Railway/Highway Crossing
Surface Performance Measures and Renewal System

By: Dr. Jerry G. Rose
University of Kentucky
Goals and Attributes
Rail/Highway Crossing Management

• Cost Effective Crossing
  – Safe
  – Smooth
  – Servicable
  – Long life

• Stable and Smooth
  – No costly disruption
  – Can be skipped over

• Accomplish
  – Minimum of time
  – 4-hour train curfew
  – 8 to 12-hour highway closure

• Utilize Cooperative Approach
  – Railroad company (contractor)
  – Local highway/governmental agency
Strengthens Trackbed Support

Waterproofs Underlying Roadbed

Confines Ballast and Track
Dense-Graded Highway Base Mix
1 – 1 ½ in. Maximum Size Aggregate
Asphalt Binder +0.5% above Optimum
Low to Medium Modulus Mix, 1 - 3% Air Voids
Trackbed Materials Classifications
• Roadbed/Subgrade Moisture Contents
  – At or Near Optimum
  – Thus, HMA Mat not Trapping Moisture
  – For Design - Use Unsoaked Condition

• HMA Cores
  – No Significant Weathering or Deterioration
  – No Loss of Fatigue Life
Planning Meeting

- All Entities Must:
  - Select a date
  - Assign responsibilities
  - Share cost
<table>
<thead>
<tr>
<th>Local Highway/Governmental Agency</th>
<th>Railroad Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Public Announcements</td>
<td>• Remove and Replace the Track and Crossing</td>
</tr>
<tr>
<td>• Traffic Control</td>
<td></td>
</tr>
<tr>
<td>• Asphalt Paving</td>
<td></td>
</tr>
</tbody>
</table>
Removing old crossing

Lifting out old panel

Excavation

Compacting roadbed
Compacting asphalt

Compacting ballast

Compacting placement of asphalt

Positioning wood tie panel
Dumping cribbing rock

Surfacing track

Placing concrete surface

Finished crossing
Excavating trackbed and checking grade

Removing old crossing 08:30

KY 3 Condition prior to rebuild

Began excavating

Excavating trackbed and checking grade
Dumping and spreading ballast

Spreading asphalt

Dumping asphalt 10:15

Compacting asphalt and dumping ballast

Dumping and spreading ballast
3 weeks later

Compacting hand-spread approaches

Regulating ballast 12:40

Finished compacting asphalt approaches 16:50

3 weeks later
Quantities

6 in. thick, 12 ft. wide, 140 lb/ft³

0.42 tons/track foot (0.50 tons/ft.)

$30/ton = $15/track foot
Pressure Cell

• Geokon Model 3500-2
• 9 in. Diameter
• Strain Gage
• Snap-Master
• Thermistor
Cell Placement on Asphalt
Cell Location at Richmond
Loaded Coal Train at Richmond

P-Cell 819 Beneath Rail in Crib

2 6-Axle Locomotives  Initial 2 Cars

Time (s)

P-Cell 820 Beneath Rail and Tie

2 6-Axle Locomotives  Initial 2 Cars

Time (s)

P-Cell 821 C/L Track in Crib

2 6-Axle Locomotives  Initial 2 Cars

Time (s)

P-Cell 822 C/L Track and Tie

2 6-Axle Locomotives  Initial 2 Cars

Time (s)
Loaded Auto Train at Richmond

P-Cell 819 Beneath Rail in Crib

P-Cell 820 Beneath Rail and Tie

P-Cell 821 C/L Track in Crib

P-Cell 822 C/L Track and Tie

Pressure (psi)

Time (s)
Loaded Concrete Truck at Richmond

P-Cell 820 Beneath Rail and Tie
Loaded Coal Truck at Lackey

P-Cell 510 Beneath High Rail and Tie

[Graph showing pressure over time]
Loaded Coal Train at Conway

5 in. HMA Layer on Wood Tie Track

2 6-Axle Locos
Initial 7 Cars

Time (s)
Deflection (in.)

4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Loaded Coal Train at Brush Creek

HMA Layer on Concrete Tie Track

-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
11 13 15 17 19 21 23

Time (s)
Deflection (in)

2 6-Axle Locos
Initial 6 Cars
Tekscan Sensor

Geokon Pressure Cell

Ballast

Subballast/HMA

Subgrade

Wooden Tie

Tekscan Sensor

Geokon Pressure Cell

Geokon Pressure Cell
View of Tekscan Sensors

- Matrix-based array of force sensitive cells
- Silver conductive electrodes
- Pressure sensitive ink – Conductivity varies
- Crossing of ink – strain gauge

Tekscan Measurement Configuration
In Track Placement During First Test

Typical Pressure Distribution Plot from Tekscan System

Scale in PSI
This represents a typical pressure distribution between a machined steel tie plate and the rail with an included rubber bladder.
Positioning of Lead Wheel with Respect to Sensor

Snapshots of the Lead Wheel
- Directly above the Sensor
- Over Sensor

F = 20985 lbf, P = 437 psi
Rear Tires of Tractor of a 151,000 lb Loaded Coal Truck on Concrete Crossing of Kentucky Coal Terminal, Mile Post 6.6. May 25, 2004

9842 lb

72.93 in$^2$

135 psi

Force vs. Frames

Pressure vs. Frames
Front Tire of a CSXT Suburban on Asphalt Parking Lot in Ashland Oil Company. May 25, 2004

1652 lb
75 PSI
22.15 in^2

Force vs. Frames
Pressure vs. Frames
Rear Tire of a CSXT Suburban on Asphalt Parking Lot in Ashland Oil Company. May 25, 2004

2197 lb

81 PSI

27.15 in$^2$

Force vs. Frames

Pressure vs. Frames
Method 1
Top-of-Rail Settlements
Method 1
Top-of-Rail Settlements

- Procedures of Measurement
  - Conventional Rod and Level
  - 19-20 Fixed Stations at Each Location
  - Crossing Area = Stations 9-12
## Highway Crossings Underlain with Asphalt

### Average Settlements in Inches

<table>
<thead>
<tr>
<th>Crossing</th>
<th>Average Rail Settlement Both Approaches</th>
<th>Average Rail Settlement Over Asphalt Underlayment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>after 14 months</td>
<td>after 29 months</td>
</tr>
<tr>
<td><strong>Big Sandy/Rockhouse Subdivisions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KY 15 Isom</td>
<td>1.520</td>
<td>1.770</td>
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<tr>
<td>Ky Power–Louisa</td>
<td>1.068</td>
<td>1.390</td>
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<tr>
<td>Ky Coal Term #1 Tk</td>
<td>0.654</td>
<td>1.104</td>
</tr>
<tr>
<td>Ky Coal Term #2 Tk</td>
<td>1.164</td>
<td>1.562</td>
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<tr>
<td><strong>Cincinnati Subdivision</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KY 8 Concord</td>
<td>1.062</td>
<td>2.102</td>
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<tr>
<td>Vanceburg, Main St</td>
<td>1.187</td>
<td>1.914</td>
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<tr>
<td>South Portsmouth access</td>
<td>0.875</td>
<td>1.522</td>
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<tr>
<td>South Shore, Main St</td>
<td>0.812</td>
<td>1.545</td>
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<tr>
<td><strong>Henderson Subdivision</strong></td>
<td></td>
<td></td>
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<tr>
<td>US 60 Stanley</td>
<td>0.500</td>
<td>0.650</td>
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<tr>
<td><strong>OVERALL AVERAGES</strong></td>
<td></td>
<td></td>
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<tr>
<td>9 Crossings</td>
<td>0.982</td>
<td>1.506</td>
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### Highway Crossings NOT Underlain with Asphalt

#### Average Settlements in Inches

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<th>Average Rail Settlement Both Approaches</th>
<th>Average Rail Settlement Over Crossing</th>
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<tr>
<td></td>
<td>after 13 months</td>
<td>after 32 months</td>
</tr>
<tr>
<td><strong>Cincinnati Subdivision</strong></td>
<td></td>
<td></td>
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<tr>
<td>Union Street</td>
<td>0.812</td>
<td>1.386</td>
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<tr>
<td>Flag Spring</td>
<td>0.969</td>
<td>1.491</td>
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<tr>
<td>Dam</td>
<td>1.125</td>
<td>1.622</td>
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<tr>
<td>Fish Camp</td>
<td>1.031</td>
<td>1.469</td>
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#### Overall Averages

<table>
<thead>
<tr>
<th></th>
<th>after 13 months</th>
<th>after 32 months</th>
<th>after 13 months</th>
<th>after 32 months</th>
</tr>
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<tbody>
<tr>
<td><strong>4 Crossings</strong></td>
<td>0.984</td>
<td>1.492</td>
<td>0.758</td>
<td>1.211</td>
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<tr>
<td></td>
<td>Approaches</td>
<td>Crossing</td>
<td></td>
<td></td>
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<tr>
<td>------------------------</td>
<td>---------------------</td>
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<td></td>
<td></td>
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<tr>
<td><strong>Asphalt Underlaymen</strong></td>
<td>After 12-15 months</td>
<td>After 12-15 months</td>
<td></td>
<td></td>
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<tr>
<td>9 Crossings</td>
<td>0.98&quot;</td>
<td>0.39&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>After 29-32 months</td>
<td>After 29-32 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.51&quot;</td>
<td>0.68&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Non-Asphalt Underlay</strong></td>
<td>After 13 months</td>
<td>After 13 months</td>
<td></td>
<td></td>
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<tr>
<td>4 Crossings</td>
<td>0.98&quot;</td>
<td>0.76&quot;</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>After 32 months</td>
<td>After 32 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.49&quot;</td>
<td>1.21&quot;</td>
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- Insignificant difference of settlement on approaches.

- At 12 to 15 months non-asphalt underlayment crossings settled 95% more than asphalt underlayment crossings.

- At 29 to 32 months non-asphalt underlayment crossings settled 78% more than asphalt underlayment crossings.
Method 1
Top-of-Rail Settlements

KY 15- Isom, KY (West Rail)

Approach Settlement (29 months) = 1.77 in.

Crossing Settlement (29 months) = 1.04 in.

Station

Elevation (ft)

98.75
99
99.25
99.5
99.75
100

11/6/02
11/21/02
1/13/04
5/24/2004
4/13/2005
Method 1
Top-of-Rail Settlements

KY Coal Terminal #2 Track (North Rail)

Approach Settlement (29 months) = 1.56 in.

Crossing Settlement (29 months) = 0.68 in.
Method 2
Pavement Profiles
Method 2 Pavement Profiles

• Procedures of Measurement
  – Total Station Instrument With Prism
  – Fixed Benchmark Assigned at 100.000 ft.
  – Vehicle Travel Paths Used as Lines of Measurement
  – Measurements Taken at Regular Intervals and Points Where Deviations Occurred
Method 2
Pavement Profiles

- Highway Centerline
- Outside Wheelpath Line
- Inside Wheelpath Line
- Crossing material