21 Million ESALs and Counting….4.75 mm HMA at the NCAT Test Track

Stockpiles of aggregate screenings have become commonplace at many quarry locations. These screenings can be used successfully in thin hot mix asphalt (HMA) overlays, including 4.75 mm mixes, that have the potential to provide excellent performance.

Constructed in August of 2003, the Mississippi Department of Transportation's (MDOT) 4.75 mm nominal maximum aggregate size (NMAS) hot mix asphalt section at the National Center for Asphalt Technology (NCAT) Pavement Test Track has successfully carried over 21 million equivalent single axle loads (ESALs) as of December 2009.

NCAT's pavement test track, originally constructed in 2000, consists of a 1.7 mile oval in which the performance of forty-six, 200-foot test sections is evaluated under accelerated loading. During a two year loading cycle, 10 million ESALs are applied to the test sections. This represents 10 to 15 years of traffic damage for most roadways. Track traffic is applied with five heavy triple tractor-trailers with gross vehicle weights of approximately 155,000 lbs. In comparison, a typical legal single tractor-trailer on today's highways would have a maximum gross weight of about 80,000 lbs. The test track operates using a pooled fund project structure in which individual state DOTs, FHWA, and private companies participate as sponsors. Test track results have been used by agencies to reduce the life cycle costs of their pavement infrastructures by improving HMA specifications and optimizing structural pavement design.

MDOT made the decision to place the 4.75 mm mix to determine its suitability for low volume road pavement preservation; however, the mix is proving to be much more than just a preservation tool. After being trafficked for two test track loading cycles (20 million ESALs total), the mix is continuing to provide excellent service during the current third loading cycle (the fourth research cycle for the Track overall). All indications are that this mix will successfully carry 30 million ESALs by the end of September 2011. Placement of the 200-foot long 4.75 mm mix test section was on the Track's west curve (Section W6) as shown in Figures 1 and 2. Construction of the 4.75 section consisted of a 3/4 inch mill and inlay. The underlying layer consists of 3.25 inches of a 12.5 mm NMAS slag/limestone dense-graded Superpave mix. This underlying mix was part of the original track test section buildup that includes a deep perpetual foundation.

Mix Properties

The aggregate blend grading is comprised of 69.3 percent Cherokee, Alabama limestone dry screenings, 18.8 percent crushed gravel, and 10.9 percent natural sand, along with 1 percent hydrated lime, which resulted in the average as-constructed quality control (QC) grading shown in Table 1. Crushed gravel and natural sand were from Guntown, Mississippi. Recycled asphalt pavement

(RAP) was not used in the mix, but the potential exists for its use. RAP fractionation would be necessary due to the small NMAS of the mix.

Mix design work was conducted using 50 gyrations of the Superpave gyratory compactor. The average as-produced asphalt binder content was 6.1 percent of a PG 76-22 SBS-modified binder. QC air voids and voids in mineral aggregate (VMA) were 4.0 and 16.0 percent, respectively.

A PG 67-22 binder at a placement rate of 0.03 lbs/yd^2 was used as the tack coat. One key economic and construction benefit of 4.75 mm mixes is their ability to be placed in relatively thin layers. In this case, the mix was placed at a 3/4 inch (~80 lbs/yd^2 spread rate) with 92.2 percent (7.8 percent air voids) of theoretical maximum specific gravity being achieved. Views of the mix surface texture and overall pavement cross section are found in Figure 3.

Performance

Truck traffic is suspended every Monday to allow for section performance evaluations, which include rutting, cracking, roughness, and surface texture determinations. In discussing the performance of the 4.75 mm mix, it is useful to use another similar section for comparison. Section S5, location shown in Figure 1, is a dense-graded 12.5 mm NMAS mix comprised of similar aggregates and the same PG binder type constructed at the same time as Section W6. S5 was placed at 1.5 inches lift thickness and is considered more in line with typical HMA overlay (i.e., mill and fill) of surface course mixes.

Rutting
Recent wire line rut depth measurements of W6 show 5.6 mm (0.22 in) of rutting, compared to 3.4 mm (0.14 in) for S5. While the rutting of W6 is slightly greater than S5, the level is still below 0.25 inch which is considered good performance. One important note is that the W6 rutting has remained stable since the completion of the initial test track cycle. Field construction notes point out the 4.75 mix was more difficult to compact than anticipated, which may partially explain its good rutting performance to date.

Cracking
No top down or bottom up cracking has been observed in the test section to date. The lack of observed cracking points not only to a good quality mix, but also to an excellent bond between the 4.75 mm and the underlying layer. This illustrates the importance of good tack coat practices.

Roughness
Automated roughness measurements are obtained using the Automatic Road Analyzer (ARAN) van and reported in terms of the international roughness index (IRI) in in/mile. The initial IRI for W6 was approximately 50 in/mile and has increased slightly to approximately 65 in/mile after 20 million ESALs. This compares very well with the IRI values measured for S5. These IRI values are

indicative of very smooth pavement surfaces and are typical of most test sections on the NCAT Pavement Test Track.

Surface Texture

Surface texture measurements can provide a good indication of pavement durability. The ARAN van measures the surface texture using a laser which samples data at a relatively high frequency (64 kHz). Onboard software quantifies the pavement macrotexture by digitizing the rapid vertical distance measurements. Macrotexture is a term used to define short (0.5 to 50 mm) wavelength irregularities in the surface of a pavement, and is a function of the gradation of the aggregates in the mix, void structure, etc. Performance history at the track strongly suggests that macrotexture is related to pavement durability. The mean texture depth (MTD), a measure of macrotexture, increases when aggregate particles are dislodged from the mat, leaving exposed surface voids in their place. This cumulative process creates a condition commonly referred to as raveling. *(1)*

Section W6 is proving to be a very durable mix. Figure 4 shows the MTD change over 20 million ESALs for sections W6 and S5. Both sections show an increase in MTD over time with the MTD for W6 always being lower. After 20 million ESALs the MTD of W6 is approximately equal to S5 at the time of construction. For further comparison purposes, the MTD results for Section N4 are also shown in Figure 4. N4 is a 9.5 mm NMAS blend of granite, limestone and natural sand aggregates. The MTD for this section was initially similar to Section W6, but has increased substantially to over twice that of W6 after 20 million ESALs.

Current 4.75 mm Mix Research

NCAT has recently completed a pooled fund study focused on refining the current AASHTO mix design criteria for 4.75 mm NMAS Superpave mixes. Participating states in the study were Alabama, Connecticut, Florida, Minnesota, Missouri, New Hampshire, Tennessee, Virginia, and Wisconsin. Based on this study, some key recommendations were made which include the following: 1) allow a range of design air voids from 4 to 6 percent, 2) replace VMA and VFA volumetric criteria with V_{be}, which is the volume of effective binder as percent of total mix volume, 3) V_{be} should be between 11.5 and 13.5 percent for projects over 3 million ESALs and between 12 and 15 for less than 3 million ESALs, 4) revised the grading criteria for the 1.18 mm sieve to 30 to 55 percent passing and for the 0.075 mm sieve to 6 to 13 percent passing. *(2)*

The 4.75 mm W6 mix properties comply with the study recommendations for air voids, grading and V_{be} (11.8 percent). Although this is only one test section, there appears to be some validation to the research findings.

4.75 mm Mix Future

Based on the test track performance, there is little doubt that 4.75 mm mixes have the potential to be more than a just a pavement preservation tool. Performance suggests these mixes can serve well as "structural" surface mixes for new construction or rehabilitation applications.

As with any mix, the decision to use 4.75 mm mixes should be based on a properly conducted benefit-cost analysis. Based on the excellent mix performance at the Track and thin layer placement, the outcome from such an analysis would be expected to be favorable.

Given today's funding difficulties, maximizing the return on pavement expenditures is more critical than ever before. Thin lift mixes such as the 4.75 mm mix certainly appear to be a viable alternative to achieve such a goal.

References

1) Powell, R. B., "Predicting Field Performance on the NCAT Pavement Test Track", Dissertation, Auburn University, 2006.

2 National Center for Asphalt Technology (NCAT), Asphalt Technology News, Volume 21, No. 2, Fall 2009, http://www.eng.auburn.edu/center/ncat/newsl/newsfall_09.pdf

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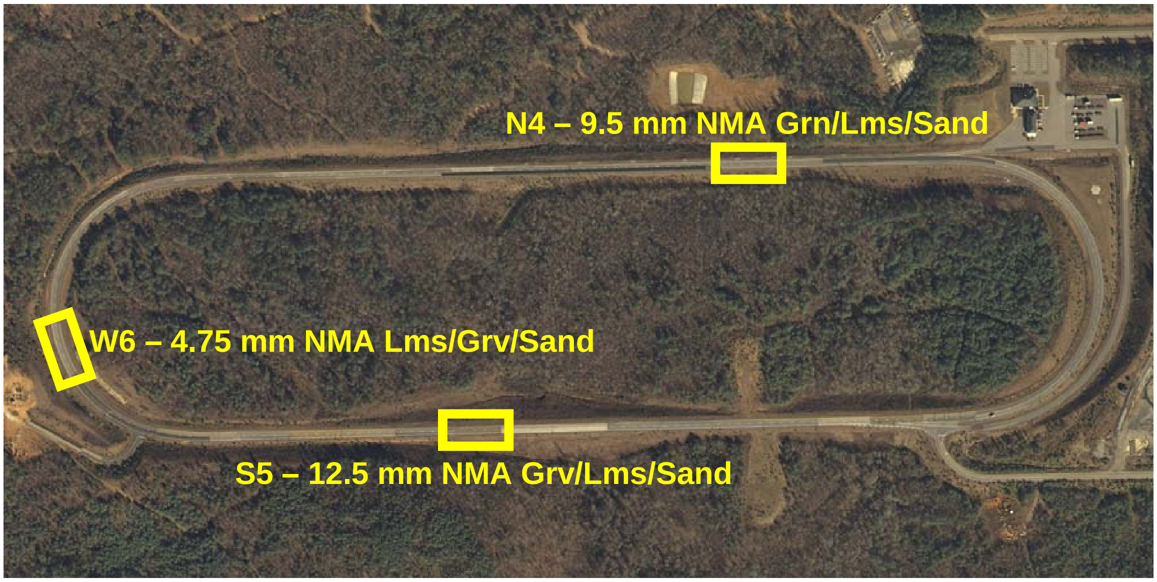

Figure 1 Aerial View of Test Track

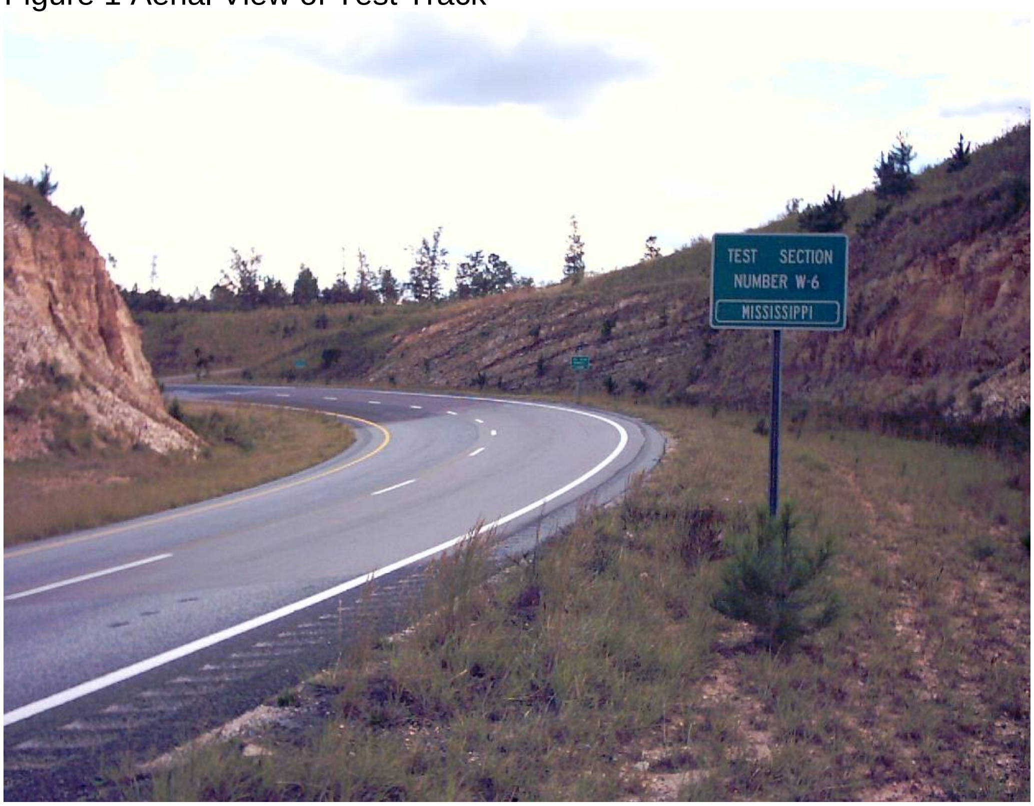

Figure 2 Mississippi 4.75 mm HMA Section W6

Table 1. Section W6 Mix Grading

Sieve Size (mm)	W6 As-Constructed Percent Passing
9.5	100
4.75	98
2.36	75
1.18	50
0.6	35
0.3	22
0.15	15
0.075	11.3

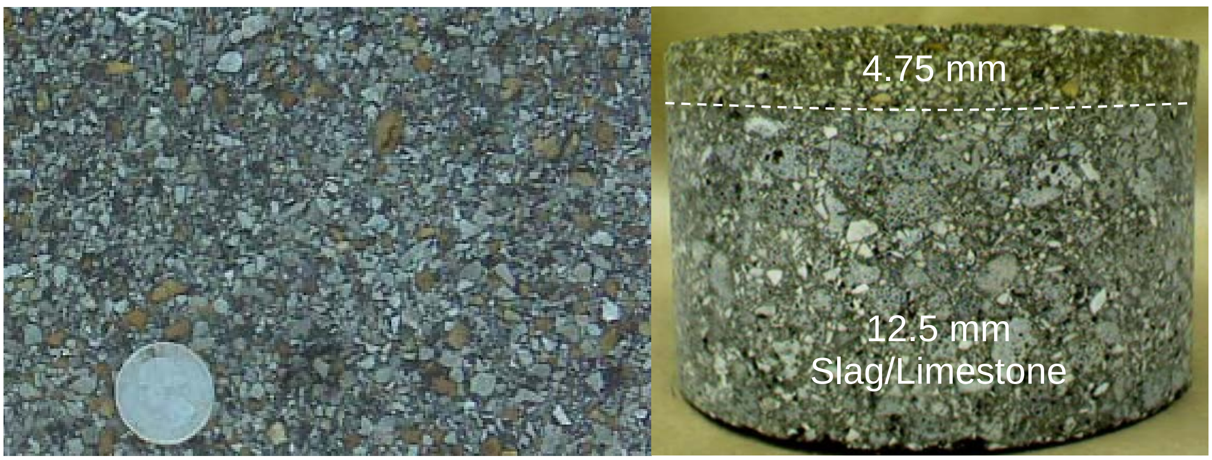

Figure 3 Section W6 Surface Texture (Left) and Core Profile (Right)

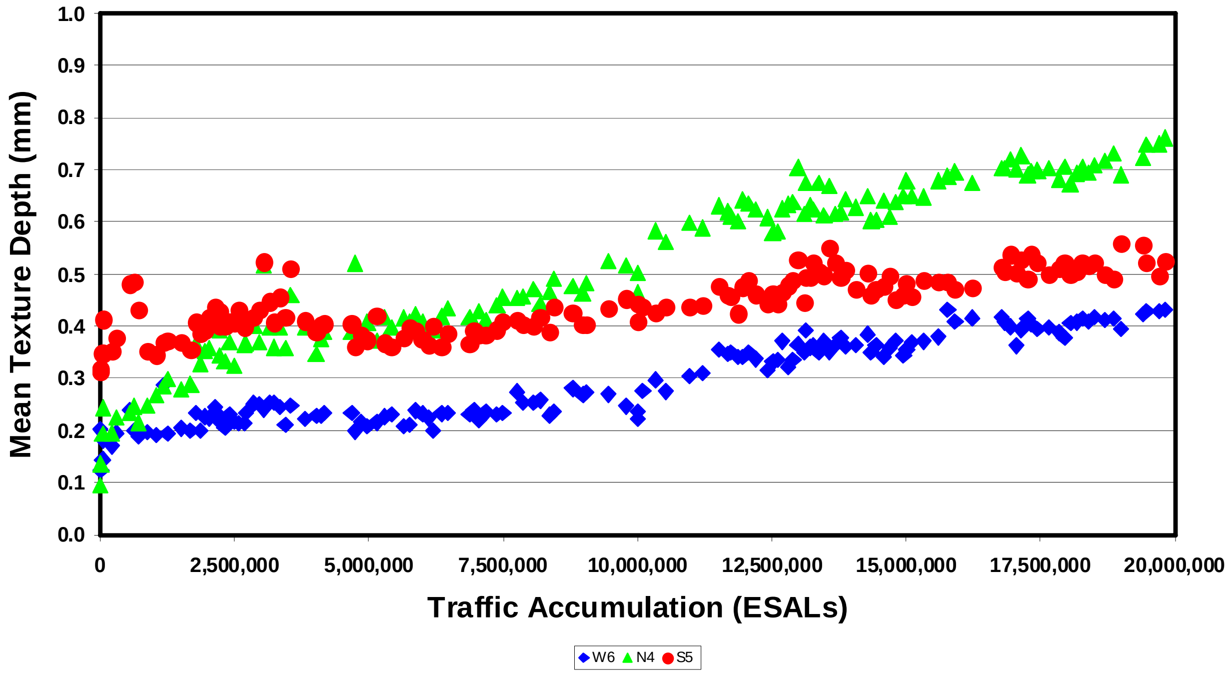

Figure 4 Mean Texture Depth