

Hot Mix Asphalt (HMA) Volumetric Properties

HMA

Volumetrics

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HMA Volumetric Terms

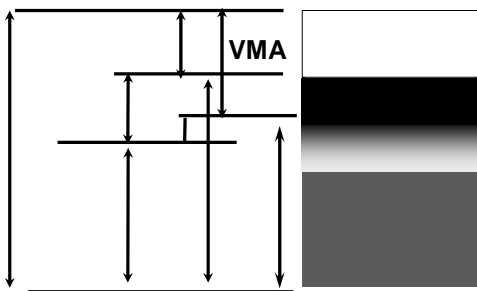
- Bulk specific gravity (BSG) of compacted HMA
- Maximum specific gravity
- Air voids
- Effective specific gravity of aggregate
- Voids in mineral aggregate, VMA
- Voids filled with asphalt, VFA

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Volumetric Relationships



HMA

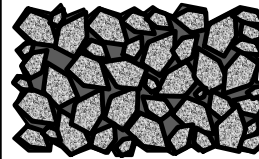
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BSG of Compacted HMA

- Asphalt binder mixed with aggregate and compacted into a sample

$$G_{mb} = \frac{\text{Mass agg. and AC}}{\text{Vol. agg., AC, air voids}}$$



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Testing

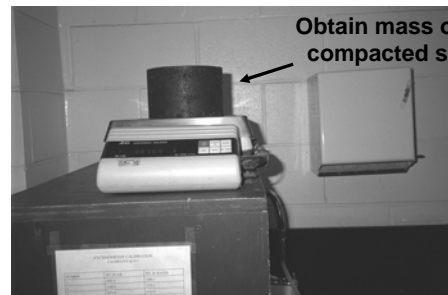
- Mixing of asphalt and aggregate
- Compaction of sample
- Mass of dry sample
- Mass under water
- Mass saturated surface dry (SSD)

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Testing



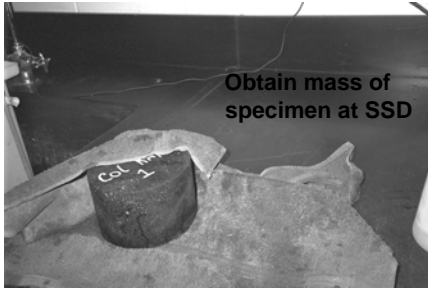
Obtain mass of dry compacted sample

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Testing



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Calculations

$$G_{mb} = A / (B - C)$$

Where:

A = mass of dry sample

B = mass of SSD sample

C = mass of sample under water

HMA

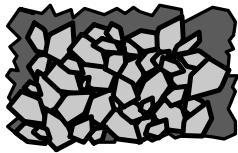
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Maximum Specific Gravity

- Loose (uncompacted) mixture

$$G_{mm} = \frac{\text{Mass agg. and AC}}{\text{Vol. agg. and AC}}$$



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Testing

- Mixing of asphalt and aggregate
 - Cool to room temperature
- Mass in air
- Mass under water

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Testing

Loose Mix at Room Temperature

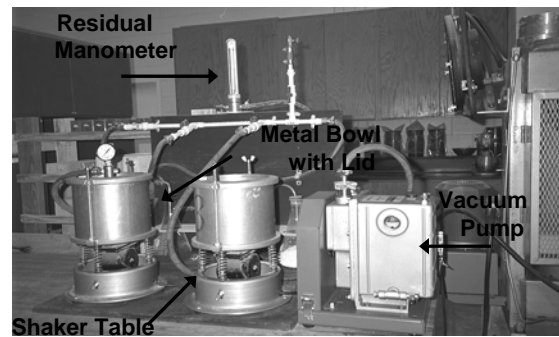


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HMA

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Calculations

- $G_{mm} = A / (A - C)$

Where:

A = mass of dry sample

C = mass of sample under water

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Percent Air Voids

- Calculated using both specific gravities

$$\text{Air voids} = \left(1 - \frac{G_{mb}}{G_{mm}} \right) 100$$

$$\frac{\text{Mass agg + AC}}{\text{Vol. agg, AC, Air Voids}} = \frac{\text{Vol. agg, AC}}{\frac{\text{Mass agg + AC}}{\text{Vol. agg, AC}}}$$

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Example Calculations

- Air voids:
 - $G_{mb} = 2.222$
 - $G_{mm} = 2.423$

HMA

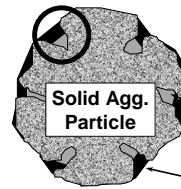
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Effective Specific Gravity

Surface Voids

$$G_{se} = \frac{\text{Mass, dry}}{\text{Effective Volume}}$$



Vol. of water-perm. voids not filled with asphalt

Absorbed asphalt

Effective volume = volume of solid aggregate particle + volume of surface voids not filled with asphalt

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Effective Specific Gravity

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

G_{se} is an aggregate property

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Example Calculations

- Mixed with 5 % asphalt cement
- $G_{mm} = 2.535$
- $G_b = 1.03$

$$G_{se} = \frac{100 - 5}{\frac{100}{2.535} - \frac{5}{1.03}}$$

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Voids in Mineral Aggregate

$$VMA = 100 - \frac{G_{mb} P_s}{G_{sb}}$$

VMA is an indication of film thickness on the surface of the aggregate

Example Calculations

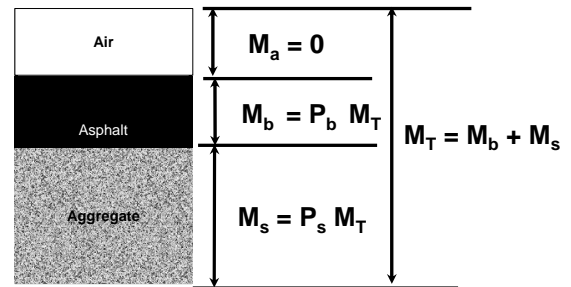
- Given that $G_{mb} = 2.455$, $P_s = 95\%$, and $G_{sb} = 2.703$

Voids Filled with Asphalt

$$VFA = 100 \times \frac{VMA - V_a}{VMA}$$

VFA is the percent of VMA that is filled with asphalt cement

Mass Relationships



Percent Binder Absorbed

$$P_{ba} = 100 \left(\frac{G_{se} - G_{sb}}{G_{sb} G_{se}} \right) G_b$$

P_{ba} is the percent of absorbed asphalt by mass of aggregate

Effective Asphalt Content

$$P_{be} = P_b - \frac{P_{ba}}{100} P_s$$

The effective asphalt content is the total asphalt content minus the percent lost to absorption (based on mass of total mix).

Summary of Terms

- VMA = Voids in mineral aggregates
- V_a = Air voids
- VFA = Voids filled with asphalt binder
- G_b = Specific gravity, asphalt binder
- G_{se} = Effective specific gravity of aggregate
- G_{sb} = Bulk specific gravity of aggregate
- P_{be} = % by mass of effective asphalt binder
- P_b = % by mass of total asphalt binder
- P_{ba} = % by mass of absorbed asphalt binder
- M_T = Total mass
- M_s = Mass of solids
- M_b = Mass of asphalt binder
- G_{mb} = Specific gravity of compacted HMA
- G_{mm} = Maximum specific gravity of loose HMA

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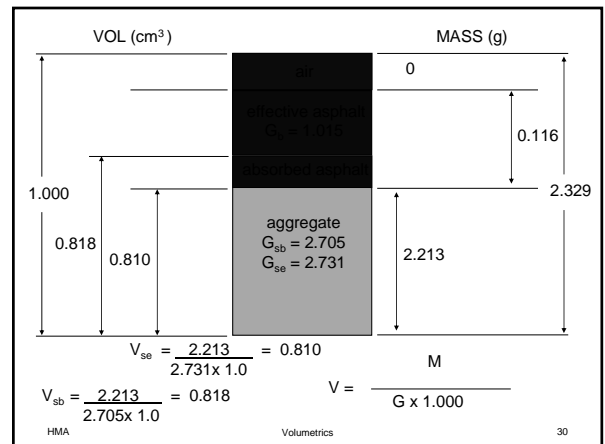
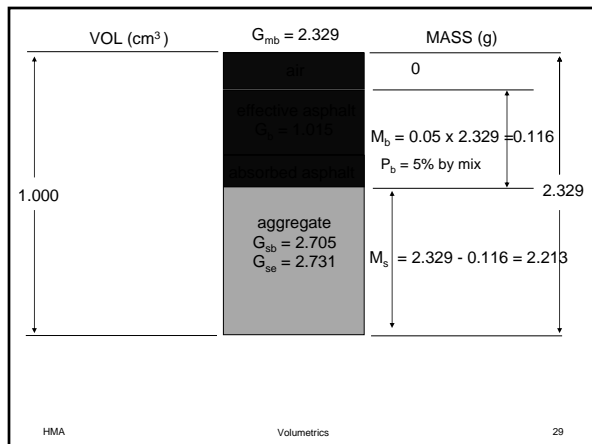
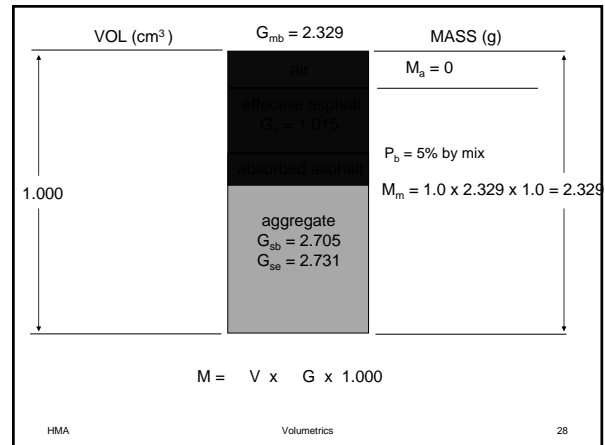
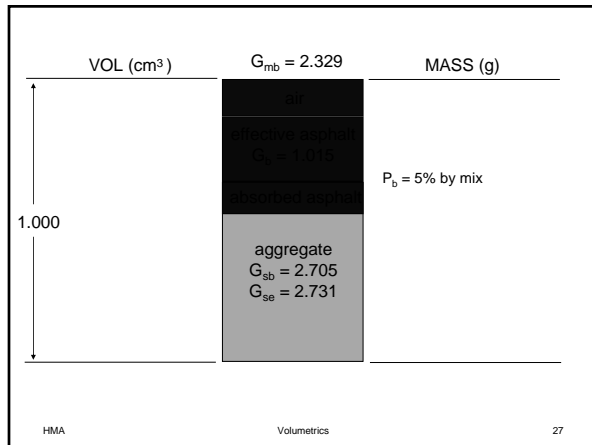
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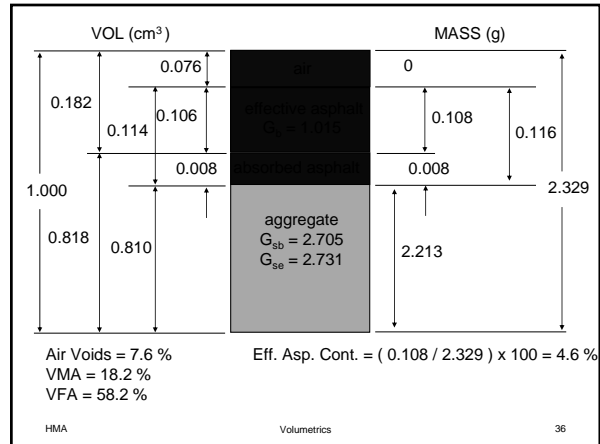
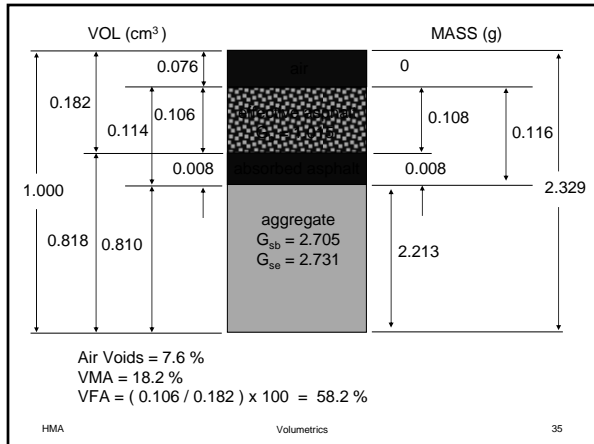
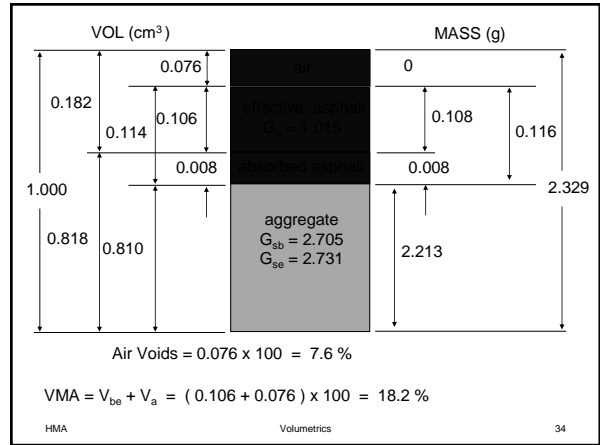
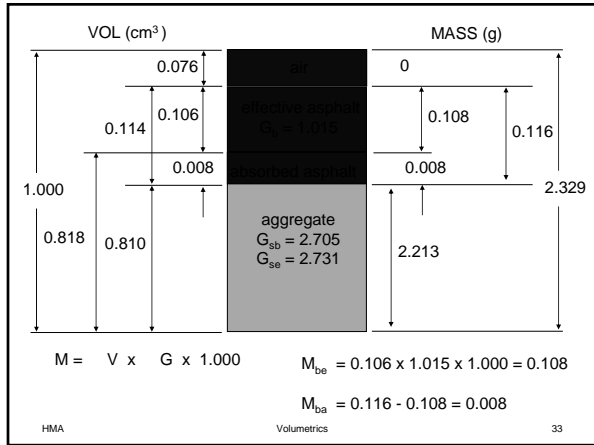
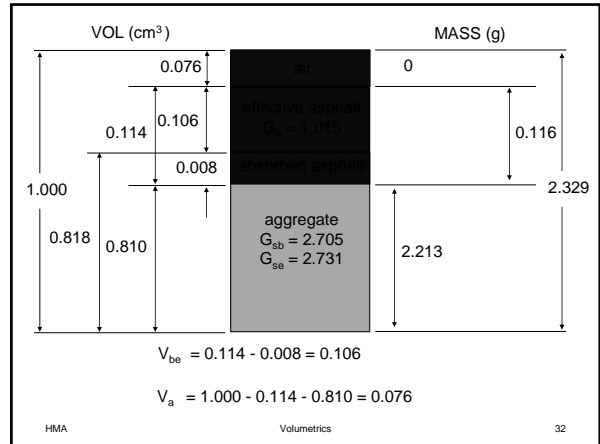
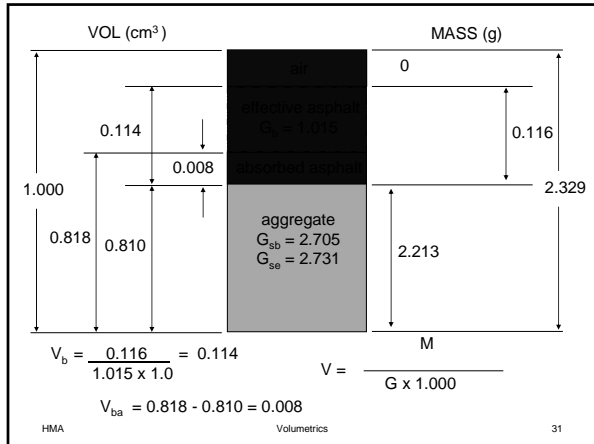
Hot Mix Asphalt (HMA) Volumetric Properties Using Phase Diagrams

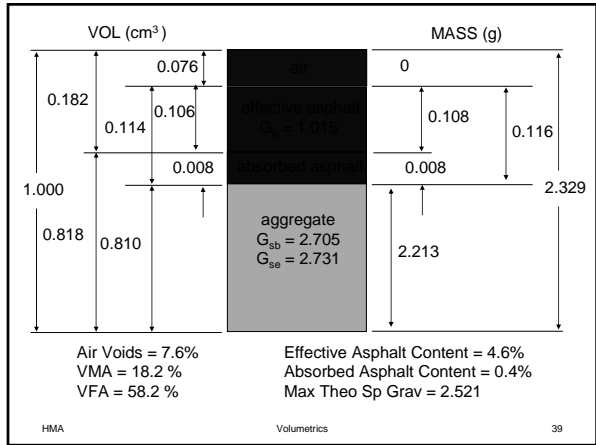
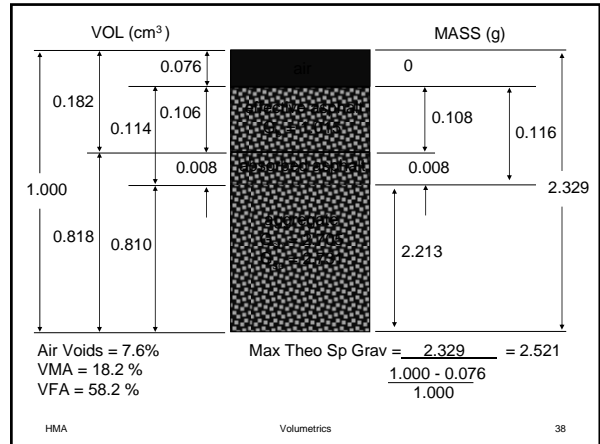
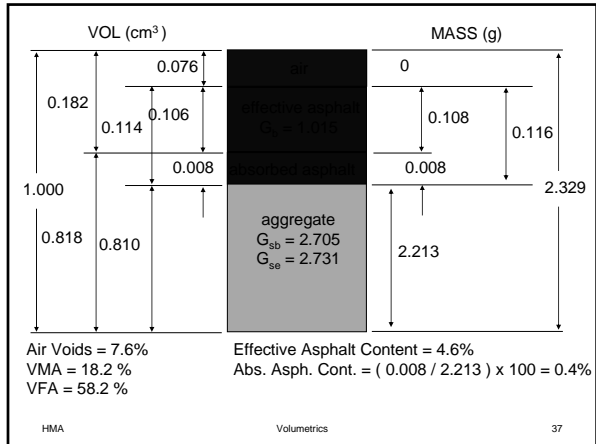
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QUESTIONS ?

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