Hot Mix Asphalt Gyratory Mix Design Procedure

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NDDOT Hot Mix Asphalt Gyratory Mix Design Procedure

A. General.

This Procedures has been developed to provide the required method for developing and verifying Hot Mix Asphalt (HMA) mix designs to meet the requirements set forth in the specifications and test methods referenced in this document.

The purpose of the gyratory mix design is to determine the optimum asphalt content for a specific blend of aggregate that will provide a pavement structure which will perform for the design life under the expected traffic loads. This procedure is for HMA that may or may not contain Recycled Asphalt Pavement (RAP).

B. Equipment.

1. Gyratory compactor and support equipment meeting the requirements in AASHTO T 312 Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor.

2. Ignition furnace and support equipment meeting the requirements of AASHTO T 308 Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method.

3. Solvent extractor and support equipment meeting the requirements of AASHTO T 164 Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA).

4. All related equipment to perform ND T 166 Bulk Specific Gravity (G_{mb}) of Hot Mix Asphalt Mixtures Using Saturated Surface Dry Specimens.

5. All related equipment to perform ND T 209 Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA).

C. References

1. NDDOT Standard Specifications for Road and Bridge Construction (Specs)
2. NDDOT Field Sampling and Testing Manual (FSTM)
3. NDDOT Technical Certification Program
4. MS-2, Asphalt Mix Design Methods, The Asphalt Institute
5. AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing and AASHTO Provisional Standards

D. Testing During Aggregate Production

1. Test stockpiles of aggregates according to section 430 of the FSTM during aggregate production. Provide samples to the Engineer for verification of specific gravities and absorption for each aggregate component according to Section 430 of the FSTM and Specs.

2. When a Mix Contains Recycled Asphalt Pavement (RAP)

   a. Determine the RAP asphalt binder content by conducting two AASHTO T 164 solvent extractions. Use the average of the two solvent extractions for mix design calculations. Submit all supporting information for the determination of the RAP asphalt content to the Engineer, including any correction factor used for solvent extraction.

   b. Obtain RAP aggregate sample by conducting AASHTO T 164 solvent extractions or AASHTO T 308 ignition furnace tests. Several tests may be required to obtain enough material for RAP aggregate testing.

   c. Determine the RAP aggregate properties including gradation according to ND T 27, fine aggregate angularity (FAA) according to ND T 304, and aggregate bulk specific gravity according to ND T 84 and ND T 85 or MS-2 RAP SpG Method 2A. If Method 2A is used, AASHTO T 209 section 13 "dry back procedure" or an acceptable alternative is required to account for absorption.

      (1) When 15 percent or less RAP is used in the mix design, the combined values from the virgin coarse aggregate bulk specific gravity (G_{sb}) and the combined fine aggregate bulk specific gravity (G_{sb}) from the virgin aggregates will be used for the RAP G_{sb} portion of the final blend.

      (2) When more than 15 percent RAP is used in the mix design, determine the bulk specific gravity (G_{sb}) of the RAP aggregates.

   d. The RAP gradation, FAA and aggregate bulk specific gravity (G_{sb}) are used to determine the final aggregate blend.

   e. It is not required to test RAP for the properties in the NDDOT Standard Specifications Table 430-02.

   f. Submit a 90 lbs. split of RAP material to the Engineer for verification of RAP properties. The Engineer will use AASHTO T 308 ignition furnace test to determine the RAP aggregate properties for verification.

3. Determine an appropriate blend of aggregate sources to produce a proper gradation of mineral aggregates. The average gradation of each individual aggregate source and the average gradation of the RAP, when used, will be combined to form the aggregate blend. Adjust the aggregate blend to meet mixture parameters.

4. Plot the blend gradation on the 0.45 power chart using the procedure in MS-2. This chart graphically displays any trends of the actual gradation with respect to a maximum density line.

5. After at least 10,000 tons of virgin aggregate material is produced and uniform production of each aggregate component is assured, the Contractor shall produce a mix design.

E. Mix Design

Preparing samples of mixture in the laboratory for mix design analysis requires batching the aggregates, mixing in the proper amount of binder, conditioning the prepared mixture, heating the mixture to compaction temperature, compacting the specimens, and testing the specimens to determine the mix design parameters.

1. Aggregate Preparation

   a. Dry each virgin aggregate sample to a constant weight at 230° F ± 9° F. Fractionate by dry sieving on the 3/8-inch sieve and the No. 4 sieve as follows:
      (1) + 3/8 inch
      (2) - 3/8 inch to + No. 4
      (3) - No. 4

   b. For gyratory specimens, weigh out the appropriate amounts of the required aggregate size fractions and combine in a bowl to the proper batch weight. Typically, a batch weight of 4500 - 4700 grams of aggregate will provide enough material for a finished specimen height of 115 ± 5 mm. Two gyratory specimens are required per asphalt cement (AC) content used for the mix design.

   c. For ND T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA), weigh out the appropriate amounts of the required aggregate size fractions and combine in a bowl to the proper batch weight. Typically, a batch weight of 2000 - 2500 grams of aggregate will provide enough material for the ND T 209 test.

   d. Heat the aggregate samples in an oven at approximately 325° F. Virgin aggregate may be heated over night or for a minimum of four hours.

2. Mixture Preparation

    a. Obtain the type and grade of asphalt to be used on the project from the asphalt Supplier. Obtain the specific gravity of the asphalt from the supplier to determine mix properties. If the project requires two different grades of AC, use only one type for producing the mix design. Supply the same grade used for the mix design to the Engineer for verification testing.

    b. Heat the asphalt cement according to the supplier's recommendation or 290 ± 10° F without exceeding a maximum heating time of 4 hours. Heat the asphalt only once.

    c. Charge the mixing bowl with the heated aggregate for one sample and mix thoroughly. If the sample is slightly less than originally weighed, add a small amount of hot minus No. 4 natural fine material to bring the sample to the proper weight. Form a crater in the dry blended aggregate, place the mixing bowl on a scale, tare the scale and pour the asphalt cement into the crater until the required weight is obtained. Use a mechanical mixer to mix the aggregate and asphalt cement as quickly and thoroughly as possible to yield a mixture having a uniform distribution of asphalt throughout. Repeat this process for the various asphalt percentages.

    d. If RAP is used, heat the RAP for a minimum of two hours and a maximum of four hours at 230 ± 5° F. After heated, add the RAP to the aggregate and binder mixture. Care must be taken to thoroughly mix all components.

    e. After mixing, spread the loose mixture in a flat, shallow pan in a 1-to-2-inch layer and cover. Place each sample of mix into an oven set at the compaction temperature shown below (Table 1) for a two-hour curing period. After one hour, thoroughly mix each sample to maintain uniform conditioning, and continue the curing process. The two-hour cure is for lab mixed material only. Do not cure bituminous mixture samples that have been produced in a hot-mix plant.

3. Compaction of Specimens

    a. A minimum of two gyratory specimens is required at four different asphalt contents for the mix design. Additional specimens at a fifth asphalt content may be needed to determine the optimum asphalt content. Choose the AC contents at 0.3 to 0.5 percentage points apart. Preheat the gyratory molds, base plates, and funnel in an oven set at a temperature of 290 ± 10° F.

    b. Compaction temperature will vary based on the Performance Graded (PG) Asphalt Cement used (Table 1).

Table 1

Performance Graded AC	**Compaction Temperature** ° F
58S-28	270 ± 5° F
58S-34 and 58H-28	275 ± 5° F
58H-34 and 58V-28	280 ± 5° F
58V-34 and 58E-(28 or 34)	Manufacturer's Recommendation

c. Compact the specimens in a gyratory compactor according to AASHTO T 312 at the N_{design} gyration level shown in the contract documents.

d. After compaction, allow the specimens to cool in the mold an amount of time to prevent damage. Remove the gyratory specimen from the mold with an extrusion jack. Place the specimens on a smooth, level surface and allow them to cool to room temperature. The use of a fan will facilitate the cooling process. Identify the specimen by number using a marker or crayon.

e. If the gyratory specimen is outside the height tolerance (115 ± 5 mm), adjust the batch weight accordingly for the next specimen.

f. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with ND T 166, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens.

g. Conduct the theoretical maximum specific gravity test for each asphalt content used during the gyratory mix design in accordance with ND T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA).

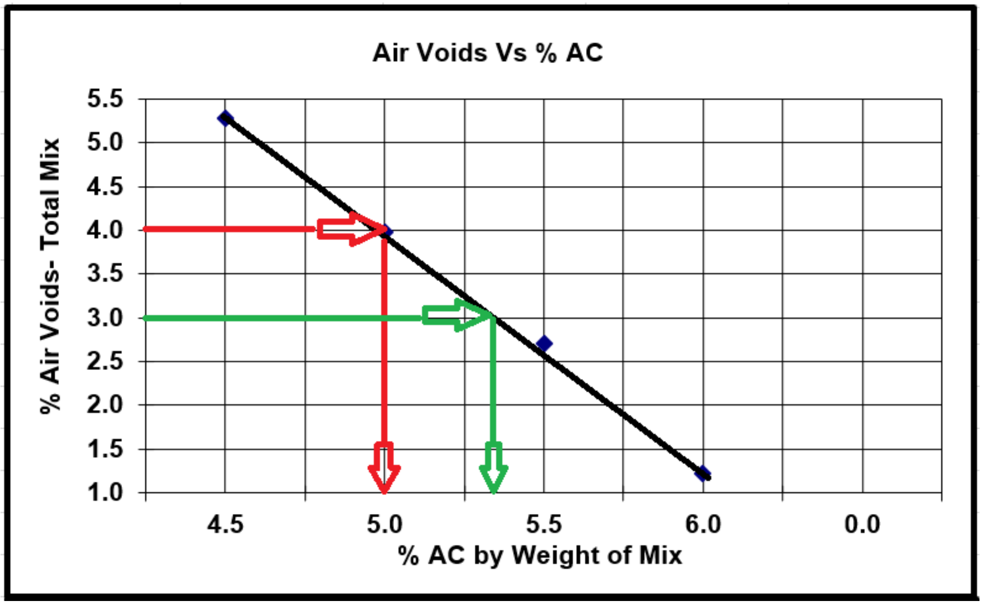
h. After all the required mix testing has been completed, plot the results, for each of the four AC contents on a graph comparing the percentage air voids in the total mix to each percentage AC content point. Draw a best fit curve connecting all the points. Determine, from the graph, the point where the curve intersects at 4.0% air voids and read straight down to determine the optimum % AC content of the asphalt mixture.

   (1) Use the optimum % AC content determined at 4.0% air voids to calculate the remaining mixture properties from the graphs for: VFA vs % AC, Theoretical Maximum SpG vs % AC, % Gmm @ Ninitial vs % AC, VMA vs % AC, and Unit Weight vs. % AC. Record these properties on the mix design summary. These properties must meet the values specified in Table 430-03 and Table 430-05 in the Specs.

(2) The specified air void target has changed from 4.0% to 3.0%. This target change will be accomplished by adding additional binder content to the mix.

(3) From the Air Voids vs % AC graph, determine the optimum % AC at 3.0% air voids (See Example). Record this as your Optimum % AC on the summary.

Example:



From the Example graph:
AC Content at 4.0% Air Voids (red) = 5.0% (Used to determine mix properties)
AC Content at 3.0% Air Voids (green)= 5.3% (Optimum % AC for production)

i. Using the % AC at 4.0% Air Voids, batch enough mixture at the optimum % AC and compact to $N_{maximum}$ to determine % Gmm @ $N_{maximum}$. This value must meet the specified criteria in Table 430-05 of the Specs.

4. Reporting:

a. Use the NDDOT's Asphalt mix Design spreadsheet to report the mix design results located at www.dot.nd.gov/business/contractors.htm#resources. Submit the completed mix design, including all test data, to the Engineer.

b. The Contractors mix design will be approved when the verification testing correlates within the tolerances listed in the Standard Specifications and FSTM. If the mix design is not approved, the Contractor shall submit another mix design. An approved mix design is required prior to beginning production of hot mix asphalt.

5. Specific Gravity Definitions

   Bulk Specific Gravity, G_{sb} is the volume measurement that includes the overall volume of the aggregate particle as well as the volume of the water permeable voids.

   Effective Specific Gravity, G_{se}, includes all void spaces in the aggregate particles except those that absorb asphalt.

   Apparent Specific Gravity, G_{sa}, considers the volume as being the volume of the entire aggregate.

   The G_{sb} should be lower than the G_{se} and the G_{se} should be lower than the G_{sa}.