AF2903 Road Construction and Maintenance

Design of Asphalt Mixtures

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Hot Mix Asphalt Design

Objective:

Develop an economical blend of aggregates and asphalt that meet design requirements

Most important mix design methods

- Marshall
- Superpave

Requirements in Common

- Sufficient asphalt to ensure durability
- Sufficient stability under traffic loads
- Sufficient air voids

  Lower limit to allow room for initial densification
  due to traffic (bleeding)

  Upper limit to prevent excessive environmental damage (aging)

- Sufficient workability

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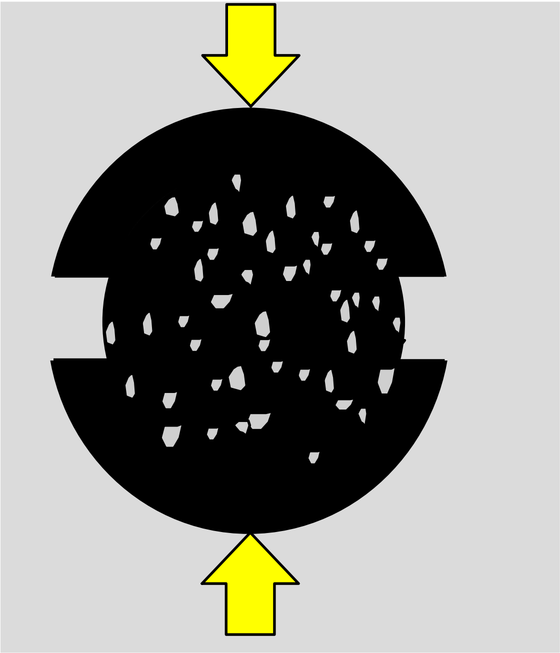
MARSHALL MIX DESIGN



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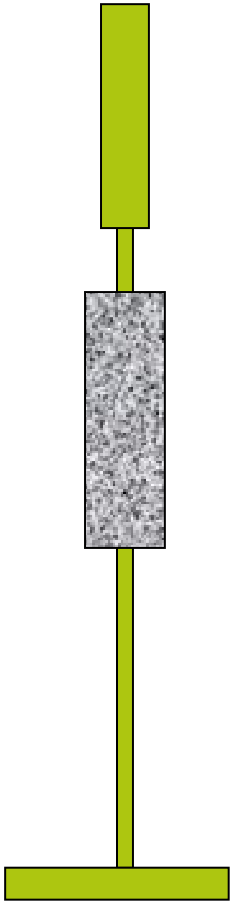
Marshall Mix Design

Developed by Bruce Marshall for the Mississippi Highway Department in the late 30's

- Evaluated compaction effort
  - Hammer weight: 10 lb
  - 50 blows/side as an initial standard
  - 4% voids after traffic

Initial criteria were established and upgraded for increased tire pressures and loads



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Marshall Hammer

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Marshall Mix Design

Select and test aggregate

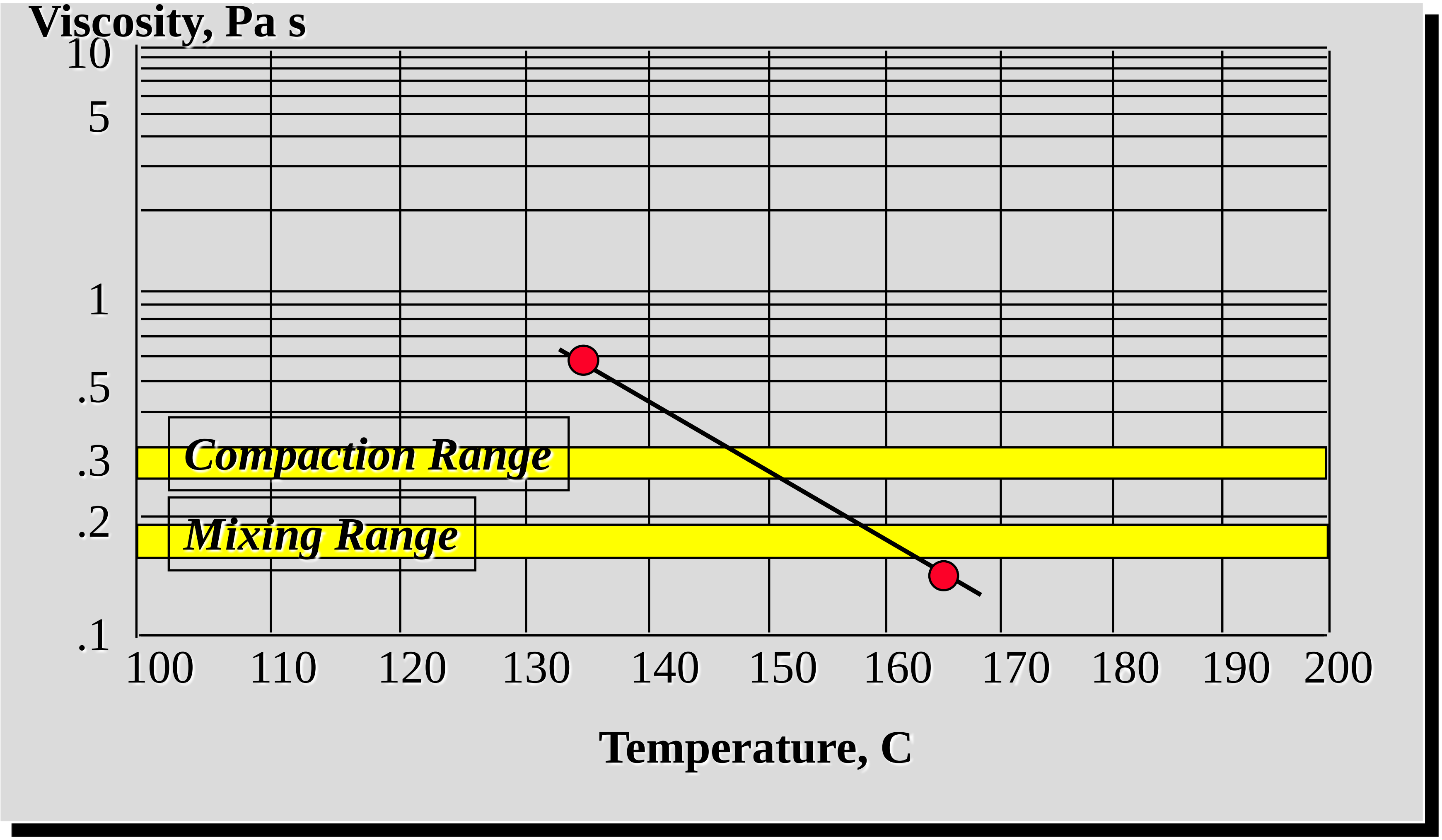
Select and test asphalt cement

- Establish mixing and compaction temperatures

Develop trial blends

- Heat and mix asphalt cement and aggregates
- Compact specimen (100 mm diameter)

Mixing/Compaction Temperatures



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Marshall Design Criteria

	Light Traffic ESAL < 10^4	Medium Traffic 10^4 < ESAL< 10	Heavy Traffic ESAL > 10^6
Compaction	35	50	75
Stability N (lb.)	3336 (750)	5338 (1200)	8006 (1800)
Flow, 0.25 mm (0.1 in)	8 to 18	8 to 16	8 to 14
Air Voids, %	3 to 5	3 to 5	3 to 5
Voids in Mineral Agg. (VMA)	Varies with aggregate size		

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Marshall Mix Design Tests

Bulk specific gravity of compacted sample

Maximum specific gravity of loose mix

Stability and flow

- 60^{o}C water bath (30 to 40 minutes)
- 50 mm/min loading rate
- Max. load = uncorrected stability
- Corresponding vertical deformation = flow

Marshall Stability and Flow

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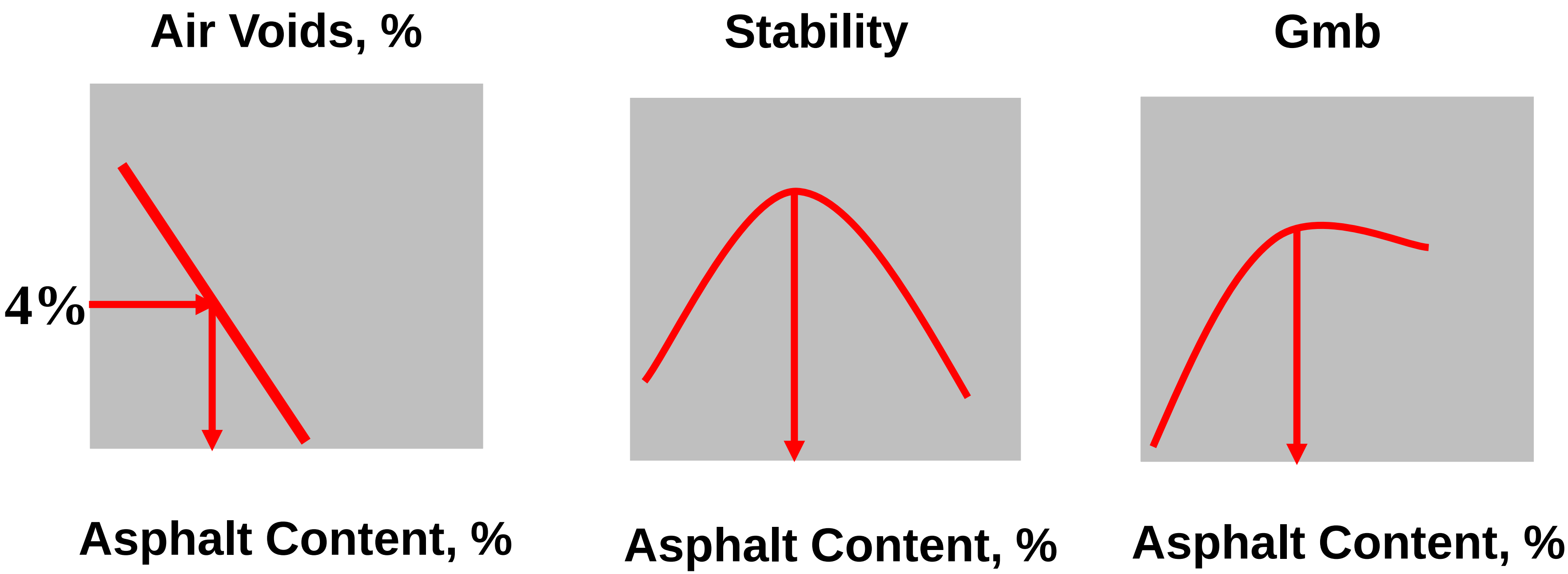
Marshall Design / Asphalt Institute Procedure



Target optimum asphalt content = average

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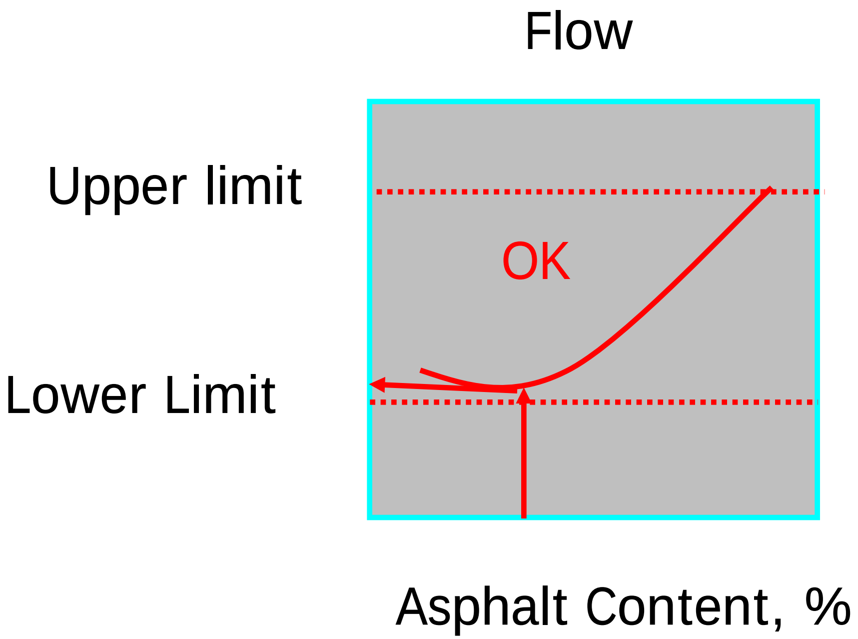
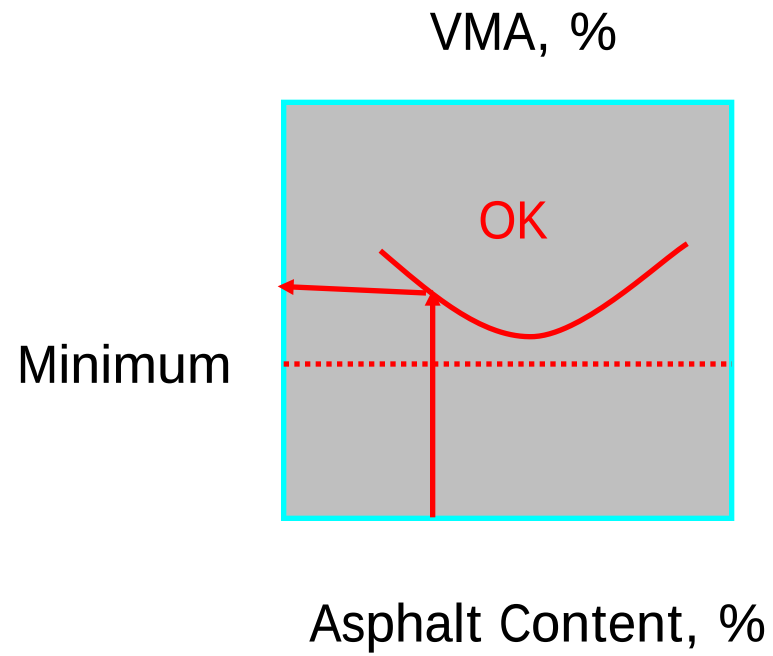
Marshall Design / Asphalt Institute Procedure





Use target optimum asphalt content to check if these criteria are met

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Marshall Design Method

Advantages

- Attention on voids, strength, durability
- Inexpensive equipment
- Easy to use in process control/acceptance

Disadvantages

- Impact method of compaction
- Does not consider shear strength
- Load perpendicular to compaction axis

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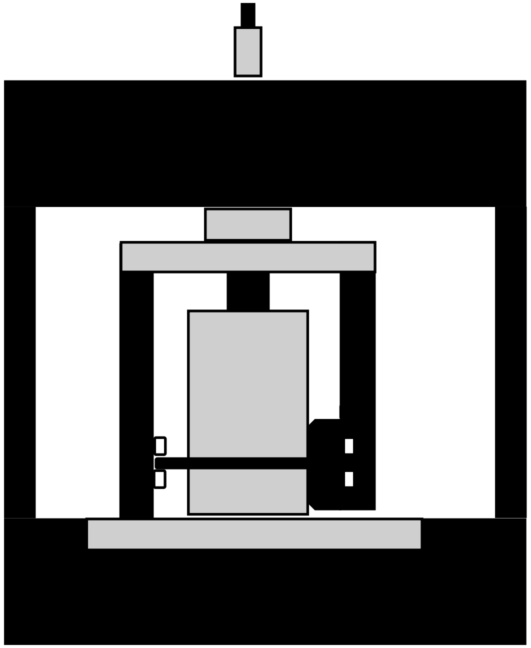
Superior Performing Asphalt Pavements



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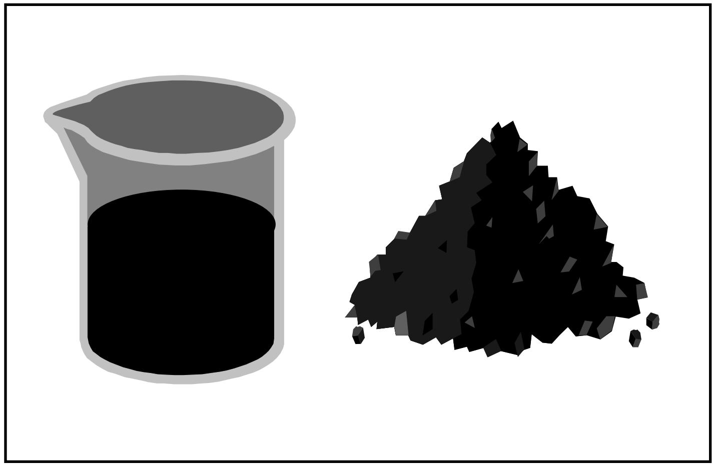
Gyratory Compaction and Mixture Requirements

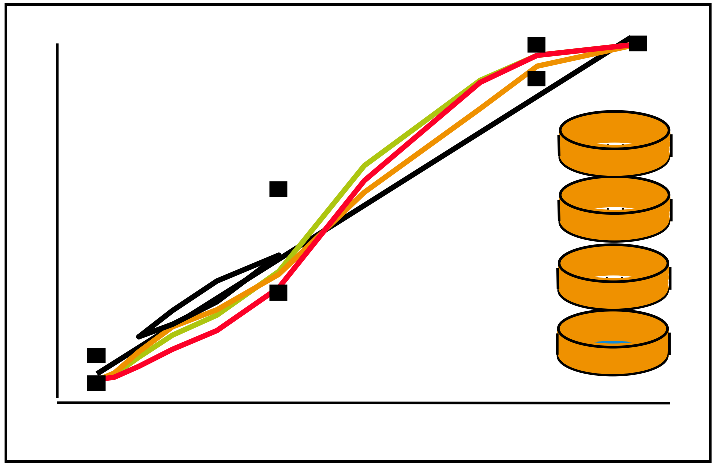
Section objectives:

- Describe the Superpave gyratory compactor
- Review the Superpave mixture requirements
- Summarize the moisture sensitivity test

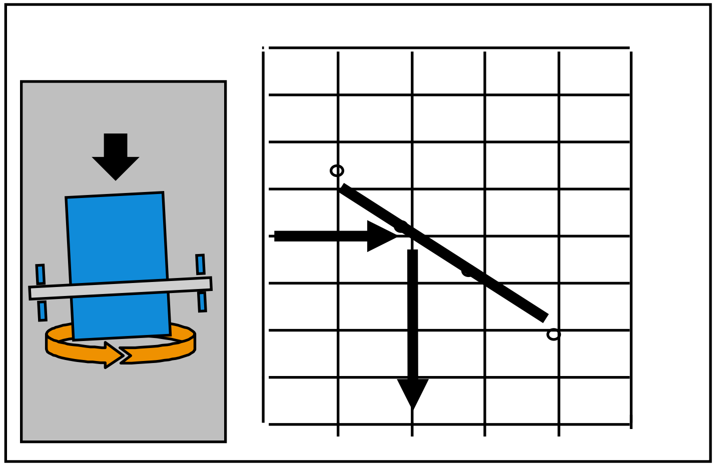
Four Steps of Superpave Mix Design



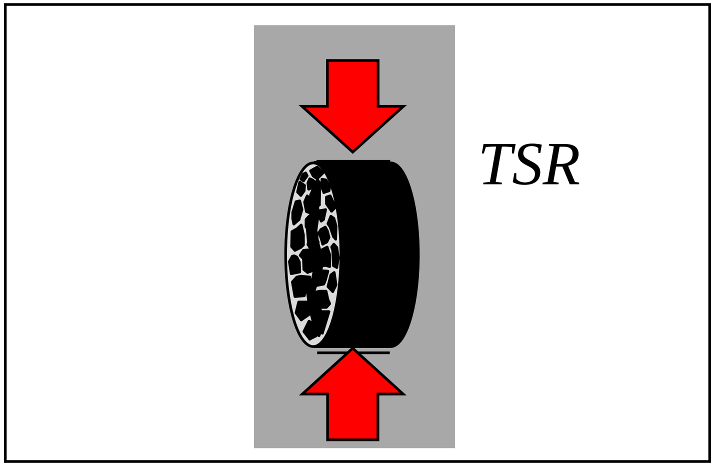
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



4. Moisture Sensitivity

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Goals of Compaction

Simulate field densification
- Traffic
- Climate

Accommodate large aggregates

Measure of compactability

Conducive to QC

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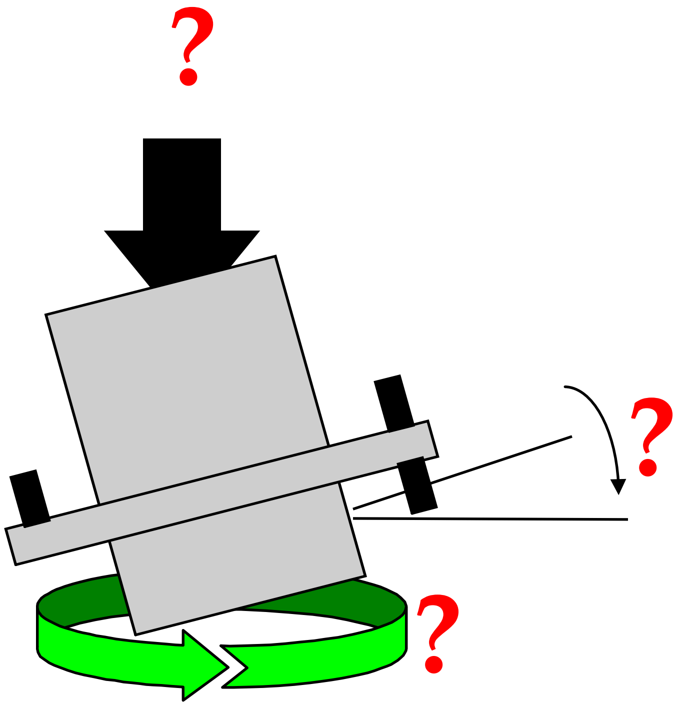
Superpave Gyratory Compactor (SGC)

Basis

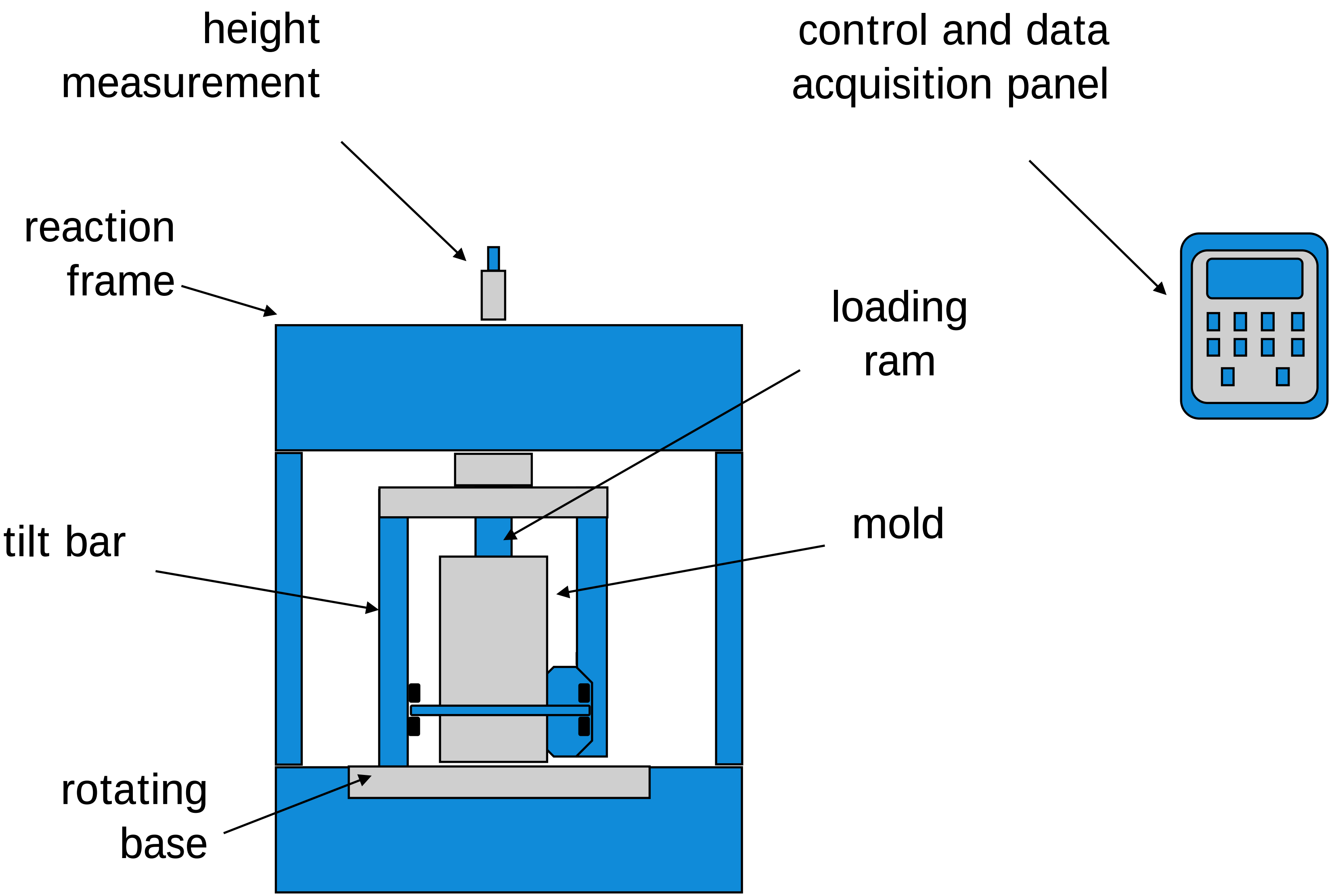
Texas equipment
French operational characteristics

150 mm diameter

Up to 37.5 mm nominal size
Height recordation



Superpave Gyratory Compactor (SGC)



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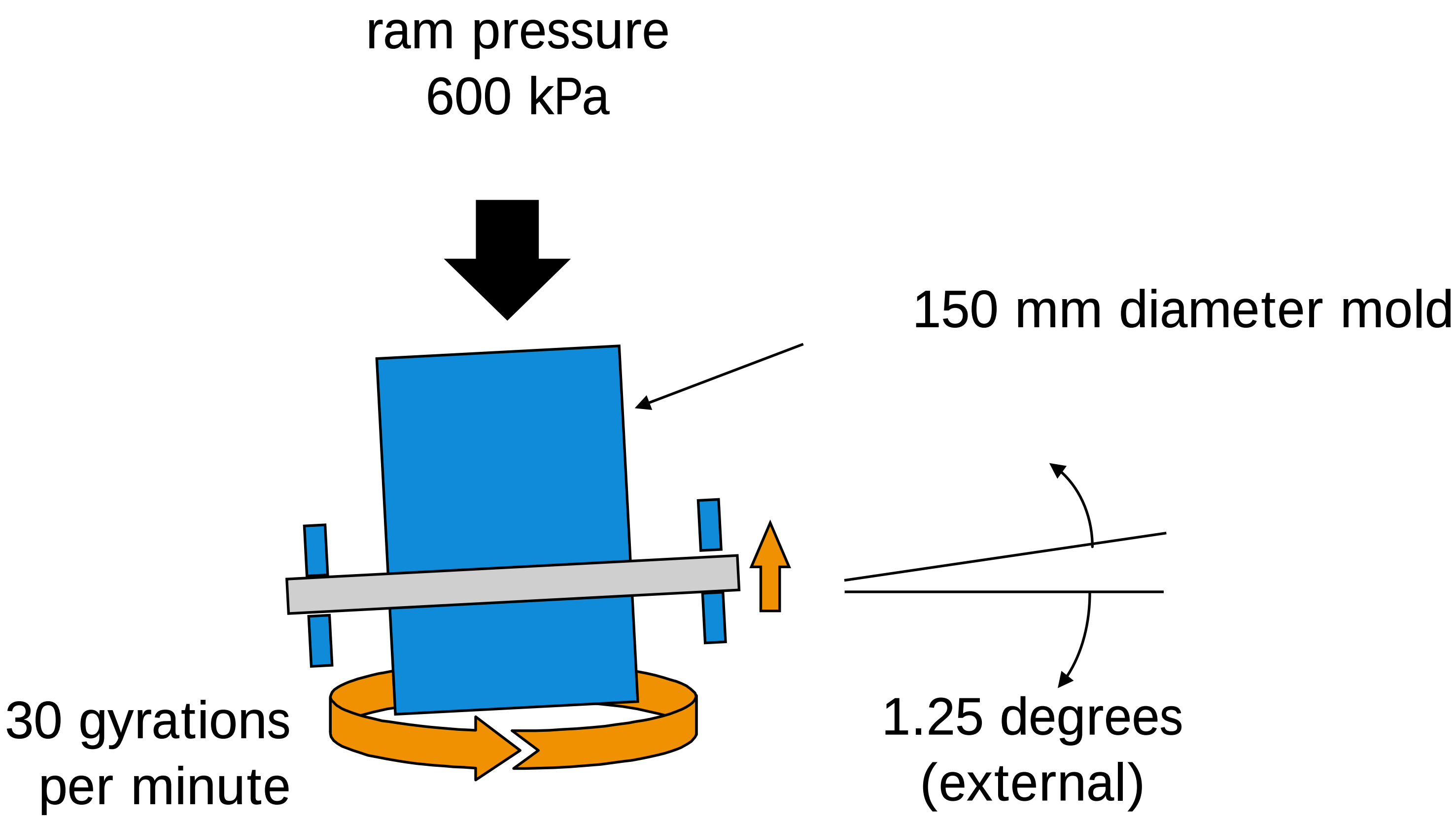
Superpave Gyratory Compactor (SGC)



Superpave Gyratory Compactor (SGC)

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Specimen Preparation

Mechanical mixer

0.170 Pa-s binder viscosity

Short term oven aging

4 hours at 135° C

2 hours at Compaction Temperature (optional)

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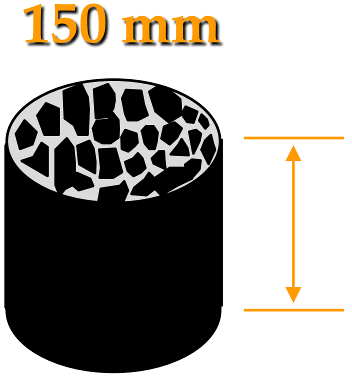
Specimen Preparation

Specimen height

- Mix design - 115 ± 5 mm (4700 g)
- Moisture sens. - 95 mm (3500 g)

Loose specimen for max. theor. (Rice)

- Varies with nominal max size
  - 19 mm (2000 g)
  - 12.5 mm (1500 g)



Specimen Preparation

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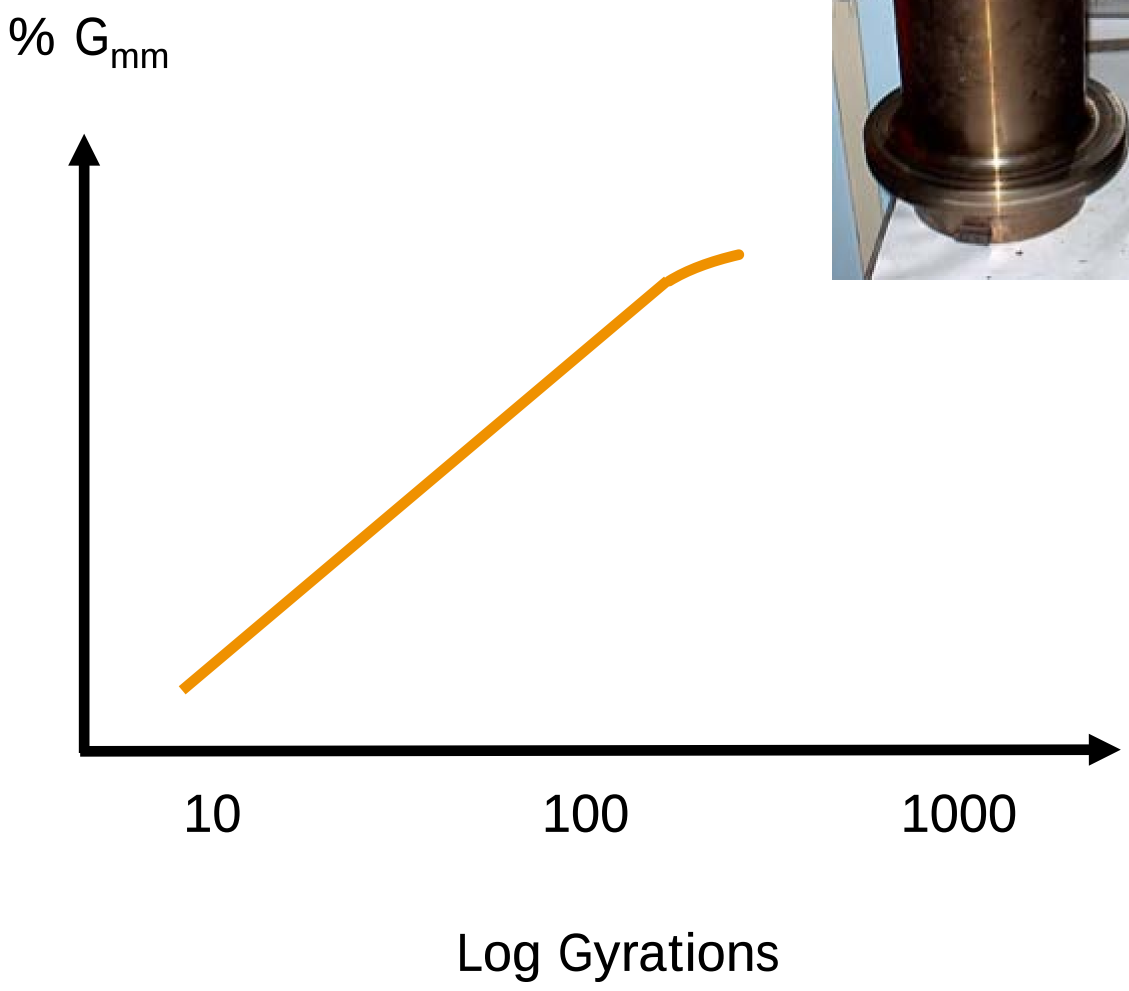
Specimen Preparation

Three Points on SGC Curve



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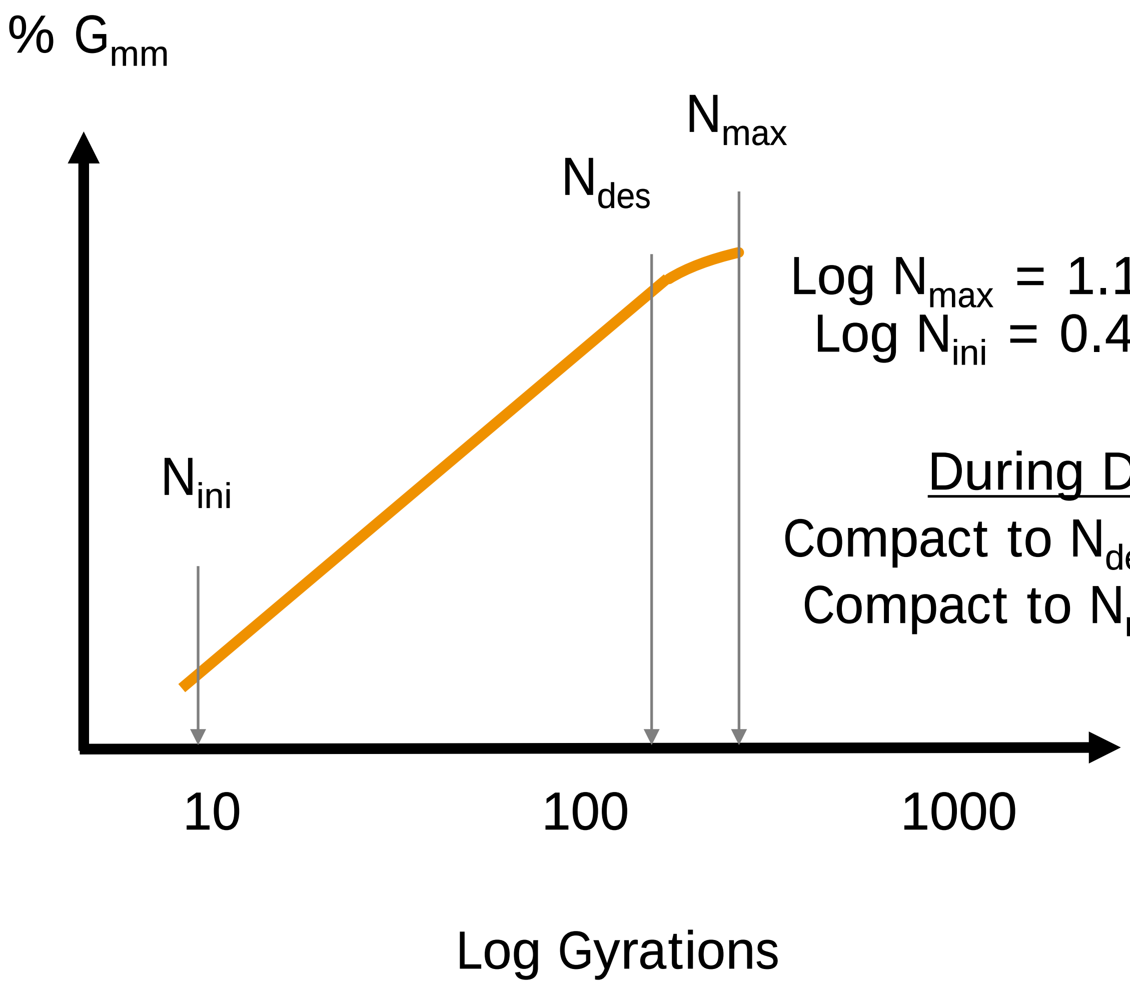
Three Points on SGC Curve



$\text{Log } N_{max} = 1.10 \text{ Log } N_{des}$

$\text{Log } N_{ini} = 0.45 \text{ Log } N_{des}$

During Design:

Compact to N_{des} to get opt.

Compact to N_{max} to check

N_i: measure of mixture compactability during compaction

N_{des}: expected density in the field after the indicated amount of traffic

N_{max}: laboratory density that should never be exceeded in the field

N_{ini}, N_{des}, and N_{max}

Traffic Level	Compaction Level		
	N initial	N design	N maximum
< 0.3	6	50	75
0.3 to < 3.0	7	75	115
3.0 to 30.0	8	100	160
> 30.00	9	125	205

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Superpave Mixture Requirements

Mixture Volumetrics

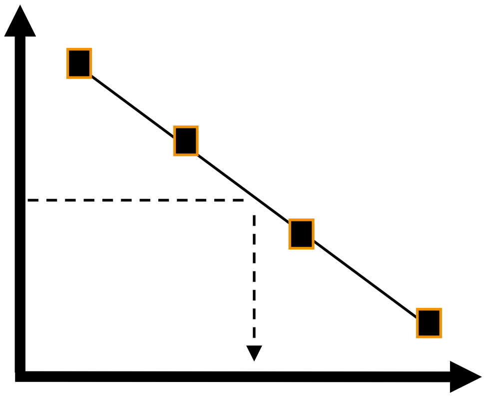
- Air Voids (V_a)
- Voids in the Mineral Aggregate (VMA)
- Voids Filled with Asphalt (VFA)
- Mixture Density Characteristics

Dust Proportion

Moisture Sensitivity

Mix Air Voids Requirement

air voids



% binder

4 % at N_{des} Regardless of the Traffic Level

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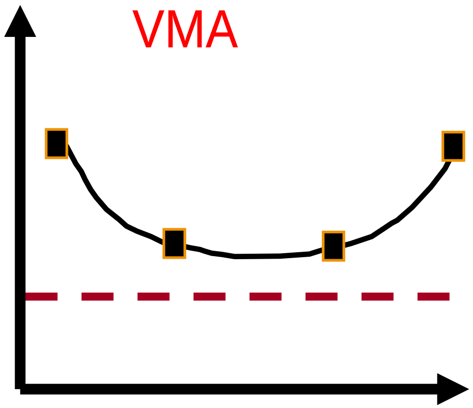
VMA Requirements



Nom Max Size (mm)	Minimum VMA %
9.5	15.0
12.5	14.0
19	13.0
25	12.0
37.5	11.0

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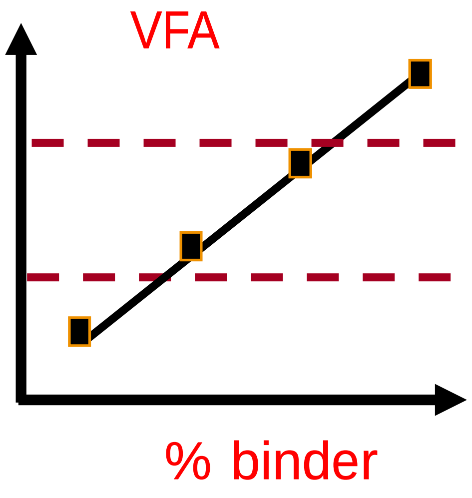
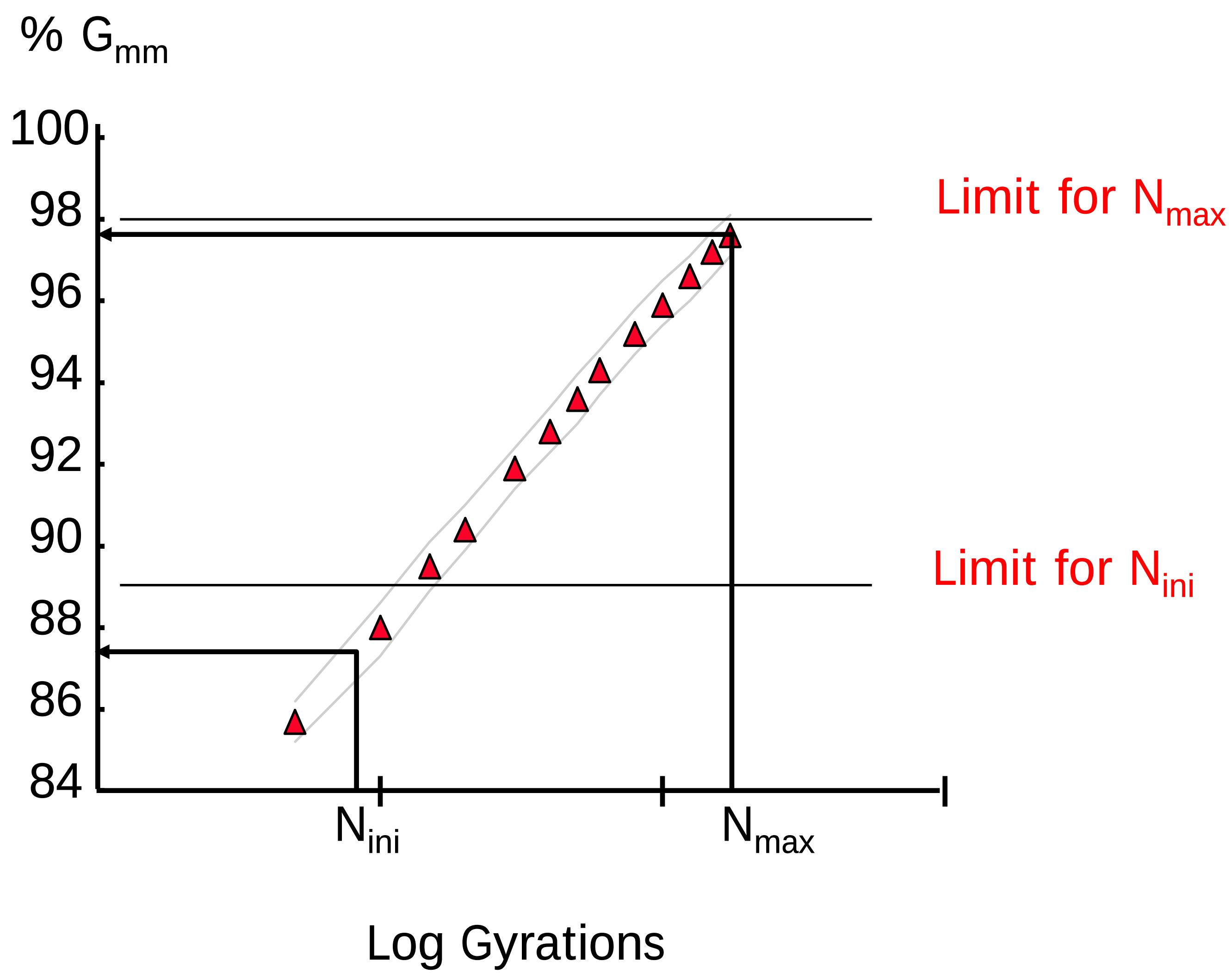
VFA Requirements



Traffic 10^6 ESALs	Range of VFA %
< 0.3	70 – 80
0.3 to < 3	65 – 7
3.0 to < 30	65 – 75
> 30	65 - 75

Mixture Density



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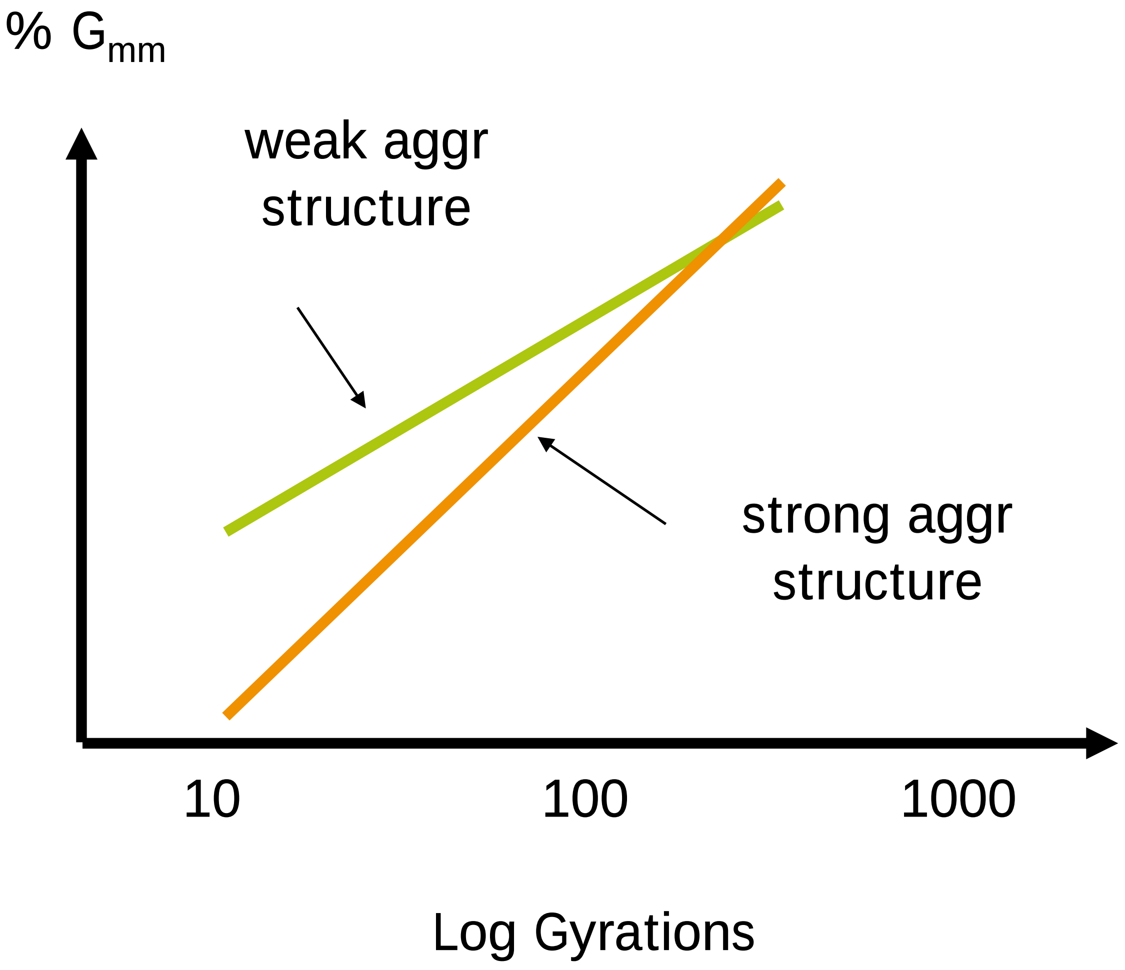
Evaluate Aggregate Structure



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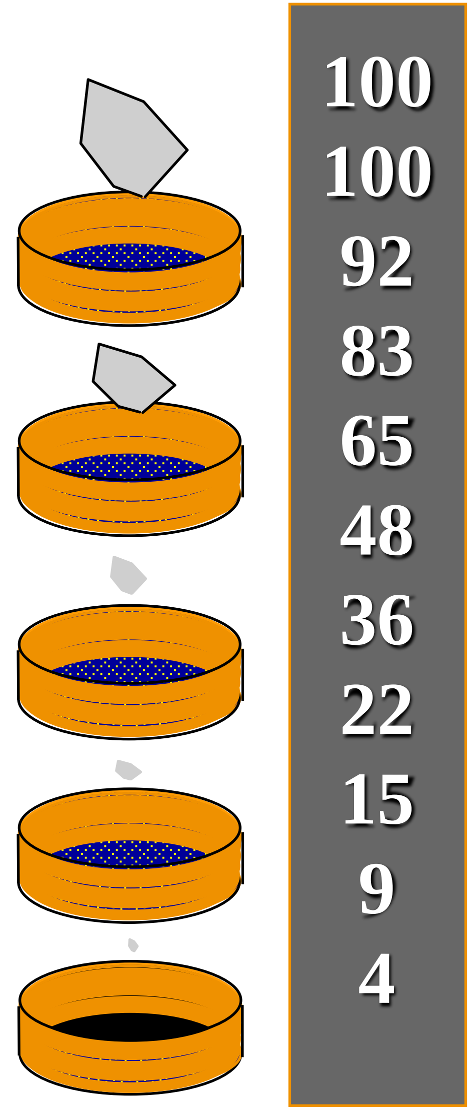
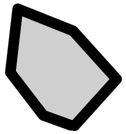
Dust Proportion

$$0.6 \le \frac{\%\ \text{weight of - 0.075 material}}{\%\ \text{weight of}\ \textit{effective}\ \text{asphalt}} \le 1.2$$





<u>Unabsorbed</u> binder in mix

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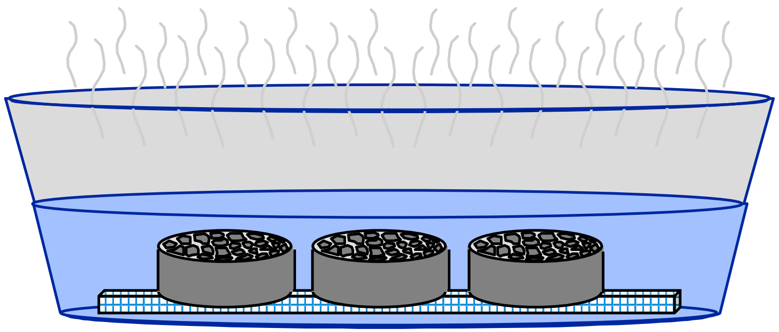
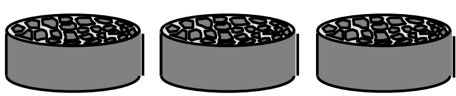
Moisture Sensitivity AASHTO T 283

Measured on proposed aggregate blend and asphalt content



3 Conditioned Specimens



3 Dry Specimens

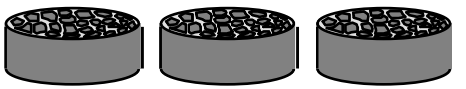
80 % minimum

Tensile Strength Ratio

AASHTO T 283 Conditioning

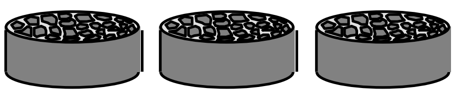
- Short term aging
  - Loose mix 16 hrs @ 60° C
  - Comp mix 72-96 hrs @ 25° C
- Two subsets with equal voids
  - One “dry”
  - One saturated

6 to 8 % air



Dry

6 to 8 % air



55 to 80 % saturation

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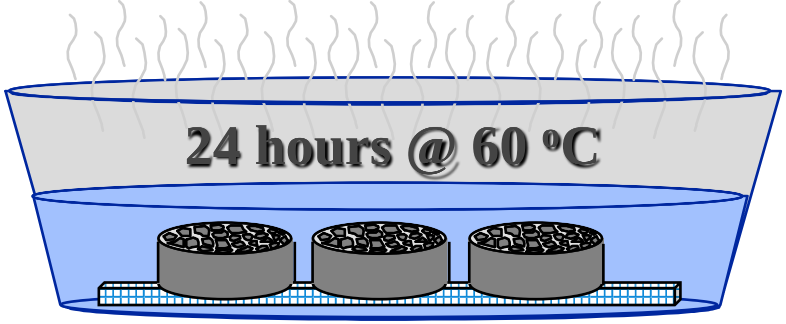
AASHTO T 283 Conditioning

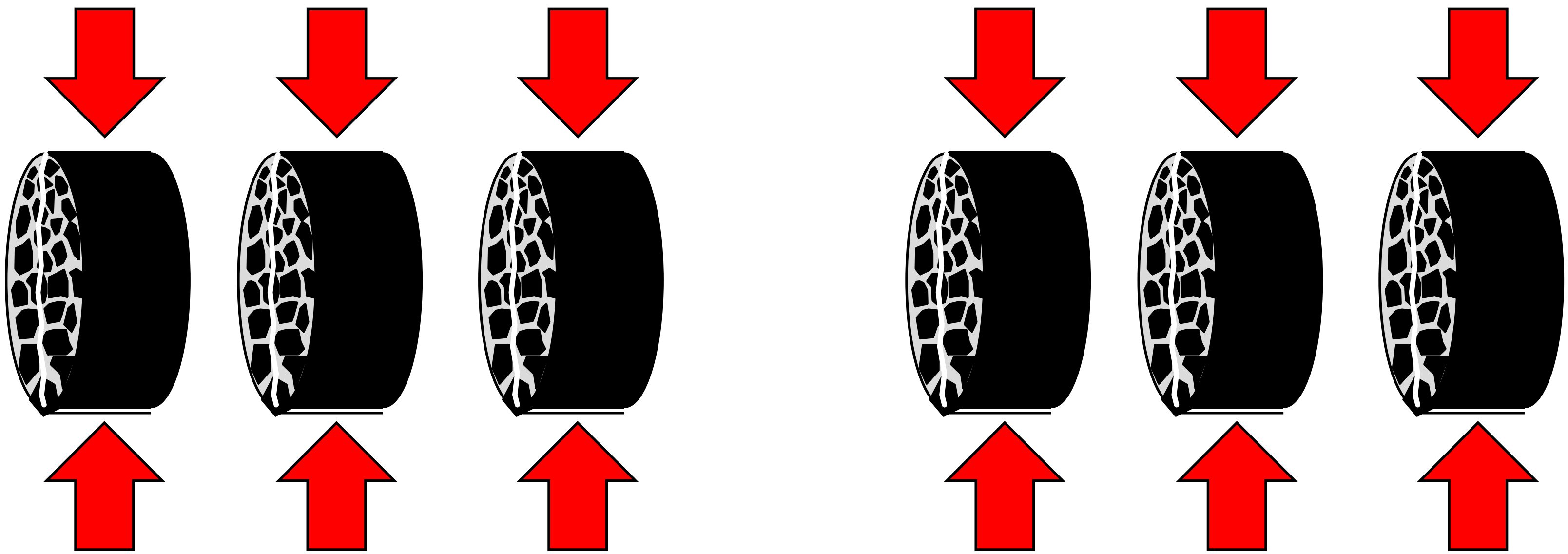
Optional freeze cycle

Hot water soak



AASHTO T 283 Test Procedure

51 mm / min @ 25 ^{o}C



Avg Dry Tensile Strength

Avg Wet Tensile Strength

$$\textbf{TSR} = \frac{\textbf{Wet}}{\textbf{Dry}} \geq 80\ \%$$

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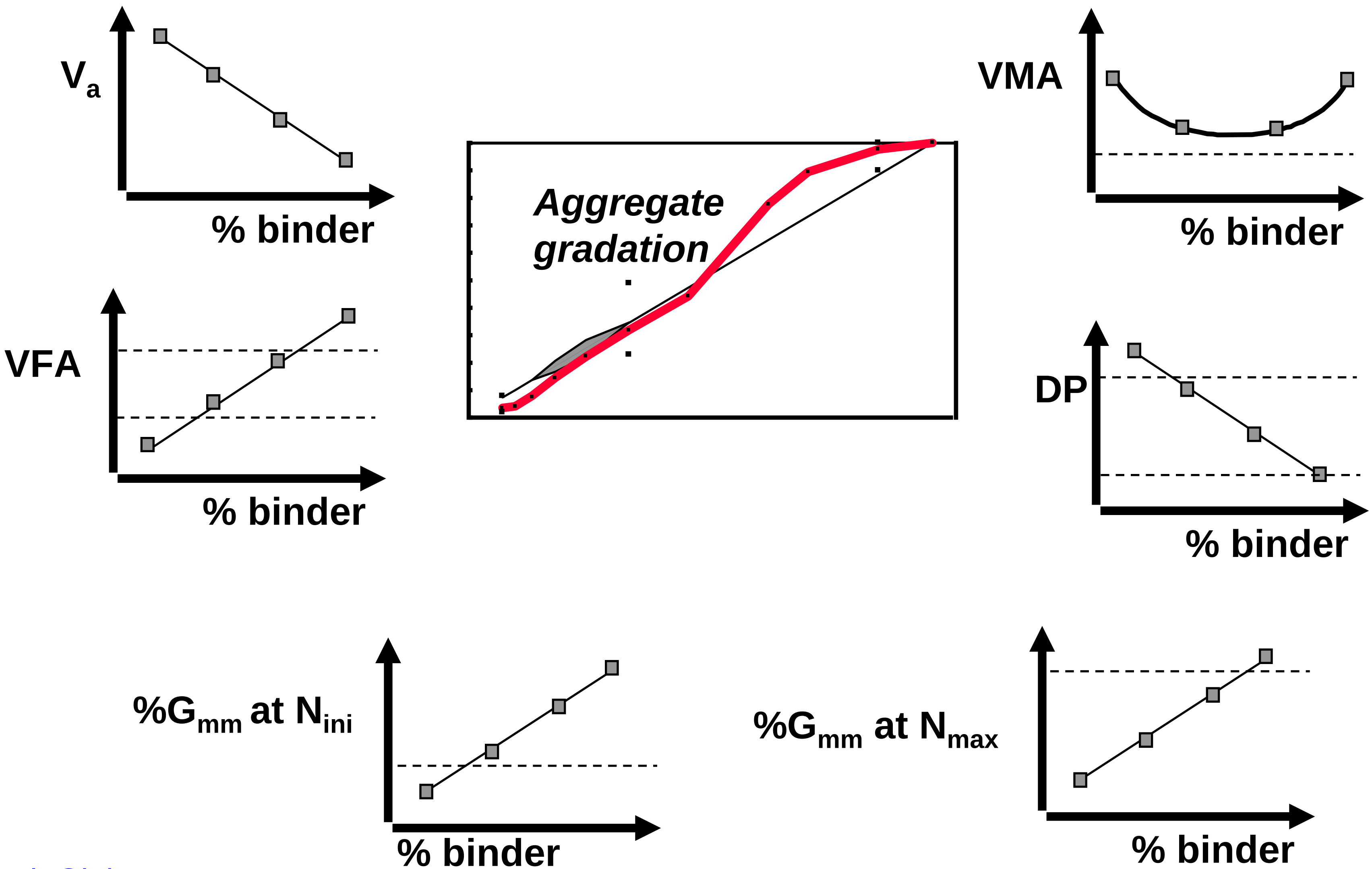
Selection of Design Asphalt Binder Content



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Look for the Unusual!!!

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