FATIGUE AND FRACTURE ASSESSMENT

JESSE STUART HIGHWAY BRIDGE

HUNTINGTON DISTRICT

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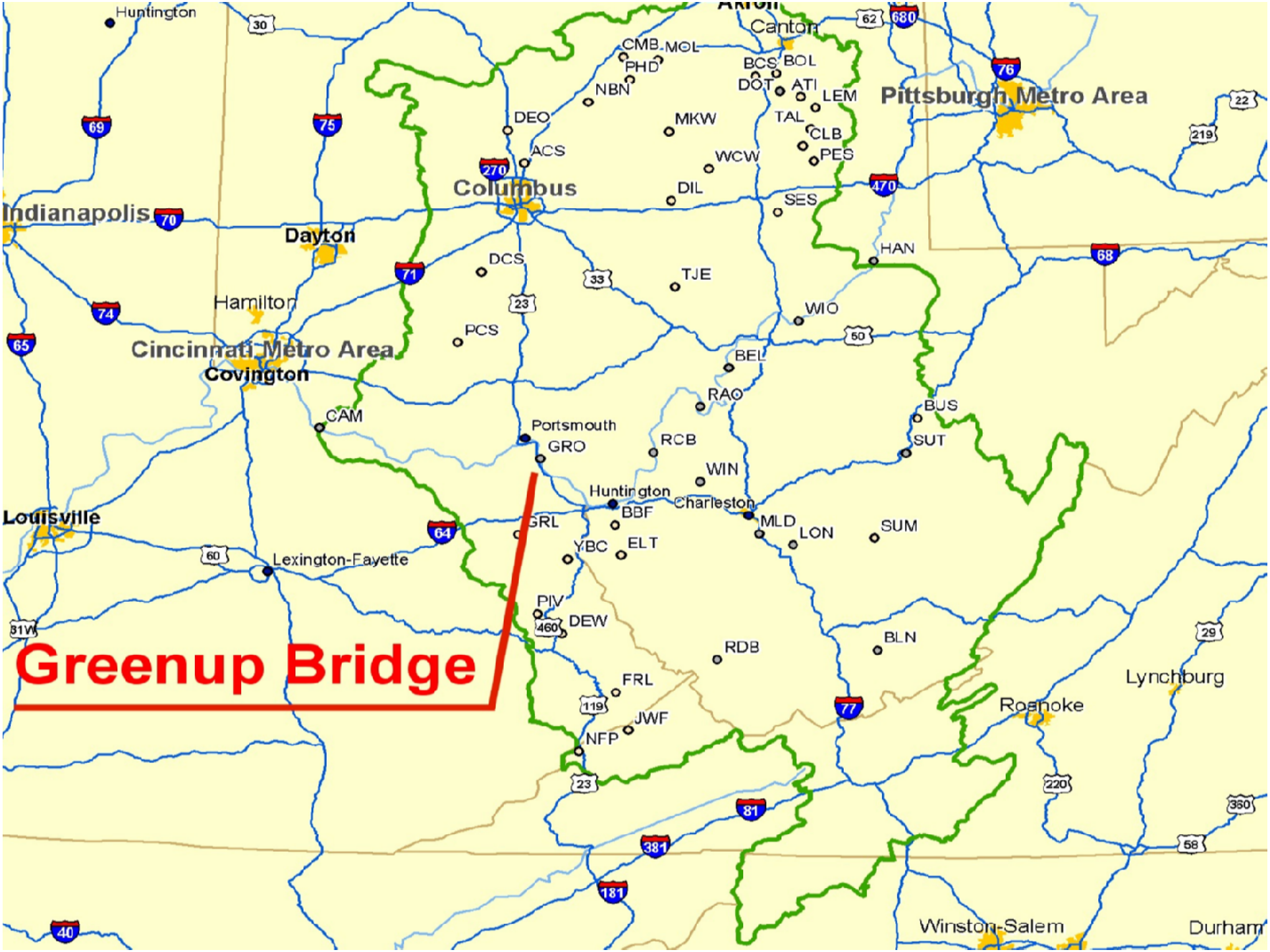
Greenup Bridge
Huntington
Canton
Pittsburgh Metro Area
Columbus
Indianapolis
Dayton
Hamilton
Cincinnati Metro Area
Covington
Portsmouth
Louisville
Lexington-Fayette
Charleston
Lynchburg
Roanoke
Winston-Salem
Durham
CMB
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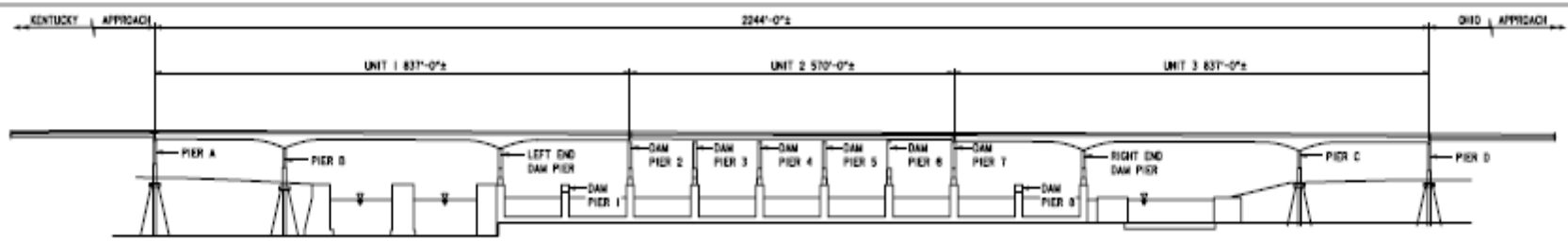
RCB
WIN
BBF
MLD
LON
SUM
GRL
YBC
ELT
PIV
DEW
RDB
BLN
FRL
JWF
NFP

View of Jesse Stuart Highway Bridge looking north (downstream) from Kentucky side of the Ohio River.

JESSE STUART HIGHWAY BRIDGE
GREENUP LOCKS AND DAM OHIO RIVER
SEPTEMBER 9, 2003

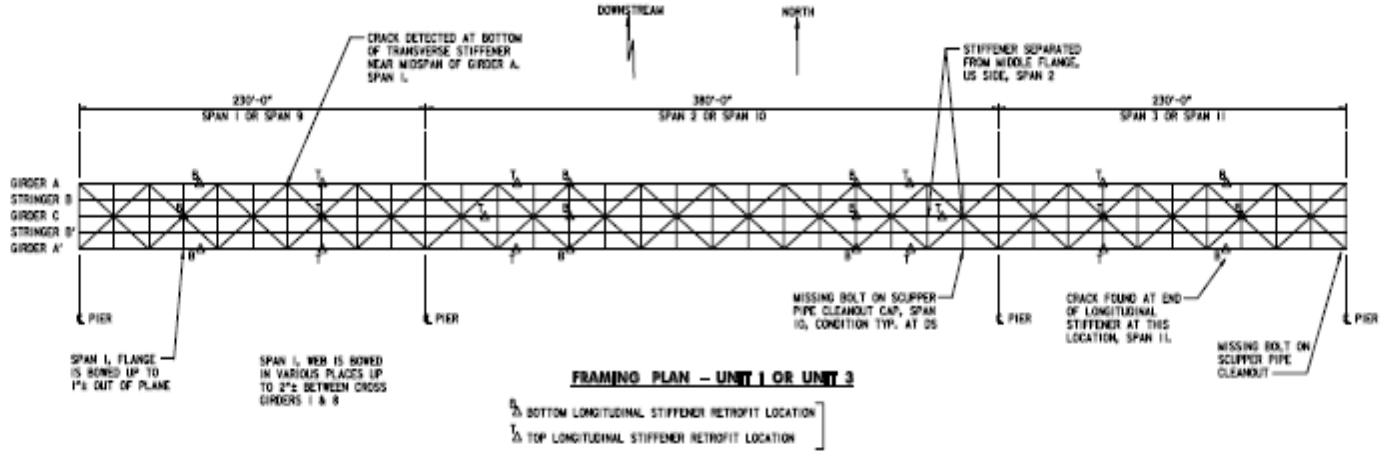


UPSTREAM ELEVATION

SCALE: 1" = 10'-0"

NOTE:
DIAGONAL HAIRLINE CRACKS IN CAP OF LEFT END DAM PIER, US WEST SIDE AND US & DS EAST SIDE.

NOTE:
DIAGONAL HAIRLINE CRACKS IN CAP, ALL FOUR SIDES.



FRAMING PLAN – UNIT 1 OR UNIT 3

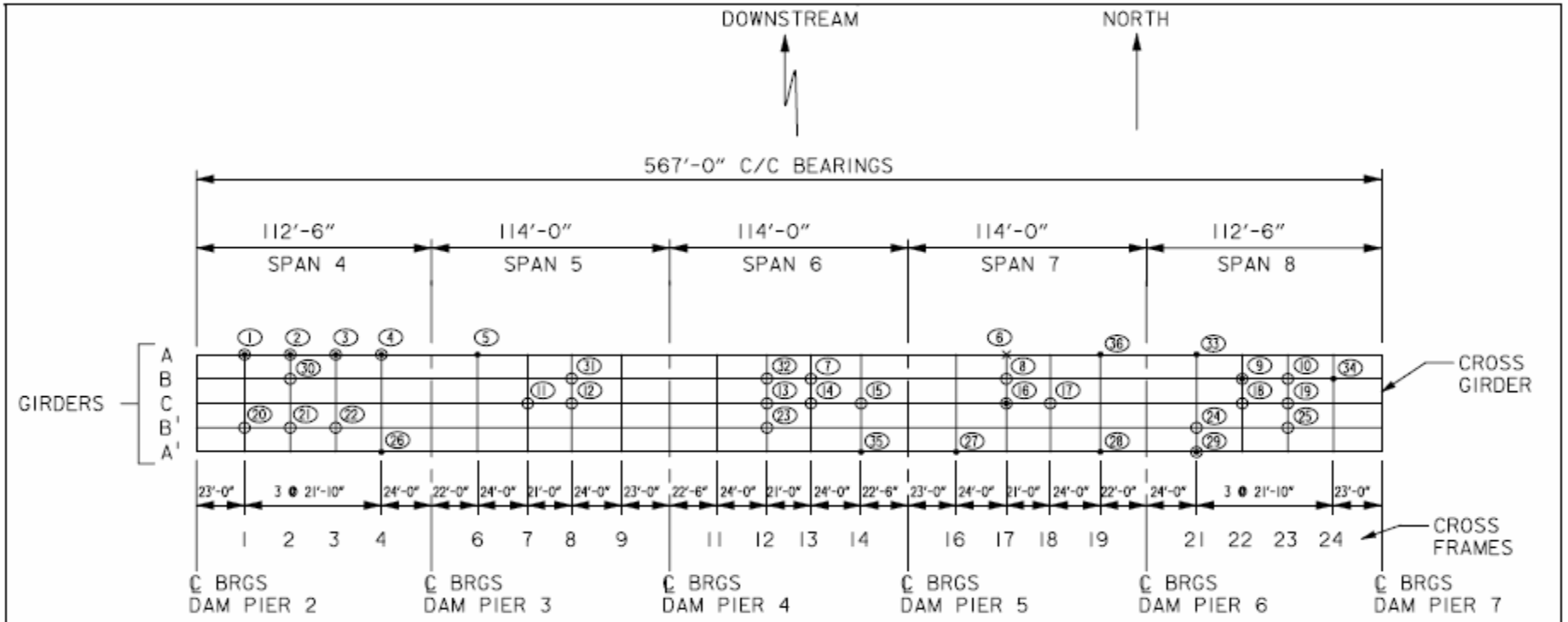
B_R BOTTOM LONGITUDINAL STIFFENER RETROFIT LOCATION
T_R TOP LONGITUDINAL STIFFENER RETROFIT LOCATION

OBSERVED BY: JBS/MRL DATE: 9/9/03

Longitudinal stiffener termination, Girder A’, Span 11, Unit 3

Crack at the Termination of the Longitudinal Web Stiffeners

Close-up view of cracked longitudinal stiffener termination.



CRACK LOCATION PLAN (SUPERSTRUCTURE 2)

- • TYPE 1 CRACK BELOW WEB - FLANGE WELD
- o TYPE 2 CRACK ABOVE STIFFENER - WEB WELD
- × TESTING INDICATED NO ACTUAL CRACK

SEE DETAIL

① TEST NUMBER

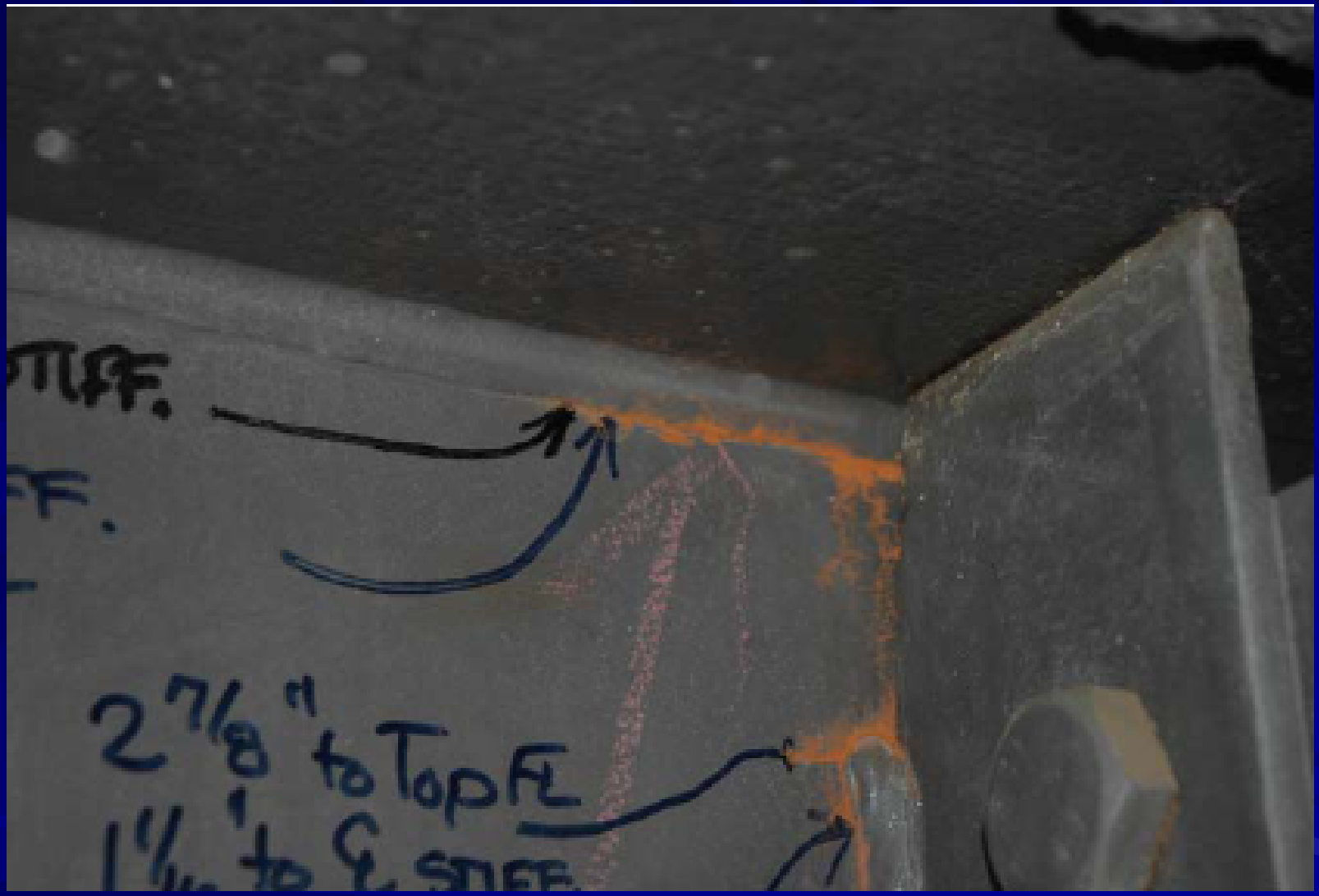
JESSE STUART HIGHWAY BRIDGE
GREENUP LOCKS AND DAM OHIO RIVER
SEPTEMBER 9, 2003

Web gap cracking at inside (upstream) web face at Cross Frame 1, Span 4 of Girder A, Unit 2.

Web gap cracking at outside (downstream) web face at Cross Frame 2, Span 4 of Girder A, Unit 2.

Web gap cracking at inside (upstream) face at Cross Frame 2, Span 4 of Girder A, Unit 2.

Web gap cracking at inside (upstream) face at Cross Frame 2, Span 4 of Girder A, Unit 2.



Web gap cracking at inside (upstream) face at Cross Frame 3, Span 4 of Girder A, Unit 2

Web gap cracking at inside (upstream) face at Cross Frame 3, Span 4 of Girder A, Unit 2.

Web gap cracking at outside (downstream) web face at Cross Frame 3, Span 4 of Girder A, Unit 2.

General Types of Fatigue Cracking

- Load-Induced
- Distortion-Induced

Load-Induced Fatigue Cracking

- Nominal Stress Range
- Number of Applied Load Cycles
- Connection Details

Load-Induced Fatigue (Type 3 Cracking)

- Longitudinal Stiffener Termination
  - Category E Detail
  - Stress Range 6.3 ksi < 13.0 ksi
  - Termination Opposite a Transverse Stiffener

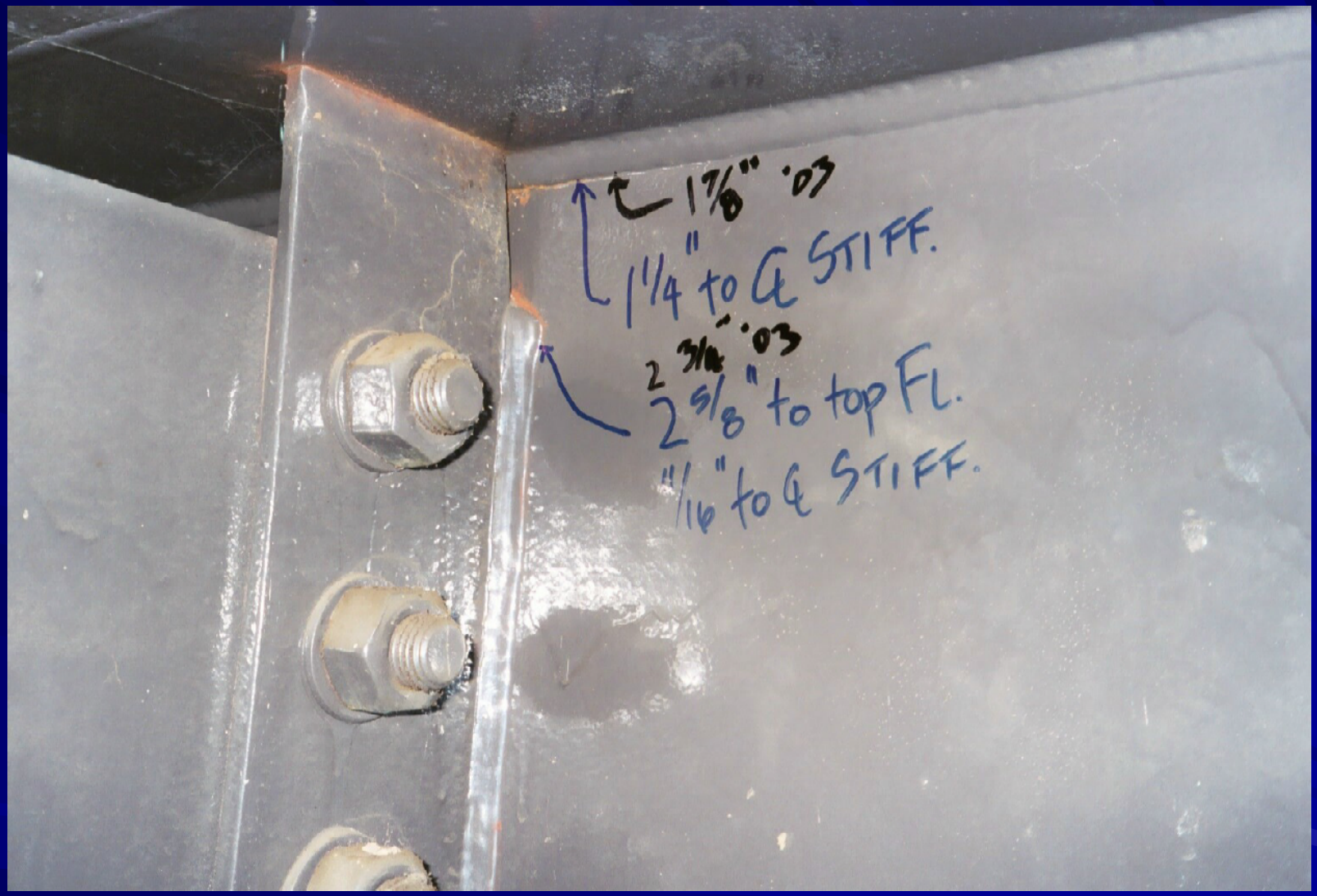
Distortion-induced Fatigue Cracking (Type 1 & 2 Cracking)

- Stress Ranges Complex
- Localized Stresses unintended/Unknown
- Out-of-Plane Distortion

View of typical cross frame in Unit 2.

Distortion-Induced Fatigue

- Transverse Stiffener Connection
  - "Tight Fit (No Weld)"



Typical Cracks in Center Spans

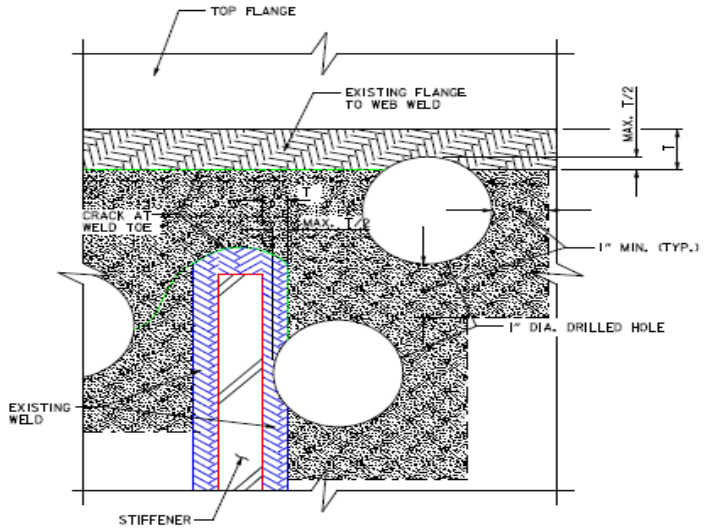
***Note measurements from Periodic Inspections. Blue writing is from FY01. Black writing is from FY03. Top crack grew 5/8” and the lower crack grew 1/8” in a two year period.**

View of typical cross frame in Unit 1 (and Unit 3).

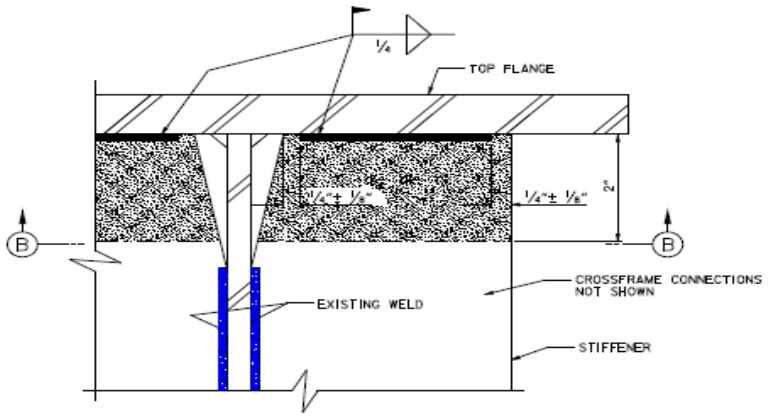
Fracture Assessment

- Three Charpy V-Notch impact test specimens were tested from each of Units 2 and 3.
- Unit 2 web specimens averaged energy absorption is 261 ft-lbf.
- Unit 3 web specimens averaged energy absorption is 38 ft-lbf (low value 29 ft-lbf)
- Test temperature 40F corresponding to AASHTO Temperature Zone 2
- AASHTO required minimum energy absorbed value is 25 ft-lbf for ASTM 588 in Temperature Zone II.
- LEFM used to assess Type 3 crack as “thru-thickness in infinite wide plate”.
- Critical crack length is conservatively twice the existing length of 2.25”.

Retrofit for Type 1 and Type 2 Cracks.



HOLE DETAIL
TYPE 1 AND TYPE 2 CRACKS WITH CRACK FOLLOWING TOE OF WELD

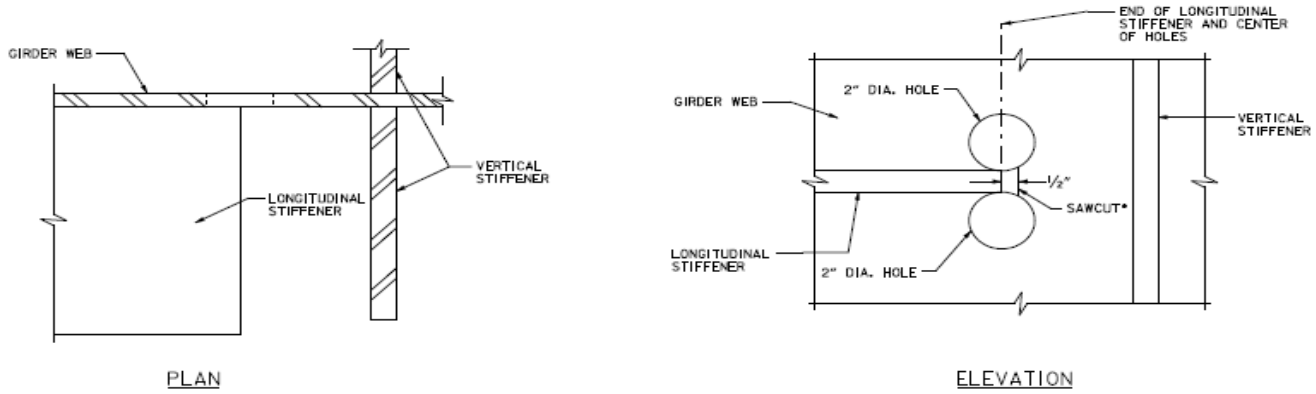


TOP FLANGE WELD
TERMINATION DETAIL

LEGEND:

= AREA TO BE SANDBLASTED

Retrofit for Type 3 Crack



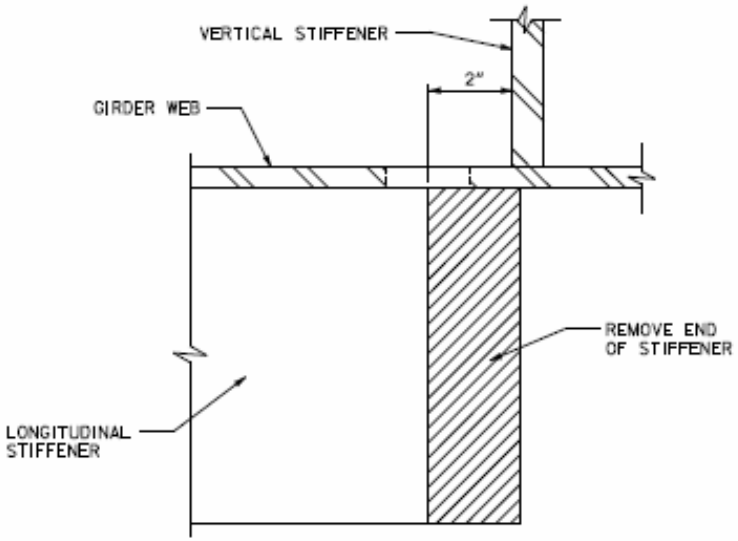
RETROFIT TYPE L2

LONGITUDINAL STIFFENER RETROFIT WITHOUT TRANSVERSE STIFFENER ON OPPOSITE SIDE

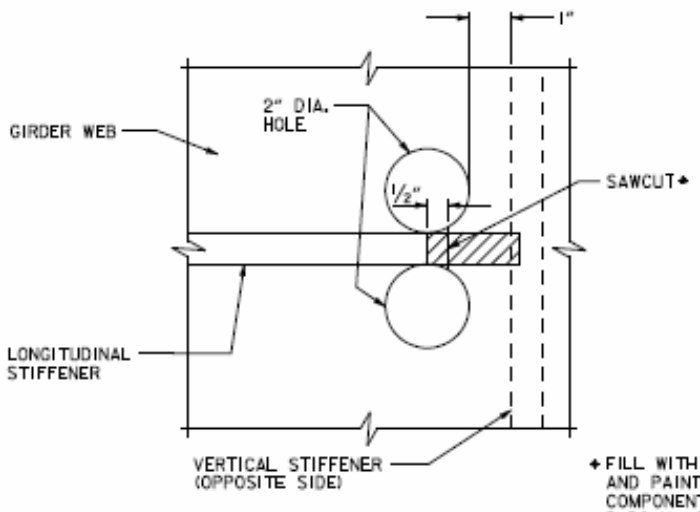
Summary

- 42 fatigue cracks exist as of September 2003
- Probable cause is load-induced and distortion-induced fatigue cracking
- Limited material testing indicates adequate fracture toughness for webs
- Observed Type 1, 2, & 3 cracking does not impose an immediate structural threat.
- Existing web gap cracking does not reduce load-carrying capacity of girders.
- Permitted loads will be assessed and limited where possible.

Discussion!



PLAN



ELEVATION

✦ FILL WITH CAULK PRIOR TO PRIMING AND PAINTING. CAULK SHALL BE A TWO-COMPONENT, NON-SAG, NON SHRINK 100 PERCENT SOLIDS EPOXY CAPABLE OF FILLING VOIDS UP TO ½ INCH.

RETROFIT TYPE LI

LONGITUDINAL STIFFENER RETROFIT WITH TRANSVERSE STIFFENER ON OPPOSITE SIDE