<u>March 31, 2009 Progress Report on Pooled Fund Study TPF-5(189):</u>
"***Enhancement of Welded Steel Bridge Girders Susceptible to Distortion-Induced Fatigue***"

Introduction

Progress made for the reporting quarter between January 1, 2010 and March 31, 2010 includes the following highlights:

- An analytical investigation was performed concerning the effectiveness of various retrofit techniques on reducing web gap stresses in a steel bridge susceptible to distortion induced fatigue
- Component level tests of PICK treated undersized crack-stop holes were performed
- Design of the test specimens for the three-girder bridge system was refined and reviewed

Analytical Investigation

An investigation was performed this quarter in which the effectiveness of various retrofit techniques in reducing web gap stresses were investigated analytically. Retrofit methods that were investigated on the studied detail (Fig. 1a.) were as follows:

- Supplying positive attachment between connection stiffener and flanges (Fig. 1b.)
- Supplying partial depth "back-up stiffeners" behind connection stiffeners to help stabilize the web gap region (Fig. 1c.). Because back-up stiffeners are more often used in skewed bridges with staggered cross bracing members, the effects of this particular retrofit technique were investigated in a 40 deg. skewed bridge with staggered cross frames as well as the right bridge.
- Softening the web gap region to alleviate stresses by using a "slot" retrofit (Fig. 1d.)
- Removing cross-frames entirely to eliminate the driving forces behind distortion-induced fatigue stresses

It was found that all of the retrofits investigated reduced the maximum stress in the bridge by over 30%, although the back-up stiffener configuration was only effective in the skewed bridge with staggered cross frames. Results for the non-skewed (right) bridge are presented in Table 1.

The effect of implementing the retrofits at only the most highly stressed regions of the bridge was also considered (as opposed to applying the retrofits at every connection stiffener on the bridge), to determine the necessity of retrofitting every connection within the bridge. It was determined that treating all connections is indeed important and beneficial, because when the retrofits were applied at all cross frame locations, the maximum stress in the bridge was reduced by more than twice as much as compared to the case in which the retrofits were only applied in specific locations of high stress demand.

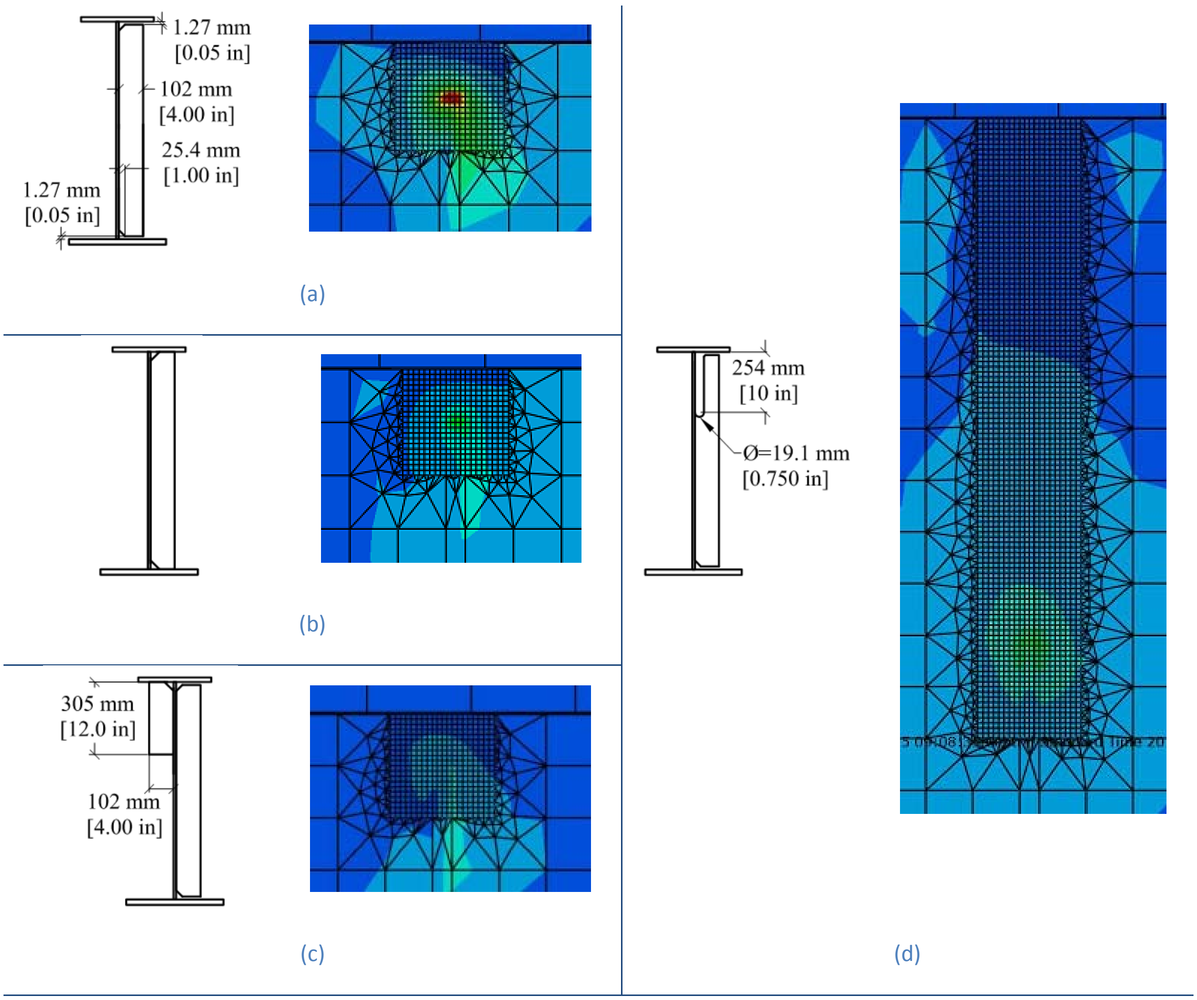


Figure 1. (a) No-retrofit stiffener. (b) Positively attached stiffener. (c) Back-up transverse stiffener. (d). Slotted connection stiffener.

Table 1. Maximum web gap stresses determined using Hot Spot Stress analysis, right bridge.

Retrofit Description	***Stress MPa [ksi]***	***% Change from no-retrofit model***
No Retrofit		
Positive Attachment	52.5 [7.62]	-49%
Back-Up Stiffener	69.2 [14.4]	-3%*
Slotted Stiffener	99.4 [10.1]	-33%
Cross Frame Removal	45.4 [6.58]	-56%

*The back-up stiffener was not effective in reducing maximum stress in the no-skew bridge, but reduced the maximum web gap stress in a skewed bridge with staggered cross frames almost 50%.

Component-Level Studies

Testing was continued on component level 1/8" thick specimens. An S-N diagram presenting data for control and treated specimens tested to-date is shown in Fig. 2. Testing was performed at a stress range of 32 ksi.

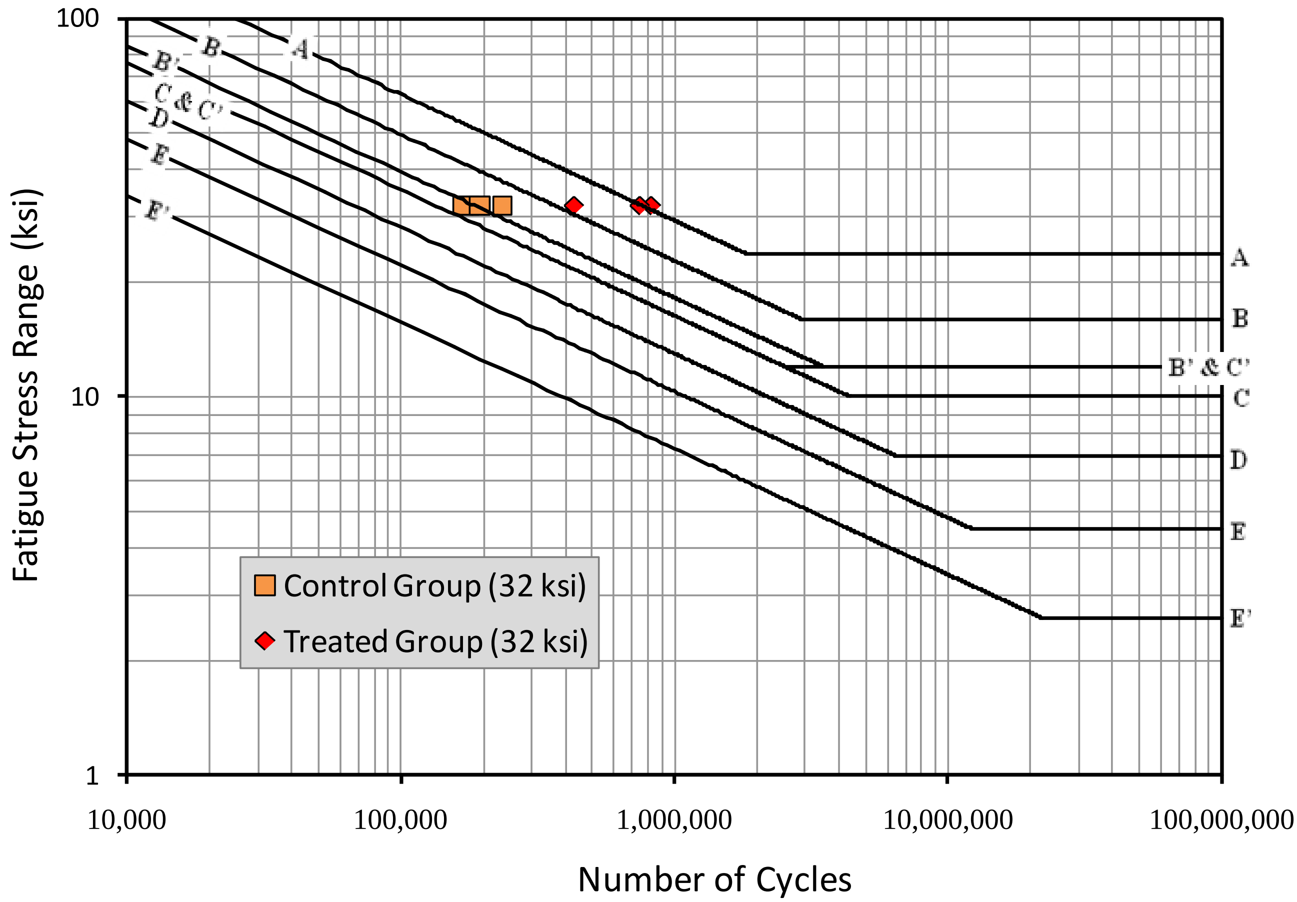


Figure 1: S-N diagram showing results for untreated and PICK-treated specimens tested at 32 ksi.

Design of Test Specimens for the Three-Girder Test Set-Up

Design of the test specimens was refined and reviewed this semester. Drawings are presented on pages 5-9 of this progress report. The three girder bridge systems are designed to be modular in nature, with two moment splice locations provided in each girder, such that the interior portion of each girder is replaceable after a test. In this manner, system behavior will be ensured for the bridge, but economies will be realized for the actual details being tested and retrofitted. An appropriately scaled concrete deck will be attached compositely to the girders, using custom-constructed precast panels.

Upcoming Tasks

The following tasks are anticipated to occur in the next project quarter:

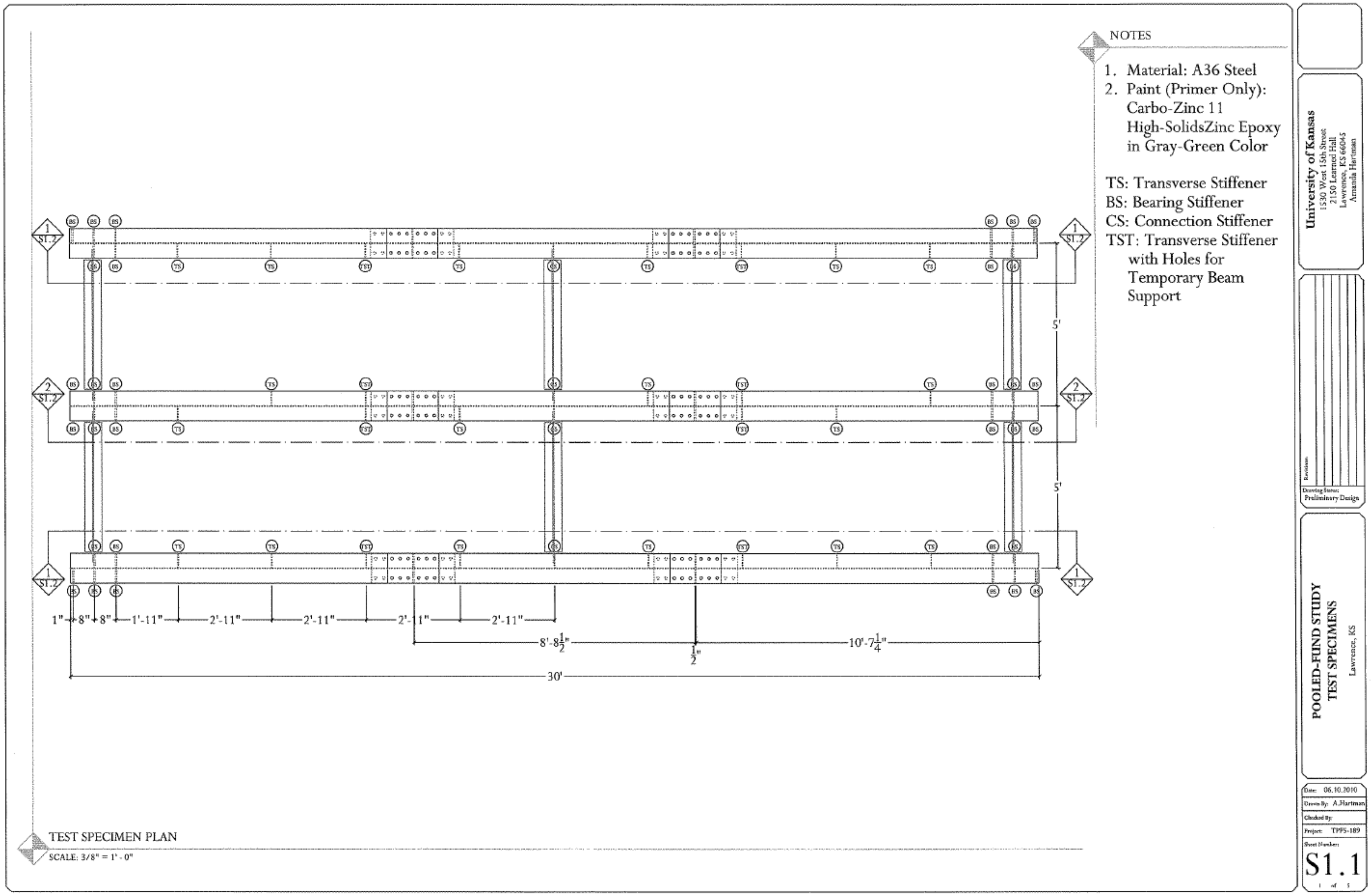
1. Component level tests will continue on PICK-treated 1/8" thick and 1/4" thick specimens.
2. 9-ft segments of the half-scale girders will be designed for testing retrofit techniques on girder segments, to augment bridge system testing.
3. Effectiveness of weld grinding will be examined as a fatigue enhancement technique.
4. Three-girder bridge test specimen design will be sent to fabricators for bids.
5. Precast concrete deck panels will be designed for the three-girder bridge system tests.

Conclusion

TPF 5(189) progressed steadily this reporting quarter. Component level studies continued, and an analytical investigation was performed studying the effectiveness of various accepted retrofit techniques. Specimens for the three-girder test set-up were refined and reviewed; drawings were produced.

Contact Information

Please contact Caroline Bennett at (785)864-3235 or crb@ku.edu with any questions or discussion items.


NOTES
1. Material: A36 Steel
2. Paint (Primer Only): Carbo-Zinc 11 High-SolidsZinc Epoxy in Gray-Green Color
TS: Transverse Stiffener
BS: Bearing Stiffener
CS: Connection Stiffener
TST: Transverse Stiffener with Holes for Temporary Beam Support
TEST SPECIMEN PLAN
SCALE: 3/8" = 1' - 0"
5'
5'
30'
University of Kansas
1530 West 15th Street
2150 Learned Hall
Lawrence, KS 66045
Amanda Hartman
Drawing Issue: Preliminary Design
POOLED-FUND STUDY
TEST SPECIMENS
Lawrence, KS
Date: 06.10.2010
Drawn By: A.Hartman
Checked By:
Project: TPF5-189
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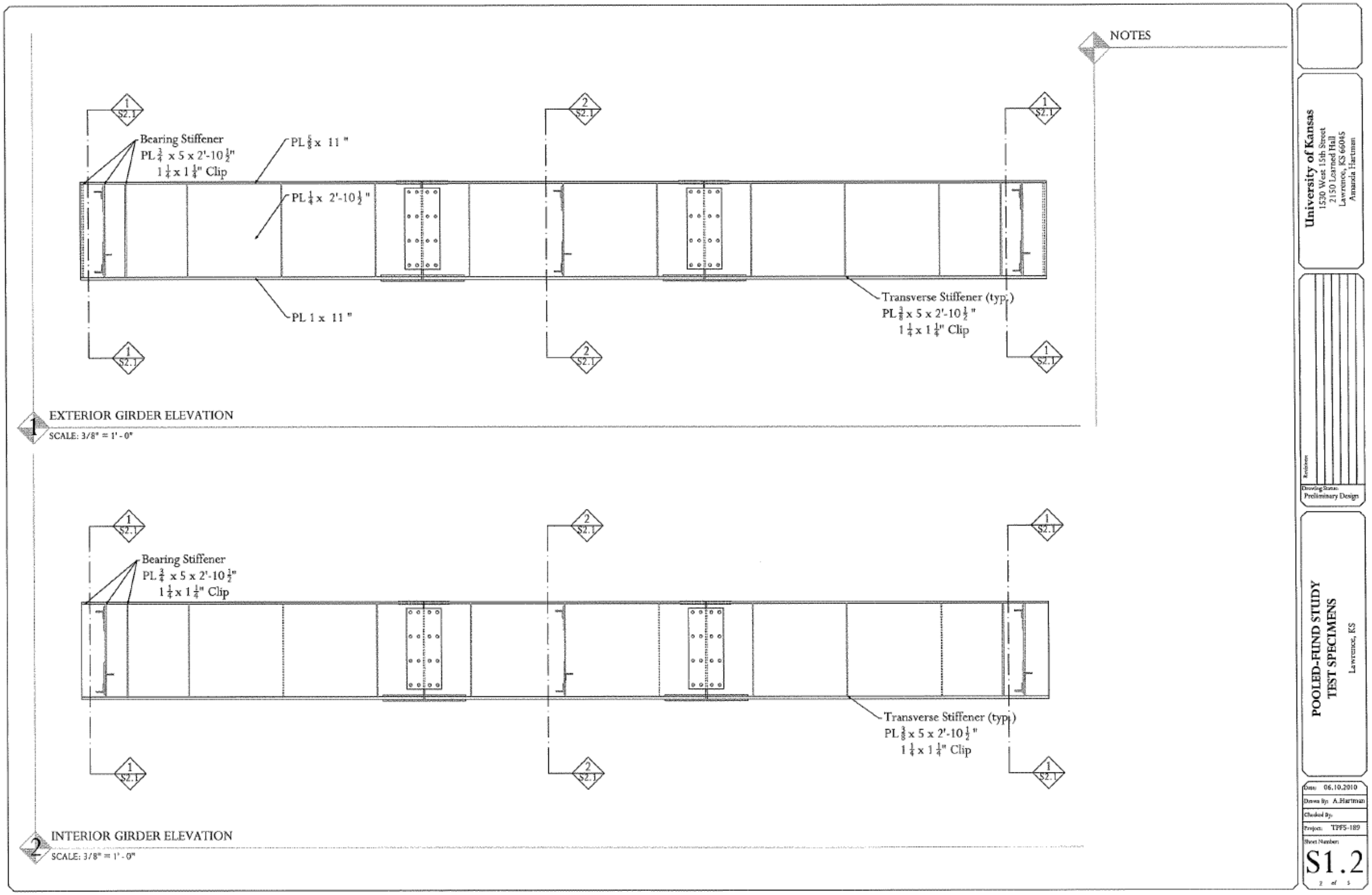
S1.1
1 of 5


NOTES
Bearing Stiffener
PL 3/4 x 5 x 2'-10 1/2"
1 1/4 x 1 1/4" Clip
PL 5/8 x 11"
PL 1/4 x 2'-10 1/2"
PL 1 x 11"
Transverse Stiffener (typ.)
PL 3/8 x 5 x 2'-10 1/2"
1 1/4 x 1 1/4" Clip
EXTERIOR GIRDER ELEVATION
SCALE: 3/8" = 1' - 0"
Bearing Stiffener
PL 3/4 x 5 x 2'-10 1/2"
1 1/4 x 1 1/4" Clip
Transverse Stiffener (typ.)
PL 3/8 x 5 x 2'-10 1/2"
1 1/4 x 1 1/4" Clip
INTERIOR GIRDER ELEVATION
SCALE: 3/8" = 1' - 0"
University of Kansas
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Revisions:
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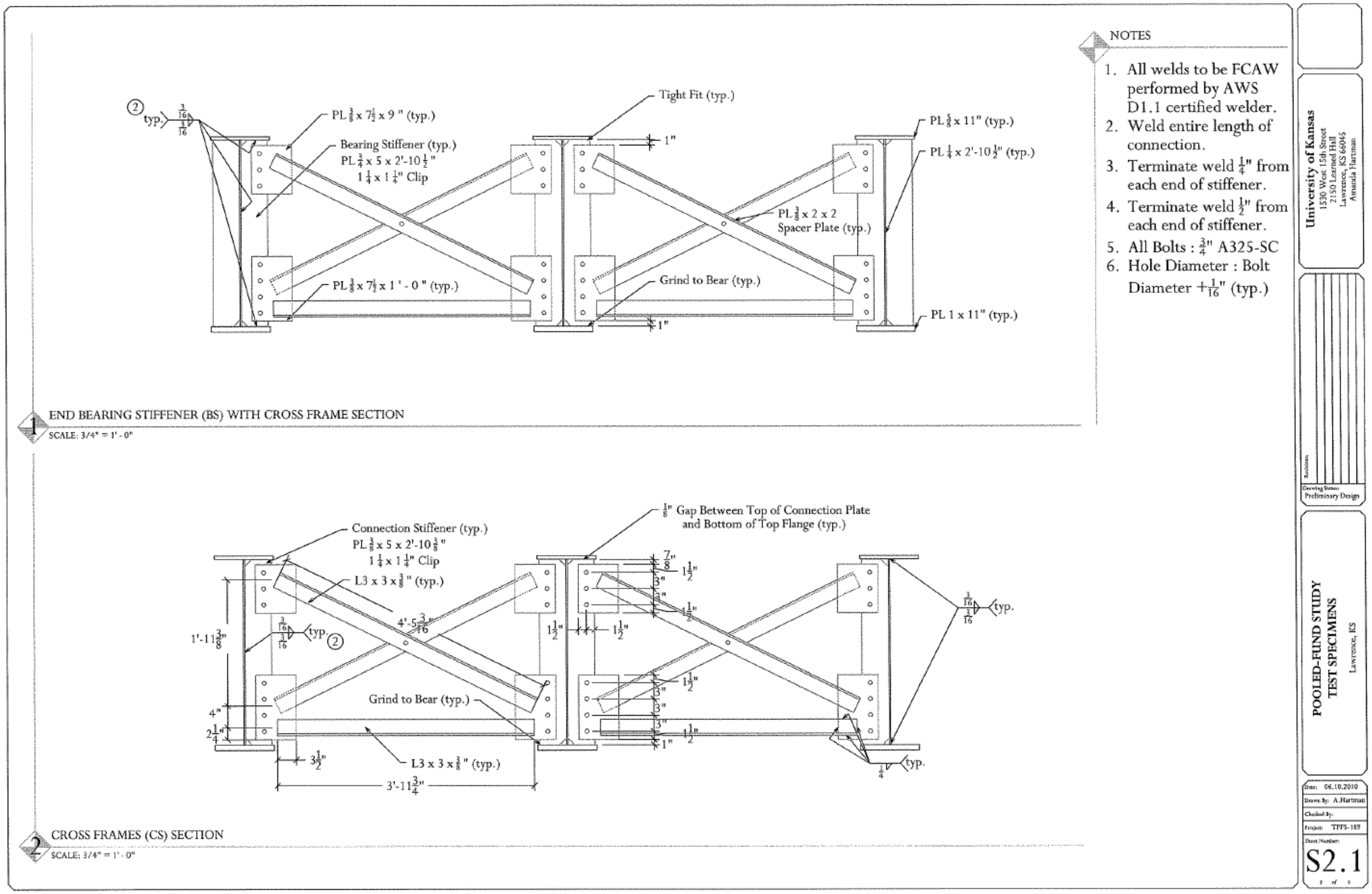
S1.2
2 of 5


NOTES
1. All welds to be FCAW performed by AWS D1.1 certified welder.
2. Weld entire length of connection.
3. Terminate weld 1/4" from each end of stiffener.
4. Terminate weld 1/2" from each end of stiffener.
5. All Bolts : 3/4" A325-SC
6. Hole Diameter : Bolt Diameter +1/16" (typ.)
Tight Fit (typ.)
PL 5/8 x 11" (typ.)
PL 1/4 x 2'-10 1/2" (typ.)
PL 3/8 x 7 1/2 x 9 " (typ.)
Bearing Stiffener (typ.)
PL 3/4 x 5 x 2'-10 1/2 "
1 1/4 x 1 1/4" Clip
PL 3/8 x 2 x 2
Spacer Plate (typ.)
Grind to Bear (typ.)
PL 3/8 x 7 1/2 x 1 ' - 0 " (typ.)
PL 1 x 11" (typ.)
END BEARING STIFFENER (BS) WITH CROSS FRAME SECTION
SCALE: 3/4" = 1' - 0"
1/8" Gap Between Top of Connection Plate and Bottom of Top Flange (typ.)
Connection Stiffener (typ.)
PL 3/8 x 5 x 2'-10 3/8 "
1 1/4 x 1 1/4" Clip
L3 x 3 x 3/8 " (typ.)
4'-5 3/16"
1'-11 3/8"
Grind to Bear (typ.)
L3 x 3 x 3/8 " (typ.)
3 1/2"
3'-11 3/4"
CROSS FRAMES (CS) SECTION
SCALE: 3/4" = 1' - 0"
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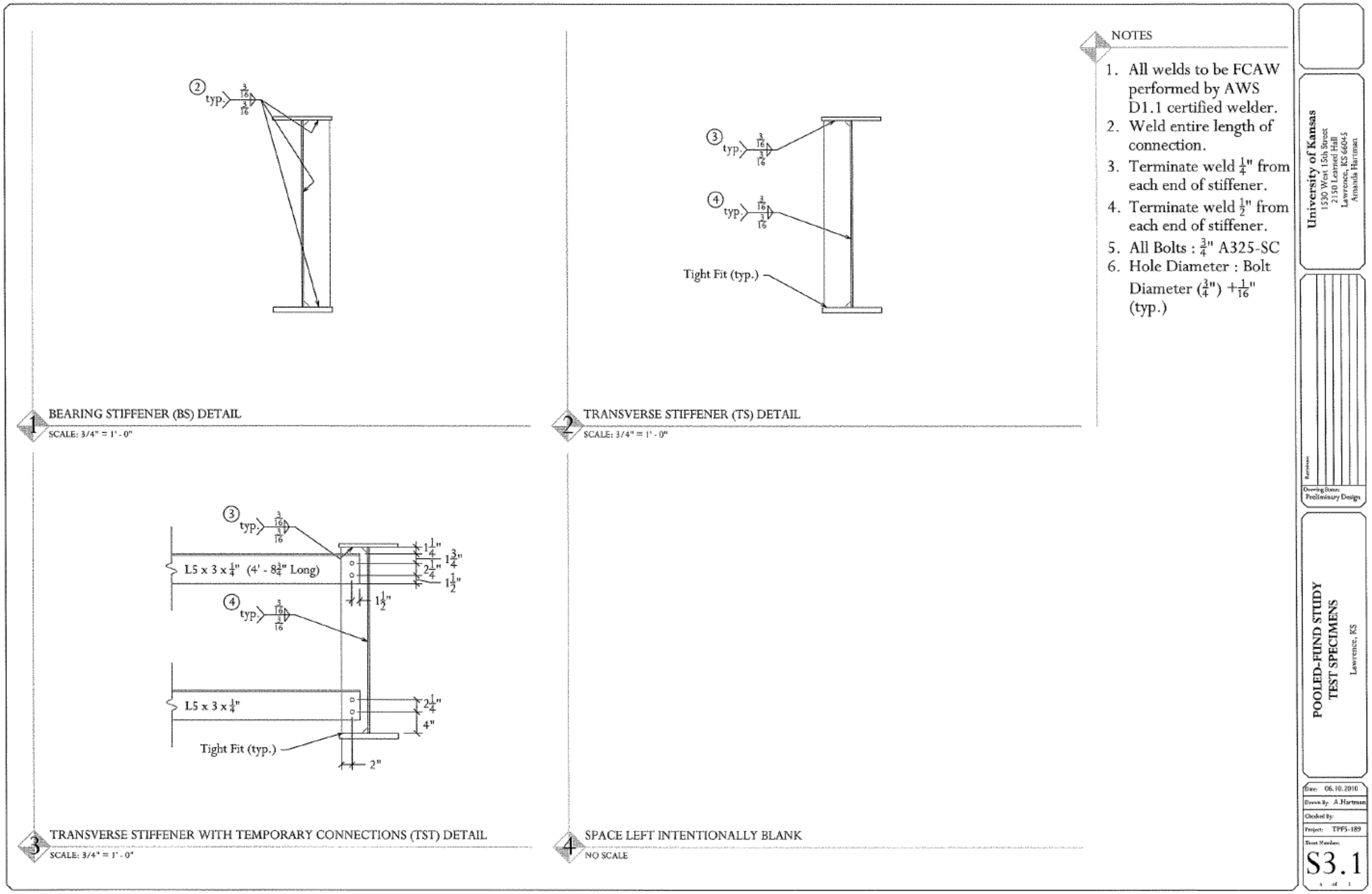
S2.1


NOTES
1. All welds to be FCAW performed by AWS D1.1 certified welder.
2. Weld entire length of connection.
3. Terminate weld 1/4" from each end of stiffener.
4. Terminate weld 1/2" from each end of stiffener.
5. All Bolts : 3/4" A325-SC
6. Hole Diameter : Bolt Diameter (3/4") +1/16" (typ.)
BEARING STIFFENER (BS) DETAIL
SCALE: 3/4" = 1' - 0"
TRANSVERSE STIFFENER (TS) DETAIL
SCALE: 3/4" = 1' - 0"
Tight Fit (typ.)
TRANSVERSE STIFFENER WITH TEMPORARY CONNECTIONS (TST) DETAIL
SCALE: 3/4" = 1' - 0"
L5 x 3 x 1/4" (4' - 8 3/4" Long)
L5 x 3 x 1/4"
Tight Fit (typ.)
SPACE LEFT INTENTIONALLY BLANK
NO SCALE
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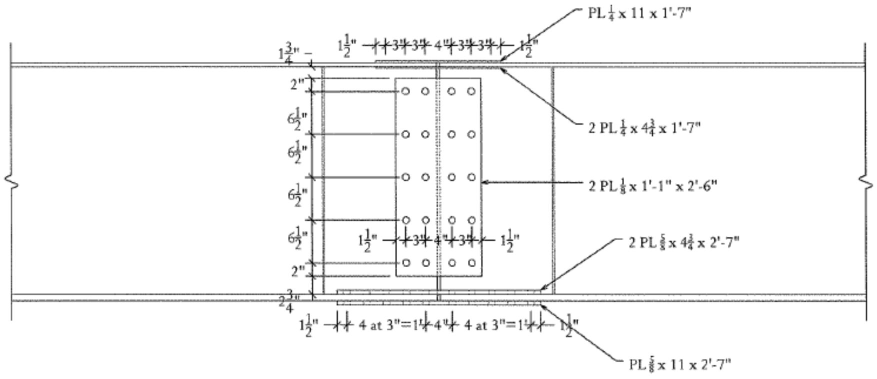
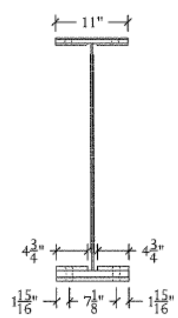
NOTES

1. All Bolts: 1" A325 - SC
2. Hole Diameter : Bolt Diameter (1") + $\frac{1}{16}$" = $1\frac{1}{16}$" (typ.)



1 SPLICE ELEVATION
SCALE: 3/4" = 1'-0"



2 SPLICE CROSS SECTION
SCALE: 3/4" = 1'-0"

Materials - Fabricator to Verify	
1in A325 - SC 2.25in Long	1440
1in A325 - SC 2.75in Long	864
1in A325 - SC 4in Long	1440
3/4in A325 - SC	1080
3/4in A325	32
1in Squirter DTI Washers	3744
3/4in Squirter DTI Washers	1080
3/4in Washers	32
Girder-Exterior, Support (4 Total)*	4784 lb
Girder-Interior, Support (2 Total)*	2504 lb
Girder-Exterior, Test (24 Total)	20184 lb
Girder-Interior, Test (12 Total)	10320 lb
Splices (6 Total)*	1008 lb
Cross Frames, Support (4 Total)	512 lb
Cross Frames, Test (2 Total)*	256 lb
Temporary Support Angles (4 Total)	248 lb
TOTAL WEIGHT	39816 lb

*Will order more at later date if necessary.

3 MATERIALS
NO SCALE

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