INSTALLATION REPORT

EXPERIMENTAL MIX USING FOAMED ASPHALT

by

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Senior Research Scientist

Virginia Highway and Transportation Research Council
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SUMMARY

This report describes the first foam asphalt mix produced and used in a highway pavement in Virginia. The aggregate used was a local Eastern Shore sand modified with 5% fly ash to improve the gradation. A foam asphalt chamber on a portable pug-mixer was used to produce slightly more than 500 tons of mix. While the early performance of the pavement overlaid with the foam asphalt mix has not been too favorable, the project will be watched closely into the spring before determining whether to continue with the experiments.

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INTRODUCTION

Foamed asphalt is produced by adding small amounts of water to hot asphalt cement, thus causing it to foam and expand to 10 or 15 times its original volume. This process allows coating of moist, cold aggregates and is reported to improve the performance of marginal local materials.

Foamed paving mixtures may provide an alternative to hot mixes and emulsion mixes. Because they can be produced in a portable mixer using a typical asphalt cement, they may be more economical than hot mixes when the hot mix plants are not located near the job. Also, they may be more economical than emulsion mixes because the water contained in the emulsion requires a greater amount of binder to produce the required residual asphalt content than mixes using an asphalt cement.

Several reports have been written on laboratory investigations of foamed asphalt mixes,[1-3] and several field applications have been reported.[4,5] Yet, in the author's opinion, the technique is still very much experimental.

The foaming process requires a special unit into which carefully measured quantities of water and asphalt can be introduced. Small laboratory units can be rented or purchased from Conoco, which has a patent on the process, and field units can be rented or purchased from Calenco Equipment Company, which is working closely with Conoco.

The foamed asphalts have potential for use in stabilizing local materials such as crusher run limestone aggregate and Eastern Shore sands, and in patching materials.

PURPOSE

The study evaluated the use of a small amount of foamed asphalt in a surface course mix. The Eastern Shore was chosen for the first experiment because of the abundance of economical local sand and the absence of a hot mix plant in the vicinity.

SCOPE

Eastern Shore sand has been found to be adequate for use as an aggregate in mixes for secondary and low-traffic primary roads when used with about 5% lime or fly ash and 7.5% asphalt cement.(6,7)

The Maintenance Division agreed to support this small initial effort in which about 500 tons of mix was placed.

The mix was placed on Route 187 in Accomack County as shown in Figure 1.

MATERIALS

As stated previously, the abundance of economical local sands on the Eastern Shore make it an ideal location for an experimental mix using the foaming process. The one-size gradation of the sands, as shown in Table 1, requires the addition of filler to achieve acceptable stabilities. Fly ash was chosen for this experiment because of its relatively low cost and because almost all of it passes the #200 sieve. The gradation with the sand and 5% fly ash is shown in Table 2. Both gradations are typical. Because of the variability in the pit material and because the fly ash was blended with the sand using the most expedient method, a front-end loader, large variations in gradation are expected and do exist.

The asphalt cement was supplied by the Koch Asphalt Company and was selected because of its high penetration value. It very nearly met the specifications of an AC-5 asphalt. The pertinent properties are shown in Table 3.

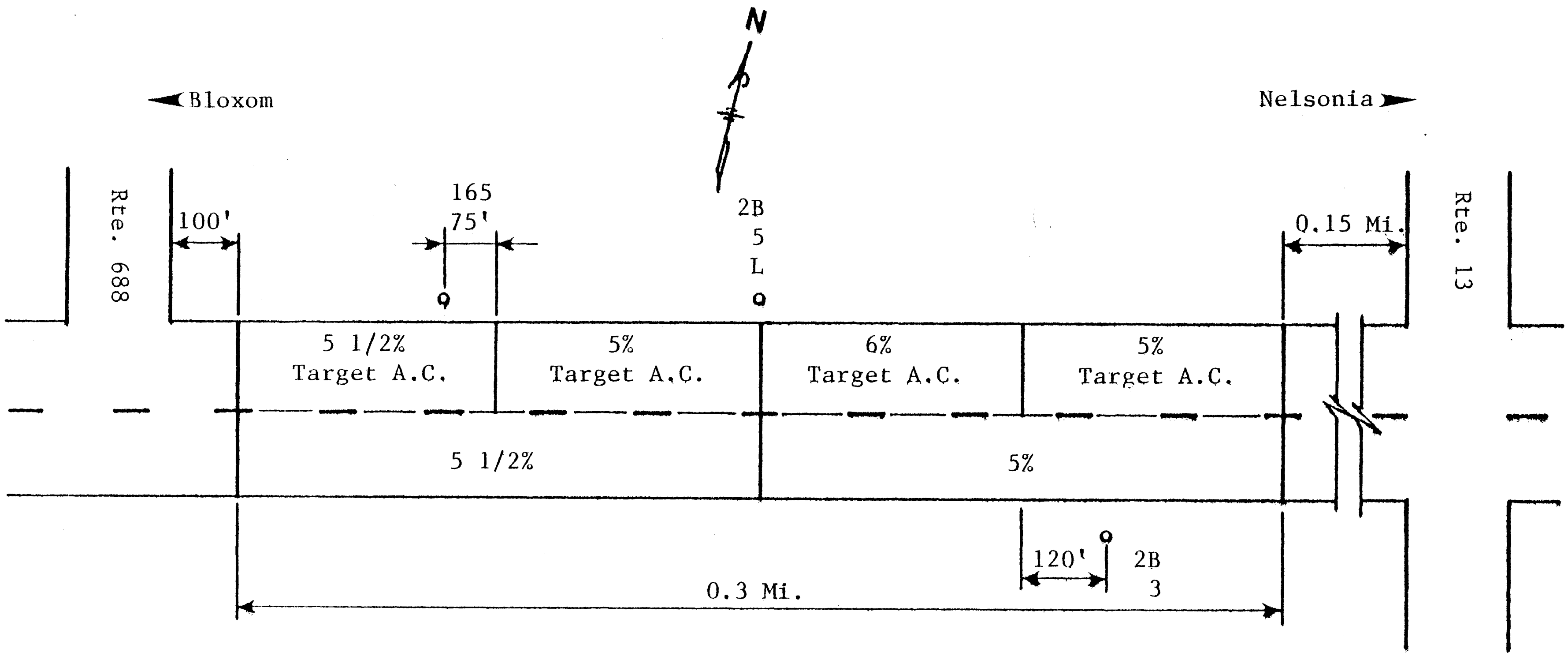

Figure 1. Foam mix location - Rte. 187.

Table 1.

Typical Gradation of Eastern Shore Sand

Sieve Size	Percent Passing
3/8"	100
4	99
8	95
30	70
50	50
100	5
200	1

Table 2.

Gradation of Sand and 5% Fly Ash

Sieve Size	Percent Passing
3/8"	100
4	98
8	95
30	78
50	56
100	9
200	4

Table 3.

Properties of Asphalt Cement

Penetration	201
Sp. Gravity	1.018
Flash Point, ^{O}F	575
Viscosity $140^{O}F$, Poises	604
Viscosity $275^{O}F$, cSt	249
TFOT Residue	
Ductility $77^{O}F$	150+
Viscosity $140^{O}F$, Poises	1,693

The soft grade asphalt was desirable because the sand tends to be absorptive and flexibility on the local roads is a high requisite. Further, because the void content of mixes made with the local sands is traditionally high, the effect of oxidation of the asphalt cement is pronounced and reduces flexibility.

EQUIPMENT

The most important equipment in the process was the mixer. Because there was no foam mixer in Virginia, one was brought in from Illinois. Intermix, Inc., from Springfield, Illinois, provided a Calenco Foam-Master. This piece of equipment is shown in Figure 2.

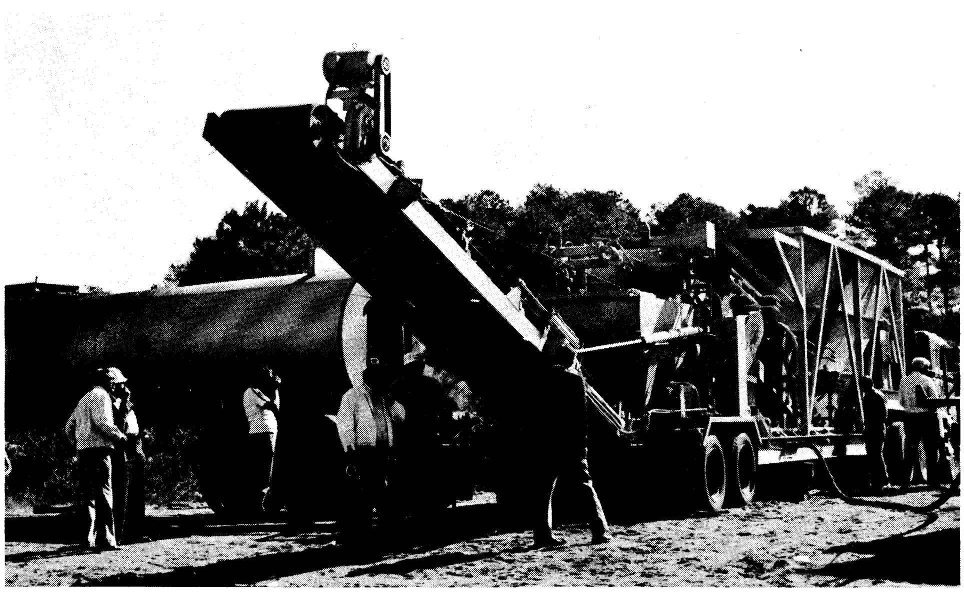

Figure 2. Foam mixer.

Hot asphalt (300-350°F) was pumped from a tanker through a circulation system on the mixer. Two percent water by weight of asphalt was added in a foaming chamber and then sprayed on the sand and mixed in a pugmill. The amount of foam is determined by the amount of sand used, which is weighed on a belt scale on the conveyor. The mixer reportedly has a capability of producing 600 tons/hr. In this experiment, 150 tons/hr. was easily accomplished.

The mix was hauled in Department dump trucks and laid with a state-owned Barber-Greene paver. After placement of a short trial section on which a steel-wheel roller was used and found to be detrimental to the pavement, a rubber-tired roller was used for compaction.

EXPERIMENTAL WORK

On the morning of October 28, 1981, George Binkley from Conoco gave a briefing at the Accomac Residency Office concerning his experiences with foam mixes and what could be expected on the roadway. A list of those in attendance is appended.

After the briefing, the group went to the pit on Route 762 in Accomack County where the foam mixer was located. Upon inspection, it was found that the temperature of the asphalt in the haul tankers was only 270°F. While asphalt at this temperature will foam upon the addition of water, it will not produce the quality of foamed asphalt necessary for adequate mixing.

The tankers were equipped with propane burners and these were turned on to heat up the asphalt. However, by midafternoon it was obvious that the asphalt would not reach 300°F in time to produce any mix on that day. Since several people had come from neighboring states to view the experiment and could not stay another day, it was decided to run two truck loads of mix so they could get an idea of what the foam mix might look like.

Two truck loads were mixed, and it was obvious that the foamed asphalt tended to ball up and was not uniformly mixed with the sand.

The night of October 28 the propane burners were turned on, and by morning the asphalt in the tankers was 350°F. However, as a result of the limited demonstration on the 28th the asphalt pump and circulation lines in the mixer were not thoroughly clean and the need to clean them delayed the operation another half day. Finally, at about noon on October 29, the first foam mix was produced. The weather was cloudy and the temperature was in the mid-50's. The first trial asphalt content was aimed at 5%. Hot mix using the same type sand and fly ash normally has an optimum asphalt content of about 7.5%. However, from Mr. Binkley's experience, 5% asphalt appeared adequate. As will be discussed later, the target asphalt contents were lower than the extraction test results indicated.

Compaction was started using a steel-wheel roller, but after a short distance it was apparent this would not work. The mix easily supported the roller, but the roller caused a delamination or flaking within the mix as can be seen in Figure 3. A rubber-tired roller was then used and the results were much better. The ability of the mix to support the roller was surprising, considering the tenderness normally encountered in a hot mix made with the same material. The roller made only slight wheel indentations (Figure 4). The rubber-tired roller did cause some roughness in the road, and in an attempt to smooth out this roughness the steel-wheel roller was used on the first section the next morning. Failures in the mix were observed very quickly (Figure 5), and this roller was once again removed and was not used further.

Because the first section of the road looked dry, the author chose to increase the asphalt content. Therefore, after one round of trucks (5 loads), the target asphalt was raised to 6%. Another round of trucks (5 more loads), were placed at this higher asphalt content, and there was some thought that this asphalt content was too high. It was decided to move the paver to the adjacent lane and place 10 more loads to square up for the day. These 10 loads were laid at a 5% target asphalt content.

The confusion over the proper asphalt content was caused by several factors. The primary cause was the gradation of the sand, particularly the one-size gradation and the relatively low amount of -#200 material. Because the foam process coats the -#200 material, which forms a matrix to hold the large aggregate together, the less -#200 that is present, the less asphalt is usually necessary. However, because so much of the sand was nearly the same size and was very fine, there was quite a bit of surface area. Therefore, one might expect that a higher than usual asphalt content would be needed. As stated previously, a hot mix using the same gradation would require about 7.5% asphalt. One further factor adding to the confusion was the question of the accuracy and uniformity of the mixing process. As will be discussed in more detail later, extraction tests indicated that the mixes had higher asphalt contents than expected and that the variability in asphalt content was high.

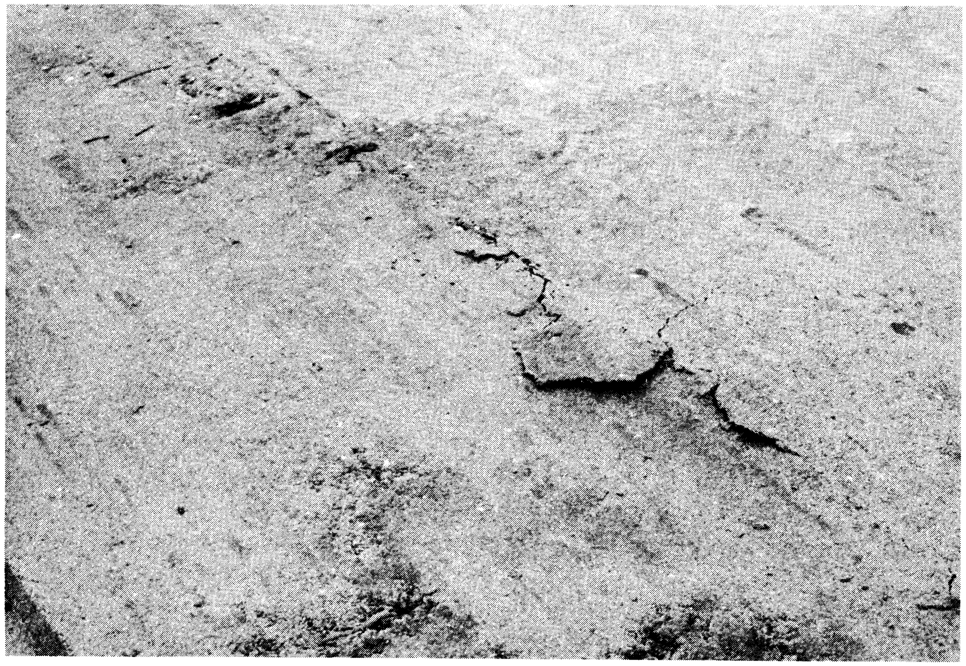

Figure 3. Flaking of mix under steel-wheel roller.

Figure 4. Mix showed good stability under rubber-tired roller.

Figure 5. Failures due to final rolling with steel-wheel roller.

On the second day, the first round of trucks hauled mix at 5% asphalt content. After this, the next 3 rounds of trucks, which finished the sand mix, contained mix at 5.5% asphalt content.

Five loads of a patching material were made using a crusher-run granite aggregate and 5% asphalt content. This material was stockpiled for future use.

TEST RESULTS

Tests conducted on the mix consisted of extraction tests to determine gradation and asphalt content, Marshall stability and flow tests, and the Rice maximum theoretical specific gravity test for void determinations.

Tests were run by the Bituminous Section of the Materials Division and the APAC, of Atlanta, as well as the Research Council.

Asphalt Content and Gradation

Table 4 shows extraction results for the mixes sampled.

Table 4.

Extracted Asphalt Contents, Percent

Asphalt Content	Testing Agency: Research Council			Materials Division	APAC
Target	5.0	5.5	6.0	6.0	5.0
Average extracted	5.8	7.9	9.6	8.0	5.9

All test results indicate a higher than expected asphalt content. Using the total tons of asphalt used (31.2) as a percentage of the total tons of mix produced gives an average asphalt content of 6.1%. It is evident that the 7.5% optimum asphalt content for hot mix was bracketed using the foam process.

The gradations from the extraction tests are given in Table 5.

Table 5.

Gradations from Extraction Tests, Percent Passing

Sieve Size	Testing Agency: Research Council	Materials Division	APAC
1/2	100	100	
3/8	100	99	100
4	99	98	99
8	96	95	96
30	77	77	78
50	49	51	51
100	8	7	7
200	3.8	3.6	4.4

The average gradation results from the testing agencies compare closely; however, although not shown here, the variability within each agency indicated that the pit material, the fly ash blending, and possibly the pugmill proportioning and mixing contributed to the overall mix variability. This is not mentioned as a criticism but rather as something that should be expected with the materials and processes involved.

Marshall Stability

As far as is known by the author, no standard procedure has been accepted for determining the Marshall stability of foam mix samples. Factors affecting the Marshall results are

1. moisture content at compaction,
2. compactive effort,
3. curing after compaction, and
4. test temperature.

Therefore, the Marshall stability values shown in Table 6 should be expected to vary, as they do, according to these factors.

While the results do tend to vary, the order of magnitude is the item of importance. For instance, a hot mix made of this sand and tested by the standard Marshall procedure at 140°F. typically yields a stability of 250 lb., and an emulsion mix tested at 77°F. has a typical stability around 1,300 lb.* From these figures it appears that the foam mix can produce stabilities comparable to that of hot mixes but less than that of emulsion mixes.

Voids Total Mix

Because of the one-size aggregate gradation, the voids in the mix tend to run 10% to 15% for hot mix and 22% to 26% for an emulsion mix.* The voids in the foam mix based on 50-blow Marshall densities were comparably high, running between 15% and 25%. The high void content is one reason that these sand mixes tend to oxidize rapidly , and was the main reason that the high penetration grade asphalt was used. Recovered penetration values were about 90, for a loss of about 55%. The recovered viscosities (140°F.) averaged about 2,200 poises. The hardening was evidently due to a combination of oxidation and volatilization.

*These results stem from a laboratory investigation, since no sand emulsion mixes have been placed in the field. They seem inordinately high.

Table 6

Marshall Stability Values

	Testing Agency						
	Research Council				Materials Division		APAC
Marshall stability, lb.	500	450	790	675	225	215	425
Moisture at compaction, %	-	-	-	-	-	-	6.0
Curing condition	3 hr. at 140°F	3 hr. at 140°F	24 hr. at 140°F	24 hr. at 140°F	2 hr. at 140°F	2 hr. at 140°F	24 hr. at 140°F
Test temperature, °F	77°F	77°F	77°F	77°F	77°F	77°F	140°F
Asphalt content, %	5.7	9.2	5.9	9.8	7.7	8.4	5.9

ADJUNCT WORK

While the foam mixer was available, five loads of a crusher-run aggregate material were mixed and stockpiled for future use as a patching material. This mix, which was mixed with a target 5% asphalt, looked dry in the stockpile (Figure 6). Extraction tests, Table 7, indicate a relatively low -#200 aggregate percentage. This may explain the dry appearance and lack of success in using the mix as a patching material.

Figure 6. Crusher-run patching material.

Table 7.

Asphalt Content and Gradation of
Crusher Run Patching Material

Sieve Size	Percent Passing
1"	100
3/4"	92
1/2"	64
3/8"	54
4	43
8	31
30	19
50	15
100	10
200	6.8
A.C., %	4.7

SHORT-TERM PERFORMANCE

The first five loads of material laid exhibited potholes after three days and had to be patched (Figure 7). This was in a lean asphalt section and one in which failures were evident the day after laying due to rolling with the steel-wheel roller. The author met with the resident engineer after the mix had been down a week, and decided to prime and seal the first section of the road extending to the beginning of the rich mix.

After 8 weeks, most of the remainder of the road was showing distress. Freezing and thawing appeared to be the condition most responsible for this deterioration. Failures had occurred even in the section that had been primed and sealed. Consequently, on January 5, 1982, the entire section was primed and sealed.

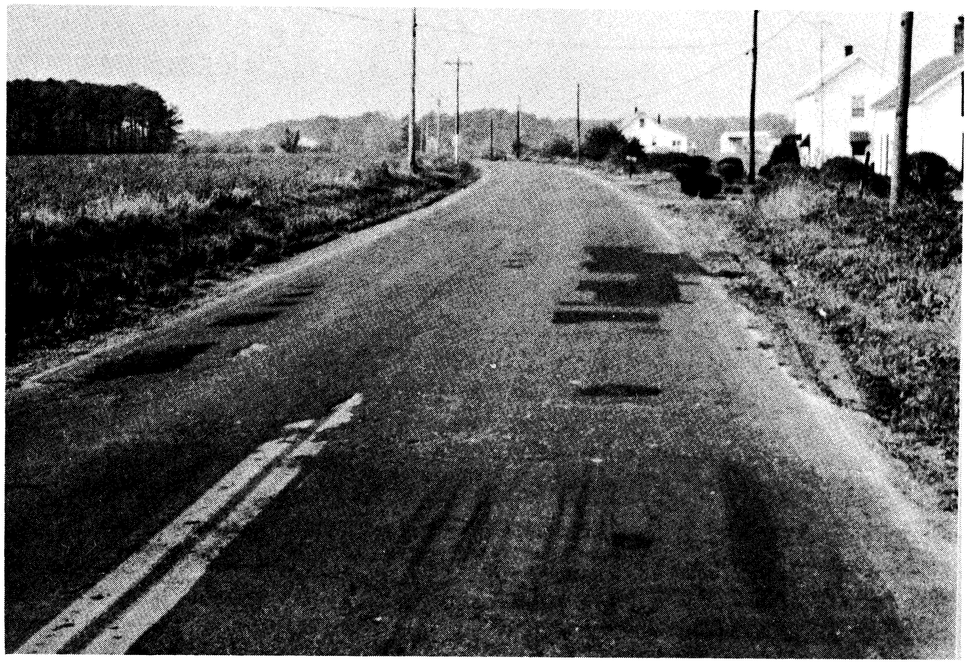

Figure 7. Patched area after one week.

COST

In almost any experimental work, the costs incurred are much higher than would be expected under normal construction conditions because of the limited scope and newness of the operation. This experiment was no different. The costs are listed in Table 8.

Table 8.

Costs of Experiment

<u>Materials</u>:		
Asphalt cement	$ 4,993.60	
Asphalt cement shipping charges	654.57	
Sand	79.50	
Fly Ash	430.38	
Crusher run aggregate	1,379.52	$ 7,537.57

Equipment:

Foam mixer ($10/ton)	$ 5,120.00	
Control trailer	510.00	
Foam mixer shipping charges	5,080.00	
Trucks, paver, etc.	2,522.50	$13,232.50
Labor		4,922.49
Miscellaneous		181.22
	Total	$25,873.58

Cost/Ton $50.53

The cost of foam mix under operational conditions should be in the range of $25 to $30/ton. This would bring the cost in line with that for an emulsion mix, which was $28/ton in 1981.

ACKNOWLEDGEMENTS

Although the project was small, a great deal of effort was put into it by many individuals. George Binkley with Conoco, John Miller with Intermix, Inc., and Pat Dunnigan with Koch Asphalt were instrumental in getting the bugs worked out of the process so that the mix could be produced. Harry Yeaman, the resident engineer, is thanked for the coordination of the project. The many hours and hard work of Kenny Wright, maintenance superintendent, are greatly appreciated and gratefully acknowledged. C. M. Clarke and C. O. Leigh are thanked for funding the project, especially considering it took more money than anticipated.

Joe Love of the Materials Division and Bill Kellam and Lansing Tuttle of APAC, Inc. are acknowledged and thanked for their testing, which helped provide additional data.

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APPENDIX

ATTENDEES

Foam Mix
Accomac, Virginia
October 28, 1981

Name	Affiliation
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