



# **ASPHALT BINDER**

## **Section 4 – Mix Design**

# Mix Design

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## ➤ Purpose

- ▶ To select the optimum combination of materials (aggregates, asphalt, etc.) to meet specific mixture characteristics and performance properties

## ➤ Methods

- ▶ Marshall
- ▶ Hveem
- ▶ Superpave

# Mixture Characteristics

- **Density**
- **Air voids**
- **VMA**
- **Binder content**
- **Film thickness**
- **Dust to effective asphalt ratio**

# Density

- **Definition – Weight per unit volume lb/ft<sup>3</sup>**
- **Density – Bulk S.G. x unit weight of water  
(62.4 lb/ft<sup>3</sup>)**
- **High Density → Performance**

## Maximum Density (Voidless unit weight)

- Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures (ASTM D2041)
  - The ratio of the weight in air of a unit volume of an uncompacted bituminous paving mixture at a stated temperature to the weight of an equal volume of gas-free distilled water at a stated temperature. It is also called Rice Specific Gravity, or theoretical maximum density (TMD).

# Air Voids

- **Definition**
  - ▶ **Air spaces between coated aggregate in compacted mix**
- **Some necessary**
- **Too high vs too low**
- **Design – usually 3% to 5%**
- **Related to density**

# Voids in the Mineral Aggregate (VMA)

- **Definition**
  - ▶ **Void spaces between aggregate in compacted mix**
- **Air voids and asphalt volume**
- **Total space available for asphalt**
- **High VMA**
  - ▶ **High film thickness**
  - ▶ **High durability**
- **Low VMA**
  - ▶ **Low film thickness**
  - ▶ **Dry mix**
  - ▶ **Low durability**

# VMA

Representation of  
volume in a compacted  
asphalt specimen

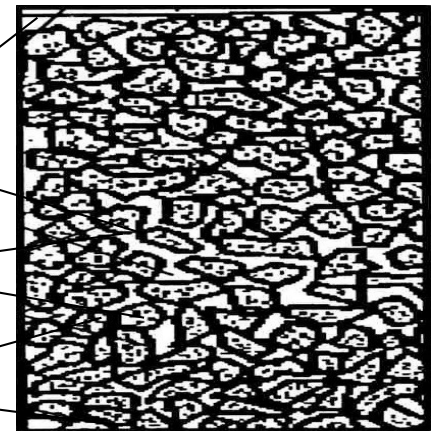


Air Voids  
Asphalt

Mix specimen with  
Asphalt removed



Compacted asphalt  
mix specimen



VMA  
Air Void  
Aggregate  
Asphalt



# Asphalt Content

## ➤ Definition

- ▶ % of asphalt by weight, in a mix
- ▶ The optimum % of asphalt to meet mix design and performance criteria

## ➤ Function of:

### ▶ Gradation

- ◆ Surface area

- ◆ % minus #200

### ▶ Aggregate Absorption

## ➤ Total vs. Effective

# Performance Properties

- **Stability**
- **Durability**
- **Impermeability**
- **Workability**
- **Flexibility**
- **Fatigue Resistance**
- **Skid Resistance**

# Stability

- **Definition – Ability to resist shoving and rutting under loads**
- **Requirements can vary with load**

# Stability (continued)

- **Function of:**
  - ▶ **Internal Friction of Aggregate**
    - ◆ **Shape**
    - ◆ **Size**
    - ◆ **Surface characteristics**
  - ▶ **Cohesion**
    - ◆ **Increases with loading**
    - ◆ **Increases with binder viscosity**
    - ◆ **Decreases with time**
  - ▶ **Asphalt Content**
  - ▶ **Temperature**

# Durability

- **Definition – Ability to resist weather, traffic, time**
- **Function of:**
  - ▶ **Asphalt Content**
    - ◆ **Film thickness**
    - ◆ **Low air voids**
  - ▶ **Aggregate Gradation**
    - ◆ **Dense mixes**
    - ◆ **Impermeability**
  - ▶ **Aggregate Water Susceptibility**
    - ◆ **Stripping**
  - ▶ **Asphalt Aging**
  - ▶ **Compaction**

# Impermeability

- **Definition – Resistance to passage of air or water**
  
- **Function of:**
  - ▶ **Asphalt Content**
    - ◆ **High air voids**
  - ▶ **Compaction**

# Workability

- **Definition – Ease of placing and compacting**
- **Function of:**
  - ▶ **Aggregate Gradation**
    - ◆ **Coarse Fraction**
    - ◆ **Sand Fraction**
    - ◆ **Minus #200**
  - ▶ **Aggregate Shape**
  - ▶ **Asphalt Content**
  - ▶ **Asphalt Viscosity**

# Flexibility

- **Definition – Ability to adjust to movements due to loads or settlement without cracking**
  
- **Function of:**
  - ▶ **Aggregate Gradation**
    - ◆ **Dense vs. open**
  - ▶ **Asphalt Content**
  - ▶ **Temperature**
  - ▶ **Asphalt Grade**



# Fatigue Resistance

- **Definition – Resistance to repeated bending under load without cracking**
  
- **Function of:**
  - ▶ **Asphalt Content**
    - ◆ **Air Voids**
  - ▶ **Compaction**
  - ▶ **Asphalt Viscosity**
    - ◆ **Grade**
    - ◆ **Aging**
  - ▶ **Pavement Thickness**

# Skid Resistance

- **Definition – Ability to minimize slipping or hydroplaning, especially when wet**
  
- **Function of:**
  - ▶ **Aggregate Gradation**
  - ▶ **Surface Texture**
  - ▶ **Asphalt Content**
  - ▶ **Aggregate Durability**
  - ▶ **Mix Stability**

# Mix Design

- **Purpose – To select the optimum combination of materials to meet mixture characteristics and performance properties**
  
- **Properties to be Balanced**
  - ▶ **Stability vs. Workability**
  - ▶ **Durability vs. Skid Resistance**
  - ▶ **Durability vs. Flexibility**
  - ▶ **Stability vs. Flexibility**

# Mix Design (continued)

- **Optimize Properties**
  - ▶ **Enough AC for Durability**
  - ▶ **Adequate Stability for Traffic**
  - ▶ **Adequate Voids for Additional Compaction under Traffic**
  - ▶ **Low Enough Voids to keep out Air and Moisture**
  - ▶ **Adequate Workability**