ASPHALT

THE SMOOTH QUIET RIDE

ASPHALT 100% RECYCLABLE

2017 Local Roads Workshop

Mix Design Basics

March 2017

Mix Design Basics

ASPHALT
PAVEMENT
ASSOCIATION
OF
MICHIGAN

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Outline

- HMA Volumetric Properties/Terms
- Mix Design

The 3 A's of Hot Mix Asphalt

Asphalt (binder), Aggregates,

and Air

HMA = Asphalt + Aggregates + Air

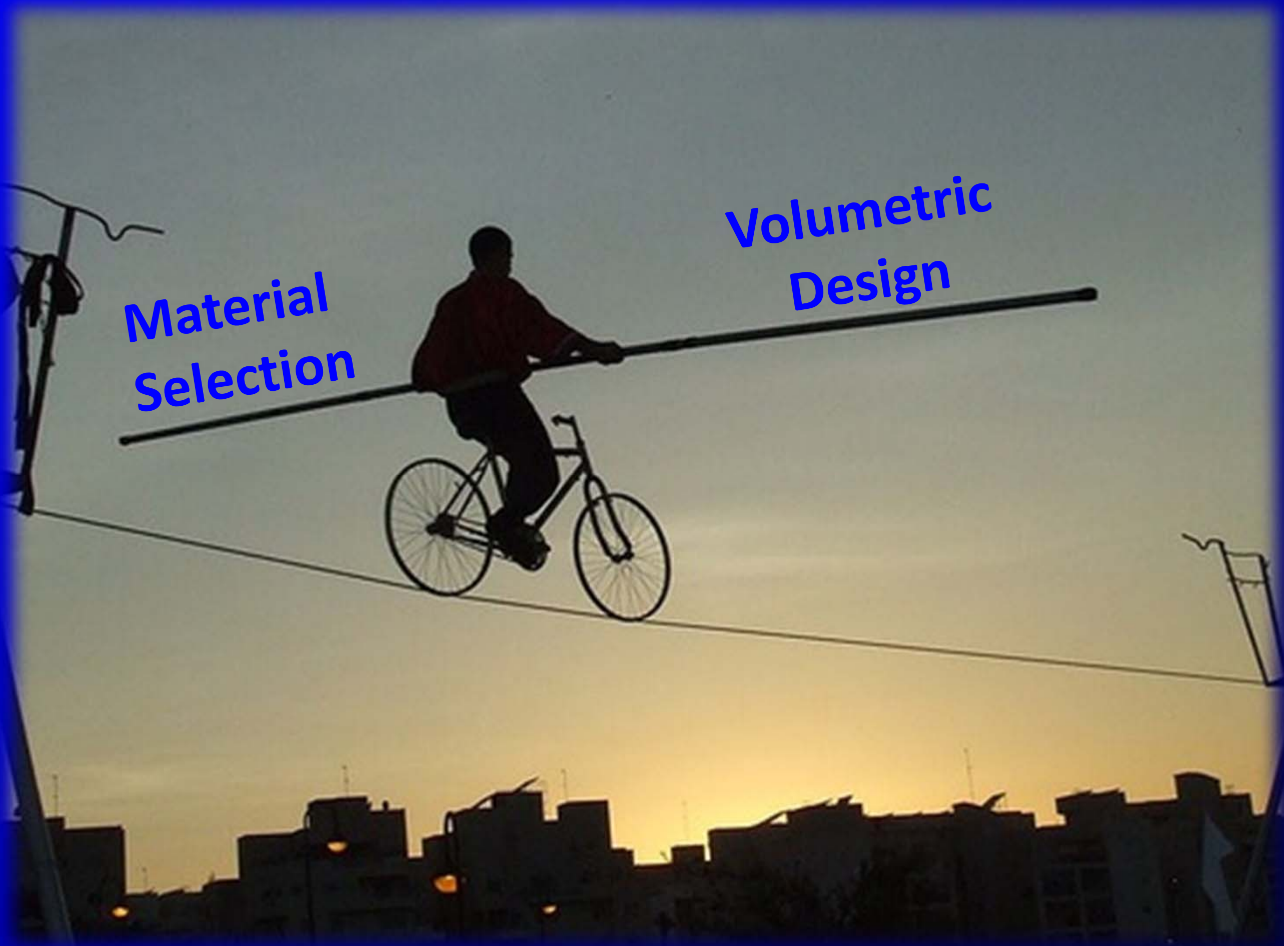
Mix Design Goals
Balancing Act

Smooth Quite Ride

Strength & Stability

No
- **Rutting**
- **Shoving**
- **Flushing**

Workability



Durable

No
- **Cracking**
- **Raveling**

Skid Resistance

Important HMA Mix Properties

We want

- Stability
- Durability
  - – Fatigue resistance
  - – Low temperature crack resistance
- Impermeability
- Workability
- Skid Resistance

How?

Materials Selection

Volumetric design

Volumetric Analysis
Definition

The measurement or calculation of the relative masses and volumes occupied by the aggregate, asphalt binder, and air voids in a <u>compacted</u> asphalt mixture

Mass vs. Weight

The difference between mass and weight is that mass is the amount of matter in a material and weight is a measure of how the force of gravity acts upon that mass.

Mass is the measure of the amount of matter in a body. Mass is denoted using m or M.

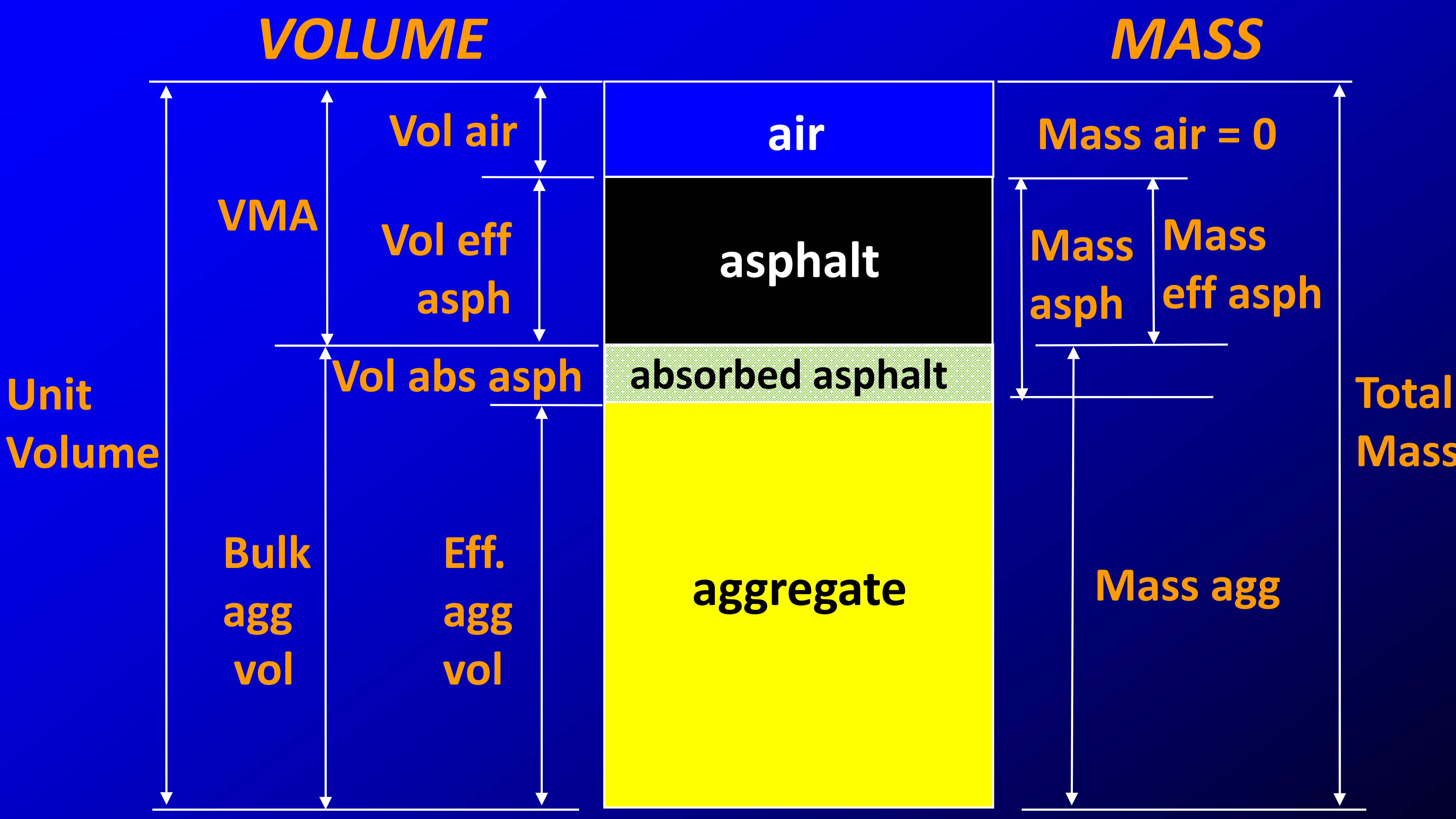
Weight is the measure of the amount of force acting on a mass due to the acceleration due to gravity. Weight is usually denoted as W. Weight is mass multiplied by the acceleration of gravity.

$$W = m * g$$

Volumetric Analysis

- All matter has mass and occupies space
- Volumetric analysis is a way of evaluating the relationships between mass and volume
- Volumetric characteristics assure that there is adequate space within the aggregate structure to accommodate the optimum amount of air and asphalt
- Detailed description
  - MS-2, Chapter 4
  - SP-2, Chapter 4

Component Diagram

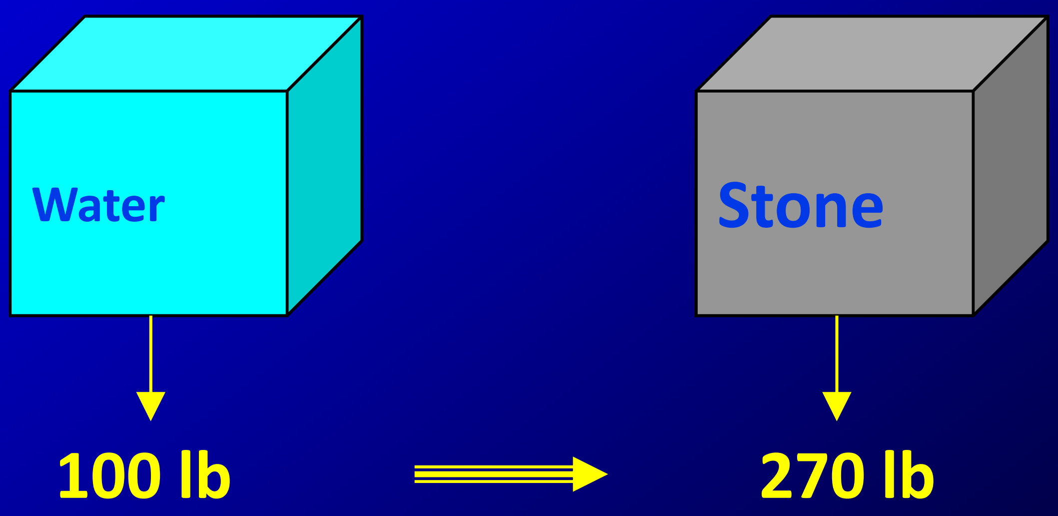


SP-2, Fig. 4.2

Specific Gravity

- **Ratio of a material's weight to the weight of an equal volume of water**
  - **Dimensionless number (no units attached)**

Specific Gravity = 2.70 means that the rock weighs 2.70 times an equal volume of water



HMA Volumetric Terms

- Bulk specific gravity of compacted HMA - Gmb
- Maximum specific gravity - Gmm
- Air voids - Va
- Voids in mineral aggregate, VMA
- Effective specific gravity of aggregate - Gse
- Voids filled with asphalt, VFA

HMA Volumetric Terms

Gmb

Specific Gravity

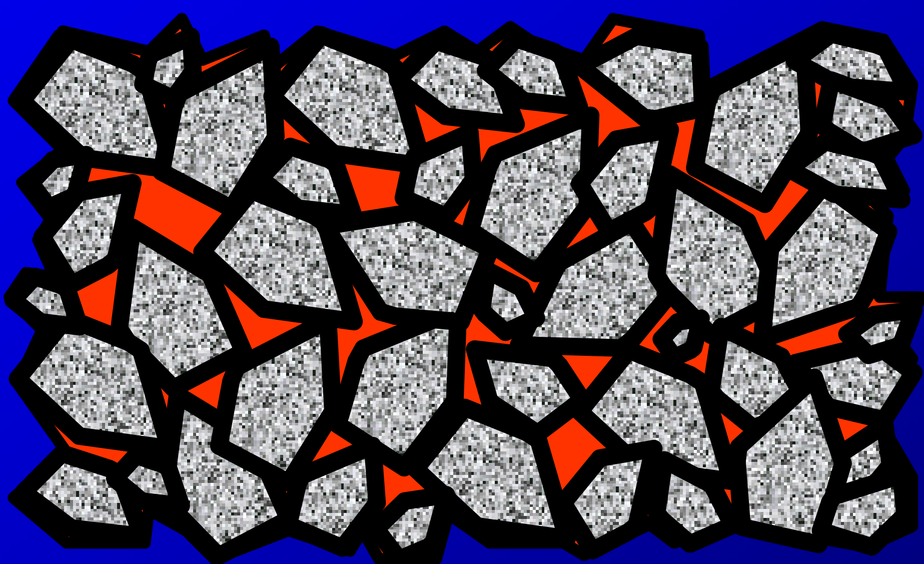
Mixture

Bulk

BSG of Compacted HMA

- Asphalt binder mixed with aggregate and compacted into a sample

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

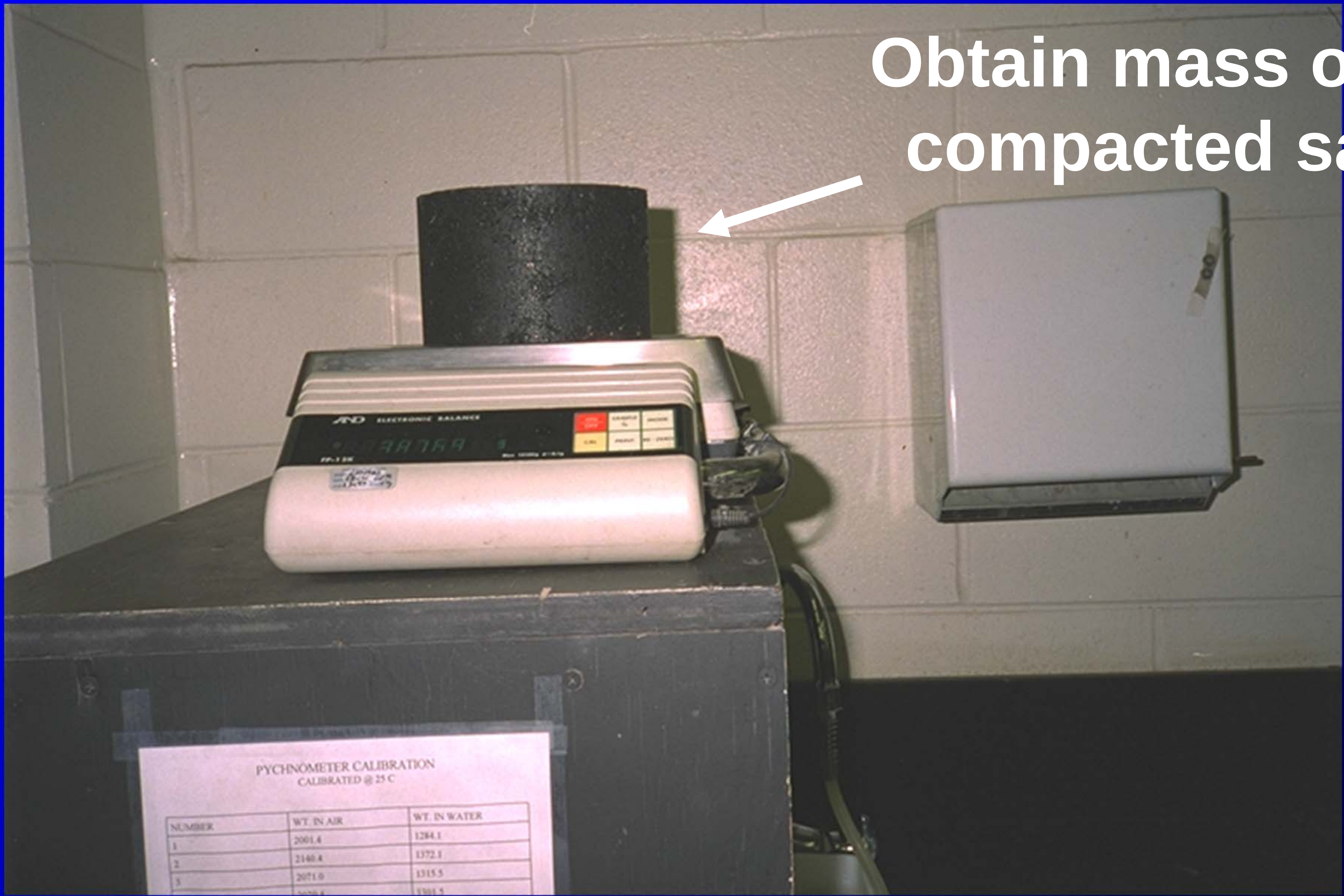


Testing

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

Testing

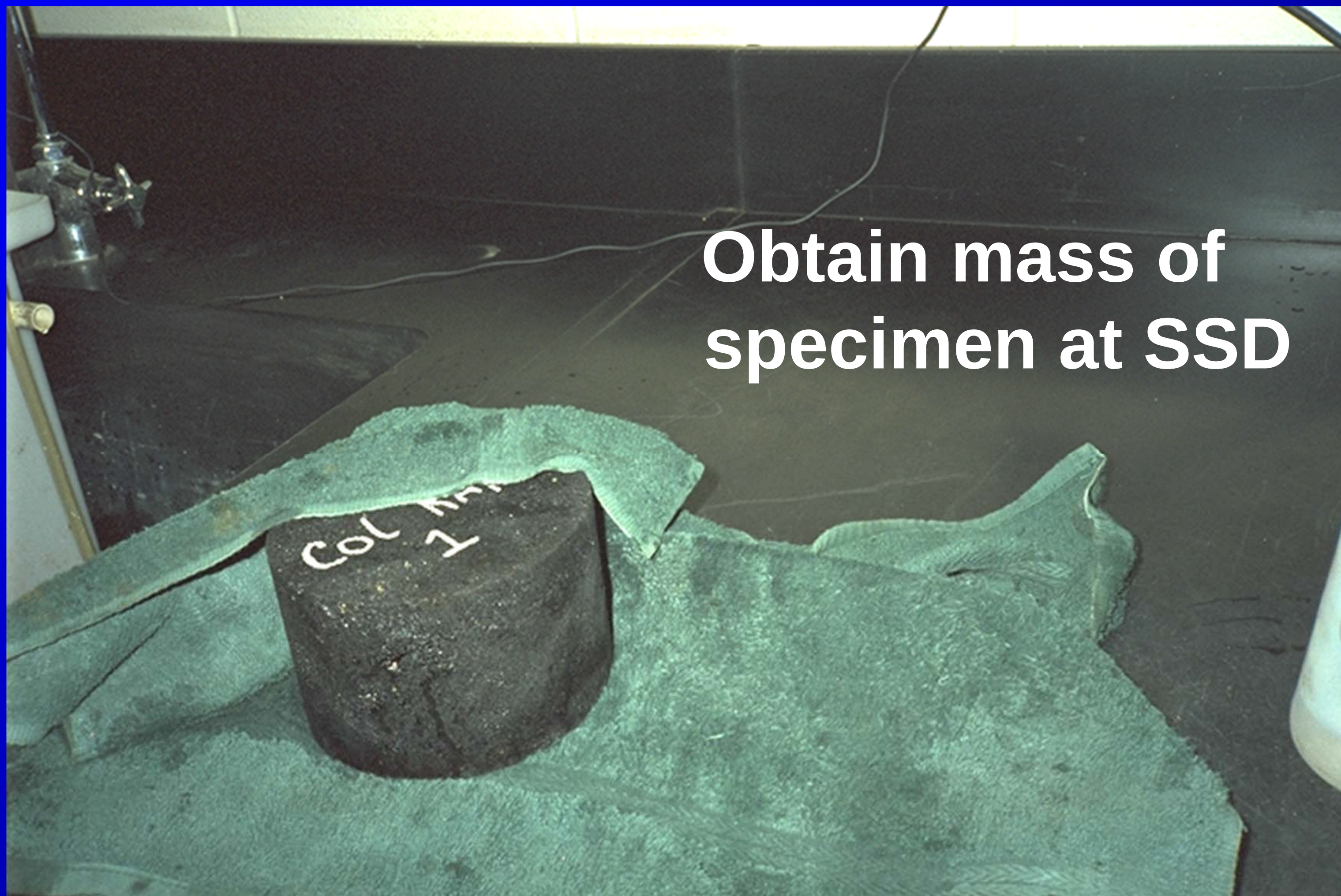
Obtain mass of dry compacted sample



Testing

Obtain mass under water

Testing



Obtain mass of specimen at SSD

Calculations

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

Where:

A = mass of dry sample

B = mass of SSD sample

C = mass of sample under water

Example Calculations

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

  mass of dry sample A = 4819.7

  mass of SSD sample B = 4822.3

  mass of sample under water C = 2816.3

4819.7/(4822.3 – 2816.3) = 2.403

HMA Volumetric Terms

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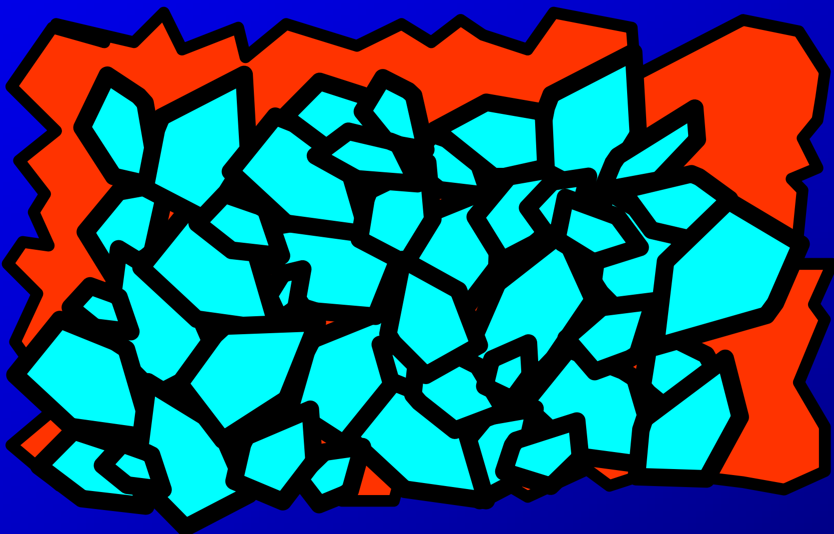
Maximum Specific Gravity - Gmm

Loose (uncompacted) mixture



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

Testing of Specimens

- Maximum Specific Gravity of Mixture
  - “Zero” air voids
  - Tested on Loose Mix
  - Dry Weight in Air
  - Vacuum and vibrating to get all air out
  - Submerged Weight in Water

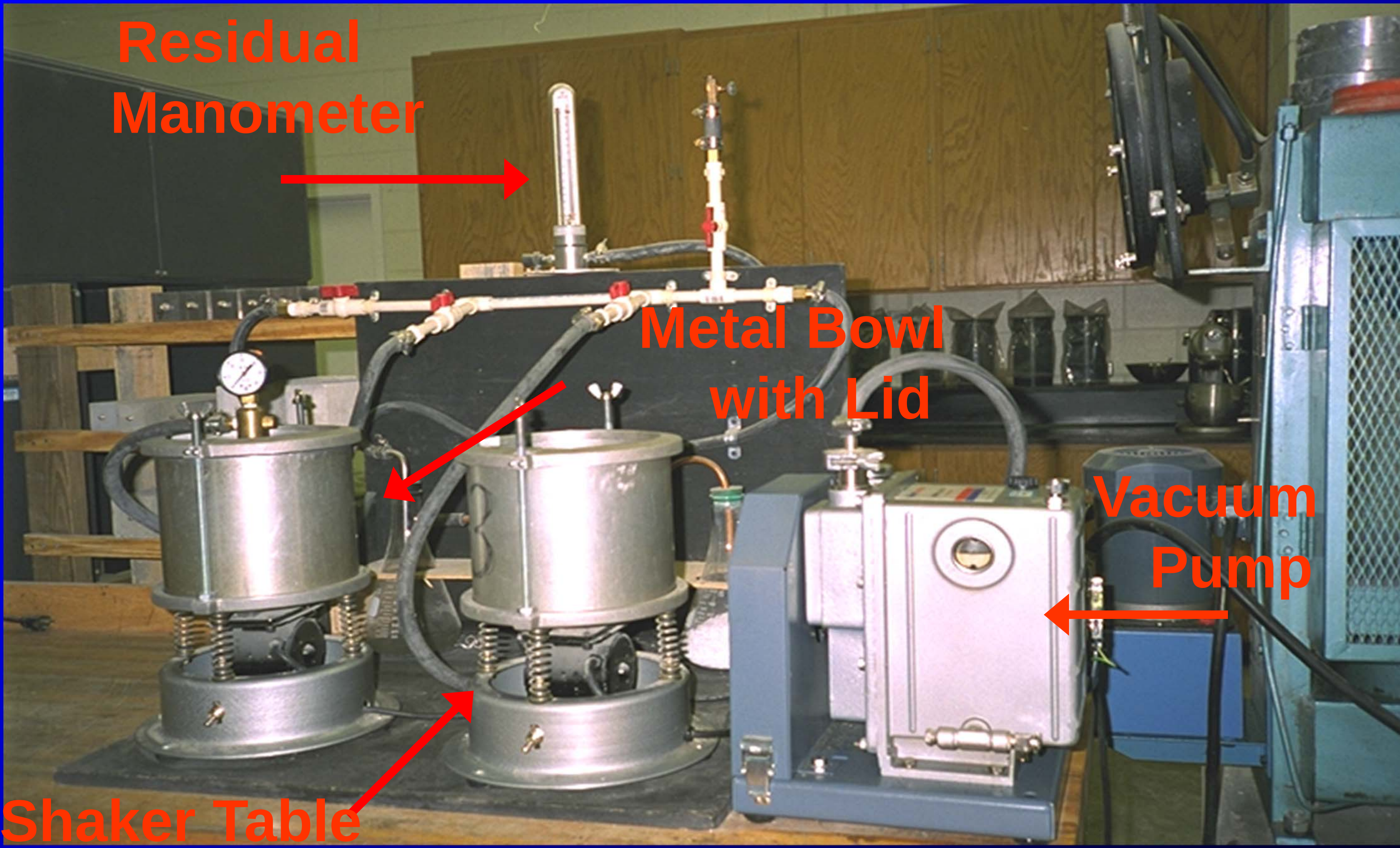
Testing

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

Testing

Loose Mix at Room Temperature

Testing



Residual Manometer
Metal Bowl with Lid
Vacuum Pump
Shaker Table

Calculations

Maximum Specific Gravity

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

Where:

A = mass of dry sample

C = mass of sample under water

Example Calculations

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

  mass of dry sample A = 2050.0

  mass of sample under water C = 1226.4

2050.0/(2050.0 – 1226.4) = 2.489

TMD – Theoretical Maximum Density

What is it?

- Density at 100% compaction
- Rock + Oil….No Air

TMD – Theoretical Maximum Density

TMD = Gmm x unit wt. of water (62.4 lbs/ft^3)

If Gmm = 2.489,

TMD = 2.489 x 62.4 = 155 lbs/ft^3

HMA Volumetric Terms

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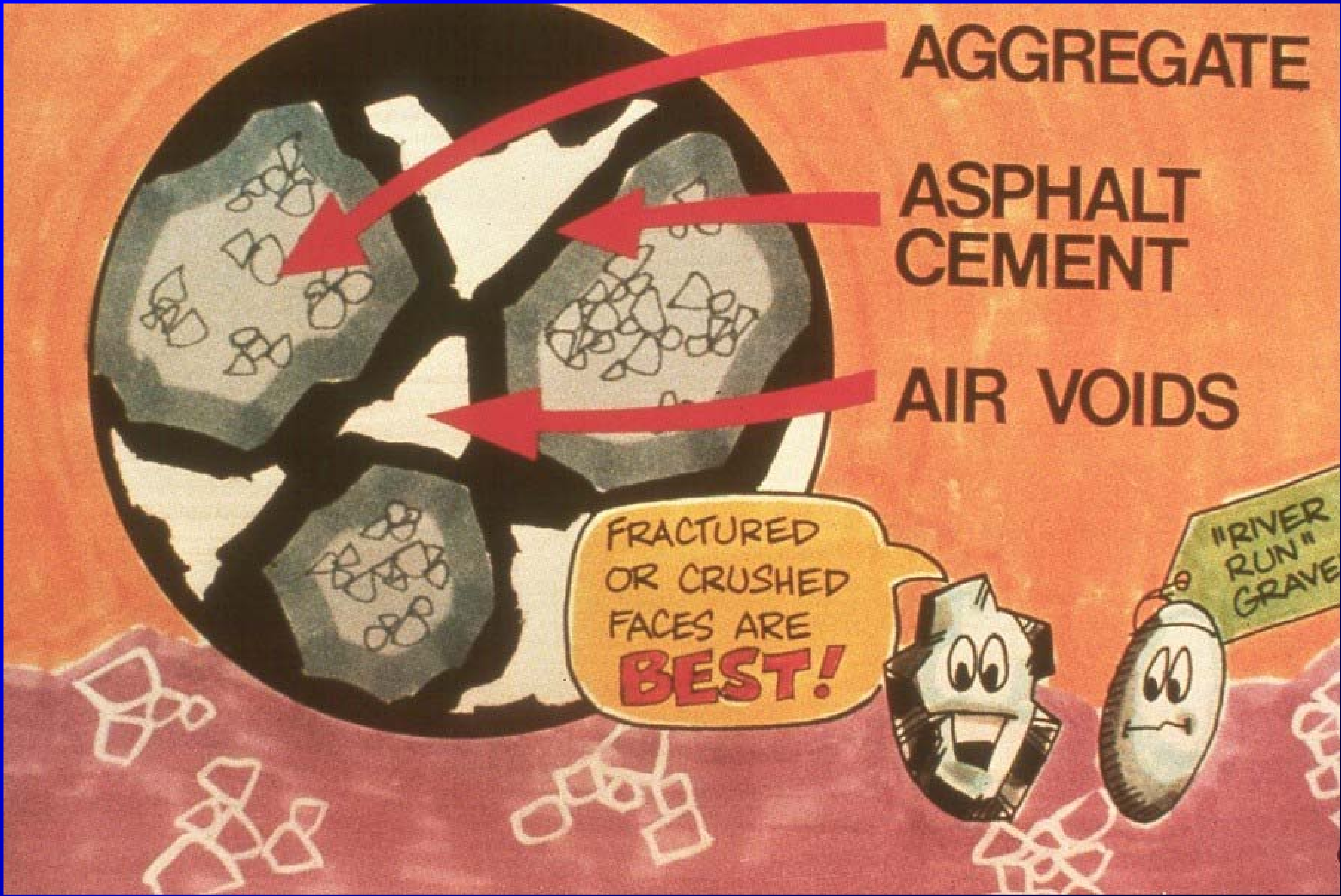
Air Voids



AGGREGATE
ASPHALT CEMENT
AIR VOIDS
FRACTURED OR CRUSHED FACES ARE BEST!
"RIVER RUN" GRAVE

Hot Mix Asphalt Compaction

Field performance has shown design air voids:

- **Below 3% are susceptible to rutting & shoving**
- **Over 5% are susceptible to raveling, oxidation**
- **4% air voids typically allows for optimal design**
  - **Not too open**
  - **Little extra compaction under traffic**

Percent Air Voids

Calculated using both specific gravities

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

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

Example Calculations

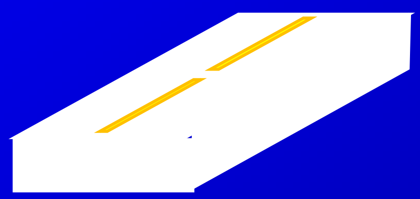
- Air voids:
  - $G_{mb} = 2.403$
  - $G_{mm} = 2.489$

$(1 - 2.403 / 2.489) 100 = 3.5\ \%$

Intent of Laboratory Compaction?

Simulate the in-place density of HMA after it has endured several years of traffic in the roadway

In-place Density



Air Voids

15-25% Before Rolling

6 – 9% After Rolling

Future Traffic

Design Density

Air Voids

3 – 5% Marshall

4% Superpave

Air Voids

- Important for Pavement Performance
  - Stiffness and Strength
    - Rutting
  - Durability
    - Cracking
    - Raveling
  - Fatigue Life
  - Moisture Damage

HMA Volumetric Terms

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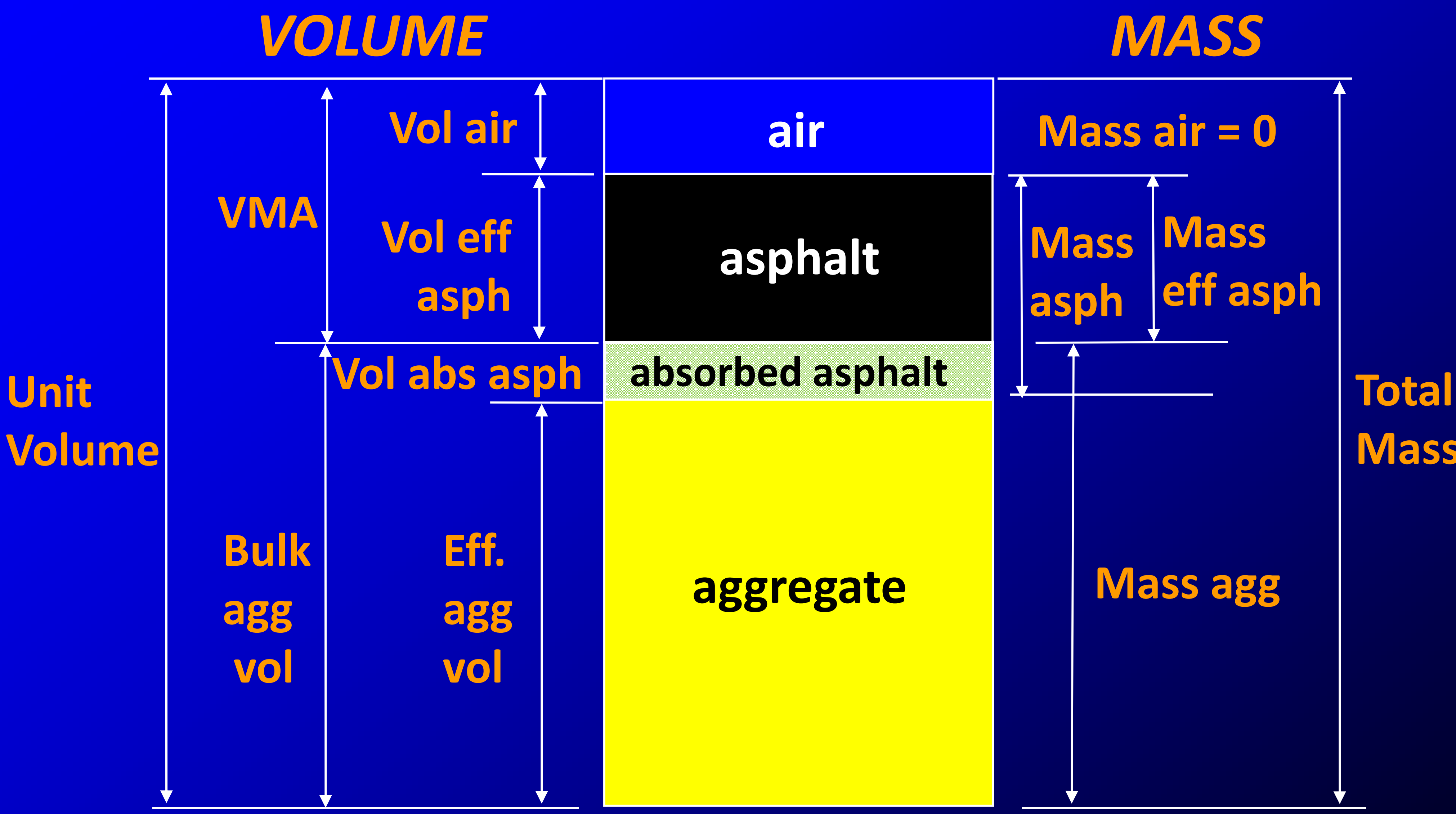
Voids in Mineral Aggregate

VMA is the void space available for effective asphalt and Air. It is also an indication of film thickness on the surface of the aggregate.

VMA is determined by gradation and particle texture.

Component Diagram



SP-2, Fig. 4.2

Voids in Mineral Aggregate

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

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

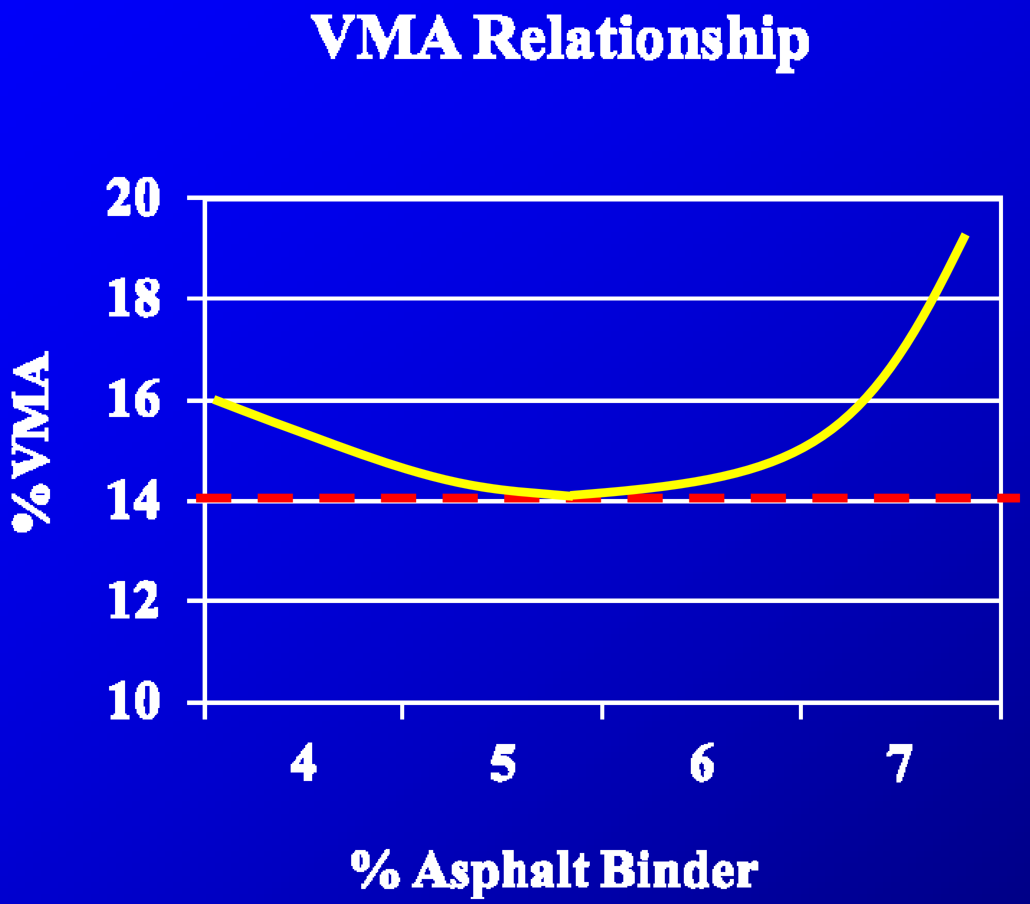
$$VMA = 100 - \frac{(2.455)(95)}{2.703} = 13.7$$

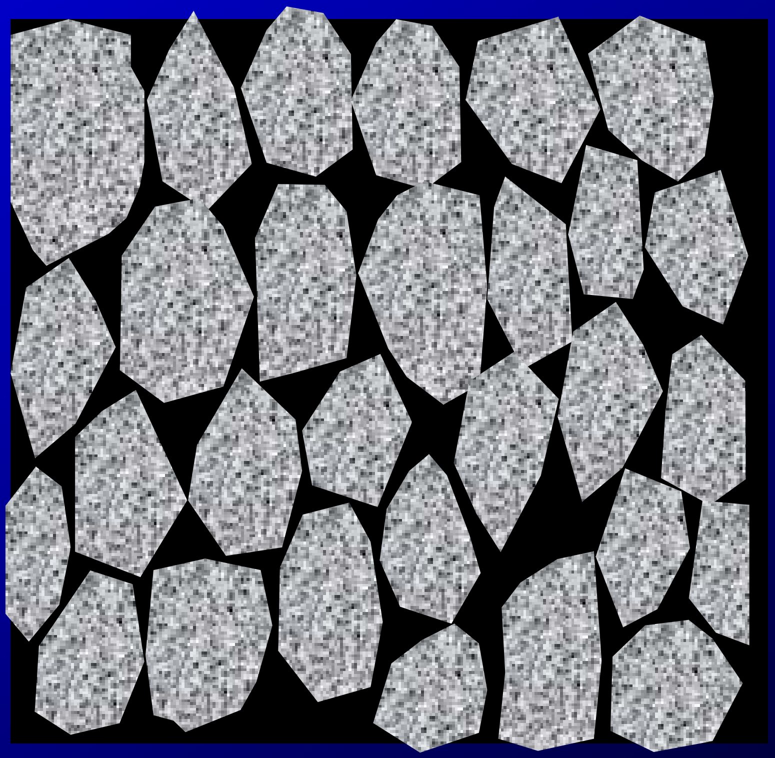
Minimum VMA Requirements

Nominal Maximum Aggregate Size, mm (in)	*Minimum VMA, percent*
9.5 (3/8)	15.0
12.5 (1/2)	14.0
19.0 (3/4)	13.0
25.0 (1.0)	12.0
37.5 (1.5)	11.0

SP-2, Table 5.2

VMA and %AC





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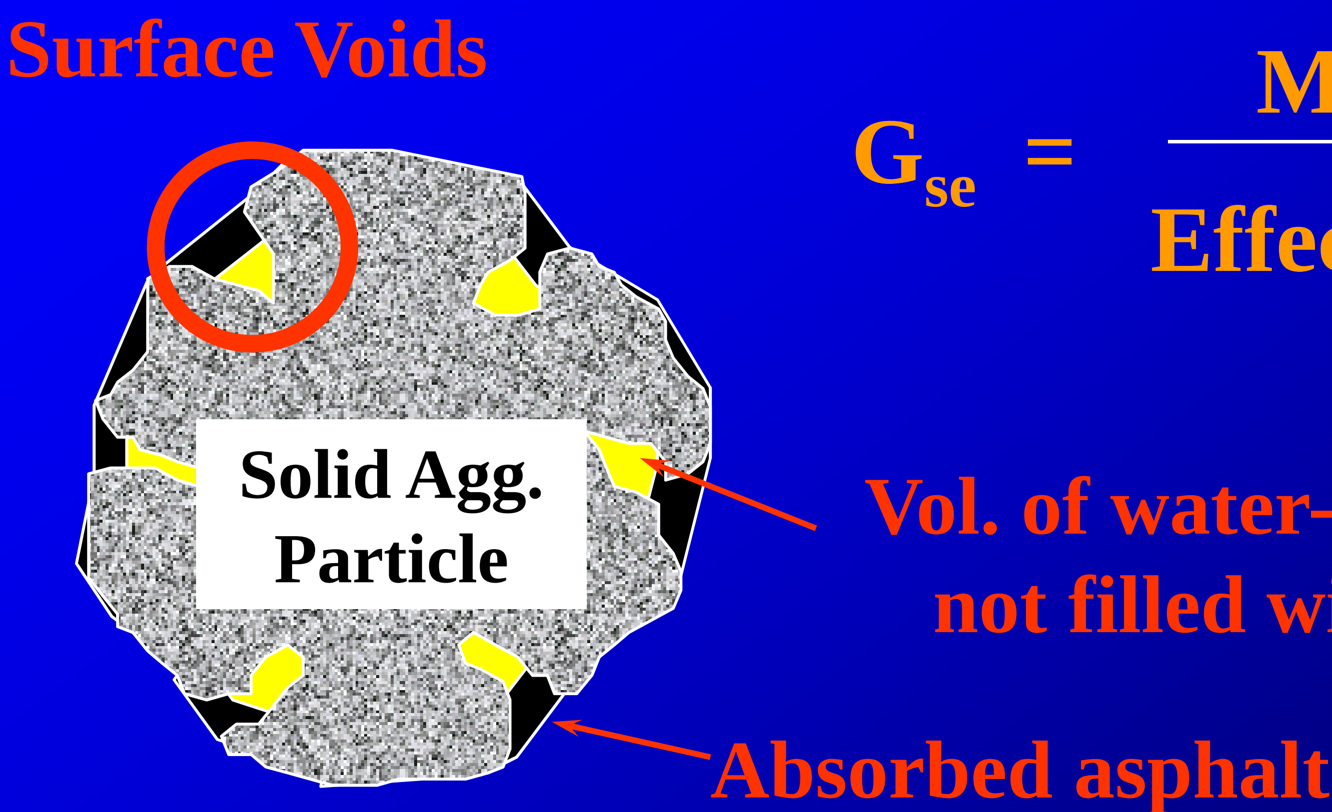
Effective Specific Gravity



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

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

Effective Specific Gravity

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

G_{se} is an aggregate property, and is used to calculate asphalt absorption.

Example Calculations

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

$$G_{se} = \frac{100 - 5}{\dfrac{100}{2.535} - \dfrac{5}{1.03}} = 2.770$$

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).

HMA Volumetric Terms

- Bulk specific gravity of compacted HMA - Gmb
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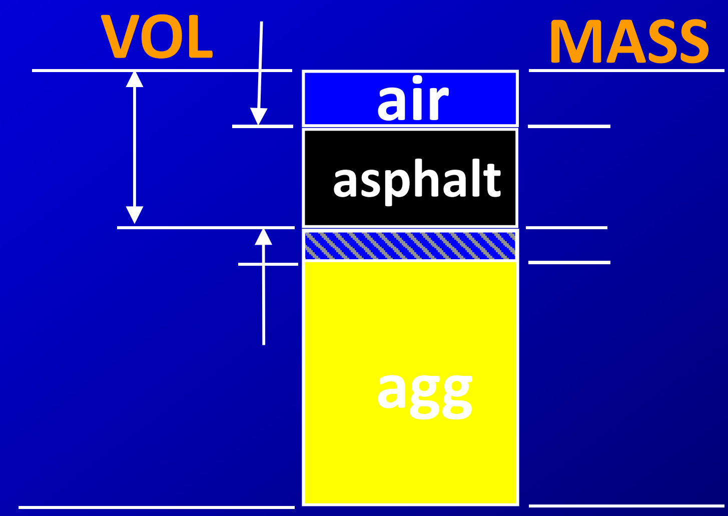
Voids Filled with Asphalt (VFA)



- Definition
  - percentage of VMA filled with asphalt
- Similar to degree of saturation in soils

Voids Filled with Asphalt

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

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

Summary of Terms

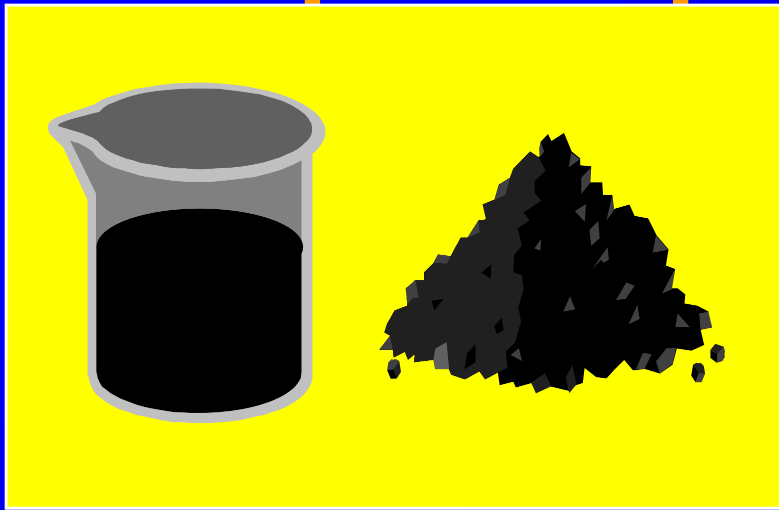
- G_{mb} = Specific gravity of compacted HMA
- G_{mm} = Maximum specific gravity of loose HMA
- V_a = Air voids
- VMA = Voids in mineral aggregates
- G_{se} = Effective specific gravity of aggregate
- VFA = Voids filled with asphalt binder
- G_b = Specific gravity, asphalt binder
- G_{sb} = Bulk specific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

MIXTURE DESIGN

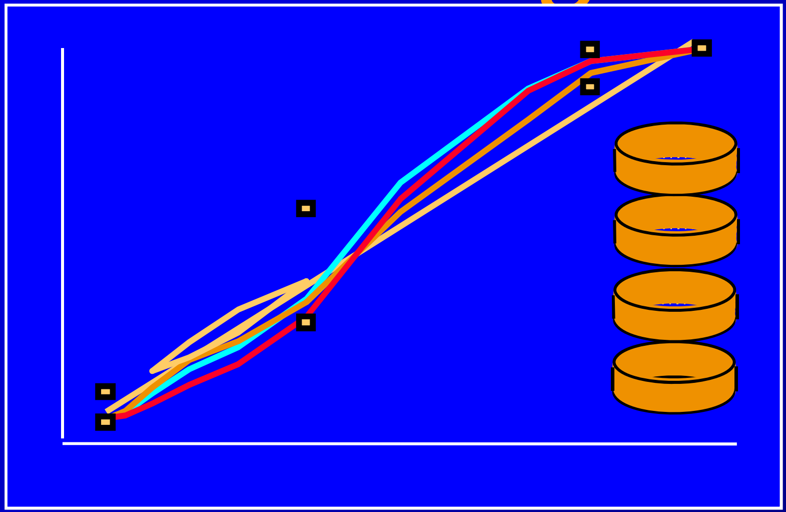
Requirements in Common

- Sufficient asphalt binder to ensure a durable pavement
- Sufficient stability under traffic loads
- Sufficient air voids
  - Upper limit to prevent excessive environmental damage
  - Lower limit to allow room for initial densification due to traffic
- Sufficient workability

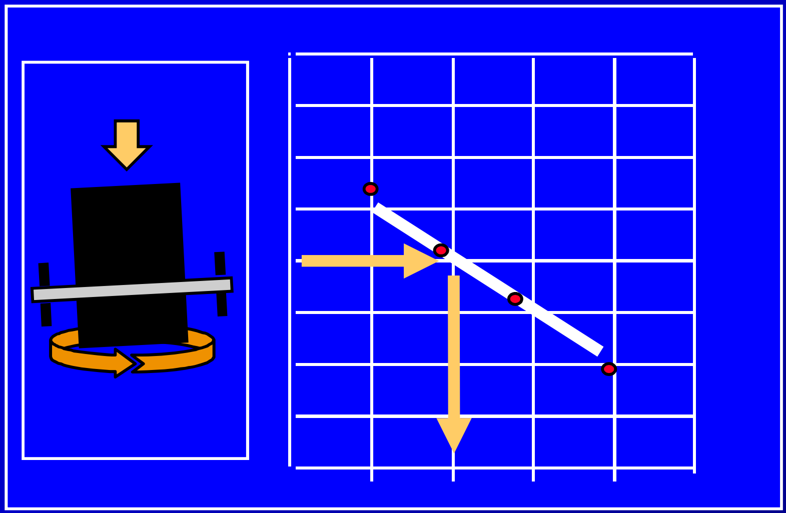
4 Steps of Superpave Mix Design



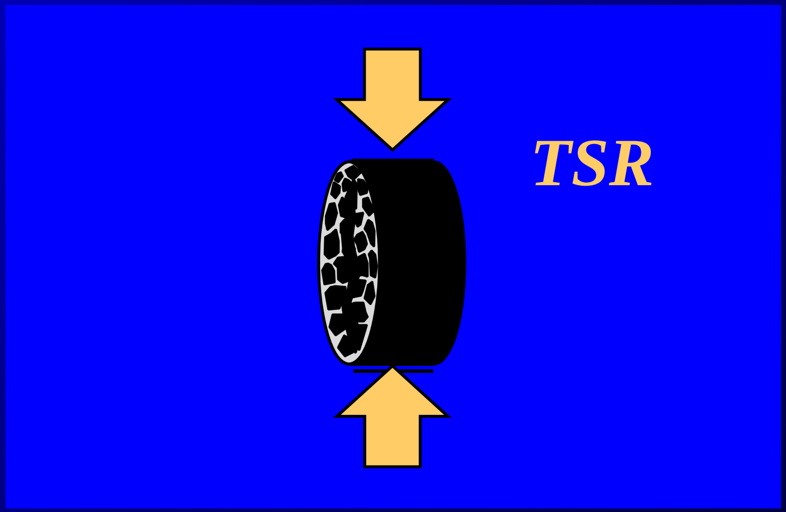
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



4. Moisture Sensitivity

Step 1: Materials Selection

- Materials Selection consists of:
  – Choosing the correct asphalt binder
  – Choosing the aggregates that meet the quality requirements for the mix

Superpave Asphalt Binder Specification

The grading system is based on climate

PG 58 - 28

Performance Grade

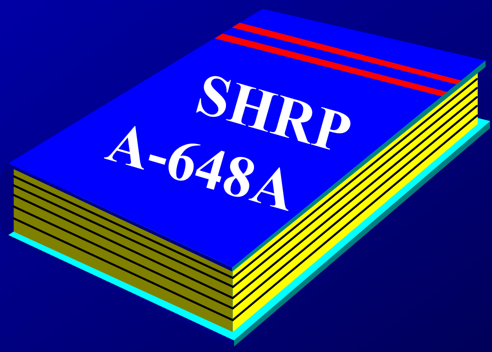
Average 7-day max pavement temperature

Min pavement temperature

Developed from Air Temperatures

- **Superpave Weather Database**
  - **6500 stations in U.S. and Canada http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/ltppbind.cfm**
- **Annual air temperatures**
  - **hottest seven-day temp (avg and std dev)**
  - **coldest temp (avg and std dev)**
- **Calculated pavement temps used in PG selection**

> 20 years



LTPP Bind Software

Binder Grade vs. Pavement Performance

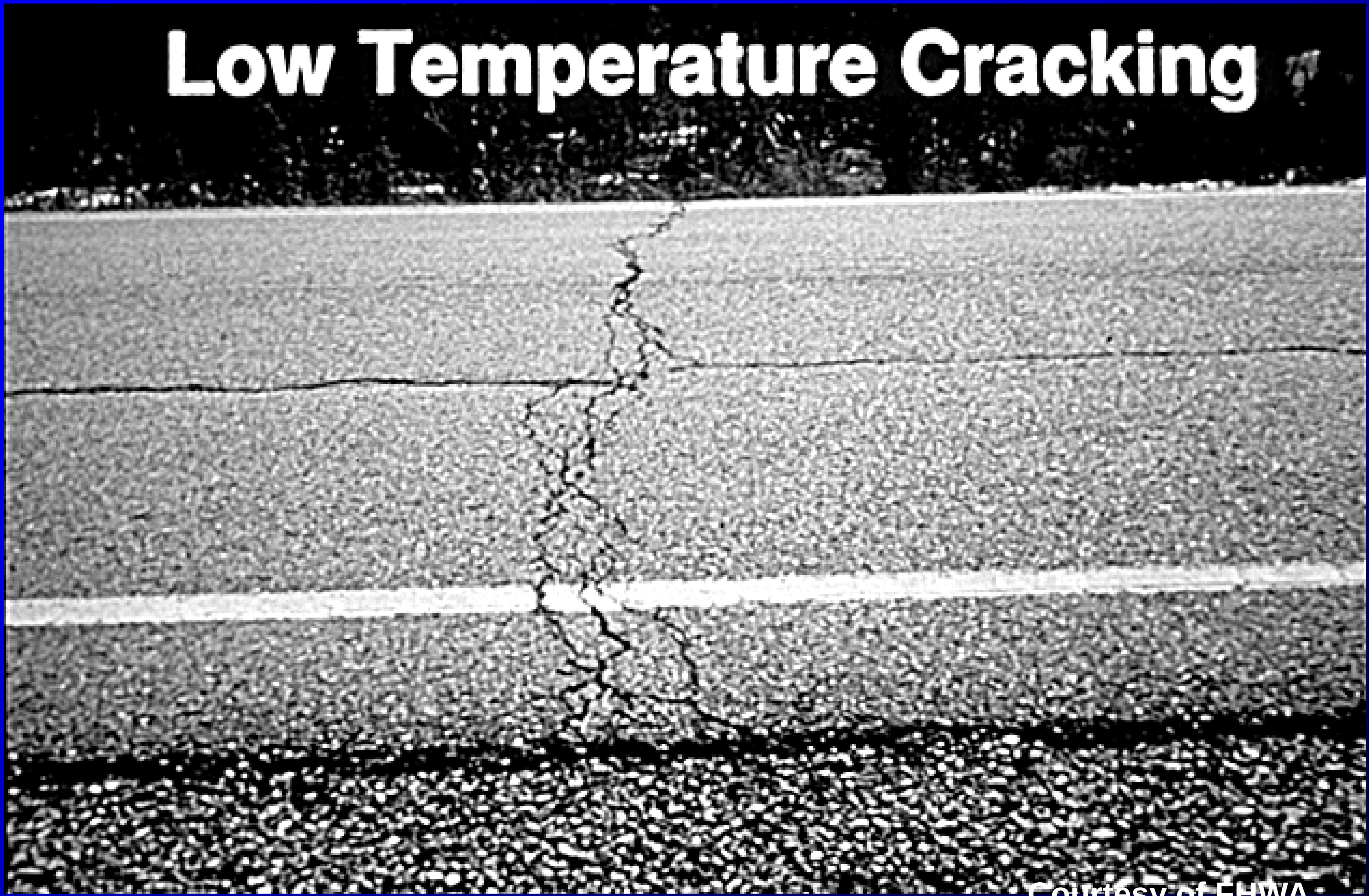
Other Performance Factors:

- Rutting - shear strength of mix, aggregate properties
- Fatigue Cracking - pavement structure, traffic

Important Factor:

- Low temperature Cracking – correlates well to binder properties

Thermal Cracking



Courtesy of FHWA

Local Agency Programs
Hot Mix Asphalt (HMA) Selection Guidelines
Rev: 06/14/2016 - FHWA Approval: 08/29/2016

The following guidelines have been developed at the request of Local Agency Engineers for use on Local Agency projects. These guidelines have been reviewed and approved by the County Road Association of Michigan Engineering Committee. Previous experience and performance shall permit variations from these guidelines as per Section D. Alternative Mixes.

A. HMA Mixture Type and Binder Selection

Selection is based on present day two-way commercial ADT. The commercial ADT ranges for each of the mixture types have taken into account an assumed future traffic growth rate.

Com. ADT.	Com. ADT 0-300	Com. ADT 301-700	Com. ADT 701-1000	Com. ADT 1001-3400	Com. ADT 3401- 9999
Mixture Type					
Top	LVSP or 13A, 36A	4C 5E1/4E1	5E3, or 4E3	5E10, or 4E10	5E30, or 5E10
Leveling	LVSP or 13A	3C 4E1	4E3	4E10	4E30
Base	13A / 3C	2C / 3C	3E3	3E10	3E30
Binder Grades by Region					
Superior	PG 58-34	PG 58-34	PG 58-34	PG 58-34	
Metro	PG 58-22	PG 64-22	PG 64-22	PG 64-22	PG 70-22P
All Other	PG 58-28	PG64-28	PG-64-28	PG64-28	PG70-28P

Note 1: If the designer wishes to reduce the target air voids on projects to 3.5%, a note needs to be added to the plans on the HMA Application Table stating that the air voids have been changed to 3.5% for that particular project for top and leveling courses. For mixtures meeting the definition of base course, field regress air void content to 3.0 percent with liquid asphalt cement unless specified otherwise on HMA application estimate.

Note 2: The mixture type in each traffic category listed in the above table is specifically designed to perform under their respective Commercial ADT. Selecting a mixture type that is specifically designed for a higher Commercial ADT than the project being designed may adversely affect performance.

Local Agency Guide

Local Agency Programs
HMA Selection Guidelines

- Developed for use on Local Agency Projects
- Reviewed and Approved by CRA
- Variations Allowed

Local Agency Programs
HMA Selection Guidelines

- SuperPave and Marshall mix designs
- SuperPave for Commercial ADT > 700
- Variations Allowed

Local Agency Programs
HMA Selection Guidelines

Commercial ADT	0 – 300	301 – 700	701 – 1000	1001 – 3400	3401 – 9999
Binder Grades by Region					
Superior	PG 58-34	PG 58-34	PG 58-34	PG 58-34	
Metro	PG 58-22	PG 64-22	PG 64-22	PG 64-22	PG 70-22P
All Other	PG 58-28	PG 64-28	PG 64-28	PG 64-28	PG 70-28P

For Surface and Leveling Courses

Aggregate Consensus Properties

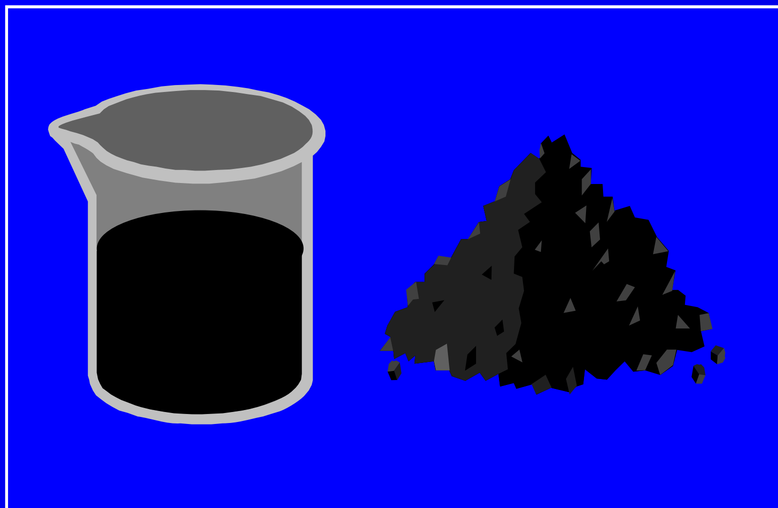
Table 902-6
Superpave Final Aggregate Blend Physical Requirements

Est. Traffic (million ESAL)	Mix Type	Percent Crushed Minimum Criteria		Fine Aggregate Angularity Minimum Criteria		% Sand Equivalent Minimum Criteria		Los Angeles Abrasion % Loss Maximum Criteria		% Soft Particles Maximum Criteria (a)		% Flat and Elongated Particles Maximum Criteria (b)	
		Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course
< 0.3	LVSP	55/—	—	—	—	40	40	45	45	10	10	—	—
< 0.3	E03	55/—	—	—	—	40	40	45	45	10	10	—	—
≥0.3 -<1.0	E1	65/—	—	40	—	40	40	40	45	10	10	—	—
≥1.0 - < 3	E3	75/—	50/—	43	40	40	40	35	40	5	5	10	10
≥3 - <10	E10	85/80	60/—	45	40	45	45	35	40	5	5	10	10
≥10 - <30	E30	95/90	80/75	45	40	45	45	35	35	3	4.5	10	10
≥30 - <100	E50	100/100	95/90	45	45	50	50	35	35	3	4.5	10	10

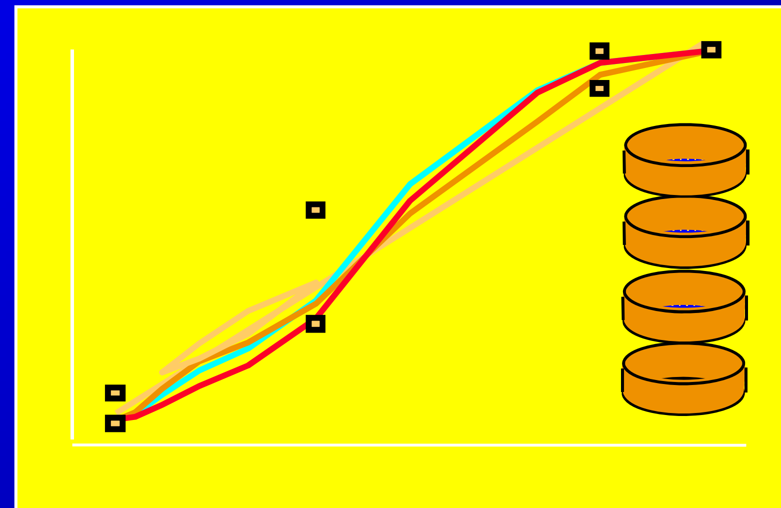
(a) Soft particles maximum is the sum of the shale, siltstone, ochre, coal, clay-ironstone and particles that are structurally weak or are non-durable in service.
(b) Maximum by weight with a 1 to 5 aspect ratio.

Note: "85/80" denotes that 85 percent of the coarse aggregate has one fractured face and 80 percent has at least two fractured faces.

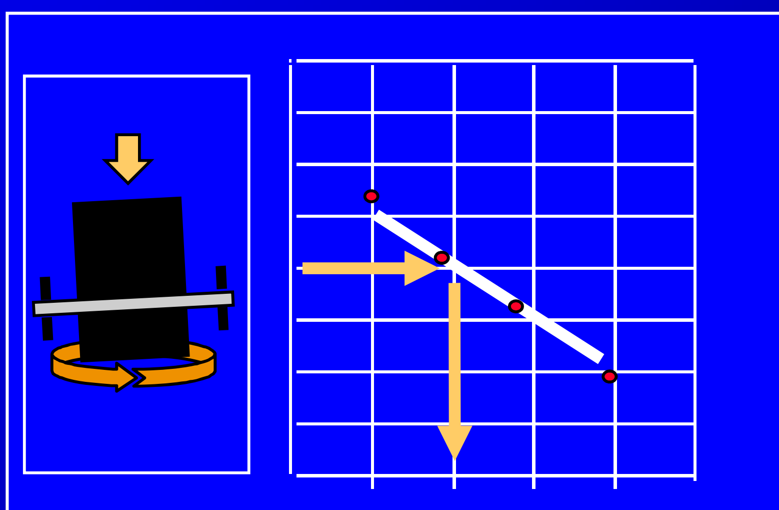
Steps of Superpave HMA Mix Design



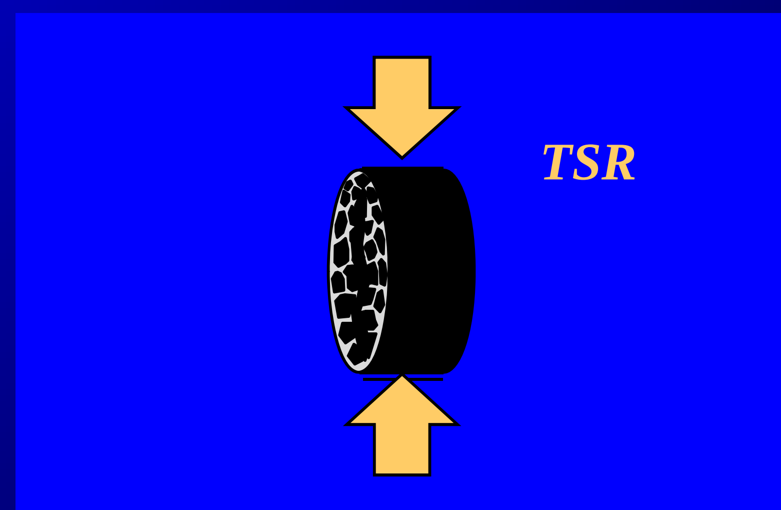
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



4. Moisture Sensitivity

Step 2: Aggregate Gradation

- Establish trial aggregate blends
  - 3 suggested
  - evaluate combined aggregate properties
- Estimate optimum asphalt binder content
- Manufacture and compact trial blends
- Evaluate the trial blends
- Select the most promising blend

Aggregate Gradation

Table 902-5
Superpave Final Aggregate Blend Gradation Requirements

Standard Sieve	Percent Passing Criteria (control points)					
	Mixture Number					
	5	4	3 Leveling Course	3 Base Course	2	LVSP (a)
1½ inch	—	—	—	—	100	—
1 inch	—	—	100	100	90–100	—
3/4 inch	—	100	90–100	90–100	≤90	100
1/2 inch	100	90–100	≤90	≤90	—	75–95
3/8 inch	90–100	≤90	—	—	—	60–90
No. 4	≤90	—	—	—	—	45–80
No. 8	47-67	39-58	35–49	23–49	19–45	30–65
No. 16	—	—	—	—	—	20–50
No. 30	—	—	—	—	—	15–40
No. 50	—	—	—	—	—	10–25
No. 100	—	—	—	—	—	5–15
No. 200	2.0–10.0	2.0–10.0	2.0–8.0	2.0–8.0	1.0–7.0	3–6

a. For LVSP, less than 50 percent of the material passing the No. 4 sieve may pass the No. 30 sieve.

Establish Trial Blends

- Develop three gradations based on
  - Stockpile gradation information
  - Gradation specification
- Optimize use of materials in the most economical blends
- Estimate properties of combined stockpiles

Establish trial asphalt binder content

- Superpave Method
- Engineering judgement method

Trial Asphalt Binder Content

- Use known or estimated values for
  - Effective aggregate specific gravity, G_{se}
  - Asphalt binder absorbed, V_{ba}
- Calculate the effective binder content, V_{be}

Trial Asphalt Binder Content

- Calculate the initial asphalt binder content:

$$P_{bi} = \frac{100\ G_b\ (V_{be} + V_{ba})}{(G_b\ (V_{be} + V_{ba})) + W_s}$$

- Where:

$$W_s = \frac{P_s\ (1 - V_a)}{(P_b\ /\ G_b) + (P_s\ G_s)}$$

Next steps

- Sample preparation
  - Select mixing and compaction temperatures
  - Preheat aggregates and asphalt
  - Mix components
  - Compact specimens
- Extrude and determine volumetrics

General Guidance

- Compact the trial mixtures in accordance with AASHTO T 312 which now requires specimens be compacted to the design number of gyrations (N_d)
- When doing a mix design you compact a pair of samples to $N_{maximum}$ and check them to see if the $N_{maximum}$ value of 98% is exceeded.

Superpave Compaction criteria

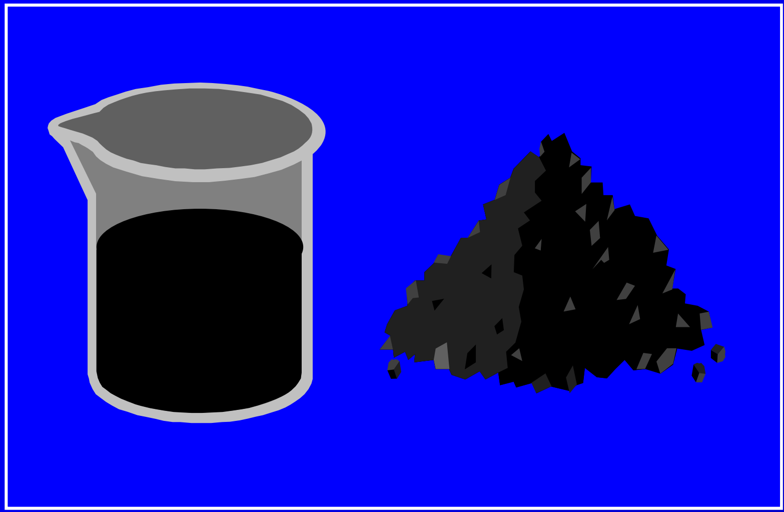
Table 501-3 Superpave Gyratory Compactor (SGC) Compaction Criteria					
Estimated Traffic (million ESAL)	**Mix Type**	**%G_{mm} at (N_i)**	**Number of Gyrations** (a)		
			N_i	**N_d**	**N_m**
≤0.3	LVSP	91.5%	6	45	70
≤0.3	E03	91.5%	7	50	75
>0.3 – ≤1.0	E1	90.5%	7	76	117
>1.0 – ≤3.0	E3	90.5%	7	86	134
>3.0 – ≤10	E10	89.0%	8	96	152
>10 – ≤30	E30	89.0%	8	109	174
>30 – ≤100	E50	89.0%	9	126	204

a. Compact mix specimens fabricated in the SGC to N_d. Use height data provided by the SGC to calculate volumetric properties at N_i.. Compact mix specimens at optimum P_b to verify N_m for mix design specimens only.

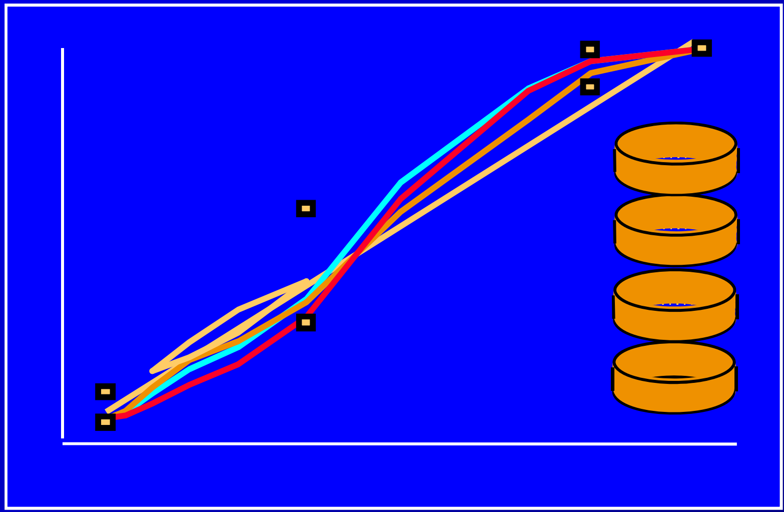
Estimate Aggregate Blend Properties (Example)

Property	Criteria	Trial Blend 1	2	3
$N_{initial}$, %	< 89.0	87.1	85.6	86.3
N_{design}, %	96.0	97.6	97.4	96.5
N_{max}, %	< 98.0	96.2	95.7	95.2
Air Voids, %	4	4.4	4.4	4.4
VMA, %	13	12.7	13.0	13.5

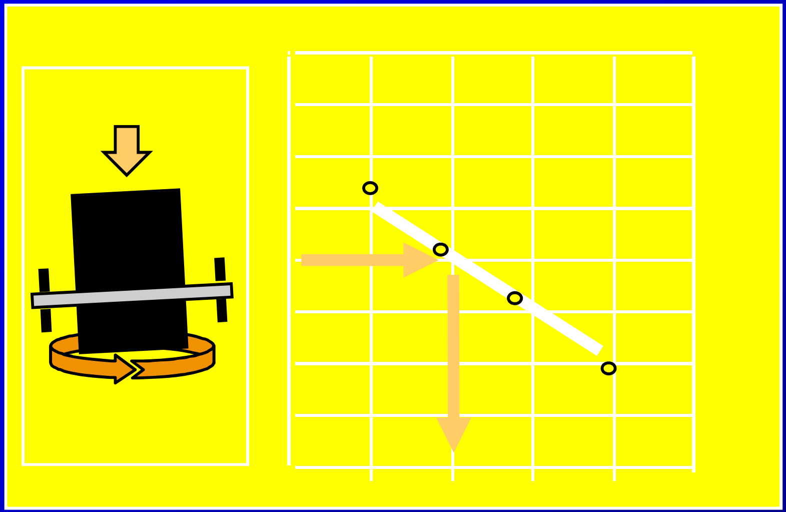
4 Steps of Superpave Mix Design



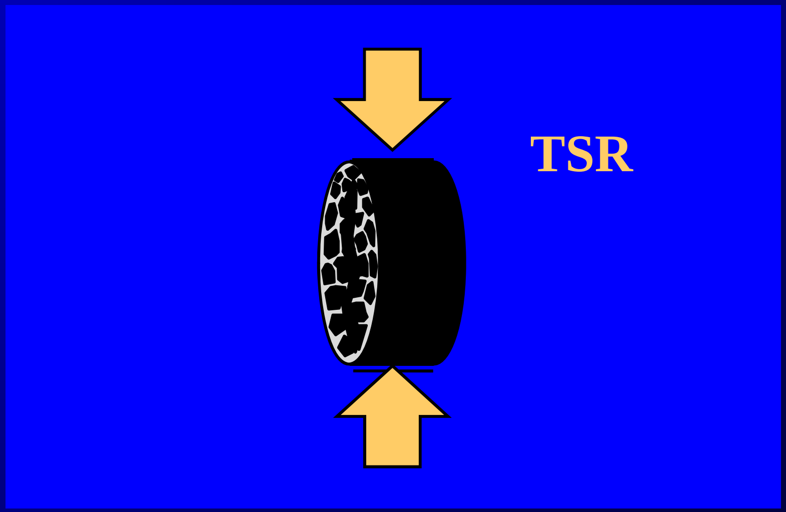
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



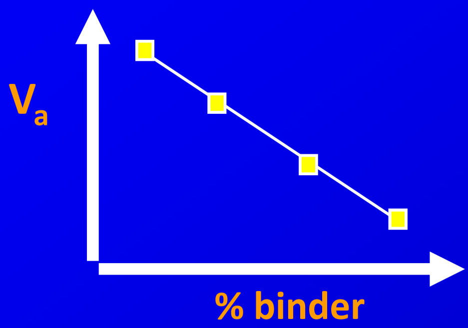
4. Moisture Sensitivity

Design Binder Content

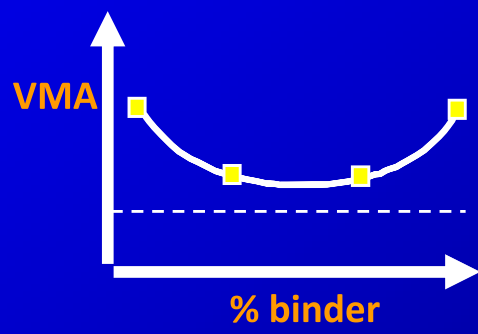
1) Choose the “Best” Trial Blend
2) Mix Aggregates and Binder at 4 different Asphalt Contents
   - 0.5% Increments
3) Compact Specimens
4) Extrude and Determine Volumetric Properties

Design Binder Content

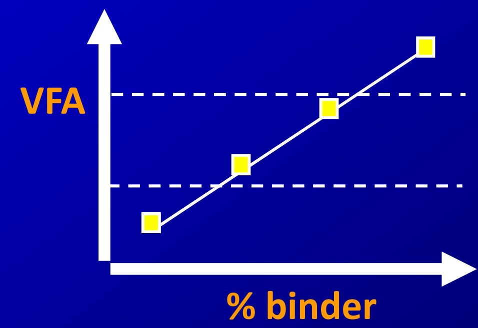
Air Voids



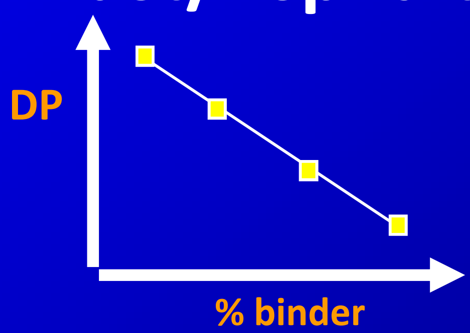
VMA



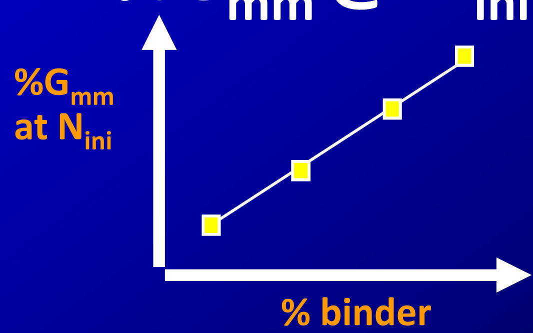
VFA



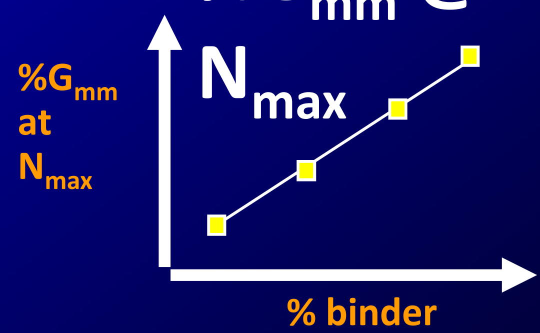
Dust/Asphalt



$\%G_{mm}$ @ N_{ini}



$\%G_{mm}$ @ N_{max}



Superpave Mixture Requirements

- **Mixture Volumetrics**
  - **Air Voids (V_a)**
  - **Mixture Density Characteristics**
  - **Voids in the Mineral Aggregate (VMA)**
  - **Voids Filled with Asphalt (VFA)**
- **Dust Proportion**
- **Moisture Sensitivity**

Mix Design Summary Sheet - SuperPave

Michigan Department
of Transportation
1858 (03/08)

SUBMITTED SUPERPAVE MIX DESIGN SUMMARY SHEET

CONTRACTOR		CONSULTANT
CONTROL SECTION I.D.	JOB NO.	TYPE OF MIXTURE
N_{INT}	N_{DES}	N_{MAX}

MIXING TEMPERTURE RANGE °F
_______________ °F _______________ °F

COMPACTION TEMPERTURE RANGE °F
_______________ °F _______________ °F

SUPERPAVE MIX PROPERTIES AT TESTED & OPTIMUM ASPHALT CONTENT

ITEM	TEST POINTS				RECOMMENDED OPTIMUM Regression Value at Optimum Asphalt Content	VERIFICATION TEST RESULTS @ N_{MAX}
	4 POINT DESIGN					
	FINAL		BLEND			
ASPHALT CONTENT (%)	5.0	5.5	6.0	6.5		
BULK SPECIFIC GRAVITY @ N_{DES}						
BULK SPECIFIC GRAVITY @ N_{MAX}						
THEORETICAL MAXIMUM (S.G.)						
AIR VOIDS (%) @ N_{DES}						
VOIDS IN MINERAL AGGREGATE % (VMA) @ N_{DES}						
VOIDS FILLED WITH ASPHALT % (VFA) @ N_{DES}						
% G_{mm} @ N_{INT}						
% G_{mm} @ N_{DES}						
% G_{mm} @ N_{MAX}						
FINES/EFF ASPHALT RATIO						

The submitted superpave mix design final blend shall have a minimum of 4 test points at 0.5 percent asphalt content increments. At least one full asphalt content (0.5%) above and below optimum asphalt content is required.

ASPHALT CONTENT OF SUBMITTED SUPERPAVE MIX DESIGN 5.7

ASPHALT SPECIFIC GRAVITY ____________________

SPECIFIC GRAVITY OF COMBINED AGGREGATE G_{sb} ____________________

Mix Design Summary Sheet – Marshall

Michigan Department
of Transportation
1813 (02/06)

SUBMITTED MIX DESIGN SUMMARY SHEET

CONTRACTOR		CONSULTANT
CONTROL SECTION I.D.	JOB NO.	TYPE OF MIXTURE

MIXING TEMPERATURE °F
_______ °F _______ °F

COMPACTION TEMPERATURE °F
_______ °F _______ °F

MARSHALL MIX PROPERTIES AT TESTED & OPTIMUM ASPHALT CONTENT

ITEM	TEST POINTS Actual Test Data					RECOMMENDED OPTIMUM Regression Value at Optimum Asphalt Content
ASPHALT CONTENT (%)	4.5	5.0	5.5	6.0	6.5	5.7
BULK SPECIFIC GRAVITY (Compacted)						
THEORETICAL MAXIMUM (S.G.)						
AIR VOIDS (%)						
VOIDS IN MINERAL AGGREGATE % (VMA)						
VOIDS FILLED WITH ASPHALT % (VFA)						
STABILITY (LBS.)						
FLOW (0.01 IN.)						
COMPACTIVE EFFORT (BLOWS)						

NOTES

SPECIFIC GRAVITY OF COMBINED AGGREGATE _______ Gsb

ASPHALT CONTENT OF SUBMITTED MIX DESIGN 5.7

ASPHALT SPECIFIC GRAVITY _______

The submitted mix design shall have a minimum of 4 test points at 0.5 percent asphalt content increments. At least one full asphalt content (0.5%) above and below optimum asphalt content is required.

Mix Design Example

Michigan Department of Transportation form 1931

Report of Test
SUPERPAVE ™ HMA Design Mix Formula

File 300 ______

ACCEPTED

Distribution: Project Engineer (1) -- TMI (1) -- Mix Design (1) -- Contractor (1) -- Bit File (1)

Control Section: B806 54038	Job Number: 54321A	Project Engineer: R. Steel P.E.	Engineering Firm: MDOT	Date: 8/9/0X	
Contractor: General Pavement	Plant Location: BIG RAPIDS	Plant No.: 701-01			
Mix Type: 5E3	Mix Design Number: 06MD540	Project Location:	Specification: 03SP501(F)		
% Air Voids: 4.0	VMA: 15.9	VFA: 74.8	$P200/P_{be}$: 1.1	AWI: 288	AI: 40.9
Gmm: 2.457	Gmb: 2.359	Gb: 1.029	Gsb: 2.644	Gse: 2.682	Film Thickness: 7.21

	A	B	C	D	E	F	G	H	I	J	
Pit Number	54-101	54-101	95-76	95-76						Plant	% AC
Aggregate Type	Sand FSU	Slag Sand	5/16 FSU	Sand	BHF					Rap	5.7
										Rap/Ac	9.48%
Blend %	10.0%	15.0%	26.0%	33.0%	1.0%					15.0%	Combined Gradation
Sieve Size	GRADATION							% Binder of RAP		3.60	
1 1/2" - (37.5mm)											0.0%
1" - (25.0mm)											0.0%
3/4" - (19mm)											0.0%
1/2" - (12.5mm)	100.0%	100.0%	100.0%	100.0%	100.0%					100.0%	100.0%
3/8" - (9.5mm)	100.0%	100.0%	100.0%	100.0%	100.0%					87.5%	98.1%
#4 - (4.75mm)	91.3%	91.7%	65.0%	99.9%	100.0%					67.9%	83.9%
#8 - (2.36mm)	69.9%	59.6%	39.7%	79.9%	100.0%					50.2%	61.1%
#16 - (1.18mm)	52.4%	38.7%	29.2%	66.2%	100.0%					40.8%	47.6%
#30 - (0.80mm)	36.8%	26.3%	23.8%	54.9%	100.0%					33.6%	38.0%
#50 - (0.30mm)	11.8%	18.0%	17.2%	24.9%	100.0%					20.8%	20.7%
#100 - (0.1mm)	3.6%	11.7%	11.7%	2.8%	100.0%					10.6%	8.6%
#200 - (0.075mm)	2.5%	7.7%	9.0%	0.4%	85.0%					7.4%	5.8%
1 FACE CRUSH %	30.0%	100.0%	100.0%	30.0%						75.0%	88.6%
2 FACE CRUSH %											-
L.A. ABRASION & YEAR	22-03	25-02	22-03								
Angularity Index	37.8	48.8	43	38							40.90
AWI FACTOR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
AWI VALUE #16	225	401	300	240						240	288
COMBINED Calc. Gsb	2.601	2.720	2.610	2.648						2.675	2.648
#4+ COARSE BULK S.G.			2.621								
#8 COARSE BULK S.G.		2.702	2.582								
FINE BULK S.G.	2.601	2.73	2.619	2.648						2.678	
FLAT & ELONGATED %											
SOFT PARTICLES %	0.1		0.5	0.5						0.5	

Asphalt Binder	Grade: PG 64-28	A.C. Supplier I.D. #: ABS 1005	% New AC Added: 5.16

REMARKS:

______ Bituminous Engineer

Mix Design Example

Michigan Department of Transportation form 1931

Report of Test
SUPERPAVE ™ HMA Design Mix Formula

File 300 ________

ACCEPTED

Distribution: Project Engineer (1) -- TMI (1) -- Mix Design (1) -- Contractor (1) -- Bit File (1)

Control Section	Job Number	Project Engineer	Engineering Firm	Date
B06 54038	54321A	R. Steel P.E.	MDOT	8/9/0X

Contractor	Plant Location	Plant No.
General Pavement	BIG RAPIDS	701-01

Mix Type	Mix Design Number	Project Location	Specification
5E3	06MD540		03SP501(F)

% Air Voids	VMA	VFA	$P200/P_{be}$	AWI	AI
4.0	15.9	74.8	1.1	288	40.9

Gmm	Gmb	Gb	Gsb	Gse	Film Thickness
2.457	2.359	1.029	2.644	2.682	7.21

	A	B	C	D	E	F	G	H	I	J	
Pit Number	54-101	54-101	95-76	95-76						Plant	% AC
Aggregate Type	Sand FSU	Slag Sand	5/16 FSU	Sand	BHF					Rap	5.7
										Rap%	9.48%
Blend %	10.0%	15.0%	26.0%	33.0%	1.0%					15.0%	Combined Gradation
Sieve Size	GRADATION							% Binder of RAP		3.60	
1 1/2" - (37.5mm)											0.0%
1" - (25.0mm)											0.0%
3/4" - (19mm)											0.0%
1/2" - (12.5mm)	100.0%	100.0%	100.0%	100.0%	100.0%					100.0%	100.0%
3/8" - (9.5mm)	100.0%	100.0%	100.0%	100.0%	100.0%					87.5%	98.1%
#4 - (4.75mm)	91.3%	91.7%	65.0%	99.9%	100.0%					67.9%	83.9%
#8 - (2.36mm)	69.9%	59.6%	39.7%	79.9%	100.0%					50.2%	61.1%

Mix Design Example

#4 - (4.75mm)	[illegible]	[illegible]	[illegible]	[illegible]	100.0%					67.9%	83.9%
#8 - (2.36mm)	69.9%	59.6%	39.7%	79.9%	100.0%					50.2%	61.1%
#16 - (1.18mm)	52.4%	38.7%	29.2%	66.2%	100.0%					40.8%	47.6%
#30 - (0.60mm)	36.8%	26.3%	23.8%	54.9%	100.0%					33.6%	38.0%
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#200 - (0.075mm)	2.5%	7.7%	9.0%	0.4%	85.0%					7.4%	5.8%
1 FACE CRUSH %	30.0%	100.0%	100.0%	30.0%						75.0%	88.6%
2 FACE CRUSH %											-
L.A. ABRASION & YEAR	22-03	25-02	22-03								
Angularity Index	37.8	48.8	43	38							40.90
AWI FACTOR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
AWI VALUE #16	225	401	300	240						240	288
COMBINED Calc. Gsb	2.601	2.720	2.610	2.648						2.675	2.648
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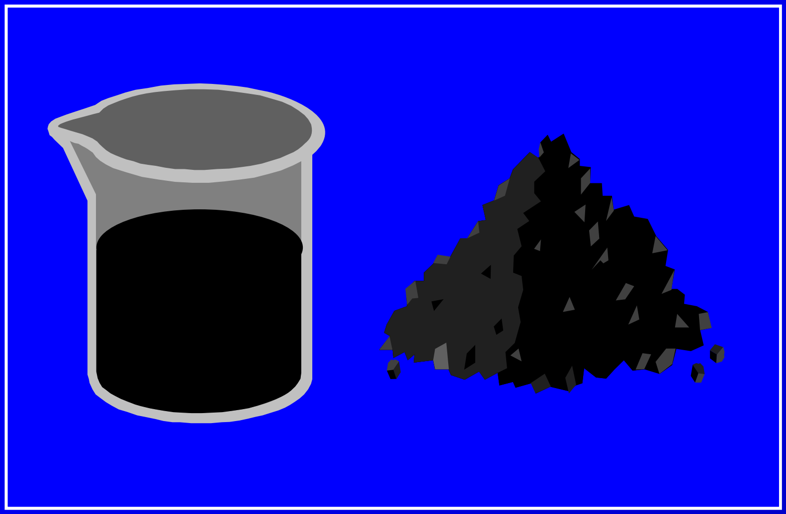
#8 COARSE BULK S.G.		2.702	2.582								
FINE BULK S.G.	2.601	2.73	2.619	2.648						2.678	
FLAT & ELONGATED %											
SOFT PARTICLES %	0.1		0.5	0.5						0.5	

Asphalt Binder	Grade PG 64-28	A.C. Supplier I.D. # ABS 1005	% New AC Added 5.16

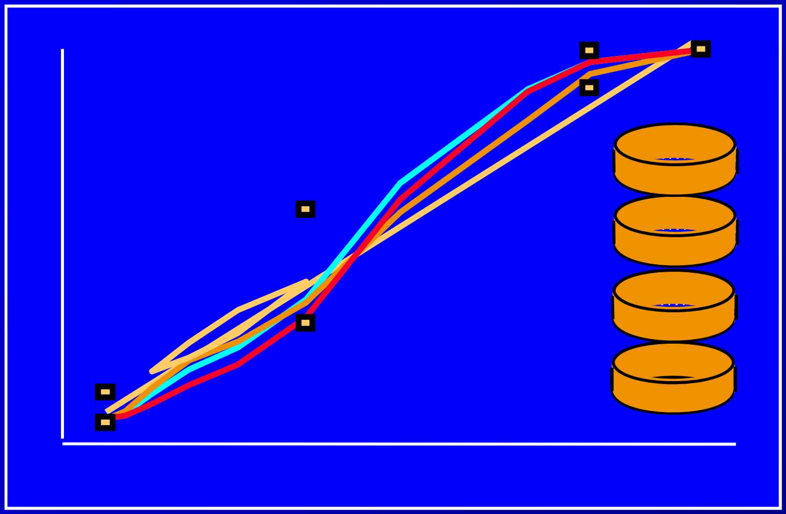
REMARKS:

Bituminous Engineer

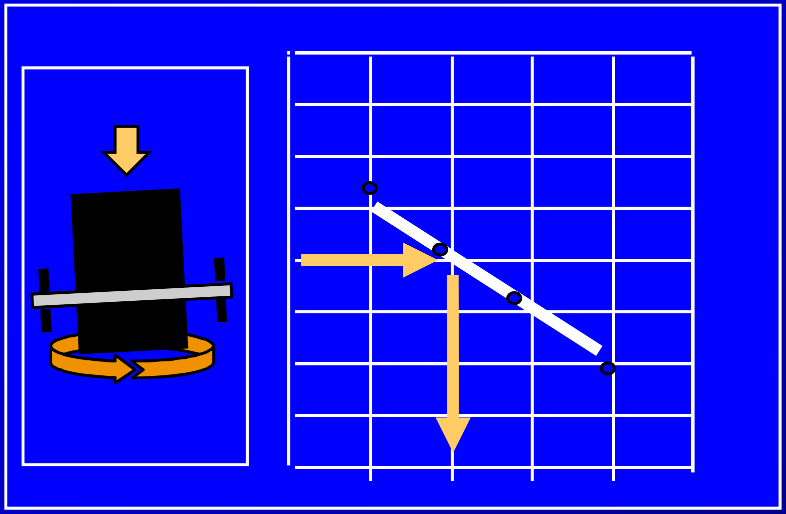
4 Steps of Superpave Mix Design



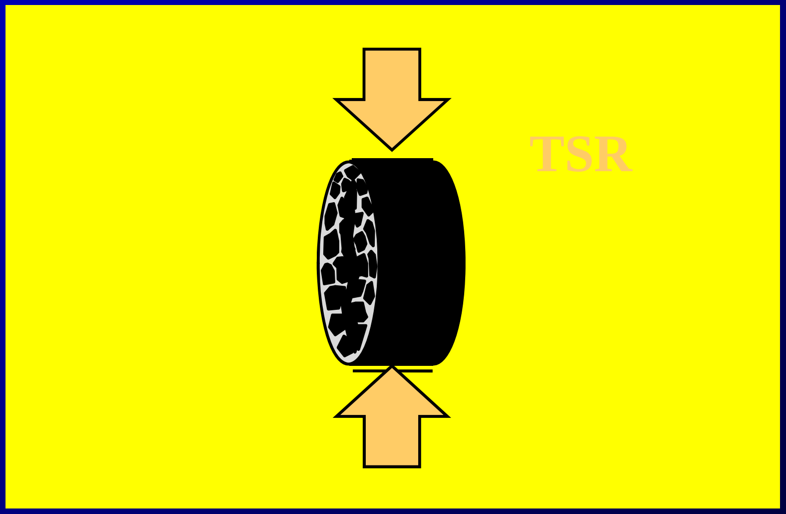
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



4. Moisture Sensitivity

Moisture Sensitivity

AASTHO T-283, Tensile Strength Ratio (TSR) Test

- 6 specimens compacted to 6 – 8% air voids
  - 3 conditioned and 3 unconditioned
- Conditioned specimens
  - 55 to 80 percent saturation
  - Freeze-thaw cycle (min. 16 Hrs. freeze)
  - 24 hour soak in 140°F water bath
  - Cooled to 77°F and broken on IDT Tester
- Unconditioned specimens
  - Left undisturbed until broken on IDT Tester
- TSR $\geq$ 80%

Moisture Sensitivity

AASTHO T-283, Tensile Strength Ratio (TSR) Test

- Testing of specimens
  - Remove from 77°F (25°C) water bath and place between two bearing plates.
  - Apply load to specimens by means of constant rate movement, two inches (50 mm) per minute.
  - Record maximum compressive strength.

Moisture Sensitivity

AASTHO T-283, Tensile Strength Ratio (TSR) Test

- Calculations
  - Take the average tensile strength of the three conditioned specimens and divide by the average of the three unconditioned specimens.
  - The ratio has to be a minimum of 80%.

$$TSR = \frac{T\ Conditioned\ (Avg.)}{T\ Unconditioned\ (Avg.)}$$

ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN

Questions?

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