ASPHALT BINDER

Section 5 – Marshall Mix Design

1

Mix Design-Marshall Method

- Test Procedure – AASHTO T 245 (Wyoming Modified)*
- General
  - 4 inch ϕ x 2.5 inch specimens
  - Same aggregate blend
  - Varying binder content
  - Multiple specimens at each binder content
- Components
  - Bulk Specific Gravity Measurement
  - Density – Voids Analysis
  - Stability – Flow Test

2

Procedure

- Sample Preparation
  - Obtain representative Asphalt and Aggregate Samples
    - Proposed for Use
  - Dry Aggregate
    - 230°F
    - Constant Weight
  - Conduct Sieve Analysis
  - Determine S.G. of Aggregate and binder

3

Procedure (continued)

- **Prepare Mix Samples**
  - **Select binder Content Range**
  - **Heat binder and Aggregate to mix temperature specifications**
  - **Combine binder and Aggregate**
  - **Mix to thoroughly coat**
  - **Cure 2 hours at compaction temperature (Wyoming modified)**
  - **Place in heated molds**

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4

Procedure (continued)

- **Compact with Marshall Hammer**
  - **10 lbs**
  - **18" drop**
  - **50 or 75 blows <u>per side</u>**
- **Cool and remove for molds**

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Marshall Compactor

Section 5 - 6

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Procedure (continued)

- Testing
  - Measure Bulk S.G. of samples
    - AASHTO T 166
    - Weight in air – dry mass
    - Immerse in water 3 – 5 minutes and determine mass in water
    - Remove and blot dry with damp cloth
    - Weight immediately – SSD mass
    - Calculate Bulk S.G.

$$BULK\ S.G. = \frac{dry\ mass}{(SSD\ mass - mass\ in\ water)}$$

Section 5 - 7

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Procedure (continued)

- Measure Stability And Flow Of Samples
  - Immerse in water - 140°F, 30 minutes
  - Remove from water and place in Marshall Tester
  - Apply load to failure
    - 2 inches per minute
  - Record Stability – failure load
  - Record Flow – 0.01 inch
  - Complete in < 30 seconds

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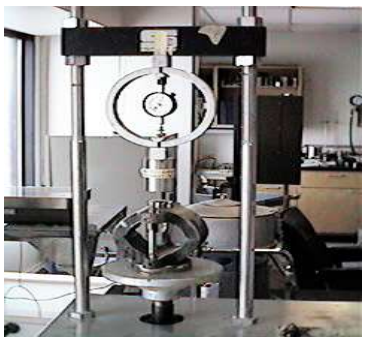
Marshall Stability Device



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Procedure (continued)

- Analyze Density And Voids
  - Calculate Density
  - Calculate Air Voids
  - Calculate VMA
  - Calculate VFA

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Procedure (continued)

- Plot Test Results Versus Asphalt Content
  - Stability
  - Air Voids
  - Density
  - Flow
  - VMA

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Procedure (continued)

- From Plots, Find Binder or Asphalt Content At:
  - Maximum Density
  - Maximum Stability
  - 4% Air Voids
- Calculate Average
- Determine Characteristics at Average
- Compare vs. Criteria
- Select Binder Content

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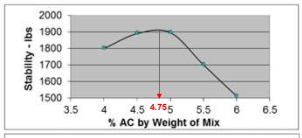
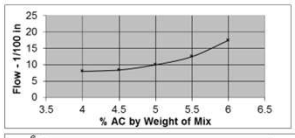
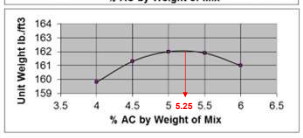
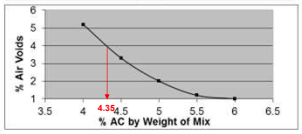
Maximum Density
Maximum Stability
4% Air Voids

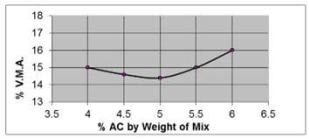
Marshall Graphs











Example:
Max Density- 5.25% AC
Max Stability- 4.75% AC
4% Air Voids- 4.35 % AC
Avg of above = 4.8% AC

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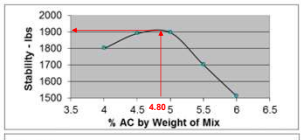
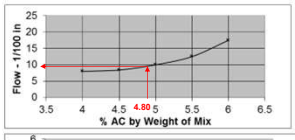
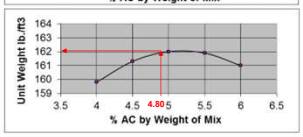
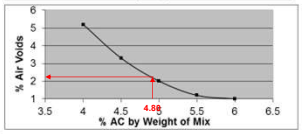
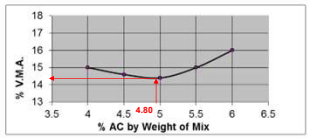
Marshall Graphs











Example Continued: Use 4.80% AC
Density with 4.8% AC = 162 lb/ft^3
Stability with 4.8% AC = 1910 lbs
Air Voids with 4.8% AC = 2.1 %
Flow with 4.8% AC = 9.9 1/100in
VMA with 4.8% = 14.3%
Compare to Mix Design Criteria

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Marshall Mix-Design Criteria

Table 401.4.1-2

	Class I-M	Class II-M	Class III-M
Number of Marshall Blows	75	75	50
Marshall Stability (lbs [N]) minimum 1910 - Fail	2500 [11000]	2500 [11000]	2000 [9000]
Marshall Flow (0.01 in [0.25 mm]) 14.3 - Pass	8-16 [8-16]	8-16 [8-16]	8-16 [8-16]
% Voids in Laboratory Mix 2.1 - Fail % Voids in Production Mix	5.0-6.0 4.0-6.0	4.0-5.0 3.0-5.0	4.0-5.0 2.5-5.0
Dust/Effective Asphalt	0.8-1.4	0.8-1.4	0.8-1.4
Minimum % Asphalt 4.8 - Pass	4.5	4.5	4.5
Minimum Tensile Strength Retained %	75	75	75
Film Thickness µm	6-12	6-12	6-12

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Percent Voids in Mineral Aggregate (VMA)

Table 401.4.1-3

	1 in Maximum Nominal Size	¾ in Maximum Nominal Size	½ in Maximum Nominal Size	3/8 in Maximum Nominal Size
	9.9 - Fail	Laboratory Mix		
CLASS IM, IIM	12.0-15.0	13.0-16.0	14.0-17.0	14.0-17.0
CLASS IIIM	11.0-14.0	12.0-15.0	13.0-16.0	13.0-16.0
		Production Mix		
CLASS IM, IIM	11.0-15.0	12.0-16.0	13.0-17.0	13.0-17.0
CLASS IIIM	10.0-14.0	11.0-15.0	12.0-16.0	12.0-16.0

Due to Fails -- Need to Redesign Mix

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Mix Design- Moisture Resistance

Test Procedure – AASHTO T 283

Procedure

- Mix samples at Marshall Design AC Content
- Cure 16 hours at 140°F
- Heat to compaction temperature
- Compact to 7.0 ± 0.5% air voids with Marshall hammer
- Remove from molds and cure in air for 24 ± 3 hours
- Divide into two subsets

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Mix Design-Moisture Resistance (continued)

- **Procedure**
  - Test one subset in indirect tension
  - Condition other subset
    - Vacuum saturate to 70% to 80%
    - Freeze 16 hours at 0°F
    - Immerse in water 24 hours at 140°F
  - Immerse in water bath 1 hour at 77°F
  - Test in indirect tension
  - Calculate % retained strength

$$\frac{\text{Conditioned Subset Average Strength}}{\text{Unconditioned Subset Average Strength}}(100) = \%\ \text{Retained Strength}$$

WYDOT – greater than 80% retained

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