Washington State Department of Transportation

FATIGUE TECHNOLOGY

Steel Bridge Crack Repair

Topics

- Introduction and purpose
- Problem of cracks in steel bridges
- Current repair methods
- Cold Expansion/Enhanced Drill Stop
- Survey
- Conclusions

Introduction and Purpose

- Time wasting repairs.
- Need to find a better way.
- Good results
- Checked w/FTI
- Only 13 states purchased the tool
- Conducted survey through TSP2

Problem of Cracks in Steel Bridges

- Repair for fatigue cracks in steel has been:
  - Find the end of the crack.
  - Small crack – grind it out
  - Longer cracks -Drill a crack arrest hole
  - Polish the hole
  - Chase the crack if it extends beyond the CAH
  - Try a bolt to put some compression in the steel
  - After next inspection repeat and sandwich the area in steel plates

Current Repair Methods

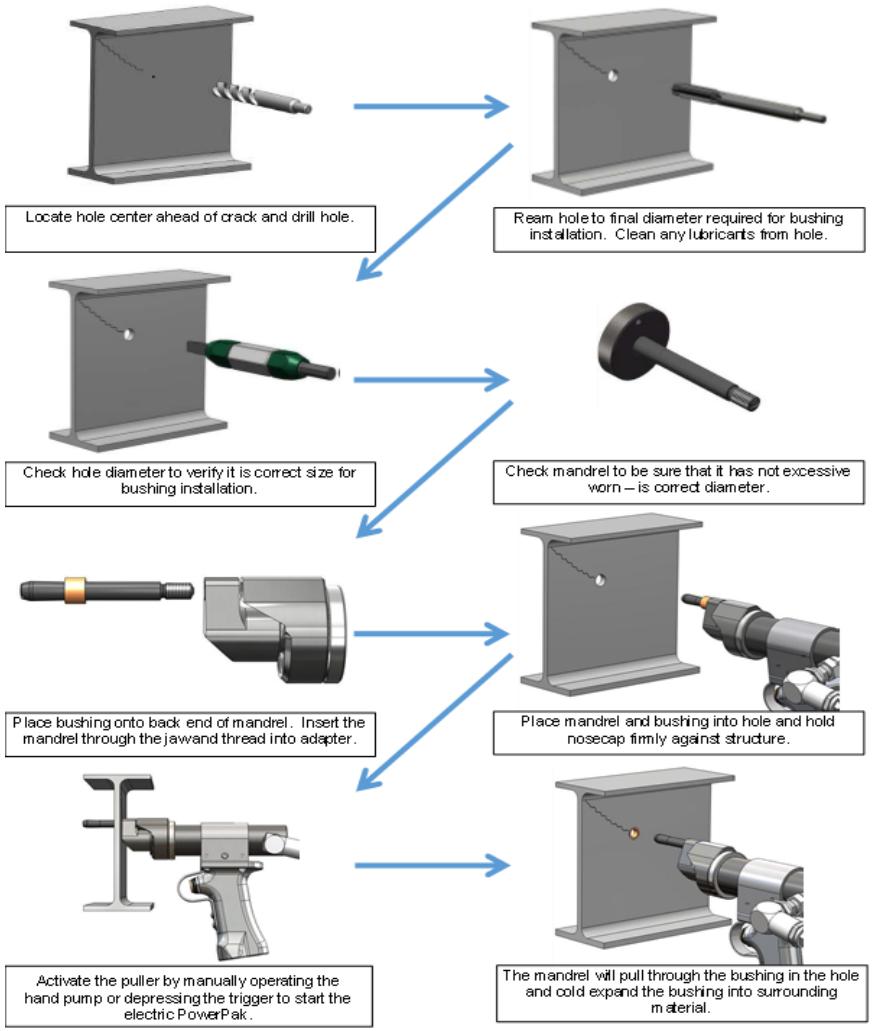
- Satsop River Bridge 12/51S
- End of crack, crack arrest hole drilled 2012
- Note crack propagation 2015, 2016, 2017

Cold Expansion / Enhanced Drill Stop

- Aviation derived technology introducing zone of residual compressive stress
- Zone “shields” the crack from cyclic loading
- Currently used by 13 state DoTs and in several other industries

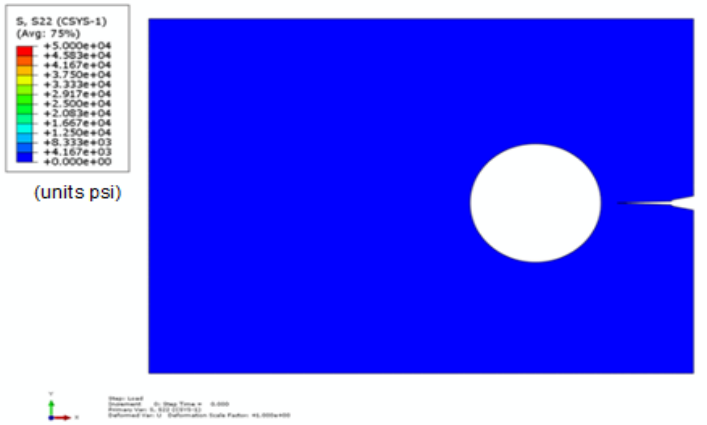
Cold Expansion / Enhanced Drill Stop

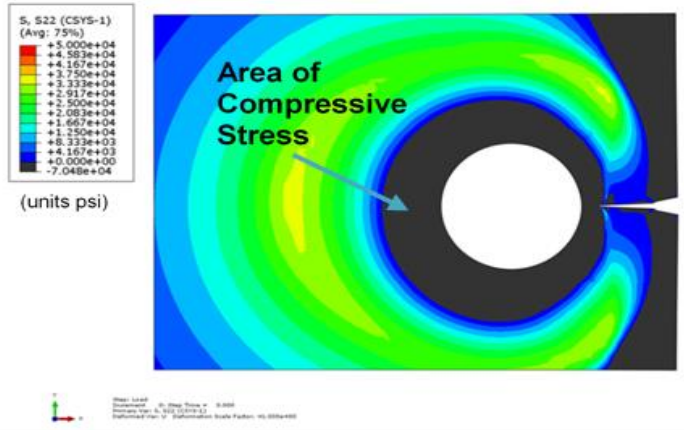
- Locate crack tip
- Drill hole 5/16 in front of crack (leaves 1/16th ligament)
- Confirm hole size and mandrel wear allowance
- Install bushing on mandrel
- Install bushing and cold expand drill stop hole
- Monitor



Cold Expansion / Enhanced Drill Stop

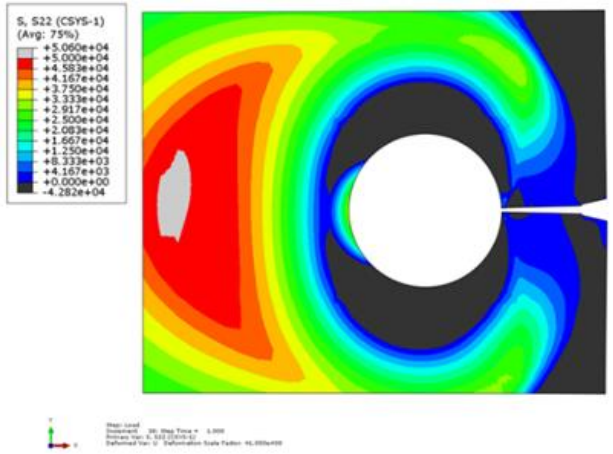
- Finite Element Analysis
- Model assumptions
  - A36 steel
  - Baseline with no load
  - CAH and Cx enhanced repair

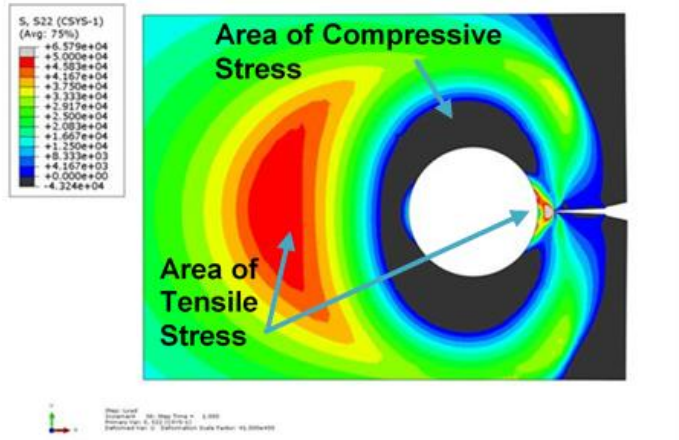




Cold Expansion / Enhanced Drill Stop

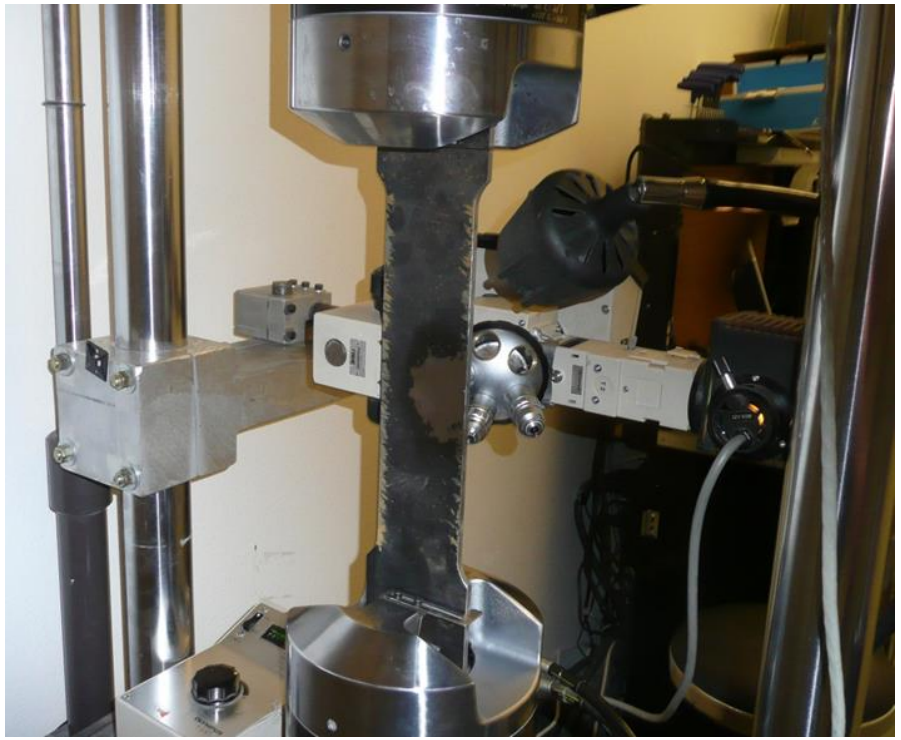
- FEA Under Load
  - 20.5 ksi stress
  - Crack tip in front of hole
  - Crack tip at hole

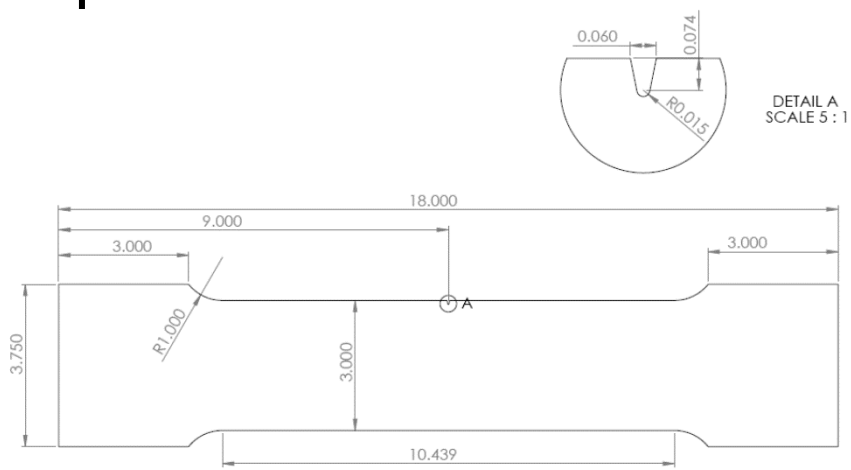




Cold Expansion / Enhanced Drill Stop

- Independent testing conducted by Southern Utah Engineering
- 7 Samples pre-cracked
- 3 Repaired with traditional crack repair and 4 with Cx enhanced repair





Cold Expansion / Enhanced Drill Stop

- Repaired specimens cycled at 20.5 ksi
- Test stopped upon visual indication of crack propagation or 4,000,000 cycles
- Specimen 7 allowed to run to 20,000,000 cycles; stopped with no propagation

SPECIMEN	RETROFIT METHOD	CRACK LENGTH (inches)	MAX NET STRESS (ksi)	R	CYCLES TO BREAK HOLE	CYCLES TO BECOME A THROUGH CRACK	CYCLES TO REINITIATE	CRACK LENGTH (inches)
1	StopCrackEX™	0.29	20.5	0.05	580,000	1,700,000	4,000,000	No Crack
2	StopCrackEX™	0.285	20.5	0.05	250,200	300,000	4,000,000	No Crack
3	CAH	0.298	20.5	0.05	15,600	17,500	230,000	0.145
4	CAH	0.264	20.5	0.05	5,868	7,000	440,000	0.149
5	StopCrackEX™	0.265	20.5	0.05	700,000	4,000,000	4,000,000	No Crack
6	CAH	0.265	20.5	0.05	4,165	6,000	250,000	0.14
7	StopCrackEX™	0.262	20.5	0.05	210,000	3,700,000	20,000,000	No Crack

Cold Expansion / Enhanced Drill Stop

Manahawkin Bay Bridge, NJDOT (Oct 2011)

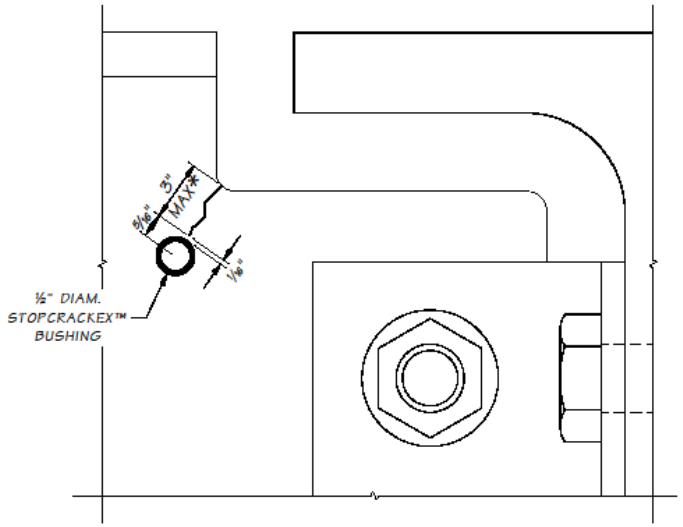
Lincoln Tunnel Interchange, NJTA (Mar 2012)

Bridge over Delaware River, NYSDOT (Apr 2012)

Satsop River Bridge, WADOT (Oct 2017)

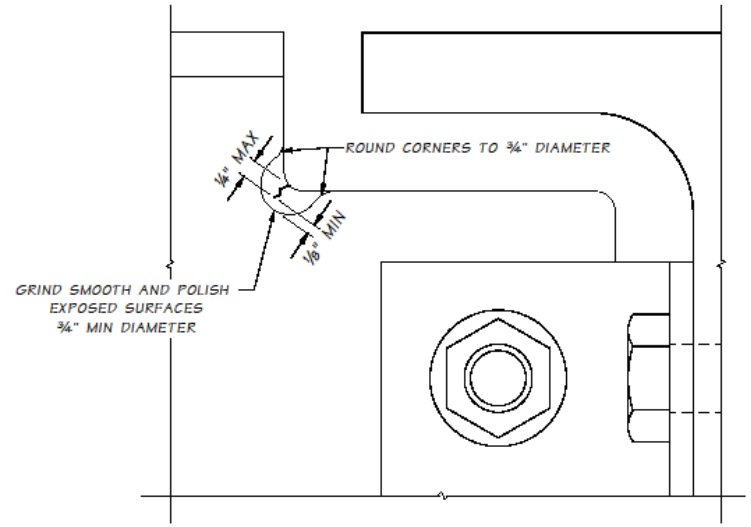
Survey

- 18 replies from 17 states
- 14 states; Grind out small cracks, Crack arrest holes for longer cracks, Plate the crack
- Size of crack arrest hole varied from ½ inch to 2 inches.
- 1 State: hole encompasses all the crack or cracks; then plate the hole.
- Results were mixed. For several states no propagation of the crack. For others some of the cracks continued in 2 to 4 years.
- 5 states used the crack arrest tool. 3 in process of purchasing
- No reports of the crack going past the cold expansion bushing



FOR CRACKS > ¼"
USE STOPCRACKEX™ BUSHING

- LOCATE CRACK TERMINATION BY DYE PENETRANT TESTING.
- INSTALL STOPCRACKEX™ BUSHING ALONG THE CRACK TRAJECTORY LEAVING 1/16" BETWEEN CRACK TIP AND BUSHING. A ½" BUSHING WOULD BE CENTERED AT 5/16" FROM THE TIP OF CRACK (REFER TO INSTALLATION MANUAL).
- PAINT

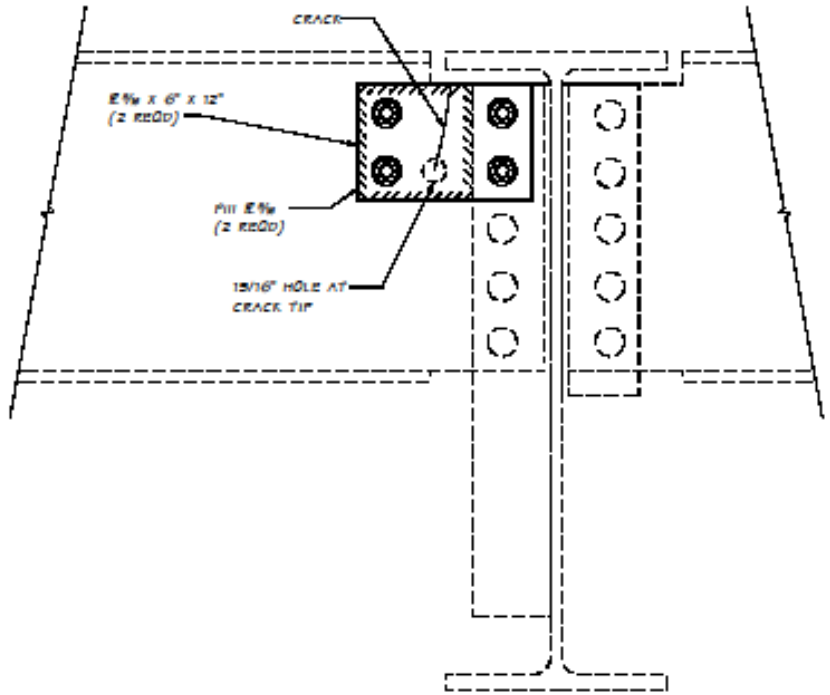


FOR CRACKS ≤ ¼"
GRIND AND POLISH

- GRIND OUT CRACK TO ¾" MINIMUM DIAMETER (GRIND MIN. ⅛" BEYOND IDENTIFIED TIP)
- REMOVE ALL SHARP CORNERS IN VICINITY OF REPAIR (¾" MIN. DIAMETER)
- POLISH EXPOSED SURFACES
- PAINT

* CRACKS LONGER THAN 3" REQUIRE ADDITIONAL REVIEW. CONTACT BRIDGE REPAIR SPECIALIST AT 360-570-2560.

Date: 3/25/2013	Washington State Department of Transportation Bridge and Structures Office	STRINGER COPE CRACK REPAIR	Sheet No. 1
Drawn By: J. S. MARTIN			of
Checked By: N/A			
Reviewed By: G. C. SCROGGINS	Revision: STANDARD	REPAIR PROTOCOLS	1



STRINGER/FLOORBEAM CONNECTION

NOTES

PLATE SHALL BE ASTM A36.

MINIMUM EDGE DISTANCE OF ANY BOLT IS 1-1/2"

BOLTS SHALL BE 7/8" DIA. ASTM A325 STRUCTURAL BOLTS IN 15/16" DIA. HOLES. BOLTS SHALL BE INSTALLED WITH DIRECT TENSION INDICATING WASHERS.

REPAIR TYPICAL AT:

STR 7B @ FBT
STR 7G @ FB6
STR 6B @ FB6
STR 2B @ FB 2

STRINGER WEB REPAIR

BRIDGE 12/23
DESIGNED BY J. E. DODSON
CHECKED BY
6/30/2008
BRIDGE PRESERVATION OFFICE
360.570.2572

Conclusions

- The states that have used the tool have found it effective in stopping fatigue cracks.
- No state that answered the survey reported that they had a crack move past the bushing.
- There is a large cost savings in not having to redo a repair.