Asphalt Mix Design

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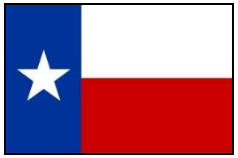

HMA Mix Design

Strength/ Stability

Rut Resistance

Raveling

Durability

Crack Resistance

Shoving

Flushing

HMA Mix Characteristics

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

	Typical % By Mass:	Typical % By Volume:
1) Aggregate	94 - 96	81 - 85
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.

Volumetrics

The way that these three components fit together is largely based on the way that the aggregate particles fit together in the mix

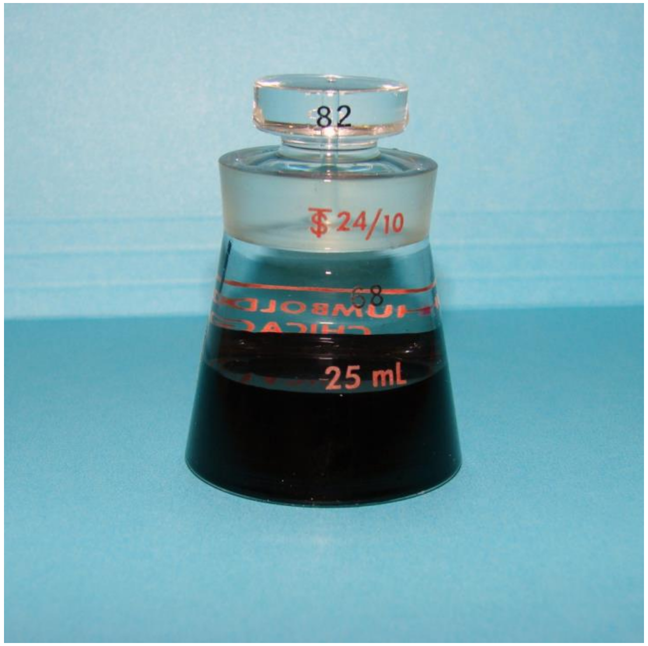
- **Gradation**
  - *Particle size distribution*
- **Shape**
  - *Relative cubicity, angularity*
- **Strength**
  - *Resistance to destructive forces*
- **Surface Texture**
  - *Smooth or rough*
- **Type & Amount of Compactive Effort**
  - *Static pressure, impact, shearing*

Basic Design Procedure

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

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

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

Basic Design Procedure

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

Training, so necessary.

Mixing / Compaction Temperatures

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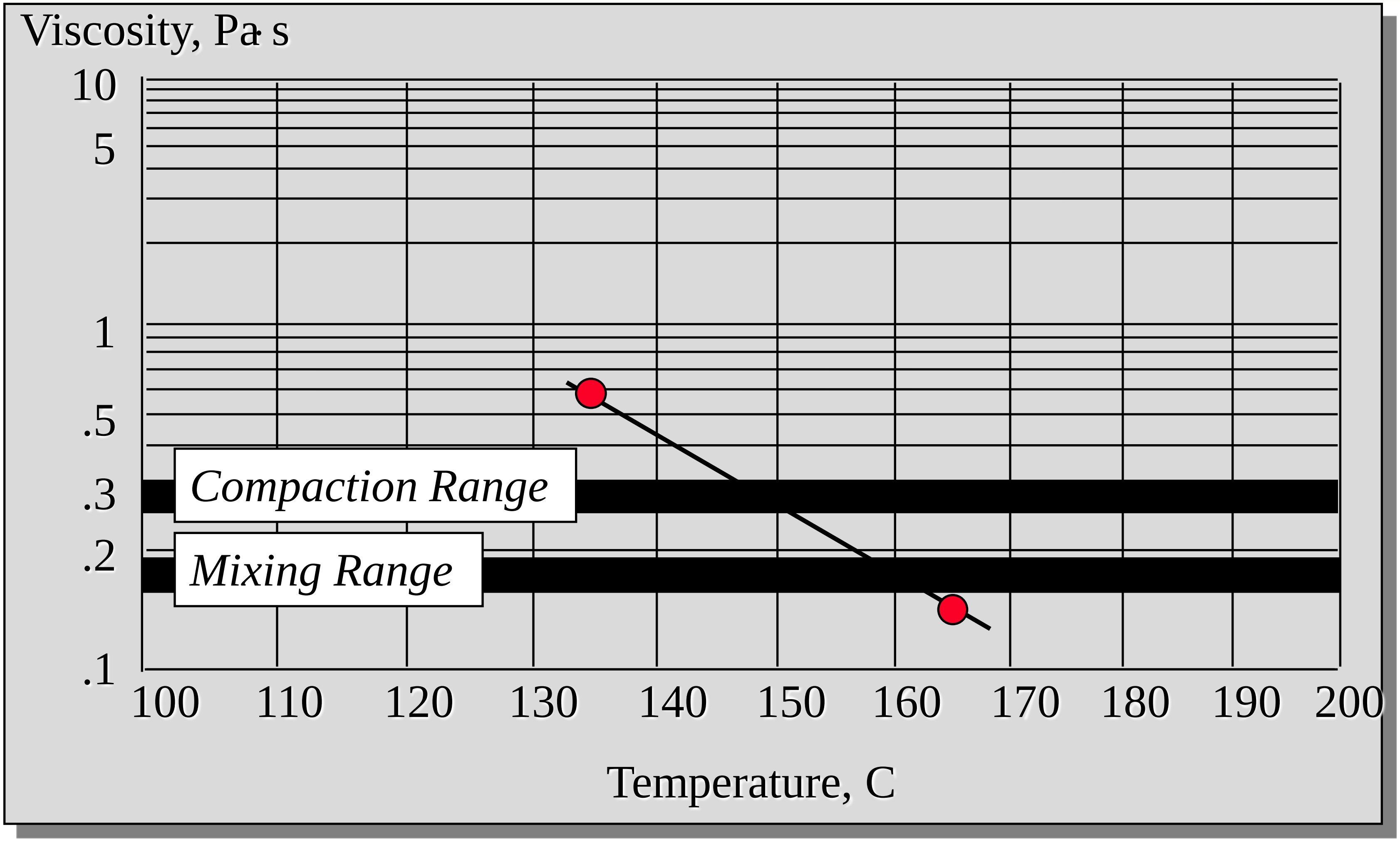

*** Works well with neat binders only**

Mixing / Compaction Temperatures

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Tex-205-F
Laboratory Method of Mixing Bituminous Mix

Texas Department of Transportation

Table 1 - Asphaltic Material Mixing Temperatures by Grade and Type

Type-Grade	Mixing Temp. °F (°C)
PG 70-28, PG 76-22	325 (163)
PG 64-28, PG 70-22	300 (149)
PG 64-22, PG 64-16	290 (143)
AC-3, 5, 10; PG 58-28, PG 58-22	275 (135)

1. If using RAP or RAS and a substitute binder in lieu of originally-specified binder, select mixing temperature for originally specified binder grade
2. When using RAP or RAS, mixing temperature my be increased to 325°F to achieve adequate coating

Temperature Issues

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Maltenes: Oily and resinous in appearance – the first to be absorbed & the first to evaporate at high temps

Asphaltenes: Hard, brittle, insoluble, unaffected by oxidation

Never heat over 350ºF!

Basic Design Procedure

- **Oven-age the mixture to account for absorption, binder stiffening** *(TxDOT 275ºF, 2 hrs for HMA, 4 hrs for WMA)*

Think about how this relates to field production and placement!

Binder Content

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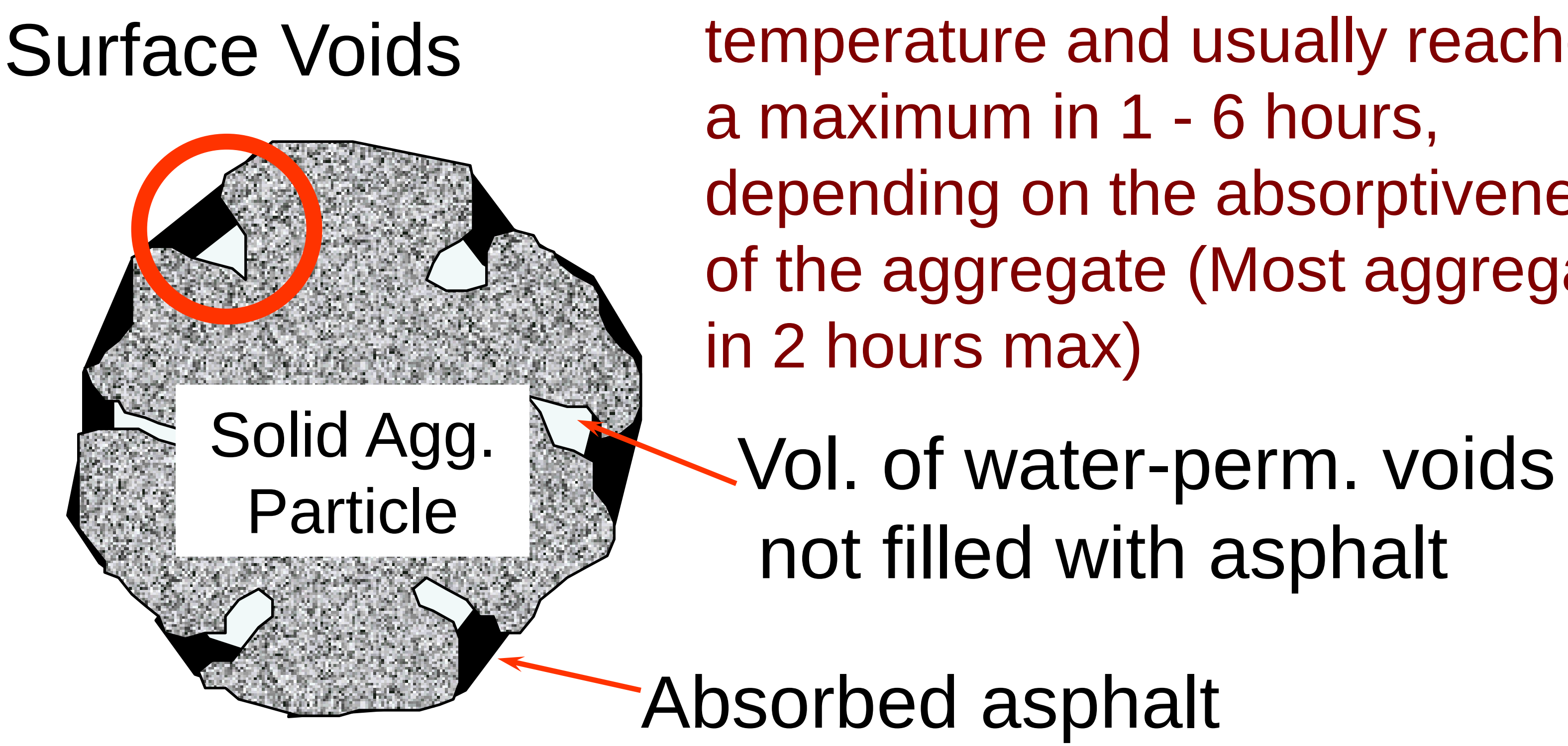
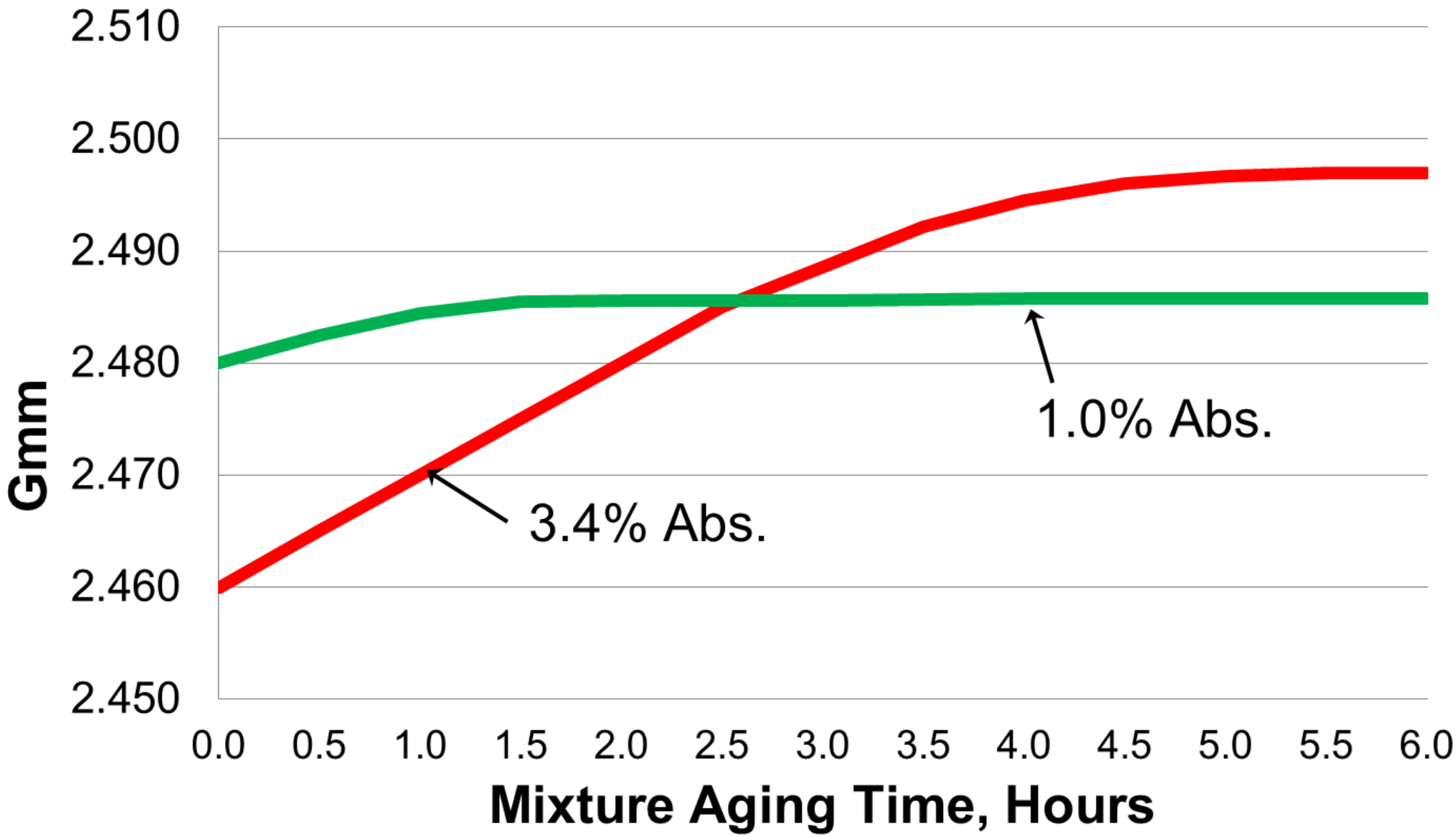
The absorptiveness of the aggregate affects the final binder content



Absorption takes place at high temperature and usually reaches a maximum in 1 - 6 hours, depending on the absorptiveness of the aggregate (Most aggregates in 2 hours max)

Binder Content



Basic Design Procedure

- Determine the theoretical maximum specific gravity, G_r (G_{mm})

Basic Design Procedure

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

Volumetrics

Various volumetric properties are then calculated, such as:

- **Percent binder**
- **Percent air voids**
- **Percent Density**
- **Voids in the Mineral Aggregate (VMA)**
- **Voids Filled with Asphalt (VFA)**

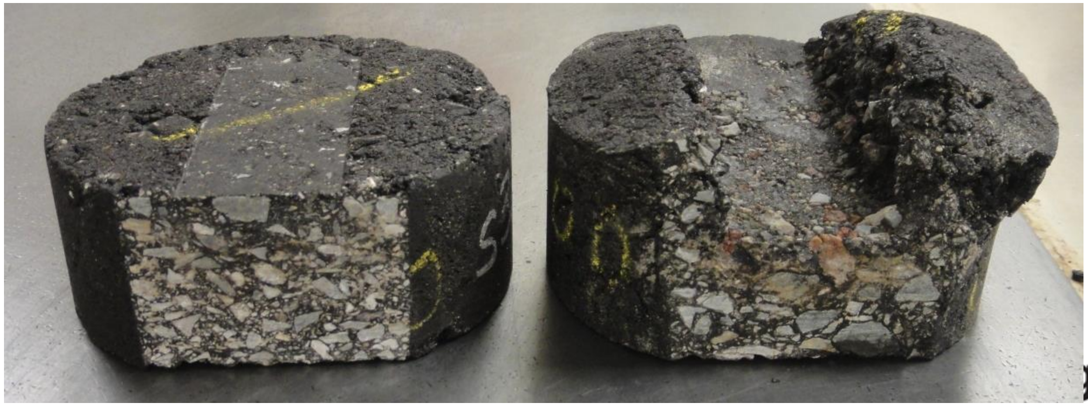
Mechanical Tests - Moisture Sensitivity

Tex-530-C Boil Test

Texas Department of Transportation

- Prepare 1000 g of mix, cool at room temp for 24 ± 2 hrs
- Bring oil bath to between 325 and 350°F
- Obtain a 200 g representative sample of the mix
- Fill 2000 mL beaker about halfway with distilled water and heat to boiling
- Add mix sample to beaker, maintain boil for 10 m ± 30 s
- Remove beaker and skim asphalt from water surface
- Decant water and empty wet mix onto white towel
- Visually estimate degree of stripping
- Repeat after mix has dried for 24 ± 2 hrs
- Report as estimated % stripping after drying period

Mechanical Tests - Rut Testing



Mechanical Tests - Indirect Tensile Strength

Tex-226-F Indirect Tensile Strength

- Calibrate loading press to a deformation rate of 2”/min
- Ensure loading strips remain parallel during testing
- Determine the height and diameter of the test specimen
- Place test specimen in the constant temperature apparatus long enough to ensure a consistent temperature of 77ºF ± 2ºF throughout test specimen
- Carefully place specimen on lower loading strip
- Slowly lower top loading strip into light contact
- Apply load at 2” per minute and determine the total vertical load at specimen failure

Calculate S_T using load, specimen height & diameter

Volumetrics

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Let’s take a closer 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

Mix Type	A	B	C	D	F
Average Binder Content	4.2	4.5	4.7	5.0	5.5

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

% Air Voids = 100 - % Density

% Density = 100 - % Air Voids

Lab-Molded / Roadway Air Voids

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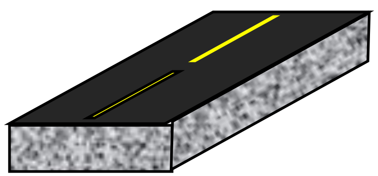
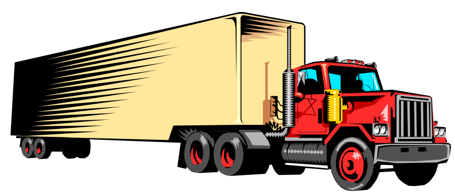
Why are the target values for lab-molded air voids and roadway air voids different? Lab-molded air voids simulate the in-place density of HMA after it has endured several years of traffic in the roadway.

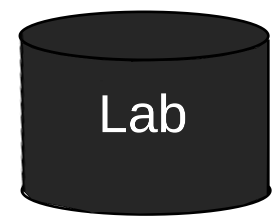
In-place Density





Future Traffic

Lab-Molded Density



Air Voids

≈20-25% Before Rolling

6 - 7 % After Rolling

Air Voids

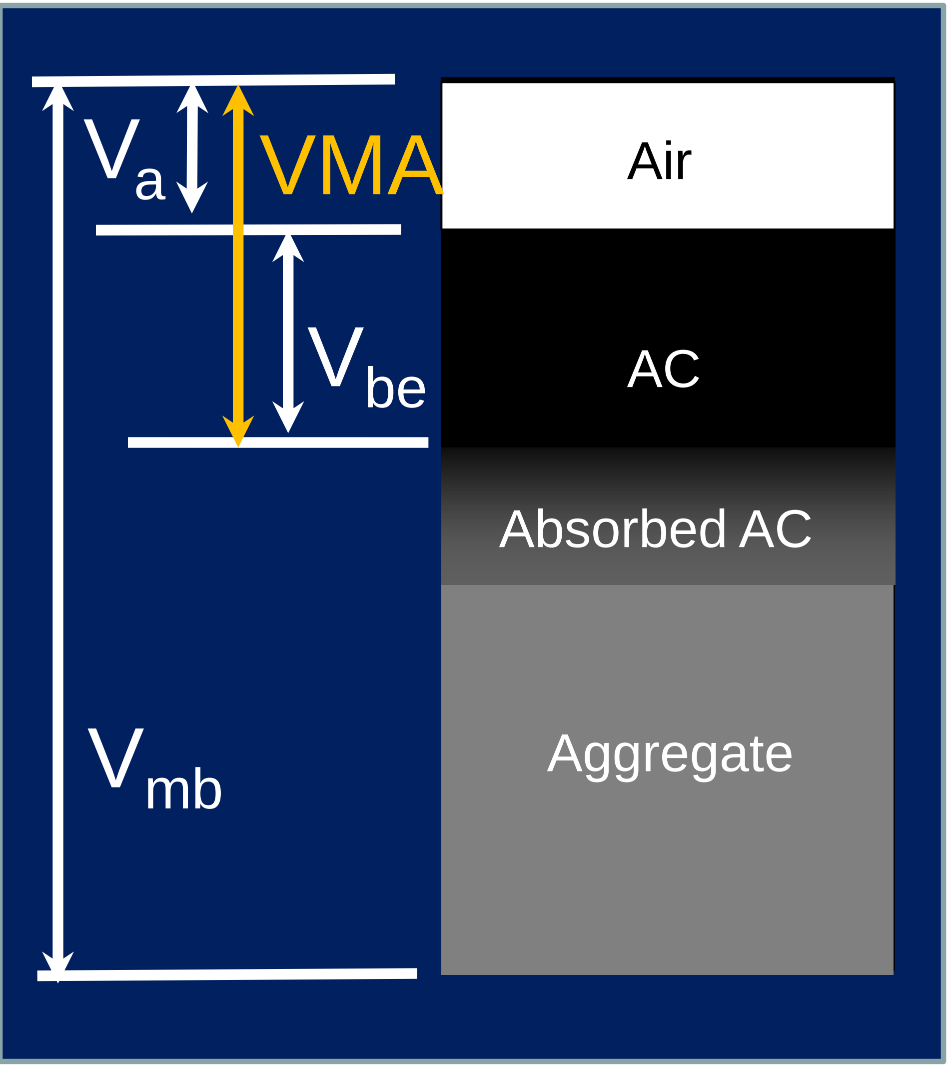
3.5%

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 (AASHTO definition)



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 (TxDOT definition)

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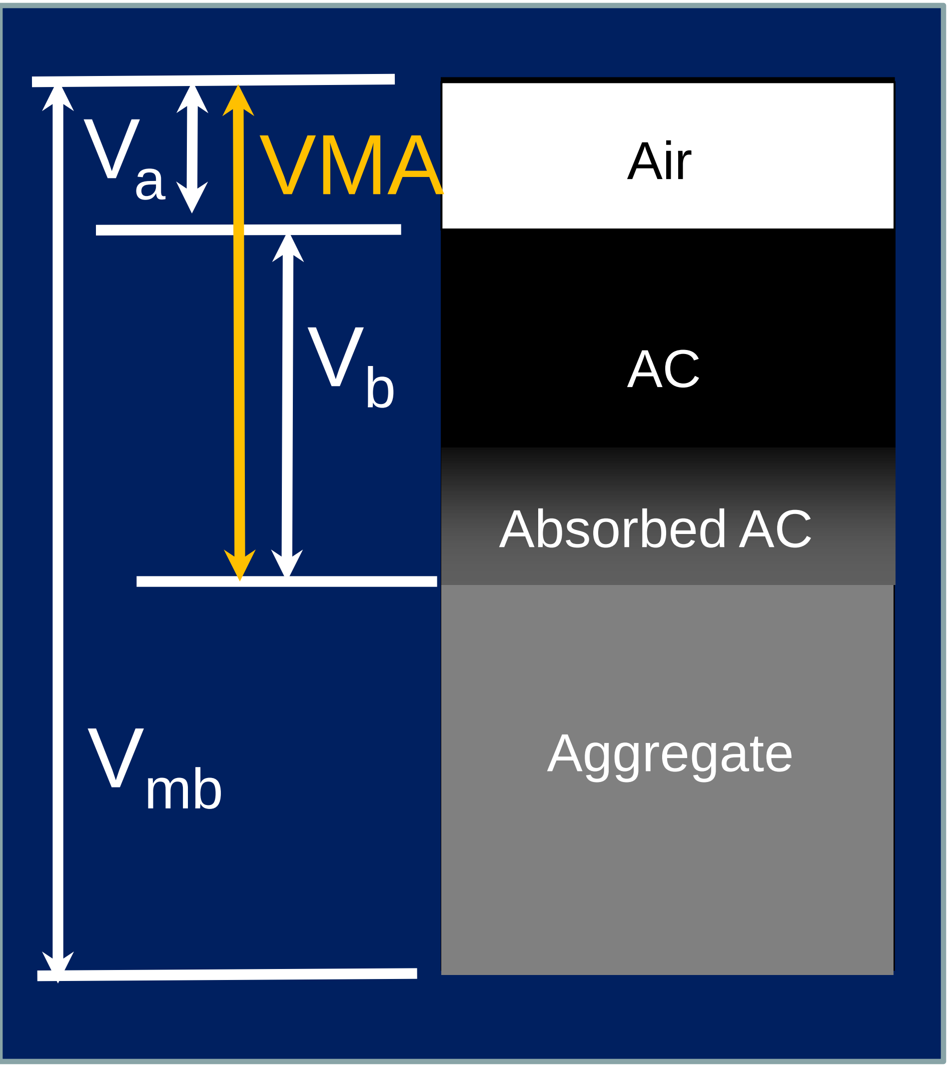

TxDOT includes the volume of the absorbed binder in the calculation of VMA.

Therefore, more absorptive aggregates inherently produce higher VMA and vice versa.

**TxDOT VMA minimums are 1% higher than AASHTO, which mitigates the issue to some degree.*

VMA

Texas Department of Transportation

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

Design VMA Requirements (341 Table 8)

Mix Type	A	B	C	D	F
Minimum VMA	12.0	13.0	14.0	15.0	16.0

VMA

Question:

Why can't you add the percent binder (A_s) to the percent air voids (100-% Density) to get the VMA?

Answer:

Because A_s is a percentage by mass and percent air voids is a percentage by volume.

Mix Composition

TxDOT's automated Mix Design Report includes the following worksheets:

- Combined Gradation
- Material Properties
- Aggregate Classification Blending
- Weigh-Up Sheet
- Aggregate Bulk Gravity
- Summary
- Power 0.45 Curve
- Asphalt Content versus Density, VMA, G_a, and G_r

Mix Composition

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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)**

HMA Mix Selection vs. Lift Thickness

- **Optimum lift thickness = 4x Nominal Maximum Aggregate Size (NMAS)**
- **Acceptable lift thickness = 3x to 5x NMAS**
- **Problems Compacting - 2x NMAS or less**
  6x NMAS or more
- **2x guidelines especially critical if surface to be laid upon is uneven.**

QUESTIONS?

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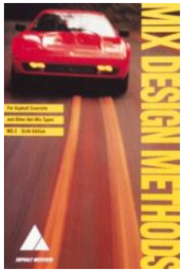
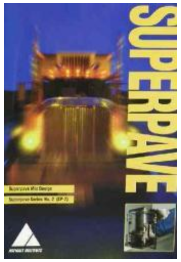
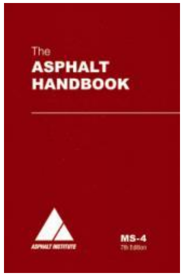
Good Reference Materials on the Topic:

MS-2: Mix Design Methods

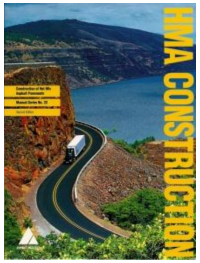




SP-2: Superpave Mix Design



MS-4: The Asphalt Handbook



MS-22: HMA Construction

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