Pavement Distress and Evaluation

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Distresses in Asphalt Pavement
Basic Distress Mechanisms

- Load-related
- Temperature-related
- Moisture-related
- Age-related
- Material-related
- Construction-related
- Combinations
Distribution of Wheel Load

- Hot-mix asphalt
- Base
- Subbase
- Natural soil
FATIGUE
Fatigue Cracking
Advanced Stage of Fatigue Cracking
Permanent Deformation (Rutting)

Wheel load

HMA Surface

Base

Subbase

Soil
Rutting
Rutting Confined to HMA Layer
Unstable HMA

Poor Compaction During Construction

Poor Subgrade
Thermal Cracking
Thermal Cracks
Wide Thermal Crack
CAUTION
FAULT ZONE
WATCH FOR
CRACKS IN ROAD
Frost penetration

HMA surface

Base

Subbase

Ice lenses
Water Bleeding & Pumping
Depression due to Pumping
Separation of asphalt from aggregate

Stripping
Stripping
Stripping
Raveling
Flushing / Bleeding
Polished Aggregate
Shoving
Distresses in Concrete Pavement
Basic Distress Mechanisms

• Load-related
  – Fatigue
  – Faulting
• Temperature-related
  – Low-temp. mid-slab cracking
  – High-temp. joint / crack distress
• Moisture-related
  – Pumping
  – D - Cracking
Fatigue

Location of maximum tensile stress

Aggregate base/subbase

HMA shoulder

PCC Slab

Natural soil
Longitudinal Cracking
Diagonal Cracking
Thermal-Gradient Related Stresses

Temperature differential between the top and bottom of the slab
Moisture-Gradient Related Stresses

Variations in moisture content between top and bottom of slab

No Rain

Rain
Curling / Warping Crack
High-Temperature Joint / Crack Distress

Expansive forces
Joint Spalling
Spalling
Mid-Slab Cracking
Pumping

Travel
Pumping
Pumping
Alkali-Silica Reactivity (ASR) Damage
D-Cracking
Scaling
Asphalt / Concrete Composite Pavements

- HMA surface
- PCC slab
- Existing joint or crack
Reflection Cracking
Lane-to-Shoulder Dropoff
Pavement Evaluation Techniques
Pavement Evaluation

1. Surface condition / distress
2. Serviceability / roughness
3. Structural capacity
4. Surface friction
1. Condition (Distress) Survey

- Document existing condition
- Determine causes of deterioration
- Identify repair locations and quantities
- Identify feasible maintenance alternatives
Distress Characterization

- Type
- Severity
- Extent
Distress Types for Asphalt Pavements

- Fatigue cracking
- Potholes
- Thermal cracking
- Rutting
- Bleeding
- Raveling
- Shoving
- Etc.
Distress Types for Concrete Pavements

- Cracking
- Spalling
- Faulting
- Pumping
- Etc.
Severity

- Low
- Moderate
- High
Cracking Severity

Moderate

Low

High
Extra High Severity Cracking
Extent

- Low
- Moderate
- High
Distress Identification Manual
Fatigue - Low Severity
Potholes - High Severity & Extent
Large Potholes-Signing?
Transverse Crack - Medium Severity
Transverse Crack - High Severity
Rutting - High Severity
Flushing / Bleeding – High Severity
Raveling – HighSeverity
Transverse Crack - Spalling
Diagonal Cracking
Pumping - High Severity
Alkali-Silica Reactivity (ASR) Damage
Condition (Distress) Survey

• Types of condition survey
  ✓ Manual
  ✓ Mechanical (automated)

• Sampling versus complete coverage

• Network level versus project level

• Frequency of surveys
Manual Distress Survey

- More detailed than automated
- Slower than automated

Types
- Windshield survey
- Walking
- Combination

Photos
Windshield Survey
Walking Survey
Knees and Elbows Survey
Hand-Held Computer
Automated Distress Surveys

- More consistent
- Increased safety
- No traffic disturbance
- Predictable productivity
- Objective output
- Increased sample size
- Cost saving (Long term)
Profilometer for Measuring Rutting and Roughness
Pasco Equipment
Pave Tech Equipment
Pavement Evaluation

1. Surface condition / distress
2. Serviceability / roughness
3. Structural capacity
4. Surface friction
2. Serviceability / Roughness

Roughness

- Deviations in pavement surface that affect ride quality
- Caused by:
  - Built-in surface irregularities
  - Irregularities caused by traffic and environment

- Present Serviceability Index (PSI)
- International Roughness Index (IRI)
K.J. Law Profilometer
Profilometer for Measuring Rutting and Roughness
Maysmeter
Pavement Evaluation

1. Surface condition / distress
2. Serviceability / roughness
3. Structural capacity
4. Surface friction
3. Structural Capacity

• Nondestructive testing (NDT)
  ➢ Deflection measurement
  ➢ Seismic technique

• Lab testing
NDT

- Productive - 200 to 400 measurements per day
- Repeatable
- Deflection measurements are used by most states for project and some network evaluations
Pavement Responses Under Load

Axle Load

Surface $\varepsilon_{\text{SUR}}$

Base/Subbase $\varepsilon_{\text{SUB}}$

Subgrade Soil

$\delta$
Measurement of Surface Deflection

NDT Load

NDT Sensors
Strong vs. Weak Pavements

NDT Load

“Strong” Pavement

“Weak” Pavement
Potential Results From NDT

- Project variability
- Subgrade soil support
- Void location
- Joint load transfer
- Critical periods
- In-situ material properties
- Structural adequacy
Falling Weight Deflectometer
Factors that Influence Measured Deflections

- Load magnitude
- Pavement factors (distresses, transverse location, etc.)
- Climatic factors (moisture, temperature, frost)
Testing Locations / Frequency

• 100 to 500 ft intervals
• Typically outer lane only
• Both directions - staggered
• Flexible - outer wheel path
• Concrete - midslab, joint, corner
Testing at Joints
Interpretation of NDT Data

• Uniformity of project
  ✓ Design sections for rehabilitation
  ✓ Locations for sampling / testing

• Determining pavement layer moduli
  ✓ In-situ characterization
  ✓ “Backcalculation” process
Uniformity (Non-uniformity) of Project

Sensor No.

Distance Along Roadway (m)

Deflection $\Delta$ (mm)
Typical Pavement Case

NDT Load

Layer Characteristics

Surface

E₁, V₁, D₁

Base/Subbase

E₂, V₂, D₂

Natural Soil

E₃, V₃

∞
Seismic Pavement Analyzer

Hammer

Sensors

Amplitude
Pavement Evaluation

1. Surface condition / distress
2. Serviceability / roughness
3. Structural capacity
4. Surface friction
4. Surface Friction Surveys

Surface friction
• Skid resistance
• Safety concerns
  ✓ Hydroplaning
  ✓ Wet weather accidents
• Influenced by
  ✓ Microtexture
  ✓ Macrotexture
  ✓ Cross-slope
Skid Resistance

- Interaction between tire and pavement
- Coefficient of friction:
  \[ f = \frac{F}{W} \]
- Wet condition is more critical
Measurement Equipment

- Locked wheel skid
- Mu meter
- British Pendulum Tester
- Others
Mu Meter
AND THIS WHAT THEY WANT!