FDR Pavement Design/Technical Concepts

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FDR Symposium, Richmond, Virginia
October 24, 2016
What is a pavement supposed to do?

• Functional aspects:
  • Noise
  • Ride
  • Friction
  • Rutting
What is a pavement supposed to do?

• Structural aspects:
  • Protect the subgrade from permanent deformation
  • Have sufficient fatigue resistance to withstand repeated loading
Structural Pavement Aspects

- Protect subgrade from permanent deformation
Structural Pavement Aspects

• Protect subgrade from permanent deformation

100 psi

8” Cement Treated Layer

Pressure ~3 to 7 psi

+/- 20 ft
Structural Pavement Aspects

• Resist fatigue damage from repeated traffic loading
Pavement Design

• For most pavements consisting of bound materials, fatigue damage is the controlling factor.
• The larger the stress or strain at the critical point, the fewer load repetitions to failure.
• The relationship between material response and damage is referred to as a transfer function.
Pavement Design

• At one extreme, a pavement can fail in one load repetition. This is a consideration for airfield pavement, but not so much for highways.

• At the other extreme, the load-induced response in the pavement can be so low that the fatigue life is “infinite”.
Pavement Design

• For asphalt, the “infinite” condition is determined by the endurance limit and expressed in microstrain.

• Researchers differ somewhat on what the endurance limit is, but the range is generally 70 to 200 microstrain and depends on the mix design.
Pavement Design

• For concrete and cement-treated bases, the fatigue life is generally expressed as the ratio of horizontal stress to the modulus of rupture.
• It is often assumed that if the ratio is less than 0.45 to 0.40, the fatigue life is also infinite.
Sample Pavement Structure

- 2” Asphalt Surface
- 10” FDR
- Subgrade

Unconfined compressive strength = 400 psi at 8 days
Modulus of Rupture = 139 psi at 28 days
Modulus of Elasticity = 595,000 at 28 days
Sample Pavement Structure

• Horizontal stress in our example is -57 psi.
• Horizontal Stress/Modulus of Rupture = 0.41.
• Using AASHTO MEPDG transfer function, this would give unlimited repetitions to failure.
• Estimated asphalt strain is 88 microstrain, below typical endurance limits for fatigue.
• Vertical stress on the subgrade is 5.5 psi.
Sample Pavement Structure

2” Asphalt Surface

10” FDR

Subgrade

Horizontal Stress (psi)

Negative = Tension
Positive = Compression
Pavement thickness design procedures

- “New” AASHTO Design Guide
  - Mechanistic-Empirical Design
  - Evaluates effects of pavement materials, traffic loading conditions, environmental factors, design features, and construction practices
  - Must be calibrated to local conditions
AASHTO PavementME Results

Chemically Stabilized Layer Cracking

- Threshold Value
- @ 50% Reliability

CSM Cracking (%)

Pavement Age (years/date)
Pavement thickness design procedures

- 1993 AASHTO Pavement Design Guide
  - Structural Numbers
  - Layer coefficients
    - SCDOT – 0.26/inch
    - VDOT – 0.30/inch
    - NCAT – 0.37/inch
Reflective cracking:
• When Portland cement and water cure, the resulting product has a slightly lower volume than what went in.
• The pavement is restrained by friction to its original length. It wants to shrink, but can’t.
• This creates tensile stresses in the pavement.
• If the tensile stresses exceed the tensile strength at a given point in time and space, the pavement will crack.
What’s the catch?

• Reflective cracking:
  • These cracks are NOT the same as fatigue cracks and have high load transfer efficiency.
  • Concern is that these cracks will lose their LTE over time, water will get into pavement and subgrade. This water could lead to softening of the subgrade and damage.
  • Also the cracks reflect through the asphalt overlay and may allow water damage.
AASHTO PavementME Results

Total Cracking (Reflective + Alligator)

- Threshold Value
- @ 50% Reliability

Pavement Age (years/date)

Dealing with reflective cracking

- Several strategies available
  - Stress absorbing interlayer
  - Geosynthetics
  - Pre-cracking/microcracking
  - Crack sealing
  - Use lower cement content/greater depth
  - Don’t worry about it...
SC-311, Dorchester Co, SC
February 2015
Age ~8 years
SC-311, Dorchester Co, SC
February 2015
Age ~8 years
Crack Sealing?
Cracking is not limited to FDR

• Patching, milling, and overlay can also develop reflective cracking over patch boundaries and existing cracks.
• Unlike FDR-related shrinkage cracking, the reflected cracks are often promptly structural in nature.
• Need to consider the FDR cracking behavior in perspective with the alternatives.
Conclusions

• FDR can provide a very long-lasting base, even under high traffic conditions.
• In mild climates reflected shrinkage cracks are primarily an aesthetic issue.
• Shrinkage cracking may be mitigated by a variety of means, if necessary.
SC Route 41, Johnsonville, SC, 1935
SC Route 41, Johnsonville, SC

1965

2014
SC Route 41, Johnsonville, SC
SC Route 41, Johnsonville, SC
Thank you.

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