REPAIR OF STUDDED TIRE DAMAGE
I-5 PILOT PROJECT
M.P. 276 - 278 NORTHBOUND SECTION

Construction Report

State Planning and Research
Project Number 5276, Phase 3

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16. Abstract

In 1996, a pilot project to repair studded tire damage on CRC Pavement was constructed on Interstate 5 north of Salem, Oregon. The test section was about 5 km (3 mi.) long on a three-lane section of highway. Rut depths on this section were about 20 mm (.80 in.) with most of the damage in the center lane. Since the average daily traffic volume (ADT) was greater than 45,000, the work was done at night.

Four different thin AC overlays were placed on the test section. The first was a standard open graded F-mix. The second was the same F-mix with mineral fibers added. The third was a 38 mm (1.5 in.) stone mastic course aggregate mix. Finally, the last section was paved with a 25 mm (1.0 in.) lift of a fine stone mastic lift.

The work was completed near the end of the paving season and was delayed by a week due to rain. The night paving and the late season low temperatures caused some lay down problems. Lumping of the mix slowed the paving operation and produced a rough ride. Compaction was also low and inconsistent.

The section will be monitored for distress for two years. Raveling and/or rutting will be checked periodically.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

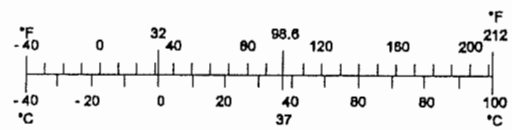
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

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DISCLAIMER

REPAIR OF STUDDED TIRE DAMAGE PILOT PROJECT

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1.0 BACKGROUND

After reviewing several methods of repair for studded tire damage, ODOT selected four different thin asphalt overlays for comparison (*Hoffman 1995*). Two of these were open graded mixes (F-mix), one with mineral fibers and one without. The F-mixes were compared to a coarse stone mastic (SMA, coarse) and fine stone mastic (SMA, fine) mix.

Bidding for the project occurred in August of 1996. The only bidder was Morse Brothers Construction Company. Morse Brothers was awarded the contract despite that their bid was 25% greater than the original estimate. Work was delayed until after Labor Day because of high holiday traffic volumes.

Paving started on September 8, 1996. It was completed on September 26, 1996. Due to equipment and weather problems, the project was delayed about one week. Despite the delay, the project was completed before the September 30 deadline for open graded paving.

1.1 SITE LOCATION

The test site is located on Interstate 5 northbound from milepost 275.84 to 278.32. This section is north of Woodburn, Oregon (see Figure 1.1). The road surface is a 22-year old continuously reinforced concrete (CRC) pavement. The average daily traffic volume (ADT) of this section is about 45,000.

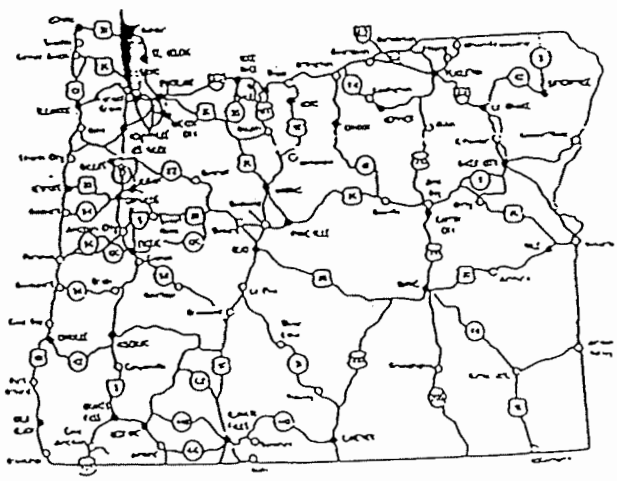


Figure 1.1 Test Site Location.

1.2 TEST SECTION LAYOUT

The 3.99 km (2.48 mi.) paving job was divided into four test sections. The division lines are shown in Figure 1.2, along with the depths paved. Note that not all sections are of the same length. Green and white signs have been installed at these boundaries near the roadway shoulder to aid in future evaluations.

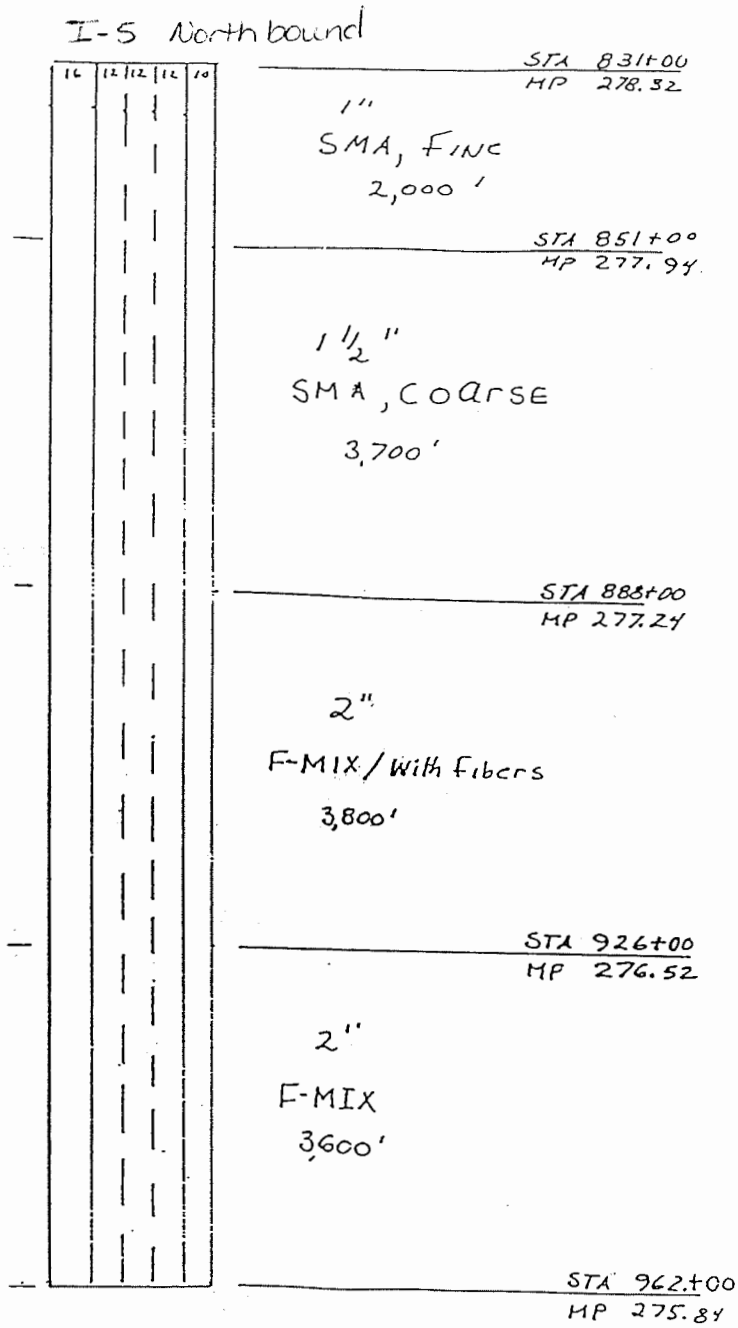


Figure 1.2 Test Section Divisions.

2.0 PAVEMENT SURFACE (ORIGINAL CONDITION)

2.1 RUTTING

Transverse profiles were taken in each section by stretching a string line across the lane and measuring down to the pavement in 30 cm (12 in.) intervals (see Figure 2.3).

Rutting, especially in the center lane, is highly developed and has a depth of about 17mm (.67 in.). The depth and shape of these ruts affect both steering and ride comfort. Most of the center lane rutting is believed to be caused by studded tires. The typical section in Figure 2.1 gives the general shape of the rut. Note that the center to center spacing is about 2 m (5 ft.) which is similar to the distance between the tires of many passenger cars. In addition, the width of the main channel is about that of a passenger car tire or about 20 cm (8 in.).

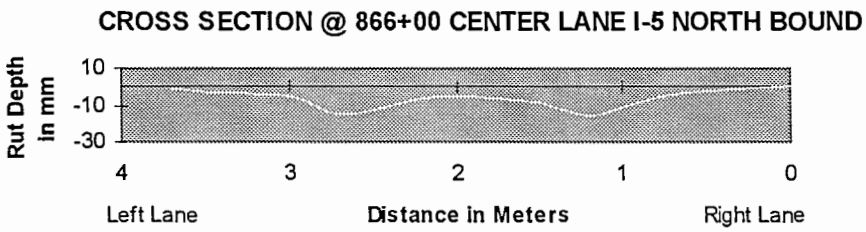


Figure 2.1 Cross Section of I-5 at MP 866.

In contrast, the right lane has a wider and shallower basin. This corresponds closer to the width of commercial truck dual tires. Fully loaded trucks use the right lane more then they do the center lane. This shape is common to many older pavements (see Figure 2.2).

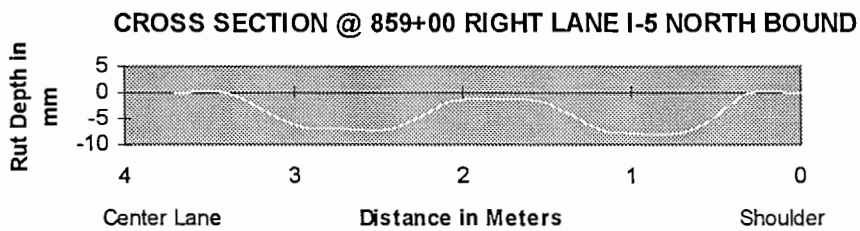


Figure 2.2 Cross Section of I-5 at MP 859.

2.2 OTHER DISTRESS

Transverse cracking, popouts, polished aggregates and longitudinal cracks were observed in the test section. Longitudinal cracking was found only in a few instances. In addition, the transverse cracking was mostly near the surface. This was evident when the surface was ground 51 mm (2 in.) inches deep for the end tapers of the test section. Popouts appear to be the result of loosing a single large aggregate. Figures 2.3 & 2.4 show some of these with a width of 3.8 cm (1.5 in.) and a length close to 8 cm (3 in.). These distresses were minor, compared to the rutting.

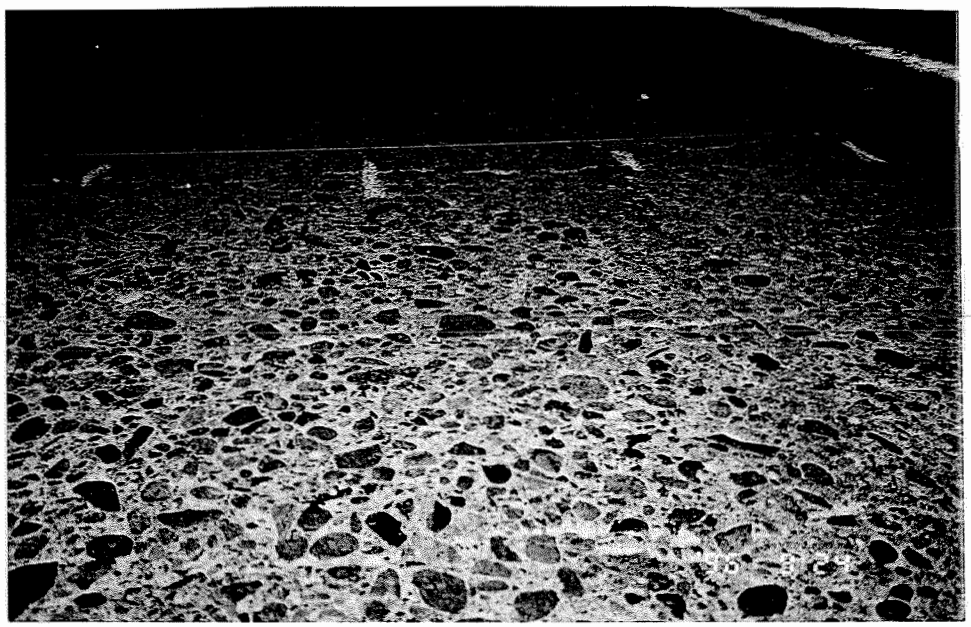


Figure 2.3 Rutting in CRC Pavement.

Figure 2.4 Large aggregates in the original CRC pavement.

3.0 PAVING OPERATIONS

The paving on this job was done using standard paving procedures. The mix was produced in a conventional batch plant and hauled to the site in commercial belly-dump type trucks. The asphalt was spread-out with standard paving equipment.

The paving started after 8:00 p.m. to minimize traffic delay on the interstate. Night work made traffic control more difficult because motorists were confused by the operating lights near the equipment. In addition, the mixture cooled rapidly, especially toward the end of the shift when the air temperature was low and the relative humidity was high (see Appendix D).

3.1 SURFACE PREPARATION

The CRC surface was prepared for paving by first removing lane marker buttons from the travel lane junctions. A great deal of surface debris was produced when the buttons were removed. Fragments of the markers and the mounting epoxy, were ground flush because of the thin SMA mix to be applied. This debris along with the normal road dust was removed by brooming before the paving started.

After the brooming, a tack coat of CSS-1 was applied at the rate of 0.28 liters per square meter (0.06 gallons per square yd.). This was done for both the leveling course and the top wearing course. The distributor truck applying the tack coat was equipped with a computer to control the spread rate but was not used after the second night of paving due to a malfunction. Tack coat application rates for the remainder of the job were estimated by the operator. The calculated rate for the entire job based on the weight of the tack coat used was 0.37 l/m^2 (0.08 gal. $/yd.^2$).

Ruts in the center lane were filled with a leveling course of D-mix (13mm-minus) (.51 in.-minus). This fine graded mix was applied by a spreader box attached to an 11 m^3 (12 $yd.^3$) end dump truck. Modifications to the spreader box enabled the operator to pave one wheel path at a time. Compaction of the 1 m (4 ft.) wide strip was first attempted using a pneumatic tired roller. Because the mix was being picked up and scattered by the rubber tires, a smaller steel wheel roller was substituted. The final compacted lift was about 1 m (4 ft.) wide and 6.4 mm (.25 in.) higher than the CRC. A 244 m (800 ft.) section of the left lane was also leveled. This effort was later abandoned because it caused a hump worse then the rut being filled (see Figure 3.1).

Figure 3.1 Leveling course on center and left lane.

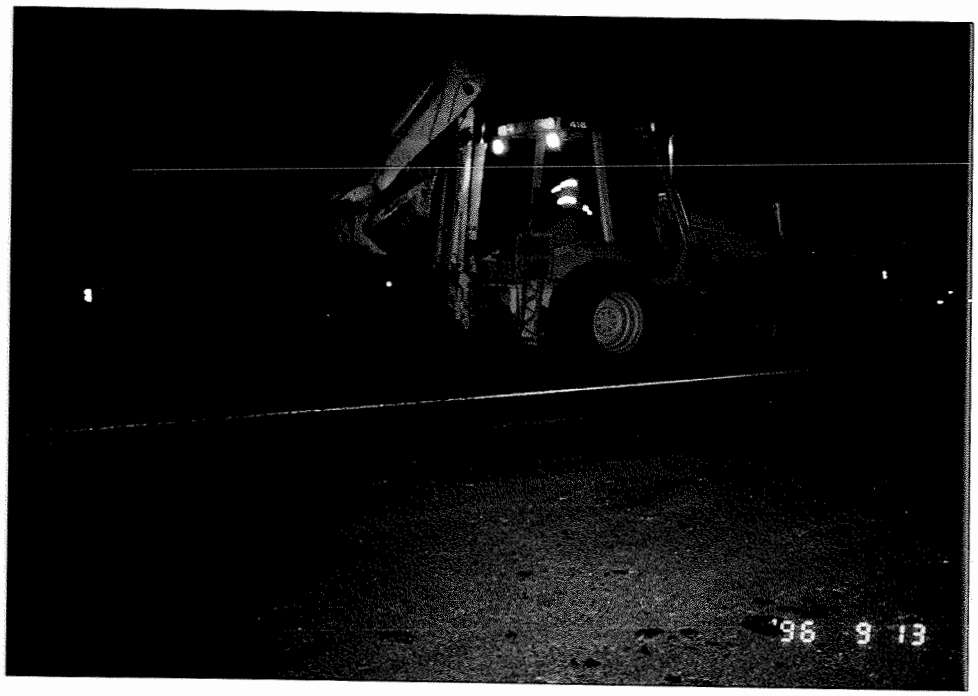


Figure 3.2 Backhoe became important part of paving operation.

3.2 LAYDOWN PROCEDURE

The asphalt mixture was hauled from the batch plant in 23 m^3 (25 $yd.^3$) belly dump trucks. Each truck load was dumped in a windrow in front of the paving machine, and spread by the paver before the next load was dumped. This was done to keep the mix from cooling too rapidly and gave the paving crew a chance to check the windrow for cooled lumps of poorly mixed asphalt. The backhoe became an important tool in the paving operation, removing much of the bad mix (see Figure 3.2). Even with the help of the backhoe, clean-up took time so that the paving operation was not continuous. This happened in all four sections, but was particularly bad in the first section of conventional F-mix. Much of the lumping in the F-mix was caused by low temperatures (see Tables 3.1 and 3.2). The lumps were found near the end of each dumped load where the top layer had been exposed to the cold night air (see Figure 3.3). The drivers later were instructed to cover the loads with a tarp.

The F-mixes were compacted using static rollers while the SMA's were compacted using rollers in the vibratory mode. The contractor started each mix type on the shoulder in order to develop a roller pattern required to obtain adequate compaction. Compaction was monitored with a nuclear gauge, and roller patterns were adjusted several times. The basic roller pattern was four passes by the break down roller before the mix temperature dropped below a specified value for each mix type. Marks left by the break down roller were removed using four passes of a static finish roller.

Quality control during the paving operation was done visually. The paving crew watched for lumps and gouges in the mat and repaired them as needed. Grade was set by a 15 m (50 ft.) ski, which rested on the edge of the adjacent lane. Pavement depth was tested by a calibrated rod and adjusted by the paving machine operator.

Table 3.1 Recommended Temperatures of the Mixes

Type of Mix Delivered by Plant	Recommended Mixing Temperature	Recommended Placement Temperature
Heavy Duty course SMA Mix w/Lime	159 - 164°C	150 - 154°C
Heavy Duty Fine SMA Mix w/ Lime	159 - 164°C	150-154°C
Heavy Duty D Mix Design w/Lime	150 - 155°C	141-145°C
Heavy Duty F Mix Design w/Lime	Unavailable	Unavailable

Table 3.2 Actual Recorded Temperatures

Date	Mix	Lane	Beginning Station	Ending Station	Air Temp. °C/°F	Windrow Temp. °C/°F	Plant Temp. °C/°F
9/8/96	D-Mix	Center Lane	962	926	Unavailable	Unavailable	Unavailable
9/9/96	D-Mix	Left Lane	962	958	Unavailable	Unavailable	Unavailable
9/10/96	F-Mix	Left Shoulder	962	926	13°C/55°F	116°C/240°F	135°C/275°F
9/11/96	F-Mix	Left Lane	962	926	13°C/55°F	116°C/240°F	132°C/270°F
9/12/96	F-Mix	Right Lane	962	926	13°C/55°F	127°C/260°F	132°C/270°F
		Center Lane	962	926	10°C/50°F	127°C/260°F	132°C/270°F
9/17/96	F-Mix with Fibers	Left Shoulder	926	888	8.9°C/48°F	121°C/250°F	132°C/270°F
		Left Lane	926	888	8.9°C/48°F	121°C/250°F	132°C/270°F
9/19/96	F-Mix with Fibers	Center Lane	926	888	12°C/53°F	129°C/265°F	138°C/280°F
		Right Lane	926	888	12°C/53°F	129°C/265°F	138°C/280°F
9/20/96	F-Mix	Right Shoulder	962	926	8.3°C/47°F	129°C/265°F	135°C/275°F
	F-Mix with Fibers	Right Shoulder	926	888	8.3°C/47°F	129°C/265°F	135°C/275°F
9/23/96	SMA, Course	Left Shoulder	888	851	8.3°C/47°F	149°C/300°F	165°C/329°F
9/24/96	SMA, Course	Center Lane	888	851	8.9°C/48°F	151°C/303°F	165°C/329°F
		Right Lane	888	851	8.9°C/48°F	151°C/303°F	165°C/329°F
		Right Shoulder	888	851	8.9°C/48°F	151°C/303°F	165°C/329°F
	SMA, Fine	Right Shoulder	888	837	8.9°C/48°F	151°C/303°F	165°C/329°F
9/25/96	SMA, Fine	Left Shoulder	851	831	12°C/54°F	154°C/310°F	165°C/329°F
		Left Lane	851	831	12°C/54°F	154°C/310°F	165°C/329°F
		Center Lane	851	831	12°C/54°F	154°C/310°F	165°C/329°F
		Right Lane	851	831	12°C/54°F	154°C/310°F	165°C/329°F
		Right Shoulder	831	831	12°C/54°F	154°C/310°F	165°C/329°F

Figure 3.3 Lumpy asphalt mix was removed from the windrow and piled on shoulder.

4.0 BATCH PLANT OPERATION

Morse Brothers Asphalt Plant near Stafford, Oregon, can produce 360 Mg (400 ton) of mixture per hour. Although the batch plant is computer controlled, some operator input is needed. Several times a message of "...scale unbalanced..." would flash on the control screen, the operator would have to change the speed or stop one of the feed belts to get the plant balanced. The plant operator said it usually takes about 180 Mg (200 tons) before a good balance is reached. He was very alert to changes needed and made them promptly.

The mix temperature was controlled by adjusting the burner thermostat. The thermocouple at the bottom of the batch plant indicated the mix temperature which lagged behind the actual temperature. The mix was checked at the output by a hand-held infrared scanner so that very accurate temperature control was not obtained. A nighttime noise reduction agreement with residents living near the cement plant required Morse Brothers to use a longer haul route. Covered loads were necessary due to the long haul route and cool night temperatures.

The mix design for SMA required a mineral filler. To make this addition, a temporary mineral feed system was installed. The system was rented from a company in Georgia. The company also provided training on the operation of the equipment. The feeder dismantled large bales of the mineral filler (which looked like fiberglass insulation) and blew a 16 kg (36 lb.) charge into each batch of AC. The timing for the charge was not linked to the batch computer but had to be done manually by the operator on cue from the batch computer. The plant operator said that it could be set-up for computer control, but because it was rental equipment, Morse Brothers did not want the additional expense of a permanent hook-up now. The feeder console sat on a chair in the control tower. The batch cycle time was doubled to allow complete mixing of the mineral fibers.

5.0 MIX DESIGNS

Mix designs for the F-mix and for the SMA are covered in section 5.1 and 5.2. The ½" to ¼" range included 42% of the F-Mix aggregates and 90% of the SMA aggregates. The asphalt content design value for the F-mixes was 5.8%, while the design value for SMA coarse and fine mixes was 6.5%. All mixes, except the D-mix, used Chevron PBA-6 polymer asphalt. The D-mix leveling course used PBA-5 supplied by McCall Oil Company. The distribution of aggregate size is shown in Figure 5.1. See Appendix E for mix design details.

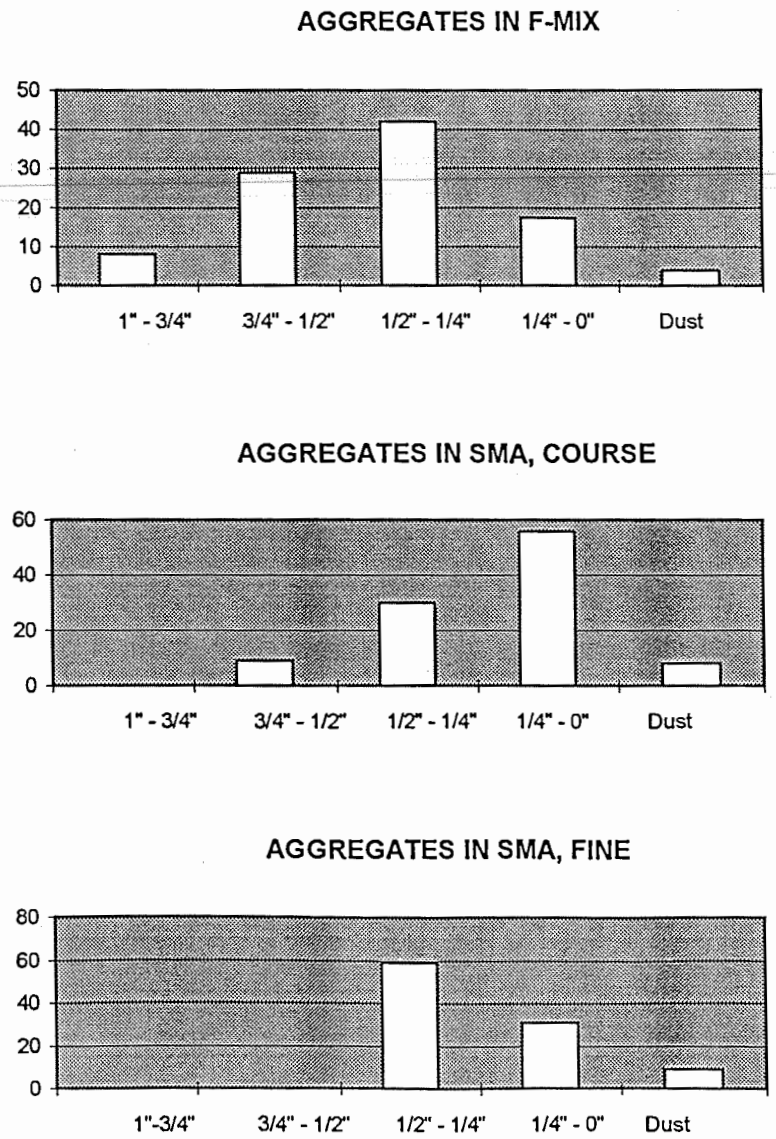


Figure 5.1 Distribution of aggregates in the mixes.

5.1 DESIGN OF OPEN-GRADED MIXTURES

The contract specified heavy duty F-mix with lime using PBA-6 asphalt. The contractor selected aggregate materials from Stearns Quarry (34-098-2) and asphalt materials from Chevron. The contractor opted to use three stockpiles, 1.9 – 1.3 cm (.75 - .50 in.), 1.3 - .64 cm (.50 - .25 in.), and .64 – 0.0 cm (.25 – 0.0 in.). Fiber materials were produced by Fiberand Corp.

Job mix formulas (JMF's) for the two open-graded F-mixes (with and without fibers) were developed using ODOT mix design procedures. This included measuring volumetric properties and draindown characteristics at three different asphalt contents. The three asphalt contents selected for mix design purposes were 4.5, 5.5 and 6.5% asphalt per total weight of mixture (see Appendix E).

Design specimens were compacted per AASHTO T-167 Section 7.1 at a temperature corresponding to 800 ± 100 CST on the asphalt temperature/viscosity curve. Draindown characteristics were measured per ODOT's mix design procedure and were checked per the August 1996 draft AASHTO test procedure for *Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures.*

Table 5.1 Selected Gradation for the JMF's of both mixes.

SIEVE	% PASSING
3.18 cm (1.25 in.)	100
3 cm (1 in.)	100
1.9 cm (.75 in.)	92
1 cm (.5 in.)	63
.64 cm (.25 in.)	21
#10	10
#40	6
#200	3.0

The design asphalt content for both mixes was 5.8% per total weight of mixture. The F-mix with fiber used 0.3% by weight mineral fiber.

5.2 DESIGN OF STONE MATRIX ASPHALT MIXTURES

The contract specifications called for heavy duty SMA with lime using PBA-6 asphalt. The contractor elected to use aggregate material from Stearns Quarry (34-098-2) for the SMA-C mixture. The aggregate material for the SMA-F was a combination of Stearns Quarry material and a .953 cm (.375 in.) - #4 material brought in from the Deer Island Pit (05-037-1). The mineral filler was baghouse material from the contractors' batch plant operation which primarily uses Stearns Quarry material.

Job mix formulas (JMF's) for the two SMA gradations were developed using a 50 blow Marshall mix design procedure to determine volumetric properties. Draindown characteristics were

measured using the August 1996 draft AASHTO methods for *Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures.*

Table 5.2 Gradations Selected for the SMA-C and SMA-F.

SIEVE	SVA-C % PASSING	SMA-F % PASSING
1.9 cm (.75 in.)	100	100
1 cm (.5 in.)	91	100
.953 cm (.375 in.)	60	94
#4	26	27
#8	18	17
#30	11	11
#50	10	10
#200	8.1	7.8

The design asphalt content for both mixes was 6.5% by total weight of mixture. Both mixes included 0.3% mineral fiber by total weight of mixture.

6.0 TEST RESULT SUMMARY

Limited material tests were conducted on this project because of the small quantities involved. ODOT testing frequency specifies one sample per 450 Mg (500 tons) which resulted in one sample per paving day. Actual frequency was about 680 Mg (750 tons) or three per mix type. The aggregates, asphalt, lime, mineral filler were tested, and all met ODOT specifications.

Test results for the asphalt mixture is summarized in Table 6.2. Project target values are in bold type while the test values are in italic type. Note that the test values are close to the design values.

Table 6.2 Asphalt Mixture Testing.

Mix Type	Asphalt % by Meter		Moist % TM 311											
			Gradation TM 204/205											
			1	.75	.5	.375	.25	#4	#8	#10	#30	#40	#50	#200
F Hi	**5.8**	**1.1**	**100**	**96**	**71**		**26**			**14**				**5.9**
F Lo	**5.4**	**0.0**	**99**	**85**	**55**		**16**			**6**				**1.9**
***F (Target)**	*5.6*	*0.41*	*100*	*91*	*60*		*19*			*10*				*4.6*
F/FIB, Hi	**5.8**	**1.1**	**100**	**96**	**71**		**26**			**14**				**5.9**
F/FIB, Lo	**5.4**	**0**	**99**	**85**	**55**		**16**			**4**				**1.9**
***F/FIB (Target)**	*5.6*	*0.3*	*100*	*90*	*59*		*19*			*9*				*3.8*
SMA-C, Hi	**6.7**	**1.1**		**100**	**96**	**71**		**31**	**28**		**17**			**12.1**
SMA-C, Lo	**6.3**	**0**		**99**	**85**	**55**		**21**	**20**		**11**			**8.1**
SMA-C (Target)	*6.5*	*0.26*		*100*	*93*	*61*		*25*	*17*		*11*			*7.4*
SMA-F, Hi	**6.7**	**1.1**			**100**	**98**		**42**	**27**		**17**		**16**	**11.1**
SMA-F, Lo	**6.3**	**0**			**99**	**90**		**32**	**19**		**9**		**8**	**7.1**
SMA-F(Target)	*6.47*	*0.25*			*100*	*95*		*35*	*20*		*11*		*10*	*7.5*

* Asphalt content target value was changed from 5.8% to 5.6% on September 10, 1996 after one day of paving.

QA samples were taken from the silo at the plant. Tests were conducted at the ODOT Materials lab. Asphalt content was determined by meter readings at the plant.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Problems on this job included, cool weather, equipment break downs and sporadic paving operations. The finished surfacing on all mixes looks good. However, ride quality is "choppy" and is most noticeable in the first F-mix section.

Starting the job earlier in the summer could eliminate much of the cold weather paving. July and August nights have air temperatures of about 16°C (60°F) rather than the low 4°C (40°F) temperatures found in late September. Truck drivers should also be required to cover their loads with a tarp to reduce the lumping at the top surface of the mix.

Quick repairs or standby equipment could reduce many of the problems of equipment break downs. These break downs cause the operation to produce the choppy ride reported.

In addition, the paving machine should be operated continuously with a full hopper of mix. This was not done well because removing lumps from the windrow caused many interruptions. In addition, mix from the plant did not always arrive at the jobsite when it was needed.

The project should be monitored more closely. If it survives the first winter, then annual evaluations should be made. In two or three years, ODOT should know if F-mix and SMA are effective methods for rut repair on CRC pavements.

8.0 REFERENCES

Hoffmann, Kaaren, E.I.T.. *Repair of Rutting Caused by Studded Tires. Literature Review.* SPR Project #5273, FHWA-OR-RD-96-04. July, 1995.

APPENDIX A

DAILY CONSTRUCTION REPORTS

REPAIR OF STUDDED TIRE DAMAGE
I-5 PILOT PROJECT
M.P. 276- M.P. 278 (N.B.) SEC.
DAILY CONSTRUCTION REPORT

SEPTEMBER 8TH: The job started on Sunday night about 8:00 p.m. Traffic was still very heavy at this hour and made lane closure difficult. The work for the day included milling the butt joints in the center lane, right lane and right shoulder at stations 831+00 and 962+00. The traffic lane marker buttons were also removed with an air chisel. (The contractor was instructed to remove the buttons and epoxy to grade level because of the thin lift.) The center lane was also leveled from 962+00 to 926+00. The leveling was done with a modified spreader box pulled by the 11 m^3 (12 $yd.^3$) asphalt truck supplying the special D-Mix. The spreader box broke as soon as the first load was started. Repairs took about an hour, in the meantime the truck of D-Mix had cooled. This made spreading and rolling very difficult. Rolling was being done by a pneumatic tire roller. The mix either stuck to the tires or was scattered by the roller. The next truck load went down better, but some aggregates were still being thrown by the roller. The next day, some of the leveling course had been thrown to the shoulder by traffic, but most remained bonded to the concrete. The tack coat was CSS-1 cold emulsion, applied at a 0.08 rate by a computer controlled tack truck.

SEPTEMBER 9TH: Work included milling the butt joints for 962+00 and 831+00 on the left shoulder and left lane. The left lane was leveled from 962+00 to 958+00 with D-Mix. The work was halted by Ron Clay, the project manager, when he decided that level would cause a hump rather than help level the ruts.

SEPTEMBER 10: Paving of the left shoulder, from 962+00 to 927+00 with F-Mix, was completed today. The contractor had rented 18 belly dump trucks but only eight showed up, and three of these quit before the shift was over. They did not like cleaning the F-Mix out of the truck beds. This truck shortage reduced the planned work by over half. The left shoulder and the left lane were scheduled for paving, but only the left shoulder, which is 4.9 m (16 ft.) wide, was paved. The paving quality was also effected by the truck shortage. The operation was stop-and-go with many long waits for mix and cleaning out lumps of mix in the windrow at the end of each truck load.

The AC content was reduced from 5.8 to 5.6% by Jeff Gower. The plant mix target temperature was also reduced from 138°C (280°F) to 132°C (270°F) because of bleeding. The air temperature for the shift ranged from 16°C (60°F) to 9.4°C (49°F).

SEPTEMBER 11: Today the left lane was paved from station 962+00 to 926+00 with F-Mix. The operation today was smother because more trucks were used to haul the mix. Stop-and-go paving and low mix temperature (116°C (240°F)) were found to cause waves which may produce a bad riding pavement.

SEPTEMBER 12: Today the center lane and right lane were paved with 5 cm (2 in.) of F-Mix. The operation went well with the mix being delivered to the job at a rate which kept the Cedar Rapids Greyhound paver running smoothly. Roller patterns, which had been established on the left shoulder, were checked with a nuclear gauge. Two steel wheel rollers were used in non-vibration mode. The finish roller broke down about half way through the shift. It was replaced by a smaller roller. In addition, the threat of rain was present during the entire shift, although the micro-forecaster said no measurable rain would fall. Only a slight mist fell for about 20 minutes when the paver was near the Fellers Road overcrossing, both in the center and right-hand lane. Relative humidity was about 78% and air temperature was 14°C (58°F). Windrow temperature was 127°C (260°F), and the mat temperature behind the paver was 110°C (230°F). The rollers were completing four passes before the mix temperature cooled below 99°C (210°F).

SEPTEMBER 13: NO WORK; RAIN

SEPTEMBER 14: NO WORK; WEEKEND

SEPTEMBER 15: NO WORK; WEEKEND

SEPTEMBER 16: NO WORK; RAIN

SEPTEMBER 17: Today the left shoulder and left lane were paved with 5 cm (2 in.) of F-MIX with fibers from station 926 to station 888. The mix temperature was low at times causing clumps to form. Removing clumps from the windrow slowed the paving operation and caused some waving. Air temperature was about 10°C (50°F) for the low.

SEPTEMBER 18: NO WORK; RAIN

SEPTEMBER 19: Today the center lane and the right lane were paved with 5 cm (2 in.) of F-Mix with fibers from station 926 to station 888. The paving operation went smoothly, with few lumps in the mix and very few slicks developing. The belly dump drivers had been told to cover their loads with tarps, which most of them did. This night paving job after 10 p.m. called for a 20% increase in haul time because of a problem with neighbors near the AC plant. The windrow temperature was about 129°C (265°F) and the mat temperature just behind the paver was about 113°C (235°F). The break down roller and the finish roller were working much closer today, easily completing the four non-vibration passes before the mix cooled to below 99°C (210°F).

While the right lane was being paved with F-Mix/fibers, the center lane was being leveled with the modified screen box paver. The D-Mix looked cold and hard to work and was being rolled with a small, steel-wheeled roller (BOMAG 510). Some areas, especially 870+00 to 872+50, had very sparse cover in the left wheel path. This truckload was found to be poorly mixed and was rejected after about 90 m (300 ft.) had been paved. The tack coat for the leveling mix was applied by estimate. Normally a computer on the tack truck controls the application rate, but it broke down and remained down for the rest of the job. Therefore, the tack coat application rates for the F-Mix/fibers and all of the SMA sections were set by the operators' estimate.

SEPTEMBER 20: Today the crew paved the right shoulder from section 962 to 926 using F-mix. F-mix with fibers was used from section 926 to 888. Because this was shoulder work, the research observer was not present.

SEPTEMBER 21: NO WORK; WEEKEND

SEPTEMBER 22: NO WORK; WEEKEND

SEPTEMBER 23: Today the contractor started paving the left shoulder from 888+00 to 851+00 with 3.8 cm (1.5 in.) of SMA course. The first load had to be scraped off the road because dirt and sand in the truck had not been cleaned out prior to loading the SMA. In addition, the temperature of this first load was only about 116°C (240°F) and would have been difficult to lay. Adjustments in the AC content and the plant temperature had to be made because of slicks on the finished mat. After the first five loads, the operation went smoothly, with mix being delivered to the paver to keep it moving almost all of the time. Mix temperature was a problem. The target temperature at the plant was 160°C (320°F). Despite the target temperature, the mix was measuring below 149°C (300°F) in the windrow (138-143°C (280-290°F)). Because of this, it was raised at the plant to 165°C (329°F). The air temperature dropped rapidly after 2:00 a.m. from 11°C (51°F) at 11:30 to 7.2°C (45°F) and the relative humidity increased from 40% to 75%. This cooling was accompanied by more lumps in the windrow at the end of each truck load.

The roller patterns were again checked and adjusted by Tony Mandich based on the nuclear density of the compacted mat. Four passes of the vibration rollers were used. The rollers kept up with the paver quite easily on the left shoulder, which is 4.9 m (16 ft.) wide. However, paving the left lane went faster and the rollers behind the paver were not always completing the four passes before the mat cooled to below 93°C (200°F). A third roller was added but it broke down after a short time.

TIME	TEMP.	RH	SURFACE TEMP.
8:00 PM	15°C	36	
	59°F		
12:30 PM	11°C	41	
	51°F		
2:00 AM	7.2°C	60	9.4°C
	45°F		49°F
3:30 AM	5.6°C	80	Slight breeze, thin fog
	42°F		

Note: The leveling course on the center lane was raveling in the LWP (left wheel path) from 888+00 to 860+00.

Plant Visit: While the shoulder work was in progress, the research observer made a visit to Morse Brothers Asphalt Plant near Stafford, Oregon. Although the batch plant is computer controlled, some operator input is still needed. Several times a message of "...scale unbalanced..." would flash on the control screen, the operator would have to change speed or stop one of the feed belts to get the plant balanced. The plant operator said it usually takes about 180 Mg (200 ton) before a good balance is reached. He was very alert to changes needed and made them promptly. The mix temperature was adjusted by setting the burner thermostat. The thermocouple at the bottom of the batch plant indicated the mix temperature lagged behind the actual temperature. The mix was checked by a hand-held infrared scanner, thus, very accurate temperature control was not possible. The final test was the windrow temperature, which was also not very accurate because the paver would feed the windrow from a single truck load faster then a thermometer could reach a stable temperature. The plant loading operator reminded the truckers to use the long route and to tarp their loads. One trucker asked the operator to place the center of the load 46 cm (18 in.) behind the truck center.

The mix design included the addition of mineral filler. To make this addition, a temporary mineral feed system was installed. The system was rented from a company in Georgia. The company also provided training on operation of the equipment. The feeder dismantled large bales of the mineral filler (which looked like fiberglass insulation) and blew a 16 kg (36 lb.) charge into each batch of AC. The timing for the charge was not linked to the batch computer but had to be done manually by the operator on cue from the batch computer. The plant operator said that it could be set-up for computer control, but because it was rental equipment, Morse Brothers did not want the additional expense of a permanent hook-up. The feeder console was sitting on a chair in the control tower. The batch cycle time had to be doubled to allow complete mixing of the mineral fibers.

SEPTEMBER 24: Today the contractor paved 3.8 cm (1.5 in.) of SMA course from 888-851 in the center lane, right lane and right shoulder. SMA, fine was also used on the right shoulder from 888-837. The operation went smoothly for most of the shift. Oil spots started at MP 870 to 851. The windrow temperature was 151°C (303°F), and the mat just behind the paver was 130°C

(270°F). The plant temperature was decreased to stop the oil spots. Three rollers were used until the static roller broke down at station 860. The two vibration rollers were making four passes. At 3:45 a.m., the contractor switched to SMA fine on the right shoulder. This was done to get a sample before the travel lanes were paved with SMA fine and made a lane to detour traffic near the end of the next nights paving. The mat looked good except for the slicks. (The sample had voids higher than the target value so that the gradation had to adjusted.) Because the last truck was held at a state port of entry due to lack of insurance on the truck, the final 122 m (400 ft.) of the right shoulder was not completed.

TIME	TEMP.	RH
08:30 PM	15°C	40
	59°F	
11:30 PM	9.4°C	65
	49°F	
12:30PM	8.9°C	72
	48°F	
02:00AM	7.8°C	82
	46°F	
03:45AM	6.7°C	73
	44°F	
05::00AM	6.1°C	90
	43°F	

SEPTEMBER 25: Today the contractor paved the remainder of the project with SMA fine mix. This included the left shoulder, left lane, center lane, right lane, and the final 122 m (400 ft.) of the right shoulder. Paving started on the left shoulder and worked to the right. Traffic was first directed onto the right lane and right shoulder, as paving progressed the traffic was reduced to one lane on the right shoulder at 11:30 p.m. This switch allowed simultaneous operations of paving the left lane and leveling the center lane. Traffic was again switched at 2:30 a.m. to one lane on the left shoulder. Thus, all newly paved travel lanes had adequate time to be rolled and cooled before traffic was restored.

Paving went very smoothly today except that the first load arrived with dirt and sand in the mix. The new mat had to be scraped off to the side. The mix design was adjusted to decrease voids by increasing the amount of material passing the #4 screen by 3%. The contractor used three rollers, two in vibration mode close behind the paver. A static roller was doing the finish work. Although Tony Mandich said that they were getting the same compact on three roller passes as they were on four, they continued to do four. The mix temperature in the windrow averaged about 154°C (310°F). The plant target temperature was 165°C (329°F). A few large clumps were found in the windrow at the beginning of the shift. These decreased after a few loads.

TIME	TEMP.	RH	CONC.
08:00PM	17°C	36	surf
	63°F		
11:30PM	13°C	48	
	56°F		
03:00AM	8.9°C	63	
	48°F		
04:00AM	8.3°C	70	9.4°C
	47°F		49°F

List of equipment used:

4 rollers:

- Ingersoll-Rand VIBRATORY DD-110
- BOMAG 2490 VIBRATORY BW202AD
- HYSTER HYPAC CYCLIC WEST C766B
- BOMAG 510

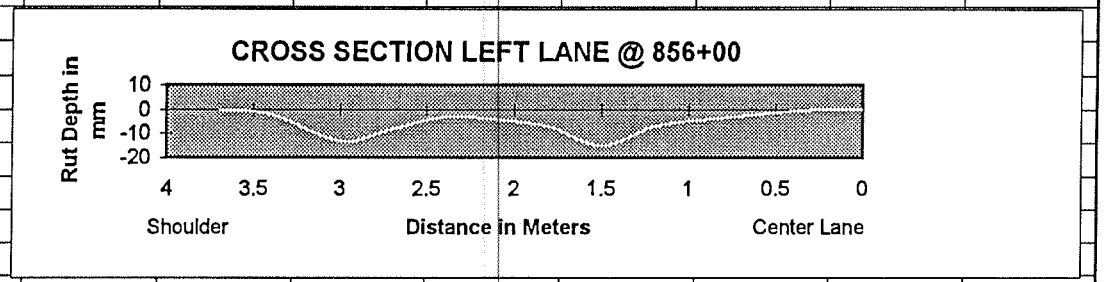
1 CEDAR RAPIDS GREYHOUND PAVER WITH PROCAL
1 BACKHOE
SEVERAL BELLY DUMP TRUCKS (with a legal haul of about 25 tons: 2 with 32+ tons).
2-12 YARD DUMP TRUCKS
3 LIGHT PLANTS
1 TACK TRACK
1 WATER TRUCK
1 GREASE TRUCK

APPENDIX B

TYPICAL CROSS SECTIONS

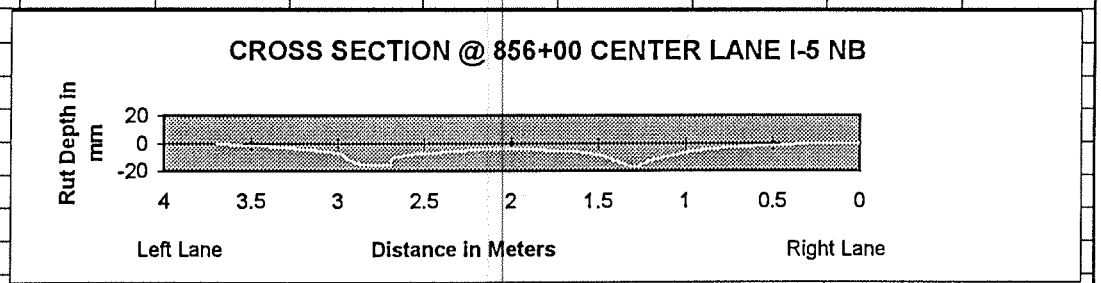
The following cross sections were taken on I-5 North bound in September 1996 just before the AC ovelay.
left lane @sta 856 sma course

dist in m			depth
3.7	0		0
3.4	2		-2
3	13		-13
2.7	8		-8
2.4	3		-3
2.1	4		-4
1.8	7		-7
1.5	15		-15
1.2	7		-7
0.91	4		-4
0.61	2		-2
0.3	0		0
0	0		0

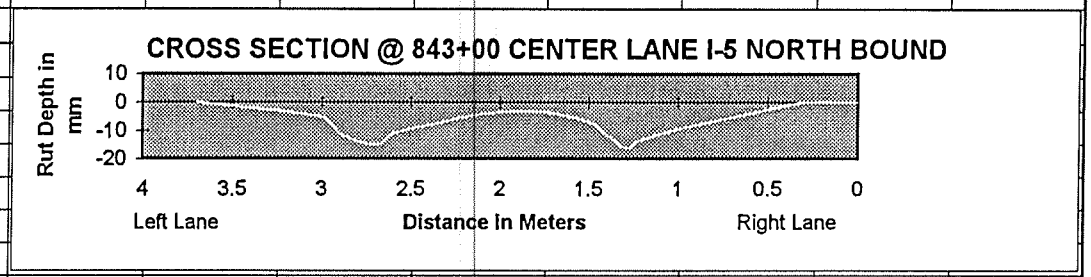


center lane cross section @ sta 856+00 north bound i-5

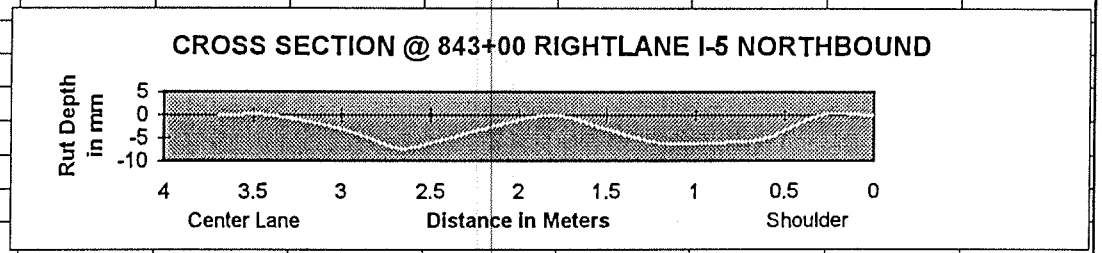
dist in m	depth		depth
3.7	0		0
3.4	2		-2
3	7		-7
2.9	14		-14
2.7	16		-16
2.68	10		-10
2.4	6		-6
2.1	4		-4
1.8	5		-5
1.5	8		-8
1.3	17		-17
1.2	12		-12
0.91	5		-5
0.61	2		-2
0.3	0		0
0	0		0



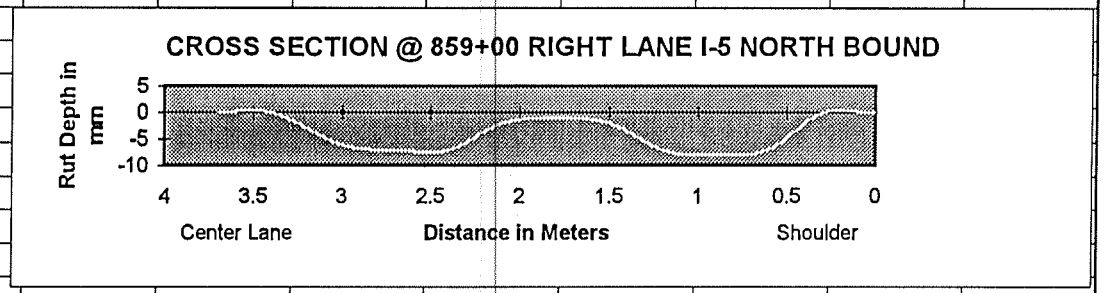
center lane cross section @ sta 843+00 north bound i-5			
dist	depth		
3.7	0		0
3.4	2		-2
3	5		-5
2.9	11		-11
2.7	15		-15
2.6	11		-11
2.4	8		-8
2.1	4		-4
1.8	3		-3
1.5	7		-7
1.3	16		-16
1.2	13		-13
0.91	8		-8
0.61	4		-4
0.3	0		0
0	0		0



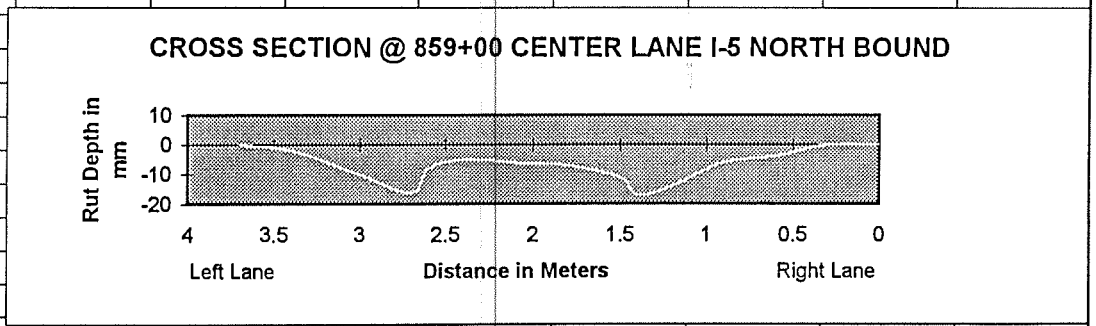
right lane sta 843+00 I-5 north bound			
dist	depth		depth
right	mm		mm
3.7	0		0
3.4	0		0
3	3		-3
2.7	7		-7
2.6	7		-7
2.4	5		-5
2.1	2		-2
1.8	0		0
1.5	3		-3
1.2	6		-6
0.91	6		-6
0.61	5		-5
0.3	0		0
0	0		0



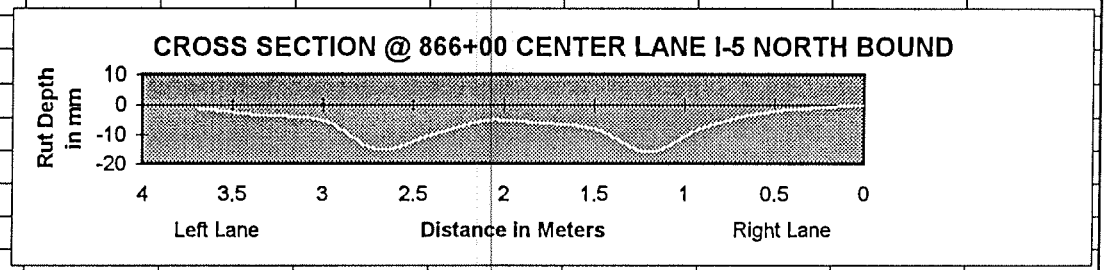
right lane @ 859+00 I-5 North bound			
right	depth		depth
	mm		mm
3.7	0		0
3.4	0		0
3	6		-6
2.7	7		-7
2.4	7		-7
2.1	2		-2
1.8	1		-1
1.5	2		-2
1.2	7		-7
0.91	8		-8
0.61	8		-7
0.3	0		0
0	0		0

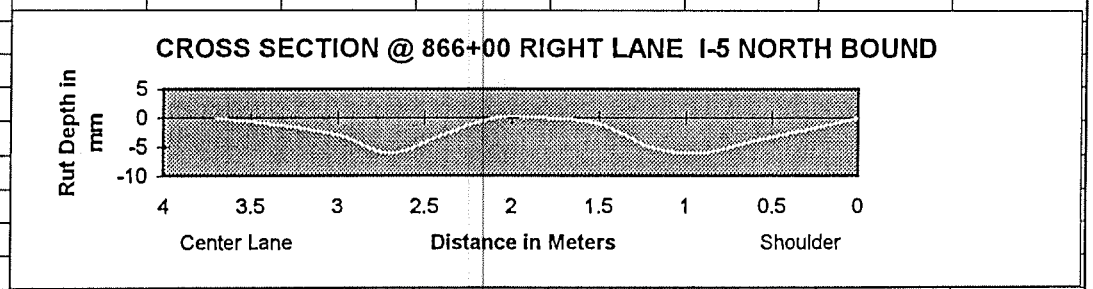


center lane sta 859+00 i-5 north bound			
dist			
right	depth		depth
3.7	0		0
3.4	2		-2
3	10		-10
2.7	16		-16
2.6	8		-8
2.4	5		-5
2.1	6		-6
1.8	7		-7
1.5	11		-11
1.4	17		-17
1.2	14		-14
0.91	6		-6
0.61	4		-4
0.3	0		0
0	0		0

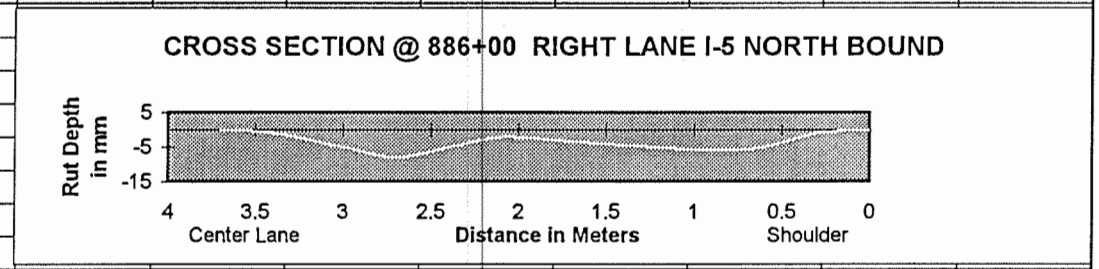


dist	866+00 I-5 CENTER LANE I-5 North Bound			
right	depth			
	mm			
3.7	1		-1	
3.4	3		-3	
3	5		-5	
2.7	15		-15	
2.4	10		-10	
2.1	5		-5	
1.8	6		-6	
1.5	8		-8	
1.2	16		-16	
0.91	8		-8	
0.61	3		-3	
0.3	1		-1	
0	0		0	
right lane				
dist	866+00 I-5 North Bound			
right	depth			
	mm			
3.7	0		0	
3.4	1		-1	
3	3		-3	
2.7	6		-6	
2.4	3		-3	
2.1	0		0	
1.8	0		0	
1.5	1		-1	
1.2	5		-5	
0.91	6		-6	
0.61	4		-4	
0.3	2		-2	
0	0		0	

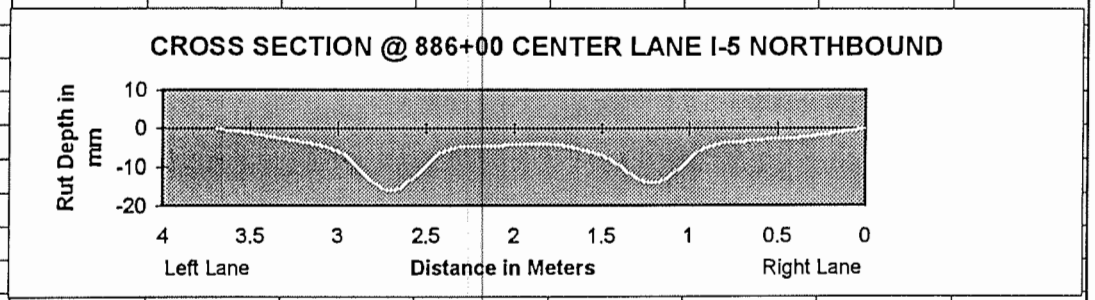




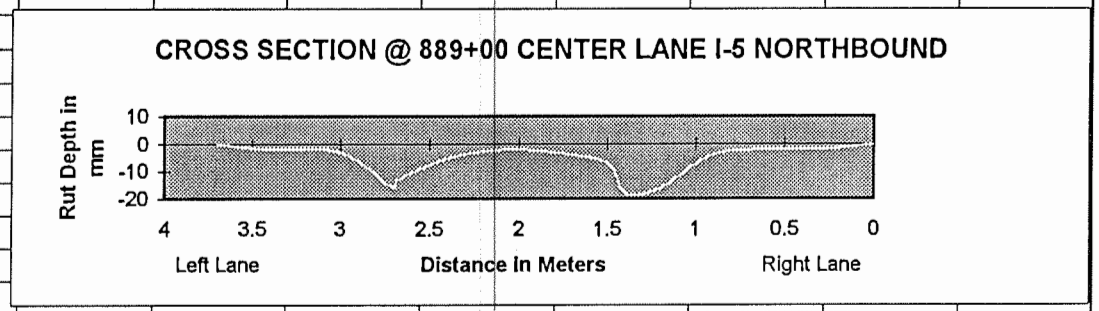
cross section @ 886+00 right lane I-5 northbound			
dist	depth		
right	mm		
3.7	0		0
3.4	1		-1
3	5		-5
2.7	8		-8
2.4	5		-5
2.1	2		-2
1.8	3		-3
1.5	4		-4
1.2	5		-5
0.91	6		-6
0.61	5		-5
0.3	1		-1
0	0		0



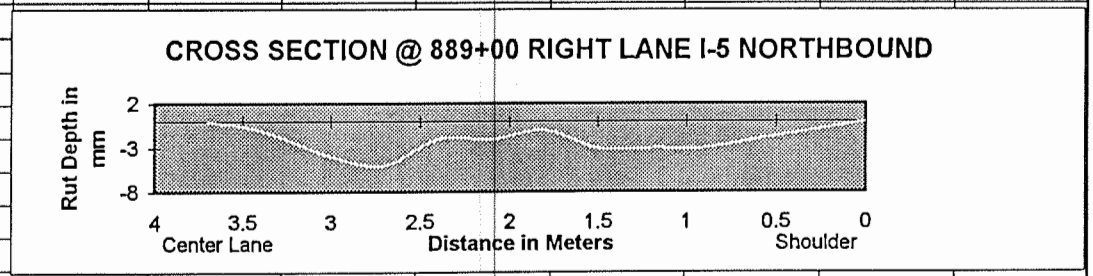
cross section 886+00 center lane I-5 North bound			
dist	depth		
right	mm		
3.7	0		0
3.4	2		-2
3	6		-6
2.7	16		-16
2.4	6		-6
2.1	4.5		-4.5
1.8	4		-4
1.5	7		-7
1.2	14		-14
0.91	5		-5
0.61	3		-3
0.3	2		-2
0	0		0



cross section 889+00 center lane I-5 North bound			
dist	depth		
right	mm		
3.7	0		0
3.4	2		-2
3	3		-3
2.7	16		-16
2.68	13		-13
2.4	5		-5
2.1	2		-2
1.8	3		-3
1.5	7		-7
1.4	18		-18
1.2	16		-16
0.91	4		-4
0.61	2		-2
0.3	2		-2
0	0		0



cross section 889+00 right lane I-5 North bound			
dist	depth		
right	mm		
3.7	0		0
3.4	1		-1
3	4		-4
2.7	5		-5
2.4	2		-2
2.1	2		-2
1.8	1		-1
1.5	3		-3
1.2	3		-3
0.91	3		-3
0.61	2		-2
0.3	1		-1
0	0		0



APPENDIX C

RUTS AFTER PAVING

Table C.1 Ruts After Paving 105 North Bound MP 276-279 (Taken From 9/10/96 to 9/26/96).

Station	Left Lane		Center Lane		Right Lane		Mix
	Left Wheel Path	Right Wheel Path	Left Wheel Path	Right Wheel Path	Left Wheel Path	Right Wheel Path	
835	0	0	1.52 mm (0.005 ft.)	0			SMA, Fine
840	0	0	1.52 mm (0.005 ft.)	0	0	0	SMA, Fine
845	1.52 mm (0.005 ft.)	0	1.52 mm (0.005 ft.)	0	0	0	SMA, Fine
850	0	0	1.52 mm (0.005 ft.)	0	1.52 mm (0.005 ft.)	0	SMA, Fine
855			1.52 mm (0.005 ft.)	0	0	0	SMA, Course
860			3.05 mm (0.01 ft.)	0	0	0	SMA, Course
865			3.05 mm (0.01 ft.)	0	0	0	SMA, Course
870			0	0	0	0	SMA, Course
875			0	0	0	0	SMA, Course
880			0	0	0	0	SMA, Course
885			0	0	0	0	SMA, Course
890			0	0	0	0	F-Mix with Fibers
895			0	0	0	0	F-Mix with Fibers
900			0	0	1.52 mm (0.005 ft.)	0	F-Mix with Fibers
905			0	0	0	0	F-Mix with Fibers
910			0	0	0	0	F-Mix with Fibers
915			3.05 mm (0.01 ft.)	0	0	0	F-Mix with Fibers
920			3.05 mm (0.01 ft.)	0	0	0	F-Mix with Fibers
925			0	0	0	0	F-Mix with Fibers
930			0	0	0	0	F-Mix
935			0	0	0	0	F-Mix
940			0	0	0	0	F-Mix
945			0	0	0	0	F-Mix
950			0	0	0	0	F-Mix
955			0	0	0	0	F-Mix
960			0	0	0	0	F-Mix

APPENDIX D

WEATHER CONDITIONS

Station: NO. WILLAMETTE RESEARCH | County: CLACKAMAS | State: OREGON | Date (Mo & Yr): SEPT 1996 | Time of Observation: 7:00 am PACIFIC

RECORD OF EVAPORATION AND CLIMATOLOGICAL OBSERVATIONS

Date	Air Temperature F							Precipitat	Wind		Evaporation	Water Temp. F		Additional Data Remarks			
						6"	Therm			24 Hr				Soil Temperature F			
	Max	Min	Degree Days	Dry	Wet	Max	Min		1996			Max	Min	2" Max	2" Min	8" Max	8" Min
1	71	47	9.0	60	56	85	48	t	19599	32	0.22	104	82	80	74	98	56
2	78	47	12.5	49	47	86	48	0.00	19628	29	0.23	106	81	80	77	102	57
3	74	46	10.0	52	51	80	47	0.00	19644	16	0.10	98	85	nr	nr	nr	nr
4	73	47	10.0	49	49	79	48	0.00	19670	27	0.06	98	82	80	77	94	57
5	67	45	6.0	52	50	72	45	0.00	19710	40	0.15	93	80	73	70	80	53
6	67	44	5.5	48	47	69	44	0.04	19744	34	0.00	90	80	70	68	77	50
7	74	47	10.5	55	53	81	46	0.00	19764	20	0.09	100	80	74	70	95	60
8	80	50	15.0	59	57	89	50	0.00	19790	27	0.28	106	82	78	75	102	60
9	82	52	17.0	53	51	90	52	0.00	19814	24	0.15	109	84	79	75	105	60
10	77	46	11.5	48	47	90	46	0.00	19838	24	0.10	105	82	78	74	102	56
11	89	47	18.0	55	55	95	46	0.00	19551	-287	nr	106	79	80	76	106	61
12	81	54	18.5	60	58	90	54	0.00	19883	332	0.15	104	78	79	75	100	64
13	65	55	10.0	60	57	66	55	0.00	19910	28	0.01	88	84	68	60	73	70
14	70	55	12.5	59	56	66	53	0.27	19973	62	(0.15)	92	84	73	68	72	56
15	64	53	7.5	56	54	68	70	1.35	20028	55	(1.23)	90	82	68	66	68	56
16	64	46	5.0	49	49	61	46	0.87	20060	32	(0.87)	90	79	66	52	66	50
17	66	46	7.0	50	50	66	46	0.32	20115	54	(0.28)	92	79	66	64	76	54
18	68	41	4.5	45	43	70	42	0.00	20127	12	0.10	98	80	68	62	80	49
19	65	42	3.5	55	55	65	42	0.11	20156	29	(0.04)	92	80	64	62	72	55
20	67	45	6.0	47	47	68	45	0.00	20187	32	0.00	94	80	64	64	74	51
21	77	42	9.5	48	47	72	42	0.00	20205	18	0.09	97	82	66	64	80	50
22	65	42	3.5	44	44	70	42	0.10	20223	18	0.00	93	80	66	62	80	48
23	64	43	3.5	47	43	69	42	0.00	20251	28	0.15	96	78	66	62	79	46
24	73	80	6.5	43	43	76	40	0.00	20277	26	0.14	94	76	66	62	77	47
25	74	40	7.0	49	47	80	40	0.00	20292	16	0.08	98	78	61	46	66	61
26	75	45	10.0	48	46	81	46	0.00	20311	21	0.15	100	80	67	63	84	50
27	80	46	13.0	48	47	89	46	0.00	20329	16	0.15	100	78	68	66	86	53
28	82	46	14.0	50	50	88	44	0.00	20340	11	0.15	104	82	70	67	89	54
29	82	49	15.5	62	60	88	48	0.00	20356	17	0.13	105	86	71	66	90	55
30	77	51	14.0	57	55	85	50	0.00	20370	13	0.08	102	86	70	67	87	56
31			50.0							######							
Sum	2193	1399		1555	1510	2334	1413	3.06	600144	######	0.47	2942	2390	2077	1934	2457	1593
Avg	73.1	46.63		51.83	50.33	77.8	47.1	0.10	20005	-631	0.02	98.07	79.67	69.23	64.47	81.9	53.1

WS FORM B-92

STATION 835-6151-2

APPENDIX E

MIX DESIGNS

OREGON DEPARTMENT OF TRANSPORTATION
MATERIALS LABORATORY
800 AIRPORT RD. SE SALEM, OR 97310
(503)986-3100
FAX(503)986-3096

Contract No.: C11804 EA No.: CON01020 Lab No.: 96-005127
Project: MP 276 - MP 279, NB I-5
Type of Test: Mix Design - 301 F Use: HEAVY DUTY F MIX DESIGN W/ LIME

BITUMINOUS MIXTURE DESIGN

Agg. Source : 34-098-2 STEARNS QUARRY QUARRY **Original Mix Design No. : 96-05127**

	Agg Size: 3/4-1/2	1/2-1/4	1/4-0	LIME	Combined Wet Sieve
	% Comb : 34	46	19	1	
1 1/4" :	100	100	100	100	1 1/4": 100
1 :	100	100	100	100	1 : 100
3/4 :	75	100	100	100	3/4 : 92
1/2 :	8	87	100	100	1/2 : 63
3/8 :	3	42	100	100	3/8 : 40
1/4 :	2	5	88	100	1/4 : 21
# 4 :	2	3	72	100	# 4 : 17
10 :	2	3	38	100	10 : 10
40 :	2	2	16	100	40 : 6
200 :	1.3	1.8	8.8	100.0	200 : 3.9
Sp Gr :	2.74	2.72	2.70	2.27	2.718
% Absorb. :	1.75				

% Asphalt :	4.5	5.5	6.5
Sp Gr - 1st :	2.151	2.185	2.209
% Voids-1st :	16.7	14.5	12.0
Max Sp Gr :	2.582	2.557	2.511
Ind Ret Str :			
Drain Dwn % :	40	70	95
V F A :	32	40	50
V M A :	24.4	24.0	24.0

Paving Course	% A/C Tot Wt	% A/C RAP	Max Sp Grav	Brand/Grade: CHEVRON /PBA-6
Wearing Course	5.8		2.543	Asphalt Lab # : 96-004243 Asphalt Sp Grav : 1.010 Additive : LIME 1% Additive : %

JOB MIX FORMULA :

Sieve	% Pass
1 "	100
3/4 "	92
1/2 "	63
1/4 "	21
# 10	10
# 40	6
# 200	3.9

Mixing Temp. : C
Placement Temp. : C

	1st Comp.	2nd Comp.
Design Sp Grav:	2.192	
Design Voids:	13.8	

OREGON DEPARTMENT OF TRANSPORTATION
MATERIALS LABORATORY
800 AIRPORT RD. SE SALEM, OR 97310
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Contract No.: C11804 **EA No.: CON01020** **Lab No.: 96-004593**

Project: MP 276 - MP 279, NB I-5

Type of Test: Mix Design - 301 SMA-C **Use: HEAVY DUTY CRSE SMA MIX W/ LIME**

BITUMINOUS MIXTURE DESIGN

Agg. Source : 34-098-2 STEARNS QUARRY QUARRY **Original Mix Design No. : 96-04593**

Agg Size:	1/2-1/4	1/4-0	MIN FIL	LIME	Combined Wet Sieve
% Comb :	69	26.5	3.5	1	
1 1/4" :	100	100	100	100	1 1/4": 100
1 :	100	100	100	100	1 : 100
3/4 :	100	100	100	100	3/4 : 100
1/2 :	87	100	100	100	1/2 : 91
3/8 :	42	100	100	100	3/8 : 60
# 4 :	3	72	100	100	# 4 : 26
8 :	3	42	100	100	8 : 18
30 :	2	18	100	100	30 : 11
50 :	2	14	100	100	50 : 10
200 :	1.8	8.8	100.0	100.0	200 : 8.1
Sp Gr :	2.71	2.71	2.81	2.27	2.708
% Absorb. :	1.81	2.06	2.06		

% Asphalt :	5.5	6.0	6.5	7.0
Sp Gr - 1st :	2.324	2.343	2.361	2.360
% Voids-1st :	7.2	5.5	4.2	3.6
Max Sp Gr :	2.503	2.480	2.465	2.448
Ind Ret Str :	86		93	
Drain Dwn % :	0	0	0	0
V F A :	62	71	77	81
V M A :	18.9	18.7	18.5	19.0

Paving Course	% A/C Tot Wt	% A/C RAP	Max Sp Grav
Wearing Course	6.5		2.465

Brand/Grade: CHEVRON /PBA-6
Asphalt Lab # : 96-004243
Asphalt Sp Grav : 1.010
Additive : LIME 1%
Additive : MIN FILLER 0.3%

JOB MIX FORMULA :	Sieve	% Pass
	1/2 "	91
	3/8 "	60
	# 4	26
	# 8	18
	# 30	11
	# 50	10
	# 200	8.1

Mixing Temp. : 159-164 C
Placement Temp. : 150-154 C

	1st Comp.	2nd Comp.
Design Sp Grav:	2.361	
Design Voids:	4.2	

OREGON DEPARTMENT OF TRANSPORTATION
MATERIALS LABORATORY
800 AIRPORT RD. SE SALEM, OR 97310
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Contract No.: C11804 **EA No.: CON01020** **Lab No.: 96-004651**

Project: MP 276 - MP 279, NB I-5

Type of Test: Mix Design - 301 SMA-F **Use: HEAVY DUTY FINE SMA MIX W/ LIME**

BITUMINOUS MIXTURE DESIGN

Agg. Source : 05-037-1 DEER ISLAND PIT QUARRY **Original Mix Design No. : 96-04651**

Agg Size:	3/8-4	1/4-0	min.fill.	lime	Combined Wet Sieve
% Comb :	55	39.5	4.5	1	
1 1/4" :	100	100	100	100	1 1/4": 100
1 :	100	100	100	100	1 : 100
3/4 :	100	100	100	100	3/4 : 100
1/2 :	100	100	100	100	1/2 : 100
3/8 :	92	100	100	100	3/8 : 94
# 4 :	6	72	100	100	# 4 : 27
8 :	1	42	100	100	8 : 17
30 :	1	18	100	100	30 : 11
50 :	1	14	100	100	50 : 10
200 :	0.2	8.8	100.0	100.0	200 : 7.8
Sp Gr :	2.68	2.71	2.59	2.27	2.684
% Absorb. :	1.66	2.06	2.06		

% Asphalt :	6.0	6.5	7.0	7.5
Sp Gr - 1st :	2.308	2.332	2.353	
% Voids-1st :	7.2	5.6	3.8	
Max Sp Gr :	2.488	2.470	2.446	
Ind Ret Str :		95		92
Drain Dwn % :	0	0	0	0
V F A :	62	70	79	
V M A :	19.2	18.8	18.5	

Paving Course	% A/C Tot Wt	% A/C RAP	Max Sp Grav
Wearing Course	6.5		2.470

Brand/Grade: CHEVRON /PBA-6
Asphalt Lab # : 96-004243
Asphalt Sp Grav : 1.010
Additive : LIME 1%
Additive : MIN FILLER 0.3%

JOB MIX FORMULA : Sieve	% Pass
1/2 "	100
3/8 "	96
# 4	37
# 8	23
# 30	13
# 50	12
# 200	9.1

Mixing Temp. : 159-164 C
Placement Temp. : 150-154 C

	1st Comp.	2nd Comp.
Design Sp Grav:	2.332	
Design Voids:	5.6	

OREGON DEPARTMENT OF TRANSPORTATION
MATERIALS LABORATORY
800 AIRPORT RD. SE SALEM, OR 97310
(503)986-3100
FAX(503)986-3096

Contract No.: C11804 EA No.: CON01020 Lab No.: 96-005112
Project: MP 276 - MP 279, NB I-5
Type of Test: Mix Design w/ MR - 301 M **Use: HEAVY DUTY D MIX DESIGN W/ LIME**

BITUMINOUS MIXTURE DESIGN

Agg. Source : 34-098-2 STEARNS QUARRY QUARRY **Original Mix Design No. : 96-05112**

	Agg Size: 1/4-0	LIME			Combined Wet Sieve
	% Comb : 99	1			
1 1/4"	100	100			100
1	100	100			100
3/4	100	100			100
1/2	100	100			100
3/8	100	100			100
1/4	88	100			88
# 4	72	100			72
10	38	100			39
40	16	100			17
200	8.8	100.0			9.7
Sp Gr	2.71	2.27			2.710
% Absorb.	2.07	2.06	2.06		

% Asphalt	5.0	5.5	6.0	6.5	7.0	7.5
Sp Gr - 1st	2.352	2.376	2.391	2.441	2.451	
% Voids-1st	8.6	6.6	5.0	2.7	1.4	
Stabil-1st	34	36	33	32	31	
Sp Gr - 2nd	2.420	2.436	2.461	2.491	2.479	
% Voids-2nd	5.9	4.3	2.2	0.7	0.3	
Stabil-2nd	35	36	31			
Max Sp Gr	2.572	2.545	2.517	2.508	2.486	
Ind Ret Str		81		80		88
Ind Ret Mr		108		118		120
Eff A/C %	0.0	0.0	0.0	0.0	0.0	
V F A	50	61	71	83	91	
V M A	17.5	17.1	17.1	15.8	15.9	
200/AC Ratio	1.4	1.3	1.2	1.1	1.0	

Paving Course	% A/C Tot Wt	% A/C RAP	Max Sp Grav	Brand/Grade: MCCALL OIL /PBA-5
				Asphalt Lab # : 96-004452
				Asphalt Sp Grav : 1.016
Leveling Course	6.1		2.515	Additive : LIME 1%
				Additive : %

JOB MIX FORMULA : Sieve	% Pass
1 "	100
3/4 "	100
1/2 "	100
1/4 "	88
# 10	39
# 40	17
# 200	7.2

Mixing Temp. : 150-155 C
Placement Temp. : 141-145 C

	1st Comp.	2nd Comp.
Design Sp Grav:	2.401	2.467
Design Voids:	4.5	2.0