Photo: 2020 Prize Bridge National Winner – Manning Crevice (Idaho) – Photo Credit: Ken Saindon

Mississippi Steel Bridge Forum

John Hastings, PE

Bridge Steel Specialist, Southeast

Smarter. Stronger. Steel.


Enter Full Screen
John Hastings
Unmute
Start Video
Participants
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Chat
Share Screen
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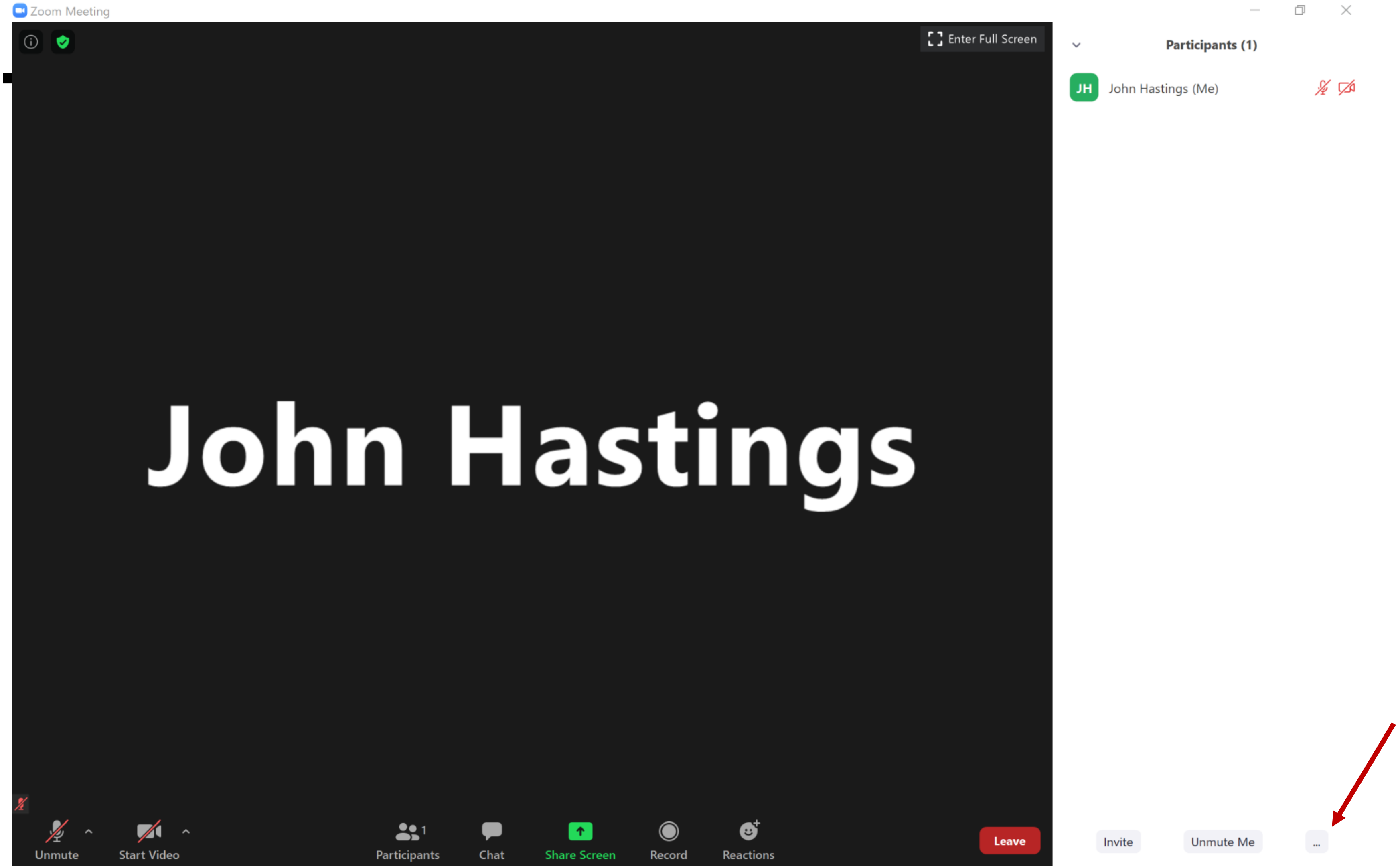
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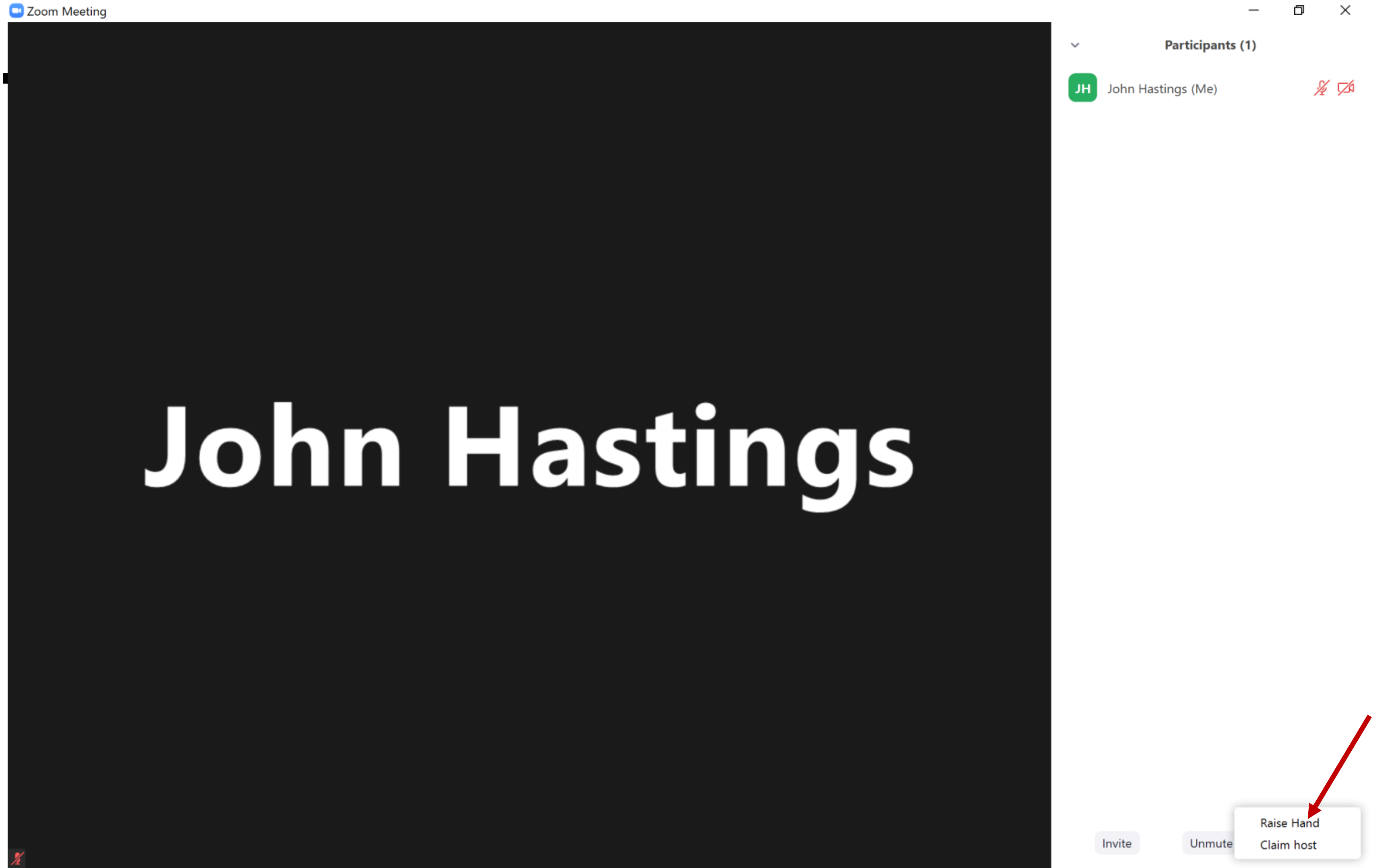
Zoom Meeting
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John Hastings
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Thank You

Mississippi Department of Transportation

Justin Walker

ACEC Mississippi

Craig Carter

Jessica Gosa

Structural Engineers Association of Mississippi

Trish Ballard

Louisiana Department of Transportation

Jenny Fu

Speakers

Justin Walker, PE – MDOT

Rob Connor, PhD – Purdue University

Sean Peterson, W&W|AFCO Steel

Michael Grubb, PE – MA Grubb and Associates

Chris Garrell, PE – NSBA

Brandon Chavel, PhD, PE – NSBA

Panel Members

Fabricators

Dale Ison – Florida Structural Steel

Tom Leb – Stupp Bridge Company

Kevin Bird – Veritas Steel

Kevin Reynolds, PE – W&W|AFCO Steel

Producers

Martin Francis – ArcelorMittal

Graham Holman – Nucor

David Stoddard – SSAB Americas

Agenda – September 17, 2020

Time*	Topic
11:00am - 11:30am	Introduction and Industry Overview
11:30am - 12:30pm	Steel I-Girder Fatigue, Details, and Repairs
12:30pm - 1:00pm	Cost Effective and Efficient Detailing for Fabrication of Steel Girders

* All times are approximate.

Agenda – September 22, 2020

Time*	Topic
11:00am - 12:00pm	Practical approaches & Tools for the Design of Steel Bridges Part 1: Layout, Design, & Simon
12:00pm - 12:30pm	Bolted Connections and Field Splices (AASHTO's Simplified Method)
12:30pm - 1:00pm	Updates to AASHTO 9th Edition LRFD Bridge Design Specifications

* All times are approximate.

Agenda – September 24, 2020

Time*	Topic
11:00am - 12:00pm	Practical approaches & Tools for the Design of Steel Bridges Part 2: Availability, Constructability, & Resources
12:00pm - 1:00pm	Producer and Fabricator Panel Discussion

* All times are approximate.


Photo: Eads Bridge Over the Mississippi River, St. Louis, Missouri

Who We Are

Meet the NSBA Team

Smarter.
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Steel.

Meet the **NSBA**

Bridge Steel Specialists

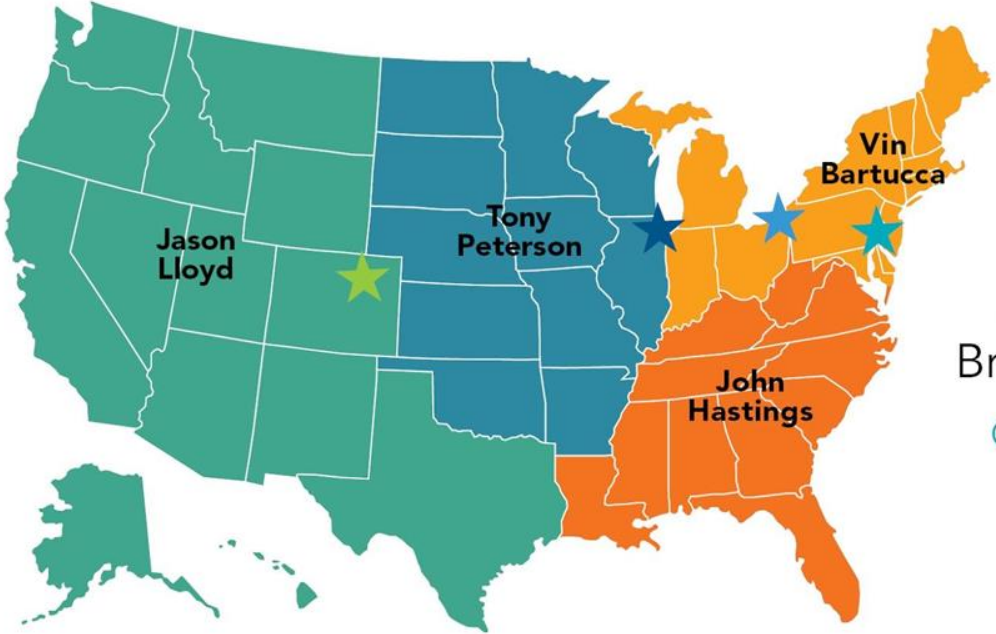
Western Market
Jason Lloyd

Central Market
Tony Peterson

Southeast Market
John Hastings

Northeast Market
Vin Bartucca

Steel Solutions Center
Devin Altman ★



Leadership Team

Director of Market Development
Jeff Carlson ★

Director of Market Development
Brandon Chavel ★

Chief Bridge Engineer
Chris Garrell ★

Who We Are

National Steel Bridge Alliance, a Division of AISC

- Technical Institute & Trade Association
- Not-for-profit: working for the advancement of steel bridge design and construction
- Services: free resources, forums, AASHTO/NSBA collaboration, preliminary design & evaluation tools, continuing education

STEEL SOLUTIONS CENTER

The Steel Solutions Center is your gateway to nearly 100 years of steel knowledge, and it's just a phone call or email away.

aisc.org/askaisc

solutions@aisc.org

866.ASK.AISC

- answer your technical questions about structural steel design.
- help you understand NSBA's technical publications.
- help you reduce project risk by connecting decision-makers with AISC bridge-member fabricators for price and schedule information.
- provide conceptual solutions for steel girder and beam bridges, including framing plan and girder spacing concepts, preliminary girder sizes, and steel tonnage estimates.

Upcoming Events

World Steel Bridge Symposium

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Photo: 2020 Prize Bridge National Winner, Major Span – Gov Cuomo/Tappen Zee (New York) – Photo Credit: New York State Thruway Authority

More Information

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More Information

- National Steel Bridge Alliance
  www.aisc.org/nsba
- Resources for Design and Estimation
  www.aisc.org/nsba/design-and-estimation-resources/
- Steel Bridge Forums
  www.aisc.org/nsba/steel-bridge-forum/
- Bridges to Prosperity
  www.aisc.org/nsba/bridges-to-prosperity/
- Modern Steel Construction
  www.modernsteel.com


Photo: 2020 Prize Bridge National Winner – Manning Crevice (Idaho) – Photo Credit: Ken Saindon

John Hastings, P.E.

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Justin Walker, PE

MDOT Update

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BASIC CONCEPTS ON FATIGUE DESIGN FOR STEEL BRIDGES

ROBERT J. CONNOR
PURDUE UNIVERSITY
JACK AND KAY HOCKEMA PROFESSOR OF CIVIL ENGINEERING

SEPTEMBER 2020

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WHAT IS FATIGUE?

- Process by which cracks initiate and grow by cyclic loading
  - "Cyclic loading"
    - E.g. trucks repeatedly passing over a bridge
  - Clearly loading is time dependent (not static)
- The stress/load ranges producing fatigue damage do not need to be large
- Brittle/ductile fracture is a concern in the presence of a crack, especially as it grows
- Fracture at a crack is NOT the same as a net section strength checks at holes

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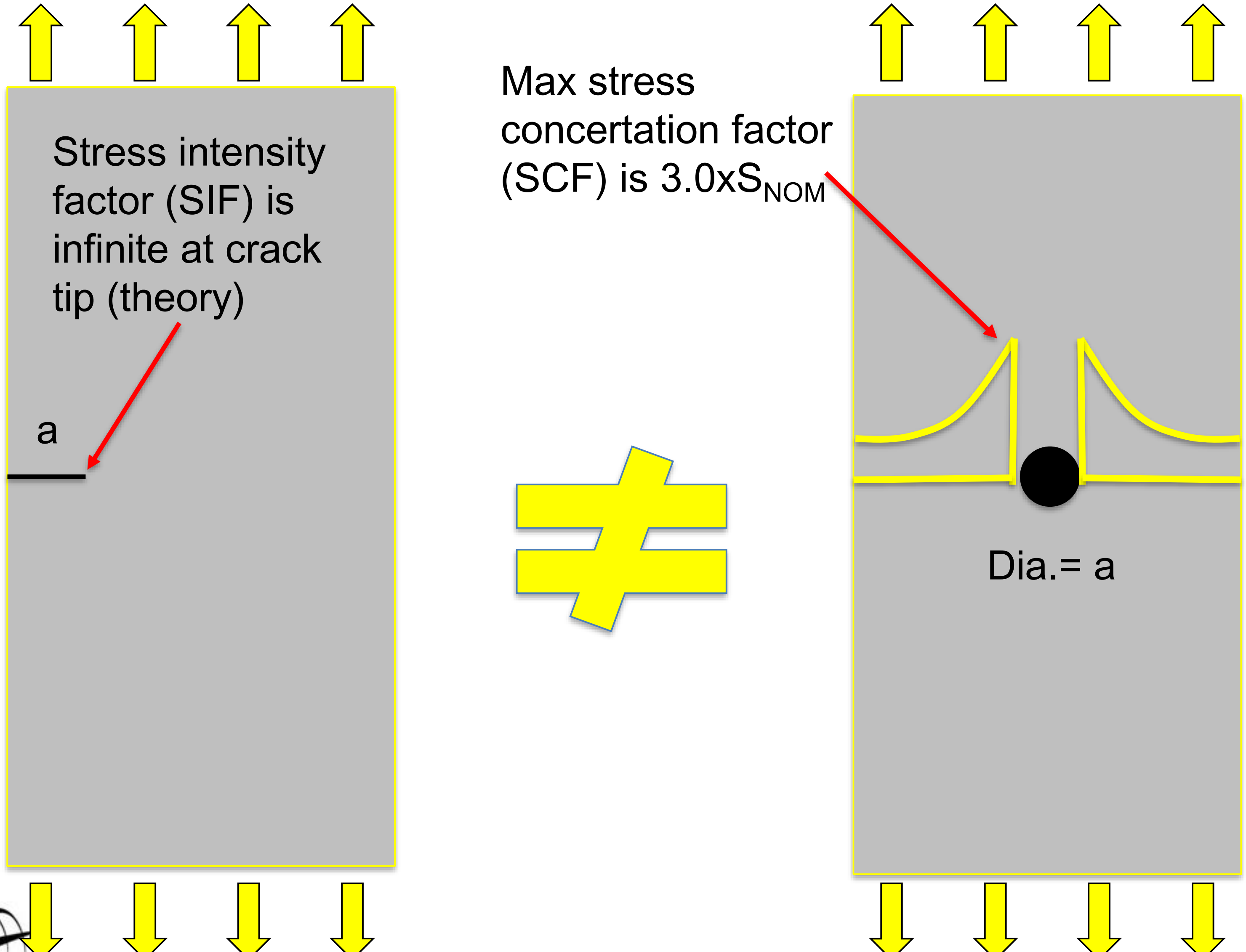
CRACK VS NET SECTION (FOR STRENGTH)



FATIGUE LIFE

- Generally refers to interval of time during which no *significant cracking* is expected
  - *Significant cracking* is based on laboratory testing and is not a unique value
    - Could be ½" crack, or 5% of member strength, etc.
    - Does not mean member fractures
    - Would generally be detectable at room temperature
  - Fatigue life is measured in number of stress cycles
  - Based on probabilities of cracking found from laboratory testing

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FATIGUE LIFE CONT.

- Two regions of fatigue life:
  - **Infinite life**
    - Significant cracking (i.e. failure) never expected to occur
  - **Finite life**
    - Based on stress range (S_r), # cycles (N), and detail category
- Constant-Amplitude Fatigue Limit (CAFL): Boundary between finite and infinite life

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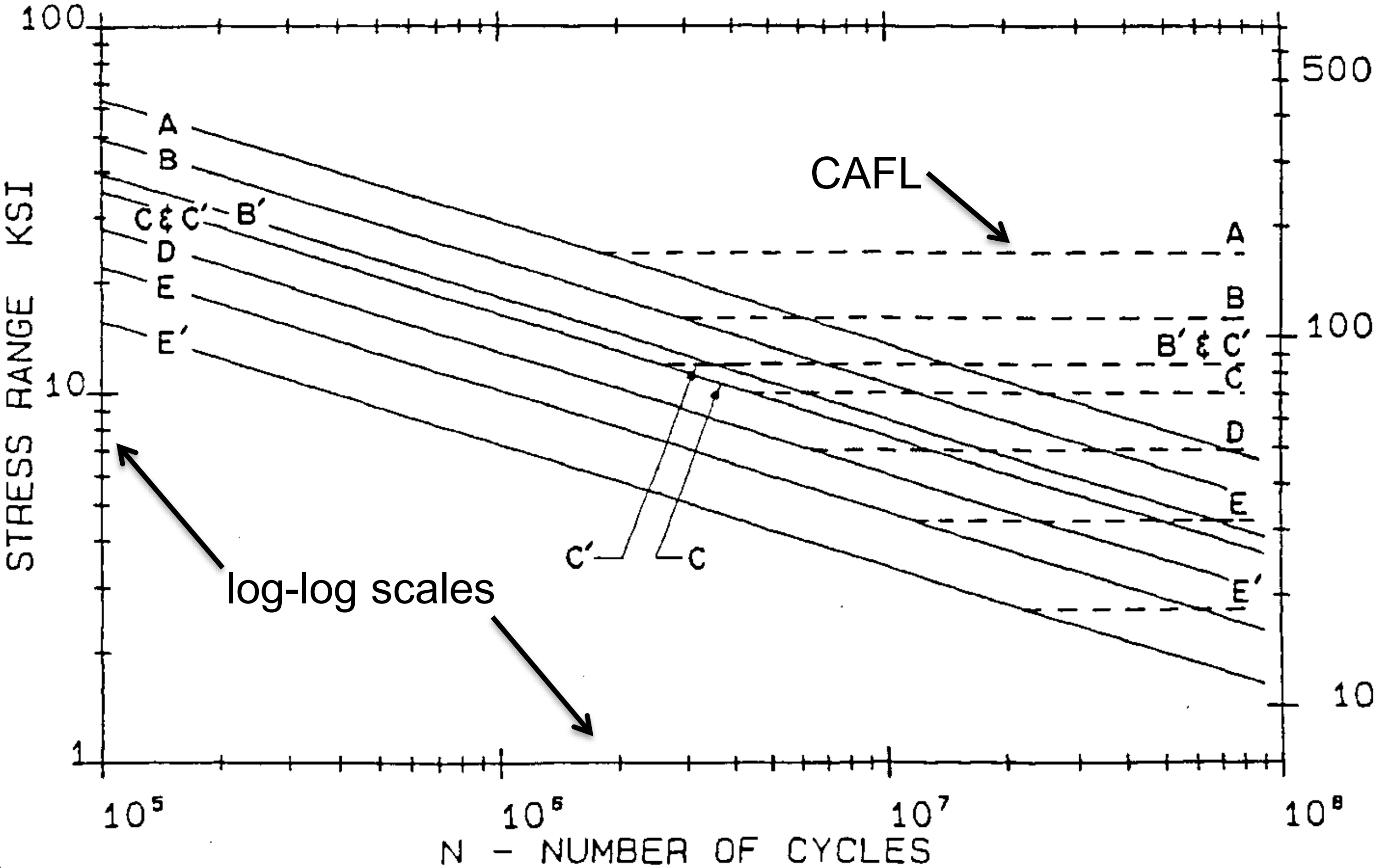
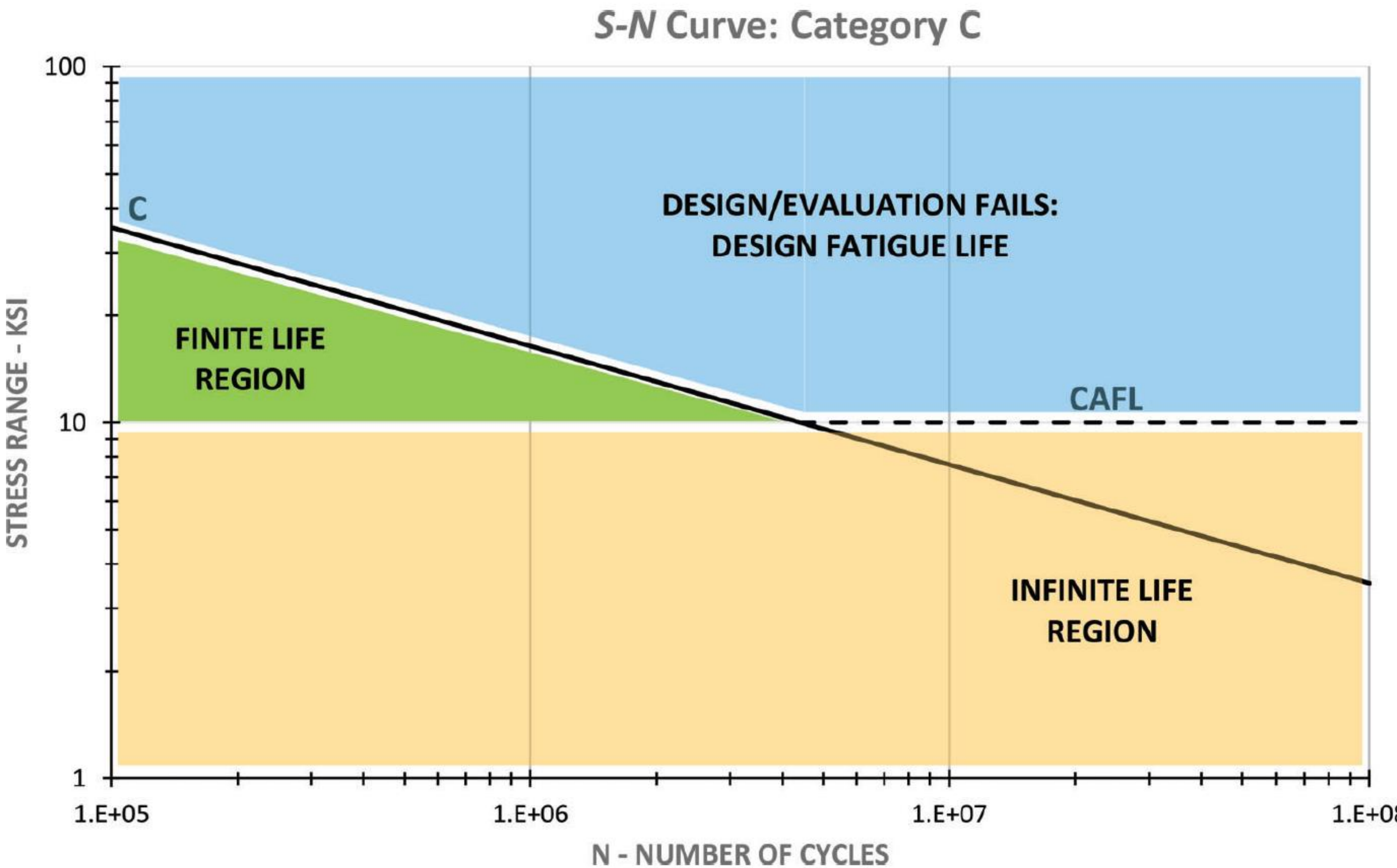
FATIGUE LIFE BASED ON S-N CURVES



FATIGUE LIFE BASED ON S-N CURVES



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THREE MOST IMPORTANT PARAMETERS INFLUENCING THE LIKELIHOOD OF FATIGUE DAMAGE ARE:

- Stress range (S_r)
- Number of cycles (N)
- Detail classification (A, B, C, etc.)

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DEGREE OF DAMAGE (CRACKING) IS A FUNCTION OF TWO PARAMETERS

- Magnitude of load (S_r)
  - How large is the stress range?
  - Stress range = S_r
- Frequency of occurrence (N)
  - How often are cycles applied?
  - ADTT
- *Above parameters define load or stress-range spectrum*

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SUMMARY OF FATIGUE

- Trucks produce damage
  - Cars & light trucks not much of an issue
- More trucks = more cycles
- Some details more susceptible to cracking
  - Today, we can selected “good” details quite easily
    - “Good” = Category C and better
    - Avoid E and E’ details in tension applications as much as practical

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FATIGUE VS. FRACTURE

- Fatigue
  - Slow stable crack growth over time.
  - If loading stops, growth stops
  - Crack growth is independent of material properties
  - You can inspect for fatigue damage
- Fracture
  - Brittle or explosive instantaneous cracking
  - Potential for fracture is influence by material properties
  - Can still occur even without live load
  - Generally, you find fractures <u>after</u> they occur

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SOME GUIDANCE ON USING THE AASHTO DETAIL CATEGORES

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AASHTO TABLE 6.6.1.2.3-1

- First, consider title of the table?
  - "Detail Categories for Load-Induced Fatigue"
- What does this mean?
- Sort of confusing, as all fatigue is "load" induced
- Really means "live loads that produce stress ranges we calculate"
  - Includes Mc/I & P/A
  - "Nominal Stresses"

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AASHTO TABLE 6.6.1.2.3-1

- Second, what loading (i.e., stress range) is not considered?
  - Out-of-plane distortion
  - Secondary stresses
  - etc.
- We don't calculate these stresses
- These stresses also are very complex and local in nature
  - Details based on nominal stress, not local stress

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AASHTO TABLE 6.6.1.2.3-1

- Third, must understand what <u>defects</u> are not included in the details
  - Categories don't include specific defects
    - Existing cracks
    - Gouges
    - Corrosion
    - Impact damage
  - Thus, if a member is cracked, details/categories in the table don't apply
    - Need to use fracture mechanics

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INFO. INCLUDED IN THE TABLE

- Illustration of "typical" detail
  - Trick is mapping your detail to an illustration
- Orientation of nominal stress range that is being checked
- Specific information regarding detail constants and CAFL
  - For life calculations
- Location where cracking is expected
  - Useful when mapping your detail to illustration

STEPS TO USING TABLE

- Determine the nominal LL stress range orientation in the member
- Compare relative orientation of the detail being evaluated to that of the applied stress range
  - e.g., perpendicular or parallel to the weld toe

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STEPS TO USING TABLE

- Attempt to determine where cracks will form
  - Weld toe?
  - Inside of the weld?
  - At rivet hole?
- Maybe more than one location per detail

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STEPS TO USING TABLE

- Welded details
  - Determine weld type and length
  - Determine orientation of weld axis
- Determine orientation of weld toe to stress range
  - For welded details, cracking will almost always occur at weld toes oriented <u>perpendicular</u> to applied stress range
  - True even if ground smooth
  - Still must check portion that is parallel, but almost always a better category

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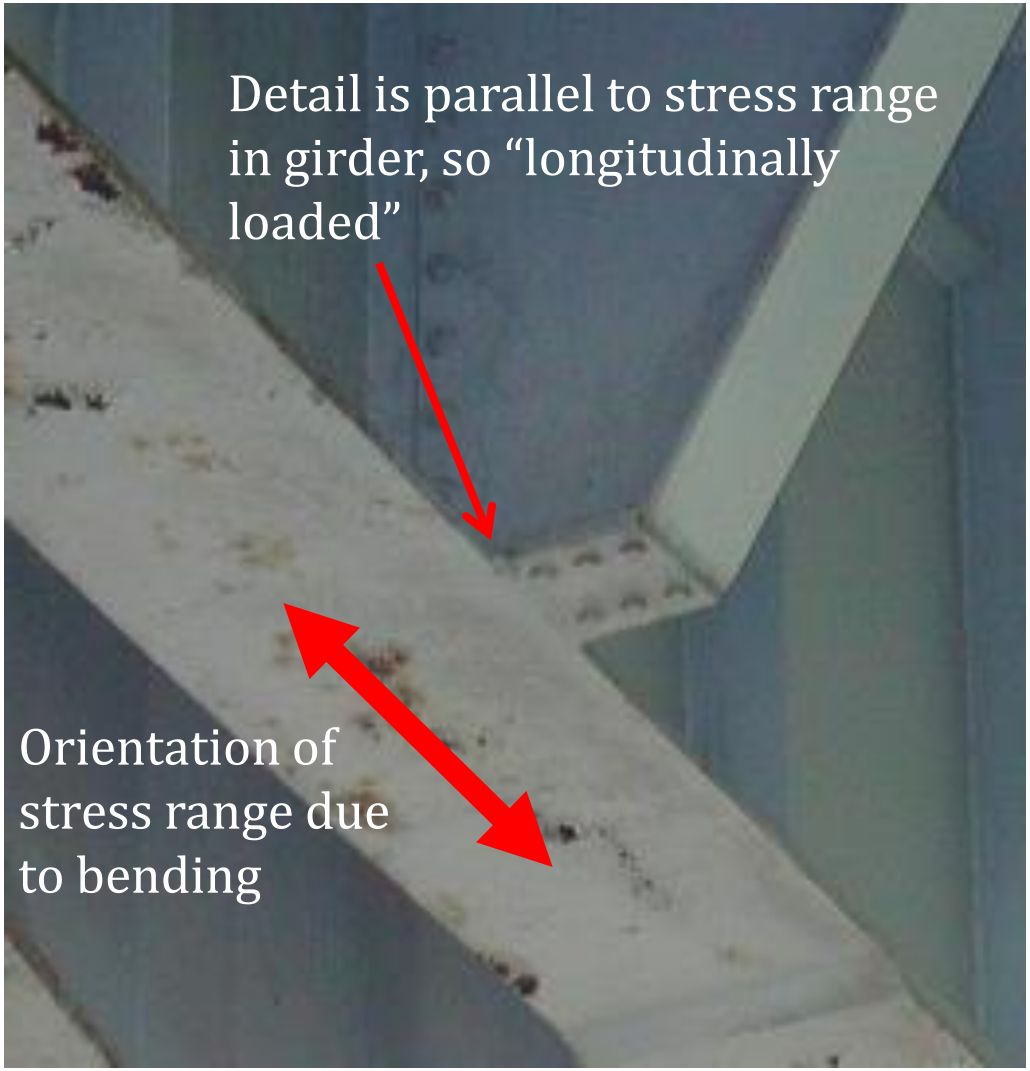
STEPS TO USING TABLE

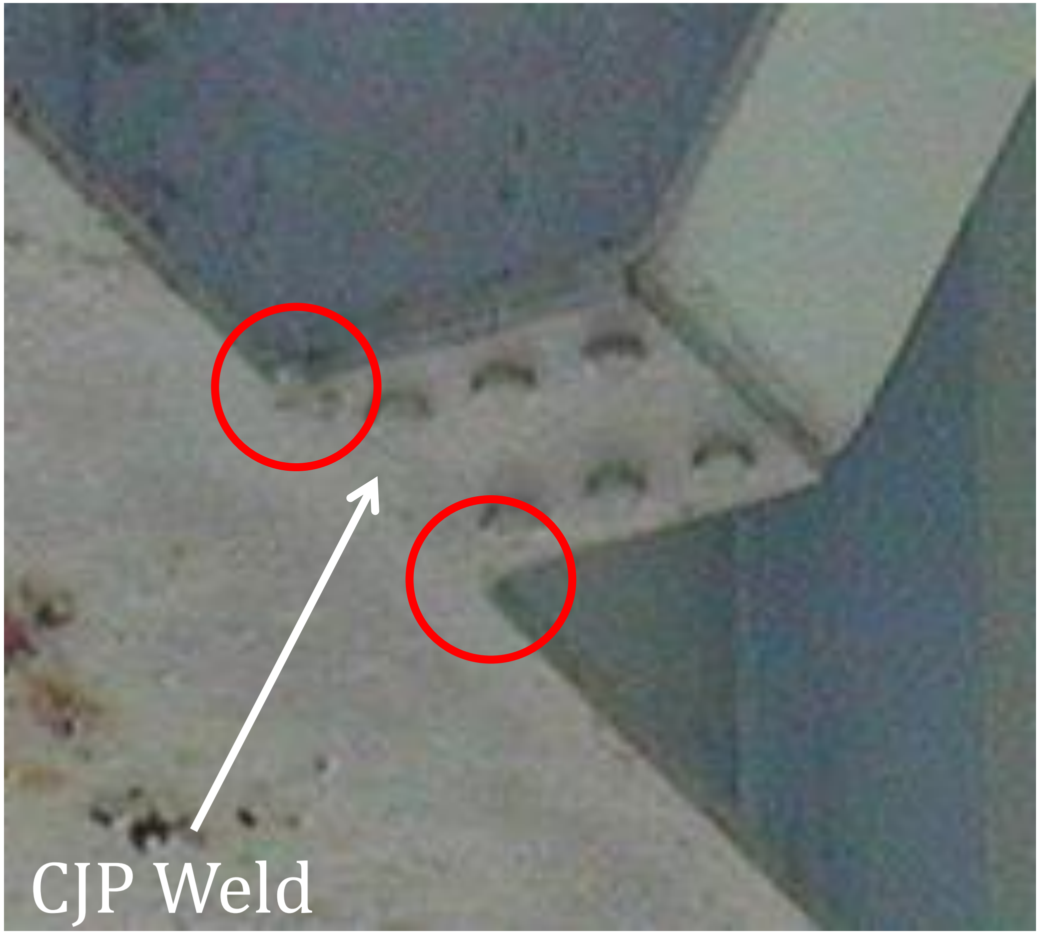
- Bolted/riveted details
  - Orientation w.r.t holes
    - Circles so pretty easy!
    - There is always a stress range tangent to the hole

FOR EXAMPLE




CJP Weld

FOR EXAMPLE

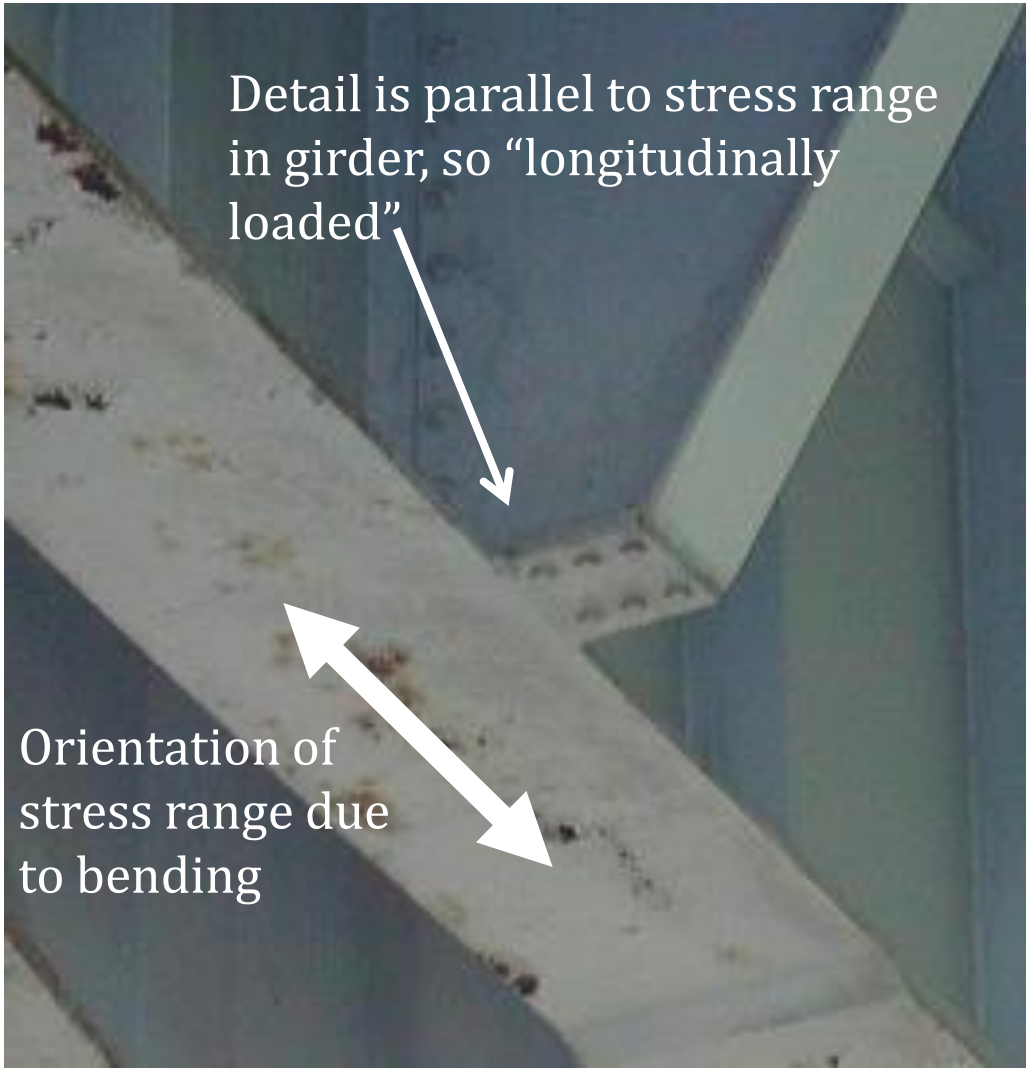


Where is weld toe that is perpendicular to applied stress range?

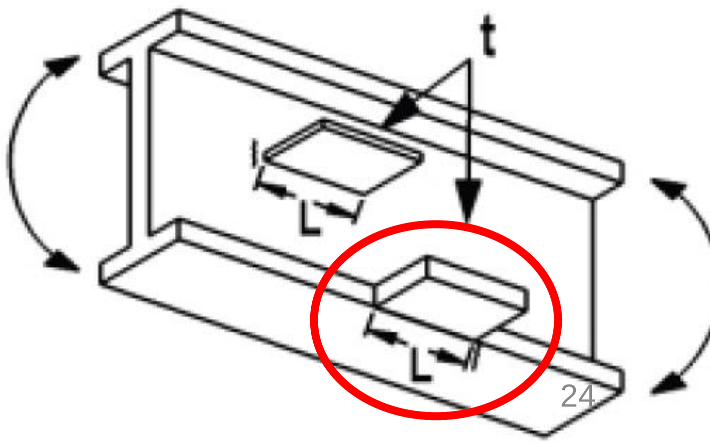
FOR EXAMPLE

What is expected orientation of cracking?

FOR EXAMPLE



Detail is parallel to stress range in girder, so "longitudinally loaded"
Orientation of stress range due to bending



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RETROFITTING STEEL BRIDGES FOR FATIGUE

- Excellent "FREE" resources available published documents on retrofitting:
  - NCHRP 20-07/Task 387 (2017)
  - US Army Corps Manual (2015)
  - FHWA Manual (2013)
- Many "bad" retrofits out there…
  - BE SURE IT WILL WORK
  - TRY PROTOTYPES

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QUESTIONS ?

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NSBA Steel Bridge Forum
September, 2020

W&W | AFCO STEEL

Cost Effective and Efficient Detailing for Fabrication of Steel Girders

Agenda

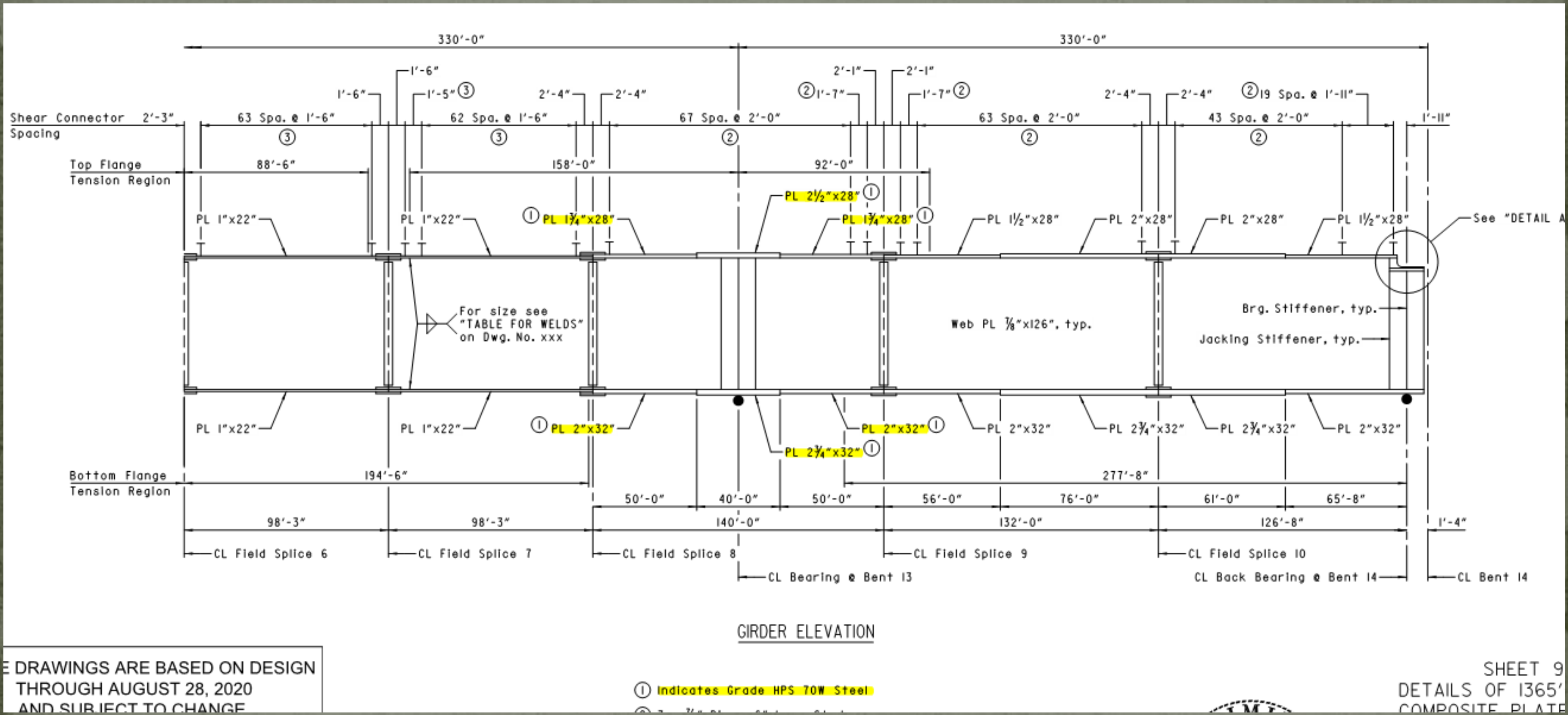
- Raw Material Selection
- Girder Details
- Crossframe Details

Raw Material Selection

- We suggest the use of 50W steel in lieu of grade 50 painted. The cost of grade 50 <u>PRIMER ONLY</u> is approximately the same cost as 50W uncoated.
- Due to recent changes in HPS-70W material pricing it may be economical to explore its use. Contact your local fabricator for additional information.
- Plate availability
  - Webs depths <u>DO NOT</u> have to be specified in 3" increments
  - Plates thicknesses are available in 1/16" increments between ¼" to 4"

Raw Material Selection

- Good example of HPS-70W material use



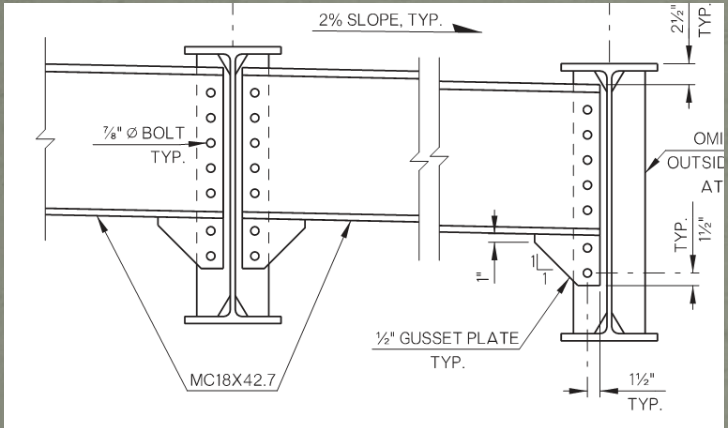
Raw Material Selection

- When possible avoid expensive sections such as W40s and MCs
- Depending on market conditions and schedule, fabricating a plate girder can be less expensive than W40s. In multiple cases we have seen savings of as much as 10% on the total steel package.

THE CONTRACTOR MAY PROPOSE PLATE GIRDERS USING EQUIVALENT SECTION PROPERTIES IN LIEU OF THE ROLLED BEAM SHAPE SHOWN AT NO ADDITIONAL COST TO THE DEPARTMENT. PROVIDE 5⁄16" MINIMUM FILLET WELDS BETWEEN WEB AND FLANGES. NON-DESTRUCTIVE TESTING WILL BE REQUIRED AS APPROPRIATE.

Raw Material Selection

- MC diaphragms can cost up to 60% more than bent plate diaphragms or rolled beams. Especially if tab plates are welded to the MCs.



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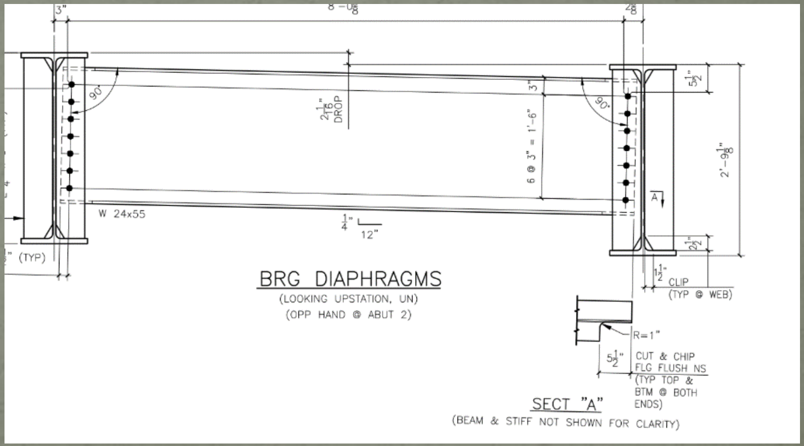
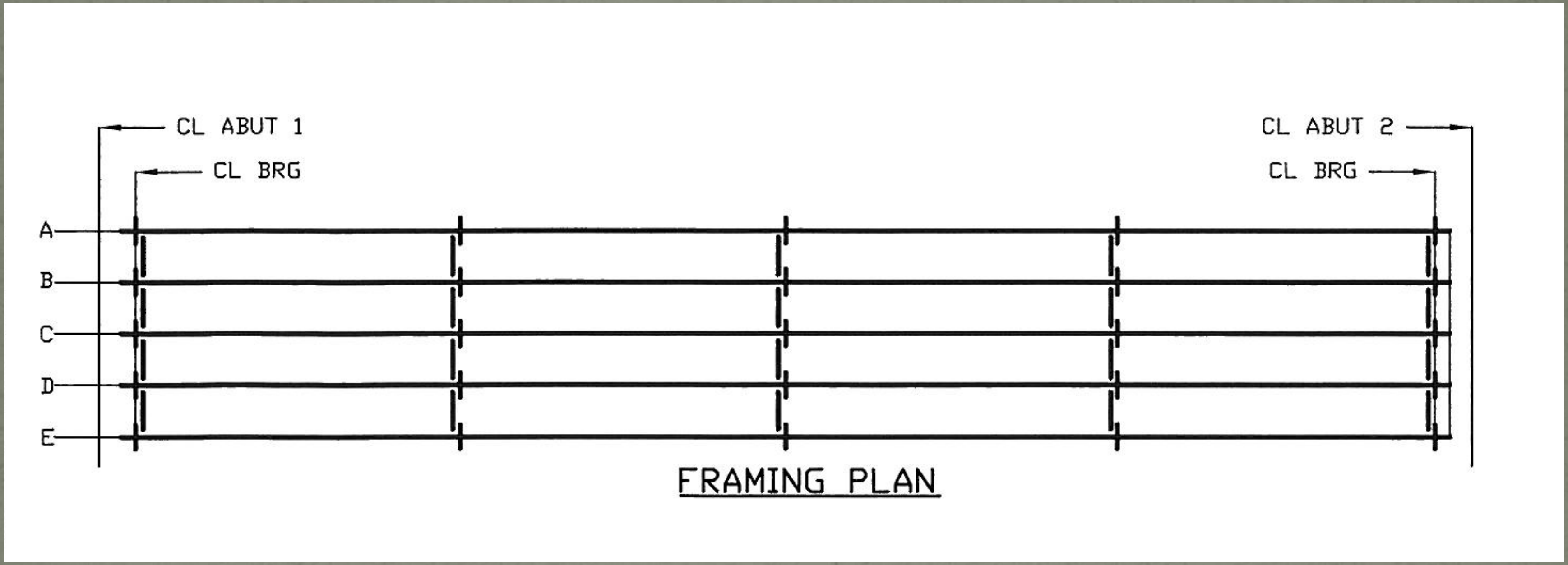


Girder Details

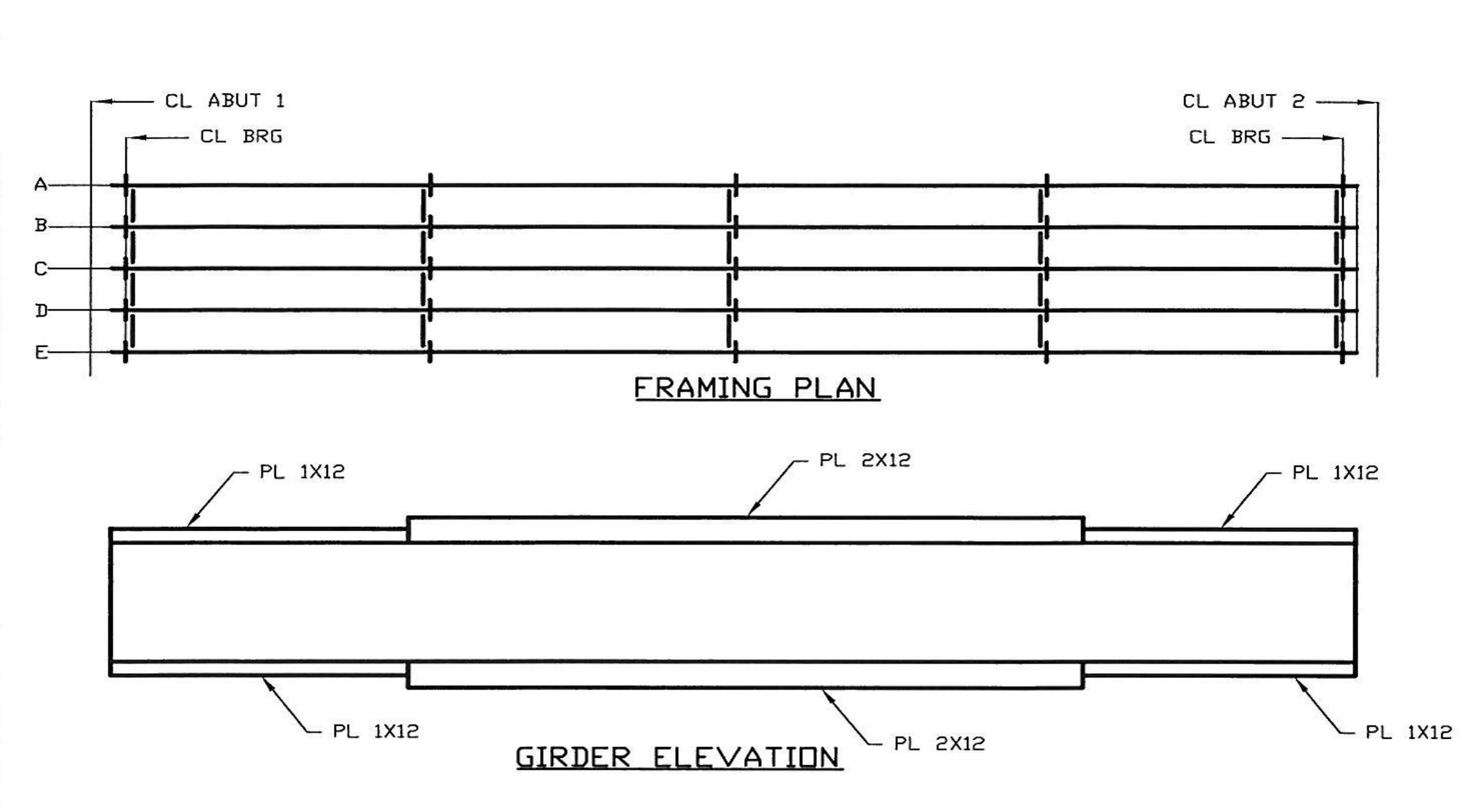
- What is slab splicing and why does it matter to you?
- Splicing can dictate your delivery schedule.
- Slab splicing is up to 34% more efficient than splicing single flanges.

*FRAMING PLAN



*FRAMING PLAN

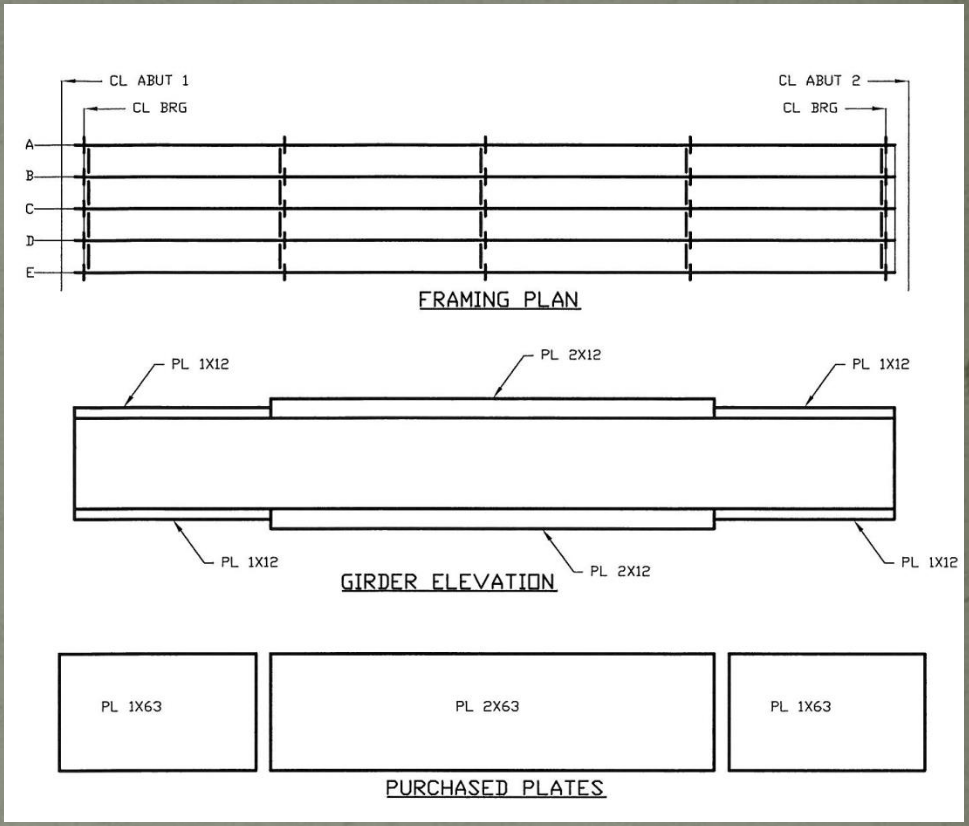
*GIRDER ELEVATION



*FRAMING PLAN

*GIRDER ELEVATION

*PURCHASED PLATES

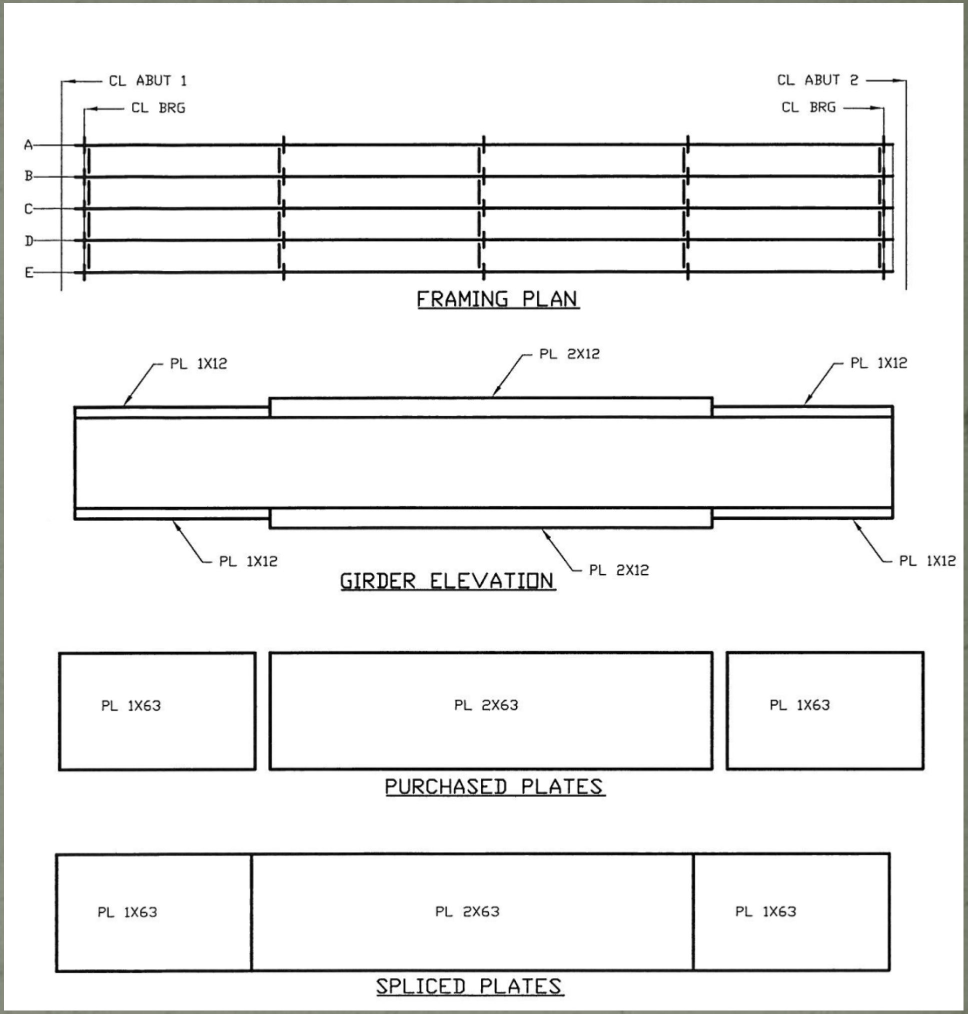


*FRAMING PLAN

*GIRDER ELEVATION

*PURCHASED PLATES

*SPLICED PLATES



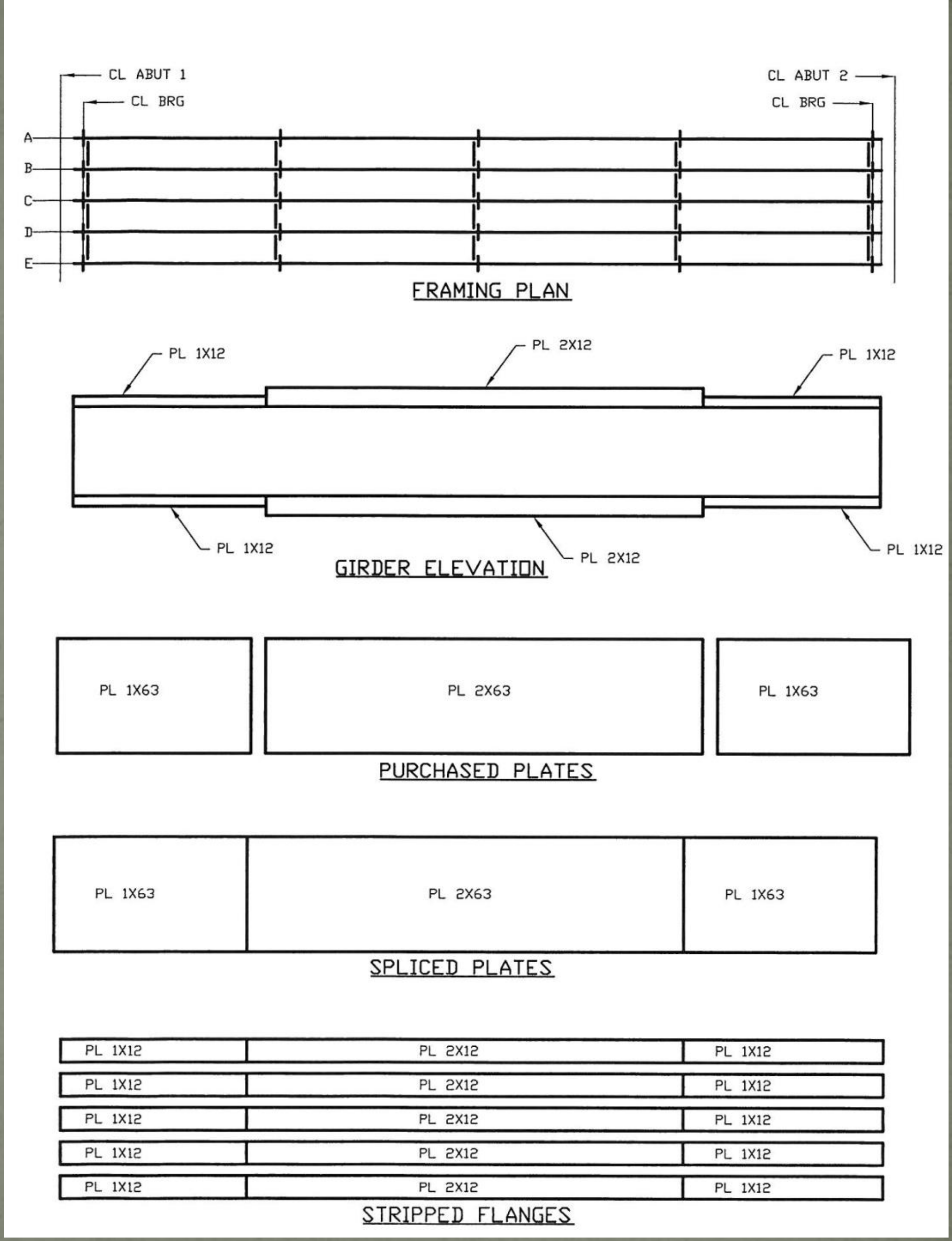
* FRAMING PLAN

* GIRDER ELEVATION

* PURCHASED PLATES

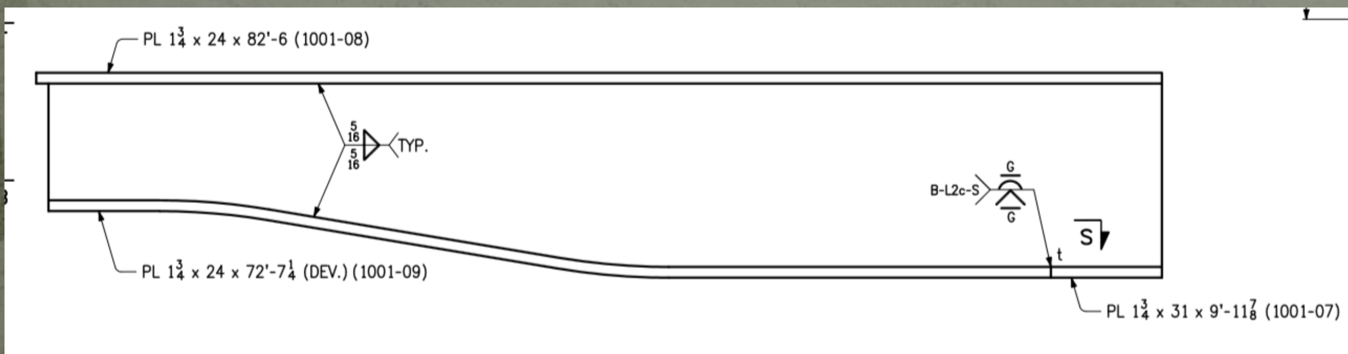
* SPLICED PLATES

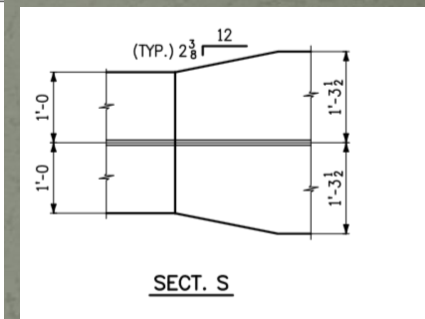
*STRIPPED FLANGES



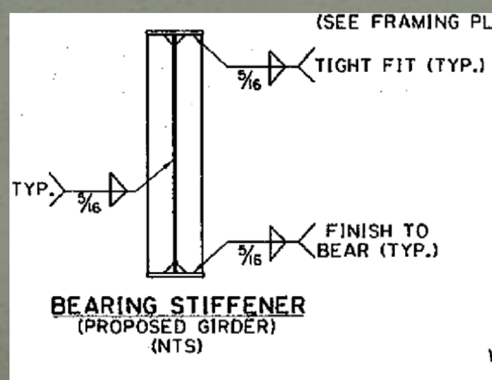
Girder Details

- Limit flange width transitions to field splice locations.





- Finish to bear in lieu of full pen welded stiffeners can save 10-15% on stiffener fitting/welding cost.



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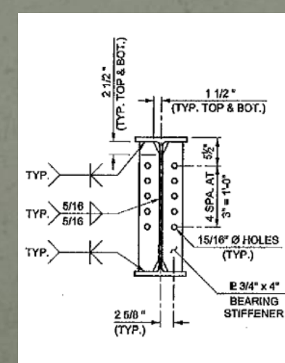


Girder Details

- Limit web to flange welds to AWS D1.5 minimum fillet weld sizes (max 5/16”). Anything beyond a 5/16” fillet will at minimum double web to flange welding cost.

Table 2.1
Minimum Fillet Weld Size[a, b] (see 2.8)

Base Metal Thickness of Thicker Part Joined (T)	Minimum Size of Fillet Weld	
$T \leq 20$ mm [3/4 in]	6 mm [1/4 in]	Single-pass welds shall be used
$T > 20$ mm [3/4 in]	8 mm [5/16 in]	

[a] Smaller fillet welds may be approved by the Engineer based upon applied stress and the use of appropriate preheat.
[b] Except that the weld size need not exceed the thickness of the thinner part joined. For this exception, particular care should be taken to provide sufficient preheat to ensure weld soundness.

- Use the latest splice design criteria and larger bolts up to 1” dia when it reduces the number of holes.

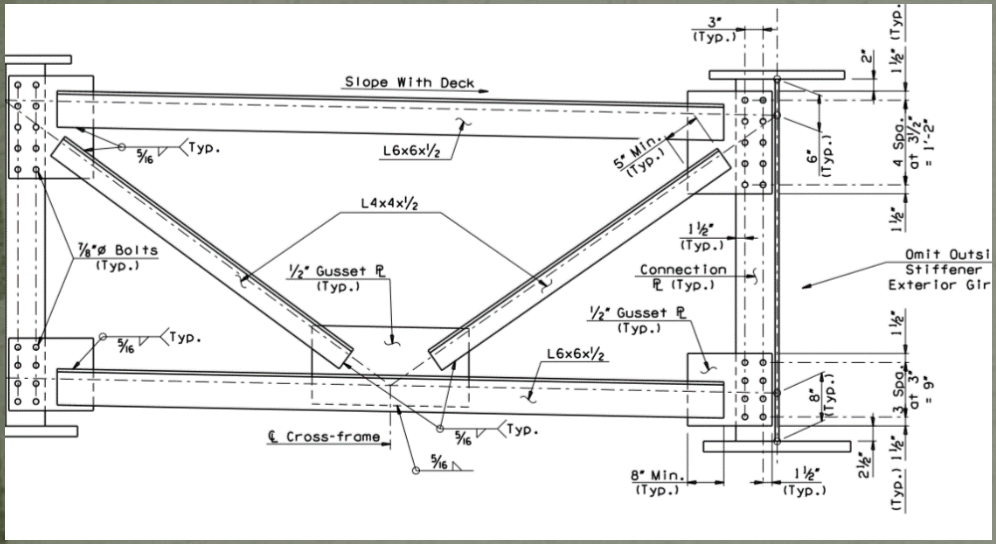
Crossframe Details

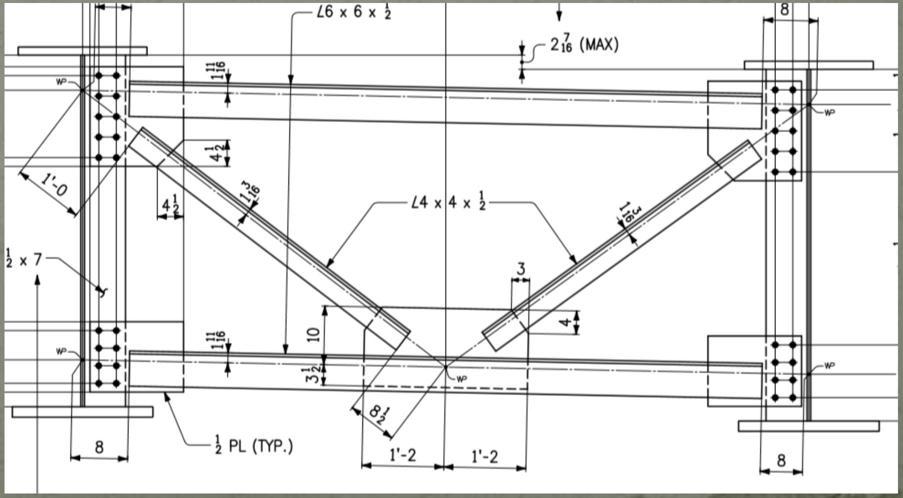
- Avoid the use of back to back angles.
- K-frames with all welding on one side eliminates the need to flip crossframes in the shop.
- Please specify minimum weld lap sizes. This allows the fabricator to create non-rectangular gussets and reduce the amount of welding required.
- Use larger bolt diameters to reduce the number of bolt holes in crossframes. 1” dia. A325 bolts are readily available.

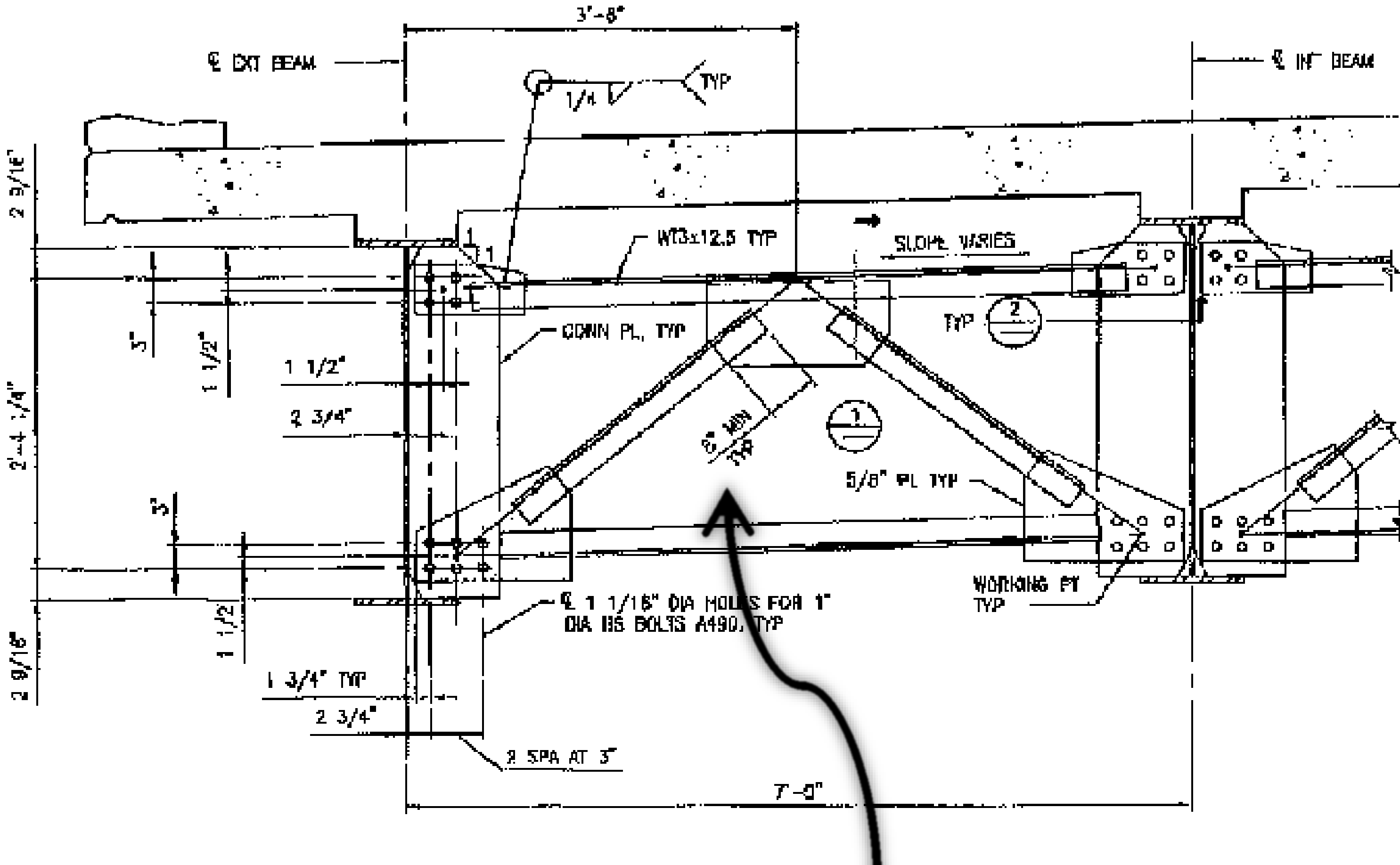
NOTE FULL LENGTH WELDS

NOTE PARTIAL LENGTH WELDS

Examples of Clipped Crossframe Gussets







LOOKS INNOCENT ENOUGH

LACK OF INNOCENCE REVEALED

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