Background

- Constructed in 1913
- Complicated Rall style double-leaf bascule
- Built by the City of Portland
- Given to Multnomah County on Opening Day to “Operate and Maintain”
- COP retains right to construct/operate streetcar on bridge
Background

Key Mechanical Components

• Gear Rack and Motors
• Operating Strut
• Counterweight
• Control Strut
• Live Load Shoe/Anchor Strut
• Rall Wheel/Track
Multnomah County // Broadway Rall Wheels Replacement

Background

Diagram showing:
- Operating Strut
- Rall Wheel
- Control Strut
- Live Load Shoe
What was the Problem?
What was the Problem?

- 100 years of use had severely damaged the surface of the Rall Wheels and their tracks.
- Needed replacement - never attempted before on the Broadway Bridge.
- Bridge not designed to be taken apart
- Each wheel always loaded (2M lb)
What was the Problem?  Rall Wheel

- Iregular surface wear
- Surface fatigue damage
- Cracks and divots
What was the Problem?
Rall Wheel Track

- Iregular surface wear
- Surface fatigue damage
- Cracks and divots
Existing Design
Existing Design - Wheel

- Complex triple web casting
- Designed for 2M lb load with small contact area
- Designer concerned about wheels ability to support load
- Developed Nickel Chrome Alloy, new technology for 1912, to solve problem

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate Strength</td>
<td>102,000</td>
</tr>
<tr>
<td>Elastic Limit</td>
<td>52,000</td>
</tr>
<tr>
<td>Elongation</td>
<td>14%</td>
</tr>
<tr>
<td>Reduction</td>
<td>17%</td>
</tr>
</tbody>
</table>

The above are the results of actual tests made of Nickel Chrome Cast Steel containing .40 Carbon and were discussed with Mr. Modjeski April 16th. We propose, for the 4 rollers, to use the same character of steel, with physical results reasonably close to the above.
Existing Design - Track

- Same material as wheel
- Had triple web design, modified during fab to double
- Designed to support 2M lb rolling load
New Design
New Design - Wheel

- Chose One Piece Forging
- Steel was cheap
- Simple fabrication and detailing
- Looked at weight reduction holes
- Original wheel 50 kip, new 80 kip w/o holes
- Cost of holes more than crane lo lift heavier load
New Design - Forged Tracks

- Solid forged base
- Solid forged upper track (higher strength forging)
- Held together by turned bolts
- Load transfer via shear stud pins
New Design – Assembly
New Design - Jacking System

- Posted from bearing shoe on pier through bridge deck to beam that supports trunnion.
- Jacks under grillage at roadway level
- W14X605 Braced to column that supports Rall Wheel Track – released during jacking
- Used two 880 ton jacks per wheel. 7040 kips of lifting capacity per leaf
- Needed 0.5” lift to overcome column growth and get weight of wheels off trunnions
Fabrication
Multnomah County // Broadway Rail Wheels Replacement

Fabrication – Forging the Wheels
Fabrication – Machining the Rall Wheel Tracks and Bases
Fabrication – Machining the trunnions
Construction
Construction – Jacking System
Construction – Removal of Trunnions
Multnomah County // Broadway Rail Wheels Replacement

Construction – Removal of Trunnions
Construction – Removal of Old Wheels
Construction – Removal of Old Wheels
Construction – Removal of Old Wheels
Construction – Taking Measurements for Machining the New Trunnions
Multnomah County // Broadway Rail Wheels Replacement

Construction – Final Machine and Measurement after Existing Trunnions Dimensions Verified
Multnomah County // Broadway Rail Wheels Replacement

Construction – Removal of Old Tracks
Construction – Removal of Old Tracks
Construction – Installation
Construction – Installation
Multnomah County // Broadway Rail Wheels Replacement

Construction – Installation
Multnomah County // Broadway Rail Wheels Replacement

Construction – Installation
Construction – Installation
Multnomah County // Broadway Rail Wheels Replacement

Construction – Installation
Construction – Installation
Multnomah County // Broadway Rall Wheels Replacement

Construction – Installation
Multnomah County // Broadway Rail Wheels Replacement

Construction – Installation
Partners
Questions?
New Design – Wheel Design Specification

• Design and fabrication simple
• Forging so big that specification not straightforward
• Testing requirements borrowed/modified from several ASTM Specifications

WHEEL SHALL BE ASTM A668 CL M MODIFIED AS SPECIFIED BELOW DUE TO THE FORGING EXCEEDING THE SIZE LIMITATIONS OF THE ASTM SPECIFICATION. CHARPY V NOTCH TESTS SHALL BE PERFORMED PER ASTM A788 S13 BETWEEN 70 TO 80°F AND REPORTED. ULTRASONIC EXAMS SHALL BE IN ACCORDANCE WITH ASTM A788 S20. TEST LOCATIONS SHALL BE AS PER SECTION 7.1.4.5 OF A668 WHERE T=1” EXCEPT THAT 3 LOCATIONS SHALL BE TESTED. THE FINISHED OUTSIDE DIAMETER OF THE WHEEL TO A DEPTH OF ½” SHALL BE AT A MINIMUM 300BHN, 75KSI YIELD, AND 100KSI ULTIMATE STRENGTH. THE REMAINDER OF THE WHEEL SECTION SHALL HAVE A MINIMUM 37.5 KSI YIELD AND 75 KSI ULTIMATE STRENGTH.