EVALUATION OF POROUS PAVEMENTS FOR ROAD SURFACES

INTERIM REPORT

by

Krey Younger
Graduate Research Assistant

Dr. R.G. Hicks
Professor

and

Dr. Manfred Partl
Visiting Associate Professor

Department of Civil Engineering
Oregon State University
Corvallis, OR 97331

Prepared for

Oregon Department of Transportation
Salem, OR 97310

and

Federal Highway Administration
Washington, DC 20590

January 1994

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-OR-RD-95-03		

4. Title and Subtitle	5. Report Date
Evaluation of Porous Pavements for Road Surfaces: Interim Report	January 1994
	6. Performing Organization Code: TRR-93-23
7. Author(s): Krey Younger, R.G. Hicks, and M. Partl	8. Performing Organization Report No.: FHWA-OR-RD-95-03
9. Performing Organization Name and Address: Oregon State University, Department of Civil Engineering, Corvallis, OR 97331-2302	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.: SPR 5298
12. Sponsoring Agency Name and Address: Oregon Dept of Transportation, Research Unit, Salem, OR 97310; Federal Highway Administration, 400 Seventh Street SW, Washington, DC 20590	13. Type of Report and Period Covered: Interim Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Porous pavements or open graded asphalt mixtures have been in use in Oregon since the late 1960s. The use of this pavement type has increased over the years because the pores in the mat provide a better way for water to drain from the surface. This greatly increases the safety in the areas of skid resistance and splash and spray. Added benefits to these pavements are that sound emitted from tire noise is partly absorbed into the voids of the pavement.

Not all the attributes of porous pavements are beneficial. There have been some durability and construction problems associated with this pavement type. Experience and trial and error have reduced many of the disadvantages of porous pavements. Recent experiences with these mix types in the U.S. and abroad have been positive.

17. Key Words	18. Distribution Statement
Asphalt pavements, overlays, design, porous asphalt mixtures	No restrictions

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	29	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

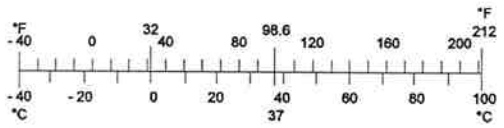
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	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)

ACKNOWLEDGEMENTS

The authors would like to thank the Technical Advisory Committee (see list below) for their input regarding this project and their review of this report:

Chuck Curtis, ODOT District Manager
Dick Dominick, ODOT Materials Unit
Rob Edgar, ODOT Materials Unit
Jeff Gower, ODOT Pavements Unit
Gene Hoelker, FHWA
Jim Huddleston, Asphalt Paving Association of Oregon
Scott Nodes, ODOT Research Unit
Bob Reinhard, Morse Bros.
Ken Stoneman, ODOT Region 2
Gary Thompson, ODOT Operations Support Section

DISCLAIMER

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 Background

Oregon began experimenting with an open graded type asphaltic concrete in the 1930s. Early tests showed high skid resistance and decreased glare from headlights. Due to the noticed advantages, this pavement type developed into the plant-mix seal coat that saw substantial use by Western states in the late 1940s and 1950s (Copas, et al., 1978). The late 1970s saw the change in open graded mixtures that started Oregon toward the designation of their E and F mixes (Huddleston et al., 1993).

These mixtures were originally developed as a friction course, but they have also proven to reduce noise, splash and spray, and rutting. These benefits, along with some problems such as reduced durability and increased winter maintenance have made it necessary to improve the quality of the mixes used in porous pavements. To facilitate this improvement, there is a need to quantify the improved safety as well as monitor the change in mixture properties (e.g., permeability, voids, etc.) over time. Finally, there is a need to evaluate the feasibility of placing porous pavements on both existing and new portland cement concrete, because of the limited experience in this area.

1.2 Scope of Study

This study consists of six tasks:

- Task 1: Literature review/questionnaire survey
- Task 2: Field evaluation of porous pavements used in Oregon
- Task 3: Laboratory evaluation
- Task 4: Analysis of data

- Task 5: Field study
- Task 6: Reports

This literature review will complete the first task in a study of porous pavements used in Oregon. It evaluates the studies which have been completed on porous pavements, and identifies what needs to be accomplished. Included in this review is a summary of the questionnaire results from both contractors and users of porous pavements.

2.0 TYPES OF POROUS PAVEMENTS

The purpose of this chapter is to define the properties of a porous pavement. These properties will be related to the aggregate, asphalt binder, and compacted mix.

2.1 Aggregate

2.1.2 Gradation

Aggregate selection is an important part of the pavement. The Oregon Department of Transportation (ODOT) uses two types of open graded pavements, and one type of open graded emulsion mixture (OGEM). The gradations for the open graded E and F-mix and the OGEM, along with the standard dense graded B-mix are shown in Table 2.1 (ODOT, 1993). Also included in the table are the gradations for open graded mixes used by the Federal Highway Administration (FHWA, 1992), the Arizona Department of Transportation (Hossain et al., 1991), and the Australian State Road Authority (AAPA, 1993).

Table 2.1 Broadband limit gradations

Sieve size % passing	1"	3/4"	1/2"	3/8"	1/4"	No. 8	No. 10	No. 40	No. 200
B-mix (ODOT)	99-100	92-100	75-91	—	50-70	—	21-41	6-24	2-7
OGEM (ODOT)		100	95-100	—	15-40				
E-mix (ODOT)	—	99-100	95-100	—	52-72	—	5-15	—	1-5
F-mix (ODOT)	99-100	85-96	60-71	—	17-31	—	7-19	—	1-6
FHWA (WDFD)	—	—		100	33-47	7-13	—	—	2-4
Australia	—	—	100	96	29	12	—	—	4
Arizona DOT	—	—	100	95-100	19-46	0-28	—	0-16	0-5

2.1.2 Aggregate Types

In order to maintain the desired surface microtexture, a good polish resistant aggregate is desired. The aggregate must be 100% crushed material with at least 75% by weight of the coarse aggregate having at least two fractured faces, and 90% with one or more fractured faces. This enhances the structural stability, particularly with thicker layers (Smith, 1992).

2.2 Asphalt Binders

2.2.1 Asphalt Content

Section 745.12 of the Oregon Specifications states that the asphalt content should be 4-8% by weight for the total mix. The actual job mix formula (JMF) is to be submitted to and approved by the ODOT Engineer of Materials and Research (ODOT, 1993). The large proportion of voids in porous pavements necessitate a high binder film thickness on the aggregates. This reduces the oxidation of the binder. Typical dense graded mixes achieve a 4-8 micron average film thickness, but porous pavements achieve 20-25 micron film thickness. Because of this, the asphalt tends to have a problem with draining down to the bottom of the mixture. Asphalt cements used in open graded mixtures have to be resistant to this effect. Research has been conducted in Belgium concerning the addition of cellulose fibers to the mix as a mineral filler to help the asphalt cement hold on to the aggregate (Decoene, 1990). Mixing temperature is also reduced well below that of conventional dense graded mixtures. The maximum recommended temperature at the mixer is 265°F (129° C) for open and 325°F (163°C) for dense graded mixtures (OSHD, 1991).

2.2.2 Asphalt Grade

The current ODOT specifications for use in open graded mixes are shown in Table 2.2 (Huddleston et al. 1993).

Table 2.2 Binder specifications for porous pavements (After Huddleston et al., 1993)

Asphalt Binder Test	Asphalt Binder Grade	
	PBA-5 (mild climate)	PBA-6 (cold climate)
Penetration (4°C, 200 g. 60s) dmm	15 min.	30 min.
Absolute Viscosity (60°C) P RTFO Aged Residue	4000 min.	5000 min.
Kinematic Viscosity (135°C) CST RTFO Aged Residue	400 min.	400 min.

The FHWA technical advisory T5040.31 recommends AC-20 for use with open graded mixtures (FHWA, 1990). It also adds that this can be modified for different mixture needs.

2.2.2.1 Polymers

Polymer modified asphalts are believed to provide better stability and resistance to ravelling (Booth, 1991). A study in Spain has shown that the use of polymeric bitumen can diminish the effect of post compaction of porous pavements (Ruiz et al., 1990). This same study has shown that the use of the polymer bitumen can significantly reduce the problem of asphalt draindown.

2.2.2.2 Emulsions

Open graded emulsion mixes have been used throughout Oregon. These mixes generally use a CMS-2 or CMS-2h emulsion (Hicks et al., 1993). Open graded emulsions are also being used as a method of patching hot mixed open graded asphalt.

2.3 Mix Properties

2.3.1 Voids

Porous pavement mix properties seem to be constantly changing. When ODOT constructed their first open graded mixes, the design voids were around 10 to 15%. Presently the F-mixes are being designed for 15-20% voids in the mixture (ODOT, 1993). This is because experience has shown that increasing the voids in porous pavements provides greater safety advantages without reducing the durability of the mixture. Voids used in Arizona are 22% (Hossain et al., 1991), 15-20% in France (Berengier et al., 1990), and 20% in the United Kingdom (Nelson et al., 1990).

2.3.2 Strengths

Research by Caltrans in 1989 indicated that the 70°F (21°C) resilient modulus of OGFC is around 150 ksi (1.03 GPa) (Moore, 1989). A similar study by the Arizona DOT produced a 77°F (25 °C) resilient modulus of 185 ksi (1.27 GPa) (Gameyel et al. 1988). This shows that there is some agreement as to the modulus of porous pavements. Pavement designers at ODOT have stated that because of the relatively low structural capacity of the F-mix, this pavement type is generally used as a wearing course, and not considered part of the pavement's strength. The idea that the porous mixture does not contribute to the structural strength is supported by FHWA (FHWA, 1990).

2.4 Uses of Porous Pavements

There are various uses for porous pavements. These can be divided into two major categories, one is a partial depth pavement overlay which improves the condition of the pavement surface. The other is a full depth porous pavement which allows the surface water to drain through all of the pavement layers.

2.4.1 Partial Depth

Generally, porous pavements are used as a non-structural friction course. The depth of these pavement layers are usually around 1.5 to 2 inches (3.8 to 5.1 cm). Open graded pavements are usually only placed over sound underlying layers because of the low structural capacity. In order to obtain good internal drainage, it is necessary to place a leveling course under the open graded layer, and then seal the leveling course to minimize water infiltration.

2.4.2 Full Depth

Another use of open graded pavements is as a full depth porous pavement structure. The Arizona Department of Transportation conducted a study on full depth porous pavement structures (Hossain et al. 1991). This pavement consisted of an 8 in (200 mm) open graded hot mix, 6 in (150 mm) of open graded asphalt treated base, and an 8 in (200 mm) open graded subbase. A 3500 ft (1070 m) section of this pavement was layed in 1986. This pavement was evaluated for subgrade moisture level, rut depth, pavement distress, structural adequacy using the falling weight deflectometer, ride using the Mays roughness meter, surface friction using the Mu skid resistance meter, and mix properties using core tests. This pavement section has performed quite well, and by 1991 the permeability of the pavement was still significantly above the permeability required to drain the design storm. Interestingly, this pavement had a slightly higher rut depth than the adjacent dense graded control pavement.

3.0 ADVANTAGES AND DISADVANTAGES OF POROUS PAVEMENTS

This chapter discusses the important characteristics of porous pavements and identifies advantages/disadvantages of their use.

3.1 Skid Resistance

A major advantage of porous pavements is their ability to improve wet weather skid resistance. In a dry situation, the skid resistant properties of open graded friction courses (OGFC) are equal to or slightly less than that of a normal dense graded asphalt concrete (DGAC). The main benefit of an OGFC is that the skid resistance is not as speed dependent as conventional pavement. The high macro-texture of the pavement improves the skid resistance at higher speeds (Huddleston et al., 1993). An example of this is shown in Figure 3.1. The skid properties of OGFC at low speeds are not as good because the pavement lacks the necessary micro-texture. Because of this, it is necessary to use high polish resistant aggregate with a high number of fractured faces (Isenring et al., 1990).

Porous pavements have acceptable friction numbers just after construction; however, the friction numbers are lower than ODOT staff would like them to be. Because of the high binder film thickness required for the mix, the surface can be glossy and slippery just after laydown (Booth, 1991). This problem is worse when wet weather occurs after a new surface is finished. ODOT completed a study of five newly constructed F-mix pavements in an attempt to quantify this phenomenon (ODOT, 1993). Figure 3.2 shows the change in friction numbers over time from 0-50 weeks for both B and F-mixes. It can be seen that the friction values of the porous F-mix seem to raise at a slower rate than those for the B-mix. However, ODOT believes that the advantages of

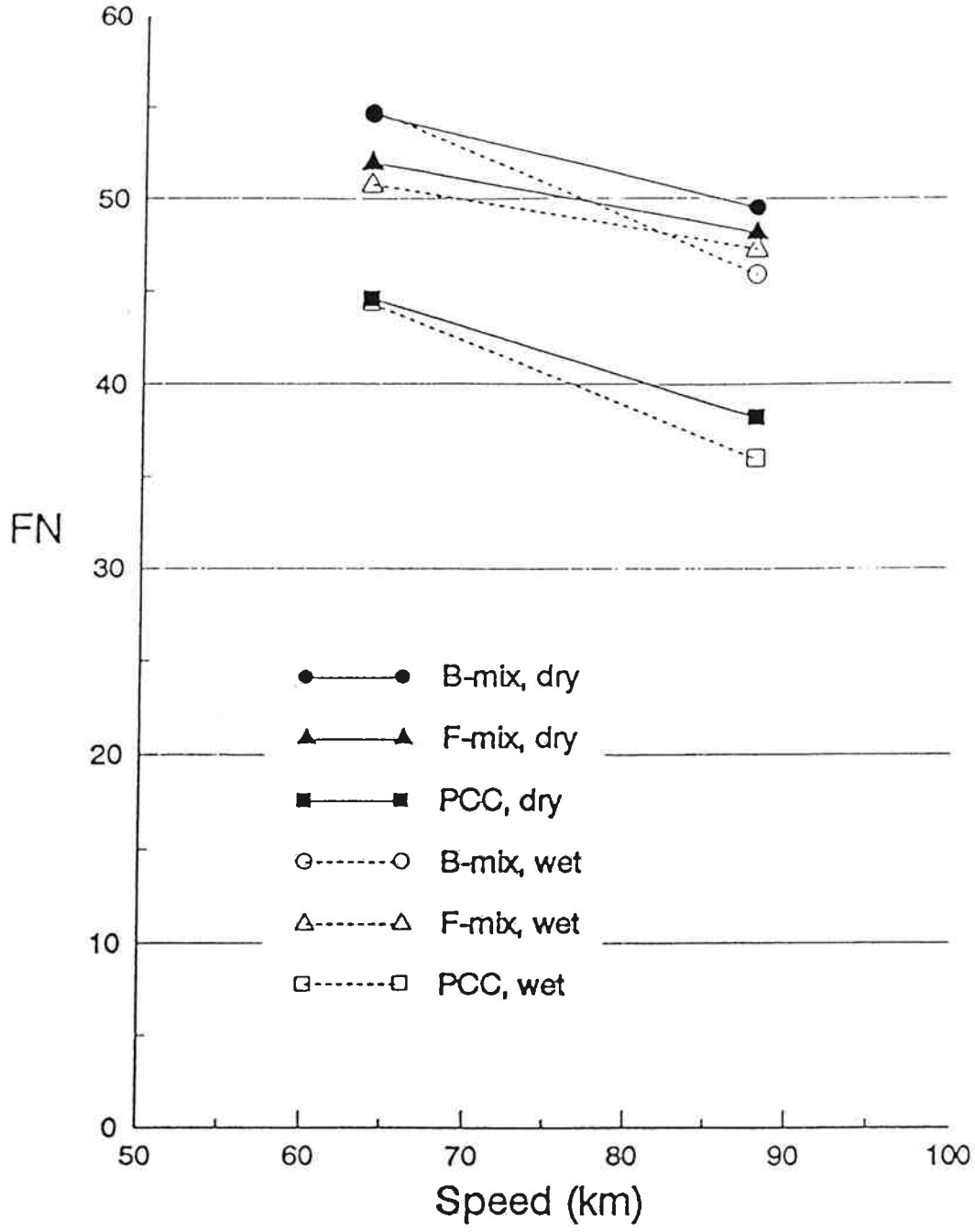


Figure 3.1 Effect of speed and moisture on frictional values (After Huddleston, 1993).

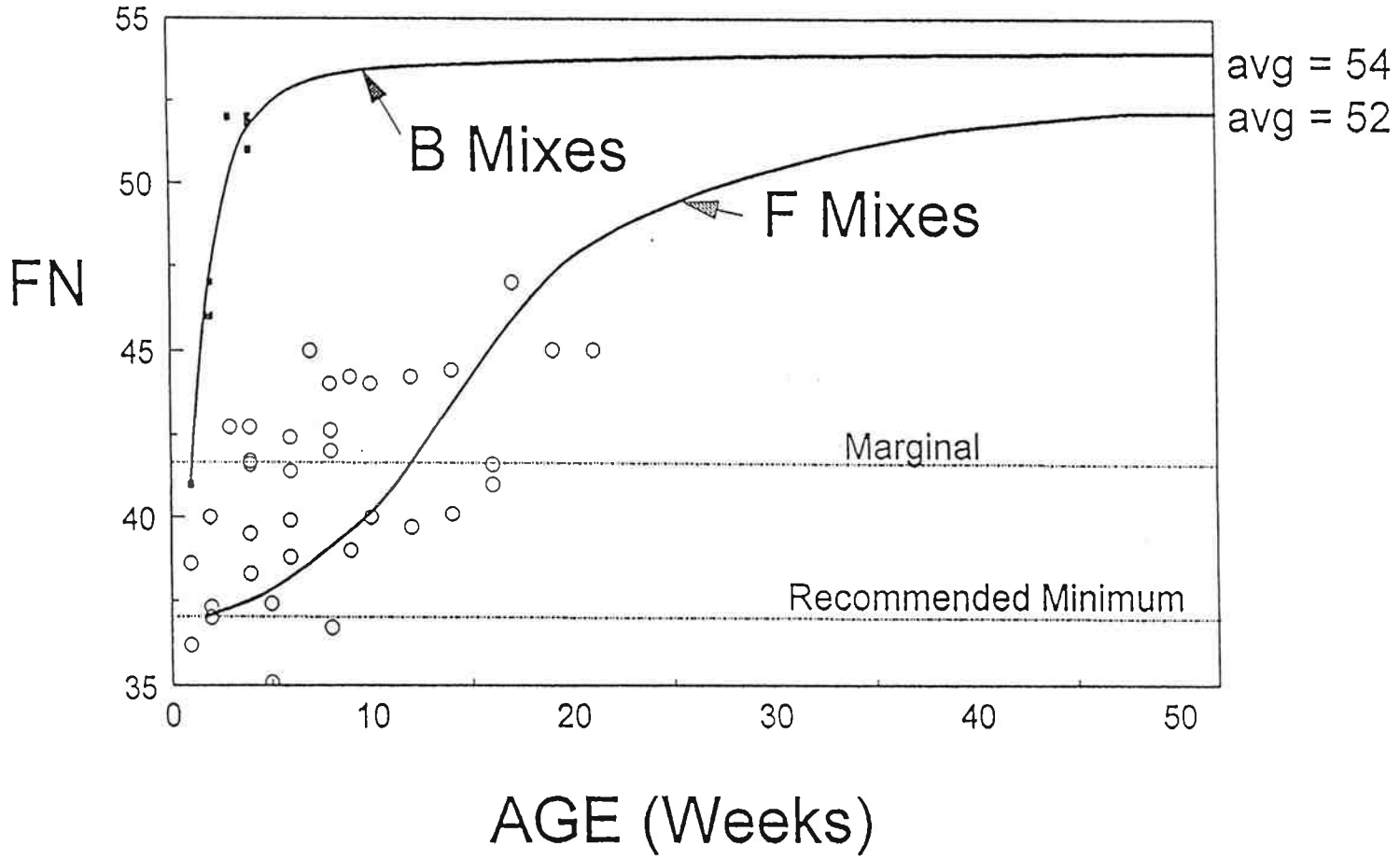


Figure 3.2 Frictional testing of newly constructed mixes (After ODOT, 1993)

porous pavements still outweigh the disadvantages. A few different methods of increasing the friction properties of OGFC include applying a sand seal or lightly grinding the mix surface.

3.2 Noise Reduction

Another benefit of porous pavements is their noise reducing capabilities. When porous pavements were first developed, there were concerns that the increased macro-texture would increase the noise, but the early reaction from drivers was that the noise from porous pavements seemed to be lower (Copas, et al., 1978). Because of this, many studies have been completed dealing with the acoustic properties of porous pavements. The noise levels are a function of traffic flow rate, smoothness of traffic flow, percentage of heavy vehicles in the traffic stream, average speed, gradient of road, and condition and type of pavement surface (Horak, et al., 1994).

The reason porous asphalt pavement is actually quieter than conventional pavements is that the pores absorb some of the sound (Berengier et al., 1990). This is unusual because dense AC and PCC pavements absorb almost none of the sound. A 1986 environmental law that fixed noise emission values in parts of Europe, made the concept of a quiet pavement very desirable. The general consensus is that porous pavements tend to decrease the sound pressures by around 0 to 6 Db(A) (Smith, 1991).

Because the human ear can only detect about a 3 dB(A) change in sound, there must be another reason the public believes porous pavements to be quieter. A number of agencies have conducted 1/3 octave frequency analyses on porous pavements. An example of a typical study was one from the Maryland State Highway Administration (Polcak, 1990). In this experiment, measurements were taken on the northbound and southbound lanes of I-695 at a junction between an OGFC and a PCC pavement. Figure 3.3 shows the results from the northbound lane. Another study is one completed by TRRL in the U.K. (Nelson et al., 1990). This experiment was conducted

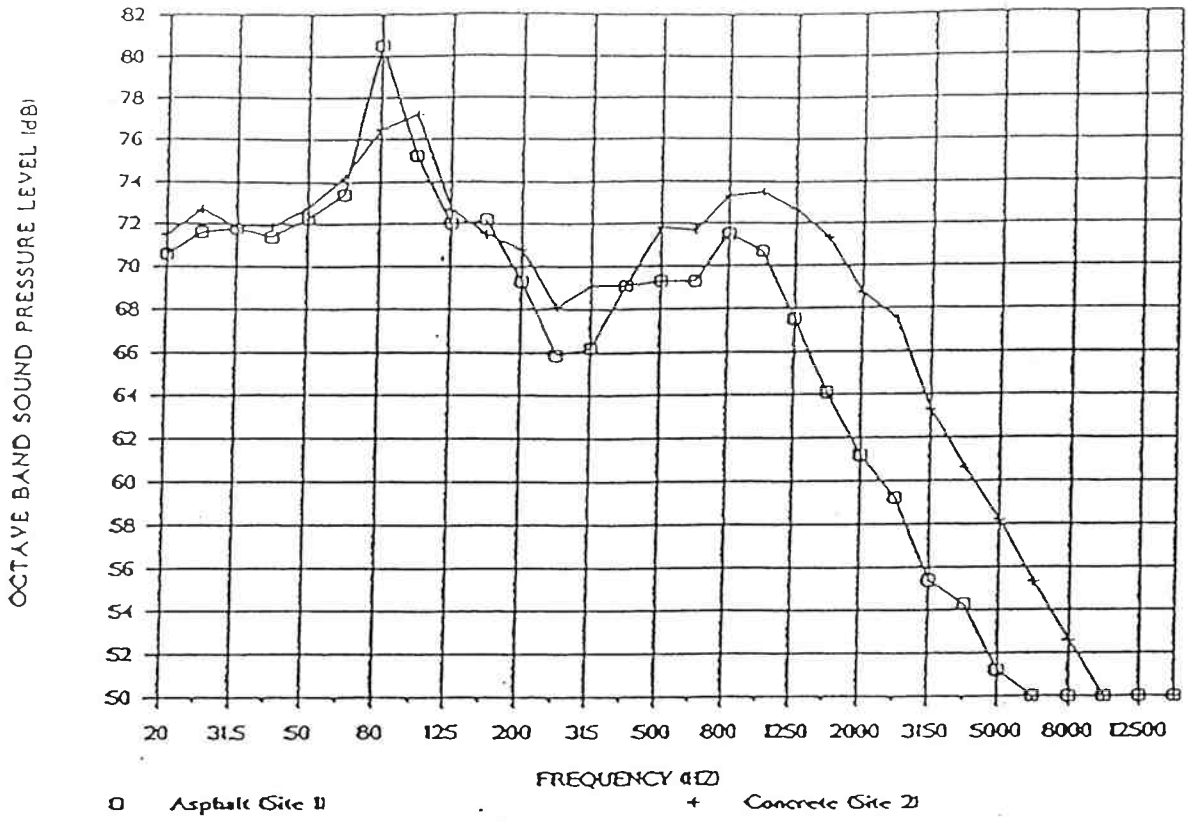


Figure 3.3 Comparison of the 1/3 octave band for porous asphalt and concrete (After Polcak, 1990).

on A38, about 39 km north of Birmingham. This 2.8 km stretch of roadway contained about 15 different types of mixes from conventional hot rolled asphalt (HRA) to polymer modified porous pavement. Figure 3.4 shows the difference in decibel levels between a HRA and a polymer modified OGFC which were layed in 1984. Noise tests were conducted in 1985 and 1988. The graph for both Maryland and the U.K. show that at higher frequency levels (> 600 Hz), the decibel levels decrease. Because humans perceive higher frequencies as being more annoying, porous pavements are believed to provide a quieter ride.

3.3 Hydroplaning

During high intensity rain storms PCC and dense graded AC pavements can pose a hydroplaning safety problem because the surface water may not run off fast enough. The porosity of OGFCs provide an efficient way to drain water from a pavement surface. The rain can escape into the voids of the pavement, thus providing extra drainage which can greatly decrease the problem of hydroplaning (Copas, et al., 1978).

A study in Switzerland evaluated the changes in permeability over time. Figure 3.5 shows how the permeability changed over a five year period. The permeability normally decreases when the pavement voids are filled with soil particles. This effect is reduced in the wheel tracks because of the suction effect from the tires which pulls the soil out of the voids (Isenring et al., 1990).

3.4 Splash and Spray

A significant advantage of porous pavements is the ability of this pavement type to reduce splash and spray. Many agencies have noted this attribute of OGFCs, and there are many good pictorial representations of the reduced spray. An interesting study was carried out by the Transport

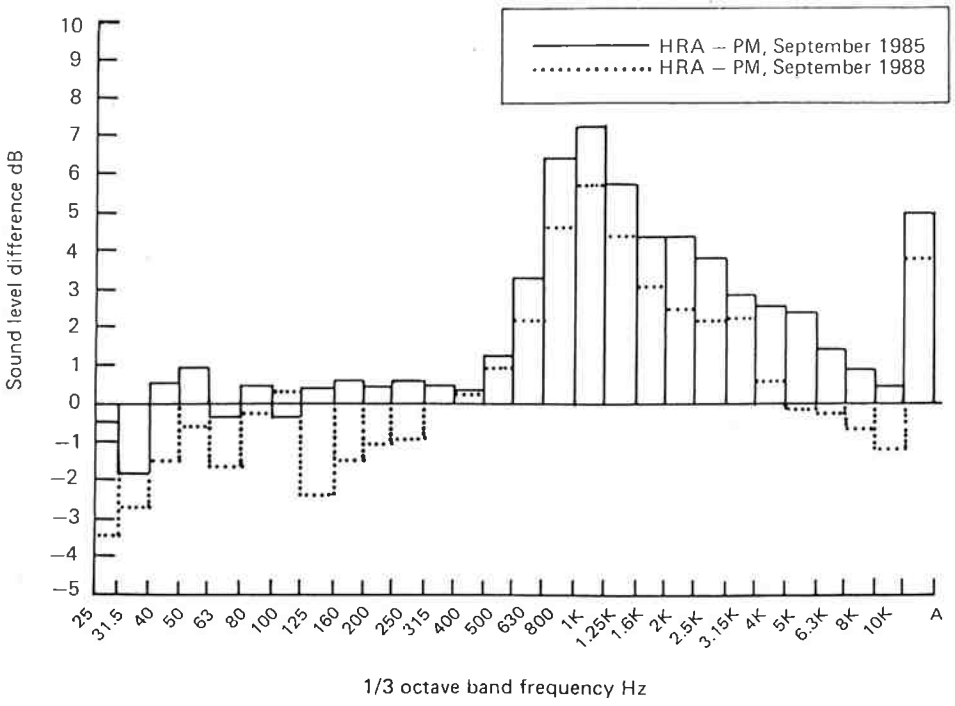


Figure 3.4 Difference between the 1/3 octave spectra obtained on hot rolled asphalt and porous asphalt (90 km/hr) (After Nelson, 1990).

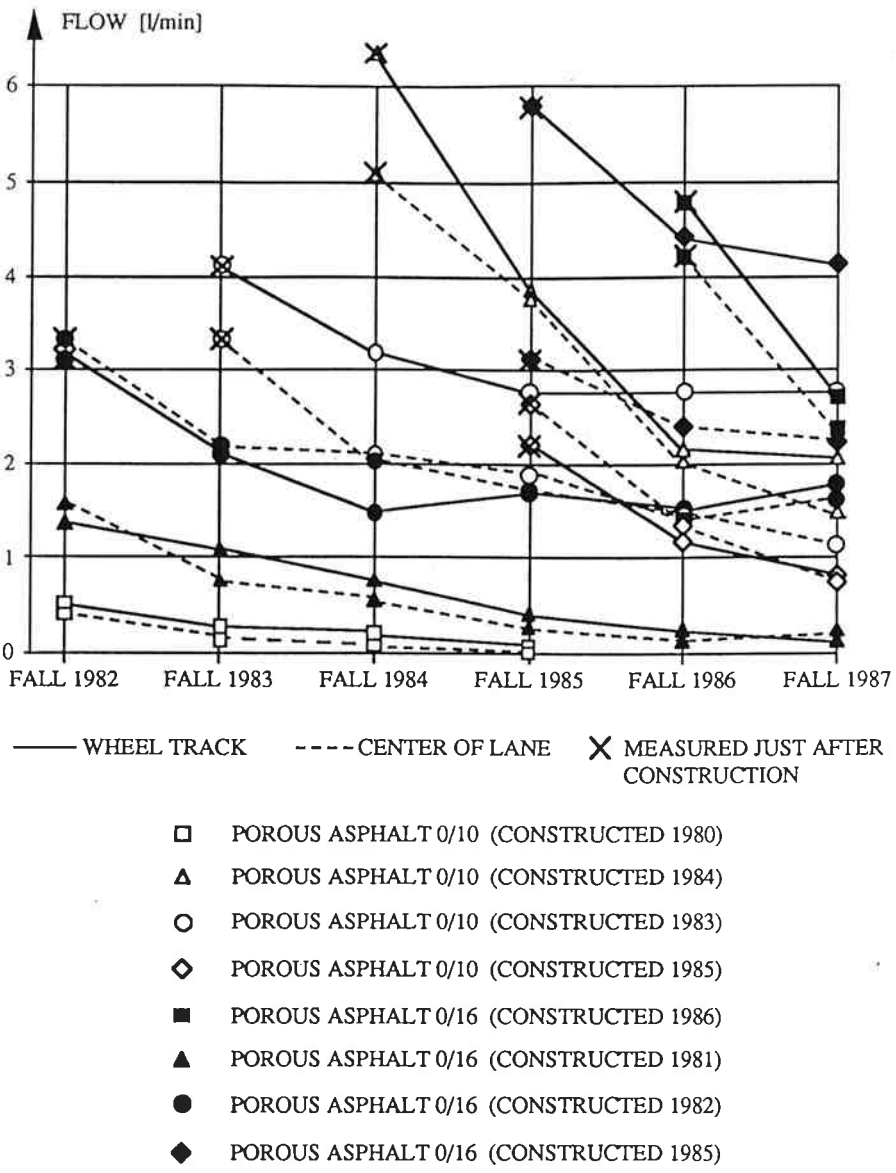


Figure 3.5 Development of permeability with time. (After Isenring et al., 1990)

and Road Research Laboratory (TRRL) in the U.K. using the same pavement strip described in their noise study (Nelson, 1990). TRRL developed an electronic device which measures light backscatter from a laser source in which the spray is measured as a voltage received from the detector. Figure 3.6 shows the graphical representation TRRL used to show the results of their test. The results show that the porous mixes have little to no splash and spray when compared with the control, hot rolled asphalt.

3.5 Construction

From the questionnaire survey (see Chapter 4), some interesting observations on the construction of Oregon's F-mix were noted. There are both good and bad points in the construction of porous pavements. One of the good points is that for compaction, only the number of roller passes required for acceptability is specified. For general construction practices, however, the laydown of porous pavements presents some challenges. Due to the lack of fine particles in the mix, it is difficult to feather the mix to conform to the adjacent pavement grade. Tapers (or any handwork) create problems, as porous mixtures do not rake well. Because porous mixtures have such a high binder film thickness, draindown of the asphalt during hauling can occur. In order to minimize draindown, haul distances have to be reduced. The use of modified binders also reduce draindown.

3.6 Winter Performance

In general, the winter performance of porous pavements has been variable because the macro-texture of an OGFC poses a problem with snow plowing. The blades of the plows have been found to pick the coarse aggregate out of the pavement surface (Huddleston et al. 1993). The increased

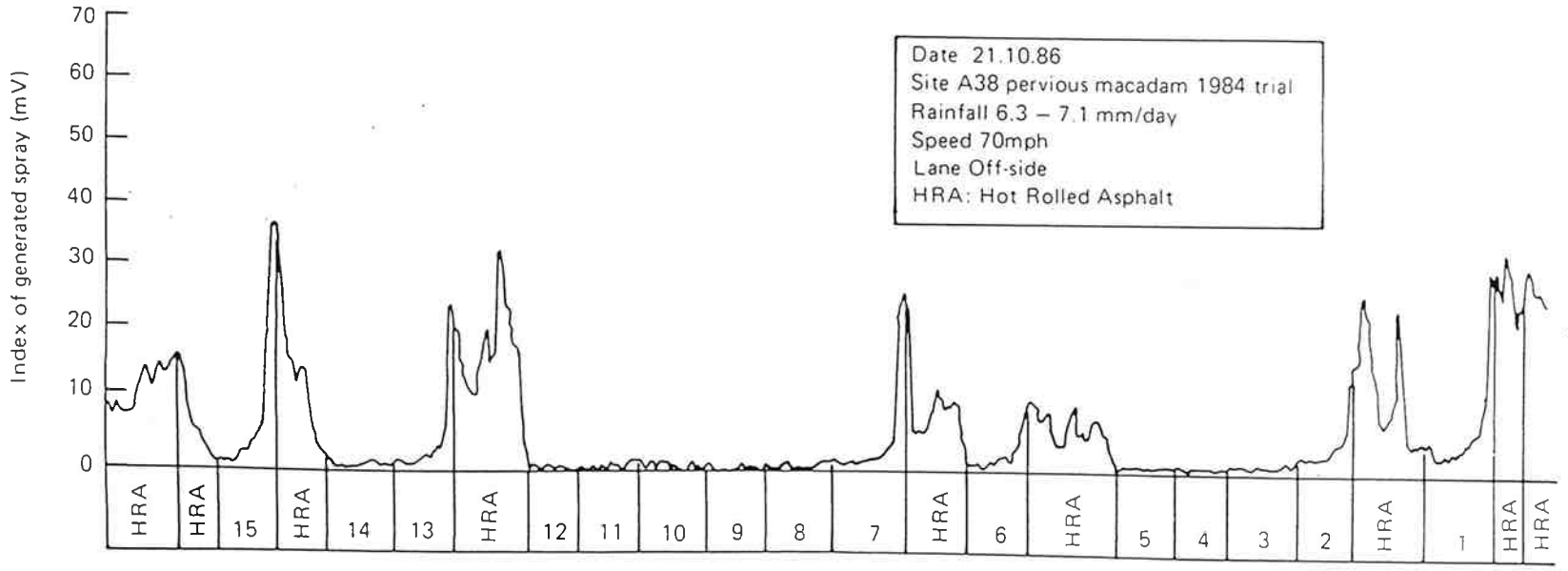


Figure 3.6 Typical spray record for the trial road sections laid on the A38. (After Nelson, 1990)

voids also make it more difficult to use deicing chemicals on porous pavements. The chemicals tend to drain through the porous layer faster than for dense graded pavements. A study in Italy states that porous pavements require about three times the amount of chemical used for dense graded removal (Camomilla et al., 1990). There is not complete agreement on the topic of de-icing chemicals. A survey for OGFC use in the USA is documented in NCHRP Synthesis 180 (Smith, 1992). The survey states that 12 agencies indicated no difference, eight agencies indicated less effectiveness, and two indicated that de-icing chemicals were more effective on OGFC.

Another winter maintenance problem with OGFCs is that the use of sand for winter traction may clog the voids of the pavement and reduce the drainage characteristics. Also, the porosity of this pavement type make it more susceptible to rapid temperature changes. OGFCs tend to freeze faster than conventional pavements. For the same reason, OGFCs have been noted to thaw faster than conventional pavement types. The Italian study also reports research on the winter performance of open graded mixes (Camomilla et al., 1990). An interesting observation by the authors of this paper is that the blade of snowplows tended to compress the snow into the pavement voids until traffic brings the snow to the surface in the form of a slush which easily freezes at low temperatures.

3.7 Oxidation

Oxidation of the porous asphalt surfaces has been a problem (Smith, 1992). When oxidation occurs, the pavement tends to have problems with ravelling. Due to the large quantity of voids in a porous pavement, oxidation of the binder can be a major problem. This can be prevented by the high binder film thickness described earlier.

3.8 Rutting

Porous pavements have shown a considerable resistance to rutting. This is primarily due to the interlock of the large quantity of coarse material in the mix (Huddleston et al. 1993). A study in the U.K. has shown that porous asphalt pavement does not deform excessively (Colwill et al. 1993). The rutting that did occur in their porous pavements was attributed to post compaction of the binder after some aging.

3.9 Glare Reduction

Porous pavements have been known to reduce headlight glare during wet weather. A good example of this is shown in NCHRP Synthesis 180 (Smith, 1992). Without the annoying headlight glare, drivers can see the road more clearly and feel safer about keeping up normal speeds. This can minimize traffic congestion, because the headlight glare is no longer a nuisance to the driver.

3.10 Patching

Patching of open graded mixtures has posed a problem. Since porous pavements drain laterally, large patches of dense graded mix will disrupt the lateral draining. These roads are usually not patched with open graded hot mix, because asphalt batching plants do not like to make small quantities of open graded mix due to the different mixing properties associated with this mix type. A good practice to solve this problem is to patch problem areas with open graded emulsion mixtures.

3.11 Summary

3.11.1 Major Advantages

The following are the major advantages of porous pavements:

- Spray reduction
- Reduced hydroplaning
- Noise reduction
- Improved skid resistance
- Good rutting resistance
- Reduction in headlight glare

3.11.2 Major Limitations

The following are the major limitations of porous pavements:

- Potential construction problems, particularly involving thin lifts
- Increased potential for oxidation
- Increased potential for snow plow damage

4.0 QUESTIONNAIRE SURVEY

This chapter describes the procedure used in the questionnaire survey. It also summarizes some of the major findings which resulted from the survey.

4.1 Scope

A questionnaire survey was conducted with the users of the F-mix in Oregon. These users include the contractors, ODOT project managers (construction), and the ODOT district managers (maintenance). A questionnaire was sent to each of these user groups. Responses were received from 20 out of 48 contractors, 9 out of 16 district managers, and 19 out of 31 project managers. The questionnaire forms are shown in the appendix along with the tabulated results.

These surveys were sent to these groups in an attempt to facilitate better communication of current practices. During the literature search, several problems with porous pavements were discovered. The questionnaires were an attempt to gain the opinions of the users on some of these problems.

4.2 Contractors

The contractors' survey provided a good insight into some of the F-mix construction problems that have been noted, including tapering, feathering, draindown, raking, and chunking. The survey addresses how contractors relate to construction aspects. Question #2 asked the contractors how F-mixes compared to dense graded mixes. On a scale of 1 to 5 (with 1 being very poor, 5 being very good, and 3 being equal), there is agreement that compaction of F-mixes is easier to construct than dense graded mixes (avg = 4.5), and that hand work is more difficult (avg = 1.1).

As far as mixing and laydown, there appeared to be no difference. The tables in the appendix display some of the problems encountered and their solutions.

4.3 Project Managers

The project managers' survey was much like the contractors survey, except that it dealt also with the use of F-mix in different applications. One of the aspects of this survey was a question about placing F-mix over PCC. There was no agreement between the project managers. Some indicated they did not foresee any problems, while others recommended against the process. Some offered no opinion. An interesting result of the survey is that about 50% of the project managers did not have any experience with modified asphalts.

4.4 District Managers

The district managers' survey dealt with the problems of maintaining an F-mix. A section of this survey dealt with winter maintenance areas. There seems to be little agreement between managers. Some say that F-mixes reduce ice problems, that snow dissipates quicker, and that less sanding is required. Others say that winter maintenance is more difficult for F-mixes

Another aspect the district managers were asked about was type and extent of distress. The survey asked the managers to compare F-mix with dense graded mixes in the areas of rutting, potholing, bleeding, reflection cracking, and stripping. On a scale of 1 to 5 (with 1 being very poor, 5 being very good, and 3 being equal), F-mixes came out 4 or higher for all five distress types.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Porous pavements have many desirable characteristics. They reduce noise, hydroplaning, splash and spray, rutting, and cracking. In order to improve upon this pavement type, it is necessary to correct some of the maintenance, oxidation, and construction problems. Since porous pavements greatly improve roadway safety over either dense graded AC or PCC pavements, the advantages of porous pavements seem to outweigh the disadvantages. With further experimentation, the disadvantages may be minimized.

5.2 Research Recommendations

The information gathered during the literature review indicates that ODOT needs to better quantify their porous pavements. A study which documents the change of properties over time would be very helpful. From the reviewed literature, it appears as if many agencies have found that polymerized binders have improved many of the pavements characteristics, but ODOT has not looked into optimizing the mix properties of F-mixes.

The Oregon Department of Transportation should attempt to quantify how their open graded pavements stand up to noise reduction and splash and spray. Devices that could measure these properties could be invaluable in determining which open graded mixtures will work best. The monitoring study will be very helpful in tracking these changes over time.

Placing OGFC over PCC could be beneficial in increasing safety on road surfaces. Due to the lack of agreement between the ODOT managers (or any of the literature reviewed), there is a need to evaluate this practice. Studies should be performed to evaluate this type of composite

pavement. This study should focus on bonding of layers, reflection cracking problems, and conditions required for PCC layers.

6.0 REFERENCES

Anderson, K., Asphalt-Rubber Open-Graded Friction Course: I-5, Vancouver Vicinity, Washington Department of Transportation, 1987, 7 p.

Australian Asphalt Pavement Association, "Open Graded Asphalt," Asphalt Review, December, 1993, pp. 5-8.

Berengier, M., Hamet, J.F., and Bar, P., "Acoustical Properties of Porous Asphalts: Theoretical and Environmental Aspects," TRR 1265, Transportation Research Board, 1990, pp. 9-24

Booth, E., "Some Applications of Open-Grade Asphalt in South Australia," Australian Asphalt Paving Association, 1991, 4 p.

Brule, B., Le Bourlot, F., and Simaillaud, B., "Pervious Macadams: Optimization of the Binder's and Mastic' Composition," Transportation Research Board, 1993, 16 p.

Camomilla, G., Malgarini, M., and Gervasio, S., "Sound Absorption and Winter Performance of Porous Asphalt Pavement," TRR 1265, Transportation Research Board, 1990, pp. 1-8

Colwill, D., et al., "Porous Asphalt Trials in the UK," TRR 1427, Transportation Research Board, 1993, pp. 13-21.

Copas, T.L., and H.A. Pennock, Open Graded Friction Courses for Highways, Syntheses of Highway Practice 49, Transportation Research Board, 1978.

Currie, D., and Bethune, J.D., "Design and Use of Open-Graded Friction Course Asphalt for Road Surfacing," County Roads Board, Victoria, Australia, 1976, 7 p.

Decoene, Y., "Contribution of Cellulose Fibers to the Performance of Porous Asphalts," TRR 1265, Transportation Research Board, 1990, pp. 82-86.

Federal Highway Administration, "Open Graded Friction Courses," FHWA Technical advisory T5040.31, Washington, D.C., 1990.

Federal Highway Administration, "Standard Specifications for Construction of Roads and Bridges for Federal Highway Projects," FP-92, 1992.

Gameyel, C., et al., "Characterization of Hot-Mixed Open-Graded Asphalt Mixtures," TRR 1171, Transportation Research Board, 1988, pp. 181-192.

Gunderson B.L., "Open-Graded Emulsion Mixes in New Zealand," Australian Asphalt Pavement Association, 1988, 4 p.

Hicks, R.G. et al. "Open-Graded Emulsion Mixtures: 25 Years of Experience," TRI Report 94-4, Transportation Research Institute, Oregon State University, 1993, 47 p.

Horak, E., et al., "The Use of Porous Asphalt on Major Roads in Johannesburg," Division for Roads and Transport Technology, South Africa, 1994.

Hossain, M., and Scofield, L., "Porous Pavement for control of Highway Run-Off," Arizona Department of Transportation, July 1991, 47 p.

Huddleston, I.J., Zhou, H., and Hicks, R.G., "Evaluation of Open-Graded Asphalt Concrete Mixtures Used in Oregon", TRR 1427, Transportation Research Board, 1993, pp. 5-12.

Huet, M., et al., "Experiments with Porous Asphalt on the Nantes Fatigue Test Track," TRR 1265, Transportation Research Board, 1990, pp. 54-58.

Isenring, T., Köster, H., and Scazziga, I., "Experiences with Porous Asphalt in Switzerland," TRR 1265, Transportation Research Board, 1990, pp. 41-53.

Kazmierowski, T.J, Bradbury, A., and Hajek, J, "Field Evaluation of Various Types of Open Graded Drainage Layers," Transportation Research Board, 1994.

Moore, R.L., Structural Value of Asphalt Treated Permeable Base and Open Graded Asphalt Concrete, California Department of Transportation, 1989, 27 p.

Nelson, P.M, and Abbot, P.G., "Acoustical Performance of Pervious Macadam Surfaces for High-Speed Roads," TRR 1265, Transportation Research Board, 1990, pp. 25-33.

Nicholls, J.C., and Daines, M.E., "Spray Suppression of Pervious Macadam," Transportation Research Board, 1993, 12 p.

Oregon Department of Transportation, "Friction Testing of Newly Constructed F-Mixes," Inter-office memo, February 1994.

Oregon State Highway Division, "Standard Specifications for Highway Construction," Oregon Department of Transportation, 1991.

Page, G.C., "Open-Graded Friction Courses: Florida's Experience," TRR 1427, Transportation Research Board, 1993, pp. 1-4.

Pérez-Jiménez, F. E., and Gordillo, J., "Optimization of Porous Mixes Through the Use of Special Binders," TRR 1265, Transportation Research Board, 1990, pp. 59-68.

Polcak K., "Field Testing of the Effectiveness of Open-Graded Asphalt Pavement in Reducing Tire Noise from Highway Vehicles," TRR 1255, Transportation Research Board, 1990, pp. 94-101.

Ribbechi, J.J., "Twelve Years History of Open Graded Asphalt Performance," Australian Asphalt Pavement Association, 1986, 5 p.

Ruiz, A., et al., "Porous Asphalt Mixtures in Spain," TRR 1265, Transportation Research Board, 1990, pp. 87-94.

Sainton, A., "Advantages of Asphalt Rubber Binder for Porous Asphalt Concrete," TRR 1265, Transportation Research Board, 1990, pp. 69-81.

Smith, H.A., "Performance Characteristics of Open Graded Friction Courses," NCHRP Syntheses of Highway Practice 180, Transportation Research Board, 1992.

Terrel, R.L, Kleiwer, J.E., and Al-Joaib, A., "Evaluation of Open-Graded "F" Mixtures for Water Sensitivity," ODOT Project number 5252 final report, July 1993.

van der Zwan, Th., et al., "Porous Asphalt Wearing Courses in the Netherlands: State of the Art Review," TRR 1265, Transportation Research Board, 1990, pp. 95-110.

Van Heystraeten, G., and Moraux, C., "Ten Years' Experience of Porous Asphalt in Belgium," TRR 1265, Transportation Research Board, 1990, pp. 34-40.

Verhaeghe, B., "Advantage of Porous Asphalt Wearing Courses," Asphalt News , 1992, 2 p.

"VicRoads (State Road Authority in Victoria) standard specification section 417Q - Open-Graded Friction Course Asphalt," Australia, 1991.

APPENDIX A

Contractors Survey

Name: _____
Position _____
Phone No. _____
Fax No. _____
Address: _____
_____
_____

F-MIX PAVEMENT CONTRACTORS QUESTIONNAIRE

1. Have you constructed an F-mix pavement in the last five years? (Circle one)

   1 YES
   2 NO

   → 1a. Briefly, please explain why you have not been involved with this pavement type before returning this questionnaire.

2. How would you rate the following F-mix construction processes as compared to conventional dense graded mixes? (Circle one number for each

	VERY POOR				VERY GOOD
a) Mixing	1	2	3	4	5
b) Compaction	1	2	3	4	5
c) Hand work	1	2	3	4	5
d) Laydown	1	2	3	4	5

3. Please indicate whether or not you use the following methods to deal with draindown. (Circle one number for each)

	YES USE	DON'T USE
a) Lower mix temperature	1	2
b) Remixing at site	1	2
c) Lower asphalt content	1	2
d) Other (specify _____)	1	2

4. Do you have a problem with chunking of your F-mixes? (Circle one number)

1 NO
2 YES

4a. Briefly, what is the primary cause for the chunking, and what is the cure?

5. Are the porous pavements easier to compact than conventional mixtures? (Circle one number)

1 YES (Answer question 5a.)
2 NO (Answer question 5b.)

5a. Briefly, why are porous pavements easier to compact?

5b. Briefly, what compaction problems are found?

6. How soon after final rolling pass can traffic be allowed on the new mixture? (Circle one)

1 Immediately
2 Within 1 to 2 hours
3 Other (specify _____)

7. How does modified asphalt (PBA-6) effect the constuctability of F-mixes

8. Briefly, how do you deal with the problem of tapering an F-mix?

9. Briefly, how do you deal with the problem of feathering an F-mix?

10. Are there any conventional pavement construction processes you feel can not be reasonably achieved with an F-mix?

11. Is there anything else you would like to say about porous pavements?

Please return this questionnaire to:

Dr. R. Gary Hicks
Professor of Civil Engineering
Oregon State University
Covell Hall 106
Corvallis, OR 97331

QUESTION #3 Please indicate whether or not you use the following methods to deal with draindown.

CONTRACTOR	LOWER MIX TEMP.	REMIXING AT SITE	LOWER ASPHALT CONTENT	OTHER (SPECIFY)	COMMENTS
Bracelin-Yeager Excavating & Trucking Irv Yeager	Yes	Yes			
Copeland Paving, Inc. Dennis Krois	Yes	No	Yes		
Eagle-Elsner, Inc. David Elsner	Yes		No		Remixing at site depends on haul distance.
Eugene Sand & Gravel, Inc. Kevin Alltucker	Yes	No	Yes		
J.C. Compton, Contractor Inc. Mike Flanigan					We have done 7 or 8 F-mix jobs with no drain down.
LTM, Incorporated Robert E. Vaughn	Yes	No	No		
Morse Bros., Inc. Robert R. Reinhard	Yes	Yes			
North Santiam Paving Co. Ron Bochsler	Yes	No	Yes	P.U. or Transfer Machine	Remixing or what we'd refer to as reload would be the answer for projects exceeding a 45 min. haul time. Regarding oil content: With our projects state design persons have been more concerned with keeping oil percentage to maximum per mix design. Not being overly concerned with a few supreme boils.
Road & Driveway Co. Bob Wienert	Yes	No	Yes		
Rogers Asphalt Paving Co. Don Hampton	No	No	No		
Roseburg Paving Co. Steve Loosley	Yes	No	No		We don't have problems.

QUESTION #1: Have you constructed an F-mix pavement in the last five years?

CONTRACTOR	YES	NO	COMMENTS
Baker Rock Resources James A. Records		X	No F-Mix projects have been constructed in our area.
Bracelin-Yeager Excavating & Trucking Irv Yeager	X		
Copeland Paving, Inc. Dennis Krois	X		
Eagle- Elsner, Inc. David Elsner		X	Primary reason: We have bid F Mix projects, but haven't been the low bidder.
Eugene Sand & Gravel, Inc. Kevin W. Alltucker	X		
Harney Rock and Pavement Troy Hooker		X	None has bid in our area.
J.C. Compton, Contractor Inc. Mike Flanigan	X		
K.F. Jacobsen & Co., Inc. Donald R. Donovan		X	Have not bid any F-Mix because of stock pile room for aggregates. We are a commercial plant and run to may mixes at 300-325 degrees.
Lakeside Industries Charles W. Gaskill		X	Have not been low bidder on any "F" Mix jobs.
LTM, Incorporated Robert E. Vaughn	X		
Morse Bros., Inc. Robert R. Reinhard	X		
North Santiam Paving Co. Ron Bochsler	X		
Portland Road & Driveway Co.,Inc. Mike Bright		X	Portland Road and Driveway does not use F Mix.
RJ Armstrong & Associates Bob Armstrong		X	We do not place F-Mix because we do not do OSHD paving projects.
Road & Driveway Co. Bob Wienert	X		

QUESTION #1 Have you constructed an F-mix pavement in the last five years? (Continued)

Rogers Asphalt Paving Co. Don Hampton	X		
Roseburg Paving Co. Steve Loosley	X		
Salem Road & Driveway Co. Jay Compton		X	Haven't done any F-mixes
Salem Blacktop & Asphalt Paving, Inc. Tom Weir		X	We are not set up for large state work. We are a small 120 per hour plant and do mostly commercial work.
Scappoose Sand & Gravel Co. Scott Parker		X	We are strictly a commercial asphalt supplier. Although I supply OSHD maintenance divisions with asphalt it is exclusively C-Mix, Modified C-Mix or B-Mix.

QUESTION #2 How would you rate the following F-mix construction processes as compared to conventional dense graded mixes?
(On a scale of 1 to 5, 1 being very poor and 5 being very good)

	F-MIX CONSTRUCTION PROCESSES			
CONTRACTOR	MIXING	COMPACTION	HAND WORK	LAYDOWN
Bracelin-Yeager Excavating & Trucking Irv Yeager	4	5	1	5
Copeland Paving, Inc. Dennis Krois	3	3	1	2
Eagle-Elsner, Inc. David Elsner	3	5	1	3
Eugene Sand & Gravel, Inc. Kevin W. Alltucker	2	5	1	3
J.C. Compton, Contractor Inc. Mike Flanigan	4	5	1	2
LTM, Incorporated Robert E. Vaughn	3	5	1	3
Morse Bros., Inc. Robert R. Reinhard	3	5	1	4
North Santiam Paving Co. Ron Bochsler	No Response	5	2	4
Road & Driveway Co. Bob Wienert	3	4	1	4
Rogers Asphalt Paving Co. Don Hampton	3	3	1	2
Roseburg Paving Co. Steve Loosley	5	5	1	4

QUESTION #4 Do you have a problem with chunking of your F-mixes?

CONTRACTOR	YES	NO	COMMENTS: CAUSES AND CURES OF CHUNKING
Bracelin-Yeager Excavating & Trucking Irv Yeager	X		Cause: Distance of haul Cure: Reload at laydown site
Copeland Paving, Inc. Dennis Krois	X		Low mix temperature
Eagle-Elsner Inc. David Elsner	X		Long hauls and low mixing temperatures
Eugene Sand & Gravel, Inc. Kevin Alltucker		X	
J.C. Compton, Contractor Inc. Mike Flanigan	X		Hauling any distance, low ambient temperature
LTM, Incorporated Robert E. Vaughn		X	
Morse Bros., Inc. Robert R. Reinhard	X		Long haul, cooler days. Chunking occurs at corners of dump boxes (front edge) and at the gates in belly dumps.
North Santiam Paving Co. Ron Bochsler	X		Short truck hauls no problem, longer hauls (30 min) we have experienced some. Dumping direct into paver would present problems with chunks and hauls 30 min+. Tarps covering the load properly ("well sealed") can help as much as anything. We have a 50 min. haul coming July 12, could comment further.
Road & Driveway Co. Bob Wienert	X		Low temperature
Rogers Asphalt Paving Co. Don Hampton		X	
Roseburg Paving Co. Steve Loosley	X		Long hauls and cold ambient temperatures. Nothing can be done to stop the problem when it's cool. We pick out the chunks.

QUESTION #5 Are the porous pavements easier to compact than conventional mixtures?

CONTRACTOR	YES	NO	WHY ARE POROUS PAVEMENTS EASIER TO COMPACT?	WHAT COMPACTION PROBLEMS ARE FOUND?
Bracelin-Yeager Excavating & Trucking Irv Yeager	X		Mix temp is not as critical on porous pavements. The mix is much more stable, the mat is rolled static.	
Copeland Paving, Inc. Dennis Krois	X		No tests are run	
Eagle-Elsner Inc. David Elsner	X		Because once the roller pattern is established the compaction is accepted on that basis.	
Eugene Sand & Gravel, Inc. Kevin Alltucker	X		No density spec. Just use the right weight roller and give the necessary coverage.	
J.C. Compton, Contractor Inc. Mike Flanigan	X		No compaction spec.	None
LTM, Incorporated Robert E. Vaughn	X		Less time required to complete rolling, since spec covers number of coverage rather than to a specified density.	
Morse Bros., Inc. Robert R. Reinhard	X		A specified density is not required	
North Santiam Paving Co. Scott Bochsler	X		Stone to stone contact	
Road & Driveway Co. Bob Wienert	X		No real requirement	
Rogers Asphalt Paving Co. Don Hampton	X		No spec	
Roseburg Paving Co. Steve Loosley	X		Takes less effort	

QUESTION #6 How soon after final rolling pass can traffic be allowed on the new mixture?

CONTRACTOR	IMMEDIATELY	WITHIN 1-2 HOURS	OTHER (SPECIFY)	COMMENTS
Bracelin-Yeager Excavating & Trucking Irv Yeager	X			
Copeland Paving, Inc. Dennis Krois		X		
Eagle-Elsner Inc. David Elsner		X		
Eugene Sand & Gravel, Inc. Kevin Alltucker	X			
J.C. Compton, Contractor Inc. Mike Flanigan		X		
LTM, Incorporated Robert E. Vaughn	X			
Morse Bros., Inc. Robert R. Reinhard		X		Cool day = quicker turn to traffic
North Santiam Paving Co. Ron Bochsler		X		Depending on ambient temperature
Road & Driveway Co. Bob Wienert	X			
Rogers Asphalt Paving Co. Don Hampton		X		
Roseburg Paving Co. Steve Loosley			When cools, varies	

QUESTION #7 How does modified asphalt (PBA-6) effect the constructability of F-mixes?
QUESTION #8 Briefly, how do you deal with the problem of tapering an F-mix?

CONTRACTOR	QUESTION #7	QUESTION #8
Bracelin-Yeager Excavating & Trucking Irv Yeager	No experience with this mixture	Use C-mix or D-mix for tapers
Copeland Paving, Inc. Dennis Krois	Have not used it.	___
Eagle-Elsner Inc. David Elsner	___	By using dense graded materials for beginning and ending panels.
Eugene Sand & Gravel, Inc. Kevin Alltucker	Haven't used	Use shorter pulls to lap out quicker and/or use two paving machines in tandem to lap out.
J.C. Compton, Contractor Inc. Mike Flanigan	PBA-6 this year is the worst F-mix I've seen. Very hard on slat ?? motors and lay down machines.	We have cut all taper in hot with blade, pick up excess with pick up machine on main line paving.
LTM, Incorporated Robert E. Vaughn	Have not used PBA-6 with <u>any</u> mixes.	Use a load of Class C for each taper or construct the taper after the fact as an approach.
Morse Bros., Inc. Robert R. Reinhard	Have not used PBA-6	Lots of hand raking, usually a good time not to be around site so I don't have to work and hear all of the swearing. Resulting appearance of joint is usually less than satisfactory (very rough and open)
North Santiam Paving Co. Ron Bochsler	Have not used PBA-6, only PBA-5 (1 job with lime)	<u>Plan</u> with C-mix at ends and D.W.s less than 1" and it is next to impossible.
Road & Driveway Co. Bob Wienert	___	Use C-mix
Rogers Asphalt Paving Co. Don Hampton	Makes stronger mix	We don't taper F-mix
Roseburg Paving Co. Steve Loosley	We have no experience with PBA-6	Use dense mix for feathering. When we have tapers that must be done by hand we try to get permission to use dense mix.

QUESTION #9 Briefly, how do you deal with the problem of feathering an F-mix?

CONTRACTOR	COMMENTS
Bracelin-Yeager Excavating & Trucking Irv Yeager	Use C or D mix.
Copeland Paving, Inc. Dennis Krois	You can't feather F mix to less than 3/4".
Eagle-Elsner Inc. David Elsner	Not possible
Eugene Sand & Gravel, Inc. Kevin Alltucker	Have always used standard C mix. Our projects have allowed this.
J.C. Compton, Contractor Inc. Mike Flanigan	Can't feather any closer than 3/4"
LTM, Incorporated Robert E. Vaughn	Don't feather, use only sawed joints
Morse Bros., Inc. Robert R. Reinhard	Results in even an uglier area than a taper. Bony material being feathered out leaves drag marks and an abrupt drop off as there are minimal fines to work with as you decrease depth.
North Santiam Paving Co. Ron Bochsler	We do not. Use C-mix and seal edges well with tack coat and sand at C-mix joints.
Road & Driveway Co. Bob Wienert	Haven't had this problem, only done one project.
Rogers Asphalt Paving Co. Don Hampton	Use B or C mix.
Roseburg Paving Co. Steve Loosley	We use a dense mix for feathers.

QUESTION #10 Are there any conventional pavement construction processes you feel can not be reasonably achieved with an F-mix?

CONTRACTOR	COMMENTS
Bracelin-Yeager Excavating & Trucking Irv Yeager	Streets and roads that have large amounts of utilities and/or structures (M.H., C.B., curbs)
Copeland Paving, Inc. Dennis Krois	——
Eagle-Elsner Inc. David Elsner	Any situation which calls for tapers, laps, approaches, etc.
Eugene Sand & Gravel, Inc. Kevin Alltucker	Very thin lifts/overlays, projects requiring extensive handwork/raking, long distance hauling, and paving on rock grades.
J.C. Compton, Contractor Inc. Mike Flanigan	Driveways
LTM, Incorporated Robert E. Vaughn	Raking as in street radii and cul de sacs (and feathering).
Morse Bros., Inc. Robert R. Reinhard	Any overlays that require feathering at the edge (i.e. city and county - around gutter lines). Intersection rehabs, unless header cuts are made along gutters and cross streets.
North Santiam Paving Co. Ron Bochsler	Projects which require hand work/tapers, city streets subject to continual need for sweepers and cleaning. Basically any area that cannot be constructed with a paver and layed to a uniform 1 time thickness.
Road & Driveway Co. Bob Wienert	Yes, feathering and tapering, any hand work.
Rogers Asphalt Paving Co. Don Hampton	Can't taper or lap, won't release from truck box.
Roseburg Paving Co. Steve Loosley	——

QUESTION #11 Is there anything else you would like to say about porous pavements?

CONTRACTOR	COMMENTS
Bracelin-Yeager Excavating & Trucking Irv Yeager	It's great for highways and secondary roads in western Oregon with huge rainfalls. the season in western Oregon should be extended to October 15 for F-mixes. Temperatures are still very mild in lower elevations.
Copeland Paving, Inc. Dennis Krois	———
Eagle-Elsner Inc. David Elsner	———
Eugene Sand & Gravel, Inc. Kevin Alltucker	It ties up a commercial plant to producing F mix only on that day.
J.C. Compton, Contractor Inc. Mike Flanigan	———
LTM, Incorporated Robert E. Vaughn	Seems to be very tough and durable, causes more resistance to motors at plant, cleanup of trucks and equipment is a problem.
Morse Bros., Inc. Robert R. Reinhard	———
North Santiam Paving Co. Ron Bochsler	Our experience has been very good as far as workmanship/end result. The traveling public is becoming much more aware of the benefits, re: spray, visibility, reflection. I believe the key to a good F-mix is the correct oil type and percent, temperature, and surface/air temp. F-mix handles differently if the sun is out than on a cloudy day. We need to keep perfecting this mix every way possible and begin covering all the white pavements throughout the state system.
Road & Driveway Co. Bob Wienert	Public seems to like, did a job one year ago and still get lots of compliments.
Rogers Asphalt Paving Co. Don Hampton	———
Roseburg Paving Co. Steve Loosley	———
Scappoose Sand & Gravel Co. Scott Parker	I drove on the I-5 section that Babler did a couple of years ago by the Terwilliger Curves in Portland after a heavy rain and it seemed to hold less water and have much less spray coming off of tires than conventional asphalt.

APPENDIX B

Project Manager User Survey

Name: _____
Position _____
Phone No. _____
Fax No. _____
Address: _____
_____
_____

F-MIX PAVEMENT PROJECT MANAGERS QUESTIONNAIRE

1. Have you been in involved with the construction of an F-mix pavement in the last five years? (Circle one)

   1 YES
   2 NO

   → 1a. Briefly, please explain why you have not been involved with this pavement type, then return this questionnaire.

2. How would you rate the following F-mix construction processes as compared to conventional dense graded mixes? (Circle one number for each

	VERY POOR				VERY GOOD
a) Mixing	1	2	3	4	5
b) Compaction	1	2	3	4	5
d) Raking	1	2	3	4	5
e) Construction	1	2	3	4	5

3. Please indicate whether or not you use the following methods to deal with draindown. (Circle one number for each)

	YES USE	DON'T USE
a) Lower mix temperature	1	2
b) Remixing at site	1	2
c) Modified Asphalts	1	2
d) Only short transport distances	1	2
c) Other (specify _____)	1	2

4. To what depth are F-mixed usually constructed?

_____ INCHES

5. How does modified asphalt effect the following F-mix properties? (Circle one number for Each)

	GOOD		POOR
a) Film thickness	1	2	3
b) Durability	1	2	3
c) Constructability	1	2	3

6. In the placement operations, do the porous pavements tend to segregate more than conventional mixtures? (Circle one number)

1 NO
2 YES → 5a. Briefly, what is the primary cause for the segregation?

7. What would be the preferred method for rehabilitating F-mixes? (Circle one number)

1 Recycling
2 Mill and Fill
3 Overlay
4 Other (specify _____)

8. When can traffic be allowed on the new mixture? (Circle one)

1 Immediately
2 Within 1 to 2 hours
3 Other (specify _____)

9. Would there be any long term problems in placing a porous overlay on concrete pavements? (Circle one number)

1 NO
2 YES

→ 8a. What problems would you expect? (Circle appropriate numbers)

	YES PROBLEM	NO PROBLEM
a) Bonding of layers	1	2
b) Reflection cracking	1	2
c) Ride quality	1	2
d) Other (specify _____)	1	2

10. What F-mix construction problems and solutions do you believe are important?

PROBLEM SOLUTION

11. Is there anything else you would like to say about porous pavements?

QUESTION #1 Have you been involved with the construction of an F-mix pavement in the last five years?

PROJECT MANAGER	YES	NO	COMMENTS
Larry E. Carson Central Point	X		
Chuck Curtis Newport	X		
Steve Donaldson Coquille	X		
Tom Falls Astoria	X		
Lee Franklin Salem	X		
P. Gagnier Portland	X		
Thomas A. Garner Bend	X		
Merle Hill Clackamas	X		
Byron Inman Salem	X		
Buzz Kleemeyer Troutdale	X		
Larry Lewter Hermiston	X		
Larry Lindley Eugene	X		
Michael B. Merrigan Portland	X		
Earl Mershon Portland	X		
Paul Meyers Corvallis	X		
Jerry Mills Hermiston	X		
Donald A. Pasel Coquille	X		
Jarard G. Richardson Portland		X	Have not had F-mix specified on any projects.
Jim Risley Coquille	X		
Bob Staggs Salem	X		

QUESTION #2 How would you rate the following F-mix construction processes as compared to conventional dense graded mixes?

(On a scale of 1 to 5, 1 being very poor and 5 being very good)

	F-MIX CONSTRUCTION PROCESSES			
PROJECT MANAGER	MIXING	COMPACTION	RAKING	CONSTRUCTION
Larry E. Carson Central Point	3	3	2	3
Chuck Curtis Newport	4	5	1	4
Steve Richardson Coquille	No Comment	2	No Comment	No Comment
Tom Falls Astoria	3	4	1	3
Lee Franklin Salem	5	No Comment	1	4
P. Gagnier Portland	4	3-4	1	4-5
Thomas A Garner Bend	4	5	3	4
Merle Hill Clackamas	3	4	1	4
Byron Inman Salem	4	4	2	4
Buzz Kleemeyer Troutdale	2	4	2	4
Larry Lewter Hermiston	3	4	1	3
Larry D. Lindley Eugene	4	5	1	4
Michael B. Merrigan Portland	4	3	1	3
Earl Mershon Portland	4	4	2	4
Paul Meyers Corvallis	3	3	2	3
Jerry Mills Hermiston	4	4	2	3
Donald A. Pasel Coquille	2	4	2	3
Jim Risley Coquille	3	3	1	3
Bob Staggs Salem	4	3	1	5

QUESTION #3 Please indicate whether or not you use the following methods to deal with draindown.

PROJECT MANAGER	LOWER MIX TEMP.	REMIXING AT SITE	MODIFIED ASPHALTS	ONLY SHORT TRANSPORT DISTANCES	OTHER (SPECIFY)	COMMENTS
Larry E. Carson Central Point	Yes	Yes	No	Yes		
Chuck Curtis Newport	Yes	No	No	Yes		
Steve Donaldson Coquille	Yes	No	No	No		
Tom Falls Astoria	Yes	No	No	No		
Lee Franklin Salem	Yes	Yes	No	No Comment		Have had long and short hauls.
P. Gagnier Portland	Yes	No	No	No		
Thomas A. Garner Bend	Yes	No	Yes	No	Mineral filler	
Merle Hill Clackamas	Yes	No	Yes	No		
Buzz Kleemeyer Troutdale	Yes	No	Yes	No Comment		
Larry Lewter Hermiston	No	No	Yes	No	Adjust asphalt content	
Larry D. Lindley Eugene	No	No	No	No		Lower mix temp.: stay within JMF
Michael B. Merrigan Portland	Yes	No	No	No		
Earl Mershon Portland	Yes	No	No	No	Reduce asphalt content	We have only had this occur on one job
Paul Meyers Corvallis	No	No	No	No		

PROJECT MANAGER	LOWER MIX TEMP.	REMIXING AT SITE	MODIFIED ASPHALTS	ONLY SHORT TRANSPORT DISTANCES	OTHER (SPECIFY)	COMMENTS

QUESTION #3 Please indicate whether or not you use the following methods to deal with draindown. (Continued)

Jerry Mills Hermiston	Yes	No	Yes	No	Reduce asphalt content	
Donald A. Pasel Coquille	Yes	Yes	Yes	Yes		
Jim Risley Coquille	Yes	No	No	No	Increase mineral Filler	Not been a problem for some time
Bob Staggs Salem	Yes	No	Yes	No		

QUESTION #4 To what depth are F-mixes usually constructed?

PROJECT MANAGER	DEPTH (IN INCHES)
Larry E. Carson Central Point	1.5 - 2
Chuck Curtis Newport	1.5 - 2
Steve Donaldson Coquille	2
Tom Falls Astoria	2
Lee Franklin Salem	2
P. Gagnier Portland	2 -3
Thomas A. Garner Bend	2
Merle Hill Clackamas	2
Byron Inman Salem	2
Buzz Kleemeyer Troutdale	2 - 2.5
Larry Lewter Hermiston	2
Larry D. Lindley Eugene	2 -3
Michael B. Merrigan Portland	2
Earl Mershon Portland	2
Paul Meyers Corvallis	2
Jerry Mills Hermiston	2
Donald A. Pasel Coquille	2
Jim Risley Coquille	1.5
Bob Staggs Salem	2+

QUESTION #5 How does modified asphalt effect the following F-mix properties?
(On a scale of 1 to 3, 1 being good and 3 being poor)

	F-MIX PROPERTIES			
PROJECT MANAGER	FILM THICKNESS	DURABILITY	CONSTRUCTABILITY	COMMENTS
Larry E. Carson Central Point	___	___	___	Never used modified asphalts
Chuck Curtis Newport	___	___	___	Haven't used modified asphalt.
Steve Donaldson Coquille	----	----	----	Haven't been involved
Tom Falls Astoria	___	___	___	Have not used modified asphalts.
Lee Franklin Salem	___	___	___	No experience
P. Gagnier Portland	2	2	2	
Thomas A. Garner Bend	1	1	2	
Merle Hill Clackamas	1	2	2	
Byron Inman Salem	1	2	1	
Buzz Kleemeyer Troutdale	___	___	___	
Larry Lewter Hermiston	1	1	2-3	Unknown, but appears good.
Larry D. Lindley Eugene	___	___	___	We have not used any modified asphalts.
Michael B. Merrigan Portland	1	1	2	

QUESTION #5 How does modified asphalt effect the following properties? (Continued)

Earl Mershon Portland	——	——	——	No opinion
Paul Meyers Corvallis	2	2	2	
Jerry Mills Hermiston	1	——	3	Durability: too early to tell
Donald A. Pasel Coquille	2	1	2	
Jim Risley Coquille				Haven't been involved
Bob Staggs Salem	1	2	1	

QUESTION #6 In the placement operations, do the porous pavements tend to segregate more than conventional mixtures?

PROJECT MANAGER	YES	NO	COMMENTS
Larry E. Carson Central Point		X	
Chuck Curtis Newport		X	
Tom Falls Astoria		X	
Lee Franklin Salem		X	
P. Gagnier Portland		X	
Thomas A. Garner Bend		X	
Merle Hill Clackamas	X		The larger aggregates tend to roll down the sides whenever mix is dumped or placed
Byron Inman Salem	X		Proper laydown methods are critical, i.e. overlapped windrows, proper screed adjustments, not emptying wings on hopper, keeping proper load on augers.
Buzz Kleemeyer Troutdale		X	
Larry Lewter Hermiston		X	
Larry D. Lindley Eugene		X	
Michael B. Merrigan Portland		X	
Earl Mershon Portland	X		Raking can cause segregation after placement.
Paul Meyers Corvallis		X	
Jerry Mills Hermiston		X	
Donald A. Pasel Coquille	X		Improper mixing, overhandling, and overheating
Jim Risley Coquille		X	
Bob Staggs Salem	X		The boniness of the mix to begin with and the draindown causing less bonding

QUESTION #7 What would be the preferred method for rehabilitating F-mixes?

PROJECT MANAGER	RECYCLING	MILL AND FILL	OVERLAY	OTHER (SPECIFY)
Larry E. Carson Central Point		X		
Chuck Curtis Newport		X		
Tom Falls Astoria		X		
Lee Franklin Salem				Depends on situation and condition of existing surface.
P. Gagnier Portland		X		
Thomas A. Garner Bend		X		
Merle Hill Clackamas				Unknown
Byron Inman Salem		X	X	Chip seals or fog seals
Buzz Kleemeyer Troutdale		X		
Larry Lewter Hermiston				Depends on the type of distress.
Larry D. Lindley Eugene		X		
Michael B. Merrigan Portland		X		
Earl Mershon Portland		X		Might create a barrier for water at the edge of the panel. This should be tried with a pilot project.
Paul Meyers Corvallis		X		

QUESTION #7 What would be the preferred method for rehabilitating F-mixes? (Continued)

Jerry Mills Hermiston				Depends on type of distress.
Donald A. Pasel Coquille			X	
Jim Risley				Don't Know
Bob Staggs Salem				Would try a slurry seal.

QUESTION #8 When can traffic be allowed on the new mixture?

PROJECT MANAGER	IMMEDIATELY	WITHIN 1-2 HOURS	OTHER (SPECIFY)
Larry E. Carson Central Point		X	
Chuck Curtis Newport		X	
Steve Donaldson Coquille		X	
Tom Falls Astoria		X	
Lee Franklin Salem		X	Generally 1-2, unless in a heat wave situation.
P. Gagnier Portland			Depends on temperature, ambient and mix.
Thomas A. Garner Bend			Varies, some mixes can handle traffic in two hours, others may take four to six hours. The type of polymers may be the difference.
Merle Hill Clackamas		X	
Byron Inman Salem		X	
Buzz Kleemeyer Troutdale		X	
Larry Lewter Hermiston		X	Depends on the weather and temperature.
Larry D. Lindley Eugene		X	
Michael B. Merrigan Portland		X	
Earl Mershon Portland		X	
Paul Meyers Corvallis		X	
Jerry Mills Hermiston	X (when watered)	X	
Donald A. Pasel Coquille			2-3 hours
Jim Risley Coquille			Generally after the roller has made a pass. I have seen cars cross the new mat right behind the paver without doing permanent damage
Bob Staggs Salem		X	

QUESTION #9 Would there be any long term problems in placing a porous overlay on concrete pavements?

PROJECT MANAGER	YES	NO	IF YES, WHAT PROBLEMS WOULD YOU EXPECT?			
			BONDING OF LAYERS	REFLECTION CRACKING	RIDE QUALITY	OTHER (SPECIFY)
Larry E. Carson Central Point		X				
Chuck Curtis Newport	X		Yes	Yes	No	
Steve Donaldson Coquille	X					
Tom Falls Astoria	X		Yes	Yes	No	
Lee Franklin Salem		X				
P. Gagnier Portland	X		Yes	Likely	No	
Thomas A. Garner Bend	X		No	?	Yes	
Merle Hill Clackamas		X (?)	Yes	Yes	No	
Byron Inman Salem	X		Yes	Yes	Yes	
Buzz Kleemeyer Troutdale		X	No	No	No	
Larry Lewter Hermiston	X (maybe)		Yes (?)	Yes (?)		
Larry D. Lindley Eugene	X			Yes		
Michael B. Merrigan Portland	X		Yes	Yes	Yes	Deflection in PCC Panels

QUESTION #9 Would there be any long term problems in placing a porous overlay on concrete pavements? (Continued)

Earl Mershon Portland		X (This is an opinion, not based on exper.)	No	No	No	
Paul Meyers Corvallis	X		Yes	Yes	Yes	
Jerry Mills Hermiston	No Comment	No Comment				
Donald A. Pasel Coquille		X	Yes	No	No	
Jim Risley Coquille						No, if concrete in good shape
Bob Staggs Salem	X		Yes	Yes (2" or less)		

QUESTION #10 What F-mix construction problems and solutions do you believe are important?

PROJECT MANAGER	PROBLEM	SOLUTION
Larry E. Carson Central Point	—	—
Chuck Curtis Newport	Driveways and road approaches (feathering)	Use finer open graded mix (E-mix) for driveways and road approaches.
	Feathering at ends of job (repave)	Grind out and inlay at ends.
	Inadequate cross slope	Make sure there is enough leveling mix on the project to restore cross slope.
Steve Donaldson Coquille	Oil separating in mix	Reduce temperature of mix. Keep plant discharge to a minimum
Tom Falls Astoria	Temperature Control	Do not allow long distance hauling of F-mixtures. Do not place F-mix at night in the coastal environment, especially in areas that are adjacent to large bodies of water like the ocean or the Columbia River.
Lee Franklin Salem	Recessing pavement markers cause a loss in lateral support for the aggregate.	Saw cell recesses might help some but not eliminate the loss of lateral support.
P. Gagnier Portland		Dedicating plant to F-mix production for daily output.
Thomas A. Garner Bend	Ride	Prelevel existing for overlays
		Place underlay courses to good grade. F-mix as any porous mixture will conform to underlaying surfaces in time.
	Surface wear	Use only polymer modified asphalts.
Merle Hill Clackamas	Flushing	Correct oil content and type.
Merle Hill Clackamas	Joints	Must have paver set up to place the proper amount of mix at the joints.
Byron Inman Salem	Oil slicks	Don't seal for approximately 2 years, then fog seal.
Buzz Kleemeyer Troutdale	Not able to adequately dry very wet A99, due to high bag house temperature.	Use dry A99.

QUESTION #10 What F-mix construction problems and solutions do you believe are important? (Continued)

Larry Lewter Hermiston	Rakeability	Don't specify F-mix in areas that will be labor intensive (raking)
	F-mix inlays of old B-mix	Need standard for trenching and backfill mix to allow drainage flow.
	Corrective action (grinding)	Specify type of grinder (diamond tip)
	PBA-6 sticking to trailers	Drain-down oil sticks to trailers and being sticky/stringy drops off in globs on roadway and coming back as "slicks." Don't know solution
Larry D. Lindley Eugene	Inlay	Provide adequate drainage.
	Design project so joints are kept to a minimum.	Keep raking to a minimum.
Michael B. Merrigan Portland	Clogging of F-mix due to sanding and wear.	
Earl Mershon Portland	Plastic striping tape had adhesion problems on an open graded mix.	Paint the permanent striping instead of using tape.
	Difficult to rake or feather out the road approach connections.	Use C-mix for road approaches or grind in at the paving limits.
Paul Meyers Corvallis	Drainage	Make sure all F-mix A.C. has positive plan for drainage and does not trap water in roadway section F-mix.
	Water permeating into cracked layer below and into base.	1" C-mix cap/leveling
Jerry Mills Hermiston	PBA-6 stickiness	Possibly don't use in urban areas.
Donald A. Pasel Coquille	Segregation	Proper temperature at mixing
Jim Risley Coquille	———	———
Bob Staggs Salem	Chunks in the mix	Limit haul distance.

QUESTION #11 Is there anything else you would like to say about porous pavements?

PROJECT MANAGER	COMMENTS
Larry E. Carson Central Point	—
Chuck Curtis Newport	Production appears to be lower than for dense graded mixes, at least for the local drum mix plant.
Steve Donaldson Coquille	I have been involved with the testing of F-mix and it is sticky and messy as compared to dense graded mixes. It is also harder to compact F-mix into the nuke testing pans than B-mix.
Tom Falls Astoria	Porous pavements do not perform as well in the higher elevations where snow removal is required. I had a project that took second place in asphalt pavement construction in 1992 that looks like it is five years old after the snow plows tore it up this past winter.
Lee Franklin Salem	—
P. Gagnier Portland	—
Thomas A. Garner Bend	Having placed F-mix pavements on a number of projects in the past five years, in general, I have only good things to say about F-mix. Excellent ride quality can be obtained by using good construction practices (though poor construction results in poor rides). Last season we placed a F-mix overlay as a maintenance preservation measure on 11 miles of the Ochoco highway. If this overlay holds up through the 1993 summer season I would then recommend this treatment for many maintenance jobs, rather than recycle or chip seal. The end result is more expensive but maybe a more permanent fix.
Merle Hill Clackamas	—
Buzz Kleemeyer Troutdale	—
Larry Lewter Hermiston	Very difficult to work with but depending on contractor quality gives very good end product. Seems to be some problem in receiving "passing" oil (asphalt). Samples are just as apt to fail as pass.
Larry D. Lindley Eugene	On F-mix overlays of 2" or less, the rode quality tends to deteriorate after about one year. A solution would be to require a dense leveling prior to placing F-mix.
Michael B. Merrigan Portland	—
Earl Mershon Portland	Our first F-mix project experienced its first potholing during Spring 1993. I notified Dick Dominick in Materials. He was going to inspect the damage. I don't know if he determined the problem; the project was completed in 1989.

QUESTION #11 Is there anything else you would like to say about porous pavements? (Continued)

Paul Meyers Corvallis	General positive results, lots of good comments about spray reduction. Spray reduction, though, is still noticeable on 4-5 year old projects.
Jerry Mills Hermiston	Concern that F-mix with PBA-6 stays soft and may rut under extended hot weather, performance needs to be monitored carefully.
Donald A. Pasel Coquille	Works great if good F-mixes have good mix design and the mixing and placement procedures are followed.
Jim Risley Coquille	F-mixes have good ride, seem to ride well, and hold down the spray very well.
Bob Staggs Salem	Like the idea of a 1" leveling lift followed by 2"+ F-mix, the deeper the F-mix the better the quality of the ride.

APPENDIX C

District Managers User Survey

Name: _____
Position _____
Phone No. _____
Fax No. _____
Address: _____
_____
_____

F-MIX DISTRICT MAINTENANCE SUPERVISORS QUESTIONNAIRE

1. Have you been in involved with the maintenance of an F-mix pavement in the last five years? (Circle one)

   1 YES
   2 NO

   → 1a. Briefly, please explain why you have not been involved with this pavement type, then return this questionnaire.

2. How do your F-mixes compare with conventional dense graded pavements for each of the following distress problems (Circle number for each).

	VERY POOR		EQUAL		VERY GOOD
a) Rutting	1	2	3	4	5
b) Potholing	1	2	3	4	5
c) Bleeding	1	2	3	4	5
d) Reflection Cracking	1	2	3	4	5
e) Stripping	1	2	3	4	5

3. Briefly describe your feelings on de-icing chemicals for F-mix pavements.

4. Briefly describe your feelings on winter sanding of F-mix pavements.

5. Briefly describe your feelings toward sweeping of F-mix pavements.

6. Which of the following do you use for patching F-mix distress problems (Circle one number for each)

	DON'T USE	YES USE
a) F-mix	1	2
b) Open Graded Emulsion	1	2
c) Dense graded hot mix	1	2
d) Dense graded Emulsion	1	2

7. What would be the preferred method for rehabilitating F-mixes? (Circle one number)

1 Recycling
2 Mill and Fill
3 Overlay
4 Other (specify _____)

8. Do you feel there are any F-mix maintenance problems and solutions that deserve recognition

PROBLEM SOLUTION

9. Is there anything else you would like to say about F-mix pavements?

QUESTION #1 Have you been involved with the maintenance of an F-mix pavement in the last five years?

DISTRICT MANAGER	YES	NO	COMMENTS
Larry Asburry Springfield	X		
Dan Bacon Troutdale		X	Until this past winter we have not had a problem with it, other than it is slicker in the winter as more water is trapped in the open design and freezes up quicker. The snow pack seems to build up sooner and stays on longer also. This past winter it started to ravel out and is continuing to do so. I met with Dick Dominick from Salem on February 25, 1993 to look at damage to the highway (Hwy. 26, m.p. 21.5)
Mike Gardner Clackamas	X		
John Grassman Salem	X		
M.G. Havig Roseburg	X		
Ken Hilton Corvallis	X		
Harold Lasley Portland	X		
Jim Sampson Portland	X		

QUESTION #2 How do your F-mixes compare with conventional dense graded pavements for each of the following distress problems? (On a scale of 1 to 5, 1 being very poor and 5 being very good)

	DISTRESS PROBLEMS				
DISTRICT MANAGER	RUTTING	POTHOLING	BLEEDING	REFLECTION CRACKING	STRIPPING
Larry Asburry Springfield	5	4	3	5	4
Dan Bacon Troutdale	3	3	4	3	2
Mike Gardner Clackamas	4	4	5	4	3
John Grassman Salem	4	Unknown	5	Unknown	4
M.G. Havig Roseburg	4	4	4	5	5
Ken Hilton Corvallis	5	4	5	5	4
Harold Lasley Portland	5	5	2	5	5
Jim Sampson Portland	5	4	4	3	5

QUESTION #3 Briefly describe your feelings on de-icing chemicals for F-mix pavements.
QUESTION #4 Briefly describe your feelings on winter sanding of F-mix pavements.
QUESTION #5 Briefly describe your feelings toward sweeping of F-mix pavements.

DISTRICT MANAGER	QUESTION #3	QUESTION #4	QUESTION #5
Larry Asburry Springfield	Have not used.	In some areas sanding has been reduced on coarse open mixes.	None. In grass seed farming areas, shoulders and turn lanes will grow grass.
Dan Bacon Troutdale	I am not in favor of using any kind of deicing chemicals on any of my highways.	I seem to sand them more than other mix designs.	I have noticed that the sanding material is harder to pick up.
Mike Gardner Clackamas	I believe there is real opportunity for using less sand by using de-icer on F-mix.	Sand has a tendency to plug the voids.	I have not noticed a difference.
John Grassman Salem	Have not used deicing chemicals to any extent.	Sanding is less effective but F-mix pavement generally is less icy or frosty.	Causes more wear on brooms.
M.G. Havig Roseburg	No experience.	No problems encountered. Generally I believe we use less sanding material on the F-mixes.	I'm not aware of any problem in this area.
Ken Hilton Corvallis	None used.	Frosts faster and ice is more difficult to see. Sand tends to drop into voids in mix - must sand heavier.	No problems sweeping surface clean, some fines are retained in pavement voids.
Harold Lasley Portland	Haven't used deicer on F-mix.	Can't use fine graded sand. 1/4-10 works fine. Good results.	Had no problems sweeping 1/4-10 off F-mix.
Jim Sampson Portland	Deicing chemicals work on F-mix pavements as well as they perform on other pavements.	Use only clean sanding material that is composed of materials 1/4" to 3/8". No cinders.	No noticeable differences.

QUESTION #6 Which of the following do you use for patching F-mix distress problems?

DISTRICT MANAGER	F-MIX	OPEN GRADED EMULSION	DENSE GRADE HOT MIX	DENSE GRADED EMULSION	COMMENTS
Larry Asburry Springfield	No	No	Yes	No	
Dan Bacon Troutdale	___	___	___	___	Have not had to patch yet but need to this year. I will use PBA-5 Hot Tack and D-mix to fill in the raveled area.
Mike Gardner Clackamas	No	No	Yes	No	
John Grassman Salem	No	Yes	No	Yes	
M.G. Havig Roseburg	No	No	Yes	No	
Ken Hilton Corvallis	No	No	Yes	No	
Harold Lasley Portland	___	___	___	___	Haven't had to do any patching yet (2 year old F-mix)
Jim Sampson Portland	___	___	Yes	___	

QUESTION #7 What would be the preferred method for rehabilitating F-mixes?

DISTRICT MANAGER	RECYCLING	MILL AND FILL	OVERLAY	OTHER (SPECIFY)	COMMENTS
Larry Asburry Springfield		X	X		
Dan Bacon Troutdale			X		At least in our area where we have so much moisture and ice and snow.
Mike Gardner Clackamas		X			
John Grassman Salem					Have not had any rehabilitation experiences.
M.G. Havig Roseburg					Not sure.
Ken Hilton Corvallis		X			We haven't had a section deteriorate enough to evaluate what corrective action would work best
Harold Lasley Portland					Not sure until we see what the damage is.
Jim Sampson Portland		X			

QUESTION #8 Do you feel there are any F-mix maintenance problems and solutions that deserve recognition?

DISTRICT MANAGER	PROBLEM	SOLUTION	COMMENTS
Larry Asburry Springfield	___	___	
Dan Bacon Troutdale	Ravelling	It appears that in the raveled area there was not sufficient oil to hold it together. Some of the rock appears to have no oil on it.	
Mike Gardner Clackamas	Longitudinal joints over compacted	Make sure the matching panel is carries at the proper uncompacted depth. Too deep causes over dense mix at joint because roller pinches it together. This creates a dam that causes water traveling through the mix to come to the surface.	
John Grassman Salem	___	___	
M.G. Havig Roseburg	___	___	None so far.
Ken Hilton Corvallis	___	___	
Harold Lasley Portland	Bleeding	Unknown	
Jim Sampson Portland	___	___	None noticed up to this point.

QUESTION #9 Is there anything else you would like to say about F-mix pavements?

DISTRICT MANAGER	COMMENTS
Larry Asburry Springfield	——
Dan Bacon Troutdale	Maybe in the right area it will work but I am not real crazy about it. It has a good wear surface because of the larger rock but it is too open and when water gets into the mat and freezes, it pops it apart. More oil in the mix might help.
Mike Gardner Clackamas	I have been pleased by their performance; rutting and shoving is not a problem, although I really thought it would be. The elimination of tire spray is great. Project managers and contractors need to make sure the gradation stays within specs at all times. Too many fines quickly eliminate the free draining feature and cause problems when moisture surfaces and freezes.
John Grassman Salem	Less icy spots (better drainage) and snow dissipates more quickly.
M.G. Havig Roseburg	I like F-mixes and want to see them continued.
Ken Hilton Corvallis	It is difficult to sweep up glass (by hand) at accident scenes. There is an abundance of grass seed in the Willamette Valley. Some seed lands in the F-mix voids and germinates. On shoulders, gore points, and other untraveled areas, this grass imparts a green sheen to the surface. This spring was especially wet and the normally fine, newly germinated grass developed into full, highly visible blades. On new mixes the grass dies as soon as the weather dries. My concern is that on older mixes there will be enough soil in the voids for the grass to develop a good root system and not die. We are contemplating setting up a spray program for F-mix pavement. For good drainage, a full dense mix leveling course (not milling) is essential before F-mix is laid. There is no need for drain curb.
Harold Lasley Portland	F-mix from Tide Creek to Rainier on 2W is doing the job it was expected to do, cutting down on traffic spray. It is holding up well except for bleeding and seems to be more skid resistant than conventional mixtures.
Jim Sampson Portland	——