PRACTICE FOR SUPERPAVE VOLUMETRIC DESIGN FOR HOT MIX ASPHALT (HMA)

AASHTO R 35

GLOSSARY

Air Voids (V_a) -- the total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as percent of the bulk volume of the compacted paving mixture.

Binder Content (P_b) -- the percent by weight of binder in the total mixture.

Bulk Specific Gravity ($G_{1,\ 2,n}$; G_{sb}, G_{mb}) -- the ratio of the weight in air of a unit volume of a permeable material (including both permeable and impermeable voids connected to the surface of the aggregate particle) at a stated temperature relative to the weight in air of an equal volume of gas-free distilled water at a stated temperature. Can apply to individual aggregate stockpiles (G_l through G_n), the blended aggregate (G_{sb}) or the mix (G_{mb}).

Dust to Binder Ratio ($P_{0.075}/P_{be}$) -- ratio by weight of the percentage of aggregate passing the #200 (75 µm) sieve (P_{200}) to the effective binder content (P_{be}).

Effective Binder Volume (V_{be}) -- the volume of binder which is not absorbed into the aggregate.

Effective Specific Gravity (G_{se}) -- the ratio of the weight in air of a unit volume of a permeable material (excluding voids permeable to binder) at a stated temperature relative to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

ESAL's -- Equivalent Single Axle Loads, a measure of the axle loads expressed relative to an 18,000 pound axle load.

Maximum aggregate size -- one size larger than the nominal maximum aggregate size. (This terminology and definition apply only to Superpave mix design.)

Nominal maximum aggregate size -- one size larger than the first sieve that retains more than 10 percent of the aggregate. (This terminology and definition apply only to Superpave mix design)

Theoretical Maximum Specific Gravity (G_{mm}) -- the ratio of the weight of a given volume of voidless (V_a=0) HMA at a stated temperature (usually 77 °F (25°C)) to a weight of an equal volume of gas-free distilled water at the same temperature.

Voids in Mineral Aggregate (VMA) -- the volume of void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective binder expressed as a percent of the total volume of the specimen.

Volume of Absorbed Binder (V_{ba}) -- the volume of binder in the HMA that has been absorbed into the pore structure of the aggregate.

GENERALIZED MIX DESIGN PROCESS

There are four major steps in the volumetric mix design process. These steps consist of (1) Material Selection, (2) Selection of a Design Aggregate Structure, (3) Selection of a Design Binder Content, and (4) Evaluation of the Moisture Sensitivity of the Mixture.

Materials Selection

This process includes the selection of both a binder grade and aggregates that meet the Superpave criteria. The first step in this process is to determine the traffic in ESALs that the proposed pavement will be subjected to during the pavement's intended life. This information is typically included in the contract documents and is used in both the selection of binder grade and aggregate materials. The selection of binder grade also necessitates an understanding of the climatic (temperature) environment in which the pavement will be located. This includes both the seven-day maximum high temperature and the single-day minimum low temperature for that particular geographic location. Adjustments may be made to the binder grade to account for heavy traffic, slow-moving traffic, or both.

The requirement for aggregate quality is directly related to the anticipated traffic. Aggregate quality is also related to the depth (e.g., distance form the pavement surface) at which a given material will be used within a pavement structure. The quality criteria for Superpave aggregates are presented in the AASHTO M 323. In order to be used in Superpave mixtures, the aggregate blends are required to meet two sets of criteria known as source properties and consensus properties. The source properties are established by the specifying agency and are specific to the geology of a particular region while the consensus properties are mandatory for all Superpave aggregate blends. Source property requirements may apply to each aggregate stockpile, but consensus properties apply to the combined blend of multiple stockpiles.

Selection of a Design Aggregate Structure

Once a group of aggregates has been identified, the combination of these aggregates with regard to the percentage of each used to make the aggregate blend will need to be determined. Not all blends of aggregates are satisfactory. The blend of aggregates needs to be such that the Superpave volumetric criteria are satisfied. Once a blend of aggregate has been selected to meet the gradation requirements, the blended aggregate is required to also be shown to meet the Superpave consensus aggregate criteria. The aggregate trial blends may be eliminated if the designer has previous Superpave mix design experience with the aggregates.

The most difficult part of designing an aggregate structure is the creation of the VMA necessary to meet the volumetric criteria. The procedure is typically a trial and error process; however, there are some general guidelines that will assist in obtaining the VMA. The following is a non-inclusive list of techniques that may be tried to increase VMA:

1. movement of the gradation away from the maximum density line
2. use of highly angular particles
3. use of particles with a rough surface texture
4. use of different shaped particles
5. reduction in the amount of P_{200} used in the HMA

Selection of a satisfactory aggregate structure will consider economics in addition to satisfying the volumetric criteria. This may result in a large number of potential blends being considered.

Selection of the Design Binder Content

Selection of a trial binder content to initiate the design process will generally be made on the basis of past experience. The proposed aggregate blend will then be combined with four different proportions of binder from 0.5% lean to 1% rich of the trial binder content at 0.5% intervals. A sufficient amount of the proposed aggregate blend will need to be prepared to permit two samples to be compacted in the SGC, and the maximum specific gravity to be determined at each of the four binder contents. Preparation of the binder/aggregate mixtures for the SGC samples should be timed such that a minimum of 20 minutes is allotted between batches. Preparation of each binder/aggregate mixture, at each binder content, is considered one batch. Batched samples should be conditioned in a closed draft oven for a minimum of 2 hours prior to compacting the samples in the SGC (See R 30 for details). This is to permit time for the aggregate to absorb binder. All samples including those for SGC and maximum specific gravity tests, should be cured the same amount of time.

The procedure used for design in the laboratory will need to closely match the field conditions at the time of construction. Failure to consistently test the materials at the same time interval will result in a highly erratic maximum specific gravity value and possibly failure to achieve the required VMA.

After the necessary testing has been accomplished, the calculation of the volumetric parameters can begin. Having numeric values that correctly correspond with the sample being tested is important. The averaged results of the various volumetric calculations need to be plotted relative to the corresponding binder content. The design binder content is selected as that which satisfies the specified volumetric criteria at 4 percent air voids.

Evaluation of the Moisture Sensitivity of the Mixture.

The identification of the combination of a design aggregate structure and a design binder content is now complete. The mixture now needs to demonstrate capability of passing the moisture sensitivity test without premature failure. This test is conducted in accordance with AASHTO T 283, except that the loose mixture curing is replaced by short term aging for 2 hours in accordance with AASHTO R 30. The test procedure requires that a total of six replicate samples consisting of the proposed aggregate blend and binder at the design binder content, be prepared and compacted to approximately 7% air voids. This group of samples is divided into two subsets with three of the samples being identified as the unconditioned control samples and the other three being identified as conditioned samples. At the end of the conditioning period all of the samples are loaded to failure in indirect tension. If the combination of binder and aggregate blend results in a mixture where the ratio of the strength of the condition to the unconditioned samples is 80% or more, then the mixture passes the test. If the combination of binder and the aggregate blend results in a mixture where the ratio of conditioned to unconditioned samples is less than 80%, then the mixture fails and the design process is repeated. The addition of chemical anti-strip agents to the binder or mineral admixtures to the mixture are methods used to increase the tensile strength ratio.