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

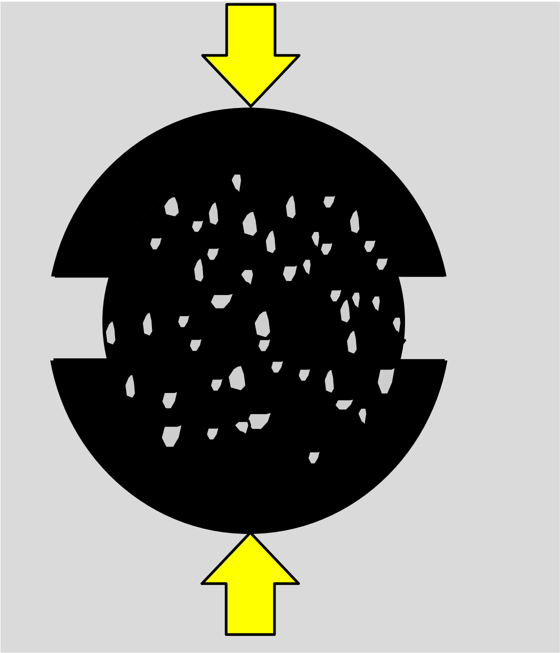
- Sufficient asphalt to ensure durability
- Sufficient stability under traffic loads
- Sufficient air voids

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

  Upper limit to prevent excessive environmental damage (aging)

- Sufficient workability

MARSHALL MIX DESIGN



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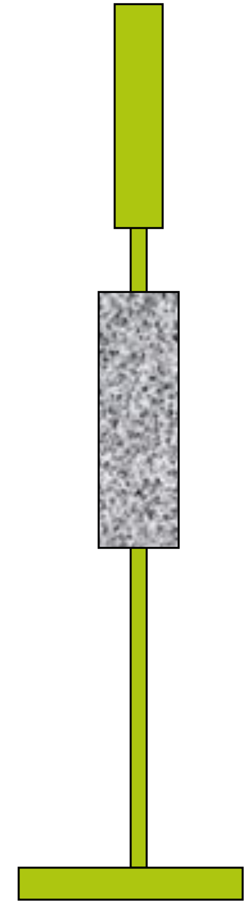
Marshall Mix Design

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



Marshall Hammer

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Marshall Mix Design

Select and test aggregate

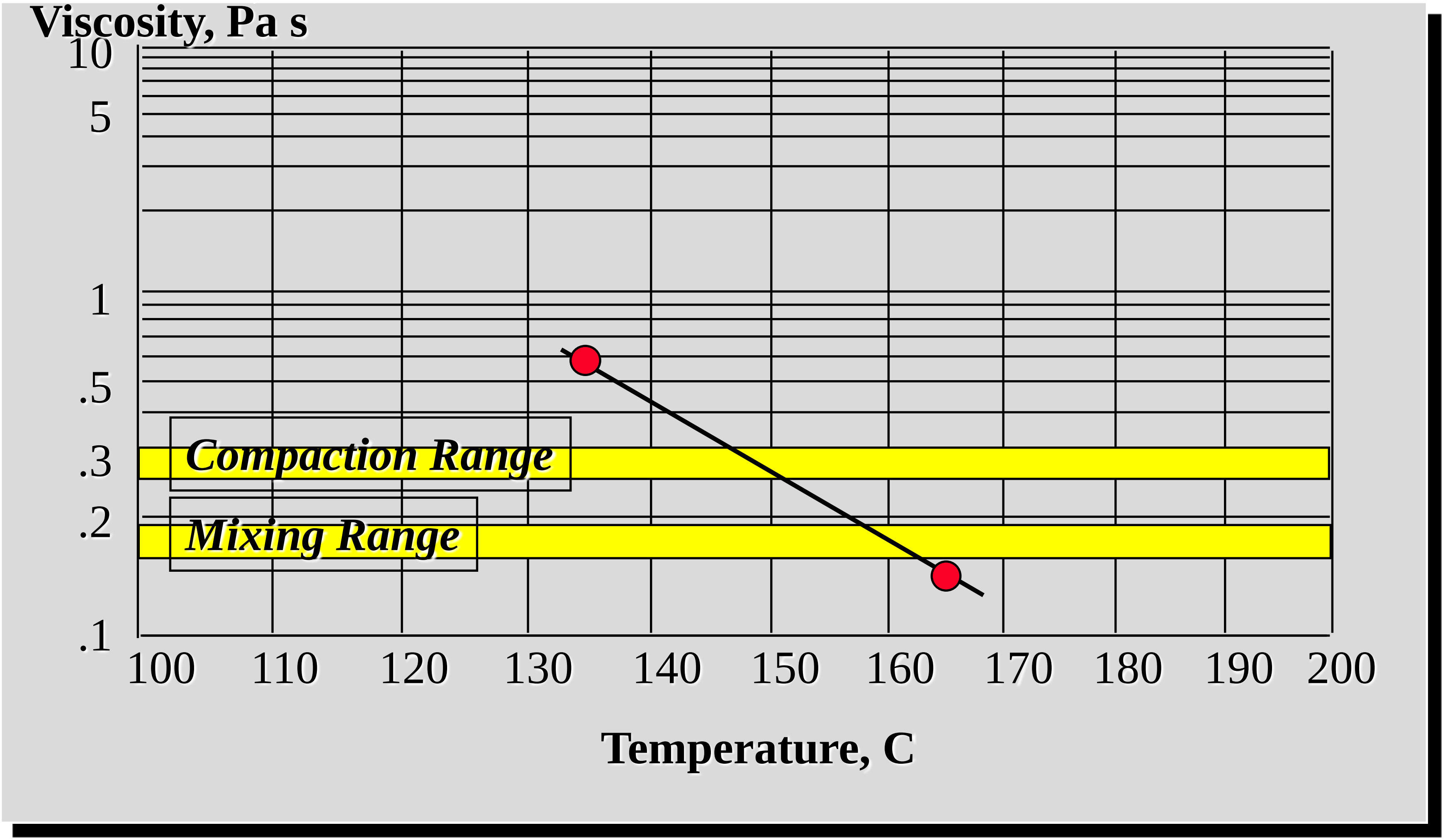
Select and test asphalt cement

- Establish mixing and compaction temperatures

Develop trial blends

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

Mixing/Compaction Temperatures



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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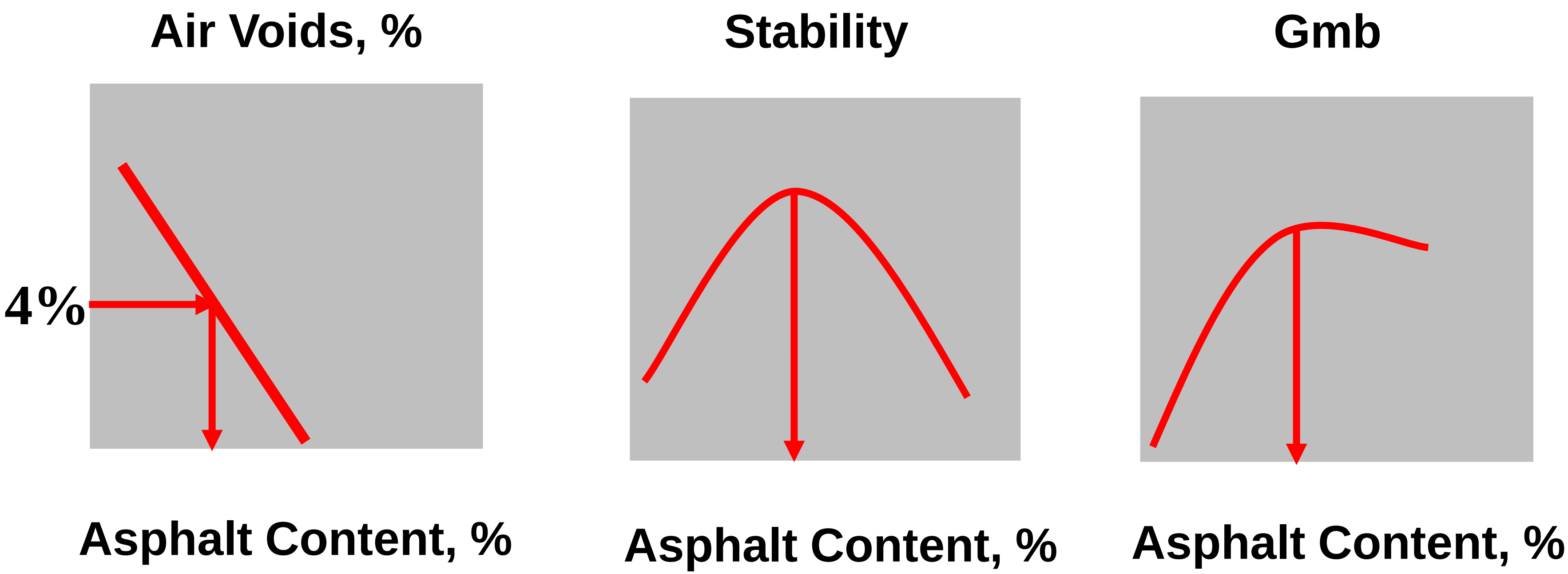
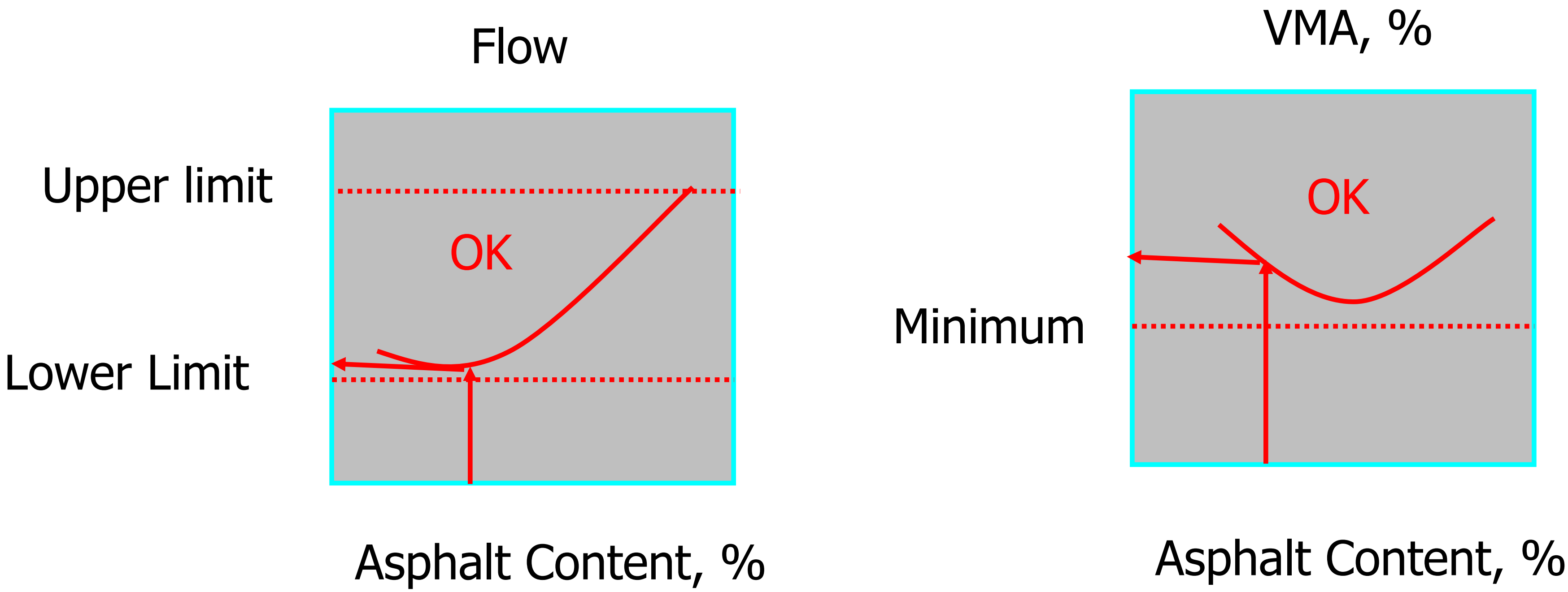
Marshall Design / Asphalt Institute Procedure



Target optimum asphalt content = average

Marshall Design / Asphalt Institute Procedure



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

Marshall Design Method

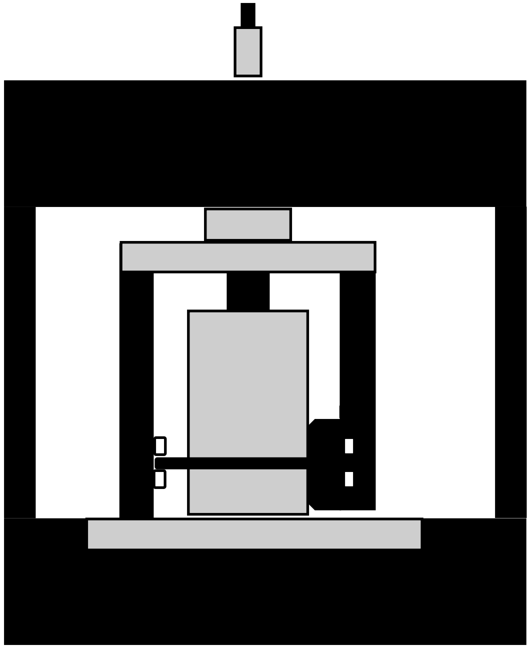
Advantages

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

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

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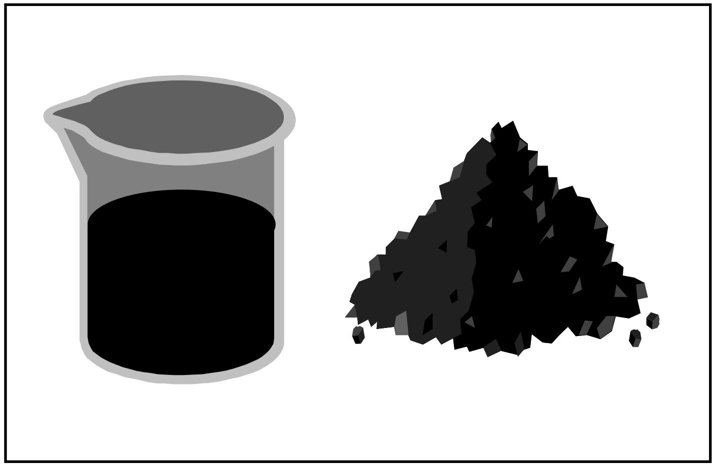
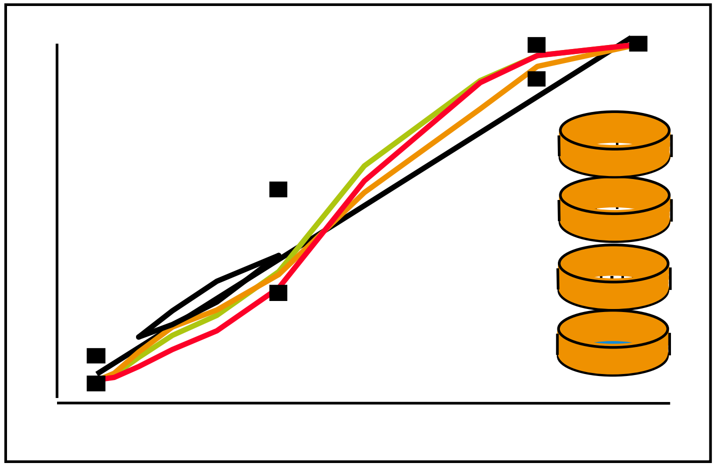
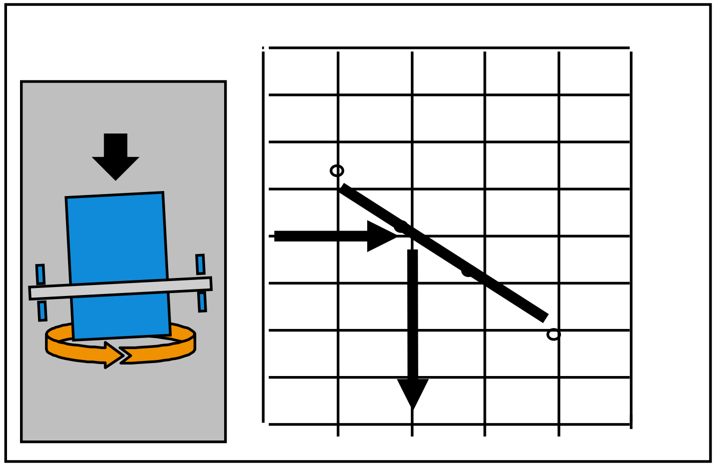
Four Steps of Superpave Mix Design



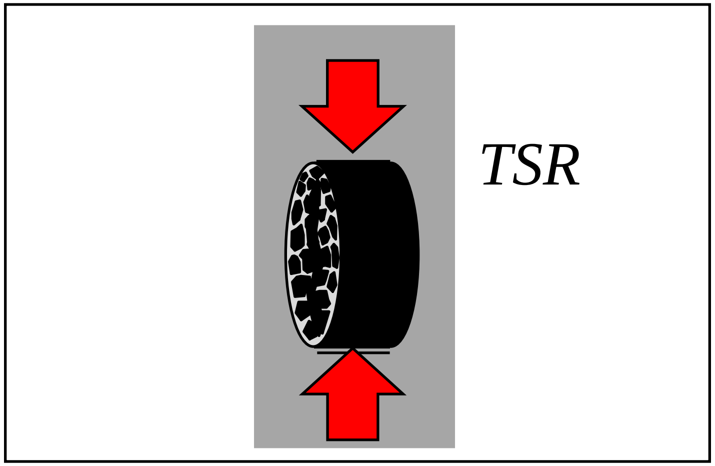
1. Materials Selection



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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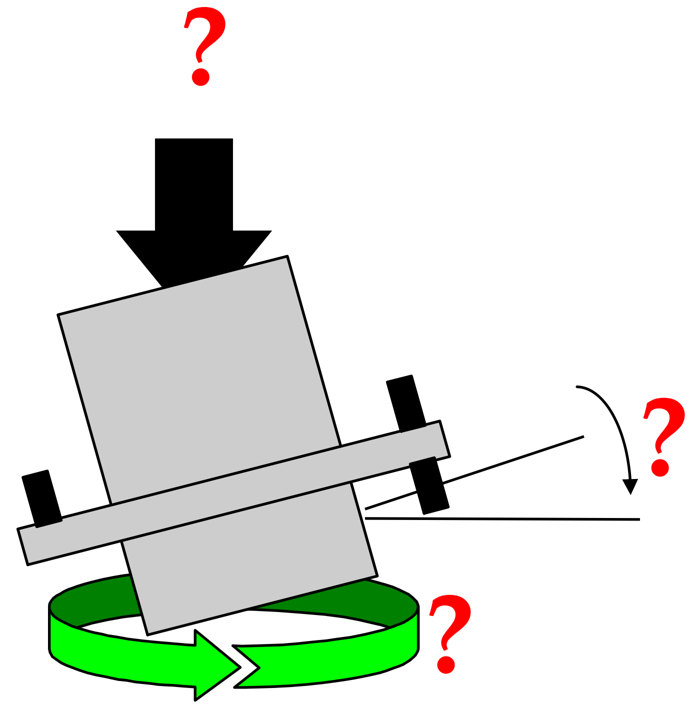
Superpave Gyratory Compactor (SGC)

Basis

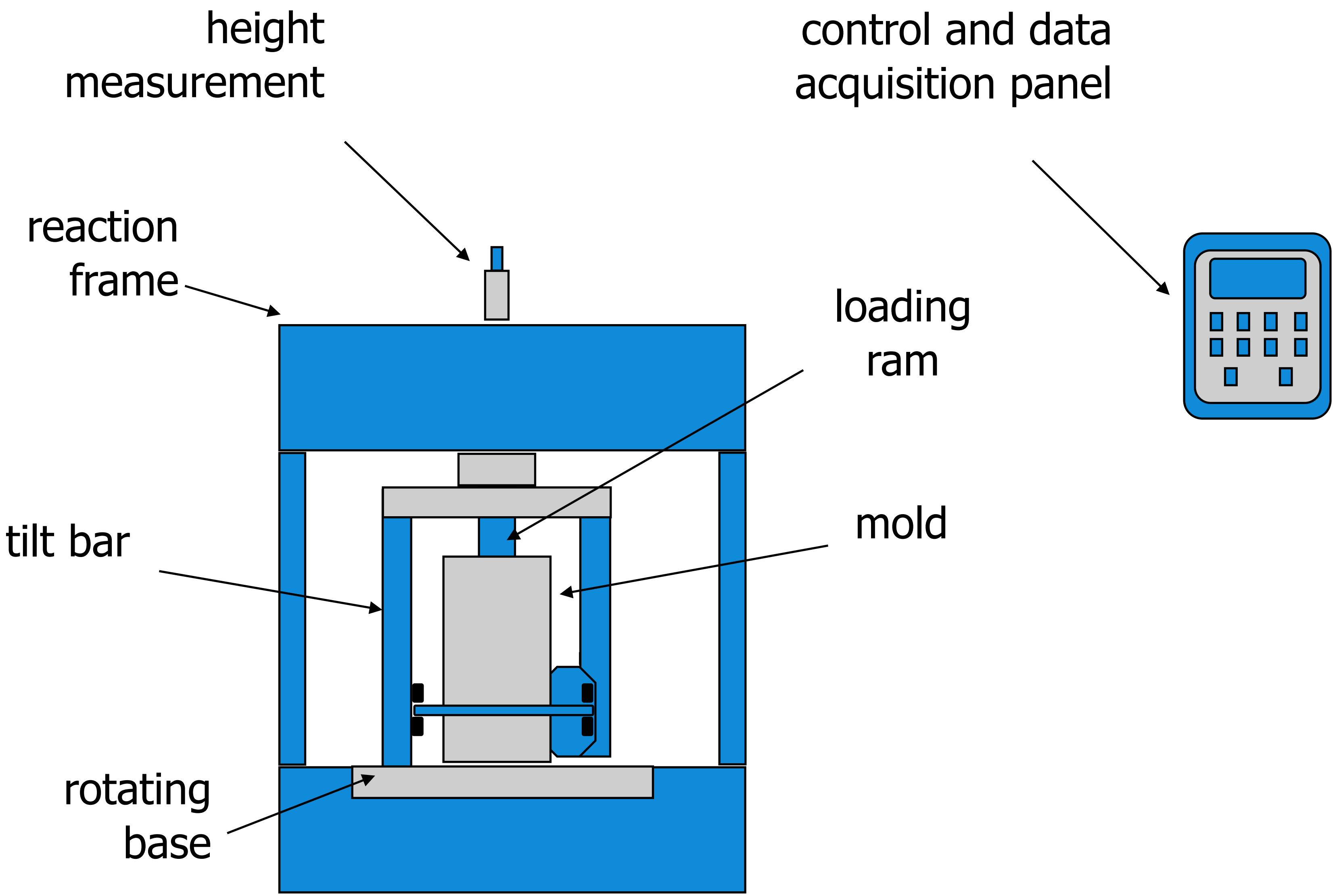
- Texas equipment
- French operational characteristics

150 mm diameter

Up to 37.5 mm nominal size
Height recordation



Superpave Gyratory Compactor (SGC)



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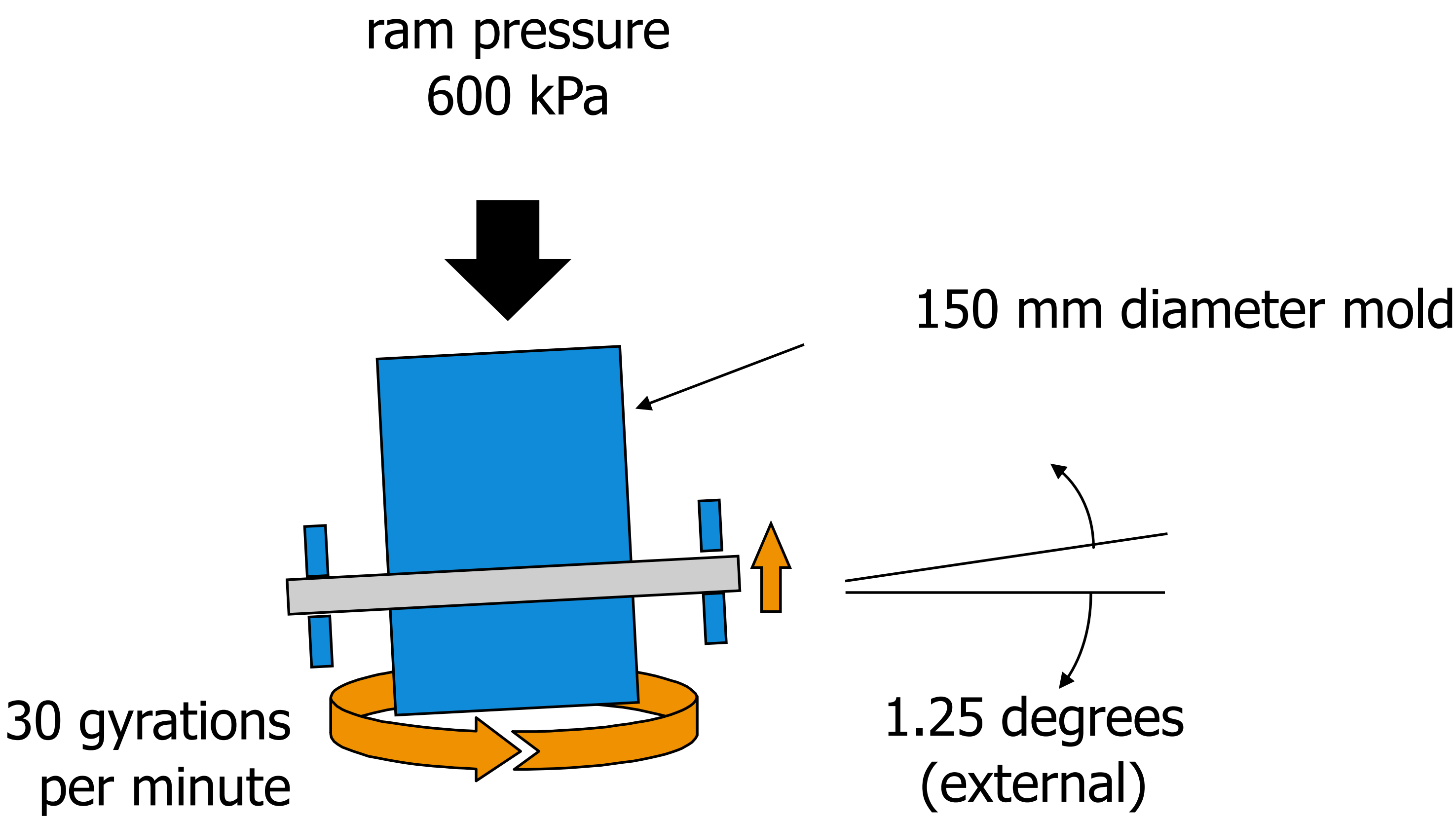
Superpave Gyratory Compactor (SGC)



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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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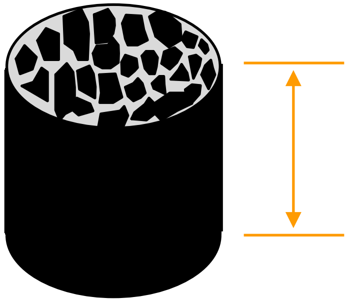
Specimen Preparation

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)



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Specimen Preparation

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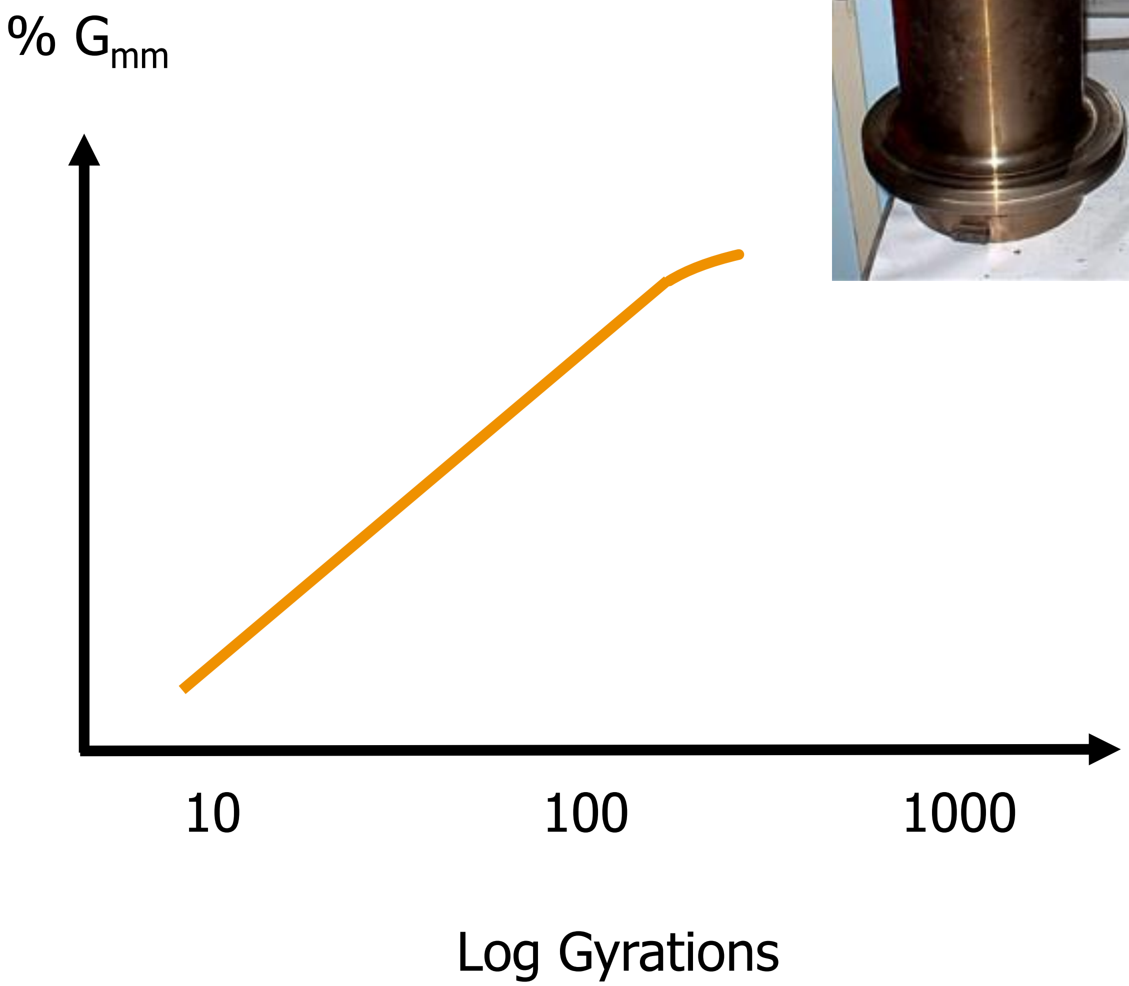
Specimen Preparation

Three Points on SGC Curve



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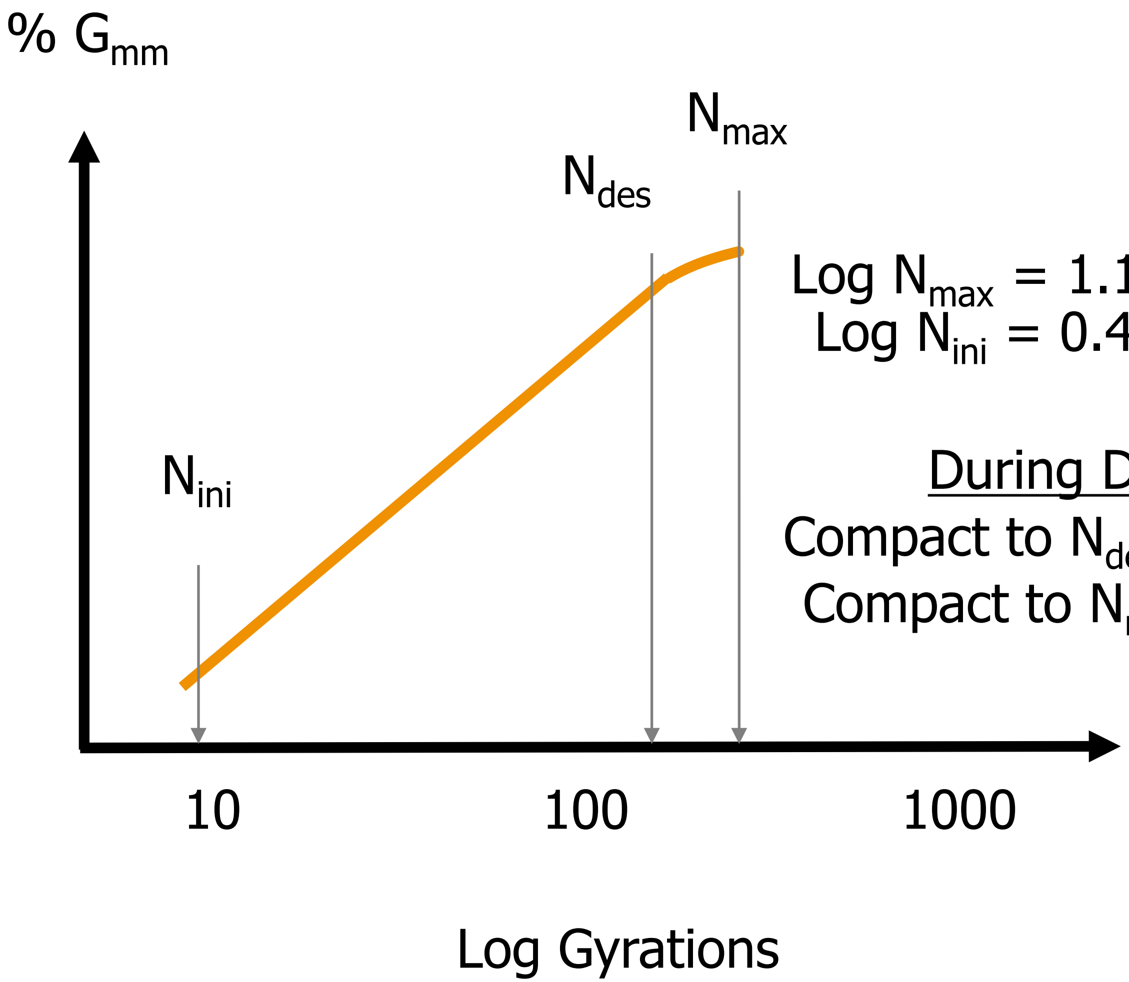
Three Points on SGC Curve



$$\text{Log } N_{max} = 1.10 \text{ Log } N_{des}$$
$$\text{Log } N_{ini} = 0.45 \text{ Log } N_{des}$$

<u>During Design:</u>

Compact to N_{des} to get opt.

Compact to N_{max} to check

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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

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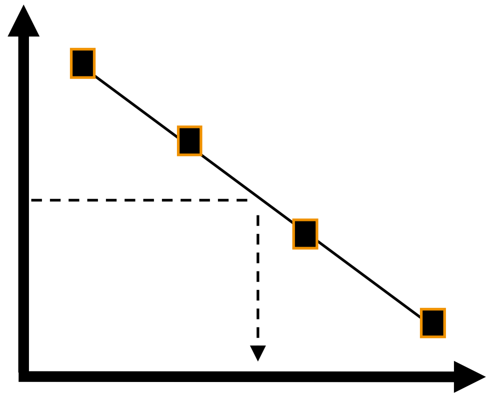
Mix Air Voids Requirement



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

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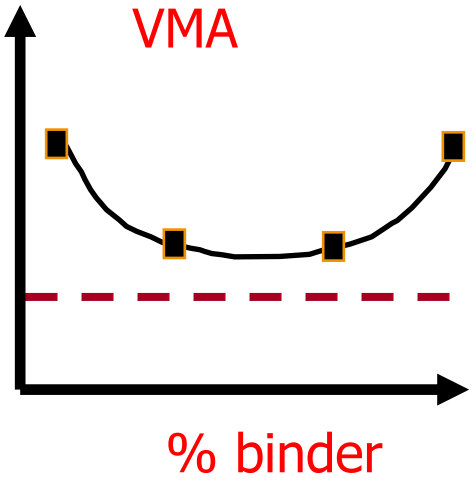
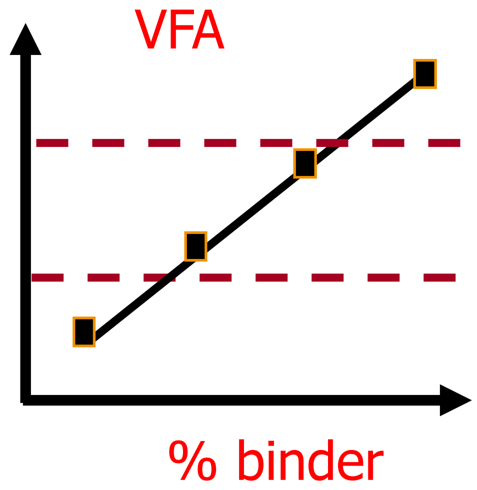
VMA Requirements



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

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

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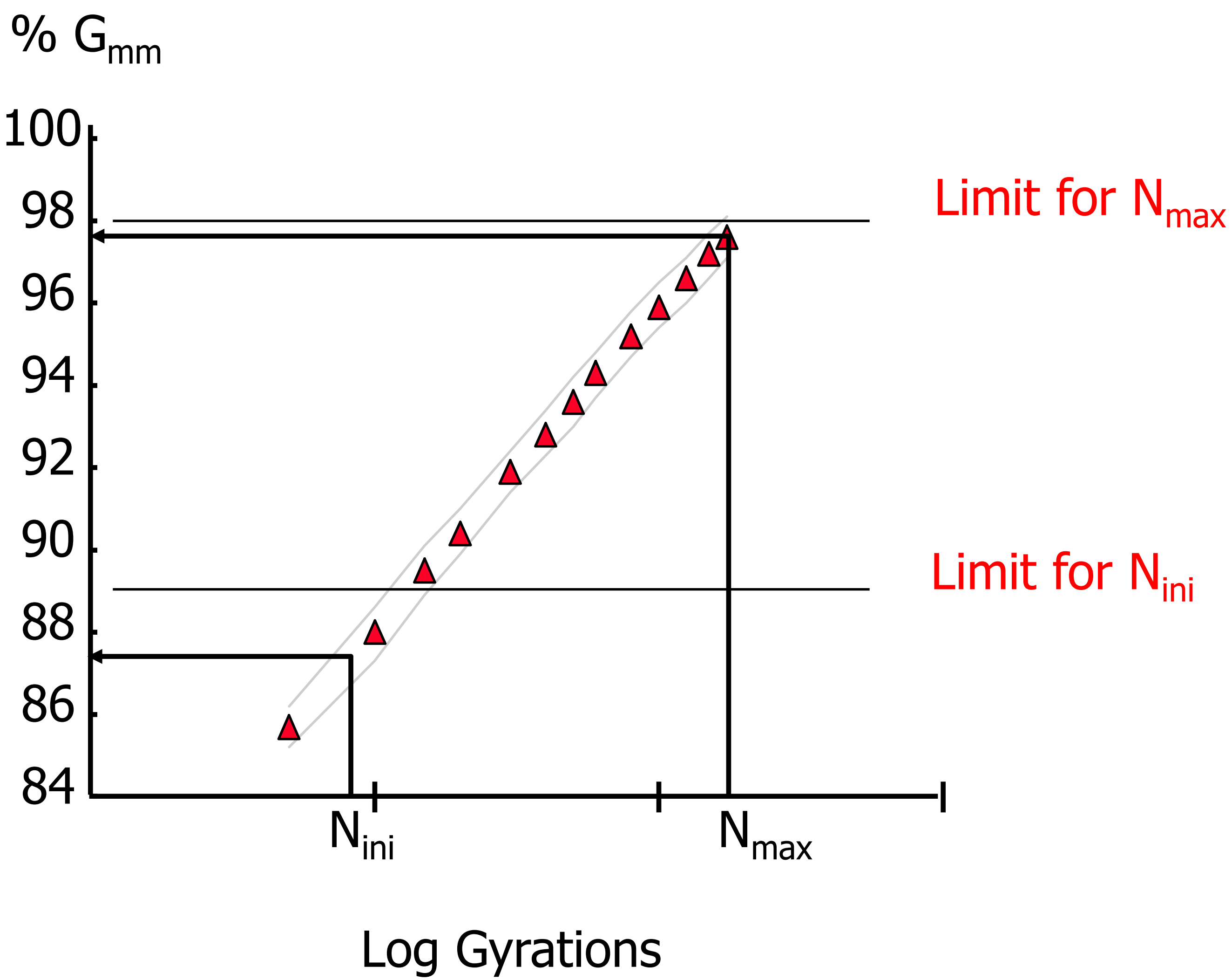
Mixture Density



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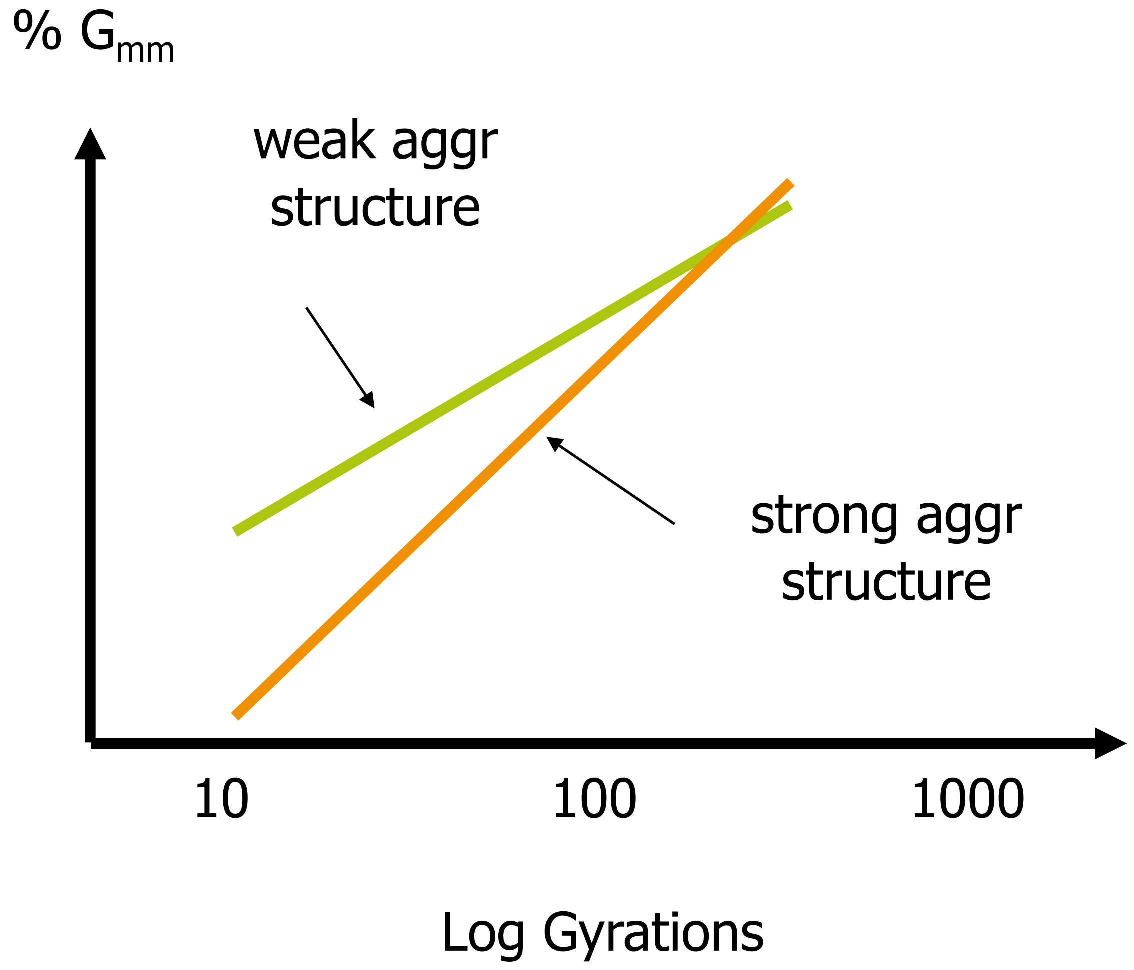
Evaluate Aggregate Structure



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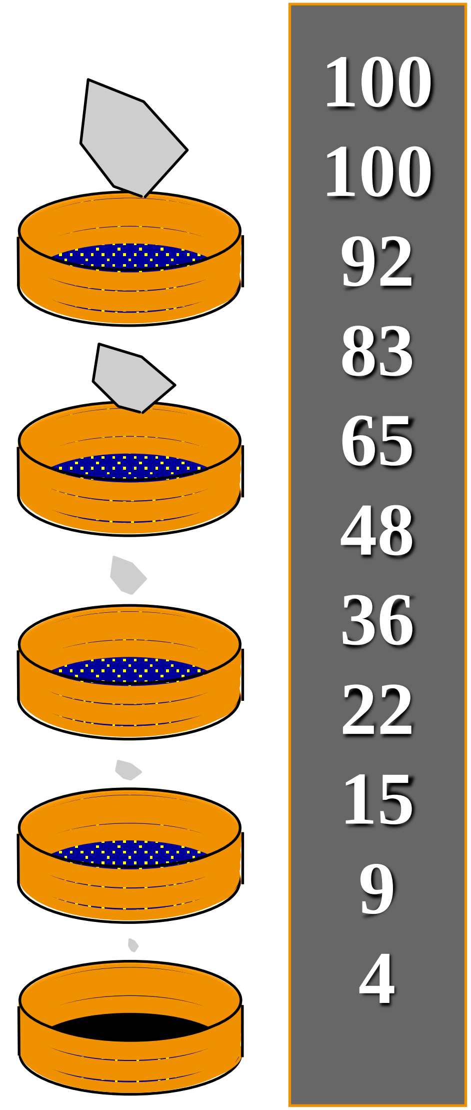
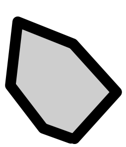
Dust Proportion

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





Unabsorbed binder in mix

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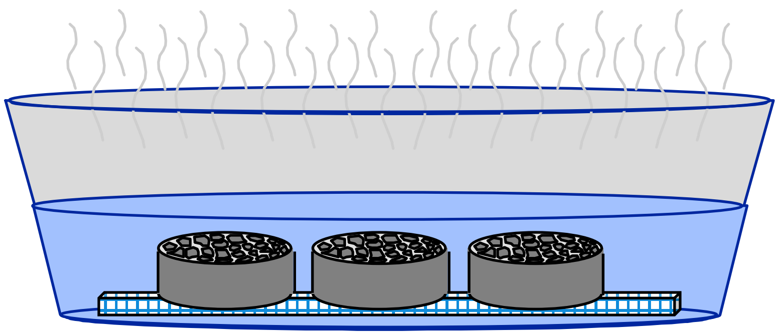
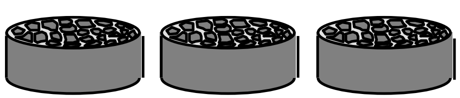
Moisture Sensitivity AASHTO T 283

Measured on proposed aggregate blend and asphalt content



3 Conditioned Specimens



3 Dry Specimens

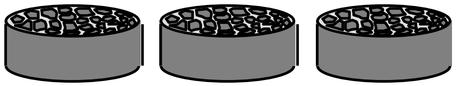
80 % minimum

Tensile Strength Ratio

AASHTO T 283 Conditioning

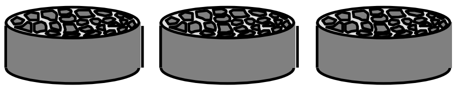
- Short term aging
  - Loose mix 16 hrs @ 60° C
  - Comp mix 72-96 hrs @ 25° C
- Two subsets with equal voids
  - One “dry”
  - One saturated

6 to 8 % air



Dry

6 to 8 % air



55 to 80 % saturation

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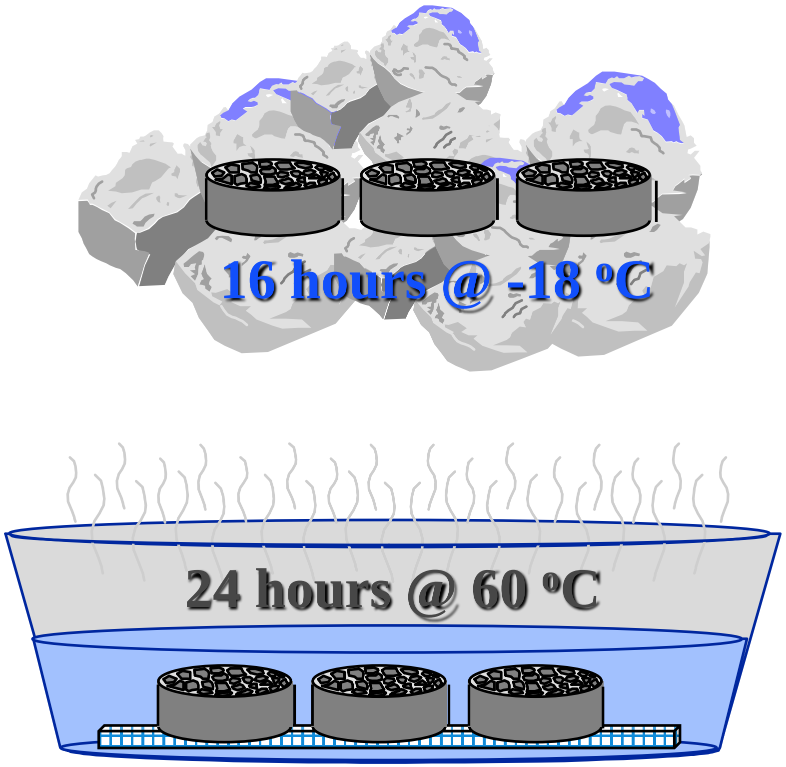
AASHTO T 283 Conditioning

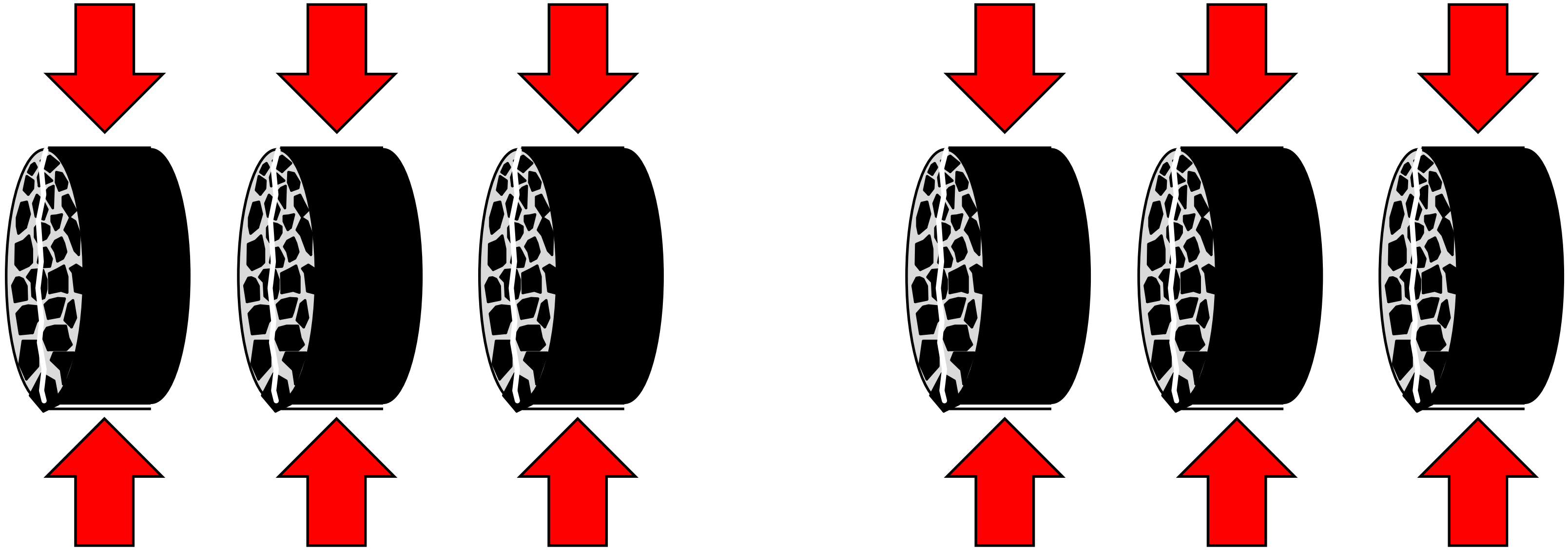
Optional freeze cycle

Hot water soak



AASHTO T 283 Test Procedure

51 mm / min @ 25 ºC



Avg Dry Tensile Strength **Avg Wet Tensile Strength**

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

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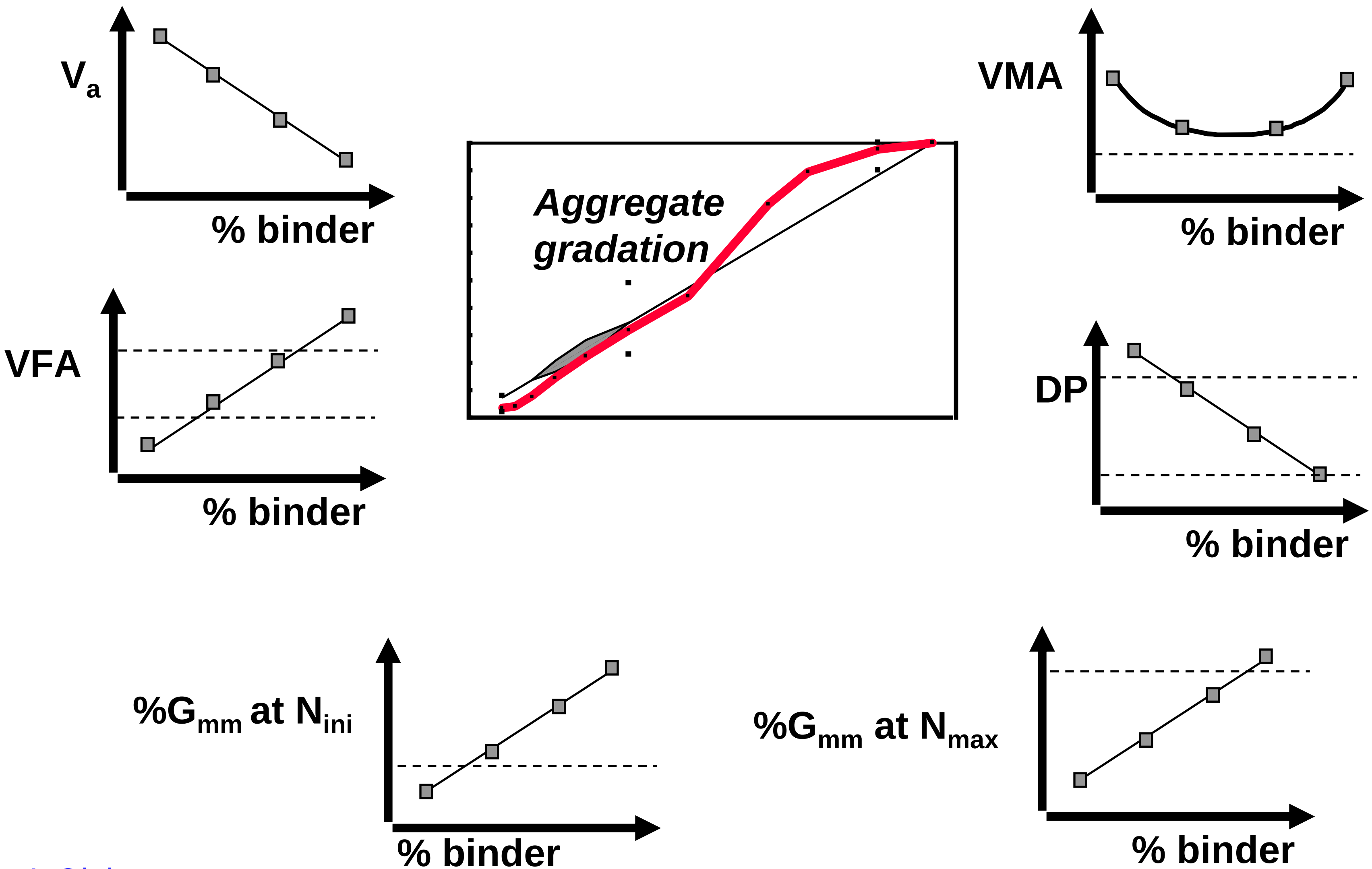
Selection of Design Asphalt Binder Content



Look for the Unusual!!!

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