SOUTHEAST CEMENT
PROMOTION ASSOCIATION

FDR Pavement Design/Technical Concepts

Andy Johnson, Ph.D., P.E.
Pavement Design Engineer
Southeast Cement Promotion Association

FDR Symposium, Macon, GA
May 15, 2018

What is a pavement supposed to do?

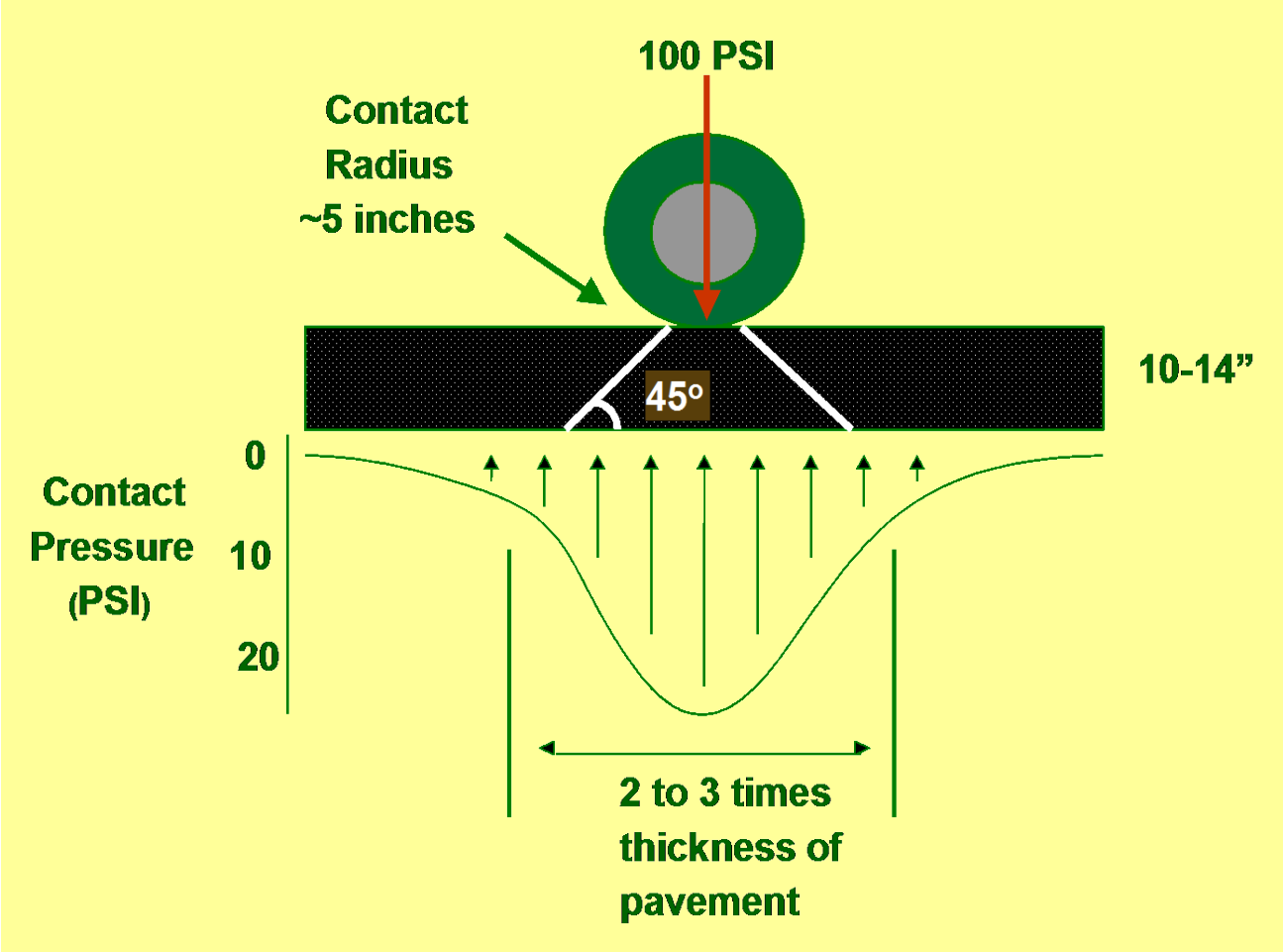
- Functional aspects:
  - Noise
  - Ride
  - Friction
  - Rutting

What is a pavement supposed to do?

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

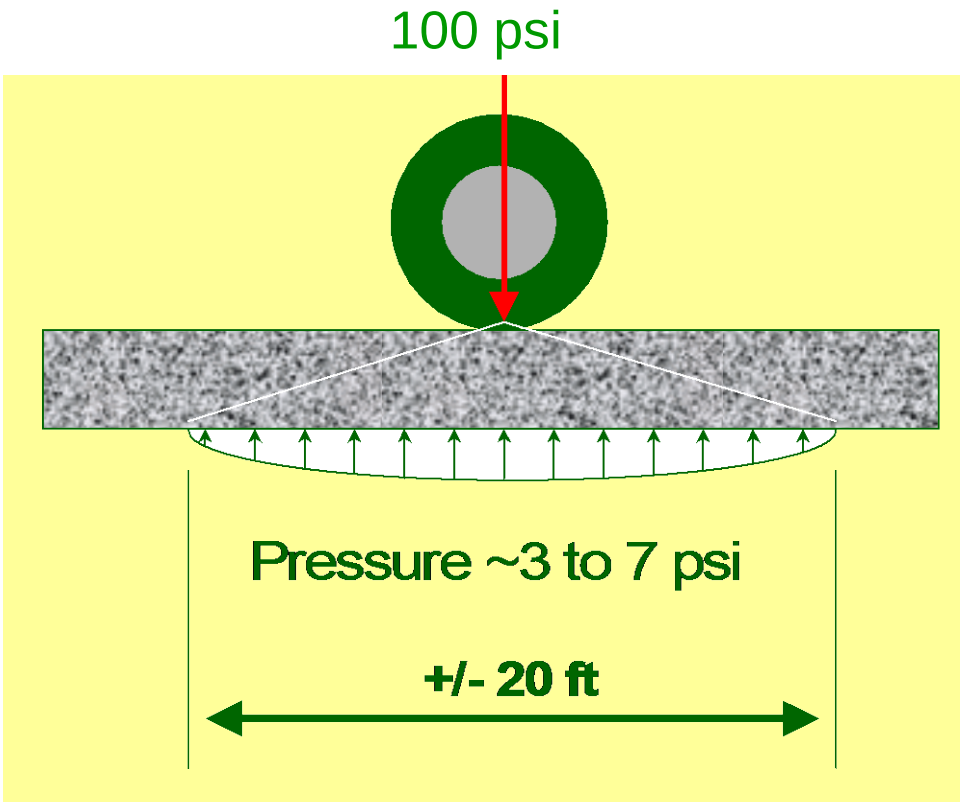
Structural Pavement Aspects

- Protect subgrade from permanent deformation



Structural Pavement Aspects

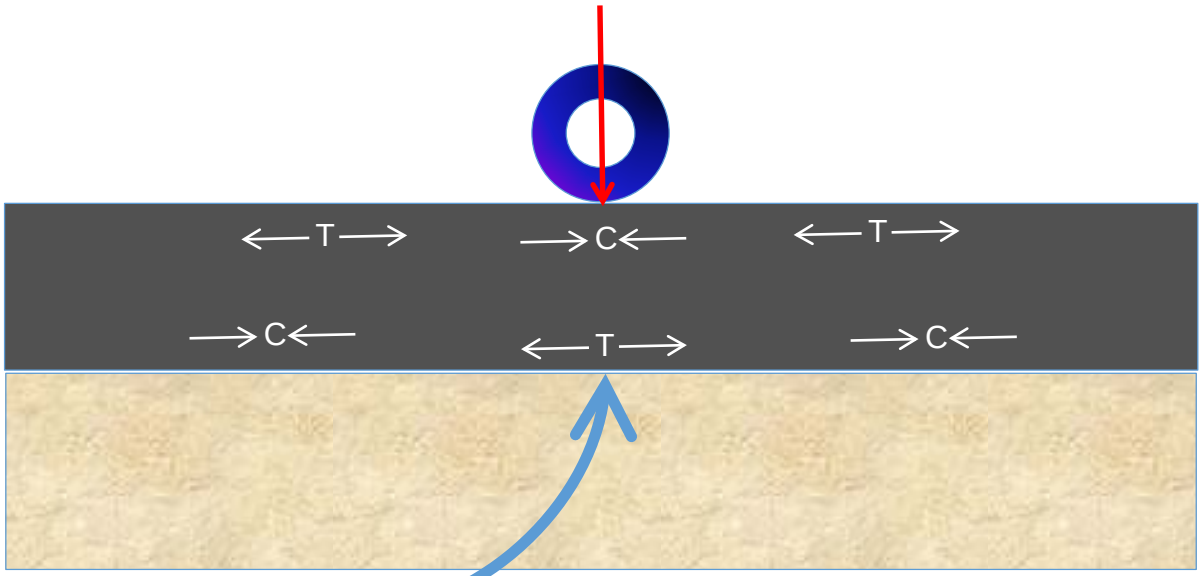
- Protect subgrade from permanent deformation



8” Cement Treated Layer

Structural Pavement Aspects

- Resist fatigue damage from repeated traffic loading



Critical Stress/Strain

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.

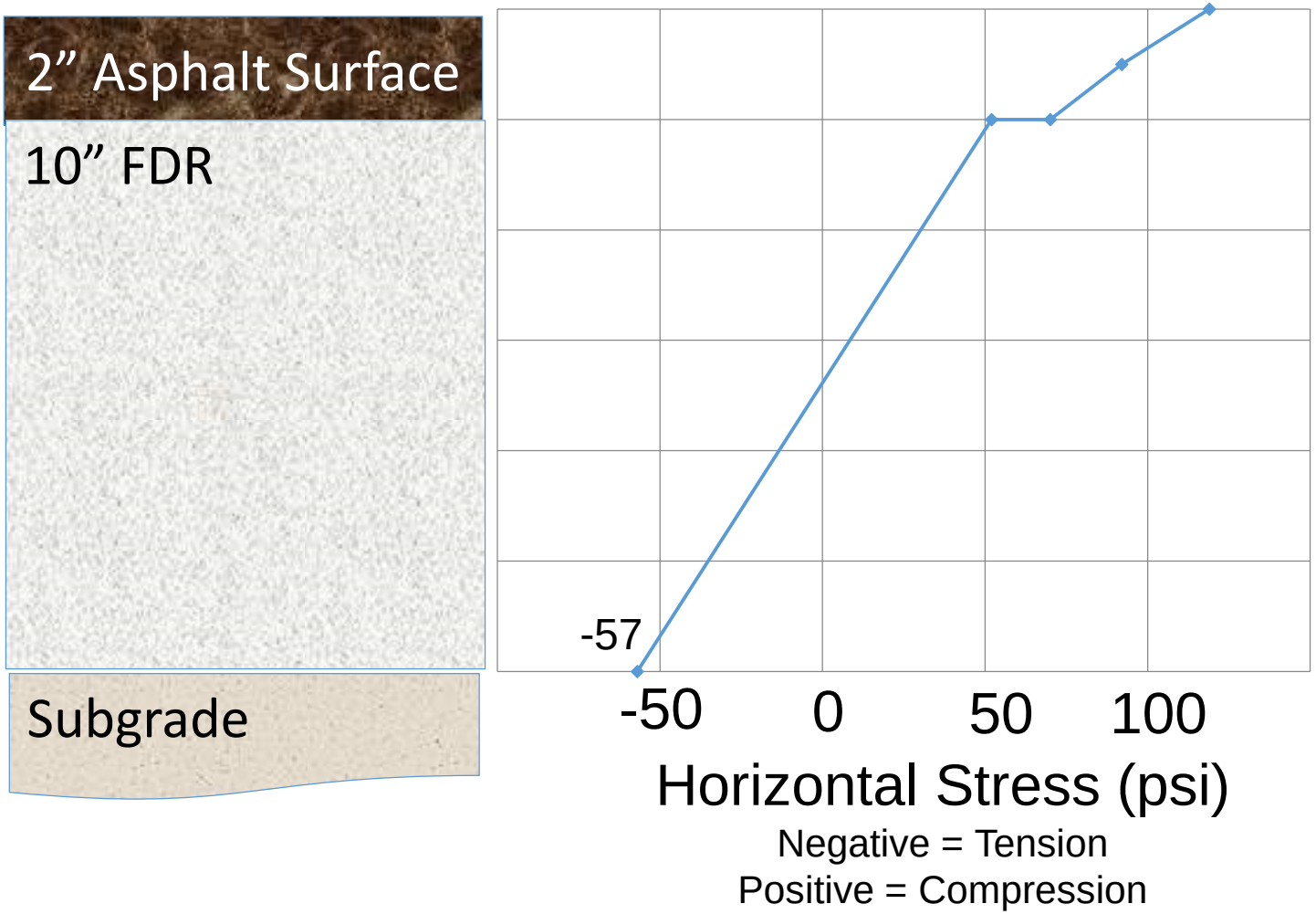
Sample Pavement Structure

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



Effect of Base Thickness

Base Thickness (inches)	Tensile Stress (psi)	Stress Ratio	Loads to failure (MEPDG)
3	181	1.3	1
6	100	0.71	1,200
8	71	0.51	389,000
9	61	0.44	2,900,000
10	53	0.38	14,460,000
12	40	0.29	196,700,000

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

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

What's the catch?

- 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.

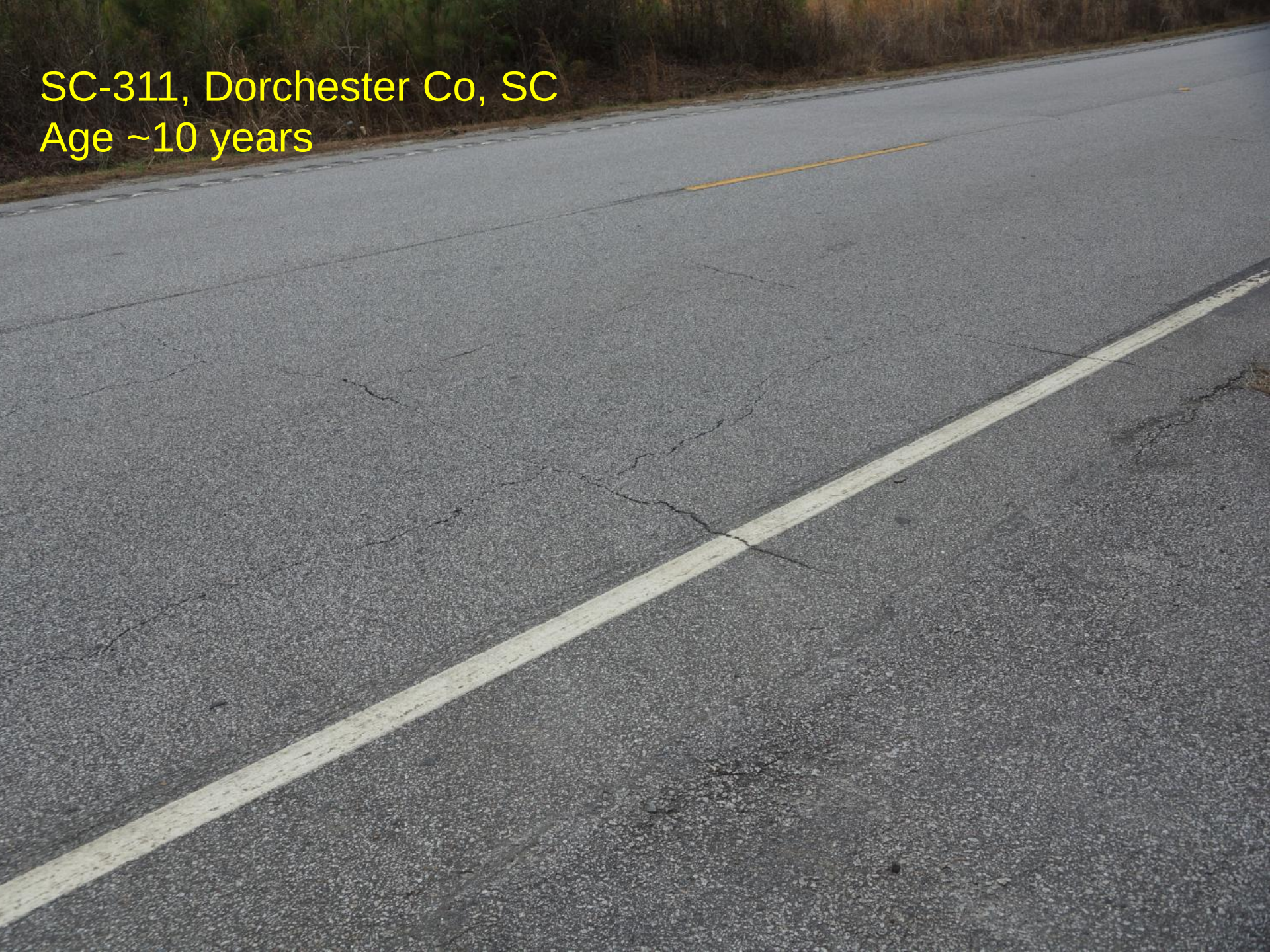
What's the catch?

- 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.

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
Age ~10 years


SC-311, Dorchester Co, SC
Age ~10 years


Old Pardue Rd
Lancaster Co, SC
Age ~10 years
Crack


Crack Sealing ?

Cracking is not limited to CTB

- Patching, milling, and overlay can also develop reflective cracking over patch boundaries and existing cracks.
- Unlike CTB-related shrinkage cracking, the reflected cracks are often promptly structural in nature.
- Need to consider the CTB 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.

SOUTHEAST CEMENT PROMOTION ASSOCIATION

Thank you.

Andy Johnson, Ph.D., P.E.
Pavement Design Engineer
ajohnson@secement.org
(803) 556-2889