Improving Hot Mix Asphalt Performance with SUPERPAVE

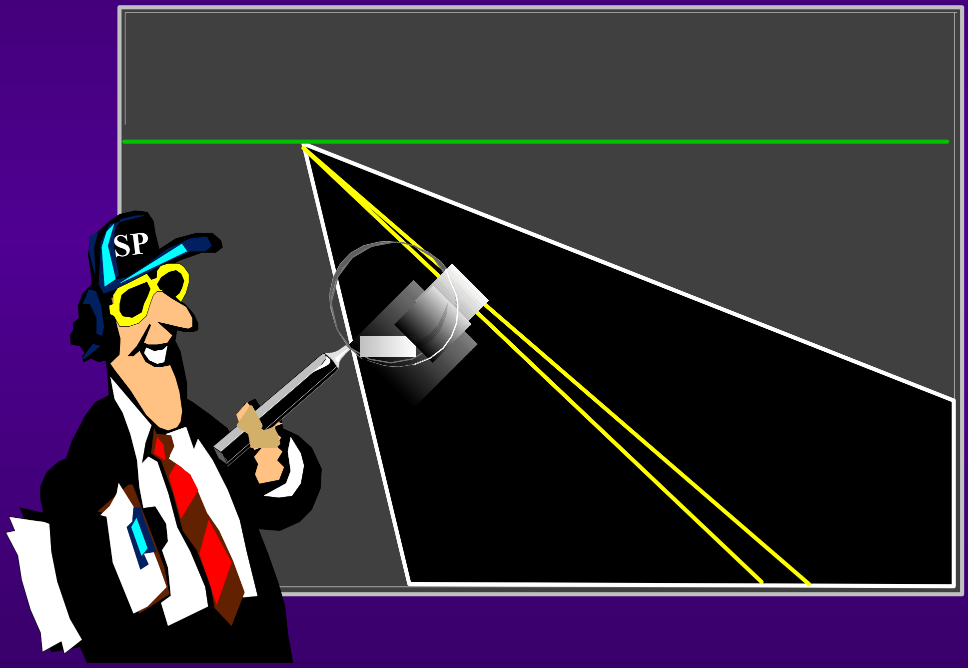
CITGO Asphalt

A Driving Force In Asphalt

SUPERPAVE Update for Intevep

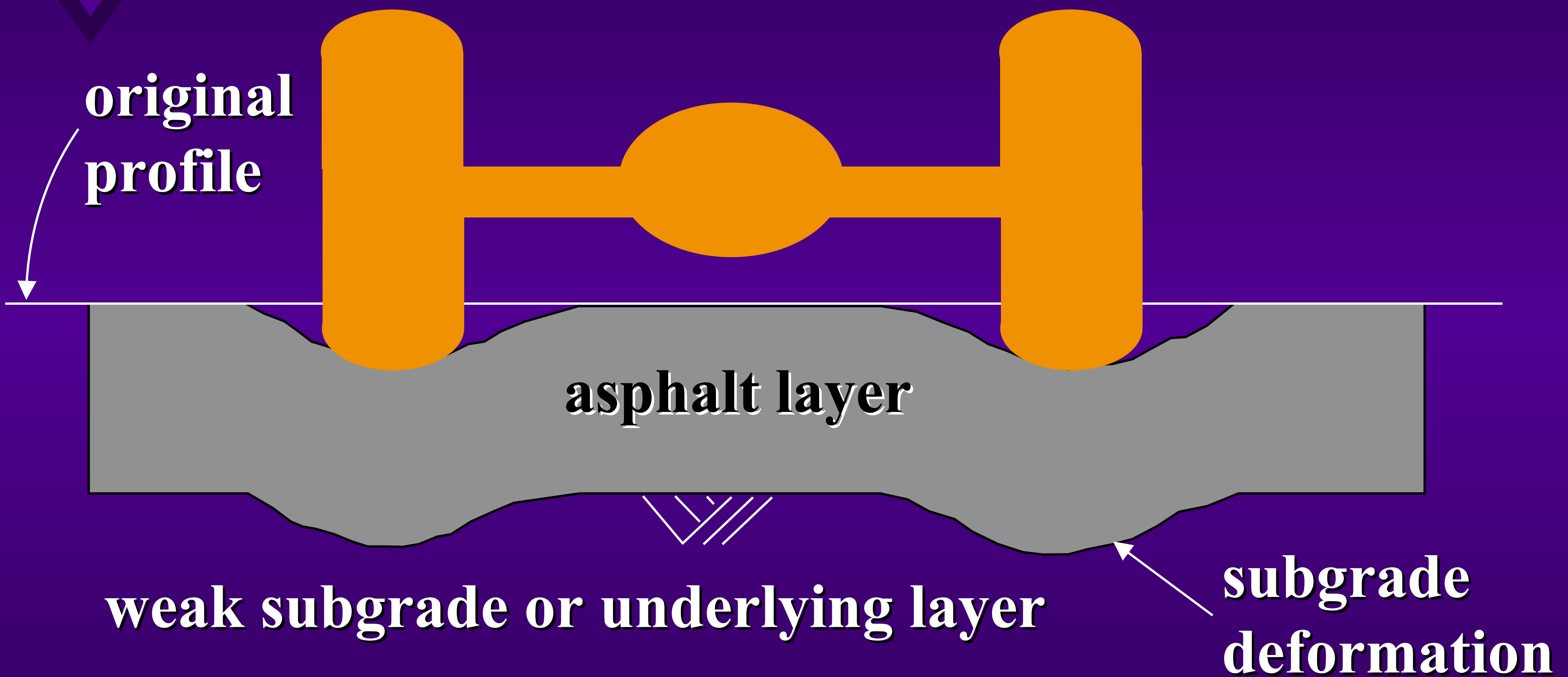
April 8, 2002

Asphalt Mixture Behavior

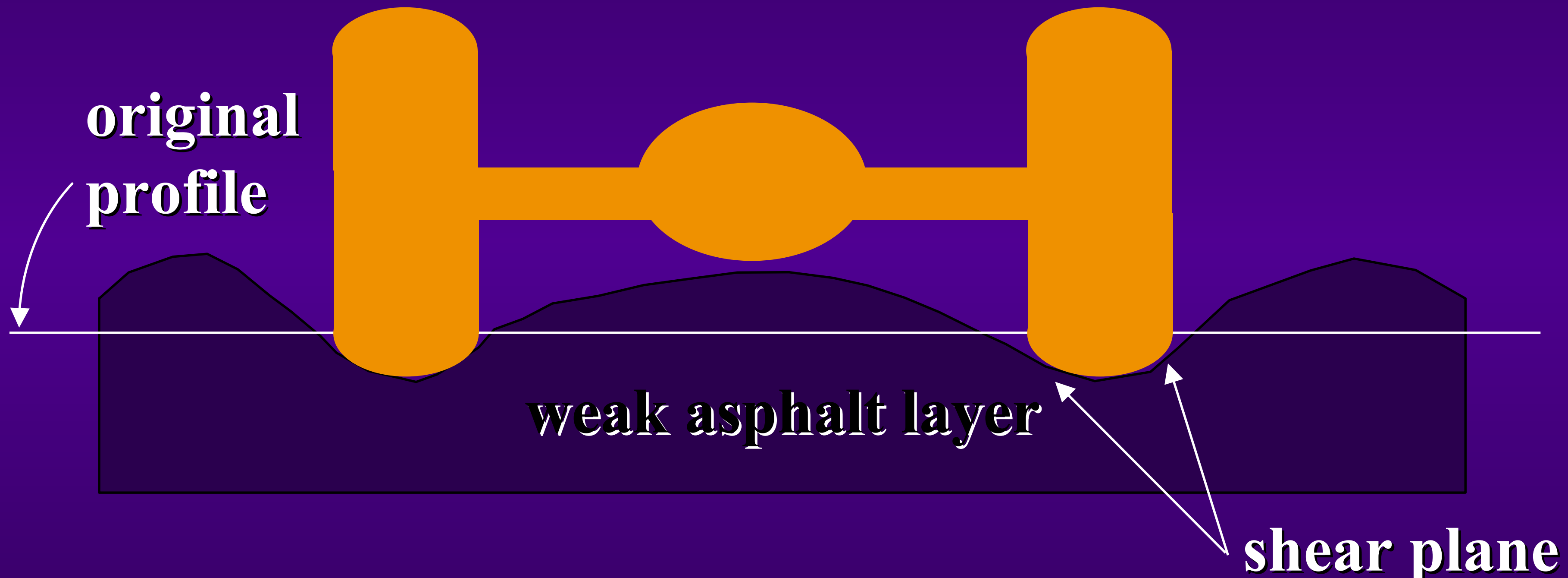


- Permanent Deformation
- Fatigue Cracking
- Low Temperature Cracking

Rutting in Subgrade or Base



Rutting in Asphalt Layer

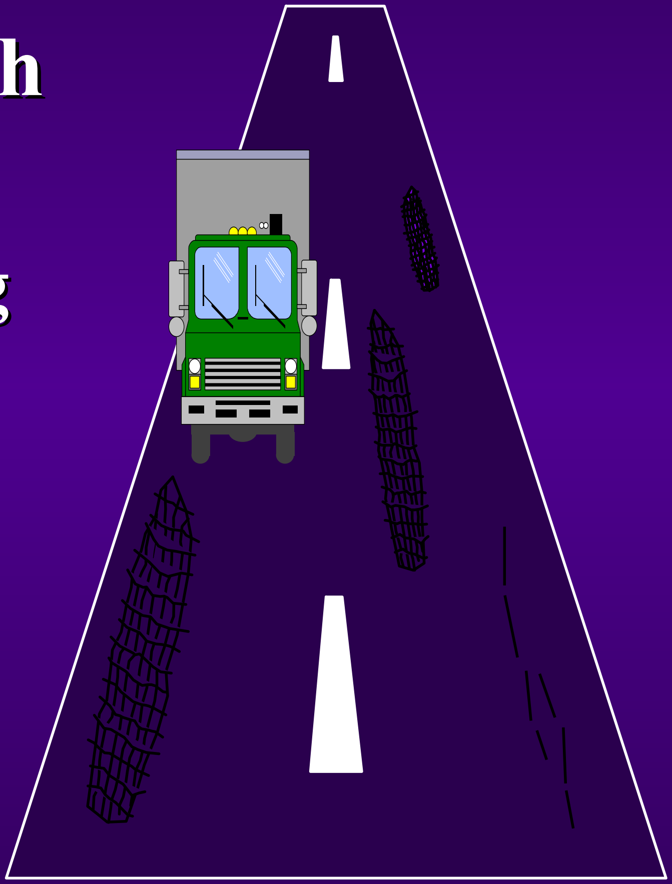


Mixture Resistance to Rutting

- **Asphalt Binder**
  - **stiff and elastic at high temperatures**
- **Aggregate**
  - **high interparticle friction**
  - **gradation acts like *one large elastic stone***

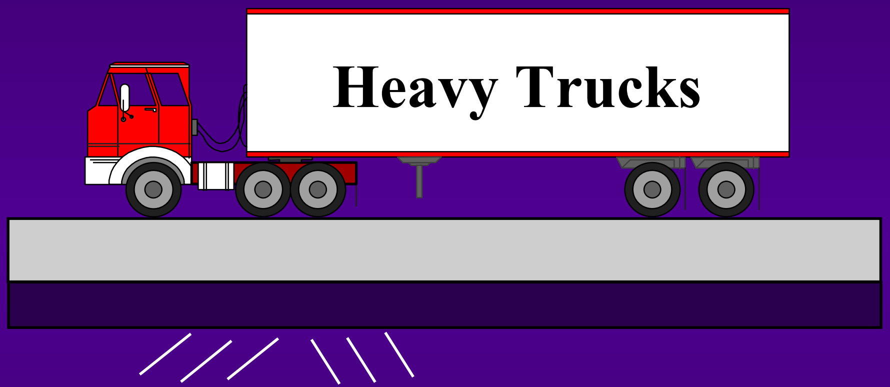
Fatigue Cracking

- Distress in Wheelpath
- Progressive Damage
  - longitudinal cracking
  - alligator cracking
  - potholes
- Affected by
  - asphalt binder
  - aggregates
  - pavement structure

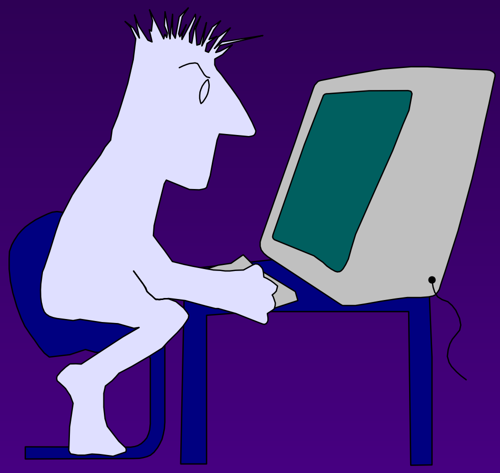


HMA Fatigue Behavior

- Longer Fatigue Life
  - flexible materials
  - low stress/strain level
- Shorter Fatigue Life
  - stiff materials
  - high stress/strain level
- Exception
  - thick pavements
  - non-deflecting support layers

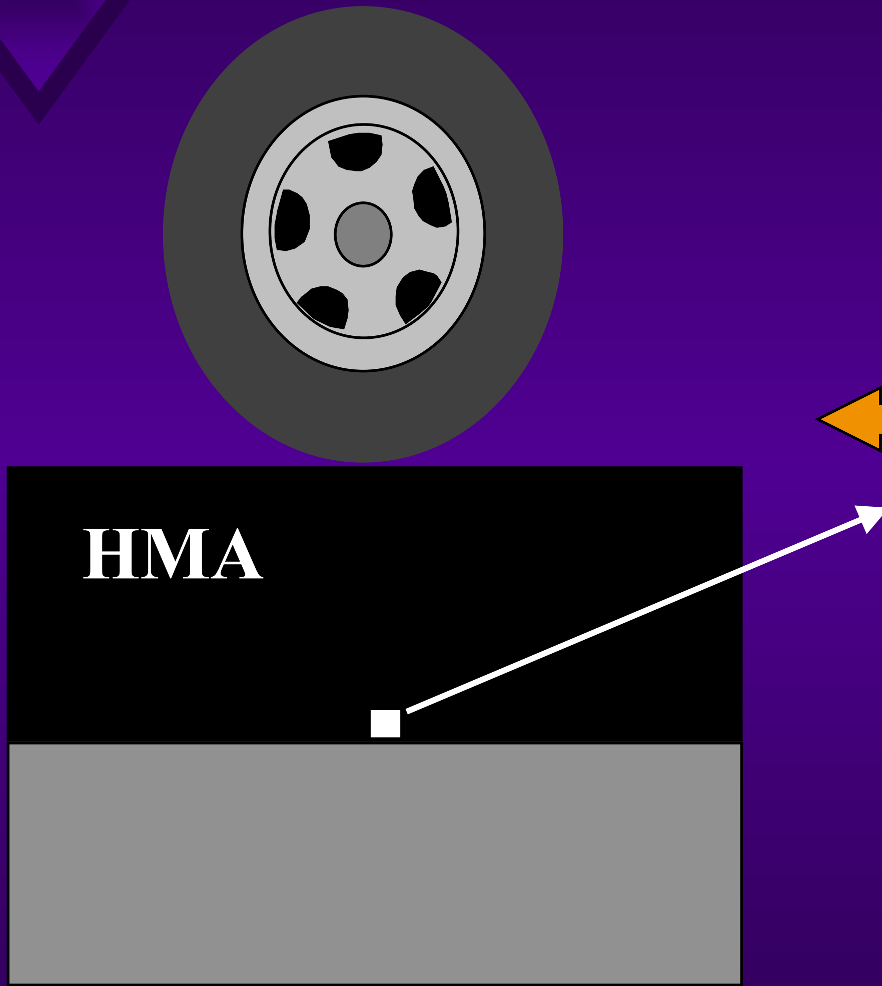


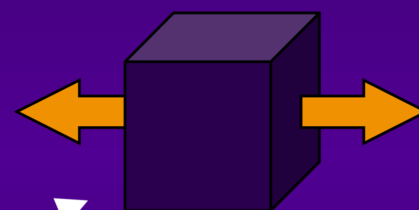
Cures for Fatigue Cracking



- Design for actual number of heavy loads
- Keep subgrade dry (i.e., low deflections)
- Use thicker pavements
- Use non-moisture susceptible materials
- Use paving materials that are resilient

Fatigue Cracking

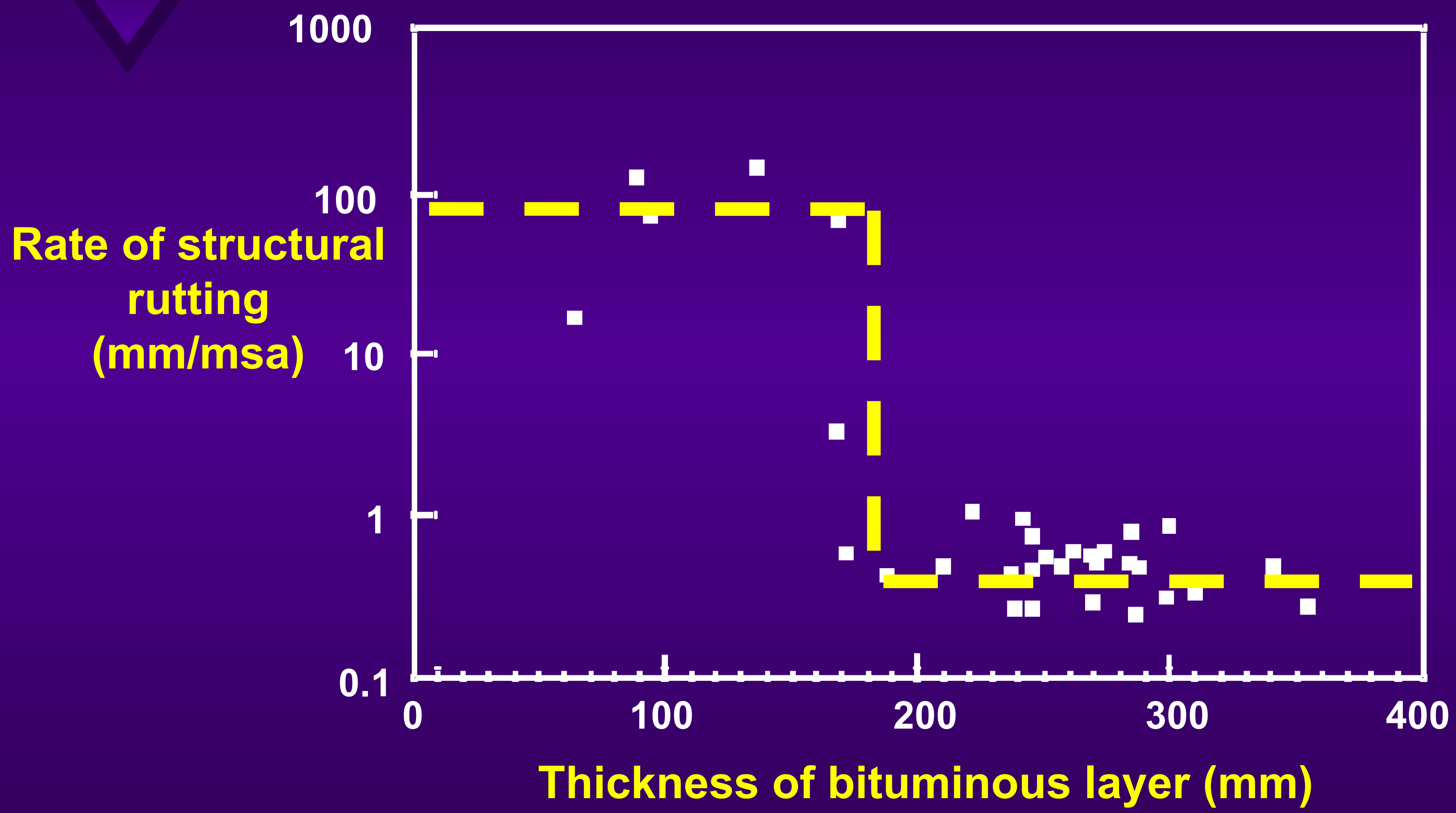




tensile stresses at bottom of pavement

HMA must be strong & resilient

Experience with Perpetual Pavements
Mike Nunn – TRL/ UK



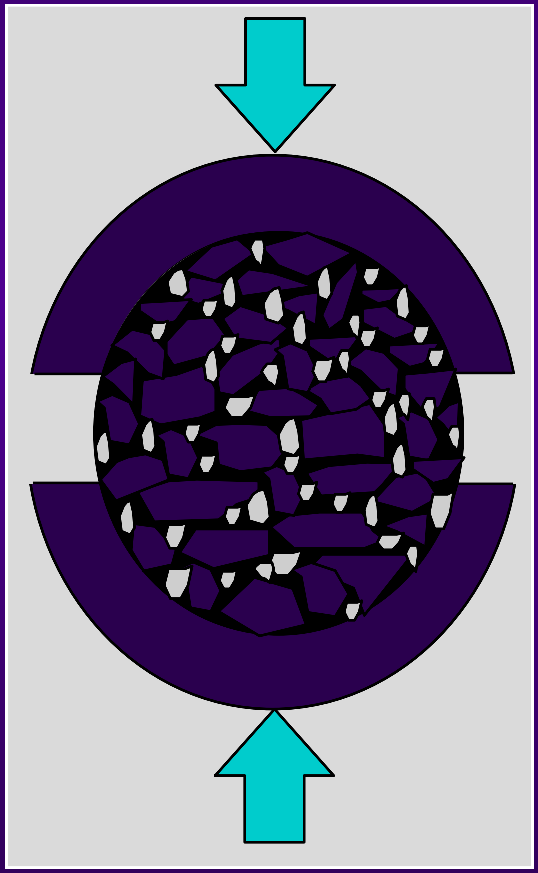
Top-Down Fatigue Cracking

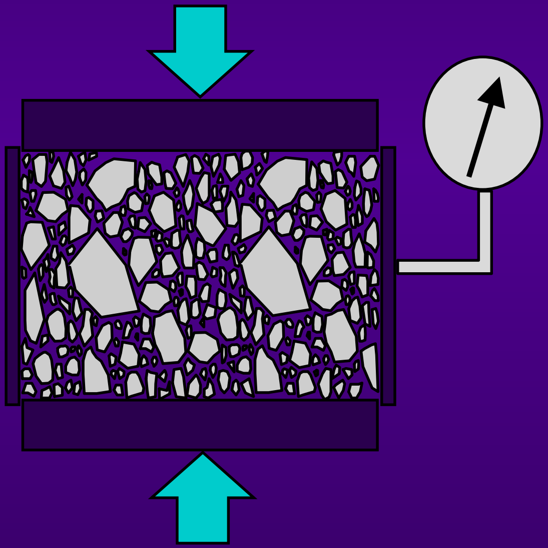
Top-down fatigue cracking on New Jersey I-287

Top-Down Cracking

- Core from New Jersey I-287

Pre-Superpave Asphalt Mixture Design





Pre-Superpave Mix Design Shortcomings

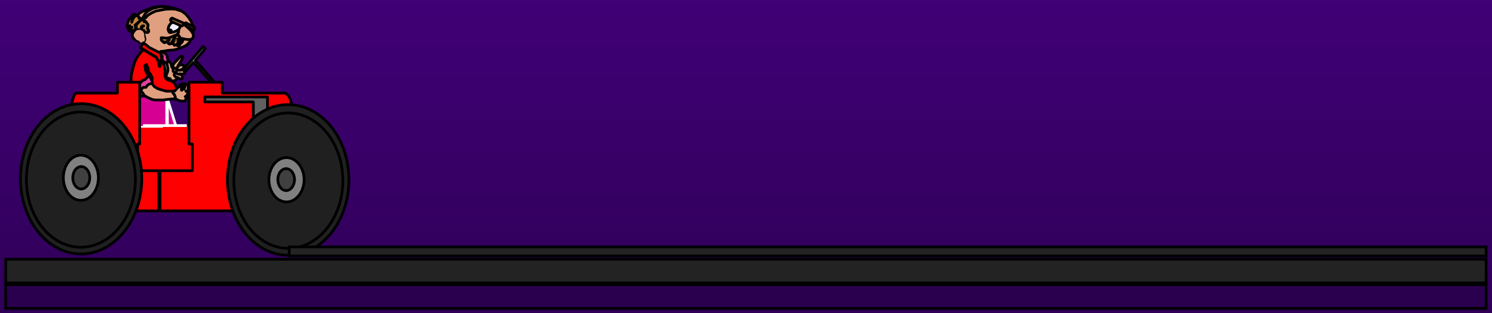
- Marshall Mix Design
  - impact compaction unrealistic
  - Marshall stability not related to performance
- Hveem Mix Design
  - equipment more expensive and not portable
  - some volumetric properties not emphasized
  - asphalt content selection very subjective

Goals of SHRP

- <u>Performance Spec for "Binders"</u>
  - physical property tests
- <u>Mix Design System</u>
- Mixes that resist rutting and cracking
  - component requirements
  - volumetric proportioning
- Performance Based Mix Analysis System

Goals of Compaction Method

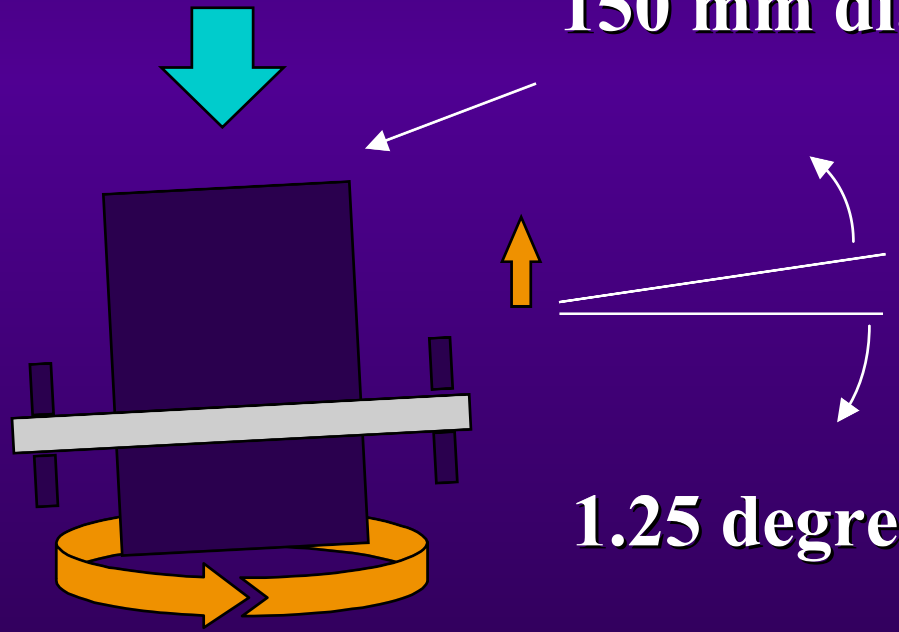
- Simulate field densification
  - Accommodate large aggregates
- Measure compactability
- Conducive to field QC



SUPERPAVE Gyratory Compactor (SGC)

ram pressure
600 kPa

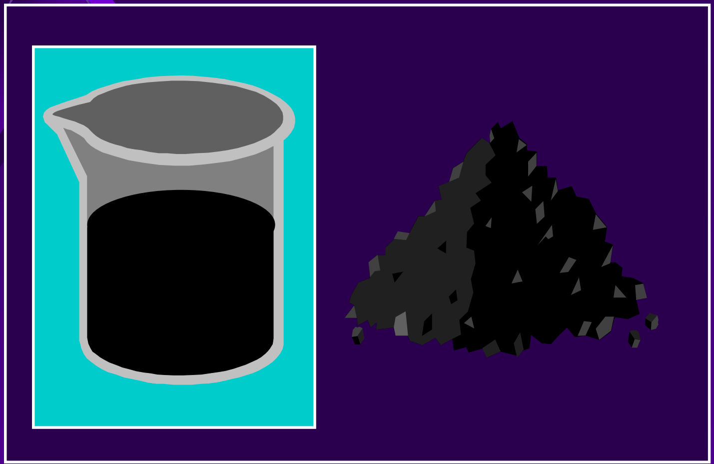
150 mm diameter mold



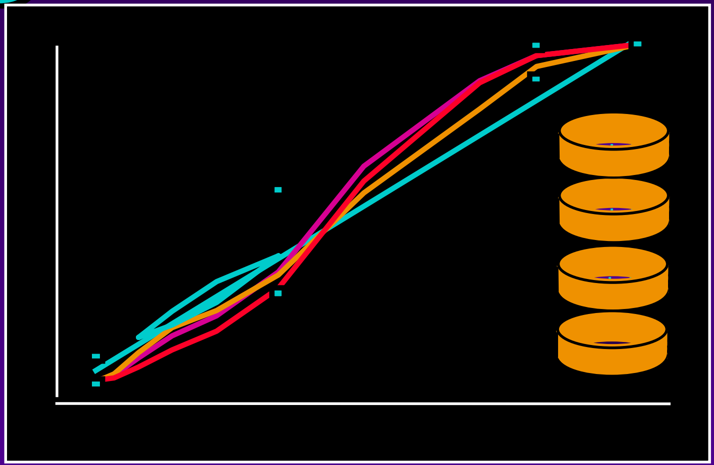
30 gyrations
per minute

1.25 degrees

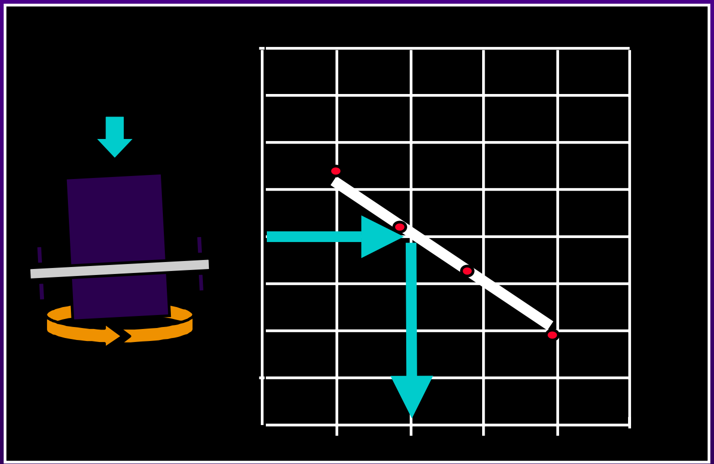
4 Steps of Superpave Mix Design



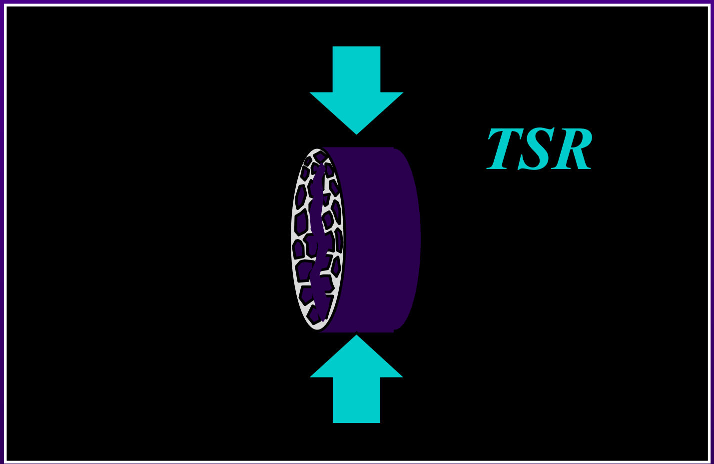
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content

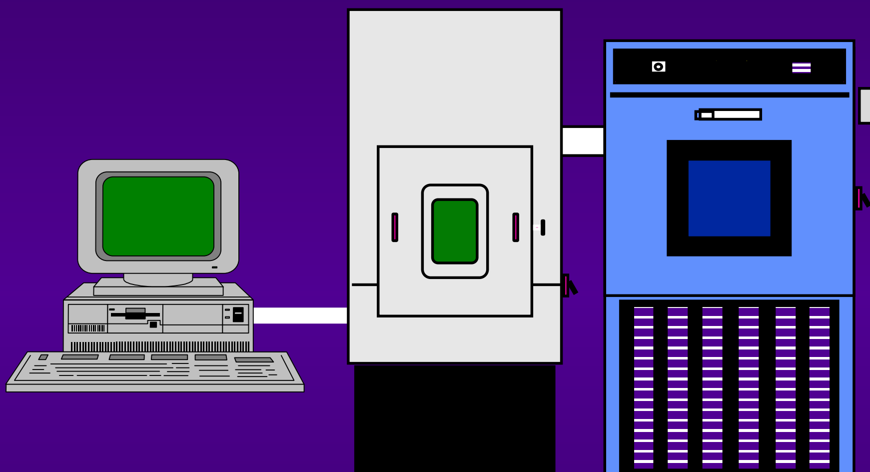


4. Moisture Sensitivity

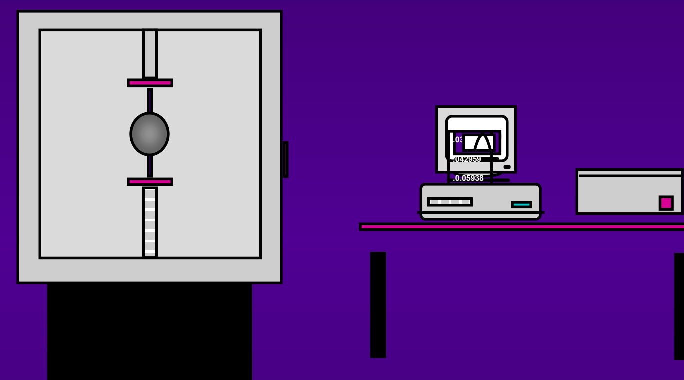
Original Concept of SHRP

- **Three tiered approach**
- **<u>Level 1</u> – Volumetric mix design**
- **<u>Level 2&3</u> – Mix Preformance tests and models**

Performance Based Tests

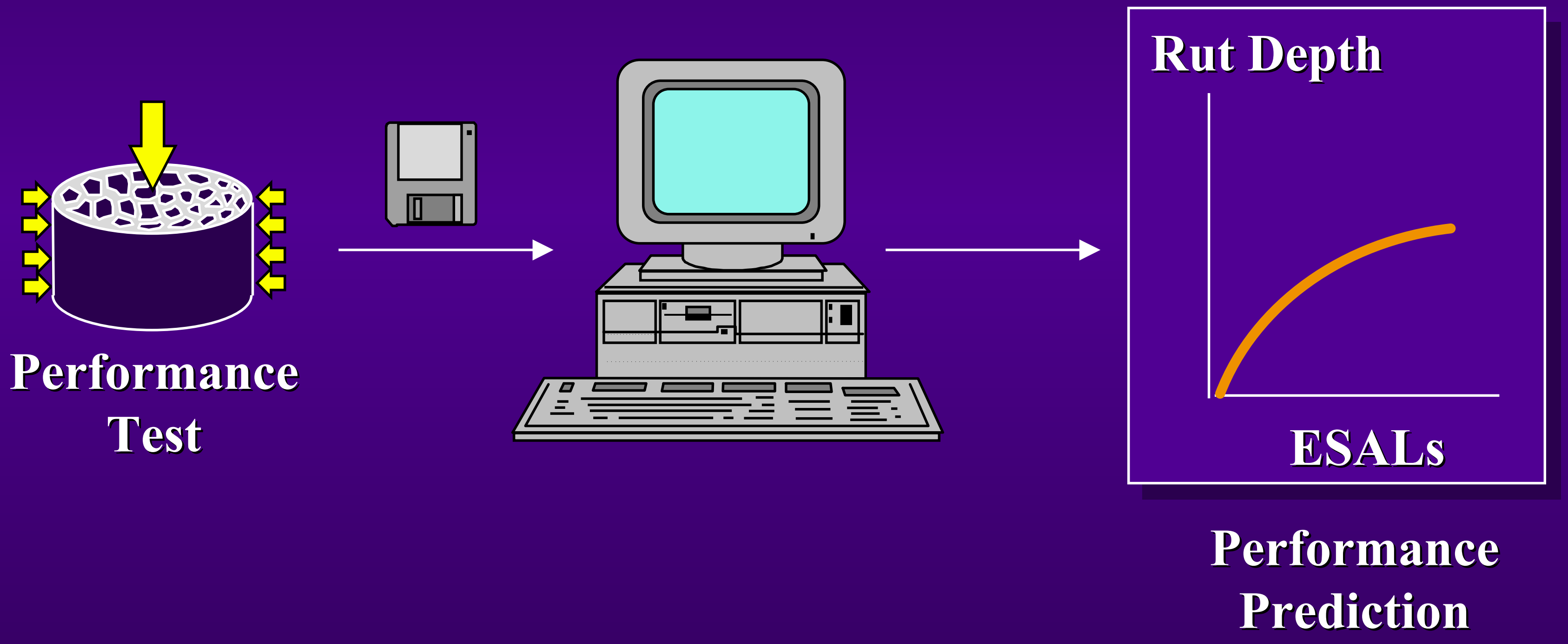


Superpave Shear Tester (SST)

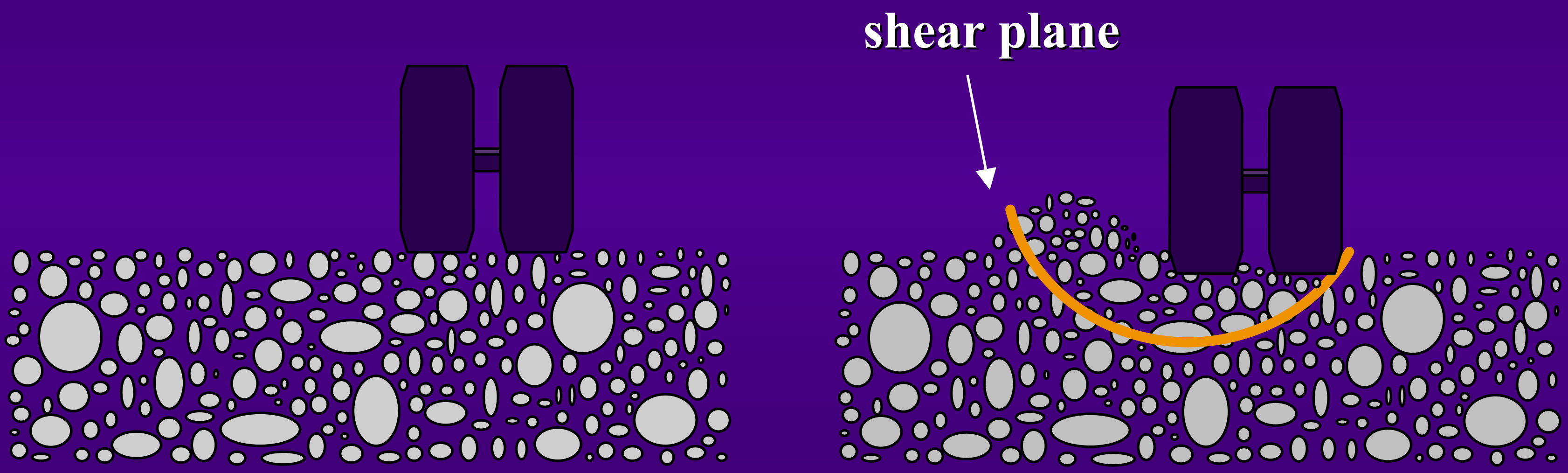


Indirect Tensile Tester (IDT)

Superpave Performance Testing
What Are We Doing?



Shearing Behavior of Aggregate

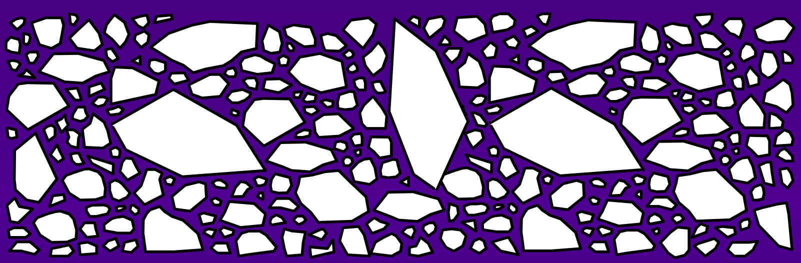


Before Load **After Load**

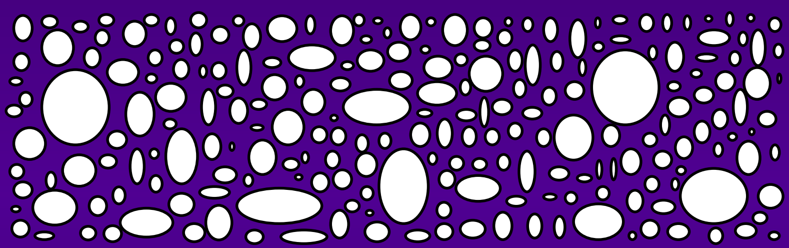
Aggregate Properties

- **Consensus Properties - *required***
  - coarse aggregate angularity (CAA)
  - fine aggregate angularity (FAA)
  - flat, elongated particles
  - clay content
- **Source Properties - *agency option***
  - toughness
  - soundness
  - deleterious materials

Contrasting Stone Skeletons



Cubical Aggregate



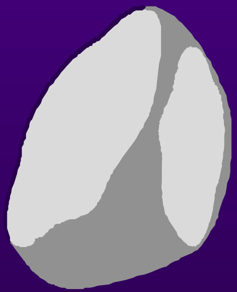
Rounded Aggregate

Coarse Aggregate Angularity

Traffic ESALs	Depth from Surface < 100 mm	Depth from Surface > 100 mm	
•	•	•	
10 - 30 x 10^6	95/90	80/75	Minimum
•	•	•	
•	•	•	

95% one fractured face

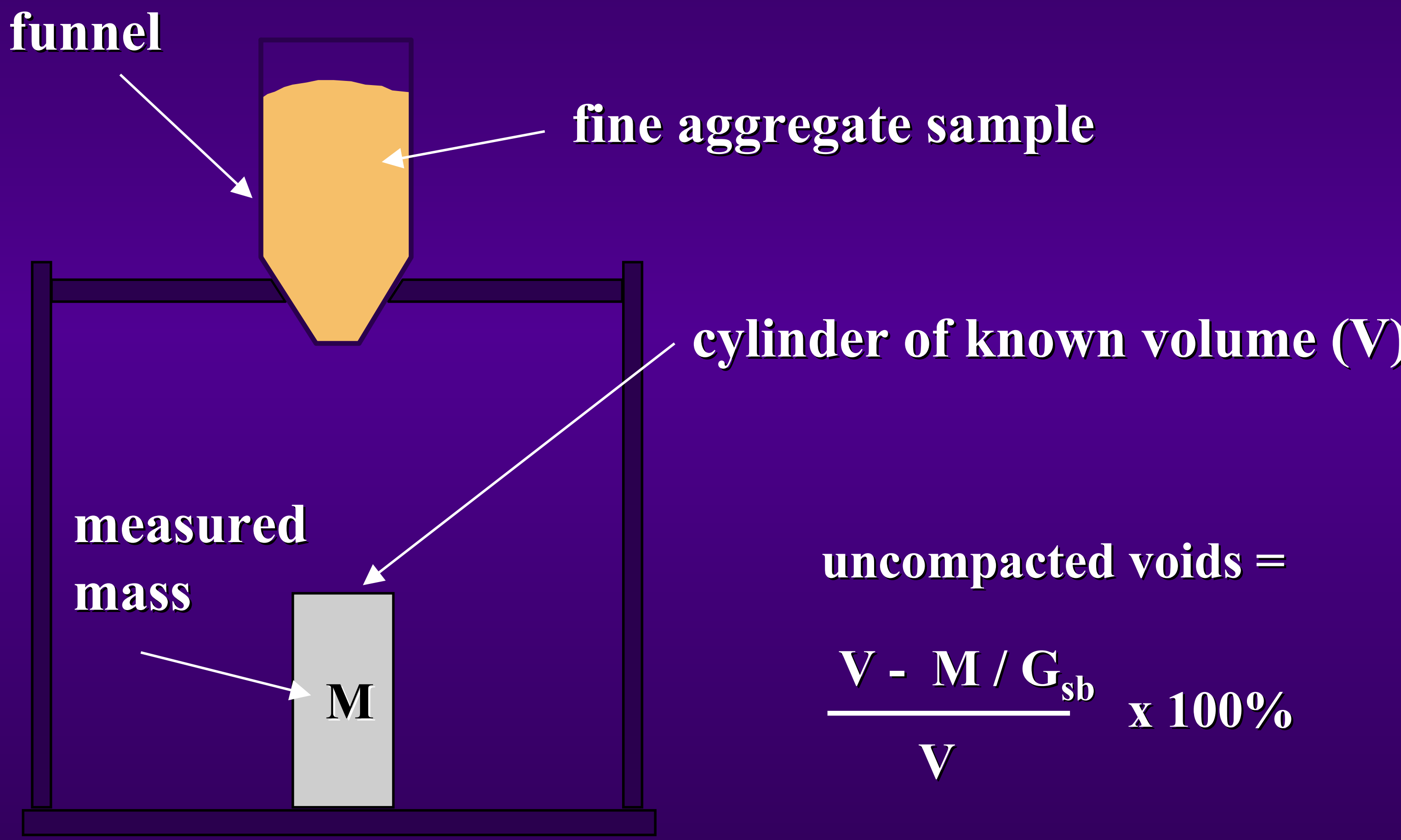
90% two+ fractured faces



Fine Aggregate Angularity

- Measured on - 2.36 mm Material
- Based on Air Voids in Loose Sample
- AASHTO T 304
- Requirements Depend on
  - depth of layer within pavement
  - traffic level

Fine Aggregate Angularity



uncompacted voids =

$$\frac{V - M / G_{sb}}{V} \times 100\%$$

Fine Aggregate Angularity

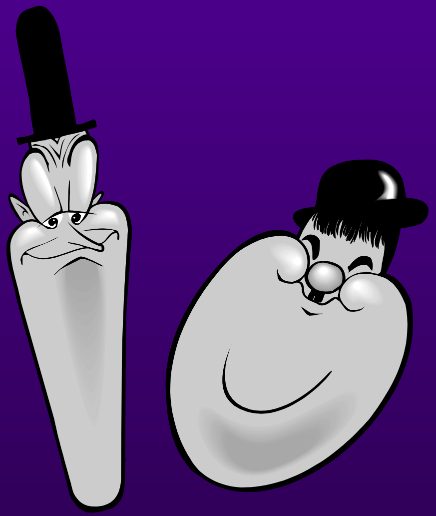
Traffic ESALs	Depth from Surface < 100 mm	Depth from Surface > 100 mm
.	.	.
$10 - 30 \times 10^6$	45	40 Minimum
.	.	.
.	.	.

% air voids in loose sample

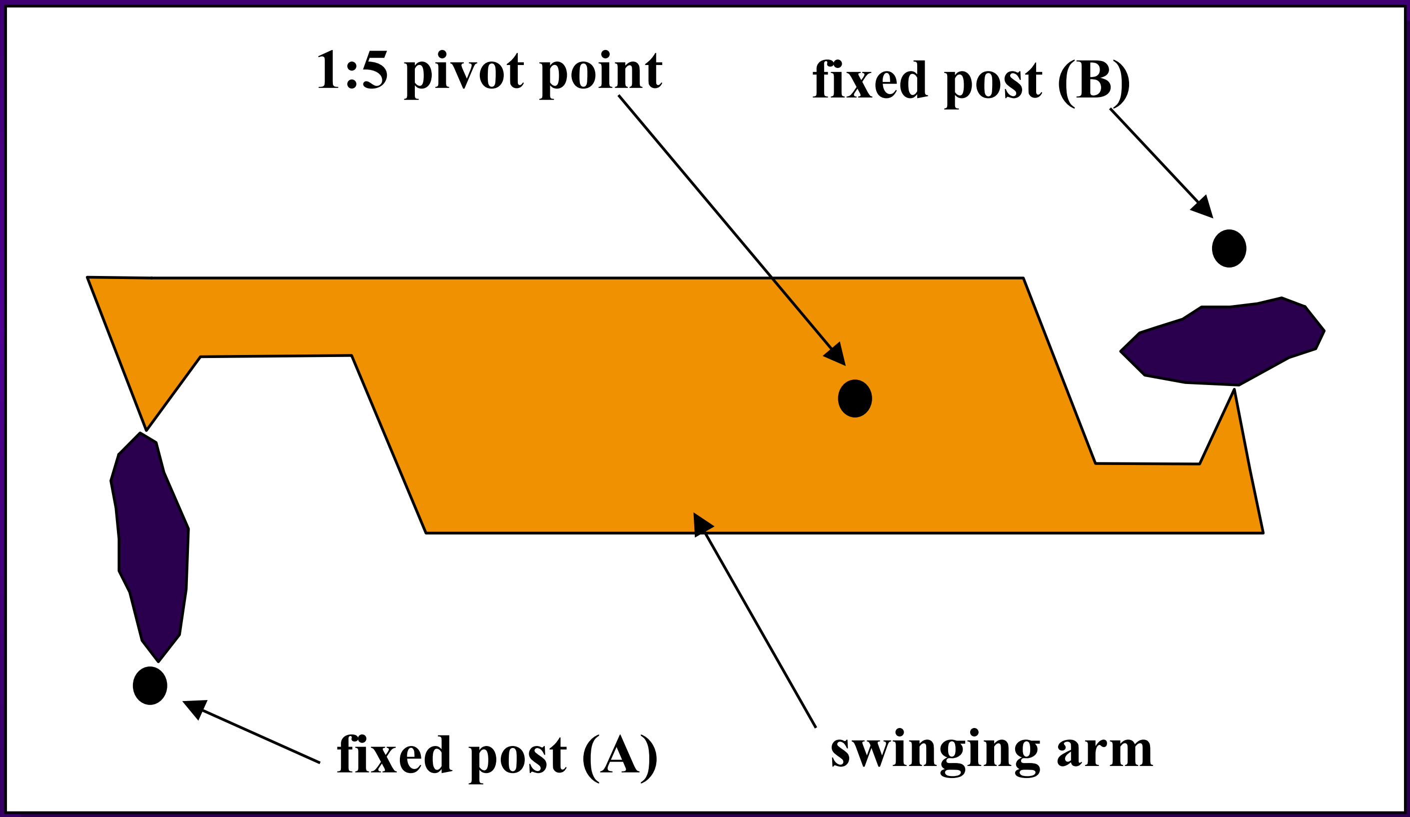
> Rounder particles pack tighter together -- less air

Flat, Elongated Particles

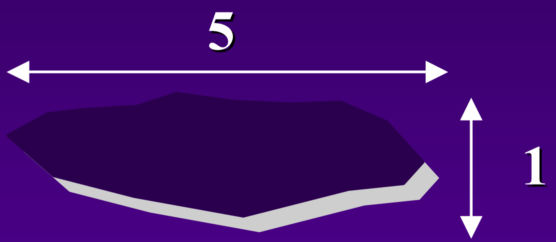
- Measured on + 4.75 mm Material
- Based on Dimensional Ratio of Particles
  - ratio of max to min dimension < 5
- ASTM D 4791
- Requirements Depend on
  - traffic level



Flat, Elongated Particles



Flat, Elongated Particles

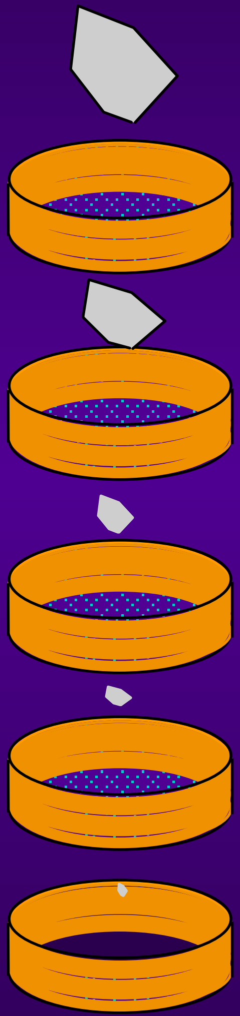


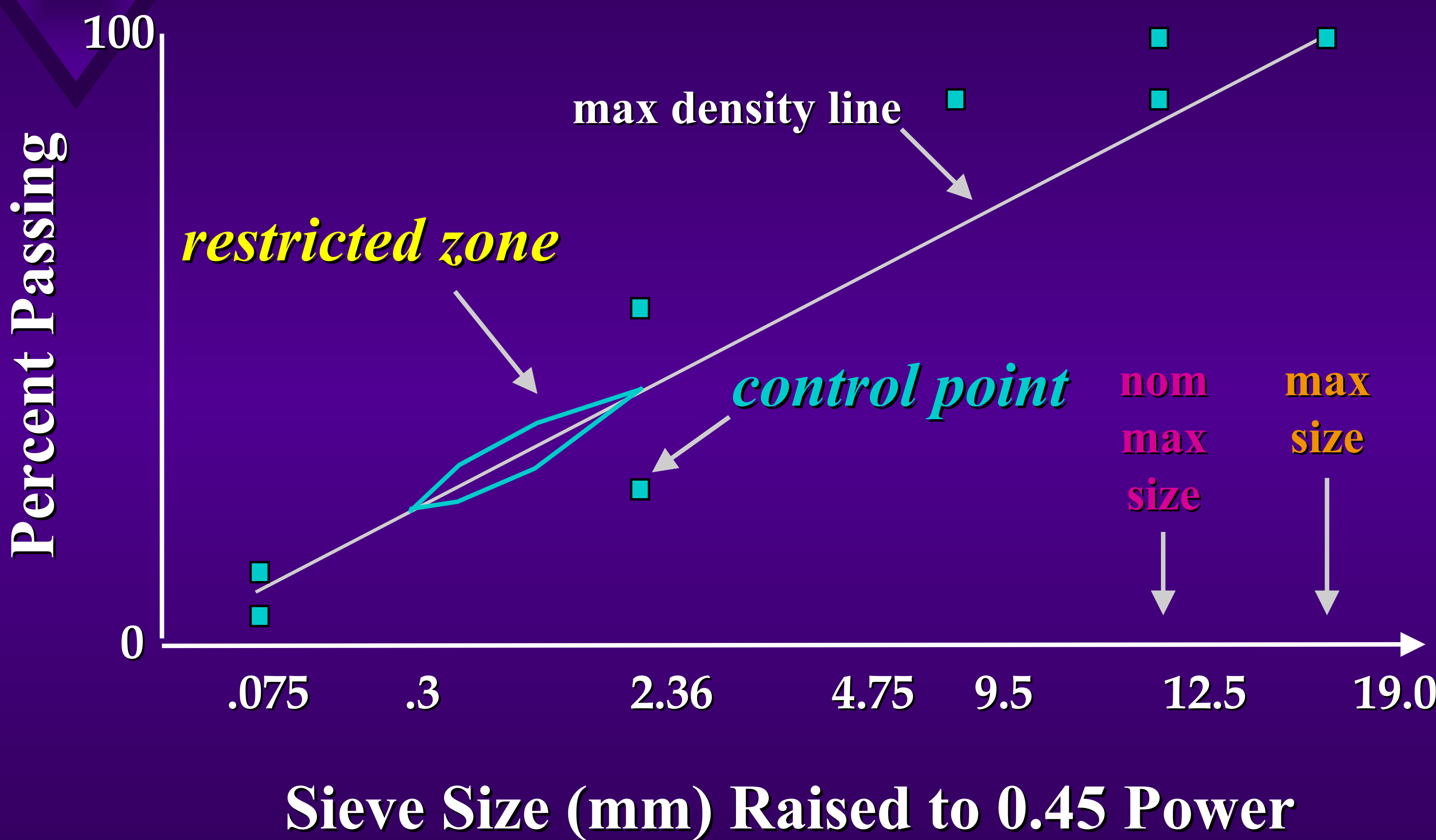
Traffic ESALs	Percent	
•	•	
$10 - 30 \times 10^{6}$	10	Maximum
•	•	
•	•	

percentage
of flat and elongated particles

Superpave Aggregate Gradation

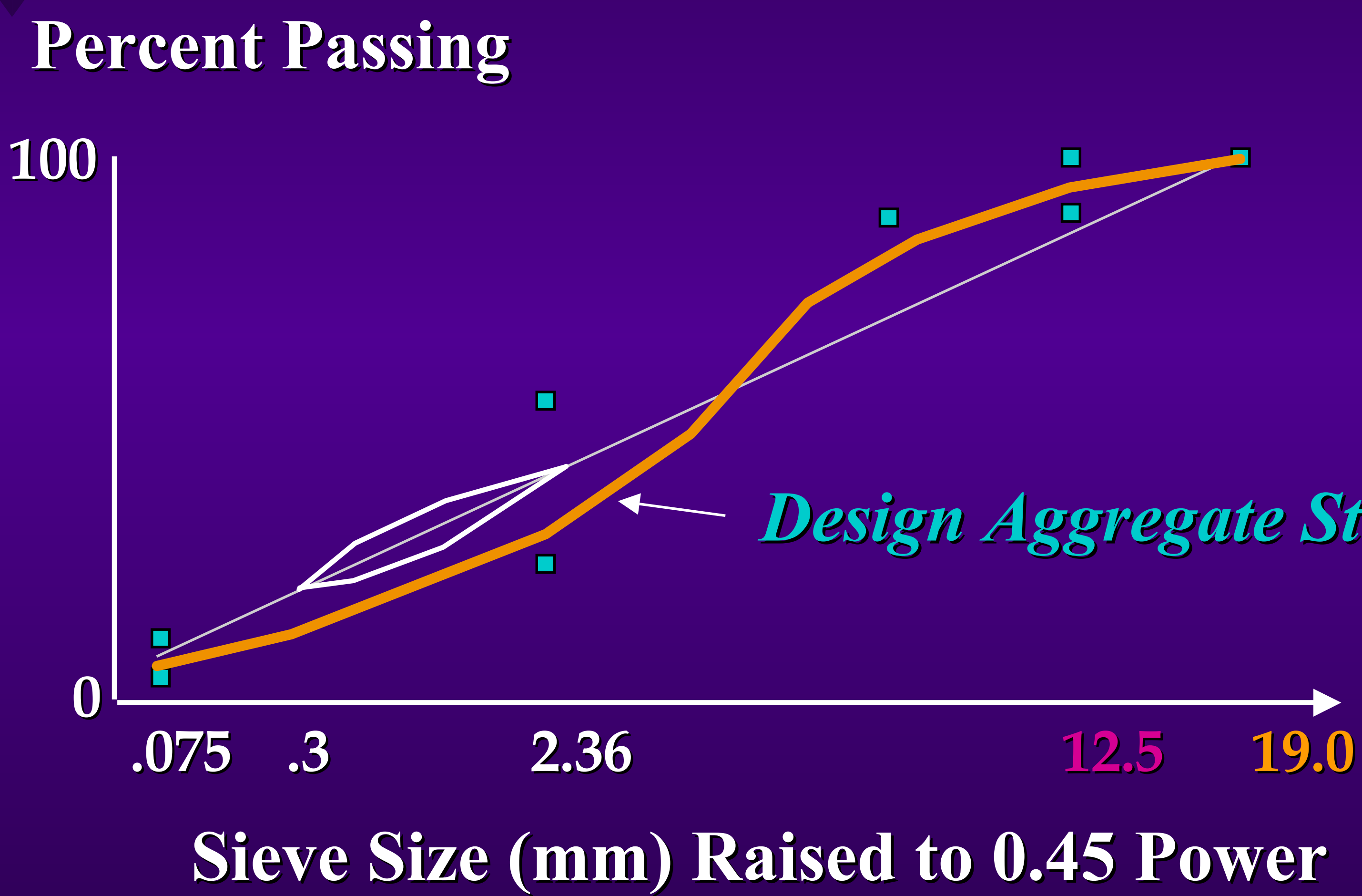
- Use 0.45 Power Gradation Chart
- Blend Size Definitions
  - maximum size
  - nominal maximum size
- Gradation Limits
  - control points
  - restricted zone





100
0
Percent Passing
max density line
restricted zone
control point
nom
max
size
max
size
.075
.3
2.36
4.75
9.5
12.5
19.0
Sieve Size (mm) Raised to 0.45 Power

Superpave Aggregate Gradation



Superpave Mix Size Designations

Superpave Designation	Nom Max Size (mm)	Max Size (mm)
37.5 mm	37.5	50
25 mm	25	37.5
19 mm	19	25
12.5 mm	12.5	19
9.5 mm	9.5	12.5

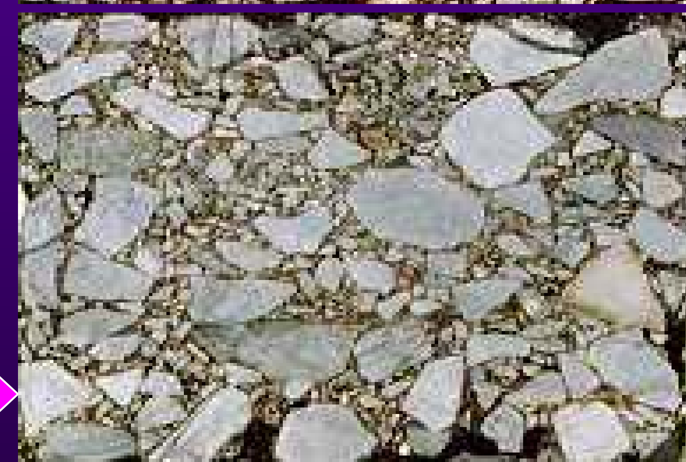
4.75 mm

19.0 mm

9.5 mm

25.0 mm

12.5 mm



37.5 mm


TROXLER

Practical ESALs (20 year life)

1 truck / day = 7,300 EAL
10 truck / day = 73,000 EAL
100 truck / day = 730,000 EAL

EAL	=	Trucks/Day
300,000		40
3,000,000		400
10,000,000		1,300
30,000,000		3,900

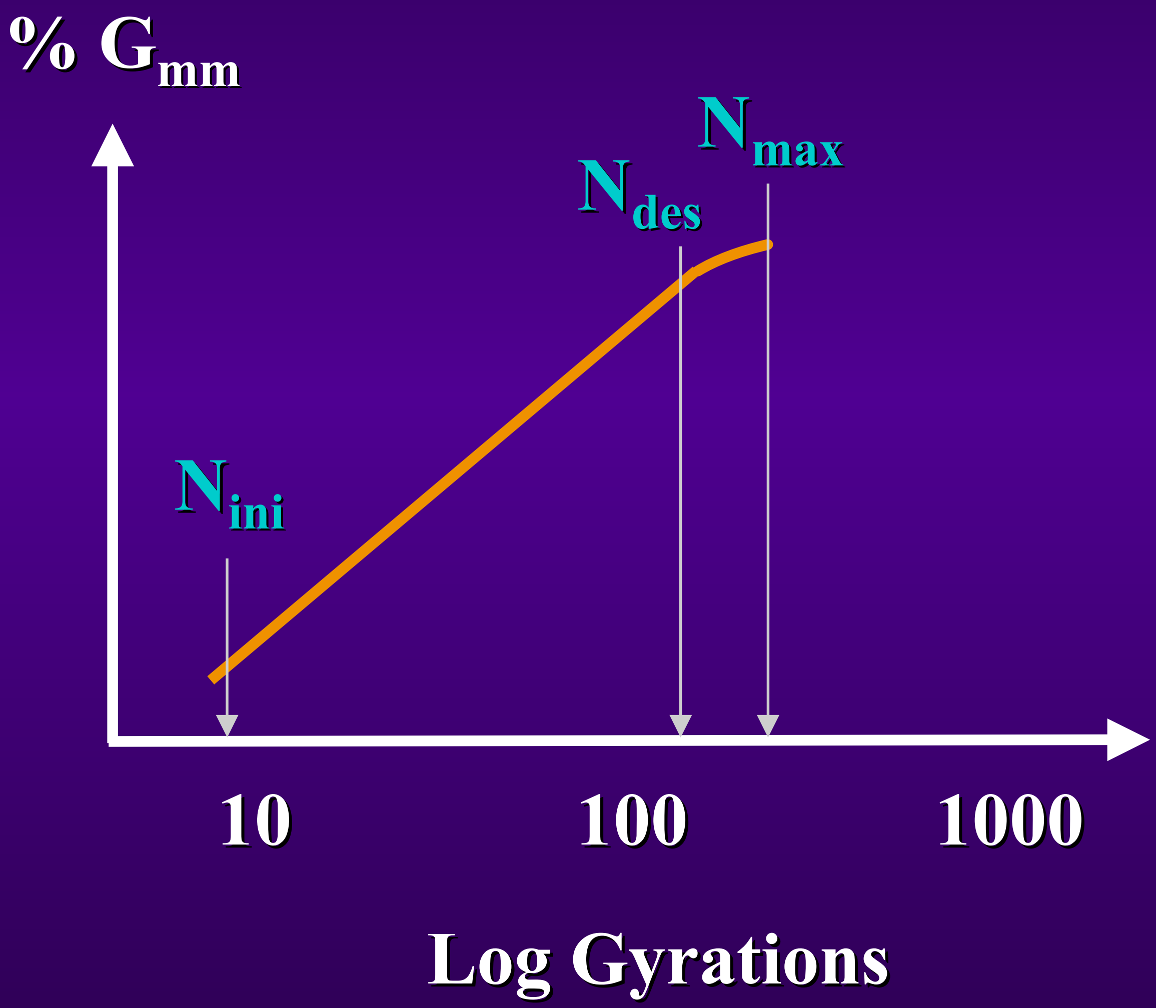
Note: 1 ESAL/truck

SUPERPAVE Gyratory Compaction Effort

ESAL's	N ini	N des	N max	App
< 0.3	6	50	75	Light
0.3 to < 3	7	75	115	Medium
3 to < 10	8	100*	115	High
10 to <30	8	100	115	High
≥ 30	9	125	205	Heavy

Base mix *(< 100 mm)* option to drop one level, unless the mix will be exposed to traffic during construction. Too high ESAL level = Too little asphalt binder.

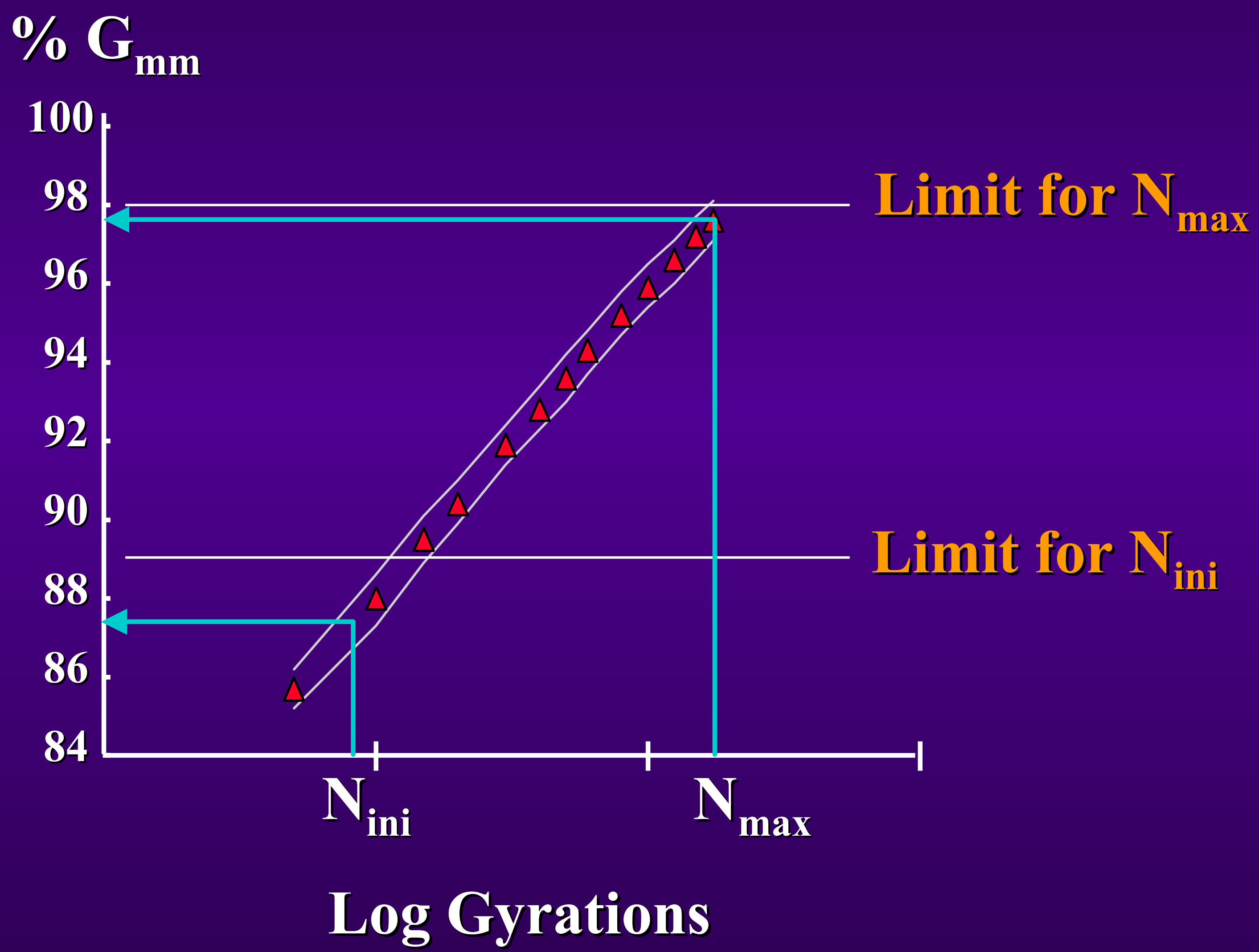
Three Points on SGC Curve



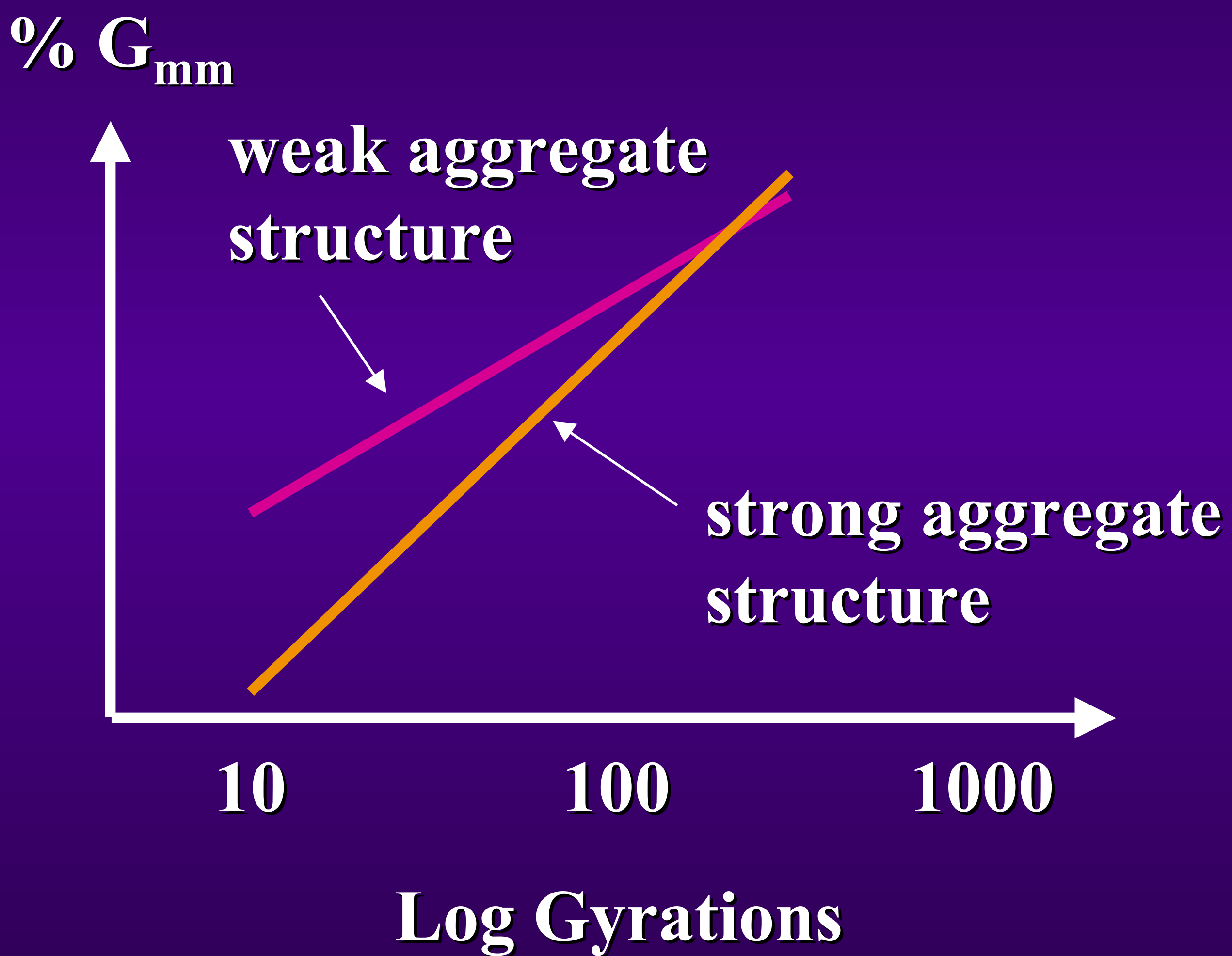
Superpave Mixture Requirements

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

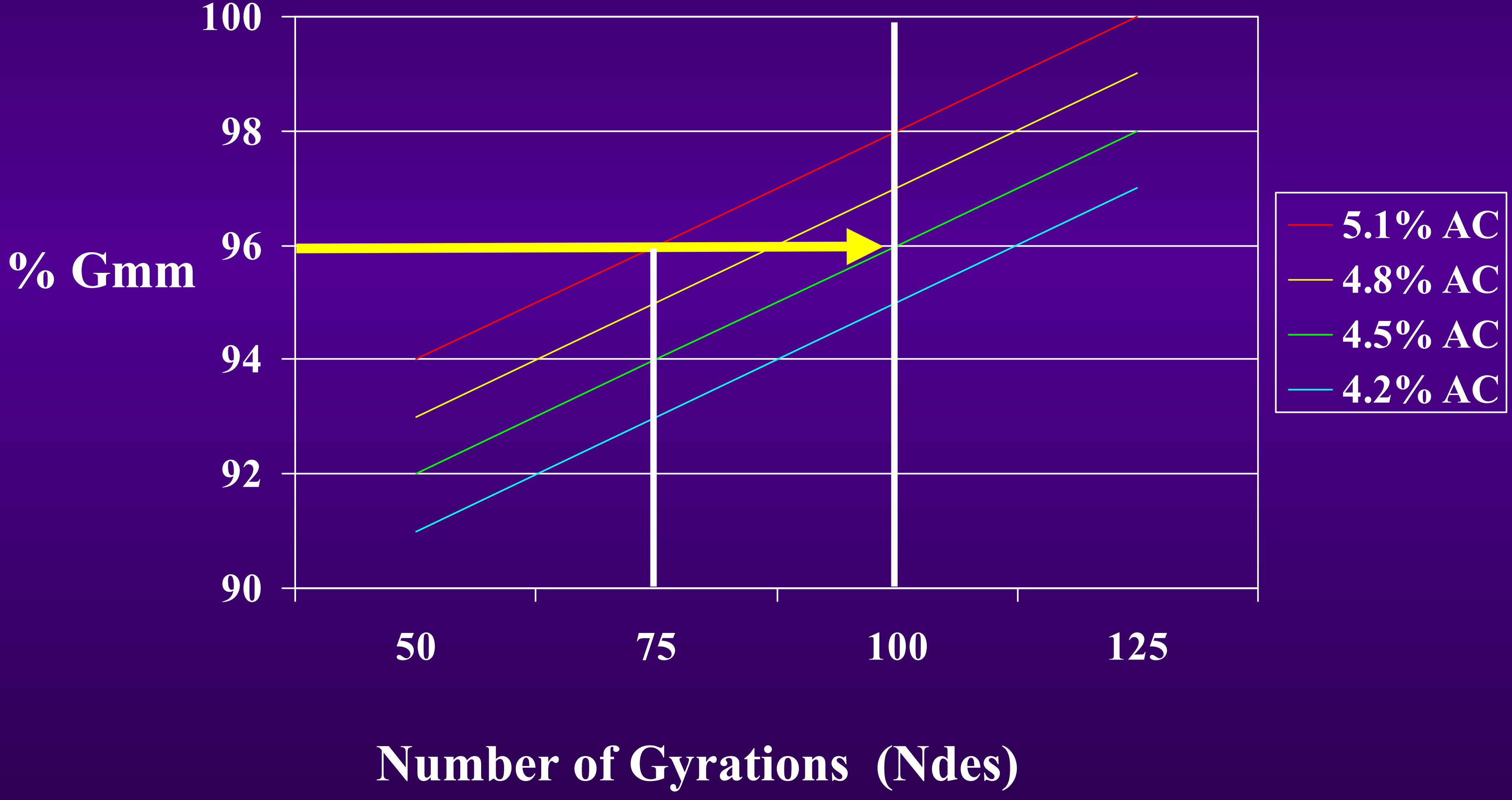
Mixture Density



Evaluate Aggregate Structure

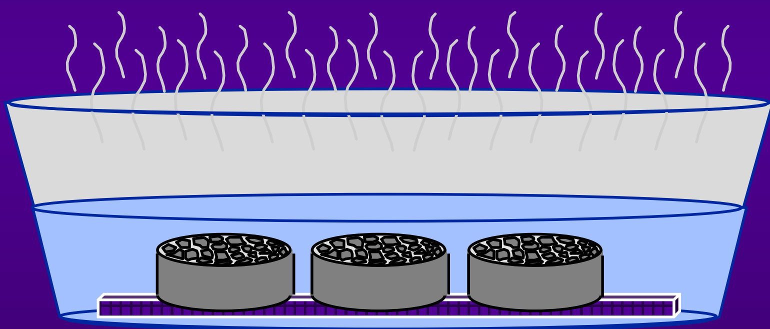


Design Asphalt Binder Content

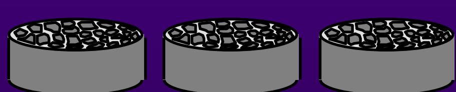


Moisture Sensitivity
AASHTO T 283

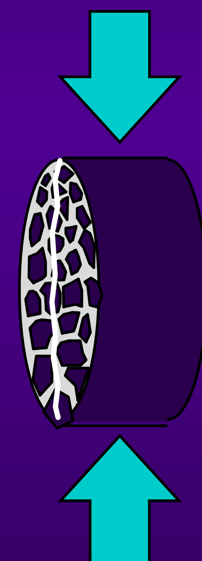
- **Measured on Proposed Aggregate Blend and Asphalt Content**



3 Conditioned Specimens



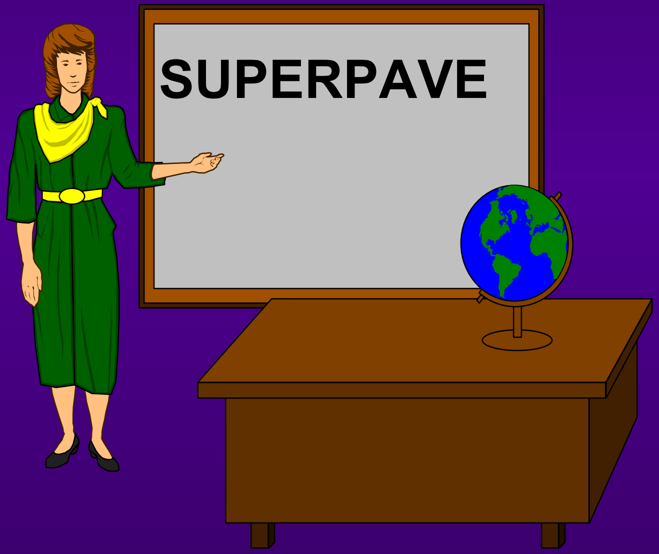
3 Dry Specimens



80 % minimum

Tensile Strength Ratio

CONCLUSIONS



- Training needed for everyone if SUPERPAVE is to be used successfully
- PG Grade System provides the right asphalt for varying climate and traffic conditions
- SUPERPAVE places more tools in the Pavement Designers' Tool Box
- Designers can solve pavement problems they were unable to in the past using SUPERPAVE