



OREGON DEPARTMENT OF TRANSPORTATION

REGION 4 BRIDGE ENGINEERING

63055 N. Highway 97, Building M
BEND, OR 97701-5765
(541) 388-6225



GOOD BRIDGES, BAD DETAILS, AND UGLY CRACKS

A STUDY IN TITANIUM ALTERNATIVES TO FIBER REINFORCED POLYMERS

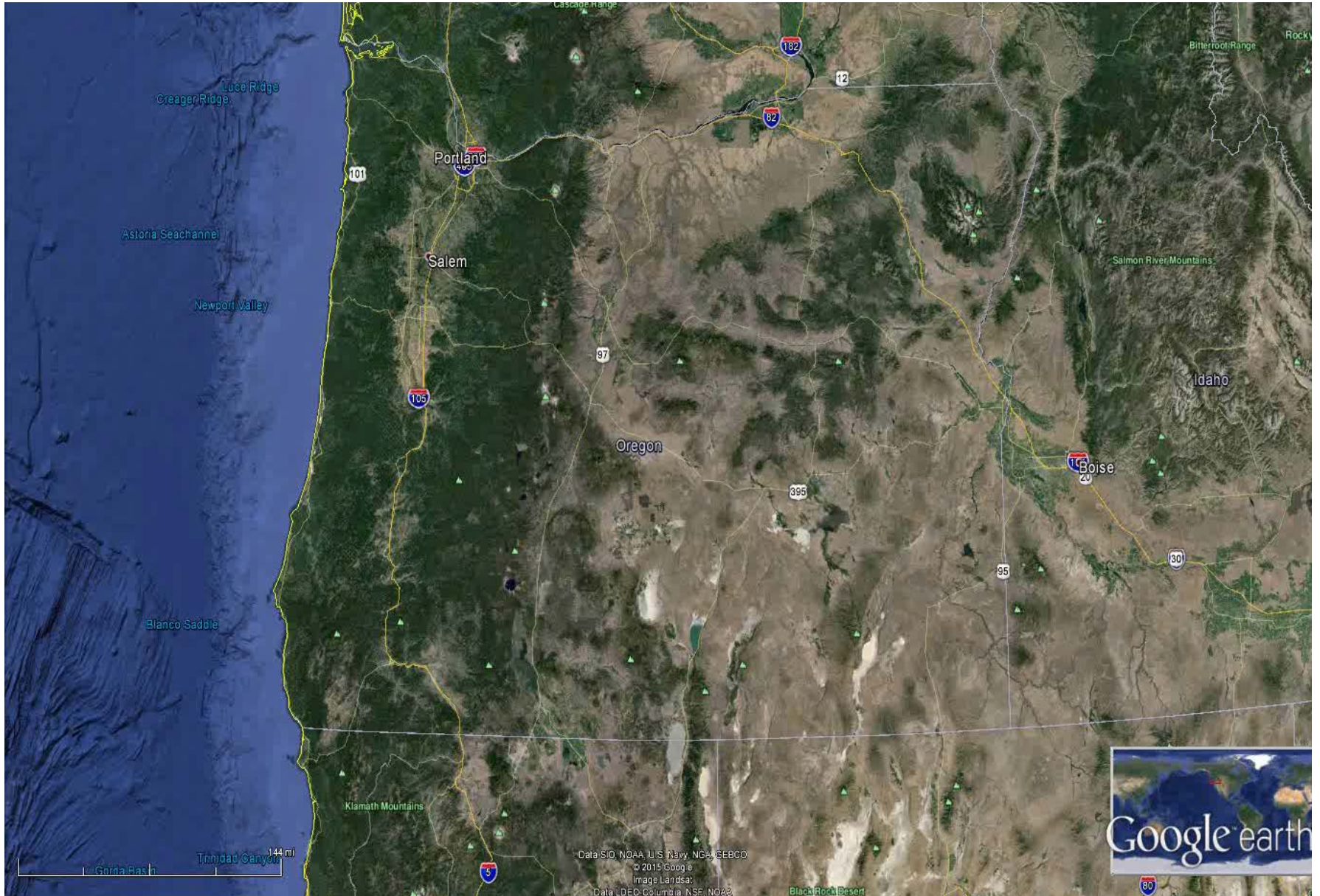
By Paul Strauser, PE

Overview



- Str. No. 07626A Mosier WB Conn over Hwy 002
- Titanium Strengthening Technology
- Discovery (Cracking) → Design → Construction

Site Location



Vicinity Map

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Mosier WB Conn Over Hwy 002
Write a description for your map.

Legend
07626A - Mosier Westbound Conn Over Hwy 002



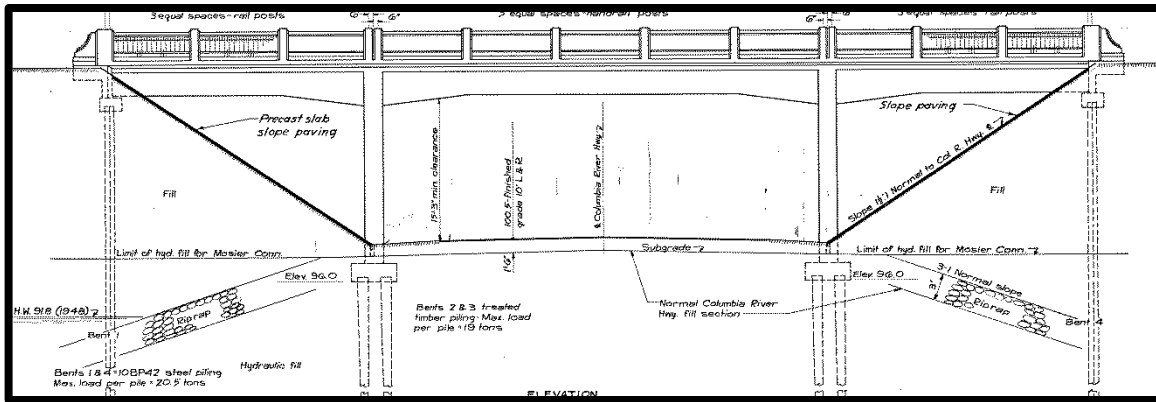
Structure No. 07626A

Mosier WB Conn over Hwy 002



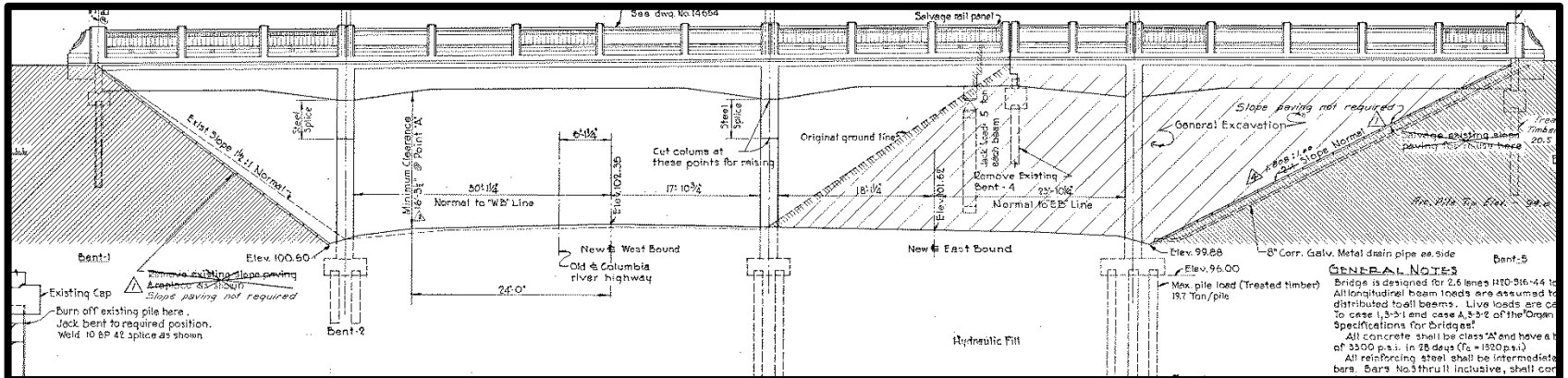
Bridge Original Construction

1952



Bridge Lengthened

1960



GENERAL NOTES
 Bridge is designed for 2.6 lanes H20-S16-44 to distributed toll beams. Live loads are as to case 1, 3.3-1 and case A, 3.3-2 of the Oregon Specifications for Bridges.
 All concrete shall be class "A" and have a f_c of 3500 p.s.i. in 28 days ($f_c = 1900$ p.s.i.)
 All reinforcing steel shall be intermediate bars. Bars No. 3 thru 11 inclusive, shall cor

June 4th, 2013



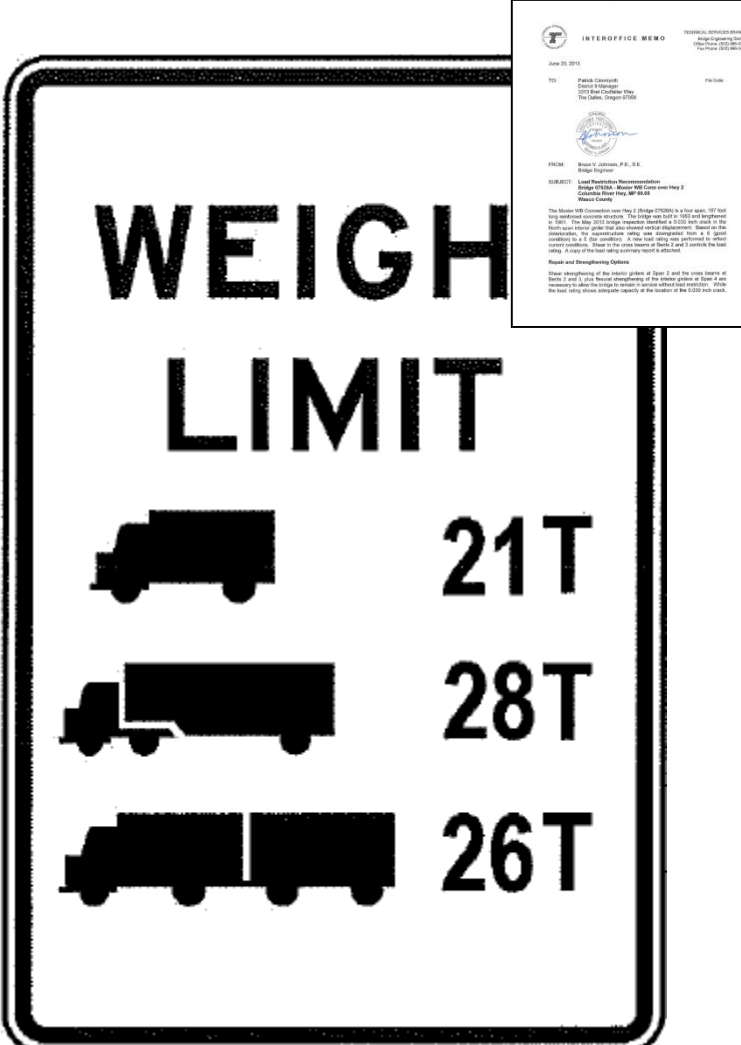
- John Adkins, PE – R4 Bridge Inspector
 - Span 1 – Interior Girders
 - “These cracks seem different from any other cracks I’ve seen on RCDG structures.”
- ODOT Brainstorm
 - Load Rating, HQ, Inspectors
 - Region Notified Salem
 - Updated Load Rating
 - John Milcarek, PE



June 19, 2013




- ODOT Load Rating Unit
 - Update from 1995 Rating
 - Low RFs
 - Crossbeams Bents 2 & 3
 - Shear
 - Moment
 - Int. Girders Spans 2 & 4
 - Shear
 - Moment
 - Longitudinal Reinforcement
 - Legal and Permit Vehicles
 - Load Posting Recommendation



**WEIGH
LIMIT**

 **21T**

 **28T**

 **26T**

INTEROFFICE MEMO

June 20, 2013

To: Paula Christy
District Engineer
1212 East Commerce Way
The Dalles, Oregon 97130

FROM: Brian V. Johnson, P.E., S.E.
Bridge Engineer

SUBJECT: Load Rating Recommendation
Bridge 0723A - Maximize Allowance over Hwy 2
Corvallis Street, Mt. Hood

The Mount Hood Corridor over Hwy 2 (Bridge 0723A) is four spans, 167 feet long and carries traffic over the Mt. Hood Corridor. The bridge was built and designed in 1967. The May 2013 bridge inspection classified a 20% increase in the bridge's weight capacity from the previous rating of 26T to 31T. Based on the inspection, the maximum weight capacity is now 31T. A 5% safety margin is required for the bridge to be used for the 31T weight capacity. A copy of the final rating report is attached.

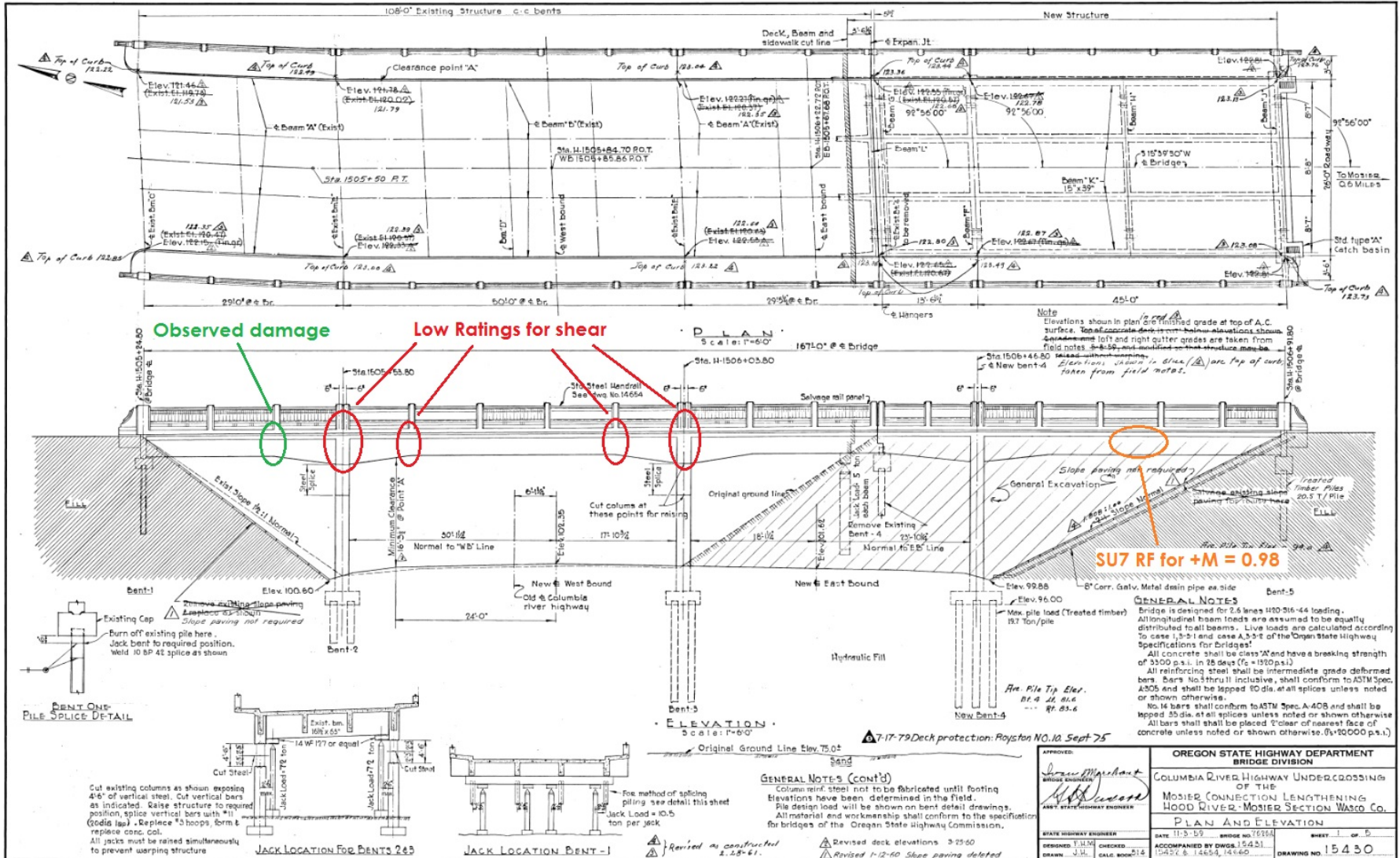
Request and Disposition of Comments:

Clear all references of the 26T weight limit on signs 2 and 4 and the cross beams at Bents 2 and 4. The Mount Corridor Bridge at the Mount Corridor is now a 31T bridge. The bridge is now a 31T bridge. The bridge is now a 31T bridge. The bridge is now a 31T bridge.

Load Rating

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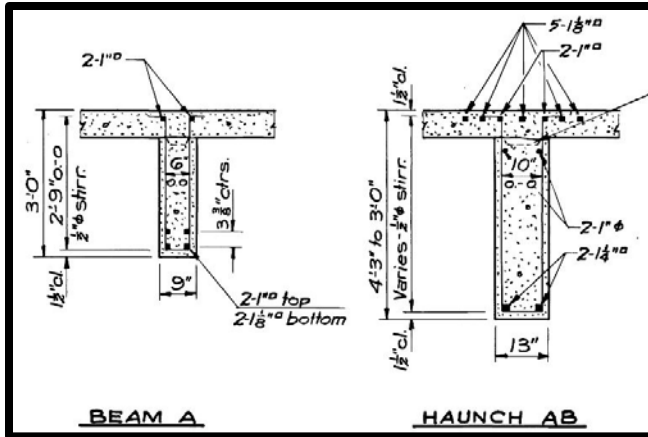
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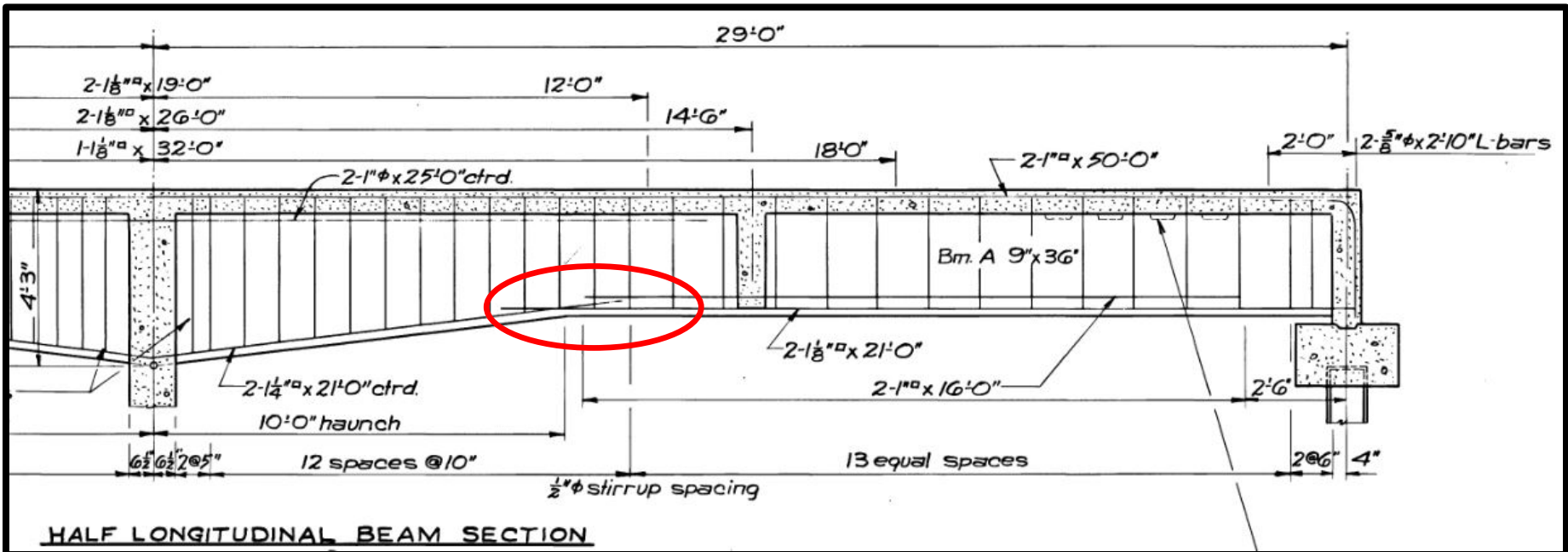
Poor Detailing

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- ❑ Limited Development
 - Less than shown
- ❑ Vertical Crack Turns Horizontal
 - Anchorage Failure (Not Yield)



S/13

0.030 S/13







Elevation View

(2) No. 8 @ 130" o-o
(2) No. 8 @ 160" o-o
(2) No. 7 @ 212" o-o
(1) No. 8 @ 202" o-o

(2) No. 6 Gr 60 @ 136" o-o

(2) No. 8 @ 132" o-o

(2) No. 7 @ 97" o-o

(2) No. 9 @ 112" o-o

2'-8"

8'

11'-2"



Temporary Support



- Zach Beget, PE & District 9 Bridge Crew
 - Temporary Shoring Design and Installation



- Posting Improves

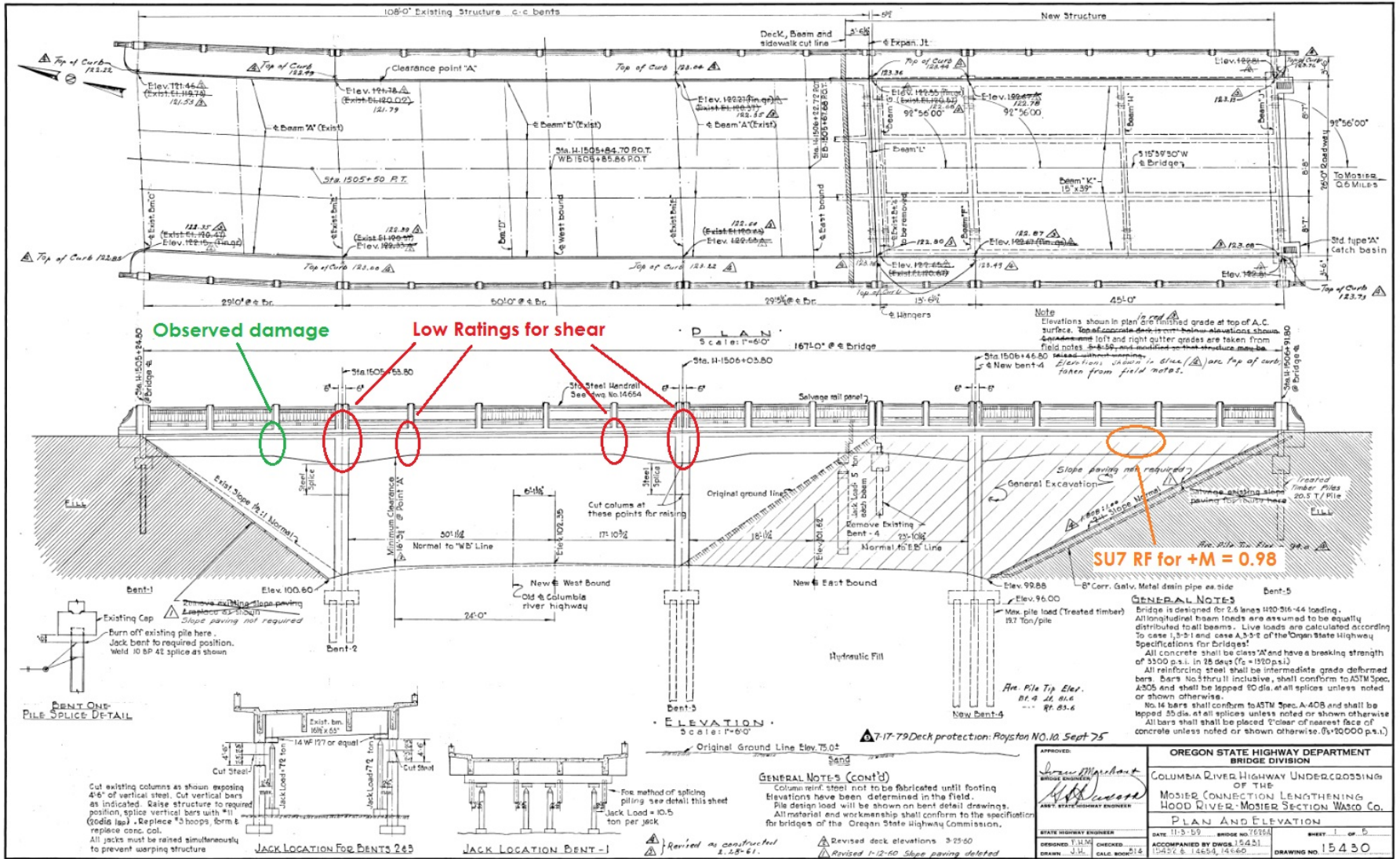


Load Rating



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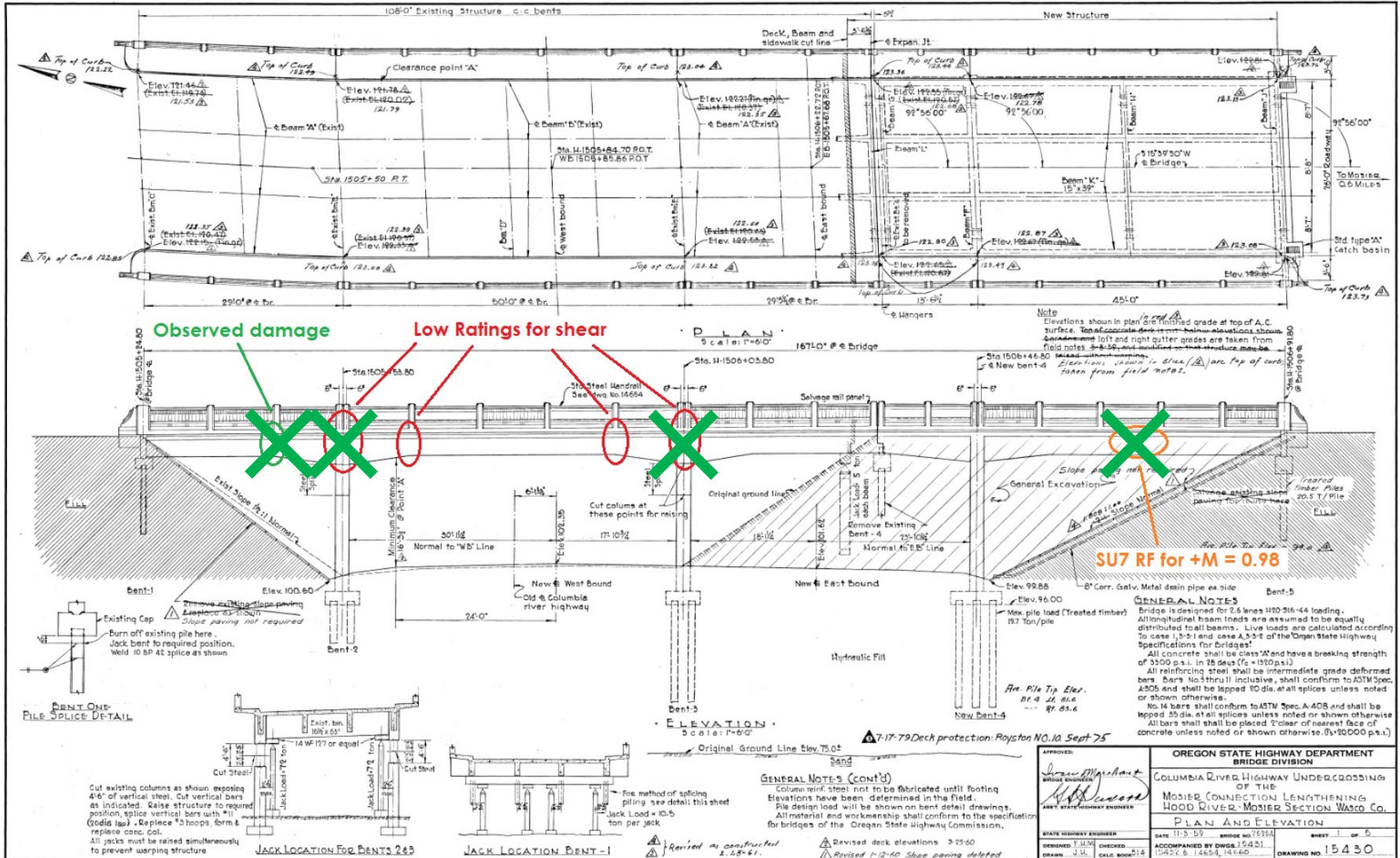


Load Rating



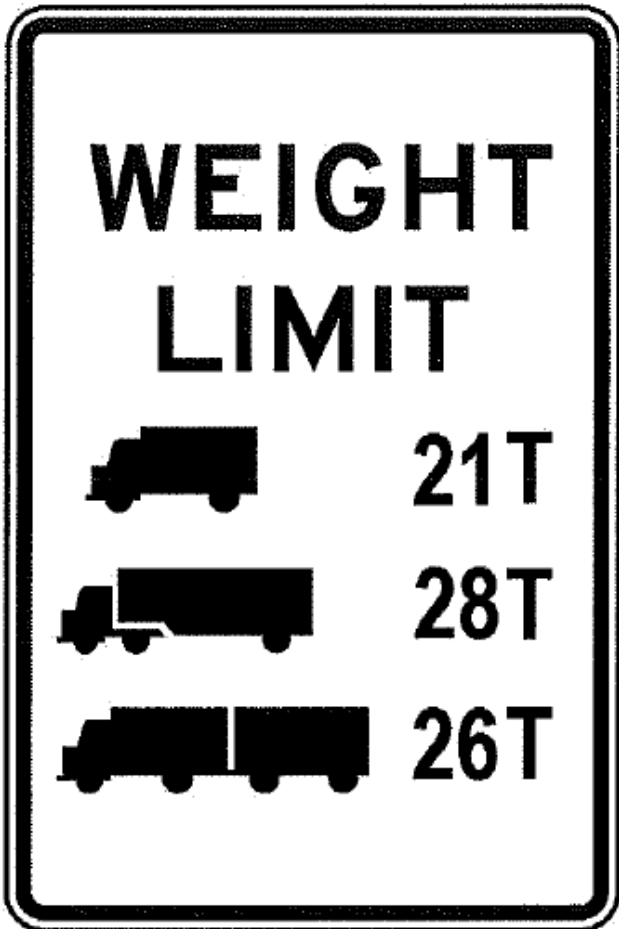
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Posting Improvement

- Best we can do without substantial investment



Community Impact

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□ Local need?

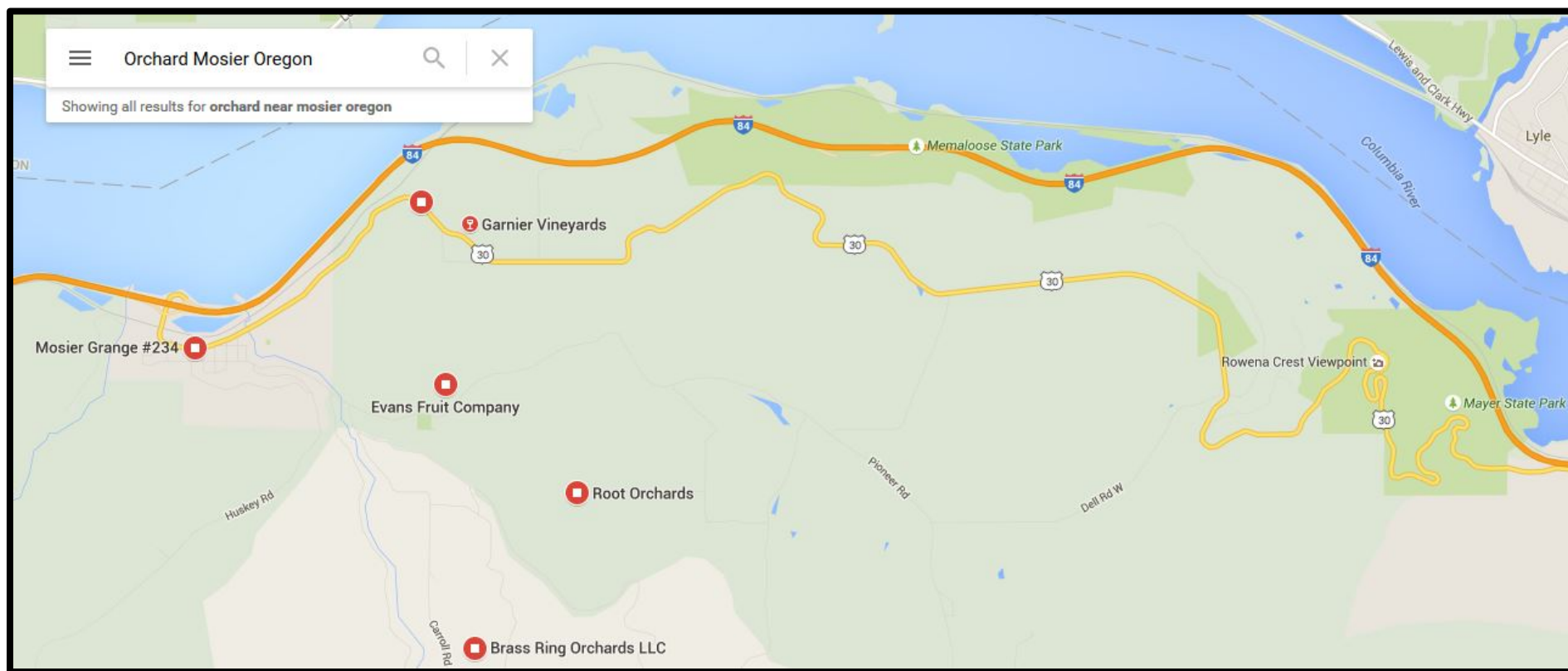


□ Alternative routes?

Mosier, OR



- Google Maps – “Orchard Mosier, OR”



- Harvest Season Target Start Date – June 1st

Construction Schedule



- Goal ----- Accommodate Local Harvest



- Schedule
 - ▣ Project Kickoff September
 - ▣ Back-out Bid Date of February 6th
 - ▣ Plans, Specifications & Estimate - Early December

Longitudinal Fix

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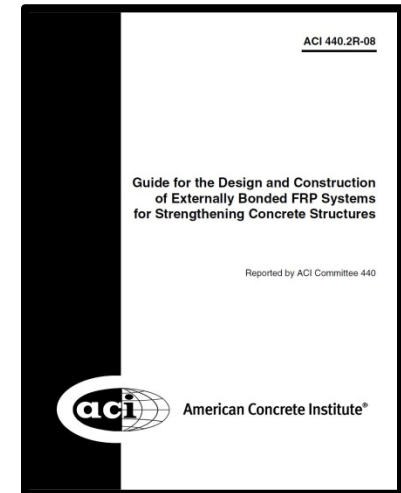
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- Fiber Reinforced Polymer (FRP) Strengthening
 - Code - ACI 440 2R-08
 - 8~63NSM177 strips required
 - Narrow beams → Limited real estate
 - Existing strength requirements

$$(\phi R_n)_{existing} \geq (1.1S_{DL} + 0.75S_{LL})_{new} \quad (9-1)$$

- Tanarat Potisuk, P.E., S.E., PhD
 - ODOT Research Initiative
 - OSU's Dr. Higgins
 - Beam w/ Haunch & Taper
 - NSM Titanium

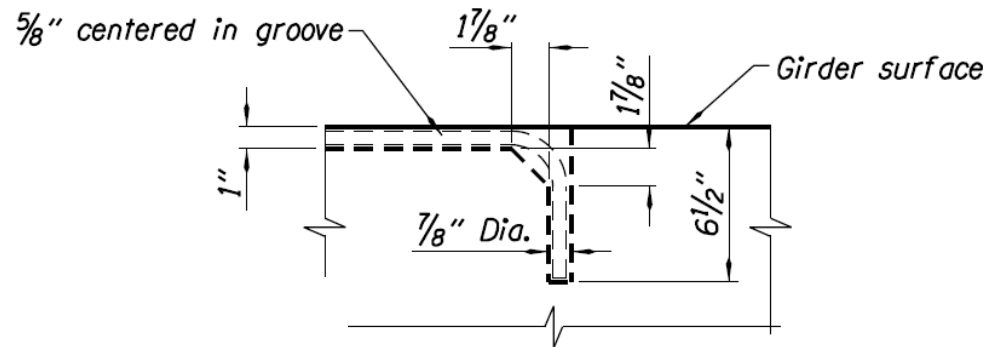


Material Properties

- Material Properties – From OSU Research
 - Available Bars 5/8” Diameter
 - Available Lengths 14’-0”
 - Yield Stress 140 ksi
 - Ultimate 155 ksi
 - Youngs Modulus 15,500 ksi
- ODOT Research Funding
 - Jon Rooper, PE encourages use of research resources
 - OSU Fast track production and use of Mosier Test specimens
 - Anchorage, anchorage, anchorage.

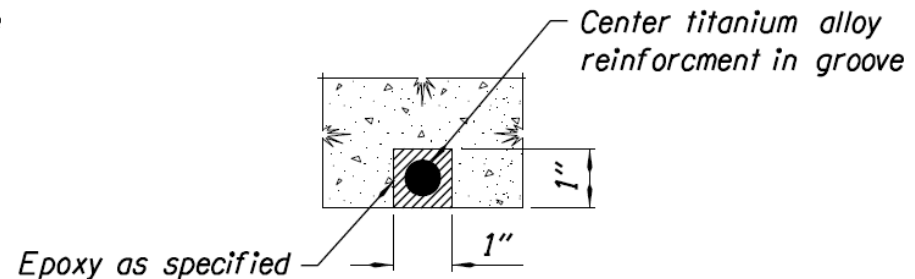
Titanium Restraints

- Max length -14ft
- 5/8" Dia.
- 1"x1" groove required
- 6" embedment hook required



CHAMFER DETAIL

Not to Scale



GROOVE DETAIL

Not to Scale

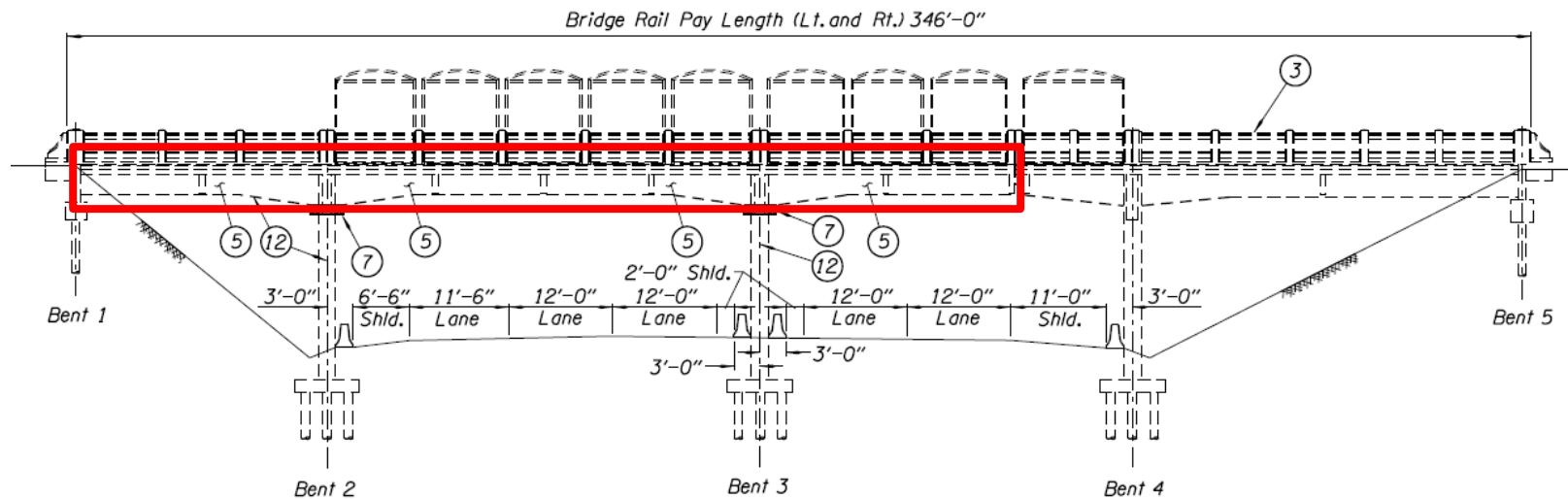
Titanium Design

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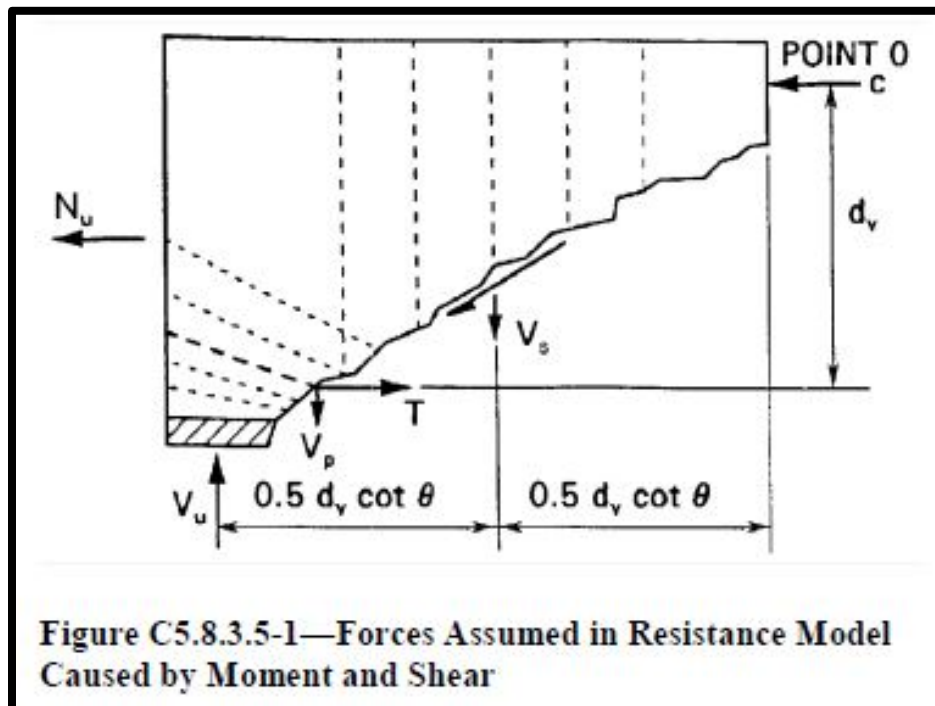
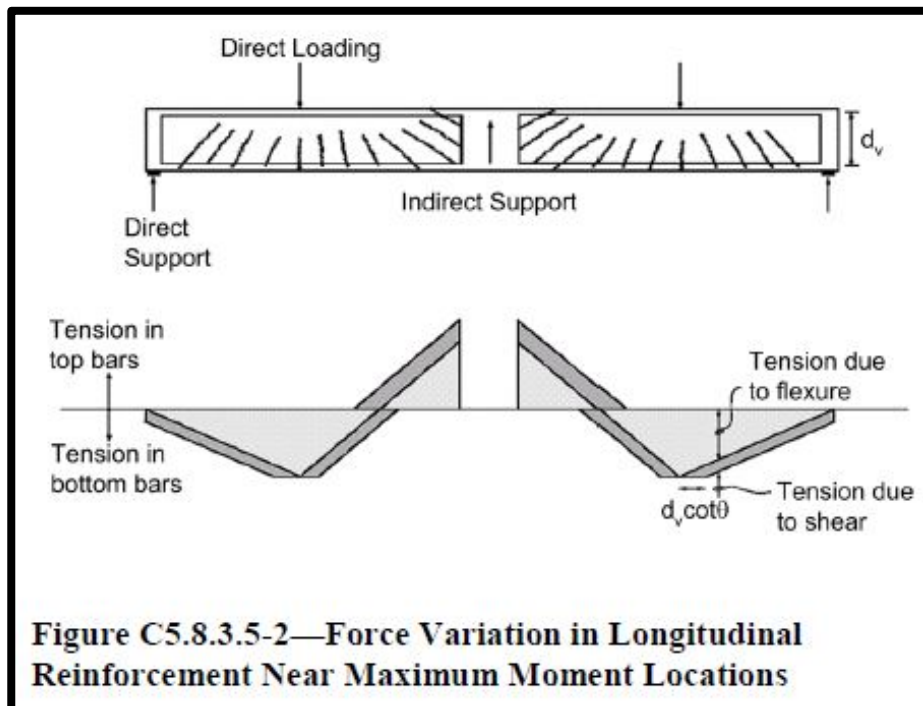


- Titanium design required 4 bars maximum
- Mid-span deficiencies cause staging issues



AASHTO LRFD Provision 5.8.3.5.1

- “The area of longitudinal reinforcement on the flexural tension side of the member need not exceed the area required to resist the maximum moment acting alone...”



Provision 5.8.3.5.1

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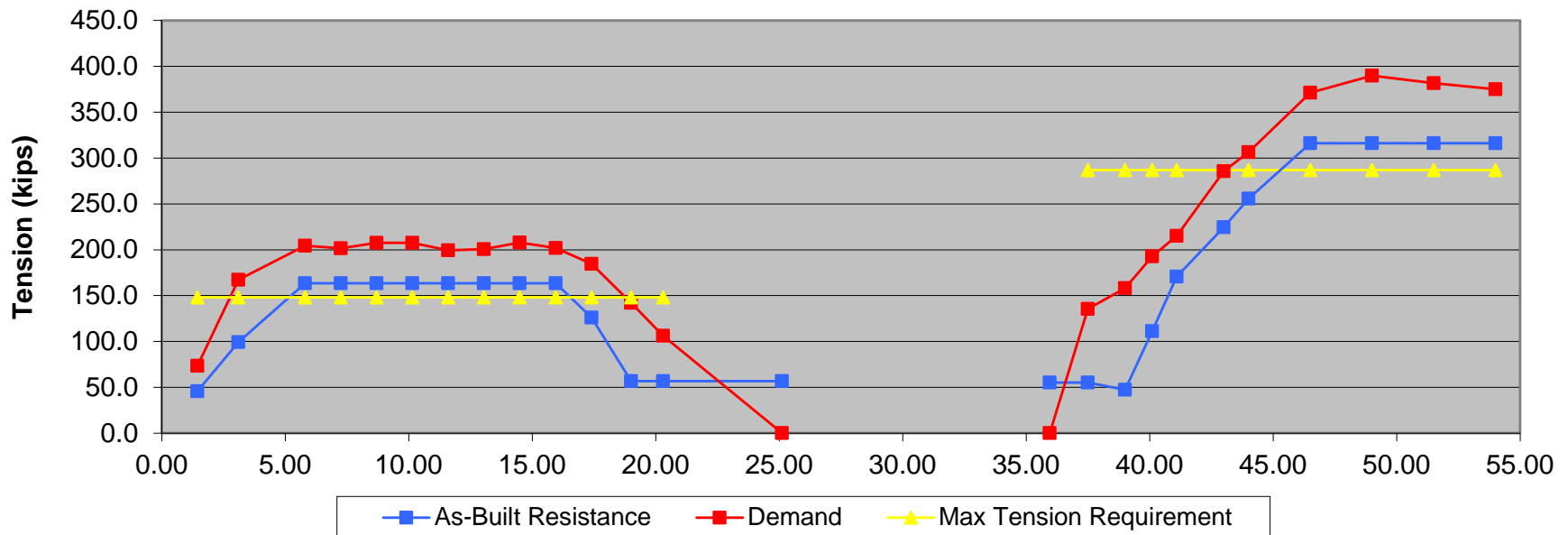
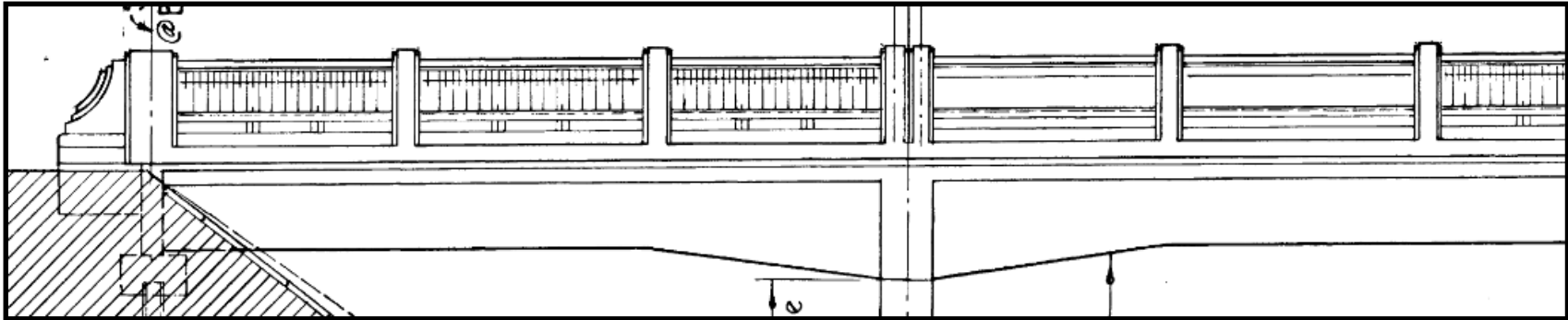
Bent 1

Span 1

Bent 2

Span 2

Mid



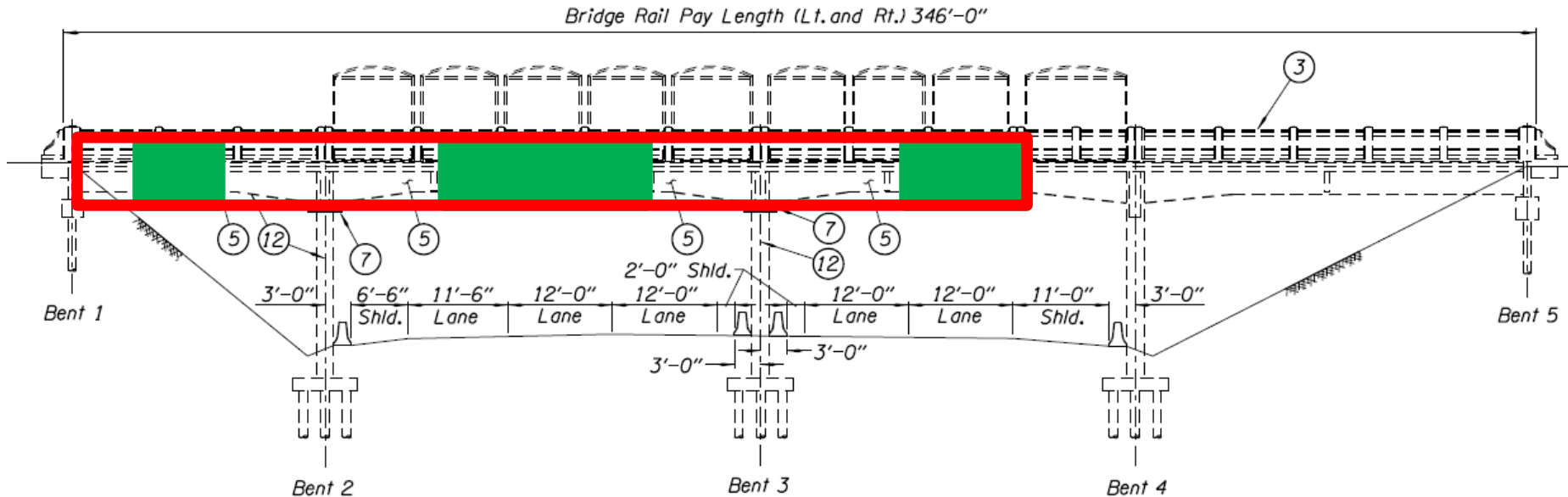
Access issues cont.

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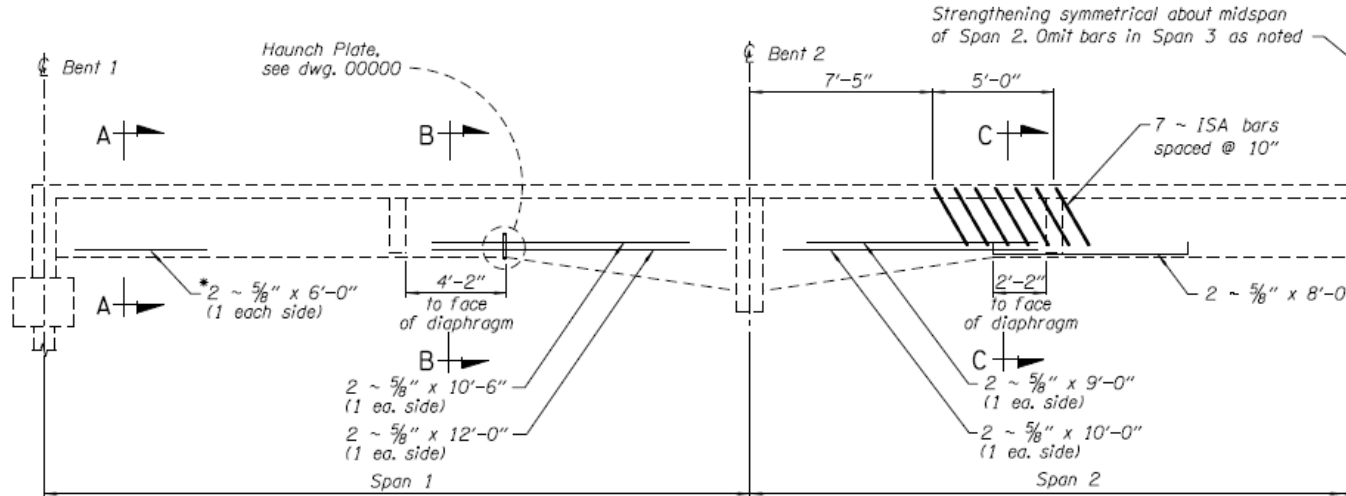
- Alleviates strengthening in most difficult location



Titanium Design

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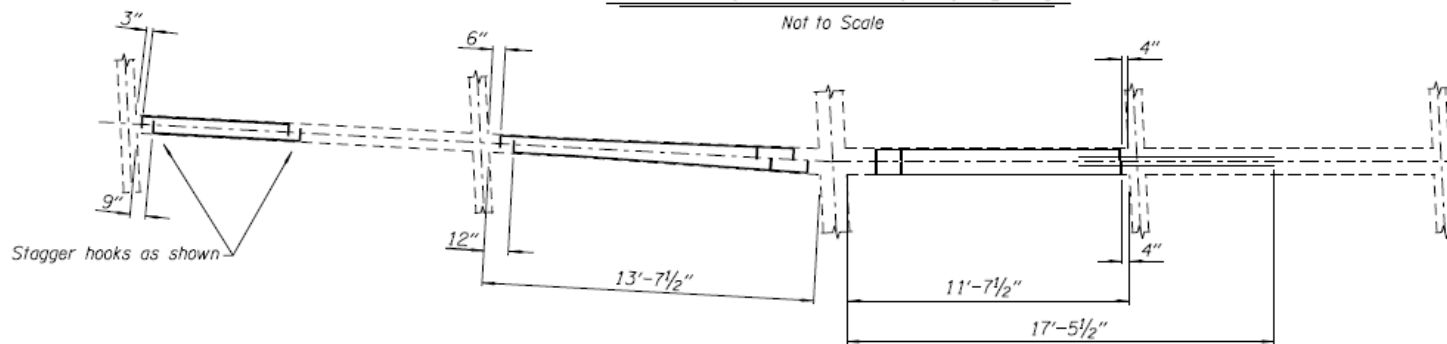


*Designated bars omitted in Span 3

ELEVATION - INTERIOR GIRDERS

Not to Scale

ISA @ detail th



Note: External post-tensioning not shown for clarity.

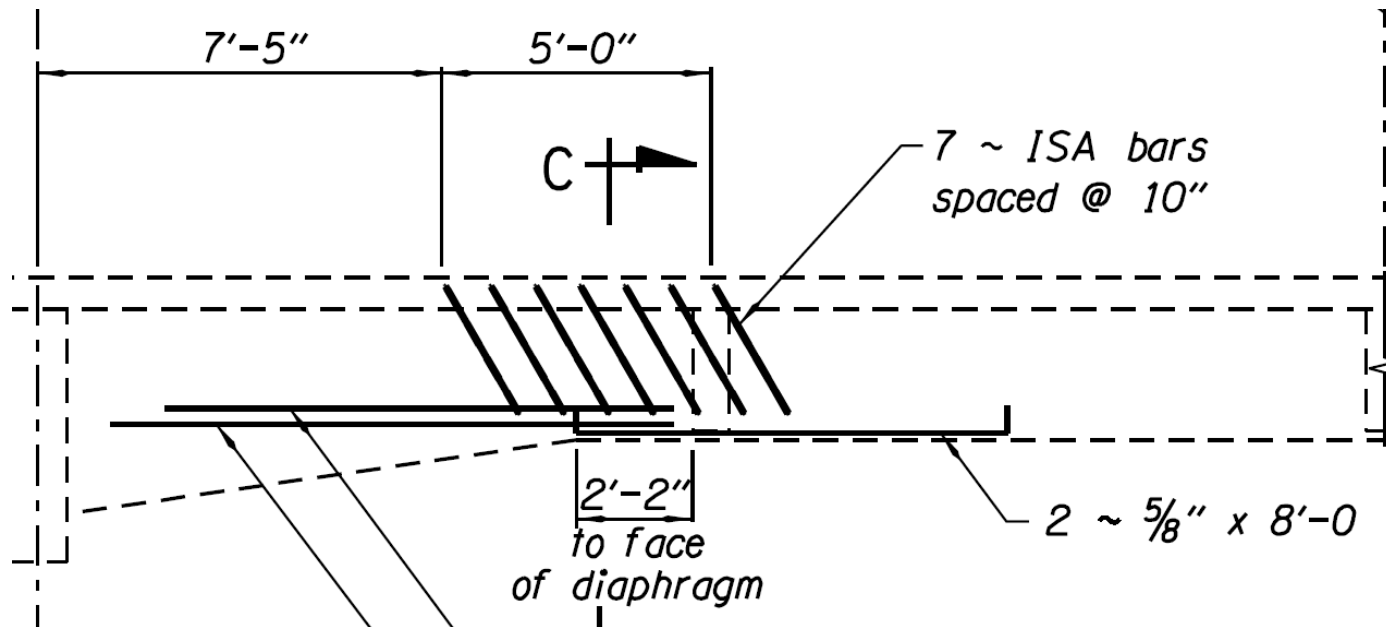
PLAN - INTERIOR GIRDERS

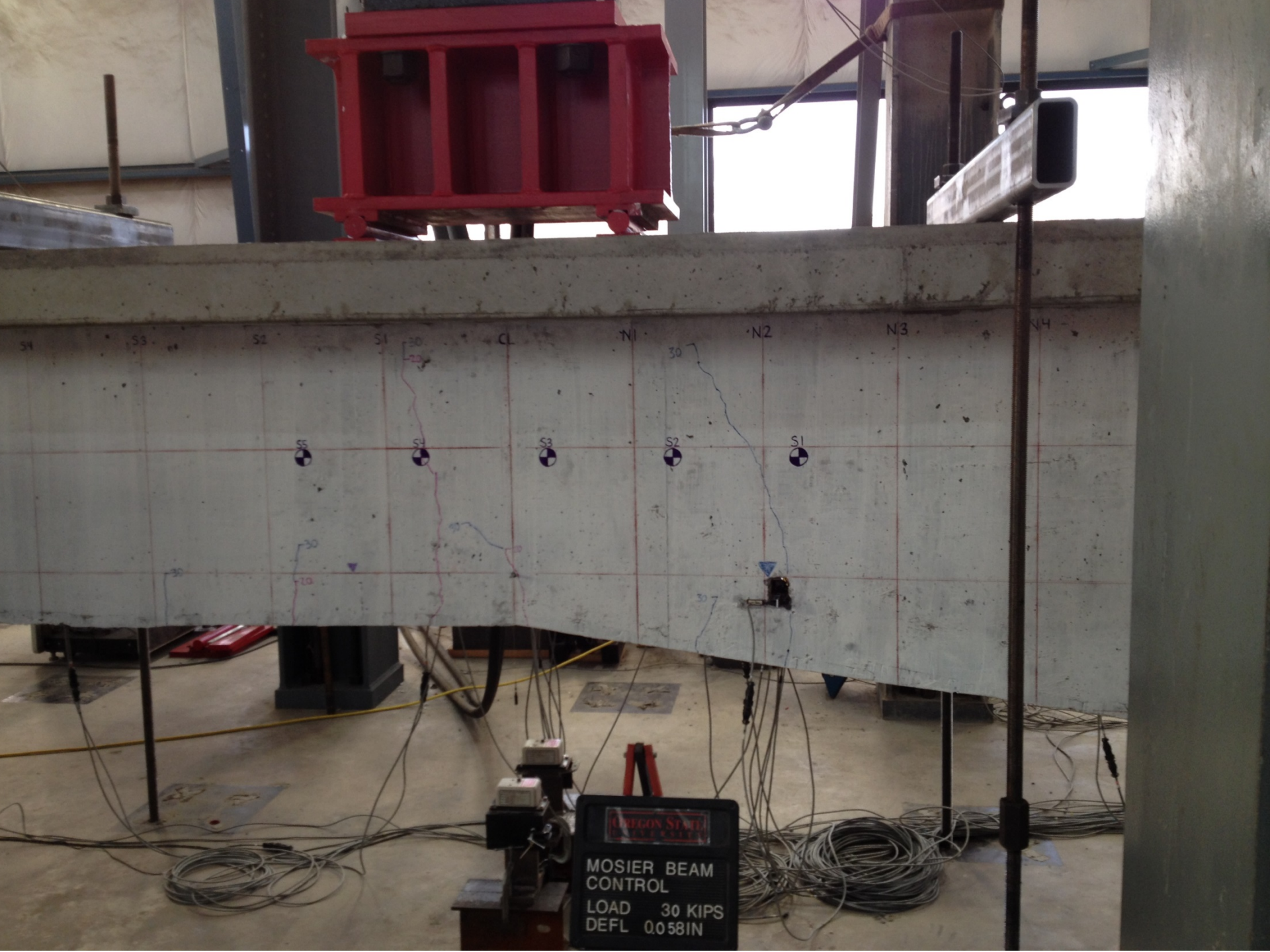
Not to Scale

Shear Strengthening



- Shear Strengthening via Internal shear anchors (ISA)
- Utilize the additional long. capacity of the titanium to decrease the number of ISA bars required





S4 S3 S2 S1 30 CL N1 30 N2 N3 N4

S5 S4 S3 S2 S1

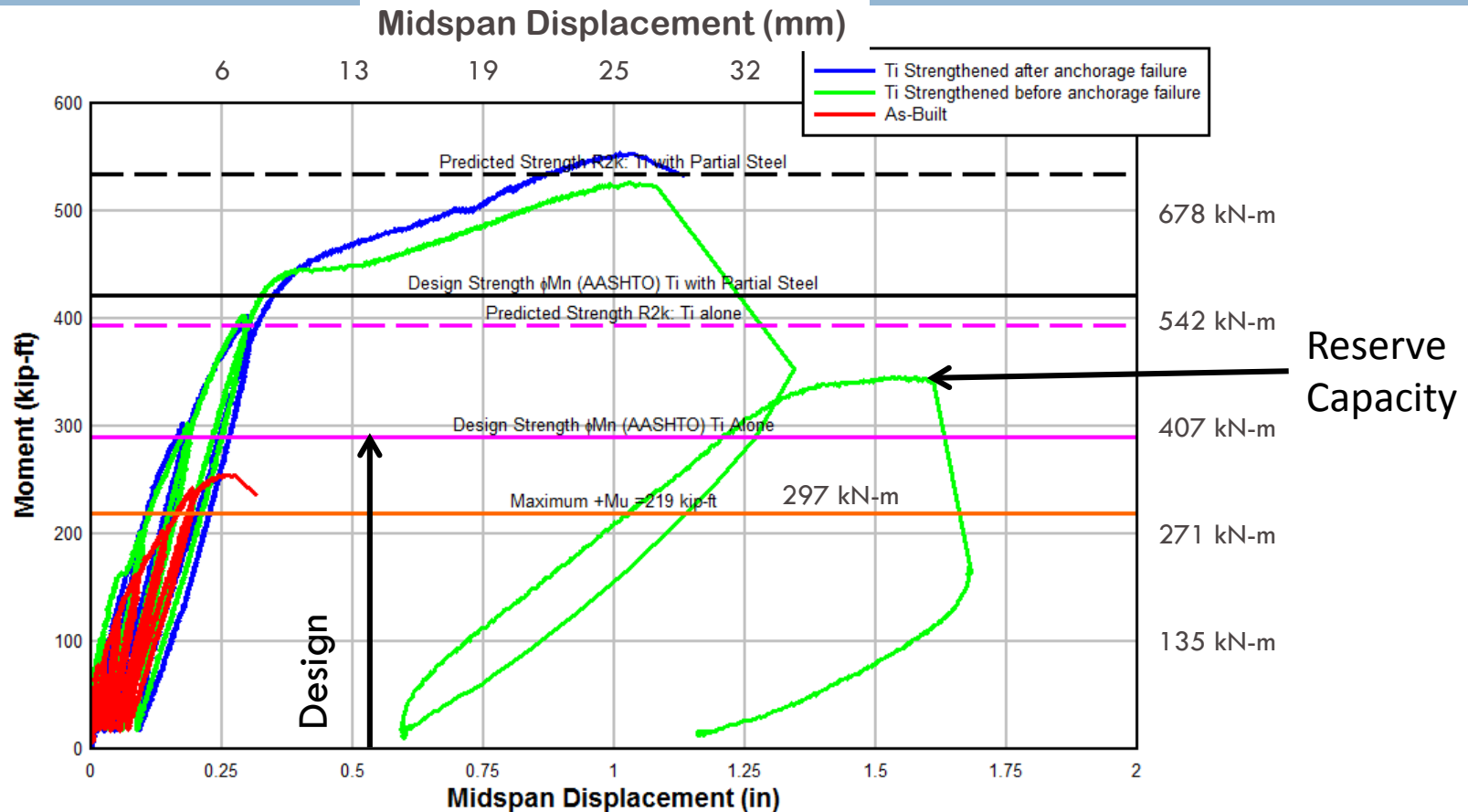
OREGON STEEL
MOSIER BEAM CONTROL
LOAD 30 KIPS
DEFL 0.058 IN



MOSIER BEAM CONTROL
LOAD 60 KIPS
DEFL 0.215 IN

Analysis

- Reserve strength of Ti girder substantially exceeds factored demands
- Failed anchorage provided similar response as intact



- Design strength of Ti girder exceeds factored demands even with conservative assumptions

Construction





PM12:22 APR/ 7/2014



PM12:09 APR/ 7/2014





AM 7:54 MAY/ 6/2014



AM 8:32 MAY/ 6/2014



PM12:37 MAY/ 6/2014





AM10:23 SEP/10/2014

Project Schedule

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□ Project June Completion Date → Success!

Crack Observed

6/4/13

Shoring Installed

7/15/13

PS&E

12/13/13

Construction Begins

3/24/14

6/19/13

Initial Load Rating

8/15/13

Begin Long-term Design

1/23/14

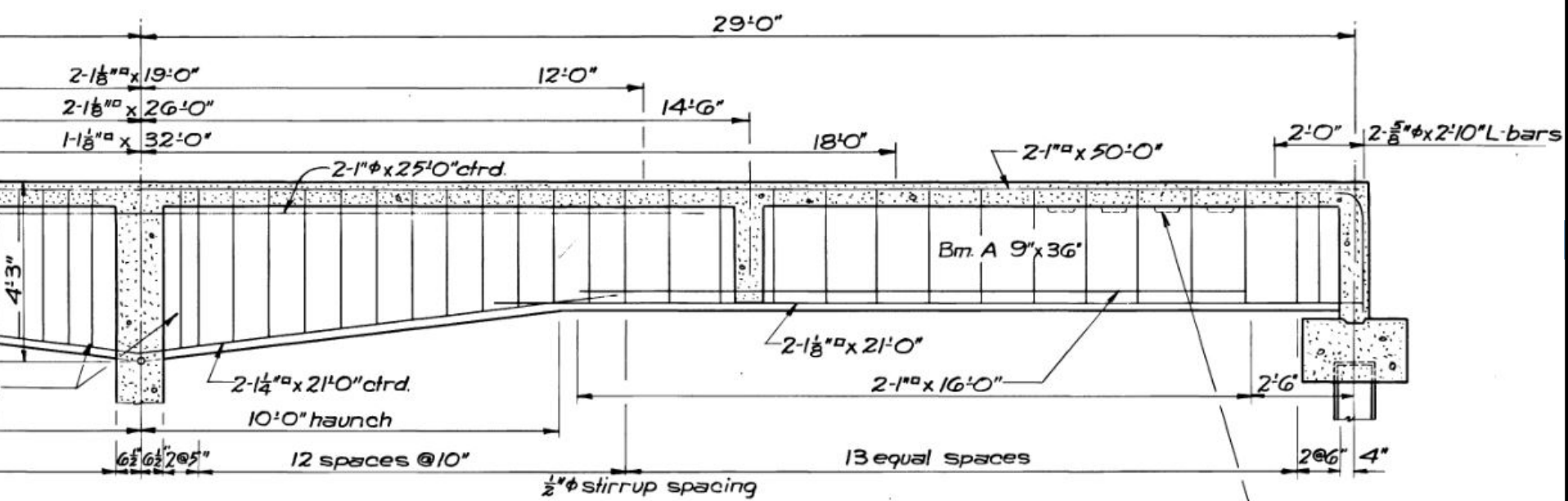
Bid Opening

5/30/14

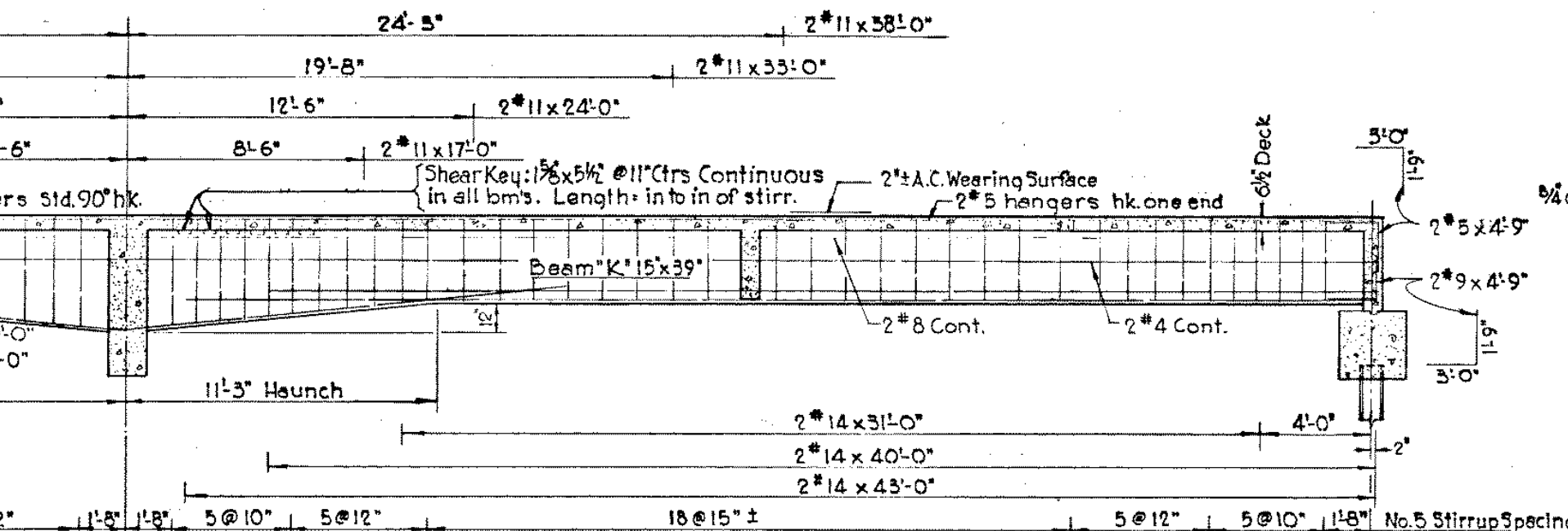
Project Completion

Final Thoughts

- Total project cost \$800,000
 - ▣ Bridge strengthening cost \$350,000
- Titanium extends the range of strengthening capabilities moving forward
- Things to keep in mind
 - ▣ Shallow stirrups....
 - ▣ Working with untrained manufacturer/supplier
 - ▣ Field bend versus shop bent hooks
 - ▣ Hooks, haunch, web taper, anchorage!
 - ▣ \$110 per foot with good access



HALF LONGITUDINAL BEAM SECTION



Questions

- Paul Strauser, P.E.
 - Paul.J.Strauser@odot.state.or.us
 - 541-388-6210
- OSU Research by Dr. Christopher Higgins
 - “METHODS FOR STRENGTHENING REINFORCED CONCRETE BRIDGE GIRDERS CONTAINING POORLY DETAILED FLEXURAL STEEL USING NEAR-SURFACE MOUNTED METALICS”
- GIANT THANK YOU TO PERRYMAN COMPANY