



# **Volumetrics**

## **Section 1 Introduction**

# 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

## ➤ Follow AASHTO R 35

# Mixture Characteristics

- **Density**
- **Air voids**
- **VMA**
- **Binder content**
- **Film thickness**

# 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**

# Voids in Total Mix

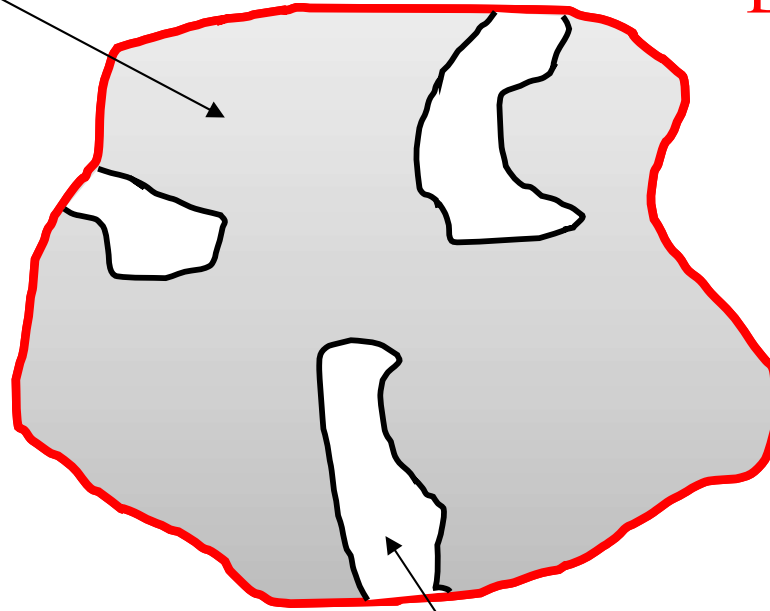
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- **When mixing asphalt with aggregate, there will be some air voids in between the asphalt-coated aggregate particles.**
- **The voids in total mix (VTM) is the ratio of the air void volume to the total volume of the asphalt.**
- **You can think of the (VTM) as the void content of the asphalt-coated aggregate particles in the specimen.**

# Mix Volumetrics

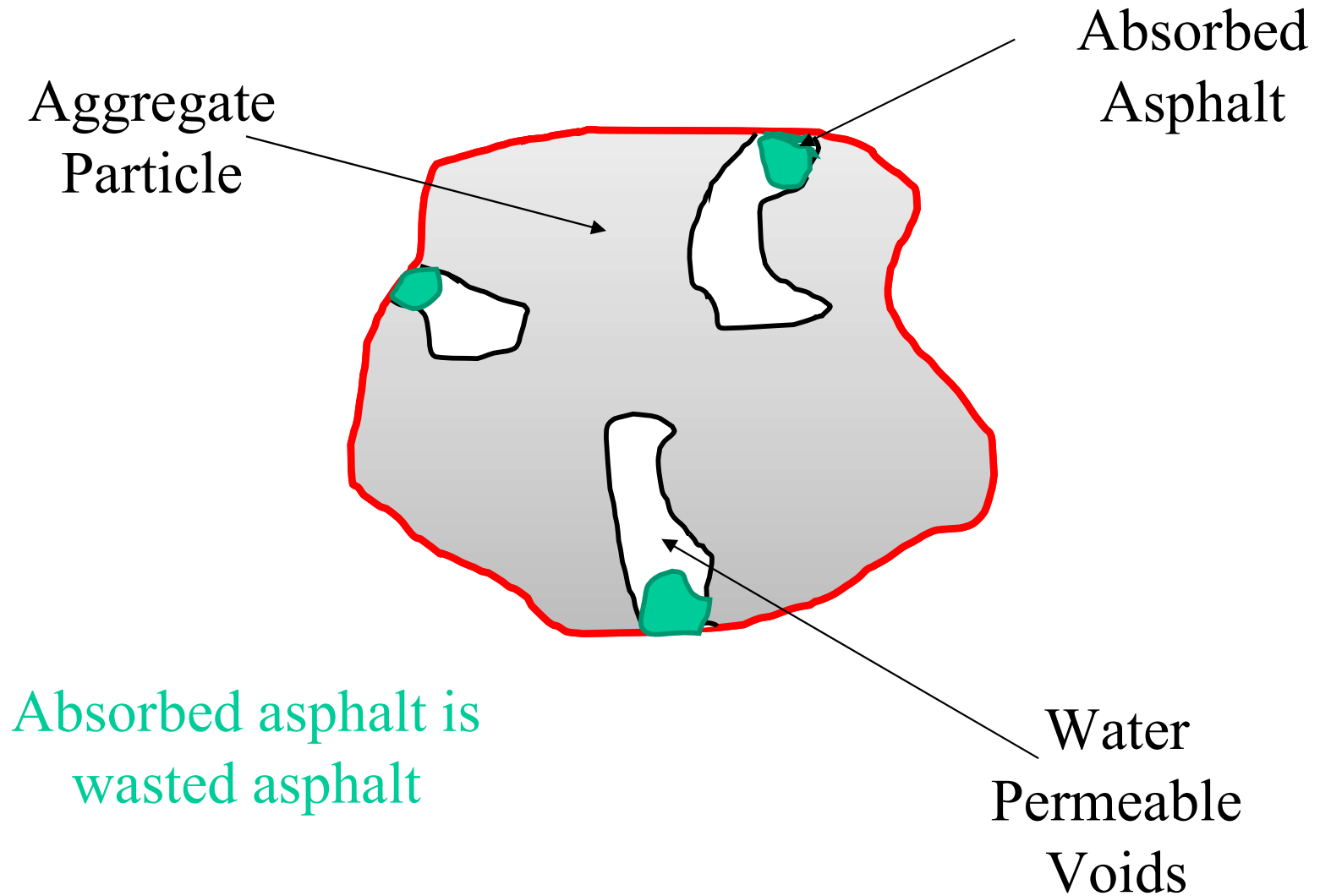
Aggregate  
Particle

Bulk Volume ( $V_G$ )

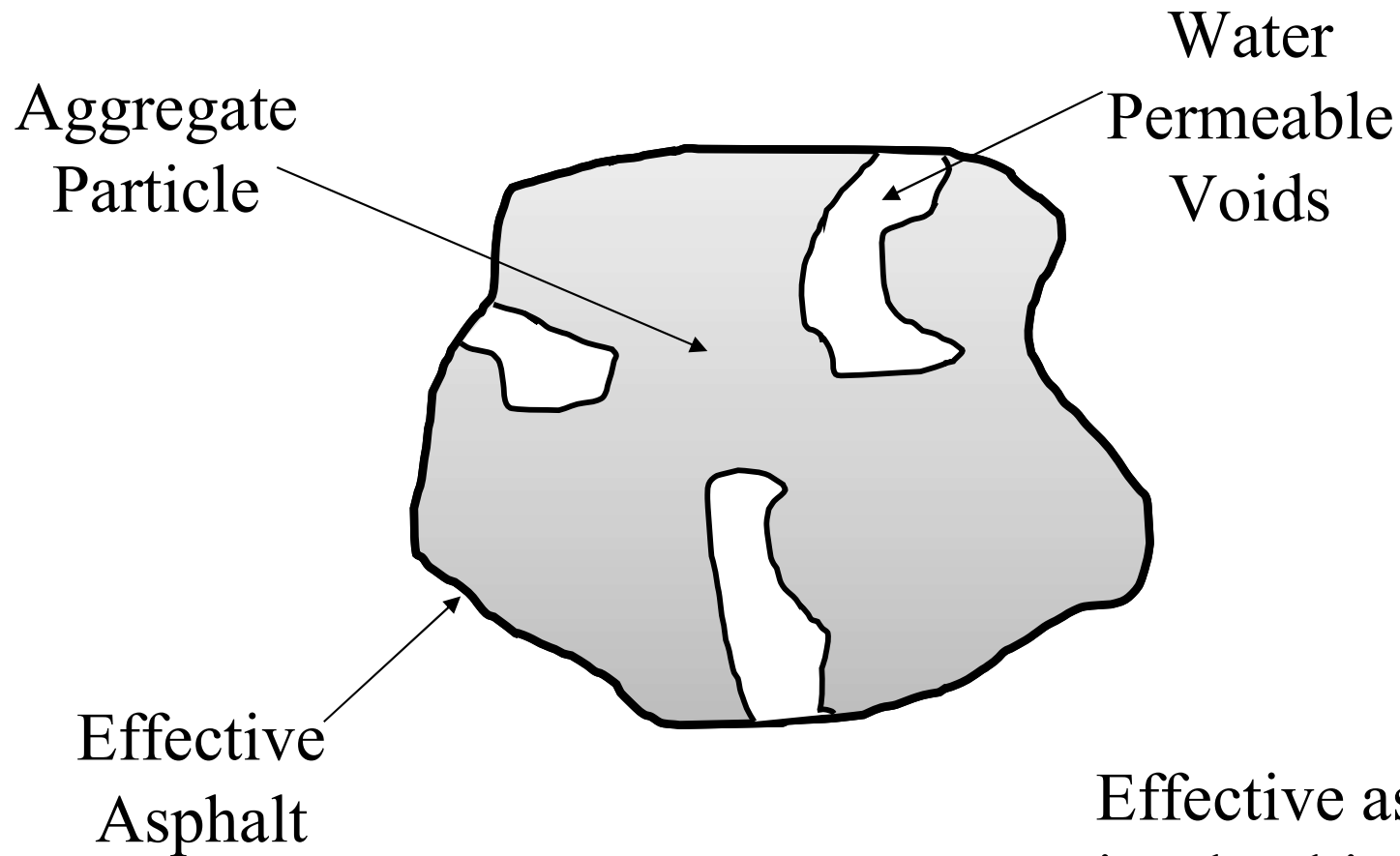


Water  
Permeable  
Voids

# Mix Volumetrics



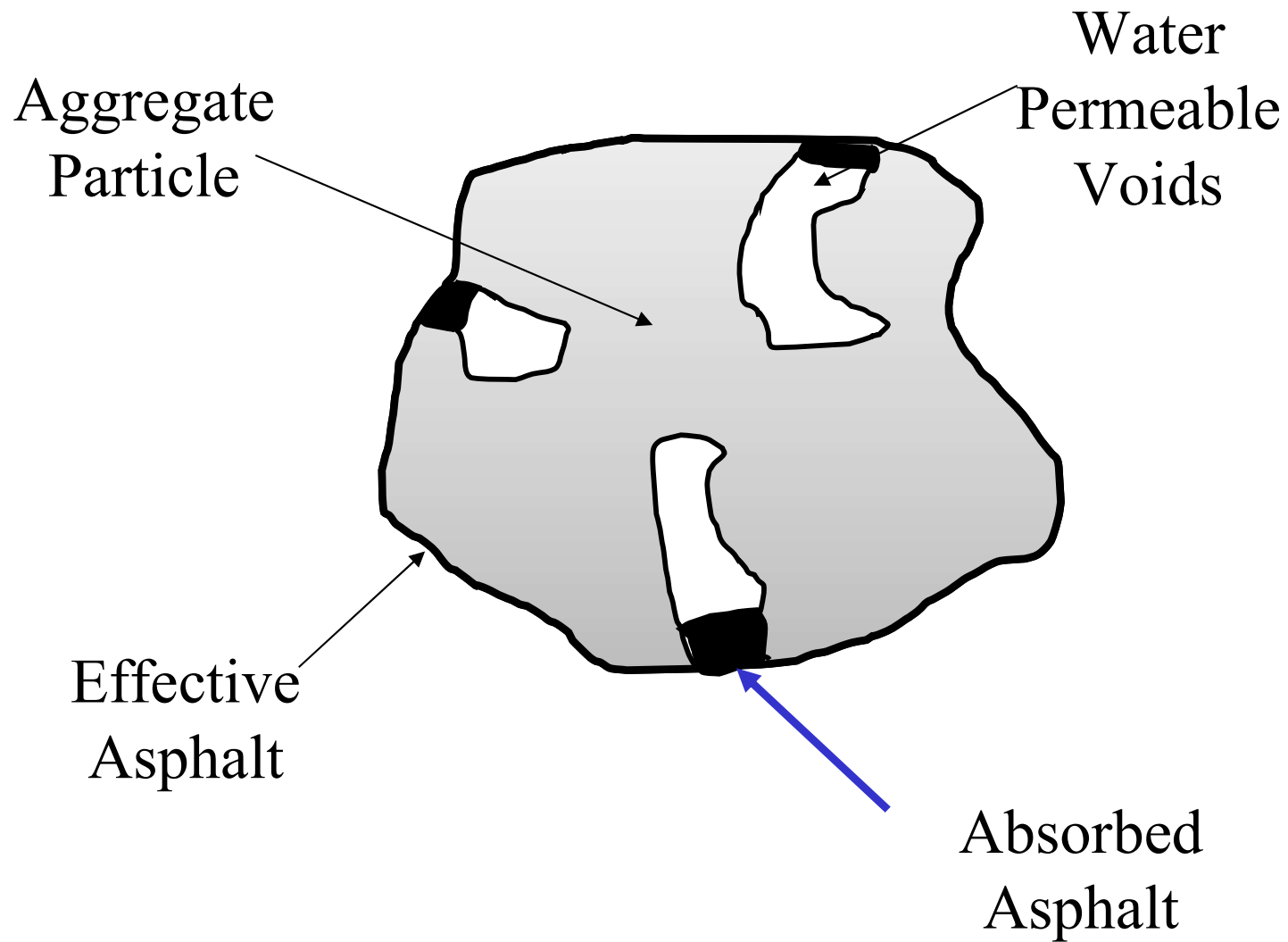
# Mix Volumetrics



Effective asphalt is what binds the aggregate particles together



# Mix Volumetrics

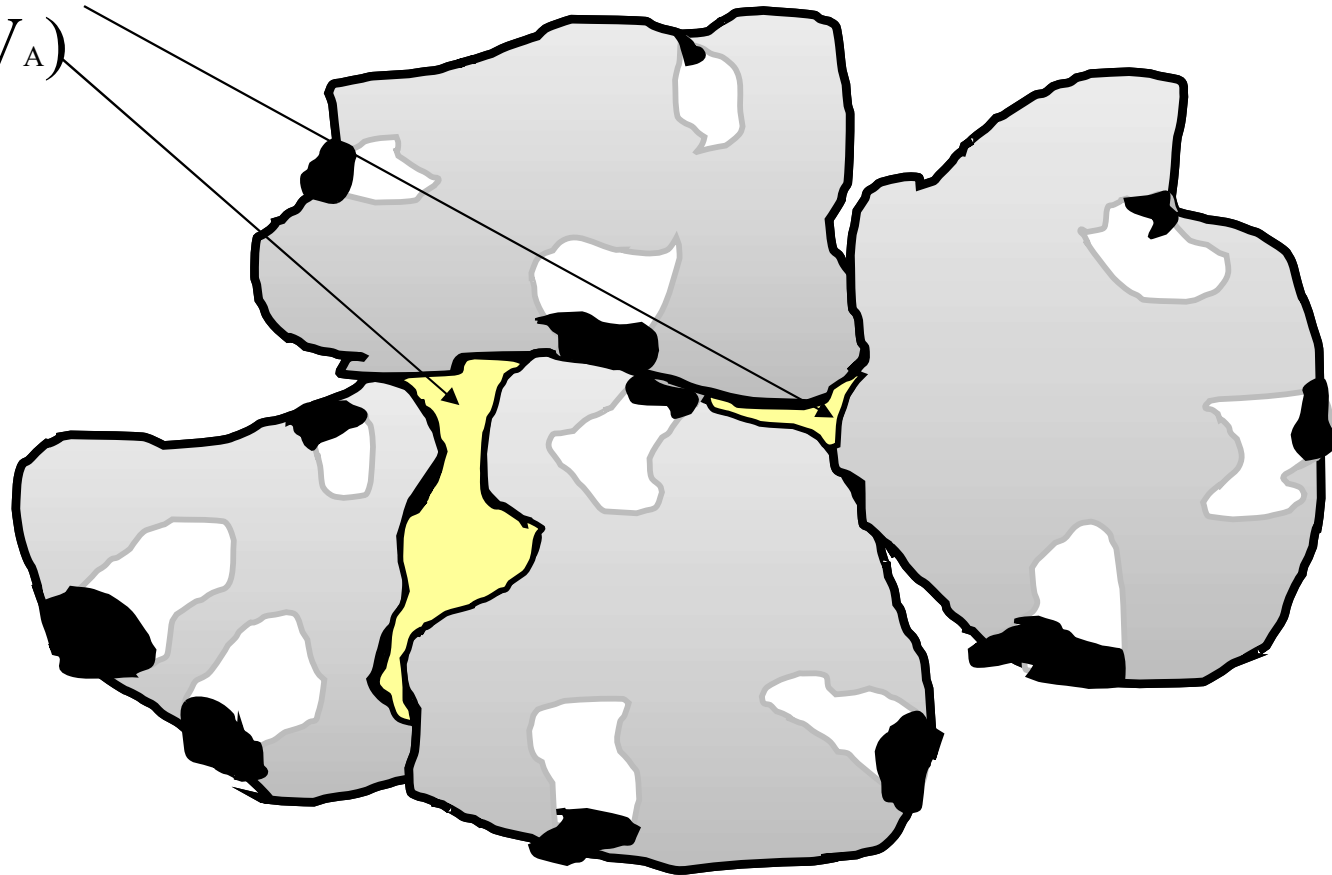


# Voids in Total Mix

- **When you mix asphalt cement with aggregate, there will inevitably be some air voids in between the asphalt-coated aggregate particles. The voids in total mix (VTM) is the ratio of the air void volume to the total volume of the asphalt concrete. You can think of the VTM as the void content of the asphalt-coated aggregate particles inside the specimen.**

# Voids in Total Mix

Air Voids  
( $V_A$ )



# Voids in Total Mix

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

# AIR VOIDS FUNCTION

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- **The main purpose of air voids is to provide space for the binder to "flex" into and out of.**
- **If the spaces are too big, then the binder will over stress itself and essentially fatigue or crack faster.**
- **If the spaces are too small, the binder will overfill the space and it has nowhere else to go, "shove" the rock structure out of the way, this creates rutting and shoving.**

# Voids in the Mineral Aggregate (VMA)

## ➤ Definition

- Void spaces between aggregate in compacted mix
- Air voids and effective asphalt volume
- Total space available for asphalt

## ➤ High VMA

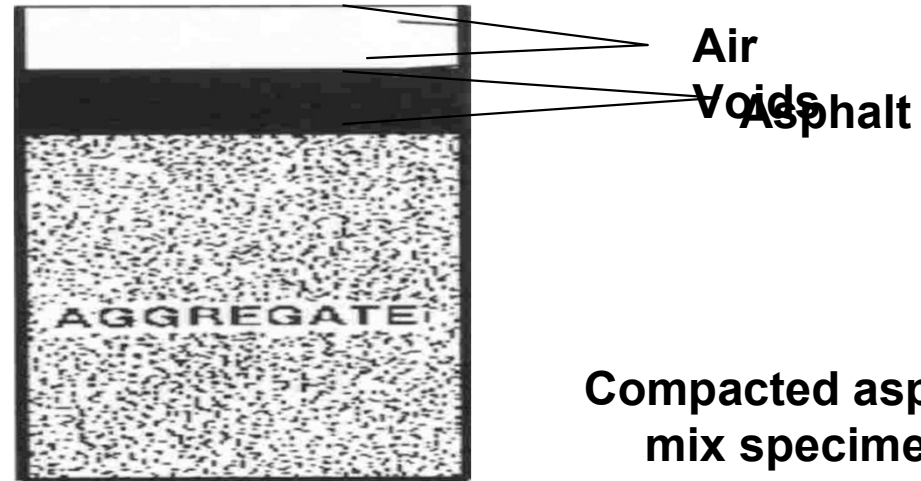
- Low Stability - rutting
- Not Economical-needs more binder to fill voids to maintain 4% air voids

## ➤ Low VMA

- Low durability (from Low film thickness) - increase susceptibility to moisture damage as water will break the asphalt bond due to binder being oxidized faster.
- Dry mix-cracking

# VMA

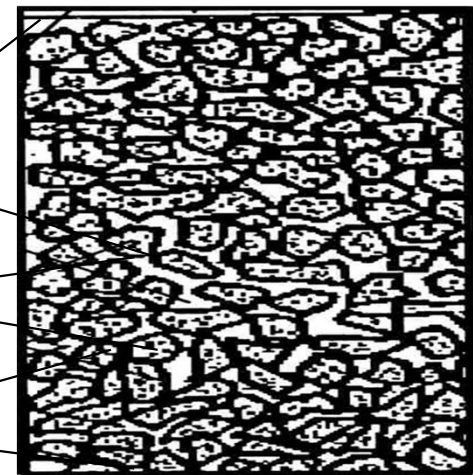
Representation of  
volume in a compacted  
asphalt specimen



Mix specimen with  
Asphalt removed

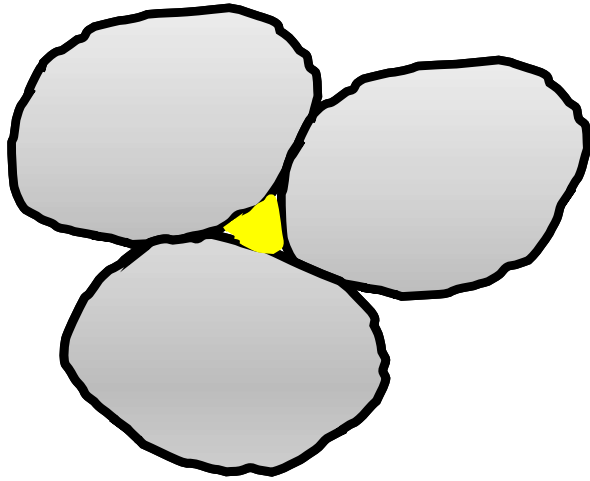


Compacted asphalt  
mix specimen

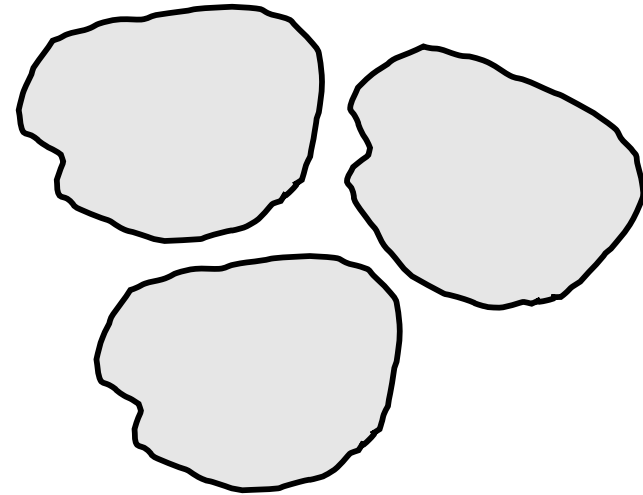


VMA  
Air  
Void  
Aggregate  
Asphalt

# Voids in Mineral Aggregate



VTM  
(Voids in Total Mix)



VMA  
(Voids in Aggregate)



# Voids Filled with Asphalt

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- **The voids filled with asphalt (VFA) is simply the percentage of the void space between the suspended aggregate particles that is filled with asphalt cement.**

# VFA

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- **The percentage of voids in the compacted aggregate mass that are filled with asphalt cement.**
- **A volumetric measurement of the % of effective 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

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

# Stability (continued)

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- **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

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

# Fatigue Resistance

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

# Skid Resistance

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