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16. Abstract

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INSTALLATION REPORT

TEST SECTIONS CONTAINING NATURAL AND MANUFACTURED SAND

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Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Transportation and the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

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ABSTRACT

This report describes the materials, mix properties, and early pavement cross sections of two mixes placed on Route 50, Fairfax County, in August 1988. The difference in the two mixes was that one contained a natural and the other a manufactured sand. Because the natural sand used was similar in surface characteristics to the manufactured sand, no significant differences in mix characteristics or performance were discerned. Measurements will be made periodically to determine if rutting is occurring.

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INTRODUCTION

In 1987, the Virginia Department of Transportation (VDOT) added a requirement to Section 212 of the Special Provisions that a minimum of 15 percent natural sand be used in all asphalt surface mixes. This requirement was added to "open" the mixes, i.e., to increase the voids in mineral aggregate (VMA), which would allow more room for the asphalt cement. As in many asphalt mix design considerations, a change to address one failure may have repercussions that affect other features of the mix. In the case of natural sand, theory indicates that the addition of a material with a different particle shape will often increase the VMA; thus, the addition of natural sand, which tends to have a rounded shape, will likely increase the VMA of a mix composed of crushed aggregate. However, theory also indicates that the rounded shape of natural sand often causes the sand to act as small ball bearings, thereby adversely affecting the resistance to rutting of the mix.

A contractor, APAC Finley Division, and an aggregate producer, Vulcan Materials, requested that the VDOT test one mix using natural sand and another using manufactured (stone) sand, to determine if one was appreciably better than the the other in resisting rutting. The VDOT requested that the Research Council oversee the installation and monitor the test sections to assess the performance of each mix.

OBJECTIVE

The objective of this study was to monitor the installation, analyze Marshall and Gyratory Testing Machine results, and assess the field performance of test sections containing either natural or manufactured sand.

JOB MIX FORMULAS

The job mix formulas of the two mixes were not appreciably different (see Table 1).

INSTALLATION

On the night of August 24, 1988, four test sections were placed in the WBL of Route 50 just west of the western Fairfax city limits. Two sections were placed in the traffic lane and two in the passing lane (see Figure 1). The traffic count (27,250 vpd in one direction) is sufficiently high that there is little difference in traffic count between the traffic and passing lanes.

Nuclear density tests were taken at the time of placement; sawed plugs were taken and rut measurements were made after rolling was completed. Additionally, mix was taken to various labs where extraction results and Marshall properties were determined. The Research Council used the Gyratory Testing Machine (GTM) to evaluate the two mixes and also ran resilient modulus tests.

Results

Gradation

Gradations and asphalt contents obtained from extraction tests run on plant-produced material are shown in Table 2. APAC and Vulcan determined gradations and asphalt contents on only what was considered the experimental mix, the one containing the manufactured sand. As average results show, there is little difference in extraction results between the two mixes. The percent passing the no. 50 sieve is slightly higher for the manufactured sand. The similarity in gradation is obvious from the plot on the .45 graph (Figure 2).

Marshall Properties

Marshall properties also were determined from plant-produced materials, and these results are shown in Table 3. The average results reveal little difference between the two mixes. The lower voids filled with asphalt (VFA) and higher voids total mix (VTM) for the natural sand indicate that the asphalt content may have been lower than desirable for this mix. If this assumption is true, rutting should not become a problem, but the distress modes--such as fatigue cracking, raveling, and possibly moisture damage--that are usually attributable to a dry mix may occur.

Gyratory Shear Machine Properties

The GTM has been used as an aid in evaluating mixes for susceptibility to rutting. The two mixes were tested in the GTM and the results are shown in Table 4.

The shear strengths of the two mixes were surprising: the natural sand had a greater strength than the manufactured sand. It was found that this particular natural sand from Solite--Fredericksburg is not rounded but very angular and thus would be expected to act like a manufactured sand. The GSF indicates the likelihood that neither mix will have a tendency to rut, i.e., the values are 1.00 or above. The GSI, with values nearly 1.0, indicates that plastic deformation will not be a problem. The Ultimate VTM indicates that after several years of traffic, the manufactured sand mix will have an average air void lower than that of the natural sand. This may be a concern except for the fact that the compactive effort of the GTM is substantially higher than that of the Marshall procedure using a 75-blow compactive effort as evidenced by the appreciably lower VTM of the former device. The difference in VTM between the manufactured and natural sand mixes obtained from the GTM indicates a lower relative asphalt content in the natural sand mix than the manufactured and thus verifies the Marshall results in that regard.

Resilient Modulus Results

Resilient modulus tests run with the Retsina device at 72°F produced a stiffness of 86,000 psi for the manufactured sand and 62,000 psi for the natural sand. Because of the testing variability of this procedure, this difference should not be considered statistically significant.

Field Density

Nuclear density tests were taken during and after compaction and sawed plugs were also taken after rolling. The average results are shown in Table 5.

The test section densities indicate that essentially 100 percent of the density obtained on the control strip was obtained. However, the air voids after rolling are extremely high. If the air voids are reduced by the additional compaction of traffic, i.e., consolidation to the void level predicted by the GTM, ruts of almost 0.2 in can be expected. Because of the shear strength of the two mixes, no plastic deformation should be anticipated.

RUT MEASUREMENTS

As previously stated, rut measurements were made at the time of construction. They were also made in November, approximately three months after construction. Table 6 shows the results.

As the results show, no appreciable rutting has taken place in any section after three months traffic. Rut measurements have also been referenced with regard to the traffic light because of the possibility that decelerating and stopped traffic may cause more severe shear stresses than moving traffic. Thus far, no significant differences have been found in relation to the traffic light.

CONCLUSION

After installation and three months service, no appreciable rutting has taken place in any test section. Material test results indicate that plastic deformation will not be a cause for rutting. However, consolidation caused by traffic compaction reducing the air voids may be a cause of minor rutting.

Table 1

Job Mix Formula, Percentage Passing

Sieve Size	Manufactured Sand	Natural Sand
1/2 in	100	100
#4	59	59
#30	20	21
#200	5.0	5.0
AC (%)	5.2	5.0

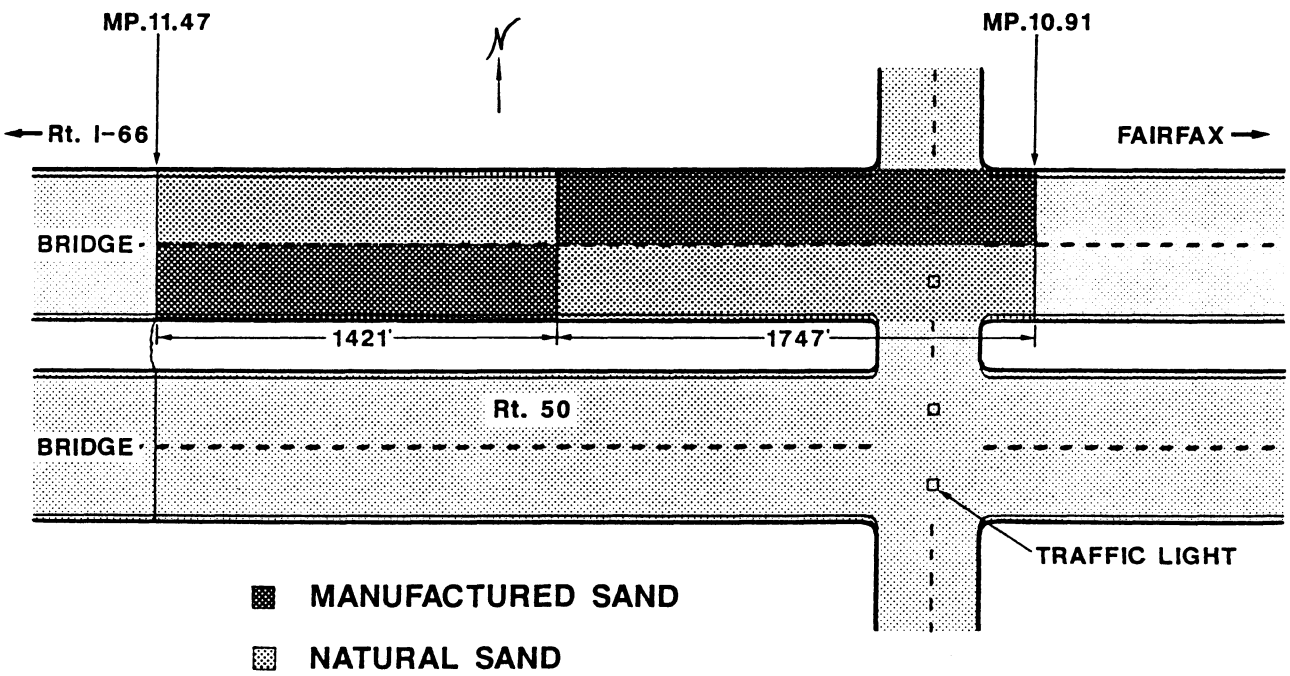

Figure 1 Location of test sections

Table 2

Gradations and Asphalt Contents

Sieve Size	Vulcan Man.	APAC Man.	District Man.	District Nat.	Elko Man.	Elko Nat.	Research Council Man.	Research Council Nat.	$\bar{X}$ Man.	$\bar{X}$ Nat.
1/2	100	100	99.6	99.9	100	100	99.5	100	99.8	100
3/8	95.8	96.7	97.4	96.7	96.4	96.8	95.8	95.1	96.4	96.2
#4	56.5	57.3	59.4	56.1	57.9	57.8	56.0	56.9	57.4	56.9
#8	41.2	38.7	40.7	39.2	40.3	39.2	37.0	38.8	39.6	39.1
#16	28.8	28.0	--	--	--	--	26.4	29.1	27.7	29.1
#30	21.2	20.0	20.7	20.2	21.2	20.2	19.0	19.4	20.4	19.9
#50	14.8	13.0	14.3	11.0	15.2	12.0	12.8	10.8	14.0	11.3
#100	9.0	--	--	--	10.0	7.7	7.8	6.2	8.9	7.0
#200	5.3	4.4	5.0	3.9	6.0	5.0	3.8	3.4	4.9	4.1
A/C	4.98	4.94	4.96	4.91	4.95	4.93	4.72	4.88	4.91	4.91

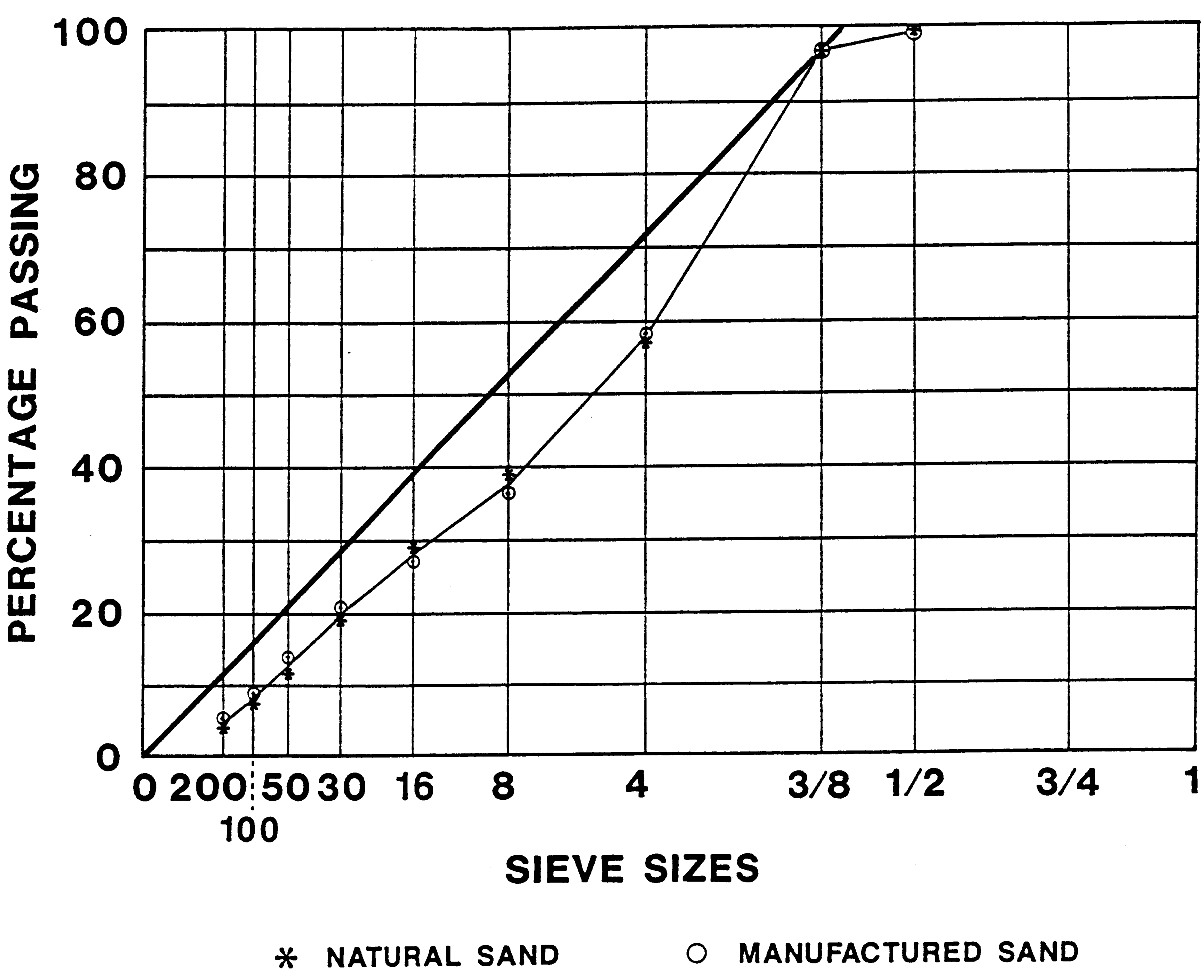

Figure 2 Gradation of mixes

Table 3

Marshall Properties

Property	Vulcan Man.	APAC Man.	District Man.	District Nat.	Elko Man.	Elko Nat.	Research Council Man.	Research Council Nat.	$\bar{X}$ Man.	$\bar{X}$ Nat.
Stab.	-	2,900	3,360	3,520	3,180	2,610	3,400	2,700	3,210	2,940
Flow	-	11.9	11.8	12.1	12.1	9.5	10	10	11.4	10.5
VMA	18.2	19.6	19.4	19.2	17.6	18.7	17.0	18.8	18.4	18.9
VFA	68.8	59.5	62.2	63.4	70.7	64.2	65.1	59.2	65.3	62.3
VTM	5.7	7.8	7.4	7.1	5.2	6.7	6.0	7.6	6.4	7.1

Table 4

Gyratory Shear Properties

Property	Manufactured	Natural
S_G	38	48
GSF	1.00	1.27
GSI	1.05	0.98
Ult. VTM	2.8	4.2
No. Rev.	210	180

S_G = shear strength: an indication of resistance to rutting--psi

GSF = gyratory shear factor: ratio of shear strength to the theoretical shear stress--a factor of safety index

GSI = gyratory stability index: ratio of maximum gyratory angle to minimum gyratory angle--an indication of plasticity

Ult. VTM = ultimate air voids: the voids total mix after several years of additional compaction from traffic

Table 5

Nuclear Density and Air Void Results

Property	Manufactured	Natural
Control strip (pcf)	144.9	143.9
Test section (pcf)	144.7	144.0
Air voids (%)	14.7	15.0

Table 6

Average Rut Measurements (in)

	Manufactured Sand		Natural Sand	
	Passing Lane	Traffic Lane	Passing Lane	Traffic Lane
Construction	.04	.03	-.01	.06
3 Months	.03	.06	-.02	.04