1. **SCOPE**

1.1. **Description of Test**

The Marshall Method for hot-mix asphalt concrete mix design is a rational approach to selecting and proportioning two materials, asphalt cement and mineral aggregates to obtain the specified properties in the finished asphalt concrete surfacing structure. The method is intended for laboratory design of asphalt hot-mix paving mixtures.

1.2. **Application of the Test**

The objective to be achieved using the Marshall Method for hot-mix asphalt concrete mix design is to determine an economical blend and gradation of aggregates (within the limits of project specifications) and asphalt that yields a mix having:

1. Sufficient asphalt cement to ensure a durable asphalt concrete surface course.

2. Sufficient mix stability to satisfy the demands of traffic without distortion or displacement.

3. Sufficient voids in the total compacted mix to allow for a slight amount of additional compaction under traffic loading without flushing, bleeding and loss of stability, yet low enough to keep out harmful air and moisture.

4. Sufficient workability to permit efficient placement of the mix without segregation.

5. Characteristics which allow normal construction operating variations without falling outside of the specified requirements.

1.3. **Units of Measure**

The units of measure will be as specified in the individual procedures that are used in the Marshall Mix Design analysis.
2. **APPARATUS AND MATERIALS**

2.1. **Equipment Required**

Refer to:

STP 204-8 Preparation of Marshall Compaction Specimens
STP 204-9 Theoretical Maximum Specific Gravity
STP 204-11 Marshall Stability and Flow
STP 204-15 Stripping Potential
STP 204-19 Asphalt Film Thickness Determination
STP 204-20 Hveem Stability
STP 204-21 Marshall Compaction Specimens - Density and Void Characteristics Determination
STP 204-22 Retained Marshall Stability
STP 206-4 Plasticity Index Coarse Grained Soils
STP 206-5 Sand Equivalent
STP 206-7 Specific Gravity - Bulk, Apparent
STP 206-9 Lightweight Pieces in Aggregate
STP 206-14 Percent Fractured Faces in Aggregate
STP 206-15 Clay Lumps and Friable Particles in Aggregate

2.2. **Materials Required**

Refer to the Standard Test Procedures as outlined in 2.1 above.
2.3. **Sample to be Tested**

Representative samples of all aggregate components to be used on the project and asphalt cement of the same grade and from the same manufacturer as will be used for the field work.

2.3.1. **Obtaining Required Gradation For Each Aggregate Component**

Dry the samples of aggregate in the oven for approximately 18 hours at 105° C to 110° C. Separate aggregate into individual sieve sizes by dry sieving. Select the sieve sizes corresponding to the specifications for the "type" of

Recombine individual aggregate fractions in correct proportions to obtain the average stockpile gradation which is submitted from the field along with the sample. Use a trial and error method as described in the following paragraph.

Combine trial percentages of each size, then run a wet sieve and compare the result to the stockpile average. Adjust the proportions of each size and repeat the procedure until the desired gradation is achieved. Use the final percentages of each size to produce specimens as required later in the procedure.

2.4. **Data Required**

The following data is required for each proposed aggregate gradation when preparing a Marshall Mix Design;

- Lightweight Pieces in Aggregate
- Plasticity Index of the Aggregate
- and Equivalent of the Aggregate
- Percent Fractured Faces in the Aggregate
- Clay Lumps and Friable Particles in Aggregate
- Theoretical Maximum Specific Gravity for each asphalt/aggregate combination
- Specific gravities for all aggregate fractions
- Density, air voids and voids in mineral aggregate determination for each asphalt/aggregate combination
Marshall stability and flow for each asphalt/aggregate combination

Stripping Potential Analysis on the recommended mix design

Hveem stability on the recommended mix design

Retained stability for the recommended mix design

Asphalt film thickness determination for the design aggregate gradation at each asphalt content evaluated.

3. **PROCEDURE**

3.1. **Test Procedure**

Prepare two or more initial trial specimens as described in STP 204-8 at an estimated optimum asphalt content. Use the combined stockpile gradation of the natural split for one set of molds.

Determine the Marshall Mix Design characteristics using STP 206-7, 204-21, 204-9 and 204-11.

Compare the Marshall properties for the trial molds with SHT specified properties for that aggregate type and asphalt type.

If the Marshall properties for one of the chosen gradations are satisfactory, proceed with the full design procedure. If the properties are obviously outside the range, make further adjustments by changing split combinations or adding blenders/fillers. Estimate by plotting the gradation on an e.45 graph and comparing to the theoretical maximum density line (a line drawn between the origin and the point where the gradation line crosses 90% passing). Continue until the properties are satisfactory.

Using the procedures previously described, prepare a series of Marshall specimens in triplicate at four asphalt contents (by weight of dry aggregate) to bracket optimum.

Determine the Marshall properties for each specimen and average the results of the triplicates at each asphalt content.

On a graph MR-71 or EPS-71, plot the Marshall properties (density, air voids, VMA and Marshall stability) as a function of asphalt content.

Select optimum asphalt for each property; for density and stability use the peak of the curves and for VMA use the low point. For air voids, select the optimum asphalt content.
where air voids are 0.5 to 0.75% above the minimum specified value for that particular asphalt type.

After selecting optimum asphalt from each graph average the values and use this new asphalt content for further design requirements (Stripping Potential, Hveem stability, Retained Stability, Asphalt Film Thickness).

4. RESULTS AND CALCULATIONS

4.1. Reporting Results

Marshall Mix Designs shall be reported on Form MR-71 or Form EPS-71 whichever is applicable. Additional information on other options evaluated should be attached to the formal design as an Appendix.

5. ADDITIONAL INFORMATION

5.1. Asphalt Cement Content

5.1.1. Design AC Content

Type 1 and Type 2 extraction corrections must be determined for the design asphalt cement content (refer to STP 204-23, Extractions and Moisture Corrections).

5.1.2. Mix Design

Mix design properties are to be based on the percentage asphalt cement added.

5.2. References

STP 204-8 Preparation of Marshall Compaction Specimens
STP 204-9 Theoretical Maximum Specific Gravity
STP 204-11 Marshall Stability and Flow
STP 204-15 Stripping Potential
STP 204-19 Asphalt Film Thickness Determination
STP 204-20 Hveem Stability
<table>
<thead>
<tr>
<th>Code</th>
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<tr>
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<td>Marshall Compaction Specimens - Density and Void Characteristics Determination</td>
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<td>Retained Marshall Stability</td>
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APPROVAL SHEET

New ___ Revision  X  Date of Previous Document  92-12-10
Effective Date:  93-03-26

Description of Revision (Reason for Revision):
Further discussion between the Lab Supervisors and End Product Specification Committee resulted in
the agreement that mix design properties are to be based on the % asphalt added.

Review/Implementation Process:
Reviewed by the End Product Specification Committee and Lab Supervisors Committee.

Other Manuals/Policies Affected:
Nil

Follow Up/Training Required:
Nil

Comments/Concerns/Implications (Budget/Environment/Stakeholders):

Prepared and Recommended by  D. MacLeod 93-03-22
Quality Control Engineer Date

Approval Recommended by  R.A. Widger 93-03-24
Date

Approval Recommended by  A.R. Gerbrandt 93-03-24
Dir., Technical Standards & Policies Br. Date

Approved by  D.G. Metz 93-03-26
Assistant Deputy Minister, Infrastructure Date

Electronic File Updated 93-04-29
Update Mailed - -