"Bridging the Next Century: An Overview of Metra Rail Engineering and Update on Metra Bridge Projects"

February 10, 2011

Joseph Lorenzini, P.E.
Chief Engineering Officer
• 6 Counties
• 546 Route Miles
• 1,189 Track Miles
• 704 Trains each weekday
• 86.8 Million riders in 2008
• Largest commuter railroad in North America in terms of trackage
• Track Miles – 1,102
• Route Miles – 475
• Road Grade Crossings – 534
• RR Grade Crossings – 19
• Bridges – 821
• Stations – 240
• Parking Spaces – 92,734

LEGEND
- METRA OWNED OR CONTROLLED LINES
- UNION PACIFIC RAILROAD
- CANADIAN NATIONAL RAILWAY
- BNSF RAILWAY
Metra System Ridership
Reported w/ Free Trips
August, 1983-2009

Ridership in Millions

Responsible for Fixed Assets

- Stations and Parking Lots
- Track
- Maintenance Facilities
- Signal Systems
- Communications
- Electrical Propulsion
- Line Extensions and Expansions
- Bridges
Stations and Parking Lots

- 5 Downtown Stations
- 235 Outlying Stations
- 92,955 Parking Spaces
- 30 New Stations Since 1983
- 40,355 New Parking Spaces Since 1987
- 14,387 Parking Spaces Rehabilitated Since 1983
La Salle Street Station
Millennium Station (Randolph Street)
51st – 53rd Streets  Hyde Park
Track

- 1,155 Miles of Track
- 574 Grade Crossings
- 3,800,000 Track Ties
- 115,000 Switch Ties
Track surfacing
Track Renewal
Maintenance Facilities
Facilities & Equipment

Western Avenue Yard
Signals, Electrical, & Communications

Interlocking Upgrades
Signals, Electrical, & Communications

Interlocking Upgrades
Signals, Electrical, & Communications
Signal Operation
Automatic Block Signal
Manual Interlocking
Positive Train Control (PTC)
PTC Description

PTC enforces compliance with train operational restrictions

- Provides a “safety net” for train operations while retaining the existing operations and rules as a primary means of train control
- Otherwise referred to as a “safety-overlay” system

PTC will warn the engineer of a pending restriction, then automatically stop the train if no action is taken
PTC Benefits

Safety Related Benefits
- Train Collision Avoidance
- Switch Protection
- Over Speed Avoidance
PTC – How Does It Work?

- Before a train leaves its originating terminal all relevant information is downloaded.
- GPS works in conjunction with the geographic track data base.
- As the train moves the PTC onboard computer constantly calculates a warning and braking curve based on all downloaded information.
- As the train moves PTC pings wayside devices checking for broken rails, proper switch alignment, and signal aspects.

Office Systems —— Track Database —— Speed Restrictions —— Movement Authorities ——

Initialization —— Braking Curve —— Warning Curve —— Predictive Braking
Phase 1 – Onboard & Wayside Integration

PTC Wayside
Route determined by:
• Switch Position interrogation
• Signal State interrogation

PTC Onboard Package
• Onboard Computer
• Engineer Display
• Data Communications
Railroad Communications
Passenger Communications
Passenger Communications
Passenger Communications
Passenger Communications

Wireless Connection:

GPS Center
547 W. Jackson

- Provides location and status of train to GPS Center from on-board equipment
- GPS Center can send on-board announcements to trains

GPS Satellite Connection:

GPS

Provides location of train to on-board equipment
Electric Propulsion
Electrical Facilities

- 11 Substations
- 5 Tie Stations
- 109 Miles of 1500 Volt D.C. Catenary
- 114 Miles of 4kV A.C. Transmission Wire
Electrical Upgrades
Electrical Upgrades
Electrical Upgrades
Electrical Upgrades
Electrical Upgrades
Electrical Upgrades
Special Equipment
Metra’s Recent New Start Projects

- NCS Expansion
- UP West Extension
- SWS Expansion & Extension
NCS Expansion Project
North Central Service Expansion

- Additional Rush Hour and Mid-Day Trains
- Track Improvements
- New 2nd Main Track
- Signal Improvements
- Four New Stations
- Upgraded Station & Parking Facilities
North Central Service Expansion

Track to be Added

Existing Multi-Track
Union Pacific West Line New Start Project

- New Yard
- New 3rd Main Track
- Signal Improvements
- Improved Train Service
- Two New Station Facilities
SWS Extension & Expansion
Southwest Service New Start Project

- Additional Rush Hour and Mid-Day Trains
- Track Improvements
- New 2nd Main Track
- Signal Improvements
- Three New Stations
- Upgraded Station & Parking Facilities
Future New Expansion Projects
Proposed Metra SES Line
Snow Fighting
Bridges & Structures

- 821 Bridges
- 903 Catenary Structures
- More Than 25 Miles of Retaining Walls
- Numerous Pipes and Culverts
Construction Date of Bridges as of 2008

Number of Bridges

Decade


123 205 160 89 51 24

0 20 40 60 80 100 120 140 160 180 200 220 240 260
Bridge Replacement

- Union Pacific Northwest Line
- 14 Bridges Between Webster and Kostner
- $120 Million
Rock Island District

- 28 Bridges from 18th Street to 60th Street
- $125 Million
Union Pacific – North Line

- 22 Bridges from Fullerton Avenue to Balmoral Avenue
- $200 Million over 10 years
Reconstruct 22 Bridges on the Union Pacific North Line
Fig. 451. Bridge at Montrose Ave., 80 ft. Between Abutments, Posts on Curb Line.
Phase I

RAVENSWOOD STATION

BALMORAL
FOSTER
WINNEMAC

LAWRENCE
LELAND
WILSON
SUNNYSIDE
MONTROSE
BERTEAU
IRVING PARK
GRACE
Phase II

- CORNELIA
- ROSCOE
- SCHOOL
- MELROSE
- BELMONT
- BARRY
- WELLINGTON
- DIVERSEY
- WRIGHTWOOD
- CLYBOURN
- FULLERTON
Typical Existing Bridge
New Bridge

Clear Span
Table 15-1-1. Structural Steel (Note 1)

<table>
<thead>
<tr>
<th>ASTM Designation</th>
<th>$F_Y$ - Min Yield Point psi</th>
<th>$F_U$ Ultimate Strength psi</th>
<th>Thickness Limitation</th>
<th>Applicable to Shapes</th>
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<tr>
<td>A36</td>
<td>36,000</td>
<td>58,000 min 80,000 max</td>
<td>To 6 incl.</td>
<td>All</td>
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<tr>
<td>A709, Grade 36</td>
<td>36,000</td>
<td>58,000 min 80,000 max</td>
<td>To 4 incl.</td>
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<td>A709, Grade 50W (Note 2)</td>
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<td>A709, Grade HPS 50W (Note 2)</td>
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<td>A588 (Note 2)</td>
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<td>A588 (Note 2)</td>
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<td>A572, Grade 50</td>
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<td>A572, Grade 42</td>
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<td>A709, Grade HPS 70W (Note 2)</td>
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</table>

Note 1: These data are current as of January 2002.
Note 2: A588 and A709, Grade 50W, Grade HPS 50W, and Grade HPS 70W have atmospheric corrosion resistance in most environments substantially better than that of carbon steels with or without copper addition. In many applications these steels can be used unpainted.

a. The deflection of the structure shall be computed for the live loading plus impact loading condition producing the maximum bending moment at mid-span for simple spans. The computation of component stiffness shall be based on the following assumed behavior:

- For flexural members use the gross moment of inertia.
- For truss members without perforated cover plates use the gross area.
- For truss members with perforated cover plates use the effective area.

The effective area shall be the gross area reduced by the area determined by dividing the volume of a perforation by the distance center to center of perforations.

b. The structure shall be so designed that the computed deflection shall not exceed \( \frac{1}{640} \) of the span length center to center of bearings for simple spans.

c. Lateral deflection of spans shall be limited to 3/8 inch (10 mm) for tangent track as measured on a 62 foot (19 meter) chord. On curved track, lateral deflection shall be limited to 1/4 inch (6 mm) as measured on a 31 foot (9.5 meter) chord. Allowable lateral deflection for spans shall be calculated based on these limits taken in squared proportion to the span length under consideration.

The lateral deflection calculated is to be the maximum lateral deflection at track level due to all applicable lateral forces and loads specified in Section 1.3 excepting those due to earthquake (seismic) or wind on unloaded bridges. The maximum lateral deflection at track level shall be referenced to the point on a vertical plane below which lateral deflection is restrained (i.e. base of structure, span bearings, bottom flange of girder; depending on the lateral deflection being considered).
BEAM DIAGRAMS AND FORMULAS
For various static loading conditions

For meaning of symbols, see page 2 - 293

1. SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD

Total Equiv. Uniform Load \( = \frac{wL}{2} \)

\[ R = \frac{V}{2} \]

\[ V_x = \frac{w}{2} \left( \frac{L}{2} - x \right) \]

\[ M_{\text{max.}} \text{ (at center)} = \frac{wL^2}{8} \]

\[ M_x = \frac{wx}{2} \left( L - x \right) \]

\[ \Delta_{\text{max.}} \text{ (at center)} = \frac{5wL^4}{384EI} \]

\[ \Delta_x = \frac{wx^4}{256EI} \left( 4 - 12x^2 + x^4 \right) \]

2. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO ONE END

Total Equiv. Uniform Load \( = \frac{19W}{9 + \sqrt{3}} = 1.0264W \)

\[ R_1 = V_1 = \frac{W}{3} \]

\[ R_2 = V_2 \text{ max.} = \frac{2W}{3} \]

\[ V_x = \frac{W}{6} \left( \frac{9 - \sqrt{3}}{18} \right) \]

\[ M_{\text{max.}} \text{ (at } x = \frac{L}{\sqrt{3}} = \frac{5774L}{18} \text{)} = \frac{2W}{3} \left( \frac{9 - \sqrt{3}}{18} \right) \]

\[ M_x = \frac{Wx^3}{3!} \left( \frac{32}{3} - x^2 \right) \]

\[ \Delta_{\text{max.}} \text{ (at } x = l - \sqrt{\frac{15}{18}} = \frac{5193L}{18} \text{)} = \frac{0.01304 Wx^4}{EI} \]

\[ \Delta_x = \frac{Wx^4}{160EI} \left( 3x^4 - 10x^2 + 7x^4 \right) \]

3. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO CENTER

Total Equiv. Uniform Load \( = \frac{4W}{3} \)

\[ R = \frac{V}{2} \]

\[ V_x \text{ (when } x < \frac{L}{2} \text{)} = \frac{W}{2} \left( \frac{L}{2} - x \right) \]

\[ M_{\text{max.}} \text{ (at center)} = \frac{W}{6} \]

\[ M_x \text{ (when } x < \frac{L}{2} \text{)} = \frac{Wx}{3} \left( \frac{1}{2} - \frac{2x}{3} \right) \]

\[ M_{\text{max.}} \text{ (at center)} = \frac{Wx}{480EI} \]

\[ \Delta_x \text{ (when } x < \frac{L}{2} \text{)} = \frac{Wx}{480EI} \left( \frac{51x^4}{6} - 4x^6 \right) \]
Belmont Road Grade Separation
Existing Grade Crossing

Existing Pedestrian Crossing
Major Project Elements

- 3-Track RR Bridge Over Belmont Road (Incl. Boarding Platforms & Stairwell Structures)
- Pedestrian Underpass Tunnel with access Ramps & Stairwells Adjacent to Tunnel
- Lowered & Reconstructed Highway with Interchange Ramps
- Burlington / Warren Ave. Highway Bridge over Belmont Road
- Pump Station for Underpass
Temporary Run-around of Belmont Road
(July 2010 through September 2011)
CREATE P-1

Englewood Flyover

Grade separation of Metra
Rock Island District and NS
Main Line
Riverdale Bridge Fire

04/09/2003
Engineering Department

J. L. Lorenzini, P.E.
Chief Engineering Officer

It takes over 1,000 things done right for your train to run on time, but only one error to make it late.