Methods Used to Obtain Measurements of a Large Truss Bridge with No Plans

T-19 : AASHTO Technical Subcommittee for Software and Technology
Bridge of the Gods – Cascade Locks, OR
Bridge of the Gods – Cascade Locks, OR

White Salmon Bridge

Bridge of the Gods
Bridge of the Gods – Cascade Locks, OR

- Bridge of the Gods
- The Dalles Bridge
- I-205 Glen Jackson Bridge
Bridge of the Gods

- Originally built in 1926
- Raised and lengthened in 1940 to a total length of 1,851 feet
- Inspection and load rating administered by ODOT per Intergovernmental Agreement (IGA)
Oregon Approach: 3 span - steel plate girders
Washington Approach: 3 spans - steel deck truss
Main Spans: 3 spans - steel thru-truss
Gusset Plate Deflections
Collision Damage
Gusset Plate Deflections

Erection Damage
Gusset Plate Deflections
Pack Rust
Gusset Plate Deflections
Possible Load Induced
Missing Data Required for Load Rating
Missing Data Required for Load Rating
Missing Data Required for Load Rating

- Cross-sections of non-fracture critical members
- Missing dimensions of some fracture critical members
- Cross-sections of stringers and floor beams
- Cross-sections of cross-bracing and sway frames
2011 special inspection

Hired a consultant to climb the bridge and take measurements

- Cross-sections of non-fracture critical members
- Missing dimensions of some fracture critical members
- Cross-sections of stringers and floor beams
- Cross-sections of cross-bracing and sway frames
Collect Gusset Plate Data

Take high resolution photos of vertical gusset plates in one-quarter or quadrant of spans 4, 5, & 6
OSU Photo Rectification

Capture images
OSU Photo Rectification

Capture images

Process images into scaled orthographic photographs
OSU Photo Rectification

Capture images

Process images into scaled orthographic photographs

Query and extract geometric data
**OSU Photo Rectification**

Capture images

Process images into scaled orthographic photographs

Query and extract geometric data

Use for inputs:
- CAD
- Analysis
Implementation

• Consumer grade camera
  • Single-lens reflex (SLR) digital camera
  • Resolution: 3872x2592 Pixels (10 Megapixel)
  • Deploy flat-field or fish-eye lenses

• 8” and 24” Reference Targets
  • Nine aluminum control points
  • Aluminum encased round ceramic magnet

• MathWorks MATLAB w/ Image Processing Toolbox
  • http://www.mathworks.com/products/matlab/
  • MATLAB scripts that were created by Oregon State University
### Field Measurements

<table>
<thead>
<tr>
<th>Photo</th>
<th>Distance between camera and gusset plate</th>
<th>Plate Thickness</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>T6-001.jpg</td>
<td>1' 7&quot;</td>
<td>3/8&quot;</td>
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</tr>
<tr>
<td>T6-002.jpg</td>
<td>1' 6&quot;</td>
<td>3/8&quot;</td>
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<tr>
<td>L7-001.jpg</td>
<td>2' 10&quot;</td>
<td>1/2&quot;</td>
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<tr>
<td>L7-002.jpg</td>
<td>2' 11&quot;</td>
<td>1/2&quot;</td>
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<tr>
<td>M7-001.jpg</td>
<td>2' 10&quot;</td>
<td>3/8&quot;</td>
<td></td>
</tr>
<tr>
<td>M7-002.jpg</td>
<td>3' 1&quot;</td>
<td>3/8&quot;</td>
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<tr>
<td>U7-001.jpg</td>
<td>1' 6&quot;</td>
<td>3/4&quot;</td>
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<td>1' 7&quot;</td>
<td>3/4&quot;</td>
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<tr>
<td>B8-001.jpg</td>
<td>2' 0&quot;</td>
<td>3/8&quot;</td>
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<tr>
<td>B8-002.jpg</td>
<td>2' 9&quot;</td>
<td>3/8&quot;</td>
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<tr>
<td>B9-001.jpg</td>
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<td>3/8&quot;</td>
<td></td>
</tr>
<tr>
<td>B9-002.jpg</td>
<td>2' 6&quot;</td>
<td>3/8&quot;</td>
<td></td>
</tr>
<tr>
<td>L9-001.jpg</td>
<td>3' 1&quot;</td>
<td>5/8&quot; with 1/2&quot; shingle plate</td>
<td></td>
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<tr>
<td>L9-002.jpg</td>
<td>3' 10&quot;</td>
<td>5/8&quot; with 1/2&quot; shingle plate</td>
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<td>T9 and B9 similar</td>
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<td>1/2&quot; with 3/4&quot; shingle plate</td>
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<tr>
<td>B10-001.jpg</td>
<td>2' 2&quot;</td>
<td>3/8&quot;</td>
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</tr>
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<td>3/8&quot;</td>
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</table>

- Take the best available image with the camera as orthogonal to the gusset plate surface as possible.
- Take at least one physical length measurement on the gusset plate (and mark on the plate so it is visible in the image).
- Take a measurement of the plate thickness (and mark on the plate so it is visible in the image).
Original photo with fish-eye lens
Original photo with fish-eye lens

“De-fished” photo
Performing Photo Rectification in MATLAB

- Load the “de-fished” photo
- Select the size of the target used in the photo
- Enter the camera distance from the target in feet
Performing Photo Rectification in MATLAB

- Load the “de-fished” photo
- Select the size of the target used in the photo
- Enter the camera distance from the target in feet
- Zoom in and select the 9 control points on the target
Performing Photo Rectification in MATLAB

- Load the “de-fished” photo
- Select the size of the target used in the photo
- Enter the camera distance from the target in feet
- Zoom in and select the 9 control points on the target
POOLED FUND RESEARCH PROJECT

Imaging Tools for Evaluation of Gusset Plate Connections in Steel Truss Bridges

Transportation Pooled Fund Program Project# TPF 5(259)

Oregon State University

Project Completion: 9/30/2014

Lead Agency: Oregon Department of Transportation

Participation from:

• FHWA
• Texas
• Wisconsin
• California
• New York
• North Carolina
• Idaho
POOLED FUND RESEARCH PROJECT

Imaging Tools for Evaluation of Gusset Plate Connections in Steel Truss Bridges

- Develop methods to collect dimensional gusset plate information including out-of-plane distortions of the gusset plate.

- Develop methods to automate the identification of:
  - reference target points
  - gusset plate edges
  - fastener locations
  - corresponding member affiliations
  - member orientations

- Develop finite element modeling and analysis to directly rate gusset plates using extracted digital image data.

- Develop software tools to manage and organize images and data.
How to Measure the Overall Geometry

Field measure the lengths of every member?

How would the angles be measured?

How would we get the lengths of all of the secondary members?

Have a survey crew shoot coordinates at each node?

Would they require a climber to go to each node with a target?

Would there be too much down time waiting on the climbers to get into position?
LIDAR (Light Detection and Ranging)

Leica Scan Station C10

- Accurate to ¼” at 150 feet
- Approximate cost: $150,000.
LIDAR (Light Detection and Ranging)
Point Cloud Model
LIDAR (Light Detection and Ranging)
Point Cloud Model
LIDAR (Light Detection and Ranging)
Point Cloud Model
LIDAR (Light Detection and Ranging) Point Cloud Model

LIDAR Range is 500’ for this point cloud density
LIDAR (Light Detection and Ranging)
Point Cloud Model
LIDAR (Light Detection and Ranging)
Converting Point Cloud Model to CAD
3-D CAD Model

- Extract Coordinates for truss geometry
- Measure lengths of secondary members for dead load
Many Uses for this Technology

Other Work ODOT Used LIDAR On:

- Rockfalls
- Highways
- Monitoring Movement
- Environmental Areas
- Archeology Sites
- Map Tunnel Linings
- Monitor Bridge Scour
Perform Load Rating Analysis
Questions?

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