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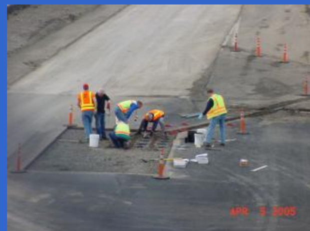
ODOT Long-Life Pavement Design & Construction



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What is a Long-Life Pavement?

- **Mechanistic-Empirical Design Guide - MEPDG (2008)**
  - **Long-Life Pavements** – *Flexible or rigid pavements that have been designed for 50+ years. Long-life pavements are also referred to as perpetual pavements.*
  - **Endurance Limit** – *The endurance limit is defined as the tensile strain or stress below which no load-related fatigue damage occurs.* (User input of value)

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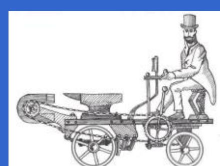
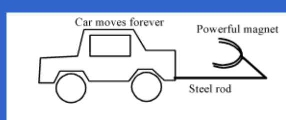
What Happened to Terminology "Perpetual Pavements"?





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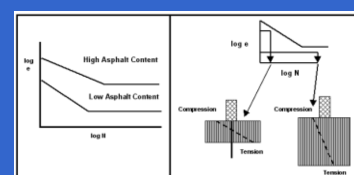
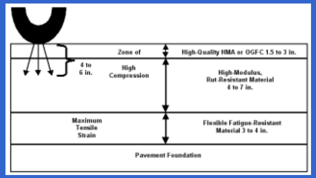
Mechanics of Materials



- Asphalt Content ⇑, Fatigue Resistance ⇑
- Thin Pavement = Higher Strain, N_f ⇓
- Thick Pavement = Lower Strain, N_f ⇑
- Endurance Limit – assumed as 70 microstrain, "unlimited" repetitions

Concept for Long-Life Pavement



- Wearing Course At Surface
- Rut Resistant Intermediate Base Layer
- Fatigue Resistant And Durable (High Binder Content) Bottom Base Layer

(TRC No. 503, 2001)

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Concept for Long-Life Pavement

- minimize/eliminate bottom-up cracking, maintain durability
- periodically repair/replace top-down cracking in wearing course
- Top-down cracking can be dealt with through "mill and fill"

Is top-down cracking a long-term problem?

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Concept for Long-Life Pavement

- **ASSUMPTION A:** endurance limit is applicable to any mix at any temperature
- **ASSUMPTION B:** top-down cracking is not a structural problem
- **ASSUMPTION C:** we can predict traffic and materials performance out to 50 years

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Assumptions for Long-Life Pavement

ODOT Proposed Design Method for Long-Life Pavements

RESEARCH OF INTEREST

- *Determining The Causes of Top-Down Cracks in Bituminous Pavements (Michigan State University PRCE, 2003)*
- *Phase III NCAT Test Track Findings (February 2009)*
- *Evaluation of Poisson's Ratio for Use in the MEPDG (Rutgers/NJDOT, 2008)*

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Top-Down Cracking (PRCE)

- *No design method is capable of predicting or analyzing TDC potential*
- *Causes of TDC can be summarized*
  - *High tensile stresses & strains induced by load/temp/construction*
  - *Low tensile strength or fatigue resistance of AC due to the AC mix properties*
    - *Aging or hardening of AC binder*
    - *Segregation, high in-place air voids*

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Solutions for TDC (Emery)

- *The key aspect… is enhanced cracking (tensile and shear fracture) resistance, while maintaining rutting resistance, through improved gradations and mix volumetrics,*
- *appropriate mix design performance monitoring and the use of asphalt binder modifiers such as polymers (crumb rubber and styrene-butadiene-styrene (SBS), for instance)*

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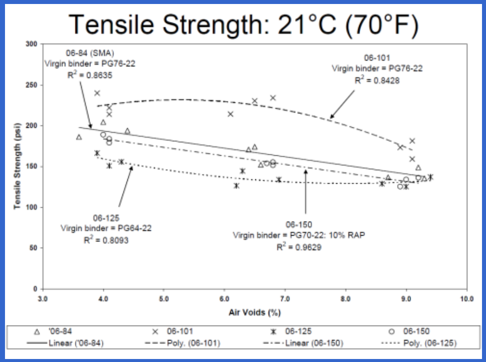
MUS&T St by Binder vs. Va (Richardson & Lusher)



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VTRC IDT vs Mr vs E*

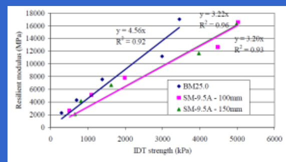

Figure 50. Correlation between IDT strength and resilient modulus

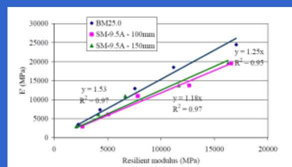

Figure 51. Correlation between resilient modulus and elastic part of the dynamic modulus

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VTRC IDT Strength vs. NMAS

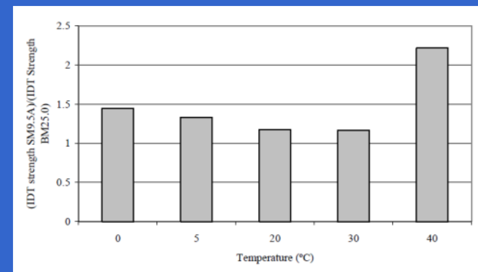

Figure 17. Ratio of the IDT strength of the SM-9.5A mix to the BM-25.0 mix

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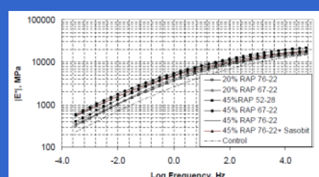
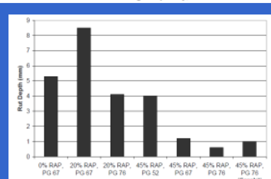
NCAT E* & Rut Depth - RAP





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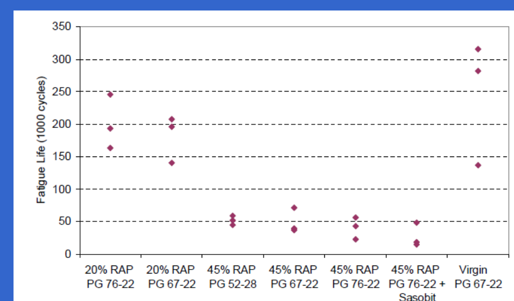
NCAT Fatigue Life-RAP



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So that takes care of the top, what about the bottom?

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NCAT Temperature & Strain

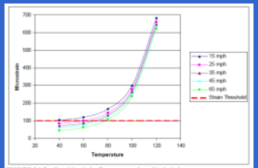

FIGURE 5.1 Predicted Strain by Temperature for a Single Axle.

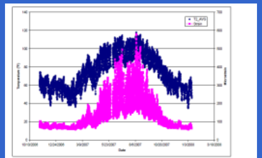

FIGURE 5.2 Measured Strain and Mid-Depth Temperatures for the N9 Test Section (28).

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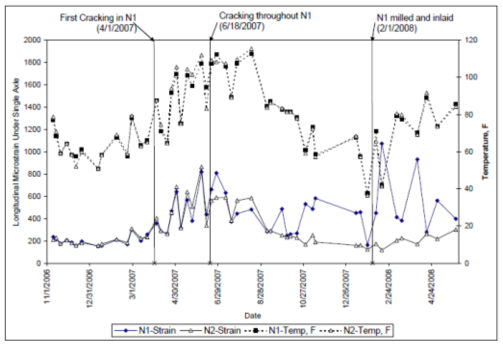
NCAT Bottom Strain vs. Time



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Canada (Emery) Fatigue-Mix Type

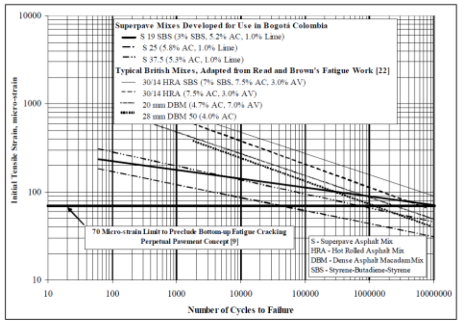

Figure 3. Fatigue Characteristics of Typical British Asphalt Mixes and New Colombian Superpave Mixes Determined Using the Nottingham Asphalt Tester

ODOT Proposed Design Method for Long-Life Pavements

USE MEPDG!

- Seasonally adjust the HMA layers for temperature at layer mid-depth
- Seasonally Adjust Both The Unbound Aggregate Base Moduli and the subgrade
- Rutgers - Poisson's Ratio value does influence rutting, longitudinal cracking and fatigue—use MEPDG predictive or study

ODOT Proposed Design Method for Long-Life Pavements

- Define HMA Mix Characteristics Each Layer, Use Previous Project Data
  - *ODOT Traditional use of ¾" Dense and ¾" Open Graded HMA*
  - *ODOT direction is toward ½" Dense HMA, more research of Open Graded HMA*
  - *ODOT to consider use of SMA or 3/8" Dense W.C., Polymer-modified*

ODOT Proposed Design Method for Long-Life Pavements

INTERSTATE DESIGN

- Analyze Project-Specific proposed design section using MEPDG
  - *Fatigue criteria of 95% reliability of 5% distress at 50 years*
  - *Meet rutting and longitudinal distress criteria of 95% reliability at 15 years (first rehabilitation)*

ODOT Proposed Design Method for Long-Life Pavements

- MEPDG allows input of strain criteria
  - *≤70 μstrain unless mix-specific data*
  - *What about effect of temperature & speed on strain criteria?*
  - *Future truck loading? Aging effect?*

  Use as a check, not for thickness determination

✓ Total thickness is "optimal" section plus 1" (factor of safety)

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ODOT Proposed Long-Life Pavement Structure

Proposed ODOT Long-Life Pavement Structure

		Ex.
1 - 2"	Wearing Course, Level 4-100, PG 76/70-28 ER (SBS polymer?) SMA or 3/8" Dense HMA, 4% Lab Air Voids, 94%+ Compaction RAP = 0-10%?, Minimum ITS = 100? Psi	2"
3 - 5"	Rut Resistant Base Course, Level 4-100, PG 70/64-xx 1/2" Dense HMA, 4% Lab Air Voids, 92%+ Compaction RAP = 0-30%, Minimum ITS=?	2"
3-6"	Intermediate Base Course, Level 4-100, PG 64-xx 1/2" Dense HMA, 4% Lab Air Voids, 92%+ Compaction RAP = 0-30%, Lime or Latex Treated?, Min. ITS=? psi	6"
3 to 6"	Rich Binder Base Course, Level 4-100, PG 64-xx 1/2" Dense HMA, 3% Lab Air Voids, 94%+ Compaction RAP = 0-10%, Lime or Latex Treated?, Min. ITS=100? psi	3" =13"
4"? 10"+	*Dense-Graded Aggregate TOP Base (free-draining)* *Dense-Graded Aggregate Base*	

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ODOT Proposed Construction for Long-Life Pavements

Rich Binder Base Course (RBBit?)

- *Kept at Level 4 (100 gyros) until further investigation*
- *3% lab V_a mix approx. +0.4-0.5% binder content compared to 4% V_a mix*
- *Lab: ⇑ VMA 13.5-18% VFA 70-82%*
- *Minimum 94% compaction*
  - *Has been obtained, with bonus*

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ODOT Long-Life Pavement Projects

- **I-5 SB MP 239.6** (2005)
  - *O.G./HMA/rubblized CRCP/DG Aggr Base*
- **I-205 MP 0-3.0** (2007)
  - *O.G./HMA/rubblized CRCP/CTB*
- **I-5 Victory-Lombard Sec.** (2010)
  - *D.G. or SMA?/HMA/DG aggregate base*
- **I-5 South Medford Intc.** (2009)
  - *D.G./HMA/DG aggregate base*

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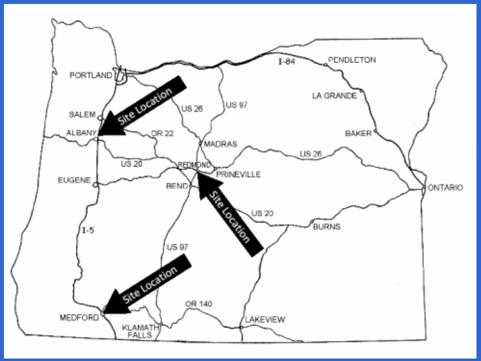
ODOT Instrumented Pavements



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ODOT Instrumented Sites

- On-going Research Projects (OSU)
  - *Strain gauges at base of HMA*
  - *Thermistors in HMA for temperature*
  - *Weigh-in-Motion for wheel load weight*
  - *Photos of truck position in lane (truck wander location from fog line)*
  - *HMA cores for modulus testing*
  - *FWD deflections for back-analysis*

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I-5 at MP 239.6 Instrumented Site

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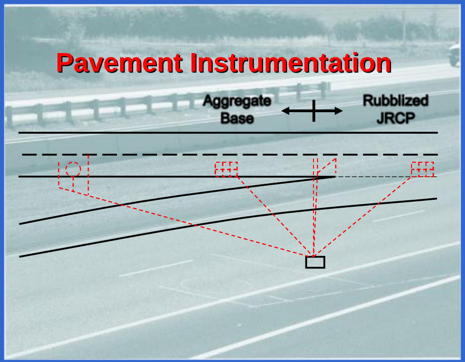
I-5 at MP 239.6 Instrumented Site



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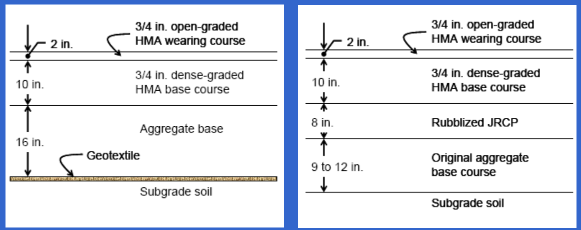
I-5 at MP 239.6 Instrumented Site



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I-5 at MP 239.6 Instrumented Site

- Predicted Tensile Strain, Bottom of HMA, Rubblized Section
  - *<70 microstrain at typical loading*
  - *70-92 microstrain, max loading, summer*
- As-Built Condition over Rubblized
  - *Actual HMA thickness +1.25 to +1.5 inch*
  - *Preliminary results from summer data*

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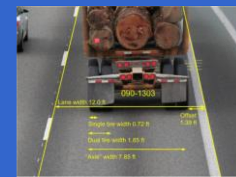
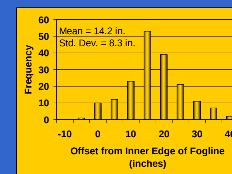
I-5 at MP 239.6 Instrumented Site

- Some Early Results
  - *Truck Wander Determined from Photo Record*
  - *Trend Shows Lots of Wander in Lane*





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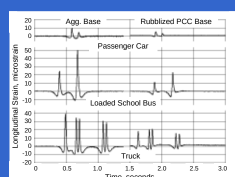
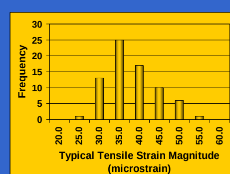
I-5 at MP 239.6 Instrumented Site

- Various Loading
  - *Passenger Car*
    - <10 microstrain
  - *Bus/Truck*
    - <55 microstrain
- Typical Tensile Strain (summer)
  - *36 microstrain*
- Maximum Tensile Strain (summer)
  - *55 microstrain*





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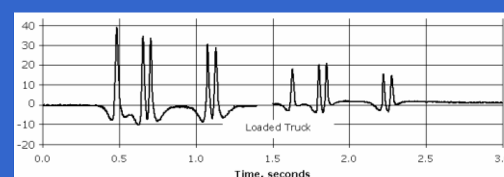
ODOT Further Study

- What Is The Effect Of Improved (Higher Modulus) Aggregate Base?
  - *Instrumentation of HMA over Rubblized PCC and Aggregate Base indicates:*
    - for same loading/HMA thickness

Aggregate Base | Rubblized



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ODOT Further Study

- Early MEPDG trials
  - *½" Dense has better fatigue resistance over ¾" Dense*
  - *PG 64-22 in RBBit better than PG 70-22*
  - *Questions raised*
    - How much total rutting is too much?
    - How do we manage *top-down* cracking over 50 years?

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ODOT Further Study

What Alternative Wearing Course Designs Can We Use?

- *Early SMA projects (½" NMAS) were not successful, current I-405 struggled, but not dead yet! Future ½" or 3/8" NMAS?*
- *Existing ¾" Open Graded requires 2" lift, other less expensive OGFC?*
- *Use of 3/8" Dense Wearing Course is being explored*

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Design and Construction for Long-Life Pavements

Long-Life Pavement Success is only as good as the Assumptions!

'Cutting-Edge' Design

Engineered Materials

High-Quality Construction

Appropriate Data Collection

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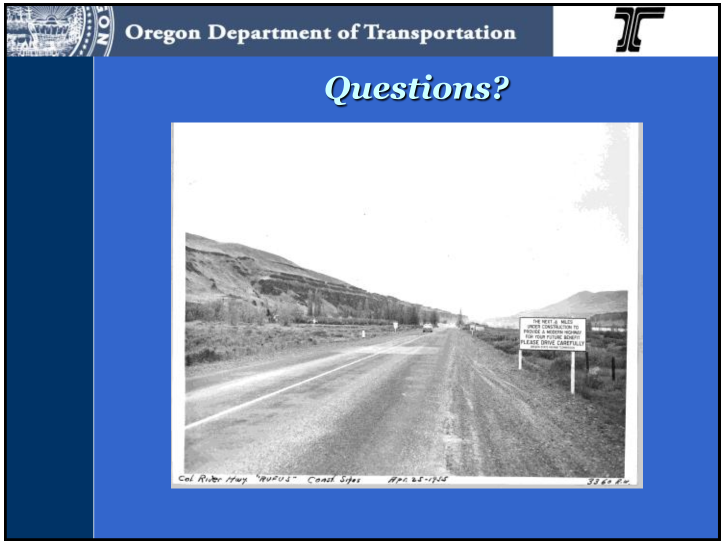
We All Have a Part in Making a Long-Life Pavement Succeed!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Questions?
THE NEXT 6 MILES
UNDER CONSTRUCTION TO
PROVIDE A MODERN HIGHWAY
FOR YOUR FUTURE BENEFIT
PLEASE DRIVE CAREFULLY
Col. River Hwy "RUFUS" Const. Sites
Apr. 25-1955
33 60 R.W.