Optimizing Sub-Structure Designs and Installation Practices to Improve Long-Term Performances of Highway-Railway At-Grade Crossings

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Purpose

• Smooth Surface

• Safe Passage of Rubber-Tired Vehicles Across the Railroad
Ideal

• Stay Smooth and Stable for Long Period of Time

• Reduce Costly Interruptions to Rail and Highway Traffic

• Improve Operating Performance
Ideal

• Rapidly Install/Renew

• One Day (RR 4 hrs/Hwy 8-12 hrs)

• Layered Support

• Premium Materials
Procedure

• Complete Rebuild
• Support Layer
• Pre-Compacted Ballast
• New Track Panel
• New Crossing Surface
Ideal

• Cooperative Effort

• Local Highway agency and RR Company

• Reduce Costs/Improve Quality/Minimize Disruption
• Procedures/Case Studies

• Pressure Measurements—On Surfaces within Layers

• Long-Term Settlements
• Deteriorate

• Low Ride Quality
  R-O-U-G-H
• Typical Granular Crossings

• Excessive Deflections
  ¼ inch (6mm)

• Structurally Dissimilar
Permanent Settlement

- Impact Loadings
- Low Spot
- Impaired Drainage
- Deterioration
- Rehabilitated
Ideal

- Adequate Strength and Support
- Minimize Deflections
- Reduce Permanent Deformations
- Waterproof
- Long-Life, Smooth Crossing
Planning Meeting

Railroad Company and Governmental/Highway Agency

• Select Date
  Rail Volume/Schedule
  Highway Volume/Critical/Detours
• Assign Responsibilities
  – Highway Closure and Traffic Control
  – Public Announcements/Notifications
  – Railroad Curfew
  – Temporary Crossing/Detour
  – Track/Surface Remove and Replace
  – Highway Paving
• Share Cost

Removal and Installation of Track and Crossing (Materials, Labor and Equipment)

Traffic Control, Public Announcement, Highway Paving
• FAST-TRACK CASE STUDIES

• COSTS AND ECONOMICS

• TESTS AND PERFORMANCE MEASURES
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
Excavating trackbed and checking grade

KY 303 Condition prior to rebuild

Removing old crossing 08:30

Began excavating

Excavating trackbed and checking grade
Dumping asphalt 10:15

Spreading asphalt

Compacting asphalt and dumping ballast

Dumping and spreading ballast
Compacting ballast

Positioning new panel

Spreading cribbing rock 11:30

Tamping ballast
3 weeks later

Compacting hand-spread approaches

Regulating ballast 12:40

Finished compacting asphalt approaches 16:50

3 weeks later
Costs and Economics

Asphalt = $60/ton delivered

½ ton/ft² (6 in. thick, 12 ft. wide)

$30/ft² x 80 ft = $2,400

Underlayment

$10,000—$40,000

Crossing Renewal
TESTS AND PERFORMANCE MEASURES

• Trackbed Pressure
• Surface Pressure
• Long-Term Settlement
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

P-Cell 820 Beneath Rail and Tie

P-Cell 821 C/L Track in Crib

P-Cell 822 C/L Track and Tie
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

Time (s)

Pressure (psi)
Loaded Concrete Truck at Richmond
Cell Location at Lackey

High Rail

Low Rail
Loaded Coal Train at Lackey

P-Cell 510 Beneath High Rail and Tie

Pressure (psi)

Time (s)

P-Cell 511 Beneath High Rail and Tie

Pressure (psi)

Time (s)

P-Cell 806 C/L Track and Tie

Pressure (psi)

Time (s)

P-Cell 207 Beneath Low Rail and Tie

Pressure (psi)

Time (s)
Loaded Coal Truck at Lackey
• Matrix-based array of force sensitive cells
• Silver conductive electrodes
• Pressure sensitive ink – Conductivity varies
• Crossing of ink – strain gauge

View of Tekscan Sensors

Tekscan Measurement Configuration
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
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
Typical Pressures on Asphalt

- **286,000 lb**
  - **13 - 17 psi**
  - Loaded

- **62,000 lb**
  - **2 - 4 psi**
  - Empty

- **180 lb**
  - **6 psi**
  - Actual

- **150,000 lb**
  - **125+ psi**
  - Loaded
Long-Term Trackbed Settlement

Longitudinal view of highway/rail crossing containing asphalt underlayment

<table>
<thead>
<tr>
<th>Station 1</th>
<th>Station 9</th>
<th>Station 12</th>
<th>Station 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt Underlayment</td>
<td></td>
<td></td>
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<tr>
<td>Station 8</td>
<td>Roadbed</td>
<td>Station 13</td>
<td></td>
</tr>
</tbody>
</table>
KY Coal Terminal
Top of Rail Elevations for KY Coal Terminal # 2 Track

Installed 11/14/02
Average Asphalt/Approach Settlement for KY Coal Terminal #2

Installed 11/14/2002
Average top of Rail Elevations for KY 7 - No Name

Note:
- Installed 10/14/2005
- South Approach Surfaced 10/18/2005
- New Rail West side
Stations 1-6, 21-26, 5/7/07

Asphalt Underlayment stations 8-21 (Bold Lines)

Elevation (ft) vs Station

Station:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Average Asphalt/Approach Settlement for No Name

Installed 10/14/2005

Time (months)
Settlement (in.)
Approaches
Crossing
0 0.15 0.21 0.27 0.89 1.17
1 0.51 0.72 0.89 1.17
2 0.15 0.35 0.37
3
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Stanley
Average Top of Rail Elevations for US 60 Stanley

Station | Elevation (ft.)
---|---
0 | 99.95
5 | 100.1
10 | 100.3
15 | 100.5
20 | 100.7

Installed 5/16/2002

Graph showing the average top of rail elevations for US 60 Stanley over various dates from 5/16/2002 to 11/16/2006.
Average Asphalt/Approach Settlement for US 60 Stanley

Installed 5/16/2002
• Settlement Asphalt Crossings was 41% of non-Asphalt Crossings

• Settlement Asphalt Crossings was 44% of Abutting Approaches

• Settlement of Non-Asphalt Crossings & Approaches – Similar
References

• AREMA (2002) Annual Conference

• TRB (2009) Annual Meeting

• KTC (2009) Reports
  – 136-04-1F
  – 136-04-2F
  – 136-04-3F
Closure

• Current Practices

• Not All-Encompassing

• Typical Activities