What is a Long-Life Pavement?

  - **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)

What Happened to Terminology “Perpetual Pavements”?

- Asphalt Content ↑, Fatigue Resistance ↑
- Thin Pavement = Higher Strain, $N_f \downarrow$
- Thick Pavement = Lower Strain, $N_f \uparrow$
- 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)*

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?

Assumptions 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
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)

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

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)

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

Tensile Strength: 21°C (70°F)
So that takes care of the top, what about the bottom?

NCAT Temperature & Strain

NCAT Bottom Strain vs. Time

Canada (Emery) Fatigue-Mix Type
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)
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

- 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
**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

**I-5 at MP 239.6 Instrumented Site**

![Pavement Instrumentation Diagram]

- Aggregate Base
- Rubblized PCC Base
- 2 in. 3/4 in. open-graded HMA wearing course
- 3 in. 3/4 in. dense-graded HMA base course
- 8 in. Aggregate base
- 9 to 12 in. Subgrade soil
- 2 in. 3/4 in. dense-graded HMA base course
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

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

Typical Tensile Strain Magnitude (microstrain)
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?

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

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

We All Have a Part in Making a Long-Life Pavement Succeed!