COLORADO
Department of Transportation

CONSTRUCTABILITY REVIEW GUIDELINES

February 2020

1.0 INTRODUCTION

This document provides guidelines for the implementation of the Colorado Department of Transportation (CDOT) Constructability Review Process (CRP). The important principle associated with these guidelines is that the CRP is not a stand-alone procedure but an integral element within the CDOT statewide Project Development Process. These guidelines were created to outline the Constructability Review Process, and to describe and facilitate its integration and coordination with all of the various elements included in the Project Development Process.

The Constructability Review Process (CRP) was developed through a Task Force and in coordination with CDOT staff and management personnel with assistance of the Colorado Contractors Association (CCA).

1.1 Purpose

The purpose of a Constructability Review is to determine if the project can be constructed as designed with the information provided on the drawings and in the specifications and copied notes. The review may produce a better, quicker, more economical or safer way to construct the project. The emphasis is on "HOW" to construct the project.

In order to facilitate the overarching goal of "on time and on budget", roadway design must consider constructability during design and contract document development. The focus of a constructability review is on quantities/estimate, suggested plan changes, specifications and special provisions.

1.2 Motivation for Implementing the CRP

CDOT and most other transportation agencies in the U.S. are continually facing increasing technical complexities, increasing regulatory restrictions, and tremendous internal and external pressures to deliver quality products on time, within budget, and with unchanged scopes. These pressures tend to create a schedule-driven environment during project development, especially during the Plans, Specifications, and Estimate (PS&E) development phase, which leads to errors, omissions, and constructability problems. The Department has

become increasingly concerned about the constructability and quality of design plans for its major roadway construction projects. Furthermore, CDOT, like many public agencies, periodically has large turnovers of experienced staff that leads to a depletion of valuable construction knowledge. Each of these issues results in or exacerbates problems related to constructability.

Constructability and quality of design plans have been identified as significant national issues in need of being addressed and improved upon. The construction industry, as a whole, has expressed concern about the increasing number of projects proposed for construction that appear to be marginally biddable. Several construction industry publications have reported increases in the number of contract change orders, contracts being settled through litigation, and construction contracts that exceed the original bid (ASCE 1991). While there is much speculation about the root causes of constructability problems and the diminishing quality of design plans, it has been shown that constructability reviews applied throughout the project development process have provided cost and time savings (Construction Industry Institute 1991). Constructability improvements have been identified as an integral step in achieving quality projects.

For CDOT, the aforementioned pressures and associated problems have resulted in an increasing number of revisions, change orders (CMOs), and final contract costs on projects in the past few years. Most of the circumstances leading to the revisions and CMOs involve errors in the design documents that were not corrected prior to contract advertisement and award. It appears that errors not corrected prior to advertisement are directly attributed to the schedule-driven environment. The primary motivation of implementing the CRP is to meet CDOT's goal of delivering high quality projects while maintaining project scope, schedule, and budget. Attaining these goals will result in a reduction of the number of project revisions, CMOs, and final contract cost. The attainment of these goals can be reached by placing an emphasis on construction and maintenance knowledge during the review process.

Reduction of final contract costs is facilitated by an early determination of the actual cost of construction. Variability in the cost of construction is reduced as the design progresses and more detailed project information becomes available or is developed. The new Project

Development Process involves performing more engineering effort earlier in the project timeline. By performing some engineering during the planning stages, more information will be available earlier, thus reducing the variability in the process. The CRP, which involves performing constructability reviews during the design stage, provides one means of developing project information earlier in the project timeline.

The optimal level of engineering and design effort is based on a tradeoff between competing cost factors. Errors in the contract documents incur costs directly in dollars and indirectly in construction delays and construction administration. Other issues, such as loss of political and customer credibility with the Transportation Commission and the State Legislature, also arise. On the other hand, early detection and correction of errors add cost for additional time spent to conduct in-depth reviews and eliminate errors. The cost of construction related to design errors tend to be greater than costs of additional design effort to minimize errors. It is unrealistic to expect a contract to proceed with no errors or changes at all. However, the minimum cost cannot be achieved without minimizing errors and omissions.

1.3 Constructability Defined

The Constructability Review Process is a systematic process that provides a framework for improving the constructability of transportation construction projects. The definition of constructability adopted for this process is as follows:

> Constructability is the property of a project where construction and maintenance knowledge is applied during the design process, and where errors and omissions in the contract plans and special provisions have been minimized to enable the contractor to construct a high quality project that is biddable, buildable, and maintainable.

An evaluation of the level of constructability of a project is performed through constructability reviews. Constructability reviews are defined as follows:

A constructability review is a systematic process to ensure that the project possesses the foregoing attributes of constructability. The process starts at the inception of the project and continues throughout its duration. Various constructability reviews are incorporated into the planning and development stages of a project. The combination of the various reviews comprises the Constructability Review Process.

The definition of constructability embodies the primary goals for the success of a project.

1.4 Relationship of the CRP to the Project Development Process

CDOT's Project Development Process (PDP) is a comprehensive set of procedures involving project management, planning, and design. These procedures incorporate and integrate all elements of CDOT's planning, design, and contract development for transportation projects. The Constructability Review Process (CRP) is but one element that has been integrated into the Project Development Process.

The PDP incorporates several phases. The first phase encompasses the initial planning and engineering efforts for the project: Scoping. Several levels of effort occur within the Scoping phase. Planning, preliminary engineering stage, and environmental studies are some of the efforts included in this stage.

The second phase of the Project Development Process is the development of the plans, specifications, and estimate (PS&E). The PS&E phase utilizes the information developed in the initial phase and concludes with a complete set of project documents ready for advertisement. The second phase incorporates two primary stages of effort: FIR (Field Inspection Review) and FOR (Final Office Review). The FIR stage involves advancement of the project's critical design features and major enhancement of the project documents. The final stage, FOR, encompasses the development of specific project details and final completion of the plans.

The constructability reviews are typically performed at the FOR level, incorporating both construction and maintenance knowledge, which can then be used to guide the design of the

project. In addition, the review should reflect back on previous design decisions and determine whether the project is still on track.

1.5 Expected Benefits from the CRP

As pointed out earlier, there has been an increase in the number of change orders (CMOs) leading to an increase in the final contract costs on CDOT projects during the past few years. A large proportion of the CMOs appear to involve plan errors that were not corrected prior to contract award. Minimizing errors, omissions, and other constructability issues during the pre-construction phase of project development should reduce the amount of increase in the final cost of construction in comparison to the original contract bid amount. There should also be an appreciable reduction of CDOT construction work force working full time processing change orders, thereby reducing the final costs of construction engineering.

Significant improvements should be realized from the implementation of the CRP. Implementation of a structured review process that is initiated at the beginning of a project and that provides on-going monitoring of constructability issues should lead to better quality design plans and specifications. This in turn leads to fewer scheduling delays, fewer cost overruns, a better ability to avoid costly conflicts and contract claims, and assurance of a higher quality final product.

2.0 OVERVIEW OF THE CRP

The Constructability Review Process is designed to help improve the level of constructability of a project. The most important benefits expected from the CRP are the achievement of an efficient project development process and the realization of a cost-effective project that is biddable, buildable, and maintainable. To achieve these goals, the CRP is composed of a number of constructability reviews performed at various stages during the course of the project development process.

Each review consists of the formation of a review team, completion of relevant checklists, interoffice coordination, and participation in a review meeting. The review team should

emphasize construction and maintenance knowledge that can be used to guide the design of the project.

The first review occurs during project planning and Scoping. Subsequent reviews occur at the 30 percent (FIR) and 90 percent (FOR). Each review is directed at addressing constructability issues pertinent to a particular stage in the Project Development Process. The reviews are performed by a review team comprised of the disciplines and functions involved in planning, designing, constructing, and maintaining the project.

2.1 General Description of the CRP

The Constructability Review Process is initiated and managed by the project manager in charge of designing the project. The project manager establishes the actual review points in the project development phase, and the dates and locations for the review. If the project is being designed by a consultant, the project manager would coordinate the review with the consultant. Contractors as well as construction and Maintenance staff are recognized as being key to the success of the CRP process. Thus, their involvement is necessary to the review process.

The success of the CRP process involves the project manager ensuring that all documentation related to the project that might be needed for reference during the meeting is available. Prior to the review meeting, the project manager develops a meeting agenda.

The project manager conducts the meeting in accordance with the agenda, allowing adequate time for questions, explanations, and discussions regarding any pertinent items or issues that could impact schedules, costs, scope, biddability, buildability, and maintainability. The project manager should introduce the project and provide a brief summary of the project regarding scope, schedule, and cost. The project manager should also designate one person to record all comments made at the meeting for later evaluation. It is critical that the meeting be controlled for timing, completeness, and resolution of any issue raised or problem identified.

It is crucial that all comments, suggestions and discussions at the review meeting are recorded to provide a complete and accurate record of the meeting. All decisions, agreements, directions, and scheduling are documented. It is beneficial to write every issue and corresponding action on a display board so that decisions are unambiguous. Individuals should be made clearly responsible for each required action and for addressing any unresolved issues. Meeting minutes are developed by a designated person outlining the results of the meeting and documenting the directions discussed and agreed to for the next phase of project development. A copy of the report is circulated to all meeting participants for their records and a copy is retained in the design files.

The review meeting is an appropriate forum to discuss unique technical and programmatic solutions or engineered approaches to designing a project element. From this forum and ensuing discussions and analysis, new and creative ideas may surface that improve upon biddability, buildability, and/or maintainability.

2.2 Selecting the CRP Review Sequence

2.2.1 CRP Review Level

While constructability reviews are effective over a broad range of project types and provide the benefit of allowing multiple functions to view the overall project as it develops, the effort and cost of conducting reviews and documenting their results are significant. Therefore, the decision regarding the CRP is a trade-off between the expected benefits and the expected cost of these reviews. As a result, determining the appropriateness of a review for a project should be keyed to the type, size, and complexity of the project, and the timeline of the program. Table 1 provides direction on the appropriate type of project recommended for review. Essentially, as the level of complexity of the project increases, so does the likelihood that a CRP will be helpful. Similarly, for smaller or less complex projects, a CRP review is not necessary.

Type of Project	CRP Review
• Major roadway / facility improvements • Major, complex interchanges • Major structures with complex or very high cost features • Major preservation projects that include widening, replacement of existing structures / drainage features, etc.	Recommended
• All other roadway / facility improvements • Major, less complex, structures and interchanges • Preservation projects that involve widening, structure rehabilitation, new R/W, or safety improvements, including roadside features	Optional
• All other projects	Not recommended

Table 1. CRP Review Level by Project Type

2.3 Constructability Reviews

2.3.1 General Description of the Reviews

Performing constructability reviews at various key points during project development is extremely beneficial to the outcome of the project. Constructability reviews provide the teamwork forum necessary when multiple disciplines, functions, and special expertise are involved. Therefore, participation must include the Design project engineer, Construction project engineer, Maintenance, contractors and key support staff. Contractors, construction inspectors and maintenance staffs are recognized as having special constructability knowledge. Constructability reviews have been found to be effective on all types of projects, but are very important and effective on large and complex projects. Reviews are also critical when complex structures are being designed, when traffic control is a major construction item, when complex or difficult drainage features may be encountered, and with any required design elements that are new or seldom used and/or where constructability problems arise and can be best resolved in a team environment.

The purpose of these reviews is to raise issues, resolve problems, recommend modifications, suggest any actions required, and provide direction and guidance for the next stages of design. The primary objective of the review is to ensure that design concepts and considerations are complete, constructible and buildable and that other design and construction alternatives and concepts which haven't been considered are brought to the forefront and that further design can proceed with development toward PS&E completion.

Each decision developed during the reviews should be endorsed by the project manager before going any further with the PS&E development. Agreements should be reached and firm commitment to schedules and actions should be given. Any modified design directions or guidance should be provided that is needed to complete the next phase of the project development process.

2.4 Follow-Up and Reporting

Follow-up and reporting efforts begin with recording the decisions made and actions taken during each review. A review report is created which is an accurate record of the review and includes the topics of discussion and resolution of issues. In addition, the record should document issues that were not resolved, who was assigned the responsibility of resolving the issue, and when the resolution will occur. This allows for the tracking and monitoring of schedules, progress, and documents produced between reviews. In addition, the follow up and reporting allows the checklists to be updated, and enables the design project manager to evaluate what worked and what did not work for the review.

Following completion, a constructability review meeting report should be circulated to the CRP team members. Items of concern should be decided by the appropriate design team member, Resident Engineer or Program Engineer.

3.0 CONDUCTING THE CRP REVIEW

3.1 Organizing the CDOT Review Team

The task of organizing the review team can be just as critical as conducting the constructability reviews. This effort is a major internal partnering opportunity and is a crucial step towards attaining the CRP objectives.

One feature related to the review team is essential for successful implementation of the CRP: multi-disciplinary participation. Multi-disciplinary teamwork is needed from the beginning to the end of the project development process. Gathering all disciplines involved in a project provides the benefit of being able to immediately resolve all issues that may arise plus the long-term advantage of building a team comprised of many talents. "Team building" is a concept upon which successful constructability is dependent.

The creation of a multi-disciplinary team allows each discipline (or function) to be more knowledgeable about the other disciplines' involvement, provides for cross-training of the Department's staff, and facilitates formal communication needed throughout the process.

While team building benefits many aspects of the project, success through team building may require recognizing, addressing, and overcoming barriers. Crucial to the success of the team is the breaking of business, cultural, traditional, and internal functional barriers. Breaking barriers can be done in various ways.

The constructability review team should be made up of a mix of reviewers and managers most familiar with the project, along with others who can provide objectivity and independent thought. All team members should have the authority to make on-site decisions regarding issues that may arise during the review meeting. In addition, the team members must be able to contribute to the decision making/information gathering process. Thus, the meeting attendees must come to the meeting prepared and willing to participate. Each team member should be able to commit, if necessary, a full day for performing each review meeting. The review team must include construction project engineers and inspection staff, as well as Maintenance and Maintenance personnel.

The review team membership will depend on the type, size, and complexity of the project. For projects that are large in size and contain numerous, complex issues of design and construction, team membership should include most, if not all, of the Departmental project development disciplines. On the other hand, a selected number of disciplines might only be appropriate for smaller, less complex projects. The review team should include, at the minimum, personnel from the following disciplines: Design, Construction, Maintenance, Environmental, Traffic, Right of Way, and Bridge/Structures (whenever bridges or structures are included in the project). Personnel from the following disciplines should be included as needed depending on the type, size, and complexity of the project: Materials, Geotechnical, Hydraulics, Permits, and any other discipline or function pertinent to providing a complete review of issues that need to be addressed to develop the PS&E. If a consultant is designing a portion of the project they should also be included as a team member.

In order to achieve a high level of constructability on a project, consistent teamwork is especially needed between the Construction and Design disciplines. Exceptional coordination and communication of these disciplines greatly adds to the success of a project

3.2 Organizing the Contractor Review Team

One of the most important aspects of the CRP is the opportunity to allow Contractor's to participate in the review process. Contractors are experts in the field of construction – e.g. constructability, buildability and biddability – and are an invaluable resource to the CDOT team. They often bring a viewpoint to the process that no one in CDOT can replicate because contractors are looking at it from the perspective of someone who will not only have to bid the project but also will have to build it as well. CDOT simply cannot replicate that assessment on a project.

As the meeting is being set-up, the design project manager should contact the Colorado Contractor's Association representative and provide him the basic information about the meeting (i.e. date, time, location and specific project) and also approximately how many

contractors representatives can be accommodated at the meeting. If there is no limit to the number of contractors, this can be communicated as well.

Comments from contractors should be considered just as important as comments from CDOT staff because – as stated earlier – they have a unique perspective that should be seriously considered in the design process.

3.3 Project Documentation

Project documentation is an integral part of the project development process and oftentimes serves as important reference for the CRP Team. Documents necessary for the majority of projects should include; planning documents (STIP, EIS and other environmental studies, corridor studies, etc.), TSM&O reports, project plans and specifications, and project meeting minutes. The purpose of these documents is to provide a basis for which to communicate the design intent, and to record decisions made during each phase of development. The documents are the basis for addressing constructability issues at each stage. The project manager is responsible for retaining and developing a current set of project documents.

3.4 Preparing for CRP Review Meetings

3.4.1 Objective of the Review Meeting

Meetings are only necessary and effective when there is a verifiable need. To that end, the constructability review meetings should only be held when the appropriate documentation is complete and the team members are available to meet. In order to be effective, it is crucial that all attendees understand the purpose and objective of the meeting and be willing to participate. The objective of the CRP reviews is to verify that a project is biddable, buildable, and maintainable.

3.4.2 Organizing the Meeting

Procedures for organizing the constructability review meeting should include:

- Establish the actual point in the project development phase at which the constructability review meeting will be held.

- Set a date and location for the meeting that is mutually convenient to all parties.

- Develop an agenda for each segment of the meeting. Include in the agenda the major functions involved in the project. Also allocate time for each item of discussion. Time should also be allocated to determine whether the project is on track regarding scope, schedule, and cost.

- Accumulate, organize, and make available to each review participants, all pertinent documentation related to the project that might be needed for reference during completion of the constructability checklist and the review meeting. This information should be made available far enough in advance that the attendees can review the documents in preparation for the meeting.

- Ensure that all disciplines scheduled to be involved in the meeting have reviewed the applicable documents and plans, reviewed the proposed agenda, and completed the applicable checklist before the scheduled meeting date.

Each meeting should be conducted in accordance with the agenda, and the meeting minutes recorded. A photo log, through the use of still photographs and/or videotape, of the project site should be available at the meeting for use in specific points of discussion. The meeting record should indicate all decisions and agreements, along with all directions and scheduling impacts identified during the meeting.

3.4.3 Creating a Meeting Agenda

Meetings are generally most effective when an agenda has been prepared and sent to the invited participants prior to the meeting. The agenda should have specific items of discussion and time allocations. The project manager should allow a reasonable amount of time for discussion and any problem solving that may be necessary. In addition, the agenda should

be arranged in such a manner that the most serious items of discussion do not use up the meeting time or the meeting time runs out before the serious issues are thoroughly discussed.

The design project manager is responsible for creating and circulating a meeting agenda in a timely manner prior to the review meeting. In addition, the appropriate CRP checklist and review documents should be provided with the agenda, to the relevant functions to allow sufficient time to prepare for the meeting. The project manager is also responsible for managing the meeting, including: ensuring the meeting starts and ends on time, strictly adhering to the agenda, and monitoring the time allocated for items of discussion. Frequent references to the agenda, during the meeting, should aid in keeping the meeting on track.

The agenda should include specific items of concern to the design office, and allotted time for discussion and resolution of issues. In addition, time should be used to determine whether the project is on track with respect to scope, schedule, and cost. The agenda should also incorporate items of concern identified by the appropriate checklist. A title, meeting date, starting and ending times, and location should also be shown on the agenda. These items give the attendees a sense of purpose and the ability to plan other activities on the meeting date. A sample agenda is show below.

SAMPLE AGENDA

No.	Item	Speaker	Allotted Time
1.	Project Overview		9:00 - 9:15
2.	Roadway Sections		9:15 - 9:30
3.	Geometrics		9:30 - 9:45
4.	Earthwork, Geotechnical/Soils Report, Foundation Survey		9:45-10:15
5.	Retaining Walls/Noise Walls		10:15 - 11:45
	LUNCH		11:45 - 12:30
6.	Shoring		12:30 - 12:45
7.	Drainage		12:45 - 1:15
8.	Bridges		1:15 - 1:45
9.	Utilities Involvement		1:45 - 2:00
10.	Agreements		2:00 - 2:15
11.	Coordination with Other Agencies		2:15 - 2:30
12.	Construction Schedule/Phasing		2:30 - 2:45
13.	Special Traffic Control Plans Project		2:45 - 3:00
14.	Environmental		3:00 - 3:15
15.	Erosion Control/Storm Water Site Plans		3:15 - 3:45
16.	Maintenance Issues		3:45 - 4:00
17.	Right of Way		4:00 - 4:15
18.	Signing		4:15 - 4:30

Project Name

October 30, 2018 Location
ADDITIONAL INFORMATION

DESIGN ISSUE 1			
Topic:	Noise Wall		
Comment:	Interchange has been redesigned and the noise wall appears either unnecessary or incorrectly located.		
Conclusions:	The wall will be reassessed for need and correct placement.		
	Action Items:	**Responsible Person:**	**Deadline:**
	Provide data to environmental section to re-evaluate for need and location	Tim Smith	16-Nov-19

DESIGN ISSUE 2			
Topic:	Access to noise walls and detention ponds appear to be inadequate		
Comment:	The noise walls need to be placed at the ROW lone or additional room provided. Detention ponds need to be modified to include access roads.		
Conclusions:	Designer to add access road around detention ponds.		
Action Items:		**Responsible Person:**	**Deadline:**
Add access to ponds and walls		Kirk Wilcox	16-Nov-19

DESIGN ISSUE 3			
Topic:	Night work and weekend work may be precluded in this area due to residential zoning, concern with staging of construction activities due to heavy traffic volumes during the day.		
Comment:	The local agencies may have weekend and night restrictions on construction activities due to noise. Holiday weekends may also be restricted due to tourist traffic.		
Conclusions:	The designer will need to discuss with Traffic and the local agencies to address noise during construction activities and relevant weekend and night restrictions.		
Action Items:		**Responsible Person:**	**Deadline:**
Determine local noise & holiday restrictions		Kirk Wilcox	16-Nov-19