BUCK O'NEIL BRIDGE INSPECTION AND REHABILITATION CONCEPTS

CORE TEAM MEETING

HDR

March 29, 2017

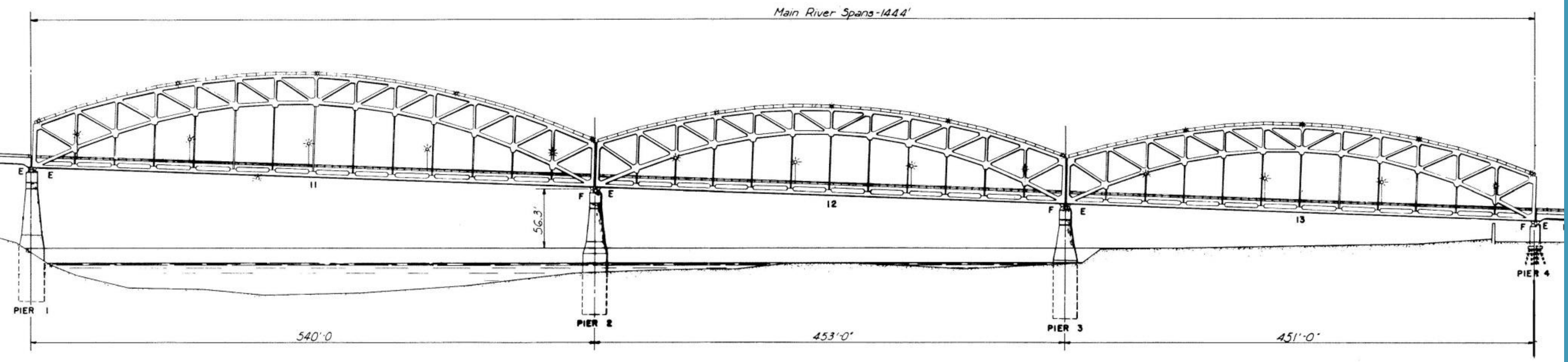
01 **Scope of Services**

02 **Bridge Inspection**

03 **Fatigue Analysis**

04 **Rehabilitation Concepts**

05 **Discussion**



01 SCOPE OF SERVICES

SCOPE OF SERVICES

- Bridge Inspection
  - In depth, hands on for all accessible members
  - Hands on for Fracture Critical members
  - Non-destructive testing of hanger cables
  - Sounding, sampling and GPR inspection of main piers
- Evaluation
  - Remaining service life of piers
  - Remaining fatigue life of steel members
- Rehabilitation Concepts & Alternatives
  - Short Term Repair – 10 years of additional service life
  - Long Term Rehabilitation – 35 years of additional service life
- Preliminary Plans
  - Bridge memo, cost estimate & preliminary plans of selected alternate

02 BRIDGE INSPECTION

DECK

- Wearing surface has numerous cracks both transverse and longitudinal
- Some bulging stay in place forms
- Deterioration near slab drains
- Deck saturation in north approach spans

RAILING

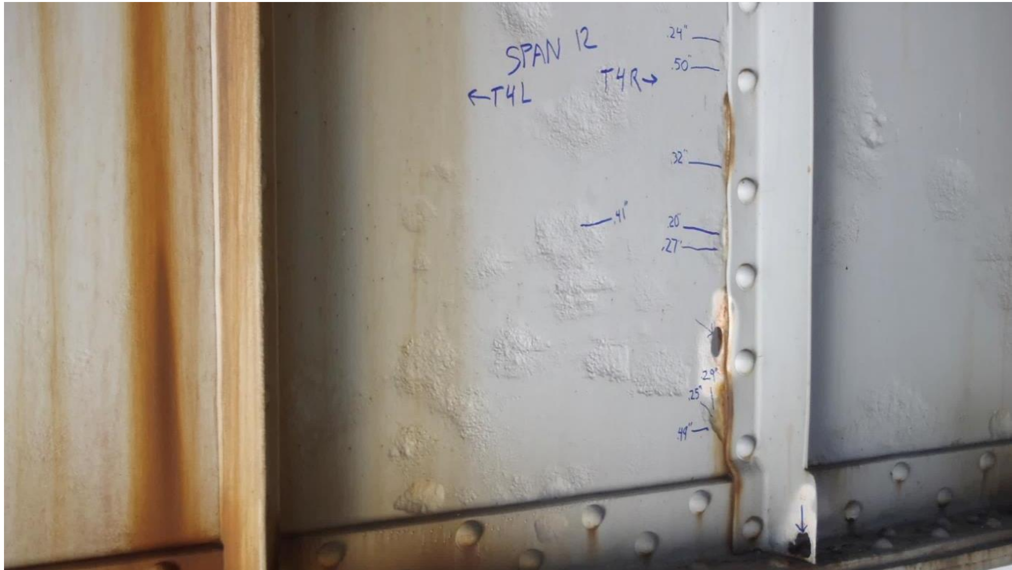
- Numerous locations of impact damage
  - Bent / broken rail tubes
  - Cracked / broken rail posts
- Spalling concrete on curb and parapet
- Pack rust on curb support brackets

EXPANSION JOINT SUPPORT

- Vertical deflections between sides of the joints
- Pack rust and deterioration of the supporting brackets
- Cracked clip angles supporting the joints
- Compression seals have failed
- Compression seal armoring has failed

STRINGER / FLOORBEAM

- Pack rust between bottom flange of the stringers and bearing plates
- Deterioration of the stringer flanges and web near locations exposed to drainage
- Deterioration of stringer bearing stiffeners
- Cracking of stringer webs near ends
- Pitting in webs of floorbeams throughout
- Section loss in top and bottom floorbeam flanges
- Pack rust between floorbeam stiffening angles and webs
- Holes in floorbeam stiffening angles



LOWER HANGER CABLE RETAINERS

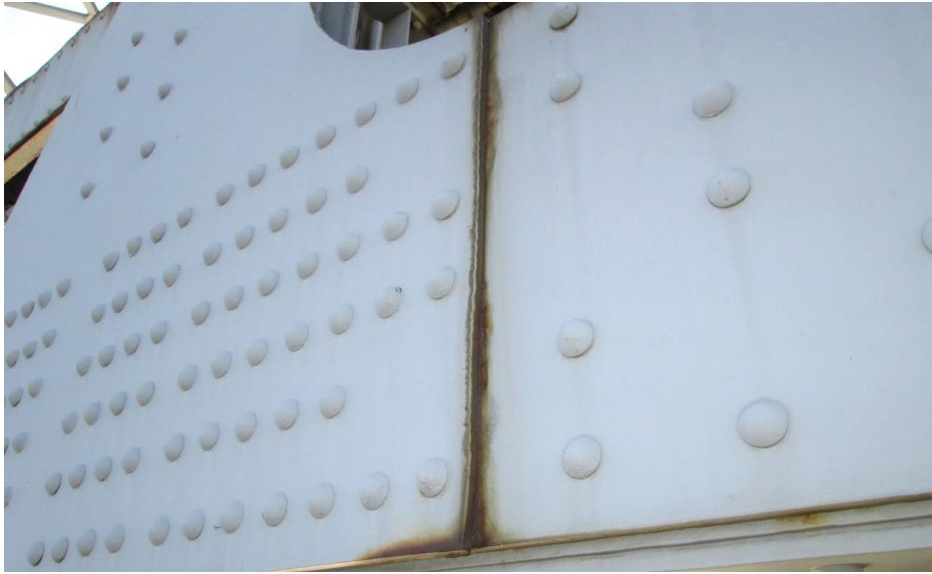
- Heavy pack rust at almost all locations
- Most locations have section loss and deflection
- Retainers have come off in several locations

TIE GIRDER

- Pack rust between top plate and connecting angles
- Cupping of top plate due to pack rust
- Localized areas of pitting
- Pack rust at old attachment points

LOWER OUTER GUSSET

- Pack rust between ends of floorbeams and gusset plate
- Pack rust between tie girder and gusset plate
- Section loss of gusset plate along areas of pack rust

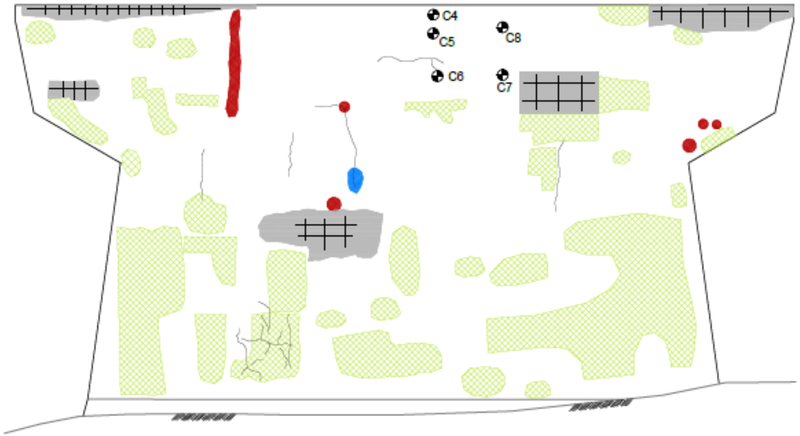


PORTAL FRAME

- Pack rust between box member web plates and connecting angles
- Deterioration of the interior of the box members below the deck

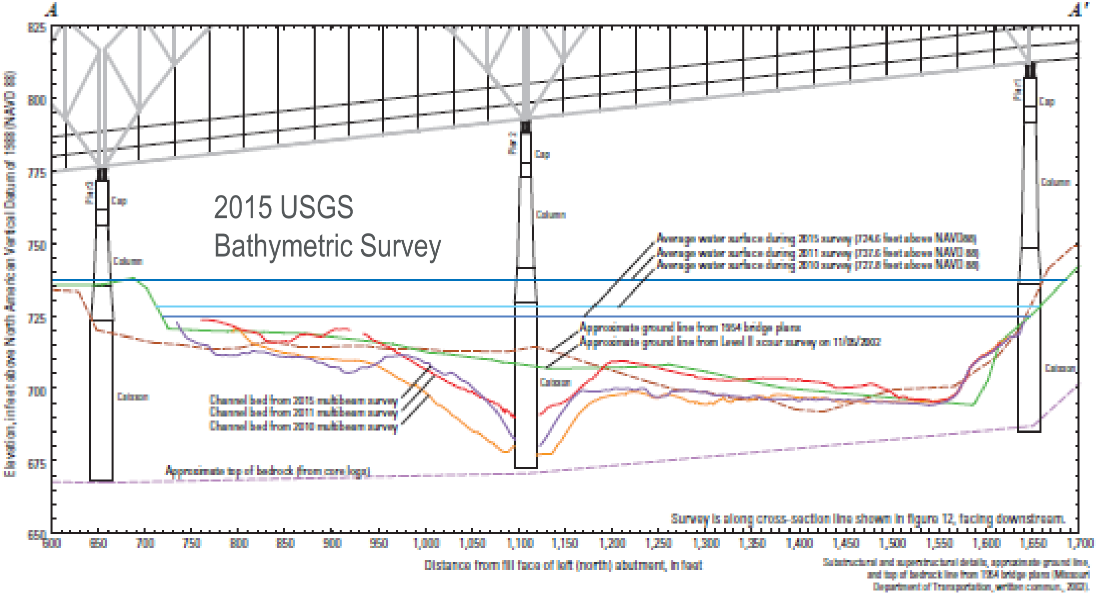
MAIN PIERS

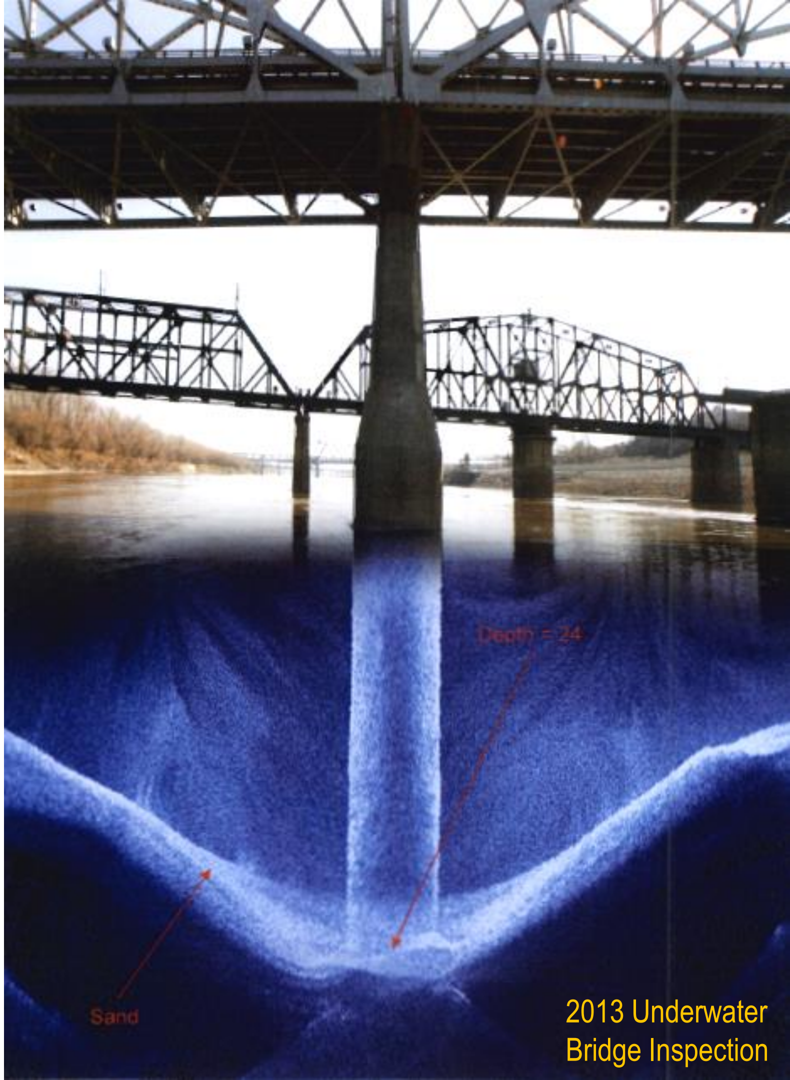
- Faces in generally poor condition
- Areas of delamination and spalls
- Elevated chloride content in the concrete



PIER SCOUR

- Large scour hole at Pier 2 in the river
- Hole is around all sides of the pier
- Pier 2 is embedded one foot into the shale



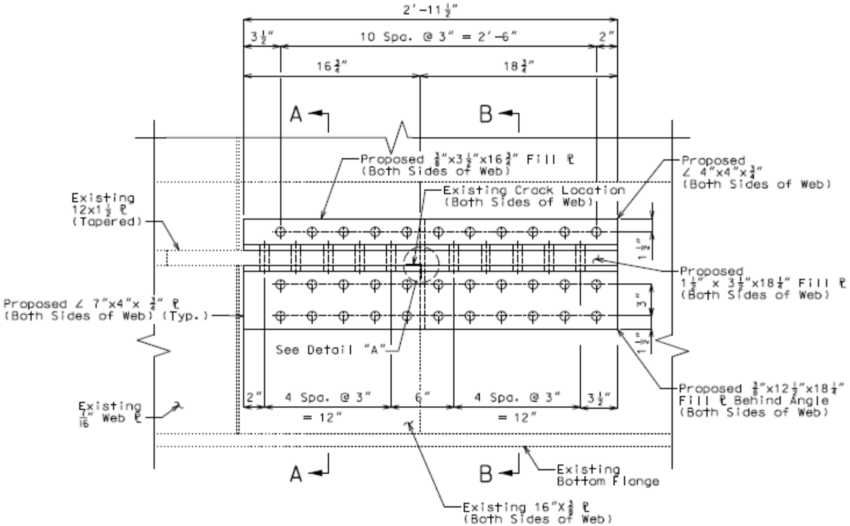


APPROACH PIERS

- Pack rust between flanges and connecting angles
- Deformation and section loss of flange and web plates
- Pack rust between end plates and connecting angles
- Localized concrete spalls

BEARING SHELF PLATE

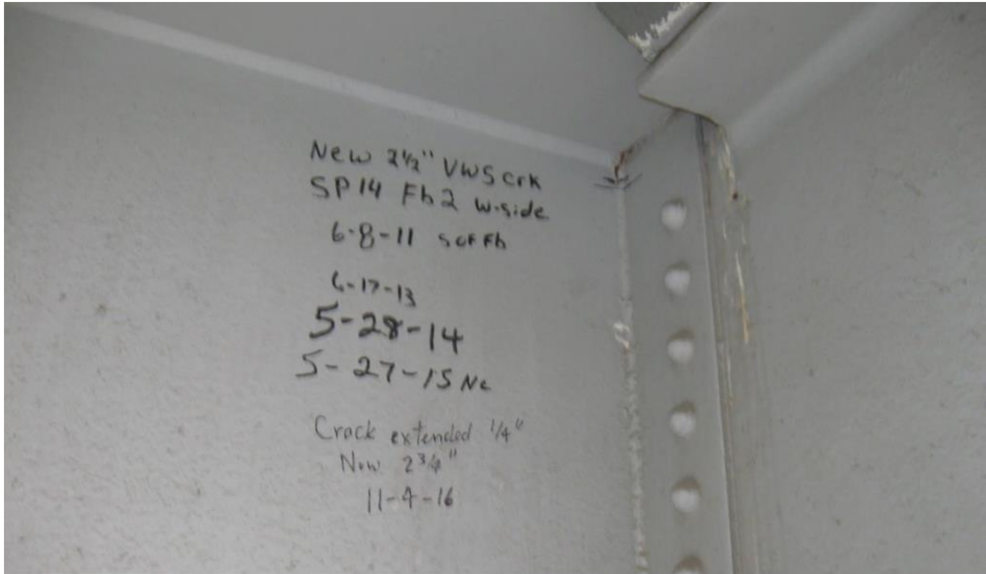
- Load induced fatigue crack at the end of the web stiffening plate
- Supports the bearing shelf
- Critical location on non-redundant member
- Reinforced after inspection
- Remaining locations should be proactively reinforced



ELEVATION

GIRDER CRACKING

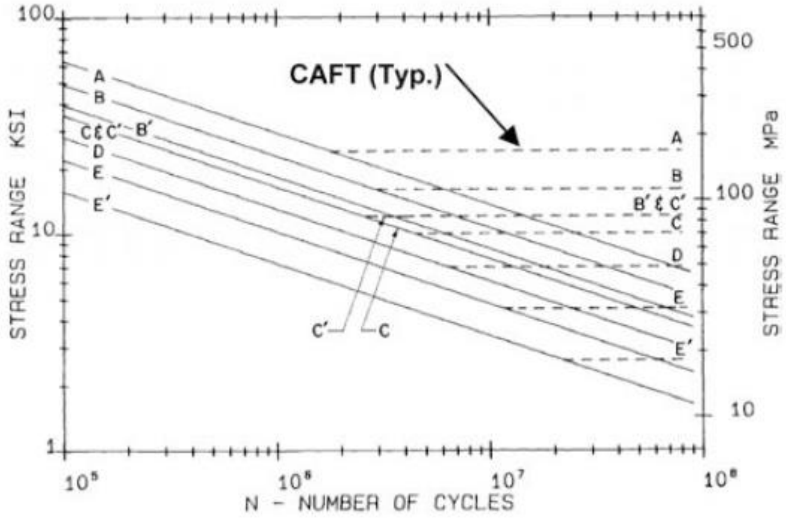
- Systemic cracking of the girder webs at the ends of stiffeners
- Distortion induced fatigue cracking
- Most cracks stay in the stiffener weld
- Some cracks have propagated into the web
- Continuing crack growth and development



03 FATIGUE ANALYSIS

MINER'S LAW OF CUMULATIVE DAMAGE

- Nominal fatigue resistance is inverse to the applied stress range, up to a threshold
- $(\Delta f)_n = \left(\frac{A}{N}\right)^{\frac{1}{3}}$
- If the applied stress is below the allowable for the threshold, fatigue damage will not occur



FATIGUE DETAIL CATEGORIES

Table 6.6.1.2.3-1—Detail Categories for Load-Induced Fatigue

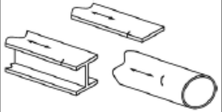
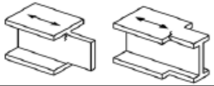
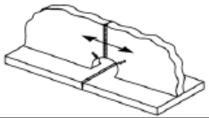
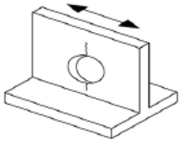
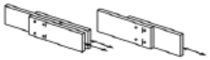
Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 1—Plain Material away from Any Welding					
1.1 Base metal, except noncoated weathering steel, with rolled or cleaned surfaces. Flame-cut edges with surface roughness value of 1,000 μ-in. or less, but without re-entrant corners.	A	250×10^8	24	Away from all welds or structural connections	
1.2 Noncoated weathering steel base metal with rolled or cleaned surfaces designed and detailed in accordance with FHWA (1989). Flame-cut edges with surface roughness value of 1,000 μ-in. or less, but without re-entrant corners.	B	120×10^8	16	Away from all welds or structural connections	
1.3 Member with re-entrant corners at copes, cuts, block-outs or other geometrical discontinuities made to the requirements of AASHTO/AWS D1.5, except weld access holes.	C	44×10^8	10	At any external edge	
1.4 Rolled cross sections with weld access holes made to the requirements of AASHTO/AWS D1.5, Article 3.2.4.	C	44×10^8	10	In the base metal at the re-entrant corner of the weld access hole	
1.5 Open holes in members (Brown et al., 2007).	D	22×10^8	7	In the net section originating at the side of the hole	
Section 2—Connected Material in Mechanically Fastened Joints					
2.1 Base metal at the gross section of high-strength bolted joints designed as slip-critical connections with pretensioned high-strength bolts installed in holes drilled full size or subpunched and reamed to size—e.g., bolted flange and web splices and bolted stiffeners. (Note: see Condition 2.3 for bolt holes punched full size; see Condition 2.5 for bolted angle or tee section member connections to gusset or connection plates.)	B	120×10^8	16	Through the gross section near the hole	

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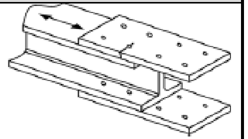
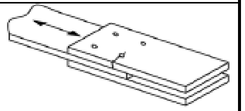
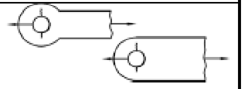
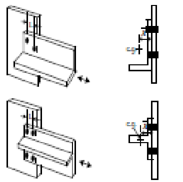
Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 2—Connected Material in Mechanically Fastened Joints (continued)					
2.2 Base metal at the net section of high-strength bolted joints designed as bearing-type connections but fabricated and installed to all requirements for slip-critical connections with pretensioned high-strength bolts installed in holes drilled full size or subpunched and reamed to size. (Note: see Condition 2.3 for bolt holes punched full size; see Condition 2.5 for bolted angle or tee section member connections to gusset or connection plates.)	B	120×10^8	16	In the net section originating at the side of the hole	
2.3 Base metal at the net or gross section of high-strength bolted joints with pretensioned bolts installed in holes punched full size (Brown et al., 2007); and base metal at the net section of other mechanically fastened joints, except for eyebars and pin plates, e.g., joints using ASTM A307 bolts or non-pretensioned high-strength bolts. (Note: see Condition 2.5 for bolted angle or tee section member connections to gusset or connection plates).	D	22×10^8	7	In the net section originating at the side of the hole or through the gross section near the hole, as applicable	
2.4 Base metal at the net section of eyebar heads or pin plates (Note: for base metal in the shank of eyebars or through the gross section of pin plates, see Condition 1.1 or 1.2, as applicable.)	E	11×10^8	4.5	In the net section originating at the side of the hole	
2.5 Base metal in angle or tee section members connected to a gusset or connection plate with high-strength bolted slip-critical connections. The fatigue stress range shall be calculated on the effective net area of the member, $A_e = UA_g$, in which $U = (1 - \bar{x}/L)$ and where A_g is the gross area of the member. $\bar{x}$ is the distance from the centroid of the member to the surface of the gusset or connection plate and L is the out-to-out distance between the bolts in the connection parallel to the line of force. The effect of the moment due to the eccentricities in the connection shall be ignored in computing the stress range (McDonald and Frank, 2009).	See applicable Category above	See applicable Constant above	See applicable Threshold above	Through the gross section near the hole, or in the net section originating at the side of the hole, as applicable	

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FATIGUE DETAIL CATEGORIES

Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

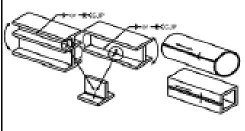
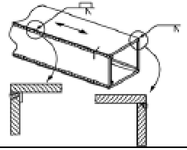
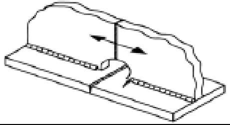
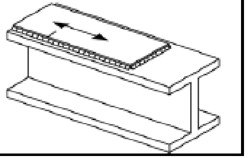
Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
2.5 (continued) The fatigue category shall be taken as that specified for Condition 2.1. For all other types of bolted connections, replace A_g with the net area of the member, A_n, in computing the effective net area according to the preceding equation and use the appropriate fatigue category for that connection type specified for Condition 2.2 or 2.3, as applicable.					
Section 3—Welded Joints Joining Components of Built-Up Members					
3.1 Base metal and weld metal in members without attachments built up of plates or shapes connected by continuous longitudinal complete joint penetration groove welds back-gouged and welded from the second side, or by continuous fillet welds parallel to the direction of applied stress.	B	120×10^8	16	From surface or internal discontinuities in the weld away from the end of the weld	
3.2 Base metal and weld metal in members without attachments built up of plates or shapes connected by continuous longitudinal complete joint penetration groove welds with backing bars not removed, or by continuous partial joint penetration groove welds parallel to the direction of applied stress.	B′	61×10^8	12	From surface or internal discontinuities in the weld, including weld attaching backing bars	
3.3 Base metal and weld metal at the termination of longitudinal welds at weld access holes made to the requirements of AASHTO/AWS D1.5, Article 3.2.4 in built-up members. (Note: does not include the flange butt splice).	D	22×10^8	7	From the weld termination into the web or flange	
3.4 Base metal and weld metal in partial length welded cover plates connected by continuous fillet welds parallel to the direction of applied stress.	B	120×10^8	16	From surface or internal discontinuities in the weld away from the end of the weld	

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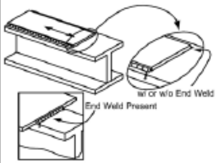
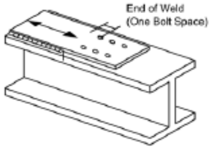
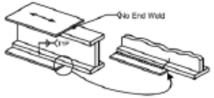
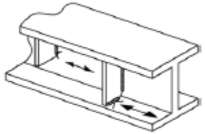
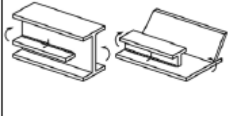
Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 3—Welded Joints Joining Components of Built-Up Members (continued)					
3.5 Base metal at the termination of partial length welded cover plates having square or tapered ends that are narrower than the flange, with or without welds across the ends, or cover plates that are wider than the flange with welds across the ends:				In the flange at the toe of the end weld or in the flange at the termination of the longitudinal weld or in the edge of the flange with wide cover plates	
Flange thickness ≤ 0.8 in.	E	11×10^8	4.5		
Flange thickness > 0.8 in.	E′	3.9×10^8	2.6		
3.6 Base metal at the termination of partial length welded cover plates with slip-critical bolted end connections satisfying the requirements of Article 6.10.12.2.3.	B	120×10^8	16	In the flange at the termination of the longitudinal weld	
3.7 Base metal at the termination of partial length welded cover plates that are wider than the flange and without welds across the ends.	E′	3.9×10^8	2.6	In the edge of the flange at the end of the cover plate weld	
Section 4—Welded Stiffener Connections					
4.1 Base metal at the toe of transverse stiffener-to-flange fillet welds and transverse stiffener-to-web fillet welds. (Note: includes similar welds on bearing stiffeners and connection plates).	C′	44×10^8	12	Initiating from the geometrical discontinuity at the toe of the fillet weld extending into the base metal	
4.2 Base metal and weld metal in longitudinal web or longitudinal box-flange stiffeners connected by continuous fillet welds parallel to the direction of applied stress.	B	120×10^8	16	From the surface or internal discontinuities in the weld away from the end of the weld	

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FATIGUE DETAIL CATEGORIES

Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

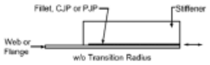
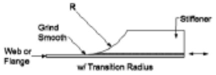
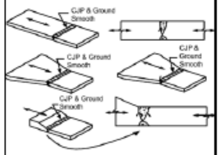
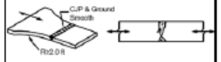
Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 4—Welded Stiffener Connections (continued)					
4.3 Base metal at the termination of longitudinal stiffener-to-web or longitudinal stiffener-to-box flange welds:					
With the stiffener attached by fillet welds and with no transition radius provided at the termination:				In the primary member at the end of the weld at the weld toe	
Stiffener thickness < 1.0 in.	E	11×10^8	4.5		
Stiffener thickness ≥ 1.0 in.	E′	3.9×10^8	2.6		
With the stiffener attached by welds and with a transition radius R provided at the termination with the weld termination ground smooth:				In the primary member near the point of tangency of the radius	
$R \geq 24$ in.	B	120×10^8	16		
24 in. > $R \geq 6$ in.	C	44×10^8	10		
6 in. > $R \geq 2$ in.	D	22×10^8	7		
2 in. > R	E	11×10^8	4.5		
Section 5—Welded Joints Transverse to the Direction of Primary Stress					
5.1 Base metal and weld metal in or adjacent to complete joint penetration groove welded butt splices, with weld soundness established by NDT and with welds ground smooth and flush parallel to the direction of stress. Transitions in thickness or width shall be made on a slope no greater than 1:2.5 (see also Figure 6.13.6.2-1).				From internal discontinuities in the filler metal or along the fusion boundary or at the start of the transition	
F_y < 100 ksi	B	120×10^8	16		
$F_y \geq 100$ ksi	B′	61×10^8	12		
5.2 Base metal and weld metal in or adjacent to complete joint penetration groove welded butt splices, with weld soundness established by NDT and with welds ground parallel to the direction of stress at transitions in width made on a radius of not less than 2 ft with the point of tangency at the end of the groove weld (see also Figure 6.13.6.2-1).	B	120×10^8	16	From internal discontinuities in the filler metal or discontinuities along the fusion boundary	

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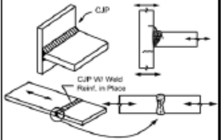
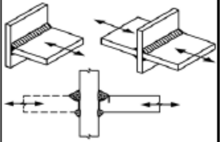
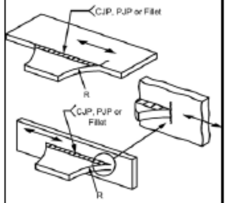
Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
5.3 Base metal and weld metal in or adjacent to the toe of complete joint penetration groove welded T or corner joints, or in complete joint penetration groove welded butt splices, with or without transitions in thickness having slopes no greater than 1:2.5 when weld reinforcement is not removed. (Note: cracking in the flange of the "T" may occur due to out-of-plane bending stresses induced by the stem).	C	44×10^8	10	From the surface discontinuity at the toe of the weld extending into the base metal or along the fusion boundary	
5.4 Base metal and weld metal at details where loaded discontinuous plate elements are connected with a pair of fillet welds or partial joint penetration groove welds on opposite sides of the plate normal to the direction of primary stress.	C as adjusted in Eq. 6.6.1.2.5-4	44×10^8	10	Initiating from the geometrical discontinuity at the toe of the weld extending into the base metal or initiating at the weld root subject to tension extending up and then out through the weld	
Section 6—Transversely Loaded Welded Attachments					
6.1 Base metal in a longitudinally loaded component at a transversely loaded detail (e.g. a lateral connection plate) attached by a weld parallel to the direction of primary stress and incorporating a transition radius R. With the weld termination ground smooth:				Near point of tangency of the radius at the edge of the longitudinally loaded component or at the toe of the weld at the weld termination if not ground smooth	
$R \geq 24$ in.	B	120×10^8	16		
24 in. > $R \geq 6$ in.	C	44×10^8	10		
6 in. > $R \geq 2$ in.	D	22×10^8	7		
2 in. > R	E	11×10^8	4.5		
For any transition radius with the weld termination not ground smooth. (Note: Condition 6.2, 6.3 or 6.4, as applicable, shall also be checked.)	E	11×10^8	4.5		

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FATIGUE DETAIL CATEGORIES

Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

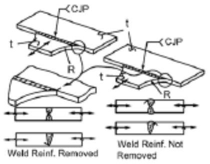
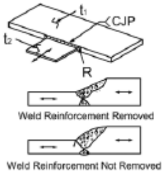
Description	Category	Constant A $(ksi)^3$	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 6—Transversely Loaded Welded Attachments (continued)					
6.2 Base metal in a transversely loaded detail (e.g. a lateral connection plate) attached to a longitudinally loaded component of equal thickness by a complete joint penetration groove weld parallel to the direction of primary stress and incorporating a transition radius R, with weld soundness established by NDT and with the weld termination ground smooth: With the weld reinforcement removed:					
$R \geq 24$ in.	B	120×10^8	16	Near points of tangency of the radius or in the weld or at the fusion boundary of the longitudinally loaded component or the transversely loaded attachment	
24 in. $> R \geq 6$ in.	C	44×10^8	10		
6 in. $> R \geq 2$ in.	D	22×10^8	7		
2 in. $> R$	E	11×10^8	4.5		
With the weld reinforcement not removed:				At the toe of the weld either along the edge of the longitudinally loaded component or the transversely loaded attachment	
$R \geq 24$ in.	C	44×10^8	10		
24 in. $> R \geq 6$ in.	C	44×10^8	10		
6 in. $> R \geq 2$ in.	D	22×10^8	7		
2 in. $> R$	E	11×10^8	4.5		
(Note: Condition 6.1 shall also be checked.)					
6.3 Base metal in a transversely loaded detail (e.g. a lateral connection plate) attached to a longitudinally loaded component of unequal thickness by a complete joint penetration groove weld parallel to the direction of primary stress and incorporating a weld transition radius R, with weld soundness established by NDT and with the weld termination ground smooth: With the weld reinforcement removed:				At the toe of the weld along the edge of the thinner plate In the weld termination of small radius weld transitions At the toe of the weld along the edge of the thinner plate	
R ≥ 2 in.	D	22×10^8	7		
$R < 2$ in.	E	11×10^8	4.5		
For any weld transition radius with the weld reinforcement not removed. (Note: Condition 6.1 shall also be checked.)	E	11×10^8	4.5		

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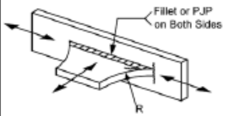
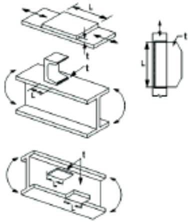
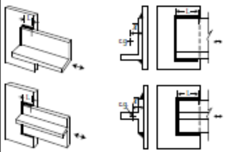
Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

Description	Category	Constant A $(ksi)^3$	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 6—Transversely Loaded Welded Attachments (continued)					
6.4 Base metal in a transversely loaded detail (e.g. a lateral connection plate) attached to a longitudinally loaded component by a fillet weld or a partial joint penetration groove weld, with the weld parallel to the direction of primary stress (Note: Condition 6.1 shall also be checked.)	See Condition 5.4				
Section 7—Longitudinally Loaded Welded Attachments					
7.1 Base metal in a longitudinally loaded component at a detail with a length L in the direction of the primary stress and a thickness t attached by groove or fillet welds parallel or transverse to the direction of primary stress where the detail incorporates no transition radius:				In the primary member at the end of the weld at the weld toe	
$L < 2$ in.	C	44×10^8	10		
2 in. $\leq L \leq 12t$ or 4 in	D	22×10^8	7		
$L > 12t$ or 4 in.					
$t < 1.0$ in.	E	11×10^8	4.5		
$t \geq 1.0$ in.	E′	3.9×10^8	2.6		
(Note: see Condition 7.2 for welded angle or tee section member connections to gusset or connection plates.)					
7.2 Base metal in angle or tee section members connected to a gusset or connection plate by longitudinal fillet welds along both sides of the connected element of the member cross-section. The fatigue stress range shall be calculated on the effective net area of the member, $A_e = UA_g$, in which $U = (1 - \bar{x}/L)$ and where A_g is the gross area of the member. $\bar{x}$ is the distance from the centroid of the member to the surface of the gusset or connection plate and L is the maximum length of the longitudinal welds. The effect of the moment due to the eccentricities in the connection shall be ignored in computing the stress range (McDonald and Frank, 2009).	E	11×10^8	4.5	Toe of fillet welds in connected element	

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FATIGUE DETAIL CATEGORIES

Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

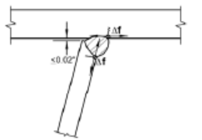
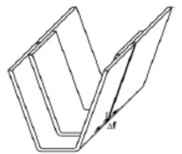
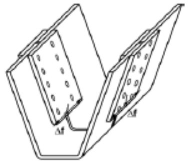
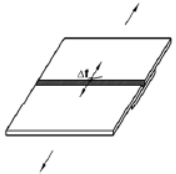
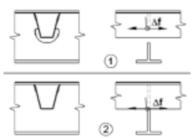
Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 8—Orthotropic Deck Details					
8.1 Rib to Deck Weld—One-sided 80% (70% min) penetration weld with root gap ≤ 0.02 in. prior to welding Allowable Design Level 1, 2, or 3	C	44×10^8	10	See Figure	
8.2 Rib Splice (Welded)—Single groove butt weld with permanent backing bar left in place. Weld gap > rib wall thickness Allowable Design Level 1, 2, or 3	D	22×10^8	7	See Figure	
8.3 Rib Splice (Bolted)—Base metal at gross section of high strength slip critical connection Allowable Design Level 1, 2, or 3	B	120×10^8	16	See Figure	
8.4 Deck Plate Splice (in Plane)—Transverse or Longitudinal single groove butt splice with permanent backing bar left in place Allowable Design Level 1, 2, or 3	D	22×10^8	7	See Figure	
8.5 Rib to FB Weld (Rib)—Rib wall at rib to FB weld (fillet or CJP) Allowable Design Level 1, 2, or 3	C	44×10^8	10	See Figure	

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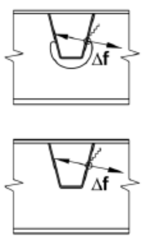
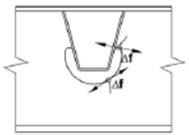
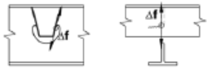
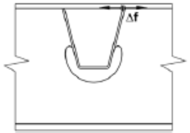
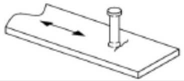
Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

Description	Category	Constant A (ksi)^3	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
8.6 Rib to FB Weld (FB Web)—FB web at rib to FB weld (fillet, PJP, or CJP) Allowable Design Level 1 or 3	C (see Note 1)	44×10^8	10	See Figure	
8.7 FB Cutout—Base metal at edge with "smooth" flame cut finish as per AWS D1.5 Allowable Design Level 1 or 3	A	250×10^8	24	See Figure	
8.8 Rib Wall at Cutout—Rib wall at rib to FB weld (fillet, PJP, or CJP) Allowable Design Level 1 or 3	C	44×10^8	10	See Figure	
8.9 Rib to Deck Plate at FB Allowable Design Level 1 or 3	C	44×10^8	10	See Figure	
Note 1: Where stresses are dominated by in-plane component at fillet or PJP welds, Eq. 6.6.1.2.5-4 shall be considered. In this case, Δf should be calculated at the mid-thickness and the extrapolation procedure as per Article 9.8.3.4.3 need not be applied.					
Section 9—Miscellaneous					
9.1 Base metal at stud-type shear connectors attached by fillet or automatic stud welding		44×10^8	10	At the toe of the weld in the base metal	

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FATIGUE PRONE DETAILS

- Riveted girder / floorbeam flanges
- Longitudinal web welds
- Flange cover plate terminations
- Web stiffeners disconnected from flanges
- Weld termination access holes

FATIGUE PRONE DETAILS

- Bearing shelf supports with inadequate flange lengths
- Transverse welds at girder splices
- Open holes from past attachments
- Welded attachments
- Bolted attachments
- Shear connectors to top flange

REPAIR APPROACH

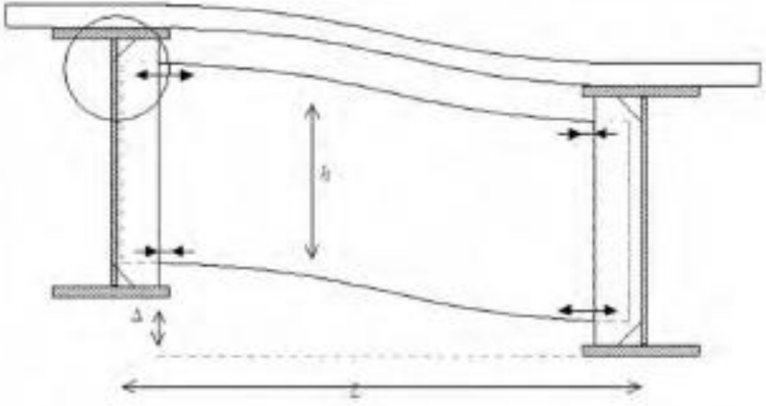
- Tension Flange in Approach Girders
  - Load induced fatigue
    - Rivets are counted as open holes
    - Replace rivets with bolts and make the structure composite while replacing the deck
  - Accept. Fatigue Range Exist. Rivets = 7 ksi
  - Accept. Fatigue Range Proposed Bolts = 16 ksi
  - Exist. Non-Composite Design = 11.87 ksi at extreme fiber
  - Proposed Composite Design = 10.90 ksi at extreme fiber

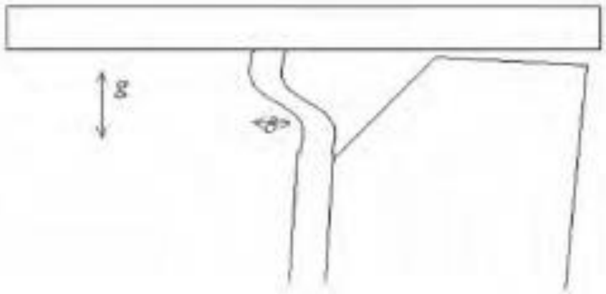
REPAIR APPROACH

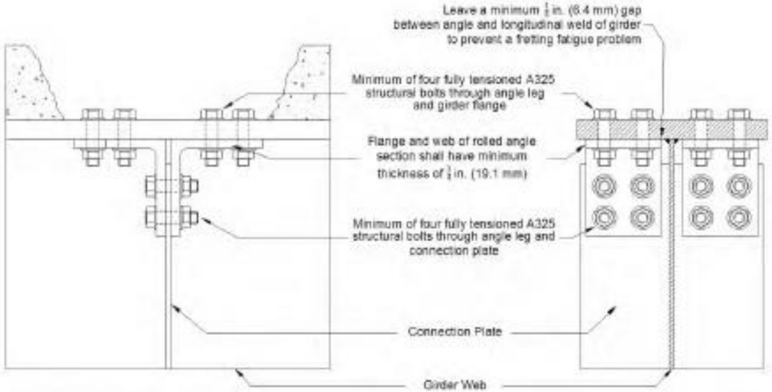
- Cover Plate Terminations in Approach Girders
  - Load induced fatigue
    - Welds at plate ends are highly susceptible to cracking
    - Remove weld back from the end of the plate and added a bolted reinforcing plate, make the girder composite
  - Accept. Fatigue Range Exist. Welds = 2.6 ksi
  - Accept. Fatigue Range Proposed Bolts = 16 ksi
  - Exist. Non-Composite Design = 16.36 ksi at extreme fiber
  - Proposed Composite Design = 11.54 ksi at extreme fiber

REPAIR APPROACH

- Disconnected Stiffeners
  - Distortion induced fatigue
  - Web stiffeners not connected to flanges, stress occurs at stiffener to web weld
  - Stress caused by differential loading across the section
  - Add clip angles to stiffener and flanges to limit the distortion

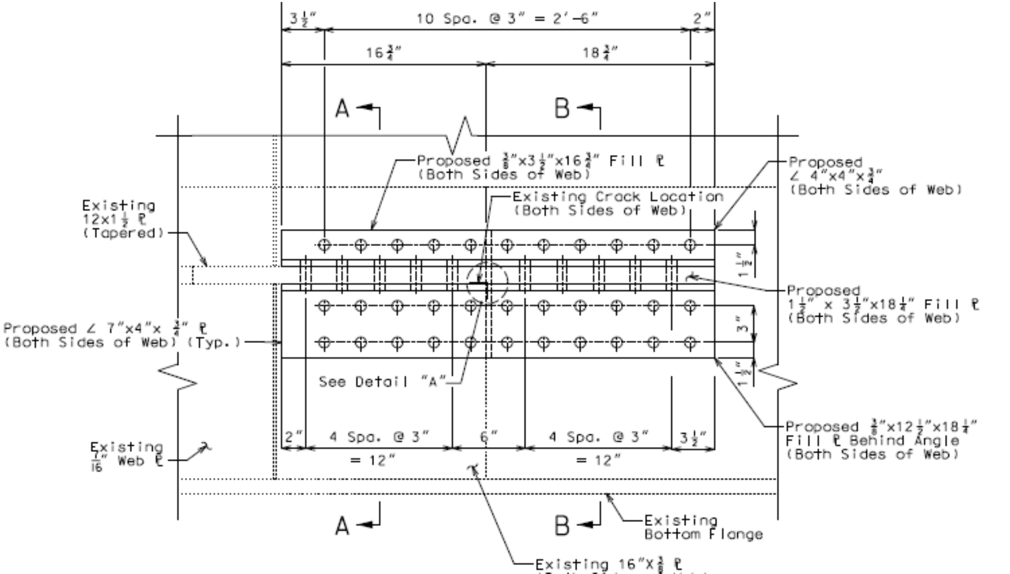


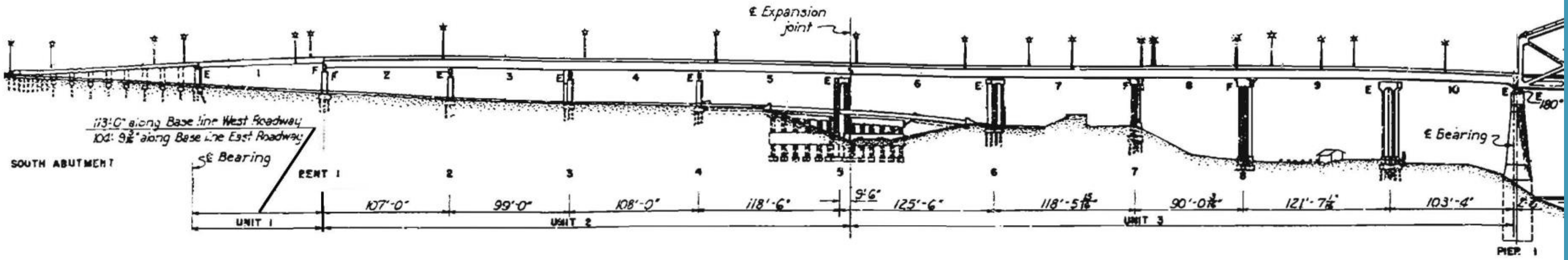




REPAIR APPROACH

- Bearing Shelf Plate
  - Load induced fatigue crack at the end of the web stiffening plate
  - Supports the bearing shelf
  - Critical location
  - Remaining locations should be proactively reinforced





04 REHABILITATION CONCEPTS

SHORT TERM REPAIR

- A4649 Main Spans
  - Isolated Deck Repairs
  - Stringer End and Bearing Replacement
  - Expansion Joint Replacement
  - Cable Keeper Replacement
  - Floorbeam Repairs
  - Stringer Repairs
  - Railing Repairs
  - Lower Lateral Bracing Repairs
  - Tie Girder Repairs
  - Scour Remediation
  - Partial Repainting
- A4649 South Approach Spans
  - Isolated Deck Repairs
  - Drain Replacements
  - Girder Repairs
  - Approach Bent Bearings
  - Railing Repairs
  - Hinge Modifications
  - Partial Repainting

SHORT TERM REPAIR

- A4649 North Approach Spans
  - Isolated Deck Repairs
  - Railing Repairs
  - Cover Plate Retrofit
  - Bearing Support Shelf Modifications
  - Partial Repainting

- A4646 (Southbound North Approach)
  - Isolated Deck Repairs
  - Railing Repairs
  - Stiffener Retrofit
  - Cover Plate Retrofit
  - Hinge Modification
  - Partial Repainting

LONG TERM REHABILITATION

- A4649 Main Spans
  - Deck, Stringer and Rail Replacement
  - Expansion Joint Replacement
  - New Roadway Lighting
  - Deck Drainage System
  - Floorbeam Repairs
  - Cable Keeper Replacement
  - Tie Girder Rivet Replacement
  - Lower Outer Gusset Rivet Replacement
  - Lower Portal Frame Rivet Replacement
  - Tie Girder Repairs
- A4649 Main Spans (Cont.)
  - Lower Lateral Bracing Replacement
  - Main Pier Repairs
  - Scour Remediation
  - Complete Repainting

LONG TERM REHABILITATION

- A4649 South Approach Spans
  - Deck and Rail Replacement
  - Expansion Joint Replacement
  - Partial Bearing Replacement
  - New Roadway Lighting
  - Deck Drainage System
  - Girder Repairs
  - Girder Rivet Replacement
  - Shear Connector Addition
  - Hinge Modifications
  - Approach Bent Repairs
  - Complete Repainting

- A4649 North Approach Spans
  - Deck and Rail Replacement
  - Expansion Joint Replacement
  - Partial Bearing Replacement
  - New Roadway Lighting
  - Deck Drainage System
  - Cover Plate Retrofit
  - Shear Connector Addition
  - Bearing Support Shelf Modifications
  - Complete Repainting

LONG TERM REHABILITATION

- A4646 (Southbound North Approach)
  - Deck and Rail Replacement
  - Expansion Joint Replacement
  - New Roadway Lighting
  - Girder Replacement
  - Steel Framed Cap Beams
  - New Bearings
  - Column Rehabilitation

Replacement in Kind

- Same footprint as existing bridge
- Built on existing alignment
- Assumes significant structure above roadway, similar to existing bridge
- Provided for comparison purposes only, not meant to represent a true replacement structure

SUMMARY

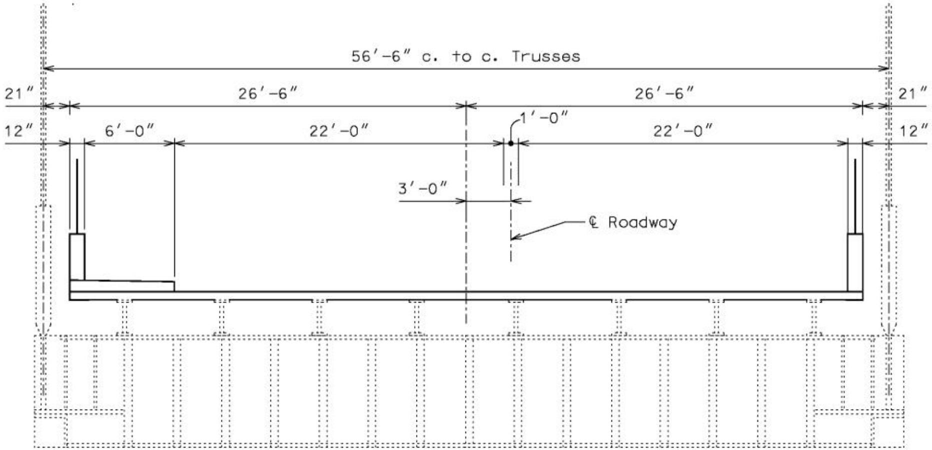
Option	Estimated Cost	Assumed Life	Cost per Year	Road Closure
Short Term Repair	$18,760,000	10 – 15 Years	$1,876,000 - $1,251,000	9 – 12 Months
Long Term Rehabilitation	$52,260,000	35 – 50 Years	$1,493,000 - $1,045,000	18 – 24 Months
Replacement in Kind[1]	$94,310,000	75 – 100 Years	$1,258,000 - $943,000	24 – 30 Months
Short Term Repair – plus – Replacement in Kind[1]	$113,070,000	85 – 110 Years	$1,330,000 - $1,028,000	9 – 12 Months – plus – 24 – 30 Months

1 – Includes one assumed redecking with a current year cost of $11,810,000

RECOMMENDATION

Long Term Rehabilitation

- Can be implemented quickly to limit further deterioration
- Provides good annualized investment benefits to the public
- Fits the fiscal constraints
- Provides significant benefit to the public for the cost of the road closure
- Will prevent ongoing maintenance concerns that cause additional road closures



05 DISCUSSION

Opening Day ??

Hannibal Bridge Road Deck

Original Hannibal Bridge

THE OPENING OF THE HANNIBAL BRIDGE IN 1869 was an occasion for celebration. Since the bridge was the first East-West railroad connection across the Missouri River west of St. Louis, it was a commercial triumph for Kansas City.