Use of Fine Aggregate Screenings to Produce HMA Mixes

In 1987, the U.S. Congress authorized the Strategic Highway Research Program (SHRP). In order to recommend aggregate specifications, SHRP formed an Aggregate Expert Task Group (ETG) that was charged with recommending aggregate properties and gradations for use in HMA. Specifications for gradations resulting from the ETG included definitions for nominal maximum aggregate size, maximum aggregate size, maximum density line, gradation control limits and a restricted zone. Additionally, a recommendation was made by the ETG that HMA mixes designed for high traffic volume roadways have gradations passing below the restricted zone (i.e., coarse-graded).

Based upon the recommendations of the ETG, many states required gradations passing below the restricted zone for most HMA mixes. The net result of these requirements was that a large proportion of the Superpave mixes that have been designed within the U.S. have been coarse-graded.

The increased use of coarse-graded HMA has led to large volumes of fine aggregate stockpiles being accumulated. These fine aggregate stockpiles are generally called screenings. Combined with the need for durable and rut-resistant HMA for use in thin-lift pavement layers, the use of screenings mixes could be beneficial for HMA producers, aggregate producers and transportation agencies.

Based upon the results of a recent NCAT study, it appears that screenings mixes can be designed to be rut-resistant. Two different sources of aggregate screenings, granite and limestone, were utilized to design mixtures at varying design air void contents and then tested for rut susceptibility. The use of a neat versus modified asphalt binder was also evaluated, as well as evaluating potential advantages of fiber additives. (Gradations shown on Figure 1 on Page 2). Some of these mixes using 100 percent manufactured screenings proved to be acceptable with regards to rutting resistance. The primary problem with mixtures deemed unacceptable was low voids in mineral aggregate (14 percent and below) and, thus, low optimum binder contents (4 to 5 percent).

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As a mix designer, the best tool in the design of these screening mixes was design air void content. For this study, mixes were designed at 4, 5, and 6 percent air voids. If the screenings mix is intended for low volume roadways where long-term durability is most important, mixes should be designed at 4 percent air voids. Designing at 4 percent air voids will provide the highest optimum binder content of the design air voids evaluated.

Another method to increase the binder content would be to add fibers. Results from this study showed a significant increase in binder content (0.7 percent on average) with the inclusion of cellulose fibers. Intuitively, an increase in the long-term durability of pavements would be expected for mixes containing fibers when compared to mixes designed without the fibers because of the increased binder content. Another factor that may affect the use of fibers in this mix type is the cost-benefit. The cost of the cellulose fibers and higher binder content would increase overall mix costs. Until the benefit of using the fibers is quantified, it is unclear whether the inclusion of cellulose fibers is justified.

When a designed mix is intended for a roadway that will contain either heavy or slow/standing traffic, design air void contents above 4 percent may be required. By increasing the design void level, optimum binder content is reduced and, thus, a given mixture would be more resistant to rutting. A maximum VFA criterion of 80 percent can be used to help identify mixes with a high potential for rutting. As with any mix designed for heavy and/or slow/standing traffic, some type of torture test is needed to verify the designed mix.

There are a number of potential applications for these screenings mixes. First, this type of mix can be used as a thin-lift maintenance mix. If the screenings mix is intended for this application, the underlying pavement should be structurally sound. Typically, a screenings mix would be placed 19 to 25 mm thick. Therefore, it should not be placed to significantly increase the structural integrity of a pavement structure.

Another possible application for this mix type would be low volume traffic areas such as residential streets and parking lots. Results of this study indicated that these mixes can be designed to resist the standing loads of passenger vehicles. The increased binder contents also should make these mixes durable. However, this mix type should not be used on truck delivery lanes unless the PG grade is bumped, and then with caution. Otherwise, the relatively small aggregate size and high binder contents may lead to rutting and or shoving in these lanes.

A final possible application for this mix type is as a leveling course to correct surface defects. Generally, small aggregate size mixes are used for this application. Depending on the roadway for the intended use, an appropriate design binder content could be chosen.

In summary, mixes comprised of manufactured aggregate screenings as the sole aggregate portion have the potential for use in a number of thin-lift pavement layer applications. A copy of the final report from this study can be found on NCAT’s web page at www.eng.auburn.edu/centers/ncat/.

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Fine Aggregate Screenings

Continued from Page 1

A major concern of the hot mix asphalt (HMA) industry is the proper measurement of the bulk specific gravity ($G_{mb}$) for compacted HMA samples. This issue has become a bigger problem with the increased use of coarser gradations. Bulk specific gravity measurements are the basis for volumetric calculations used during HMA mix design, field control, and construction acceptance. During mix design, volumetric properties such as air voids, voids in mineral aggregates, voids filled with asphalt, and percent maximum density at a certain number of gyrations are used to evaluate the acceptability of mixes. All of these properties are based upon $G_{mb}$.

In most states, acceptance of constructed pavements is based upon percent compaction (density based upon $G_{mb}$ and theoretical maximum specific gravity). Whether nuclear gages or cores are used as the basis of acceptance, $G_{mb}$ measurements are equally important. When nuclear gages are utilized, each gage has to first be calibrated to the $G_{mb}$ of cores. If the $G_{mb}$ measurements of the cores are inaccurate in this calibration step, then the gage will provide inaccurate data. Additionally, pay factors for construction, whether reductions or bonuses, are generally applied to percent compaction. Thus, errors in $G_{mb}$ measurements can potentially affect both the agency and producer.

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Measuring the Bulk Specific Gravity of Compacted HMA

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Figure 1. Gradations for Screenings Used in Study

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Measuring Bulk Specific Gravity

For many years, the measurement of $G_{mb}$ has been accomplished by the water displacement concept, using saturated-surface dry (SSD) samples. This consists of first weighing a dry sample in air, then obtaining a submerged mass after the sample has been placed in a water bath for a specified time interval. Upon removal from the water bath, the SSD mass is determined after patting the sample dry using a damp towel. Procedures for this test method are outlined in AASHTO T166 and ASTM D2726.

The SSD method has proved adequate for conventionally designed mixes that utilized fine-graded aggregates (e.g., Marshall and Hveem). Historically, mixes have been designed to have gradations passing close to or above the maximum density line (fine-graded). However, since the adoption of the Superpave mix design system and the increased use of stone matrix asphalt (SMA), mixes are being designed with coarse-graded aggregate resulting in erroneous $G_{mb}$ measurements. Many of the HMA mixes that were designed with the Superpave mix design system have been coarse-graded (gradation passing below the restricted zone and maximum density line). SMA mixes utilize a gap-graded gradation that is also coarse-graded.

The problem in measuring the $G_{mb}$ of coarse-graded Superpave and SMA mixes using the SSD method comes from the internal air void structure within these mix types. These types of mixes tend to have larger internal air voids than the conventional mixes, though the volume of air voids is the same. Mixes with coarser gradations have a much higher percentage of large aggregate particles. At a certain overall air void volume, which is mix specific, the large internal air voids of the coarse mixes can become interconnected. During $G_{mb}$ testing with the SSD method, water can quickly infiltrate into the sample while submerged in water. However, after removing the sample from the water bath to obtain the SSD condition the water can also drain from the sample quickly. This draining of the water from the sample is what causes the errors with the water displacement method.

There are a number of alternatives to alleviate the problem. Researchers have tried substances that would impede the water from penetrating the surface connected voids like parafilm, paraffin wax, rubber membranes, and masking tape. Others have also investigated compounds like zinc stearate that are hydrophobic which would prevent water from penetrating into the sample. However, these methods have not been adopted due to increased variability in bulk specific gravity measurements and/or damaging the sample such that additional testing could not be performed (e.g., asphalt content and gradation).

Equipment for Gamma Ray Test

Results from a recent evaluation of the Corelok vacuum-sealing device indicated that the device could be used to determine the $G_{mb}$ of compacted HMA samples with greater accuracy than conventional methods, such as water displacement, parafilm, and dimensional analysis. This vacuum-sealing device utilizes an automatic vacuum chamber with a plastic bag, which tightly conforms to the sides of the sample and prevents water from infiltrating into the sample.

Another device that has recently been introduced is the CoreReader gamma ray device. This method is based upon the scattering and absorption characteristics of gamma rays within a material. The instrument works in transmission mode which means that a sample is placed between the source of gamma rays and the gamma ray detector. During the test, the device counts the gamma rays that travel through the sample in order to determine the sample's volume.

Evaluations are being conducted by numerous researchers on both of these new devices. Results from these studies may provide an alternative to the SSD method for determining the bulk specific gravity when large interconnected voids are encountered.
2003 Calendar of Events

June 22-25  8th International Conference on Low-Volume Roads
           Silver Legacy Hotel
           Reno, Nevada
           Website:  http://www4.trb.org/trb/calendar.nsf/web/lvr8

June 29-July 1  Summer Workshop on Beneficial Use, Sustainability and
                Pollution Prevention in Transportation Infrastructure
                Sheraton Harborside Portsmouth
                Portsmouth, New Hampshire
                Website:  http://www.rmrc.unh.edu/summer2003/overview.asp

July 14-16  Petersen Asphalt Research Conference
           University of Wyoming, Union Yellowstone Ballroom
           Laramie, Wyoming
           Website:  http://www.westernresearch.org/

July 16-18  2003 Pavement Failure Symposium on Aging of Pavement Asphalts
           University of Wyoming, Union Yellowstone Ballroom
           Laramie, Wyoming
           Website:  http://www.westernresearch.org/
           Contact:  Ray Robertson, (307) 721-2325

Sept 5-9  AASHTO Annual Conference
           Minneapolis, Minnesota
           Website:  http://www.aashto.org/aashto/home.nsf/FrontPage

Sept 8-10  International Conference on Highway Pavement Data, Analysis &
           Mechanistic Design Applications
           Hyatt on Capital Square
           Columbus, Ohio
           Website:  http://webce.ent.ohiou.edu/ICHP.html

Sept 16-18  Superpave Mix and Aggregate Expert Task Group
           Location to be determined
           Contact:  Tom Harman, FHWA, Tom.Harman@igate.fhwa.dot.gov

Nov 18-20  SEAUPG Annual Meeting
           Hilton Head, SC
           Contact:  Jill Baumgardner E-Mail:  SEAUPG@aol.com, 601-206-5330

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