

**Fabrication error  
Indexed eXamples and Solutions:  
FIXS**

**By**

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# ABSTRACT

The major goal of the Regional/National Bridge Fabrication Error Expert System research project is to develop a sharable and well reasoned bridge fabrication error repair database which can be used by several state DOTs within a geographical region. This report focuses on the enhancement of the knowledge base and improvement of the system performance based on the initial work of Fabrication error Indexed eXamples and Solutions (FIXS). FIXS is a knowledge-based system in the domain of steel bridge fabrication errors using both rule-based reasoning and case-based reasoning.

To expand the knowledge base to cover errors experienced by multiple DOTs and to improve the system effectiveness, 38 new cases were solicited from the North Central States Consortium and the Repair Database Task Group of the AASHTO-NSBA Steel Bridge Collaboration. The new cases, along with the existing 120 rule solutions and 112 case solutions in the knowledge base, were reviewed by the Task Group members. The sketches and instructions summarized from actual cases and the comments obtained from the Task Group members were implemented in the software to provide graphical and instructive information for case solutions. In addition, generic problems and corrections were also collected and implemented in the software as a tutorial tool for common fabrication errors.

To improve the accuracy of similar case retrieval, the case-based reasoning shell SCBR was revised by introducing continuous feature evaluation for numeric features, replacing the simple match approach in the first version of FIXS. The explanation facility was also improved.

# ACKNOWLEDGEMENTS

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Special thanks to Dr. Lindsey Spratt who revised his expert system shell, MESS and SCBR for final version of FIXS, which improved the case matching process and explanation facilities.

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# LIST OF ABBREVIATIONS

DOT.....	Department of Transportation
KDOT .....	Kansas Department of Transportation
BFX .....	Bridge Fabrication error solution eXpert system
CB-BFX.....	Case Based Approach for Bridge Fabrication Errors
FIXS .....	Fabrication error Indexed eXamples and Solutions
NCSC .....	North Central States Consortium
NSBA .....	National Steel Bridge Alliance
SCBR.....	Simple Case Based Reasoning
MESS .....	Modest Expert System Shell
RBR.....	Rule-Based Reasoning
CBR.....	Case-Based Reasoning

# CHAPTER 1

## INTRODUCTION & BACKGROUND

### 1.1 PROBLEM STATEMENT

During the fabrication of steel bridges errors occur. These errors need to be recognized and corrected properly and efficiently according to each individual situation. Although some Departments of Transportation (DOTs) have carried out teamwork between the designer, fabricator, and contractor to resolve problems and avoid delays, the solutions are still not found as rapidly as all parties would like. To arrive at the best possible solutions, engineers need not only knowledge of material and fabrication specifications but also experience and good understanding of the practical limitations faced by fabricators. This expertise is scattered and varies among both individuals and DOTs. A database of corrective actions can provide guidance to bridge engineers and improve engineers' confidence in non-textbook solutions to unusual but not unique problems. Specifically, generic solutions for common errors may assist engineers in categorizing situations; a list of ranked alternative solutions for a particular error may help engineers in determining the best possible solutions. When a sharable and well reasoned repair database is used by several state DOTs within a geographical region, the database can lead to

standardized solution procedures that reduces the uncertainty of area fabricators, which can result in a reduction of costs passed back to the DOTs.

As a first generation knowledge-based system in this area, a rule-based expert system, Bridge Fabrication error solution eXpert system (BFX) (Hess, Roddis, Nagaraja, Melhem, and Moran 1994; Roddis and Hess 1995; Roddis, Hess, Melhem, and Nagaraja 1995; Melhem, Roddis, Nagaraja, and Hess 1996) was developed for the Kansas Department of Transportation (KDOT). BFX is in operation at the bridge design offices of KDOT. Testing indicates BFX provides correct solutions approximately two third of the time and fails to give a solution for the remainder. To overcome rule-based expert systems' restrictions, a case-based approach in steel bridge fabrication errors (CB-BFX) (Bocox and Roddis 1996; Roddis and Bocox 1997) was also investigated. CB-BFX showed that a case-based approach can compliment and extend BFX by retrieving similar cases to a problem which can be used by bridge engineers to derive a solution to the problem at hand.

Building on this background, the primary goal of the current project is to develop a knowledge-based system to provide possible solutions to fabrication errors suitable for use by multiple DOTs. The first step of the current research focused on combining rule and case approaches to develop a more advanced knowledge-based system in the domain of steel bridge fabrication errors. The initial version of the software: Fabrication error Indexed eXamples and Solutions (FIXS) (Greenfield and Roddis 1998) has been completed by reusing the knowledge bases of BFX and CB-BFX. To develop a sharable and instructive repair database usable by multiple DOTs,

the second step of the current research is concentrated on improving the knowledge level of the system. This is the subject of this report. This project delivers a final version of the software that provides solutions and examples to steel bridge fabrication errors with detailed graphical and instructive information and enhanced explanations based on both rule-based and case-based reasoning.

## **1.2 PROJECT OBJECTIVES**

The objectives of this project are to:

1. Enlarge the knowledge base to cover errors experienced by multiple DOTs, not just KDOT, and to improve the ability of the system to successfully provide solutions.
2. Clean the knowledge base to keep solutions consistent and well reasoned.
3. Add sketches and instruction to each case solution to provide graphical and instructive information for the solutions.
4. Develop a tutorial tool to give generic solutions for common errors.
5. Improve the case retrieval algorithm to gain increased performance.
6. Enhance the explanation functions of the software.
7. Evaluate the system performance.

To accomplish objective 1, technical contacts are made with member states of the North Central States Consortium (NCSC) and through the AASHTO/NSBA Steel Bridge Collaboration Task Group 5 Repair Database. New actual cases are solicited from task group members. A fabrication plant visit, interviews with fabrication

personnel, and historical fabrication error documents are used in the collection process.

To accomplish objective 2, a review panel from task group members is established. All rule solutions and case solutions in the software are categorized with original cases and sketches into paper-based documents. The panel reviews all rule and case solutions in the documents and provides commentary information. Finally, each rule and case with comments is summarized and implemented into the software.

Objective 3 is accomplished by attaching sketches and instructive information to each case solution in the software based on the original cases and the comments obtained from the review panel.

Objective 4 is addressed by gathering additional information on common errors and developing a tutorial tool to provide generic solutions. Some information also is summarized from existing cases.

Objective 5 is accomplished by improving case matching for case-based reasoning. Currently, FIXS uses a simple CBR matching process to retrieve similar cases built on the Simple Case Based Reasoning (SCBR) expert shell (Rick Greenfield and Roddis 1998). The matching process used by SCBR currently matches case features by exact value only. Exact matching of numerical values is not practical when considering the possible variance in hole sizes, hole spacing, member dimensions, etc. One practical way is to introduce feature evaluations to the simple matching process to consider reasonable maximum ranges for continuous features.

To accomplish objective 6, the expert shell MESS (Spratt, Lindsey, 1998) for rule-based tools and an expert shell SCBR for case-based tools are revised to meet the requirements and to elaborate the explanation functions. More understandable "Why" and "How" explanation functions are incorporated in the rule-based tool MESS. Original cases and sketches with instruction are added to provide graphical information and instructive explanation to case solutions.

Finally to accomplish objective 7, two approaches are used in the evaluation process. First, during development of the system, a series of workshops (presentations and computer demonstrations in different software development stages) are given to national DOTs, fabricators and steel designers. Comments and feedback will be incorporated into the final version of the system. Second, after the system is completed, evaluation tests are done by members of Task Group 5. These tests consist of running the final software on a set of cases which have not been used during system development, as well as a review of all project documents. The results of the tests and the questionnaire will be collected to make the final evaluation.

# CHAPTER 2

## KNOWLEDGE BASE ENHANCEMENT

### 2.1. ENLARGE THE KNOWLEDGE BASE

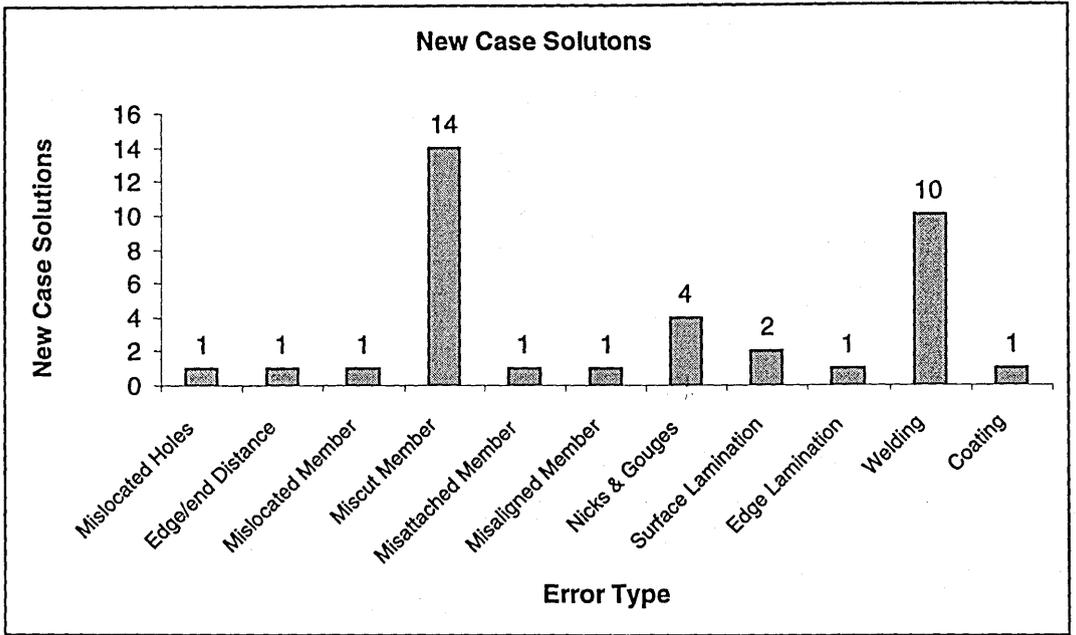
The initial knowledge base for FIXS was developed by reusing rule-based knowledge from BFX along with case-based knowledge from CB-BFX. One hundred twenty one rule solutions with 350 rules used to search for rule solutions were converted from Level 5 Object's Production Rule Language (Information Builders, Inc 1993) used in BFX to a similar format for use with MESS. One hundred twelve case solutions were converted from LISP structures used in CB-BFX to PROLOG syntax for use with SCBR (Rick Greenfield and Roddis 1998). The knowledge was generated from the actual cases gathered from fabricators, inspectors, and bridge engineers in KDOT. The error types were divided into the four categories of Tolerance, Drilling & Punching, Cutting, and Lamination.

It is necessary to enlarge the knowledge base beyond the rules and cases in BFX and CB-BFX for two reasons. First, the knowledge base needs to be enlarged to cover errors experienced by other DOTs, not just KDOT. Second expanding the knowledge base will result in improvements in effectiveness such that more near equivalent cases are recognized and solved, thus providing a more consistent solution

process. Increasing the usability of the system will allow more end users to efficiently and accurately draw information from the knowledge base.

In order to develop the repair data base for use by multiple DOTs, additional cases were needed from multiple DOTs. To obtain additional cases and technical support, DOTs from member states of the North Central States Consortium were invited to participate in the project by designating a bridge design representative to provide cases and comments. In addition, Task Group 5 Repair Database was formed within the AASHTO/NSBA Steel Bridge Collaboration to provide additional case data and comments for expansion of the knowledge base.

Solicitation for available bridge fabrication error case data from North Central States Consortium and Task Group 5-97 of the AASHTO-NSBA Steel Bridge Collaboration started September 8, 1997 and ended July 30, 1998. Steel Bridge Fabrication Error Report forms and instruction sheets, as well as three completed examples, were provided to participants to use in describing each case. The FIXS software was demonstrated at the Task Group 5 meeting on Tuesday, October 27, 1998 during the AASHTO/NSBA Steel Bridge Collaboration Meeting in Salt Lake City, Utah, in order to motivate participants to submit more cases. As a result, thirty eight new actual cases were obtained from North Central States Consortium and Task Group 5-97 of the AASHTO-NSBA Steel Bridge Collaboration. Thirty-seven cases were added to the knowledge base and one case were implemented in the Tutorial Tool. Figures 1 & 2 shows the distribution of new thirty-seven case solutions.



**Figure 1 New Case Solution Distribution**

<u>Error Type</u>	<u>New Case Solutions</u>
Mislocated Holes	1
Edge/end Distance	1
Mislocated Member	1
Miscut Member	14
Misattached Member	1
Misaligned Member	1
Nicks & Gouges	4
Surface Lamination	2
Edge Lamination	1
Welding	10
Coating	1
<b>Total:</b>	<b>37</b>

**Figure 2 New Case Solution Distribution**

## 2.2 CLEAN THE KNOWLEDGE BASE

In order to provide a repair database for use by multiple DOTs, the solutions must be clear, consistent, well reasoned, and instructive. The completeness of information available on collected actual cases varies quite a bit. Inadequate solutions or conflicting methods may cause engineers confusion or to be even more conservative and less results-oriented than usual. To improve the quality of the solutions, actual cases and knowledge in the software needed to be reviewed by a standing peer review panel to determine their pertinence, general applicability, and logical consequences and add necessary instructive information. As a result, Task Group 5 was asked to review all rule knowledge and actual cases from both DOT and fabrication perspectives and to provide commentary and instructive information on them.

Paper-based documents of the FIXS repair database, consisting of 121 rule solutions and 112 actual case collected from KDOT and 38 cases solicited from NCSC and Task Group 5, were presented to participants of Task Group 5 for review. One hundred twenty one rule solutions converted from BFX were listed in a book (referred to as "FIXS Rule Knowledge"). One hundred twelve actual cases gathered from KDOT, with actual case descriptions and sketches, which will be shown in a detail box in the software along with the description implemented in the software, were put together in a second book (referred to as "The White Book"). In addition, thirty-eight new cases collected from Task Group 5 were similarly gathered in a third book (referred to as "New FIXS Fab. Error New Cases"). In the Task Group 5 meeting on Tuesday, October 27, 1998 during AASHTO/NSBA Steel Bridge

Collaboration Meeting in Salt Lake City, Utah, those documents were presented to the participants of Task Group 5 for comment. Al Laffoon, Russ Panico, and Buck Roberds offered to review certain sets of cases and to give comments from either fabricator or DOT viewpoint. Gary Wisch volunteered to provide some draft information on stiffeners. Paul McDad promised to provide some examples with solutions that are often seen in fabrication. As the final result, Russ Panico of High Steel Structures Inc. provided comments on "FIXS Rule Knowledge". Gary W. Wisch of Delong's Inc. commented on page 1 to page 82 in "The White Book". Buck Roberds of PDM Bridge voluntarily reviewed page 83 to page 114 in "The White Book". Al Laffoon of Missouri DOT provided some comments on the first 19 cases in "New FIXS Fab. Error New Cases", and Buck Roberds of PDM Bridge presented the comments on the last 19 cases in "New FIXS Fab. Error New Cases".

The rule solutions and actual cases with the comments obtained from Task Group 5 were finalized. The following systematic changes were made:

- 1) Generalize the case description
- 2) Add more detailed information
- 3) Add other possible solutions
- 4) Add more sketches
- 5) Clarify sketches
- 6) Add case cross-references
- 7) Add additional comments
- 8) Plug welds not recommended

Each of the change types is discussed in turn below with examples provided.

### **2.2.1 Generalize the case description**

To generalize the problems from specific cases and specific DOTs, such that they can be suitable for use by multiple DOTs, the following editorial approach was taken.

Example 1 shows a case that was generalized from a specific case. In the description of the error, instead of Girder 119A3, stiffener 100TF and stiffener 160 DB, a girder, a horizontal stiffener, and a vertical stiffener were used to describe the case based on the concept of the original case.

Example 2 shows a case that was generalized from a specific DOT. The original case was gathered from KDOT. In this case, instead of mentioning the specific fabricator and specific DOT, generic words, such as the fabricator, DOT, were used to describe the case in general.

## Example 1:

### Repair:

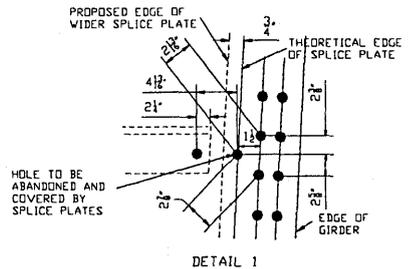
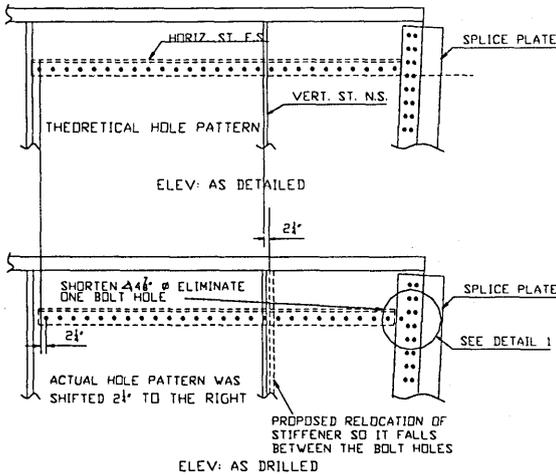
Holes for the horizontal stiffener attachment were mislocated by 2.25 in.

The hole pattern interferes with a splice plate and a vertical stiffener.

The angle will be shortened to eliminate the bolt hole that interferes with the splice plate.

The splice plate will be widened to cover the abandoned hole.

The vertical stiffener will be relocated so it falls between the bolt holes.



### Case #TF204:

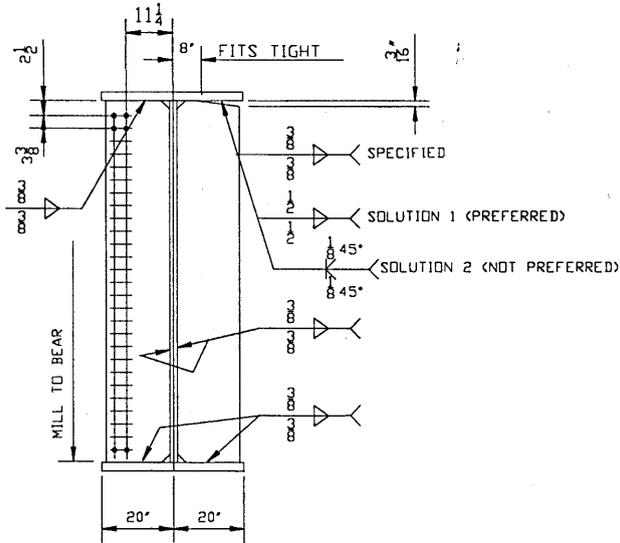
**Description of Error:** Holes for fastening the horizontal stiffener have been misdrilled. The actual hole pattern was shifted 2 1/4" to the right (see "as drilled" sketch). The hole pattern interferes with a splice plate and a vertical stiffener. The vertical stiffener is an angle bolted to the girder web with bolt locations above and below horizontal stiffener. In sketches, only outstanding leg of vertical stiffener angle is shown.

**Solution Recommended:** To shorten the angle by 4 7/8 inch and eliminate one bolt hole. The bolt hole to be abandoned will be covered by splice plate wider than called out originally by design. The vertical stiffener will be relocated so it falls between bolt holes.

## Example 2:

### Repair:

A bearing stiffener does not have the required tight fit at stiffener to flange. There is a gap of  $3/16$  in. that occurs at about midway on the stiffener to the outer edge of the stiffener. Either increase the current fillet weld size of stiffener to flange or (avoid full penetration weld if possible) use a full penetration weld of stiffener to flange.



### Case # TF176:

Description of Error: Blank bearing stiffener installed on girder does not have the required "tight fit" at stiffener to flange. The gap starts approximately  $8$  inches from girder centerline and extends toward stiffener outer edge with maximum  $3/16$  inch gap at girder flange edge.

Solution Recommended: Either increase the current  $3/8$  fillet weld size to  $1/2$  inch or (avoid full penetration weld if possible) use a full penetration weld of stiffener to flange whichever is acceptable to DOT.

## 2.2.2 Add more detailed information

Example 3 shows a case where more detail available from original case documents was added.

In this case, instead of simply saying a new stiffener will be installed by a certified welder, detailed information about the process of stiffener installation “New stiffeners will be fabricated and shipped loose to job site. The existing stiffeners will be removed as follows: using oxygen-acetylene torch, cut away existing stiffener leaving approximately two inch stub. This stub is then to be removed using air-arc carbon gouging down to the toe of the weld material exercising care not to gouge into parent material. The entire weld material and any stub material remaining will be removed by grinding so as to provide a smooth surface suitable for attaching the new stiffeners. New stiffeners will be attached by a certified welder using approved weld procedure. Preheat (prior to tacking) shall be required throughout the welding process. Field weld inspection will include magnetic particle testing.” was added to the solution recommended.

Example 4 is another case where more detail was added.

In this case, detailed information “Maximum temperature of 1100 ° F. Top flange and bottom flange to be heated at same time with two rose buds per flange (one rose bud on each side of flange). Additional heat may be needed. Heating to be done in horizontal position, blocked at both ends with middle unsupported (1' gap between girder and center blocking).” was added to provide detailed requirements for the heating process.

### Example 3:

*Repair:*

*A stiffener was connected upside down to the girder.*

*Therefore its bolt hole pattern does not match that of the floor beam.*

*The stiffener will be removed by means of air arc gouging exercising care not to gouge into web plate material.*

*The web plate shall be ground smooth after existing stiffener removal.*

*A new stiffener will be installed by a certified welder.*

Case #TF170:

**Description of Error:** Three fabricated girders have one connection stiffener each installed incorrectly ( upside down whereas the hole pattern no longer will match floor beam).

**Solution Recommended:** New stiffeners will be fabricated and shipped loose to job site. The existing stiffeners will be removed as follows: using oxygen-acetylene torch, cut away existing stiffener leaving approximately two inch stub. This stub is then to be removed using air-arc carbon gouging down to the toe of the weld material exercising care not to gouge into parent material. The entire weld material and any stub material remaining will be removed by grinding so as to provide a smooth surface suitable for attaching the new stiffeners. New stiffeners will be attached by a certified welder using approved weld procedure. Preheat (prior to tacking) shall be required throughout the welding process. Field weld inspection will include magnetic particle testing.

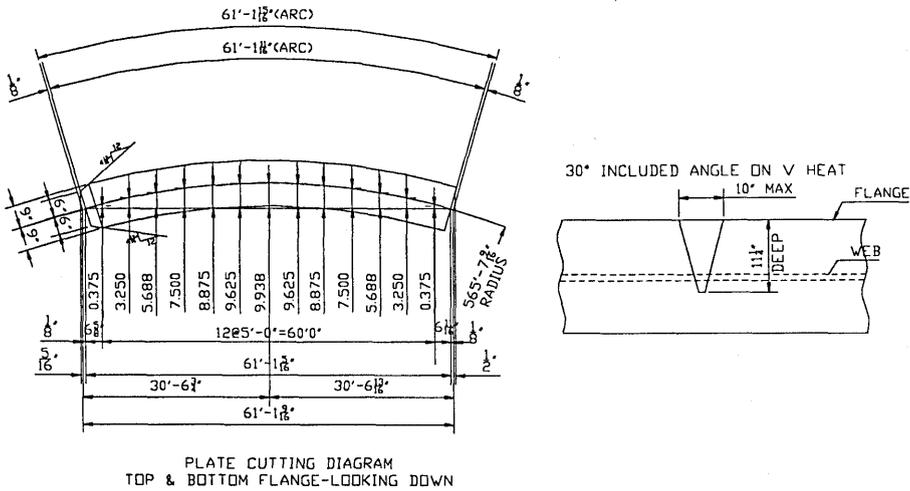
**Other possible solutions:** leave mislocated stiffener in place, coping stiffener to eliminate interference with other pieces as necessary. Field weld new stiffener in required position. Note dimensions in actual case did not allow use of this preferred solution.

### Example 4:

**Repair:**

The flanges could not be burned to the proper sweep.

Heat curve the flanges to meet the sweep requirements by following the appropriate DOT Special Provisions Section.



**Case # FB160:**

**Description of Error:** Due to purchasing error, girder top and bottom flange plates could not be burned with the detailed 9 15/16" of sweep but only 4" of sweep.

**Solution Recommended:** Add the remaining 5 15/16" of sweep by the heat curving method following the procedure outlined in the appropriate Special Provisions Section for heat curved rolled beams and welded plate girders. Fabricator will locate the heats working from center line of girder and heating at 5' increments of the length of the girder. Maximum temperature of 1100 ° F. Top flange and bottom flange to be heated at same time with two rose buds per flange (one rose bud on each side of flange). Additional heat may be needed. Heating to be done in horizontal position, blocked at both ends with middle unsupported (1' gap between girder and center blocking).

### 2.2.3 Add other possible solutions

Example 5 is a case where other possible solutions were added.

In this case, not only the solution recommended is provided, but also "Other Possible Solutions: the stiffener could have been moved far enough to miss the splice plate. This would have been the best solution had the error been noticed before the stiffener was in place. In actual case, shop did not realize there was a problem until they tried to clamp the splice plates in place for drilling." was added to provide guidance for different situations.

Example 6 shows another case that was added to other possible solutions.

In this case, other possible solutions: "Avoid removal unless absolutely needed so can avoid air arc gouging and grinding in the high stress bearing area. 1) If bottom location of stiffener is within middle 50% of sole plate, leave stiffener as is and check plumbness. If out of plumb more than 5%, weld additional stiffeners to create a shear panel (space new stiffeners between 6" and 12" on center. New stiffeners half the thickness of bearing stiffeners). Check cross-frame connection clearance. 2) If bottom location of stiffener is not within middle 50% of sole plate, add 2<sup>nd</sup> bearing stiffener." was also added.

Example 7 is a case that was added to other possible solutions based on the comments obtained from Task Group 5 members. On this case, a comment "The use of 1 1/8" bolts is not common in the industry, and if specified, the quality could be questionable." was obtained from a Task Group 5 member showing the fabricator view point. To assist an engineer in determining the best solutions for the fabricator

based on the shop preferences, experience and equipment, “Other Possible Solutions: Instead of using the uncommon bolt size of 1 1/8 inch as done in actual repair, consider use of 1 inch bolts in oversize holes and use hardened washers on both sides.” was added.

## Example 5:

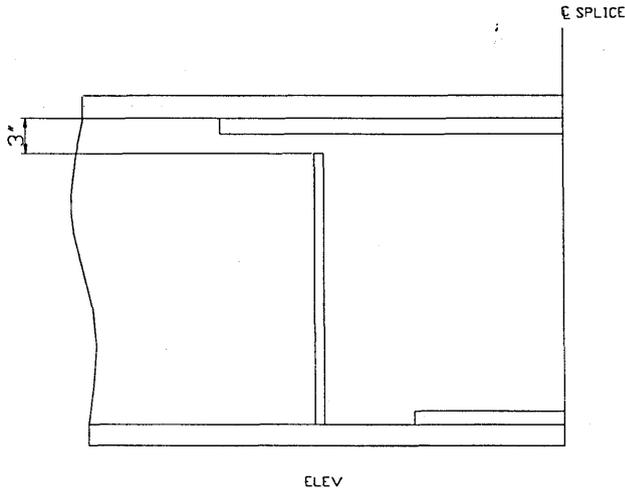
### Repair:

*A splice plate extended beyond the location of the stiffener.*

*The stiffener was shown to tight fit against both flanges.*

*The stiffener had already been welded into place.*

*Cut the stiffener off 3 in. from the flange to allow the splice plate to be placed in the proper location.*



### Case #DL169:

**Description of Error:** A stiffener was shown to fit tight against both flanges. One inside splice plate extended beyond the location of the stiffener.

**Solution Recommended:** Cut the stiffener off 3" from the flange. This was acceptable since this was a plain stiffener rather than a diaphragm connection plate.

**Other possible solutions:** the stiffener could have been moved far enough to miss the splice plate. This would have been the best solution had the error been noticed before the stiffener was in place. In actual case, shop did not realize there was a problem until they tried to clamp the splice plates in place for drilling.

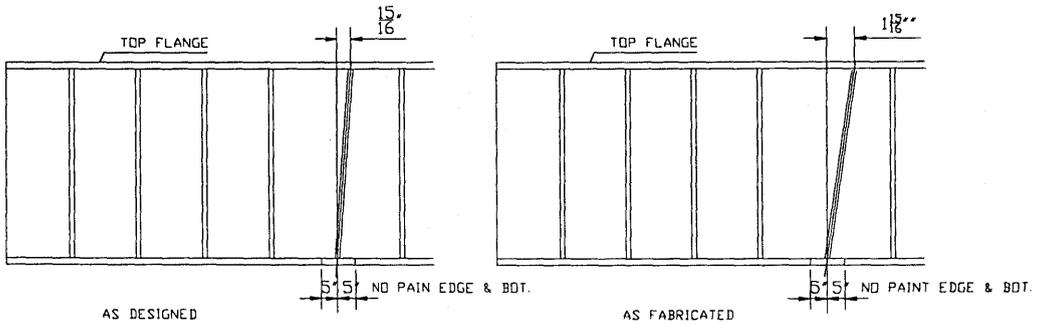
## Example 6:

### Repair:

Bearing stiffener welded in place out of plumb.

Kick equals  $1 \frac{15}{16}$  in. in lieu of  $15/16$  in.

The stiffener was left in place and a shim used to bolt cross frame to stiffener.



### Case #NC501:

**Description of Error:** Bearing stiffeners welded in place out of plumb--kick =  $1 \frac{15}{16}$ " in lieu of  $15/16$ ".

**Solution Recommended:** Since bottom location of stiffener above the sole plate is correct and out of plumbness was less than 5%, stiffener was left in place and a shim used to bolt cross frame to stiffener.

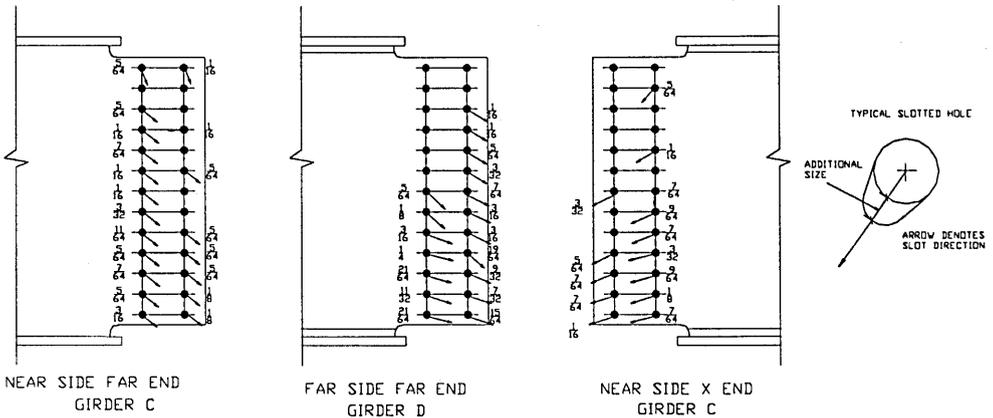
**Other possible solutions:** Avoid removal unless absolutely needed so can avoid air arc gouging and grinding in the high stress bearing area. 1) If bottom location of stiffener is within middle 50% of sole plate, leave stiffener as is and check plumbness. If out of plumb more than 5%, weld additional stiffeners to create a shear panel (space new stiffeners between 6" and 12" on center. New stiffeners half the thickness of bearing stiffeners). Check cross-frame connection clearance. 2) If bottom location of stiffener is not within middle 50% of sole plate, add 2<sup>nd</sup> bearing stiffener.

## Example 7:

### Repair:

Several holes in the web were elongated at the splice connection.

Drill  $1 \frac{3}{16}$  in diameter holes for  $1 \frac{1}{8}$  in. bolts and use hardened washers on both sides.



### Case #TF195:

**Description of Error:** Several holes in the web were elongated at the splice connection.

**Solution Recommended:** Drill  $1 \frac{3}{16}$  inch diameter holes for  $1 \frac{1}{8}$  inch bolts and use hardened washers on both sides.

**Other Possible Solutions:** Instead of using the uncommon bolt size of  $1 \frac{1}{8}$  inch as done in actual repair, consider use of 1 inch bolts in oversize holes and use hardened washers on both sides.

## 2.2.4 Add more sketches

Example 8 shows a case where more sketches were added.

For this case, sketches were not available from the original case. According to the description of the original case, two sketches, one showing the error situation, the other showing the repair solution, were added to provide graphical information. In addition, “Additional Comments: This repair approach is suitable for shallow partial holes. See tutorial topic on partially drilled holes for further discussion.” Was added to provide complete information on partially drilled holes.

Example 9 is another case where more sketches were added.

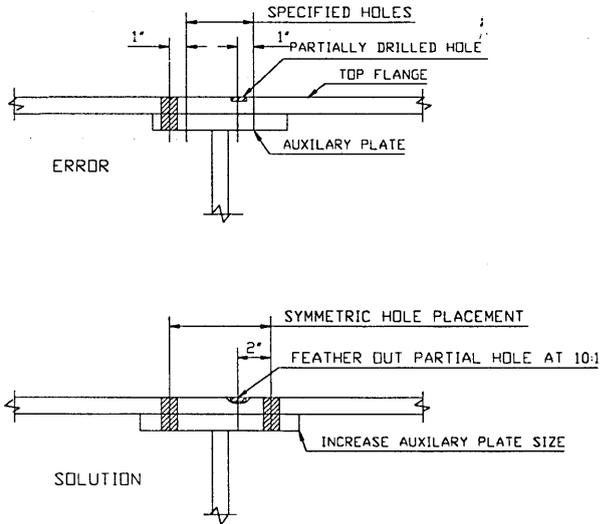
In this case, only the "weld detail" sketch was available from the original case. ELEV was added to provide clear figuration.

## Example 8:

### Repair:

A hole was mislocated in the top flange for the auxiliary plate.

Make a larger auxiliary plate to fit the hole spacing pattern on the top flange.



### Case #DL126:

**Description of Error:** A hole (see left hole in error sketch) was drilled 1" off in the top flange for the auxiliary plate. This causes auxiliary plate to be too small (see left edge of auxiliary plate in error sketch). Next hole in pattern was partially drilled.

**Solution Recommended:** Make larger auxiliary plate to fit the hole spacing. Feather out partial hole at 10:1. Locate new right hole to be in symmetry with existing left hole.

**Additional Comments:** This repair approach is suitable for shallow partial holes. See tutorial topic on partially drilled holes for further discussion.

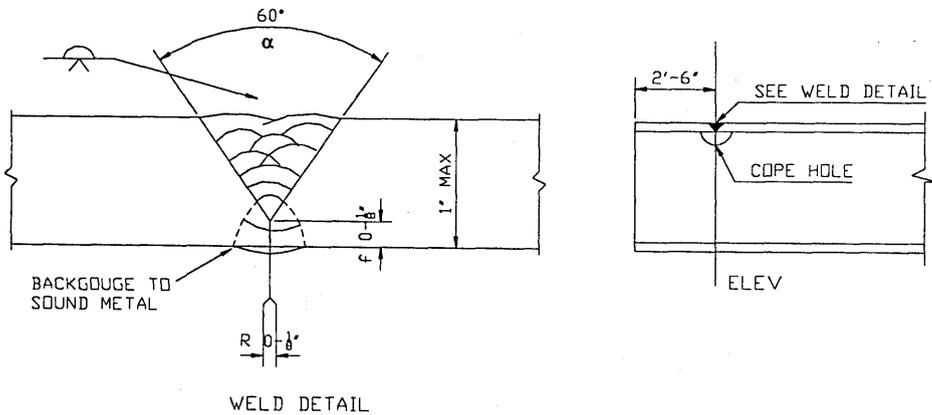
### Example 9:

**Repair:**

The web plate is misaligned 1/2 in. centerline of top flange plate approximately 1 ft 10 1/2 in from left end.

Required holes in top flange have been drilled and were gaged from centerline of misaligned web. This has caused these holes to be 1/2 in. off theoretical centerline therefore reducing edge distance on one side.

Air carbon arc gouge web to flange weld 2 ft. 6in. from left hand end and add 1" web cope hole. Cut out top flange 2 ft. 6 in from left hand and splice new flange. Radiograph flange splice 100% Web will be realigned and welded with 100 percent MT. Holes will be drilled in new flange plate.



**Case # TF189:**

**Description of Error:** Web plate is misaligned 1/2" off centerline of top flange plate approximately 1'-10 1/2" from left hand end. Required holes in top flange have been drilled and were gaged from centerline of mis-aligned web. This has caused these holes to be 1/2" off theoretical centerline, reducing edge distance from 1 1/2" to 1" on far side and increasing edge distance near side to 2".

**Solution Recommended:** Air carbon arc gouge web-to-flange weld 2'-6 from left hand end, and add 1" web cope hole. The cope hole is to allow 100% RT of flange weld. Cut out top flange 2'-6 from left hand end and splice new flange using approved weld procedure (see sketch) and RT splice 100%. Web will then be re-aligned and welded with 100% MT. Holes will then be drilled in new flange plate. All work to be witnessed by DOT.

## 2.2.5 Clarify sketches

Example 10 shows a case with clarified sketches from shop drawings. The original case gathered from KDOT included two pages of shop drawings showing PLAN, ELEVATION, and STEEL CAP BEAM DETAILS. In order to show the misfit between the top flange splice plates, girders, and steel cap beams clearly in limited space, PLAN VIEW OF TOP FLANGE SPLICE PLATE, ELEV THROUGH CAP BEAM and a section showing the relationship between top flange splice plates, girders and cap beam, were added as sketches.

Example 11 is another case with clarified sketches from shop drawings. The original case was attached several sheets of shop drawings. In order to show the error clearly, only directly information was drawn in the sketch.

## Example 10:

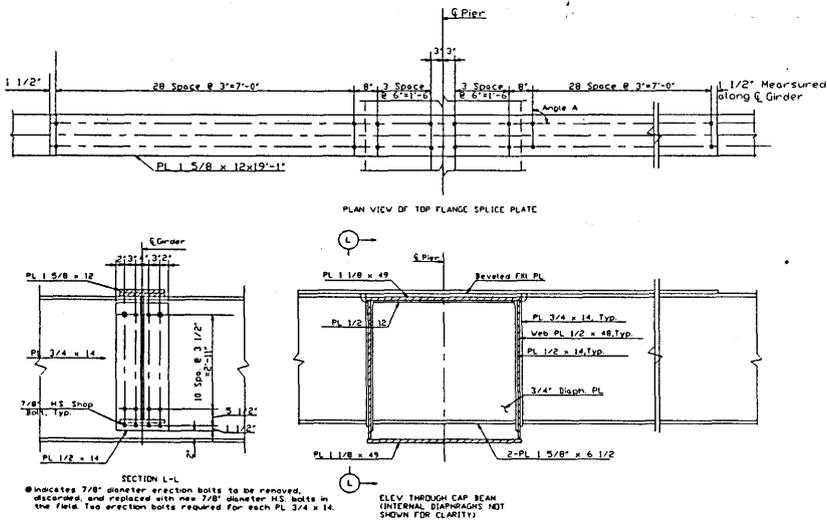
### Repair:

The girder to steel cap beam connection must be completed prior to placing and bolting the top flange splice plate.

When the erection procedure was followed the top flange plates were placed and misfit occurred between bolt holes.

1) A shim plate between the girder and cap beam may be used, or 2) the top flange splice plate holes may be reamed.

If the holes were reamed then install hardened washers over the oversized holes in the outer ply and tighten the bolts.



### Case #JJ142:

**Description of Error:** In order to assure that a full contact friction/moment connection is made between the girders and steel cap beam, without introducing residual stresses into the joint, the girder to steel cap beam connection must be completed prior to placing and bolting the top flange splice plate. The erection procedure was followed at the two locations mentioned. When the top flange splice plates were placed, misfit occurred between the bolt holes of the top flange splice plates, steel cap beam, and girders.

**Solution Recommended:** These misfits may be resolved by one of the following methods:

1. Provide a shim plate between one of the girders and the steel cap beam.
2. "fit-up" the top flange splice plate to the steel cap beam. Then, ream the top flange splice plate to girder holes. Install hardened washers over the oversized holes in the outer ply and tighten the bolts. No bolt holes shall exceed 1 1/16" in diameter.
3. Provide a new top flange splice plate.

In all cases, the girder to steel cap beam connection must be finalized prior to placing and inserting bolts in the top flange splice plate.

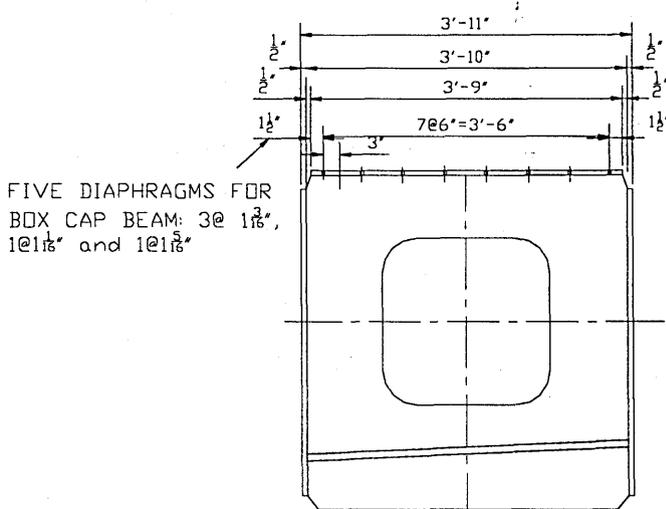
Angle A varies from 90°00'00.0" to 89°51'58.5" depending on girder.

## Example 11:

### Repair:

In the box cap beam the internal bracing diaphragms located where the girder connection plate bolt to the top flange of the girder and the top flange of the box have insufficient edge distance.

Drill an extra set of bolt holes at 3 in. from the last two bolt holes that have insufficient end distance.



### Case #MG119:

**Description of Error:** In the box cap beam five internal bracing diaphragms located where the girder connection plate bolt to the top flange of the girder and the top flange of the box have insufficient edge distance. Three diaphragms have two bolts with 1 3/16" edge distance; 1 has two bolts with 1 1/16" edge distance; and 1 diaphragm has two bolts with 1 5/16" edge distance.

**Solution Recommended:** Drill an extra set of bolt holes at 3" from the last two bolt holes that have insufficient end distance.

## 2.2.6 Add case cross-references

Two sets of examples 12 and 13 as well as example 14 and 15 had cross-references added.

Example 12 and example 13 are implemented as separate two cases in the case library, but came from the same original case gathered from KDOT. The original case had several different types of mislocated holes in the field splice. Example 12-case 'MLCCH\_C005' focuses on a 7/8" plug welded hole in the field splice. Example 13- case 'MLCH-C013') focuses on the other six 1 1/4" mislocated holes in the same member. In order to provide complete information for the fabrication errors, in case 'MLCCH\_C005', the cross-reference "(see case 'MLCH-C013' for following error on same member)" was added; in case 'MLCH-C013', the cross-reference "(see case 'MLCH-C005' for following error on same member) was added.

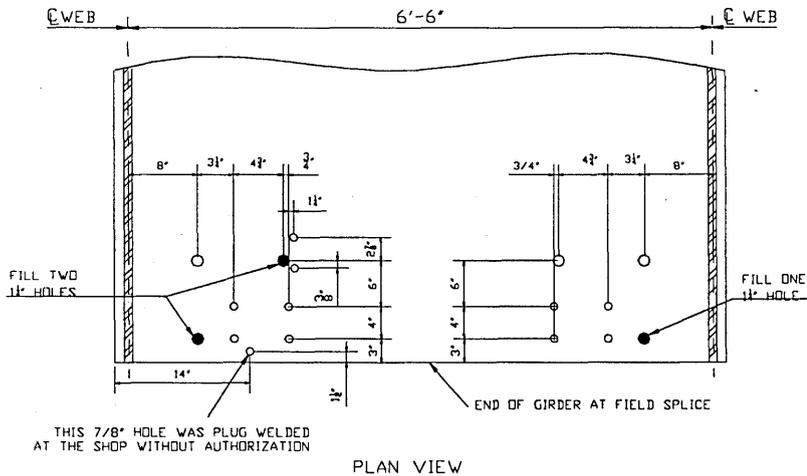
Example 14 and example 15 also came from one original case. Example 14-case 'MSPH-C001' focuses on the 1 1/8" egg shaped hole in the girder flanges, and example 15-case 'MSPH-C008' focuses on the other small egg shaped holes in the same member. As a result, the cross-reference "(Also see misshapedHole, 'MSPH-C008') was added in the case 'MSPH-C001' while the cross-reference "(Also see misshapedHole, 'MSPH-C001') was added in the case 'MSPH-C008'.

## Example 12:

### Repair:

The hole intersects with the connection.

Plug weld the hole and NDT test.



### Case #MG102:

**Description of Error:** The 7/8" diameter hole shown on the diagram was drilled and plug welded without any permission at the shop and was discovered by chance during field radiography. The six 1 1/4" holes were also drilled wrong but were evaluated, repaired and NDT tested before acceptance of the girder. (see case 'MLCH-C013' for following error on same member)

**Solution Recommended:** This is a two-part problem.

- 1) Since conditions allowed filling and NDT testing of the 1 1/4"  $\phi$  holes, the same technical fix should be possible on the 7/8" hole.
- 2) Since the fabricator did not bring the 7/8" hole to the attention of the owner, the fabricator's QC is called into question. For this reason, repair of this defect will be decided on by design department and the consulting engineers handling the project.



**Example 14:**

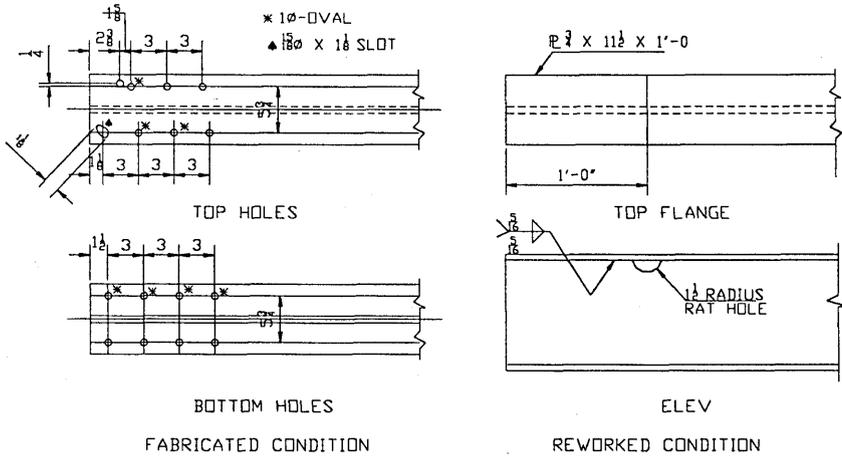
**Repair:**

There is an egg shaped hole in the girder flange.

Cut off existing flanges.

Add new plate using full penetration weld at flange and 5/16 in. weld at web.

100% RT at flange and 100% MT at web.



**Case #FB150:**

**Description of Error:** There is an egg shaped hole in the girder flange. The hole is approximately a 15/16 φ by 1 1/8 slot. (Also see misshapedHole, 'MSPH-C008').

**Solution Recommended:** Cut off existing flanges. Add new plate using full penetration weld at flange and 5/16 inch fillet weld at web. 100% RT at flange and 100% MT at web.

## Example 15:

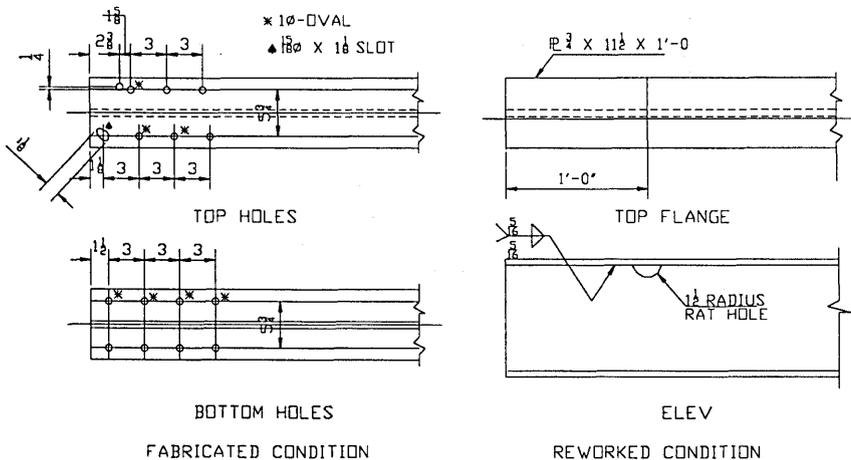
### Repair:

Egg-shaped holes occur on the flanges at a splice location. Cut off the existing flange.

Add new plate using full penetration weld at flange and fillet weld at web.

100 percent RT a flange and 100 percent MT at web.

Drill holes correctly.



### Case #TF214:

**Description of Error:** Egg-shaped holes occur on the flanges at a splice location. The holes are approximately 1"  $\phi$  ovals. (Also see misshapedHole, 'MSPH-C001')

**Solution Recommended:** Cut off the existing flange. Add new plate using full penetration weld at flange and fillet weld at web. 100 percent RT at flange and 100 percent MT at web. Drill holes correctly.

**Other Possible Solutions:** Drill all holes from the solid to 1 1/16" diameter holes for 1" diameter A325 holes if edge distance (AASHTO 1 3/4" edge distance for 1" bolts) had been present.

### **2.2.7 Add additional comments**

Example 16 is a case that was collected from KDOT, but was not a fabrication error. Since this case was submitted in response to our request for fabrication errors, it is likely that it was encountered by the same individuals in the same context as a fabrication error. Therefore it was decided to include it in the case base. In order to avoid confusion, “Additional Comments: This in not a fabrication error. This case arose during the retrofit of an existing bridge. The case is included here to provide an example of cracking repair. If a similar case is encountered, refer to NCHRP Report (National Cooperative Highway Research Program Report 336: DISTORTION-INDUCED FATIGUE CRACKING IN STEEL BRIDGES)” was added.

## Example 16:

### Repair:

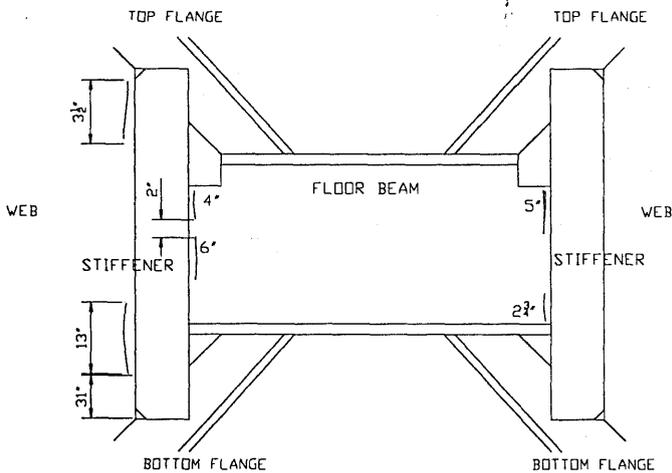
Cracks occur in the vertical weld attaching the stiffeners to the web or else in the vertical weld connecting the floorbeam to the stiffener.

Preheat. Remove the cracked weld using air-arc carbon gouging.

Grind the gouged areas.

Inspect the gouged areas using magnetic particle testing.

Replace the removed weld metals by rewelding, air cool to ambient temperature and then reinspect the crack area using magnetic particle testing not before 24 hours after welding is complete.



### Case #FB154

**Description of Error:** Cracks occur in the vertical weld attaching the stiffeners to the web or else in the vertical weld connecting the floorbeam to the stiffener.

**Solution Recommended:** Preheat. Remove the cracked weld using air-arc carbon gouging.

Grind the gouged areas. Inspect the gouged areas using magnetic particle testing. Replace the removed weld metals by rewelding, air cool to ambient temperature and then reinspect the crack area using magnetic particle testing not before 24 hours after welding is complete.

**Additional Comments:** This is not a fabrication error. This case arose during the retrofit of an existing bridge. The case is included here to provide an example of cracking. If a similar case is encountered, refer to NCHRP Report (National Cooperative Highway Research Program Report 336: DISTORTION-INDUCED FATIGUE CRACKING IN STEEL BRIDGES ).

### **2.2.8 Plug welds not recommended**

Some actual cases had plugging weld mislocated holes as solutions. But plugging weld holes is not recommended, since plug welds can result in cracklike discontinuities that are susceptible to crack propagation. To remind users not plugging weld mislocated holes, special note “\*\*\*THE ACTUAL REPAIR IS NOT A RECOMMENDED REPAIR.\*\*\*” is added in the beginning of Solution Recommended as shown in Example 17. Then in the following, first the actual repair is reported, second the actual repair is critiqued, and third a recommended alternative is given. Consequently, users can not only avoid plugging weld holes, but also can get alternative solutions to solve problems.

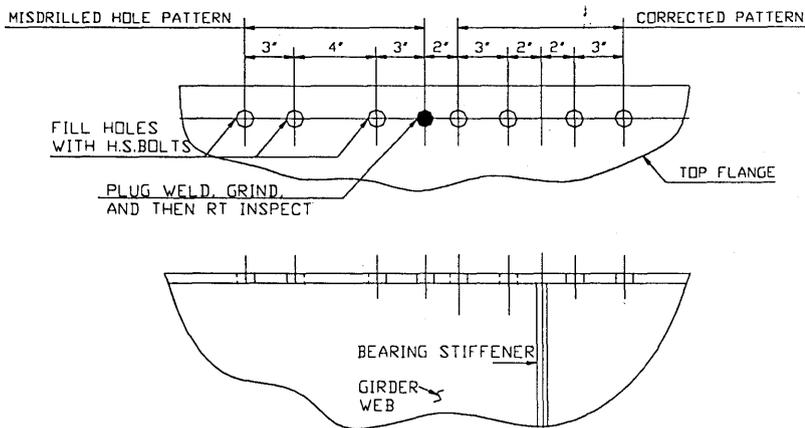
## Example 17:

### Repair:

The bearing stiffener holes were drilled in the wrong location in the girder flange.

The specified pattern was drilled in the correct location.

The holes drilled in the wrong location were filled with bolts. \*\*\*However the hole nearest the correct location is too close to the correct pattern and was filled with weld material and ground smooth. THIS IS NOT A RECOMMENDED REPAIR.\*\*\*



### Case #TF200:

**Description of Error:** The bearing stiffeners of the girder were initially located wrong. This error was identified prior to welding of bearing stiffeners but after holes had already been drilled in top flange. The result, as fabricated, is two sets of four bolt hole patterns.

**Solution Recommended:** \*\*\*THE ACTUAL REPAIR IS NOT RECOMMENDED REPAIR.\*\*\* In the following, first the actual repair is reported, second the actual repair is critiqued, and third a recommended alternative is given.

- 1) The mislocated hole pattern, hole nearest the correctly located hole pattern, allows a center to center of bolt spacing of two inches. As this is less than required by AASHTO, the preferred solution of incorporating excess holes into the bolted connection is not feasible. To abandon the mislocated holes in entirety, filling the holes with H.S. bolts only for appearance reasons. The live bolt hole nearest the dead hole of the abandoned pattern would have an edge distance of  $1 \frac{7}{16}$  inches. AASHTO allows  $1 \frac{5}{16}$  inches for a planed edge (drilled) using  $\frac{7}{8}$  inch diameter bolt and  $1 \frac{1}{16}$  inch diameter oversize hole. The fabricator proposed to retain as an open hole the misdrilled hole closest to the corrected pattern, the DOT chose instead to plug weld, grind, and then RT inspect that hole.

- 2) The actual repair is not recommended due to the adverse effect of plug welds on fatigue performance as discussed in tutorial topic on avoiding plug welds. Filling abandoned holes with high strength torqued bolts is not cosmetic but rather provides the structural benefit of pre compressing the edge of the extraneous hole so that fatigue cracking is discouraged. The fact that there is adequate edge distance at the corrected hole closest to the abandoned holes means that no additional bolts need to be added to the corrected pattern.
- 3) The alternative solution recommended is to abandon the misplaced holes, filling with high strength bolts and tightening so that area around extraneous holes is pre compressed decreasing likelihood of fatigue cracking. If 2' distance prevents tightening of hex bolt, use button head bolt for abandoned hole closest to corrected pattern. See tutorial topic on avoiding plug welds for further discussion.

# CHAPTER 3

## IMPLEMENTATION

### 3.1 IMPROVE THE SOLUTION DETAIL BOX

In the initial version of the software, at the end of a Find Solutions search, if any solutions have been located either by rule-based reasoning (RBR) or case-based reasoning (CBR), a Solution Results dialog box is displayed. A list of solutions ranked by a similarity metric is given along with their respective Solution repair procedures (figure 3) (Greenfield and Roddis 1998). A Solution Detail box was designed to

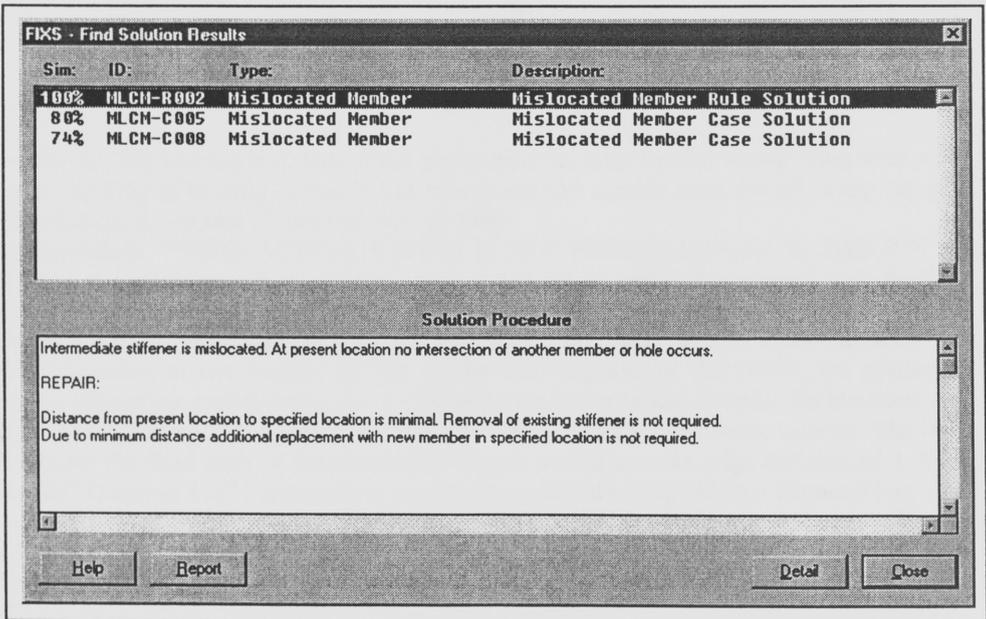
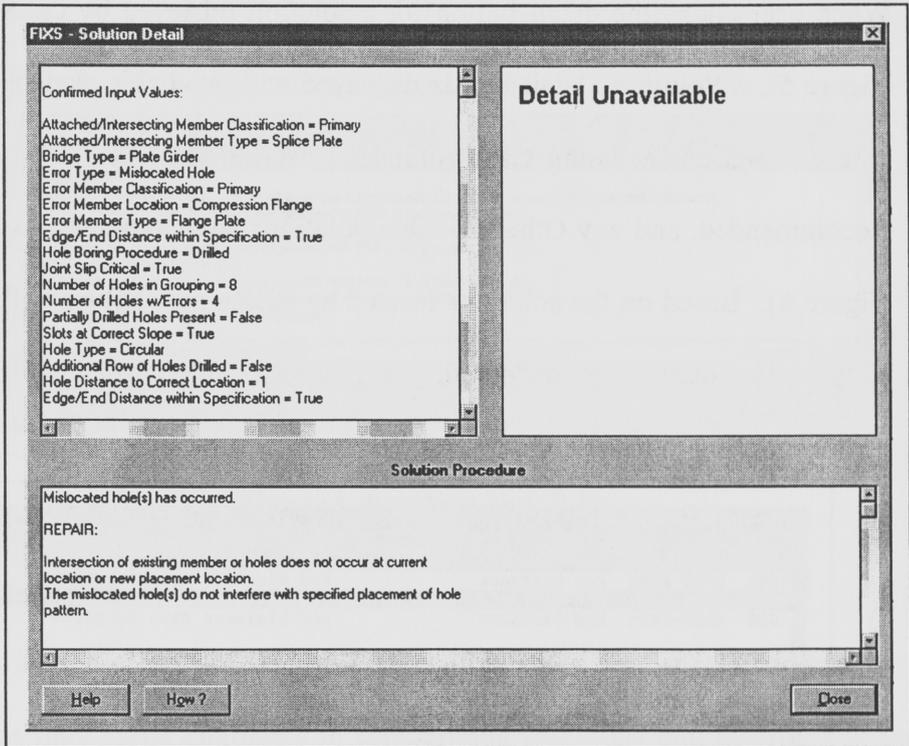


Figure 3 Solution Results Dialog

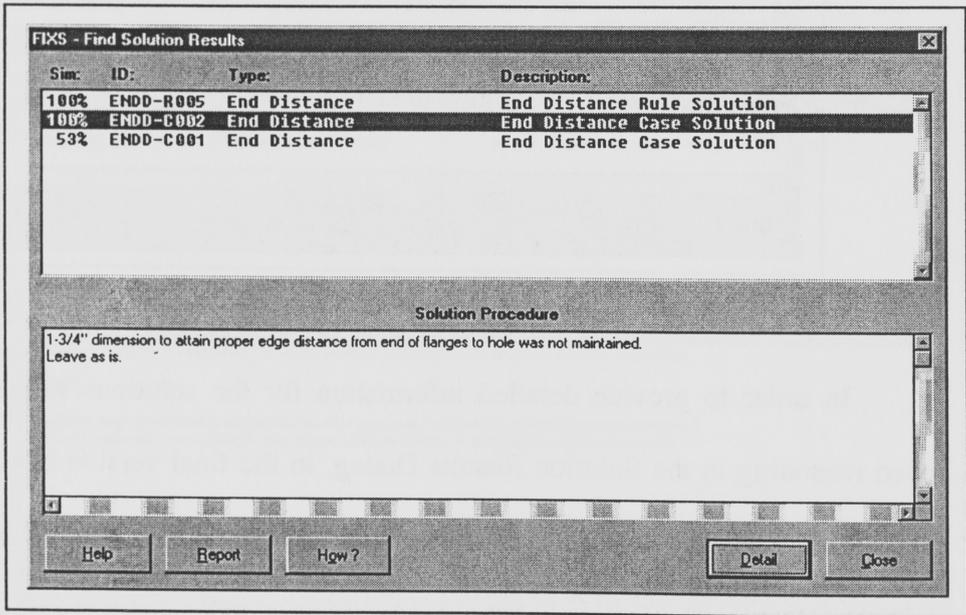
allow user to display more detailed information for a solution. However, the graphic window was left empty, the explanation window was filled with confirmed input values, and the solution window repeated the same solutions as shown in the Solution Results dialog box (figure 4).



**Figure 4 Solution Detail Box**

In order to provide detailed information for the solutions located by case-based reasoning in the Solution Results Dialog, in the final version of the software, sketches and actual case descriptions associated with case solutions are added to the Solution Detail box. The Solution Detail box was redesigned. To show sketches clearly, the graphic window was enlarged. Since the confirmed input value can be

found in the report when user selects the Report button at the end of the Find Solution Results, the explanation window was removed from the original Solution Detail box. As a result, for each case solution, available sketches are shown in the enlarged graphic window and actual case description generated from the actual case (as described in Chapter 2) is added in the text window in the Solution Detail Dialog box. When user clicks the detail button for a solution retrieved by case-based reasoning (figure 5), a Solution Detail box is displayed with available sketches and the actual case description including Case Number, Description of Error, as well as Solution Recommended, and any Other Possible Solutions and Comments in the text window (figure 6). Based on the solutions located by RBR and CBR as well as the reference of the actual cases, the user can derive the best solutions for a particular fabrication error according to the individual situation.



**Figure 5 Solution Results Dialog**

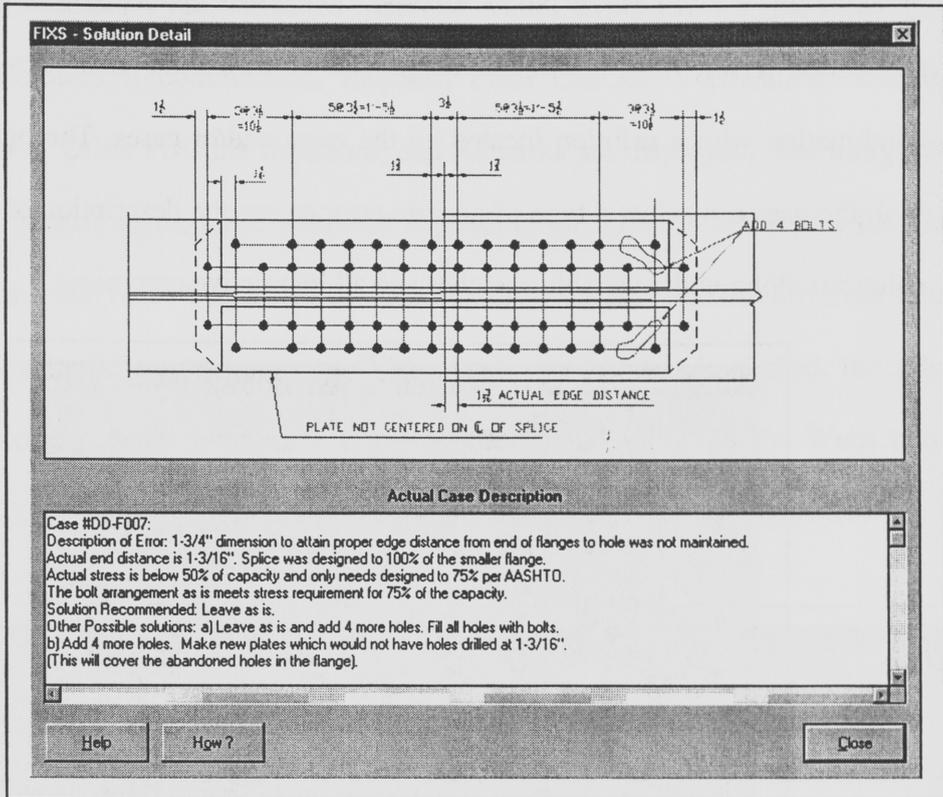


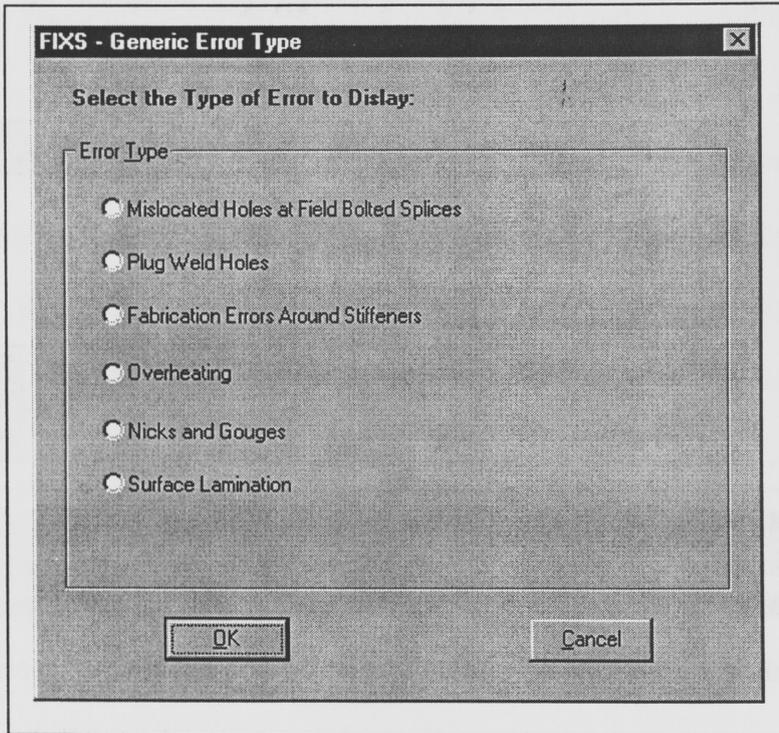
Figure 6 Solution Detail Box

### 3.2 DEVELOP A TUTORIAL TOOL

Since fabrication errors are seldom identical but often similar, generic problems and corrections may assist engineers in categorizing situations and determining the best possible solutions to offer the fabricator. Besides the Find Solutions and Browse Solutions tools in the initial version of the software, in the final version of the software, a Tutorial tool was developed to provide generic solutions for common fabrication errors.

The Tutorial tool provides user with a set of categorized generic fabrication errors and solutions, which are collected from multiple DOTs and national fabricators

or generalized from actual cases (figure 7). When using FIXS for a particular fabrication error, the tutorial may provide information that can be used in combination with a solution located by the rules and/or cases. Through the tutorial tool, the user can select a type of generic error to see the description of the error and solutions along with available sketches and all instructive comments.



**Figure 7 Generic Error Type Dialog Box**

For example, when the user selects the error type of Mislocated Holes at Field Bolted Splices from the generic error type dialog, a generic solutions dialog for mislocated holes at field bolted splices is displayed (figure 8). A list of descriptions

of Main Member Type, Attached Member/ Detail Type, Error Type, Description of Error, Solution Recommended, Required Final Checks/ Verification, Was Repair Successful, Other Possible Solutions, and Remarks are displayed. For this particular type of generic error, since solutions depending on different situations, the Flanges button and the Webs button are designed to allow users to look at different solutions according to different situations. When the Flanges button is clicked, the solutions for mislocated holes in flanges are displayed (figure 9); when the Webs button is clicked, the solutions for mislocated holes in webs are displayed (figure 10).

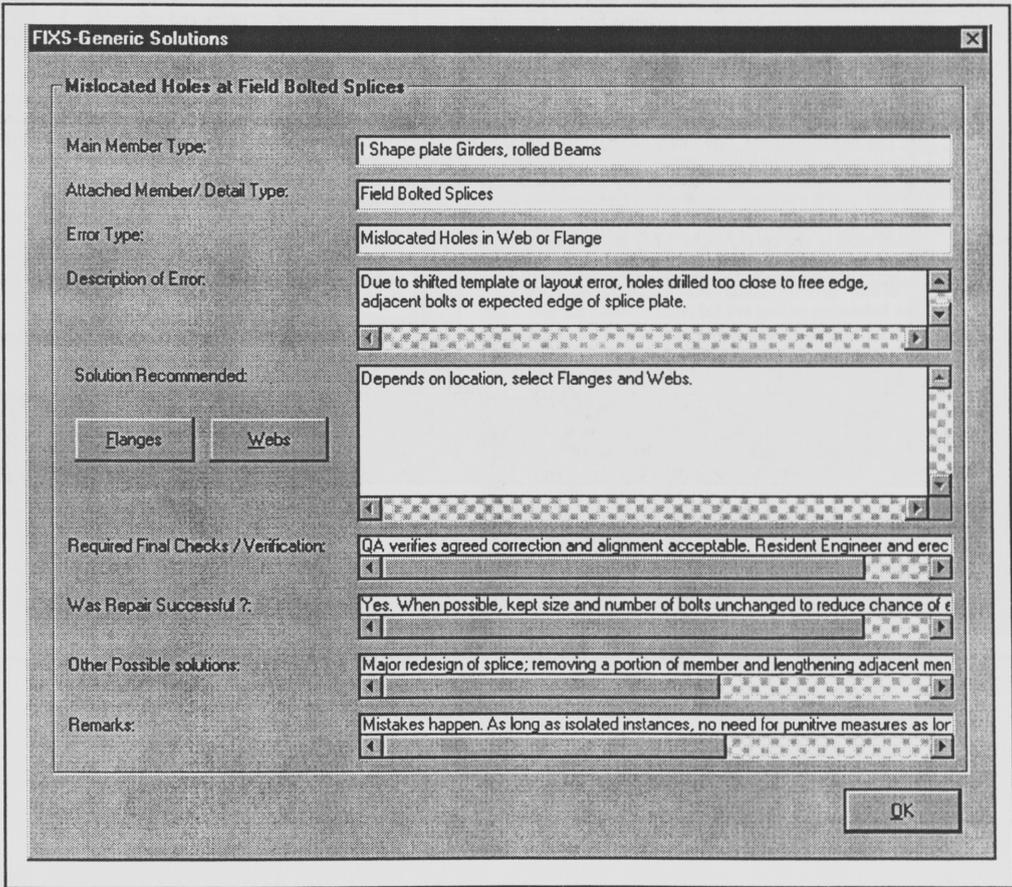


Figure 8 Generic Solutions Dialog for Mislocated Holes at Field Bolted Splices

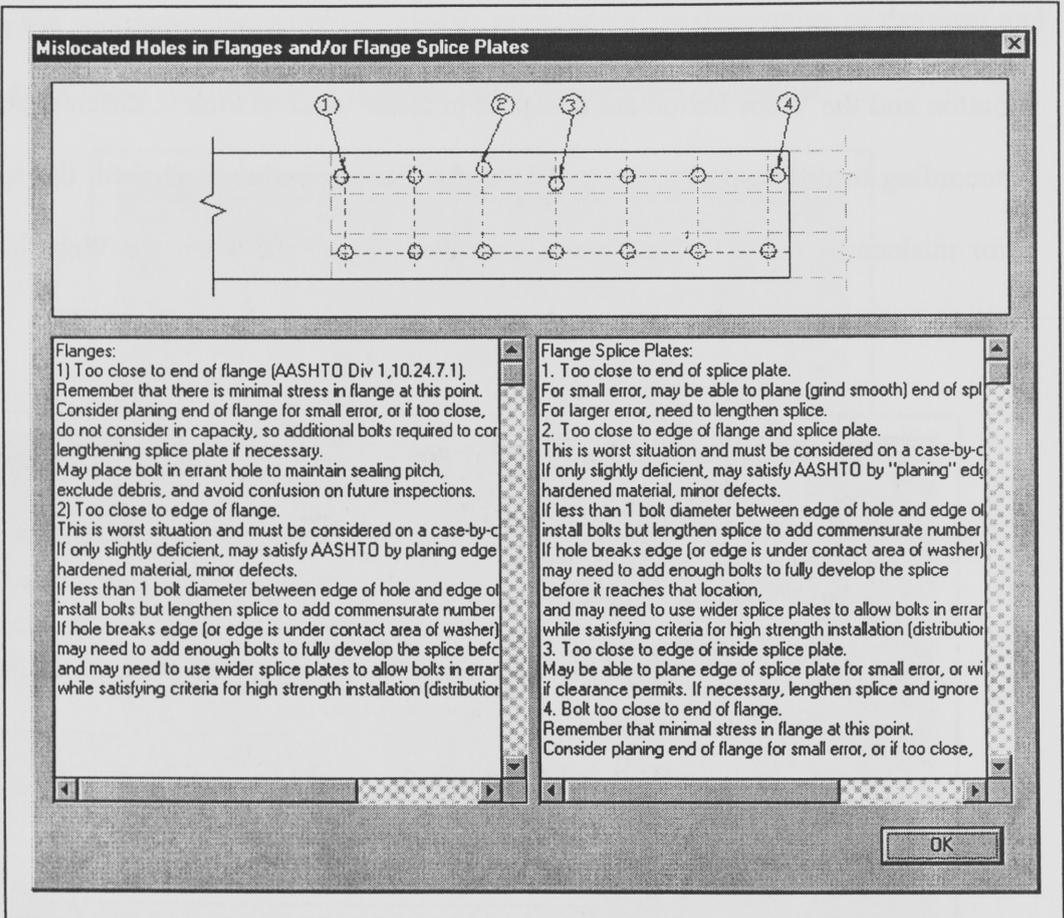


Figure 9 Mislocated Holes in Flanges Dialog

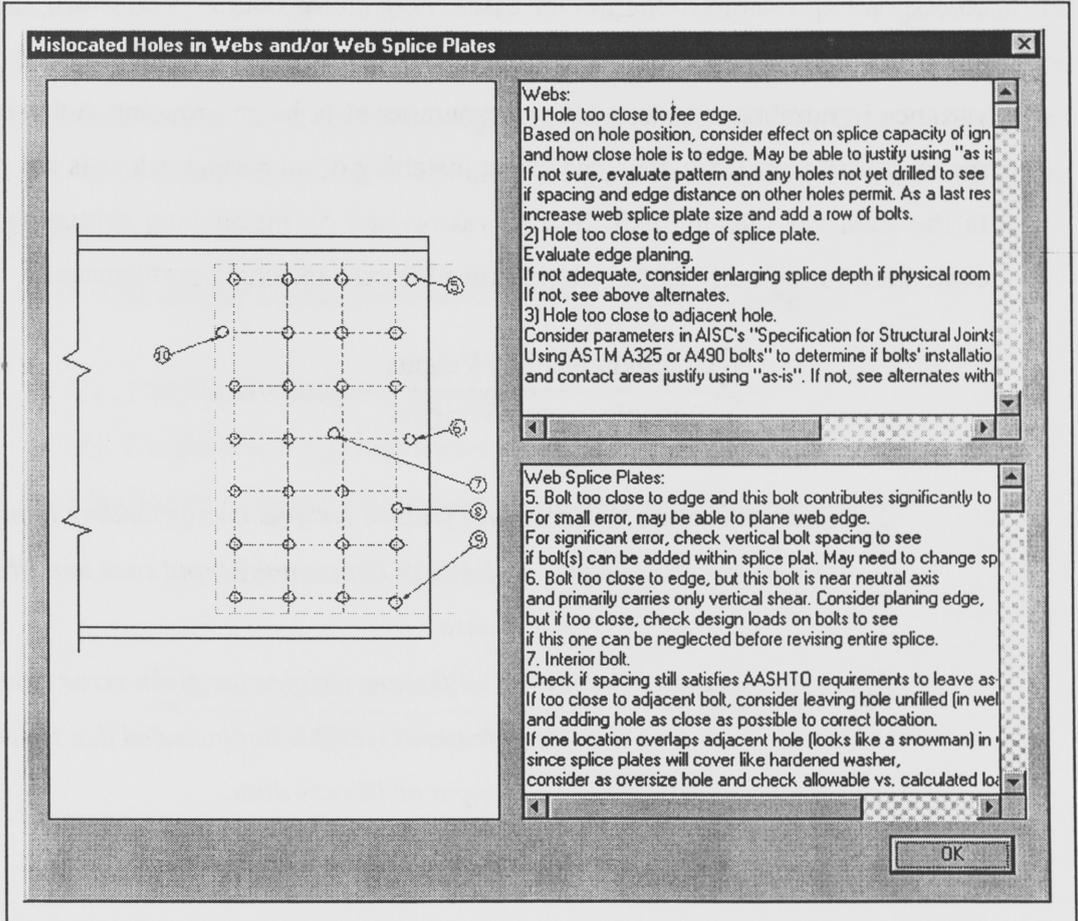


Figure 10 Mislocated Holes in Webs Dialog

### 3.3 CASE MATCHING

The initial version of FIXS used a simple CBR matching process using features and feature weights to retrieve similar cases built on the SCBR expert shell (Greenfield and Roddis 1998). Similarity values were calculated as the summation for common features divided by the summation for possible features (Equation 1). Common features mean those features for the input case that match exactly with the corresponding feature in the library case. The features not matched exactly with each other were thrown out of the matching process. When considering the possible variance in number of holes with error, number of holes in grouping, hole sizes, hole spacing, member dimensions, etc, exact matching of numerical values is not practical. In the final version of FIXS, SCBR was revised by introducing continuous feature evaluation for numeric features to improve the case matching performance,

$$\frac{\sum \text{Common Feature Weights}}{\sum \text{Possible Feature Weights}} = \text{Similarity (\%)}$$

$\sum$  Common Feature Weights - *All feature weights corresponding to matching features between the input case and library case.*

$\sum$  Possible Feature Weights - *All feature weights for given error type less all features weights not included due to lack of input or library data.*

#### Equation 1 Similarity Value Calculation

The revised SCBR is a simple case matching process using features, feature weights and feature evaluations. Feature evaluations are used in the case matching process to describe reasonable maximum ranges for numeric features. Appendix A gives a complete listing of features, feature weights, and feature evaluations for each error type.

Considering reasonable maximum ranges for numeric features, similarity values are calculated for each library case using the feature weights and similarity distances. By default, similarity distance for discrete features is 1, when the feature for the input case matches exactly to the respective feature in the library case, and 0 when the feature for the input case does not match exactly to the respective feature in the library case. For numeric features, the similarity distance equals 1 minus the minimum value of absolute difference of the feature weight of input case and the respective feature weight of library case divided by maximum range, and 1 (Equation 2). The summation for all feature weights multiply the similarity distance is divided by the summation for possible features giving a percentage or similarity value (Equation 3).

$$\text{Similarity Distance} = 1 - \min(\text{abs}(V_2 - V_1) / \text{MaxRange}, 1)$$

$V_1$  . *The feature weight of input case.*

$V_2$  . *The feature weight of library case.*

MaxRange - *The maximum range of the numeric feature.*

### Equation 2 Similarity Distance Calculation

$$\frac{\sum \text{SimilarityDistance} * \text{Feature Weights}}{\sum \text{Possible Feature Weights}} = \text{Similarity (\%)}$$

$\sum \text{Similarity Distance} * \text{Feature Weights}$  - *All features weights multiplied by each similarity distance available between the input case and library case.*

$\sum \text{Possible Feature Weights}$  - *All feature weights for given error type less all features weights not included due to lack of input or library data.*

### Equation 3 Similarity Value Calculation

#### 4.4 EXPLANATION FACILITY

The user interface supports use of an explanation facility. In the initial version of the software, the Why explanation function was implemented providing the explanation why a particular piece of information is being requested during a Find Solutions search. In the final version of the software, the How explanation function is also implemented to provide explanation how a particular solution is being provided at the end of a Find Solutions search.

At the end of a Find Solutions search, the user has the option of asking the application how a particular solution is being provided. Selecting the How button from the Find Solutions dialog box provides either a proof tree for finding a rule solution or a list of features required to locate a case solution of given error type. For a provided rule solution, the proof tree is a tracing of rules used to conclude the rule solution. Rules are shown in a manner that is readable by the user by converting predicate names and values to short descriptions. For a retrieved case solution, the list of features is the features used to describe the similar case. Each feature predicate is translated to a short description in the same manner as rule predicates are translated. The list simply allows the user to see how a similar case is being retrieved to build an input case for searching the case library.

# CHAPTER 4

## EVALUATION

### 4.1 OBJECTIVES OF TESTING AND EVALUATION

Evaluation is an important element in expert system development. Evaluation, which includes field testing, addresses the issue "is the system valuable?" Value is indicated by the degree of end user approval, which in turn determines the extent of acceptance and use of the expert system. According to Gaschnig et al. (J. Gaschnig, P. Klagr, H. Pople, E. Shortliffe, and A. Terry 1983), expert systems are evaluated primarily to test for program accuracy and utility. Gaschnig et al. state that:

*"Evaluations by domain experts help to determine the accuracy of the embedded knowledge and the accuracy of any advice or conclusions that the system provides. Evaluations by users help to determine the utility of the system - namely, whether it produces useful results, the extent of its capabilities, its ease of interaction, the intelligibility and credibility of its results, its efficiency and speed, and its reliability."*

The main purposes of testing and evaluating FIXS are:

- 1) Guaranteeing satisfactory performance to the users and the sponsors of the development efforts.
- 2) Locating weaknesses in the system so further development can be made, e.g., to see whether the knowledge-base is adequately rich, whether problem solving

is sufficiently powerful. As soon as problems are detected, further theoretical or system development will be called for.

3) Evaluating different functions of FIXS. For instance, FIXS can be evaluated as a useful tool for steel engineers, as a reference repository for both national DOTs and fabricators.

## 4.2 DEVELOP EVALUATION CRITERIA

In order to perform the evaluation of FIXS, a set of evaluation criteria is needed. Based on the purposes of testing and evaluating FIXS, the following list of evaluation criteria are developed:

### User Interface

- Is the system easy to learn and to use?
- Are the required input data available and reasonable?

### Guidance and Explanation

- Does the software provide guidance to the user for input data process?
- How well can the system explain its actions?

### System Scope

- How well does the system covers actual cases?

### Quality of Results

- Does the system retrieve a useful case or a set of cases?
- Is the logic of the system correct?
- Does the system provide solutions consistently?

## Overall Performance

- Does the user accept the system?
- Is the system useful as a training tool?
- Can the system be used in the intended work environment?
- Does the system offer an improvement over the practices it is intended to supplement?

## Improvements

- What kind of improvement does the system need to?

## Future Development

- On what kind of aspects does the system need to future develop?

### **4.3 PROPOSED EVALUATION PROCEDURES**

The following evaluation procedures are proposed for FIXS evaluation.

- 1) Select evaluation criteria and specify how each criterion will be measured.

An Evaluation Questionnaire Form is prepared as shown in Appendix E.

- 2) Select a sample of users. Members of Task Group 5 Repair Database formed by national bridge engineers and fabricators from multiple DOTs are good candidates to evaluate FIXS.

- 3) Gather data. Have each user use FIXS on a minimum of three cases. After each case, have the user fill out the field testing report and the evaluation questionnaire form, rating each criterion on the five-point scale.

4) Analyze the data. Summarize all of the ratings of each user on each criterion and across all users for each criterion. Determine if the target level of acceptability has been reached or exceeded for each criterion. The data can then be analyzed.

5) Report the results and recommendations. Report on the strengths and weaknesses of the expert system. Concentrate on suggestions for improving the likelihood of user acceptance by emphasizing features which receive low ratings from the most users and those that could be the most quickly and economically improved.

# CHAPTER 5

## CONCLUSIONS & FUTURE WORK

### 5.1 CONCLUSIONS

As its predecessors have proved, expert systems for fabrication errors can provide solutions and guidance quickly for bridge engineers, reducing cost to both DOTs and fabricators. FIXS, as a second generation expert system in fabrication errors, was successful not only in combining rule-based and case-based approaches to improve effectiveness in performance, but also in enhancing the knowledge base with graphical and instructive information to improve the quality of the knowledge.

For knowledge-based systems, rather than clever search techniques, the knowledge about tasks and problems is a main source of power in problem solving (David, Krivine and Simmons 1993). Although knowledge base enhancement was a time consuming process, the knowledge base of the initial version of FIXS was not only enlarged and cleaned, but also enhanced with sketches and instructions. Collecting actual cases from Task Group 5 and NCSC to enlarge the knowledge base and to cover fabrication errors experienced by multiple DOTs lasted almost one year. A standing peer review panel representing both national DOTs and fabricators formed from Task Group 5 reviewed all rule and case solutions along with sketches contained in FIXS and guaranteed that all solutions were clean and accepted by both multiple

DOTs and fabricators. Sketches and actual case descriptions providing visual and instructive information for case solutions would provide ideas and improve engineers' confidence in non-textbook solutions. In addition to the software, the paper-based knowledge base, FIXS the White Book containing all rule solutions, case solutions, and generic solutions with sketches, could be also used to check solutions as a training guide book or reference. Documentation and exchange of information on fabrication errors could be used by fabricators to prevent the occurrence of such errors in the first place, leading to a reduced number of errors, improving the quality of bridge member fabrication.

A Tutorial tool providing users with a set of categorized generic fabrication errors and solutions was successfully implemented in the software. The tutorial allows users to see what errors occur most commonly for a particular type of design or member and how they could be repaired according to different situations. Bridge engineers, especially new engineers can use this information to produce designs considering some limitations and realities about fabrication; fabricators can use this information to prevent the occurrence of such errors, improving the quality of bridge member fabrication. Also, combining with the Find Solutions tool, the Tutorial tool can provide important information and solutions for common fabrication errors assisting engineers in categorizing situations and determining the best possible solutions to offer the fabricator.

The overall enhancement of the initial version of FIXS has resulted in the following conclusions:

- FIXS covered the actual cases experienced by multiple DOTs.
- The knowledge contained in FIXS was reviewed by a standing peer review panel and accepted by both multiple DOTs and fabricators.
- All solutions in the knowledge base were enhanced with sketches and detailed information.
- The paper-based documents, FIXS the White Book with complete knowledge in FIXS as a training guidebook or reference could be a very useful and valuable document.
- The Tutorial tool can provide general but important information for both engineers and fabricators to improve bridge fabrication.
- The improved case retrieval algorithm by introducing continuous feature evaluations for numeric features improved the case matching performance.
- The Why and How explanation facilities can allow users to see why a piece of information is required and how a solution is located to eliminate the “black box” analogy.
- Evaluation including field testing by Task Group 5 members would provide feedback on both knowledge and utility for FIXS from DOTs and fabricators perspectives.

## 5.2 FUTURE WORK

The software along with documents will be sent out to Task Group 5 members for field evaluation. A set of evaluation criteria was developed to obtain information on User Interface, Guidance and Explanation, System Scope, Quality of Results, Overall Performance, Improvements, and Future Development. After the feedback comes back, the evaluation testing report and questionnaire form will need to be analyzed. Knowing the strengths and weaknesses of the system from evaluation, the aspects which receive low ratings from the most users and those that could be the most quickly and economically done need to be improved.

Once the expert system development effort has been completed, the task of system maintenance begins. It is needed to establish a mechanism for soliciting, receiving and acting upon feedback from the user community. Also in some ways the development of a CBR system is never complete; indeed, this is one of the major benefits of the technology--their ability to learn and improve their performance by acquiring new cases (Watson 1997). The Logic Programming Associates newly retailed ProWeb Server which supports the development, testing and deployment of intelligent, dynamic server-based applications on intranets and the Internet (Logic Programming Associates Ltd 1999). Since the LPA ProWeb Server allows Web sites to use the powerful reasoning capacity of Prolog completely in the background, one practical way is to put the software on the Internet. In addition, a function that can add new cases into the case library after they are reviewed needs to be implemented in the software, such that the system can grow and continue improvement with time.

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# **APPENDIX A**

## **RULE ATTRIBUTES / FEATURES**

## Fabrication error Indexed eXamples & Solutions - Rule Attributes / Features

CLASS	ATTRIBUTE / FEATURE	INPUT PREDICATE	POSSIBLE VALUES				
<b>Error Classification</b>	<i>Tolerance</i>	errorClassification	mislocated hole	edge distance	end distance	mislocated member	
	<i>Cutting</i>		misaligned member	miscut member	misattached member	stress fracture	
	<i>Drilling / Punching</i>		nicks & gouges				
	<i>Lamination</i>		misshaped hole	missized hole	partially drilled hole	welding/heating distortion	
			internal	edge	surface	coating	
<b>Error Stage</b>	<i>Error member attached?</i>	errorStageErrorMemberAttached	yes	no			
	<i>Stage error occurred</i>		layout	fitup	blocking / laydown	field erection	
	<i>Stage error found</i>		layout	fitup	blocking / laydown	field erection	
<b>Structure</b>	<i>Bridge type</i>	bridgeType	plate girder	rolled	box girder	truss	
			combination	other	bascule		
	<i>End supports</i>		simple	continuous	cantilever	balanced cantilever	
	<i>Intermediate supports</i>		simple	continuous	cantilever	balanced cantilever	
	<i>Number of spans</i>						
	<i>Error member type</i>	errorMemberType		plate girder	box girder	capbeam	splice plate
				bearing stiffener	intermediate stiffener	filler plate	diaphragm or brace
				k-connection	flange plate	web plate	rocker
				rolled beam	sole plate	base metal	expansion device
	<i>Error member location</i>	errorMemberLocation		compression flange	web	tension flange	splice
				stiffener attachment	bearing	gusset plate	bolted connection
				base metal			
	<i>Error member classification</i>	errorMemberClass		fracture critical	primary	secondary	unknown
<i>Attached or Intersecting member type</i>	attachMemberType		plate girder	box girder	capbeam	splice plate	
			bearing stiffener	intermediate stiffener	filler plate	diaphragm or brace	
			k-connection	flange plate	web plate	rocker	
			pin and hanger				
<i>Attached or Intersecting member classification</i>	attachMemberClass		fracture critical	primary	secondary	unknown	
<b>Error Member Dimensions</b>	<i>Specified length</i>	errorMemberDesignLength					
	<i>Specified width</i>	errorMemberDesignWidth					
	<i>Specified thickness</i>						
	<i>Specified edge type</i>		flame cut	sheared	rolled	planed	
	<i>Actual length</i>	errorMemberActualLength					
	<i>Actual width</i>	errorMemberActualWidth					
	<i>Actual thickness</i>	errorMemberActualThickness					
	<i>Actual edge type</i>	errorMemberActualEdgeType		flame cut	sheared	rolled	planed

## Fabrication error Indexed eXamples & Solutions - Rule Attributes / Features

CLASS	ATTRIBUTE / FEATURE	INPUT PREDICATE	POSSIBLE VALUES			
Attached or Intersecting Member Dimensions	<i>Specified length</i>					
	<i>Specified width</i>					
	<i>Specified thickness</i>					
	<i>Specified edge type</i>		flame cut	sheared	rolled	planed
	<i>Actual length</i>					
	<i>Actual width</i>					
	<i>Actual thickness</i>					
	<i>Actual edge type</i>		flame cut	sheared	rolled	planed
Hole Details	<i>Hole type</i>	holeDetailsType	circular	short slotted	long slotted	egg shaped
			irregular shaped	oversize	other	
	<i>Boring Procedure</i>	holeDetailsHoleBoringProcedure	drilled	sub drilled	punched	sub punched
			drilled from solid	reamed	template	
	<i>Number with errors</i>	holeDetailsNumberWithErrors				
	<i>Number in grouping</i>	holeDetailsNumberInGrouping				
	<i>Joint slip critical?</i>	holeDetailsJointSlipCritical	yes	no		
	<i>Slots at correct slope?</i>	holeDetailsSlotsAtCorrectSlope	yes	no		
	<i>Holes meet edge &amp; end distance specification?</i>	holeDetailsEdgeEndDistanceSpecification	yes	no		
	<i>Specified bolt diameter</i>					
	<i>Specified hole diameter</i>	holeDetailsSpecifiedHoleDiameter				
	<i>Specified longitudinal hole spacing</i>					
	<i>Specified transverse hole spacing</i>					
	<i>Actual bolt diameter</i>	holeDetailsActualBoltDiameter				
	<i>Actual hole diameter</i>					
	<i>Actual longitudinal hole spacing</i>	holeDetailsActualLongHoleSpacing				
	<i>Actual transverse hole spacing</i>	holeDetailsActualTransverseHoleSpacing				
	<i>Actual elongation distance</i>					
	<i>Partially drilled hole(s) ?</i>		yes	no		
	<i>Partially drilled hole depth</i>	holeDetailsPartDrilledHoleDepth				
<i>Partially drilled hole diameter</i>						
<i>Partially drilled hole coverage of specified hole (%)</i>						
Hole Distance	<i>Distance from error member</i>					
	<i>Distance from intersecting member</i>	holeDistanceFromIntersectingMember				
	<i>Distance from member edge</i>	holeDistanceFromEdge				
	<i>Distance from member end</i>	holeDistanceFromEnd				

## Fabrication error Indexed eXamples & Solutions - Rule Attributes / Features

CLASS	ATTRIBUTE / FEATURE	INPUT PREDICATE	POSSIBLE VALUES			
Mislocated Hole	<i>Distance to correct location</i>	mislocatedHoleDistanceCorrectLocation				
	<i>Hole placed in wrong flange?</i>	mislocatedHoleIncorrectFlange	yes	no		
	<i>Reinforcing steel hole(s)?</i>	mislocatedHoleReinforcingSteelHole	yes	no		
	<i>Error due to additional row bored?</i>	mislocatedHoleAdditionalRowHolesDrilled	yes	no		
	<i>Holes meet edge &amp; end distance specification?</i>	mislocatedHoleEdgeEndDistanceSpecification	yes	no		
	<i>Intersection at current location?</i>	mislocatedHoleIntersectionCurrentPosition	yes	no		
	<i>Specified hole pattern bored correctly?</i>	mislocatedHoleSpecifiedHolePatternCorrect	yes	no		
	<i>Hole pattern interferes with specified pattern?</i>	mislocatedHoleInterfereWithSpecifiedPattern	yes	no		
	<i>Intersection with additional bolt line?</i>	mislocatedHoleIntersectionNewPosition	yes	no		
Mislocated Member	<i>Intersection occurs?</i>	mislocatedMemberIntersection	yes	no		
	<i>Intersected item</i>	mislocatedMemberIntersectedItem	hole	splice plate	attached member	other
	<i>Inverted placement?</i>	mislocatedMemberInvertedPlacement	yes	no		
	<i>Distance to correct location</i>	mislocatedMemberDistanceCorrectLocation				
Stiffener	<i>Stiffener type</i>	stiffenerType	bearing	intermediate	longitudinal	
	<i>Specified thickness</i>					
	<i>Specified length</i>					
	<i>Specified width</i>					
	<i>Specified web thickness</i>					
	<i>Specified clip dimension on web</i>					
	<i>Specified clip dimension on flange</i>					
	<i>Specified spacing between stiffeners</i>					
	<i>Specified diaphragm or brace attachment?</i>	stiffenerSpecifiedDiaphragmAttachment	yes	no		
	<i>Specified flange attachment</i>	stiffenerSpecifiedFlangeAttachment	tension only	compression only	tension & compression	
	<i>Specified tension flange attachment type</i>	stiffenerSpecifiedTensionFlangeAttachmentType	weld	bolted angle	bolted plate	
	<i>Specified compression flange attachment type</i>	stiffenerSpecifiedCompFlangeAttachmentType	weld	bolted angle	bolted plate	
	<i>Actual category 'C' qualified?</i>	stiffenerActualCategoryCFlange	yes	no		
	<i>Actual tension flange clipped?</i>		yes	no		
	<i>Actual compression flange clipped?</i>		yes	no		
	<i>Actual tension flange attached?</i>	stiffenerActualTensionFlangeAttached	yes	no		
	<i>Actual compression flange attached?</i>	stiffenerActualCompFlangeAttached	yes	no		
	<i>Actual tension flange attachment type</i>	stiffenerActualTensionFlangeAttachmentType	weld	bolted angle	bolted plate	
	<i>Actual compression flange attachment type</i>	stiffenerActualCompFlangeAttachmentType	weld	bolted angle	bolted plate	
	<i>Actual bottom within middle 50% of sole plate?</i>	stiffenerActualMiddleOfSolePlate	yes	no		
<i>Actual out of plumbness (%)</i>	stiffenerActualPlumbness					

## Fabrication error Indexed eXamples & Solutions - Rule Attributes / Features

CLASS	ATTRIBUTE / FEATURE	INPUT PREDICATE	POSSIBLE VALUES			
<b>Miscut Member</b>	<i>Miscut occurs at</i>	miscutMemberErrorOccursAt	end	center	entire member	
	<i>Specified sweep</i>	miscutMemberSpecifiedSweep				
	<i>Actual sweep</i>	miscutMemberActualSweep				
	<i>Specified clipped?</i>	miscutMemberSpecifiedClipped	yes	no		
	<i>Actual clipped?</i>	miscutMemberActualClipped	yes	no		
	<i>Clipped dimension correct?</i>	miscutMemberClippedDimensionsCorrect	yes	no		
<b>Stress</b>	<i>Error member stress type</i>	stressErrorMemberType	tension	compression	unknown	
	<i>Error member stress level</i>	stressErrorMemberLevel	high	medium	low	unknown
	<i>Attached or Intersecting member stress level</i>		high	medium	low	unknown
	<i>Fatigue concerns</i>	stressFatigueConcerns	high	medium	low	unknown
	<i>Stress fracture(s) ?</i>	stressFractures	yes	no		
	<i>Maximum gap between fracture(s)</i>	stressMaxGap				
	<i>Number of fractures at location</i>		excessive	moderate	few	single
<b>Lamination</b>	<i>Surface lamination type</i>	laminationSurfaceType	rolling	beer tabs		
	<i>Mapping / Documentation</i>		complete	not complete	in progress	
	<i>Test required</i>		RT	UT	dye penetration	MT
			visual	linear gauge	other	
	<i>Lamination area w.r.t. plate area</i>		small	medium	large	
	<i>Length of deformity</i>					
	<i>Width of deformity</i>					
<b>Nicks &amp; Gouges</b>	<i>Nick or Gouge type</i>	nickGougeType	surface	edge	end	cope
			hole			
	<i>Depth</i>	nickGougeDepth				
	<i>Length</i>					
	<i>Reduction of area</i>		excessive	moderate	small	very small
	<i>Number near location</i>		excessive	moderate	few	single
	<i>Perpendicular to bolt hole?</i>		yes	no		
<i>Grinding causes edge or end distance problem?</i>	nickGougeGrindEdgeEndDistance	yes	no			

## Fabrication error Indexed eXamples & Solutions - Rule Attributes / Features

CLASS	ATTRIBUTE / FEATURE	INPUT PREDICATE	POSSIBLE VALUES			
Surface Alignment	Full surface contact?	surfaceFullSurfaceContact	yes	no		
	Fill plate specified?	surfaceFillPlate	yes	no		
	Heat procedure approved?	surfaceHeatProcedure	yes	no		
	Contact spacing	surfaceContactSpacing				
	Percent contact	surfacePercentContact				
	Fill plate thickness	surfaceFillPlateThickness				
Welding Heating Distortion	Designed Temperature?	designedTemperature				
	Actual Temperature?	actualTemperature				
	Cause of Distortion?	causeOfDistortion	welding	heating	overHeating	
			underSizeWeld	lackOfPreheating	burnThru	
	Type of Distortion?	typeOfDistortion	cupping	tilt	undercamber	overcamber
		buckling	cracking			
Fabrication Status	Detail extensiveness		large	medium	small	
	Connection details		completed	in progress	to be made	
	Curvature		large	medium	small	
	Camber		large	medium	small	
	Percent complete					
	Ease of replacement		hard	medium	easy	
	Curvature complete?		yes	no		
	Camber complete?		yes	no		
Project	Type		fast track	regular speed		
Inspection	Experience		good	medium	poor	
	Examination procedures		RT	UT	dye penetration	MT
			visual	linear gauge	other	
Error	Proximity from intersecting member		very close	close	medium	far
	Degree		large	medium	low	
Paint	Paint damage		undamaged	medium	damaged	
Fabrication	Fabrication experience		good	medium	poor	
	Quality control program		good	medium	poor	
	Fabrication equipment		good	medium	poor	
	Final Products		good	medium	poor	

# **APPENDIX B**

## **CASE ATTRIBUTES / FEATURES**

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Edge Distance (EDGD)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.7	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Error member actual edge type</i>	errorMemberActualEdgeType	0.8	
	<i>Attached or Intersecting member actual edge type</i>	attachMemberActualEdgeType	0.4	
	<i>Hole type</i>	holeDetailsType	0.8	
	<i>Number of holes with errors</i>	holeDetailsNumberWithErrors	0.5	50
	<i>Number of holes in grouping</i>	holeDetailsNumberInGrouping	0.5	100
	<i>Actual bolt diameter</i>	holeDetailsActualBoltDiameter	0.5	2
	<i>Actual hole diameter</i>	holeDetailsActualHoleDiameter	0.5	2
	<i>Actual longitudinal hole spacing</i>	holeDetailsActualLongHoleSpacing	0.3	10
	<i>Actual transverse hole spacing</i>	holeDetailsActualTransverseHoleSpacing	0.3	10
	<i>Specified bolt diameter</i>	holeDetailsSpecifiedBoltDiameter	0.5	2
	<i>Specified hole diameter</i>	holeDetailsSpecifiedHoleDiameter	0.5	2
	<i>Specified longitudinal hole spacing</i>	holeDetailsSpecifiedLongHoleSpacing	0.3	10
	<i>Specified transverse hole spacing</i>	holeDetailsSpecifiedTransverseHoleSpacing	0.3	10
	<i>Partially drilled hole(s)?</i>	holeDetailsPartDrilledHole	0.5	
	<i>Partially drilled hole diameter</i>	holeDetailsPartDrilledHoleDiameter	0.2	2
	<i>Partially drilled hole depth</i>	holeDetailsPartDrilledHoleDepth	0.5	2
	<i>Partially drilled hole coverage of specified hole (%)</i>	holeDetailsPartDrilledHoleCoverage	0.5	100
	<i>Hole boring Procedure</i>	holeDetailsHoleBoringProcedure	0.6	
	<i>Hole distance from intersecting member</i>	holeDistanceFromIntersectingMember	0.3	20
	<i>Hole distance from error member</i>	holeDistanceFromErrorMember	0.3	20
	<i>Hole distance from member edge</i>	holeDistanceFromEdge	0.8	5
	<i>Hole distance from member end</i>	holeDistanceFromEnd	0.5	5

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
End Distance (ENDD)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.7	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Error member actual edge type</i>	errorMemberActualEdgeType	0.8	
	<i>Attached or Intersecting member actual edge type</i>	attachMemberActualEdgeType	0.4	
	<i>Hole type</i>	holeDetailsType	0.8	
	<i>Number of holes with errors</i>	holeDetailsNumberWithErrors	0.5	50
	<i>Number of holes in grouping</i>	holeDetailsNumberInGrouping	0.5	100
	<i>Actual bolt diameter</i>	holeDetailsActualBoltDiameter	0.5	2
	<i>Actual hole diameter</i>	holeDetailsActualHoleDiameter	0.5	2
	<i>Actual longitudinal hole spacing</i>	holeDetailsActualLongHoleSpacing	0.3	10
	<i>Actual transverse hole spacing</i>	holeDetailsActualTransverseHoleSpacing	0.3	10
	<i>Specified bolt diameter</i>	holeDetailsSpecifiedBoltDiameter	0.5	2
	<i>Specified hole diameter</i>	holeDetailsSpecifiedHoleDiameter	0.5	2
	<i>Specified longitudinal hole spacing</i>	holeDetailsSpecifiedLongHoleSpacing	0.3	10
	<i>Specified transverse hole spacing</i>	holeDetailsSpecifiedTransverseHoleSpacing	0.3	10
	<i>Partially drilled hole(s)?</i>	holeDetailsPartDrilledHole	0.5	
	<i>Partially drilled hole diameter</i>	holeDetailsPartDrilledHoleDiameter	0.2	2
	<i>Partially drilled hole depth</i>	holeDetailsPartDrilledHoleDepth	0.5	2
	<i>Partially drilled hole coverage of specified hole (%)</i>	holeDetailsPartDrilledHoleCoverage	0.5	100
	<i>Hole boring Procedure</i>	holeDetailsHoleBoringProcedure	0.6	
	<i>Hole distance from intersecting member</i>	holeDistanceFromIntersectingMember	0.3	20
	<i>Hole distance from error member</i>	holeDistanceFromErrorMember	0.3	20
	<i>Hole distance from member edge</i>	holeDistanceFromEdge	0.5	5
<i>Hole distance from member end</i>	holeDistanceFromEnd	0.8	5	

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
<b>Edge Lamination (EDGL)</b>	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.6	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.3	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Mapping / Documentation</i>	laminationMappingDocumentation	0.7	
	<i>Test required</i>	laminationTestRequired	0.6	
	<i>Length of deformity</i>	laminationLengthOfDeformity	0.5	200
<i>Width of deformity</i>	laminationWidthOfDeformity	0.5	100	
<b>Internal Lamination (INTL)</b>	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.6	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.3	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Mapping / Documentation</i>	laminationMappingDocumentation	0.7	
	<i>Test required</i>	laminationTestRequired	0.6	
	<i>Length of deformity</i>	laminationLengthOfDeformity	0.5	200
<i>Width of deformity</i>	laminationWidthOfDeformity	0.5	100	
<b>Surface Lamination (SURL)</b>	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.6	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.3	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Surface lamination type</i>	laminationSurfaceType	0.9	
	<i>Mapping / Documentation</i>	laminationMappingDocumentation	0.7	
	<i>Test required</i>	laminationTestRequired	0.6	
<i>Length of deformity</i>	laminationLengthOfDeformity	0.5	200	
<i>Width of deformity</i>	laminationWidthOfDeformity	0.5	100	

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Misaligned Member (MALM)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.7	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Contact spacing</i>	surfaceContactSpacing	0.7	5
	<i>Percent contact</i>	surfacePercentContact	0.7	100
	<i>Fill plate thickness</i>	surfaceFillPlateThickness	0.5	2
	<i>Fill plate specified?</i>	surfaceFillPlate	0.7	
	<i>Full surface contact?</i>	surfaceFullSurfaceContact	0.7	
	<i>Heat procedure approved?</i>	surfaceHeatProcedure	0.7	
	<i>Member distance to correct location</i>	mislocatedMemberDistanceCorrectLocation	0.5	20
Misattached Member (MATM)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.6	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Stiffener type</i>	stiffenerType	0.7	
	<i>Specified thickness</i>	stiffenerSpecifiedThickness	0.2	1
	<i>Specified width</i>	stiffenerSpecifiedWidth	0.2	10
	<i>Specified length</i>	stiffenerSpecifiedLength	0.2	1000
	<i>Specified web thickness</i>	stiffenerSpecifiedWebThickness	0.3	1.5
	<i>Specified clip dimensions on web</i>	stiffenerSpecifiedClipDimensionsOnWeb	0.3	10
	<i>Specified clip dimensions on flange</i>	stiffenerSpecifiedClipDimensionsOnFlange	0.3	10
	<i>Specified spacing between stiffeners</i>	stiffenerSpecifiedSpacingBetween	0.5	50
	<i>Specified diaphragm or brace attachment?</i>	stiffenerSpecifiedDiaphragmAttachment	0.5	
	<i>Specified flange attachment</i>	stiffenerSpecifiedFlangeAttachment	0.7	
	<i>Specified tension flange attachment type</i>	stiffenerSpecifiedTensionFlangeAttachmentType	0.7	
	<i>Specified compression flange attachment type</i>	stiffenerSpecifiedCompFlangeAttachmentType	0.7	
	<i>Actual tension flange attachment type</i>	stiffenerActualTensionFlangeAttachmentType	0.7	
	<i>Actual compression flange attachment type</i>	stiffenerActualCompFlangeAttachmentType	0.7	

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Misattached Member (MATM)	<i>Actual category 'C' qualified?</i>	stiffenerActualCategoryCFlange	0.5	
	<i>Actual tension flange clipped?</i>	stiffenerActualTensionFlangeClipped	0.3	
	<i>Actual compression flange clipped?</i>	stiffenerActualCompFlangeClipped	0.3	
	<i>Actual tension flange attached?</i>	stiffenerActualTensionFlangeAttached	0.8	
	<i>Actual compression flange attached?</i>	stiffenerActualCompFlangeAttached	0.8	
Miscut Member (MCTM)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.8	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Error member specified length</i>	errorMemberDesignLength	0.5	2000
	<i>Error member specified width</i>	errorMemberDesignWidth	0.6	20
	<i>Error member specified thickness</i>	errorMemberDesignThickness	0.6	3
	<i>Error member actual length</i>	errorMemberActualLength	0.6	2000
	<i>Error member actual width</i>	errorMemberActualWidth	0.6	20
	<i>Error member actual thickness</i>	errorMemberActualThickness	0.6	3
	<i>Attached or Intersecting member specified length</i>	attachMemberDesignLength	0.3	2000
	<i>Attached or Intersecting member specified width</i>	attachMemberDesignWidth	0.3	20
	<i>Attached or Intersecting member specified thickness</i>	attachMemberDesignThickness	0.3	3
	<i>Attached or Intersecting member actual length</i>	attachMemberActualLength	0.3	2000
	<i>Attached or Intersecting member actual width</i>	attachMemberActualWidth	0.3	20
	<i>Attached or Intersecting member actual thickness</i>	attachMemberActualThickness	0.3	3
	<i>Error member stress level</i>	stressErrorMemberLevel	0.9	
	<i>Attached or Intersecting member stress level</i>	stressAttachMemberLevel	0.7	
	<i>Miscut occurs at</i>	miscutMemberErrorOccursAt	0.7	
	<i>Member specified clipped?</i>	miscutMemberSpecifiedClipped	0.6	
	<i>Member actually clipped?</i>	miscutMemberActualClipped	0.6	
	<i>Clipped dimension correct?</i>	miscutMemberClippedDimensionsCorrect	0.6	
	<i>Member actual sweep</i>	miscutMemberActualSweep	0.5	10
	<i>Member specified sweep</i>	miscutMemberSpecifiedSweep	0.5	10

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Mislocated	Bridge type	bridgeType	0.2	
Hole	Error member type	errorMemberType	0.8	
(MLCH)	Attached or Intersecting member type	attachMemberType	0.5	
	Error member location	errorMemberLocation	0.7	
	Error member classification	errorMemberClass	0.3	
	Attached or Intersecting member classification	attachMemberClass	0.3	
	Hole type	holeDetailsType	0.5	
	Number of holes with errors	holeDetailsNumberWithErrors	0.5	50
	Number of holes in grouping	holeDetailsNumberInGrouping	0.5	100
	Actual bolt diameter	holeDetailsActualBoltDiameter	0.3	2
	Actual hole diameter	holeDetailsActualHoleDiameter	0.3	2
	Actual longitudinal hole spacing	holeDetailsActualLongHoleSpacing	0.5	10
	Actual transverse hole spacing	holeDetailsActualTransverseHoleSpacing	0.5	10
	Specified bolt diameter	holeDetailsSpecifiedBoltDiameter	0.3	2
	Specified hole diameter	holeDetailsSpecifiedHoleDiameter	0.3	2
	Specified longitudinal hole spacing	holeDetailsSpecifiedLongHoleSpacing	0.5	10
	Specified transverse hole spacing	holeDetailsSpecifiedTransverseHoleSpacing	0.5	10
	Partially drilled hole(s)?	holeDetailsPartDrilledHole	0.6	
	Partially drilled hole diameter	holeDetailsPartDrilledHoleDiameter	0.3	2
	Partially drilled hole depth	holeDetailsPartDrilledHoleDepth	0.6	3
	Partially drilled hole coverage of specified hole (%)	holeDetailsPartDrilledHoleCoverage	0.7	100
	Hole boring Procedure	holeDetailsHoleBoringProcedure	0.2	
	Hole distance from intersecting member	holeDistanceFromIntersectingMember	0.6	20
	Hole distance from error member	holeDistanceFromErrorMember	0.6	20
	Hole distance from member edge	holeDistanceFromEdge	0.7	5
	Hole distance from member end	holeDistanceFromEnd	0.7	5
	Hole distance to correct location	mislocatedHoleDistanceCorrectLocation	0.5	20
	Hole placed in wrong flange?	mislocatedHoleIncorrectFlange	0.8	
	Reinforcing steel hole(s)?	mislocatedHoleReinforcingSteelHole	0.9	
	Error due to additional row bored?	mislocatedHoleAdditionalRowHolesDrilled	0.7	
	Holes meet edge & end distance specification?	mislocatedHoleEdgeEndDistanceSpecification	0.7	
	Intersection at current location?	mislocatedHoleIntersectionCurrentPosition	0.8	
	Specified hole pattern bored correctly?	mislocatedHoleSpecifiedHolePatternCorrect	0.7	
	Hole pattern interferes with specified pattern?	mislocatedHoleInterfereWithSpecifiedPattern	0.8	
	Intersection with additional bolt line?	mislocatedHoleIntersectionNewPosition	0.7	

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Mislocated Member (MLCM)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.8	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.8	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Intersection occurs?</i>	mislocatedMemberIntersection	0.9	
	<i>Inverted placement?</i>	mislocatedMemberInvertedPlacement	0.8	
	<i>Member distance to correct location</i>	mislocatedMemberDistanceCorrectLocation	0.5	
	<i>Intersected item</i>	mislocatedMemberIntersectedItem	0.5	
	<i>Stiffener type</i>	stiffenerType	0.7	
	<i>Specified thickness</i>	stiffenerSpecifiedThickness	0.2	1
	<i>Specified width</i>	stiffenerSpecifiedWidth	0.2	10
	<i>Specified length</i>	stiffenerSpecifiedLength	0.2	1000
	<i>Specified web thickness</i>	stiffenerSpecifiedWebThickness	0.4	1.5
	<i>Specified clip dimensions on web</i>	stiffenerSpecifiedClipDimensionsOnWeb	0.2	10
	<i>Specified clip dimensions on flange</i>	stiffenerSpecifiedClipDimensionsOnFlange	0.2	10
	<i>Specified spacing between stiffeners</i>	stiffenerSpecifiedSpacingBetween	0.5	50
	<i>Specified diaphragm or brace attachment?</i>	stiffenerSpecifiedDiaphragmAttachment	0.7	
	<i>Specified flange attachment</i>	stiffenerSpecifiedFlangeAttachment	0.2	
	<i>Specified tension flange attachment type</i>	stiffenerSpecifiedTensionFlangeAttachmentType	0.2	
	<i>Specified compression flange attachment type</i>	stiffenerSpecifiedCompFlangeAttachmentType	0.2	
	<i>Actual tension flange attachment type</i>	stiffenerActualTensionFlangeAttachmentType	0.5	
	<i>Actual compression flange attachment type</i>	stiffenerActualCompFlangeAttachmentType	0.5	
	<i>Actual category 'C' qualified?</i>	stiffenerActualCategoryCFlange	0.7	
	<i>Actual tension flange clipped?</i>	stiffenerActualTensionFlangeClipped	0.2	
	<i>Actual compression flange clipped?</i>	stiffenerActualCompFlangeClipped	0.2	
	<i>Actual tension flange attached?</i>	stiffenerActualTensionFlangeAttached	0.3	
	<i>Actual compression flange attached?</i>	stiffenerActualCompFlangeAttached	0.3	
	<i>Actual out of plumbness (%)</i>	stiffenerActualPlumbness	0.8	10
	<i>Actual bottom within middle 50% of sole plate?</i>	stiffenerActualMiddleOfSolePlate	0.8	

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Missshaped Hole (MSPH)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.6	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.7	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Hole type</i>	holeDetailsType	0.9	
	<i>Joint slip critical?</i>	holeDetailsJointSlipCritical	0.8	
	<i>Specified hole diameter</i>	holeDetailsSpecifiedHoleDiameter	0.5	2
	<i>Actual hole elongation distance</i>	holeDetailsActualDistanceElongated	0.7	2
<i>Slots at correct slope?</i>	holeDetailsSlotsAtCorrectSlope	0.8		
Missized Hole (MSZH)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.5	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.4	
	<i>Error member location</i>	errorMemberLocation	0.6	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Hole type</i>	holeDetailsType	0.7	
	<i>Number of holes with errors</i>	holeDetailsNumberWithErrors	0.4	50
	<i>Number of holes in grouping</i>	holeDetailsNumberInGrouping	0.4	100
	<i>Actual bolt diameter</i>	holeDetailsActualBoltDiameter	0.8	2
	<i>Actual hole diameter</i>	holeDetailsActualHoleDiameter	0.8	2
	<i>Specified bolt diameter</i>	holeDetailsSpecifiedBoltDiameter	0.8	2
	<i>Specified hole diameter</i>	holeDetailsSpecifiedHoleDiameter	0.8	2
<i>Holes meet edge &amp; end distance specification?</i>	holeDetailsEdgeEndDistanceSpecification	0.8		

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Nicks & Gouges (NAGS)	<i>Bridge type</i>	bridgeType	0.5	
	<i>Error member type</i>	errorMemberType	0.6	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member location</i>	errorMemberLocation	0.6	
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Nick or Gouge type</i>	nickGougeType	1.0	
	<i>Nick or Gouge depth</i>	nickGougeDepth	0.5	1
	<i>Nick or Gouge length</i>	nickGougeLength	0.5	5
	<i>Error member actual thickness</i>	errorMemberActualThickness	0.5	3
	<i>Error member stress type</i>	stressErrorMemberType	0.6	
	<i>Error member stress level</i>	stressErrorMemberLevel	0.8	
	<i>Error member actual edge type</i>	errorMemberActualEdgeType	0.4	
	<i>Nick or Gouge reduction of area</i>	nickGougeReductionOfArea	0.8	
	<i>Number of nicks or gouges near location</i>	nickGougeNumberNearLocation	0.5	
	<i>Nick or Gouge perpendicular to bolt hole?</i>	nickGougePerpendicularToBoltHole	1.0	
	<i>Error member actual width</i>	errorMemberActualWidth	0.4	20
	<i>Error member specified width</i>	errorMemberDesignWidth	0.4	20
<i>Error member actual length</i>	errorMemberActualLength	0.4	1000	
<i>Error member specified length</i>	errorMemberDesignLength	0.4	1000	
Partially Drilled Hole (PDRH)	<i>Bridge type</i>	bridgeType	0.4	
	<i>Error member type</i>	errorMemberType	0.6	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.3	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.5	
	<i>Error member actual thickness</i>	errorMemberActualThickness	0.8	3
	<i>Error member classification</i>	errorMemberClass	0.3	
	<i>Error member location</i>	errorMemberLocation	0.5	
	<i>Actual hole diameter</i>	holeDetailsActualHoleDiameter	0.5	2
	<i>Partially drilled hole depth</i>	holeDetailsPartDrilledHoleDepth	0.8	3
	<i>Specified hole diameter</i>	holeDetailsSpecifiedHoleDiameter	0.5	2
	<i>Hole type</i>	holeDetailsType	0.6	

## Fabrication error Indexed eXamples & Solutions - Case Attributes / Features

TYPE	ATTRIBUTE / FEATURE	INPUT PREDICATE	WEIGHT	MAXIMUM RANGE
Stress Fracture (SFRC)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.7	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.7	
	<i>Error member location</i>	errorMemberLocation	0.8	
	<i>Error member classification</i>	errorMemberClass	0.5	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.5	
	<i>Error member stress level</i>	stressErrorMemberLevel	0.8	
	<i>Attached or Intersecting member stress level</i>	stressAttachMemberLevel	0.8	
	<i>Fatigue concerns</i>	stressFatigueConcerns	0.8	
	<i>Stress fracture(s) ?</i>	stressFractures	0.9	
	<i>Maximum gap between fracture(s)</i>	stressMaxGap	0.6	0.5
<i>Number of fractures near location</i>	stressNumberOfFracturesAtLocation	0.6		
<i>Angle of bend at fracture(s)</i>	stressAngleOfBend	0.5	2	
Welding Heating Distortion (WHD)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.7	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.5	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.7	
	<i>Error member classification</i>	errorMemberClass	0.5	
	<i>Error member location</i>	errorMemberLocation	0.8	
	<i>Designed temperature?</i>	designedTemperature	0.6	
	<i>Actual temperature?</i>	actualTemperature	0.6	
	<i>Cause of distortion</i>	causeOfDistortion	0.8	
<i>Type of distortion</i>	typeOfDistortion	0.8		
Coating (COAT)	<i>Bridge type</i>	bridgeType	0.3	
	<i>Error member type</i>	errorMemberType	0.7	
	<i>Attached or Intersecting member classification</i>	attachMemberClass	0.5	
	<i>Attached or Intersecting member type</i>	attachMemberType	0.7	
	<i>Error member classification</i>	errorMemberClass	0.5	
	<i>Error member location</i>	errorMemberLocation	0.8	

# **APPENDIX C**

## **TASK GROUP 5 REPAIR DATABASE PARTICIPATION LISTING**

## Task Group 5 Repair Database Participation Listing

Name	Organization	Address	Phone / Fax	E-mail
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Buck Roberds BR	PDM Bridge - Wausau	3526 West Sherman Street Wausau, WI 54401	(715) 845-3191 x247 fax (715) 845-9129	_____
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# **APPENDIX D**

## **NCSC PARTICIPATION LISTING**

## NCSC Participation Listing

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# **APPENDIX E**

## **FIXS EVALUATION QUESTIONNAIRE LIST**

# FIXS Evaluation Questionnaire Form

User Name: \_\_\_\_\_ State DOT Name: \_\_\_\_\_

Date of Evaluation: \_\_\_\_\_

## Evaluation System:

N/A	Not Applicable
1	Unacceptable
2	Somewhat Acceptable
3	Acceptable
4	Somewhat Highly Acceptable
5	Highly Acceptable

## Evaluation Criteria

### A. User Interface

\_\_\_\_\_ (a) Is the system easy to learn and to use?  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_ (b) Are the required input data available and reasonable?  
\_\_\_\_\_  
\_\_\_\_\_

### B. Guidance and Explanation

\_\_\_\_\_ (a) Does the software provide guidance to the user for inputting data?  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_ (b) How well can the system explain its actions?  
\_\_\_\_\_  
\_\_\_\_\_

**C. System Scope**

\_\_\_\_\_ (a) How well does the system covers actual cases?

---

---

**D. Quality of Results**

\_\_\_\_\_ (a) Does the system retrieve a useful case or a set of cases?

---

---

\_\_\_\_\_ (b) Is the logic of the system correct?

---

---

\_\_\_\_\_ (c) Does the system provide solutions consistently?

---

---

**E. Overall Performance**

\_\_\_\_\_ (a) Does the user accept the system?

---

---

\_\_\_\_\_ (b) Is the system useful as a training tool?

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\_\_\_\_\_ (c) Can the system be used in the intended work environment?

---

---

\_\_\_\_\_ (d) Does the system offer an improvement over the practices it is intended to supplement?

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# **APPENDIX F**

## **FIXS THE WHITE BOOK**



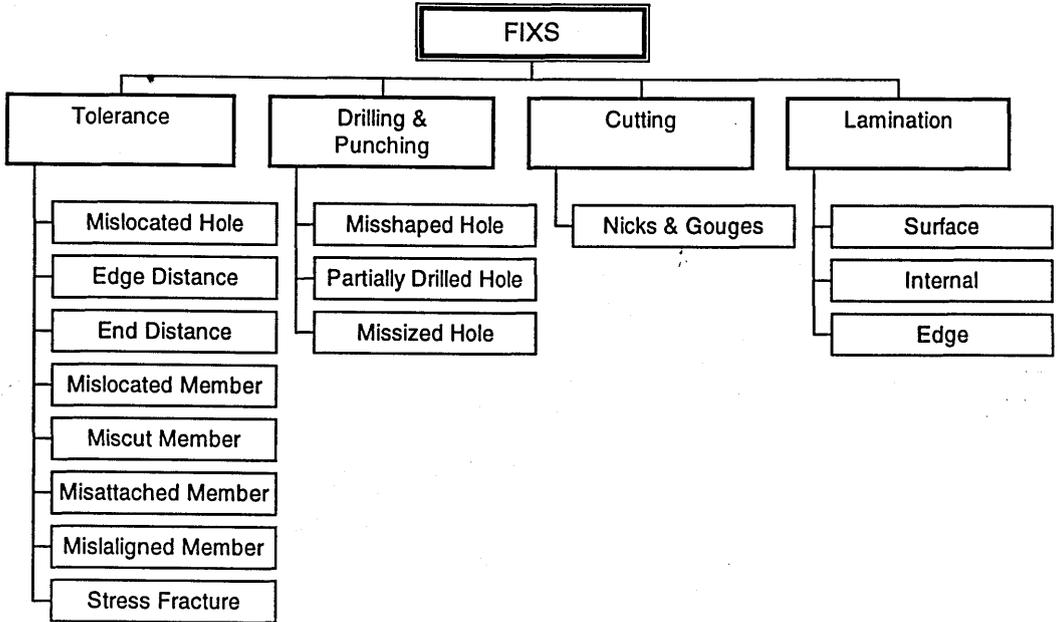
# The White Book

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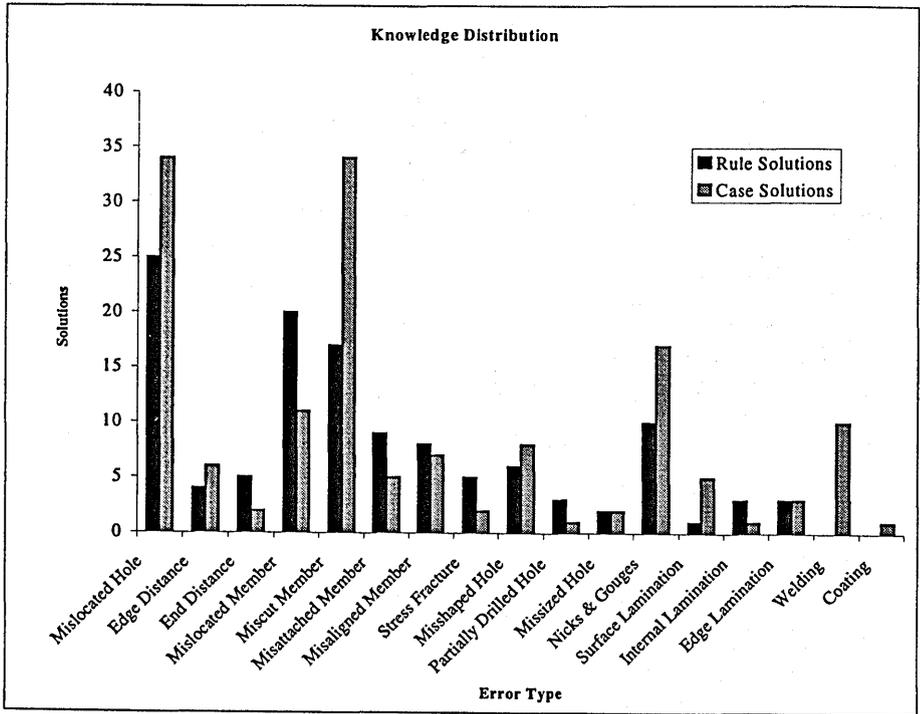
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# Fabrication Error Types



# Knowledge Distribution



Error Type	Rule Solutions	Case Solutions
Mislocated Hole	25	34
Edge Distance	4	6
End Distance	5	2
Mislocated Member	20	11
Miscut Member	17	34
Misattached Member	9	5
Misaligned Member	8	7
Stress Fracture	5	2
Misshaped Hole	6	8
Partially Drilled Hole	3	1
Missized Hole	2	2
Nicks & Gouges	10	17
Surface Lamination	1	5
Internal Lamination	3	1
Edge Lamination	3	3
Welding		10
Coating		1
<b>Total:</b>	<b>121</b>	<b>149</b>

# Tolerance

## Mislocated Hole Cases:

% Solution 1

caseSolution(misllocatedHole\_1,misllocatedHole,'MLCH-C001','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :4,
  holeDetailsNumberInGrouping :38,
  holeDetailsActualLongHoleSpacing :3,
  holeDetailsActualTransverseHoleSpacing :1,
  holeDetailsSpecifiedLongSpacing :3,
  holeDetailsSpecifiedTransverseSpacing :0,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleDistanceCorrectLocation :1,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :false,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
]
```

Intersection of existing member or holes does not occur at current location or new placement location.

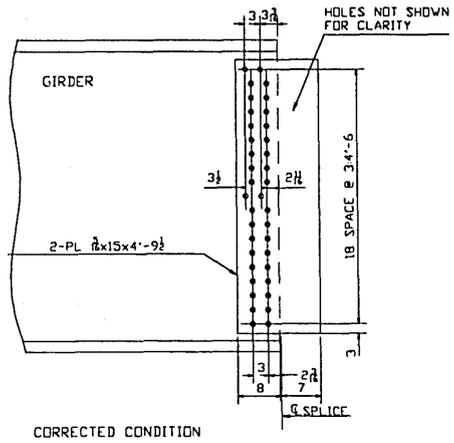
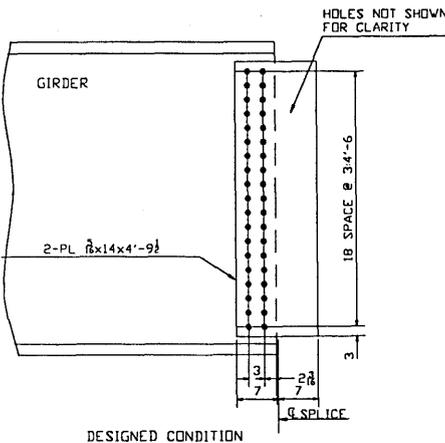
Custom fabricate new splice plates to match as built conditions.

New splice plate will require additional set of holes due to lack of Edge-End distance.\*

).

Case # JJ148:

Description of Error: The 11/16 dia. web lay down holes on a girder have been laid out and drilled. Four holes are mislocated.  
 Solution Recommended: To leave the holes in this location and custom fabricate new splice plates to match existing girder web holes.



ELEV

% Solution 2

caseSolution(misllocatedHole\_2,misllocatedHole,'MLCH-C002','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :rolled,
  attachMemberType     :diaphragmBrace,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :9,
  holeDetailsHoleBoringProcedure :punched,
  misllocatedHoleDistanceCorrectLocation :1.5,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
]
```

].  
'It is OK to leave the hole as is as long as the erroneous hole is covered.

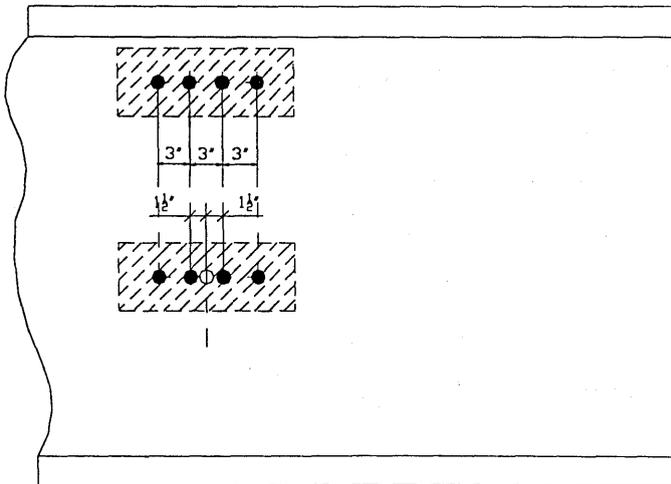
There will be diaphragms connection plates on both sides covering the erroneous hole.'

).

Case #DL167:

Description of Error: 8 holes in the beam are used to attach a diaphragm. An extra hole was inadvertently punched at the center line of the bottom hole group.

Solution Recommended: Ok, to leave error as is. This is an interior beam, so there will be diaphragms on both sides covering the erroneous hole.



ELEV

% Solution 3

caseSolution(misllocatedHole\_3,misllocatedHole,'MLCH-C003','Misllocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :capBeam,
  attachMemberType    :splicePlate,
  errorMemberLocation  :web,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :16,
  holeDetailsNumberInGrouping :16,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleDistanceCorrectLocation :30.5,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
],
```

'Intersection of existing member or holes does not occur at current location or new placement location.

The misllocated holes do not interfere with specified placement of hole pattern.

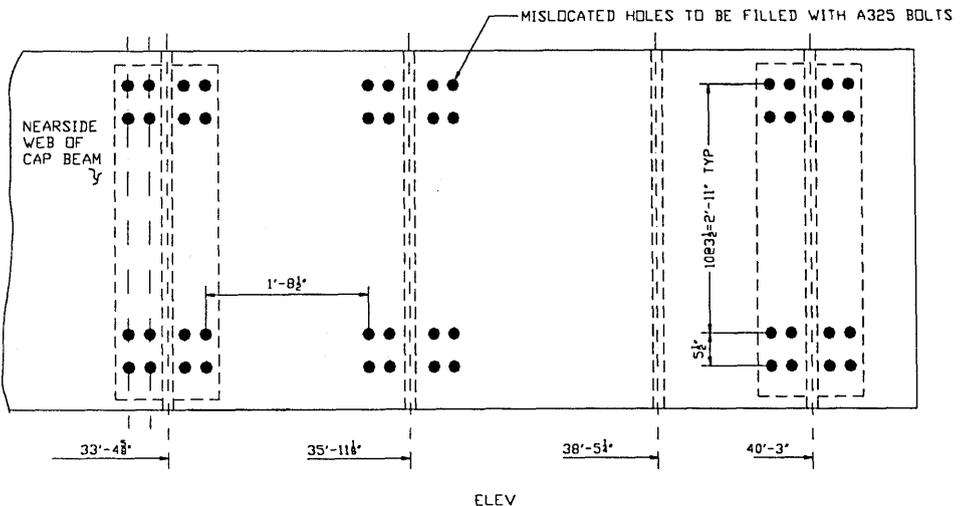
Leave existing holes in place and bolt with double washers.'

).

Case #FB155:

Description of Error: A cap beam had a hole pattern misllocated and drilled in the near side web. The hole pattern intended for extension dimension 33'-4 5/8" was misllocated and drilled at extension dimension 35'-11 1/8".

Solution Recommended: To fill these holes with A325 bolts.



% Solution 4

caseSolution(mislocatedHole\_4,mislocatedHole,'MLCH-C004','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :capBeam,
  attachMemberType    :bearingStiffener,
  errorMemberLocation  :boltedConnection,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :14,
  mislocatedHoleDistanceCorrectLocation :1.1875,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :true,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
]
```

'Intersection of the hole and stiffener occurs at the current location.

Interference occurs with the stiffener.

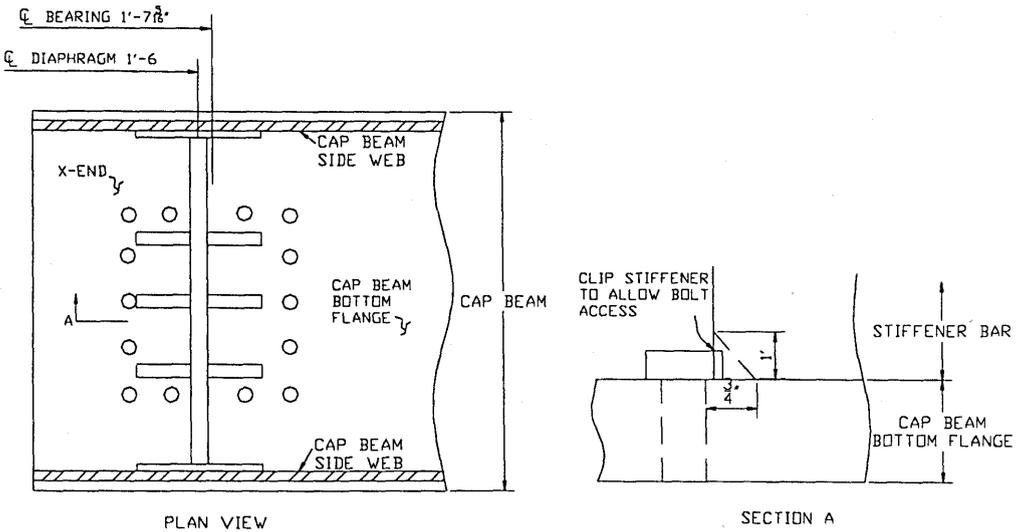
Clip the stiffener to allow bolt access.'

).

Case # MG117:

Description of Error: Due to misalignment of columns in the field, fabricator has shifted the hole pattern for the bearing assembly at one end of a cap beam by 1-3/16 inches. The results of this shifting of holes are 1 hole falls next to a stiffener and will interfere with the installation of the bolt. The fabricator requested authorization to clip the stiffener to allow bolt access.

Solution Recommended: To clip the stiffener to allow bolt access.



% Solution 5

caseSolution(misllocatedHole\_5,misllocatedHole,'MLCH-C005','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :boxGirder,
  errorMemberType     :boxGirder,
  attachMemberType    :boxGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :7,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :true,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :true,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:true
],
```

'The hole intersects with the connection.

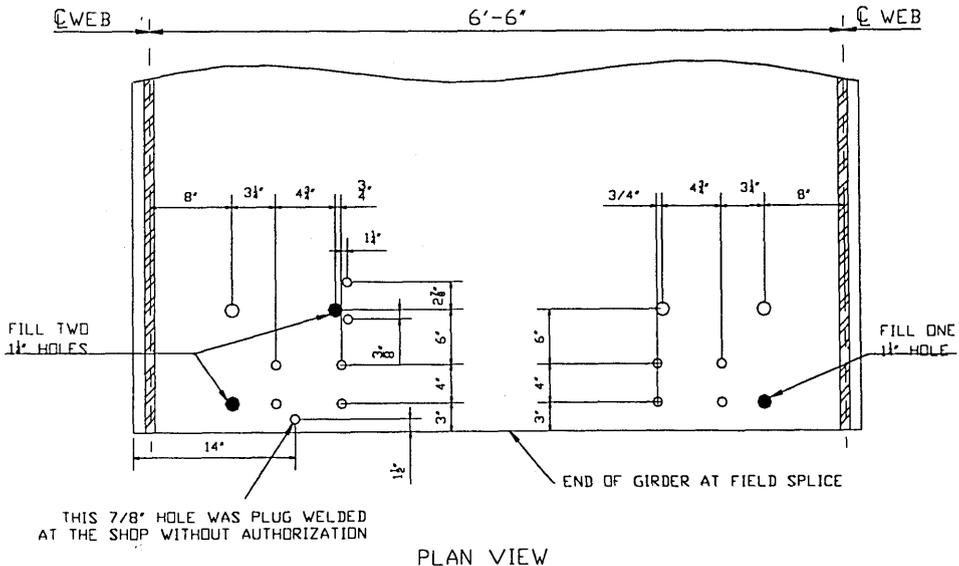
Plug weld the hole and NDT test.'

).

Case #MG102:

Description of Error: The 7/8" diameter hole shown on the diagram was drilled and plug welded without any permission at the shop and was discovered by chance during field radiography. The six 1 1/4" holes were also drilled wrong but were evaluated, repaired and NDT tested before acceptance of the girder. (see case 'MLCH-C013' for following error on same member)  
 Solution Recommended: This is a two-part problem.

- 1) Since conditions allowed filling and NDT testing of the 1 1/4" φ holes, the same technical fix should be possible on the 7/8" hole.
- 2) Since the fabricator did not bring the 7/8" hole to the attention of the owner, the fabricator's QC is called into question. For this reason, repair of this defect will be decided on by design department and the consulting engineers handing the project.



% Solution 6

caseSolution(mislocatedHole\_6,mislocatedHole,'MLCH-C006','Mislocated Hole Case Solution',[],success,

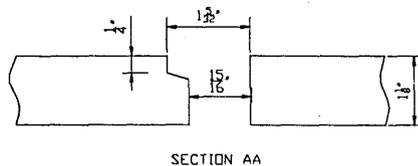
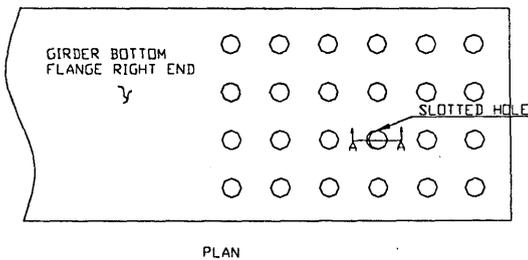
```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :splicePlate,
  errorMemberLocation :tensionFlange,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :24,
  holeDetailsActualBoltDiameter :0.875,
  holeDetailsActualHoleDiameter :0.9375,
  holeDetailsSpecifiedBoltDiameter :0.875,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsPartDrilled :true,
  holeDetailsPartDrilledHoleDiameter :0.9375,
  holeDetailsPartDrilledHoleDepth :0.25,
  holeDetailsPartDrilledHoleCoverage :80,
  holeDetailsHoleBoringProcedure :drilled,
  mislocatedHoleDistanceCorrectLocation :0.15625,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,

  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
],
'Since the splice and fill plates at this location have round holes.
It is alright to use this girder as it is fabricated.'
).
```

Case #MG110:

Description of Error: Girder bottom flange right end has a partially drilled hole mislocated by 5/32 of an inch. The splice and fill plates at this splice will have round holes.

Solution Recommended: To use this girder as fabricated.



% Solution 7

caseSolution(misllocatedHole\_7,misllocatedHole,'MLCH-C007','Mislocated Hole Case Solution',[],success,

```
[  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :web,  
  errorMemberClass     :primary,  
  holeDetailsNumberWithErrors :5,  
  holeDetailsNumberInGrouping :5,  
  holeDetailsHoleBoringProcedure :drilled,  
  misllocatedHoleDistanceCorrectLocation :0.5,  
  misllocatedHoleIncorrectFlange :false,  
  misllocatedHoleReinforcingSteelHole :true,  
  misllocatedHoleAdditionalRowHolesDrilled :false,  
  misllocatedHoleEdgeEndDistanceSpecification :true,  
  misllocatedHoleIntersectionCurrentPosition :false,  
  misllocatedHoleSpecifiedHolePatternCorrect :true,  
  misllocatedHoleInterfereWithSpecifiedPattern:false,  
  misllocatedHoleIntersectionNewPosition :false  
],
```

'Mislocation of holes has occurred at abutment end of member.

Holes are used for passing through reinforcing steel.

Distance misllocated holes are off from specified location is small enough to allow for slotting holes.

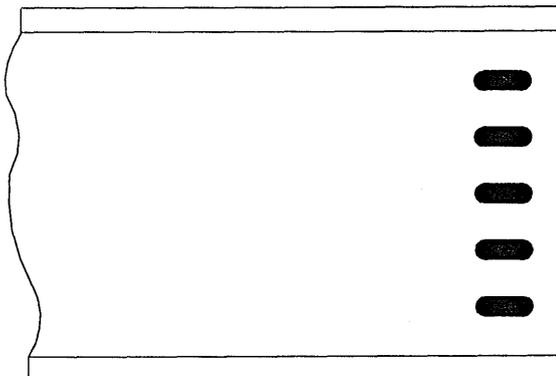
Extend holes toward specified location to make into slotted holes'

).

Case #DL168:

Description of Error: Holes drilled near the end of the girder were drilled 1/2" off. These holes are for reinforcing steel to pass through at an end abutment.

Solution Recommended: Extend holes toward end of girder, making it a slot.



ELEV

% Solution 8

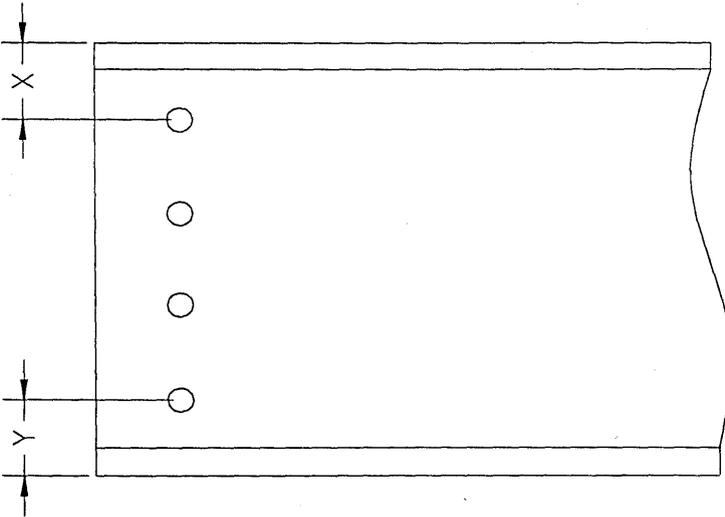
caseSolution(misllocatedHole\_8,misllocatedHole,'MLCH-C008','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :4,
  holeDetailsNumberInGrouping :4,
  misllocatedHoleDistanceCorrectLocation :3.25,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :true,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
]
```

),  
'Mislocation of holes has occurred at abutment end of member.  
Holes are used for passing through reinforcing steel.  
Distance mislocated holes are off from specified location is large.  
Leave holes in place and adjust reinforcing steel in field.'  
).

Case #DL124:

Description of Error: Dimensions X and Y were reversed when putting in holes and slots. This made them all 3 1/4" too low.  
Solution Recommended: Ok to leave as is. Reinforcing steel to be adjusted in the field.



% Solution 9

caseSolution(misllocatedHole\_9,misllocatedHole,'MLCH-C009','Mislocated Hole Case Solution',[],success,

```
1
  bridgeType                :rolled,
  errorMemberType           :rolledBeam,
  attachMemberType         :splicePlate,
  errorMemberLocation       :splice,
  errorMemberClass         :primary,
  attachMemberClass        :primary,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :true,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
```

```
1),
  'The splice plate holes were drilled in abutment end of beam.
  If the abutment is an integral design then use beam as is.
  In actual case, beam was rejected, cut for use at another location.
  A new beam was fabricated to correct the abutment beam with mislocated holes.
  ).
```

Case #MP147:

Description of Error: Splice plate holes were drilled in both ends of abutment beam. The fabricator requested to go ahead and use beam as it is.

Solution Recommended: Note that this is an unusual type of fabrication error since the beams are usually drilled or reamed while assembled, in which case the fabricator could not drill a splice in the abutment end when there is no beam for the other half of the splice.

- 1) If the abutment was an integral design, the use of the beam should have been allowed.
- 2) For the actual case, the request to go ahead and use the beam was denied. Beam was then cut from 73'3 7/8" to 43'11 3/4", and used at other place. New piece was furnished in place of the misdrilled beam.

% Solution 10

caseSolution(mislocatedHole\_10,mislocatedHole,'MLCH-C010','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :capBeam,
  attachMemberType    :splicePlate,
  errorMemberLocation :tensionFlange,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
],
```

'The girder to steel capBeam connection must be completed prior to placing and bolting the top flange splice plate.

When the erection procedure was followed the top flange plates were placed and misfit occurred between bolt holes.

1) A shim plate between the girder and capBeam may be used, or 2) the top flange splice plate holes may be reamed.

If the holes were reamed then install hardened washers over the oversized holes in the outer ply and tighten the bolts.'

).

Case #JJ142:

Description of Error: In order to assure that a full contact friction/moment connection is made between the girders and steel capbeam, without introducing residual stresses into the joint, the girder to steel capbeam connection must be completed prior to placing and bolting the top flange splice plate.

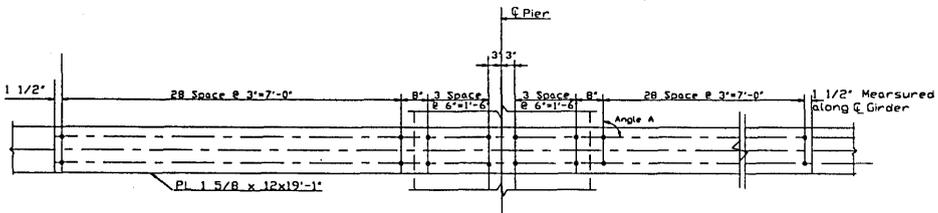
The erection procedure was followed at the two locations mentioned. When the top flange splice plates were placed, misfit occurred between the bolt holes of the top flange splice plates, steel capbeam, and girders.

Solution Recommended: These misfits may be resolved by one of the following methods:

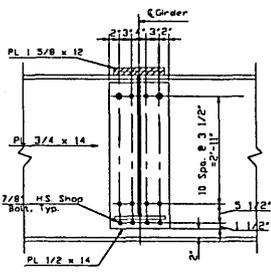
1. Provide a shim plate between one of the girders and the steel capbeam.
2. "fit-up" the top flange splice plate to the steel capbeam. Then, ream the top flange splice plate to girder holes. Install hardened washers over the oversized holes in the outer ply and tighten the bolts. No bolt holes shall exceed 1 1/16" in diameter.
3. Provide a new top flange splice plate.

In all cases, the girder to steel capbeam connection must be finalized prior to placing and inserting bolts in the top flange splice plate.

Angle A varies from 90°00'00.0" to 89°51'58.5" depending on girder.

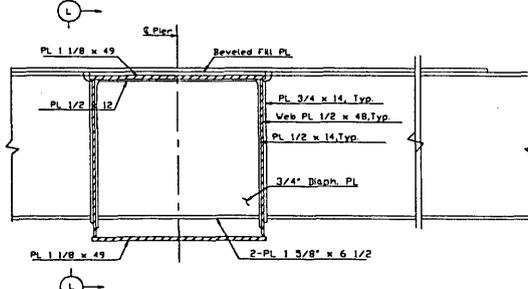


PLAN VIEW OF TOP FLANGE SPLICE PLATE



SECTION L-L

⊙ indicates 7/8" diameter erection bolts to be removed, discarded, and replaced with new 7/8" diameter H.S. bolts in the field. Two erection bolts required for each PL 3/4 x 14.



ELEV THROUGH CAP BEAM (INTERNAL DIMENSIONS NOT SHOWN FOR CLARITY)

```

% Solution 11
caseSolution(misllocatedHole_11,misllocatedHole,'MLCH-C011','Mislocated Hole Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :bearingStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :bearing,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :1,
  holeDetailsActualHoleDiameter :2.5,
  holeDetailsSpecifiedHoleDiameter :2.5,
  misllocatedHoleDistanceCorrectLocation :2.75,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
],
'Hole for earthquake restrainer was drilled wrong for all stiffeners at the abutment at the right end of the bridge.
Leave the member as is.'
).

```

**Case #DL123:**

Description of Error: Dimension from top down to center of 2 ½"φ hole for earthquake restrainer should have been 2'-3". It was drilled at 2'-1 ¼" for all stiffeners at the abutment at the right end of the bridge.

Solution Recommended: It's OK, if we send a letter to the contractor and they forward the letter to the state.

% Solution 12

caseSolution(mislocatedHole\_12,mislocatedHole,'MLCH-C012','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :boltedConnection,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  mislocatedHoleDistanceCorrectLocation :0.125,
  mislocatedHoleIncorrectFlange       :false,
  mislocatedHoleReinforcingSteelHole  :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleInterfereWithSpecifiedPattern:true,
  mislocatedHoleIntersectionNewPosition   :false
]
```

),  
'Holes on the intermediate stiffeners were mispunched. If mislocation distance is small and State DOT allows oversize holes on stiffeners and/or diaphragms, ream oversize holes. Otherwise plates need to be replaced.

).

Case #DL125:

Description of Error: 240 plates were punched with the rows of holes approximately 1/8" out of line.

Solution Recommended: Most State DOTs allow oversize holes in stiffeners and/or diaphragm. If mislocation distance is small enough, ream oversize holes. If mislocation distance is too large or if oversize holes are not allowed, make new plates. In actual case 140 plates were reamed and used while 100 plates were remade.

% Solution 13

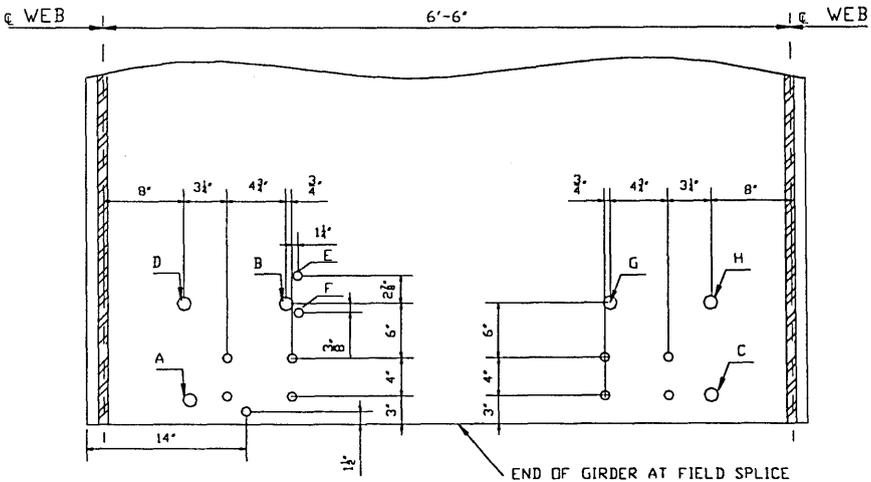
caseSolution(mislocatedHole\_13,mislocatedHole,'MLCH-C013','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :boxGirder,
  attachMemberType     :boxGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :6,
  holeDetailsNumberInGrouping :16,
  holeDetailsActualHoleDiameter :1.25,
  holeDetailsPartDrilled :false,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :true,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
]
```

),  
 'Holes were misdrilled in the bottom flange of the box girder.  
 Three of the holes are to be filled with weld material per section 3.7.7.2 of AWS D1.1-88.  
 The other holes may be filled with bolts.'  
 ).

Case #MG101:

Description of Error: The 1 1/4" holes are supposed to be at the abutment end of bottom flange plate, but were drilled at field splice by mistake. The 1" holes (E, F) are also extraneous. The 8 smaller holes at the splice attach temp. field erection channels and are later filled with 7/8" bolts.  
 Solution Recommended: 1.) Fill A, B & C with weld material in compliance with section 3.7.7 (2) of AWS D1.1-88. A repair welding procedure specification is to be generated and submitted for review before commencing the repair. The commentary to AWS Section 3.7.7 may be of help in establishing an acceptable repair procedure. 2) Fill D, E, F, G, & H with bolts. 3) Remainder use as intended for erection aid devices and fill with 7/8" bolts. (see case 'MLCH-C005' for following error on same member)



PLAN VIEW

% Solution 14

caseSolution(mislocatedHole\_14,mislocatedHole,'MLCH-C014','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :intermediateStiffener,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDistanceFromIntersectingMember :1,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :true,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleIntersectionNewPosition :false
],
```

'The top flange plate holes were drilled too close to the stiffener.

There is interference between the stiffener and the hole for the splice plate.

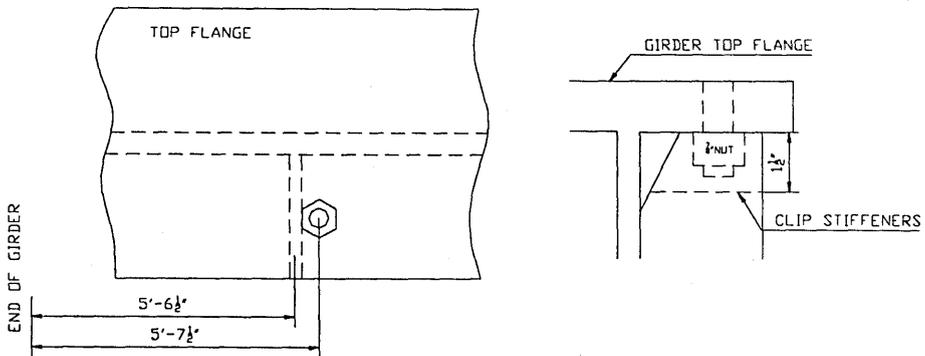
Clip the top of the stiffener to allow room for access to the bolt.'

).

Case #FB161:

Description of Error: Due to a detailing error, three girders have top flange splice plate holes drilled too close to the stiffener bar at extension dimension 5'-6 1/2" to allow bolt access. The stiffener is located at 5'-7 1/2" and the hole for the splice plate is at 5'-7 1/2" which results in a 1/4" interference.

Solution Recommended: To clip the stiffener bars.



% Solution 15

caseSolution(mislocatedHole\_15,mislocatedHole,'MLCH-C015','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :true,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
]
```

'An additional row of holes were drilled in the top splice plate connection.

Fill the extra holes with bolts to correct the problem.'

).

Case #MG166:

Description of Error: The fabricator drilled an extra row of holes. (18 are required and 19 were drilled)

Solution Recommended: Bolts can be used to fill the holes to correct the problem.

% Solution 16

caseSolution(mislocatedHole\_16,mislocatedHole,'MLCH-C016','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :rolled,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :12,
  holeDetailsNumberInGrouping :24,
  mislocatedHoleDistanceCorrectLocation :0.625,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :true,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:true,
  mislocatedHoleIntersectionNewPosition :false
]
```

),  
 'One half of the splice bolt pattern was misdrilled on the top of the beam.

Make a new splice plate to match the hole pattern on the beam.'

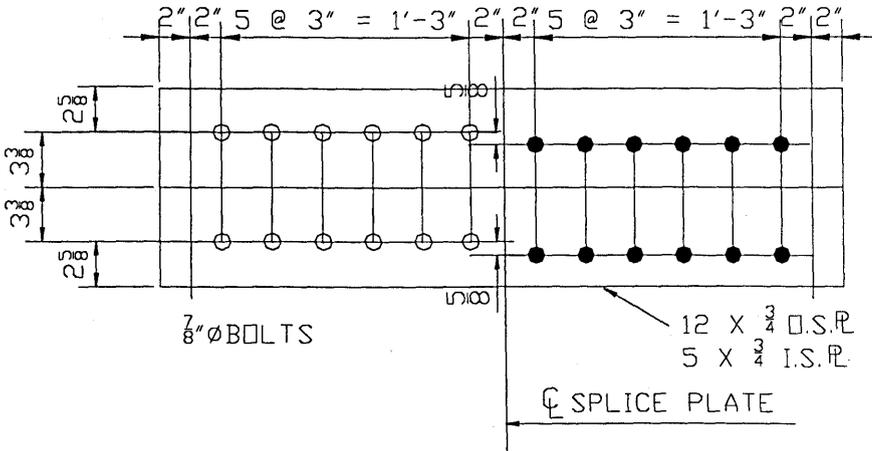
).

Case #MP144:

Description of Error: One half of the splice bolt pattern was drilled 5/8" off of center on top of beam.

Solution Recommended: Make new splice plates with mismatched hole pattern.

(Repair procedure was never implemented, as the beam was inadvertently cut 3/4" to short and was rejected for out of tolerance specification on center of holes to edge of beam. Repair would have required DOT final visual inspection.)



% Solution 17

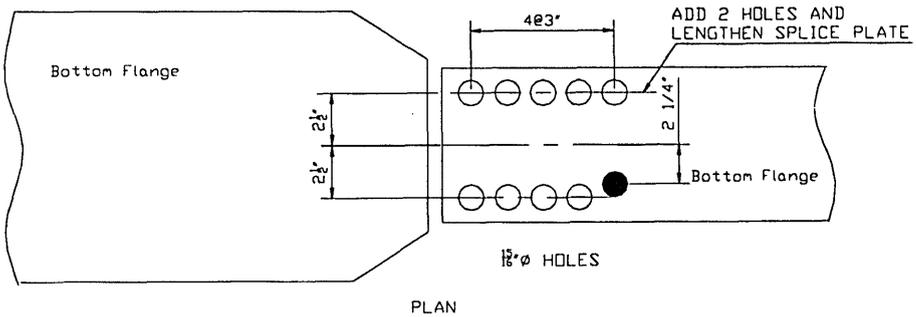
caseSolution(mislocatedHole\_17,mislocatedHole,'MLCH-C017','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :10,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :false,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleInterfereWithSpecifiedPattern:true,
  mislocatedHoleIntersectionNewPosition :false
],
```

'A hole was mislocated in the bottom flange splice hole pattern.  
 Custom fabricate new splice plate to match the as built conditions.  
 The new splice plate requires two additional holes due to the lack of edge distance on the inside splice plate for the mislocated hole.'  
 ).

\*  
 Case #JJ138:

Description of Error: Plate girder has a mislocated bottom flange splice hole.  
 Solution Recommended: To custom fabricate new splice plates to match as built conditions. The new splice plate will require 2 addition holes, due to a lack of edge distance on the inside splice plate for the mislocated hole.



% Solution 18

caseSolution(mislocatedHole\_18,mislocatedHole,'MLCH-C018','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :girder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
]
```

].  
'Eight holes were drilled in the web for a diaphragm connection at a location where two holes for a drain connection should have been drilled.

Fill the holes with high strength mech. zinc coated bolts with nut and two washers.'

).

Case #DL128:

Description of Error: Eight holes were drilled in girder web for a diaphragm connection at a location where 2 holes should have been drilled for a drain connection.

Solution Recommended: Fill the 8 holes in with 7/8  $\phi$  high strength mechanical zinc coated bolts with nut and 2 washers.

% Solution 19

caseSolution(mislocatedHole\_19,mislocatedHole,'MLCH-C019','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberLocation :compressionFlange,
  errorMemberClass    :primary,
  mislocatedHoleIncorrectFlange :true,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
```

],  
'Four holes for auxiliary angles were drilled in top flange instead of bottom flange.

Fill holes in top flange with high strength bolts and double washers.

Drill holes in bottom flange at proper location.'

).

Case #DL130:

Description of Error: Four holes for auxiliary angles were drilled on top flange instead of bottom flange.

Solution Recommended: Fill holes in top flange with high strength bolts and double washers. Drill holes in bottom flange at proper location auxiliary angles.

% Solution 20

caseSolution(mislocatedHole\_20,mislocatedHole,'MLCH-C020','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :fillerPlate,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  mislocatedHoleDistanceCorrectLocation :1,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :true,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:true,
  mislocatedHoleIntersectionNewPosition :false
],
```

'A hole was mislocated in the top flange for the auxiliary plate.

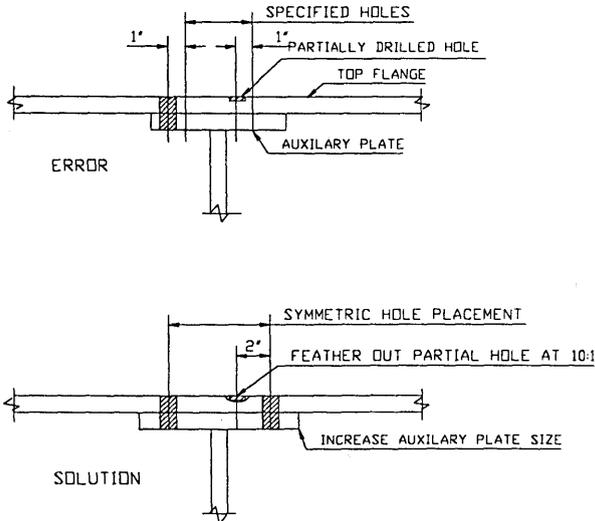
Make a larger auxiliary plate to fit the hole spacing pattern on the top flange.'

).

Case #DL126:

Description of Error: A hole (see left hole in error sketch) was drilled 1" off in the top flange for the auxiliary plate. This causes auxiliary plate to be too small (see left edge of auxiliary plate in error sketch). Next hole in pattern was partially drilled.

Solution Recommended: Make larger auxiliary plate to fit the hole spacing. Feather out partial hole at 10:1. Locate new right hole to be in symmetry with existing left hole.



% Solution 21

caseSolution(misllocatedHole\_21,misllocatedHole,'MLCH-C021','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :bearingStiffener,
  errorMemberLocation  :bearing,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :longSlotted,
  holeDetailsNumberWithErrors :2,
  holeDetailsNumberInGrouping :2,
  holeDetailsActualHoleDiameter :2,
  holeDetailsSpecifiedHoleDiameter :2.375,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
],
```

'The fabricator mislocated two of the slotted holes for the bearing attachment in the slotted flange plate at the cantilever end of the girder.

The slots were drilled 15/16 in. by 2 in. The holes were allowed to be elongated to 2 3/8 in. to allow the bearing attachment to fit.'

).

Case #:TF198:

Description of Error: The fabricator mislocated two of the slotted holes for the bearing attachment in the slotted holes flange plate at the cantilever end of the girder. The slots are presently 15/16" X 2". The reason for the error is that this girder is on a different skew than the three adjacent girders. However the holes in the partial bearing flange plates for the four girders are drilled to the same skew. As a result the holes on the girder will not work as drilled. They are 15/16" x 2" long slotted holes and they need to have the slot length increased to 2 3/8". AASHTO spec's set the maximum length equals to 2 1/2" x bolt diameter which is 2 1/2" x 7/8" = 2 3/16"

Solution Recommended: The holes were allowed to be elongated to 2 3/8". The holes may not be enlarged with a torch. They must be drilled.

% Solution 22

caseSolution(mislocatedHole\_22,mislocatedHole,'MLCH-C022','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :bearingStiffener,
  errorMemberLocation  :bearing,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :8,
  holeDetailsNumberInGrouping :8,
  holeDetailsHoleBoringProcedure :drilled,
  holeDistanceFromIntersectingMember :2,
  mislocatedHoleDistanceCorrectLocation :12,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :true,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:true,
  mislocatedHoleIntersectionNewPosition :false
],
```

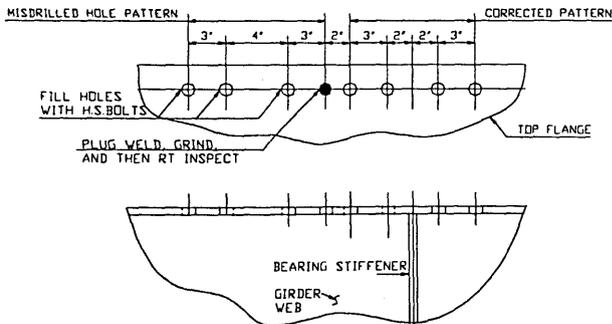
' The bearing stiffener holes were drilled in the wrong location in the girder flange. The specified pattern was drilled in the correct location. The holes drilled in the wrong location were filled with bolts. \*\*\*However the hole nearest the correct location is too close to the correct pattern and was filled with weld material and ground smooth. THIS IS NOT A RECOMMENDED REPAIR.\*\*\* '

Case #TF200:

Description of Error: The bearing stiffeners of the girder were initially located wrong. This error was identified prior to welding of bearing stiffeners but after holes had already been drilled in top flange. The result, as fabricated, is two sets of four bolt hole patterns.

Solution Recommended: \*\*\*THE ACTUAL REPAIR IS NOT RECOMMENDED REPAIR.\*\*\* In the following, first the actual repair is reported, second the actual repair is critiqued, and third a recommended alternative is given.

- 1) The mislocated hole pattern, hole nearest the correctly located hole pattern, allows a center to center of bolt spacing of two inches. As this is less than required by AASHTO, the preferred solution of incorporating excess holes into the bolted connection is not feasible. To abandon the mislocated holes in entirety, filling the holes with H.S. bolts only for appearance reasons. The live bolt hole nearest the dead hole of the abandoned pattern would have an edge distance of 1 7/16 inches. AASHTO allows 1 5/16 inches for a planed edge (drilled) using 7/8 inch diameter bolt and 1 1/16 inch diameter oversize hole. The fabricator proposed to retain as an open hole the misdrilled hole closest to the corrected pattern, the DOT chose instead to plug weld, grind, and then RT inspect that hole.
- 2) The actual repair is not recommended due to the adverse effect of plug welds on fatigue performance as discussed in tutorial topic on avoiding plug welds. Filling abandoned holes with high strength torqued bolts is not cosmetic but rather provides the structural benefit of pre compressing the edge of the extraneous hole so that fatigue cracking is discouraged. The fact that there is adequate edge distance at the corrected hole closest to the abandoned holes means that no additional bolts need to be added to the corrected pattern.
- 3) The alternative solution recommended is to abandon the misplaced holes, filling with high strength bolts and tightening so that area around extraneous holes is pre compressed decreasing likelihood of fatigue cracking. If 2' distance prevents tightening of hex bolt, use button head bolt for abandoned hole closest to corrected pattern. See tutorial topic on avoiding plug welds for further discussion.



% Solution 23

caseSolution(mislocatedHole\_23,mislocatedHole,'MLCH-C023','Mislocated Hole Case Solution',[],success,

```
[
  errorMemberType           :plateGirder,
  attachMemberType          :intermediateStiffener,
  errorMemberLocation       :stiffenerAttachment,
  errorMemberClass          :primary,
  attachMemberClass         :primary,
  holeDetailsType           :circular,
  holeDetailsNumberWithErrors :4,
  holeDetailsNumberInGrouping :4,
  holeDetailsHoleBoringProcedure :drilled,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :true,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
]
```

),  
'The holes for fastening horizontal stiffener angles were incorrectly located in the girder web.

The misdrilled holes interfere with a vertical stiffener.

The existing holes will be utilized.

The holes do interfere with a vertical stiffener so that stiffener will be moved 2 to 3 in.

The web splice plate will be modified to cover the abandoned hole.

A new stiffener angle will be fabricated to match the balance of existing holes.'

).

Case #TF201:

Description of Error: The holes for fastening two horizontal stiffener angles were incorrectly located and drilled in a girder web.

Solution Recommended: To utilize the existing misdrilled holes. A vertical stiffener will be moved 2-3 inches as currently this stiffener interferes with misdrilled hole of the lower horizontal stiffener. The first hole of upper stiffener will be abandoned and web splice plate will be increased in width so as the abandoned hole will not be visible. A new upper stiffener angle will be fabricated to match the balance of existing holes. This stiffener angle will be increased in length as necessary to maintain the 1/2" distance between vertical and horizontal stiffeners. Fabrication drawings will be revised to reflect the "as built" condition.

% Solution 24

caseSolution(misllocatedHole\_24,misllocatedHole,'MLCH-C024','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  holeDetailsType      :circular,
  holeDetailsActualTransverseHoleSpacing :5.5,
  holeDetailsSpecifiedTransverseSpacing :5,
  holeDetailsHoleBoringProcedure       :drilled,
  misllocatedHoleIncorrectFlange       :false,
  misllocatedHoleReinforcingSteelHole  :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:true,
  misllocatedHoleIntersectionNewPosition :false
],
```

'The double row of bolt holes are at 5.5 in. gage for the tee and 5 in. for the existing girder. Slot each row of holes 1/4 in. and use washers over the slotted holes.'

).

Case #TF202:

Description of Error: A tee is to be bolted to the existing girder. The double row of bolt holes are at a 5 1/2" gage for the tee and 5" gage for the existing girder.

Solution Recommended: To slot each row of bolts 1/4" and to use washers over the slotted holes.

% Solution 25

caseSolution(misllocatedHole\_25,misllocatedHole,'MLCH-C025','Mislocated Hole Case Solution',[],success,

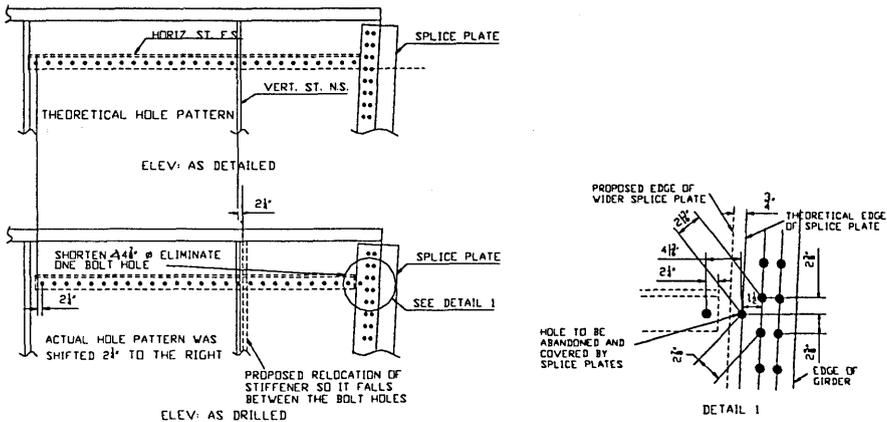
```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :intermediateStiffener,
  errorMemberLocation :stiffenerAttachment,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :26,
  holeDetailsNumberInGrouping :26,
  holeDetailsHoleBoringProcedure :drilled,
  holeDistanceFromIntersectingMember :1.5,
  misllocatedHoleDistanceCorrectLocation :2.25,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :true,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:true,
  misllocatedHoleIntersectionNewPosition :false
],
```

'Holes for the horizontal stiffener attachment were mislocated by 2.25 in. The hole pattern interferes with a splice plate and a vertical stiffener. The angle will be shortened to eliminate the bolt hole that interferes with the splice plate. The splice plate will be widened to cover the abandoned hole. The vertical stiffener will be relocated so it falls between the bolt holes.'

Case #TF204:

Description of Error: Holes for fastening the horizontal stiffener have been misdrilled. The actual hole pattern was shifted 2 1/4" to the right (see "as drilled" sketch). The hole pattern interferes with a splice plate and a vertical stiffener. The vertical stiffener is an angle bolted to the girder web with bolt locations above and below horizontal stiffener. In sketches, only outstanding leg of vertical stiffener angle is shown.

Solution Recommended: To shorten the angle by 4 7/8 inch and eliminate one bolt hole. The bolt hole to be abandoned will be covered by splice plate wider than called out originally by design. The vertical stiffener will be relocated so it falls between bolt holes.



% Solution 26

caseSolution(mislocatedHole\_26,mislocatedHole,'MLCH-C026','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :diaphragmBrace,
  errorMemberLocation :gussetPlate,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :2,
  holeDetailsNumberInGrouping :6,
  holeDetailsHoleBoringProcedure :drilled,
  mislocatedHoleDistanceCorrectLocation :1,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
]
```

),  
 'At the brace connection the interior bolt holes were drilled 1 in. off.

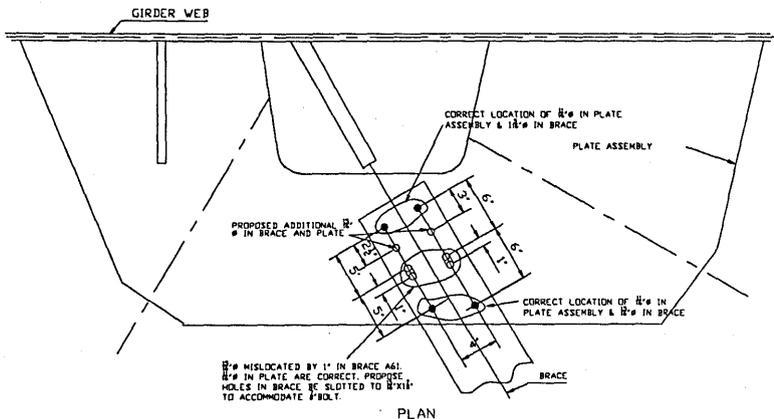
The interior holes were elongated to accommodate the interior bolts then adding two bolts at the location.  
 A plate washer must be used above the brace to cover the area in question.'

).

Case #TF206:

Description of Error: A brace has six drilled holes in the end in question. The four end holes are in the correct location, the two interior holes were drilled one inch off.

Solution Recommended: To elongate the interior holes in the brace to 15/16 X 1 7/8" to accommodate the 7/8" bolt, then add two bolts at the location shown (see sketch). A plate washer must be used above brace member to cover the slotted hole.



% Solution 27

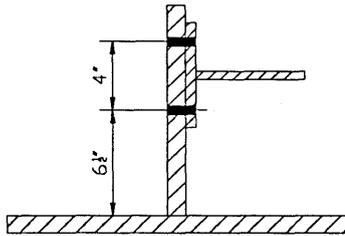
caseSolution(misllocatedHole\_27,misllocatedHole,'MLCH-C027','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :diaphragmBrace,
  errorMemberLocation :gussetPlate,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :8,
  holeDetailsNumberInGrouping :16,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleDistanceCorrectLocation :4,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :true,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
],
```

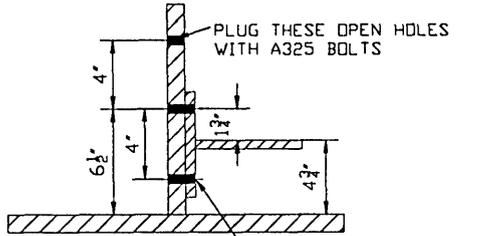
'The holes for two gusset plates were drilled 4 in. too high.  
 Fill the top row of holes with bolts.  
 Use the bottom set of holes as the new top row.  
 Then drill the bottom row in the correct location.'  
 ).

Case #TF208:

Description of Error: The holes for two gusset plates were drilled 4" too high. There are 16 bolts which attach each gusset plate to the girder.  
 Solution Recommended: Fill the top row of holes with bolts. Use the bottom set of holes as the new top row, then drill the bottom row in the correct location.



ERROR



SOLUTION

DRILL THESE HOLES IN  
 FIELD: LAY-OUT PROPER  
 MEASUREMENTS + DRILL  
 WITH MAGNETIC CORE  
 DRILL.

% Solution 28

caseSolution(misllocatedHole\_28,misllocatedHole,'MLCH-C028','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :splice,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :16,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleDistanceCorrectLocation :0.5,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :false,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :true,
  misllocatedHoleInterfereWithSpecifiedPattern:true,
  misllocatedHoleIntersectionNewPosition :false
],
```

'A hole on a field splice in the bottom flange was misdrilled.

It is out alignment by 1/2 in. in the transverse direction.

The inside support bar would have its edge distance decreased below the minimum.

The hole will not have any adverse effects on the splice.

To accommodate the edge distance in the inside support bar the bar is widen by 5/16 in. and the edge is ground to fit over the web to flange weld.'

).

Case #:TF209:

Description of Error: The field splice on the right end far side of a fascia girder has the center hole mislocated in the bottom flange far side. The hole lines up through the three plies of the splice, however, it is out of alignment in the transverse direction by 1/2" toward the web. This would not have any adverse effect on the outside splice plate on the girder flange. The inside support bar has the edge distance decreased below the minimum at this point.

Solution Recommended: To make a new support bar 3-5/16" wide rather than 3" wide with the edge ground to fit over the web to flange weld.

% Solution 29

caseSolution(misllocatedHole\_29,misllocatedHole,'MLCH-C029','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :splicePlate,
  errorMemberLocation :splice,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :80,
  holeDetailsNumberInGrouping :80,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :true,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:true,
  misllocatedHoleIntersectionNewPosition :false
],
```

'The web splice bolt patterns for the girder were drilled in the opposite ends of the girder.

One end requires 48 bolts while the other end requires 34 bolts.

On the end that has the excess bolts leave the pattern and drill splice plate to match.

On the end that has a shortage of bolts add a third row of bolts and fabricate splice plates to match.'

).

Case #TF211:

Description of Error: The web splice bolt patterns for the girder have been drilled in the opposite ends of the girder. F.S #8 requires 46 bolt holes and F.S. #7 requires 34 bolts holes. The result is that F.S. #7 is now oversized and F.S. #8 is undersized. Solution Recommended: 1) Leave F.S. #7 as it now exists with the excess number of bolts and just drill the splice plates to match. 2) At F.S. #8, add a third row of bolts bringing the total to 51 bolts (3 rows of 17 in lieu of 2 rows of 23) splice plates would be oversized to accommodate the revision.

% Solution 30

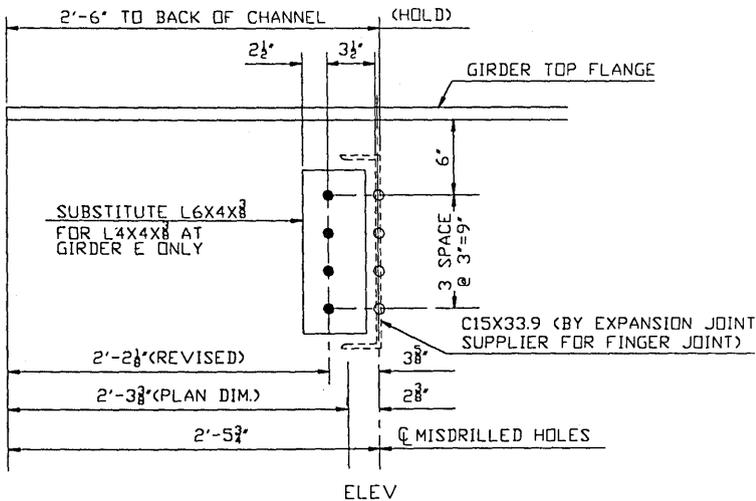
caseSolution(mislocatedHole\_30,mislocatedHole,'MLCH-C030','Mislocated Hole Case Solution',{[]},success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :diaphragmBrace,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :4,
  holeDetailsNumberInGrouping :4,
  holeDetailsHoleBoringProcedure :drilled,
  mislocatedHoleDistanceCorrectLocation :2.375,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :false,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :true,
  mislocatedHoleInterfereWithSpecifiedPattern:false,
  mislocatedHoleIntersectionNewPosition :false
],
```

'Holes were misdrilled in girder for connection to exp. joint supports.  
 Since the holes are nearly aligned with channel web, filling the misdrilled holes would cause interference with channel.  
 Leave the misdrilled holes as built and drill new holes in correct location.'

Case #NC503:

Description of Error: Holes were misdrilled in a girder for connection to exp. joint supports.  
 Solution Recommended: Since the holes are nearly aligned with channel web, filling the misdrilled holes with bolts would cause interference with channel. Leave the misdrilled holes as built, and drill new holes in correct location.



% Solution 31

```
caseSolution(misllocatedHole_31,misllocatedHole,'MLCH-C031','Mislocated Hole Case Solution',[],success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :diaphragmBrace,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :1,
  holeDetailsNumberInGrouping :5,
  holeDetailsHoleBoringProcedure :punched,
  misllocatedHoleDistanceCorrectLocation :1,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false
],
```

'An additional hole was punched in the web of the beam.

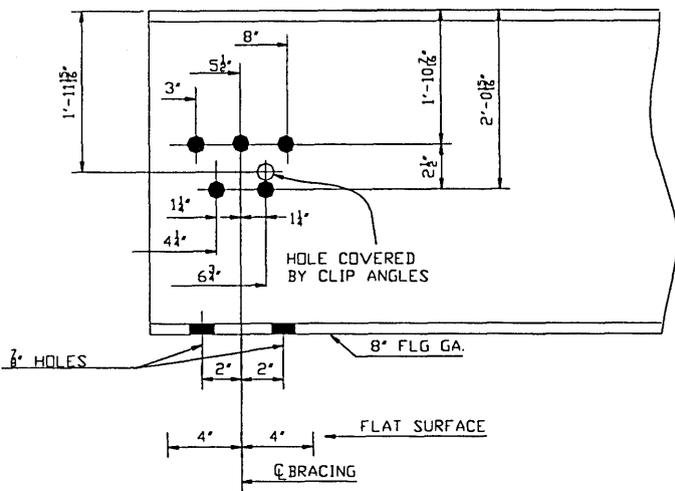
The beam is an interior beam so it is allowed to leave the extra hole in place since it will be covered with the two clip angles. Since this is an interior beam, it would seem prudent to leave the extra hole in place and cover it with the two clip angles already present as part of the connection. If the clip angles did not already cover the hole, could fill the hole with a bolt, nut, & double washer.'

).

Case #NC504:

Description of Error: An additional hole was inadvertently punched in the web of this beam.

Solution Recommended: Since this is an interior beam, it would seem prudent to leave the extra hole in place and cover it with the two clip angles already present as part of the connection. If the clip angles did not already cover the hole, could fill the hole with a bolt, nut, & double washer.



% Solution 32

caseSolution(mislocatedHole\_32,mislocatedHole,'MLCH-C032','Mislocated Hole Case Solution',[,],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :splicePlate,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType     :circular,
  holeDetailsHoleBoringProcedure :drilled,
  mislocatedHoleDistanceCorrectLocation :3,
  mislocatedHoleIncorrectFlange :false,
  mislocatedHoleReinforcingSteelHole :false,
  mislocatedHoleAdditionalRowHolesDrilled :true,
  mislocatedHoleEdgeEndDistanceSpecification :true,
  mislocatedHoleIntersectionCurrentPosition :false,
  mislocatedHoleSpecifiedHolePatternCorrect :false,
  mislocatedHoleInterfereWithSpecifiedPattern:true,
  mislocatedHoleIntersectionNewPosition :false
],
```

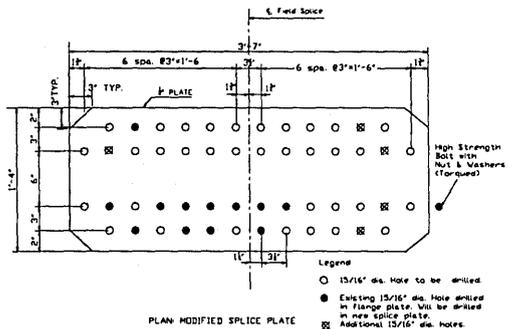
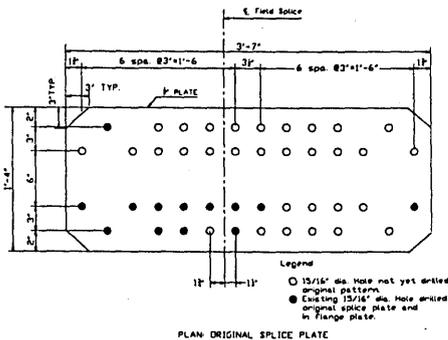
'The holes in the bottom flange were misdrilled for the field splice.  
 The correction requires new splice plate material and additional bolts plus one bolt with hardened washers to be torqued.  
 Also revise the shop drawings for the new splice.'

Case #NC505:

Description of Error: The holes in the bottom flange were misdrilled for the field splice.

Solution Recommended: Make new splice plate and additional bolts plus one bolt with hardened washers to be torqued.

The modified splice plate has additional bolts over the number shown by the fabricator, these additional bolts are required in order to keep the splice symmetrical.



% Solution 33

caseSolution(misllocatedHole\_33,misllocatedHole,'MLCH-C033','Mislocated Hole Case Solution',[],success,

```
[
  bridgeType           :rolled,
  errorMemberType      :rolledBeam,
  attachMemberType     :kConnection,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :216,
  holeDetailsNumberInGrouping :216,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleDistanceCorrectLocation :0.3125,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :true,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:true,
  misllocatedHoleIntersectionNewPosition :false
],
```

'The mislocated holes in the rolled beams are in the top flange and are used in the K-connection of the grid deck to the rolled beams.

These holes are spaced in a single row the entire length of the beams.

The longitudinal location of the holes has been fabricated out of position.

Clearance between the grid deck panels has been provided in the design plans to allow for erection tolerance.

This is a detour bridge intended for multiple uses.

\* The tolerance needs to be maintained during fabrication to allow for the numerous uses of the bridge in the future.

Therefore the beams need to be rejected and the replacement beams fabricated to specification tolerances.'

).

Case #NC509:

Description of Error: The misaligned holes in the W30x173 rolled beams are in the top flange and are used in the K-Connection of the grid deck to the rolled beam. These holes are spaced in a single row the entire length of the beams. The longitudinal location of the holes has been fabricated out of position by 1/16" at the left end and progressing to 5/16" at the right end.

Clearance between the grid deck panels has been provided in the design plans to allow for erection tolerance. This is a detour bridge intended for multiple uses.

Solution Recommended: Since the tolerance must be maintained during fabrication to allow for the numerous uses of the bridge in the future, the beam must be rejected and the replacement beams need to be fabricated to specification tolerances. The specific configuration already used oversize holes and slots for erection tolerance, which might be solutions in other configurations.

% New Solution 34

caseSolution(misllocatedHole\_34,misllocatedHole,'MLCH-C034','Mislocated Hole Case Solution',[dlf004],success,

```
[
  bridgeType           : plateGirder ,
  errorMemberType      : solePlate,
  attachMemberType     : rocker,
  errorMemberLocation  : bearing,
  errorMemberClass     : primary,
  attachMemberClass    : primary,
  holeDetailsType      : circular,
  holeDetailsNumberWithErrors :2,
  holeDetailsNumberInGrouping :4,
  holeDetailsActualBoltDiameter :0.625,
  holeDetailsSpecifiedBoltDiameter :0.625,
  holeDetailsHoleBoringProcedure :drilled,
  misllocatedHoleDistanceCorrectLocation :0.5625,
  misllocatedHoleIncorrectFlange :false,
  misllocatedHoleReinforcingSteelHole :false,
  misllocatedHoleAdditionalRowHolesDrilled :false,
  misllocatedHoleEdgeEndDistanceSpecification :true,
  misllocatedHoleIntersectionCurrentPosition :false,
  misllocatedHoleSpecifiedHolePatternCorrect :false,
  misllocatedHoleInterfereWithSpecifiedPattern:false,
  misllocatedHoleIntersectionNewPosition :false

```

],

' Plug mislocated holes with 5/8 diameter bolts, fully tightened, cut bolt off and seal weld, grind flash and re-drill/tap new holes in proper location. Verify bolt will thread into hole and of course dimensional verification.'

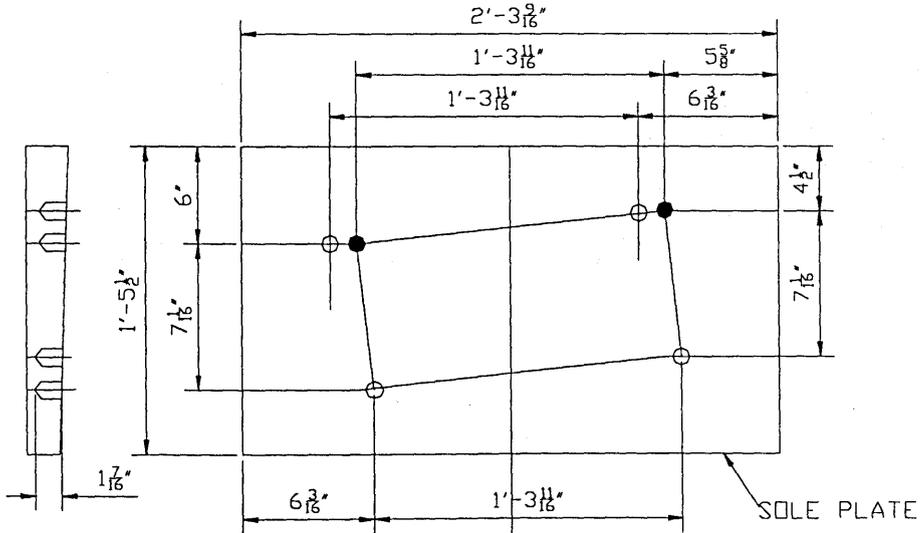
).

Case #DL-F004:

Description of Error: Detail error on shop drawings resulted in mis-located holes in sole plates. Holes are drilled and tapped for 5/8" diameter bolts.

Solution Recommended: Plug mislocated holes with 5/8 diameter bolts, fully tightened, cut bolt off and seal weld, grind flash and re-drill/tap new holes in proper location. Verify bolt will thread into hole and of course dimensional verification.

Other Possible solutions: No other reasonable solution. Do not plug weld.



# Edge Distance Cases:

% Solution 1

caseSolution(edgeDistance\_1,edgeDistance,'EDGD-C001','Edge Distance Case Solution',[],success,

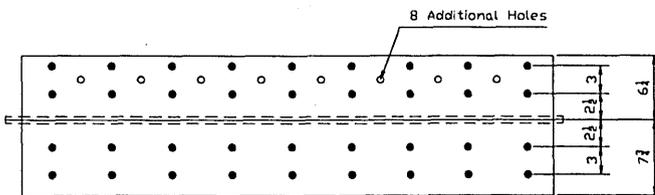
```
[
  bridgeType           :plateGirder,
  errorMemberType      :diaphragmBrace,
  attachMemberType     :capBeam,
  errorMemberLocation  :boltedConnection,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberActualEdgeType :flameCut,
  attachMemberActualEdgeType :flameCut,
  holeDetailsType      :circular,
  holeDetailsNumberWithErrors :9,
  holeDetailsNumberInGrouping :36,
  holeDetailsActualBoltDiameter :0.875,
  holeDetailsActualHoleDiameter :0.9375,
  holeDetailsActualLongHoleSpacing :5,
  holeDetailsActualTransverseHoleSpacing:3,
  holeDetailsSpecifiedBoltDiameter :0.875,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsSpecifiedLongSpacing :5,
  holeDetailsSpecifiedTransverseSpacing :3,
  holeDetailsPartDrilled :false,
  holeDetailsHoleBoringProcedure :drilled,
  holeDistanceFromEdge :0.75,
  holeDistanceFromEnd :1.5
]
```

),  
 'Diaphragm in cap beam has its connection plate misfit by 3/4 in. resulting in a lack of edge distance.  
 Eight additional bolts were drilled between the existing bolt lines in the plate.  
 The bolt holes were placed at centerline location between existing bolt lines both laterally and tangentially.'  
 ).

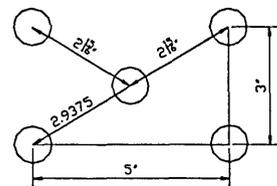
## Case #MG104:

Description of Error: Diaphragm located at extension dimension 28'-7 11/16 in cap beam has its top connection plate misfit by 3/4 inch. This misalignment results in lack of edge distance.

Solution Recommended: To add 8 additional holes to the connection to make up for shy edge distance as shown on sketch. The bolt holes were placed at centerline location between existing bolt lines both laterally and tangentially.



PLAN VIEW



DETAIL OF HOLE PLACEMENT

% Solution 2

caseSolution(edgeDistance\_2,edgeDistance,'EDGD-C002','Edge Distance Case Solution',[],success,

```
{
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :splicePlate,
  errorMemberLocation :splice,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  errorMemberActualEdgeType :flameCut,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :2,
  holeDetailsNumberInGrouping :8,
  holeDetailsActualBoltDiameter :0.875,
  holeDetailsActualHoleDiameter :0.9375,
  holeDetailsSpecifiedBoltDiameter :0.875,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsPartDrilled :false,
  holeDetailsHoleBoringProcedure :drilled,
  holeDistanceFromEdge :1.3125
}
```

),  
'Two holes in the top flange do not have sufficient edge distance.

The flange was flame cut. By grinding off 1/16 in. the edge is now equivalent to a planed edge.

The planed edge allows a smaller edge distance so now the flange meets the edge distance requirements.'

).

Case # MG113:

Description of Error: The top flange of a girder has two holes with 1 5/16 inch edge distance.

Solution Recommended: Grind the end of the flange to the equivalent of a planed edge, then 1 1/4 inch edge distance would be acceptable.

% Solution 3

```
caseSolution(edgeDistance_3,edgeDistance,'EDGD-C003','Edge Distance Case Solution',[],success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :boxGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :splice,
  errorMemberClass     :primary,
  attachMemberClass    :primary
],
```

```
'The top splice plate has an edge distance problem.
```

```
Extra holes were drilled to remedy the edge distance problem.'
```

```
).
```

#### Case # MG165:

**Description of Error:** The top splice plate on a box girder needs to have additional holes. This is caused by extra holes that were added to the corresponding top diaphragm plate inside the box due to an edge distance problem.

**Solution Recommended:** The top splice plate was revised to add extra holes to correspond with the top diaphragm plate holes.

```

% Solution 4
caseSolution(edgeDistance_4,edgeDistance,'EDGD-C004','Edge Distance Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :plateGirder,
  errorMemberLocation  :gussetPlate,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :longSlotted,
  holeDetailsNumberWithErrors :6,
  holeDetailsNumberInGrouping :6,
  holeDistanceFromEdge :2.5
],
'The edge distance for the slot in the tie plate is insufficient to transmit the load.
Provide a tie plate 3/4 in. by 7 5/8 in. in lieu of 3/4 in. by 5 1/2 in.'
).

```

Case #TF205:

Description of Error: The edge distance for the slot in the tie plate is 2 1/2" at two locations only. This is insufficient to transmit the load.

Solution Recommended: Several options can be used to rectify the problem.

1. Provide A36 tie plate 1 1/8" x 5 1/2" in lieu of 3/4" x 5 1/2".
2. Provide A572 tie plate 1' x 5 1/2" in lieu of 3/4" x 5 1/2".
3. Provide A36 tie plate 3/4" x 7 5/8" in lieu of 3/4" x 5 1/2"
4. Provide an additional A36 tie plate 5/8" x 5 1/2".

No.3 is preferred.

% Solution 5

caseSolution(edgeDistance\_5,edgeDistance,'EDGD-C005','Edge Distance Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberActualEdgeType :flameCut,
  holeDetailsType      :circular,
  holeDetailsActualBoltDiameter :.0.875,
  holeDetailsActualHoleDiameter :.0.9375,
  holeDetailsActualLongHoleSpacing :3,
  holeDetailsActualTransverseHoleSpacing:4,
  holeDetailsSpecifiedBoltDiameter :.0.875,
  holeDetailsSpecifiedHoleDiameter :.0.9375,
  holeDetailsSpecifiedLongSpacing :3,
  holeDetailsSpecifiedTransverseSpacing :4,
  holeDistanceFromEdge :1.25
]
```

'Tension flange was cut narrow causing edge distance problems. The flange has a flame cut edge.

Remove 1/16 in. to result in planed edge.

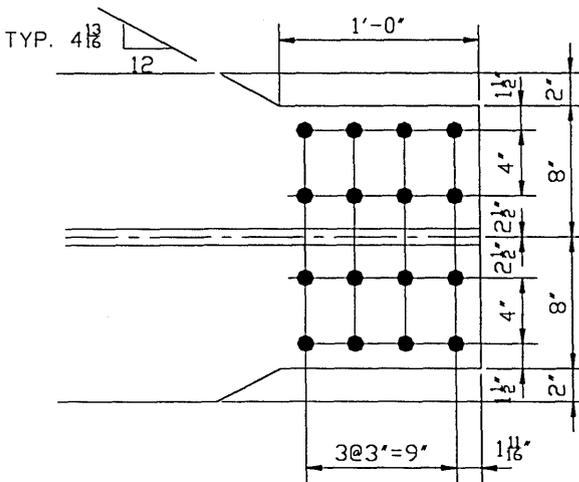
The planed edge allows a smaller edge distance requirement which allows the member to meet the requirements.'

).

Case #NC502:

Description of Error: Specified flange width was 16" (see sketch). Actual flange width is 15 3/4". Edge distance member does not meet specifications. The type of edge on member is flame cut.

Solution Recommended: Check dimensions of member to see if removal of 1/16" would allow planed edge. Planed edge will allow smaller edge distance requirement. Check edge distance specifications with planed edge and reduction of 1/16". If edge distance with planed edge will not meet specifications then cut and replace member at acceptable location or replace entire member.



% Solution 6

```
caseSolution(edgeDistance_6,edgeDistance,'EDGD-C006','Edge Distance Case Solution',[],success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :capBeam,
  attachMemberType     :boxGirder,
  errorMemberLocation  :boltedConnection,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsPartDrilled :false,
  holeDistanceFromEdge :1.0625
],
```

'In the box cap beam the internal bracing diaphragms located where the girder connection plate bolt to the top flange of the girder and the top flange of the box have insufficient edge distance.

Drill an extra set of bolt holes at 3 in. from the last two bolt holes that have insufficient end distance.'

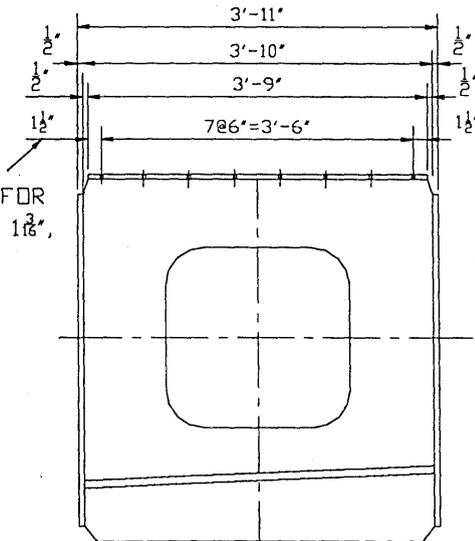
).

Case #MG119:

Description of Error: In the box cap beam five internal bracing diaphragms located where the girder connection plate bolt to the top flange of the girder and the top flange of the box have insufficient edge distance. Three diaphragms have two bolts with 1 3/16" edge distance; 1 has two bolts with 1 1/16" edge distance; and 1 diaphragm has two bolts with 1 5/16" edge distance.

Solution Recommended: Drill an extra set of bolt holes at 3" from the last two bolt holes that have insufficient end distance.

FIVE DIAPHRAGMS FOR  
BOX CAP BEAM: 3@ 1 3/8",  
1@ 1 1/8" and 1@ 1 5/8"



# End Distance Cases:

% Solution 1

caseSolution(endDistance\_1,endDistance,'ENDD-C001','End Distance Case Solution',[],success,

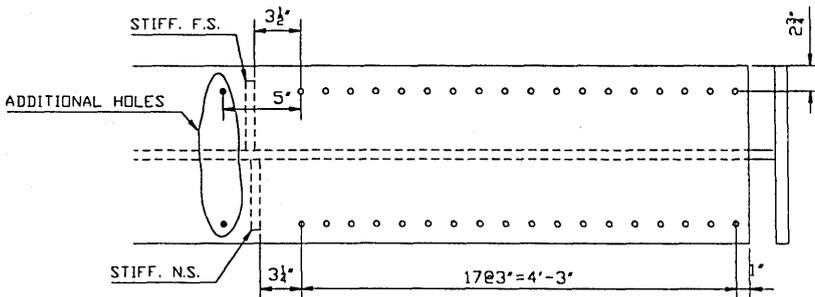
```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :splicePlate,
  errorMemberLocation  :splice,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  errorMemberActualEdgeType :flameCut,
  attachMemberActualEdgeType :flameCut,
  holeDetailsType     :circular,
  holeDetailsActualBoltDiameter :0.875,
  holeDetailsActualHoleDiameter :0.9375,
  holeDetailsActualLongHoleSpacing :3,
  holeDetailsSpecifiedBoltDiameter :0.875,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsSpecifiedLongSpacing :3,
  holeDetailsHoleBoringProcedure :drilled,
  holeDistanceFromIntersectingMember :3.25,
  holeDistanceFromEdge :2.75,
  holeDistanceFromEnd :1
],
```

'The top flange hole pattern drilled for the splice plate was shifted resulting in too short of an end distance. The splice was lengthened to allow an extra set of holes to be drilled in the splice plate and top flange.'

Case # MG103:

Description of Error: Girder top flange far end has the hole pattern drilled for the splice plate shifted by 1/2 inch which results in 1" end distance.

Solution Recommended: Lengthen the splice by 5" and add an extra set of bolts. Due to the location of the stiffener bars the gage on this extra set of holes will be 5 inches.



% New Solution 2

caseSolution(endDistance\_2,endDistance,'ENDD-C002','End Distance Case Solution',[ddf007],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :flangePlate,
  attachMemberType    :splicePlate,
  errorMemberLocation :tensionFlange,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  errorMemberActualEdgeType :flameCut,
  attachMemberActualEdgeType :flameCut,
  holeDetailsType     :circular,
  holeDetailsNumberWithErrors :30,
  holeDetailsNumberInGrouping :30,
  holeDetailsActualBoltDiameter :1,
  holeDetailsActualLongHoleSpacing :3.5,
  holeDetailsSpecifiedBoltDiameter :1,
  holeDetailsSpecifiedLongHoleSpacing :3.5,
  holeDetailsPartDrilledHole :false,
  holeDetailsHoleBoringProcedure :drilled,
  holeDistanceFromEnd :1.1875
],
```

'1-3/4" dimension to attain proper edge distance from end of flanges to hole was not maintained.

Leave as is.'

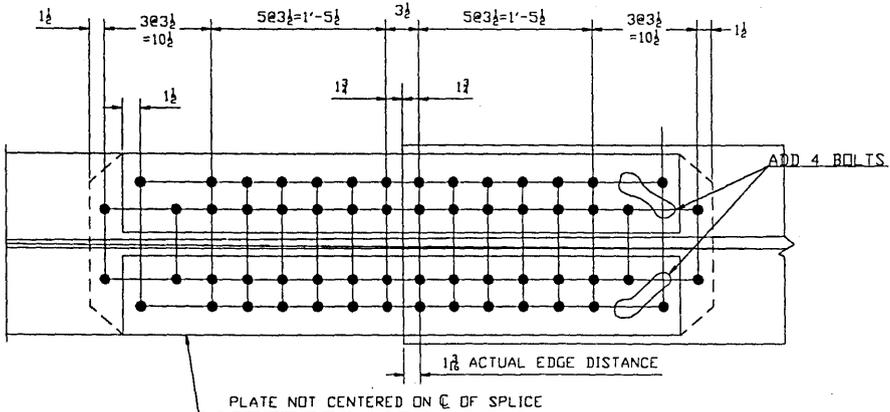
).

Case #DD-F007:

Description of Error: 1-3/4" dimension to attain proper edge distance from end of flanges to hole was not maintained. Actual end distance is 1-3/16". Splice was designed to 100% of the smaller flange. Actual stress is below 50% of capacity and only needs designed to 75% per AASHTO. The bolt arrangement as is meets stress requirement for 75% of the capacity.

Solution Recommended: Leave as is.

Other Possible solutions: a) Leave as is and add 4 more holes. Fill all holes with bolts. b) Add 4 more holes. Make new plates which would not have holes drilled at 1-3/16". (This will cover the abandoned holes in the flange).



# Mislocated Member Cases:

% Solution 1

```
caseSolution(misllocatedMember_1,misllocatedMember,'MLCM-C001','Mislocated Member Case Solution',[],success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :splicePlate,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  misllocatedMemberIntersection :true,
  misllocatedMemberIntersectedItem :splicePlate,
  stiffenerType        :intermediate,
  stiffenerSpecifiedDiaphragmAttachment :false,
  stiffenerActualTensionFlangeClipped :false,
  stiffenerActualCompFlangeClipped :false
]
```

),  
 'A splice plate extended beyond the location of the stiffener.

The stiffener was shown to tight fit against both flanges.

The stiffener had already been welded into place.

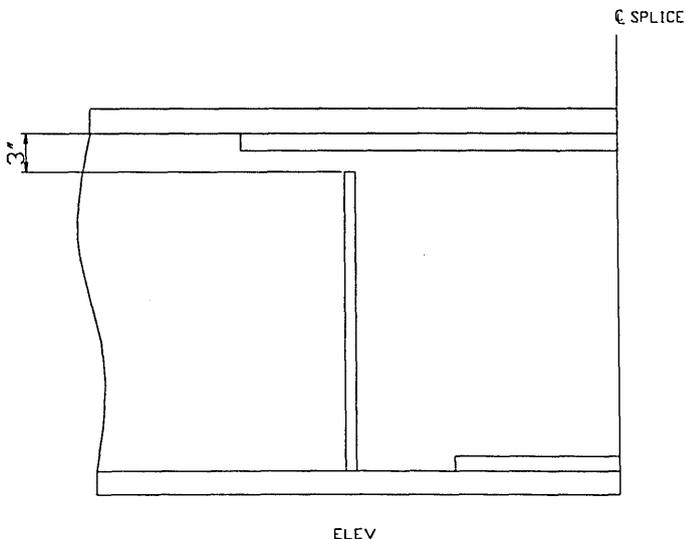
Cut the stiffener off 3 in. from the flange to allow the splice plate to be placed in the proper location.'

).

Case #DL169:

Description of Error: A stiffener was shown to fit tight against both flanges. One inside splice plate extended beyond the location of the stiffener.

Solution Recommended: Cut the stiffener off 3" from the flange. This was acceptable since this was a plain stiffener rather than a diaphragm connection plate. Other possible solutions: the stiffener could have been moved far enough to miss the splice plate. This would have been the best solution had the error been noticed before the stiffener was in place. In actual case, shop did not realize there was a problem until they tried to clamp the splice plates in place for drilling.



% Solution 2

caseSolution(misllocatedMember\_2,misllocatedMember,'MLCM-C002','Mislocated Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  misllocatedMemberIntersection :false,
  misllocatedMemberInvertedPlacement :false,
  misllocatedMemberDistanceCorrectLocation :12,
  stiffenerType        :intermediate,
  stiffenerSpecifiedDiaphragmAttachment :true
],
```

'Stiffeners were fitted and welded one foot from their specified location.

Leave stiffeners in place and weld new stiffeners at correct location.

Install bolts in holes of mislocated stiffeners.'

).

Case #MP146:

Description of Error: Near and far side stiffeners were fitted and welded at 22'11 13/16" from left hand end of girder, in lieu of 21'11 13/16".

Solution Recommended: Weld new stiffeners in place, leave old stiffeners in place, install bolts in holes of mislocated stiffeners; blast and paint.

% Solution 3

```
caseSolution(mislocatedMember_3,mislocatedMember,'MLCM-C003','Mislocated Member Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  mislocatedMemberIntersection :true,
  mislocatedMemberInvertedPlacement :false,
  mislocatedMemberDistanceCorrectLocation :0.75,
  mislocatedMemberIntersectedItem :hole,
  stiffenerType        :intermediate,
  stiffenerSpecifiedDiaphragmAttachment :false,
  stiffenerActualTensionFlangeClipped :false,
  stiffenerActualCompFlangeClipped :false
],
'Intermediate stiffener was mislocated and interferes with one of the bolts on the flange splice.
The top of the stiffener was to be tight fit.
Clip the top of the stiffener enough to clear the nut plus stick-thru by a 1/4 in.'
).
```

Case #MG115:

Description of Error: An intermediate stiffener that was to be located 5'-6 1/2" from the left end of the girder was shifted 3/4" to the right of its proper position which fouled one bolt of the flange splice.

Solution Recommended: Clip the top of the stiffener enough to clear the nut plus stick-thru by a 1/4". Probably clip 1 1/2".

% Solution 4

```
caseSolution(misllocatedMember_4,misllocatedMember,'MLCM-C004','Mislocated Member Case Solution',[],success,  
[  
  bridgeType                :plateGirder,  
  errorMemberType           :intermediateStiffener,  
  attachMemberType          :plateGirder,  
  errorMemberLocation        :stiffenerAttachment,  
  errorMemberClass           :primary,  
  attachMemberClass          :primary,  
  misllocatedMemberIntersection :false,  
  misllocatedMemberInvertedPlacement :true,  
  stiffenerType              :intermediate,  
  stiffenerSpecifiedDiaphragmAttachment :true  
],  
'The stiffener was put in upside down.  
Another hole will be drilled in the stiffener and the top hole will be filled with a bolt.'  
).
```

Case #MG164:

Description of Error: A stiffener was put in up side down.

Solution Recommended: Another hole will be drilled in the stiffener and the top hole will be filled with a bolt.

% Solution 5

caseSolution(misllocatedMember\_5,misllocatedMember,'MLCM-C005','Mislocated Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  misllocatedMemberIntersection :false,
  misllocatedMemberInvertedPlacement :false,
  misllocatedMemberDistanceCorrectLocation :2,
  stiffenerType        :intermediate,
  stiffenerSpecifiedDiaphragmAttachment :false
]
```

),  
'All studs were installed on a 5 1/2 in. gage instead of the specified 7 1/2 in. gage. It is alright to leave as is.'  
).

Case #DL133:

Description of Error: All studs were installed on a 5 1/2" gage. Should have been a 7 1/2" gage.

Solution Recommended: OK, to leave as is.

% Solution 6

```
caseSolution(mislocatedMember_6,mislocatedMember,'MLCM-C006','Mislocated Member Case Solution',[],success,  
[  
  bridgeType                :plateGirder,  
  errorMemberType           :intermediateStiffener,  
  attachMemberType          :plateGirder,  
  errorMemberLocation       :stiffenerAttachment,  
  errorMemberClass          :primary,  
  attachMemberClass         :primary,  
  mislocatedMemberIntersection :true,  
  mislocatedMemberInvertedPlacement :true,  
  mislocatedMemberDistanceCorrectLocation :0,  
  mislocatedMemberIntersectedItem :attachedMember,  
  stiffenerType              :intermediate,  
  stiffenerSpecifiedDiaphragmAttachment :true  
],
```

'A stiffener was connected upside down to the girder.

Therefore its bolt hole pattern does not match that of the floor beam.

The stiffener will be removed by means of air arc gouging exercising care not to gouge into web plate material.

The web plate shall be ground smooth after existing stiffener removal.

A new stiffener will be installed by a certified welder.'

).

Case #TF170:

Description of Error: Three fabricated girders have one connection stiffener each installed incorrectly ( upside down whereas the hole pattern no longer will match floor beam).

Solution Recommended: New stiffeners will be fabricated and shipped loose to job site. The existing stiffeners will be removed as follows: using oxygen-acetylene torch, cut away existing stiffener leaving approximately two inch stub. This stub is then to be removed using air-arc carbon gouging down to the toe of the weld material exercising care not to gouge into parent material. The entire weld material and any stub material remaining will be removed by grinding so as to provide a smooth surface suitable for attaching the new stiffeners. New stiffeners will be attached by a certified welder using approved weld procedure. Preheat (prior to tacking) shall be required throughout the welding process. Field weld inspection will include magnetic particle testing. Other possible solutions: leave mislocated stiffener in place, coping stiffener to eliminate interference with other pieces as necessary. Field weld new stiffener in required position. Note dimensions in actual case did not allow use of this preferred solution.

% Solution 7

caseSolution(mislocatedMember\_7,mislocatedMember,'MLCM-C007','Mislocated Member Case Solution',[],success,

```
{
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  mislocatedMemberIntersection :true,
  mislocatedMemberInvertedPlacement :false,
  mislocatedMemberDistanceCorrectLocation :20,
  mislocatedMemberIntersectedItem :attachedMember,
  stiffenerType        :intermediate
}
```

),  
'The girder was fabricated with stiffeners for another girder.

The three exterior web stiffeners need to be removed by arc air and grinding.

Partial removal of the web stiffeners at various locations will need to take place to make allowance for erection of cross frames.

The remaining stiffeners will be left in place with new stiffeners welded in place at desired locations.'

).

Case #TF172:

Description of Error: The Girder was built with correct flanges and web, but with another girder's stiffener spacing.

Solution Recommended: The change will require complete removal of the three exterior web stiffeners by arc and grinding, without damage to the web or flanges. Partial removal of the web stiffeners at 7'-9 9/16", 30'-9 9/16", and 53'-9 9/16" to make allowance for erection of cross frames. The remaining web stiffeners shall remain. Welding on new web stiffeners as shown on correct girder plans.

% Solution 8

caseSolution(misllocatedMember\_8,misllocatedMember,'MLCM-C008','Mislocated Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :capBeam,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  misllocatedMemberIntersection :false,
  misllocatedMemberInvertedPlacement :false,
  misllocatedMemberDistanceCorrectLocation :5
],
```

'A stiffener has been welded out of place.

Weld a new stiffener in the correct location.

Leave the misllocated stiffener in place as long as it does not interfere.'

).

Case #TF173:

Description of Error: On a steel box cap beam, an interior stiffener was welded out of place. The stiffener located 5" to the right of the plan location. It is intended to be directly opposite of a floor beam connection plate.

Solution Recommended: Weld a new stiffener in the correct location. The mislocated stiffener could be left in place as long as it didn't interfere with the bolts of the top connection plate. Probably can't use automatic welder because new stiffener will be too close to existing stiffener.

% Solution 9

caseSolution(mislocatedMember\_9,mislocatedMember,'MLCM-C009','Mislocated Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :bearingStiffener,
  attachMemberType    :plateGirder,
  errorMemberLocation :stiffenerAttachment,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  mislocatedMemberIntersection :true,
  mislocatedMemberInvertedPlacement :false,
  mislocatedMemberDistanceCorrectLocation :1,
  mislocatedMemberIntersectedItem :attachedMember,
  stiffenerType       :bearing,
  stiffenerActualPlumbness :1.3,
  stiffenerActualMiddleOfSolePlate :true
]
```

'Bearing stiffener welded in place out of plumb.

Kick equals 1 15/16 in. in lieu of 15/16 in.

The stiffener was left in place and a shim used to bolt cross frame to stiffener.'

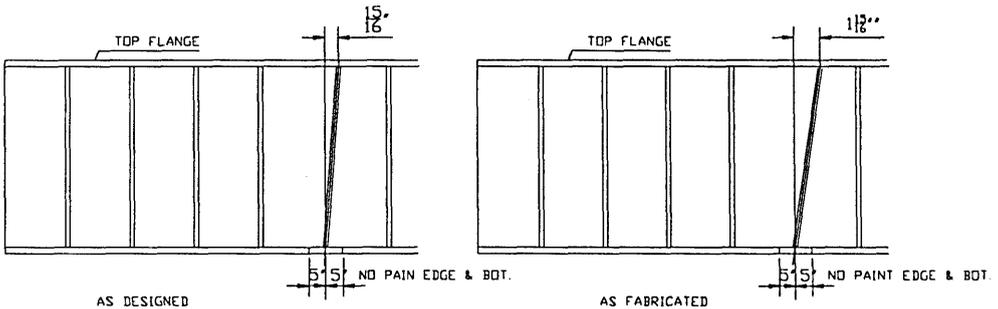
).

Case #NC501:

Description of Error: Bearing stiffeners welded in place out of plumb. Kick is 1 15/16" in lieu of 15/16".

Solution Recommended: Since bottom location of stiffener above the sole plate is correct and out of plumbness was less than 5%, stiffener was left in place and a shim used to bolt cross frame to stiffener.

Other possible solutions: Avoid removal unless absolutely needed so can avoid air arc gouging and grinding in the high stress bearing area. 1) If bottom location of stiffener is within middle 50% of sole plate, leave stiffener as is and check plumbness. If out of plumb more than 5%, weld additional stiffeners to create a shear panel (space new stiffeners between 6" and 12" on center. New stiffeners half the thickness of bearing stiffeners). Check cross-frame connection clearance. 2) If bottom location of stiffener is not within middle 50% of sole plate, add 2<sup>nd</sup> bearing stiffener.



% Solution 10

```
caseSolution(misllocatedMember_10,misllocatedMember,'MLCM-C010','Mislocated Member Case Solution',[],success,  
[  
  bridgeType           :plateGirder,  
  errorMemberType      :splicePlate,  
  attachMemberType     :plateGirder,  
  errorMemberLocation  :splice,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary,  
  misllocatedMemberIntersection :true,  
  misllocatedMemberInvertedPlacement :false,  
  misllocatedMemberIntersectedItem :attachedMember  
],
```

'The splice plate located on the low end of the floor beam interferes with the bottom flange of the floor beams.  
Cut the bottom flange flush on the near side and the far side so that it no longer interferes with the floor beam.'

).

Case #TF177:

Description of Error: A splice plate located on the low end of the floor beam, interferes with the bottom flange of a floor beam.

Solution Recommended: Cut the bottom flange flush near side and far side (like the top flange) for a distance of 7".

% New Solution 11

caseSolution(mislocatedMember\_11,mislocatedMember,'MLCM-C011','Mislocated Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :diaphragmBrace,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  mislocatedMemberIntersection :true,
  mislocatedMemberInvertedPlacement :false,
  mislocatedMemberDistanceCorrectLocation :12,
  mislocatedMemberIntersectedItem :hole,
  stiffenerType        :intermediateStiffener
],
```

' A connection stiffener for an interior cross frame was mislocated by one foot in the shop.

It was not found until the field erection process.

Drill the web to accept a bolt-in stiffener at the correct location. Visual and bolt tension verification in the field is required for final checks.'

).

Case #LY-F002:

Description of Error: A connection stiffener for an interior cross frame was mislocated by one foot in the shop. It was not found until the field erection process.

Solution Recommended: Drill the web to accept a bolt-in stiffener at the correct location. Visual and bolt tension verification in the field is required for final checks.

Other Possible solutions: Remove the mislocated stiffener and field weld a new stiffener in the correct location. This would have required three coat paint removal and repainting.

## Miscut Member Cases:

% Solution 1

```
caseSolution(miscutMember_1,miscutMember,'MCTM-C001','Miscut Member Case Solution',[],success,
```

```
[  
  bridgeType           :plateGirder,  
  errorMemberType      :intermediateStiffener,  
  attachMemberType     :plateGirder,  
  errorMemberLocation  :stiffenerAttachment,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary,  
  errorMemberDesignLength :30,  
  errorMemberActualLength :30,  
  miscutMemberSpecifiedClipped :true,  
  miscutMemberActualClipped :true,  
  miscutMemberClippedDimensionsCorrect:no  
],
```

'The difference in the clipped dimensions is minimal.

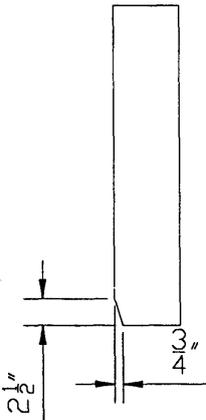
Leave the stiffeners as they are.'

```
).
```

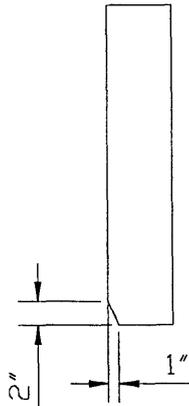
Case # DL134:

Description of Error: Clips on stiffeners (1/2" x 6" x30") were fabricated as 1"x 2" which should be 3/4" x 2 1/2".

Solution Recommended: OK to leave as is. The difference in the clipped dimensions is minimal.



DETAILED



FABRICATED

% Solution 2

```
caseSolution(miscutMember_2,miscutMember,'MCTM-C002','Miscut Member Case Solution',[],success,
```

```
{  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :tensionFlange,  
  errorMemberClass     :primary,  
  errorMemberDesignLength :711,  
  errorMemberActualLength :645  
}
```

```
),  
'The bottom flanges were purchased to short.  
Add a flange butt weld splice to make up the shortage.  
The butt weld splice shall be radiographed 100%.'  
).
```

Case # MG107:

Description of Error: Due to a purchasing error, the slab plate for girder bottom flanges was purchased 53'-9 in length but 59'-3 is needed for the three girders.

Solution Recommended: Add a flange butt weld splice at 7'6" from the right end to make up the shortage. M270 Grade 50 CVN material from this contract will be used for the repair, The butt weld splice shall be radiographed 100%.

Other Possible Solutions: If the bottom flange is in compression, less than 100% RT should be required.

% Solution 3

caseSolution(miscutMember\_3,miscutMember,'MCTM-C003','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  miscutMemberActualSweep :4,
  miscutMemberSpecifiedSweep :9.8375
]
```

The flanges could not be burned to the proper sweep.

Heat curve the flanges to meet the sweep requirements by following the appropriate DOT Special Provisions Section

Case # FB160:

Description of Error: Due to purchasing error, girder top and bottom flange plates could not be burned with the detailed 9 15/16" of sweep but only 4" of sweep.

Solution Recommended: Add the remaining 5 15/16" of sweep by the heat curving method following the procedure outlined in the appropriate Special Provisions Section for heat curved rolled beams and welded plate girders. Fabricator will locate the heats working from center line of girder and heating at 5' increments of the length of the girder. Maximum temperature of 1100 ° F. Top flange and bottom flange to be heated at same time with two rose buds per flange (one rose bud on each side of flange). Additional heat may be needed. Heating to be done in horizontal position, blocked at both ends with middle unsupported (1' gap between girder and center blocking).

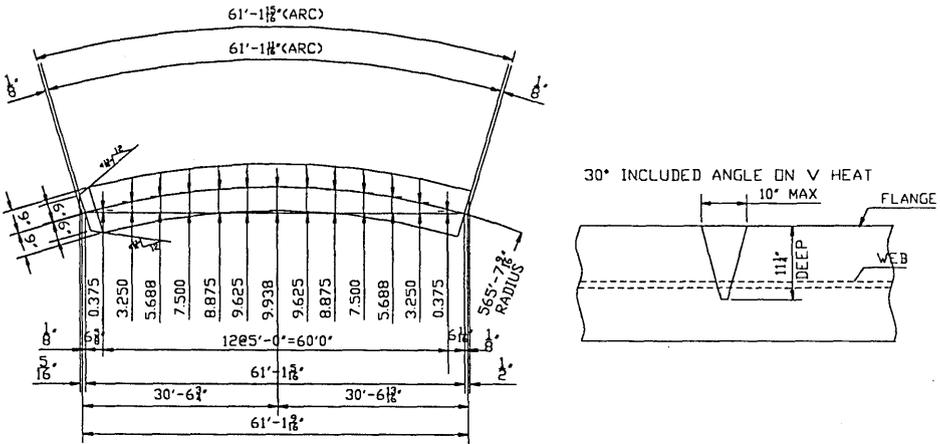


PLATE CUTTING DIAGRAM  
TOP & BOTTOM FLANGE-LOOKING DOWN

% Solution 4

caseSolution(miscutMember\_4,miscutMember,'MCTM-C004','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberLocation  :web,
  errorMemberClass    :primary,
  errorMemberDesignLength :732,
  errorMemberActualLength :731
]
```

),  
'The web of a plate girder was cut short.

The girder can be cut off to be square and the connecting girder can be extended to make up for the trim.'

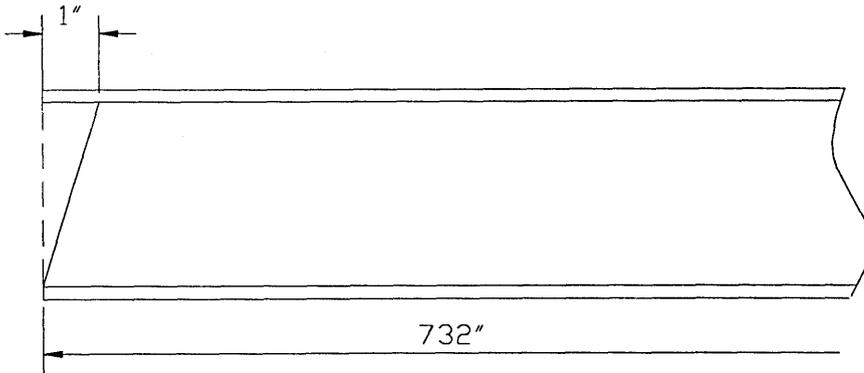
).

Case # FB151:

Description of Error: The web on a girder was miscut by 1" at the top flange.

Solution Recommended: Girder can have its end cut off to be square. The connecting girder can be lengthened 1" to make up for the trim.

Other Possible Solutions: If this was at the abutment end of a girder, leave it as is.



% Solution 5

caseSolution(miscutMember\_5,miscutMember,'MCTM-C005','Miscut Member Case Solution',[],success,

```
[  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :compressionFlange,  
  errorMemberClass     :primary,  
  miscutMemberErrorOccursAt :end  
],
```

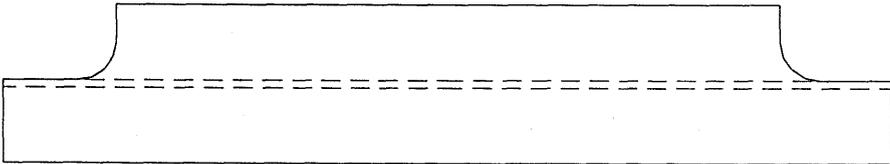
'Flange was to be stripped on far side only.  
It was stripped on the near side. Strip the far side.  
Weld tabs that were cutoff on to the near side.  
Check the weld with magnetic particle testing.'  
).

Case # DL132:

Description of Error: Top flange was to be stripped far side only. It was stripped on the near side by mistake.

Solution Recommended: Strip the far side. Weld the tabs that were cut off on the near side. Check the weld with magnetic particle testing.

Other Possible Solutions: Strip the far side and leave both sides of the flange stripped if adequate to transfer load (check blocks shear).



% Solution 6

caseSolution(miscutMember\_6,miscutMember,'MCTM-C006','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  miscutMemberErrorOccursAt :end,
  miscutMemberSpecifiedClipped :true,
  miscutMemberActualClipped   :true,
  miscutMemberClippedDimensionsCorrect:false
]
```

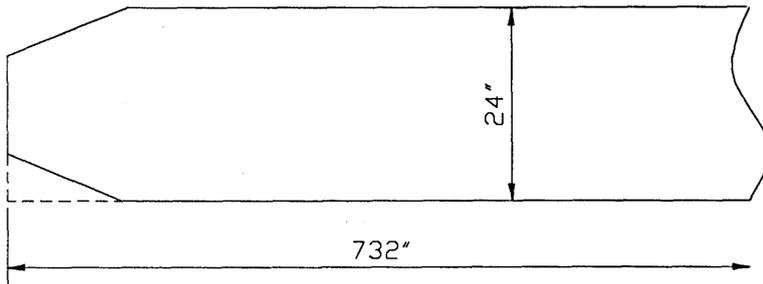
),  
'The flange was clipped on both sides when it was only to be clipped on one side.  
It is alright to leave the member as is.'

).

Case # DL131:

Description of Error: Top flange was to be clipped on the far side to miss abutment wall. It was clipped on both sides.

Solution Recommended: OK to leave as is.



% Solution 7

```
caseSolution(miscutMember_7,miscutMember,'MCTM-C007','Miscut Member Case Solution',[],success,
```

```
[  
  bridgeType           :plateGirder,  
  errorMemberType     :plateGirder,  
  errorMemberLocation :compressionFlange,  
  errorMemberClass    :primary,  
  miscutMemberErrorOccursAt :end,  
  miscutMemberSpecifiedClipped :false,  
  miscutMemberActualClipped   :true  
],
```

'Only top flange was to be clipped but both the top and bottom flange were clipped.

For the bottom plate cut off the plate 6 in. beyond last splice hole.

Weld a new flange plate on.

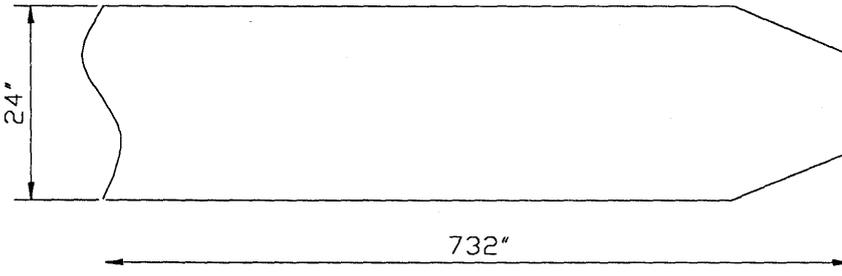
The splice should then be x-rayed.'

).

Case # 129:

Description of Error: Top flange was to be clipped. The shop clipped both the top and bottom flanges.

Solution Recommended: Cut off plate 6" beyond last splice hole. Weld a new flange plate on. Get the splice X-rayed.



% Solution 8

```
caseSolution(miscutMember_8,miscutMember,'MCTM-C008','Miscut Member Case Solution',[],success,
```

```
  [
    bridgeType           :plateGirder,
    errorMemberType      :plateGirder,
    errorMemberLocation  :compressionFlange,
    errorMemberClass     :primary,
    errorMemberDesignLength :525.75,
    errorMemberActualLength :520
  ],
```

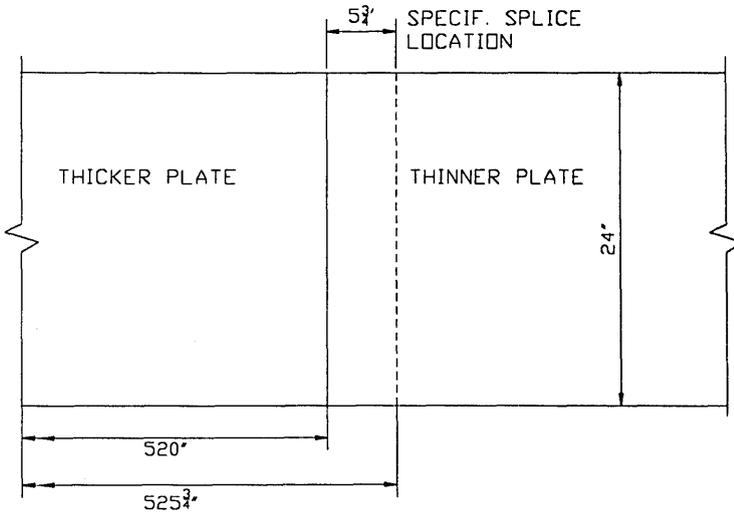
'The flange splice was off.  
The thicker plate was cut too short and the thinner plate was cut to long.  
Cut off thicker flange and return it to stock.  
Cut a new flange from stock to proper length.  
Make a new W2 weld and have it x-rayed.  
Cut excess length off of thinner plate.'  
)

Case # DL127:

Description of Error: The shop welded top flange splice was off by  $5\frac{3}{4}$ ". The thicker plate was too short and thinner plate was too long.

Solution Recommended: Cut off thicker flange and return it to stock. Cut a new flange from stock to the proper length. Make a new W2 weld. Get it x-rayed. Cut excess length off of thinner plate.

Other Possible Solutions: Designer can check design stresses at location to see if flange can be left as is.



% Solution 9

```
caseSolution(miscutMember_9,miscutMember,'MCTM-C009','Miscut Member Case Solution',[],success,
```

```
{  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :tensionFlange,  
  errorMemberClass     :primary,  
  errorMemberDesignLength :381,  
  errorMemberActualLength :360,  
  miscutMemberErrorOccursAt :end  
}
```

'The flange consisted of two plates, a narrow one and a wide one spliced together.

The wide plate was too short and the narrow plate was too long.

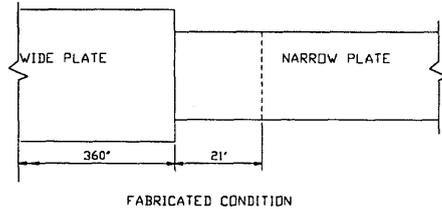
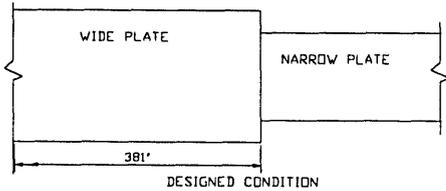
Cut off the narrow plate to the correct dimensions and splice a piece of wide plate on to the wide end and have the splice x-rayed.'

).

Case # DL122:

Description of Error: Bottom flange was made up of 2 plates spliced together in the shop. The narrow piece ended up 21" too long, the wide piece 21" too short. The flange had been spliced together and tacked to the web.

Solution Recommended: Remove flange from web. Cut 21" off narrow end. Splice a 21" piece on to the wide end. Send revised drawings. Have the splice x-rayed.



% Solution 10

```
caseSolution(miscutMember_10,miscutMember,'MCTM-C010','Miscut Member Case Solution',[],success,
```

```
{
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffeners,
  attachMemberType     :plateGirder,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignLength :21,
  errorMemberActualLength :20.6875
},
'The stiffeners were cut too short.
Build up the stiffeners with weld material and ultrasonic test.'
).
```

**Case # MG114:**

Description of Error: The milling machine had milled the stiffeners, that are below the 1 3/8" x 6 1/2" girder flange plate, the wrong direction. Twelve diaphragms were made and installed before the error was noticed. The up slope stiffener will be 5/32" long and the down slope stiffener will be 5/16" short.

Solution Recommended: Trim the long stiffeners to the proper slope. Build up the short stiffeners with weld grind and ultrasonic test.

Other Possible Solutions: If this was discovered before the stiffeners were installed, make new ones.

% Solution 11

caseSolution(miscutMember\_11,miscutMember,'MCTM-C011','Miscut Member Case Solution',[],success,

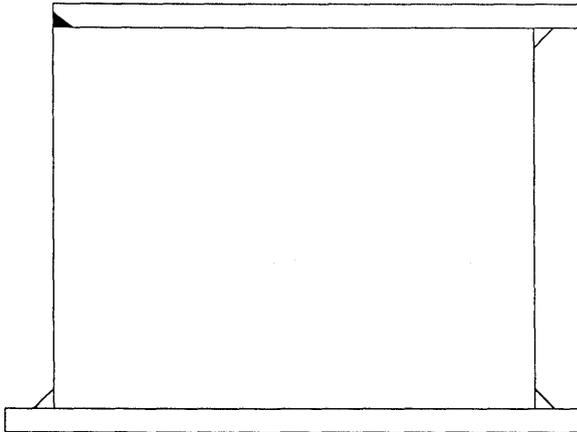
```
[
  bridgeType           :plateGirder,
  errorMemberType      :capBeam,
  attachMemberType     :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignWidth :36,
  errorMemberActualWidth :35.625
],
```

'The top flange for a steel capbeam was cut too narrow.  
The flange was supposed to overhang the web.  
Since the flange was cut too narrow to allow the overhang align the flange with the edge of the web.  
The edge that aligns with the edge will have a single bevel full penetration weld with a backing bar.'  
)

Case # MG108:

Description of Error: When flame cutting one top flange plate for a steel cap beam, the cutting machine was incorrectly set causing the plate to be cut 3/8" narrow. The flange is supposed to overhang the web by 3/8".

Solution Recommended: Align the edge of the flange plate with the web on one side of the box which will give a 3/8" overhang on the other side. The edge that aligns will have a single bevel full penetration weld with a backing bar.



% Solution 12

```
caseSolution(miscutMember_12,miscutMember,'MCTM-C012','Miscut Member Case Solution',[],success,
```

```
[  
  bridgeType           :rolled,  
  errorMemberClass     :primary,  
  errorMemberDesignLength :527.75,  
  errorMemberActualLength :527  
],
```

```
'The rolled beam was cut short and rejected for out of tolerance specifications on center of holes to edge of beam.'  
).
```

Case # MP114 (no original file)

Description of Error: The rolled beam was cut short. Also was out of tolerance on edge distance.

Solution Recommended: Rolled beam was rejected for out of tolerance specifications on center of holes to edge of beam.

% Solution 13

caseSolution(miscutMember\_13,miscutMember,'MCTM-C013','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :bearingStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :bearing,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignLength :70,
  errorMemberDesignWidth  :20,
  errorMemberActualLength :69.8125,
  errorMemberActualWidth  :20,
  miscutMemberErrorOccursAt :end
],
```

'A bearing stiffener does not have the required tight fit at stiffener to flange.

There is a gap of 3/16 in. that occurs at about midway on the stiffener to the outer edge of the stiffener.

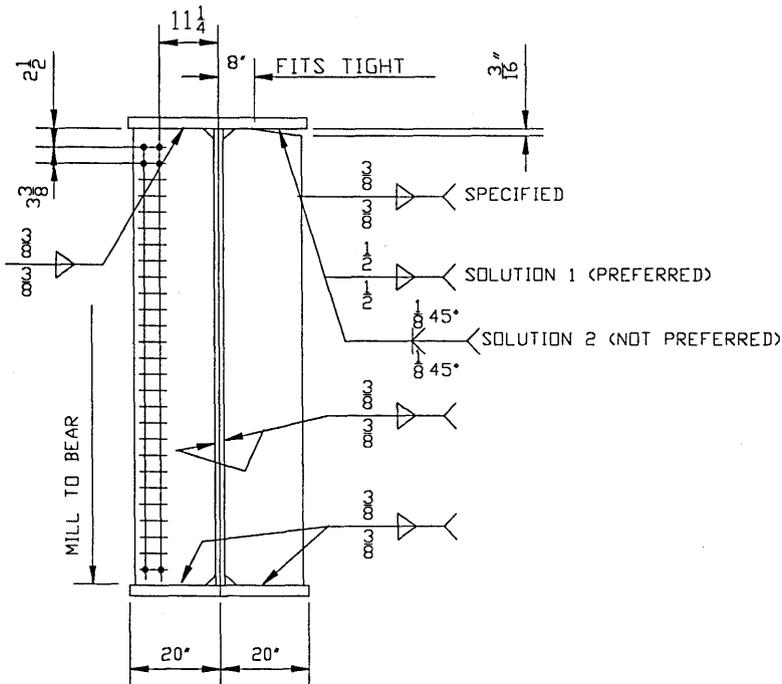
Either increase the current fillet weld size of stiffener to flange weld or (avoid full penetration weld if possible) use a full penetration weld of stiffener to flange.'

).

Case # TF176:

Description of Error: Blank bearing stiffener installed on girder does not have the required "tight fit" at stiffener to flange. The gap starts approximately 8" from girder centerline and extends toward stiffener outer edge with maximum 3/16" gap at girder flange edge.

Solution Recommended: Either increase the current 3/8 fillet weld size to 1/2 inch or (avoid full penetration weld if possible) use a full penetration weld of stiffener to flange whichever is acceptable to DOT.



% Solution 14

caseSolution(miscutMember\_14,miscutMember,'MCTM-C014','Miscut Member Case Solution',[],success,

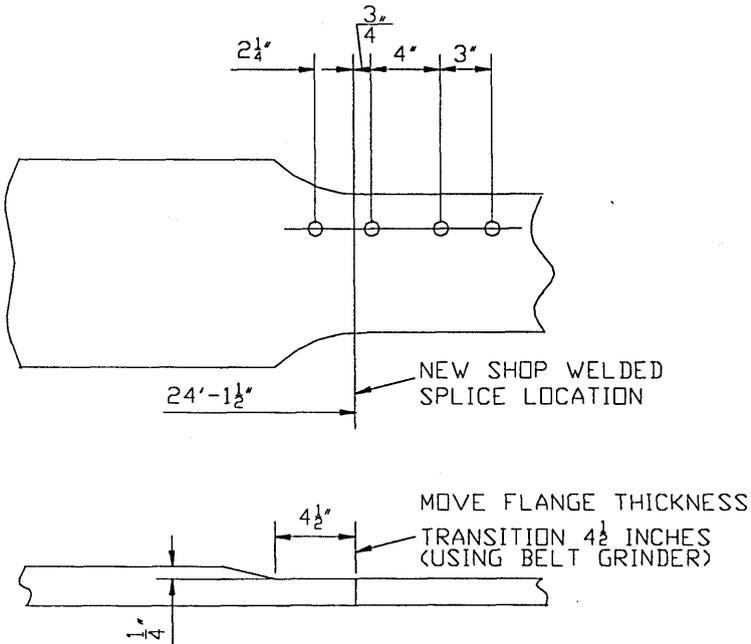
```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :spliceConnection,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignLength :282,
  errorMemberActualLength :289.5,
  miscutMemberErrorOccursAt :end
],
```

'Girder has been fabricated with the shop welded splice shifted away from X-end.  
 The thicker of the two flanges being spliced is longer than called out by design.  
 The resulting shop welded splice subsequently falls in the bolt hole pattern for floor beam.  
 Corrective action calls for grinding the thicker flange to match the thinner flange  
 thickness for approximately 4 1/2 in thus allowing the floor beam to fit properly.'

Case # TF183:

Description of Error: A girder has been fabricated with the shop welded splice shifted away from X-end. (The thicker of the two flanges being spliced is longer than called out by design). The resulting shop welded splice subsequently falls in the bolt hole pattern for floor beam at extension dimension 24'-3 3/4".

Solution Recommended: Corrective action calls for grinding the thicker flange to match the thinner flange thickness for approximately 4 1/2 inches thus allowing the floor beam to fit properly.



% Solution 15

caseSolution(miscutMember\_15,miscutMember,'MCTM-C015','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  errorMemberDesignWidth :20,
  errorMemberActualWidth :16,
  miscutMemberErrorOccursAt :end,
  miscutMemberSpecifiedClipped :false,
  miscutMemberActualClipped :true
]
```

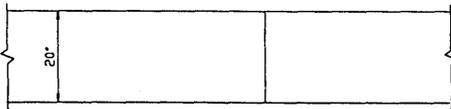
'The fabricator mistakenly cut each end of the bottom flange at a 2 ft. radius.  
Weld the cutoff pieces back onto the flange.'

).

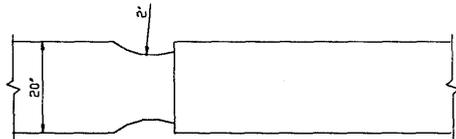
Case # TF220:

Description of Error: The top and bottom flange plates of the girder are 20" wide. The top flange has a 2'-0" radius on each end to transition to a 16" wide flange at the field splices. The 20" bottom flange splices to a 20" flange to each end of the girder. The fabricator mistakenly cut each end of the bottom flange at a 2'-0" radius.

Solution Recommended: Weld the cutoff pieces back onto the flange. Welds should be ground smooth and N.D. tested.



DESIGNED CONDITION



FABRICATED CONDITION

% Solution 16

caseSolution(miscutMember\_16,miscutMember,'MCTM-C016','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  miscutMemberErrorOccursAt :end,
  miscutMemberSpecifiedClipped :false,
  miscutMemberActualClipped  :true
],
```

'The bottom flange was incorrectly cut to the same taper as the top flange.

Corrective action will be to reattach same pieces by full penetration welding using

AWS Prequalified Joint and DOT approved weld procedures. Finished weld will be 100% UT inspected.'

).

Case # TF222:

Description of Error: Girder bottom flange was incorrectly cut to the same taper as top flange.

Solution Recommended: Corrective action will be to reattach same pieces by full penetration welding using AWS Prequalified Joint and DOT approved weld procedures. Finish weld will be 100% UT inspected. Drawings will be revised to reflect the "as built" condition.

% Solution 17

caseSolution(miscutMember\_17,miscutMember,'MCTM-C017','Miscut Member Case Solution',[],success,

```
[
  errorMemberType      :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  errorMemberDesignLength :186,
  errorMemberActualLength :150,
  miscutMemberErrorOccursAt :end
],
```

'The flange of a girder was miscut.

The configuration can be obtained by the addition of a shop welded flange splice at 5 ft. from x-end.'

).

Case # TF223:

Description of Error: Due to a numerically controlled equipment program error flange a girder has been miscut.

Solution Recommended: The correct configuration can be obtained by the addition of a shop welded flange splice at 5'-0" from X-end splice to be located between stiffeners at extension dimension 3'-9 ¾ and 7'-1 ¾. Drawings revised to show "as built" condition.

% Solution 18

```
caseSolution(miscutMember_18,miscutMember,'MCTM-C018','Miscut Member Case Solution',[],success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  miscutMemberErrorOccursAt :end,
  miscutMemberSpecifiedClipped :true,
  miscutMemberActualClipped :true,
  miscutMemberClippedDimensionsCorrect:false
],
```

'The girder has its top flange incorrectly clipped.

As a result the edge distance for one of the holes in the flange is not adequate.

Move the hole nearest the clipped edge.

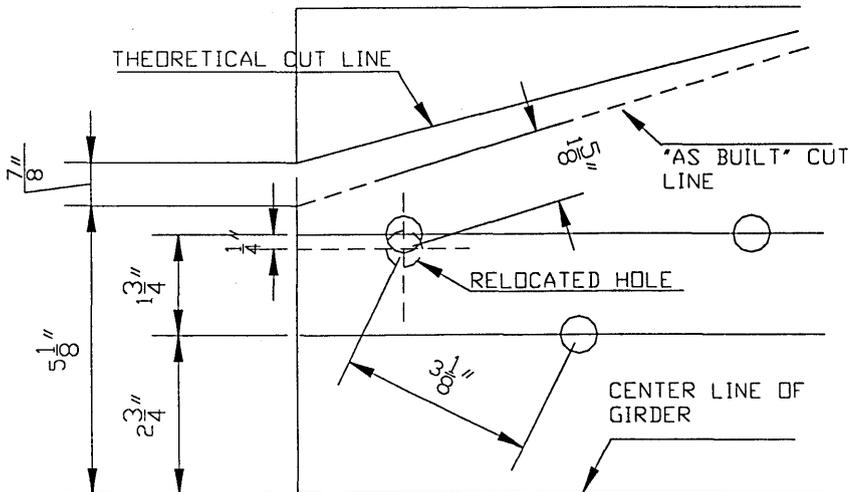
Fabricate splice plates to match the new hole pattern.'

).

Case # TF224:

Description of Error: One girder has the corners clipped incorrectly. The centerline of girder to edge of clip is called out by design to be 6 inches. As fabricated, this dimension has been cut to 5 1/8 inch (1'-0 3/8 inch along length of taper cut). Review of "As Built" indicates by relocating hole 1/4 inch (neither splice plate nor flange are drilled at this writing); an 1 1/2 inch edge distance and 3 inch optimum between holes can be maintained. In any event, the edge distance will be maintained knowing 2 5/8 inch minimum center to center of hole can still be maintained.

Solution Recommended: Relocate hole 1/4 - 3/8 inch allowing the clip (taper cut) to remain as fabricated. Drawing revised to reflect "as built" condition.



% Solution 19

```
caseSolution(miscutMember_19,miscutMember,'MCTM-C019','Miscut Member Case Solution',[],success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :rocker,
  attachMemberType     :plateGirder,
  errorMemberLocation  :bearing,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignLength :9,
  errorMemberDesignThickness :1.125,
  errorMemberActualLength :8.25,
  errorMemberActualThickness :1.25,
  miscutMemberErrorOccursAt :end
]
```

),  
'The rocker for the pier has been cut short 3/4 in.  
The rocker plates have not been milled yet. Provide a thicker sole plate or base plate and use rockers.  
The rocker plate would be remilled on a 8 1/4 in. radius instead of the 9 in. radius as specified.'  
)

Case # NC508:

Description of Error: The rockers for two piers have been fabricated incorrectly. The 1 1/8" thick vertical bearing plates were cut 3/4" short. The rocker plates have not been milled yet.

Solution Recommended: Provide a thicker sole plate or base plate and use the rockers. The rocker plates would be milled on a 8 1/4" radius instead of the 9" radius. DOT checked the movement capacity for the 8 1/4' radius before approval of the rockers.

% Solution 20

```

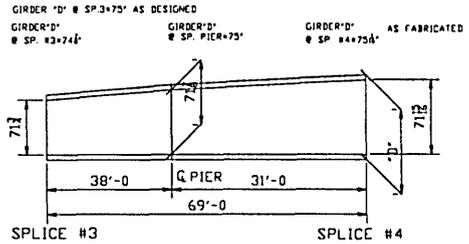
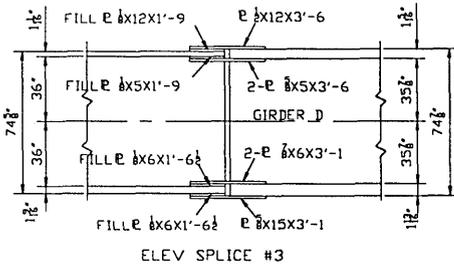
caseSolution(miscutMember_20,miscutMember,'MCTM-C020','Miscut Member Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignWidth :71.875,
  errorMemberActualWidth :71.75,
  miscutMemberErrorOccursAt :end
],
'The web plate for the girder has been cut narrow at the field splice area.
Use a fill plate at field splice to accommodate the web depth under run.'
).

```

Case # NC512:

Description of Error: The web plate for one girder (marked girder D in sketches) has been cut narrow. The as fabricated web depth is 1/4" narrow at field splice #3, 1/8" narrow at pier #2, and 1/16" narrow at field splice #4. The girder is fabricated and is in the laydown area for the drilling of the field splices.

Solution Recommended: Provide 1/8" fill plates at field splice to accommodate the web depth under run.



% New Solution 21

caseSolution(miscutMember\_21,miscutMember,'MCTM-C021','Miscut Member Case Solution',[ddf006],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  mislocatedMemberIntersection :false,
  mislocatedMemberInvertedPlacement :false,
  mislocatedMemberDistanceCorrectLocation :.0.125
]
```

Several locations had cambers less than called for on design plans.

Two locations are 1/8" different and two locations are 1/16" different.

No rework to beams.

Plans contain provisions for adjusting haunch heights based on differences between theoretical and actual top of steel elevations.

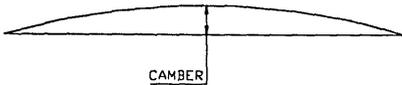
DOT construction inspection is required for final checks.

).

Case #DD-F006:

Description of Error: Several locations had cambers less than called for on design plans. Two locations are 1/8" different and two locations are 1/16" different.

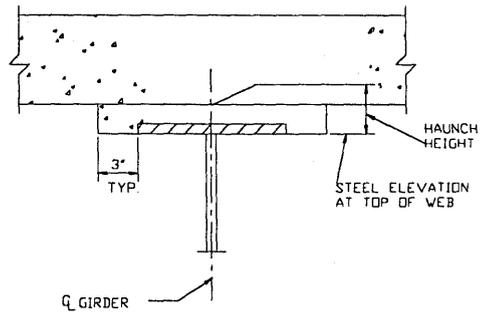
Solution Recommended: No rework to beams. Plans contain provisions for adjusting haunch heights based on differences between theoretical and actual top of steel elevations. DOT construction inspection is required for final checks.



GIRDER	RC	MC
A10	1/8"	1/16"
A11	2/8"	2/8"
A12	1/16"	1/8"
A19	2/16"	2/8"

RC=REQUIRED CAMBER

MC=MEASURED CAMBER



% New Solution 22

caseSolution(miscutMember\_22,miscutMember,'MCTM-C022','Miscut Member Case Solution',[scf001],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :webPlate,
  attachMemberType     :pinHanger,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  miscutMemberErrorOccursAt :end
],
```

\* Miscut end of rolled beam web for pin and hanger assembly at pin hole location.

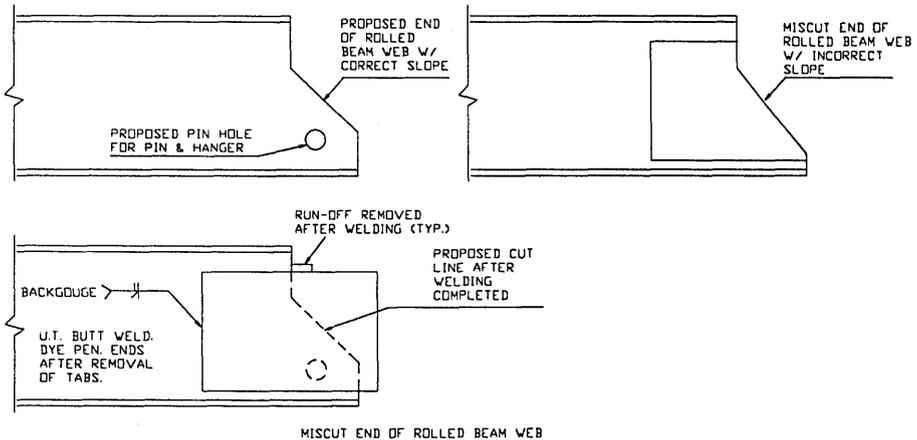
Cut out web at pin hole area as show. Cut out new plate to fit cut web in rolled beam. Use S.A.W. to weld in new plate. U.T. full penetration weld. Cut slope on new web plate at beam end. Cut hole of pin and hanger assembly. Ultrasonic testing of full penetration butt welds and liquid dye penetrate ends after run-off tab removal are required of final checks.

Case #SC-F001:

Description of Error: Miscut end of rolled beam web for pin and hanger assembly at pin hole location.

Solution Recommended: Cut out web at pin hole area as show. Cut out new plate to fit cut web in rolled beam. Use submerged arc welding to weld in new plate. U.T. full penetration weld. Cut slope on new web plate at beam end. Cut hole of pin and hanger assembly. Ultrasonic testing of full penetration butt welds, and liquid dye penetrate ends after run-off tab removal are required of final checks.

Other Possible solutions: Reject beam and fabricate new beam.



% New Solution 23

caseSolution(miscutMember\_23,miscutMember,'MCTM-C023','Miscut Member Case Solution',[BLF001],success,

```
[
  bridgeType           :bascule,
  errorMemberType     :intermediateStiffener,
  attachMemberType    :plateGirder,
  errorMemberLocation :stiffenerAttachment,
  errorMemberClass    :fractureCritical,
  attachMemberClass   :primary,
  miscutMemberErrorOccursAt :end
],
```

A stiffener in the trunnion shaft area was cut 1/4" too short.

It was fitted to the girder tight at the top (tension) end and was fillet welded on both sides to the web of the girder.

Welding procedure was for semi-automatic submerged arc fillet welds at the flange and web.

Bevel the short end with arc-air and weld the arc-aired side with SMAW.

Back gouge the other side and weld with SMAW.

Ultrasonically test the weld to the bridge code standard in AWS D1.5.

Detail was changed from fillet weld to single J groove weld-TC-U8a.

Ultrasonic testing to the bridge code standards of AWS D1.5-88, and 1988 fracture control plan by AASHTO are required for final checks.'

).

#### Case #BL-F001:

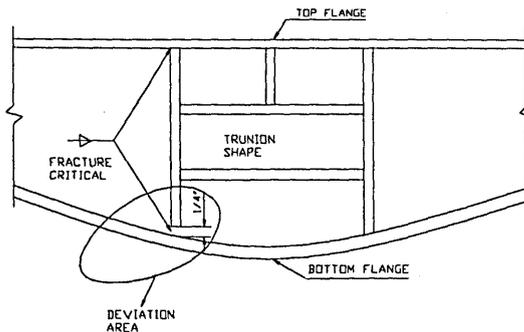
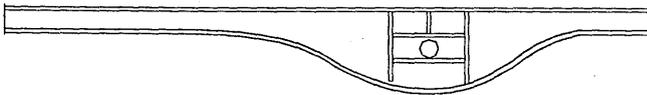
Description of Error: Error occurred on 132 ft bascule girder at trunnion. A stiffener in the trunnion shaft area was cut 1/4" too short. It was fitted to the girder tight at the top (tension) end and was fillet welded on both sides to the web of the girder.

Welding procedure was for semi-automatic submerged arc fillet welds at the flange and web.

Solution Recommended: Bevel the short end with arc-air and weld the arc-aired side with SMAW. Back gouge the other side and weld with SMAW. Ultrasonically test the weld to the bridge code standard in AWS D1.5. Detail was changed from fillet weld to single J groove weld-TC-U8a.

Ultrasonic testing to the bridge code standards of AWS D1.5-88, and 1988 fracture control plan by AASHTO are required for final checks.

Other Possible solutions: Remove the stiffener and replace it. (Horizontal stiffener had not been installed yet.)



% New Solution 24

caseSolution(miscutMember\_24,miscutMember,'MCTM-C024','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :flangePlate,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  errorMemberDesignWidth :18,
  errorMemberActualWidth :16,
  miscutMemberErrorOccursAt :end
],
```

\* Detailer failed to show width transition (16" to 18") on the shop drawings.

The error was not caught until the shop inspector noted the deviation from other girders and a check of the design drawings revealed that the width should have transitioned from 16" to 18" for the last 20' of girder length.

The flange section of insufficient width was removed by air-arcing the flange to web weld back 25', lifting to gain access to the flange splice and air-arc removal of the splice weld. A piece was flame cut to the correct width and spliced (butt welded) to the attached bottom flange. After acceptable radiography the 25' flange to web weld was re-welded by submerged arc. (fillet weld).')

Case #LY-F001:

Description of Error: Detailer failed to show width transition (16" to 18") on the shop drawings. The error was not caught until the shop inspector noted the deviation from other girders and a check of the design drawings revealed that the width should have transitioned from 16" to 18" for the last 20' of girder length.

Solution Recommended: The flange section of insufficient width was removed by air-arcing the flange to web weld back 25', lifting to gain access to the flange splice, and air-arc removal of the splice weld. A piece was flame cut to the correct width and spliced (butt welded) to the attached bottom flange. After acceptable radiography the 25' flange to web weld was re-welded by submerged arc. (fillet weld).

Other Possible solutions: Use as is, if design calculations would have allowed the 2" reduction of width.

%New Solution 25

caseSolution(miscutMember\_25,miscutMember,'MCTM-C025','Miscut Member Case Solution',[dlf001],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  miscutMemberErrorOccursAt :end
],
```

During burn-off for length, girder was cut 1' too short.

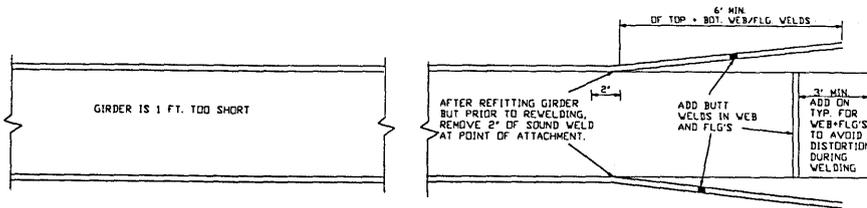
Cut top and bottom web/flange welds back 6' min. pry open to allow new web butt weld and RT. Note: new web section shall be min.3' long. While girder remains pryed open, make flange butt welds and R.T., then reweld both top and bottom web/flange welds.'

).

Case #DL-F001:

Description of Error: During burn-off for length, girder was cut 1' too short.

Solution Recommended: Cut top and bottom web/flange welds back 6' min. pry open to allow new web butt weld and RT. Note: new web section shall be min.3' long. While girder remains pryed open, make flange butt welds and R.T., then reweld both top and bottom web/flange welds. Engineer shall locate butt joints and stagger location so flange and web welds are at different cross section. 100 % R.T. is required, followed by 100% M.T. of web and flanges prior to refit, 100% M.T. after final weld.



% New Solution 26

caseSolution(miscutMember\_26,miscutMember,'MCTM-C026','Miscut Member Case Solution',[Irf001],success,

```
[  
  bridgeType           :plateGirder,  
  errorMemberType     :intermediateStiffener,  
  attachMemberType    :plateGirder,  
  errorMemberLocation  :stiffenerAttachment,  
  errorMemberClass    :primary,  
  attachMemberClass   :primary,  
  miscutMemberErrorOccursAt :end  
],
```

'The first 5 stiffener from the left and of girder are not in contact with the top flange.

Plans call for the stiffener to be fillet welded to both top and bottom flange.

The first 4 stiffeners can be fillet welded to the top flange by increasing the size of the fillet by the amount of gap (1/16" or 1/8").

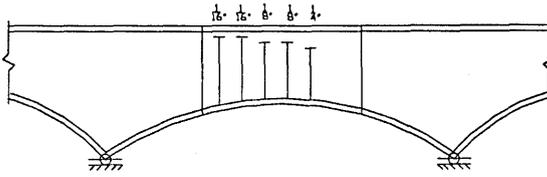
The stiffener with 1/4" gap will be welded with a full penetration weld.'

).

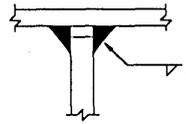
#### Case #LR-F001:

Description of Error: The first 5 stiffener from the left and of girder are not in contact with the top flange. Plans call for the stiffener to be fillet welded to both top and bottom flange.

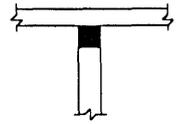
Solution Recommended: The first 4 stiffeners can be fillet welded to the top flange by increasing the size of the fillet by the amount of gap (1/16" or 1/8"). The stiffener with 1/4" gap will be welded with a full penetration weld.



OVERVIEW



FILLET DETAIL



PEN. DETAIL

% New Solution 27

caseSolution(miscutMember\_27,miscutMember,'MCTM-C027','Miscut Member Case Solution',[ddf001],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :webPlate,
  attachMemberType     :flangePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignWidth :52.375,
  errorMemberActualWidth :51.5
],
```

'The web was cut 7/8" too narrow at left end but was not discovered until flanges were already welded on.

The web was designed with a taper 4'-4 3/8" to 4'-3 1/2".

The web was cut at 4'-3 1/2" all the way across, 7/8" too narrow 6'-0 from the left end to the end.

Remove the top and bottom flanges 6'-0 from the left end,

cut out the narrow web and replace with new piece of 52 3/8" x 1/2 x 6'-0 A709 Gr.50 with Charpy, grain to run longitudinally, and x-ray.

Then weld flanges back on and mag test flange to web weld 2'-0 either side of web splice.'

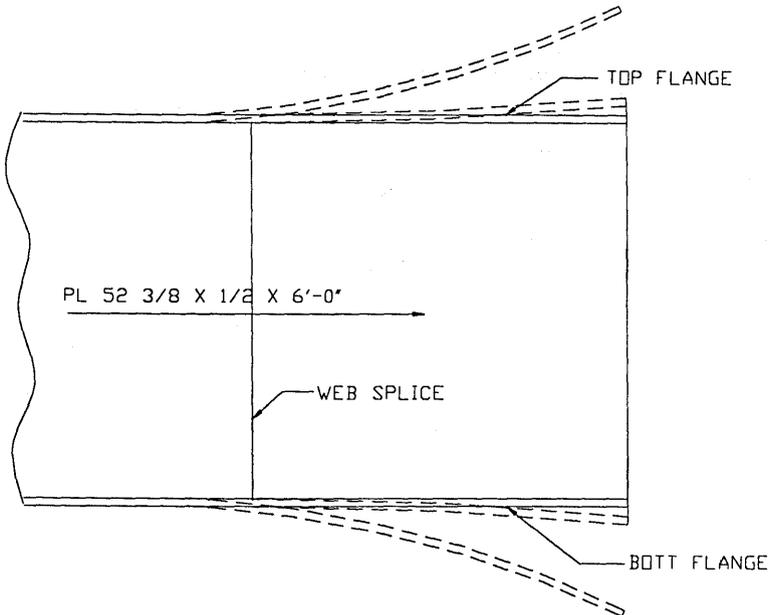
).

Case #DD-F001:

Description of Error: The web was cut 7/8" too narrow at left end but was not discovered until flanges were already welded on.

The web was designed with a taper 4'-4 3/8" to 4'-3 1/2". The web was cut at 4'-3 1/2" all the way across, 7/8" too narrow 6'-0 from the left end to the end.

Solution Recommended: Remove the top and bottom flanges 6'-0 from the left end, cut out the narrow web and replace with new piece of 52 3/8" x 1/2 x 6'-0 A709 Gr.50 with Charpy, grain to run longitudinally, and x-ray. Then weld flanges back on and mag test flange to web weld 2'-0 either side of web splice.



% New Solution 28

caseSolution(miscutMember\_28,miscutMember,'MCTM-C028','Miscut Member Case Solution',[ddf002],success,

```
[  
  bridgeType           :plateGirder,  
  errorMemberType      :bearingStiffener,  
  attachMemberType     :plateGirder,  
  errorMemberLocation  :bearing,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary,  
  miscutMemberErrorOccursAt :end  
],
```

\* The bearing stiffener was cut too short and was welded in place before they discovered the gap between the bottom flange and the bottom of the stiffener.

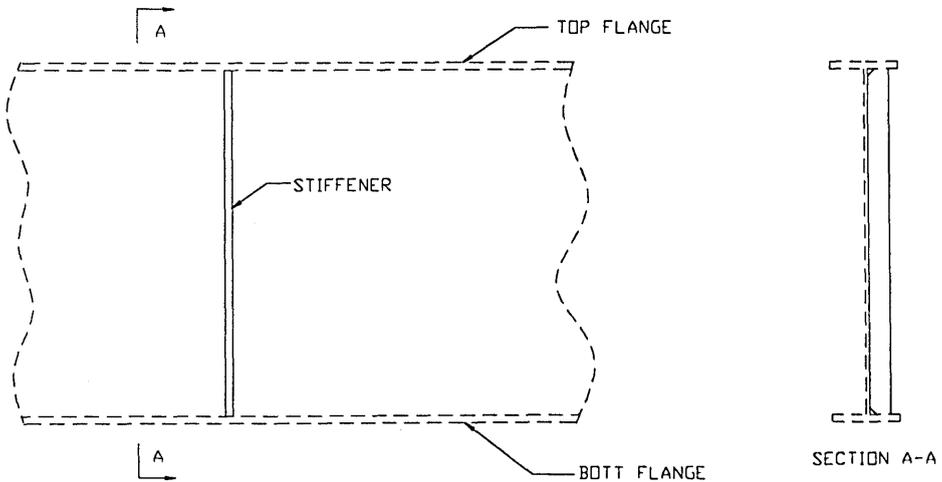
Cut stiffener out, grind weld area on the web, then magnetic particle test the web for cracking and replace with a correct length stiffener.\*

).

Case #DD-F002:

Description of Error: The bearing stiffener was cut too short and was welded in place before they discovered the gap between the bottom flange and the bottom of the stiffener.

Solution Recommended: Cut stiffener out, grind weld area on the web, then magnetic particle test the web for cracking and replace with a correct length stiffener.



% New Solution 29

caseSolution(miscutMember\_29,miscutMember,'MCTM-C029','Miscut Member Case Solution',[ddf003],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :flangePlate,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass   :primary,
  errorMemberDesignWidth :16,
  errorMemberActualWidth :15.5625,
  miscutMemberErrorOccursAt :end
]
```

),  
'The designed 16" flanges were cut from 17" down to 15.5625" back up to 16".  
Along with this irregular cut, flame cut defects were created at locations given in table.  
Cut down the flange to 16" in the first 20'-0", ground the plate to 16 3/8" between 91'-0" and 95'-0",  
and left the other widths as cut. The edge defect repairs were welded and NDT per code, or were ground at a 10 to 1 bevel.  
Each defect description and location is shown in the table with its repair method.'  
)

Case #DD-F003:

Description of Error: The designed 16" flanges were cut from 17" down to 15.5625" back up to 16". Along with this irregular cut, flame cut defects were created at locations given in table.

Solution Recommended: Cut down the flange to 16" in the first 20'-0", ground the plate to 16 3/8" between 91'-0" and 95'-0", and left the other widths as cut. The edge defect repairs were welded and NDT per code, or were ground at a 10 to 1 bevel. Each defect description and location is shown in the table with its repair method. (also see case 'NAGS-C014' for nicks and gouges on same member)

% New Solution 30

caseSolution(miscutMember\_30,miscutMember,'MCTM-C030','Miscut Member Case Solution',[ddf004],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :webPlate,
  attachMemberType     :flangePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  errorMemberDesignLength :120.0625,
  errorMemberActualLength :119.0625,
  miscutMemberErrorOccursAt :end
],
```

The web plate near the center of the girder in the haunched area was cut 1" too narrow along the parabolic curve, which caused an indentation approximately 5'-0 long.

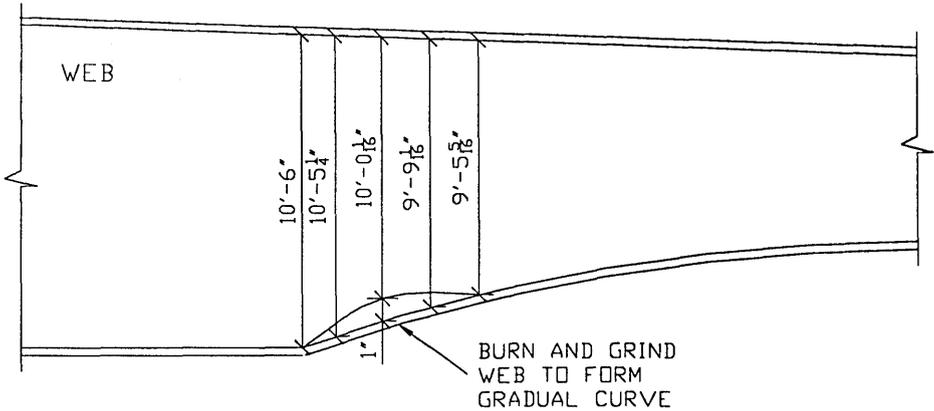
Grind web to form a gradual curve where the indentation was cut so as to create a smooth transition to weld the bottom flange to.

).

Case #DD-F004:

Description of Error: The web plate near the center of the girder in the haunched area was cut 1" too narrow along the parabolic curve, which caused an indentation approximately 5'-0 long.

Solution Recommended: Grind web to form a gradual curve where the indentation was cut so as to create a smooth transition to weld the bottom flange to. Provide radial transitions at the 10'-5 1/4" and 9'-5 5/16" web depth locations. Adjust stiffener depth as needed in affected area.



% New Solution 31

caseSolution(miscutMember\_31,miscutMember,'MCTM-C031','Miscut Member Case Solution',[ddf005],success,

```
[  
  errorMemberType      :expansionDevice,  
  attachMemberType     :flangePlate,  
  errorMemberLocation  :splice,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary  
],
```

The finger plate from one end towards the middle 19'-4" was cut too narrow which did not allow for enough overhang for the 3/8" fillet weld to attach the W12 x 35 top flange to the underneath side of the finger plate.

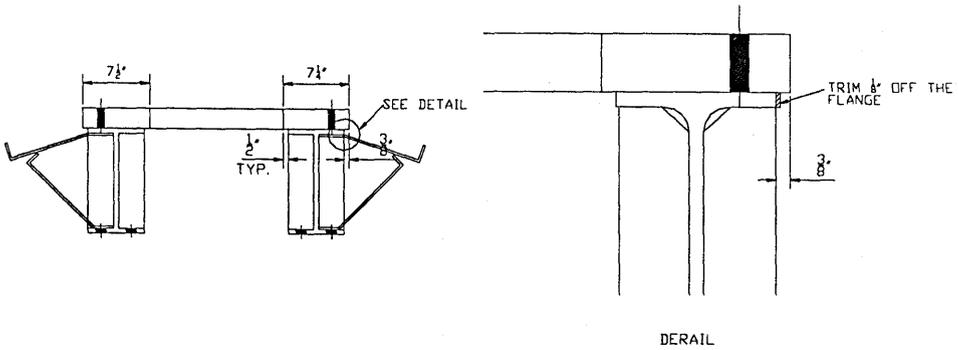
To trim 1/8" off vertically, of the top flange of the W 12 x 35 in the affected area of the finger plate on the side where there was not enough overhang, to allow for a 3/8' weld.'

).

Case #DD-F005:

Description of Error: The finger plate from one end towards the middle 19'-4" was cut too narrow which did not allow for enough overhang for the 3/8" fillet weld to attach the W12 x 35 top flange to the underneath side of the finger plate.

Solution Recommended: To trim 1/8" off vertically, of the top flange of the W 12' x 35 in the affected area of the finger plate on the side where there was not enough overhang, to allow for a 3/8' weld.



% New Solution 32

caseSolution(miscutMember\_32,miscutMember,'MCTM-C032','Miscut Member Case Solution',[],success,

```
{
  bridgeType           :plateGirder,
  errorMemberType      :diaphragmBrace,
  attachMemberType     :plateGirder,
  errorMemberClass     :primary,
  attachMemberClass    :primary
},
```

Twelve of the cross frames for this project were mistakenly detailed with the bent (skewed) connection angles as "opposite hand". While the slope of the angles changed from one side of the bridge to the other, their orientation to each other on both sides of this widening project were the same. In the plan view they were parallel (in plane) with each other and should not have been detailed as opposite hand.

The top skewed plates were bolted on and could merely be unbolted turned around, and new high-strength bolts installed.

The bottom bent plate was welded to the cross frame angles and required air-arcing to remove the welds, cleaning, re-making new bent plates, and re-welding of this item to the cross frame angles.

Since these items had a three coat paint system applied, they also required re-blasting and re-painting.

).

Case #SC-F003:

Description of Error: Twelve of the cross frames for this project were mistakenly detailed with the bent (skewed) connection angles as "opposite hand". While the slope of the angles changed from one side of the bridge to the other, their orientation to each other on both sides of this widening project were the same. In the plan view they were parallel (in plane) with each other and should not have been detailed as opposite hand.

Solution Recommended: The top skewed plates were bolted on and could merely be unbolted turned around, and new high-strength bolts installed. The bottom bent plate was welded to the cross frame angles and required air-arcing to remove the welds, cleaning, re-making new bent plates, and re-welding of this item to the cross frame angles. Since these items had a three coat paint system applied, they also required re-blasting and re-painting. Required final checks: 1. Visual examination of bent plate removal. 2. Visual examination for fitup of reinstalled plates. 3. Visual examination of re-installed fillet welds. 4. Witness turn-of-the-nut tensioning for re-installed bolting. 5. Verify acceptable blast condition and surface profile. 6. Check all three coats of the re-applied paint system.

Other Possible solutions: Scrap the cross frames and re-fabricate new ones.

% New Solution 33

caseSolution(miscutMember\_33,miscutMember,'MCTM-C033','Miscut Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  miscutMemberErrorOccursAt :end
],
```

'While trimming girder to desired length during blocking assembly, an error by Q.C. dept. resulted in girder being 100 mm short in length. Add on small section of girder by full penetration welding and then trim to proper length, relocate holes in field splice material to avoid drilling thru full-penetration welds. Required final checks: R.T, U.T, finish grinding, and dimensional and visual inspection.'

).

#### Case #DL-F005:

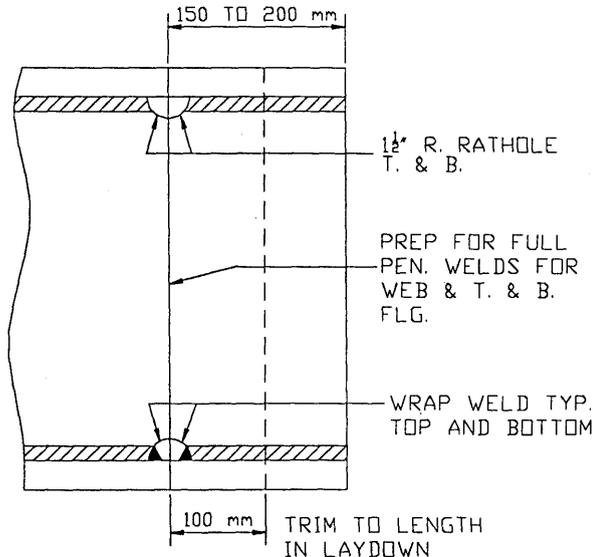
Description of Error: While trimming girder to desired length during blocking assembly, an error by Q.C. dept. resulted in girder being 100 mm short in length.

Solution Recommended: Add a section 150 to 200mm long to each flange and web, butt weld to the end of girder, and trim this section to a length of 100, to maintain the overall girder length.

The following steps are to be taken:

1. Prop flanges and prepare half of ratholes in web.
2. Butt weld flange section per approved welding procedure. RT butt welds when cooled to ambient temperature.
3. Prep web section to be added, including remaining half rathole.
4. Butt weld per approved welding procedure. Wrap welds as required in rathole. RT 100% when cooled to ambient temperature.
5. Complete fillet welds and trim girder to correct length in girder line assembly.
6. Fit and drill splice connections. The quantity of web and flange holes will remain as designed. The web splice plates will not change, but the top and bottom flange plate will be elongated to accommodate bolt spacing change for clearance between holes and butt weld.

Other Possible Solutions: Scrap entire girder.



% New Solution 34

caseSolution(miscutMember\_34,miscutMember,'MCTM-C034','Miscut Member Case Solution',[],success,

```
[  
  bridgeType           :bascule,  
  errorMemberType      :webPlate,  
  errorMemberLocation  :web,  
  errorMemberClass     :primary,  
  miscutMemberErrorOccursAt :end  
],
```

), 'Web plate placed w/rolling direction perpendicular to stress.

Leave it in the wrong way because it might be okay. Impacts were 30 # @-30° F. Transverse impacts would okay. Ripping the plate out would be horrendous.'

).

Case #CW-F001:

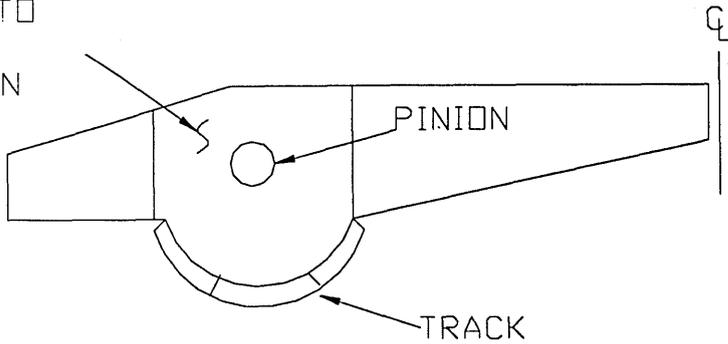
Description of Error: Web plate placed w/rolling direction perpendicular to stress.

Solution Recommended: Leave it in the wrong way because it might be okay. Impacts were 30 # @-30° F. Transverse impacts would okay. Ripping the plate out would be horrendous.

Remarks: If it cracks we were wrong to accept it.

Other Possible solutions: Cut the plate out and place parallel to roll.

PLATE  $\perp$  TO  
ROLL  
DIRECTION



## Misattached Member Cases:

% Solution 1

```
caseSolution(misattachedMember_1,misattachedMember,'MATM-C001','Misattached Member Case Solution',[],success,
[
  bridgeType                :plateGirder,
  errorMemberType           :intermediateStiffener,
  attachMemberType         :plateGirder,
  errorMemberLocation       :tensionFlange,
  errorMemberClass         :primary,
  attachMemberClass        :primary,
  stiffenerType             :intermediate,
  stiffenerSpecifiedFlangeAttachment :compressionFlange,
  stiffenerSpecifiedCompFlangeAttachmentType :weld,
  stiffenerActualTensionFlangeAttachmentType :weld,
  stiffenerActualCategoryCFlange :true,
  stiffenerActualTensionFlangeAttached :true,
  stiffenerActualCompFlangeAttached :false
],
'The intermediate stiffeners were welded to the tension flange instead of the compression flange.
Leave the tension flange welds and go ahead and weld stiffeners to the compression flange.
The tension flange welds need to be inspected using MT procedures.'
).
```

Case # FB162:

Description of Error: A girder has 8 stiffener bars welded to the tension flange. As detailed on Drawings, Section A should be welded with a 5/16" fillet on the top flange but was welded to the bottom flange; Section B shows a 5/16" fillet on the bottom flange but was welded on the top flange.

Solution Recommended: Weld the stiffener bars to both flanges of girder. In addition, it is requested the stiffener to tension flange welds be inspected using MT procedures. Fatigue category of tension flange weld was checked by DOT and found acceptable for this case, so leave stiffener welded to tension flange.

% Solution 2

caseSolution(misattachedMember\_2,misattachedMember,'MATM-C002','Misattached Member Case Solution',[],success,

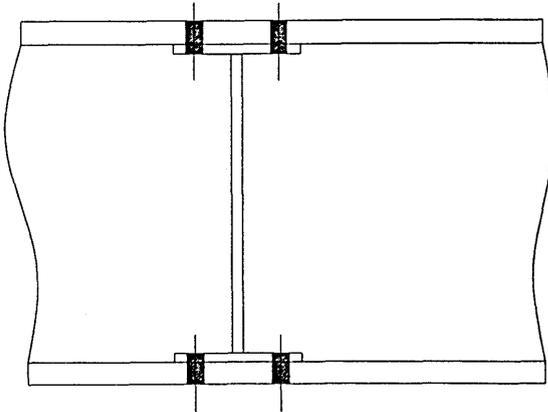
```
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  stiffenerType        :intermediateStiffener,
  stiffenerSpecifiedDiaphragmAttachment :true,
  stiffenerSpecifiedFlangeAttachment    :both,
  stiffenerSpecifiedTensionFlangeAttachmentType:boltedPlate,
  stiffenerSpecifiedCompFlangeAttachmentType :weld,
  stiffenerActualTensionFlangeAttachmentType :boltedPlate,
  stiffenerActualCompFlangeAttachmentType    :boltedPlate,
  stiffenerActualTensionFlangeAttached      :false,
  stiffenerActualCompFlangeAttached         :false
]
```

The stiffener was to be welded to the bottom flange.  
However holes were drilled in the bottom flange for an auxiliary plate attachment.  
Shorten the stiffener by 3/8 in. the thickness of the auxiliary plate.  
Put an auxiliary plate at the bottom similar to the one at the top.  
).

Case # DL170:

Description of Error: The top flange is the tension flange in this area. Its connection was made properly. The stiffener was to be welded to the bottom flange but was not welded when it was noticed the driller had drilled holes in the top and bottom flange. The stiffener was not yet welded into the girder.

Solution Recommended: Shorten the stiffener by 3/8" (the thickness of the auxiliary plate). Put an auxiliary plate at the bottom, similar to the one at the top.



% Solution 3

caseSolution(misattachedMember\_3,misattachedMember,'MATM-C003','Misattached Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :intermediateStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  stiffenerType        :intermediate,
  stiffenerSpecifiedDiaphragmAttachment :false,
  stiffenerSpecifiedFlangeAttachment    :compressionFlange,
  stiffenerSpecifiedCompFlangeAttachmentType :weld,
  stiffenerActualTensionFlangeAttachmentType :weld,
  stiffenerActualCompFlangeAttachmentType :weld,
  stiffenerActualTensionFlangeAttached    :true,
  stiffenerActualCompFlangeAttached      :true
],
```

'The intermediate stiffener was to be tight fit to bottom flange and was instead welded with 1/4 in. fillet weld on both sides.

The stiffener needs to be cut 1 in. short of the bottom flange.

The stiffener is to be ground smooth.

The piece of stiffener attached to the flange is to be removed and the flange ground smooth.'

).

Case # FB153:

Description of Error: An intermediate stiffener was to be tight fit to bottom flange. The shop welded the stiffener to the bottom flange with a both side 1/4" fillet. The fabricator then ground out as much weld as possible, but can not remove all of the weld metal. This is a fracture critical job.

Solution Recommended: The stiffener should be cut 1" short of the bottom flange. The bottom of the stiffener is to be ground smooth. The piece of stiffener attached to the flange is to be removed and the flange ground smooth.

% Solution 4

```

caseSolution(misattachedMember_4,misattachedMember,'MATM-C004','Misattached Member Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :bearingStiffener,
  attachMemberType     :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  stiffenerType        :bearing,
  stiffenerSpecifiedDiaphragmAttachment :false,
  stiffenerSpecifiedFlangeAttachment    :tensionFlange,
  stiffenerSpecifiedTensionFlangeAttachmentType:weld,
  stiffenerActualCompFlangeAttachmentType :weld,
  stiffenerActualCategoryCFlange         :true,
  stiffenerActualTensionFlangeAttached   :false,
  stiffenerActualCompFlangeAttached      :true
],
'The stiffener was welded to the top flange instead of the bottom flange.
Leave the welds and weld the stiffener to the bottom flange.'
).

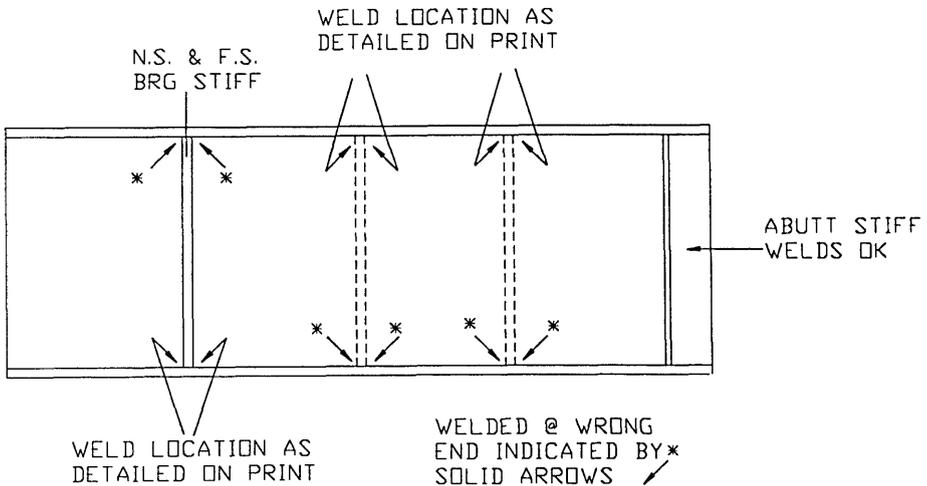
```

Case # LS137:

Description of Error: Bearing stiffeners at abutment were welded to the wrong flange.

Solution Recommended: Leave incorrect stiffener welds as is and N.D. test (MT). Weld the stiffeners to correct flanges.

Fatigue category of incorrect welds was checked by DOT and found acceptable for this case so leave incorrect welds in place.



% New Solution 5

```
caseSolution(misattachedMember_5,misattachedMember,'MATM-C005','Misattached Member Case Solution',[],success,  
[  
  bridgeType           :plateGirder,  
  errorMemberType      :diaphragmBrace,  
  errorMemberLocation  :stiffenerAttachment,  
  errorMemberClass     :primary  
],  
  'The fabricator had approximately 10 welders take the DOT welding qualification test to weld on this project. The welder  
  assigned to weld the diaphragm had failed the test.  
  Remove the welds and replace them by a certified welder.'  
).
```

Case #BL-F003:

Description of Error: The fabricator had approximately 10 welders take the DOT welding qualification test to weld on this project. The welder assigned to weld the diaphragm had failed the test.

Solution Recommended: Remove the welds and replace them by a certified welder.

Other Possible solutions: Re-test the welder who made the original welds and accept the welds made on the job if he passed the second test.

## Misaligned Member Cases:

% Solution 1

```
caseSolution(misalignedMember_1,misalignedMember,'MALM-C001','Misaligned Member Case Solution',[],success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :capBeam,
  attachMemberType     :splicePlate,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  surfaceContactSpacing :0.1875,
  surfacePercentContact :20,
  surfaceFillPlate      :true,
  surfaceFullSurfaceContact :false
```

```
],
```

'Due to the limit in gap that occurs between faying surfaces the plate can be machined to allow full surface contact.

Modify fill plates to allow full contact of surface extending if necessary for machining.'

```
).
```

Case # (original case was not found)

Description of Error: Due to the limit in gap that occurs between faying surfaces the plate can be machined to allow full surface contact.

Solution Recommended: Modify fill plates to allow full contact of surface extending if necessary for machining.

% Solution 2

```
caseSolution(misalignedMember_2,misalignedMember,'MALM-C002','Misaligned Member Case Solution',[],success,  
[  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  attachMemberType     :capBeam,  
  errorMemberLocation  :boltedConnection,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary,  
  surfaceContactSpacing :2,  
  surfacePercentContact :0,  
  surfaceFillPlate     :false,  
  surfaceFullSurfaceContact :false  
],  
'Full contact surface does not occur at error location. Member types may allow  
use of heat procedure to allow correction of non-surface contact.  
Use approved heat procedure to correct gap between surface contact.  
CAUTION - Make sure to apply and control heat process only near end of member.  
Check changes in girder camber for design limits.  
Heat should be applied as near as possible to end member.'  
).
```

Case # (original case was not found)

Description of Error: Full contact surface does not occur at error location.

Solution Recommended: Member types may allow use of heat procedure to allow correction of non-surface contact. Use approved heat procedure to correct gap between surface contact. Caution : Make sure to apply and control heat process only near end of member. Check changes in girder camber for design limits. Heat should be applied as near as possible to end member.

% Solution 3

caseSolution(misalignedMember\_3,misalignedMember,'MALM-C003','Misaligned Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :diaphragmBrace,
  attachMemberType     :plateGirder,
  errorMemberLocation  :boltedConnection,
  errorMemberClass     :primary,
  attachMemberClass    :primary
],
```

'Full contact surface does not occur at error location. Member types may allow use of heat procedure to allow correction of non-surface contact.

Use approved heat procedure to correct gap between surface contact.

CAUTION - Make sure to apply and control heat process only near end of member.

Check changes in girder camber for design limits.

Heat should be applied as near as possible to end of member.'

).

Case # (original case was not found)

Description of Error: Full contact surface does not occur at error location.

Solution Recommended: Member types may allow use of heat procedure to allow correction of non-surface contact.

Use approved heat procedure to correct gap between surface contact. Caution: Make sure to apply and control heat process only near end of member. Check changes in girder camber for design limits. Heat should be applied as near as possible to end of member.

% Solution 4

caseSolution(misalignedMember\_4,misalignedMember,'MALM-C004','Misaligned Member Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :fillerPlate,
  errorMemberLocation  :bearing,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  surfaceContactSpacing :0.09375,
  surfacePercentContact :20,
  surfaceFillPlate     :false,
  surfaceFullSurfaceContact :false
],
```

'Bearing plate and bottom flange of girder do not make full surface contact.

50% or more of contact area makes full contact.

Maximum gap is less than 1/4 in. Remove fillet welds per AWS D1.5-88 from both sides of bearing stiffener.

Move bottom flange down to achieve full surface contact between members.

One method is by jacking the bottom flange down making sure that the compression flange is not damaged.

Reweld bearing stiffener to bottom flange in accordance with AWS D1.5-88 procedures.'

).

Case # (no original file found)

Description of Error: Bearing plate and bottom flange of girder do not make full surface contact.

50% or more of contact area makes full contact.

Solution Recommended: Maximum gap is less than 1/4 in. Remove fillet welds per AWS D1.5-88 from both sides of bearing

stiffener. Move bottom flange down to achieve full surface contact between members. One method is by jacking the bottom

flange down making sure that the compression flange is not damaged. Reweld bearing stiffener to bottom flange in accordance

with AWS D1.5-88 procedures.

% Solution 5

caseSolution(misalignedMember\_5,misalignedMember,'MALM-C005','Misaligned Member Case Solution',[],success,

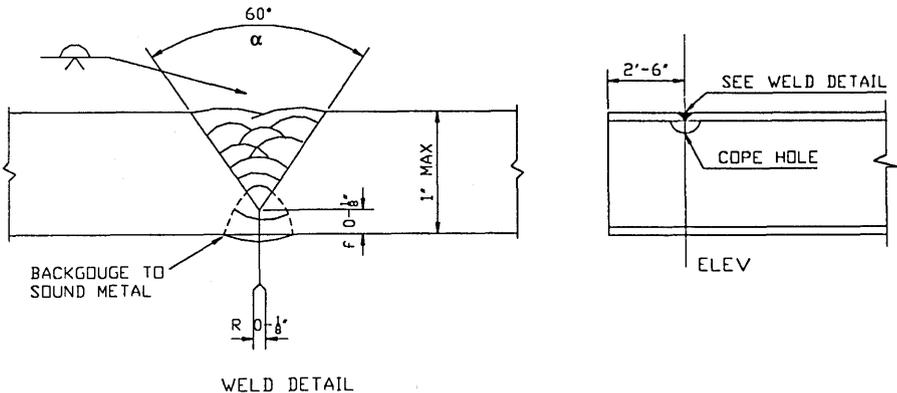
```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberLocation :web,
  errorMemberClass    :primary,
  surfaceContactSpacing :0,
  surfacePercentContact :100,
  surfaceFillPlate    :false,
  surfaceFullSurfaceContact :true
]
```

The web plate is misaligned 1/2 in. centerline of top flange plate approximately 1 ft 10 1/2 in from left end. Required holes in top flange have been drilled and were gaged from centerline of misaligned web. This has caused these holes to be 1/2 in. off theoretical centerline therefore reducing edge distance on one side. Air carbon arc gouge web to flange weld 2 ft. 6in. from left hand end and add 1" web cope hole. Cut out top flange 2 ft. 6 in from left hand and splice new flange. Radiograph flange splice 100% Web will be realigned and welded with 100 percent MT. Holes will be drilled in new flange plate.

Case # TF189:

Description of Error: Web plate is misaligned 1/2" off centerline of top flange plate approximately 1'-10 1/4" from left hand end. Required holes in top flange have been drilled and were gaged from centerline of mis-aligned web. This has caused these holes to be 1/2" off theoretical centerline, reducing edge distance from 1 1/2" to 1" on far side and increasing edge distance near side to 2".

Solution Recommended: Air carbon arc gouge web-to-flange weld 2'-6 from left hand end, and add 1" web cope hole. The cope hole is to allow 100% RT of flange weld. Cut out top flange 2'-6 from left hand end and splice new flange using approved weld procedure (see sketch) and RT splice 100%. Web will then be re-aligned and welded with 100% MT. Holes will then be drilled in new flange plate. All work to be witnessed by DOT.



% Solution 6

```
caseSolution(misalignedMember_6,misalignedMember,'MALM-C006','Misaligned Member Case Solution',[],success,  
[  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :web,  
  errorMemberClass     :primary,  
  surfaceContactSpacing :0,  
  surfacePercentContact :100,  
  surfaceFullSurfaceContact :true,  
  mislocatedMemberDistanceCorrectLocation:0.375  
],  
'The centerline of the web is 3/8 in. off center with centerline of flange.  
This occurs within a length of approximately one foot working from girder end.  
Grind and gouge web free.  
Correct alignment and reweld.'  
).
```

Case # TF225:

Description of Error: A girder has the flange to web welded X-end, bottom flange, with centerline of web 3/8 inch off center with centerline of flange. This occurs within a length of approximately one foot working from girder end.

Solution Recommended: Grind/gouge web free, correct alignment, and reweld. MT test 100%. If holes in flange plate are misaligned, replace affected flange plate if necessary with RT 100% of flange splice weld.

## % New Solution 7

caseSolution(misalignedMember\_7,misalignedMember,'MALM-C007','Misaligned Member Case Solution'.[]),success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :diaphragmBrace,
  attachMemberType     :plateGirder,
  errorMemberLocation  :diaphragmBrace,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  mislocatedMemberDistanceCorrectLocation:0.75
],
```

Existing superstructure is being replaced in stages to maintain traffic, and contractor had survey performed after first half of the deck was removed. This indicated revised beam lengths were needed and contractor advised fabricator to use new lengths along with an "average" skew for detailing and fabrication. When erection started, interior diaphragms between first two lines were off by 1 1/2", equating to an error in the skew of 0 degree, 45 minutes. Erector shifted second line 1 1/2" longitudinally, since interior diaphragms use 4 attachment bolts in horizontal lines at 3" spacing. However, by third line, shifting 1 1/2" resulted in interference between beam ends and the abutment back wall.

Shifted first and third beams 3/4" toward pier, second and fourth beams 3/4" away from pier, allowing installation of the on-site diaphragms. Interior diaphragms could have all 4 bolts installed in the first and third bays, but in the second bay (between lines 2 and 3), only 3 of 4 bolts per location could be installed until additional holes were field drilled. Unused holes in the beam webs were filled with short bolts to avoid future inspection confusion. End diaphragms sit on seat angles with only two bolts through oversize holes in the bottom flange. The 3/4" shifts caused the end diaphragms to be slightly skewed to the abutment centerlines of bearing, but this was not structurally significant. Stage 2 beams were revised to avoid this problem, based on additional field survey verification and dimensional checks.

).

### Case #JE-F007:

Description of Error: Existing superstructure is being replaced in stages to maintain traffic, and contractor had survey performed after first half of the deck was removed. This indicated revised beam lengths were needed and contractor advised fabricator to use new lengths along with an "average" skew for detailing and fabrication. When erection started, interior diaphragms between first two lines were off by 1 1/2", equating to an error in the skew of 0 degree, 45 minutes. Erector shifted second line 1 1/2" longitudinally, since interior diaphragms use 4 attachment bolts in horizontal lines at 3" spacing. However, by third line, shifting 1 1/2" resulted in interference between beam ends and the abutment back wall.

Solution Recommended: Shifted first and third beams 3/4" toward pier, second and fourth beams 3/4" away from pier, allowing installation of the on-site diaphragms. Interior diaphragms could have all 4 bolts installed in the first and third bays, but in the second bay (between lines 2 and 3), only 3 of 4 bolts per location could be installed until additional holes were field drilled.

Unused holes in the beam webs were filled with short bolts to avoid future inspection confusion. End diaphragms sit on seat angles with only two bolts through oversize holes in the bottom flange. The 3/4" shifts caused the end diaphragms to be slightly skewed to the abutment centerlines of bearing, but this was not structurally significant. Stage 2 beams were revised to avoid this problem, based on additional field survey verification and dimensional checks.

Other Possible solutions: Making custom interior diaphragms, either by field welding/drilling and assembly, or by the fabricator redetailing and fabricating new asymmetric diaphragms with connections compensating for the 1 1/2" offset. Either of these would have required additional planning, fabrication, cleaning and shop priming, possibly delaying construction of a week or more.

Remarks: Despite DOT 's standard note requiring the Contractor to field verify all pertinent dimensions for portions of existing structures incorporated into new construction, Contractors typically order fabricators to proceed based on record drawings (old design and shop plans) with minimal field checks. This is especially true when the Contractor's access is limited by traffic or other factors. Field problems routinely occur due to original construction errors, undocumented changes to the structure, substructure misalignment due to settlements, etc. between plans.

# Stress Fracture Cases:

% Solution 1

caseSolution(stressFracture\_1, stressFracture, 'SFRC-C001', 'Stress Fracture Case Solution', [], success,

```
[
  bridgeType           :rolled,
  errorMemberType     :diaphragmBrace,
  errorMemberLocation  :gussetPlate,
  errorMemberClass     :primary,
  stressAttachMemberLevel :unknown,
  stressFatigueConcerns :low,
  stressFractures      :true,
  stressMaxGap         :0.25,
  stressNumberOfFracturesAtLocation:3,
  stressAngleOfBend   :90
]
```

'Stress fractures occur at the corners of bent diaphragm plates.

The stress fractures were dye-penetrant examined.

All diaphragms with excess 1/4 in. gap were not used.

All diaphragms less than 1/4 in. gap were repaired by welding with FCAW approved welding procedure and ground smooth.'

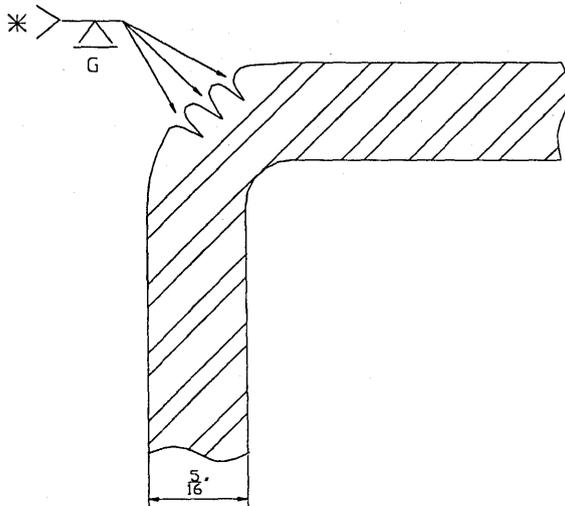
).

Case #MP143:

Description of Error: Stress fractures occur at the corners of bent diaphragm plates.

Solution Recommended: All diaphragms with stress fractures will be subject to a dye penetrant examination on the entire of length of the bend. The dye penetrant examination will be in accordance with ASTM E165 and a written dye penetrant examination procedure. All diaphragms with excess 1/4" gap will not be used on this project. All diaphragms less than 1/4" gap will be repaired by welding with FCAW approved welding procedure and ground smooth.

\* REMOVE TO SOUND METAL 1" PAST DEFECT, WELD  
AND GRIND SMOOTH AT THE APPLICABLE LOCATION



% Solution 2

```
caseSolution(stressFracture_2, stressFracture, 'SFRC-C002', 'Stress Fracture Case Solution', [], success,
```

```
[
  bridgeType           :plateGirder,
  errorMemberType      :diaphragmBrace,
  attachMemberType     :intermediateStiffener,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  stressFractures      :true,
  stressNumberOfFracturesAtLocation:2
],
```

\* Cracks occur in the vertical weld attaching the stiffeners to the web or else in the vertical weld connecting the floorbeam to the stiffener.

Preheat. Remove the cracked weld using air-arc carbon gouging.

Grind the gouged areas.

Inspect the gouged areas using magnetic particle testing.

Replace the removed weld metals by rewelding, air cool to ambient temperature and then reinspect the crack area using magnetic particle testing not before 24 hours after welding is complete.\*

).

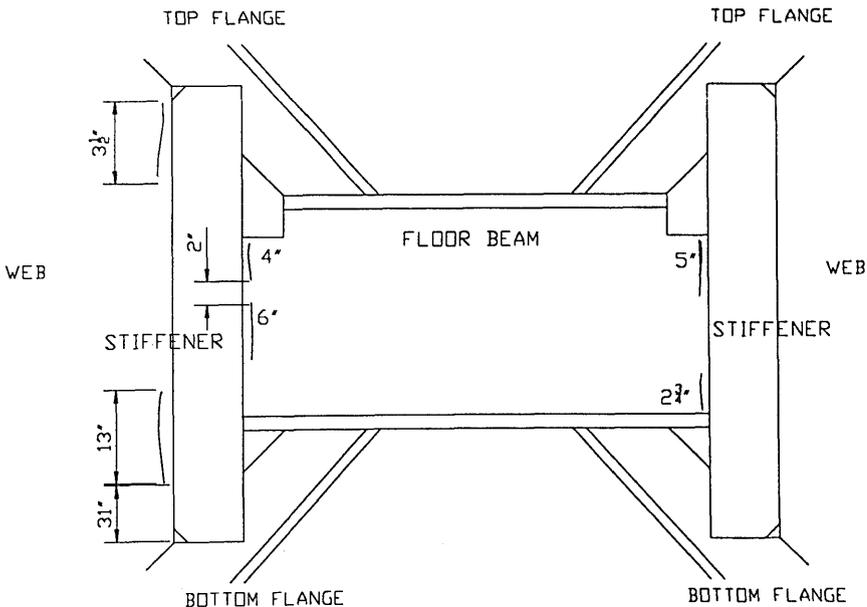
Case #FB154

Description of Error: Cracks occur in the vertical weld attaching the stiffeners to the web or else in the vertical weld connecting the floorbeam to the stiffener.

Solution Recommended: Preheat. Remove the cracked weld using air-arc carbon gouging.

Grind the gouged areas. Inspect the gouged areas using magnetic particle testing. Replace the removed weld metals by rewelding, air cool to ambient temperature and then reinspect the crack area using magnetic particle testing not before 24 hours after welding is complete.

Additional Comments: This is not a fabrication error. This case arose during the retrofit of an existing bridge. The case is included here to provide an example of cracking. If a similar case is encountered, refer to NCHRP Report (National Cooperative Highway Research Program Report 336: DISTORTION-INDUCED FATIGUE CRACKING IN STEEL BRIDGES ).



# Welding/Heating Distortion

% New Solution 1

caseSolution(weldingHeatingDistortion\_1,weldingHeatingDistortion,'WHD-C001','Welding Heating Distortion Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberClass    :primary,
  designedTemperature :1150,
  actualTemperature   :1400,
  causeOfDistortion   :overHeating,
  typeOfDistortion    :overCamber
],
```

Over heating of flange and web were occurred while heat cambering. Maximum temperature of 1150° F allowed by contract. Temperature indicating crayon of 1200 ° F was used to determine excessive heat. Actual temperature estimated at 1400 ° F using color comparison chart.

Fabricator hired metallurgical engineer to assess potential damage. A New Age Industries Pin Brinell Portable Metal Hardness Tester was used. Converts to Rockwell R81 and R89: approximately 81 ksi and 89 ksi tensile strength. Metallurgist recommended acceptance of material. Hardness was in expected range. No further testing warranted.

).

Case #RL-F001:

Description of Error: Over heating of flange and web were occurred while heat cambering. Maximum temperature of 1150° F allowed by contract. Temperature indicating crayon of 1200 ° F was used to determine excessive heat. Actual temperature estimated at 1400 ° F using color comparison chart.

Solution Recommended: Fabricator hired metallurgical engineer to assess potential damage. A New Age Industries Pin Brinell Portable Metal Hardness Tester was used. Converts to Rockwell R81 and R89: approximately 81 ksi and 89 ksi tensile strength. Metallurgist recommended acceptance of material. Hardness was in expected range. No further testing warranted.

Remarks: Damage was likely avoided due to a relatively slow cooling rate through the transition temperature range. Recommend a gradual removal of heat-source to allow a slow cooling in similar situations.

Other Possible solutions: Had hardness been excessive a microscopic examination of the grain structure could have been used to determine condition of material.

% New Solution 2

caseSolution(weldingHeatingDistortion\_2,weldingHeatingDistortion,'WHD-C002','Welding Heating Distortion Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :webPlate,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :fractureCritical,
  attachMemberClass    :fractureCritical,
  causeOfDistortion    :welding,
  typeOfDistortion     :tilt
],
```

Distortion from welding tension flange to web caused tilt (from square) in excess of 1-1/4" at flange web juncture. Fracture critical member. Tilt was excessive entire length of girder.

Fabricator proposed removing up to 50% depth of weld metal (full penetration), apply line heating to correct tilt to within 1/4" and reweld excavated area. Measure with framing square and tape measure at web/flange juncture and at edge of flange to determining offset are required for final checks.

).

Case #VK-F001:

Description of Error: Distortion from welding tension flange to web caused tilt (from square) in excess of 1-1/4" at flange web juncture. Fracture critical member. Tilt was excessive entire length of girder.

Solution Recommended: Fabricator proposed removing up to 50% depth of weld metal (full penetration), apply line heating to correct tilt to within 1/4" and reweld excavated area. Measure with framing square and tape measure at web/flange juncture and at edge of flange to determining offset are required for final checks.

Other Possible solutions: Line heating without excavation of weld was attempted, but was insufficient to correct tilt.

% New Solution 3

caseSolution(weldingHeatingDistortion\_3,weldingHeatingDistortion,'WHD-C003','Welding Heating Distortion Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :bearingStiffener,
  errorMemberLocation  :stiffenerAttachment,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  causeOfDistortion    :welding,
  typeOfDistortion     :crack
],
```

‘ Pins welded to radiused base plates formed rocker type bearing assemblies. After subjecting parts to hot dipped galvanizing, cracking was noted at corners for a minimum of eight welded assemblies. Magnetic particle testing (MT) was utilized to determine extent of cracking.

Excavate weld where cracking was detected, grind area smooth, preheat reweld and test MT method after cooling to ambient temperature.’

).

Case #VK-F002:

Description of Error: Pins welded to radiused base plates formed rocker type bearing assemblies. After subjecting parts to hot dipped galvanizing, cracking was noted at corners for a minimum of eight welded assemblies. Magnetic particle testing (MT) was utilized to determine extent of cracking.

Solution Recommended: Excavate weld where cracking was detected, grind area smooth, preheat reweld and test MT method after cooling to ambient temperature.

Remarks: Seal weld was not included on design drawings. Fabricator included it to avoid leakage from galvanizing.

Other Possible solutions: It was determined that cracks originated from seal welded ends of assemblies. Ends were excavated, grooved and rewelded to and extending beyond the corners.

% New Solution 4

caseSolution(weldingHeatingDistortion\_4,weldingHeatingDistortion,'WHD-C004','Welding Heating Distortion Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :webPlate,
  attachMemberType    :flangePlate,
  errorMemberLocation :web,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  causeOfDistortion   :welding,
  typeOfDistortion    :buckling
],
```

\* Web buckling (distortion) caused by flange to web welding.

Depth of distortion measured with straight edge between panels.

Apply spot heating in distorted area on convex side to reduce buckling to within tolerance.

Tape measure and straight edge determined that distortion was corrected to within required tolerance between panels (top and bottom flange and stiffeners).\*

).

Case #VK-F003:

Description of Error: Web buckling (distortion) caused by flange to web welding. Depth of distortion measured with straight edge between panels.

Solution Recommended: Apply spot heating in distorted area on convex side to reduce buckling to within tolerance. Tape measure and straight edge determined that distortion was corrected to within required tolerance between panels (top and bottom flange and stiffeners).

Other Possible solutions: Add stiffener in affected area.

% New Solution 5

caseSolution(weldingHeatingDistortion\_5,weldingHeatingDistortion,'WHD-C005','Welding Heating Distortion Case Solution',{dlf003},success,

```
{
  bridgeType           :plateGirder,
  errorMemberType      :webPlate,
  attachMemberType     :flangePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  causeOfDistortion    :heating,
  typeOfDistortion     :buckling
},
```

' During heat application to correct for camber, Vee heat in web caused severe distortion.

Lay-out and mark grid pattern over affected area (2" grid) on convex side. Apply spot heat to each grid square. Each heat should be approximately 1 1/2" diameter. Begin heats at outside perimeter and progress towards center. Apply jacking force during heating (optional).'

).

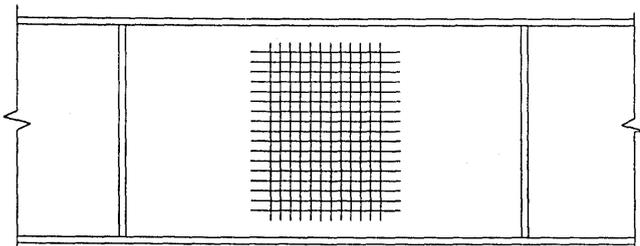
Case #DL-F003:

Description of Error: During heat application to correct for camber, Vee heat in web caused severe distortion.

Solution Recommended: Lay-out and mark grid pattern over affected area (2" grid) on convex side. Apply spot heat to each grid square. Each heat should be approximately 1 1/2" diameter. Begin heats at outside perimeter and progress towards center. Apply jacking force during heating (optional).

Remarks: Spot heats should be circular and diameter held to less than 3 times material thickness. A cutting torch affords better control than a " rose bud" or heating torch.

Other Possible solutions: None- prevention would be to avoid heating web. If web must be heated, than heat only at stiffener locations. If necessary, add a permanent stiffener at location to the heated stiffener to be left in place.



APPLY "SPOT" HEAT @ EACH GRID SECTION BEGINNING @ OUTSIDE PERIMETER AND PROGRESS TOWARDS CENTER, ON CONVEX SIDE.  
NOTE: ALL GRIDS NEED NOT BE HEATED. START BY HEATING EVERY 4th GRID, THEN EVERY OTHER GRID ON 2nd ATTEMPT, FOLLOWS BY EVERY GRID, DEPENDING ON SEVERITY OF DISTORTION.

GIRDER PANEL WITH WEB DISTORTION  
APPLY 2" GRID PATTERN WITH SOAPSTONE

% New Solution 6

caseSolution(weldingHeatingDistortion\_6,weldingHeatingDistortion,'WHD-C006','Welding Heating Distortion Case Solution',[,],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :rolledBeam,
  errorMemberClass    :primary,
  designedTemperature :1100,
  actualTemperature   :1200,
  causeOfDistortion   :overHeating
],
```

' Heating with oxy-fuel torch to camber, curve or straighten a member, but not monitoring the temperature with thermal crayons or electronic sensors. QA Inspector suspects material was overheated (over 1200 F/650 C for low alloy, 1100 F/ 600 C for Q & T) based on observation of bright red color during heating, local distortion/melting of base metal and mill scale, or temper colors on steel surface. Overheating may reduce ductility and toughness, initiate or propagate discontinuities, cause local distortion and high residual stresses, and adversely effect material properties of quenched and tempered steel.

Overheating may cause irreversible effects, so "repair" may not be possible without material replacement. Physical properties of heated areas must be assessed to determine if material is still acceptable for incorporation in structure. Possible indicators include hardness checks (Brinell, Knoop, Vickers or Rockwell) which can be down in-situ, or yield, ductility and Charpy V-notch tests which require removing material for specimens. Metallographic analysis can determine if microstructure has change, but this is very sophisticated and site-specific for this situation. Tests should be conducted by a qualified testing agency at the fabricator's expense. If hardness testing provides adequate assurance, the material bay then be accepted. Otherwise, either the material must be completely replaced or an adequate number of specimens extracted and tested to verify properties. It tests are acceptable, the fabricator must develop a method to replace the specimens.'

).

Case #JE-F001:

Description of Error: Heating with oxy-fuel torch to camber, curve or straighten a member, but not monitoring the temperature with thermal crayons or electronic sensors. QA Inspector suspects material was overheated (over 1200 F/650 C for low alloy, 1100 F/ 600 C for Q & T) based on observation of bright red color during heating, local distortion/melting of base metal and mill scale, or temper colors on steel surface. Overheating may reduce ductility and toughness, initiate or propagate discontinuities, cause local distortion and high residual stresses, and adversely effect material properties of quenched and tempered steel.

Solution Recommended: Overheating may cause irreversible effects, so "repair" may not be possible without material replacement. Physical properties of heated areas must be assessed to determine if material is still acceptable for incorporation in structure. Possible indicators include hardness checks (Brinell, Knoop, Vickers or Rockwell) which can be down in-situ, or yield, ductility and Charpy V-notch tests which require removing material for specimens. Metallographic analysis can determine if microstructure has change, but this is very sophisticated and site-specific for this situation. Tests should be conducted by a qualified testing agency at the fabricator's expense. If hardness testing provides adequate assurance, the material bay then be accepted. Otherwise, either the material must be completely replaced or an adequate number of specimens extracted and tested to verify properties. It tests are acceptable, the fabricator must develop a method to replace the specimens.

Other Possible solutions: Replace material: extensive NDE, including wet-particle MT, through thickness and surface wave UT, and hardness testing; stress relief of heated areas (difficult, and unwanted distortion possible); or adding reinforcing plates.

Remarks: For most mild steeks )nominal yield  $\leq 50$  ksi / 345 mPa), heat not exceeding transition temperature (1600 F/870 C) and cooling in air without quenching probably results in minimal adverse changes to properties, However, must have some verification.

```

% New Solution 7
caseSolution(weldingHeatingDistortion_7,weldingHeatingDistortion,'WHD-C007','Welding Heating Distortion Case
Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberClass     :primary,
  causeOfDistortion    :lackOfPreheating
],

```

\* Flange to web fillet welds made without adequately preheating flange and/or web per Section 4.2 (also 12.14 for FCM) of the D1.5 Bridge Welding Code to avoid potential problems from rapid cooling, moisture, etc. Temperature too low at juncture and/or within 3" /75 mm in all directions. Heavy flanges may have needed multiple torches or longer "soak" time for through thickness heating. Heat directed at flange may not have transferred to web between tacks.

Varied by location and circumstances as follows: 1. No preheat, temperature below 32 F / 0 C: for welds on non-load carrying members such as diaphragms, close visual inspection and 100% MT- any questionable welds replaced. For welds on main load carrying members, replace welds. 2. Inadequate preheat, but base metal above 32 F/0 C: for non-load carrying members, close visual inspection, MT 25% plus any anomalies observed –deficient welds replaced. For non-FCM main members, 100% VT plus MT- replace deficient or questionable welds. For FCM, replace welds in accord with Fracture Control Plan.

Case #JE-F002:

Description of Error: Flange to web fillet welds made without adequately preheating flange and/or web per Section 4.2 (also 12.14 for FCM) of the D1.5 Bridge Welding Code to avoid potential problems from rapid cooling, moisture, etc. Temperature too low at juncture and/or within 3" /75 mm in all directions. Heavy flanges may have needed multiple torches or longer "soak" time for through thickness heating. Heat directed at flange may not have transferred to web between tacks.

Solution Recommended: Varied by location and circumstances as follows: 1. No preheat, temperature below 32 F / 0 C: for welds on non-load carrying members such as diaphragms, close visual inspection and 100% MT- any questionable welds replaced. For welds on main load carrying members, replace welds. 2. Inadequate preheat, but base metal above 32 F/0 C: for non-load carrying members, close visual inspection, MT 25% plus any anomalies observed –deficient welds replaced. For non-FCM main members, 100% VT plus MT- replace deficient or questionable welds. For FCM, replace welds in accord with Fracture Control Plan.

Remarks: Removing welds may be done if necessary, but this causes additional thermal cycles and residual stresses in base metal and may cause more defects than are removed. Being punitive to fabricator may be justified for repeated violations, but do not require actions that may be detrimental to the final product.

Other Possible solutions: Replace all welds; postheat welds plus NDE and destructive tests on mock-ups; qualification of parameters on mock-ups (NOT encouraged!); or sophisticated tests on diffusible hydrogen and residual stresses plus NDE.

% New Solution 8

caseSolution(weldingHeatingDistortion\_8,weldingHeatingDistortion,'WHD-C008','Welding Heating Distortion Case Solution',[],success,

```
{
  bridgeType           :plateGirder,
  errorMemberType      :webPlate,
  attachMemberType     :flangePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  causeOfDistortion    :underSizeWeld
}
```

).  
\* Brackets made of web surrounded on 3 or 4 sides with fillet-welded flanges. Min fillet size prescribed by Table 2.2 of D1.5 Bridge Welding Code not satisfied: min=5/16", actual=1 1/32". Inside corners impede removal of undersize welds without damage to base metal. Time-critical project.

Just adding more weld wouldn't satisfy Code intent for minimum heat input on each pass to insure full fusion and good weld properties. Evaluated which welds sustained tensile/fatigue loads and had all weld throat sizes documented. For welds with significant fatigue and more than 1/32" undersize, required welds replacement. For welds in compression of low fatigue, required replacement of welds more than 1/16" undersize. Required 100% MT on undersize non-replaced and on replaced welds. Required future QC plan from shop to avoid recurrences.

).

Case #JE-F004:

Description of Error: Brackets made of web surrounded on 3 or 4 sides with fillet-welded flanges. Min fillet size prescribed by Table 2.2 of D1.5 Bridge Welding Code not satisfied: min=5/16", actual=1 1/32". Inside corners impede removal of undersize welds without damage to base metal. Time-critical project.

Solution Recommended: Just adding more weld wouldn't satisfy Code intent for minimum heat input on each pass to insure full fusion and good weld properties. Evaluated which welds sustained tensile/fatigue loads and had all weld throat sizes documented. For welds with significant fatigue and more than 1/32" undersize, required welds replacement. For welds in compression of low fatigue, required replacement of welds more than 1/16" undersize. Required 100% MT on undersize non-replaced and on replaced welds. Required future QC plan from shop to avoid recurrences.

Remarks: Repairs took about 2 to 3 weeks, but prioritized sequence so field work not delayed.

Other Possible solutions: Remove all subsize welds, replace all brackets (delay project), large cover weld to incorporate small welds (high distortion, defects likely).

% New Solution 9

caseSolution(weldingHeatingDistortion\_9,weldingHeatingDistortion,'WHD-C009','Welding Heating Distortion Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :webPlate,
  attachMemberType     :flangePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  causeOfDistortion    :burnThru
],
```

Machine malfunction of "dart" welder caused burn-thru in web plate directly underneath the vertical stiffener being welded. Remove stiffener, prep and plug weld hole in web plate. R.T. and U.T. weld. Then relocate stiffener toward interior of span by 150 mm, add two new stiffeners near side and far side to adjacent girder to accommodate the 150 mm. Relocation of the connection stiffener allowing proper fit up of cross-frame.

Case #SC-F004:

Description of Error: Machine malfunction of "dart" welder caused burn-thru in web plate directly underneath the vertical stiffener being welded.

Solution Recommended: Remove stiffener, prep and plug weld hole in web plate. R.T. and U.T. weld. Then relocate stiffener toward interior of span by 150 mm, add two new stiffeners near side and far side to adjacent girder to accommodate the 150 mm. Relocation of the connection stiffener allowing proper fit up of cross-frame.

Other Possible solutions: Place bolt in burn-thru hole in lieu of plug welding in either case, relocation of conn. stiffener was necessary to avoid intersecting the burn-thru location.

% New Solution 10

caseSolution(weldingHeatingDistortion\_10,weldingHeatingDistortion,'WHD-C010','Welding Heating Distortion Case Solution',[dlf002],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :flangePlate,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass   :primary,
  causeOfDistortion    :heating,
  typeOfDistortion     :tilt
],
```

Flange tilt exceeds 1/4" or 1/25" of flange width: flange is "cupped" exceeding 1/4". Error is common on "light" gage (thickness) flanges, and also on full penetration web/flange welds.

For flange tilt: apply heat aiding entire girder length at the web/flange. 900° -1000° F max. heat on obtuse side. For "cupping": apply heat along entire flange on the face opposite the web/flange weld keeping width of heat approx. 1 1/2" (Jacking force is optional). Final checks are required to verify flange tilt and cupping.

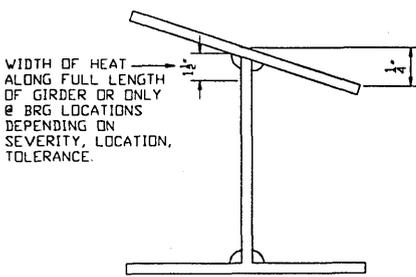
).

Case #DL-F002:

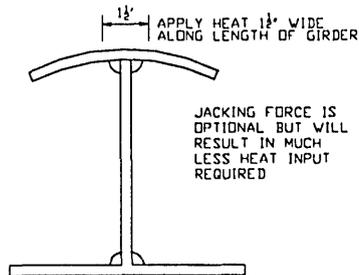
Description of Error: Flange tilt exceeds 1/4" or 1/25" of flange width: flange is "cupped" exceeding 1/4". Error is common on "light" gage (thickness) flanges, and also on full penetration web/flange welds.

Solution Recommended: For flange tilt: apply heat aiding entire girder length at the web/flange. 900° -1000° F max. heat on obtuse side. For "cupping": apply heat along entire flange on the face opposite the web/flange weld keeping width of heat approx. 1 1/2" (Jacking force is optional). Final checks are required to verify flange tilt and cupping.

Remarks: Very common problem. Heating method is always required at bearing locations where 0 degree flange tilt is allowed.



FLANGE TILT



CUPPING OF FLANGE

# Drilling & Punching

## Misshaped Hole Cases:

% Solution 1

caseSolution(misshapedHole\_1,misshapedHole,'MSPH-C001','Misshaped Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  holeDetailsType     :circular,
  holeDetailsJointSlipCritical :false
],
```

'There is an egg shaped hole in the girder flange.

Cut off existing flanges.

Add new plate using full penetration weld at flange and 5/16 in. weld at web.

100% RT at flange and 100% MT at web.'

).

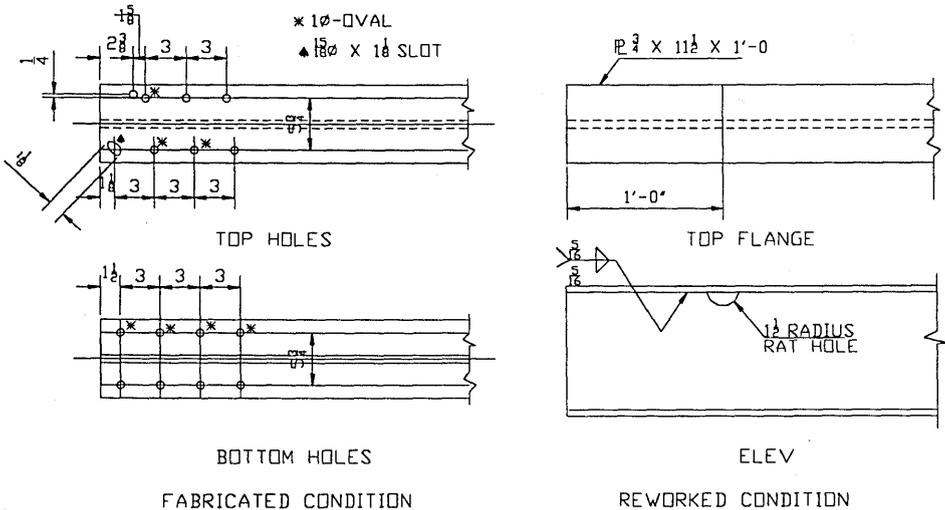
Case #FB150:

Description of Error: There is an egg shaped holes in the girder flange. The hole is approximately 15/16 dia. by 1 1/8" slot.

(Also see misshapedHole,'MSPH-C008')

Solution Recommended: Cut off existing flanges. Add new plate using full penetration weld at flange and 5/16 inch fillet weld at web.

100% RT at flange and 100% MT at web.



% Solution 2

```
caseSolution(misshapedHole_2,misshapedHole,'MSPH-C002','Misshaped Hole Case Solution',[,],success,
```

```
[  
  bridgeType           :plateGirder,  
  errorMemberType      :capBeam,  
  attachMemberType     :plateGirder,  
  errorMemberLocation  :compressionFlange,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary,  
  holeDetailsType      :circular,  
  holeDetailsJointSlipCritical :false,  
  holeDetailsActualDistanceElongated:0.0625
```

```
],
```

'The capBeam bottom flange holes where the bottom flange of span girders bolt has 36 holes elongated. Leave the holes as fabricated and supply the field erector 36 hardened washers to be applied both under the nut and head of the bolts.'

```
).
```

Case #JJ139:

Description of Error: Capbeam bottom flange holes where the bottom flange of span girders bolt to capbeam has 36 holes elongated by 1/16 inch.

Solution Recommended: Leave the holes as fabricated but supply the field erector 36 hardened washers to be applied both under the nut and head of the bolts.

% Solution 3

```
caseSolution(misshapedHole_3,misshapedHole,'MSPH-C003','Misshaped Hole Case Solution',[],success,
```

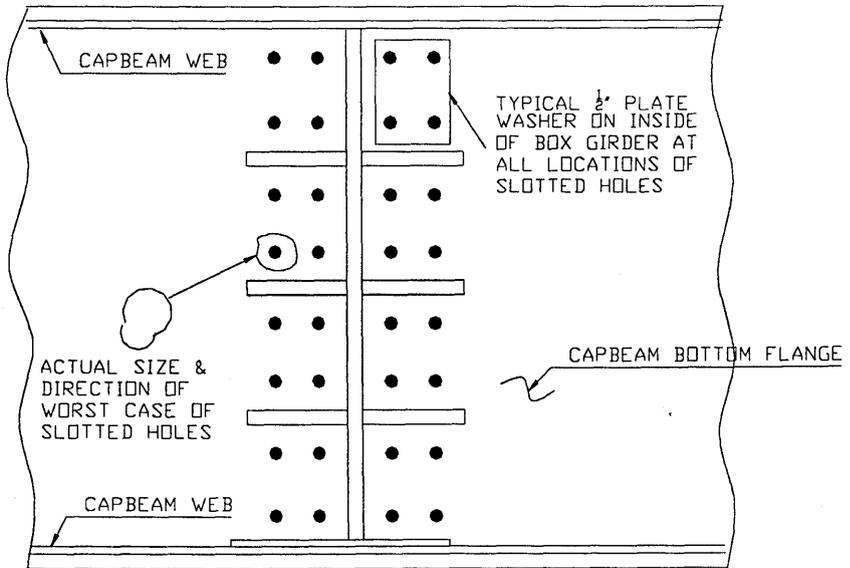
```
[
  bridgeType           :plateGirder,
  errorMemberType      :capBeam,
  attachMemberType     :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsJointSlipCritical :false
],
```

```
'Capbeam bottom flange holes where girder bottom flange bolts to capbeam are elongated.
Furnish 1/2 in. plate washers to the erector to be used with the bolts.'
).
```

Case #JJ139:

Description of Error: Capbeam bottom flange where girder bottom flange bolts to capbeam has 32 holes that are elongated up to 3/8 inch. The corresponding bottom flange holes in the girder are not elongated.

Solution Recommended: Furnish plate washers which shall be 1/2 inch.



PLAN

% Solution 4

```
caseSolution(misshapedHole_4,misshapedHole,'MSPH-C004','Misshaped Hole Case Solution',[],success,  
[  
  bridgeType           :plateGirder,  
  errorMemberType      :splicePlate,  
  attachMemberType     :plateGirder,  
  errorMemberLocation  :spliceConnection,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary,  
  holeDetailsType      :circular,  
  holeDetailsJointSlipCritical :false,  
  holeDetailsSpecifiedHoleDiameter :0.9375,  
  holeDetailsActualDistanceElongated:0.1875  
],
```

'There are several field splices that are fitting poorly.  
When using drift pins to align splices the hole were elongated.  
These holes are to be treated as short-slotted holes.  
2% of the hole were allowed to be used as short-slotted holes.  
However if the slot is in both outer plys then washers will be required under the head and nut of the bolt.'  
)

Case #MG109:

Description of Error: There are several field splices that are fitting poorly. When using drift pins to align splices the hole were elongated. The elongation amounted to 3/16". These holes now were in the category of short slots (15/16" x 1 1/8")  
Solution Recommended: 2% of the holes in a field splice were allowed to be short slots. However, if the slot is in both outer plys, then washers will be required under the head and nut of the bolt.

% Solution 5

caseSolution(misshapedHole\_5,misshapedHole,'MSPH-C005','Misshaped Hole Case Solution',[],success,

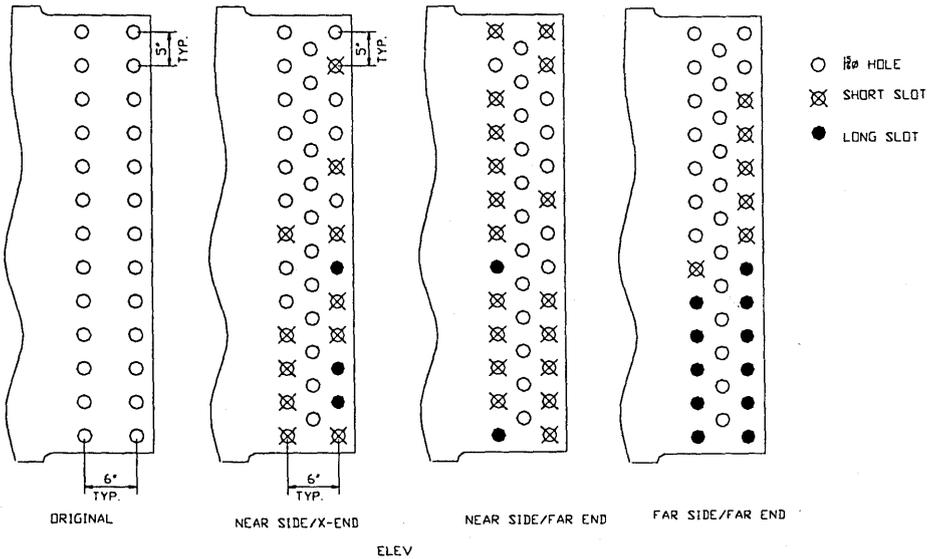
```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  attachMemberType    :splicePlate,
  errorMemberLocation  :web,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  holeDetailsType     :circular,
  holeDetailsJointSlipCritical :false,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsActualDistanceElongated:0.5
]
```

Several holes in the web were misshaped to become short or long slotted.  
 It is proposed to drill an extra set of holes down the center of the current pattern.  
 New splice plates need to be fabricated to match the new hole pattern.  
 ).

Case #TF194:

Description of Error: Several holes in the web were misshaped to become short or long slotted.

Solution Recommended: Add a center row of holes to the bolt hole pattern. In doing such, all bolts will be 7/8" diameter, this is a center ply only for slots, thus no special provisions are required for washers. The calculations indicate this approach allows the bolts to jointly develop a greater shear capacity than the original design. Calculations used allowable shear stress values of 15.5 ksi for standard hole, 13.5ksi short slot, and 9.0 ksi for long slot.



% Solution 6

caseSolution(misshapedHole\_6,misshapedHole,'MSPH-C006','Misshaped Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsJointSlipCritical :false,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsActualDistanceElongated:0.328125
],
```

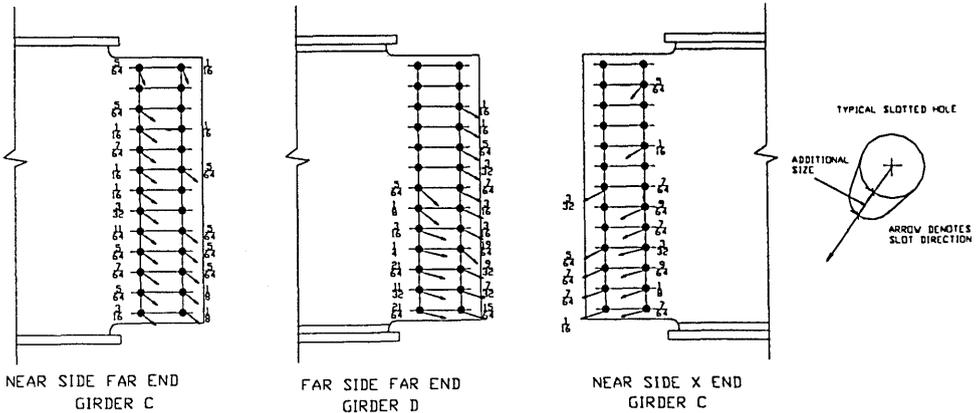
'Several holes in the web were elongated at the splice connection.  
 Drill 1 3/16 in diameter holes for 1 1/8 in. bolts and use hardened washers on both sides.'  
 ).

Case #TF195:

Description of Error: Several holes in the web were elongated at the splice connection.

Solution Recommended: Drill 1 3/16 inch diameter holes for 1 1/8 inch bolts and use hardened washers on both sides.

Other Possible Solutions: Instead of using the uncommon bolt size of 1 1/8 inch as done in actual repair, consider use of 1 inch bolts in oversize holes and use hardened washers on both sides.



% Solution 7

```
caseSolution(misshapedHole_7,misshapedHole,'MSPH-C007','Misshaped Hole Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :longSlotted,
  holeDetailsJointSlipCritical :false,
  holeDetailsSlotsAtCorrectSlope :false
],
'The slots in sole plate at the roller joints are at the wrong slope.
Plug weld the slots and relocate them on the proper slope.'
).
```

Case #TF196:

Description of Error: The 2" X 15/16" slots in sole plate h211 at the roller joint are at a 1 ¼ in 6 slope in lieu of 1 ¼ in 12.  
Solution Recommended: Plug weld the slots and relocate them on the proper slope.

% Solution 8

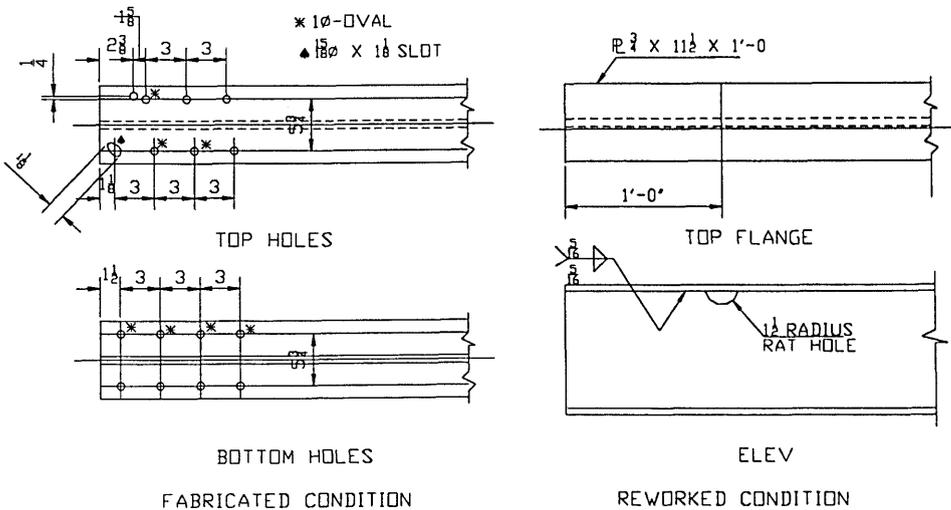
```

caseSolution(misshapedHole_8,misshapedHole,'MSPH-C008','Misshaped Hole Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsJointSlipCritical :false,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsActualDistanceElongated:0.25
],
'Egg-shaped holes occur on the flanges at a splice location. Cut off the existing flange.
Add new plate using full penetration weld at flange and fillet weld at web.
100 percent RT a flange and 100 percent MT at web.
Drill holes correctly.'
).

```

Case #TF214:

Description of Error: Egg-shaped holes occur on the flanges at a splice location. The holes are approximately 1 dia. ovals. (Also see misshapedHole, 'MSPH-C001')  
 Solution Recommended: Cut off the existing flange. Add new plate using full penetration weld at flange and fillet weld at web. 100 percent RT a flange and 100 percent MT at web. Drill holes correctly.  
 Other Possible Solutions: Drill all holes from the solid to 1 1/16" diameter holes for 1" diameter A325 bolts if edge distance (AASHTO 1 3/4" edge distance for 1" bolts) had been present.



# Partially Drilled Hole Cases:

% Solution 1

```

caseSolution(partiallyDrilledHole_1,partiallyDrilledHole,'PDRH-C001','Partially Drilled Hole Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :gussetPlate,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType     :circular
],
'A partially drilled hole was drilled shallowly in the top flange.
Feather out partially drilled hole at a 10 to 1 slope.'
).

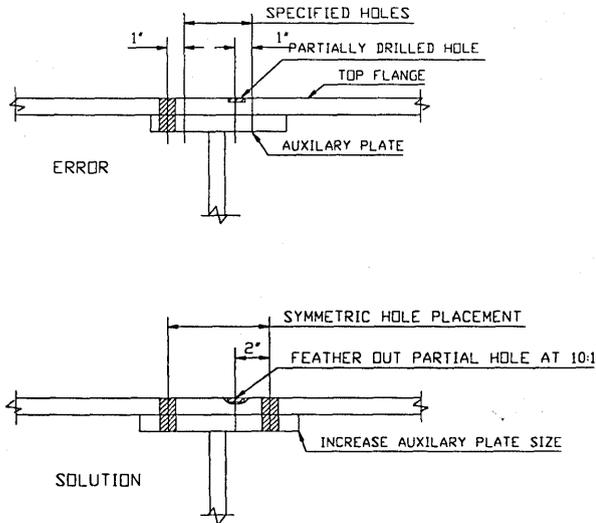
```

Case #DL126:

Description of Error: A partially drilled hole was drilled shallowly in the top flange.

Solution Recommended: Feather out partially drilled hole at a 10 to 1 slope.

Additional Comments: This repair approach is suitable for shallow partial holes. See tutorial topic on partially drilled holes for further discussion.



# Missized Hole Cases:

% Solution 1

```
caseSolution(missizedHole_1,missizedHole,'MSZH-C001','Missized Hole Case Solution',[],success,
```

```
{  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :bearing,  
  errorMemberClass     :primary,  
  holeDetailsType      :circular,  
  holeDetailsNumberWithErrors :2,  
  holeDetailsNumberInGrouping :3,  
  holeDetailsActualBoltDiameter :0.75,  
  holeDetailsActualHoleDiameter :0.8125,  
  holeDetailsSpecifiedBoltDiameter :0.875,  
  holeDetailsSpecifiedHoleDiameter :0.9375,  
  holeDetailsEdgeEndDistanceSpecification:false
```

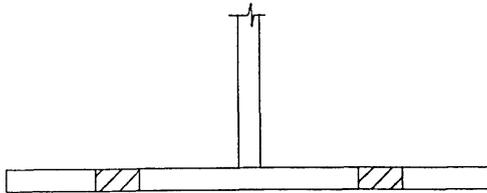
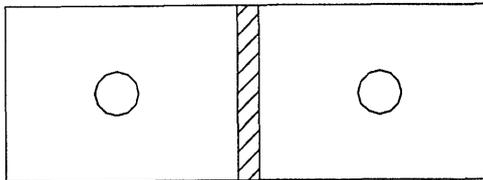
```
1,  
'Bearings should have been drilled and tapped for 3/4 in. bolts instead of 7/8 in. OK to leave as is.  
Make revised shop drawings showing larger bolts.'
```

```
).
```

## Case #DL135:

Description of Error: Bearings should have been drilled and tapped for  $\frac{3}{4}$ "  $\phi$  bolts. Were made for  $\frac{7}{8}$ "  $\phi$  bolts instead.

Solution Recommended: OK to leave as is. Make revised drawings showing larger holes. Make shop sheet to return  $\frac{3}{4}$ " bolts to stock and to order  $\frac{7}{8}$ " bolts.



% Solution 2

caseSolution(missizedHole\_2,missizedHole,'MSZH-C002','Missized Hole Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  attachMemberType     :splicePlate,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  holeDetailsType      :circular,
  holeDetailsActualHoleDiameter :1,
  holeDetailsSpecifiedBoltDiameter :0.875,
  holeDetailsSpecifiedHoleDiameter :0.9375,
  holeDetailsEdgeEndDistanceSpecification:false
]
```

),  
'1 in. holes were drilled in the web at the field splice instead of 15/16 in. holes.

Enlarge the holes to 1 1/16 in. to allow 1 in. bolts.

The splice plates need to be refabricated as they do not have the required edge distance for 1 in. bolts.'

).

Case #NC500:

Description of Error: 1 in. holes were drilled in the web at the field splice instead of 15/16 in. holes.

Solution Recommended: Enlarge the holes to 1 1/16 inch and use 1 inch bolts. New splice plates are required to provide the 1 3/4" edge distance, to satisfy the requirement for edge distance for 1" bolts. The fill plates were a little shy for edge distance for 1" bolts, OK as is, new fill plates are not required.

Other Possible Solutions: Could have used 7/8" bolts with hardened washers, but 1" bolt solution was preferred due to the fact that then if the joint slipped and bolts went into bearing all the bolts would be brought to bear.

# Cutting

## Nicks & Gouges Cases:

% Solution 1

```
caseSolution(nicksGouges_1,nicksGouges,'NAGS-C001','Nicks & Gouges Case Solution',[],success,
```

```
[  
  bridgeType           :plateGirder,  
  errorMemberType     :splicePlate,  
  attachMemberType    :plateGirder,  
  errorMemberLocation :boltedConnection,  
  errorMemberClass    :primary,  
  attachMemberClass   :primary,  
  nickGougeType       :edge,  
  nickGougeDepth      :0.125,  
  nickGougePerpendicularToBoltHole:true  
],
```

'The inside of the hole was gouged in two places.

The gouges in the bolt hole may be removed by drilling out the hole in the plate as well as in web.

Use a larger bolt to fill the hole.

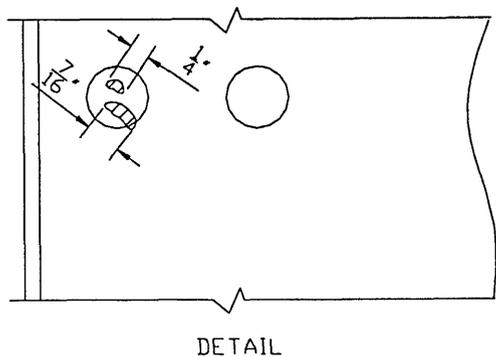
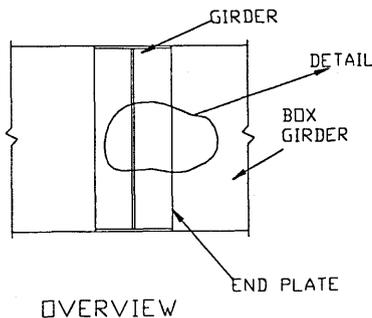
Be sure to check new edge and end distance.'

```
)
```

### Case #MG163:

Description of Error: A flange gouge at a bolt hole on the outside row 6<sup>th</sup> from the bottom on the end plate of a girder. The inside of the hole was gouged in two places approximately 1/8" deep. The girder end plate connects to a box girder web.

Solution Recommended: The gouges in the 6<sup>th</sup> bolt hole in the girder may be removed by drilling out the hole to 1 1/16" as well as the corresponding box web hole. A 1" bolt will be used to fill it.



% Solution 2

caseSolution(nicksGouges\_2,nicksGouges,'NAGS-C002','Nicks & Gouges Case Solution',[],success,

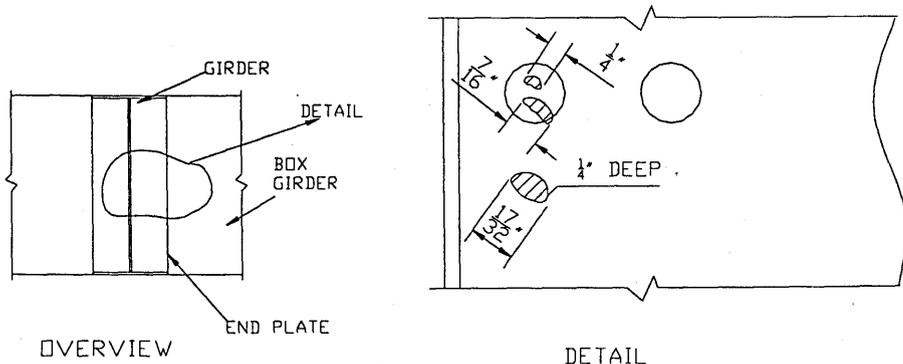
```
[
  bridgeType           :plateGirder,
  errorMemberType     :endPlate,
  attachMemberType    :plateGirder,
  errorMemberLocation :connectionPlate,
  errorMemberClass    :primary,
  attachMemberClass   :primary,
  nickGougeType       :surface,
  nickGougeDepth      :0.25,
  nickGougeReductionOfArea :small,
  nickGougeNumberNearLocation :2,
  nickGougePerpendicularToBoltHole:false
]
```

'There are flame gouges on the plate.  
 The gouges may be removed by grinding out the gouges filling with weld material grinding the weld smooth and then UT testing the area.'

Case #MG163:

Description of Error: A flange gouge at a bolt hole on the outside row 6<sup>th</sup> from the bottom on the end plate of a girder. The inside of the hole was gouged in two places approximately 1/8" deep. The girder end plate connects to a box girder web.

Solution Recommended: The 1/4" deep gouge near the 6<sup>th</sup> bolt hole may be removed by grinding, welding, grinding the weld and UTing the area.



### 3 SOLUTION 3

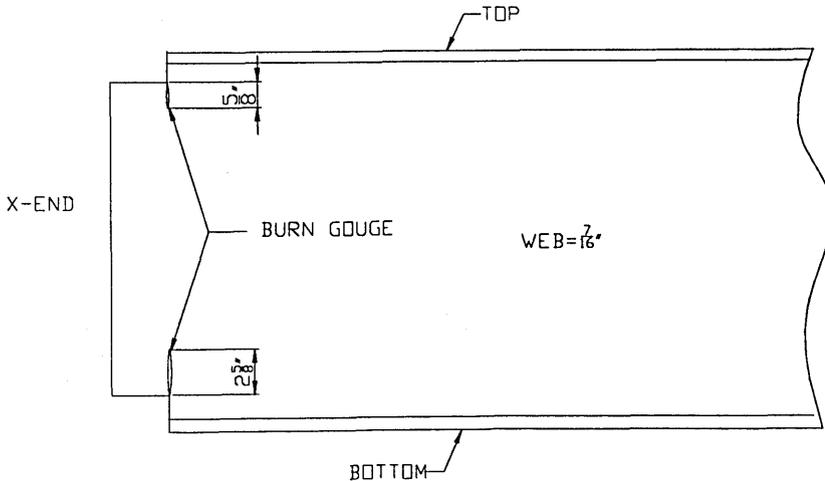
```

caseSolution(nicksGouges_3,nicksGouges,'NAGS-C003','Nicks & Gouges Case Solution',[],success,
[
  bridgeType      :plateGirder,
  errorMemberType :plateGirder,
  errorMemberLocation :web,
  errorMemberClass :primary,
  nickGougeType   :edge,
  nickGougeLength :2.625,
  errorMemberActualThickness :0.4375,
  nickGougeReductionOfArea :moderate
],
'There are burn gouges at the top and bottom of web from cutting copes.
Grind 60 degree bevel 1/4 in. deep on web repair area.
Attach run off bars by tacking in weld groove.
Preheat and weld first side per approved weld procedure.
Back gouge second side to sound weld metal.
Weld second side per approved procedure.
Remove run off bars by air-arc gouge and grind 1 in. radius per shop drawings.
RT weld repair area per contract spec.'
).

```

**Case #FB157:**

Description of Error: Burn gouges in top and bottom web from cutting copes.  
 Solution Recommended: 1) Grind 60° bevel, 1/4" deep on web repair area's. 2) Attach run off bars by tacking in weld groove (do not tack to parent material). 3) Preheat and weld 1<sup>st</sup> side per approved weld procedure. 4) Back gouge 2<sup>nd</sup> side to sound weld metal. 5) Weld 2<sup>nd</sup> side per approved weld procedure. 6) Remove run off bars by air-arc gouge and grind 1" radius per shop drawings. 7) RT weld repair area's per contract spec.



% Solution 4

caseSolution(nicksGouges\_4,nicksGouges,'NAGS-C004','Nicks & Gouges Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberLocation :tensionFlange,
  errorMemberClass    :primary,
  nickGougeType       :edge,
  nickGougeDepth      :0.375,
  stressErrorMemberType :tension,
  nickGougeReductionOfArea :moderate,
  nickGougeNumberNearLocation :2,
  errorMemberActualWidth :12.25,
  errorMemberDesignWidth :12.25
],
```

'The bottom flange has burn gouges on both edges across from each other.

Grind the defect area to remove any slag or dross remaining from the cutting operation.

Preheat gouged area to applicable temperature.

Weld gouged area with approved weld procedure with electrodes no great that 5/32 in. diameter.

Grind weld flush with base metal.

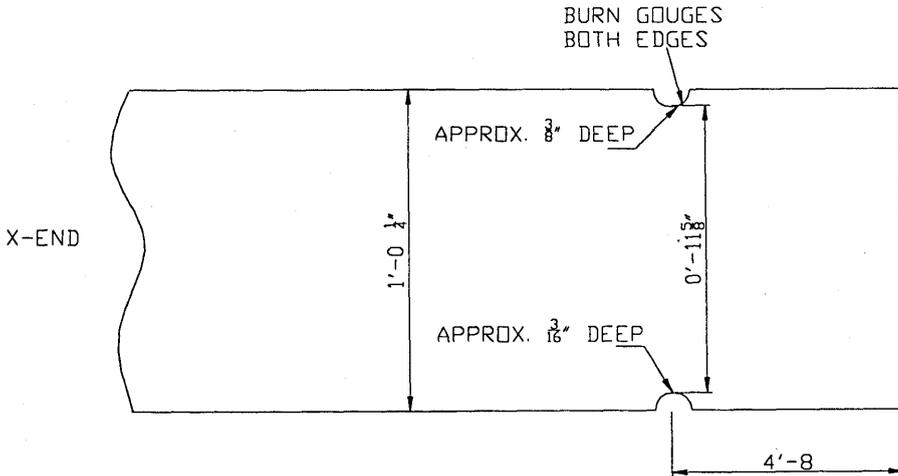
Finished and ground repair - shall be UT inspected.'

).

Case #FB156:

Description of Error: The bottom flange for a girder has burn gouges on the edges 4'-8" from the right end. The gouges are on both edges and across from each other.

Solution Recommended: 1) Grind defect area to remove any slag or dross remaining from the cutting operation. 2) Preheat gouged area to applicable temperature. 3) Weld gouged area with approved weld procedure with electrodes no greater than 5/32" diameter. 4) Grind weld flush with base metal. 5) Finished and ground repair shall be UT inspected.



% Solution 5

caseSolution(nicksGouges\_5,nicksGouges,'NAGS-C005','Nicks & Gouges Case Solution',[],success,

```
[
  bridgeType      :plateGirder,
  errorMemberType :plateGirder,
  errorMemberLocation :tensionFlange,
  errorMemberClass :primary,
  nickGougeType   :edge,
  nickGougeDepth  :0.5,
  stressErrorMemberType :tension,
  stressErrorMemberLevel :high,
  nickGougeReductionOfArea :moderate
]
```

'The bottom tension flange has a deep burn gouge.  
Because the gouge is deep and the tension flange is in a highly stressed area of the bridge the girder is rejected.'  
).

Case #JJ149:

Description of Error: Plate is the bottom tension flange of the girder and has a 1/2" deep burn gouge in the edge.

Solution Recommended: Since girder is in a highly stressed area of the bridge, plate must be replaced. This case arose on a job where the quantity of burn gouges was excessive.

% Solution 6

caseSolution(nicksGouges\_6,nicksGouges,'NAGS-C006','Nicks & Gouges Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  nickGougeType       :edge,
  nickGougeDepth      :0.625,
  nickGougeReductionOfArea :moderate,
  nickGougeNumberNearLocation :2,
  errorMemberActualWidth :12.1875,
  errorMemberDesignWidth :12.1875
]
```

'The top flanges have burn gouges on both edges of the flange across from each other.

Cut the plate past the burn gouges.

Reverse the ends and 100% butt weld the plate.

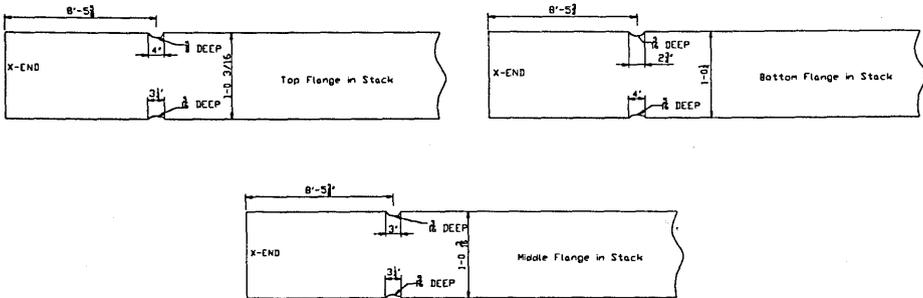
The butt weld is to be radiographed 100%.'

).

Case #JJ141:

Description of Error: Top flanges for 3 girders K, L and M have gouges on their edges at extension dimension 8'-5". The gouges are on both edges of the flanges and across from each other.

Solution Recommended: Allow a cut, reverse the ends, butt pieces together and reweld, then 100% radio graph butt weld. There is sufficient material fit. Trim off gouge material at end of piece when final welding is complete.



% Solution 7

caseSolution(nicksGouges\_7,nicksGouges,'NAGS-C007','Nicks & Gouges Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :web,
  errorMemberClass     :primary,
  nickGougeType       :edge,
  nickGougeDepth      :0.5,
  nickGougeLength     :4,
  errorMemberActualThickness :0.375,
  nickGougeReductionOfArea :moderate,
  nickGougeNumberNearLocation :4
]
```

'The web has four burn gouges on the bottom edge.

Make two cuts one on each side of the four gouges.

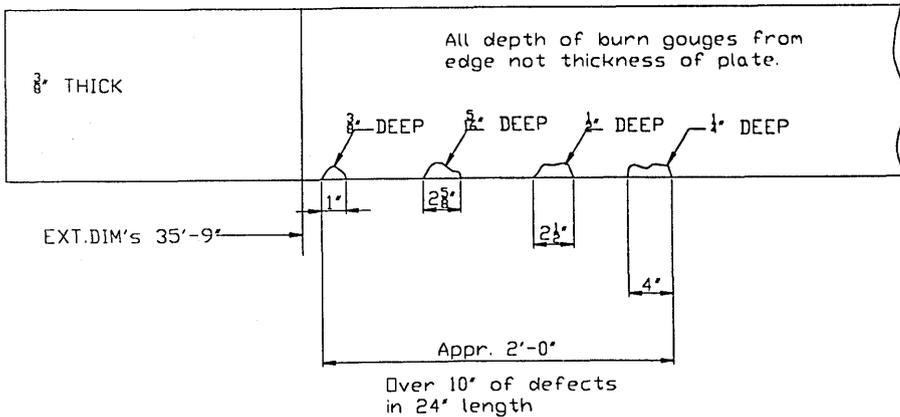
Weld in new material in its place.'

).

Case #JJ141:

Description of Error: Girder web plate has 4 burn gouges on the bottom edge. These gouges range from 1/4" to 1/2" deep.

Solution Recommended: Since this is a web, there is no extra width. Make two cuts and add new material. Radiograph butt welds 100%.



% Solution 8

caseSolution(nicksGouges\_8,nicksGouges,'NAGS-C008','Nicks & Gouges Case Solution',[],success,

```
[
  bridgeType      :plateGirder,
  errorMemberType :plateGirder,
  errorMemberLocation :compressionFlange,
  errorMemberClass :primary,
  nickGougeType   :edge,
  nickGougeDepth  :0.125,
  nickGougeReductionOfArea :verySmall,
  nickGougeNumberNearLocation :4,
  errorMemberActualWidth :18.125,
  errorMemberDesignWidth :18
]
```

'Burn gouges appear along the edge of the top flange.

The plate is actually wider than it is specified to be.

By grinding the plate down to its specified width the gouges will be taken care of.'

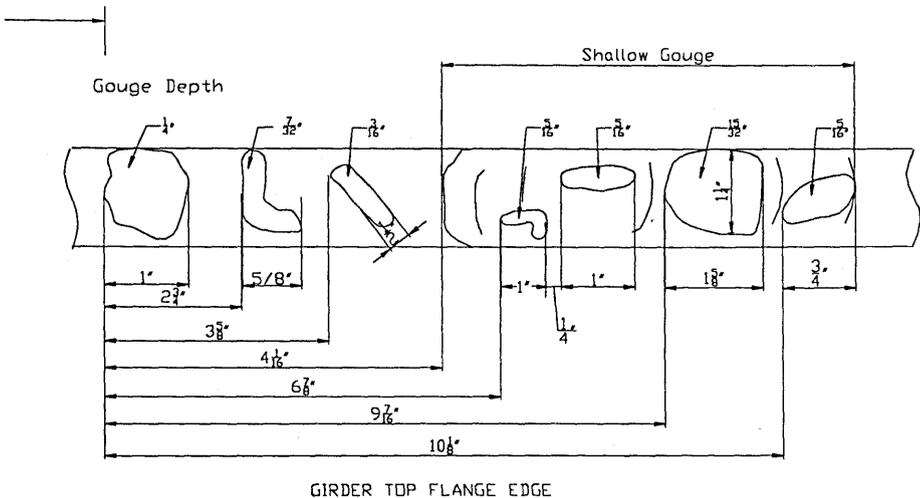
).

Case # MG106:

Description of Error: Girder top flange, 20'-10 from right end, has an area of burn gouges 11 inches long and up to 3/8 inches deep.

Solution Recommended: Grind the 18 1/8" wide plate to the design width of 18" in the area of the burn gouges. The remainder of the gouges shall be repaired by welding according to Fabrication Correction Procedure: Repair of Flame Cut Edges. The welds shall be ground smooth and the repairs ultrasonic tested.

20'-7 1/2" To RT.  
Girder End.



% Solution 9

caseSolution(nicksGouges\_9,nicksGouges,'NAGS-C009','Nicks & Gouges Case Solution',[],success,

```
[  
  bridgeType           :plateGirder,  
  errorMemberType     :plateGirder,  
  errorMemberLocation :web,  
  errorMemberClass    :primary,  
  nickGougeType       :surface,  
  nickGougeDepth      :0.2,  
  nickGougeLength     :4,  
  nickGougeReductionOfArea :small,  
  nickGougeNumberNearLocation :1  
],
```

'The web was damaged in handling while at fabricating plant.

Grind the gouge suitable for MT.

MT repair cavity to assure no defect exists. Preheat.

Using electrode purchased for Fracture Critical Members, repair using approved weld procedure SMAW flat.

Postheat.

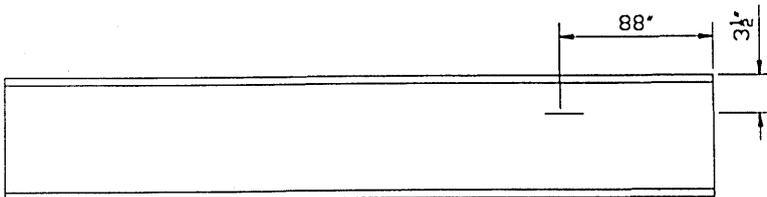
Grind repair area and visually inspect.'

).

Case #TF212:

Description of Error: Girder web plate was damaged in handling while at fabricating plant. Cavity (gouge) area is located approximately 88 inches from girder end and 3 1/2 inches down from top flange.

Solution Recommended: 1) Grind cavity (gouge) suitable for MT. 2) MT repair cavity to assure no defect exists. 3) Preheat without interruption until the repair is complete. (Preheat / interpass 250 degrees F- 450 degrees F). 4) Using electrode purchased for Fracture Critical Members, repair using approved weld procedure (SMAW flat). 5) Postheat for 15 minutes (400 degrees F - 500 degrees F). 6) Grind repair area and visually inspect.



% Solution 10

caseSolution(nicksGouges\_10,nicksGouges,'NAGS-C010','Nicks & Gouges Case Solution',[],success,

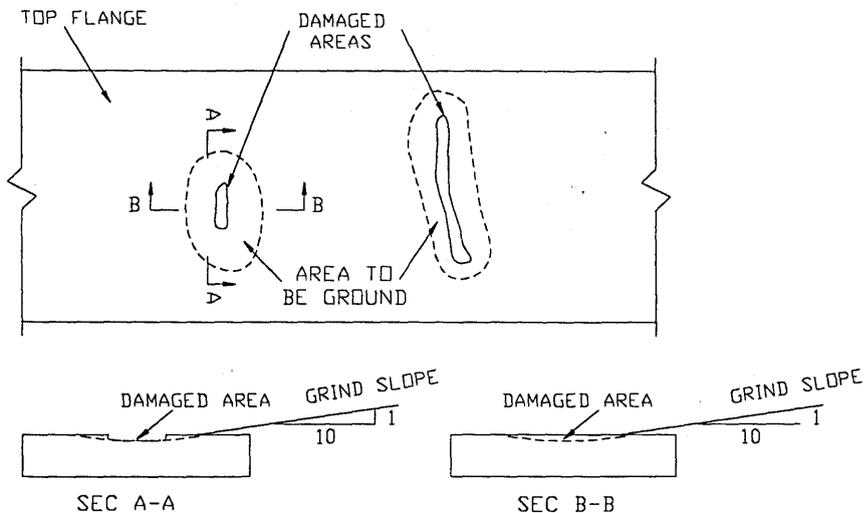
```
[
  bridgeType          :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberLocation :compressionFlange,
  errorMemberClass    :primary,
  nickGougeType       :surface,
  nickGougeDepth      :0.25,
  nickGougeReductionOfArea :small,
  nickGougeNumberNearLocation :2
]
```

'The flanges were damaged while contractor was removing an unacceptable section of deck that had been poured. The damaged areas on the flanges must be ground out smoothly. The maximum slope for the grinding is to 10 to 1. The grinding is to be done in the direction of the major stress. When the repair is complete the areas that have been ground shall be inspected by a DOT materials inspector. The repair then shall be painted with organic zinc-vinyl paint.'

Case #TF215:

Description of Error: The flanges were damaged by the Contractor while he was removing an unacceptable section of deck that had been poured.

Solution Recommended: 1) The damaged areas on the flanges must be ground out smoothly. The maximum slope for the grinding is to be 1" vertical to 10" horizontal. The grinding is to be done in the direction of the major stress (i.e.- longitudinally along the girder). A circular grinder may be used if the repair is finished with a belt grinder in the direction of the major stress. Notches deeper than 1/4" may not be repaired with this procedure without further approval. 2) When the repair is complete the areas that have been ground shall be inspected by a DOT materials inspector. After the repair has been approved the ground areas shall be painted with organic zinc-vinyl paint.



% Solution 11

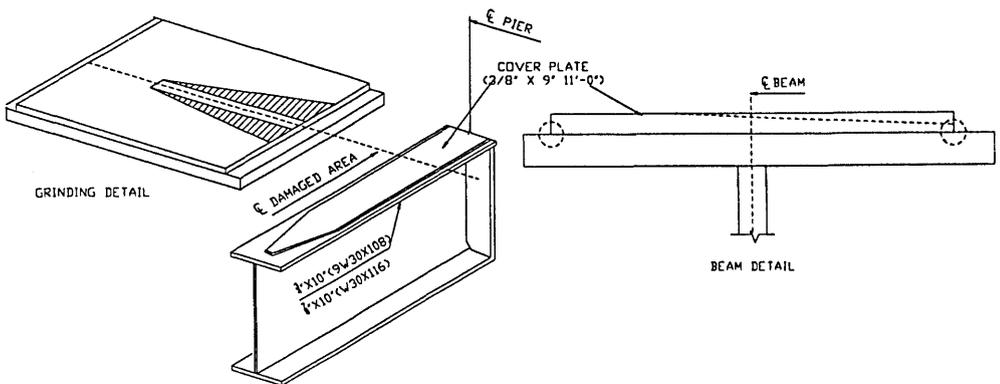
caseSolution(nicksGouges\_11,nicksGouges,'NAGS-C011','Nicks & Gouges Case Solution',[],success,

```
[
  bridgeType           :rolled,
  errorMemberType      :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  nickGougeType        :surface,
  nickGougeDepth       :0.25,
  stressErrorMemberLevel :high,
  nickGougeReductionOfArea :excessive
],
```

'When removing the concrete slab the cover plate had been cut with a saw.  
 After reviewing design calculations it was determined that the cover plate was not necessary for the composite section to carry the design loads.  
 Because there is potential for fatigue cracks to develop at the cut, the cut needs to be ground at a 16 to 1 transition.  
 Careful attention needs to be taken not to grind below the cut.'

Case #NC506:

Description of Error: A cover plate had been cut with a saw during the removal of the concrete slab. Another cut was discovered at a second location during inspection of the cover plates for weld cracking. The saw cuts were measured in the field.  
 Solution Recommended: Grind a 16:1 transition at both locations. Do not grind below saw cut depth. It is also recommended that future routine bridge inspection include observation of each saw cut location.



% Solution 12

caseSolution(nicksGouges\_12,nicksGouges,'NAGS-C012','Nicks & Gouges Case Solution',[],success,

```
[  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :web,  
  errorMemberClass     :primary,  
  nickGougeType        :edge,  
  nickGougeLength      :25,  
  stressErrorMemberLevel :medium,  
  nickGougeReductionOfArea :moderate  
],
```

'The web cutter mis-tracked causing torch to cut into web top.

Remove the web area that was gouged.

Remove all slag by grinding.

Use the area that was cut out as a template for a web slug.

Weld the web slug into the cut out area.

When web slug is welded into position grind all weld flush.

Torch cut the web slug about 1/4 in. above the top of the web.

Remove the balance of the web slug to flush with the top of web plate by grinding.

100 percent RT examine.'

).

Case # (no original case found)

Description of Error: The web cutter mis-tracked causing torch to cut into web top.

Solution Recommended: 1) Remove the web area that was gouged.

2) Remove all slag by grinding.

3) Use the area that was cut out as a template for a web slug.

4) Weld the web slug into the cut out area.

5) When web slug is welded into position grind all weld flush.

6) Torch cut the web slug about 1/4 in. above the top of the web.

7) Remove the balance of the web slug to flush with the top of web plate by grinding.

8) 100 percent RT examine.

% Solution 13

caseSolution(nicksGouges\_13,nicksGouges,'NAGS-C013','Nicks & Gouges Case Solution',[],success,

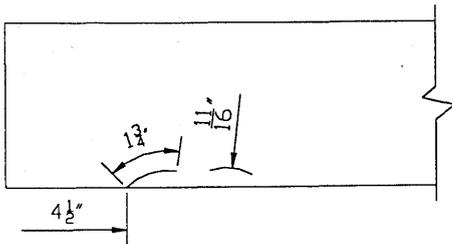
```
{  
  bridgeType           :plateGirder,  
  errorMemberType      :plateGirder,  
  errorMemberLocation  :web,  
  errorMemberClass     :primary,  
  nickGougeType        :edge,  
  nickGougeLength      :1.75,  
  errorMemberActualThickness :0.5,  
  nickGougeReductionOfArea :small  
},
```

'The web burning machine jumped its track and burned into the webs. Weld and grind the gouges and ultrasonic test the areas for soundness.'  
)

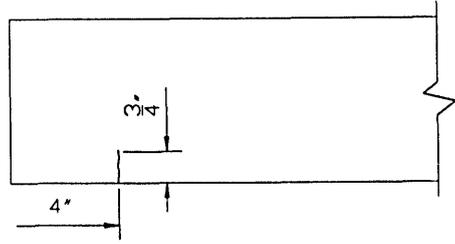
Case #NC511:

Description of Error: A fabrication error occurred when web burning machine jumped its track and burned into the webs. The webs affected are for girders A2 and B2.

Solution Recommended: Weld and grind the gouges and ultrasonic test the areas for soundness.



WEB B2 1/2 X 42 47'-1



WEB A2 1/2 X 42 47'-1

% New Solution 14

caseSolution(nicksGouges\_14,nicksGouges,'NAGS-C014','Nicks & Gouges Case Solution',[ddf0032],success,

```
[
  bridgeType      :plateGirder,
  errorMemberType :flangePlate,
  errorMemberLocation :compressionFlange,
  errorMemberClass :primary,
  attachMemberClass :primary,
  nickGougeType   :edge,
  nickGougeDepth  :0.375
]
```

'The designed 16" flanges were cut from 17" down to 15.5625" back up to 16".

Along with this irregular cut, flame cut defects were created at locations given in table.

Cut down the flange to 16" in the first 20'-0", ground the plate to 16 3/8" between 91'-0" and 95'-0",

and left the other widths as cut. The edge defect repairs were welded and NDT per code, or were ground at a 10 to 1 bevel.

Each defect description and location is shown in the table with its repair method.'

).

Case #DD-F003:

Description of Error: The designed 16" flanges were cut from 17" down to 15.5625" back up to 16". Along with this irregular cut, flame cut defects were created at locations given in table.

Solution Recommended: Cut down the flange to 16" in the first 20'-0", ground the plate to 16 3/8" between 91'-0" and 95'-0", and left the other widths as cut. The edge defect repairs were welded and NDT per code, or were ground at a 10 to 1 bevel. Each defect description and location is shown in the table with its repair method. (also see case 'MCTM-C029' for miscut member error on same member)

TYPE	ACTUAL DIMAENSION	EDGE DEFECT DESCRIPTION	REPAIR METHOD
1	15	FLAME GOUGE 3/32 DEEP & 1-1/2 LONG	WILL BE REMOVED AT FLANGE TRIM
2	19.92	FLAME CUT 1/16 DEEP & 1/2 LONG	WILL BE REMOVED AT FLANGE TRIM
3	21.88	FLAME CUT 1/4 DEEP	WELD REPAIR &ndt PER CODE
4	22.29	FLAME GOUGE 1/4 DEEP & 1/2 LONG	WELD REPAIR &ndt PER CODE
5	23.88	FLAME CUT 3/16 DEEP	GRIND REPAIR TO 10 TO 1
6	26.83	FLAME CUT 1/16 DEEP	GRIND REPAIR TO 10 TO 1
7	28.79	FLAME CUT 1/8 DEEP	GRIND REPAIR TO 10 TO 1
8	29.75	FLAME CUT 1/4 DEEP	WELD REPAIR & NDT PER CODE
9	39.46	FLAME CUT 3/16 DEEP	WELD REPAIR & NDT PER CODE
10	39.67	FLAME CUT 1/4 FOR 1/4 NOTCH	WELD REPAIR & NDT PER CODE
11	63.83	FLAME CUT 3/16 DEEP	GRIND REPAIR TO 10 TO 1
12	78.33	FLAME CUT 1/8 DEEP	GRIND REPAIR TO 10 TO 1
13	90.08	FLAME CUT 3/8 DEEP	GRIND REPAIR TO 10 TO 1
14	92.63	FLAME CUT 1/4 FOR 1/4 NOTCH	WILL BE REMOVED AT FLANGE TRIM
15	95.13	FLAME CUT 3/8 DEEP	WILL BE REMOVED AT FLANGE TRIM
16	102.75	FLAME CUT 1/8 DEEP	GRIND REPAIR TO 10 TO 1

% New Solution 15

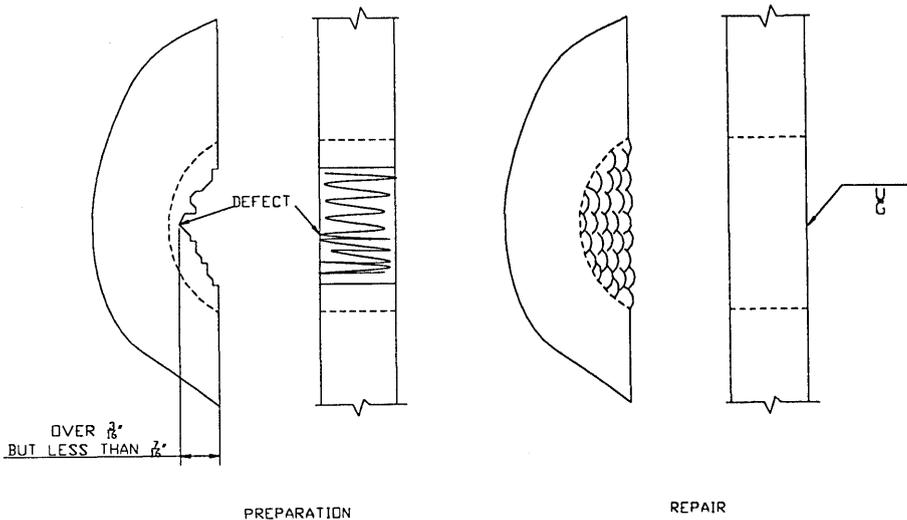
caseSolution(nicksGouges\_15,nicksGouges,'NAGS-C015','Nicks & Gouges Case Solution',[mbf001],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :baseMetal ,
  errorMemberLocation  :baseMetal,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  nickGougeType        :edge,
  nickGougeDepth       :0.4375
]
```

Gouges in cut base metal edges that are 7/16" deep or less, where the surface should be flat.  
 If the gouge meets the tolerance of greater than 3/16" and less than 7/16" from the cut edge,  
 welding with single arc shield metal arc welding (S.M.A.W) is required,  
 If gouge is less than 3/16" deep from the cut edge see below for other solution.  
 Preheat is required.

Case #MB-F001:

Description of Error: Gouges in cut base metal edges that are 7/16" deep or less, where the surface should be flat.  
 Solution Recommended: If the gouge meets the tolerance of greater than 3/16" and less than 7/16" from the cut edge, welding with single arc shield metal arc welding (S.M.A.W) is required, If gouge is less than 3/16" deep from the cut edge see below for other solution. Preparation is required for welding. (preparation of gouged area includes air-arc gouging or grinding to the bottom of the burn. Preheat is required. These are only if welding is involved) If welding is required then magnetic particle testing (M.T.) and/or ultrasonic testing (U.T.) is required.  
 Other Possible solutions: If the gouge is less than 3/16" deep from the cut edge, grinding to a slope of 1 inch to remove the gouge is acceptable. No welding required.



% New Solution 16

caseSolution(nicksGouges\_16,nicksGouges,'NAGS-C016','Nicks & Gouges Case Solution',[mbf003],success,

```
[  
  bridgeType           :plateGirder,  
  errorMemberType      :baseMetal,  
  errorMemberLocation  :baseMetal,  
  errorMemberClass     :primary,  
  attachMemberClass    :primary,  
  nickGougeType        :edge  
],
```

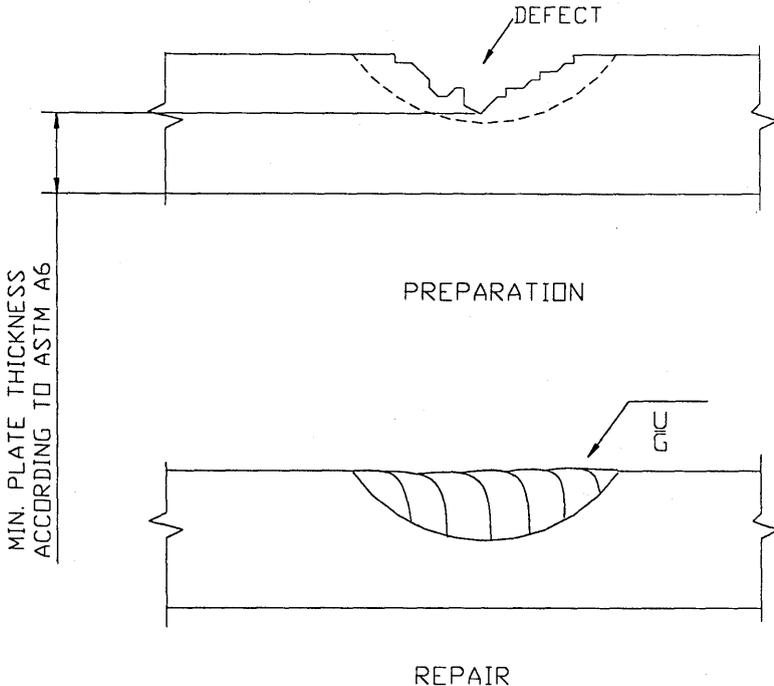
),  
'Defect in base metal where base metal should be flat with little or no discontinuities on the base metal surface.  
Single pass semi-automatic submerged arc weld (SAW) in place of the defect after preparation of base metal.  
Preparation of the defect area by air-arc gouging or grinding to the bottom of defect is required.  
Preheat is also required. Minimum plate thickness is according to ASTM A6.'  
)

Case #MB-F003:

Description of Error: Defect in base metal where base metal should be flat with little or no discontinuities on the base metal surface.

Solution Recommended: Single pass semi-automatic submerged arc weld (SAW) in place of the defect after preparation of base metal. Preparation of the defect area by air-arc gouging or grinding to the bottom of defect is required. Preheat is also required. Minimum plate thickness is according to ASTM A6.

Other Possible solutions: Removal of the defect by grinding without welding is permitted, providing the thickness of the plate is not reduced by more than the permissible minimum thickness of the plate.



% New Solution 17

caseSolution(nicksGouges\_17,nicksGouges,'NAGS-C017','Nicks & Gouges Case Solution',[blf002],success,

```
[
  bridgeType      :bascule,
  errorMemberType :webPlate,
  errorMemberLocation :web,
  errorMemberClass :primary,
  nickGougeType   :surface,
  nickGougeDepth  :0.01
],
```

'There was a transition of thickness on the web.

In the process of removing the weld reinforcement the weld was over ground in excess of 0.010"  
(in violation of 5.04.15c of the 1990 MDOT Standard Specification.)

Over grinding occurred on both sides of the web.

Build up the defection area using the same weld procedure used to make the weld originally followed by grinding properly.'

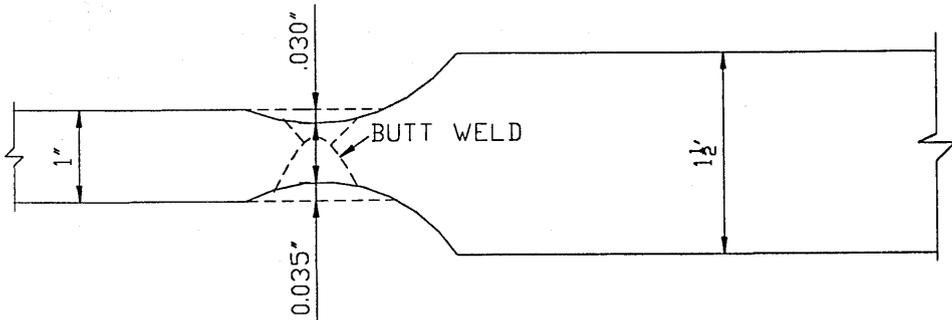
Case #BL-F002:

Description of Error: There was a transition of thickness on the web. In the process of removing the weld reinforcement the weld was over ground in excess of 0.010". (in violation of 5.04.15c of the 1990 MDOT Standard Specification.) Over grinding occurred on both sides of the web.

Solution Recommended: Build up the defection area using the same weld procedure used to make the weld originally followed by grinding properly.

Other Possible solutions: Replace the web.

Remarks: The over grinding was discovered which reviewing the original radiographs.



# Lamination

## Surface Lamination Cases:

% Solution 1

```

caseSolution(surfaceLamination_1,surfaceLamination,'SURL-C001','Surface Lamination Case Solution',[],success,
[
  bridgeType           :plateGirder,
  errorMemberType     :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass    :primary,
  laminationMappingDocumentation:complete,
  laminationLengthOfDeformity :40.25
],
'A lamination appears in the top flange of the girder.
This repair shall be made by preparing a cavity by means of grinding or air arc gouging to a depth of 1/4 to 3/8.
The ends of the cavity shall taper smoothly up to the plate surface at a slope not to exceed 1 to 1.
Where the cavity extends to the plate edge an edge run-off tab shall be used.
Preheat shall be used and temperature shall be maintained until repair is complete, and
to the end of the minimum postheat period.
The repair weld shall be ground flush and base metal suspect area shall again be inspected by means of UT to
determine if any applicable change has occurred as a result of the sealing process.
').
  
```

Case #MG112:

Description of Error: A lamination appears in the top flange of the girder.

Solution Recommended: This repair shall be made by preparing a cavity by means of grinding or air arc gouging to a depth of 1/4 to 3/8 inch. The ends of the cavity shall taper smoothly up to the plate surface at a slope not to exceed 1:1. Where the cavity extends to the plate edge, an edge run-off tab shall be used.

Preheat 250 -450° F shall be used and temperature shall be maintained until repair is complete.

Welding electrode (FCM) purchased this contract shall be used. Shielded metal arc or submerged arc may be used. However, at least the first four layers of any repair shall be shielded metal arc welding using electrodes of 1/8 or 5/32" diameter. The maximum pass thickness shall be 1/8" for SMAW or 1/4" SAW. Welding parameters shall be as specified in the applicable WPS in the following table.

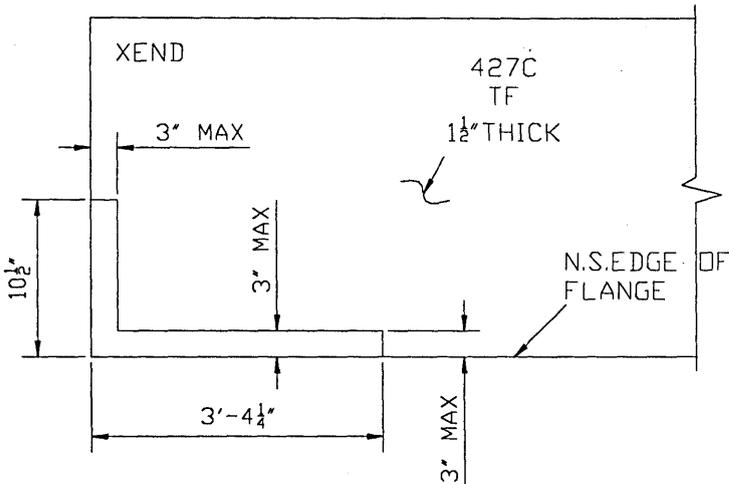
SMAW - WPS 90-15

SAW - WPS 90-890-990-1090-11

Following welding, postheat shall be employed and shall continue without interruption from the completion of repair welding to the end of the minimum postheat period.

Postheat of the repair area shall be between 400° and 500° F for one hour per inch of repair weld thickness or for two hours whichever is less.

The repair weld shall be ground flush and base metal suspect area shall again be inspected by means of UT to determine if any applicable change has occurred as a result of the sealing process.



427-15E

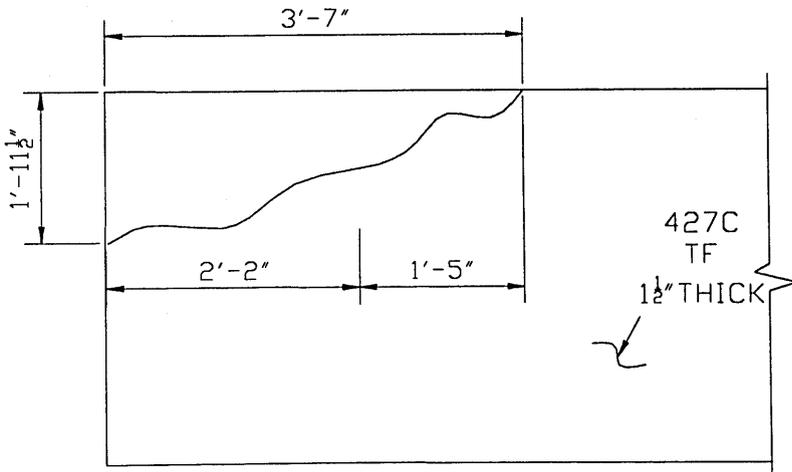
% Solution 2

```
caseSolution(surfaceLamination_2,surfaceLamination,'SURL-C002','Surface Lamination Case Solution',[],success,
[
  bridgeType      :plateGirder,
  errorMemberType :plateGirder,
  errorMemberLocation :tensionFlange,
  errorMemberClass :primary,
  laminationMappingDocumentation:complete,
  laminationLengthOfDeformity :43,
  laminationWidthOfDeformity :23.5
],
)
```

'A lamination appears in the top flange of the girder.  
 This repair shall be made by preparing a cavity by means of grinding or air arc gouging to a depth of 1/4 to 3/8.  
 The ends of the cavity shall taper smoothly up to the plate surface at a slope not to exceed 1 to 1.  
 Where the cavity extends to the plate edge an edge run-off tab shall be used.  
 Preheat shall be used and temperature shall be maintained until repair is complete, and to the end of the minimum postheat period.  
 The repair weld shall be ground flush and base metal suspect area shall again be inspected by means of UT to determine if any applicable change has occurred as a result of the sealing process.'

Case #: FB158:

Description of Error: A lamination appears in the top flange of the girder.  
 Solution Recommended: This repair shall be made by preparing a cavity by means of grinding or air arc gouging to a depth of 1/4 to 3/8 inch. The ends of the cavity shall taper smoothly up to the plate surface at a slope not to exceed 1 to 1. Where the cavity extends to the plate edge, an edge run-off tab shall be used.  
 Preheat 250-450° F shall be used and temperature shall be maintained until repair is complete. Welding electrode (FCM) purchased this contract shall be used. Shielded metal arc or submerged arc may be used. However at least the first four layers of any repair shall be shielded metal arc welding using electrodes of 1/8 or 5/32 diameter. The maximum pass thickness shall be 1/8 for SMAW or 1/4 SAW. Welding parameter shall be as specified in the applicable WPS in the following table.  
 SMAW - WPS 90-15  
 SAW - WPS 90-890-990-1090-11.  
 Following welding, postheat shall be employed and shall continue without interruption from the completion of repair welding to the end of the minimum postheat period. Postheat of the repair area shall be between 400° and 500° F for one hour per inch of repair weld thickness or for two hours whichever is less.  
 The repair weld shall be ground flush and base metal suspect area shall again be inspected by means of UT to determine if any applicable change has occurred as a result of the sealing process.



427-14E

% Solution 3

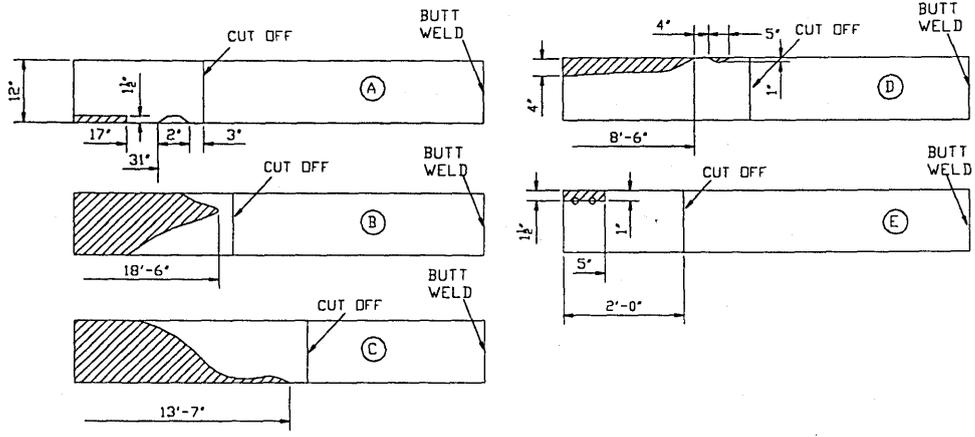
caseSolution(surfaceLamination\_3,surfaceLamination,'SURL-C003','Surface Lamination Case Solution',[],success,

```
[
  bridgeType      :plateGirder,
  errorMemberType :plateGirder,
  errorMemberLocation :compressionFlanges,
  errorMemberClass :primary,
  laminationSurfaceType :surface,
  laminationMappingDocumentation:complete,
  laminationTestRequired :ut,
  laminationLengthOfDeformity :137,
  laminationWidthOfDeformity :0.5
]
```

'Laminations occur in the girder flanges.  
 Cut off the defective area and butt-weld new flange material to the plate.  
 The repair should be tested as required for metal soundness.  
 All repaired material to be used in top flanges compression regions.'

Case #: NC510:

Description of Error: Laminations occur in the girder flanges.  
 Solution Recommended: Cut off the defective area. UT test after cutting to assure all laminations are removed. Butt-weld new flange material to the plate. Butt welds shall be at the good end, if the end far thist from the laminations. All butt welds to be radiographed. All repaired material to be used in top flange compression regions. Plates marked B, C, D, and E constitutes top flange of the drop-in piece of span 2. Plate A constitutes top flange of an end span. Laminated area of Plate A should be placed at the free end (abutment) and not the field splice end of the girder piece.



% New Solution 4

```

caseSolution(surfaceLamination_4,surfaceLamination,'SURL-C004','Surface Lamination Case Solution',[scf002],success,
[
  bridgeType      :plateGirder,
  errorMemberType :webPlate,
  attachMemberType :flangePlate,
  errorMemberLocation :web,
  errorMemberClass :primary,
  attachMemberClass :primary
],
'Lamination of 12 mm web plate as developed from the mill, discovered in process of fabrication after flange plates were attached.
Ultrasonically test for limits of lamination in web plate. Find end of lamination, drill hole and install bolt.'
).

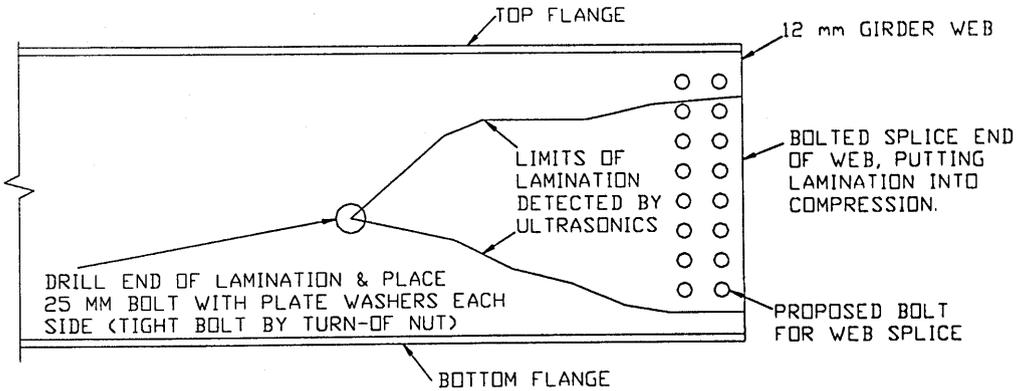
```

Case #SC-F002:

Description of Error: Lamination of 12 mm web plate as developed from the mill, discovered in process of fabrication after flange plates were attached

Solution Recommended: Ultrasonically test for limits of lamination in web plate. Find end of lamination, drill hole and install bolt.

Other Possible solutions: Reject girder and make a new one, cut web out, weld in new web.



% New Solution 5

```
caseSolution(surfaceLamination_5,surfaceLamination,'SURL-C005','Surface Lamination Case Solution',[mbf002],success,
[
  bridgeType           :plateGirder,
  errorMemberType      :baseMetal,
  errorMemberLocation  :baseMetal,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  laminationTestRequired :ut,
  laminationWidthOfDeformity :0.25
]
```

].  
 \* Laminar discontinuity in the base metal apparent on the surface of the base metal.

The recommended solutions are based on the description of the discontinuity: 1) for any discontinuity 1 inch in length or less, no plate repair is required, and need not be explored. 2) For any discontinuity over 1 inch in length and 1/8 inches maximum depth, no plate repair required, but the depth should be explored. 3) For any discontinuity over 1 inch in length with depth over 1/8 inches but not greater than 1/4 inches, removal is required, but not need weld. 4) For any discontinuity over 1 inch in length with depth over 1/4 inches but not grater than 1 inch, completely remove and weld are required. Aggregate length of the welding shall not exceed 20% of the length of the plate edge being repaired.5) For any discontinuity over 1 inch in length with depth greater than 1 inch, see AWS 3.2.3.7.'

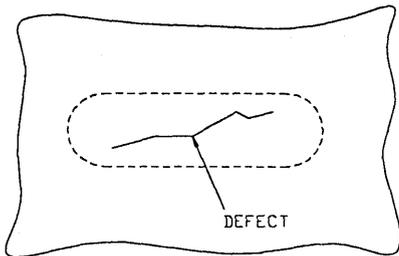
).

Case #MB-F002:

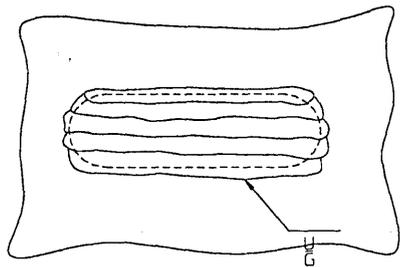
Description of Error: Laminar discontinuity in the base metal apparent on the surface of the base metal.

Solution Recommended: The recommended solutions are based on the description of the discontinuity: 1) for any discontinuity 1 inch in length or less, no plate repair is required, and need not be explored. 2) For any discontinuity over 1 inch in length and 1/8 inches maximum depth, no plate repair required, but the depth should be explored. 3) For any discontinuity over 1 inch in length with depth over 1/8 inches but not greater than 1/4 inches, removal is required, but not need weld. 4) For any discontinuity over 1 inch in length with depth over 1/4 inches but not grater than 1 inch, completely remove and weld are required. Aggregate length of the welding shall not exceed 20% of the length of the plate edge being repaired.5) For any discontinuity over 1 inch in length with depth greater than 1 inch, see AWS 3.2.3.7.

If welding is required, use a single arc semi-automatic submerged arc weld(S.A.W.) after preparation. Magnetic particle inspection (M.T.) and/or ultrasonic inspection (U.T.) are require for the final checks.



PREPARATION



REPAIR

## Internal Lamination Cases:

% Solution 1

```
caseSolution(internalLamination_1,internalLamination,'INTL-C001','Internal Lamination Case Solution',[],success,  
[  
    bridgeType           :plateGirder,  
    errorMemberType      :capBeam,  
    errorMemberLocation  :web,  
    errorMemberClass     :primary,  
    laminationMappingDocumentation:complete,  
    laminationTestRequired :ut,  
    laminationLengthOfDeformity :2,  
    laminationWidthOfDeformity  :0.5  
],  
'A defect in the capbeam was found during Ultrasonic Testing. Grind out the defect,  
weld repair, and UT.'  
).
```

Case # ( no original file found)

Description of Error: A defect in the capbeam was found during Ultrasonic Testing.

Solution Recommended: Grind out the defect. Preheat 250-450 F shall be used and temperature shall be maintained until repair is complete. Welding electrode (FCM) purchased this contract shall be used. Shielded metal arc or submerged arc may be used. However at least the first four layers of any repair shall be shielded metal arc welding using electrodes of 1/8 or 5/32 diameter. The maximum pass thickness shall be 1/8 for SMAW or 1/4 SAW. Welding parameter shall be as specified in the applicable WPS in the following table. SMAW - WPS 90-15 SAW - WPS 90-890-990-1090-11. Following welding postheat shall be employed and shall continue without interruption from the completion of repair welding to the end of the minimum postheat period. Postheat of the repair area shall be between 400 and 500 F for one hour per inch of repair weld thickness or for two hours whichever is less. The repair weld shall be ground flush and base metal suspect area shall again be inspected by means of UT to determine if any applicable change has occurred as a result of the sealing process.

# Edge Lamination Cases:

% Solution 1

caseSolution(edgeLamination\_1,edgeLamination,'EDGL-C001','Edge Lamination Case Solution',[],success,

```
[  
  bridgeType           :plateGirder,  
  errorMemberType      :capBeam,  
  errorMemberLocation  :tensionFlange,  
  errorMemberClass     :primary,  
  laminationMappingDocumentation:complete,  
  laminationLengthOfDeformity :21  
],
```

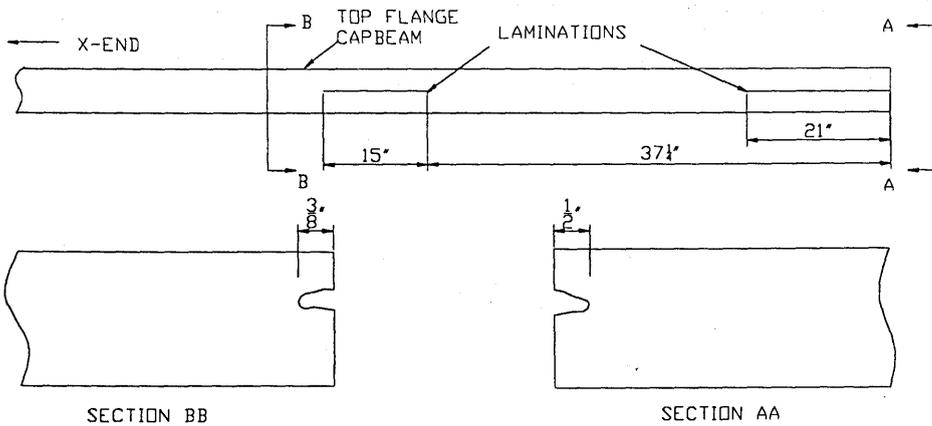
'The cap beam top flange has laminations along its edge.  
The lamination should be ground out, weld repaired, and UT tested.'

).

Case # MG116:

Description of Error: Cap beam top flange has two laminations along its edge. Fabricators have ground 3/8 inch deep in the edge of the flange and the 15" lamination was removed but the 21" lamination still shows indications.

Solution Recommended: Grind the 21" lamination the additional 1/8" to remove the indications and repair these areas per approved fabrication correction procedure.



% Solution 2

caseSolution(edgeLamination\_2,edgeLamination,'EDGL-C002','Edge Lamination Case Solution',[],success,

```
[
  bridgeType           :plateGirder,
  errorMemberType      :plateGirder,
  errorMemberLocation  :tensionFlange,
  errorMemberClass     :primary,
  laminationLengthOfDeformity :60
]
```

),  
'There is a lamellar tear along the end of the plate. Replace flange with new material.'

).

Case # TF192:

Description of Error: There is a lamellar tear in ½" x 120" flange. The tear is ½" deep along the end of the plate. The shape of the lamellar tear is triangular. The base of the triangle is 6 5/8" along the end of the plate and the height of the triangle is approximately 5' along the flange edge.

Solution Recommended: Replace flange with new material. The fabricator elected to replace (as opposed to repair) and to enter discussion with the steel mill so no cost to DOT.

Other possible Solutions: Gouge out discontinuity 1" beyond its intersection with the surface and block off by welding with the shielded metal arc process in layers not to exceed 1/8" inch thickness.

% New Solution 3

caseSolution(edgeLamination\_3,edgeLamination,'EDGL-C003','Edge Lamination Case Solution',[jef006],success,

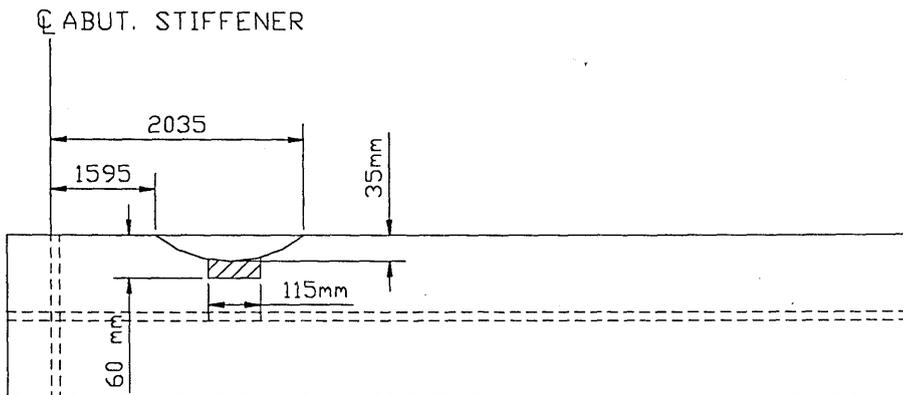
```
[
  bridgeType           :plateGirder,
  errorMemberType      :flangePlate,
  attachMemberType     :bearingStiffener,
  errorMemberLocation  :compressionFlange,
  errorMemberClass     :primary,
  attachMemberClass    :primary,
  laminationLengthOfDeformity :17.32,
  laminationWidthOfDeformity  :1.38
]
```

].  
 A lamination was discovered at mid-thickness in the edge of a top flange plate after cutting. Possible solutions could include: partial or complete flange replacement; designing an array of high strength fasteners to clamp flange together, (and/or provide composite connection to slab); or a combination of edge and slot welds to "connect" flange. Fabricator opted to remove and replace a 3500 mm long portion of the flange, starting from the abutment end. This required removing flange-to-web and stiffener-to-flange fillet welds approx. 600 mm beyond flange replacement to allow flange-web separation for butt welding and X-raying joint. To facilitate replacing flange-to-web weld, size of corner clips (snips) of stiffeners and connection plate at web-flange juncture were increased by 10 mm (horiz and vert) during weld removal. RT of butt weld and MT of replaced fillets are required for final checks.

Case #JE-F006:

Description of Error: A lamination was discovered at mid-thickness in the edge of a top flange plate after cutting. Its apparent max depth was 35 mm, so it was repaired in accord with Section 3 of the Bridge Welding Code. After shafting (welding web to flange and installing stiffeners), the lamination reappeared on the opposite flange edge, indicating a full width separation. Although this is a compression flange, stud shear connectors will be attached for composite action, so horizontal shear in the flange will be substantial. Solution Recommended: Possible solutions could include: partial or complete flange replacement; designing an array of high strength fasteners to clamp flange together, (and/or provide composite connection to slab); or a combination of edge and slot welds to "connect" flange. Fabricator opted to remove and replace a 3500 mm long portion of the flange, starting from the abutment end. This required removing flange-to-web and stiffener-to-flange fillet welds approx. 600 mm beyond flange replacement to allow flange-web separation for butt welding and X-raying joint. To facilitate replacing flange-to-web weld, size of corner clips (snips) of stiffeners and connection plate at web-flange juncture were increased by 10 mm (horiz. and vert.) to 35 mm horiz. and 75 mm vert. during weld removal. RT of butt weld and MT of replaced fillets are required for final checks.

Remarks: This is a large radius curved structure, so cross frame connection plates' welds to flange carry live load stresses. Decreasing their lengths by 10 mm was not judged critical due to the large radius involved, and larger clips allowed better access for semi-auto SAW of flange to web. Requiring fully automatic SAW for the replacement flange-to-web weld would mandate complete removal and replacement of existing sound welds attaching connecting plates and bearing stiffeners to the web and bottom (tension) flange. This would produce higher residual stresses in the girder and require extensive hand labor to accomplish.



GIRDER TOP FLANGE NEAR SIDE

# Coating/Painting

## Coating Cases:

% New Solution 1

```
caseSolution(coating_34,coating,'COAT-C001','Coating',[],success,
```

```
[  
  bridgeType           : bascule,  
  errorMemberType      : rolledBeam,  
  errorMemberClass     : primary,  
  attachMemberClass    : primary
```

```
],
```

' An improper tie coat (manufactured for vinyl topcoat) was applied to the above galvanized items which were to receive epoxy and polyurethane topcoat. The epoxy bubbled-up upon application and could be pulled off in sheets. Adhesion tape tests were performed and indicated coating failure. An attempt was made to reblast to remove only the paint coating. Unfortunately, this also removed the galvanizing. All items were blast cleaned and sent back to the galvanizer. Upon return the proper tie-coat and topcoats were applied.'

```
).
```

Case #LY-F003:

Description of Error: An improper tie coat (manufactured for vinyl topcoat) was applied to the above galvanized items which were to receive epoxy and polyurethane topcoat. The epoxy bubbled-up upon application and could be pulled off in sheets. Adhesion tape tests were performed and indicated coating failure.

Solution Recommended: An attempt was made to reblast to remove only the paint coating. Unfortunately, this also removed the galvanizing. All items were blast cleaned and sent back to the galvanizer. Upon return the proper tie-coat and topcoats were applied.

Remarks: Galvanized coating thickness is required for final checks.

## **Tutorial Tool**

### **Generic Solutions for Common Fabrication Errors**

When using FIXS for a particular fabrication error, the tutorial may provide information that can be used in combination with a solution located by the rules and/or cases.

The Tutorial Tool provides generic solutions for common fabrication errors. It contains a set of categorized generic fabrication errors and solutions, which are collected from multiple DOTs and national fabricators or generalized from actual cases. Since fabrication errors are seldom identical but often similar, generic problems and corrections may assist engineers in categorizing situations and determining the best possible solutions to offer the fabricator.

## **Generic Error Type**

**Mislocated Holes at Field Bolted Splices**

**Plug Welds**

**Fabrication Errors Around Stiffeners**

**Bearing Stiffener**

**Partially Drilled Holes**

**Overheating**

**Nicks and Gouges**

**Surface Lamination**

## Mislocated Holes at Field Bolted Splices

**Main Member Type:** I Shape plate Girders, rolled Beams

**Attached Member/ Detail Type:** Field Bolted Splices

**Error Type:** Mislocated Holes in Web or Flange

**Description of Error:** Due to shifted template or layout error, holes drilled too close to free edge, adjacent bolts or expected edge of splice plate.

**Solution Adopted:** Depends on location, select Flanges and Webs.

**Flanges:**

**Webs:**

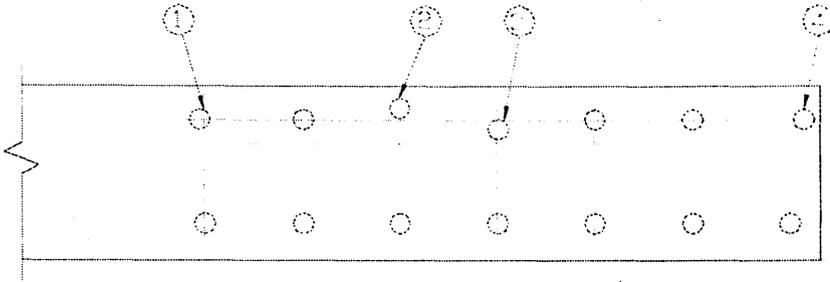
**Required Final Checks/ Verification:** QA verifies agreed correction and alignment acceptable. Resident Engineer and erector notified.

**Was Repair Successful ?:** Yes. When possible, kept size and number of bolts unchanged to reduce chance of error in field.

**Other Possible Solutions:** Major redesign of splice; removing a portion of member and lengthening adjacent member (changes many things, erection nightmare likely!)

**Remarks:** Mistakes happen. As long as isolated instances, no need for punitive measures as long as final structure satisfies designer requirements.

## Mislocated Holes in Flanges and/or Flange Splice Plates



### Flanges:

Too close to end of flange (AASHTO Div 1, 10.24.7.1). Remember that there is minimal stress in flange at this point. Consider planing end of flange for small error, or if too close, do not consider in capacity, so additional bolts required to compensate, lengthening splice plate if necessary. May place bolt in errant hole to maintain sealing pitch, exclude debris, and avoid confusion on future inspections. Too close to edge of flange. This is worst situation and must be considered on a case-by-case basis. If only slightly deficient, may satisfy AASHTO by planing edge to remove burn gouges, hardened material, minor defects. If less than 1 bolt diameter between edge of hole and edge of flange, install bolts but lengthen splice to add commensurate number of extra bolts. If hole breaks edge (or edge is under contact area of washer), may need to add enough bolts to fully develop the splice before it reaches that location, and may need to use wider splice plates to allow bolts in errant holes while satisfying criteria for high strength installation (distribution of clamping force).

### Flange Splice Plates:

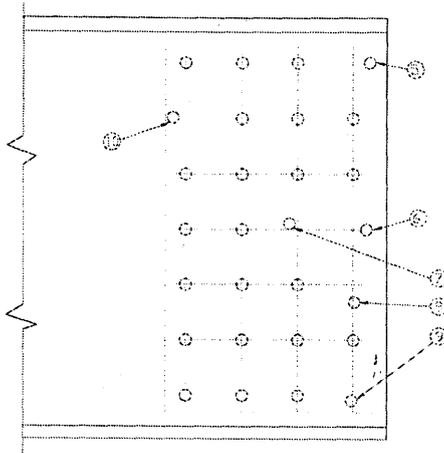
Too close to end of splice plate. For small error, may be able to plane (grind smooth) end of splice plate. For larger error, need to lengthen splice.

Too close to edge of flange and splice plate. This is worst situation and must be considered on a case-by-case basis. If only slightly deficient, may satisfy AASHTO by “planing” edge to remove burn gouges, hardened material, minor defects. If less than 1 bolt diameter between edge of hole and edge of flange, install bolts but lengthen splice to add commensurate number of extra bolts. If hole breaks edge (or edge is under contact area of washer), may need to add enough bolts to fully develop the splice before it reaches that location, and may need to use wider splice plates to allow bolts in errant holes while satisfying criteria for high strength installation (distribution of clamping force).

Too close to edge of inside splice plate. May be able to plane edge of splice plate for small error, or widen inside splice plate if clearance permits. If necessary, lengthen splice and ignore this bolt.

Bolt too close to end of flange. Remember that minimal stress in flange at this point. Consider planing end of flange for small error, or if too close, lengthen splice and add bolts. If outside splice plates only, may be able to change from straight line to staggered pattern to add bolt within same splice length.

## Mislocated Holes in Webs and/or Web Splice Plates



### Webs:

Hole too close to free edge. Based on hole position, consider effect on splice capacity of ignoring that bolt. (Min at neutral axis), and how close hole is to edge. May be able to justify using "as is". If not sure, evaluate pattern and any holes not yet drilled to see if spacing and edge distance on other holes permit. As a last resort, increase web splice plate size and add a row of bolts.

Hole too close to edge of splice plate. Evaluate edge planing. If not adequate, consider enlarging splice depth if physical room permits. If not, see above alternates.

Hole too close to adjacent hole. Consider parameters in AISC's "Specification for Structural Joints Using ASTM A325 or A490 bolts" to determine if bolts' installation requirements and contact areas justify using "as-is". If not, see alternates with #1 & #2.

### Web Splice Plates:

Bolt too close to edge and this bolt contributes significantly to 1 of bolt group. For small error, may be able to plane web edge. For significant error, check vertical bolt spacing to see if bolt(s) can be added within splice plate. May need to change splice.

Bolt too close to edge, but this bolt is near neutral axis and primarily carries only vertical shear.

Consider planing edge, but if too close, check design loads on bolts to see if this one can be neglected before revising entire splice.

Interior bolt. Check if spacing still satisfies AASHTO requirements to leave as-is. If too close to adjacent bolt, consider leaving hole unfilled (in web only) and adding hole as close as possible to correct location. If one location overlaps adjacent hole (looks like a snowman) in web only, since splice plates will cover like hardened washer, consider as oversize hole and check allowable vs. calculated load. If a number of mislocated holes occur in one splice, consider lengthening splice, enlarging bolts, welding plates on both faces or other strengthening measures.

Hole too close to adjacent bolt. Consider criteria in 5, 6, and 7 above.

Hole too close to edge of splice. For small error, may plane edge of splice. For larger error, may widen splice plate if location of flange-web fillet and flange splice plates permit. If not possible to widen plate enough, see #5 above.

Hole too close to edge of splice plate. For small error, may plane edge. For larger error, may need to widen splice plate. Consider location of bolt in group and note that stress at this edge of splice plate is low.

## Plug Welds

**Main Member Type:** Welded plate girder or rolled beam

**Attached Member /Detail Type:** Bolted attachment location

**Error Type:** Plug welded hole

**Description of Error:** PLUG WELDS SHOULD NOT BE USED. However, sometimes they are made. For example, say a person drilled hole(s) in wrong location, then attempted to conceal error by filling hole(s) with weld. Person may or may not be qualified welder. Plug welding is prohibited on a load carrying member. Weld location may be exposed or concealed by other elements (diaphragms, splice plates, etc.).

**Approval to Repair by:** QA Inspector, Fabrication Unit Chief

**Solution Recommended:** If position permits, drill out entire plug weld and install high strength bolt with 2 hardened washers. Drill must be slightly larger than and centered on original hole to remove most of HAZ and potential microcracks present. Before installing bolt, MT and PT inspection by contractual ASNT Level II at fabricator's expense. If position (or stress) precludes the above bolted repair, drill out and inspect the plug weld as above, then fill the hole either cosmetically or structurally. If the drilled hole is partially or completely covered but stresses and proximity of other connections don't require solid metal (for example a bolted diaphragm angle), fill hole with steel pin secured by brazing, epoxy, etc. and ground flush. (if pin is welded in, grind flush and MT area.) If stress, bolts within 1 bolt diameter, welds within 1"/25mm, or other considerations dictate restoring solid metal, insert pin half way into back of hole, prep transition into/out of hole by grinding or gouging, and weld with stringer passes. Go to back side and gouge /grind out fill pin to sound metal and weld with stringer passes. Grind both sides flush and have UT and/or RT inspection by outside Level II at fabricator's expense.

**Required Final Checks / Verification:** QA to oversee and review NDE results.

**Was Repair Successful ?:** Has been to date. Extent of documentation and NDE expense /delays tends to discourage repetition.

**Other Possible solutions:** Thermal stress relief, but confidence is low; remove portion of member and replace (not good idea for rolled beam); drill out and cover with bolted plates; or leave in and cover with full moment connection.

**Remarks:** Most fabricators will not sanction plug welds, but workers don't realize their potential detriment. A number of in-service fatigues have been caused by the stress concentrations and inherent defects of poorly made plug welds. Some owners still require these in "non-tensile areas" such as attaching web thickening plates at pins, but these represent long-term risks.

# Fabrication Errors around Stiffeners

## Stiffeners In General

- Bearing Stiffeners
- Plain, Intermediate Stiffeners
- Diaphragm Connection Plates

There are several types of stiffener errors, the most common of which are misplaced stiffeners, incorrect hole placement, and improper stiffener to flange attachment. Repairs to errors will vary, depending on the type of stiffener. (Bearing, Plain Intermediate, or Diaphragm Connection).

Timing is important when making decisions about repairs. If an error is caught after the stiffener has been tacked into place, but before it has been completely welded, it is not too difficult to remove the stiffener and resolve the error. After the stiffener has been fully welded, removing it becomes a much less desirable option.

Changes in design requirements in recent years have added to the types of errors than can occur with stiffeners. The diaphragm connection plates must always be attached to the tension flange. Usually welding is not allowed. Errors that are made at the compression flange attachment are generally easy to fix. Errors at the tension flange are not. If holes are inadvertently drilled in a compression flange, they can either be filled with bolts, or a connection can be made identically to those used on the tension flange.

Holes are sometimes drilled in the wrong locations in the tension flange. Usually, the best repair when this happens is to custom fabricate a direct attachment to fit the holes as they are drilled in the flange.

Occasionally, a diaphragm connection plate or stiffener is welded to a tension flange in an area where that is prohibited. Usually inspectors require the fabricator only to break the weld, and install the bolted connection in accordance with the design plan. A solution to this type of problem is still under development so this paragraph of this tutorial is incomplete.

## Bearing Stiffeners

See comments under *Stiffeners in General*

When bearing stiffeners are misplaced by a large amount (more than 6"), it is usually acceptable to leave them in place, fill the holes with bolts and add a new stiffener at the proper location. Bearing stiffeners that have been misplaced by a small amount can be a difficult problem. Removing it will risk damaging the girder, and it is also very time consuming. If it is left in place, it may not be possible to add a stiffener at the bearing location, because its close proximity to the existing stiffener makes it impossible to get a welding rod positioned on one side. If this is the case, it may be possible to add an extra stiffener a few inches to the other side of the bearing, which will result in the bearing being centered between the two stiffeners. If a diaphragm is to be attached to the bearing stiffener, refer to "Diaphragm Connection Plates" section of Tutorial.

See example case for more information on bearing stiffeners.

## **Plain, Intermediate Stiffeners**

See comments under Stiffeners in General

Plain stiffeners that are installed in the wrong location should be left as is. An exception to this is if a stiffener is installed on the outside of a fascia girder. The owner may want it removed for aesthetic reasons. If an improperly located stiffener causes the spacing between stiffeners to exceed a specified maximum, an extra one can be added to reduce the spacing to less than the maximum.

## Diaphragm Connection Plates

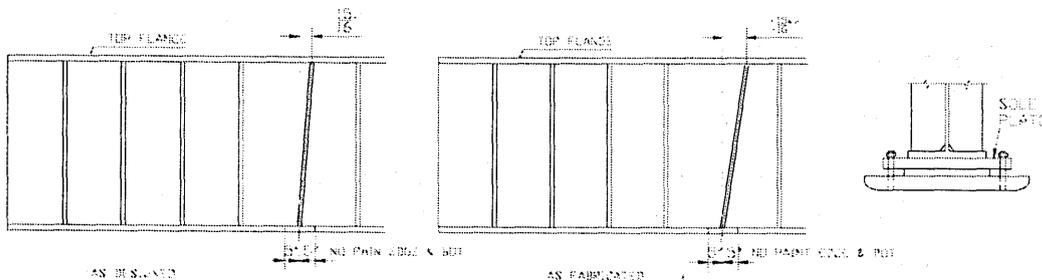
See comments under Stiffeners in General

When diaphragm connection plates are misplaced by a large amount (more than 6"), it is usually acceptable to leave them in place, fill the holes with bolts, and add a new stiffener at the proper location. When diaphragm connection plates are off by a small amount, recommend making no repairs. The diaphragm will be not quite 90 degree to the girder, but it should still fit with no problems.

If a diaphragm is to be attached to a misplaced bearing stiffener, a check should be made to insure that it will still fit when bolted to a misplaced bearing stiffener.

When holes are misplaced in a diaphragm connection plate or a bearing stiffener, it is usually easier to modify or re-make the diaphragm than it is to repair or replace the stiffener. This type of error can occur frequently, as it can be installed upside down, or a stiffener with the wrong piece mark can be installed. If a special diaphragm is made to fit specifically in this location, the shop drawing must be revised so that the erector is aware that there is a special diaphragm, and knows where it is to be located.

# Bearing Stiffener



**Main Member Type:** Rolled Beam, plate girder

**Attached Member /Detail Type:** Plate girder

**Error type:** Bearing stiffener misalignment

**Description of Error:** Bearing stiffeners welded in place out of plumb. Kick is 1 15/16" in lieu of 1 1/8".

**Approval to Repair by:** QA Inspector, Fabrication Unit Chief, Materials Unit

**Solution Recommended:** Since bottom location of stiffener above the sole plate is correct and out of plumbness was less than 5%, stiffener was left in place and a shim used to bolt cross frame to stiffener.

**Required Final Checks / Verification:** Check bearing stiffener alignment. 1) Bottom location is correct?

- a) Yes: Check plumbness. If out of plumb is less than 5%, it is OK. If out of plumb is more than 5%, weld additional stiffeners to create a shear panel (space new stiffeners between 6" and 12" on center. New stiffeners half the thickness of bearing stiffeners. Check cross-frame connection clearance.)
- b) No: If bottom location of stiffener is within middle 50% of sole plate, leave stiffener as is and check plumbness. If out of bottom location of stiffener is not within middle 50% of sole plate, add 2<sup>nd</sup> bearing stiffener. If bottom location of stiffener is off sole plate, start over.

**Was Repair Successful ?:** Yes.

**Other Possible Solutions:** Avoid removal unless absolutely needed so can avoid air arc gouging and grinding in the high stress bearing area.

If bottom location of stiffener is within middle 50% of sole plate, leave stiffener as is and check plumbness. If out of plumb more than 5%, weld additional stiffeners to create a shear panel (space new stiffeners between 6" and 12" on center. New stiffeners half the thickness of bearing stiffeners). Check cross-frame connection clearance.

If bottom location of stiffener is not within middle 50% of sole plate, add 2<sup>nd</sup> bearing stiffener.

# Overheating

**Main Member Type:** Rolled Beam (occasionally plate girder)

**Attached Member /Detail Type:** N/A

**Error type: Overheating:** Not Monitoring Temperature

**Description of Error:** Heating with oxy-fuel torch to camber, curve or straighten a member, but not monitoring the temperature with thermal crayons or electronic sensors. QA Inspector suspects material was overheated (over 1200 F/650 C for low alloy, 1100 F/ 600 C for Q & T) based on observation of bright red color during heating, local distortion/melting of base metal and mill scale, or temper colors on steel surface. Overheating may reduce ductility and toughness, initiate or propagate discontinuities, cause local distortion and high residual stresses, and adversely effect material properties of quenched and tempered steel.

**Approval to Repair by:** QA Inspector, Fabrication Unit Chief, Materials Unit

**Solution Recommended:** Overheating may cause irreversible effects, so "repair" may not be possible without material replacement. Physical properties of heated areas must be assessed to determine if material is still acceptable for incorporation in structure. Possible indicators include hardness checks (Brinell, Knoop, Vickers or Rockwell) which can be down in-situ, or yield, ductility and Charpy V-notch tests which require removing material for specimens. Metallographic analysis can determine if microstructure has change, but this is very sophisticated and site-specific for this situation. Tests should be conducted by a qualified testing agency at the fabricator's expense. If hardness testing provides adequate assurance, the material may then be accepted. Otherwise, either the material must be completely replaced or an adequate number of specimens extracted and tested to verify properties. If tests are acceptable, the fabricator must develop a method to replace the specimens.

**Required Final Checks / Verification:** If hardness testing provides adequate assurance, the material may then be accepted. Otherwise, either the material must be completely replaced or an adequate number of specimens extracted and tested to verify properties. If tests are acceptable, the fabricator must develop a method to replace the specimens.

**Was Repair Successful ?:** For cases to date involving Grade 36 & 50 250 & 345) steel, Hardness tests have satisfied ILDOT without additional destructive testing.

**Other Possible solutions:** Replace material: extensive NDE, including wet-particle MT, through thickness and surface wave UT, and hardness testing; stress relief of heated areas (difficult, and unwanted distortion possible); or adding reinforcing plates.

**Remarks:** For most mild steels (nominal yield  $\leq 50$  ksi / 345 mPa), heat not exceeding transition temperature (1600 F / 870 C) and cooling in air without quenching probably results in minimal adverse changes to properties. However, must have some verification.

# Nicks and Gouges

Main Member Type: Base Metal

Attached Member /Detail Type: Plate Girder

Error type: Nicks and Gouges

## Description of Error:

Gouges in cut base metal edges that are  $7/16''$  deep or less, where the surface should be flat.

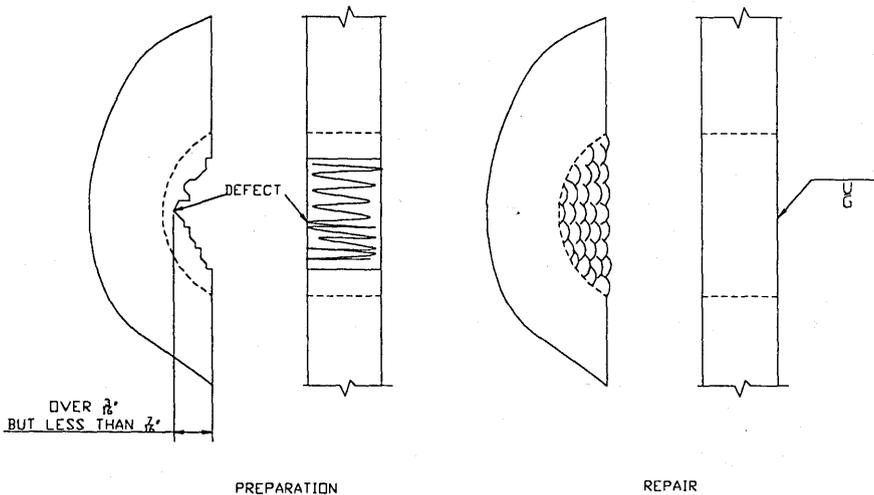
**Solution Recommended:** If the gouge meets the tolerance of greater than  $3/16''$  and less than  $7/16''$  from the cut edge, welding with single arc shield metal arc welding (S.M.A.W) is required, If gouge is less than  $3/16''$  deep from the cut edge see below for other solution.

## Required Final Checks / Verification:

If welding is required then magnetic particle testing (M.T.) and/or ultrasonic testing (U.T.) is required.

**Other Possible solutions:** If the gouge is less than  $3/16''$  deep from the cut edge, grinding to a slope of 1 inch to remove the gouge is acceptable. No welding required.

**Remarks:** Preparation is required for welding. (preparation of gouged area includes air-arc gouging or grinding to the bottom of the burn. Preheat is required. These are only if welding is involved)



# Surface Lamination

**Main Member Type:** Base Metal

**Attached Member /Detail Type:** Plate Girder

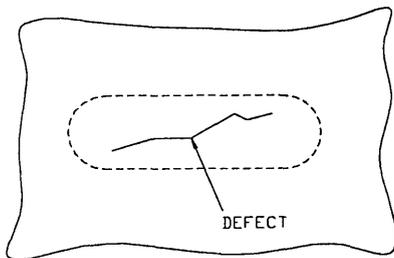
**Error type:** Surface Lamination

**Description of Error:** Laminar discontinuity in the base metal apparent on the surface of the base metal.

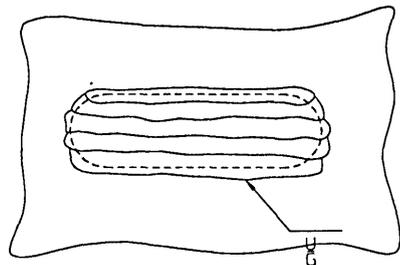
**Solution Recommended:** The recommended solutions are based on the description of the discontinuity:

- 1) for any discontinuity 1 inch in length or less, no plate repair is required, and need not be explored.
- 2) For any discontinuity over 1 inch in length and 1/8 inches maximum depth, no plate repair required, but the depth should be explored.
- 3) For any discontinuity over 1 inch in length with depth over 1/8 inches but not greater than 1/4 inches, removal is required, but not need weld.
- 4) For any discontinuity over 1 inch in length with depth over 1/4 inches but not grater than 1 inch, completely remove and weld are required. Aggregate length of the welding shall not exceed 20% of the length of the plate edge being repaired.
- 5) For any discontinuity over 1 inch in length with depth greater than 1 inch, see AWS 3.2.3.7.

**Required Final Checks / Verification:** If welding is required, use a single arc semi-automatic submerged arc weld(S.A.W.) after preparation. Magnetic particle inspection (M.T.) and/or ultrasonic inspection (U.T.) are require for the final checks.



PREPARATION



REPAIR