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**Final Report**

## **SHRP CHIP SEAL**

**William (Skip) Outcalt**



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**RESEARCH BRANCH**

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# **SHRP CHIP SEAL**

by

William (Skip) Outcalt, E/PS Tech II

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Research Branch

4201 E. Arkansas Avenue

Denver, CO 80222

303-757-9506

## **EXECUTIVE SUMMARY**

The original study was a two year evaluation conducted during 1997 and 1998 by Dr. Michael S. Mamlouk, Ph.D., P.E., of Arizona State University. The final report Pavement Maintenance Effectiveness Preventive Maintenance Treatments was published in December of 1998. This report is a follow-up to that study.

The Colorado test site consisted of three 250 m long test sections and one untreated 250 m long control section. There was no transition between sections – one started where the previous one stopped. The sections, which were in the westbound lane only, were:

Section I - Light weight chips made of expanded shale having a unit weight 60% of the standard chips. HFRS-2P emulsion applied at 0.35 gal/yd<sup>2</sup>. Chips applied at the rate of 12 lbs/yd<sup>2</sup>.

Section II - Standard chips - CDOT standard weight chips. HFRS-2P emulsion applied at 0.35 gal/yd<sup>2</sup> chips applied at the rate of 25 lbs/yd<sup>2</sup>.

Section III - Standard chips with HFRS-2P emulsion applied at 0.35 gal/yd<sup>2</sup> chips applied at the rate of 25 lbs/yd<sup>2</sup>. with a fog seal of HFRS-2P emulsion diluted 1:1 and applied at 0.05 gal/yd<sup>2</sup>

Section IV - Untreated control section

The sites were evaluated visually and through the use of skid testing, FWD, and profilograph equipment.

The site was evaluated for Dr. Mamlouk's study at about 6 months, one year, and two years after applying the treatments. The following observations can be obtained from this case study:

- The control section had the largest amount of transverse and longitudinal cracks. Most of the original cracks in treated sections have been reflected. The cracks in section 3 (chip seal plus fog) were tighter than those detected in other sections.
- All sections were structurally sound after 6 months of service, as indicated by the FWD deflections. Section 1 (light-weight chips) and section 3 (chip seal plus fog) exhibited the lowest deflections.
- The Ames profilograph readings show that the control section had the largest roughness as compared to treated sections. The roughness levels of treated sections were close to each other.

- The K.J. Law skid trailer readings indicate that the skid numbers of all sections were high. Section 1 (light-weight chips) had the highest skid number.
- There was no measurable rutting in all sections.

### **Implementation Statement**

Based on observations of this site over a four-year period:

- Both lightweight and standard chip seals extend the life of the pavement by postponing environmentally induced cracking.
- The advantages in the use of lightweight chips would be reduced windshield damage compared with standard chips, and lower haul costs because they weigh less than 50% of standard chip weight.
- There is no apparent long term advantage to applying a fog coat over a standard chip seal.
- The K.J. Law skid trailer readings for all sections were high (from 55.9 to 62.5).
- There was no measurable rutting in all sections.
- In general, the treated sections were in better condition than the untreated section at the time of the final evaluation in August of 2001. There is very little chip loss in any of the three test sections, except for some small areas in the standard chip section, where a piece of farm equipment was apparently dragged on the surface for a short distance.

There is no bleeding or rutting. In the summer, many cracks, in all three of the test sections, partially reseal due to traffic action . No information was available regarding windshield damage by loose chips for both light-weight and normal-weight chip seals.

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## BACKGROUND

In 1997, on SH 94 near MP 72, east of Punkin Center, a test site was established to evaluate different methods of chip sealing. The original study was a two year evaluation conducted by Dr. Michael S. Mamlouk, Ph.D., P. E., of Arizona State University. This report is a follow-up to that study. The site consisted of three test sections and an untreated control section. The test sections, which were in the westbound lane only, were:

- ❑ Section I - Light weight chips made of expanded shale having a unit weight 60% of the standard chips. HFRS-2P emulsion applied at 0.35 gal/yd<sup>2</sup>. Chips applied at the rate of 12 lbs/yd<sup>2</sup>.
- ❑ Section II - Standard chips - CDOT standard weight chips. HFRS-2P emulsion applied at 0.35 gal/yd<sup>2</sup> chips applied at the rate of 25 lbs/yd<sup>2</sup>.
- ❑ Section III - Standard chips with HFRS-2P emulsion applied at 0.35 gal/yd<sup>2</sup> chips applied at the rate of 25 lbs/yd<sup>2</sup>. with a fog seal of HFRS-2P emulsion diluted 1:1 and applied at 0.05 gal/yd<sup>2</sup>
- ❑ Section IV - Untreated control section

Each section was 250 m long. There was no transition between sections – one started where the previous one stopped.

The chip seals were applied during August of 1997. Subsequent evaluations were made in March of 1998, June of 1998, and the final evaluation in August of 2001. The study was originally planned as a two year evaluation by Arizona State University under contract with the FHWA. CDOT Research decided to monitor the site for a longer period if the chip seal continued to perform satisfactorily. At the final evaluation in August of 2001, the fog seal could not be seen. All three chip seal sections were in good condition with block cracking just beginning near the west end of the standard and fog seal sections along a longitudinal crack at the skip stripe. There was more severe block cracking in the control section. All of the block cracking was near the center line of the pavement and associated with a longitudinal crack that appeared to be a construction joint.

## CONSTRUCTION

A pre-construction evaluation was done in May of 1997. The evaluation consisted of:

- ❑ Locating a suitable section of highway with sound pavement and good site distance so future evaluations could be done with as little interference as possible with traffic.
- ❑ The four sections were measured out and marked.
- ❑ Crack maps were drawn to show the locations of the cracks in the pavement.

The pavement was slightly weathered with no measurable ruts. The only defects in the surface of the pavement were transverse and a limited amount of longitudinal cracks between 1/8" and 1/4" wide; there were no patches or filled areas. Before the chip seals were placed, all cracks were sealed, with a rubberized sealant with a 2" – 3" wide over-band on the surface of the pavement. When the chip seals were placed between the center line and the shoulder stripe, the locations of the sealed cracks could still be seen on the shoulder which did not receive the chip seal (Figures 1 and 2). New cracks that developed after the sealing operations were easily identifiable because there were no seals on the shoulder.

Before the sealing started in Section I, research personnel checked the calibration of the chip spreader as follows: The operators ran the chip spreader for a short distance on dry pavement (no oil) to visually check for even chip distribution across the lane. After the visual check, the rate of application was set on the spreader and 3' x 3' squares of roofing felt were laid on the pavement, one in the center and one near each side of the lane, and the machine run over them dropping chips. The researchers carefully picked up the squares and collected the aggregate and weighed it to determine the actual rate of application that was being used. This calibration and measurement process was repeated for the standard chips, after the lightweight section was laid. The light weight chips weighed 11.6 lb. per square yard. The SHRP chips averaged about 24 lb. per square yard.

Sections II & III were laid with standard chips. Calibration of the spreader was checked again and was found to vary across the spreader. It was 24.0 lbs./ yd<sup>2</sup> on the left side of the spreader,

27.8 lbs./ yd<sup>2</sup> in the center, and 22.2 lbs./ yd<sup>2</sup> at the right side. Close inspection of the spreader found inconsistent gaps in the gates and possibly a bent roller. Because repairing the spreader would have meant a considerable loss of time, it was decided to go ahead with the project. The high moisture content of the standard chips may have aggravated the problem also. The emulsion distributor truck was set for a rate of .35 gal/ yd<sup>2</sup> for Sections II and III. Section II was 250 meters of standard chips, and Section III was 250 meters of standard chips with a fog seal applied over the top. The fog seal was applied using the same emulsion (HFRS-2P) that was used for the chip seal. It was diluted 50% with water and applied at a rate of .05 gal/ yd<sup>2</sup>. The fog seal was applied later in the week.

Two sample bags of each type of chips were taken to the lab for gradation, specific gravity, and LA abrasion tests. A small sample of the SHRP chips was submitted to be tested for moisture content.

Section IV was the control section. It received no treatment during the evaluation period. The control section was 250 meters long like the test sections.

## **EVALUATION**

Before construction, the condition of the pavement at the site was visually evaluated and crack maps were made for each section showing the length and location of all visible cracks. The cracks were sealed with a rubberized sealer using an over-band method before the chip seals were applied. Since the chip seal was applied only in the lane, on the shoulder it was easy to see where the cracks had been sealed before the chip seal was applied. During post-construction evaluations those cracks that had not opened through the chip seal were not listed on the crack maps. However, if a crack had opened through the chip seal it was listed on the map at the date of the evaluation. At the time of the June '98 visit, portions of cracks that were seen and recorded during the March '98 visit had closed, probably due to the action of traffic during hot weather (the closed areas were mostly in the wheel paths). Table 1 shows the total amount of cracks measured during each visit. By the final evaluation in August of 2001, the control section had

developed some block cracking along the longitudinal cracks near the centerline. No additional crack sealing had been done in the control section since the chip seal was applied.

**Table 1. Cracking totals in each section.**

	Longitudinal by Section				Transverse by Section				Block by Section			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
5/20/97	8	2.5	12	15	96	96.5	92.5	92				
3/12/98	10	0	12	39	94	81.5	90	100				
6/1/98	10	0	12	37	94	81.5	67	95.5				
8/20/01	45.5	52	76.5	66	112	118	103.5	138.5				18

Note: Cracks were measured in the westbound lane only, not on the shoulder outside the lane. Block cracking is in square meters.

Falling weight deflectometer readings were taken during the March '98 and August '01 visits. As Table 2 shows, the changes in average readings over three and a half years for each section, are very small. The lack of changes in the FWD data combined with the fact that only the

**Table 2. FWD data average deflection for sens or #1 by section.**

	I – Lightweight Chips	II – Standard Chips	III – Standard Chips –Fog Seal	I – Control
3/12/98	15.05	18.88	14.35	17.83
8/20/01	13.81	17.72	15.62	17.15

control section developed block cracking suggests that all three types of chip seals extended the life of the pavement. There was no evident difference in the performance of the different chip types. Both the light weight chips and the standard chips performed well with very little evidence of chip loss from the sealed sections. Additionally, there was no apparent difference between the standard chip section and the fog seal section. Neither lost chips or showed more cracking than the other.

## CONCLUSIONS

Based on observations of this site over a four-year period:

- ❑ Both lightweight and standard chip seals extend the life of the pavement by postponing environmentally induced cracking.
- ❑ The advantages in the use of lightweight chips would be reduced windshield damage compared with standard chips, and lower haul costs because they weigh less than 50% of standard chip weight.
- ❑ There is no apparent long term advantage to applying a fog coat over a standard chip seal.
- ❑ The K.J. Law skid trailer readings for all sections were high (from 55.9 to 62.5).
- ❑ There was no measurable rutting in all sections.
- ❑ In general, the treated sections were in better condition than the untreated section at the time of the final evaluation in August of 2001. There is very little chip loss in any of the three test sections, except for some small areas in the standard chip section, where a piece of farm equipment was apparently dragged on the surface for a short distance.

There is no bleeding or rutting. In the summer, many cracks, in all three of the test sections, partially reseal due to traffic action . No information was available regarding windshield damage by loose chips for both light-weight and normal-weight chip seals.



**Figure 1. Looking west from the fog sealed section into the control. The dark stripe next to the figure is a sealed crack. The dark patches in the left wheel path are water where the skid tester had just finished testing.**



**Figure 2. The fog seal section starts where the pavement is darker. The dark stripes on the shoulder are seals applied to transverse cracks before the chip seals were placed.**



**Figure 3. The light weight chip section at the east end of the site. The right lane is the light weight chip seal. The dark patch in the left wheel path is water left by the skid testing equipment.**



**Figure 4. The transition from light weight to standard weight chips. Light weight chips are the dark area on the left of the picture. To the right side and in the far lane are standard chips.**



**Figure 5. A handful of the light weight chips.**

**These are loose chips piled on the old pavement surface with a dime to show their size.**



**Figure 6. Block cracking is developing in the control section near the skip stripe.**

**The longitudinal crack just to the right of the yellow stripe appears to be the construction joint. The dark patch is old crack seal material.**