

**Evaluation of Low Cost Asphalt Treated Base Mixtures**

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**Outline**

- Background
- Objective & Scope
- Methodology
- Materials Characterization
- Summary & Conclusion
- Recommendation

**Background**

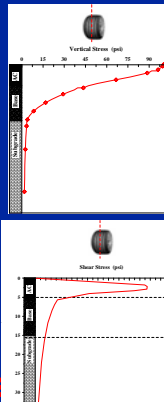
- Asphalt Treated Base (ATB)
  - dense-graded HMA mixture
  - wide gradation band
  - lower asphalt content
  - base course layer

**Background**

- ATB
  - costs less than typical HMA mixtures
    - less expensive aggregates and lower asphalt binder content
  - provide a waterproof layer
    - prevent fines infiltration
  - three times stronger than untreated granular base


**Background**

- LDOTD
  - Base Course Layer: Class I and Class II
  - one alternative of five types
  - specifications
    - similar to those required for HMA BC & WC
- use of ATB mixtures is limited
  - no well defined design procedure
  - low cost ATB mixtures
    - Stable and durable



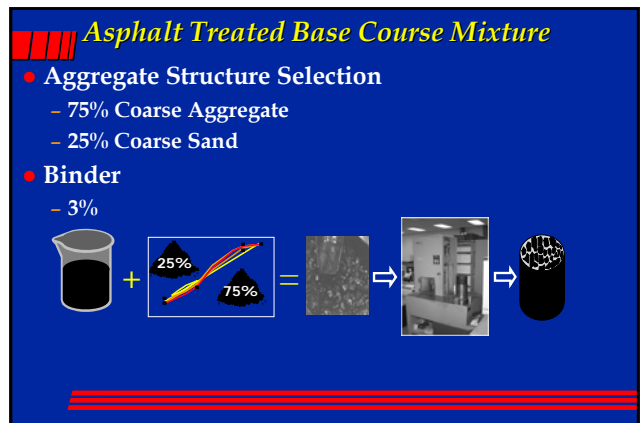
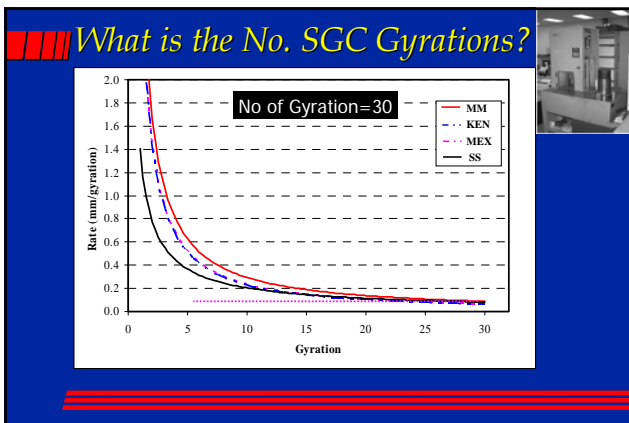
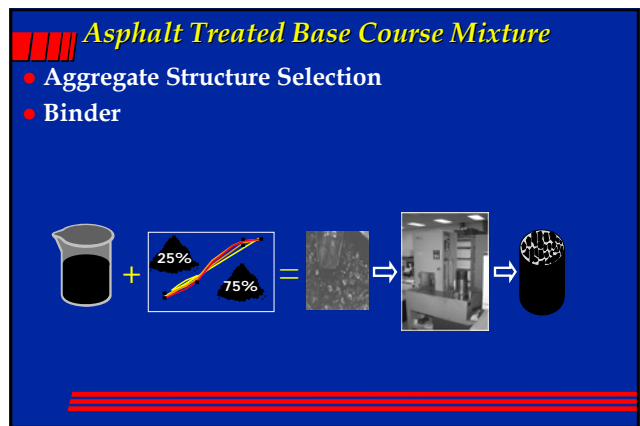
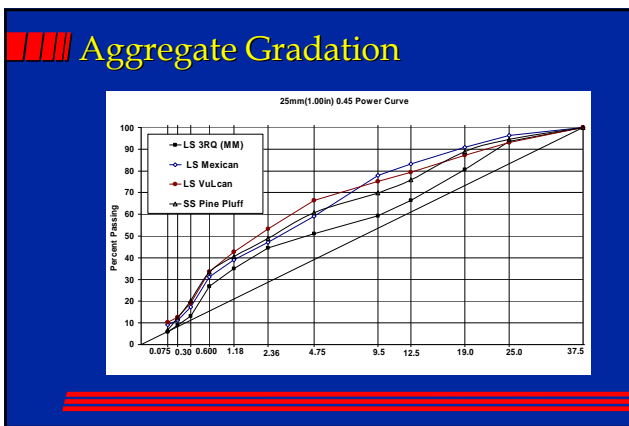
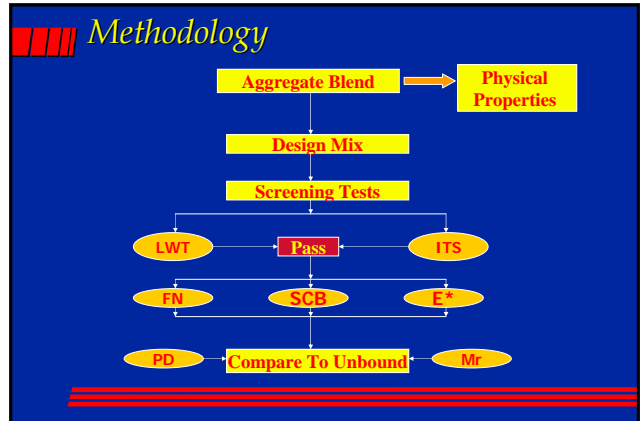
**OBJECTIVE**

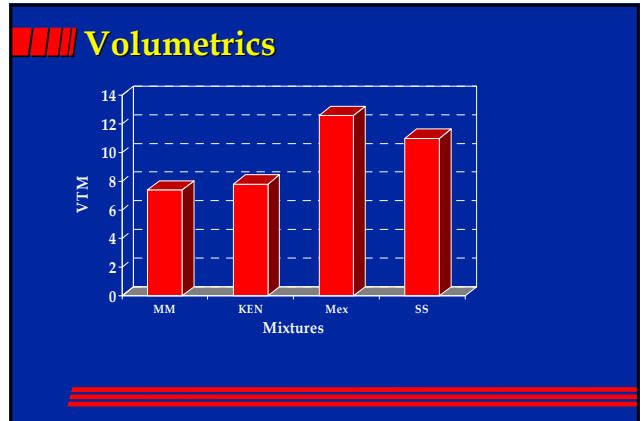
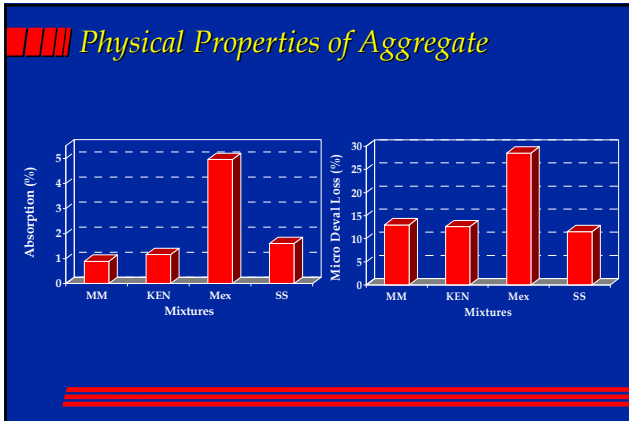
- Develop a *simplified* design methodology
  - ATB mixtures
  - Structurally stable and durable
- Compare the performance
  - ATB mixtures to untreated granular base materials (UGM)
    - currently comply with LDOTD spec for base layer



### Scope

- **Aggregates**
  - Coarse Aggregate
    - -1.5 inch sieve crushed run materials
      - sources that supply the State
    - Limestone:
      - Reed, 3RQ, Mexican
    - Sandstone
      - River Mountain Query
  - Sand
- **Binder**
  - PG 70-22 m





### Material Characterization

- Asphalt Treated Base Mixture Characterization
  - Step 1: Screening Tests
    - Permeability
    - Load Wheel Tracking Test
    - Indirect Tensile Strength Test
  - Step 2: Additional Tests
    - Dynamic Modulus Test
    - Flow Number Test
    - Semi-Circular Bend Test
- Untreated Granular Base Material Characterization
  - Resilient Modulus Test
  - Permanent deformation- Single Stage Repeated Load Triaxial Test

### Sample Preparation -- $|E^*|, F_N$

### Sample Preparation - SCB

### Loaded Wheel Tracking Test

- Damage by rolling a steel wheel across the surface of a slab
- 320 mm long, 260 mm wide, and 80 mm thick
- 50 °C
- Deformation at 20,000 passes is recorded

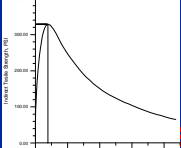


### Indirect Tensile Strength Test

**Test Protocol**  
 Cylindrical Specimen: 100mm x 63.5mm  
 50.8 mm/min vertical deformation rate  
 Temperature: 25C  
 Indirect Tensile Strength (ITS)

$$ITS = \frac{2 \cdot P_{ult}}{\pi \cdot t \cdot D}$$

$$TI = \frac{A_g - A_p}{\epsilon - \epsilon_p}$$

Where:  
 ITS – Tensile strength, kPa  
 P<sub>ult</sub> – Peak load at failure, N  
 t – Thickness of the sample, mm  
 D – Diameter of the specimen, mm

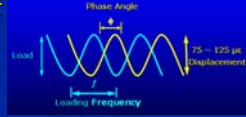
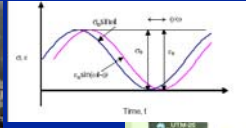


### Dynamic Modulus |E\*| Test

- IPC UTM-25
- AASHTO TP-62
- Sinusoidal axial compressive stress is applied to a specimen
  - temperature and frequency

$$|E^*| = \frac{\sigma_0}{\epsilon_0}$$

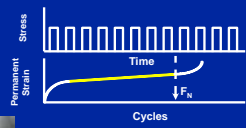


$$\phi = \omega t_i$$

Frequency (HZ): 25, 10, 5, 1, 0.5, 0.1  
 Temp. (°C): -10, 4.4, 25, 38, 54.4

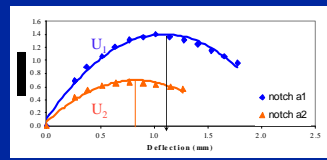
### Repeated Load Permanent Deformation Test - F<sub>N</sub>

- IPC UTM-25
- A haversine axial compressive stress is applied
  - Loading: 0.1 Second
  - Rest Period: 0.9 Second
  - 54.4°C
- F<sub>N</sub>: Number of cycles
  - Tertiary Failure
  - 10,000 cycles







### Semi Circular Bend Test

Loading rate: 0.5 mm/min  
 Notch Depth: 19-, 25-, 38-mm  
 Test temperature: 25 °C  
 Triplicate

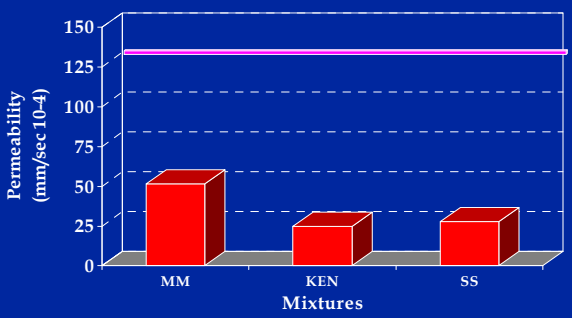
$$J_c = \left( \frac{U_1}{b_1} - \frac{U_2}{b_2} \right) \frac{1}{a_2 - a_1}$$


U is the total strain energy to failure  
 J<sub>c</sub>: the critical strain energy release rate

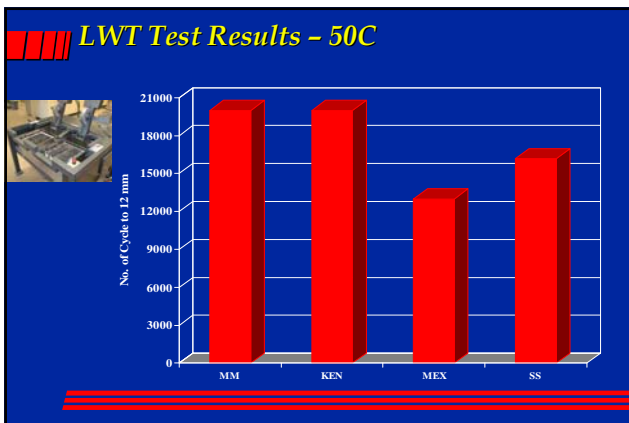
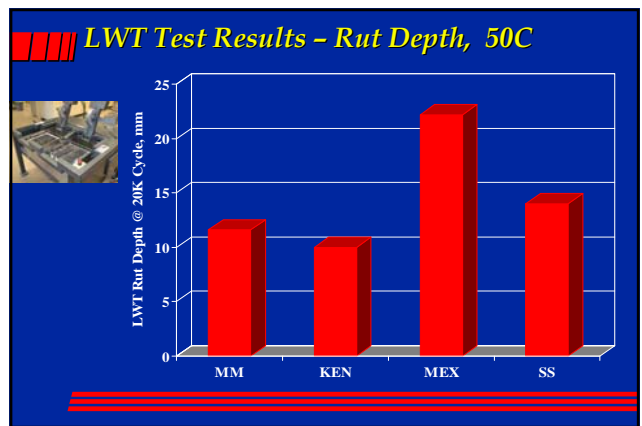
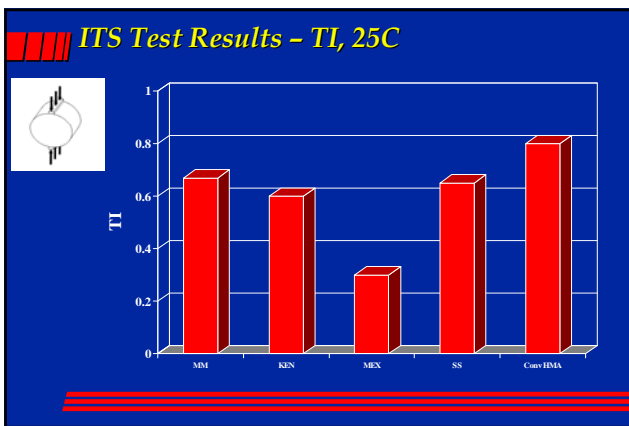
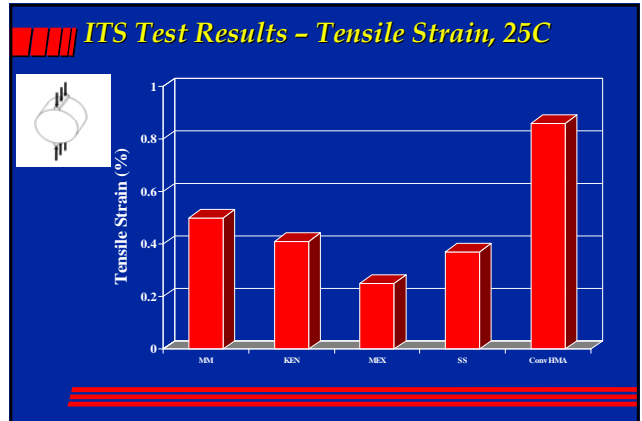
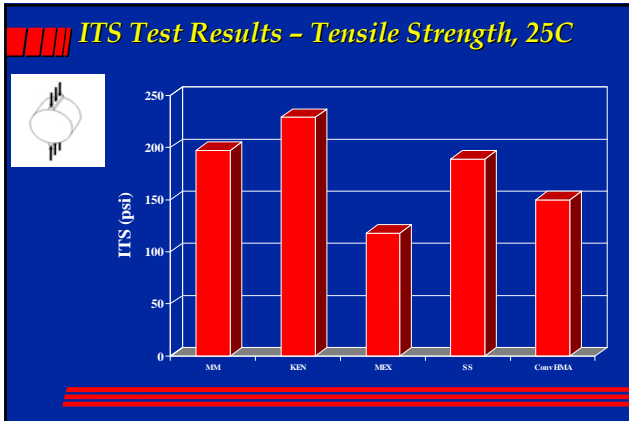



## Step: 1 SCREENING TESTS

### Permeability



Mixture	Permeability (mm/sec 10 <sup>-4</sup> )
MM	~60
KEN	~25
SS	~30



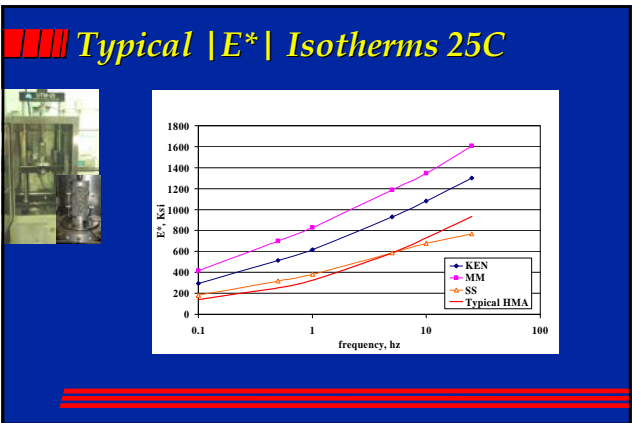
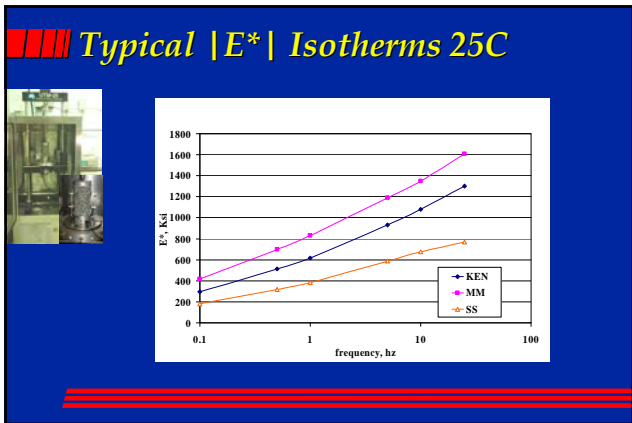
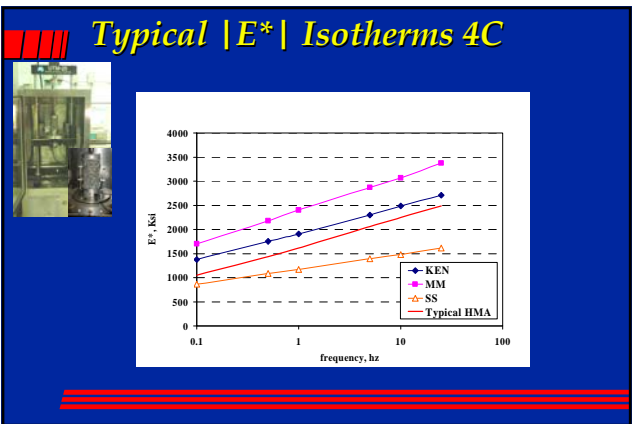
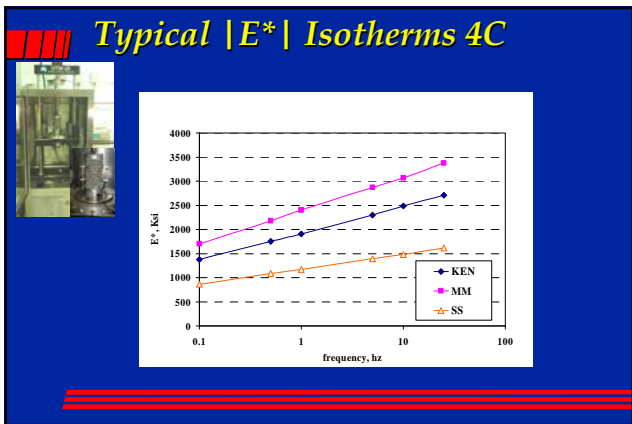
### Summary Of Screening Test Results

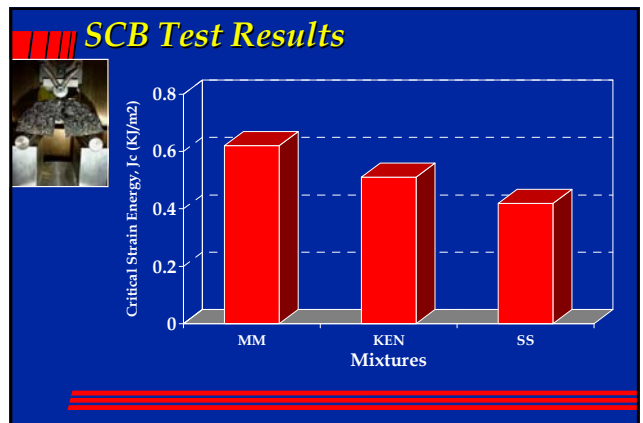
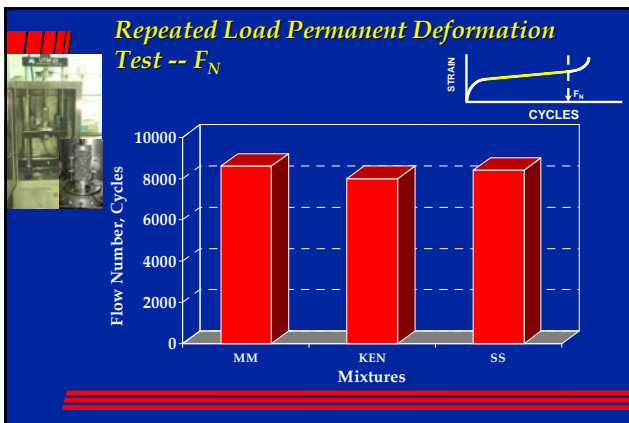
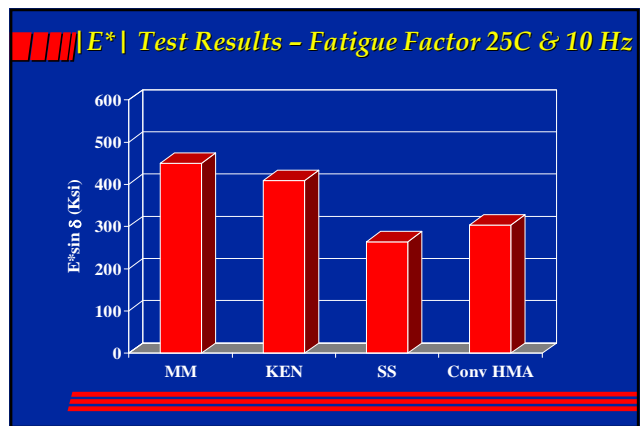
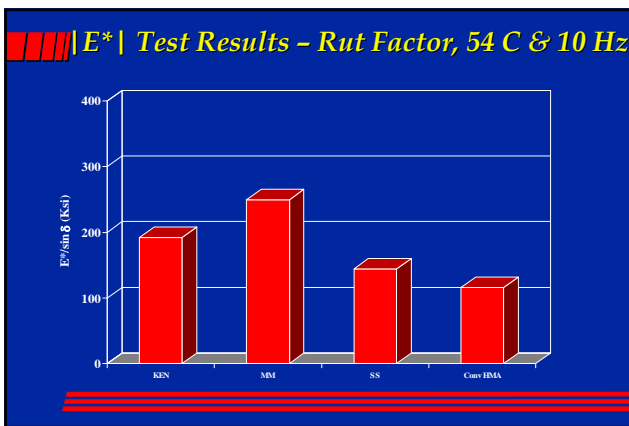
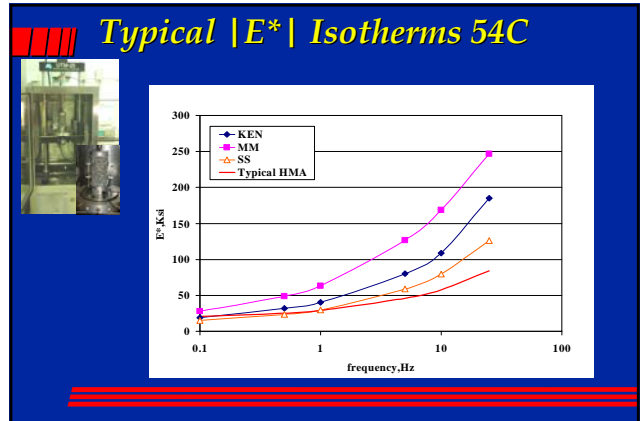
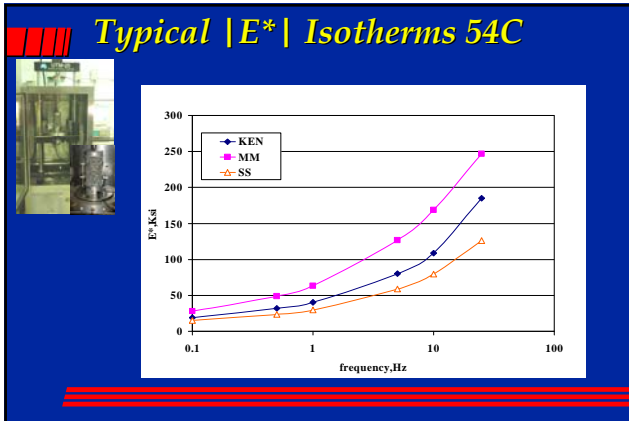
Mixture	LWT	ITS
MM	Pass	Pass
KEN	Pass	Pass
SS	Pass	Pass
MEX	Fail	Fail

**Summary Of Screening Test Results**

Mixture	LWT	ITS
MM	Pass	Pass
KEN	Pass	Pass
SS	Pass	Pass
MEX	Fail	Fail

# RESULTS OF PERFORMANCE TESTS





### Characterization of Unbound Granular Material

- Resilient Modulus
- Permanent Deformation

### Resilient Modulus Test

> Mr is determined using AASHTO standard method T307.

The diagram illustrates the test process: a specimen is subjected to a confining pressure and a deviatoric stress. It is then allowed to recover, and the resilient modulus is determined based on the recovery strain. A graph shows Resilient Modulus on the y-axis and Deviatoric Stress on the x-axis, with a linear relationship between them.

### Repeated Load Permanent Deformation Test

>The tests consist applying 10,000 load cycles at a constant confining pressure (21 kPa) and peak cyclic stress (230 kPa).

The graphs show the cyclic loading and the resulting strain response over time. The top graph plots Deviatoric stress (kPa) against Time (sec) for 10,000 cycles. The bottom graph plots Strain against Time, showing the permanent deformation (P<sub>r</sub>) and the resilient strain (R<sub>r</sub>). A photograph shows the physical test setup.

### Resilient Modulus Test-Unbound

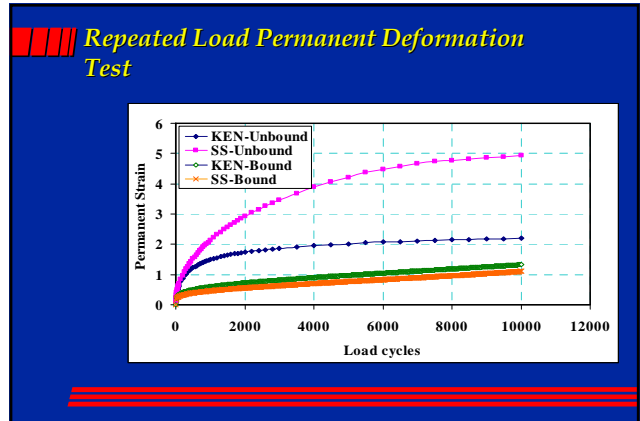
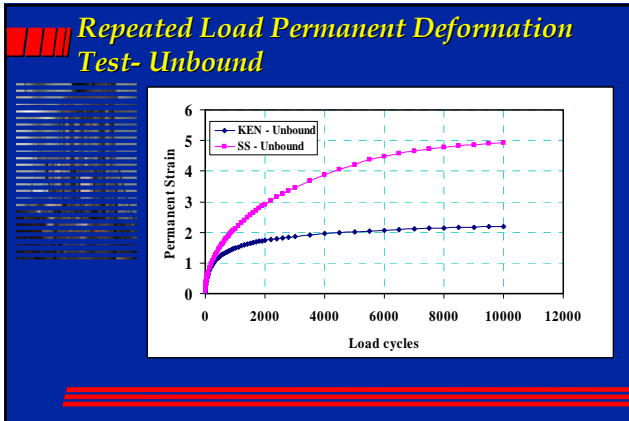
Material	Mr (ksi)
KEN	~42
SS	~22

### Resilient Modulus VS E\* @ 25 C & 10 Hz

Material	Unbound Modulus (ksi)	Bound Modulus (ksi)
KEN	~100	~1100
SS	~100	~700

### Resilient Modulus VS E\* @ 54 C & 10 Hz

Material	Unbound Modulus (ksi)	Bound Modulus (ksi)
KEN	~45	~110
SS	~25	~85



- ### Summary
- LS & SS aggregate treated with AC presented good laboratory performance
  - Mex LS aggregate treated with AC did not perform well
  - Treated aggregates have several folds improvement of UGM
    - Modulus
    - Permanent deformation



	Lane #1	Lane #2	Lane #3	Lane #4	Lane #5	Lane #6
40 mm WC	SP CONV 12.5 mm NMS N <sub>f</sub> =100	SMA 12.5 mm NMS	Bailey Design 12.5 mm NMS N <sub>f</sub> =100	OGFC (19 mm thick)	25 NMS ATB 3% AC Well Graded	SP CONV 12.5 mm NMS N <sub>f</sub> =100
50 mm BC	SP CONV 19 mm NMS N <sub>f</sub> =100	SP CONV 19 mm NMS N <sub>f</sub> =100	SP CONV 19 mm NMS N <sub>f</sub> =100	SP CONV 19 mm NMS N <sub>f</sub> =100 (71 mm thick)	75% Stone 25% Sand	SP CONV 19 mm NMS N <sub>f</sub> =100
100mm Base	Stone				ATB	ATB
A-4 / Portland Cement Treated Sub-grade						

