Use of High Percentage RAP in HMA

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Outline

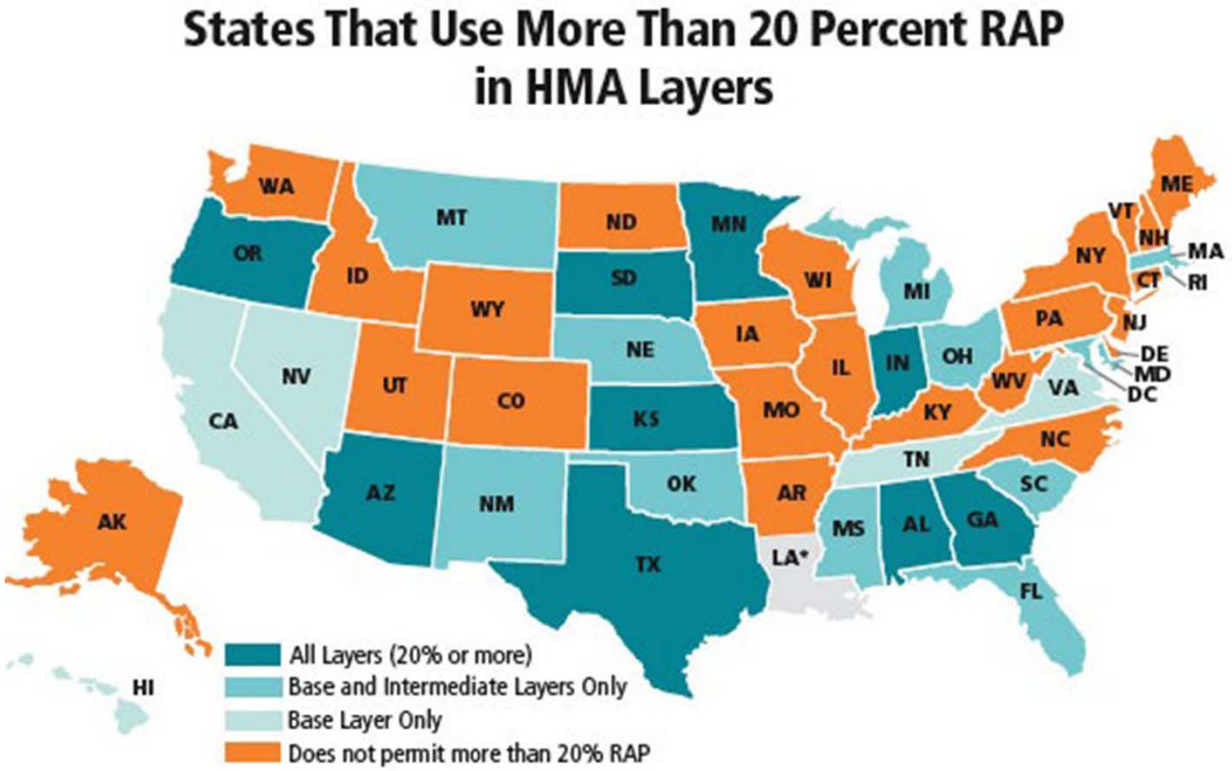
- Background
- Objectives
- Research Approach
- Schedule

Background

- Benefits of using RAP in HMA
  - Economics
    - Aggregates
    - Binder
  - Environment
    - Resources
    - Petroleum
    - Landfill

Background

- Status of the use of RAP in HMA



Source: FHWA
* Lousiana did not respond to this question

Background

- Evolution of Design of HMA with RAP
  - NCHRP 9-12 (McDaniel et al. 2000)
    - Findings
      - Black rock, partial blending or total blending?
      - Increase RAP percentage
        - Increase stiffness of HMA
        - Increase rutting resistance
        - Reduce fatigue resistance
        - Reduce thermal cracking resistance

Background

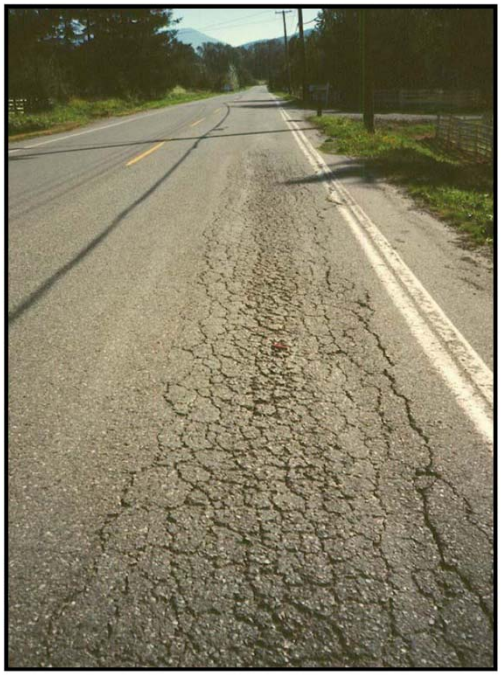
- Evolution of Design of HMA with RAP
  - NCHRP 9-12 (McDaniel et al. 2000)
    - Mix design method
      - Low RAP Level(15% or lower): no change of PG grade
      - Intermediate RAP Level (15 – 30%): one full grade softer
      - High RAP Level (30 or higher): blending chart
        - T_{virgin} x (1-RAP%)+T_{RAP} x RAP% = T_{cri}

Background

- Evolution of Design of HMA with RAP
  - NCHRP 9-46 (West et al. 2008)
    - Design HMA with 25-50% RAP
    - Test stiffness of blended mix and backcalculate the PG grade.
    - PG grade of RAP binder will not be determined.

Background

- Pavement performance
  - Fatigue



Background

- Pavement performance
  - Rutting

Background

- Pavement performance
  - Thermal Cracking

Background

- Pavement performance
  - Moisture Damage - Raveling

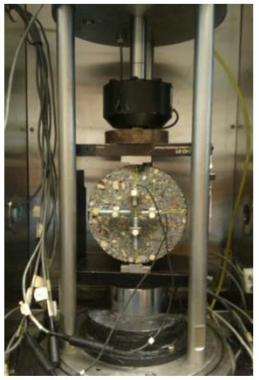
*www. pavementinteractive.com

Background

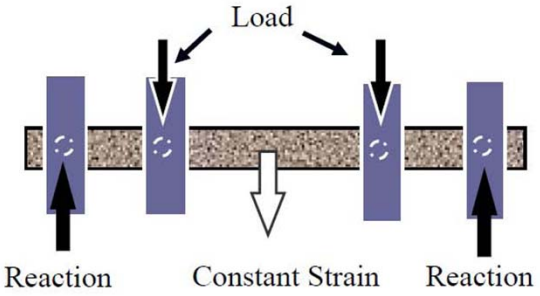
- We can not wait for 20 years to see the performance
- Need to determine the performance before pavement with high RAP percentage is built
- Key is to select materials properties from lab to relate to field performance

Background

- For fatigue, test methods in the lab can include
  - Stiffness

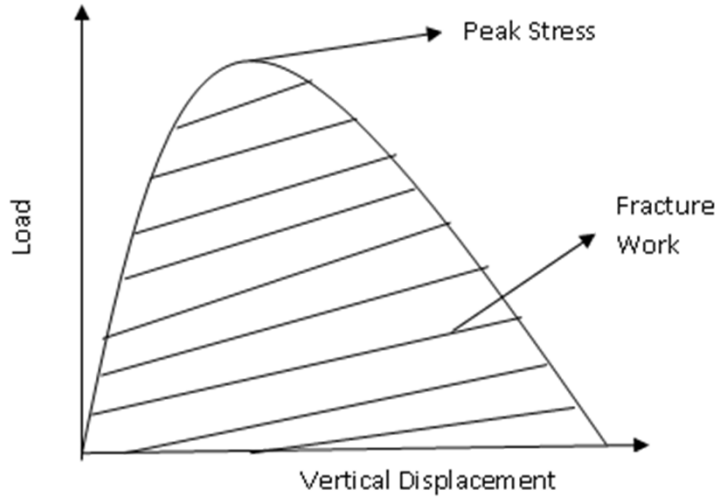


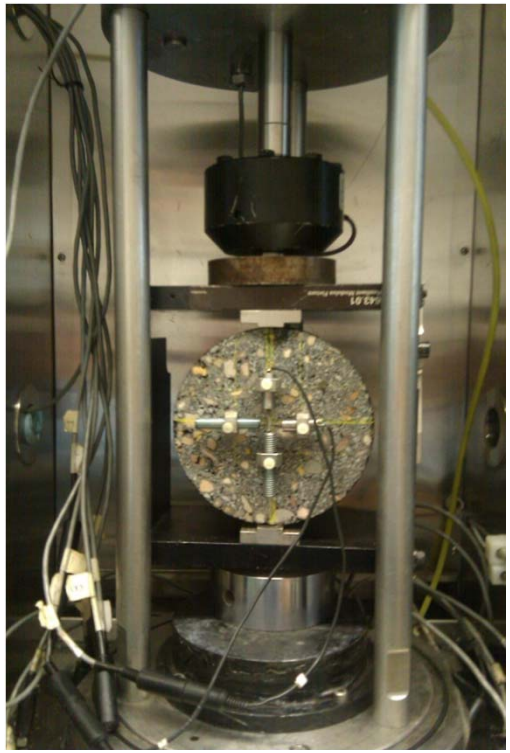
  - Indirect tensile strength
  - Beam fatigue



Background

- For fatigue, test methods in the lab can include
  - Fracture work from Indirect tensile test





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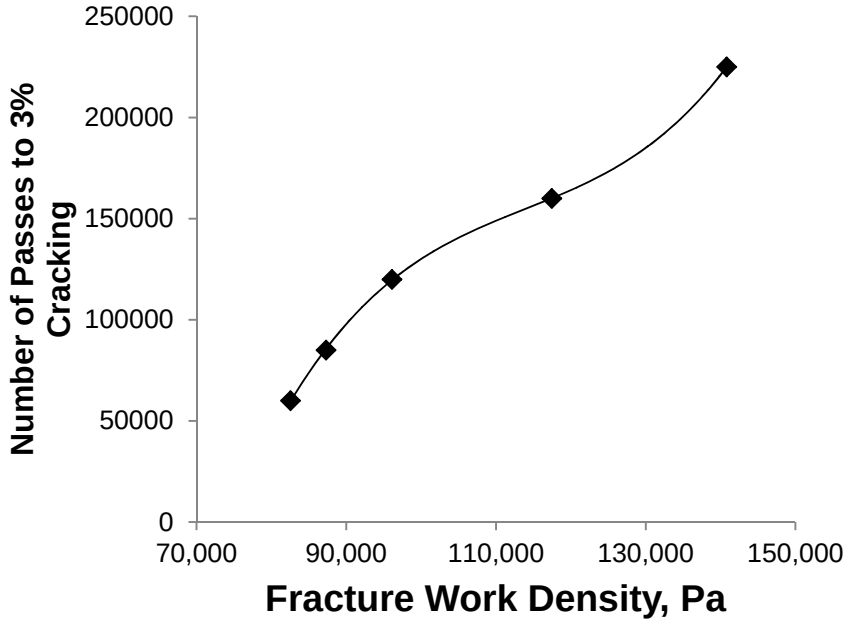


Wen H. 2011

Experiments

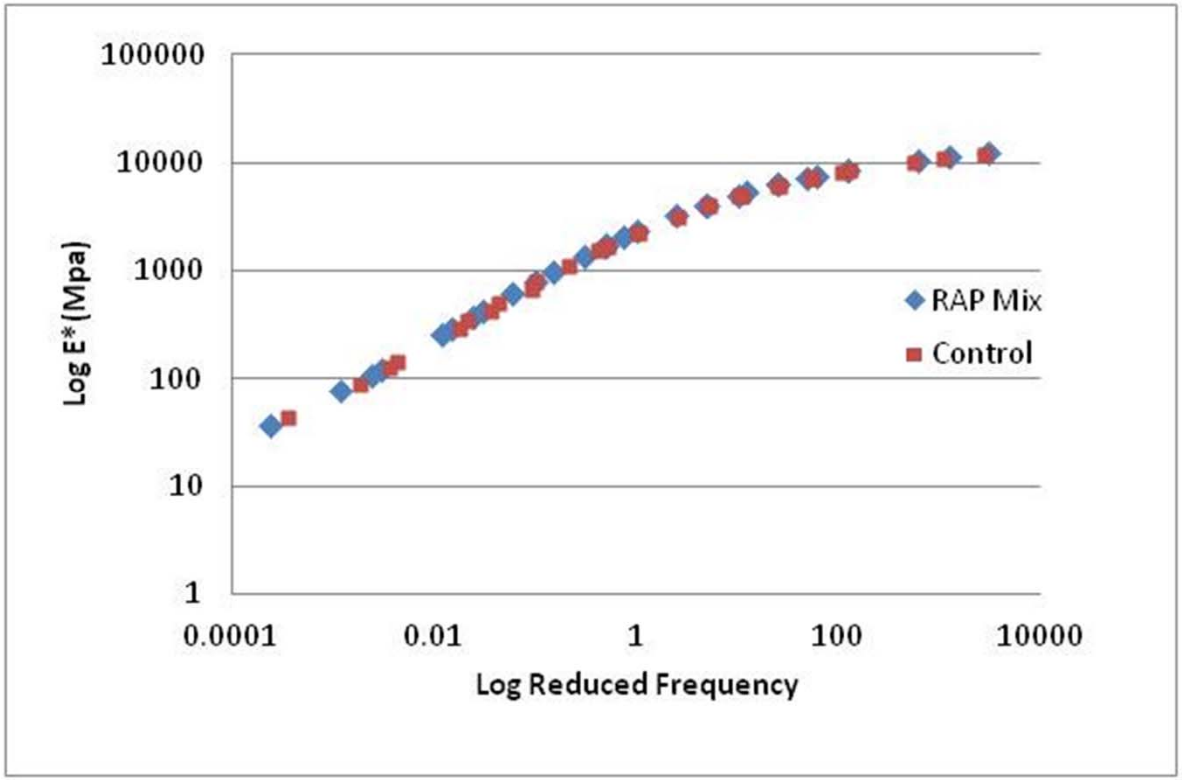
- Two mixes
  - HMA with 0% RAP
  - HMA with 20% RAP
  - Same gradation and sources of materials
  - PG58-28

Experiments

- Laboratory Tests
  - Stiffness

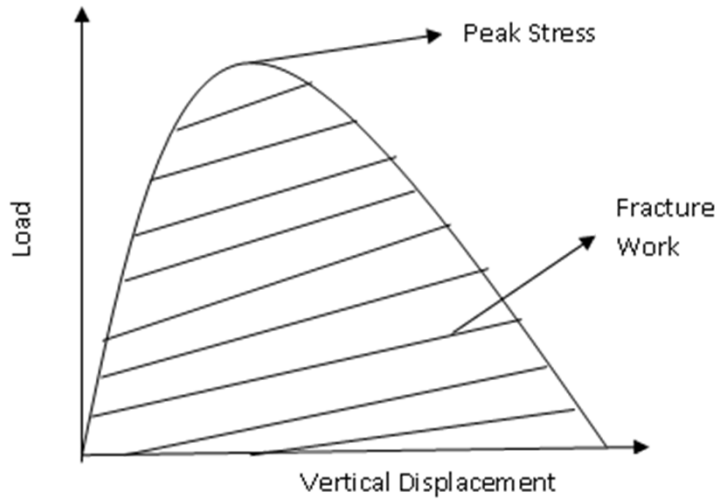
Experiments

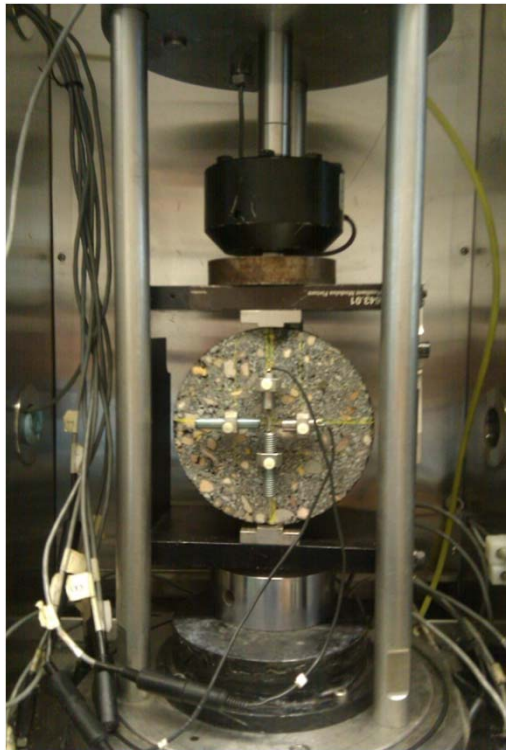
- Laboratory Tests
  - Stiffness



Experiments

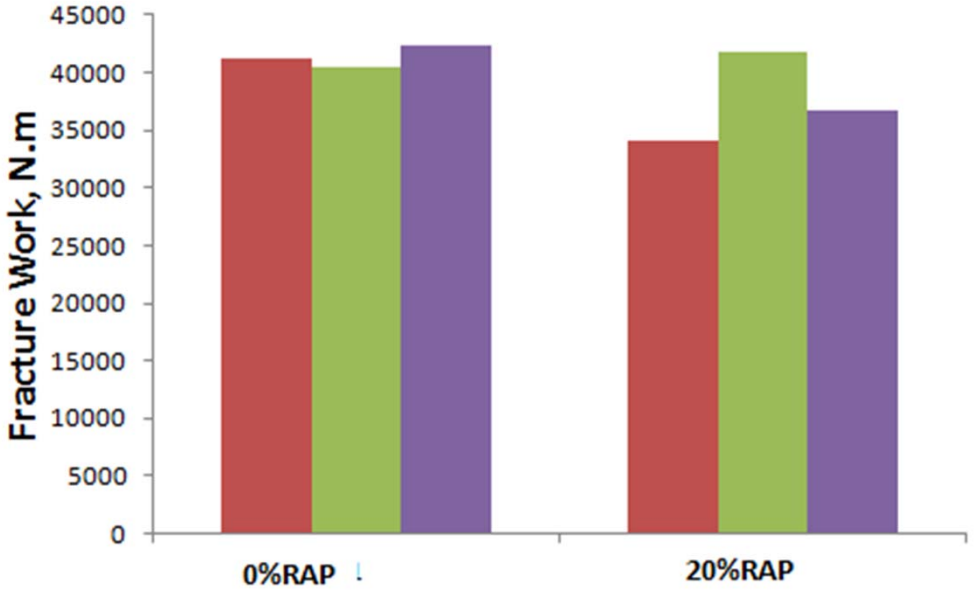
- Laboratory Tests
  - Fatigue cracking – fracture work from indirect tensile test at room temperature





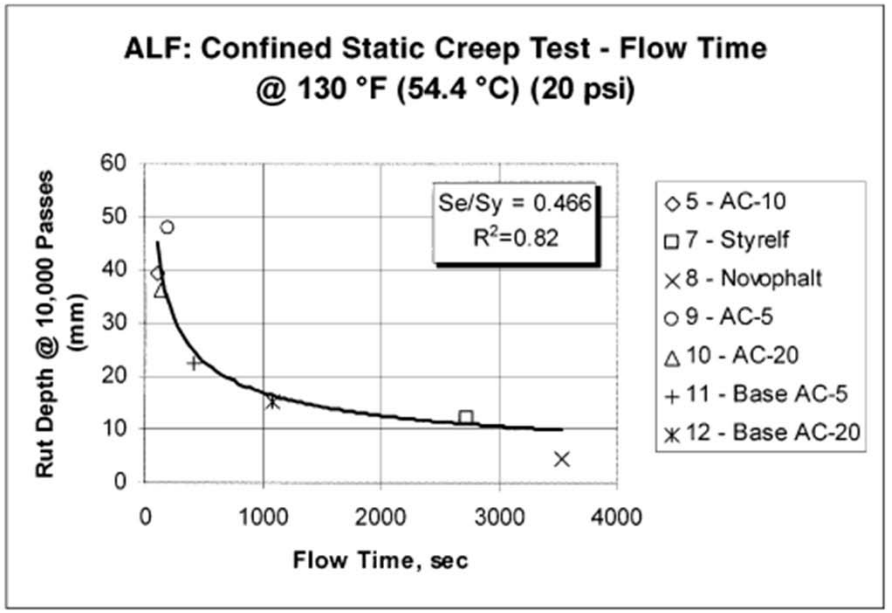
Experiments

- Laboratory Tests
  - Fatigue cracking
    - 0% RAP mix (10% higher fracture work) is slightly more resistant to 20% RAP mix.



Experiments

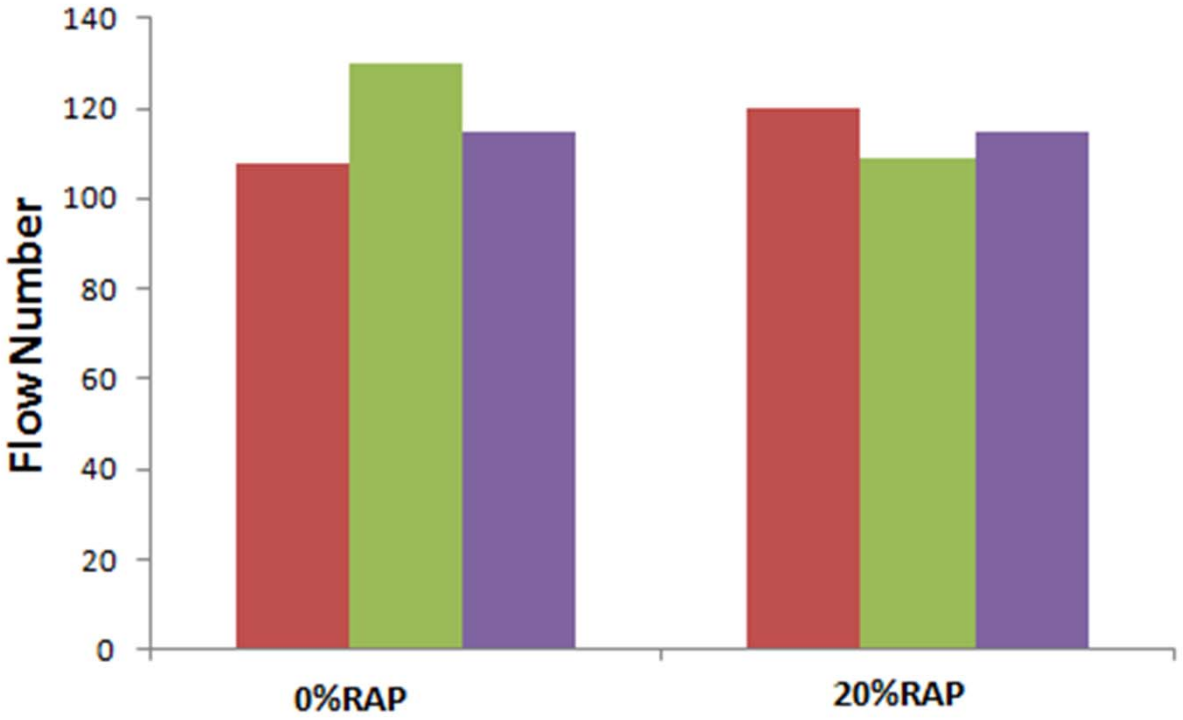
- Laboratory Tests
  - Rutting (flow number) – repeated load @ high temperature



*NCHRP Report 465

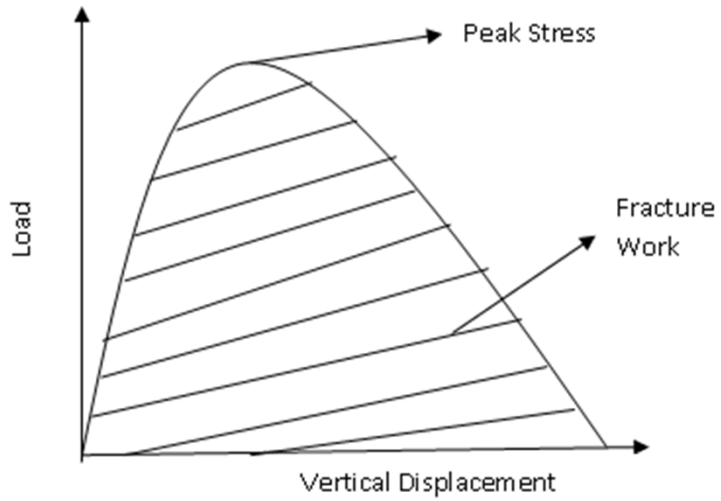
Experiments

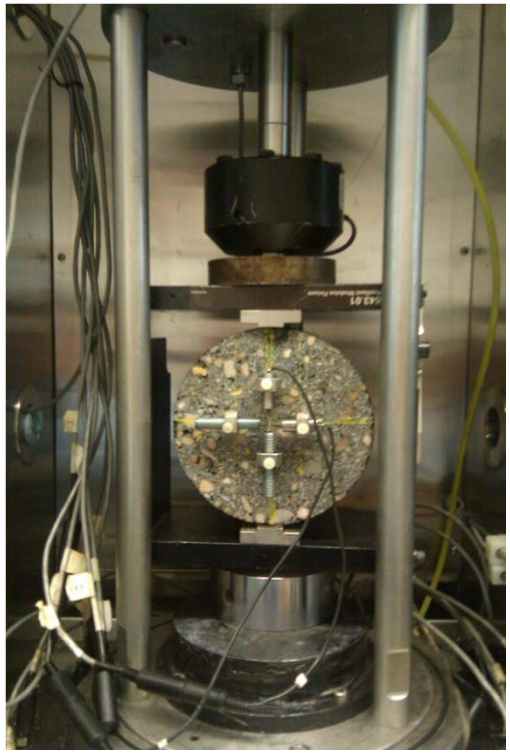
- Laboratory Tests
  - Rutting (flow number)
    - 118 (0% RAP) vs. 114 (20% RAP), no difference



Experiments

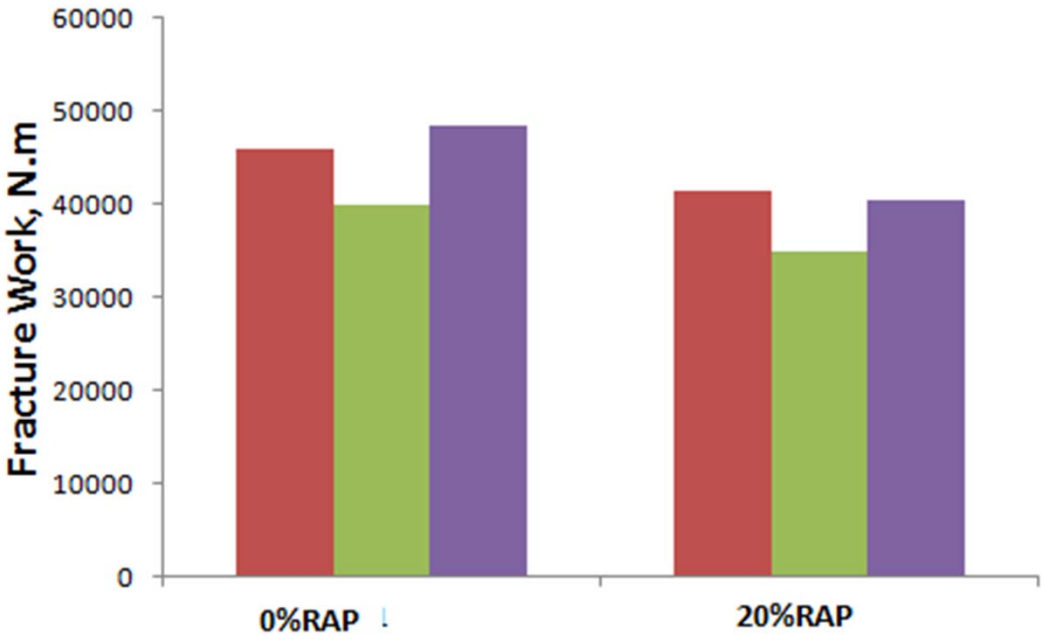
- Laboratory Tests
  - Fatigue cracking – fracture work from indirect tensile test at 14ºF





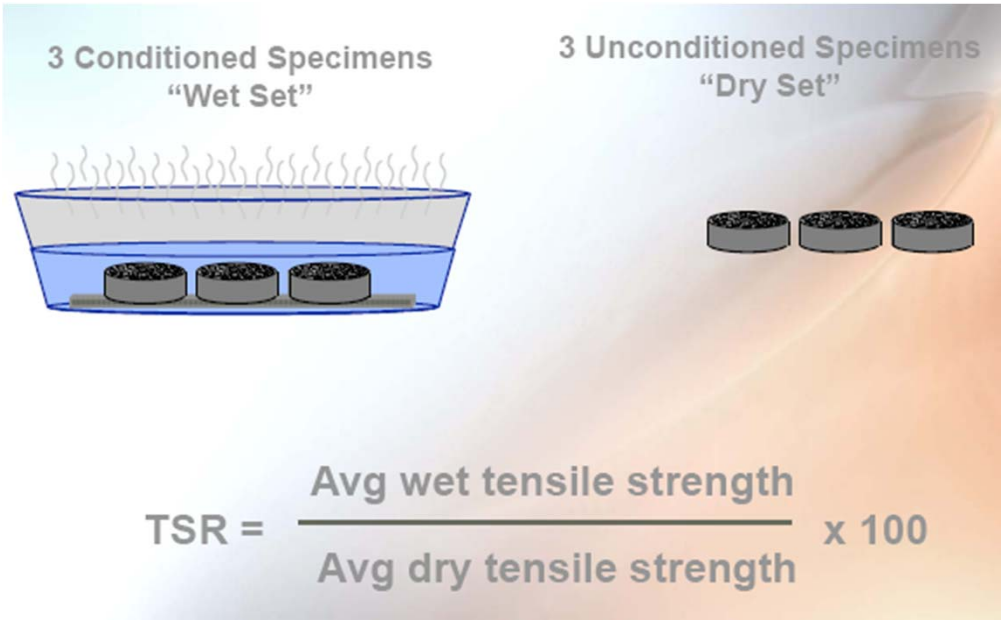
Experiments

- Laboratory Tests
  - Thermal cracking
    - 0% RAP mix (13% higher fracture work) is more resistant to thermal cracking than the 20%RAP mix



Experiments

- Laboratory Tests
  - Moisture susceptibility
    - Tensile Stress Ratio (TSR)
      - 0%RAP: 88%
      - 20%RAP: 82%



Thoughts

- RAP influences mix performance even at low RAP percentage
- We can design high RAP mix (or other mixes, i.e. war mix asphalt) through these laboratory tests
- Life cycle cost analysis determine the use of RAP

By graduate students

- Junyan Yi
- Joe Westergreen
- Mengqi Wu
- Sophie Melis
- Sushanta Bhusal