NCAT Report 03-01

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April 2003

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ABSTRACT

Stone matrix asphalt (SMA) has been used within the U.S. since 1991. To date almost all of the SMA mixes have had either a 12.5 or 19.0 mm nominal maximum aggregate size (NMAS). These two NMASs have been predominant because they conform to information obtained from European experiences with SMA. However, the existence of a "fine" SMA mix could be beneficial because it can be placed in thinner lifts, could be used as part of a preventative maintenance program, and should be more workable. For the purpose of this study, a "fine" SMA was defined as a SMA having either a 4.75 or 9.5 mm NMAS. This research study was conducted to evaluate the potential of designing fine SMAs and to compare these fine SMAs to more conventional SMA mixes (larger NMAS). Data accumulated from this study showed that these fine SMAs could be successfully designed to have stone-on-stone contact. Rut susceptibility testing with the Asphalt Pavement Analyzer confirmed that the designed fine SMA mixes were rut resistant. Permeability testing indicated that these fine SMA mixes were less permeable than conventional SMA mixes, at similar air void levels, and thus should be more durable. Based upon all information from this study, it was concluded that fine SMAs are a viable option for thin overlays.

POTENTIAL OF USING STONE MATRIX ASPHALT (SMA) FOR THIN OVERLAYS

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INTRODUCTION

Stone matrix asphalt (SMA) has been used in Europe for over 30 years. SMA was first used in Europe as a mixture that would resist the wear of studded tires; however, an additional benefit found with SMA was that it was highly rut resistant. Because of the success of SMA in Europe, five agencies within the United States constructed SMA pavements during 1991. These agencies designed the SMA mixtures using "recipe" procedures adopted from European practices.

The first publication within the United States that provided guidance on the design of SMA mixtures was produced by the SMA Technical Working Group (TWG) and published in 1994 (1). Within this publication, a single gradation band was provided. Depending upon the actual gradation utilized, SMA gradations that met the TWG's requirements had either a 12.5 or 19.0 mm nominal maximum aggregate size (Superpave definition).

In 1997, the National Center for Asphalt Technology (NCAT) conducted a performance evaluation of more than 140 SMA pavements from all over the United States (2). Most of these SMA mixes were designed using the TWG's recommended gradation band. The evaluation consisted of collecting data concerning mix design, plant production, laydown, and performance for each of the SMA projects. With respect to performance, over 90 percent of the evaluated SMA pavements had rut depths of 4 mm or less.

Of the 144 pavement sections evaluated by NCAT, only six had gradations that were not 12.5 or 19.0 mm nominal maximum aggregate sizes (NMAS). All six of these had 9.5 mm NMAS gradations (Figure 1). Five of these six SMA sections were placed on one project in Wisconsin. These five sections all had similar gradations but varied by the type of stabilizer used. All five of these sections were reported as having negligible amounts of rutting (2). The sixth 9.5 mm NMAS section evaluated by NCAT was in Illinois (Figure 2). The average rutting on this section was reported to be 3.3 mm with a standard deviation of 0.8 mm (2). All six of these test sections suggest that SMA mixtures having NMAS other than the conventional 12.5 or 19.0 mm NMAS can be designed to be rut resistant.

The performance evaluation conducted by NCAT clearly showed that most of the SMA pavements constructed in the U.S. have been either a 12.5 or 19.0 mm NMAS. However, the existence of a "fine" SMA could be beneficial to the hot mix asphalt industry. For the purposes of this study, a "fine" SMA was defined as a SMA with either a 4.75 or 9.5 mm NMAS.

Potential Advantages of a "Fine" SMA

There are several benefits that can be realized by using a fine SMA mixture. First and foremost is that a fine SMA can be placed using a thinner lift thickness which means that it could be used in a preventative maintenance program. Also, utilizing a thinner lift thickness allows for more projects to be covered with the same tonnage of mix. If the rule for lift thickness to NMAS ratio of three is used, a 4.75 mm NMAS SMA could be placed at less than 19 mm (3/4 in.) of thickness; however, in practice they should likely be placed 19 mm or thicker. Likewise, a 9.5 mm NMAS SMA can be placed with a lift thickness of less than 32 mm (1 1/4 in.).

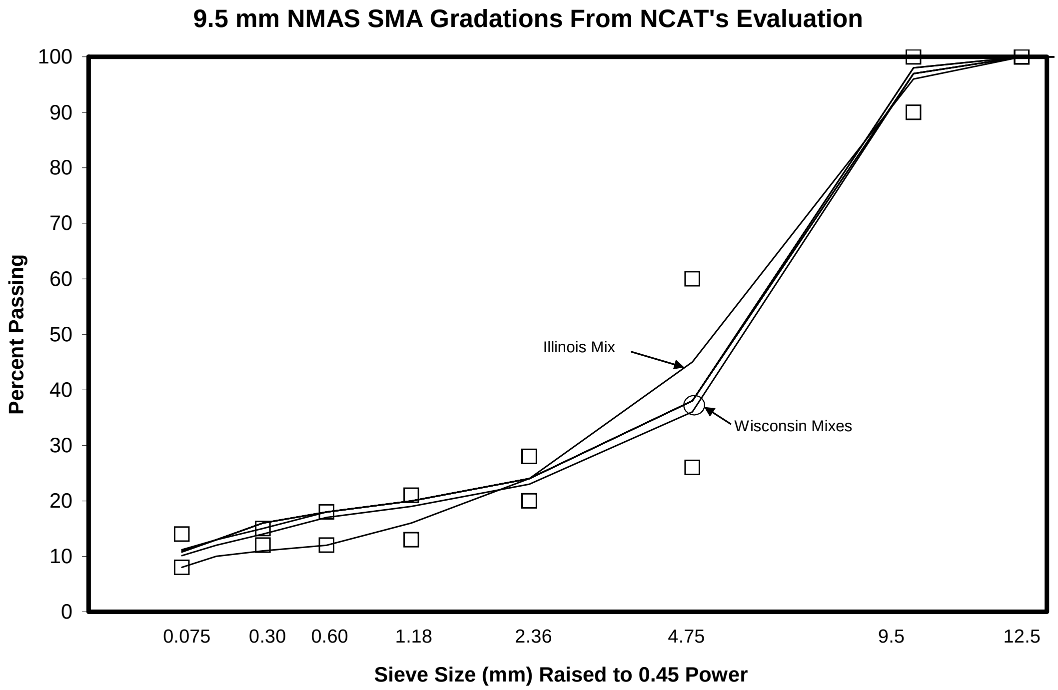

Figure 1. 9.5 mm NMAS Gradations From NCAT's Evaluation (2)

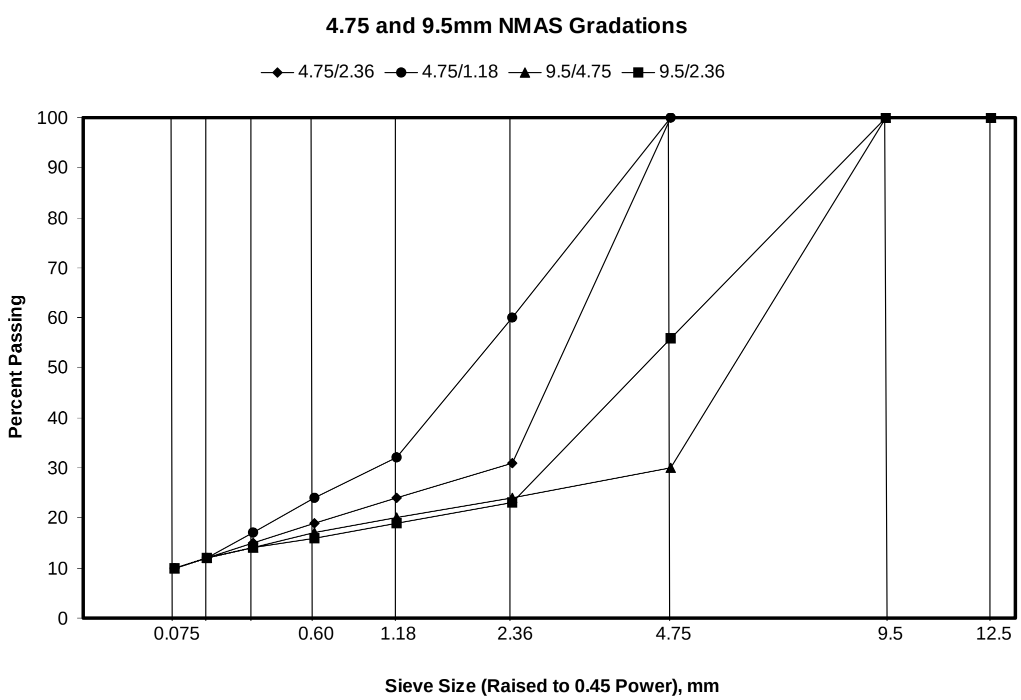

Figure 2. Fine SMA Gradations Used in This Study

Another potential benefit of a fine SMA is the reduction in permeability. Work at NCAT with field permeability testing on dense-graded Superpave mixtures has shown that as the NMAS of mixtures decrease, field permeability also decreases at a given void level.

One of the primary concerns about SMA pavements is the ride quality aspect. This concern stems from the fact that SMA has such a high percentage of coarse aggregate and thus tends to have a relatively rough surface texture. This rough surface texture can affect a traveling motorist through both vibrations and noise. SMA mixtures having smaller NMAS should be able to be placed smoother as a lower percentage of "coarse" aggregates would be used and thus a smoother surface.

Most SMA mixtures have used some type of polymer modified asphalt binder. Because of the gap-graded nature of SMA and the use of these polymer modified binders, SMA has sometimes been difficult to work. A fine SMA should have a slightly higher asphalt content than coarser SMA mixtures as well as the lower percentage of "coarse" aggregates and, therefore, should be more workable.

OBJECTIVE

The objective of this research was to compare SMA mixtures with a "fine" nominal maximum aggregate size to more conventional SMA mixes (larger NMAS). If fine SMAs can be successfully designed and compare favorably to conventional SMA mixtures (with respect to performance), then fine SMAs are a viable option for thin overlay applications.

SCOPE

In order to compare "fine" and conventional SMAs, mix designs were conducted for four NMASs using the mix design procedure developed by NCAT during NCHRP 9-8, "Designing Stone Matrix Asphalt Mixtures" (3). The four NMASs included 4.75, 9.5, 12.5, and 19.0 mm. For each NMAS, two gradations were investigated.

After the mix designs were completed, samples of each mixture were fabricated for rut susceptibility testing in the Asphalt Pavement Analyzer (APA). Within the APA, two test temperatures were utilized (50 and 64°C). A test temperature of 50°C (120°F) was selected because it was the temperature at which the Georgia Department of Transportation set a rut depth criteria of 5 mm maximum for high performance mixes. The 64°C (147°F) temperature was selected because an unmodified PG 64-22 binder was used in all mixes and these mixes should perform satisfactorily at 64°C. All APA testing was conducted in a dry condition utilizing a wheel load of 445 N (100 lb) and hose pressure of 690 kPa (100 psi).

Specimens were also fabricated to compare the permeability characteristics of the different NMAS. Samples having a range of air void contents were made by varying the number of gyrations with a Superpave gyratory compactor. Gyrations of 10, 30, and 50 were used to produce the range of air void contents. These gyration levels should provide approximately 5 to 10 percent air voids, which would be below and above the desired density level in the field (6 percent air voids). A laboratory permeameter was used for this testing and was the second generation of the laboratory device developed by the Florida Department of Transportation (4). This device utilized a falling head approach.

MATERIALS AND METHODS

Materials utilized in this study included a coarse aggregate, fine aggregate, mineral filler, asphalt binder, and stabilizing additive. Both the coarse and fine aggregate were a hard, angular traprock having the properties shown in Table 1. The mineral filler was a limestone dust (Table 2) having approximately 80 percent passing the 0.075 mm (No. 200) sieve. An unmodified PG 64-22 asphalt binder was used for all mixes. Cellulose fiber, in a loose form, was used as the stabilizing additive. This fiber was added to each mixture at 0.3 percent by total mix mass.

Table 1. Properties of Coarse and Fine Traprock Aggregate

Coarse Aggregate Properties		
Property	Test Method	Value
Bulk Specific Gravity	AASHTO T-85	2.973
Apparent Specific Gravity	AASHTO T-85	3.021
Absorption, %	AASHTO T-85	0.7
Los Angeles Abrasion, % Loss	AASHTO T-96	17
Flat or Elongated Particles	ASTM D-4791	
2 to 1		54
3 to 1		15
5 to 1		1
Soundness, % Loss	AASHTO T-104	1.1
Crushed Content, %	ASTM D-5821	
One Face		100
Two Face		100
Fine Aggregate Properties		
Property	Test Method	Value
Bulk Specific Gravity	AASHTO T-84	2.919
Apparent Specific Gravity	AASHTO T-84	3.001
Absorption, %	AASHTO T-84	1.0
Soundness, % Loss	AASHTO T-104	1.1
Angularity, %	AASHTO TP-33	48.3
Liquid Limit, %	AASHTO T-89	**
Plastic Limit, %	AASHTO T-90	NP

** - Liquid Limit could not be determined
NP - Non-Plastic

Table 2. Limestone Mineral Filler Properties

Particle Size Analysis[1]	
Size (mm)	Cumulative Percent Passing
2.36	100
1.18	100
0.600	100
0.300	98
0.150	92
0.075	79.3
0.045	69.8
0.020	57.1
Property	Value
Apparent Specific Gravity	2.876
Dry-Compacted Voids[2](%)	33.5
Surface Area (m^2/g)	1.50

[1] Determined using a Coulter LS-200 laser particle size analyzer
[2] Determined by Modified Rigden Voids Method
[3] BET determined using a Coulter SA-3100 surface area analyzer

Test Methods

Within a SMA mix design, there are two tests that are not typical of most dense-graded mix designs: voids in coarse aggregate (VCA) and draindown.

Voids in Coarse Aggregate

The VCA of the coarse aggregate fraction is determined by compacting the aggregate with the dry-rodded technique according to AASHTO T19, Unit Weight and Voids in Aggregate. The acronym VCA_{DRC} is used to indicate the voids in coarse aggregate of the coarse aggregate fraction in the dry-rodded condition. This value is used in the determination of stone-on-stone contact (2) and is calculated as follows:

$$VCA_{DRC} = \frac{G_{ca}\gamma_w - \gamma_s}{G_{ca}\gamma_w} x\, 100$$

Where,

VCA_{DRC} - voids in coarse aggregate of coarse aggregate only in dry-rodded condition, %
γ_s - dry unit weight of coarse aggregate fraction in dry-rodded condition (kg/m^3)
γ_w - unit weight of water (998 kg/m^3)
G_{ca} - combined bulk specific gravity of coarse aggregate fraction

Draindown Sensitivity
The draindown test measures the potential for asphalt binder to drain from the coarse aggregate structure while the mix is held at an elevated temperature. The test is performed in accordance with ASTM D6390, Test Method for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures. To run this test, a sample is prepared in the laboratory (during mix design) or obtained from field production. The sample is placed in a wire basket that is put onto a suitable container of known mass (generally a paper plate). The sample, basket, and container are then placed into a forced draft oven for one hour at or above the anticipated production temperature. At the end of the one hour, the mass of asphalt binder draining from the sample that is retained in the container is determined and the amount of draindown calculated.

Overview of SMA Mix Design Procedure

The first step in the mix design process is to select materials that meet requirements. Requirements utilized in this study are provided in Reference 2. Once satisfactory materials have been identified, the optimum aggregate gradation and binder content must be determined. This is accomplished by first selecting an appropriate aggregate blend. This blended gradation should provide an aggregate skeleton with stone-on-stone contact and furnish a mixture that meets or exceeds the minimum voids in mineral aggregate.

After the trial gradation samples have been compacted and allowed to cool, they are removed from the molds and tested to determine bulk specific gravity in accordance with AASHTO T166. The volumetric properties of each compacted sample is then determined. Following are the volumetric calculations of interest:

$$V_a, \% = 100\ x \left[1 - \frac{G_{mb}}{G_{mm}} \right]$$

$$VCA_{MIX}, \% = 100 - \left(\frac{G_{mb}}{G_{ca}}\ x\ P_{CA} \right)$$

$$VMA, \% = 100 - \left(\frac{G_{mb}}{G_{sb}}\ x\ P_s \right)$$

Where,

V_a - percent air voids in compacted mixture,
VCA_{MIX} - voids in coarse aggregate fraction within compacted mixture,
VMA - voids in mineral aggregate,
G_{mb} - bulk specific gravity of compacted mixture,
G_{mm} - theoretical maximum specific gravity (AASHTO T209),
P_s - percent of aggregate in the total mixture,
P_{CA} - percent of coarse aggregate in the total mixture,
G_{sb} - combined bulk specific gravity of the aggregates, and
G_{ca} - combined bulk specific gravity of the coarse aggregate fraction.

Of the trial blends evaluated, the one that meets or exceeds the minimum VMA requirement and has a VCA_{MIX} less than VCA_{DRC} should be selected as the design gradation. When a SMA mix has a VCA_{MIX} less than VCA_{DRC} it has achieved stone-on-stone contact.

Once a trial blend has been selected as the design gradation, it may be necessary to raise or lower the asphalt binder content to obtain the proper amount of air voids. Additional samples are prepared using the design gradation and the binder content varied. The optimum binder content is chosen to produce following properties .

Property	Requirement
Air Voids at Ndesign, %	4.0
Voids in Mineral Aggregate, %	17 min.
Voids in Coarse Aggregate for Mix (VCAMIX), %	Less than VCADRC
Tensile Strength Ratio (AASHTO T283), %	70 min.
Draindown at Production Temperature, %	0.30 max.

MIXTURE GRADATIONS

Gradations utilized for the eight mixes are provided in Table 3 and graphically illustrated in Figures 2 and 3. For each NMAS (except the 19.0 mm NMAS), two break point sieves were investigated. The significance of the break point (BP) sieve is that this sieve identifies the point at which the gap in the gradation begins. The aggregate fraction coarser than the BP sieve is used to evaluate the existence of stone-on-stone contact by the dry-rodded test (AASHTO T-19) as outlined in NCAT's SMA mix design procedure (3).

Figure 2 illustrated the four fine NMAS gradations used in this study. For the 4.75 mm NMAS, the two BP sieves were the 2.36 and 1.18 mm, while the 9.5 mm NMAS gradations utilized BP sieves of 4.75 and 2.36 mm. Figure 3 illustrates the four control, or conventional, SMA gradations. Similar to the fine NMAS gradations, the two 12.5 mm NMAS gradations utilized different BP sieves, 9.5 and 4.75 mm. The point at which the gap begins for 19 mm NMAS SMA mixes was previously defined from experiences in Europe and Phase 1 of NCHRP 9-8 (5). Therefore, only the 4.75 mm BP sieve was used.

Table 3. Mix Gradations

Sieve (mm)	Nominal Maximum Aggregate Size (NMAS)/Break Point (BP) Sieve Combination							
	4.75/ 2.36	4.75/ 1.18	9.5/ 4.75	9.5/ 2.36	12.5/ 9.5	12.5/ 4.75	19/ 4.75[A]	19/ 4.75[B]
19							100	100
12.5					100	100	90	73
9.5			100	100	26	75	54	57
4.75	100	100	30	56	22	27	24	24
2.36	31	60	24	23	19	22	20	20
1.18	24	32	20	19	16	18	18	17
0.6	19	24	17	16	15	16	14	15
0.3	15	17	14	14	14	14	13	14
0.15	12	12	12	12	12	12	12	12
0.075	10	10	10	10	10	10	10	10

[A] Design gradation determined in Phase I
[B] Design gradation determined in Phase II

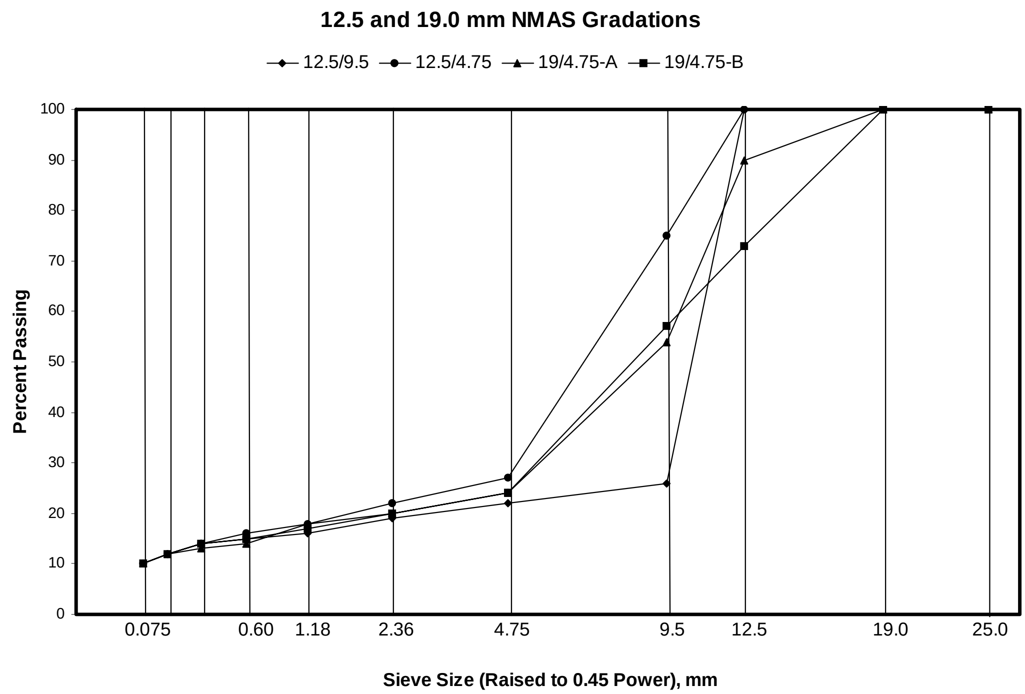

Figure 3. Conventional SMA Gradations Used in This Study

TEST RESULTS

Optimum volumetric properties for the eight designed mixes are presented in Table 4. Optimum asphalt contents for the eight mixes ranged from a low of 5.5 percent ($19/4.75^{B}$) to a high of 8.3 percent (4.75/2.36). The 5.5 percent asphalt content for combination $19/4.75^{B}$ is lower than the minimum asphalt content of 6.0 percent recommended by the SMA TWG (*1*). However, the traprock aggregate used in this study is relatively heavy (bulk specific gravity of 2.973) and on a volumetric basis the asphalt content is similar to that recommended by the TWG. Two of the mixtures had asphalt contents somewhat higher than the other six mixes. Combinations 4.75/2.36 and 12.5/9.5 both had asphalt contents in excess of 8.0 percent. These relatively higher asphalt contents were the result of the high percentage of one aggregate size within the aggregate gradation. Both combinations had 100 percent passing the NMAS (4.75 and 12.5 mm, respectively) and approximately 30 percent passing the next smallest sieve (in both cases the BP sieve). This high percentage of one aggregate size in both combinations led to voids in mineral aggregate (VMA) values that were approximately 22 percent. Within the mix design system for SMA, optimum asphalt content is defined as the asphalt content that provides 3.5 to 4 percent air voids (5). Therefore, the high asphalt contents for these two combinations were the result of the high VMA values. It is interesting to note that this did not occur for the 9.5/4.75 combination. The 9.5/4.75 combination most likely did not have the higher VMA value and thus higher asphalt content (similar to combinations 4.75/2.36 and 12.5/9.5) because of the range in aggregate sizes between the NMAS and BP sieve. Referring back to Figure 2, for the 9.5/4.75 combination there is approximately 4.8 mm difference between the NMAS (9.5 mm) and BP (4.75 mm) sieves. This 4.8 mm gap is larger than for the 4.75/2.36 and 12.5/9.5 combinations and allows a wider range of aggregate sizes. This wider range of aggregate sizes likely allowed for some VMA to be filled by the more continuous grading between the NMAS and BP sieve.

Table 4. Optimum SMA Mixture Properties

Mixture (NMAS/BP)	Asphalt Content, %	VTM %	VMA %	VCA_{MIX} %	VCA Ratio
4.75/2.36	8.3	3.8	22.5	46.6	0.982
4.75/1.18	7.3	3.8	20.2	45.8	0.996
9.5/4.75	5.6	3.8	17.5	41.7	0.932
9.5/2.36	5.8	3.8	17.6	37.9	0.864
12.5/9.5	8.0	3.8	22.0	42.4	0.996
12.5/4.75	6.1	3.8	18.0	40.3	0.948
$19/4.75^{A}$	5.6	3.6	17.4	36.3	0.876
$19/4.75^{B}$	5.5	3.6	17.0	36.3	0.825

Of special interest in Table 4 are the voids in coarse aggregate (VCA) ratios. This ratio compares the VCA of compacted SMA (VCA_{MIX}) to the VCA of the coarse aggregate only fraction in the dry-rodded condition (VCA_{DRC}) to evaluate the existence of stone-on-stone contact. The VCA_{DRC} is determined using AASHTO T19, "Unit Weight and Voids in Aggregates." Stone-on-stone contact is said to exist when the VCA_{MIX} is less than the VCA_{DRC} of the coarse aggregate fraction (6). Table 4 shows that all eight of the mixes were successfully designed to have stone-on-stone contact as all VCA ratios were less than 1.0 (VCA_{MIX} divided by VCA_{DRC}).

After completion of the mix designs, samples were prepared for rut testing in the APA. Results of this testing are shown in Table 5. At 50°C, all of the mix combinations had rut depths less than 5.0 mm. This is significant because the Georgia Department of Transportation has set a rut depth criteria of 5.0 mm maximum for mixes to be placed in high traffic areas. Of importance, the two combinations with asphalt contents of 8.3 and 8.0 percent (4.75/2.36 and 12.5/9.5, respectively) had rut depths less than 5.0 mm. This information seems to confirm that these mixes had stone-on-stone contact and thus were rut resistant.

Table 5 also presents APA results at the 64°C test temperature. As would be expected at the higher temperature, rut depths increased from the 50°C testing. However, the magnitude of rut depths were still relatively low. The highest rut depth was 5.4 mm, which would barely fail the GDOT criteria for testing at 50°C. Therefore, based upon APA testing the "fine" SMA mixtures can be designed to be rut resistant.

Results of permeability testing on the designed mixes are illustrated in Figures 4 and 5. The relationship between sample air void content and laboratory permeability for the "fine" SMA mixes is shown in Figure 4. As would be expected, the permeability of all mixes increased as the sample air void contents increased. However, the rate of change in this relationship is different for each of the mixes. The factor most affecting the relationship appears to be NMAS. Both of the 4.75 mm NMAS mixes are all less permeable than the 9.5 mm NMAS mixes at a given air void content. Similar to dense-graded HMA mixes, the NMAS of SMA probably plays an important part in the permeability characteristics of constructed pavements. As the NMAS of an SMA mixture increases, the size of individual air voids within a constructed pavement also increase. This increase in air void size leads to a greater potential for interconnected voids. Therefore, at a given air void level the larger NMAS SMA mixes have a greater potential for interconnected voids and thus permeability.

Table 5. Results of Rut Testing on Designed SMA Mixtures

Mixture Type	Average Rut Depth (mm)[1] (@ 50°C)	Average Rut Depth (mm)[1] (@ 64°C)
4.75/2.36	4.2	5.3
4.75/1.18	2.7	5.4
9.5/4.75	2.8	4.4
9.5/2.36	3.5	5.4
12.5/9.5	3.7	4.5
12.5/4.75	4.1	5.4
19/4.75[A]	1.7	2.6
19/4.75[B]	1.4	2.2

[1] Average rut depth after 8000 cycles of loading

Another factor that appears to affect the air void-permeability relationship in Figure 4 is the BP sieve. For both NMAS, the mix with the larger BP sieve is more permeable at a given air void content. Figure 2 illustrated that for a given NMAS the mix with the larger BP sieve is more gap-graded, or in other words had a higher percentage of a given aggregate size. Similar to NMAS, the higher percentage of a given aggregate size likely leads to a higher potential for interconnected voids.

Figure 5 illustrates the relationship between sample air void content and permeability for the conventional SMA mixes. An initial observation from this figure is that these 12.5 and 19 mm SMA mixes are more permeable than the fine SMA mixes shown in Figure 4, at similar air void levels. The effect of NMAS on permeability is not as clear for these conventional SMA mixes as it was on the finer mixes. This can be explained in that there was not as big a difference in the four gradations. Referring back to Figure 3, the two 19 mm mixes were actually finer than the 12.5/9.5 combination on the 9.5 mm sieve and had a similar percent passing on the 4.75 mm sieve as both 12.5 mm NMAS mixes. The effect of BP sieve is still evident with the two 12.5 mm NMAS mixes (the 19 mm NMAS mixes utilized the same BP sieve). The mix with the larger BP sieve (12.5/9.5) was more permeable at a given air void level.

In order to compare the permeability characteristics of "fine" and conventional SMA mixes, the permeability of each mix was approximated at 7 percent air voids using the regression lines shown in Figures 4 and 5. This comparison is shown in Figure 6. At 7 percent voids, the fine SMA mixes had permeability values ranging from approximately 20 to 1200 x 10^{-5} cm/sec. By contrast, the conventional SMA mixes had permeability values ranging from approximately 2100 to 5200 x 10^{-5} cm/sec. This clearly shows that the potential for permeability problems is much less for the finer SMA mixes. Interestingly, if the recommended critical permeability value of 100 x 10^{-5} cm/sec developed by the Florida Department of Transportation (4) is employed, only the two 4.75 mm NMAS mixes would comply at 7 percent voids.

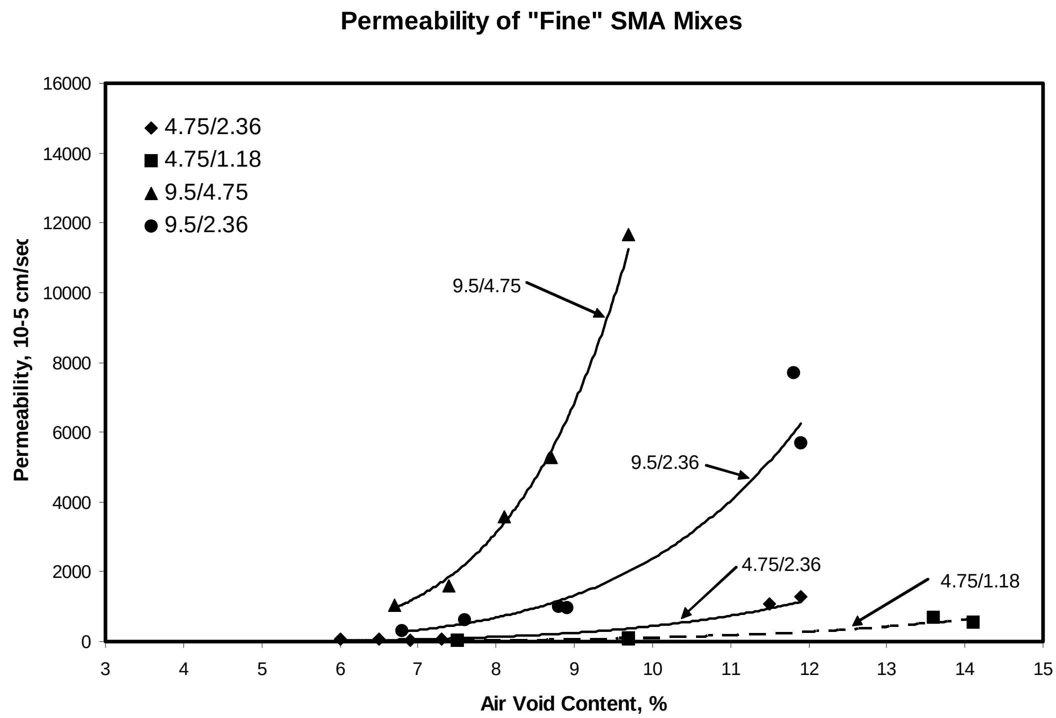

Figure 4. Results of Permeability Testing on Fine SMA Mixes

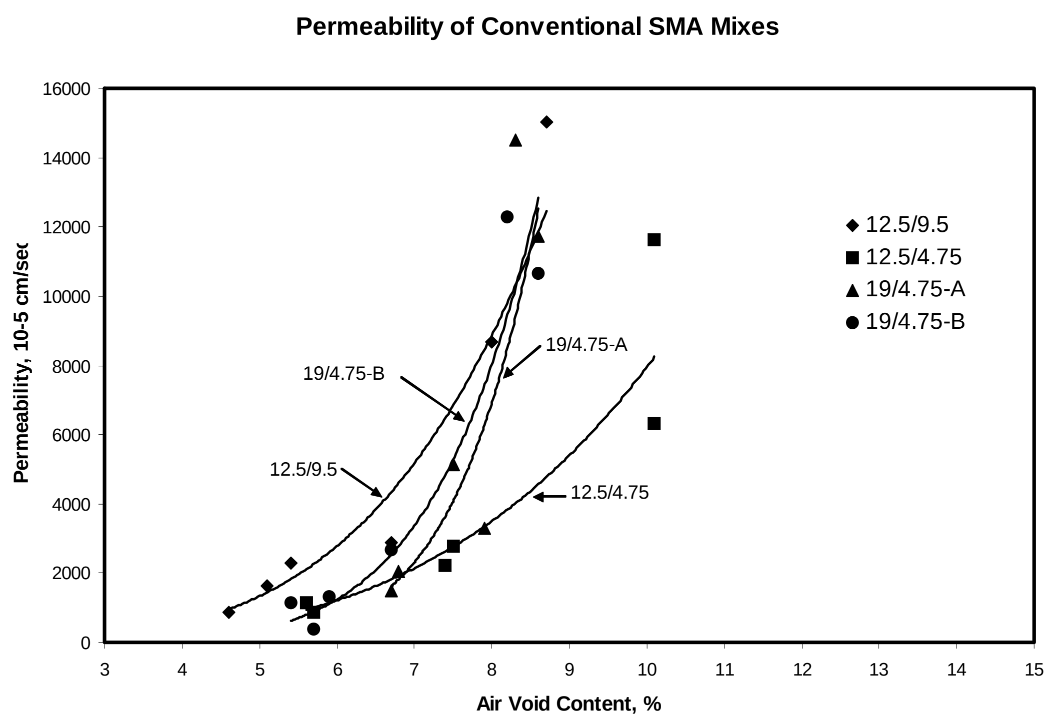

Figure 5. Results of Permeability Testing on Conventional SMA Mixes

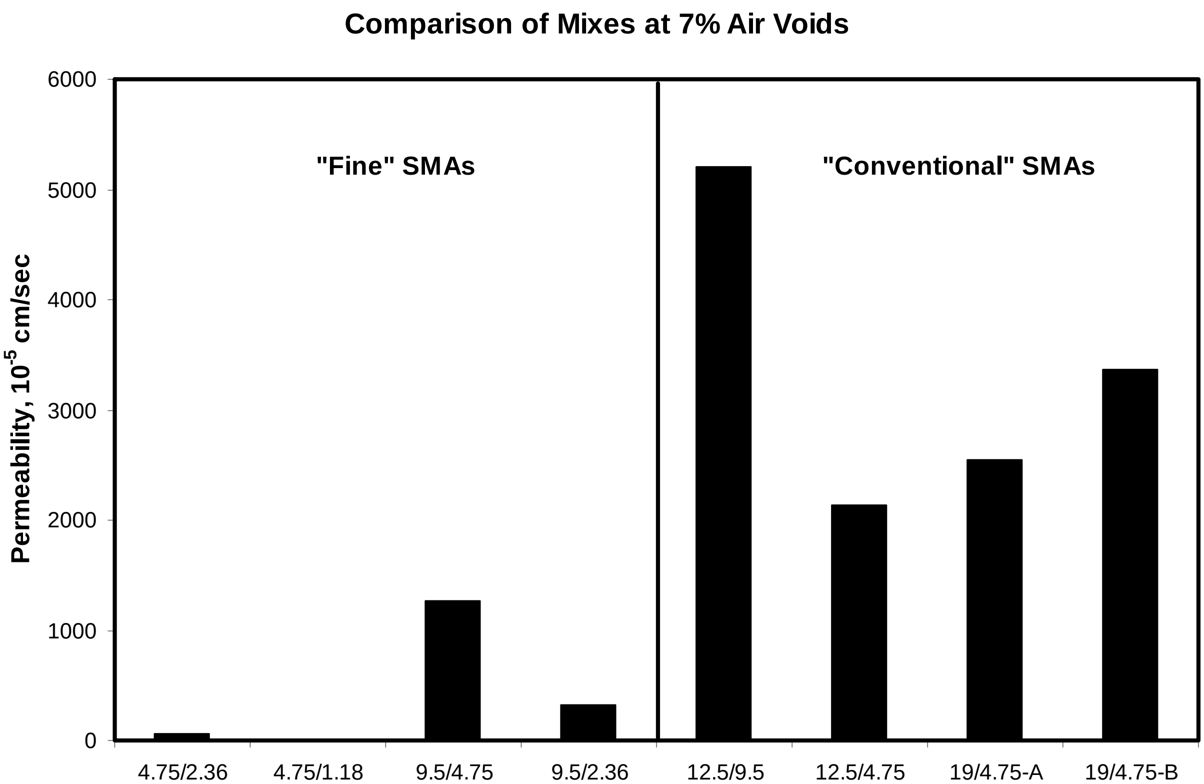

Figure 6. Comparison of Mixture Permeability at 7 Percent Air Voids

EXPERIENCE FROM STATES

Within the last two years, several states have placed fine SMA mixes. However, all of these mixes have been 9.5 mm NMAS. These pavements have not been down long enough to provide a meaningful performance evaluation, but should provide some valuable information after trafficking for five to six years.

CONCLUSIONS AND RECOMMENDATIONS

Based upon the data obtained from this study, it appears that SMA mixtures having both 4.75 and 9.5 mm NMAS can be utilized as rut resistant overlays. During the mix design phase, the "fine" SMA mixtures were successfully designed to have stone-on-stone contact. The 4.75 mm NMAS mix having a BP sieve of 2.36 mm did have a relatively high asphalt content at 8.3 percent, but still was successfully designed to have stone-on-stone contact as the VCA ratios were less than 1.0. Results of APA testing at both 50 and 64°C confirmed that the designed mixtures were rut resistant. Permeability testing also indicated that these "fine" SMA mixtures should have less potential for permeability problems than the more conventional SMA gradations (12.5 and 19.0 mm NMAS).

Based upon the conclusions, fine SMA gradations are a viable option for thin overlays. These mixes are rut resistant and should be very durable as permeability potential is less than that of more conventional SMAs. Table 6 provides gradation bands that are recommended for SMA mixes having NMAS of either 4.75 or 9.5 mm. These gradations should be used in conjunction with the SMA mix design system developed by the National Center for Asphalt Technology (3) through research sponsored by NCHRP in Project 9-8.

Table 6. Recommended "Fine" SMA Gradation Bands, Percent Passing by Volume

Sieve (mm)	9.5 mm NMAS		4.75 mm NMAS	
	Lower	Upper	Lower	Upper
12.5	100	100		
9.5	90	100	100	100
4.75	26	60	90	100
2.36	20	28	28	65
1.18	13	21	22	36
0.6	12	18	18	28
0.3	12	15	15	22
0.075	8	10	12	15

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