Evaluation of Low Cost Asphalt Treated Base Mixtures

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Outline

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

Background

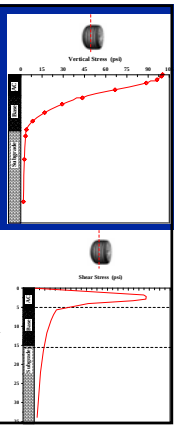
- Asphalt Treated Base (ATB)
  - dense-graded HMA mixture
  - wide gradation band
  - lower asphalt content
  - base course layer

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



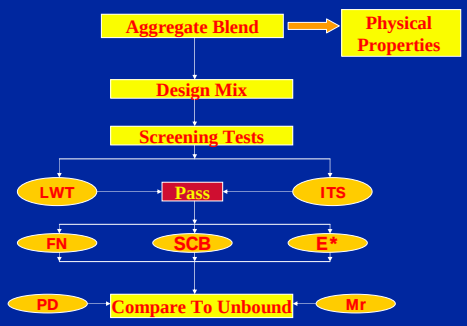
OBJECTIVE

- **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**

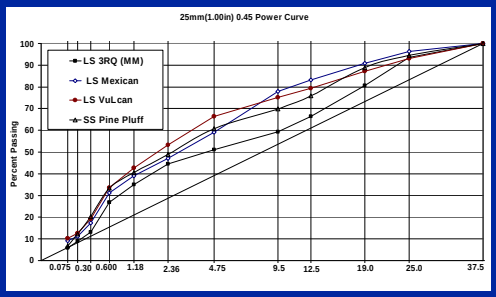
Scope

- 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

Methodology

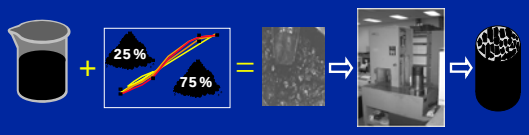


Aggregate Gradation

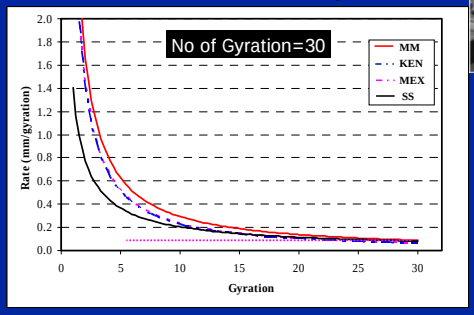


Asphalt Treated Base Course Mixture

- Aggregate Structure Selection
- Binder

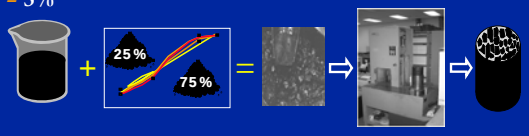


What is the No. SGC Gyrations?

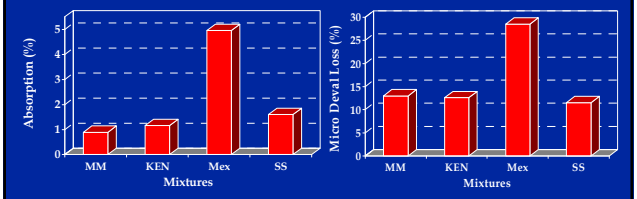


Asphalt Treated Base Course Mixture

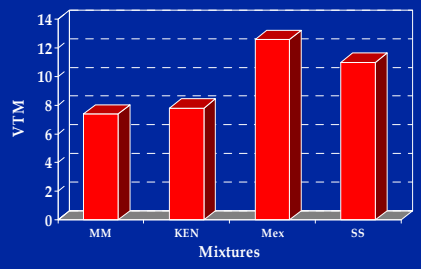
- Aggregate Structure Selection
  - 75% Coarse Aggregate
  - 25% Coarse Sand
- Binder
  - 3%



Physical Properties of Aggregate



Volumetrics

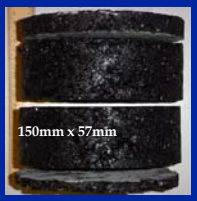


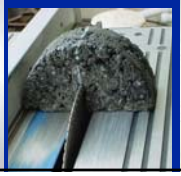
Material Characterization

- 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

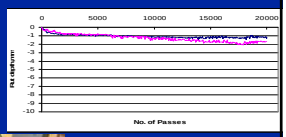
Sample Preparation – SCB

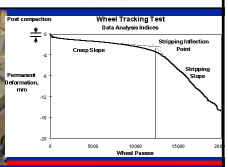




Loaded Wheel Tracking Test

- 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



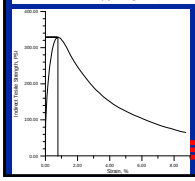


Indirect Tensile Strength Test

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

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

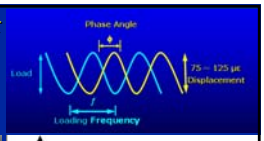
$$TI = \frac{A_e - A_p}{\varepsilon - \varepsilon_p}$$



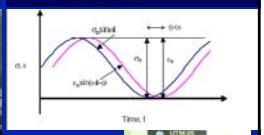
Where:
ITS – Tensile strength, kPa
P_{ult} – Peak load at failure, N
t – Thickness of the sample, mm
D – Diameter of the specimen, mm

Dynamic Modulus |E*| Test

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



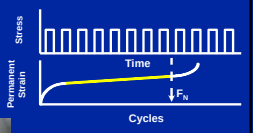
$$|E^*| = \frac{\sigma_0}{\varepsilon_0} \qquad \phi = \omega t_i$$



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_N

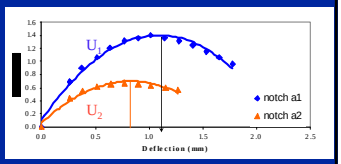
- IPC UTM-25
- A haversine axial compressive stress is applied
  - Loading: 0.1 Second
  - Rest Period: 0.9 Second
  - 54.4°C
- F_N: Number of cycles
  - Tertiary Failure
  - 10,000 cycles



Semi Circular Bend Test

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

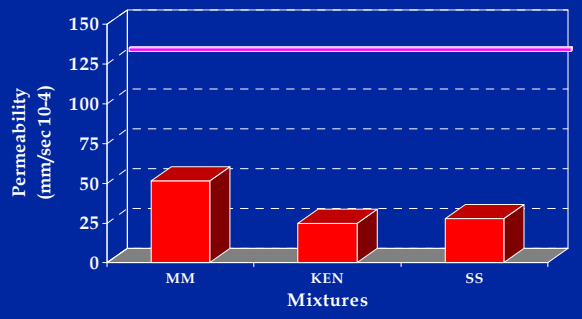
$$J_c = \left(\frac{U_1}{b_1} - \frac{U_2}{b_2}\right)\frac{1}{a_2 - a_1}$$



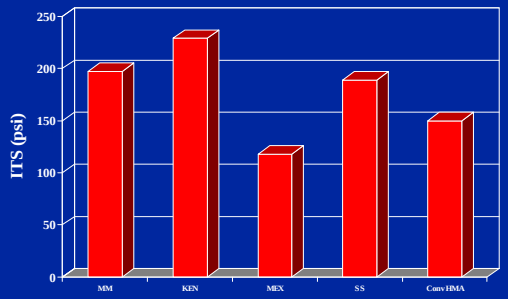
U is the total strain energy to failure
Jc: the critical strain energy release rate

Step: 1
SCREENING TESTS

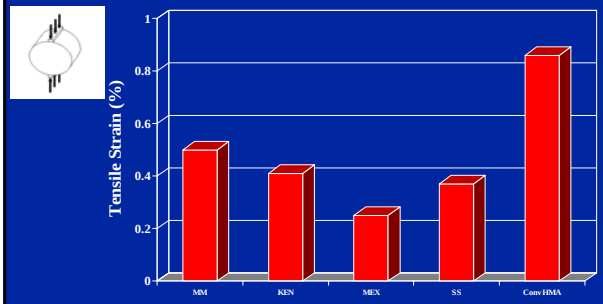
Permeability



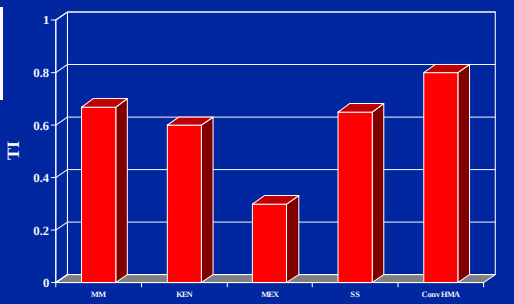
ITS Test Results – Tensile Strength, 25C



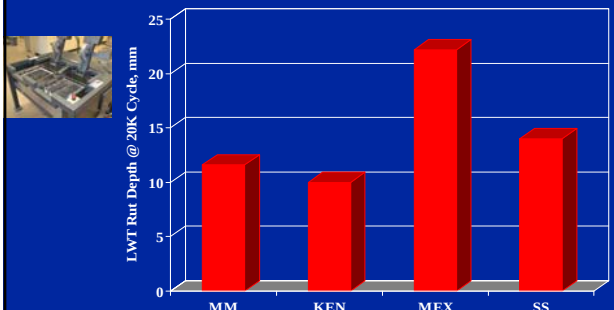
ITS Test Results – Tensile Strain, 25C



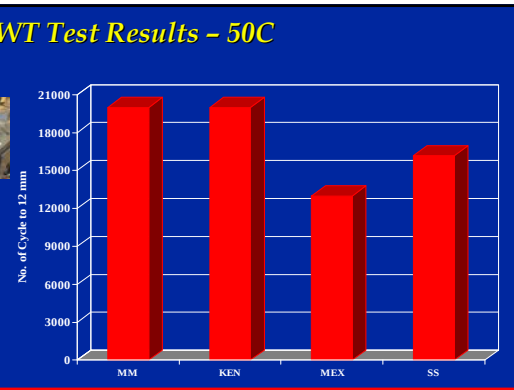
ITS Test Results – TI, 25C



LWT Test Results – Rut Depth, 50C



LWT Test Results – 50C



Summary Of Screening Test Results

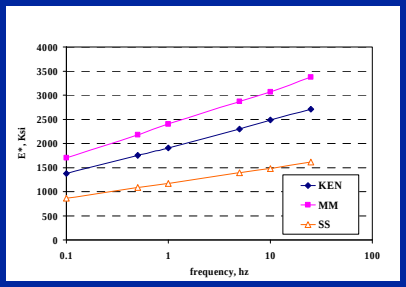
Mixture	LWT	ITS
MM	Pass	Pass
KEN	Pass	Pass
SS	Pass	Pass
MEX	Fail	Fail

Summary Of Screening Test Results

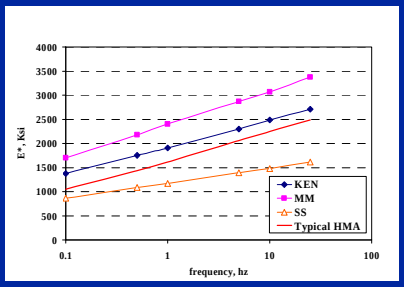
Mixture	LWT	ITS
MM	Pass	Pass
KEN	Pass	Pass
SS	Pass	Pass
MEX	Fail	Fail

RESULTS OF PERFORMANCE TESTS

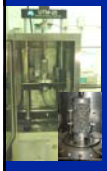
Typical |E*| Isotherms 4C

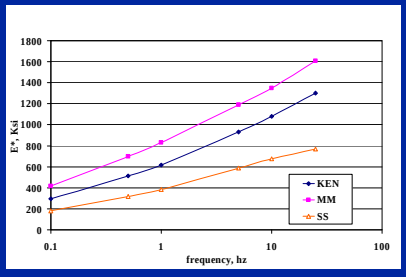


Typical |E*| Isotherms 4C

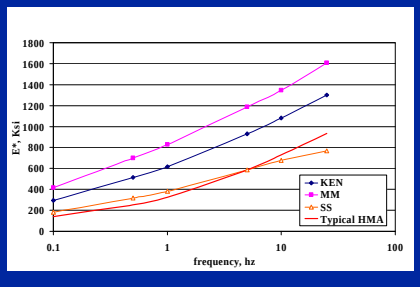


Typical |E*| Isotherms 25C

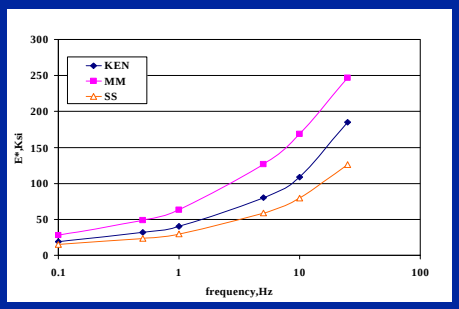




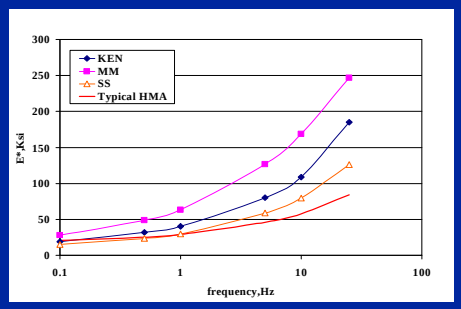
Typical |E*| Isotherms 25C



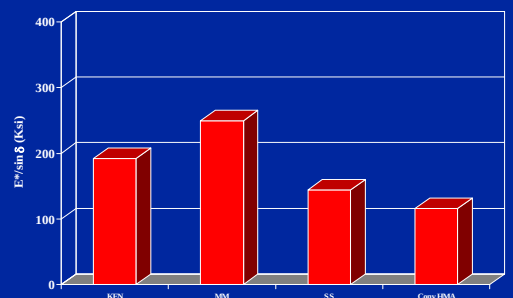
Typical |E*| Isotherms 54C



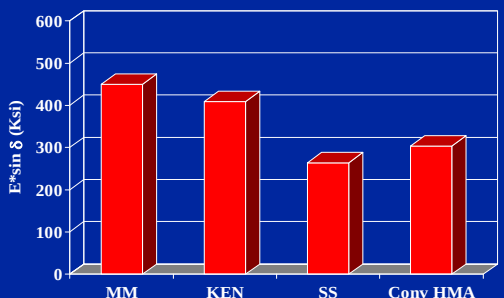
Typical |E*| Isotherms 54C



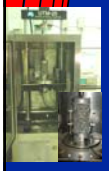
|E*| Test Results – Rut Factor, 54 C & 10 Hz

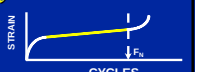


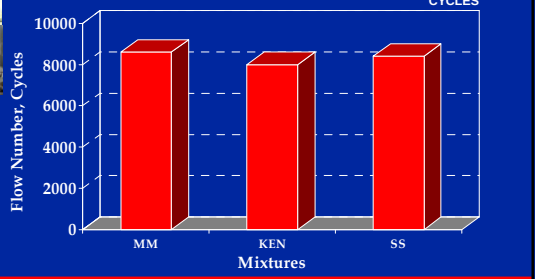
|E*| Test Results – Fatigue Factor 25C & 10 Hz



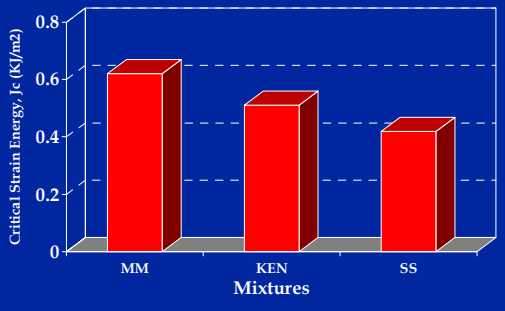
Repeated Load Permanent Deformation Test -- F_N







SCB Test Results

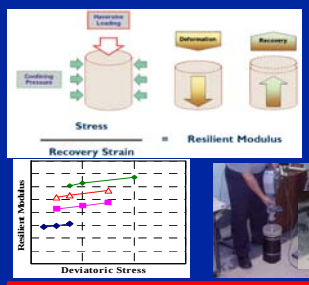


Characterization of Unbound Granular Material

- Resilient Modulus
- Permanent Deformation

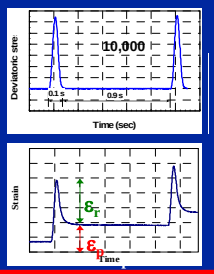
Resilient Modulus Test

➢Mr is determined using AASHTO standard method T307.

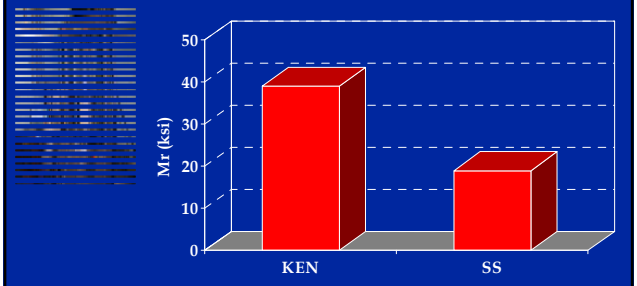


Repeated Load Permanent Deformation Test

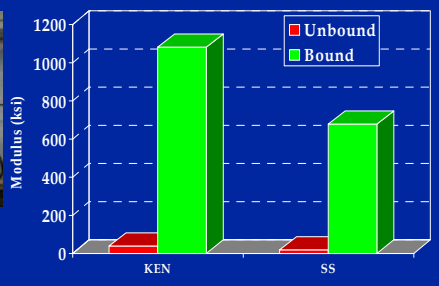
➢The tests consist applying 10,000 load cycles at a constant confining pressure (21 kPa) and peak cyclic stress (230 kPa).



Resilient Modulus Test-Unbound



Resilient Modulus VS E @ 25 C & 10 Hz*



Resilient Modulus VS E @ 54 C & 10 Hz*