Improving the Performance of Rail/Highway Crossings

By

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West Lafayette, Indiana

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Wide Variety of Crossing Surfaces (Premium to Low Cost)
Emphasis is on the Desirability of Adequate Support – Thus Stay Smooth
Purpose of Crossing

• Provide a **Smooth** Surface
For the Safe Passage of Rubber-Tired Highway Vehicles Across the Railroad Track
Material Costs per Track Foot

$100/\text{tk-ft} + \$300/\text{tk-ft} \quad \text{(Premium Surface)}

$100/\text{tk-ft} \quad \text{(Track Only)}

$100/\text{tk-ft} + \$100/\text{tk-ft} \quad \text{(Low Cost Surface)}
Ideal Objectives (Crossing Management Program)

- Crossing will Stay Smooth and Stable (not Settle) for Long Period of Time – Long Life

- Thus Minimize Costly Frequent Interruptions to Rail and Highway Traffic

- And Improve Operating Performance for the Rail and Highway Traffic

- Be able to skip crossing during T&S Programs
Ideal Practices

- Rapidly Install/Renew (If Required)
- One Day Outage (Railroad 4 hours/Highway 8-12 hours)
- Use Layered Support
- Properly Engineered
- Adequately Planned
- Structurally Designed
- Use Premium Materials
Ideal Procedure

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

• Cooperative Effort to Optimize Expertise

• Local Highway Agency and Railroad Company

• Thus Reduce Costs, Improve Quality, and Minimize Traffic Disruption
• Typical Crossings Can Deteriorate

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

• Excessive Deflections
  >¼ inch (6 mm) Common

• Structurally Dissimilar Relative to Highway

KY 7 Beaver Gap
Permanent Settlement

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

• Adequate Strength and Support

• Minimize Deflections

• Reduce Permanent Deformations (Settlement)

• Waterproof

• Long-Life, Smooth Crossing

• 20 Year Design Life
Consensus Goals -- Ideal Crossing Renewal Management Program

• Quality, Safe, Cost Effective, Stable, Smooth, Serviceable

• Minimum of Disruption 4 hr. Train and 8-12 hr. Highway Closures

• Cooperative, Cost-Sharing, Minimum Expense

US 60 Stanley
Planning Meeting

Railroad Company and Governmental/Highway Agency Must Agree on **Three** Aspects:

- **Select Date**
  
  Rail Volume/Schedule

  Highway Volume/Critical/Detours

US 129  Maryville, TN
• **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 Announcements, Highway Paving
Classic All-Granular Trackbed without Separation Layer and Adequate Drainage
Figure 2a. Asphalt Underlayment trackbed without granular subballast layer

Figure 2b. Asphalt Combination trackbed containing both asphalt and subballast layers

Figure 2c. Ballastless trackbed containing thickened asphalt and subballast layers
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 (optional)
Low to Medium Modulus Mix, 1 - 3% Air Voids (optional)
Example Costs and Economics
(Assume Crossing will be Paneled)

Asphalt = $60/ton delivered

~½ ton/tk-ft (layer: 6 in. thick, 12 ft. wide)

$30/tk-ft X 80 ft long =
  $2,400 for Underlayment

A Typical Crossing Renewal
  ≈ $10,000 to $40,000+
Railway Companies and Public Agencies

Metrolink    Caltrains    KYDOT    NS Corp.

West Virginia DOT

TTI Railroad    Iowa DOT

P&W Railroad/TriMet

Louis & Ind RR    Indiana DOT

Hillsborough County, FL

Michigan DOT    CSXT
• Bridge Decks and Approaches
• Turnouts and Crossovers
• Highway Crossings
• Yards
All Highway-Rail Grade crossings
6-inch thickness of HMAC Underlayment
CRUSHED MISCELLANEOUS BASE

10' TIMBER TIES SEE NOTE 1

SCARIFY SUBGRADE ROADBED 6" DEEP AND COMPACTED WITH STEEL VIBRATORY ROLLER TO 90% ASTM D-155.

FIELD PANEL (TYP)

ASPHALT PAVEMENT

BALLAST

GAGE PANEL (TYP)

6" PERFORATED DRAIN PIPE (TYP)

COMPACTED HOT MIX ASPHALT CONCRETE (HMAC) SECTION, 6" MINIMUM COMPACTED WITH STEEL VIBRATORY ROLLER TO 95% CROWN AT CENTER OF TRACK, 2% SLOPE AWAY FROM CENTERLINE, PLACE AC IN SINGLE 6" THICK LIFT, SEE NOTE 3 (TYP)

FIELD PANEL (TYP)

ASPHALT PAVEMENT

GAGE PANEL (TYP)

3'-0" MIN. 5'-0" PREFERRED 8'-0" MAX.

INDUCTION LOOP (TYP)

SIGNAL CONDUITS (TYP)

CRUSHED MISCELLANEOUS BASE

6" PERFORATED DRAIN PIPE (TYP)

SCARIFY SUBGRADE ROADBED 6" DEEP AND COMPACTED WITH STEEL VIBRATORY ROLLER TO 90% ASTM D-155.

TRACK SECTION FOR HORIZONTAL TANGENT

TRACK SECTION FOR HORIZONTAL TANGENT AT CROSSING WITH EXIT GATES AND INDUCTION LOOPS
• Began AUC in 2000
• Do 7 to 8 AUC per year
• Typically Concrete Surfaces
• AU is 6 inches thick
WVDOT pays for:

- Crossing Materials
- Asphalt Underlayment
- Traffic Control
- Drainage Pipe
- Tie Differential

No Failures due to lack of support
Standard Practice if state money is used
WV 601 Jefferson Rd
South Charleston

Tacketts Branch Rd.
Hurricane
55 Miles Long
Caltrain (92), UP (3)
Used Asphalt Underlayment Since 1999
- Crossovers #20=10
- Turnouts=12
- Street Crossings=37
- Pedestrian Crossings=12
- Stations, since 1999=10
- Tunnels, approaches=4 (All)
- Tunnels, Inverts=2
- Bridges, approaches=15
Using Asphalt Underlayment Since 1987

- For Initial 10 years:
  - Tunnel=1
  - Open Track=7
  - Highway Crossing=26
  - Switches=7
  - Bridge Approaches=5
  - Shop=2
Portland & Western Railroad
WES 15 of 18 Public Crossings
City of Tualatin=2
Other =6 or 7 (Albany and around)
Yard Lead Track
Underpass on WES
SW Scholls
Ferry Road

SW 5th Street in Beavertown
SW Teton Avenue in Tualatin
May 2010

SW Teton Avenue in Tualatin
May 2009
Salem Avenue SE in Albany

Geary Street in Albany
CROSSING NOTES:

1. THE TOP OF RAIL PROFILE THROUGH THE CROSSING SHALL FOLLOW DESIGN PROFILE SHOWN ON PLAN AND PROFILE DRAWINGS.

2. THE CONTRACTOR SHALL PROTECT ALL FOUNDATIONS AND EXISTING UNDERGROUND UTILITIES FROM DAMAGE BY EXCAVATION ACTIVITIES.

3. CONTRACTOR TO NOTIFY THE ENGINEER FOR INSPECTION OF CROSSING SUBGRADE. CONTRACTOR SHALL NOT COVER UP THE SUBGRADE UNTIL AFTER INSPECTION BY ENGINEER.

4. IF ALL OR PART OF THE SUBGRADE YIELDS UNDER PROOFROLL OR IS DETERMINED TO BE UNSTABLE, CONTRACTOR SHALL OVEREXCAVATE, PLACE, AND COMPACT SUITABLE IMPORTED GRANULAR BACKFILL MATERIAL AS DIRECTED BY THE ENGINEER. BALLAST REMOVED DURING SITE EXCAVATION MAY BE SUITABLE AS DETERMINED BY THE ENGINEER.

5. FOLLOWING TAMPING, CONSOLIDATE THE BALLAST SHOULDERS AND Crib WITH A VIBRATOR SHOULDER COMPACTOR MEETING ONE OF THE MODELS LISTED: JACKSON JORDAN 3100 COMPACTOR; TAMPER CSC CRIB AND SHOULDER CONSOLIDATION; TAMPER CSC II CRIB AND SHOULDER CONSOLIDATION; PLASSELL BALLAST COMPACTOR PBL 800. FILL CRIBS WITH ADDITIONAL BALLAST AFTER COMPACTION.

TYPICAL CROSSING SECTION

1/4" = 1'-0"
Asphalt Underlayment Program Since 2002
Renewed 11 Crossings
Anderson Road  
2002-2009

Shelton Road  
2006-2009
NOTE:
1. All ballast (in the normal track position and used as a roadway basis) shall be compacted in 12' lifts with a vibratory roller until the structure is visually observed (a minimum of 4 passes).
2. Filter fabric shall have high tensile strength and puncture resistance (heavy duty). All other characteristics shall meet railroad approval and shall be in accordance with the American Standard Index 1997 Type 3.
3. Corrugated or filter fabric used between the subgrade and the ballast should extend 2' beyond the crossing (parallel to the rails) and at least 5' beyond any rail joint.
4. The surface of the roadway shall be in the same plane as the top of the rails for a distance of 2.5' from each rail. The surface of the road shall slope down, away from the crossing, with a vertical curve that meets design criteria for the character of the road. The roadway surface shall be no lower than 1.5' from a plane at right angles to the top of the rails at a point measured 30' perpendicular to the nearest rail. The surface of the roadway shall be no lower than 1.5' from a plane at right angles to the top of the rails at a point measured 30' perpendicular to the nearest rail.
5. All grades of earthwork, the subgrade should be at or near 90' white possible.
6. The width of the crossing surface must not be less than the width of the approach traveling plus 2 feet beyond the shoulder.
8. Pedestrian crossings should be included in all new railroad crossings.

RAILROAD GRADE CROSSING
ASPHALT APPROACH

1.5" TC-6
MIN. 6.5" TYPE SP-12.5 - COARSE MIX
COMPACT PARALLEL TO RAIL
LAYER THICKNESS SHALL
COMPLY WITH THE RAIL REGULATIONS
OF FOOT FLEXIBLE PAVEMENT
DESIGN MANUAL.

ALTERNATE TYPICAL PAVEMENT
TYPE 5 ASPHALT CONCRETE
1.5" TYPE S-1 FINAL COURSE
MIN. 8.5" TYPE S-2 STRUCTURAL COURSE
COMPACT PARALLEL TO RAIL
(THICKNESS SHALL CONFORM TO THE
REQUIREMENT OF FOOT FLEXIBLE
PAVEMENT DESIGN MANUAL)

HILLSBOROUGH COUNTY
PUBLIC WORKS DEPARTMENT

TRANSPORTATION
TECHNICAL MANUAL
REVISED DATE: 01/2005

NEW - RAILROAD GRADE CROSSING

REVISIONS

REV NO. DATE DESCRIPTION
01/2006 REVISED TO INCLUDE HARDENED BASE OTHER NO. 12
Grade Crossing Surface Repair Issues
“Best Practices”
Ten Demonstration Projects with Asphalt Underlayment
2002.

State St.
Ann Arbor
Iowa Department of Transportation
Primary Highway Crossing Program

Mary Jo Key, Grade Crossing Project Manager

Travis Tinken, Construction Inspector

September 25, 2012
State Surface Repair

- Road Use Tax Fund
- Application based
- First come, first serve
- 60% fund, 20% local, & 20% RR
- 10 year back log in 1998
- Crossing life was 2 years
Objectives:
• Increase life/rideability
• Develop maintenance/renewal practices

Reviewed:
• Current standards
• Current methods
• Best practices
• Potential funding sources

Requirements identified to provide expected Benefits
Program Implementation

- Sept. 1999 DOT Commission Approval
- Meetings with all railroads
- Hired staff and procured equipment
- Developed simple agreement and payment process
- Prioritization of crossings process established
- Input secured from DOT field offices and railroads
- Construction program began in 2000
Primary Program Funding

• Primary Road Fund provides $400 per linear foot for materials only

• DOT provides
  – Manpower
  – DOT equipment
  – Specialized equipment rental
  – Detour costs
  – Asphalt for underlayment and approaches
  – Drainage materials

• Railroad provides
  – Manpower
  – Railroad equipment
  – Flagger
  – Removal of track panels and removal from project site
Iowa DOT and Driver Benefits

• Safer, smoother, longer lasting crossings
• Limited crossing complaints
• IowaDOT manpower, equipment, funding and resources can be used else where
• Streamed line processes allows fewer IowaDOT staff members to manage
• Fewer highway closures and driver disruptions
RR Benefit After Rebuild

- RR production track work done by gangs do not have to go thru the crossings -- skip
- The signal department has significantly fewer false activation issues
- Less maintenance time spent on surface failures and repairs
- Fewer slow orders
Iowa Crossing Surface Repair Today

City and county crossings - $900,000
(Off the top of the Road Users Tax Fund)

Primary road crossings - $500,000
(Primary Road Fund)

High Exposure city/county crossings - $500,000
(Federal 130 Safety Fund) review needs annually, ~ $4 million
Mason City, Iowa  9,000 ADT, 6% Trucks  
Placed in 2005
Albia, Iowa placed 2006, US 34
Russell, Iowa, BNSF Double Main, Placed in 2000
Rt 69 Story City, Iowa, placed in 1997, 4000 ADT, 4% trucks, 50 mph traffic
Selected Kentucky Crossing Installations
Rosemont Garden and Waller Avenue, Lexington, KY, 2002, NS
60 MGT, 60 MPH, 60 Trains/Day & ~ 15,000 ADT
Waller Avenue

T&S 2002
T&S 2007

S 2003
T&S 2006

2002
2002

#1
#2
Rosemont:  7/23/02  #1  8:30am-6:30pm
7/24/02  #2  8:30am-6:00pm

Waller:    8/16/02  #1  8:50am-7:00pm
8/17/02  #2  8:30am-7:00pm

2 backhoes, 1 track loader, 1 roller (city), surfacing equipment
Rosemont

9 years later after “surfacing through”, removed and replaced concrete panels
Waller Avenue

9 years later after “surfacing through”, removed and replaced concrete panels
Waller Avenue -- October 31, 2012 T&S Program

# 1

# 2

October 31, 2012
George’s Branch
Eastern Kentucky
September 2001
CSX
(All Asphalt Surface – Very Economical)
2003
3 Years later -- 2011
Ballastless

Installed 2008
2012
Ballastless

KY 292 Nolan, KY

Summer 2011
Prior to Installation
140-mile line
Began using asphalt underlayment in 1996
Since then 30 crossings underlain
(20 with state funds)
All on Major Crossings
All in Perfect Condition
(Two Changed Out)

Have 180 Public and 60 Private Crossings
Charlestown NA Pike, MP 104.75
Jeffersonville, IN -- 2003
Route 46 --- Bloomington --- 2011
Union Street --- Bloomington --- 2012
3rd Street --- Bloomington --- 2011
INDOT
Ft. Wayne District
Projects
Ft Wayne District

SR 3 East of Warren
Existing Condition, 2011
SR 8 east of Auburn NS, installed Aug.2012
The Web of Detectors

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<td>274,525</td>
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Supersites
WILD Only
Wheel Profile
Test Site
Our Supersites have co-located equipment
Ebenezer, (Knoxville) TN
Installed 2010
Photo 2012
TESTS AND PERFORMANCE MEASURES

• Crossing Trackbed Pressure

• Crossing Surface Pressure

• Long-Term Crossing and Track Approaches Settlements
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

- **P-Cell 820 Beneath Rail and Tie**
  - 2 6-Axle Locomotives
  - Initial 2 Cars

- **P-Cell 821 C/L Track in Crib**
  - 2 6-Axle Locomotives
  - Initial 2 Cars

- **P-Cell 822 C/L Track and Tie**
  - 2 6-Axle Locomotives
  - Initial 2 Cars
Loaded Concrete Truck at Richmond

P-Cell 820 Beneath Rail and Tie

Time (s)
Pressure (psi)

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

5 6 7 8 9 10 11 12 13 14
Flat Wheel on an Empty Coal Train at Lackey

P-Cell 511 Beneath Rail and Tie

2 6-Axle Locomotives
95 Empty Cars
• Matrix-based array of force sensitive cells
• Silver conductive electrodes
• Pressure sensitive ink – Conductivity varies
• Crossing of ink – strain gauge
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

135 psi

72.93 in^2

Force vs. Frames

Pressure vs. Frames
Long-Term Trackbed Settlement

Longitudinal view of highway/rail crossing containing asphalt underlayment

<Approach> <Extent of asphalt underlayment> <Approach>

<----Crossing---->

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Crossing Surface

Asphalt Underlayment

Station 8 Roadbed Station 13
KY Coal Terminal—Heavy Train and Extra Heavy Highway Traffic with ASPHALT
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
Stanley (US 60)--Medium Train and Heavy Highway Traffic with ASPHALT
Average Top of Rail Elevations for US 60 Stanley

5/16/2002
6/13/2002
8/28/2003
1/20/2004
7/12/2004
6/10/2005
2/13/2006
11/16/2006

Installed 5/16/2002
Average Asphalt/Approach Settlement for US 60 Stanley

Installed 5/16/2002
References

- AREMA (2002) Annual Conference
- AREMA (2008) Annual Conference
- TRB (2009) Annual Meeting
- KTC (2009) Reports
  - 136-04-1F
  - 136-04-2F
  - 136-04-3F
Ongoing Activities Relative to Asphalt Underlayment
Enhanced Structural Support for Rail/Highway Crossings

• Further Documenting the Economics of Asphalt Underlayment based on Performance of Crossings in Several States
• Developing a Consensus of Best Practices for Standards Development
• Evaluating the Merits of Cold-Mix Asphalt (Alternate Asphalt Mixes) in lieu of Hot-Mix Asphalt for Crossing Underlayment Applications
• Evaluating the Merits of “Ballastless” Crossing Designs for Applications on Light Traffic/Slow Speed Rail Line Crossings
• Evaluating the Economical Merits of Low-Cost Crossing Surfaces Incorporating Low-Cost Enhanced Support
• Evaluating Lightweight, Reusable Crossing Designs for Low Volume Roads
Closure

• Represent Current Practices

• Not All-Encompassing

• Typical Activities

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Thank You for Your Attention
Any Questions ???

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