South Dakota Asphalt Concrete Marshall Mix Design Procedure

1. Scope:

This standard practice for mix design evaluation uses aggregate and mixture properties to produce an asphalt concrete mix design formula that meets the specification requirements. This standard is for asphalt concrete hot mix that may or may not contain reclaimed asphalt pavement (RAP).

Contractors and consultants shall contact the Area Engineer when requesting to submit a mix design to the SDDOT Bituminous Mix Design Lab. Mix Designs will not be performed on samples that are not submitted through the Area Engineer and accompanied by the Area's properly filled out data sheet. The Engineer shall witness and/or take the sample. 50 percent of the plan quantity of material or 15,000 tons whichever is less shall be produced prior to material being submitted for a mix design. The Department may allow the Contractor to transport and deliver the RAP and aggregates samples for mix design and aggregate quality testing only when the Area office representative has sealed the samples with a tamper evident tag, with the DOT-1 attached.

2. Apparatus:

2.1 Humboldt slant foot (1 degree bevel) rotating base hammer is kept in the South Dakota Central Office Mix Design Lab. All other hammers will be compared/calibrated against this hammer. Slant foot rotating base hammers can be used if results can be obtained which are comparable to those obtained in the South Dakota Central Office Mix Design Lab. The South Dakota Mix Design Lab's hammer has been calibrated to a hand-operated hammer.

2.2 All related equipment and/or apparatus to perform parts or all of tests including: SD 108, SD 201, SD 202, SD 206, SD 208, SD 209, SD 210, SD 211, SD 212, SD 213, SD 214, SD 217, SD 220, SD 221, SD 301, SD 306, SD 309, SD 312, SD 313, SD 316, SD 318, AASHTO T 164, and AASHTO T 308.

3. Procedure:

3.1 Preparation of aggregates.

The average gradation of each individual aggregate fraction shall be used when combining to form an aggregate composite. This average shall come from testing done on the individual fraction/stockpile prior to the asphalt concrete mix design being performed.

NOTE: When recycled asphalt pavement (RAP) is allowed, it will not be included in meeting the total aggregate requirements set forth in the plans, Special Provisions, and/or Specification Book.

A. The following are the minimum number of size fractions to use when recombining the gradation of each individual stockpile. The 3/4", 1/2", 3/8", #4, #8, and all material passing the #8 are the minimum number of sizes required to be used when recombining the stockpiles.

B. Bulk specific gravity of the aggregate (G_{sb}) is determined by SD 209, and SD 210 for each fraction and combining to form a composite total G_{sb} and a - #4 G_{sb}. SDDOT Bituminous Office will determine both the total G_{sb} and the + #4 G_{sb} and - #4 G_{sb} on the total composite and not on individual fractions.

NOTE: When RAP is included in the plans, determine the asphalt binder content by conducting at least two extractions or ignition oven tests (Only if a correction factor is known). Determine the RAP aggregate gradation from the extractions (AASHTO T 164) or ignition oven tests (AASHTO T 308) and show the average RAP virgin aggregate only gradation on the mix design sheet. When 20 percent or less RAP is used in the mix design, use the G_{sb} from the old RAP mix design for the RAP virgin mineral aggregate G_{sb} or by conducting G_{sb} tests on the extracted or ignition oven aggregate samples using SD 209 and SD 210. If more than 20 percent RAP is used the G_{sb} shall be determined by conducting G_{sb} tests on the extracted or ignition oven aggregate samples using SD 209 and SD 210.

C. Determine consensus virgin aggregate properties for the composite gradation including:

Crushed particles (SD 211), fine aggregate angularity (SD 217), flat & elongated particles (SD 212), and sand equivalent (SD 221). Also, determine source virgin aggregate properties for lightweight particles (SD 208, SD 214), sodium sulfate soundness (SD 220) (Optional), and Los Angeles abrasion loss (AASHTO T 96) (Optional), if have previous tests from pit history.

3.2 Determination of mixing and compacting temperatures.

A. Performance graded binder (PG); mixing temperature shall be 300° ± 10°F.

B. Performance graded binder (PG 58-28, PG 64-22); compaction temperature shall be 270° ±5° F, (PG 58-34, PG 64-28) compaction temperature shall be 275° ±5° F., (PG 64-34, PG 70-28) compaction temperature shall be 280° ±5° F.

3.3 Preparation of mixtures.

A. Adjust the laboratory sample gradations to meet the average stockpile gradations down to the #8 and recalculate the laboratory - #8 gradation to reflect the changes. Weigh into pans material from each fraction to form a composite. Heat aggregate composite samples in an oven overnight or for a minimum of four hours to a temperature not exceeding 50° F above the mixing temperature.

NOTE: If recycled asphalt pavement is allowed, heat the RAP in an individual oven for a period of no more than two hours at 230° ± 5° F and add soon after heating to the mixture of aggregate and binder. Also, when RAP is added, care must be taken to thoroughly mix all components.

B. Following mixing immediately put the mixture in a covered container in an oven maintained at the compaction temperature for a period of two hours. At least three sets of specimens are to be made at 0.5% oil increments. This will include 3 Marshall samples made using SD 313. Two G_{mm} (SD 312) samples are to be made at the center oil increment. The oil content will be based on the total weight of the bituminous mixture.

NOTE: This total weight of mixture would include RAP if it is allowed in the mixture. An example of combining virgin aggregate, RAP, lime, and 4.5% virgin binder is as follows for a total sample of 4750 grams:

Virgin aggregate = 3591.0 g (80%) + RAP = 897.7 g (20%) + 47.5 g (1.00%) hydrated lime + 213.8 g (4.50%) virgin binder = 4750.0 g. The RAP contains 6.00% binder content from the average of two extractions. 53.9 g is from the RAP binder. The total asphalt binder content of the sample is (213.8 g + 53.9 g) / 4750 x 100 = 5.64%. 4.50% added from the new virgin binder is a contribution of 79.9% to the total binder content and 1.13% from the RAP binder is a contribution of 20.1% to the total binder content.

3.4 Compaction of specimens.

Combining elements of 3.1, 3.2 and 3.3 compact the specimens with a Marshall hammer using SD 313. The number of Marshall blows is included in the plans, plan notes, Standard Specification book and/or Special Provision for a specific project. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with SD 313.

3.5 Determine the air voids (V_a), voids in the mineral aggregate (VMA), voids filled with asphalt (VFA), dust to effective binder ratio, Marshall stability, and

Marshall flow for each binder percent increment in accordance with the formulas and calculations in Asphalt Institute MS-2 or SD 318.

4. Report:

4.1 The Contractor's material and data submitted to the SD DOT Mix Design Lab in Pierre must meet all of the specifications and requirements as shown in the plans, plan notes, Standard Specifications book and the Special Provision Regarding quality control/quality assurance specifications that apply to the project.

4.2 The Contractor's mix design submittal will include the source of the binder, bin splits selected to use along with the legal pit descriptions of all the materials, average gradation of the stockpiles, and the recommended JMF gradation values to be used for the mix design.

4.3 The SD DOT Mix Design Lab will complete the mix design submitted by the Contractor/Area and conduct all necessary mix design quality tests required on the mineral aggregate, RAP, and asphalt concrete mixture. When the mix design is completed by the Department's Bituminous Mix Design Lab, an approved mix design report (DOT-64) will be provided to the Area Engineer and the Contractor prior to production.

5. References:

AASHTO T 245
Listed in 2.2 above