Effect of Fog Seal and Paint Stripe Removal on Chip Seal Behavior in Two Climates

Scott Shuler
Colorado State University
Fort Collins, Colorado

Chip seals are used extensively in the US for preventive maintenance. However, damage due to snow plows, wet and cold weather and extensive solar radiation contribute to poorer performance than at lower elevations. Therefore, an experimental program was begun to evaluate these and other factors affecting long term performance of chip seals. Fog seals are often placed on chip seals in the US immediately after chip sealing, but the benefits have not been well documented. Also, chip seals often do not adhere to reflective paint marking after sealing. This paper describes an experimental pavement constructed to evaluate the performance of a chip seal placed at the top of Poncha Pass, CO (elevation 9012 ft/2745 m) and also at the bottom of the pass (elevation 6825 ft/2081 m) to evaluate the benefits of fog sealing and removal of reflective paint markings prior to sealing.. Twenty test sections were constructed in all to evaluate the performance of the seals with and without fog sealing, with and without paint removal, with controls. Results indicate that fog sealing may be effective when placed after chip sealing and that reflective paint removal is the only effective method to assure against chip loss due to reflective paint.

Keywords: Chip seal, fog seal, epoxy striping paint, snow plow damage, preventive maintenance

INTRODUCTION

Chip seals are used throughout the US as preventive maintenance treatments (Abdullah 1994; Benson 1953; Gransberg 2005). Performance of these treatments varies but the average life expectancy is usually five to seven years (Chen 2003; Jackson 1990; Jahren 2004). This life expectancy is reduced in areas of the country where snow plows operate (Beck 2006). In addition, high mountain terrain often reduces this life expectancy further due to high solar radiation resulting in rapid oxidation and consequently embrittlement of the binders. Recently, an added distress in the form of chip loss over epoxy reflective paint marking has been observed on certain chip seal projects in Colorado USA (Shuler 2006). Therefore, an experiment was designed to better understand the effect of these factors on performance and to install test sections to help mitigate these distresses.

Applying a fog seal of CSS-1h or SS-1h emulsified asphalt diluted to 50 percent at the rate of 0.23 liters/square meter (0.05 gallons/square yard) is sometimes done immediately after chip sealing by some agencies as a means of getting additional binder onto the surface of the seal in an attempt to reduce chip loss. This somewhat controversial practice has not been documented as effective. However, some engineers believe in the practice and therefore, this experiment was designed to test the effectiveness of the fog seal application.

Recent observations of chip seal loss directly over epoxy paint stripes lead to inclusion of this variable in the experiment. Although not extensively researched, the author has observed chip loss directly over epoxy paint stripes. Apparently, after multiple layers of epoxy paint stripe have built up on an existing pavement the layers of paint become brittle and form a poor substrate for a chip seal. After sealing, the brittle paint cracks under the action of traffic causing the chip seal to debond from the underling pavement resulting in an area of chip loss and a place where further debonding becomes more likely.

EXPERIMENT DESIGN

This experiment had three objectives: 1) to evaluate the preservation benefit to an existing asphalt concrete pavement of applying a chip seal, 2) to evaluate the difference in performance of the chip seal for sections that had a fog seal applied and for sections that had epoxy paint stripes removed prior to sealing, and 3) to evaluate the difference in performance of the chip seal sections at two different elevations. The test sections evaluated are shown in Figure 1.

	Elevation	
Treatment	2081m (6825 ft) MSL	2745m (9012 ft) MSL
Nothing	x	x
Chip Seal-No Fog Seal	x	x
Chip Seal-Fog Seal	x	x
Chip Seal-Fog Seal/Stripe Removed	x	x

Figure 1. Experimental Test Sections Evaluated

PROJECT LOCATION

The test sections were constructed on US285 south of Poncha Springs, CO. Test sections were constructed 152 m (500 ft) in length in both directions according to the plan shown in Figure 2. One test section of each treatment was constructed with the exception of the chip seal/fog seal/no stripe removed combination which was duplicated.

CONDITION SURVEY

A condition survey was conducted of the test pavement prior to construction to evaluate the pre-treatment condition of the roadway. Performance of the test sections can then be compared with this pre-treatment condition to determine differences between treatment variables over time. The results of the preliminary condition survey are shown in Tables 1 and 2 for test sections A to E and F to K, respectively.

CONSTRUCTION

Construction of the chip seal test sections occurred from June 5 to June 9, 2006. Materials consisted of a polymer modified HFMS-2P (high float medium setting-2P) emulsion applied at an average rate of 1.43 liters/square meter (0.31 gallons/square yard) and aggregate chips applied at an average rate of 15.1 kg/square meter (28 pounds/square yard). Physical properties of these materials are shown in Tables 3 and 4. Initial material quantities were determined using the procedure outlined by the Asphalt Institute (1). Adjustment of the aggregate rate determined by this method was made in the field by lowering the aggregate quantity approximately 1.1 kg/square meter (2 pounds/square yard). This was done to achieve the desired single layer of stone application while providing enough aggregate so adhesion of the chips to roller tires did not occur.

Removal of the white epoxy paint stripe at the edge of the pavement and the yellow stripe in the center of the pavement was achieved using a conventional motor grader in test sections C and H prior to chip seal operations. The process is shown in Figure 3 and the result of the removal in Figure 4.

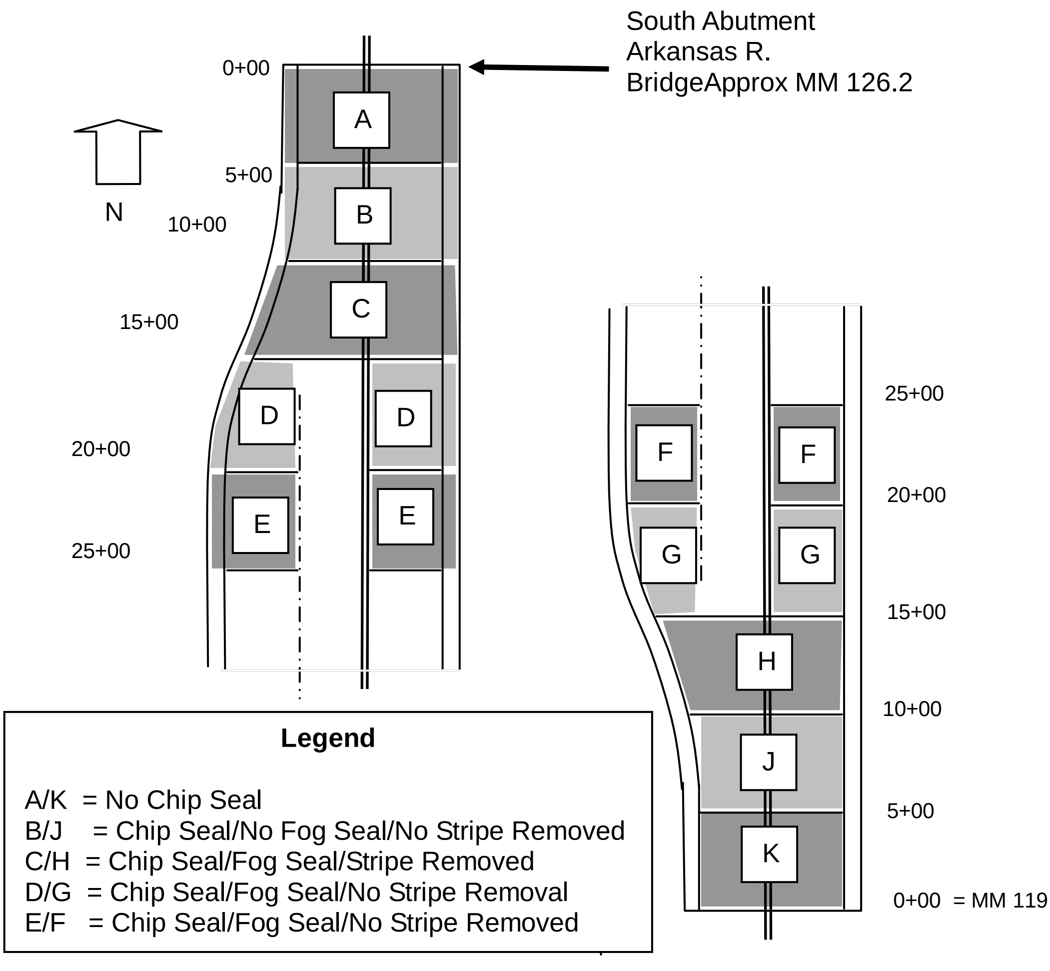

Figure 2. Test Section Locations

Table 1. Condition Survey Results- Sections A to E

Section	Stations		Direction	Distress					
				Long,		Transv ,		Allig,	
				(ft)	m	(ft)	m	(ft)	m
A	0+00	1+00	NB	70	21	3.5	1.05	0	0
			SB	70	21	0	0	0	0
	1+00	2+00	NB	62	18.6	9.5	2.85	0	0
			SB	62	18.6	3.5	1.05	0	0
	2+00	3+00	NB	21	6.3	0.5	0.15	0	0
			SB	21	6.3	4.5	1.35	0	0
	3+00	4+00	NB	39	11.7	5.5	1.65	0	0
			SB	39	11.7	7.5	2.25	0	0
	4+00	5+00	NB	73	21.9	4.5	1.35	0	0
			SB	75	22.5	6.5	1.95	0	0
B	5+00	6+00	NB	48	14.4	4.5	1.35	0	0
			SB	0	0	0	0	0	0
	6+00	7+00	NB	100	30	7	2.1	0	0
			SB	100	30	0	0	0	0
	7+00	8+00	NB	100	30	10	3	0	0
			SB	40	12	0	0	0	0
	8+00	9+00	NB	100	30	8	2.4	0	0
			SB	0	0	0	0	0	0
	9+00	10+00	NB	100	30	3	0.9	0	0
			SB	0	0	0	0	0	0
C	10+00	11+00	NB	100	30	11.5	3.45	0	0
			SB	6	1.8	0	0	0	0
	11+00	12+00	NB	79	23.7	11	3.3	0	0
			SB	6	1.8	0	0	0	0
	12+00	13+00	NB	98	29.4	9	2.7	0	0
			SB	7	2.1	0	0	0	0
	13+00	14+00	NB	95	28.5	9	2.7	0	0
			SB	0	0	0	0	0	0
	14+00	15+00	NB	100	30	9	2.7	0	0
			SB	50	15	0	0	0	0
D	15+00	16+00	NB	100	30	8	2.4	0	0
			SB	90	27	0	0	0	0
	16+00	17+00	NB	100	30	9	2.7	0	0
			SB	10	3	0	0	0	0
	17+00	18+00	NB	90	27	9	2.7	0	0
			SB	6	1.8	0	0	0	0
	18+00	19+00	NB	100	30	10	3	0	0
			SB	6	1.8	0	0	0	0
	19+00	20+00	NB	100	30	10.5	3.15	0	0
			SB	0	0	0	0	0	0
E	20+00	21+00	NB	100	30	10	3	0	0
			SB	0	0	0	0	0	0
	21+00	22+00	NB	94	28.2	9	2.7	0	0
			SB	0	0	0	0	0	0
	22+00	23+00	NB	100	30	11.5	3.45	0	0
			SB	0	0	0	0	0	0
	23+00	24+00	NB	100	30	7.5	2.25	0	0
			SB	10	3	0	0	0	0
	24+00	25+00	NB	100	30	9	2.7	0	0
			SB	0	0	0	0	0	0

Table 2. Condition Survey Results-Sections F to K

Section	Stations		Direction	Distress Long, (ft)	Long, m	Transv, (ft)	Transv, m	Allig, (ft)	Allig, m
K	0+00	1+00	NB	100	30	15	4.5	0	0
			SB	19	5.7	30	9	0	0
	1+00	2+00	NB	13	3.9	33	9.9	0	0
			SB	76	22.8	36	10.8	0	0
	2+00	3+00	NB	7	2.1	6	1.8	0	0
			SB	82	24.6	20	6	0	0
	3+00	4+00	NB	78	23.4	8	2.4	0	0
			SB	75	22.5	26	7.8	0	0
	4+00	5+00	NB	64	19.2	12	3.6	0	0
			SB	100	30	6	1.8	0	0
J	5+00	6+00	NB	100	30	0	0	0	0
			SB	100	30	41	12.3	0	0
	6+00	7+00	NB	94	28.2	0	0	0	0
			SB	28	8.4	28	8.4	0	0
	7+00	8+00	NB	100	30	0	0	0	0
			SB	38	11.4	36	10.8	0	0
	8+00	9+00	NB	100	30	4	1.2	0	0
			SB	85	25.5	23	6.9	0	0
	9+00	10+00	NB	83	24.9	3	0.9	0	0
			SB	100	30	2	0.6	0	0
H	10+00	11+00	NB	100	30	2	0.6	0	0
			SB	92	27.6	15	4.5	0	0
	11+00	12+00	NB	100	30	0	0	0	0
			SB	100	30	12	3.6	0	0
	12+00	13+00	NB	100	30	1	0.3	0	0
			SB	100	30	13	3.9	0	0
	13+00	14+00	NB	100	30	0	0	0	0
			SB	100	30	26	7.8	0	0
	14+00	15+00	NB	86	25.8	14	4.2	0	0
			SB	100	30	24	7.2	0	0
G	15+00	16+00	NB	100	30	0	0	0	0
			SB	100	30	12	3.6	0	0
	16+00	17+00	NB	100	30	0	0	0	0
			SB	66	19.8	11	3.3	0	0
	17+00	18+00	NB	83	24.9	0	0	0	0
			SB	100	30	3	0.9	0	0
	18+00	19+00	NB	100	30	3	0.9	0	0
			SB	90	27	7	2.1	0	0
	19+00	20+00	NB	100	30	0	0	0	0
			SB	100	30	4	1.2	0	0
F	20+00	21+00	NB	100	30	0	0	0	0
			SB	100	30	28	8.4	0	0
	21+00	22+00	NB	68	20.4	0	0	0	0
			SB	100	30	0	0	0	0
	22+00	23+00	NB	67	20.1	0	0	0	0
			SB	100	30	3	0.9	0	0
	23+00	24+00	NB	51	15.3	6	1.8	0	0
			SB	45	13.5	6	1.8	0	0
	24+00	25+00	NB	100	30	0	0	0	0
			SB	25	7.5	6	1.8	0	0

Figure 3. Stripe Removal Process

Figure 4. Stripe Removed

Excess chips were removed immediately following rolling operations using a very light push broom application. The estimated quantity of chips removed was from 5 to 10 percent.

Table 3. Emulsion Properties

Test Parameter	Result
Saybolt Viscosity @ 122F, sfs	86
Storage Stability, %	0.2
Sieve Test, %	0.01
Oil Distillate, %	0.3
Residue by Distillation, %	70
Penetration, dmm	72
Ductility @ 25C, cm	90
Solubility, %	100
Elastic Recovery, pull 20, hold, %	70
Float, s	1200

Table 4. Aggregate Properties

Sieve, mm	Passing, %
12.5	100
9.5	65
4.75	5
2.36	1
1.18	1
0.6	1
0.3	1
0.15	0
0.075	0

Los Angeles Abrasion Loss, %	26
Fine Aggregate Angularity, %	60
Sand Equivalent, %	85
Flat and Elongated, %	0

Additional Observations

Before a chip seal is constructed a series of elastomeric Raised Flexible Pavement Markers (RFPM) are placed over the epoxy paint stripes. Then, after the seal is placed and the epoxy paint is covered, the location of the stripe can be found for re-striping. It has been suggested (2) that since the RFPM prevents a small area of the pavement from being sealed as shown in Figure 5 that this ‘shadow’ with little binder and chips could also be a source of future distress due to moisture intrusion and/or snow plow damage.

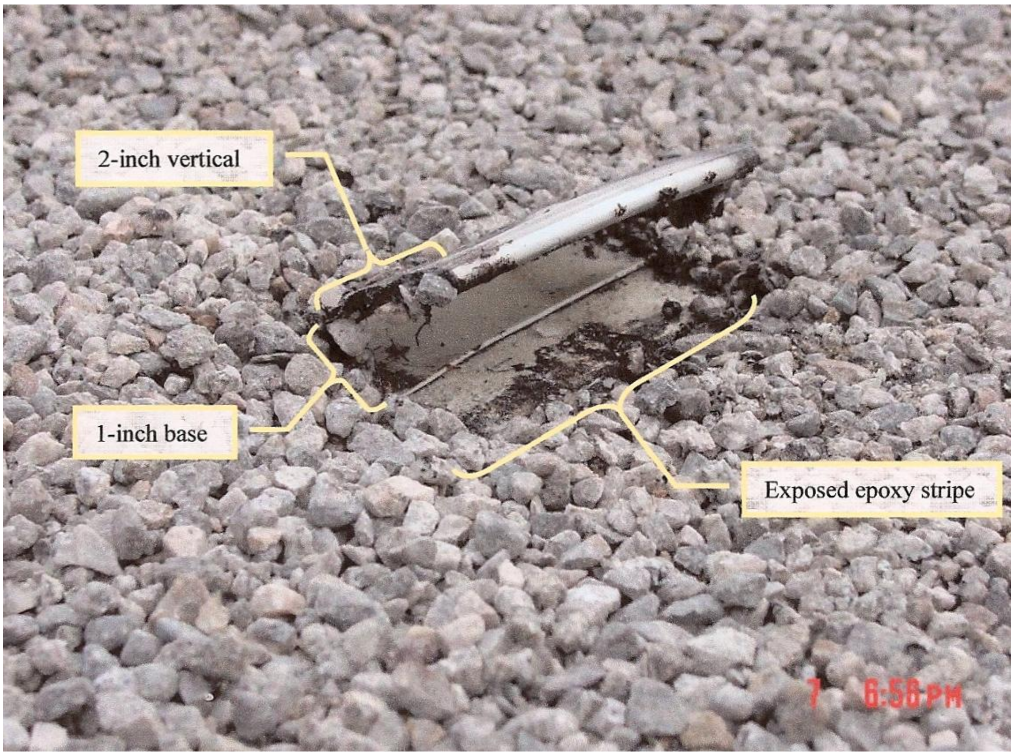

Figure 5. RFPM Shadow Effect

PERFORMANCE

A second condition survey was conducted on July 12, 2007 to assess cracking, chip loss due to traffic or snow plows and chip loss due to epoxy paint delamination. The results of this survey are presented in Figures 6 and 7 for cracking, and Figures 8 and 9 for chip loss.

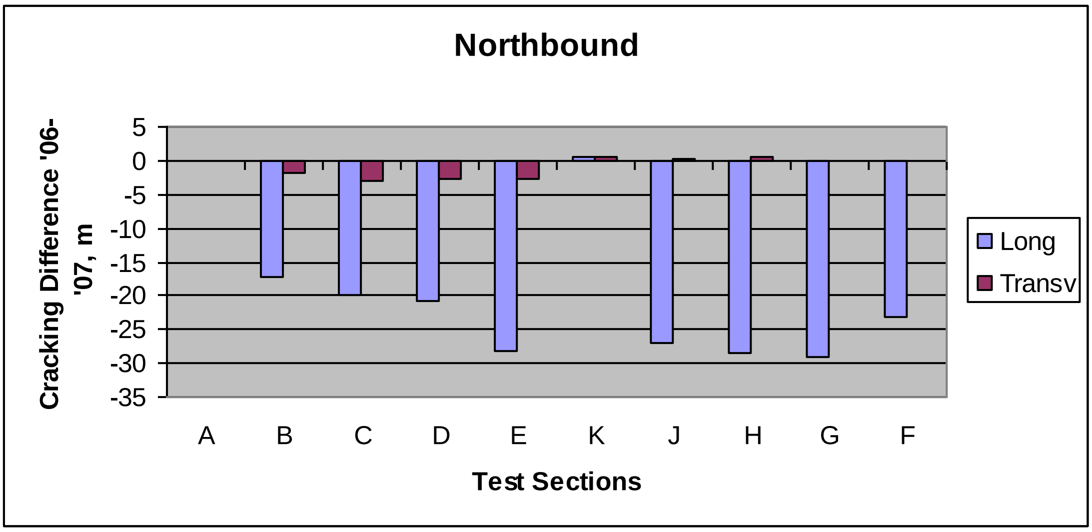

Figure 6. Cracking in Northbound Lane

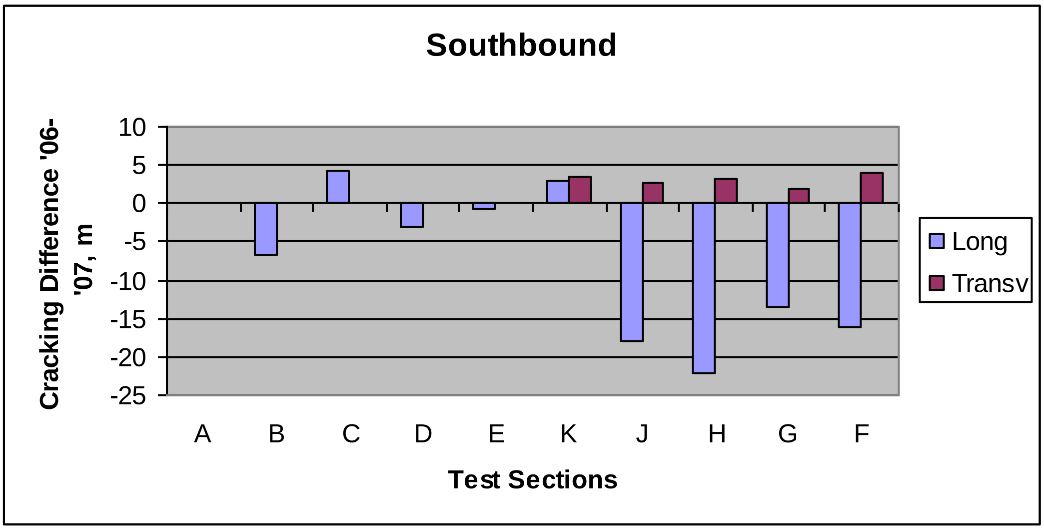

Figure 7. Cracking in Southbound Lane

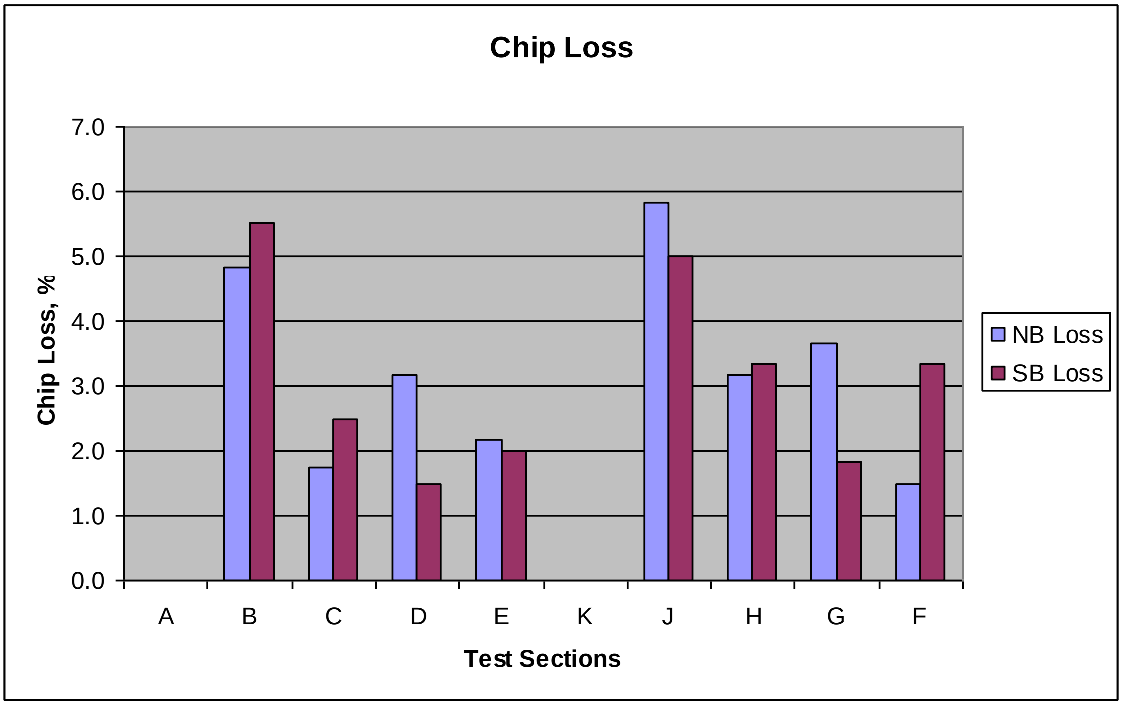

Figure 8. Average Chip Loss

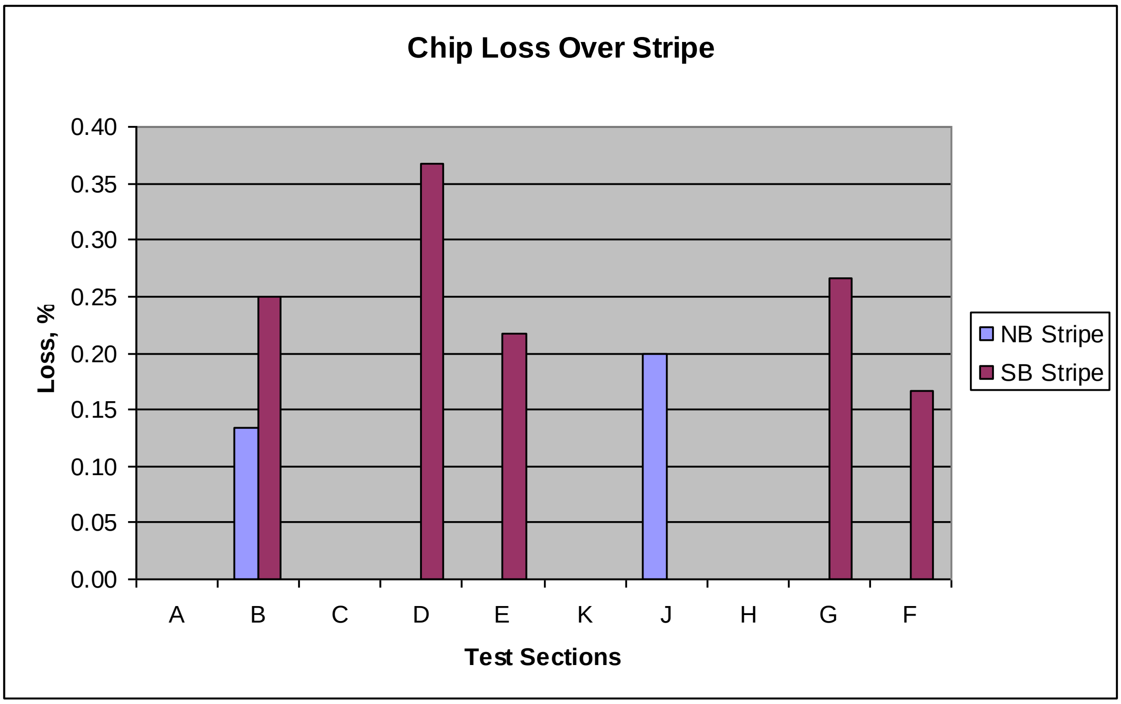

Figure 9. Chip Delamination Over Epoxy Stripe

ANALYSIS

The cracking performance shown in Figures 6 and 7 is the difference between the cracks observed in 2006 and those in 2007. Negative numbers on the ordinate indicate less cracks in 2007 than in 2006. For example, there appears to be more transverse cracking in sections F to K than sections A to E for both the northbound and southbound lanes. This may be reasonable since sections A to E are located in the lower elevation portion of the pavement (2081 m versus 2745 m). The lack of fog seal on sections B and J do not appear to have any effect on cracking, to date.

Chip loss due to traffic and/or snow plows is shown in Figure 8. In this case, the lack of fog seal on sections B and J may have contributed to an apparent increase in chip loss (approximately 5 to 6 percent loss) in these sections compared to other sections that had the fog seal applied (approximately 1.5 to 3.5 percent loss).

Chip loss due to delamination of the epoxy paint stripe is shown in Figure 9. There is evidence that removal of the stripe in sections C and H may have contributed to no loss of chips over the paint stripes on these sections as all other sections show evidence of chip loss over the paint stripes of from 0.12 to 0.37 percent or approximately 0.01 to 0.03 square meters. And, although this does not seem like much loss the void remaining makes the surrounding chip seal more vulnerable to snow plow damage and further chip removal.

CONCLUSIONS

1. There appears to be additional transverse cracking in the test sections at the higher elevation than at the lower elevation, as expected.
2. The fog seal application does not appear to affect cracking performance, to date.
3. The fog seal application does appear to have an effect on chip loss performance.
4. Removal of the epoxy paint stripe prior to chip sealing appears to have reduced the loss of chips over the stripe.
5. Raised Flexible Pavement Markers applied to the pavement surface prior to sealing may be a contributing factor to later chip loss due to the ‘shadow’ created on the pavement surface by the RFPM.

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