FATIGUE AND FRACTURE ASSESSMENT

JESSE STUART
HIGHWAY BRIDGE

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View of Jesse Stuart Highway Bridge looking north (downstream) from Kentucky side of the Ohio River.
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
- TYPE 2 CRACK ABOVE STIFFENER - WEB WELD
- TESTING INDICATED NO ACTUAL CRACK
- 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.
Retrofit for Type 3 Crack

PLAN

ELEVATION

RETROFIT TYPE 1-2
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!
RETROFIT TYPE L1
LONGITUDINAL STIFFENER RETROFIT WITH TRANSVERSE STIFFENER ON OPPOSITE SIDE

+ 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 HOLES UP TO 1/2 INCH.