Construction of Quality Hot Mix Asphalt Pavements - 1 Day Course

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Asphalt Mix Design

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HMA Mix Design

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Strength/ Stability

Rut Resistance

Raveling

Durability

Crack Resistance

Shoving

Flushing

HMA Mix Characteristics

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Let's start with the basics – A layer of HMA pavement has 3 components:

	Typical % By Mass:	Typical % By Volume:
1) Aggregate	94 - 96	83 - 84
2) Asphalt Binder	4 - 6	11 - 12
3) Air	0	4 - 7

Volumetrics

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We evaluate the quality of the HMA by setting parameters on these three components, which have historically provided a good indication of a mixture's probable performance.

Basic Design Procedure

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No matter whether it's Superpave, Marshall, Hveem, Texas Gyratory, or something else, the mix design process has some common procedures and goals.

Mix Design Flowchart

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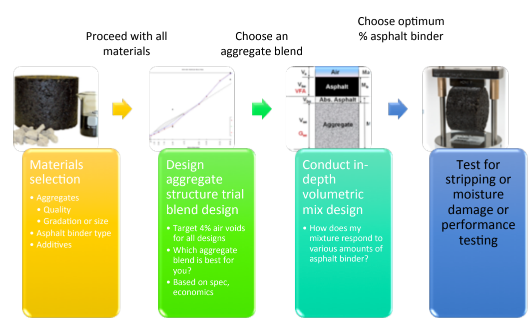
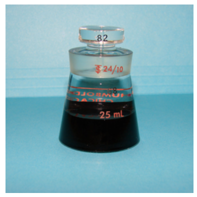


Basic Design Procedure

- **Choose binder type and test binder**
  - *Usually specified in contract*



Binder Specific Gravity

Basic Design Procedure

- **Choose aggregate types, sources, and test**
  - *Sometimes specify polish-resistant aggregates in surface*
  - *Locate aggregate sources that can be combined to meet specifications*
  - *Determine if RAP and/or RAS can be used*

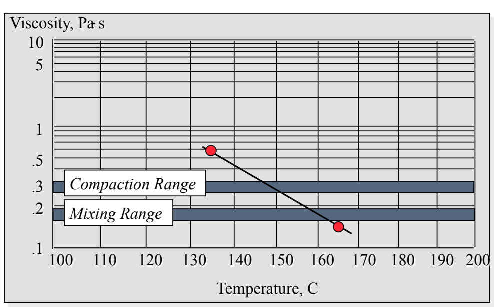
Basic Design Procedure

- **Determine trial combination(s) and batch dry aggregates**
  - *Each aggregate or batch is sieved and carefully combined*

Basic Design Procedure

- **Heat aggregates and binder, then mix**
  - *Until all aggregate is fully coated*

Mixing / Compaction Temperatures



Basic Design Procedure

- **Oven-age the mixture to account for absorption, binder stiffening**

Think about how this relates to field production and placement!

Basic Design Procedure

- **Determine the theoretical maximum specific gravity, G_{mm}**


Basic Design Procedure

- **Mold specimens to determine the bulk specific gravity, G_{mb}**



Volumetrics

Various volumetric properties are then calculated, such as:

- **Percent binder**
- **Percent air voids**
- **Percent *effective* binder**
- **Voids in the Mineral Aggregate (VMA)**
- **Voids Filled with Asphalt (VFA)**
- **Dust Proportion *(Ratio of % Passing No. 200 sieve to % effective binder)***

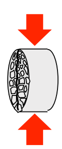
Mechanical Tests - Moisture Sensitivity

AASHTO T 283

- **Prepare set of 6 specimens**
  - **6.5 to 7.5% voids**
    - **Represents anticipated in-service voids**
- **Use 3 specimens as controls**
- **Remaining 3 specimens are vacuum-saturated 70 to 80%**
- **Min. 16 hour freezing at 0°F**
- **24 Hours in 140°F water bath**
- **Bring all specimens to test temperature (77°F) and determine indirect tensile strength**

Mechanical Tests - Moisture Sensitivity

- **Determine the indirect tensile strengths of both sets of 3 specimens**

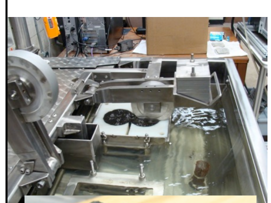
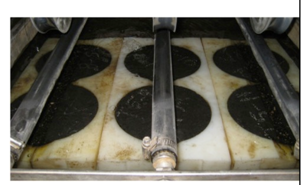


- **Calculate the Tensile Strength Ratio (TSR)**

$$\text{TSR} = \frac{\text{Avg. conditioned tensile strength}}{\text{Avg. control tensile strength}}$$

Minimum of 80% needed

Mechanical Tests - Rut Testing

Volumetrics

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Let's take a close look at:

- **Binder Content**
- **Lab-Molded Density / Air Voids**
- **Voids in the Mineral Aggregate (VMA)**

Binder Content

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The goal of establishing the correct binder content is to:

- **Provide a sufficient film coating around the aggregates to bind and waterproof**
- **Provide enough coating to make the HMA durable**
- **Not so much as to make the HMA susceptible to rutting**

Binder Content

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The correct amount of binder increases as the nominal maximum aggregate size decreases- the finer it is, the more surface area for a given volume

Nominal Max. Aggregate Size	1"	3/4"	1/2"	3/8"	No. 4
Typical Binder Content	4.0	4.4	4.9	5.4	5.9

Lab-Molded Density / Air Voids

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We use lab-molded properties to estimate the aggregate structure and binder content needed to withstand the anticipated traffic at the designed pavement thickness.

Lab-Molded Density / Air Voids

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% Air Voids = 100 - % Density

% Density = 100 - % Air Voids

Lab-Molded Density / Air Voids

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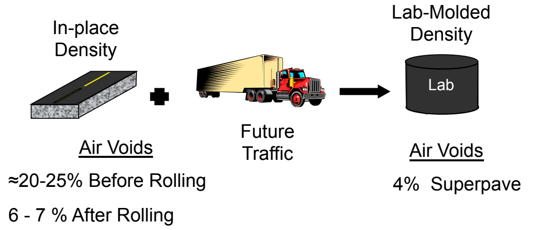
Traffic Level (ESALs)	No. of Gyrations	Required Density
< 0.3M	50	96.0%
0.3M - < 3M	75	96.0%
3M - < 30M	100	96.0%
≥ 30M	125	96.0%

- Number of gyrations change with expected ESALs
- Density requirement remains the same
- To maintain 96.0% density the amount of binder must be increased or decreased if aggregate structure stays the same (the aggregate structure will often have to be changed to maintain volumetrics at different compaction levels)
- More gyrations → Less Binder

Lab-Molded / Roadway Air Voids

Why are the target values for lab-molded air voids and roadway air voids different? **Lab-molded air voids simulate the in-place density of HMA after it has endured several years of traffic in the roadway.**

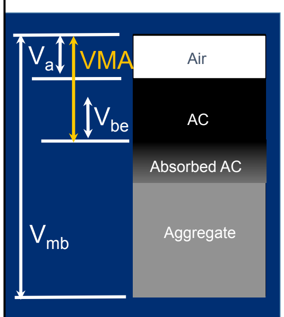


Lab-Molded / Roadway Air Voids

Don't confuse roadway density with lab-molded density:

- **Lab-molded density tells us about the mix properties**
- **Roadway density tells us about the quality of compactive effort on the roadway**

VMA



VMA is the volumetric void space created by the aggregate particles in an asphalt mixture. It is filled with the volume of air voids plus the volume of the binder not absorbed into the aggregate.

The mix needs a minimum VMA to have enough volume to hold the proper amount of air voids and the proper amount of binder.

VMA

If the VMA drops below the specified minimums, the asphalt film thickness gets thinner and the pavement becomes less durable

VMA Requirements (AASHTO M 323)

Nominal Max. Aggregate Size	1"	3/4"	1/2"	3/8"	No. 4
Minimum VMA	12.0	13.0	14.0	15.0	16.0

VMA

Question:

Why can't you add the percent effective binder (P_{be}) to the percent air voids (P_a) to get the VMA?

Answer:

Because P_{be} is a percentage by mass and P_a is a percentage by volume.

Mix Composition

The mix design typically contains (at minimum) the following important information:

- **Mix design type (Superpave, SMA, OGFC, etc.)**
- **Binder grade (PG 64-22, PG 70-22, etc)**
- **Binder source (ex. - Marathon: Tampa, FL)**
- **Nominal Maximum Aggregate Size of mix**
- **Aggregate Types (1/2" Chips, Screenings, Sand, etc.)**
- **Aggregate Sources (ex. - Vulcan: Dalton, GA Quarry)**
- **Percentage of each aggregate used**
- **Individual and combined aggregate gradations**
- **Design binder content**
- **Test data for binder, aggregates, and mix**

Mix Composition

The rule of thumb would be to never allow a different material or different source to be used than what is on the mix design. You need to know if your local agency allows:

- **Switching binder grade on same design (maybe)**
- **Switching binder source within same grade (maybe)**
- **Aggregate Types (<u>never</u>)**
- **Aggregate Sources (<u>never</u>)**
- **Changing % of each aggregate used (± small tolerance)**
- **Individual and combined aggregate gradations (maybe)**
- **Changing design binder content (maybe)**

Calculating unit weights for input into density gauges

Nuclear or electromagnetic density gauges require a maximum (or voidless) unit weight to calculate density

Check local agency to determine whether to use Gmm from:

- **mix design**
- **latest field Rice's test**
- **calculation using G_{se} from:**
  - **mix design**
  - **latest field Rice's test**
- **calculation using P_b from:**
  - **job mix formula**
  - **field lot or sublot**

Calculating unit weights for input into density gauges

Nuclear or electromagnetic density gauges require a maximum (or voidless) unit weight to calculate density

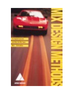
Max. Unit Weight = G_{mm} x 62.4 lbs/ft^3

Note: Density gauges <u>must</u> be correlated with roadway cores to determine accurate densities.

QUESTIONS?

Good Reference Materials on the Topic:

MS-2: Mix Design Methods



SP-2: Superpave Mix Design

MS-4: The Asphalt Handbook

MS-22: HMA Construction

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