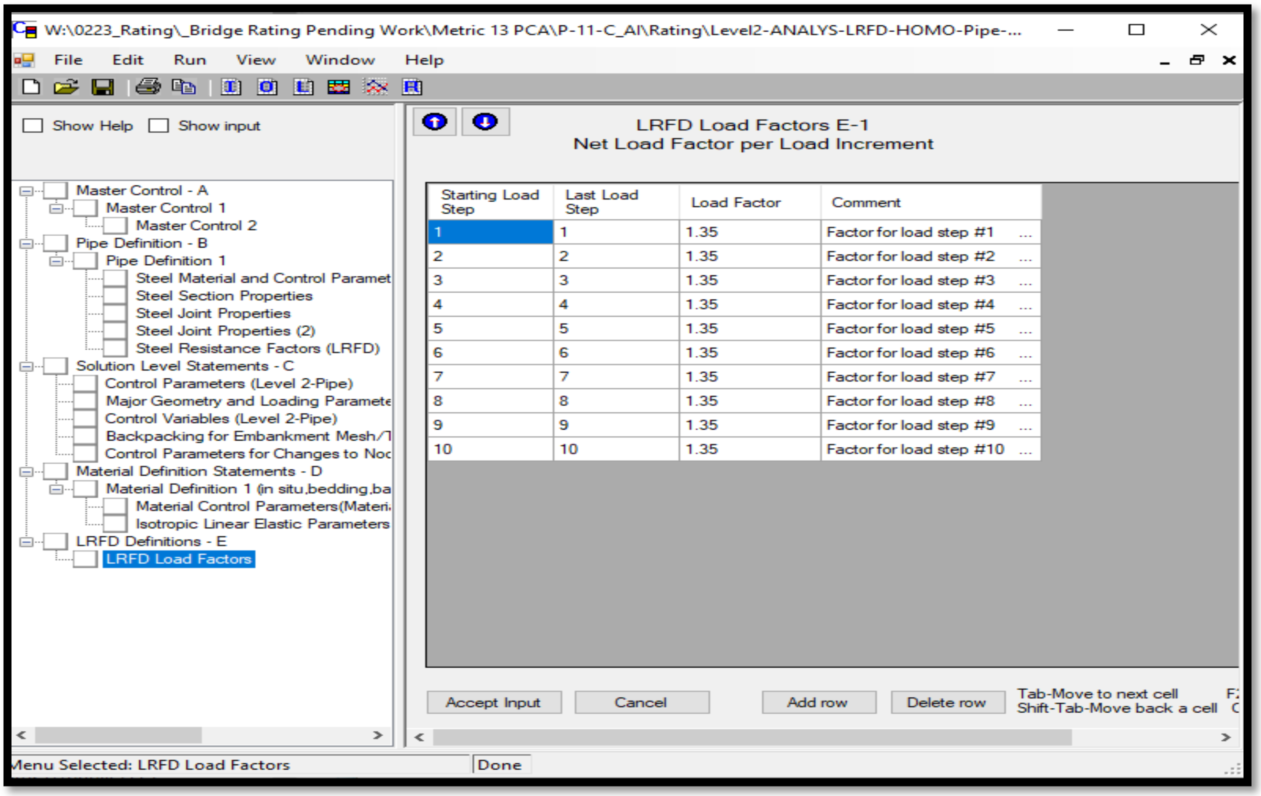


W:\0223_Rating_Bridge Rating Pending Work\Metric 13 PCA\P-11-C_AI\Rating\Level2-ANALYS-LRFD-HOMO-Pipe-...

Material Definition (Isotropic) - D-2
Elastic Parameters

Young's modulus 1450 psi
Poisson's ratio 0.4

Menu Selected: Isotropic Linear Elastic Parameters Done



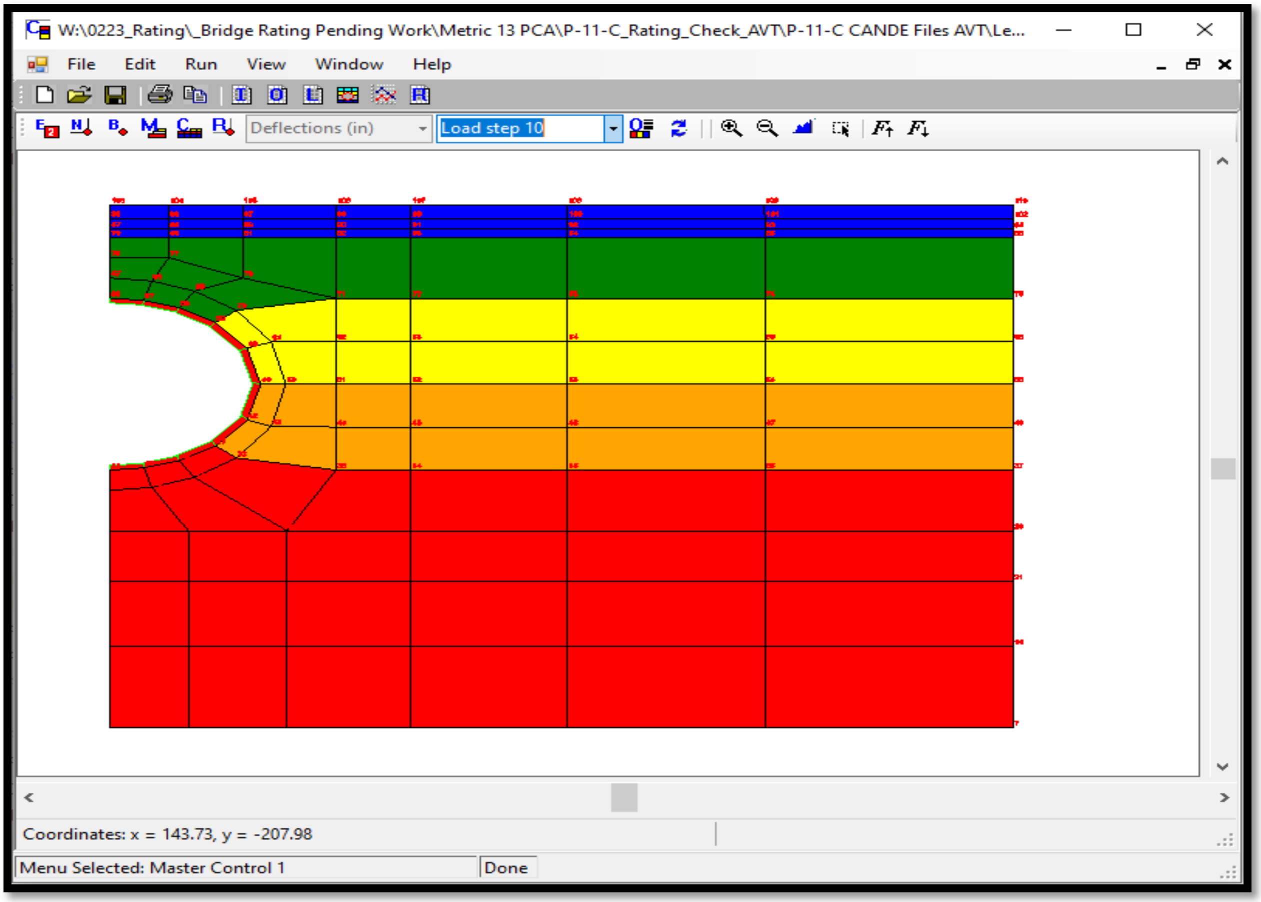
W:\0223_Rating_Bridge Rating Pending Work\Metric 13 PCA\P-11-C_AI\Rating\Level2-ANALYS-LRFD-HOMO-Pipe-...

- Master Control - A
  - Master Control 1
    - Master Control 2
- Pipe Definition - B
  - Pipe Definition 1
    - Steel Material and Control Paramet
    - Steel Section Properties
    - Steel Joint Properties
    - Steel Joint Properties (2)
    - Steel Resistance Factors (LRFD)
- Solution Level Statements - C
  - Control Parameters (Level 2-Pipe)
  - Major Geometry and Loading Paramete
  - Control Variables (Level 2-Pipe)
  - Backpacking for Embankment Mesh/T
  - Control Parameters for Changes to Noc
- Material Definition Statements - D
  - Material Definition 1 (in situ,bedding,ba
    - Material Control Parameters(Materi
    - Isotropic Linear Elastic Parameters
- LRFD Definitions - E
  - LRFD Load Factors

LRFD Load Factors E-1
Net Load Factor per Load Increment

Starting Load Step	Last Load Step	Load Factor	Comment
1	1	1.35	Factor for load step #1
2	2	1.35	Factor for load step #2
3	3	1.35	Factor for load step #3
4	4	1.35	Factor for load step #4
5	5	1.35	Factor for load step #5
6	6	1.35	Factor for load step #6
7	7	1.35	Factor for load step #7
8	8	1.35	Factor for load step #8
9	9	1.35	Factor for load step #9
10	10	1.35	Factor for load step #10

Menu Selected: LRFD Load Factors | Done



W:\0223_Rating_Bridge Rating Pending Work\Metric 13 PCA\P-11-C_Rating_Check_AVT\P-11-C CANDE Files AVT\Le...

Deflections (in)

Load step 10

Coordinates: x = 143.73, y = -207.98

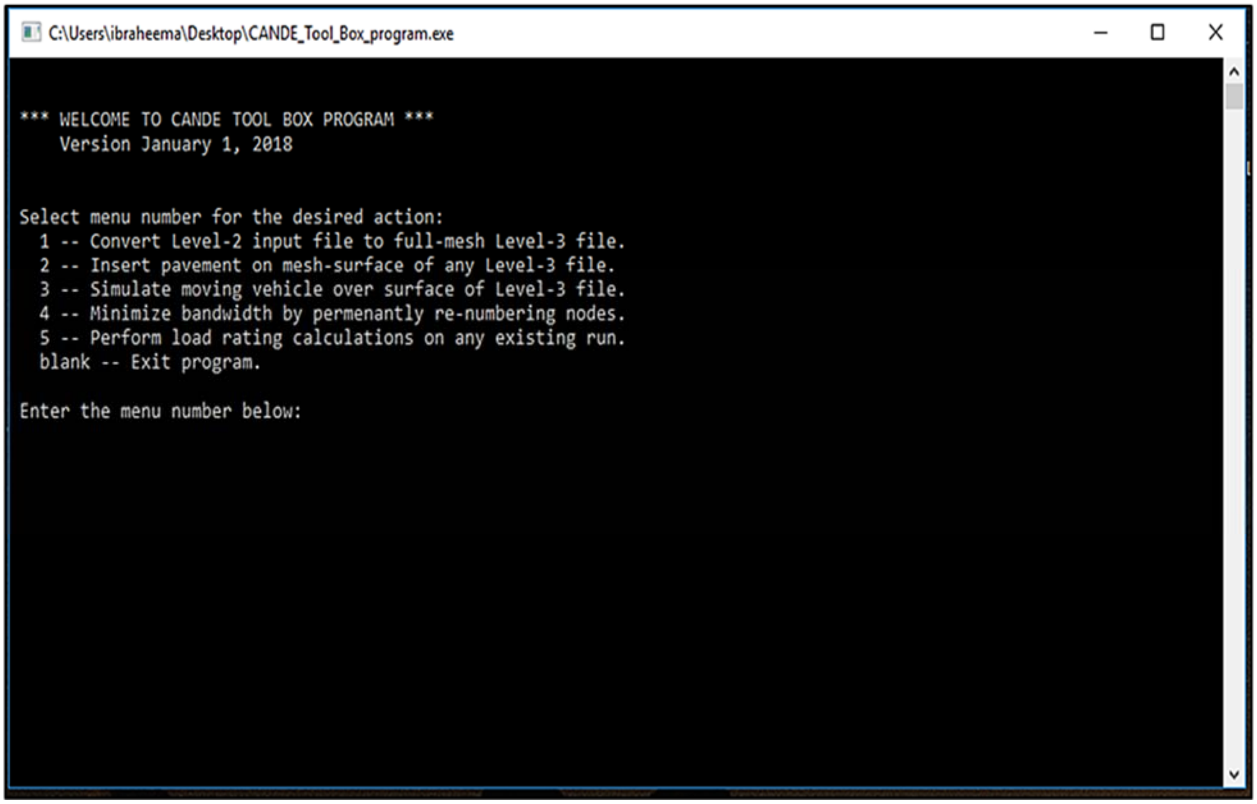
Menu Selected: Master Control 1 | Done

The CANDE Tool Box is used to convert mesh level 2 to level 3, update wearing surface thickness and unit weight, simulate various (design load, legal load, and permit load) and perform load rating calculations as shown below.

The rater must define each truck (legal and permit) configuration using option 3 in the Tool Box to get a rating for legal and permit trucks.

The rater must use live load factors specified in Section 1.3-M in CDOT Rating Manual 1.35 for design vehicle, 2.0 for legal load and 1.4 for permit load.

CANDE tool Box manual guide available in CANDE website:
https://www.candeforculverts.com/cande-tool-box.html



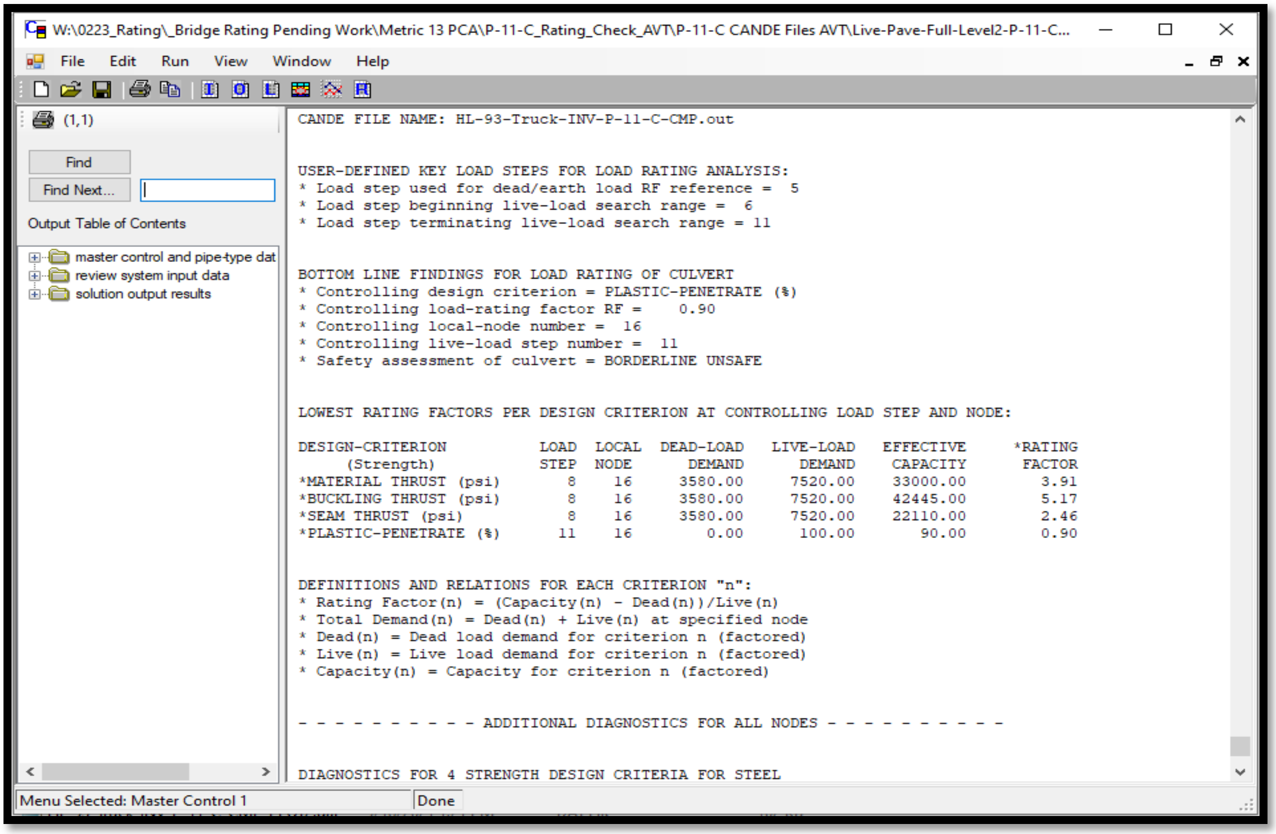
```
*** WELCOME TO CANDE TOOL BOX PROGRAM ***
    Version January 1, 2018


Select menu number for the desired action:
  1 -- Convert Level-2 input file to full-mesh Level-3 file.
  2 -- Insert pavement on mesh-surface of any Level-3 file.
  3 -- Simulate moving vehicle over surface of Level-3 file.
  4 -- Minimize bandwidth by permenantly re-numbering nodes.
  5 -- Perform load rating calculations on any existing run.
  blank -- Exit program.

Enter the menu number below:
```

Below are rating results obtained from the CANDE output report for Inventory tandem design vehicle The process is slightly different for legal and permits trucks because the user must define the truck weight and axle spacing individually for each a truck.

For more pipe rating examples visit the CANDE website.



```
CANDE FILE NAME: HL-93-Truck-INV-P-11-C-CMP.out


USER-DEFINED KEY LOAD STEPS FOR LOAD RATING ANALYSIS:
* Load step used for dead/earth load RF reference =  5
* Load step beginning live-load search range =  6
* Load step terminating live-load search range = 11


BOTTOM LINE FINDINGS FOR LOAD RATING OF CULVERT
* Controlling design criterion = PLASTIC-PENETRATE (%)
* Controlling load-rating factor RF =    0.90
* Controlling local-node number =  16
* Controlling live-load step number =  11
* Safety assessment of culvert = BORDERLINE UNSAFE

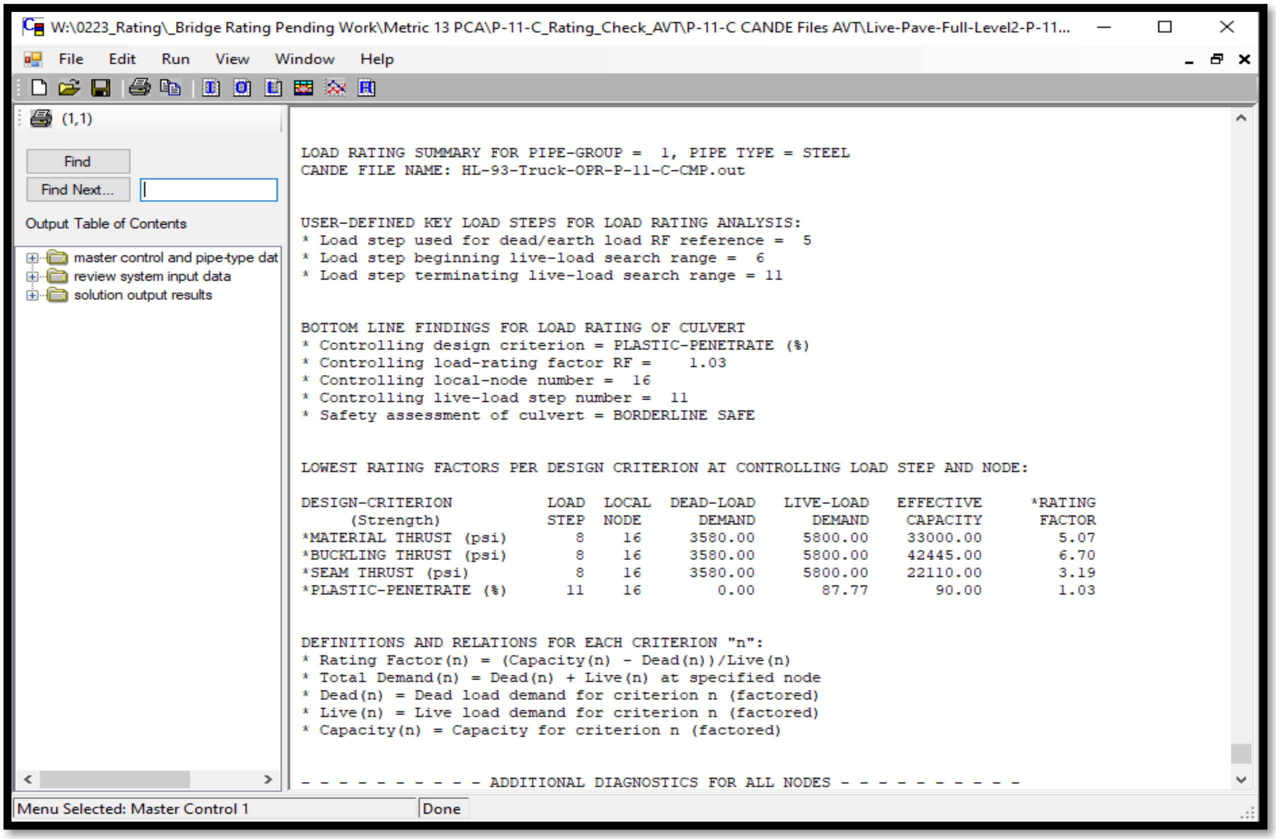

LOWEST RATING FACTORS PER DESIGN CRITERION AT CONTROLLING LOAD STEP AND NODE:

DESIGN-CRITERION          LOAD  LOCAL  DEAD-LOAD   LIVE-LOAD   EFFECTIVE    *RATING
     (Strength)           STEP  NODE     DEMAND      DEMAND    CAPACITY     FACTOR
*MATERIAL THRUST (psi)      8    16     3580.00     7520.00    33000.00       3.91
*BUCKLING THRUST (psi)      8    16     3580.00     7520.00    42445.00       5.17
*SEAM THRUST (psi)          8    16     3580.00     7520.00    22110.00       2.46
*PLASTIC-PENETRATE (%)     11    16        0.00      100.00       90.00       0.90


DEFINITIONS AND RELATIONS FOR EACH CRITERION "n":
* Rating Factor(n) = (Capacity(n) - Dead(n))/Live(n)
* Total Demand(n) = Dead(n) + Live(n) at specified node
* Dead(n) = Dead load demand for criterion n (factored)
* Live(n) = Live load demand for criterion n (factored)
* Capacity(n) = Capacity for criterion n (factored)


- - - - - - - - - - ADDITIONAL DIAGNOSTICS FOR ALL NODES - - - - - - - - - -


DIAGNOSTICS FOR 4 STRENGTH DESIGN CRITERIA FOR STEEL
```



```
LOAD RATING SUMMARY FOR PIPE-GROUP =  1, PIPE TYPE = STEEL
CANDE FILE NAME: HL-93-Truck-OPR-P-11-C-CMP.out


USER-DEFINED KEY LOAD STEPS FOR LOAD RATING ANALYSIS:
* Load step used for dead/earth load RF reference =  5
* Load step beginning live-load search range =  6
* Load step terminating live-load search range = 11

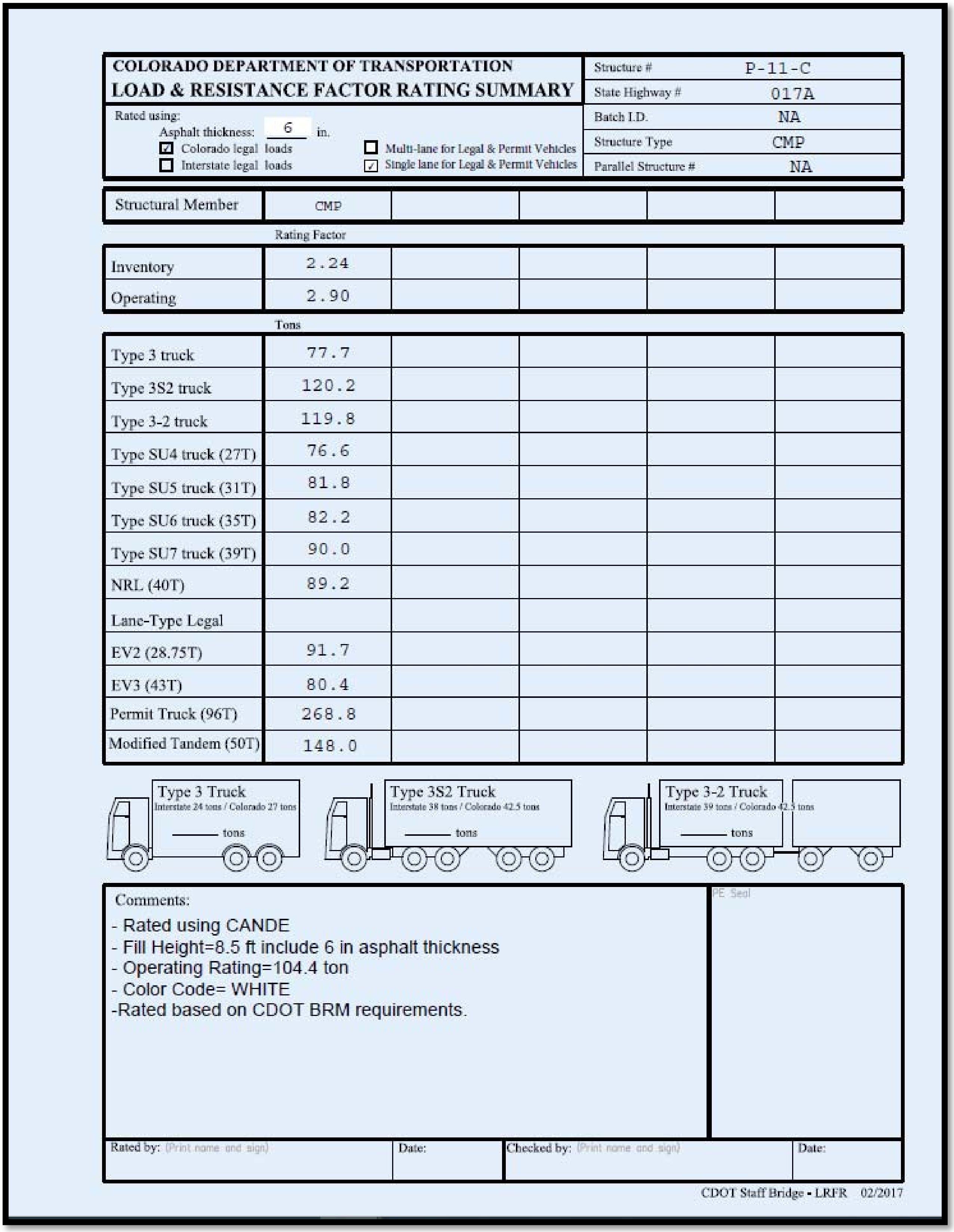

BOTTOM LINE FINDINGS FOR LOAD RATING OF CULVERT
* Controlling design criterion = PLASTIC-PENETRATE (%)
* Controlling load-rating factor RF =    1.03
* Controlling local-node number =  16
* Controlling live-load step number =  11
* Safety assessment of culvert = BORDERLINE SAFE


LOWEST RATING FACTORS PER DESIGN CRITERION AT CONTROLLING LOAD STEP AND NODE:

DESIGN-CRITERION          LOAD  LOCAL  DEAD-LOAD   LIVE-LOAD   EFFECTIVE    *RATING
     (Strength)           STEP  NODE     DEMAND      DEMAND    CAPACITY     FACTOR
*MATERIAL THRUST (psi)      8    16     3580.00     5800.00    33000.00       5.07
*BUCKLING THRUST (psi)      8    16     3580.00     5800.00    42445.00       6.70
*SEAM THRUST (psi)          8    16     3580.00     5800.00    22110.00       3.19
*PLASTIC-PENETRATE (%)     11    16        0.00       87.77       90.00       1.03


DEFINITIONS AND RELATIONS FOR EACH CRITERION "n":
* Rating Factor(n) = (Capacity(n) - Dead(n))/Live(n)
* Total Demand(n) = Dead(n) + Live(n) at specified node
* Dead(n) = Dead load demand for criterion n (factored)
* Live(n) = Live load demand for criterion n (factored)
* Capacity(n) = Capacity for criterion n (factored)


- - - - - - - - - - ADDITIONAL DIAGNOSTICS FOR ALL NODES - - - - - - - - - -
```



COLORADO DEPARTMENT OF TRANSPORTATION
LOAD & RESISTANCE FACTOR RATING SUMMARY

Structure #	P-11-C
State Highway #	017A
Batch I.D.	NA
Structure Type	CMP
Parallel Structure #	NA

Rated using:
Asphalt thickness: 6 in.
☑ Colorado legal loads
☐ Interstate legal loads
☐ Multi-lane for Legal & Permit Vehicles
☑ Single lane for Legal & Permit Vehicles

Structural Member	CMP				
Rating Factor					
Inventory	2.24				
Operating	2.90				
Tons					
Type 3 truck	77.7				
Type 3S2 truck	120.2				
Type 3-2 truck	119.8				
Type SU4 truck (27T)	76.6				
Type SU5 truck (31T)	81.8				
Type SU6 truck (35T)	82.2				
Type SU7 truck (39T)	90.0				
NRL (40T)	89.2				
Lane-Type Legal					
EV2 (28.75T)	91.7				
EV3 (43T)	80.4				
Permit Truck (96T)	268.8				
Modified Tandem (50T)	148.0				

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
______ tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
______ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
______ tons

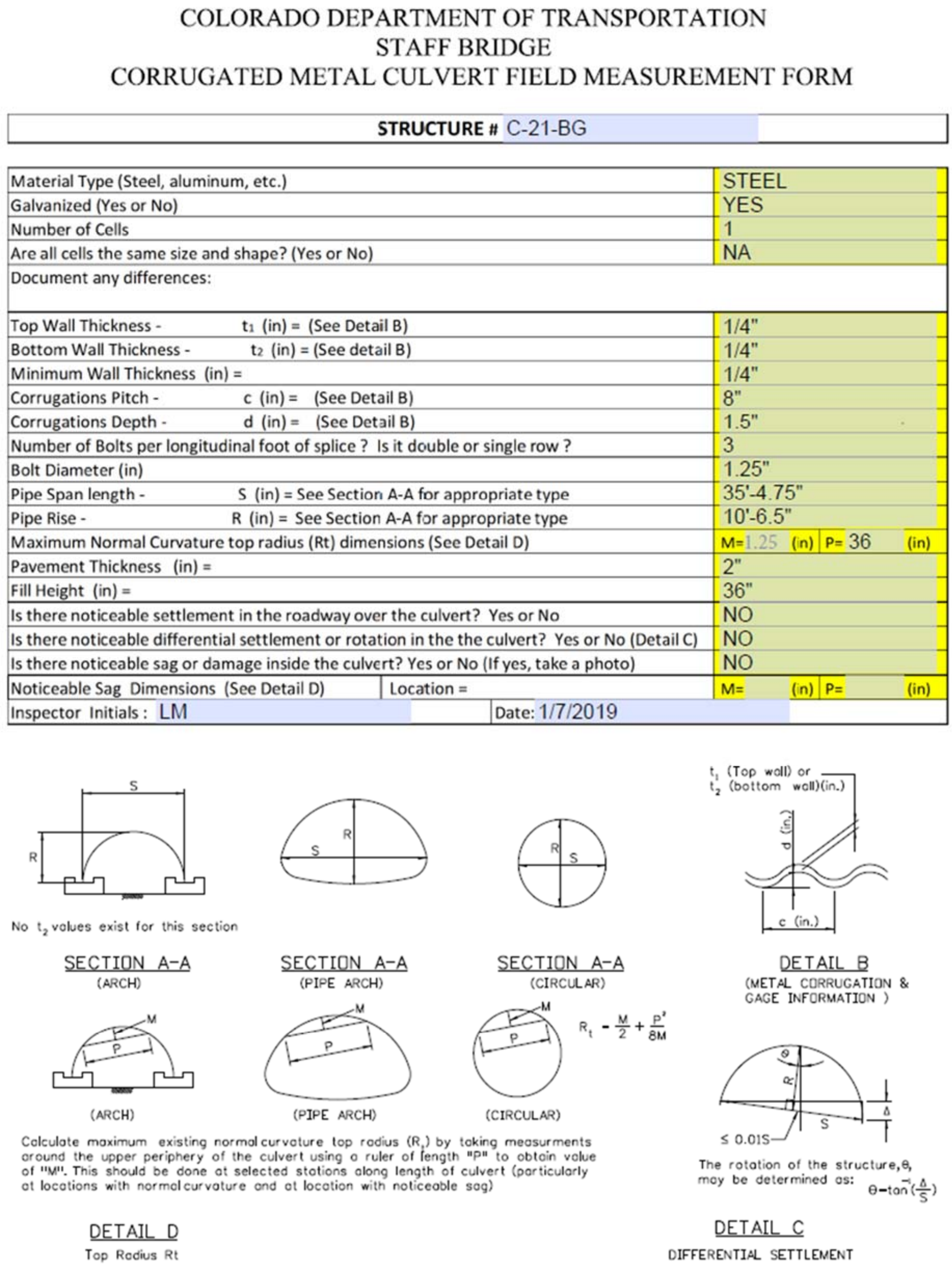
Comments:
- Rated using CANDE
- Fill Height=8.5 ft include 6 in asphalt thickness
- Operating Rating=104.4 ton
- Color Code= WHITE
-Rated based on CDOT BRM requirements.

PE Seal

Rated by: (Print name and sign)
Date:
Checked by: (Print name and sign)
Date:

CDOT Staff Bridge - LRFR 02/2017

14A.7.2 Example 2: Steel Arch Rating (SAC)



COLORADO DEPARTMENT OF TRANSPORTATION
STAFF BRIDGE
CORRUGATED METAL CULVERT FIELD MEASUREMENT FORM

STRUCTURE # C-21-BG

Material Type (Steel, aluminum, etc.)		STEEL	
Galvanized (Yes or No)		YES	
Number of Cells		1	
Are all cells the same size and shape? (Yes or No)		NA	
Document any differences:			
Top Wall Thickness - t_1 (in) = (See Detail B)		1/4"	
Bottom Wall Thickness - t_2 (in) = (See detail B)		1/4"	
Minimum Wall Thickness (in) =		1/4"	
Corrugations Pitch - c (in) = (See Detail B)		8"	
Corrugations Depth - d (in) = (See Detail B)		1.5"	
Number of Bolts per longitudinal foot of splice ? Is it double or single row ?		3	
Bolt Diameter (in)		1.25"	
Pipe Span length - S (in) = See Section A-A for appropriate type		35'-4.75"	
Pipe Rise - R (in) = See Section A-A for appropriate type		10'-6.5"	
Maximum Normal Curvature top radius (Rt) dimensions (See Detail D)		M=1.25 (in)	P= 36 (in)
Pavement Thickness (in) =		2"	
Fill Height (in) =		36"	
Is there noticeable settlement in the roadway over the culvert? Yes or No		NO	
Is there noticeable differential settlement or rotation in the the culvert? Yes or No (Detail C)		NO	
Is there noticeable sag or damage inside the culvert? Yes or No (If yes, take a photo)		NO	
Noticeable Sag Dimensions (See Detail D)	Location =	M= (in)	P= (in)
Inspector Initials : LM	Date: 1/7/2019		

No t_2 values exist for this section

SECTION A-A
(ARCH)

SECTION A-A
(PIPE ARCH)

SECTION A-A
(CIRCULAR)

DETAIL B
(METAL CORRUGATION & GAGE INFORMATION)

(ARCH)

(PIPE ARCH)

(CIRCULAR)

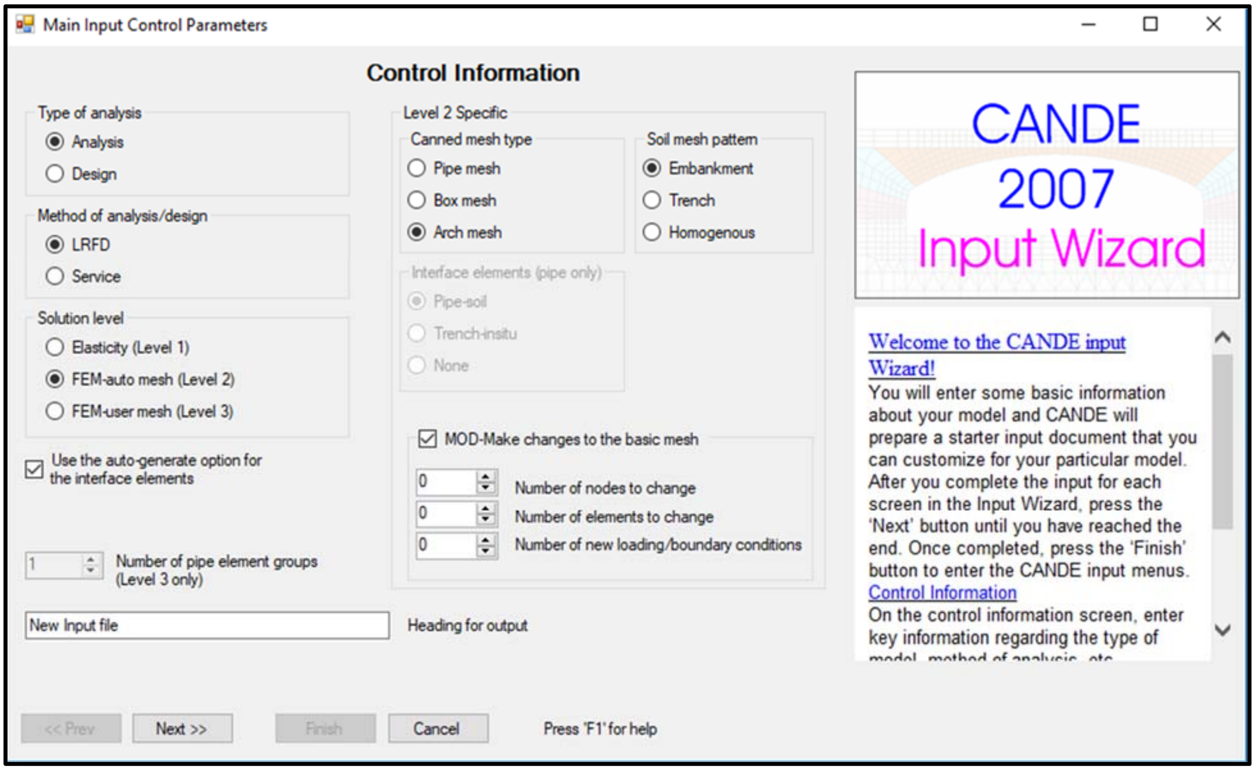
$R_t = \frac{M}{2} + \frac{P^2}{8M}$

Calculate maximum existing normal curvature top radius (R_t) by taking measurments around the upper periphery of the culvert using a ruler of length "P" to obtain value of "M". This should be done at selected stations along length of culvert (particularly at locations with normal curvature and at location with noticeable sag)

The rotation of the structure,θ, may be determined as: $\theta = \tan^{-1}(\frac{\Delta}{S})$

DETAIL D
Top Radius Rt

DETAIL C
DIFFERENTIAL SETTLEMENT



Control Information

Type of analysis
● Analysis
○ Design

Method of analysis/design
● LRFD
○ Service

Solution level
○ Elasticity (Level 1)
● FEM-auto mesh (Level 2)
○ FEM-user mesh (Level 3)

☑ Use the auto-generate option for the interface elements

1 Number of pipe element groups (Level 3 only)

Level 2 Specific

Canned mesh type
○ Pipe mesh
○ Box mesh
● Arch mesh

Soil mesh pattern
● Embankment
○ Trench
○ Homogenous

Interface elements (pipe only)
● Pipe-soil
○ Trench-insitu
○ None

☑ MOD-Make changes to the basic mesh

0 Number of nodes to change
0 Number of elements to change
0 Number of new loading/boundary conditions

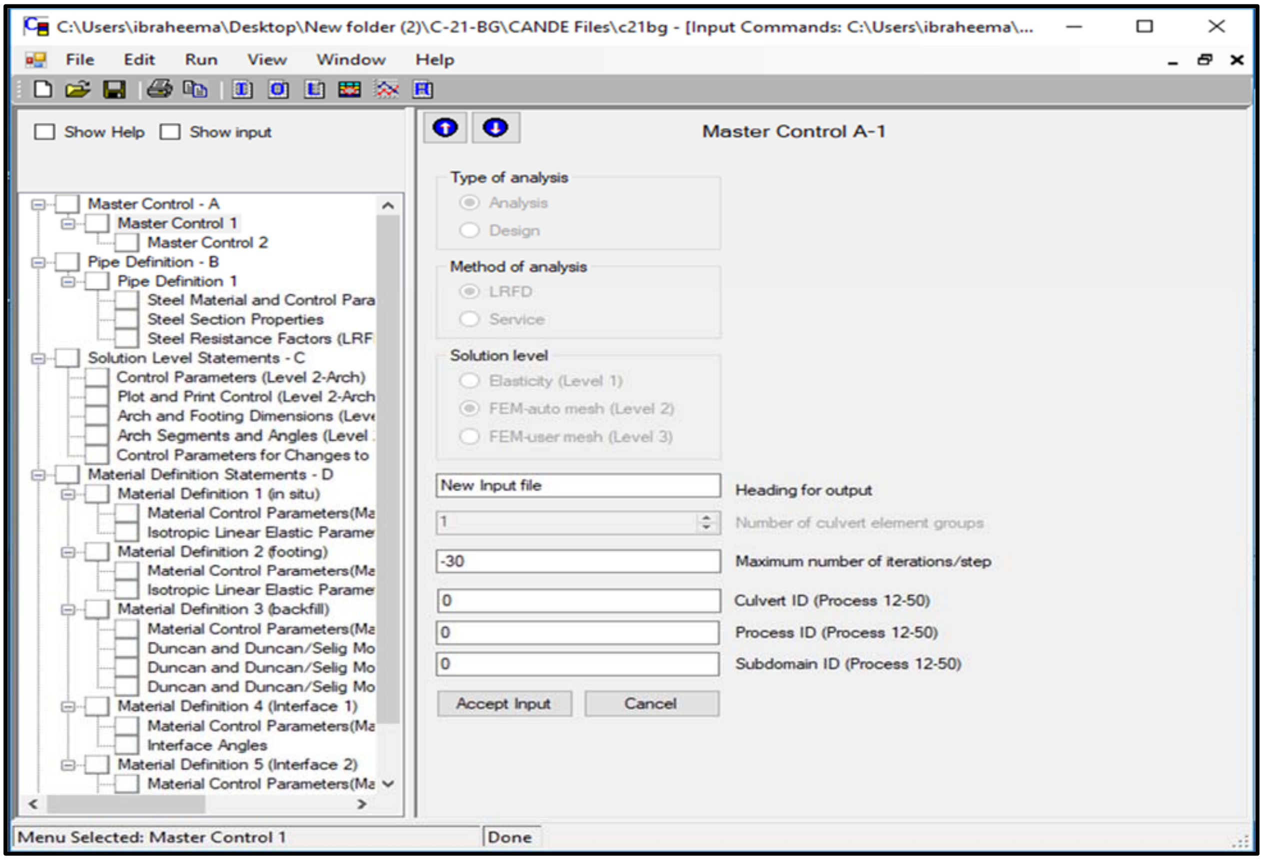
New Input file Heading for output

Welcome to the CANDE input Wizard!

You will enter some basic information about your model and CANDE will prepare a starter input document that you can customize for your particular model. After you complete the input for each screen in the Input Wizard, press the 'Next' button until you have reached the end. Once completed, press the 'Finish' button to enter the CANDE input menus.

Control Information

On the control information screen, enter key information regarding the type of model, method of analysis, etc.



☐ Show Help ☐ Show input

- Master Control - A
  - Master Control 1
    - Master Control 2
- Pipe Definition - B
  - Pipe Definition 1
    - Steel Material and Control Para
    - Steel Section Properties
    - Steel Resistance Factors (LRF
- Solution Level Statements - C
  - Control Parameters (Level 2-Arch)
  - Plot and Print Control (Level 2-Arch
  - Arch and Footing Dimensions (Leve
  - Arch Segments and Angles (Level
  - Control Parameters for Changes to
- Material Definition Statements - D
  - Material Definition 1 (in situ)
    - Material Control Parameters(Ma
    - Isotropic Linear Elastic Parame
  - Material Definition 2 (footing)
    - Material Control Parameters(Ma
    - Isotropic Linear Elastic Parame
  - Material Definition 3 (backfill)
    - Material Control Parameters(Ma
    - Duncan and Duncan/Selig Mo
    - Duncan and Duncan/Selig Mo
    - Duncan and Duncan/Selig Mo
  - Material Definition 4 (Interface 1)
    - Material Control Parameters(Ma
    - Interface Angles
  - Material Definition 5 (Interface 2)
    - Material Control Parameters(Ma

Master Control A-1

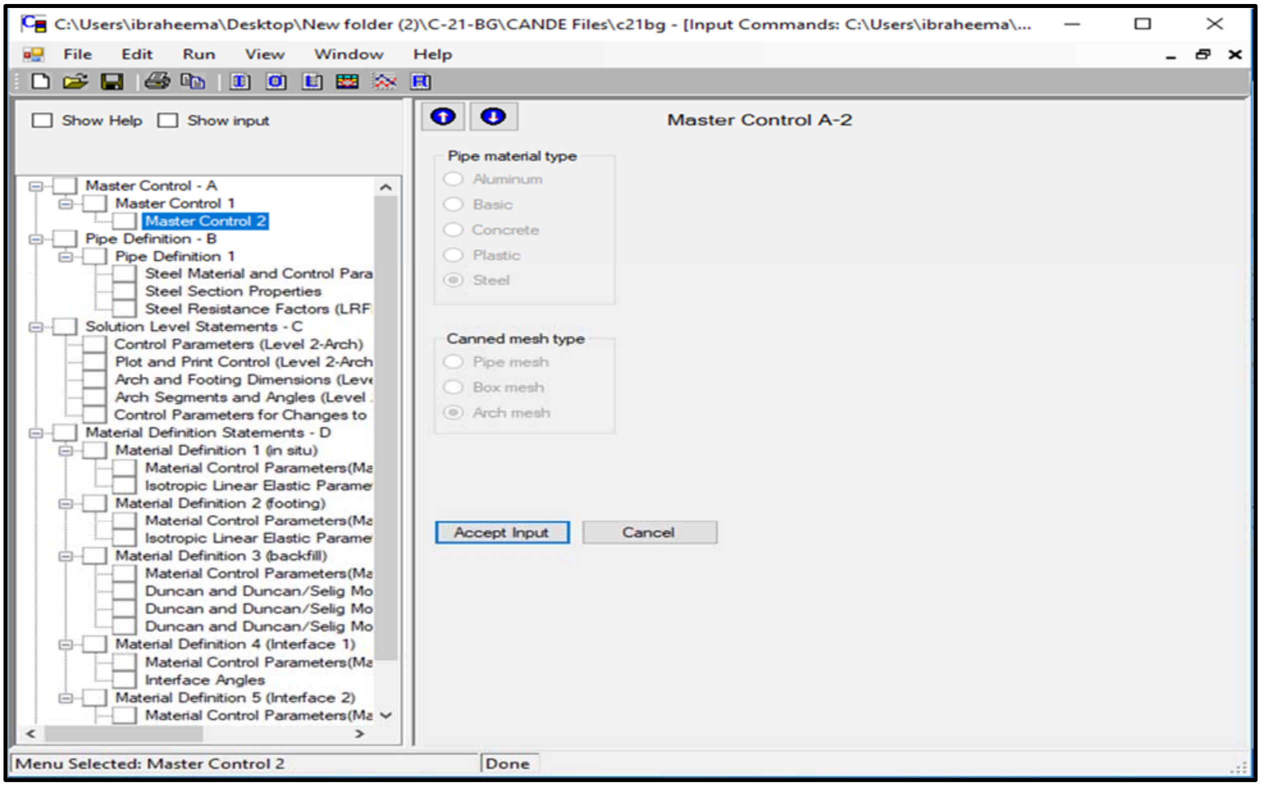
Type of analysis
● Analysis
○ Design

Method of analysis
● LRFD
○ Service

Solution level
○ Elasticity (Level 1)
● FEM-auto mesh (Level 2)
○ FEM-user mesh (Level 3)

New Input file Heading for output
1 Number of culvert element groups
-30 Maximum number of iterations/step
0 Culvert ID (Process 12-50)
0 Process ID (Process 12-50)
0 Subdomain ID (Process 12-50)

Menu Selected: Master Control 1 Done



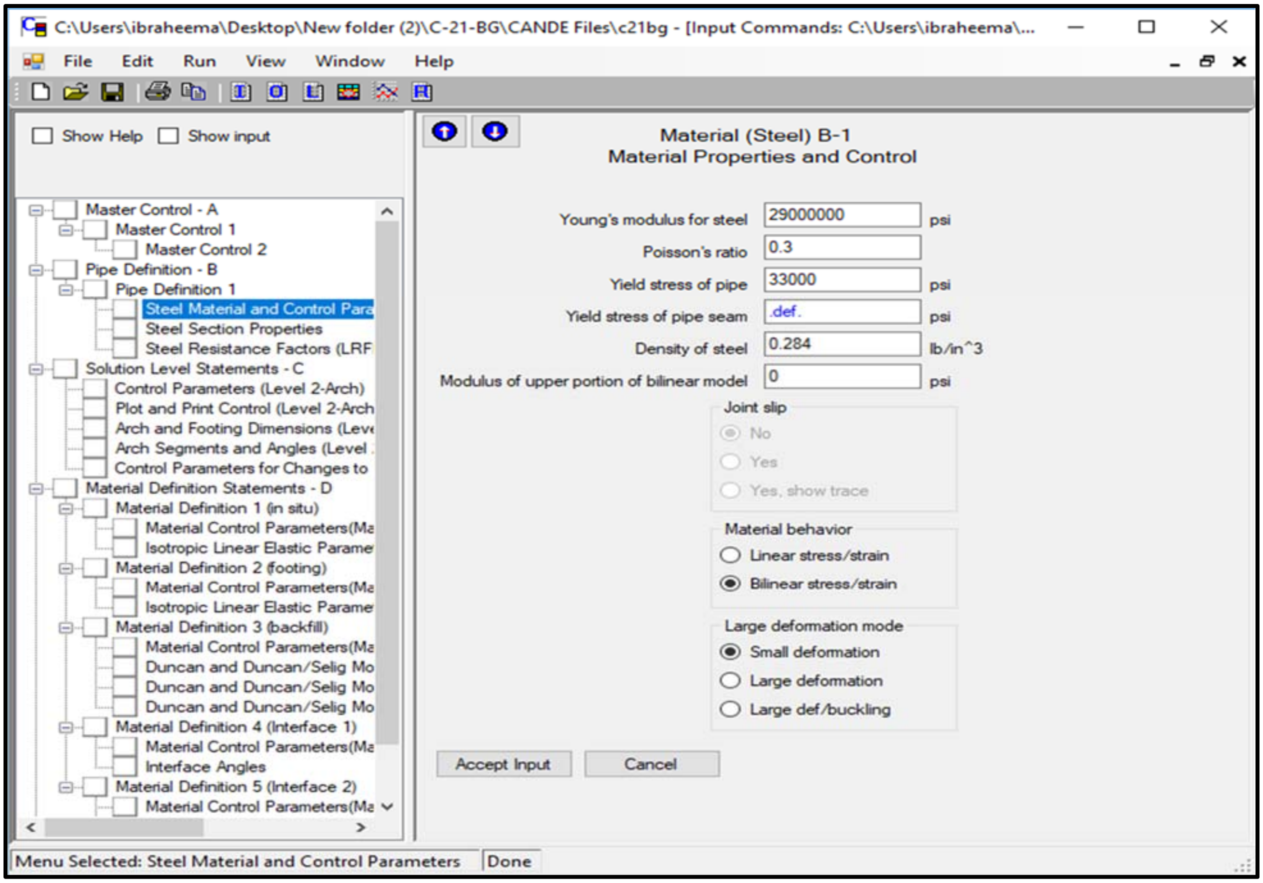
C:\Users\ibraheema\Desktop\New folder (2)\C-21-BG\CANDE Files\c21bg - [Input Commands: C:\Users\ibraheema\...

Master Control A-2

Pipe material type
- ○ Aluminum
- ○ Basic
- ○ Concrete
- ○ Plastic
- ● Steel

Canned mesh type
- ○ Pipe mesh
- ○ Box mesh
- ● Arch mesh

Menu Selected: Master Control 2 | Done



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Material (Steel) B-1
Material Properties and Control

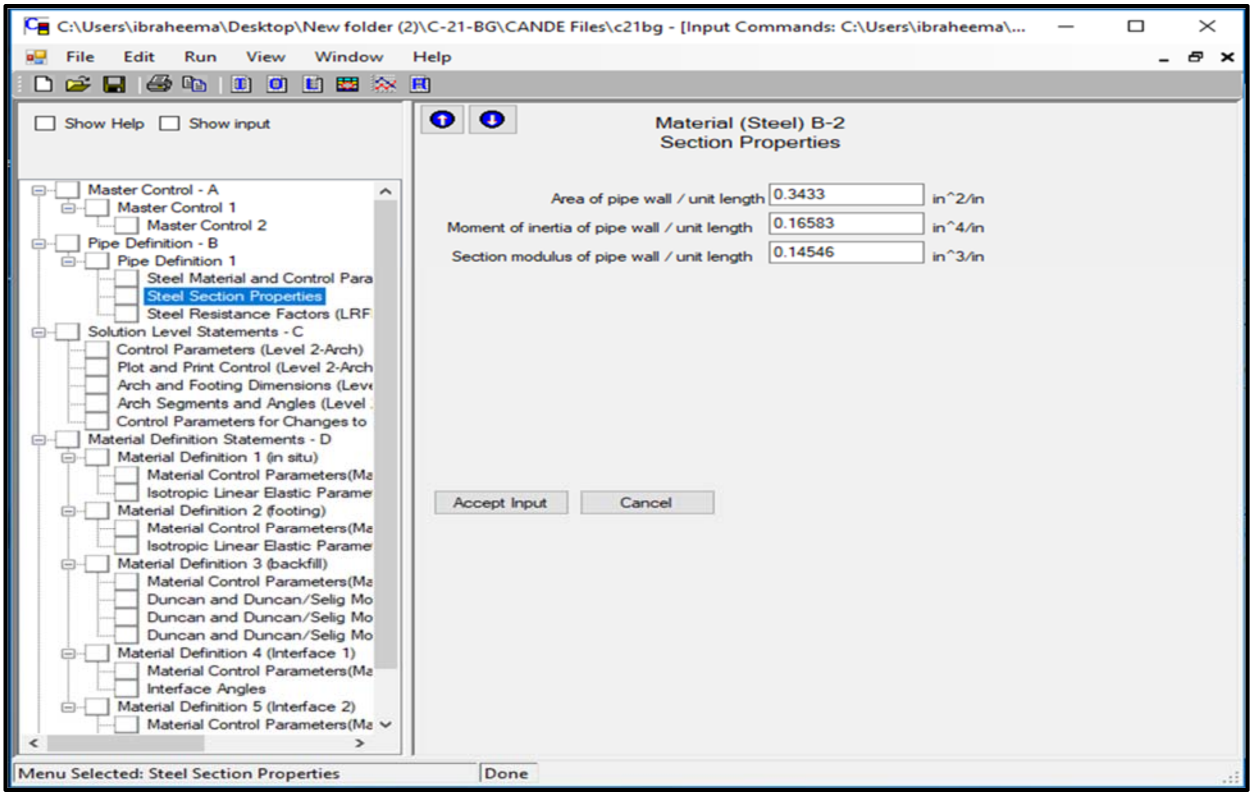
Young's modulus for steel: 29000000 psi
Poisson's ratio: 0.3
Yield stress of pipe: 33000 psi
Yield stress of pipe seam: def. psi
Density of steel: 0.284 lb/in^3
Modulus of upper portion of bilinear model: 0 psi

Joint slip
- ● No
- ○ Yes
- ○ Yes, show trace

Material behavior
- ○ Linear stress/strain
- ● Bilinear stress/strain

Large deformation mode
- ● Small deformation
- ○ Large deformation
- ○ Large def/buckling

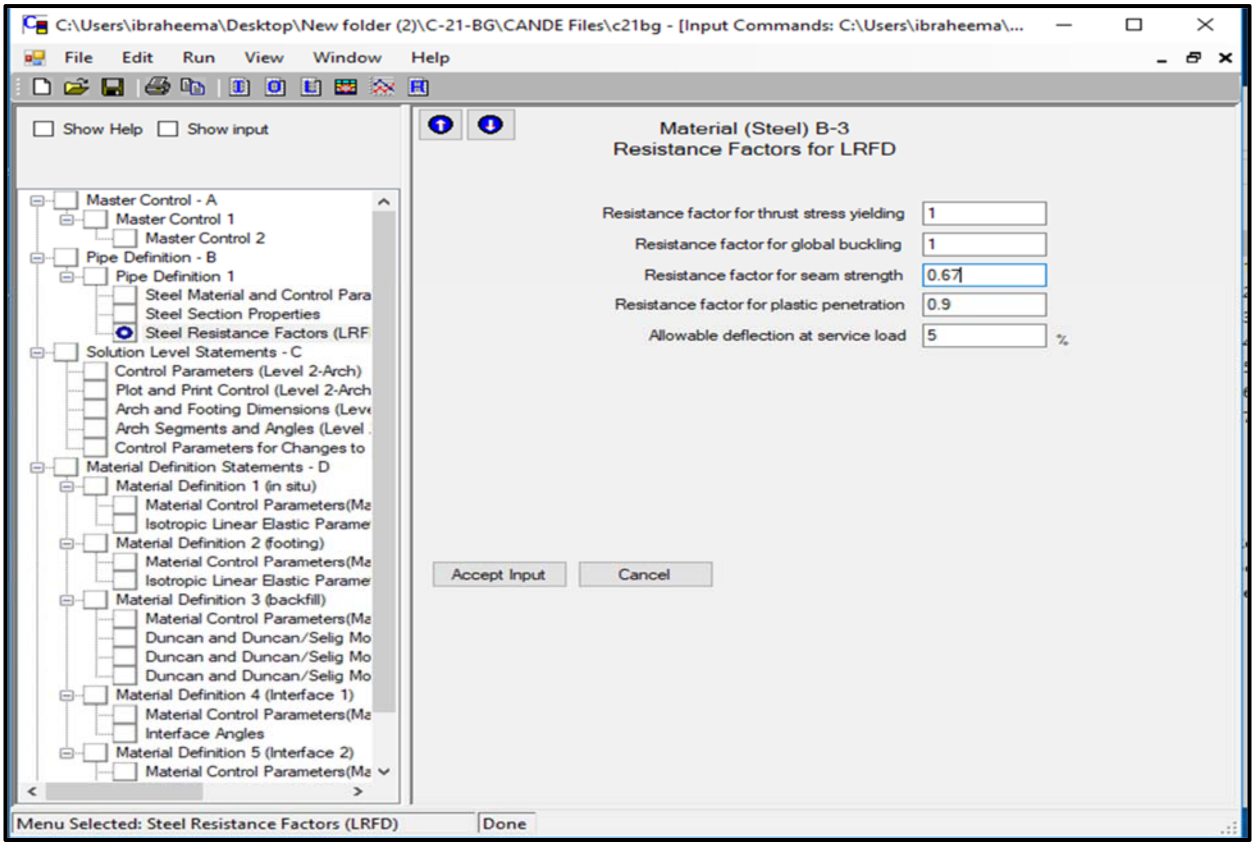
Menu Selected: Steel Material and Control Parameters | Done



Material (Steel) B-2
Section Properties

Area of pipe wall / unit length 0.3433 in^2/in
Moment of inertia of pipe wall / unit length 0.16583 in^4/in
Section modulus of pipe wall / unit length 0.14546 in^3/in

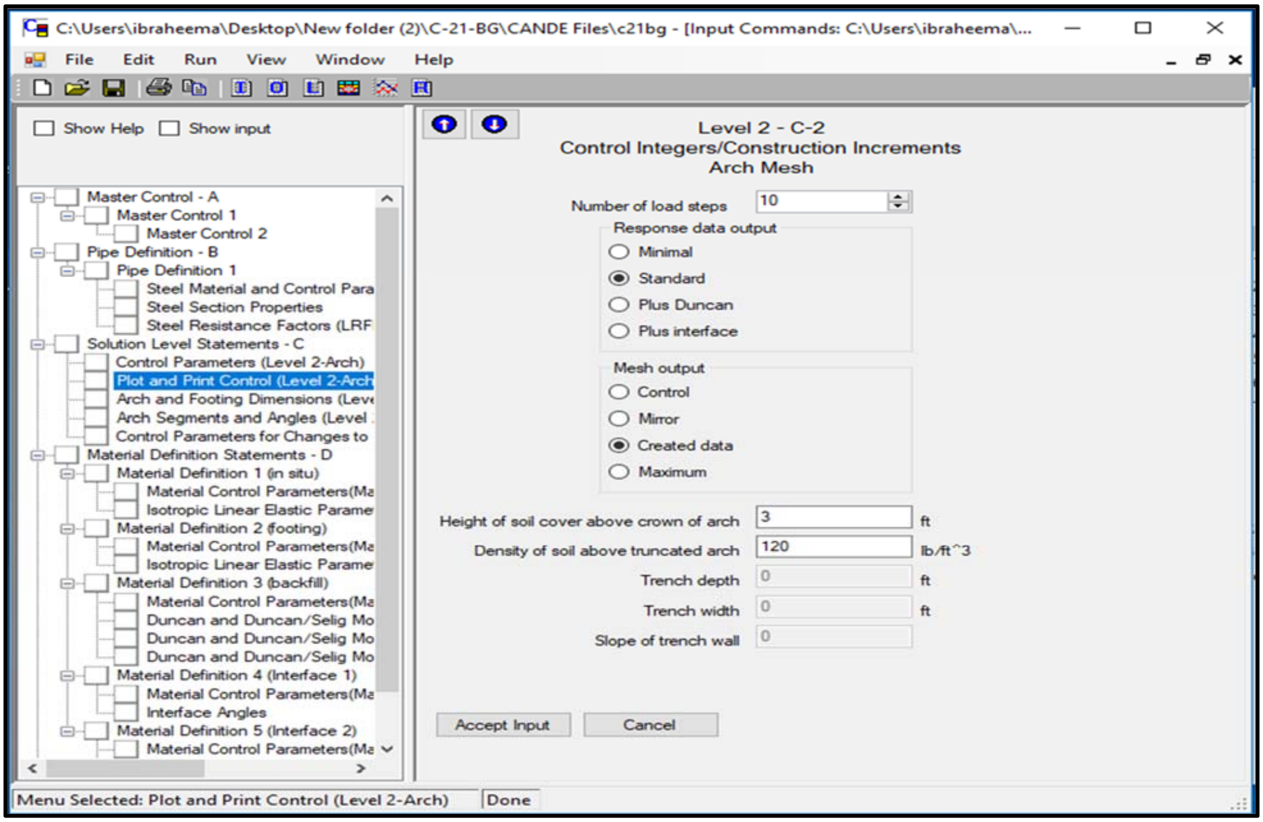
Menu Selected: Steel Section Properties



Material (Steel) B-3
Resistance Factors for LRFD

Resistance factor for thrust stress yielding 1
Resistance factor for global buckling 1
Resistance factor for seam strength 0.67
Resistance factor for plastic penetration 0.9
Allowable deflection at service load 5 %

Menu Selected: Steel Resistance Factors (LRFD)



Level 2 - C-2
Control Integers/Construction Increments
Arch Mesh

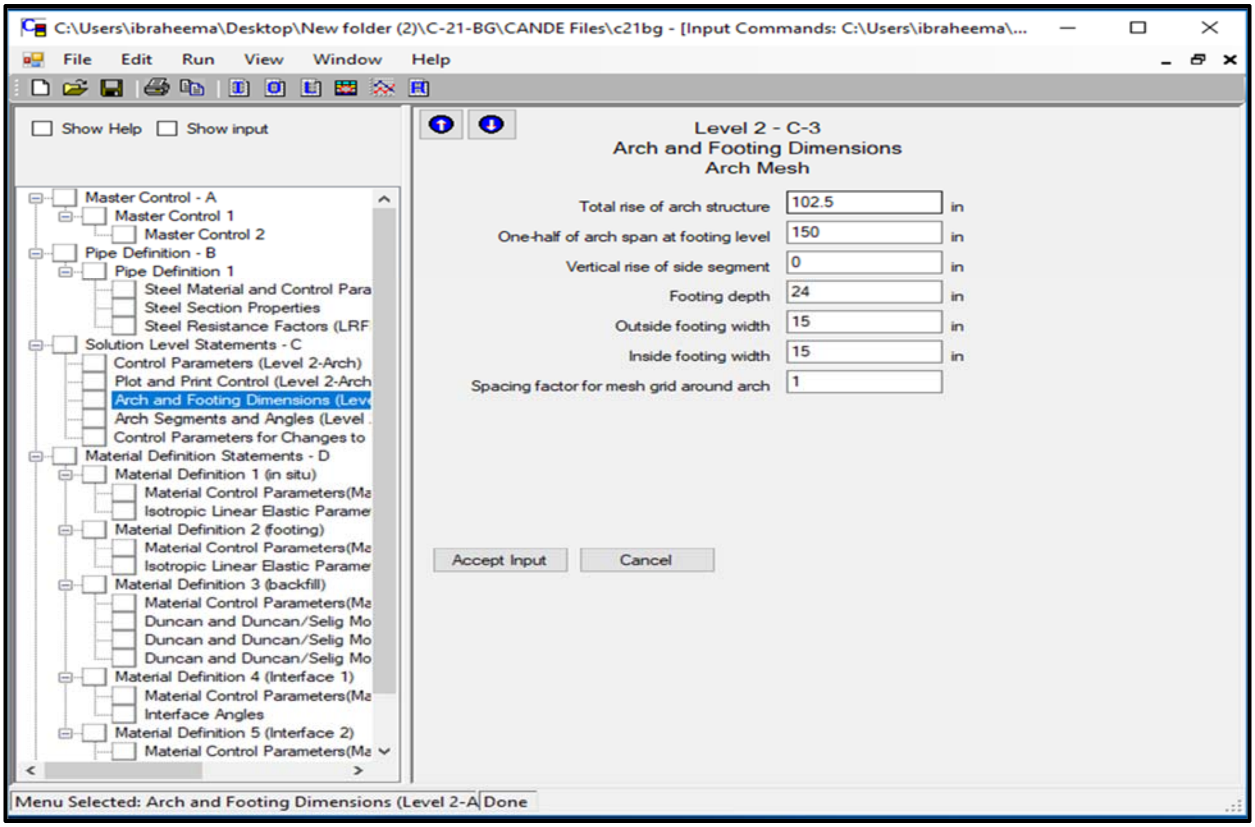
Number of load steps: 10

Response data output
○ Minimal
● Standard
○ Plus Duncan
○ Plus interface

Mesh output
○ Control
○ Mirror
● Created data
○ Maximum

Height of soil cover above crown of arch: 3 ft
Density of soil above truncated arch: 120 lb/ft^3
Trench depth: 0 ft
Trench width: 0 ft
Slope of trench wall: 0

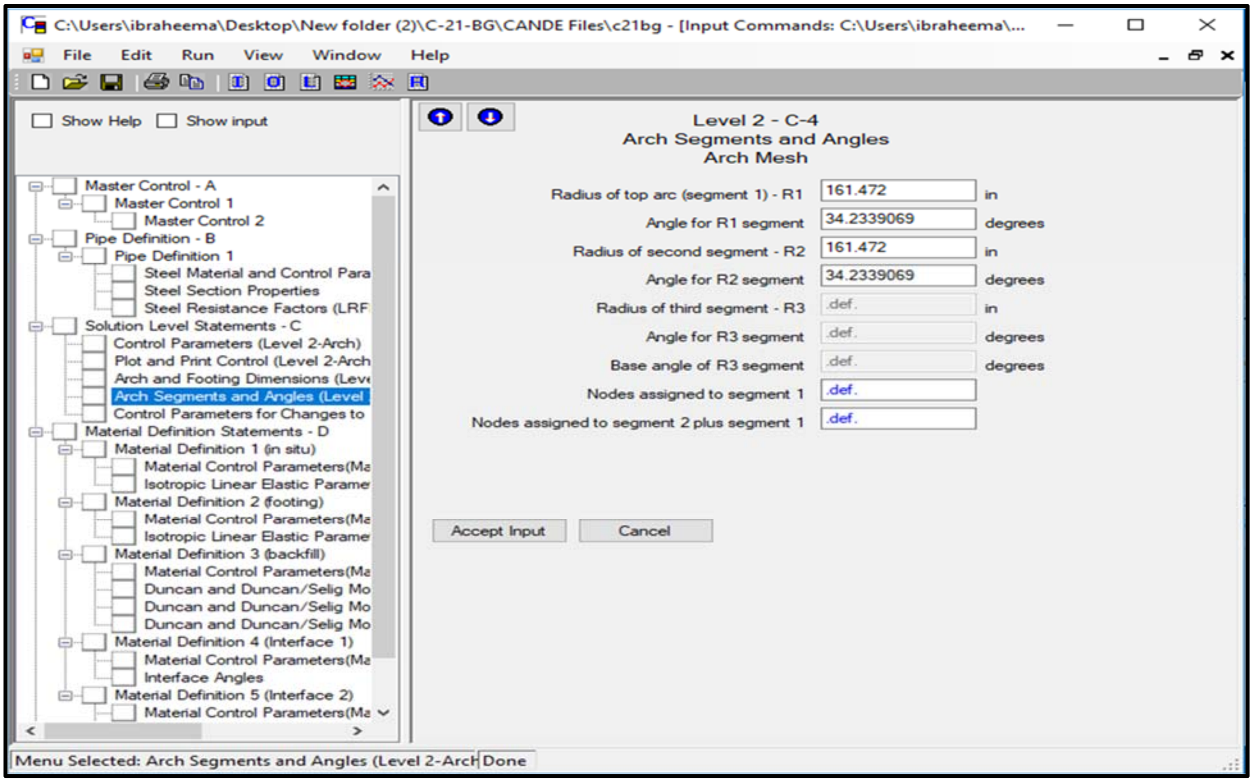
Menu Selected: Plot and Print Control (Level 2-Arch)



Level 2 - C-3
Arch and Footing Dimensions
Arch Mesh

Total rise of arch structure: 102.5 in
One-half of arch span at footing level: 150 in
Vertical rise of side segment: 0 in
Footing depth: 24 in
Outside footing width: 15 in
Inside footing width: 15 in
Spacing factor for mesh grid around arch: 1

Menu Selected: Arch and Footing Dimensions (Level 2-A



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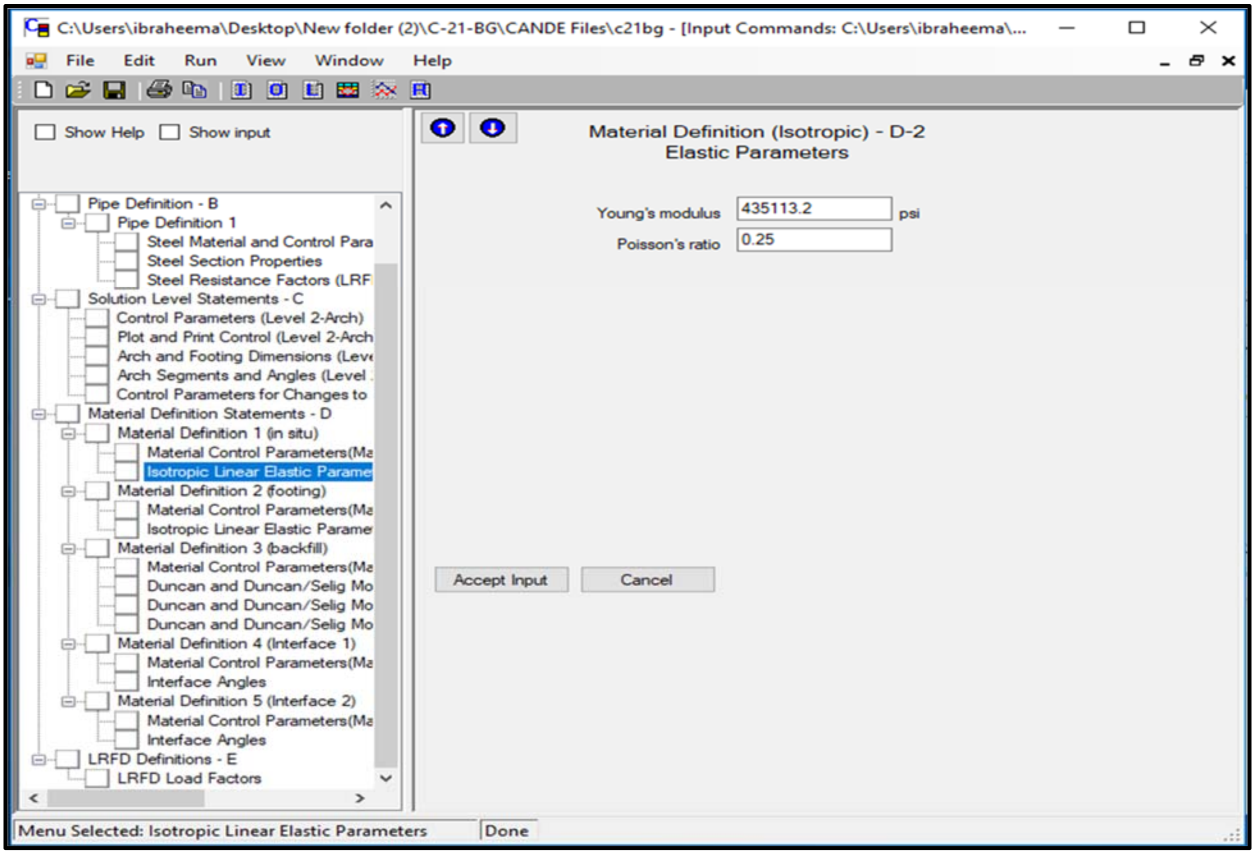
Level 2 - C-4
Arch Segments and Angles
Arch Mesh

Radius of top arc (segment 1) - R1: 161.472 in
Angle for R1 segment: 34.2339069 degrees
Radius of second segment - R2: 161.472 in
Angle for R2 segment: 34.2339069 degrees
Radius of third segment - R3: .def. in
Angle for R3 segment: .def. degrees
Base angle of R3 segment: .def. degrees
Nodes assigned to segment 1: .def.
Nodes assigned to segment 2 plus segment 1: .def.

Menu Selected: Arch Segments and Angles (Level 2-Arch Done

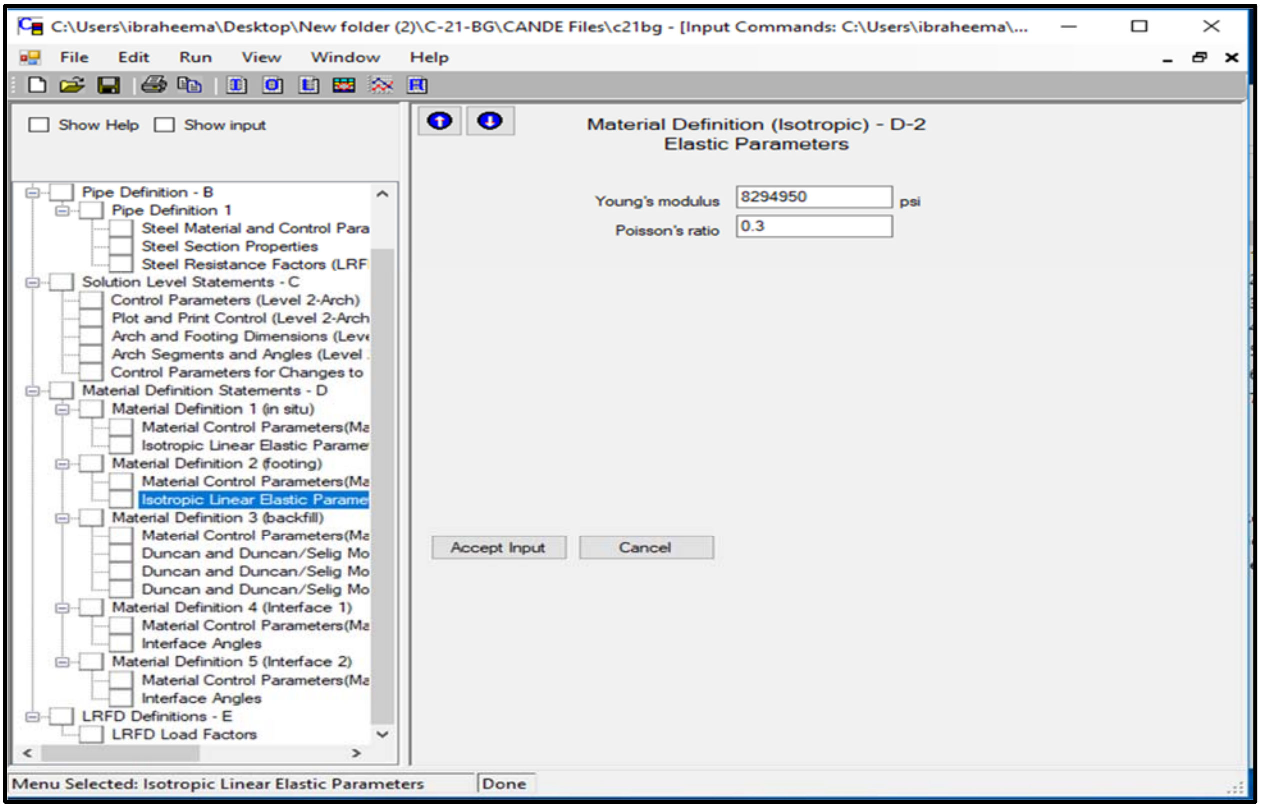


C:\Users\ibraheema\Desktop\New folder (2)\C-21-BG\CANDE Files\c21bg - [Input Commands: C:\Users\ibraheema\...

Material Definition (Isotropic) - D-2
Elastic Parameters

Young's modulus: 435113.2 psi
Poisson's ratio: 0.25

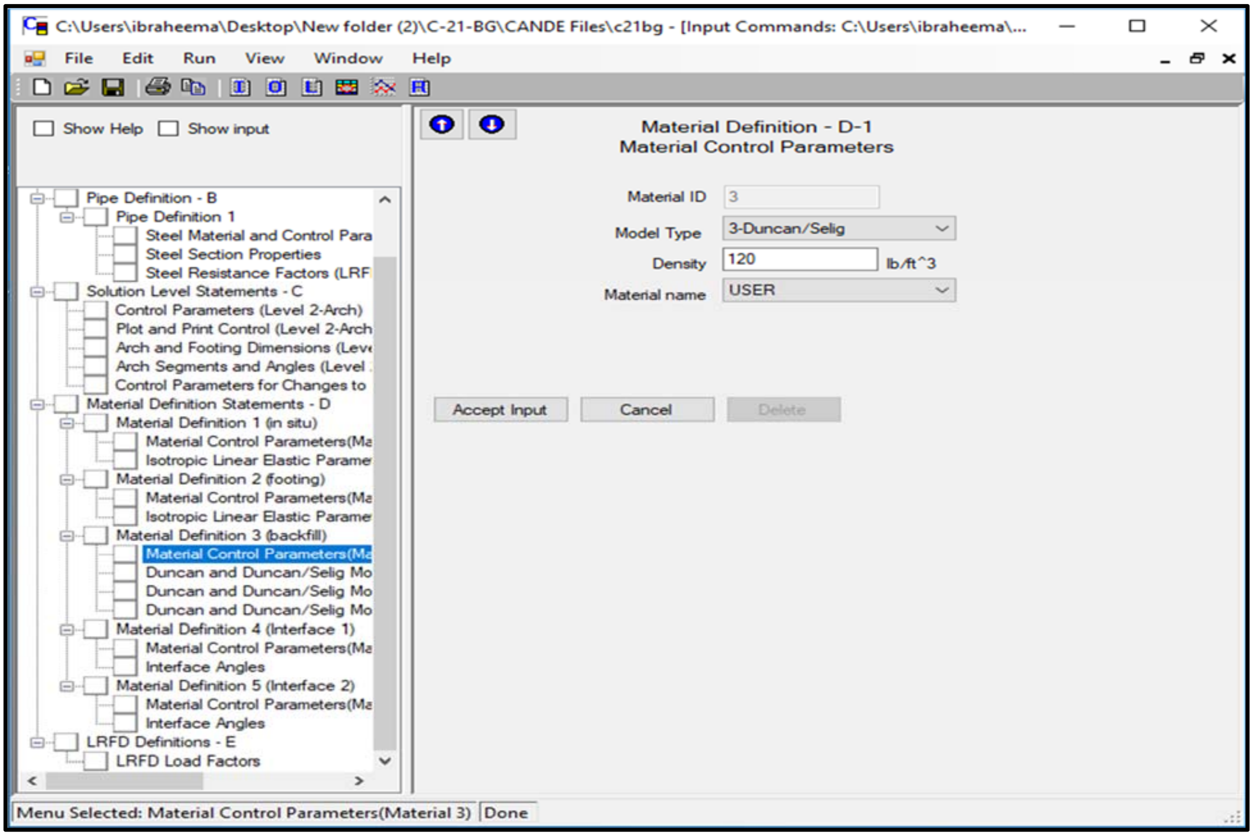
Menu Selected: Isotropic Linear Elastic Parameters Done



Material Definition (Isotropic) - D-2
Elastic Parameters

Young's modulus: 8294950 psi
Poisson's ratio: 0.3

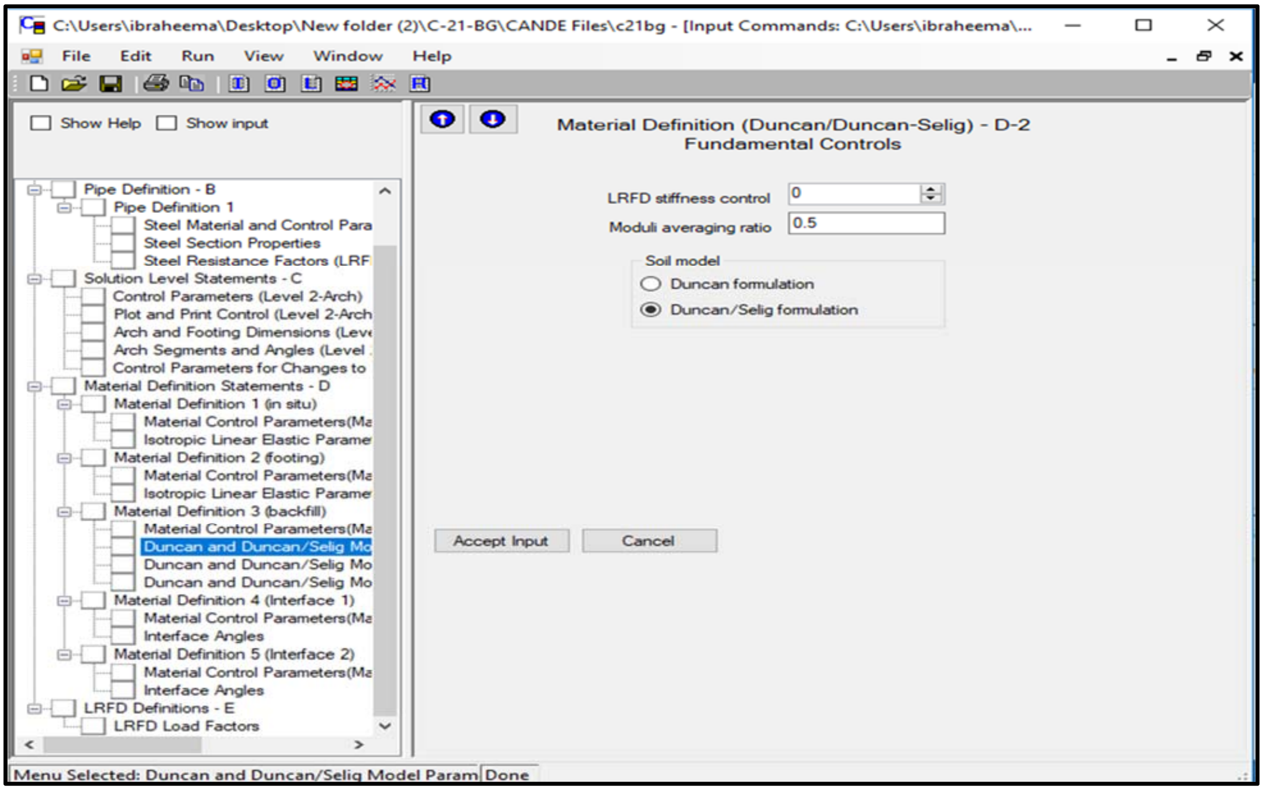
Menu Selected: Isotropic Linear Elastic Parameters | Done



Material Definition - D-1
Material Control Parameters

Material ID: 3
Model Type: 3-Duncan/Selig
Density: 120 lb/ft^3
Material name: USER

Menu Selected: Material Control Parameters(Material 3) | Done



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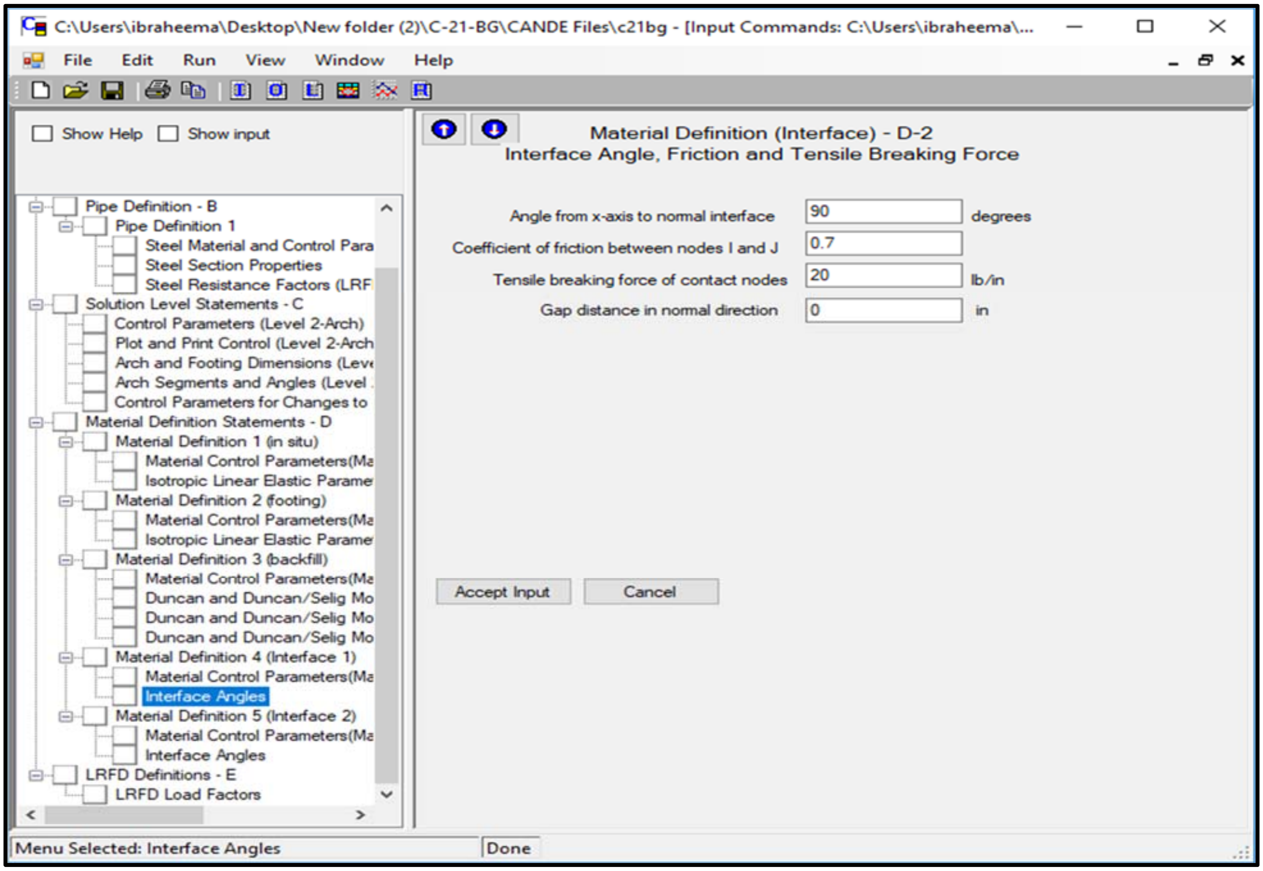
Material Definition (Duncan/Duncan-Selig) - D-2
Fundamental Controls

LRFD stiffness control: 0
Moduli averaging ratio: 0.5

Soil model
○ Duncan formulation
● Duncan/Selig formulation

Menu Selected: Duncan and Duncan/Selig Model Param Done

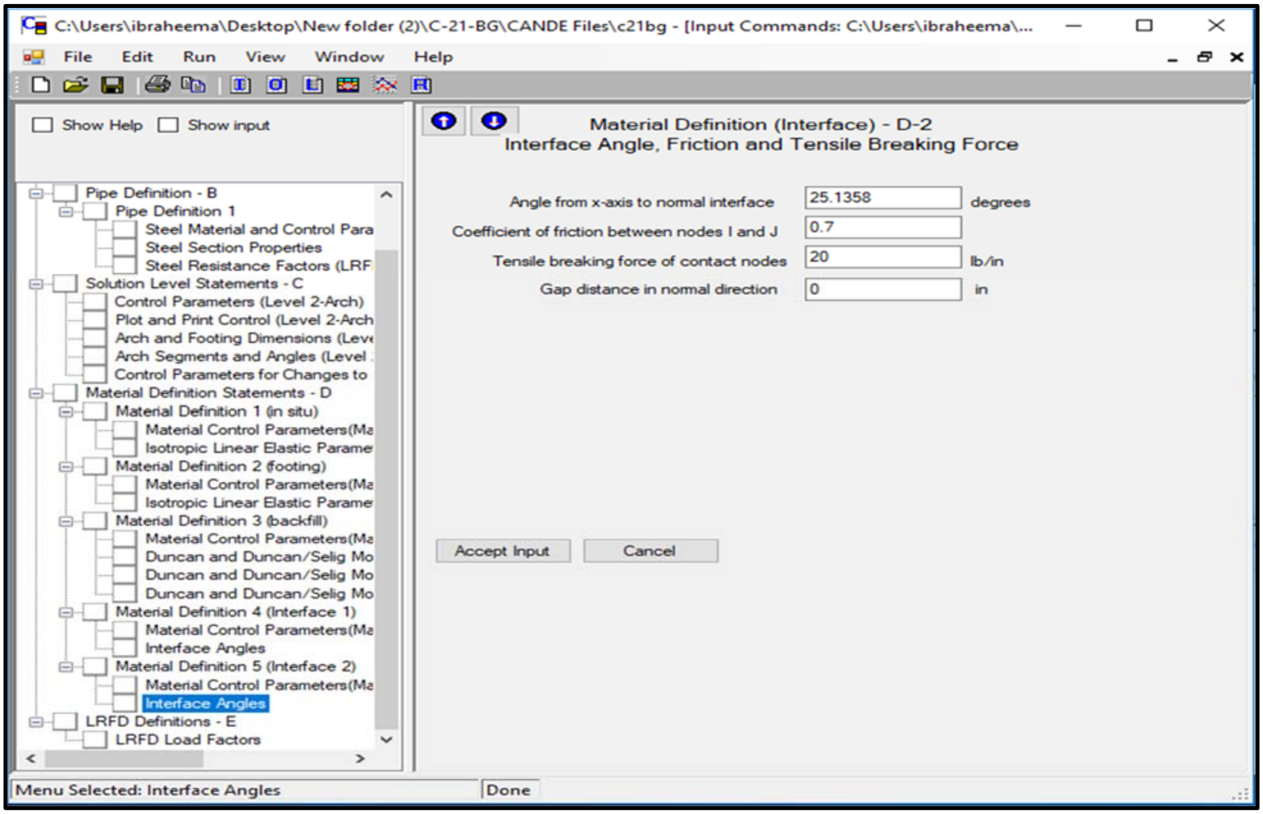


C:\Users\ibraheema\Desktop\New folder (2)\C-21-BG\CANDE Files\c21bg - [Input Commands: C:\Users\ibraheema\...

Material Definition (Interface) - D-2
Interface Angle, Friction and Tensile Breaking Force

Angle from x-axis to normal interface: 90 degrees
Coefficient of friction between nodes I and J: 0.7
Tensile breaking force of contact nodes: 20 lb/in
Gap distance in normal direction: 0 in

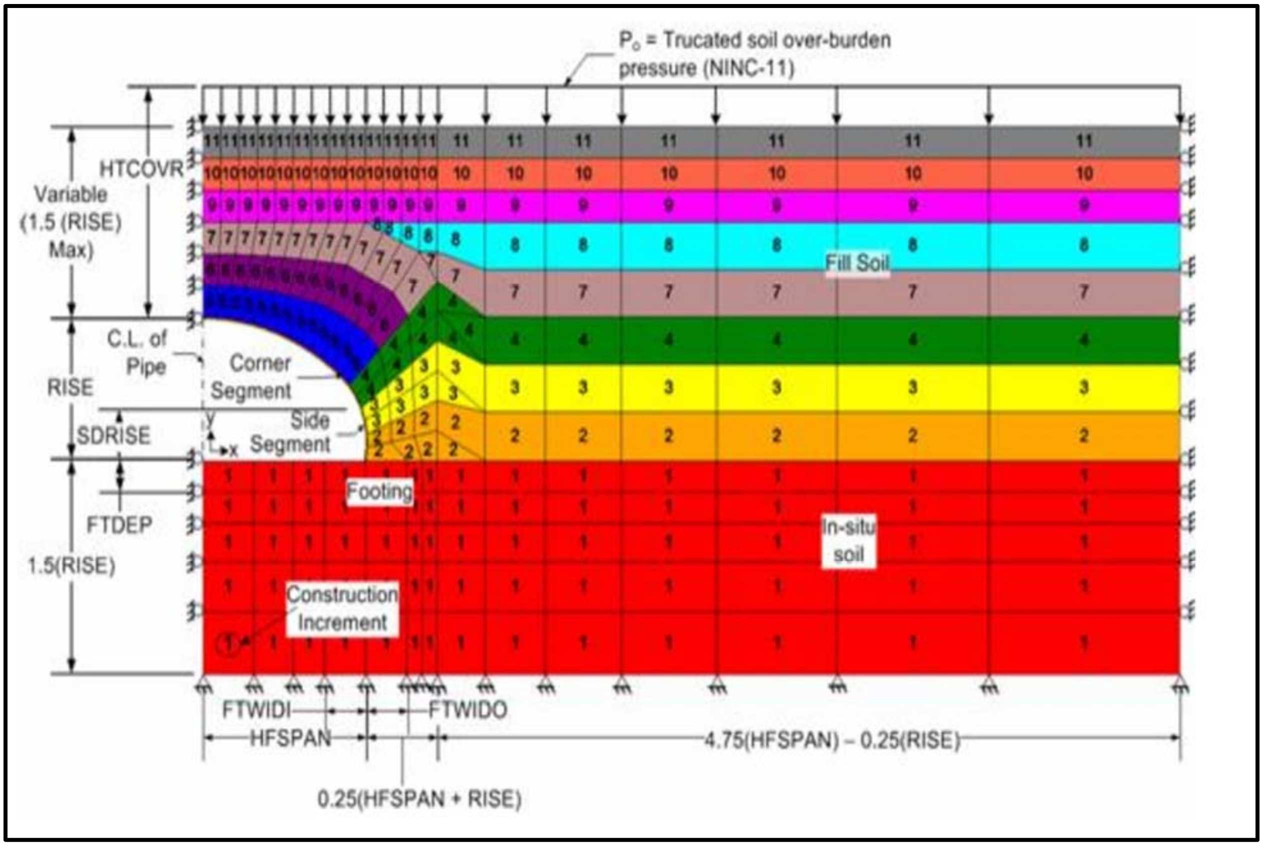
Menu Selected: Interface Angles Done



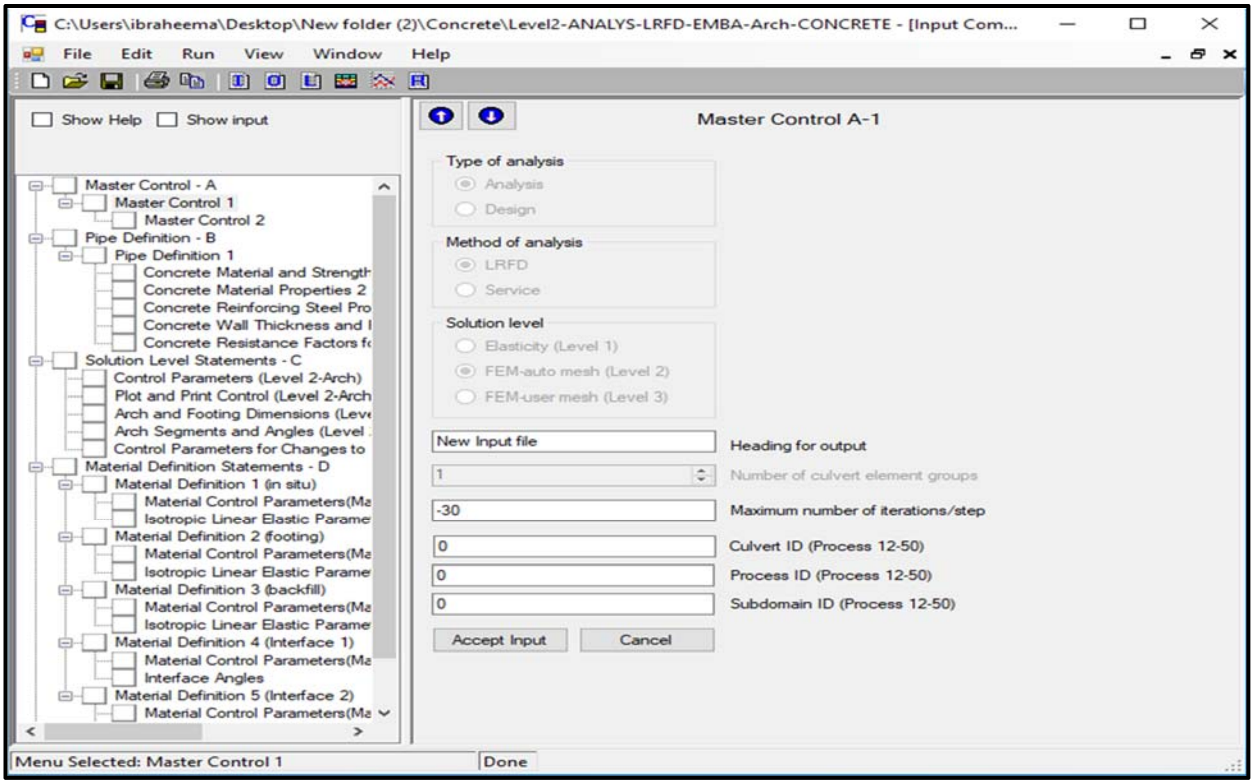
Material Definition (Interface) - D-2
Interface Angle, Friction and Tensile Breaking Force

Angle from x-axis to normal interface: 25.1358 degrees
Coefficient of friction between nodes I and J: 0.7
Tensile breaking force of contact nodes: 20 lb/in
Gap distance in normal direction: 0 in

Menu Selected: Interface Angles
Done



14A.7.3 Example 3: Concrete Arch Culvert Rating (CAC)



Master Control A-1

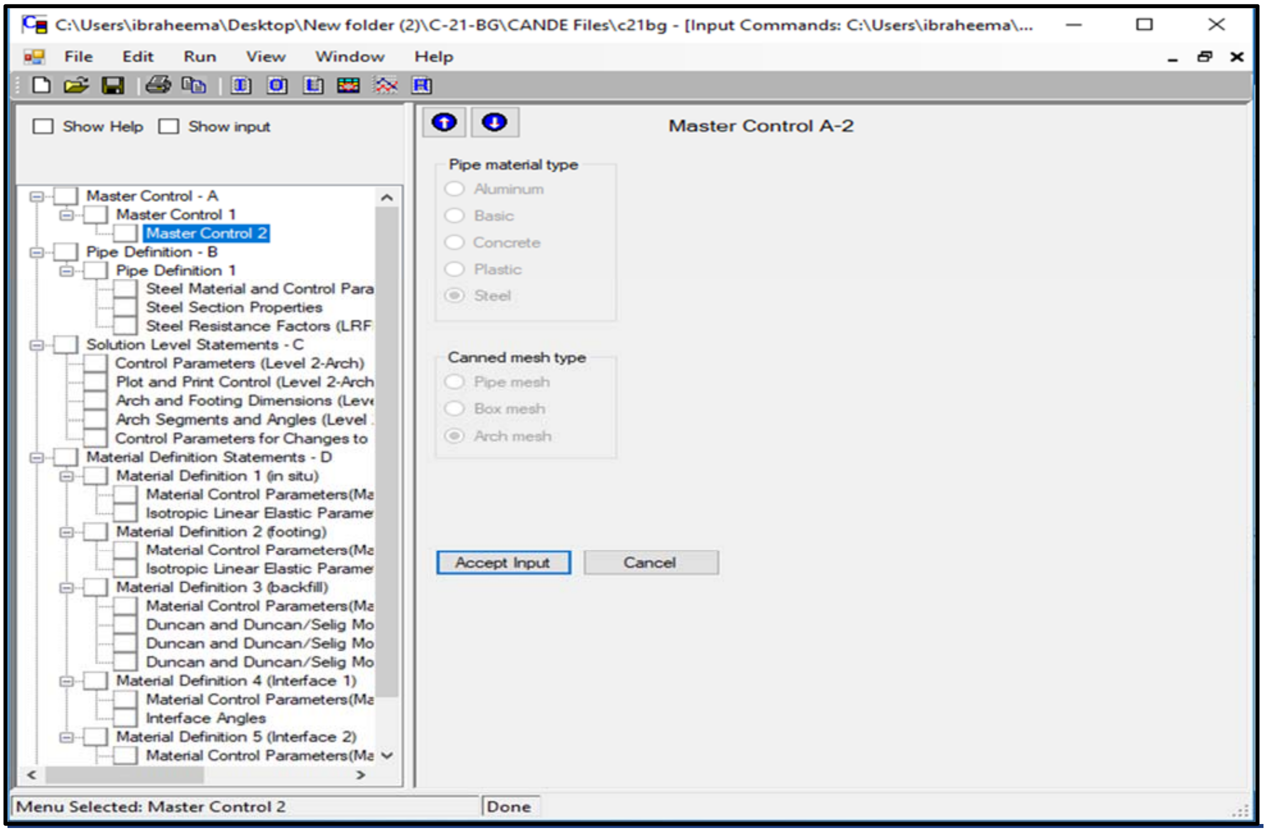
Type of analysis
● Analysis
○ Design

Method of analysis
● LRFD
○ Service

Solution level
○ Elasticity (Level 1)
● FEM-auto mesh (Level 2)
○ FEM-user mesh (Level 3)

New Input file — Heading for output
1 — Number of culvert element groups
-30 — Maximum number of iterations/step
0 — Culvert ID (Process 12-50)
0 — Process ID (Process 12-50)
0 — Subdomain ID (Process 12-50)

Menu Selected: Master Control 1 | Done

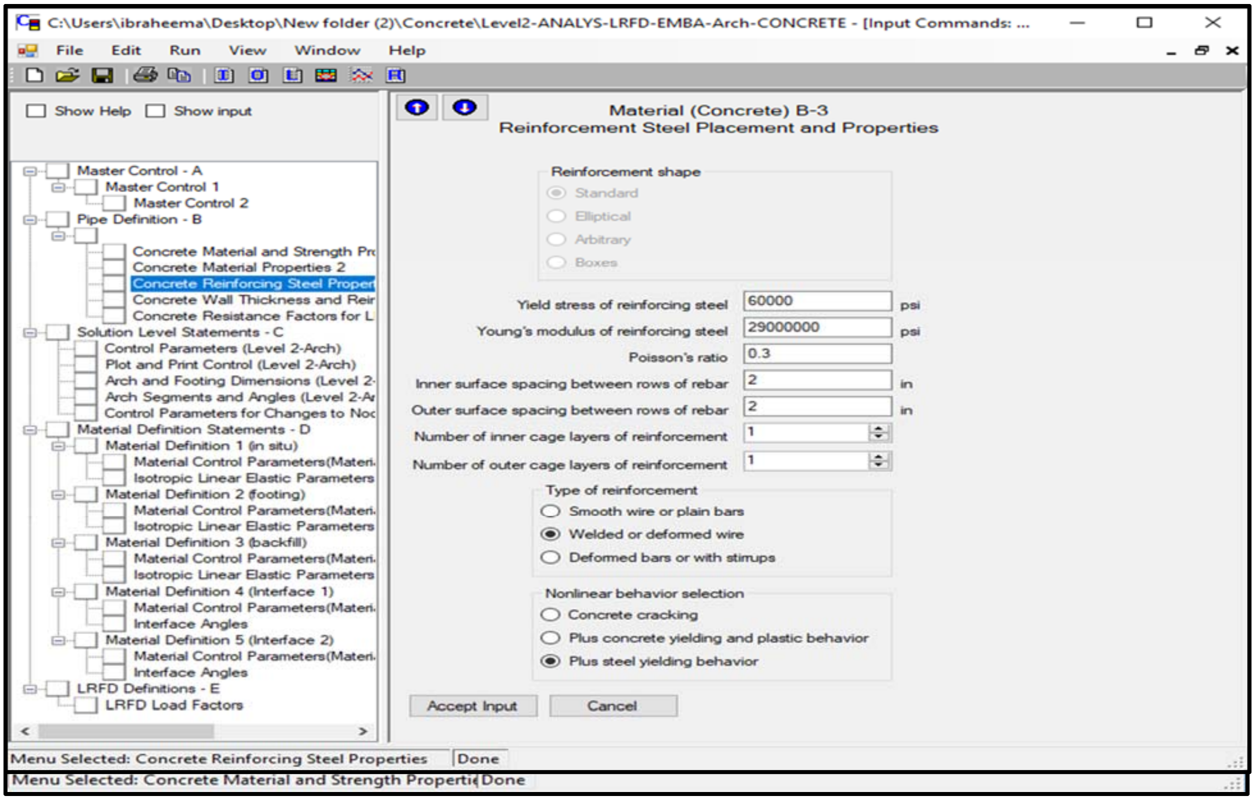


Master Control A-2

Pipe material type
○ Aluminum
○ Basic
○ Concrete
○ Plastic
● Steel

Canned mesh type
○ Pipe mesh
○ Box mesh
● Arch mesh

Menu Selected: Master Control 2 | Done



Material (Concrete) B-3
Reinforcement Steel Placement and Properties

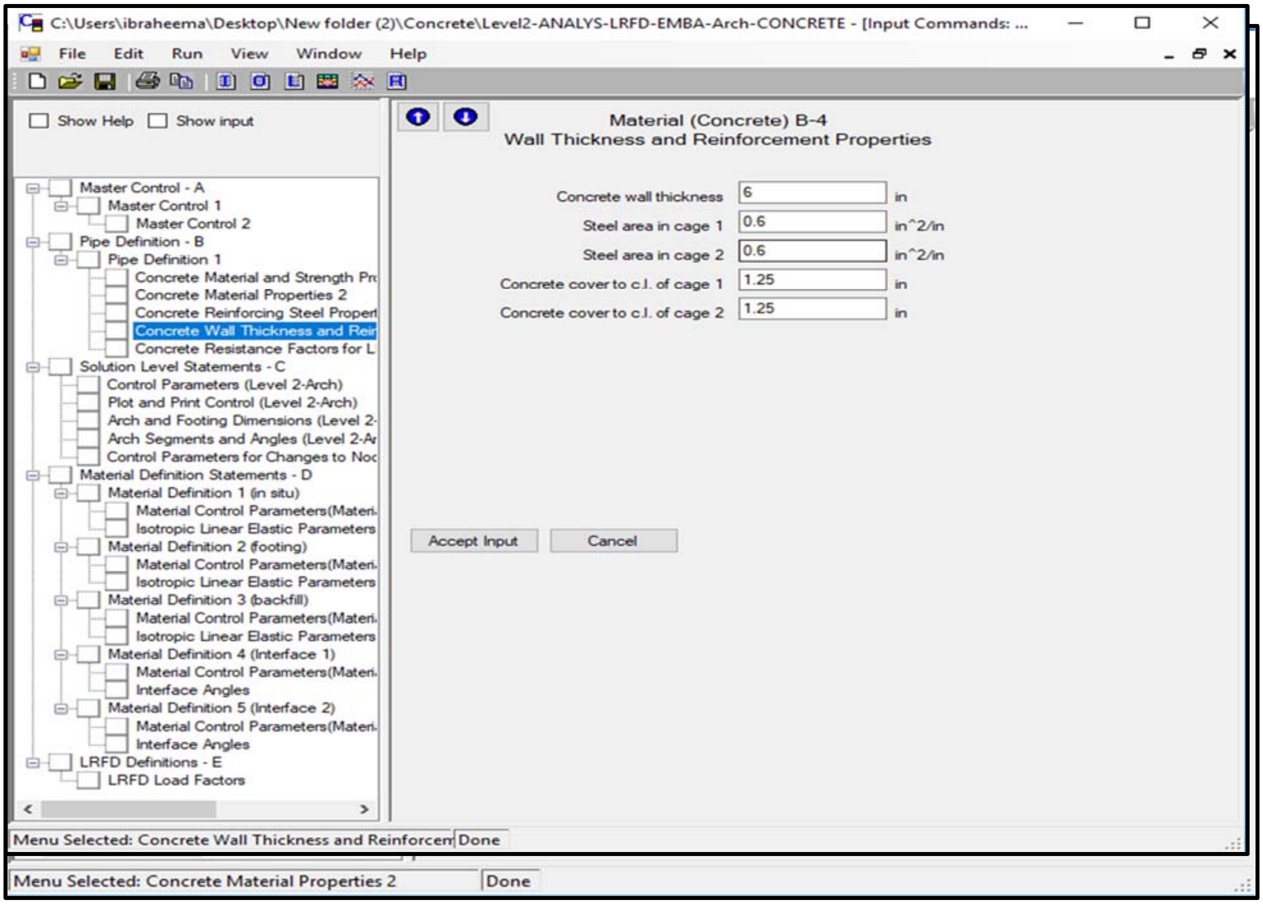
Reinforcement shape
● Standard
○ Elliptical
○ Arbitrary
○ Boxes

Yield stress of reinforcing steel 60000 psi
Young's modulus of reinforcing steel 29000000 psi
Poisson's ratio 0.3
Inner surface spacing between rows of rebar 2 in
Outer surface spacing between rows of rebar 2 in
Number of inner cage layers of reinforcement 1
Number of outer cage layers of reinforcement 1

Type of reinforcement
○ Smooth wire or plain bars
● Welded or deformed wire
○ Deformed bars or with stirrups

Nonlinear behavior selection
○ Concrete cracking
○ Plus concrete yielding and plastic behavior
● Plus steel yielding behavior

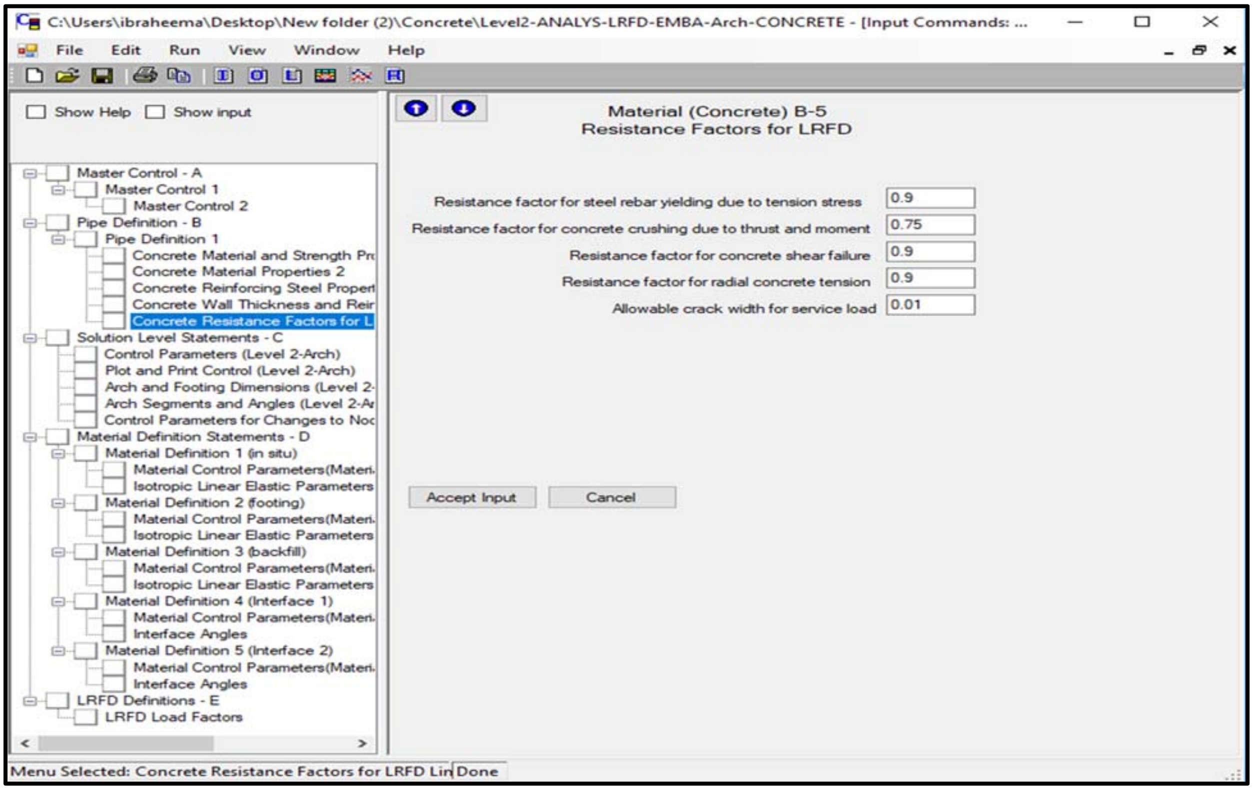
Menu Selected: Concrete Reinforcing Steel Properties Done
Menu Selected: Concrete Material and Strength Properti Done



Material (Concrete) B-4
Wall Thickness and Reinforcement Properties

Concrete wall thickness 6 in
Steel area in cage 1 0.6 in^2/in
Steel area in cage 2 0.6 in^2/in
Concrete cover to c.l. of cage 1 1.25 in
Concrete cover to c.l. of cage 2 1.25 in

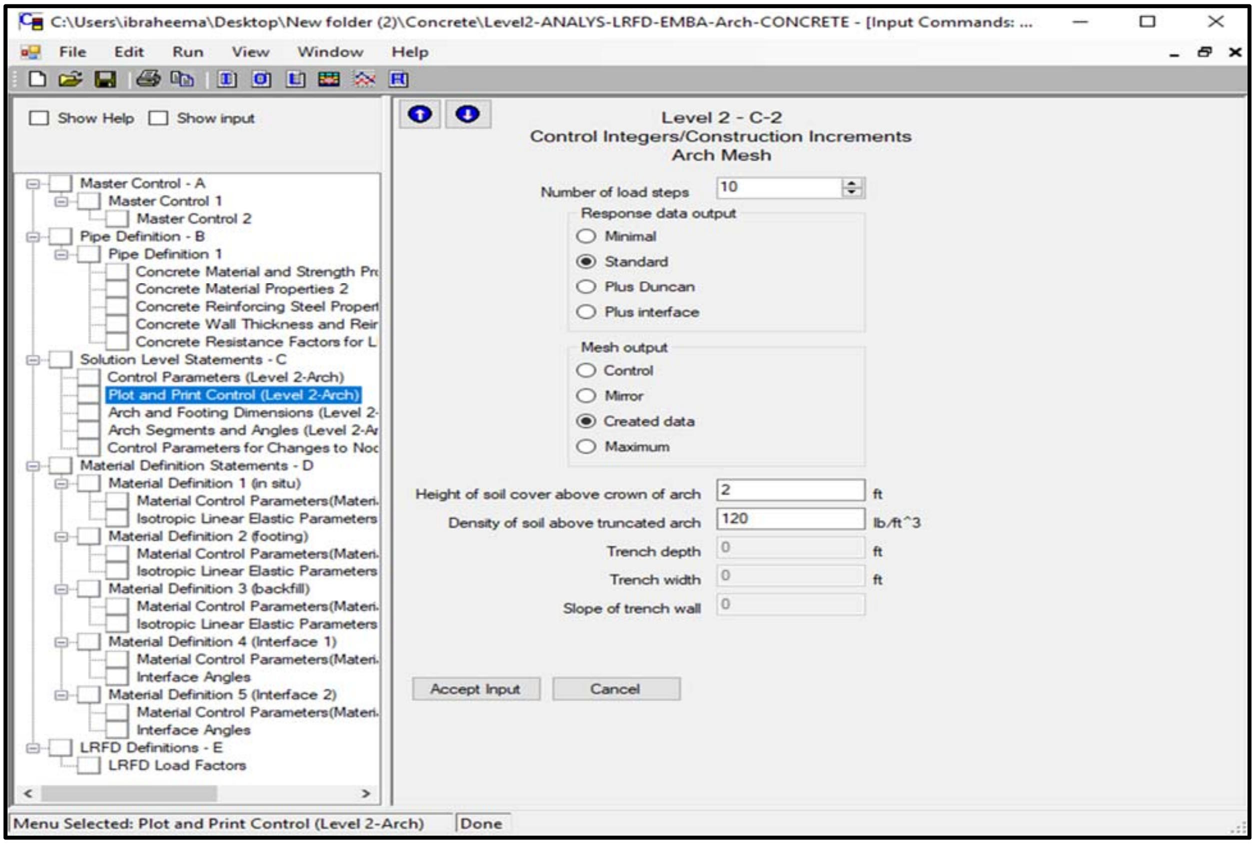
Menu Selected: Concrete Wall Thickness and Reinforcem Done
Menu Selected: Concrete Material Properties 2 Done



Material (Concrete) B-5
Resistance Factors for LRFD

Resistance factor for steel rebar yielding due to tension stress 0.9
Resistance factor for concrete crushing due to thrust and moment 0.75
Resistance factor for concrete shear failure 0.9
Resistance factor for radial concrete tension 0.9
Allowable crack width for service load 0.01

Menu Selected: Concrete Resistance Factors for LRFD Lin Done



Level 2 - C-2
Control Integers/Construction Increments
Arch Mesh

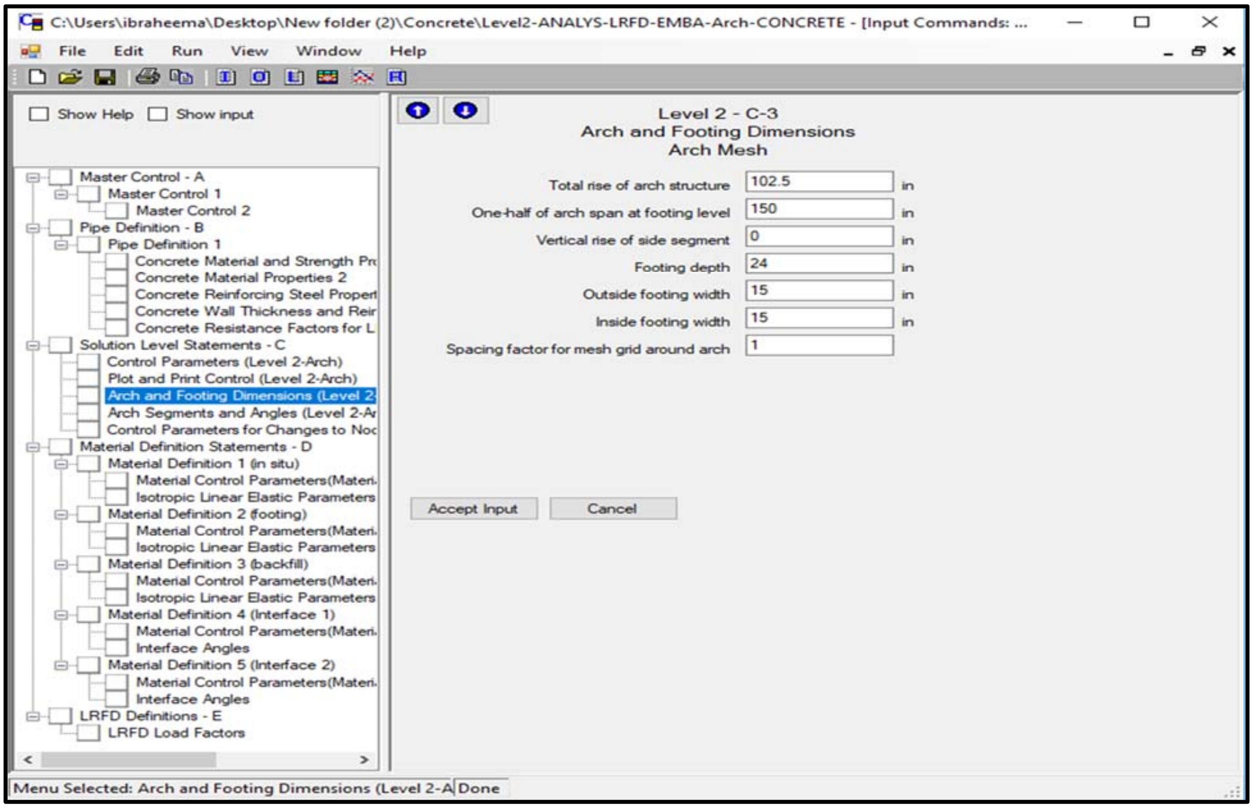
Number of load steps 10

Response data output
○ Minimal
● Standard
○ Plus Duncan
○ Plus interface

Mesh output
○ Control
○ Mirror
● Created data
○ Maximum

Height of soil cover above crown of arch 2 ft
Density of soil above truncated arch 120 lb/ft^3
Trench depth 0 ft
Trench width 0 ft
Slope of trench wall 0

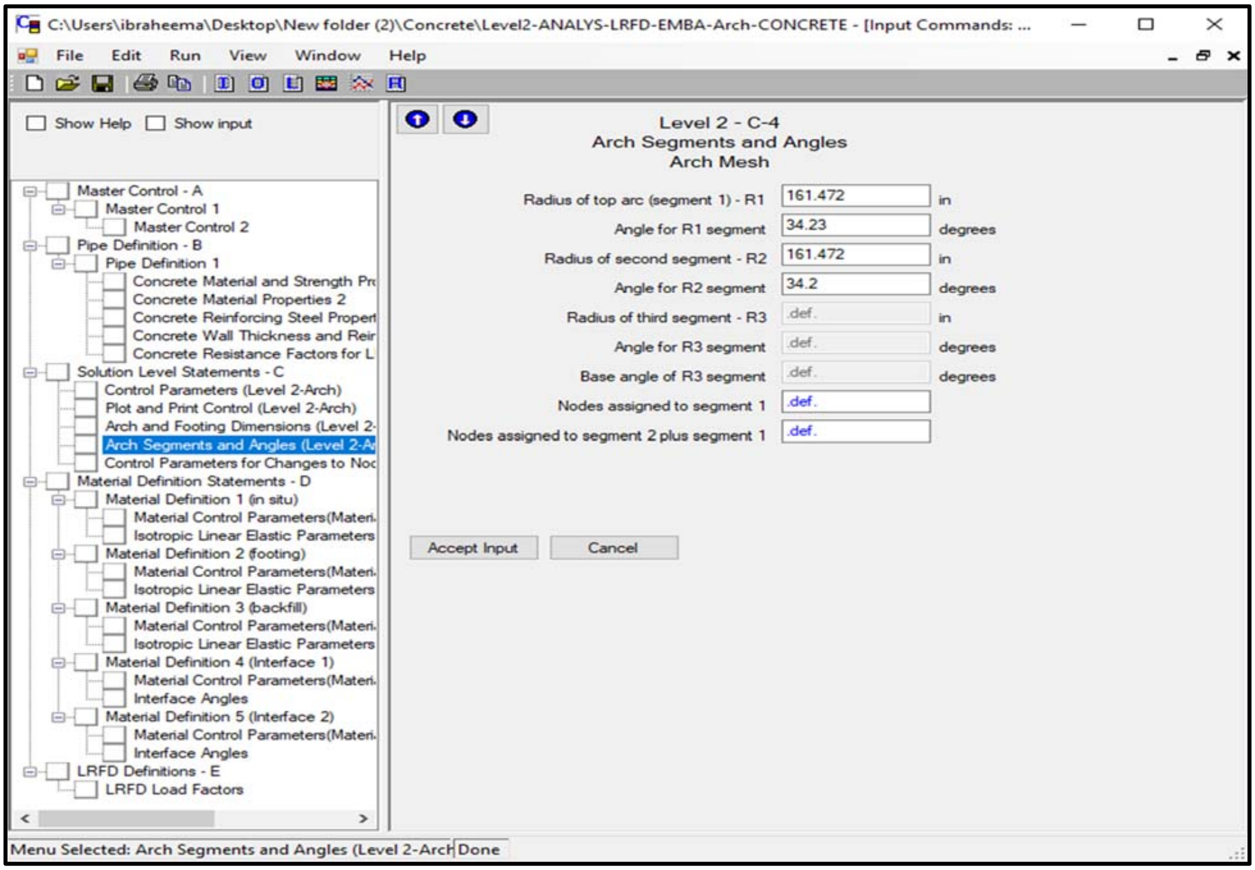
Menu Selected: Plot and Print Control (Level 2-Arch) Done



Level 2 - C-3
Arch and Footing Dimensions
Arch Mesh

Total rise of arch structure	102.5	in
One-half of arch span at footing level	150	in
Vertical rise of side segment	0	in
Footing depth	24	in
Outside footing width	15	in
Inside footing width	15	in
Spacing factor for mesh grid around arch	1	

Menu Selected: Arch and Footing Dimensions (Level 2-A Done



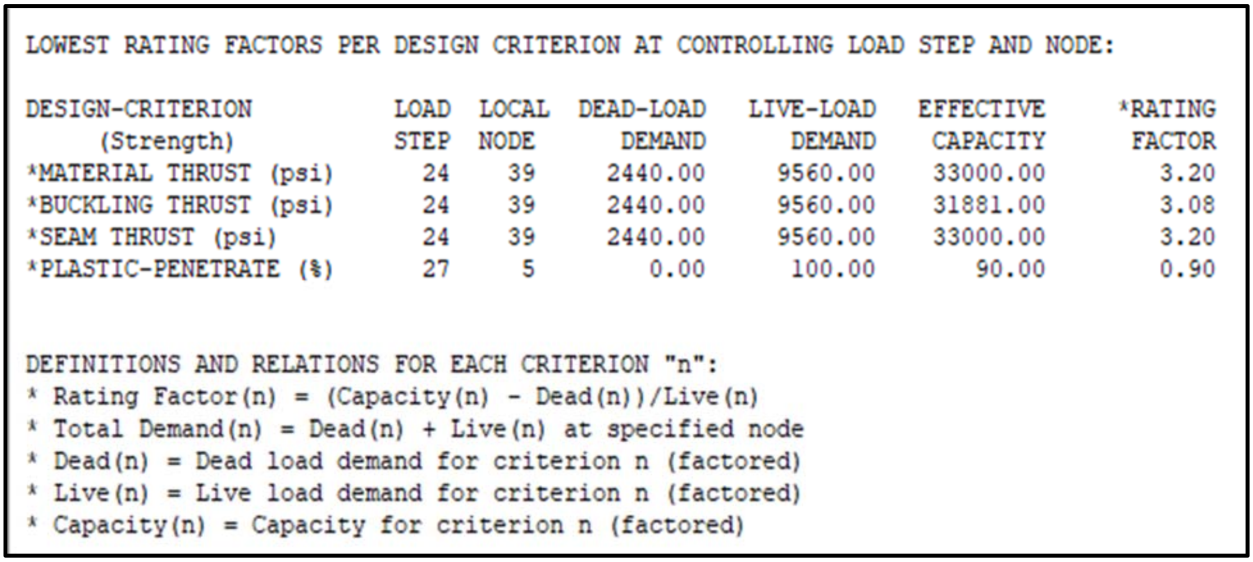
Level 2 - C-4
Arch Segments and Angles
Arch Mesh

Radius of top arc (segment 1) - R1	161.472	in
Angle for R1 segment	34.23	degrees
Radius of second segment - R2	161.472	in
Angle for R2 segment	34.2	degrees
Radius of third segment - R3	.def.	in
Angle for R3 segment	.def.	degrees
Base angle of R3 segment	.def.	degrees
Nodes assigned to segment 1	.def.	
Nodes assigned to segment 2 plus segment 1	.def.	

Menu Selected: Arch Segments and Angles (Level 2-Arch Done

Steel arch rating results vs concrete arch

- Steel Arch

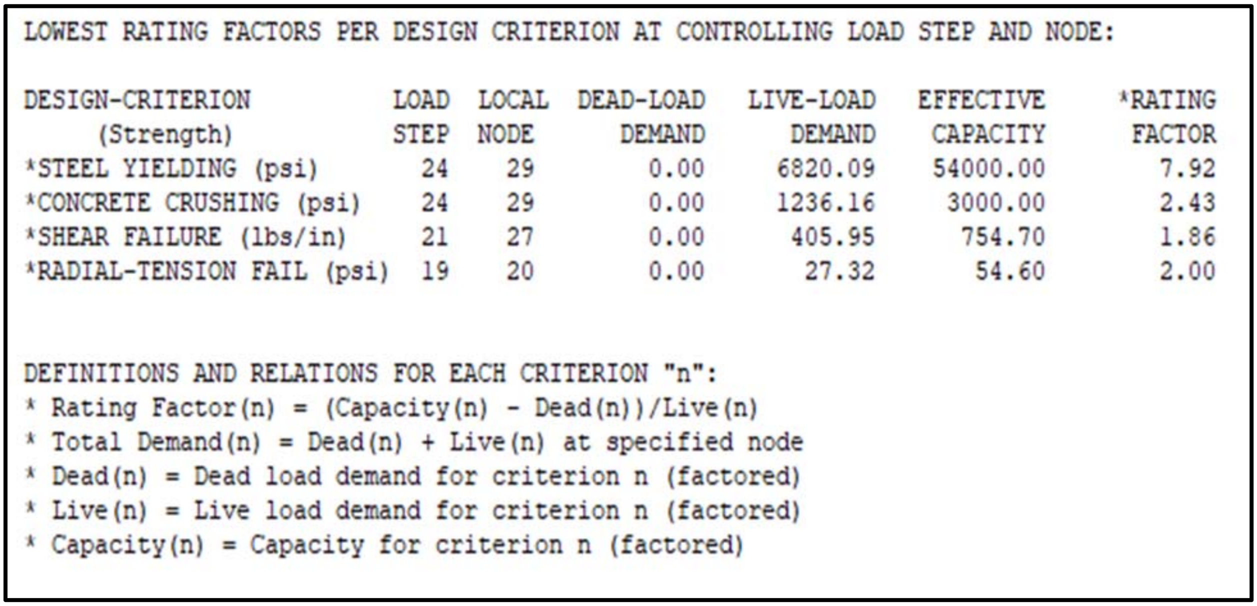


```
LOWEST RATING FACTORS PER DESIGN CRITERION AT CONTROLLING LOAD STEP AND NODE:

DESIGN-CRITERION          LOAD  LOCAL  DEAD-LOAD    LIVE-LOAD   EFFECTIVE    *RATING
     (Strength)           STEP  NODE      DEMAND       DEMAND    CAPACITY     FACTOR
*MATERIAL THRUST (psi)      24    39     2440.00      9560.00    33000.00       3.20
*BUCKLING THRUST (psi)      24    39     2440.00      9560.00    31881.00       3.08
*SEAM THRUST (psi)          24    39     2440.00      9560.00    33000.00       3.20
*PLASTIC-PENETRATE (%)      27     5        0.00       100.00       90.00       0.90


DEFINITIONS AND RELATIONS FOR EACH CRITERION "n":
* Rating Factor(n) = (Capacity(n) - Dead(n))/Live(n)
* Total Demand(n) = Dead(n) + Live(n) at specified node
* Dead(n) = Dead load demand for criterion n (factored)
* Live(n) = Live load demand for criterion n (factored)
* Capacity(n) = Capacity for criterion n (factored)
```

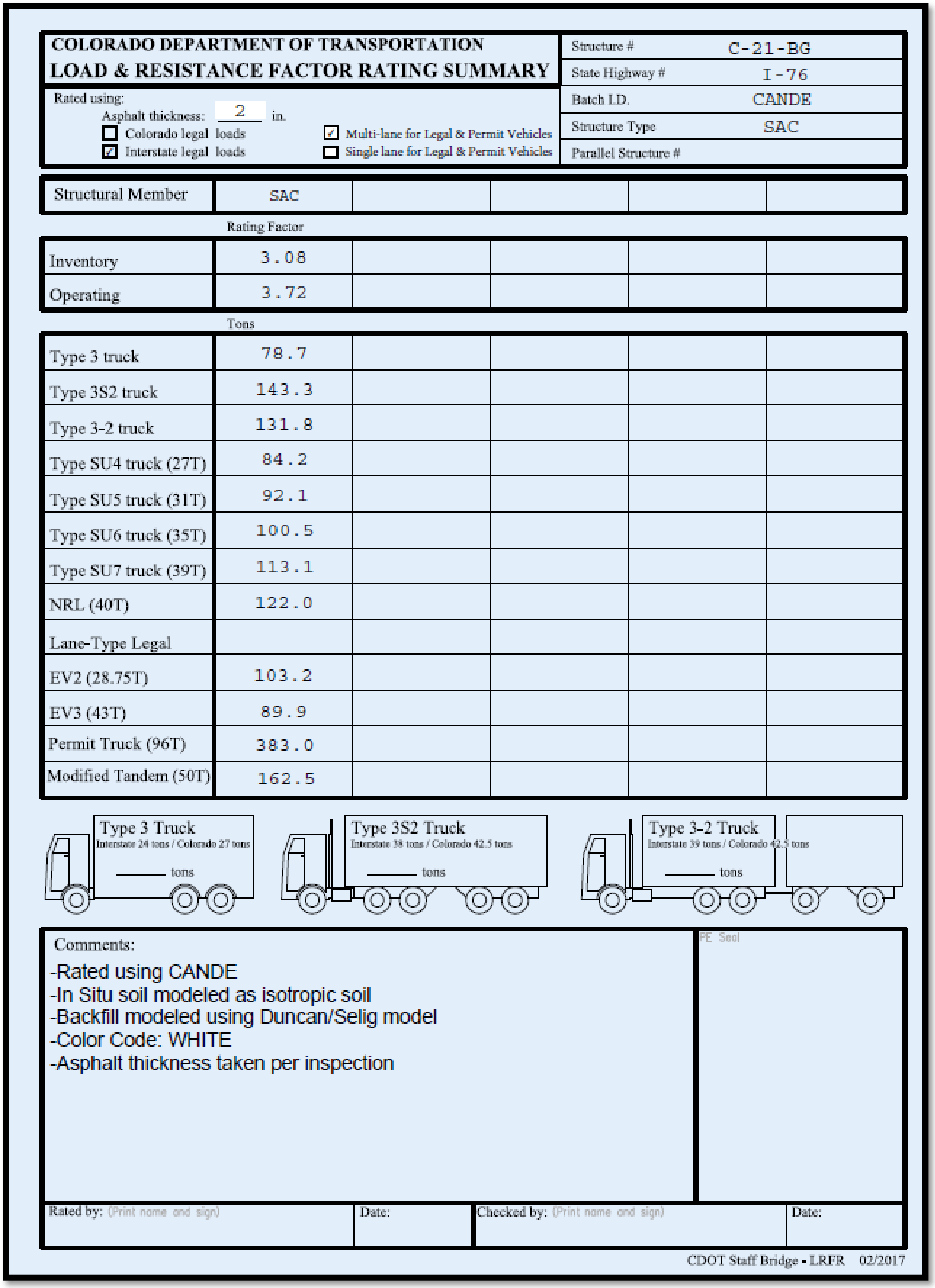
- Concrete Arch



```
LOWEST RATING FACTORS PER DESIGN CRITERION AT CONTROLLING LOAD STEP AND NODE:

DESIGN-CRITERION          LOAD  LOCAL  DEAD-LOAD    LIVE-LOAD   EFFECTIVE    *RATING
     (Strength)           STEP  NODE      DEMAND       DEMAND    CAPACITY     FACTOR
*STEEL YIELDING (psi)       24    29        0.00      6820.09    54000.00       7.92
*CONCRETE CRUSHING (psi)    24    29        0.00      1236.16     3000.00       2.43
*SHEAR FAILURE (lbs/in)     21    27        0.00       405.95      754.70       1.86
*RADIAL-TENSION FAIL (psi)  19    20        0.00        27.32       54.60       2.00


DEFINITIONS AND RELATIONS FOR EACH CRITERION "n":
* Rating Factor(n) = (Capacity(n) - Dead(n))/Live(n)
* Total Demand(n) = Dead(n) + Live(n) at specified node
* Dead(n) = Dead load demand for criterion n (factored)
* Live(n) = Live load demand for criterion n (factored)
* Capacity(n) = Capacity for criterion n (factored)
```



COLORADO DEPARTMENT OF TRANSPORTATION
LOAD & RESISTANCE FACTOR RATING SUMMARY

Rated using:
Asphalt thickness: 2 in.
☐ Colorado legal loads
☑ Interstate legal loads
☑ Multi-lane for Legal & Permit Vehicles
☐ Single lane for Legal & Permit Vehicles

Structure #	C-21-BG
State Highway #	I-76
Batch I.D.	CANDE
Structure Type	SAC
Parallel Structure #	

Structural Member	SAC				
Rating Factor					
Inventory	3.08				
Operating	3.72				
Tons					
Type 3 truck	78.7				
Type 3S2 truck	143.3				
Type 3-2 truck	131.8				
Type SU4 truck (27T)	84.2				
Type SU5 truck (31T)	92.1				
Type SU6 truck (35T)	100.5				
Type SU7 truck (39T)	113.1				
NRL (40T)	122.0				
Lane-Type Legal					
EV2 (28.75T)	103.2				
EV3 (43T)	89.9				
Permit Truck (96T)	383.0				
Modified Tandem (50T)	162.5				

Type 3 Truck
Interstate 24 tons / Colorado 27 tons
_____ tons

Type 3S2 Truck
Interstate 38 tons / Colorado 42.5 tons
_____ tons

Type 3-2 Truck
Interstate 39 tons / Colorado 42.5 tons
_____ tons

Comments:
-Rated using CANDE
-In Situ soil modeled as isotropic soil
-Backfill modeled using Duncan/Selig model
-Color Code: WHITE
-Asphalt thickness taken per inspection

PE Seal

Rated by: (Print name and sign) Date:
Checked by: (Print name and sign) Date:

CDOT Staff Bridge - LRFR 02/2017

COLORADO DEPARTMENT OF TRANSPORTATION STAFF BRIDGE BRIDGE RATING MANUAL	Section: 15 Effective: April, 1, 2011 Supersedes: None

SECTION 15 – LOAD AND RESISTANCE FACTOR RATING (LRFR)

15-1 GENERAL LRFR POLICY

This section covers the Load and Resistance Factor Rating (LRFR) method. The LRFR method is required for all structures designed after October 1, 2010 using the AASHTO LRFD Bridge Design Specifications (LRFD). Refer to Section 1-4 in this manual for additional guidance on when the LRFR method is required.

The load rating for structures using the LRFR method shall be in accordance with the current AASHTO LRFD Bridge Design Specifications and, the AASHTO Manual for Bridge Evaluation except where superseded by this manual.

The rating shall include both moment and shear for all interior and exterior girders.

Excluding post-tensioned structures, rigid frames and culverts, the AASHTOWare Virtis software shall be used for all ratings using the LRFR method. The analysis engine for LRFR shall be the Virtis engine. The rating procedure for both in-house and consultant ratings shall be as described in Sections 1-11 and 1-12 on this manual. The rating package requirements shall be as described in Section 1-13 of this manual, except no deck rating is required for structures rated with LRFR.

The requirements for rerating due to design and field changes shall be as stated in Sections 1-17 and 1-18.

15-2 DEAD LOADS

Dead loads used for the LRFR method will be calculated in accordance with Section 1-1 of this manual.

15-3 LIVE LOADS

For Load and Resistance Factor Ratings (LRFR), the live load to be used for rating shall be as specified in the current AASHTO LRFD Bridge Design Specifications, the AASHTO Manual for Bridge Evaluation and the CDOT Staff Bridge Rating Manual.

15-4 IMPACT AND DRISTRIBUTION OF LIVE LOAD

The live load impact used for rating shall be as specified in the current AAHSTO LRFD Bridge Design Specifications except as noted in Section 1-3 of this manual. Full impact shall be used for all ratings: HL-93 inventory, HL-93 operating, posting, and overload color code ratings.

For overload permit analysis (i.e., gross vehicle weight over 200,000 lbs) when reduced vehicle speed is enforced, impact may be reduced when crossing the structure.

15-4 IMPACT AND DRISTRIBUTION OF LIVE LOAD (CONTINUED)

The live load distribution factors used for rating shall be as specified in the current AAHSTO LRFD Bridge Design Specifications and AASHTO Manual for Bridge Evaluation except as noted in Section 1-3 of this manual.

15-5 MATERIAL PROPERTIES USED TO DETERMINE BRIDGE RATINGS

Material properties shall be as specified on the as built plans. When as built plans are not available, Table 1-1 of this manual maybe used.

15-6 LOAD FACTORS, CONDITION FACTORS AND SYSTEM FACTORS

The load factors used in the rating analysis shall be as specified in the current AASHTO Manual for Bridge Evaluation.

The ADTT used to select the Live Load factors shall be taken from the Structure Inspection and Appraisal sheet (SIA Sheet). The ADTT used in the analysis shall be recorded in the comments section of the Rating Summary Sheet. The value should be obtained using the following equation:

$$ADTT = ADT \times (\%\ Truck/100)$$

Where: ADT is item 29 and
% Truck is item 109.

If the ADTT is unknown the most conservative table value should be used.

The condition factor for new bridges shall be taken as 1.0.

When re-rating existing structures using the LRFR method, the actual member condition as reported in the most recent inspection shall be used. The condition factor shall be adjusted as specified in the AASHTO Manual for Bridge Evaluation.

The system factor shall be as specified in the current AASHTO Manual for Bridge Evaluation.

15-7 POSTING VEHICLE RATINGS

When performing posting vehicle ratings, Section 1-15 shall be used as a guide except as amended in the following paragraphs.

If a structure rating indicates a need for posting (i.e. operating rating factor less than 1.0), the Staff Bridge Engineer will be notified for approval and generation of a formal letter to the Permit Office, Region RTD and Region Maintenance Superintendent.

Whenever the operating rating factor or the permit truck rating factor for a structural member is less 1.0 the live load distribution factor may be adjusted using more refined analysis such as grid analysis. If the operating rating factor is still less than 1.0, the structural member shall be rated for the posting trucks. The inventory rating

15-7 POSTING VEHICLE RATINGS (CONTINUED)

shall not be adjusted from the values prescribed by the AASHTO LRFD Design Specifications.

The posting rating shall be computed using the Posting Vehicles shown in Figures 1-2, or 1-3. For mainline Interstate routes, or Interstate access ramps, the Posting Vehicles shown in Figure 1-3, shall be used. For all other routes, including Interstate business routes, the Posting Vehicles shown in Figure 1-2, shall be used.

Posting Vehicles are composed of the maximum vehicle loads allowed by Colorado law. The difference between the live loads in Figures 1-2, and 1-3, is due to the maximum legal loads allowed on Interstate highways being different from those allowed on other Colorado roadways.

The Notional Rating Load (NRL) and Lane Type Legal truck for spans greater than 200 feet as specified in the AASHTO Bridge Evaluation Manual shall be included in the posting analysis.

15-8 OVERLOAD COLOR CODE

The Overload Color Code rating shall be computed using the live load defined in Section 1-16. For span up to 200 feet, only the permit vehicle shall be considered present in the lane. For spans greater than 200 feet and when checking negative moments in continuous span bridges, an additional lane load shall be applied, see section 6A.4.5.4.1 of the Manual for Bridge Evaluation. For distribution of live load see Section 15-4 of this manual. Structures rated using LRFR shall use multi-lane live load distribution to determine overload color code.

15-9 REPORTING LRFR RATING RESULTS

When using the LRFR method, the reported value for the HL-93 load shall be the rating factor. For all other vehicles the reported values shall be in tons.

The results of rating calculations are to be reported by the Rater on the Rating Summary Sheet, CDOT Form 1187a Load and Resistance Factor Rating Summary, see Appendix A for copies of these forms and Section 1-13 for more detail. All ratings shall be reported to tenths of a ton or tenths of a rating factor for the HL-93 loading at inventory and operating levels.

APPENDIX – A

Appendix – A has three editable Rating Summary Sheets (RSS) and they are listed as follows:

CDOT Staff Bridge - ASR (ASR_Summary_Sheet_Feb2019_YELLOW.pdf)

CDOT Staff Bridge - LFR (LFR_Summary_Sheet_Feb2019_GREEN.pdf)

CDOT Staff Bridge - LRFR (LRFR_Summary_Sheet_Feb2019_BLUE.pdf)

COLORADO DEPARTMENT OF TRANSPORTATION

TIMBER RATING SUMMARY

Structure #

State Highway #

Batch I.D.

Structure Type

Parallel Structure #

Rated using:

Asphalt thickness: ______ in.

☐ Colorado legal loads

☐ Interstate legal loads

☐ Multi-lane for Legal & Permit Vehicles

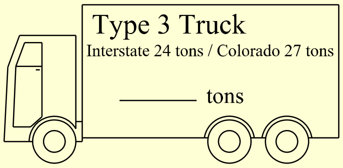
☐ Single lane for Legal & Permit Vehicles

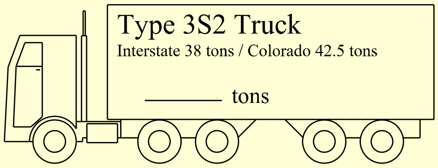
Structural Member					

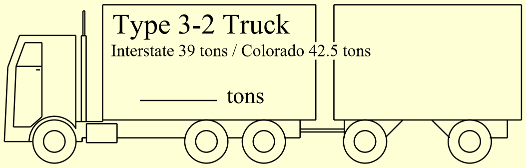
Tons

Inventory					
Operating					

Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					







Comments:

PE Seal

Rated by: (Print name and sign)

Date:

Checked by: (Print name and sign)

Date:

COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

Structure #

State Highway #

Batch I.D.

Structure Type

Parallel Structure #

Rated using:

Asphalt thickness: ______ in.

☐ Colorado legal loads

☐ Interstate legal loads

☐ Multi-lane for Legal & Permit Vehicles

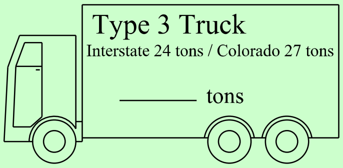
☐ Single lane for Legal & Permit Vehicles

Structural Member					

Tons

Inventory					
Operating					

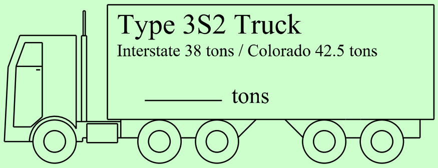
Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					



Type 3 Truck

Interstate 24 tons / Colorado 27 tons

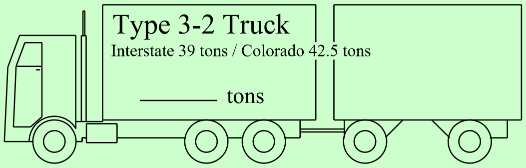
_______ tons



Type 3S2 Truck

Interstate 38 tons / Colorado 42.5 tons

_______ tons



Type 3-2 Truck

Interstate 39 tons / Colorado 42.5 tons

_______ tons

Comments:

PE Seal

Rated by: (Print name and sign)

Date:

Checked by: (Print name and sign)

Date:

COLORADO DEPARTMENT OF TRANSPORTATION

LOAD & RESISTANCE FACTOR RATING SUMMARY

Structure #

State Highway #

Batch I.D.

Structure Type

Parallel Structure #

Rated using:

Asphalt thickness: ______ in.

☐ Colorado legal loads

☐ Interstate legal loads

☐ Multi-lane for Legal & Permit Vehicles

☐ Single lane for Legal & Permit Vehicles

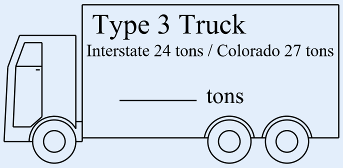
Structural Member					

Rating Factor

Inventory					
Operating					

Tons

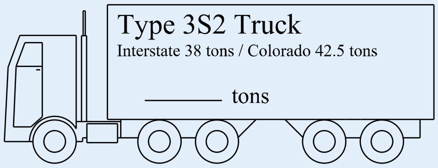
Type 3 truck					
Type 3S2 truck					
Type 3-2 truck					
Type SU4 truck (27T)					
Type SU5 truck (31T)					
Type SU6 truck (35T)					
Type SU7 truck (39T)					
NRL (40T)					
Lane-Type Legal					
EV2 (28.75T)					
EV3 (43T)					
Permit Truck (96T)					
Modified Tandem (50T)					



Type 3 Truck

Interstate 24 tons / Colorado 27 tons

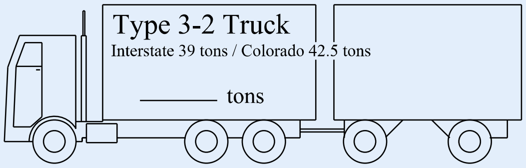
_______ tons



Type 3S2 Truck

Interstate 38 tons / Colorado 42.5 tons

_______ tons



Type 3-2 Truck

Interstate 39 tons / Colorado 42.5 tons

_______ tons

Comments:

PE Seal

Rated by: (Print name and sign)	Date:	Checked by: (Print name and sign)	Date:

APPENDIX – B

Appendix – B has a Rating QAQC Checklist

CDOT Staff Bridge – (QAQC_Checklist 2021 10.pdf)

APPENDIX B: RATING OR RE-RATING QA/QC CHECKLIST

(to be filled by Rater with concurrence from Checker who will also initial and sign on check Item 14)

☐ 1. Structure Number ________________
Verify plans available: ☑ Yes ☐ No
If no plans: ☐ Rating based on Physical inspection
☐ Rating based on non-destructive test loading

☐ 2. Verify overlay thickness and/or fill depth

☐ 3. Verify, if applicable, previously calculated loads and pertinent information

☐ 4. Verify LLDF's (live load distribution factors)
Include ☐ Hand calc. ☐ BrR calc. ☐ CANDE calc. or ☐ Other software calc.

☐ 5. The "Description" area of the Bridge ID window in BrR shall have the following information: Provide reason(s) for rating/re-rating, company name, rater initials, checker initials and date.

☐ 6. Verify that "Traffic" area of the Bridge ID window in BrR is filled

☐ 7. Verify that "Global Reference Point" area of the Bridge ID window in BrR is filled

☑ 8. System analysis or ☐ Line analysis used in BrR
If Line analysis used, explain here: ____
____

☐ 9. Completed steps required per Fig. 1-9 of CDOT Bridge Rating Manual

☐ 10. Completed steps required per Section 1.13 of CDOT Bridge Rating Manual

☐ 11. Reported the rating results per Section 1.14 of CDOT Bridge Rating Manual, including posting requirements (per Section 1.15) and color code requirements (per Section 1.16)

☐ 12. Completed Rating Summary Sheet (RSS) per section 1.14 of CDOT Bridge Rating Manual

☐ 13. Verify that the load rating results are initialed and dated by both the rater and checker

☐ 14. Initial and date this checklist
Rater initials and date ____________________
Checker initials and date ____________________

☐ 15. Send rating package in electronic format to CDOT Bridge contact / Rating Unit