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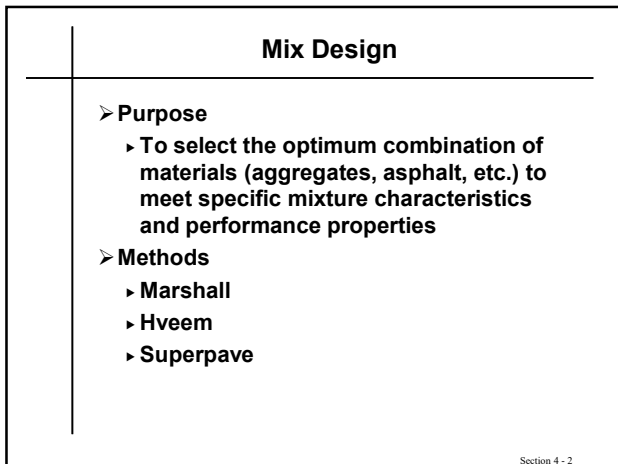
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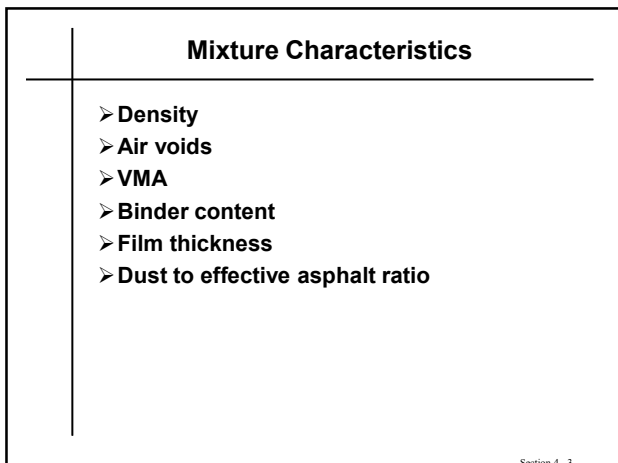
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	Density
	➤ <b>Definition</b> – Weight per unit volume lb/ft <sup>3</sup>
	➤ <b>Density</b> – Bulk S.G. x unit weight of water (62.4 lb/ft <sup>3</sup> )
	➤ <b>High Density</b> ➡ <b>Performance</b>

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	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).

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	Air Voids
	➤ <b>Definition</b> ➤ Air spaces between coated aggregate in compacted mix
	➤ <b>Some necessary</b>
	➤ <b>Too high vs too low</b>
	➤ <b>Design</b> – usually 3% to 5%
	➤ <b>Related to density</b>

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## 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

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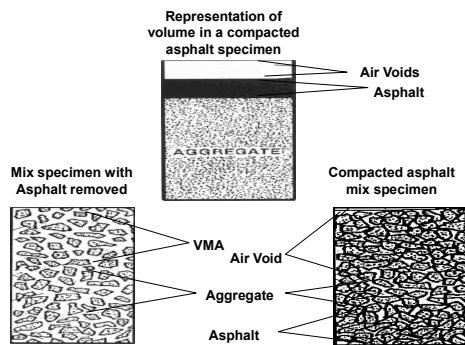
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## VMA



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## 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

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	<h3>Performance Properties</h3> <ul style="list-style-type: none"> <li>➤ <b>Stability</b></li> <li>➤ <b>Durability</b></li> <li>➤ <b>Impermeability</b></li> <li>➤ <b>Workability</b></li> <li>➤ <b>Flexibility</b></li> <li>➤ <b>Fatigue Resistance</b></li> <li>➤ <b>Skid Resistance</b></li> </ul>
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	<h3>Stability</h3> <ul style="list-style-type: none"> <li>➤ <b>Definition – Ability to resist shoving and rutting under loads</b></li> <li>➤ <b>Requirements can vary with load</b></li> </ul>
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	<h3>Stability (continued)</h3> <ul style="list-style-type: none"> <li>➤ <b>Function of:</b> <ul style="list-style-type: none"> <li>➤ <b>Internal Friction of Aggregate</b> <ul style="list-style-type: none"> <li>◆ <b>Shape</b></li> <li>◆ <b>Size</b></li> <li>◆ <b>Surface characteristics</b></li> </ul> </li> <li>➤ <b>Cohesion</b> <ul style="list-style-type: none"> <li>◆ <b>Increases with loading</b></li> <li>◆ <b>Increases with binder viscosity</b></li> <li>◆ <b>Decreases with time</b></li> </ul> </li> <li>➤ <b>Asphalt Content</b></li> <li>➤ <b>Temperature</b></li> </ul> </li> </ul>
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	<h3 style="text-align: center;">Durability</h3> <hr/> <ul style="list-style-type: none"> <li>➤ Definition – Ability to resist weather, traffic, time</li> <li>➤ Function of:             <ul style="list-style-type: none"> <li>▶ Asphalt Content                 <ul style="list-style-type: none"> <li>◆ Film thickness</li> <li>◆ Low air voids</li> </ul> </li> <li>▶ Aggregate Gradation                 <ul style="list-style-type: none"> <li>◆ Dense mixes</li> <li>◆ Impermeability</li> </ul> </li> <li>▶ Aggregate Water Susceptibility                 <ul style="list-style-type: none"> <li>◆ Stripping</li> </ul> </li> <li>▶ Asphalt Aging</li> <li>▶ Compaction</li> </ul> </li> </ul>
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	<h3 style="text-align: center;">Impermeability</h3> <hr/> <ul style="list-style-type: none"> <li>➤ Definition – Resistance to passage of air or water</li> <li>➤ Function of:             <ul style="list-style-type: none"> <li>▶ Asphalt Content                 <ul style="list-style-type: none"> <li>◆ High air voids</li> </ul> </li> <li>▶ Compaction</li> </ul> </li> </ul>
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	<h3 style="text-align: center;">Workability</h3> <hr/> <ul style="list-style-type: none"> <li>➤ Definition – Ease of placing and compacting</li> <li>➤ Function of:             <ul style="list-style-type: none"> <li>▶ Aggregate Gradation                 <ul style="list-style-type: none"> <li>◆ Coarse Fraction</li> <li>◆ Sand Fraction</li> <li>◆ Minus #200</li> </ul> </li> <li>▶ Aggregate Shape</li> <li>▶ Asphalt Content</li> <li>▶ Asphalt Viscosity</li> </ul> </li> </ul>
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	<h2 style="text-align: center;">Flexibility</h2> <hr/> <ul style="list-style-type: none"> <li>➤ <b>Definition – Ability to adjust to movements due to loads or settlement without cracking</b></li> <li>➤ <b>Function of:</b> <ul style="list-style-type: none"> <li>▸ <b>Aggregate Gradation</b> <ul style="list-style-type: none"> <li>◆ <b>Dense vs. open</b></li> </ul> </li> <li>▸ <b>Asphalt Content</b></li> <li>▸ <b>Temperature</b></li> <li>▸ <b>Asphalt Grade</b></li> </ul> </li> </ul>
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	<h2 style="text-align: center;">Fatigue Resistance</h2> <hr/> <ul style="list-style-type: none"> <li>➤ <b>Definition – Resistance to repeated bending under load without cracking</b></li> <li>➤ <b>Function of:</b> <ul style="list-style-type: none"> <li>▸ <b>Asphalt Content</b> <ul style="list-style-type: none"> <li>◆ <b>Air Voids</b></li> </ul> </li> <li>▸ <b>Compaction</b></li> <li>▸ <b>Asphalt Viscosity</b> <ul style="list-style-type: none"> <li>◆ <b>Grade</b></li> <li>◆ <b>Aging</b></li> </ul> </li> <li>▸ <b>Pavement Thickness</b></li> </ul> </li> </ul>
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	<h2 style="text-align: center;">Skid Resistance</h2> <hr/> <ul style="list-style-type: none"> <li>➤ <b>Definition – Ability to minimize slipping or hydroplaning, especially when wet</b></li> <li>➤ <b>Function of:</b> <ul style="list-style-type: none"> <li>▸ <b>Aggregate Gradation</b></li> <li>▸ <b>Surface Texture</b></li> <li>▸ <b>Asphalt Content</b></li> <li>▸ <b>Aggregate Durability</b></li> <li>▸ <b>Mix Stability</b></li> </ul> </li> </ul>
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### 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

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### 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

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