

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



October 17, 2008

MATERIALS LABORATORY ANNOTATED PHOTOGRAPHS

Report No. 82-032A

A. ACCIDENT

Place : Minneapolis, Minnesota
Date : August 1, 2007
Vehicle : I35W Highway Bridge
NTSB No. : HWY07MH024
Investigator : Mark Bagnard

B. ACCIDENT SUMMARY

About 6:05 p.m. (CDT), on Wednesday, August 1, 2007, the 35W Interstate Highway Bridge over the Mississippi River, in Minneapolis, Minnesota experienced a catastrophic failure in the main span of the deck truss portion of the 1,907-foot-long bridge. As a result, approximately 1,000 feet of the deck truss collapsed with about 456 feet of the main span falling into the river. An assessment of the gusset plates within the deck truss revealed that the connections at nodes U10, U10 prime, L11 and L11 prime were under-designed. The bridge was comprised of eight traffic lanes, with four lanes in each direction. At the time of the collapse, a roadway construction project was underway that resulted in the closure of two northbound and two southbound traffic lanes causing traffic queues on the bridge. A total of 111 vehicles were documented as being on the portion of the bridge that collapsed. Of these, 17 vehicles were recovered from the water. As a result of the bridge collapse, 13 people died and 145 people were injured.

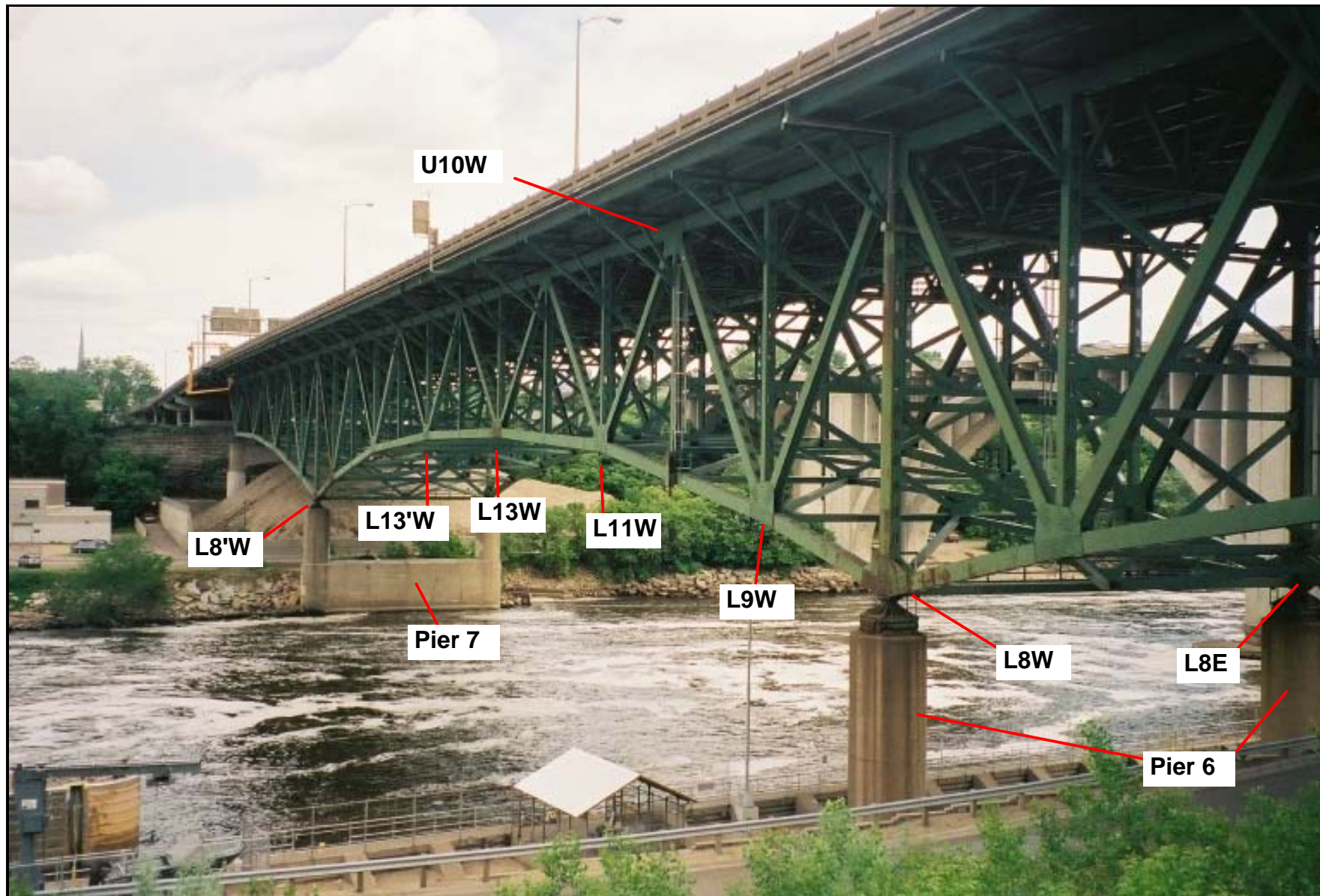
C. DISCUSSION

The photographs and captions contained in this document are intended to be used in conjunction with Materials Laboratory Sequencing Study, Report No. 08-032. The following is a list of the figures and a description of what is shown in each.

- Figure 1. Pre-collapse, deck truss portion.
- Figure 2. Overall view of the bridge after the collapse.
- Figure 3. Overall view of the collapsed deck truss portion.
- Figure 4. South fracture area and the south portion of the deck truss adjacent to the river, with nodes and pier 6 indicated.
- Figure 5. South fracture area and the south portion of the deck truss adjacent to the river, with main truss members indicated.
- Figure 6. Enlarged portion of figure 5, showing floor truss 9 and vertical U9/L9E.

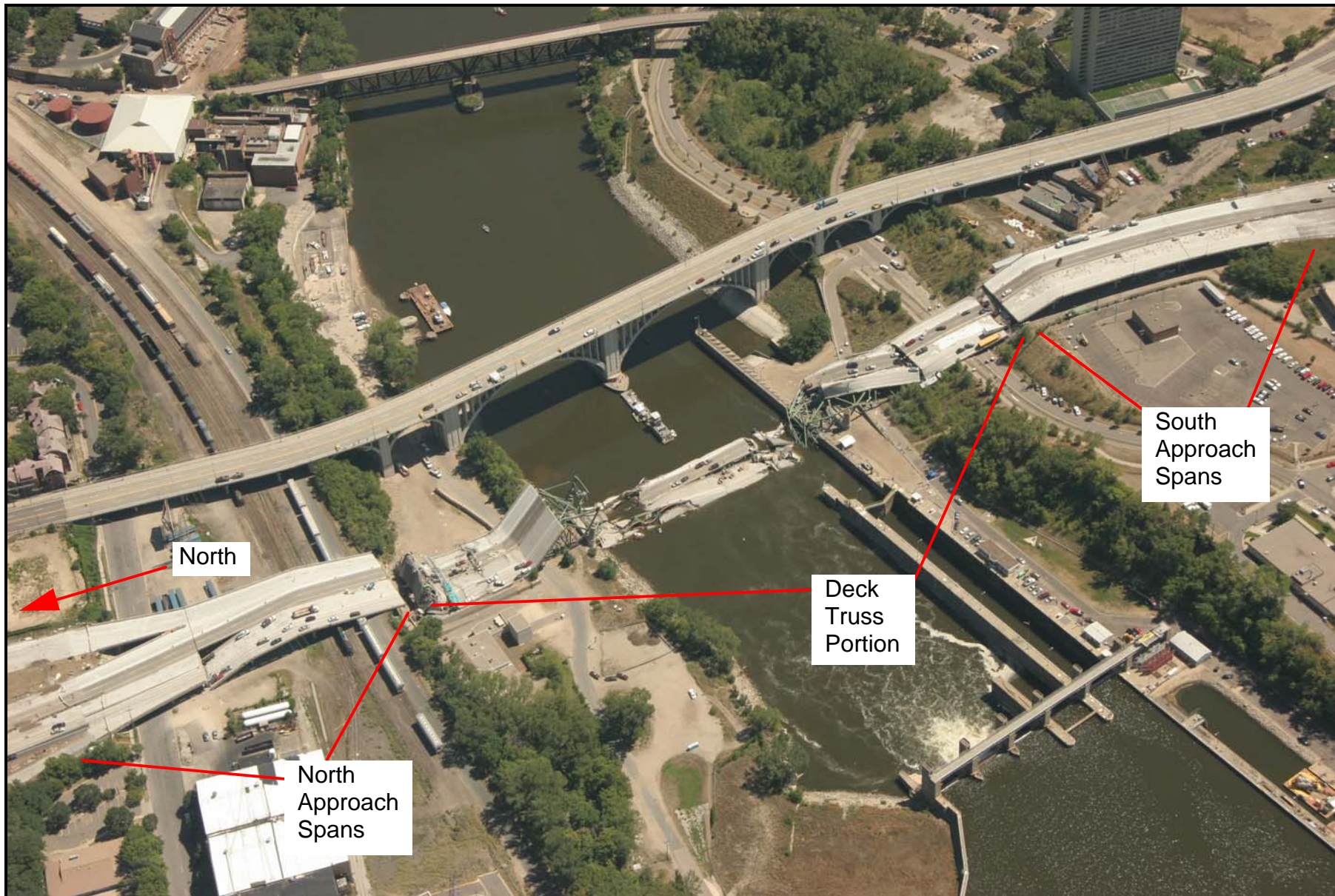
- Figure 7. Enlarged portion of figure 5, showing floor truss 10 and verticals U10/L10 East and West.
- Figure 8A. Drawings of the U10 East and West nodes showing the fracture locations of the west gusset plates.
- Figure 8B. Drawings of the U10 East and West nodes showing the fracture locations of the east gusset plates.
- Figure 9. U10W west gusset plate on diagonal L9U10W.
- Figure 10. U10E west gusset plate on diagonal L9U10E.
- Figure 11. U10W east gusset plate on diagonal L9U10W.
- Figure 12. U10E east gusset plate on diagonal L9U10E.
- Figure 13. Oblique view of U10W end of diagonal L9/U10W.
- Figure 14. Impact mark on node U10 West, upper cover plate of U10/U11W.
- Figure 15. Fractures through upper chord portion of U10 gusset plates
- Figure 16. West and central portion of FT 10 being removed from the river
- Figure 17. Compression damage to the portion of U10/L10 West above the lower chord of floor truss 10
- Figure 18. Node U10 East, showing impact mark on the upper end of the web of the vertical
- Figure 19. Lower chord L9/L10W fracture at node L9W
- Figure 20. Vertical member U9/L9 East showing the bent area below the floor truss lower chord
- Figure 21. Post collapse position of the deck above the south fracture area.
- Figure 22. Overall view of a large portion of the deck truss above and north of pier 7.
- Figure 23. Fractured and deformed west gusset plate on the U10'E end of diagonal L9'/U10' East.
- Figure 24. Deformation pattern associated with the fracture through the west gusset plate of node U10' East on upper chord member U9'/U10' East.
- Figure 25. West side of the main portion of node U10' West in the post-collapse position.
- Figure 26. Compression buckling, lower chord member L10'/L11'E
- Figure 27. Compression buckling, lower chord member L10'/L11'W
- Figure 28. Impact and scraping damage on the lower surface of lower chord member L7/L8W.
- Figure 29. Impact and scraping damage on the lower surface of lower chord member L7/L8E.
- Figure 30. Partial fracture in L7/L8E.
- Figure 31. Node L7 East end of L7/L8E.
- Figure 32. Overall view of the north portion of the deck truss after the collapse.
- Figure 33. Closer view of node L8'E on pier 7.
- Figure 34. Deck truss on pier 8.
- Figure 35. Fracture in the upper chord of FT 10 near node U10 East.

James F. Wildey II
Supervisory Metallurgist



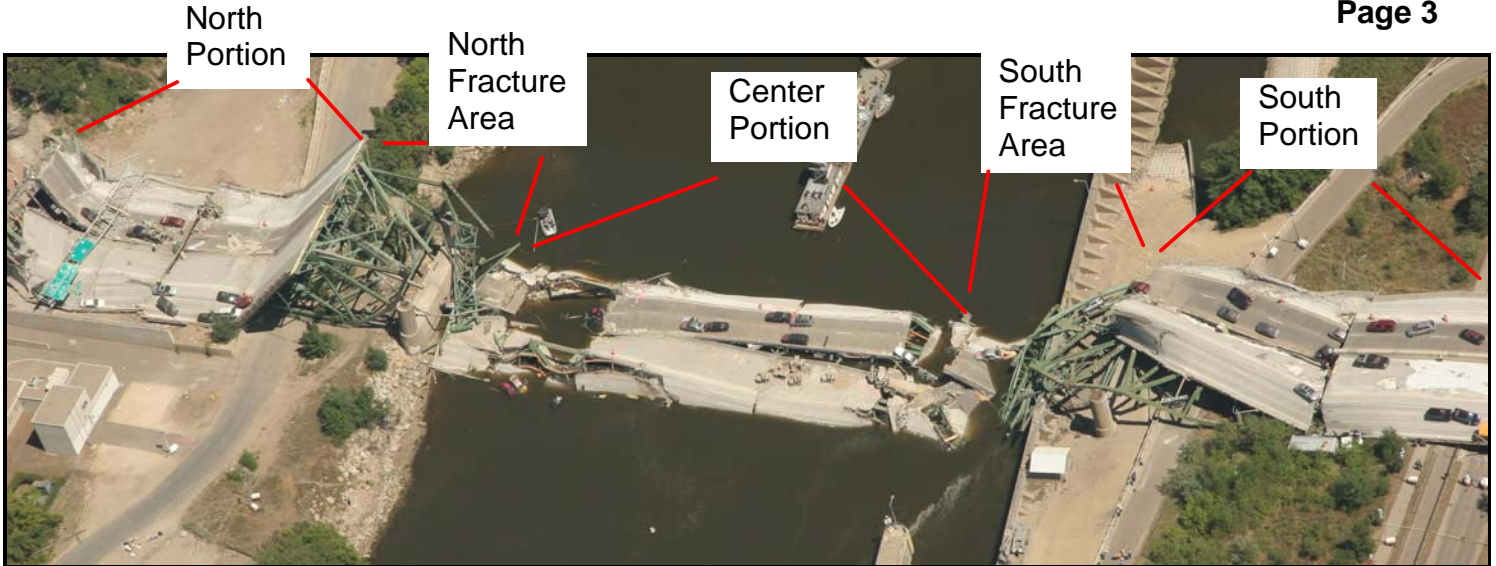
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Figure 1. Overall view of the center span of the deck truss portion of the bridge before the collapse. View is looking north and slightly east, and key nodes have been labeled, as described in the Structural Investigation Group Chairman Factual Report.



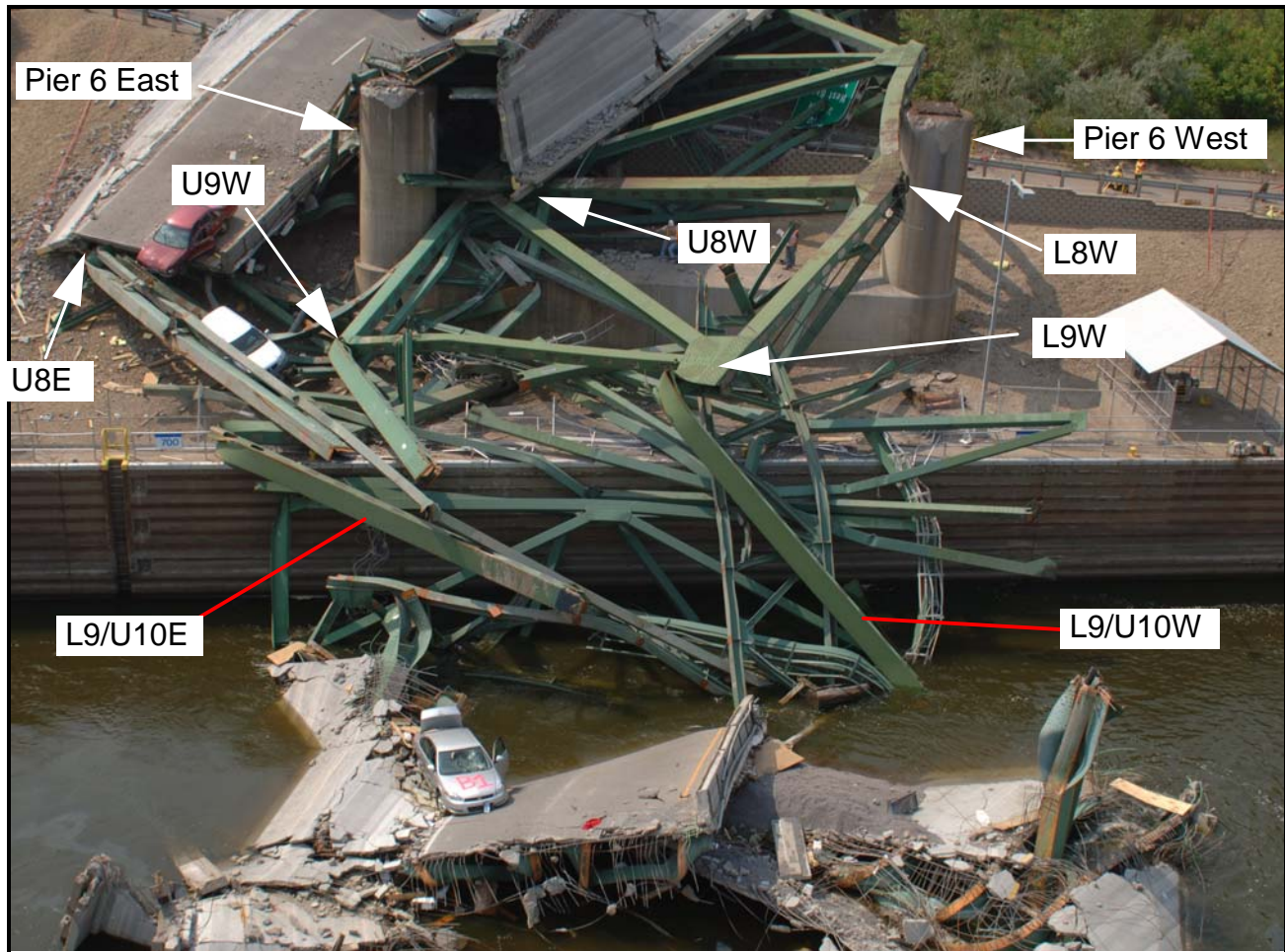
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Figure 2. Overall view of the bridge after the collapse. Direction of viewing is east and slightly south.



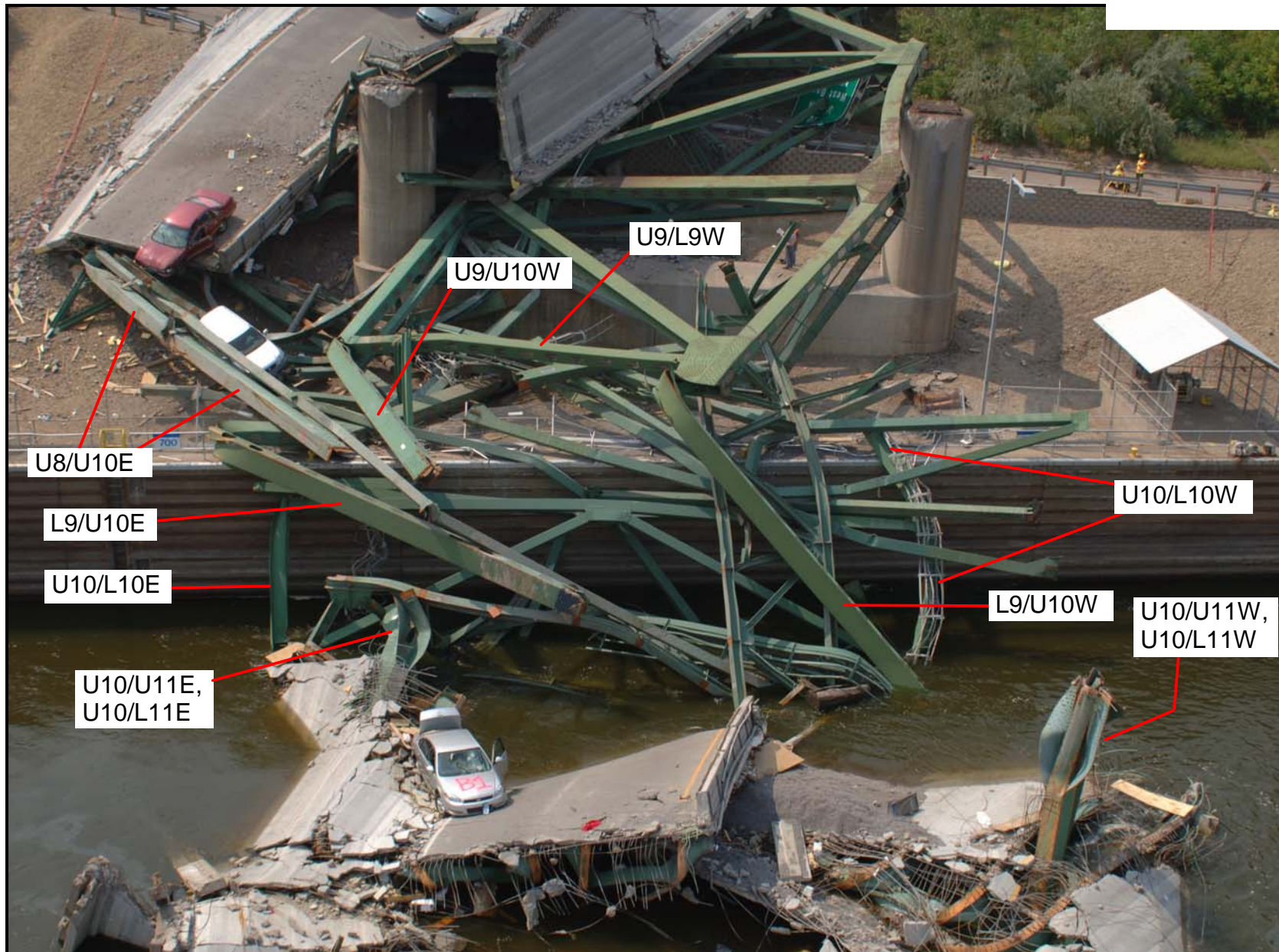
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Figure 3. Overall view of the collapsed deck truss portion of the bridge, with the South and North Fracture Areas and the south, center, and north portions indicated. View is looking east.



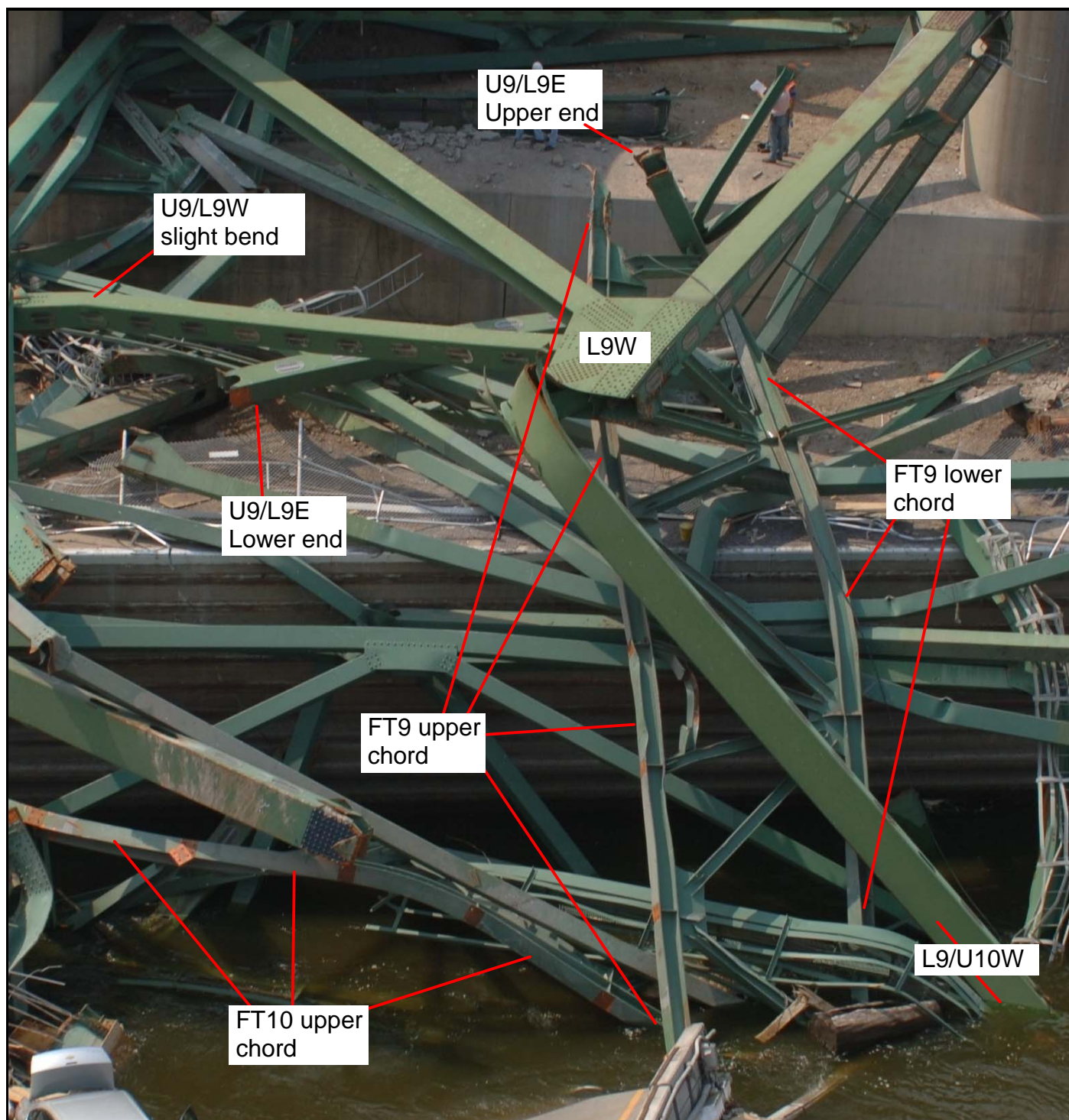
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Figure 4. View of the South Fracture Area and the south portion of the deck truss adjacent to the river, viewed looking south.



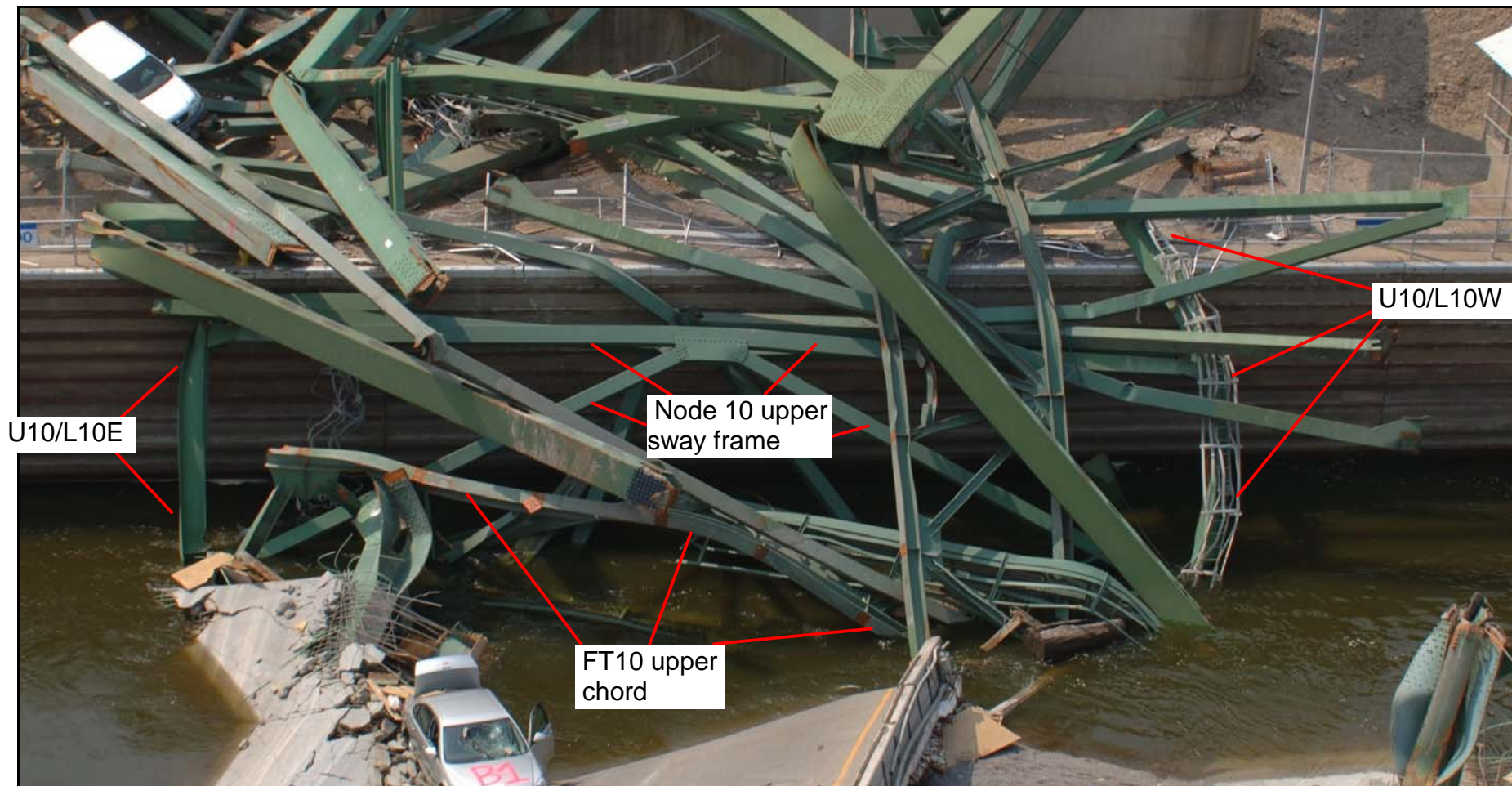
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Figure 5. (Repeated photograph from figure 4.) View of the South Fracture Area and the south portion of the deck truss adjacent to the river, viewed looking south. Main truss members that separated from their nodes in the South Fracture Area as well as other main truss members are identified.



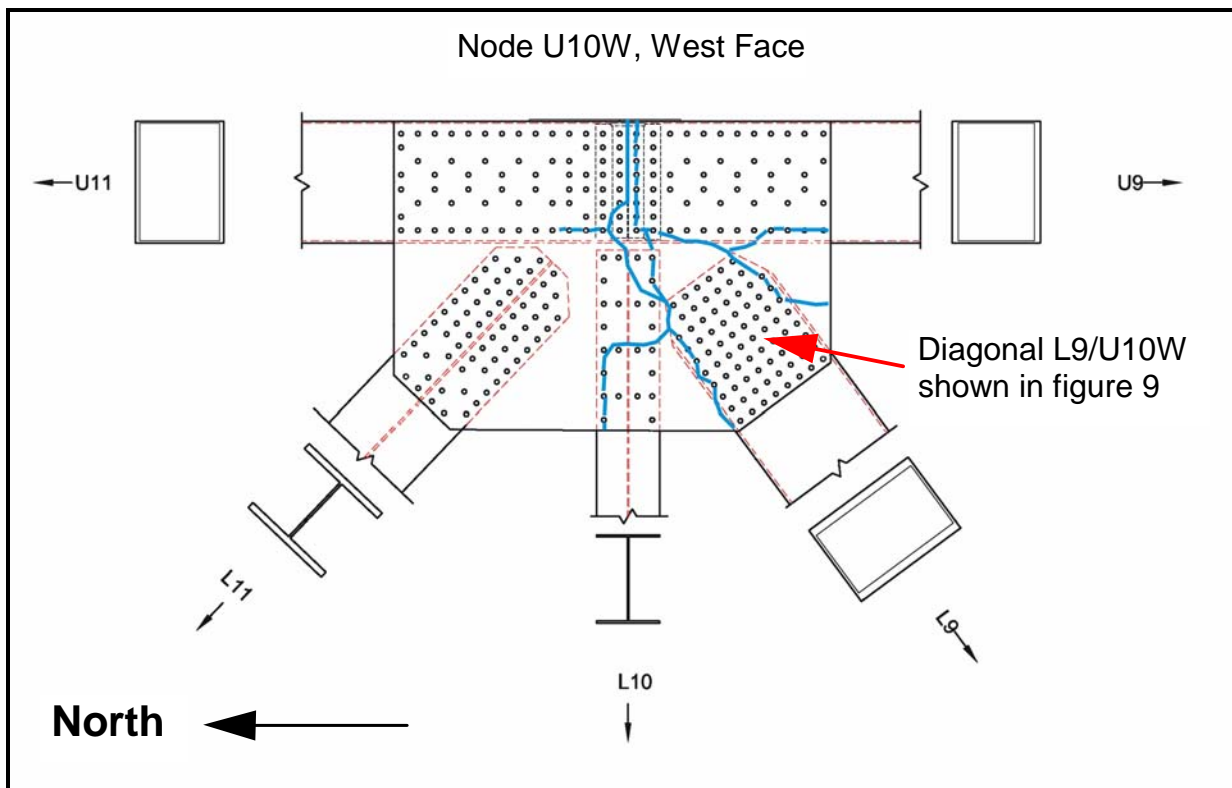
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Figure 6. Enlarged portion of the photograph in figure 5. This area primarily shows the location of floor truss 9 (FT9) and vertical U9/L9E, which remained attached to the floor truss.

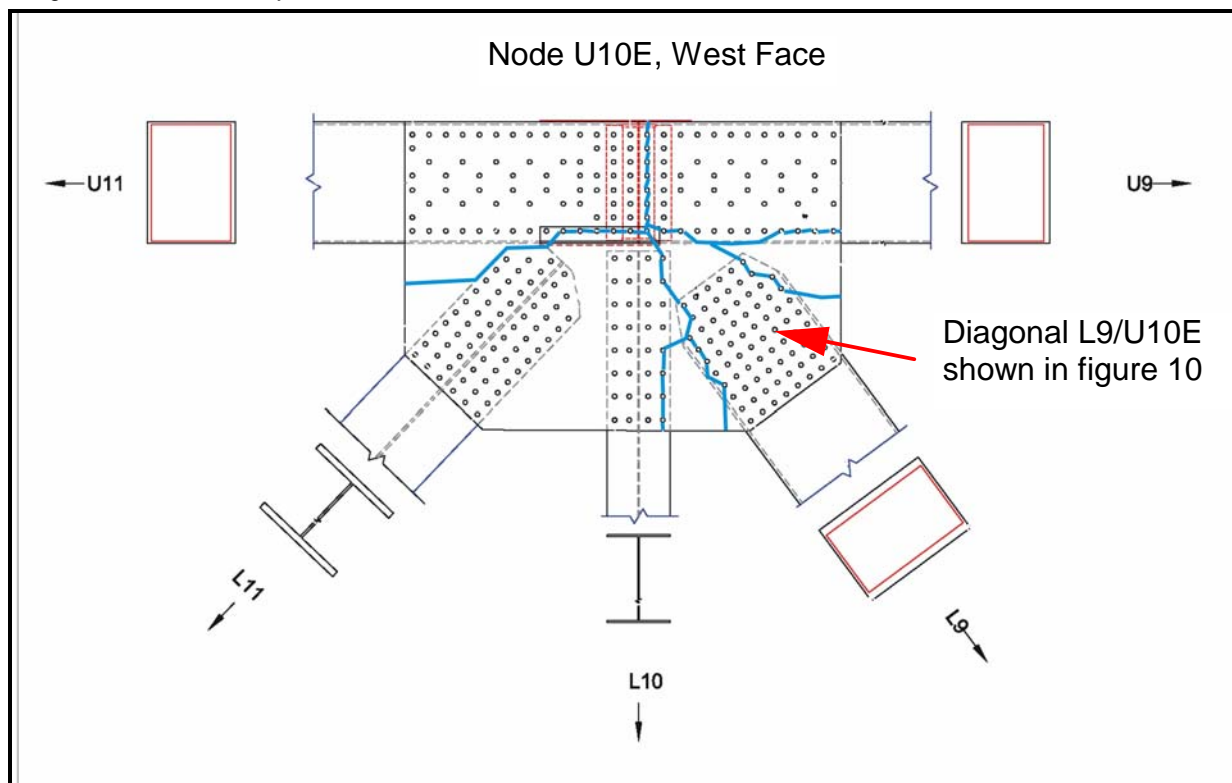


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Figure 7. Enlarged portion of the photograph in figure 5. This area primarily shows the location of floor truss 10 (FT10) and verticals U10/L10 East and West, which remained attached to the lower chord of the floor truss.

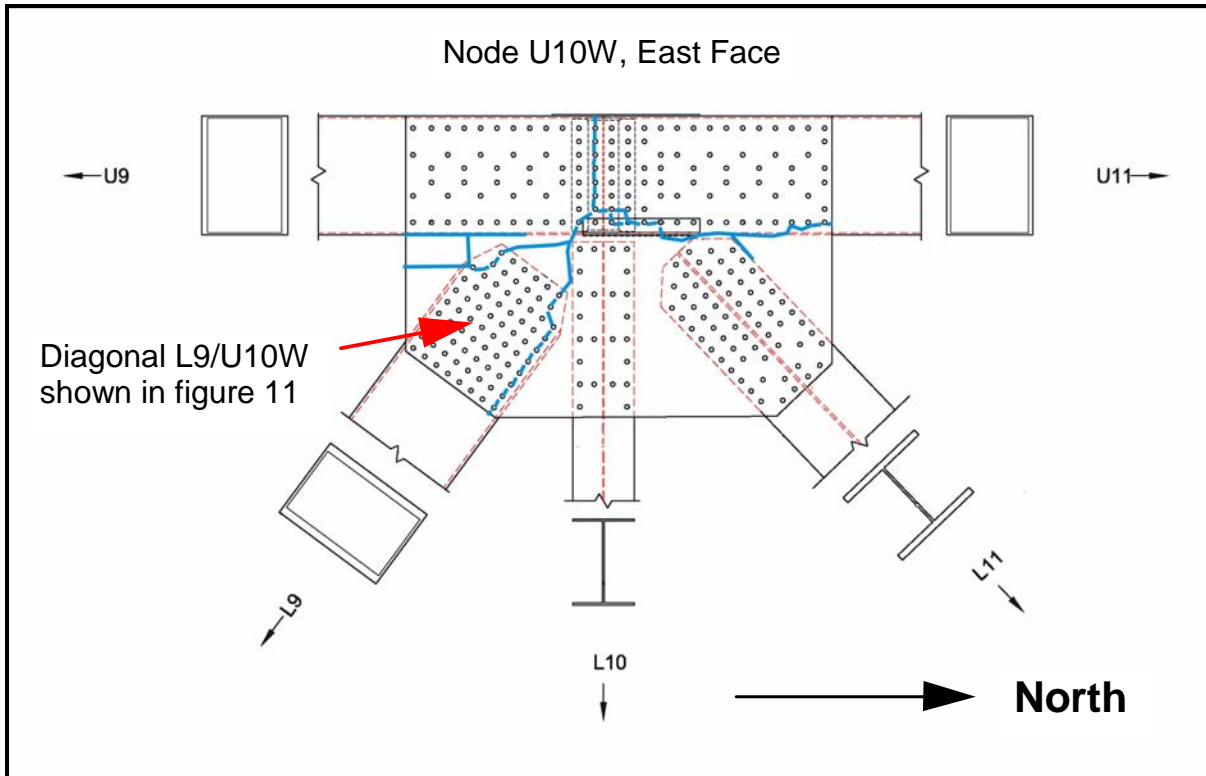


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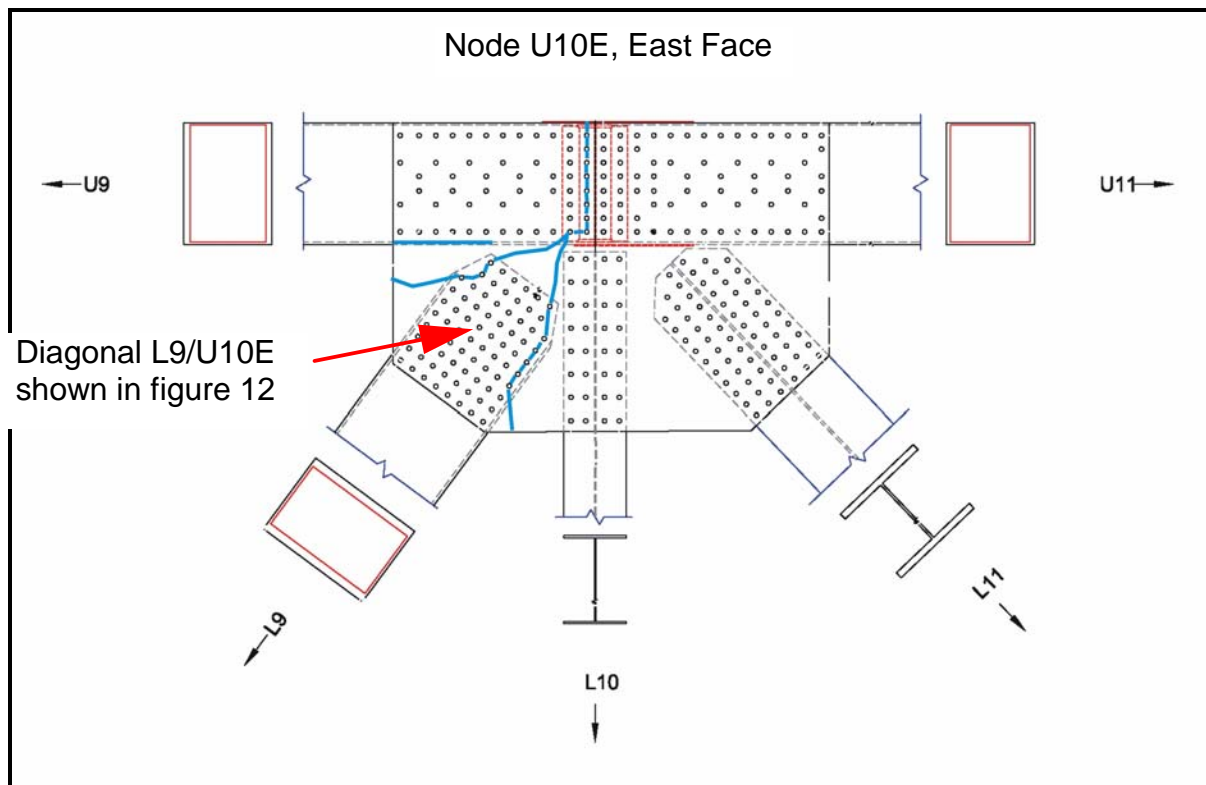


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Figure 8A. Drawings of the U10 East and West nodes showing the fracture locations (blue lines) of the west gusset plates.

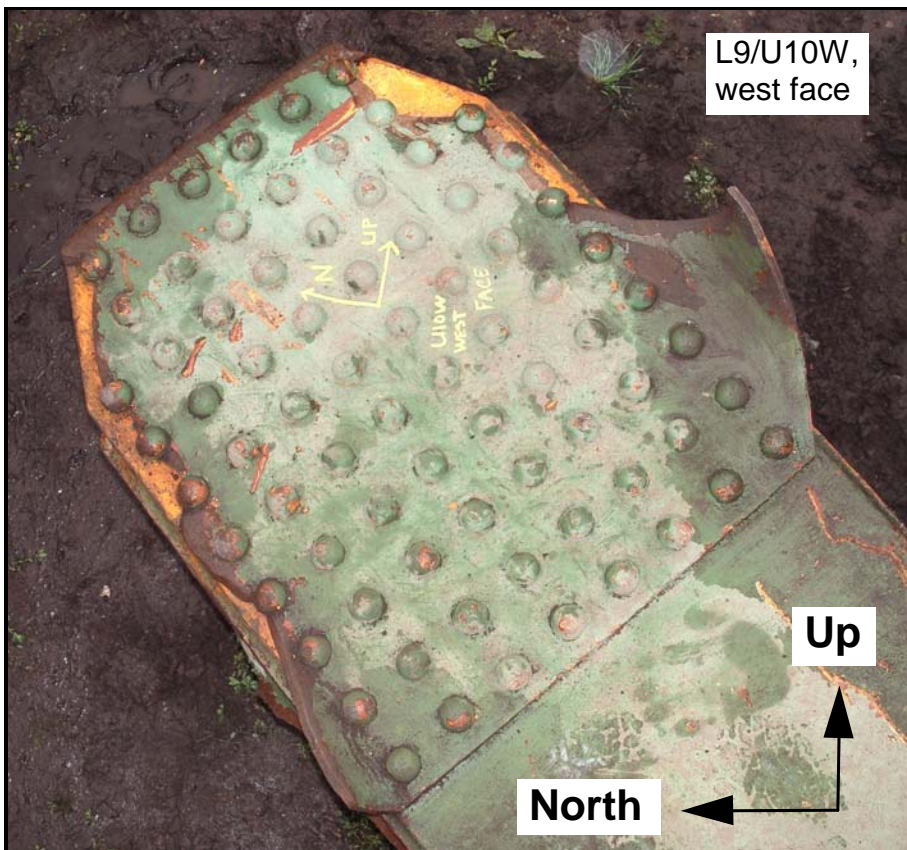


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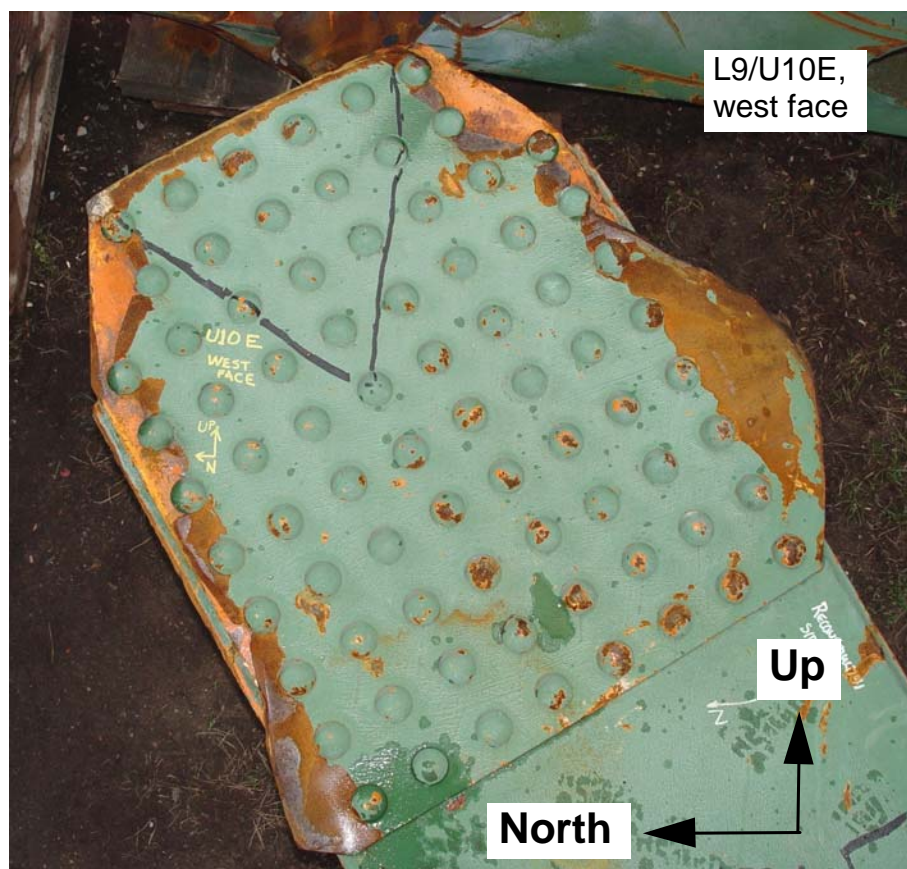
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Figure 8B. Drawings of the U10 East and West nodes showing the fracture locations (blue lines) of the east gusset plates.



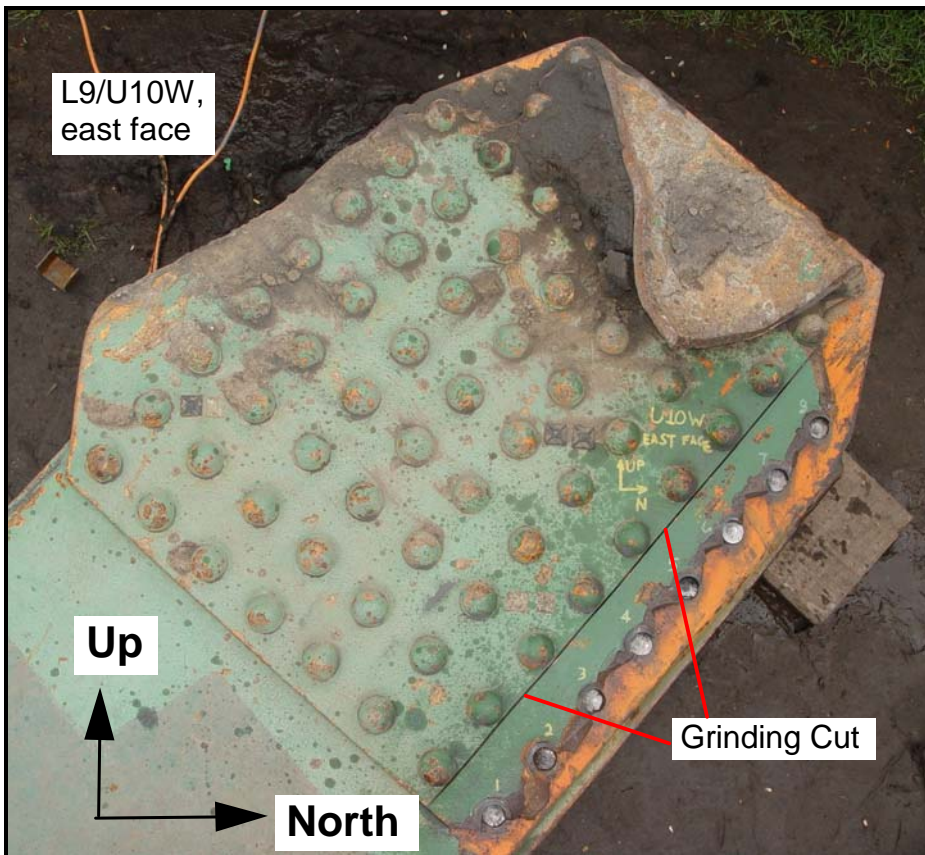
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Figure 9. Photograph of the portion of the U10W west gusset plate attached to the U10W end of diagonal L9/U10W. The V-shaped tip portion of the plate above the end of the diagonal has been folded under the west side plate of the diagonal. Compare to figure 8A. Also see figure 13.



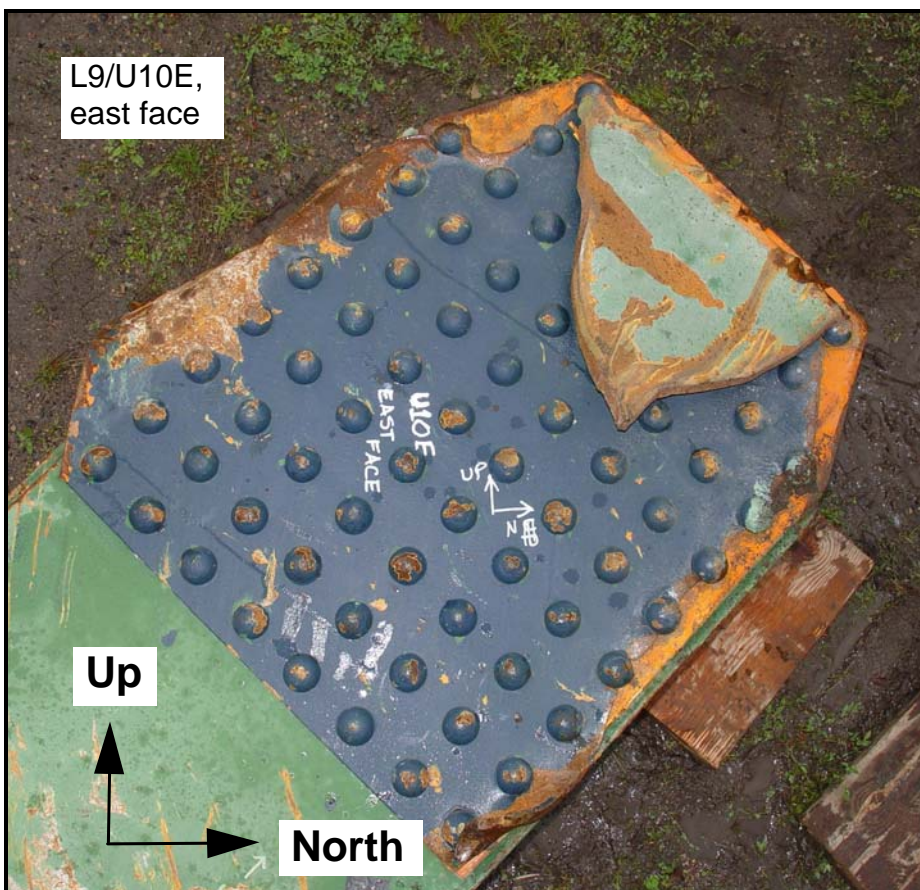
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Figure 10. Photograph of the portion of the U10E west gusset plate attached to the U10E end of diagonal L9/U10E. The V-shaped tip portion of the plate above the end of the diagonal has been folded under the west side plate of the diagonal. The black lines drawn on the visible face show the location of the V-shaped tip portion on the other side of the west side plate. Compare to figure 8A.



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Figure 11. Photograph of the portion of the U10W east gusset plate attached to the U10W end of diagonal L9/U10W. The V-shaped tip portion of the plate above the end of the diagonal has been folded back over the east side plate of the diagonal. Compare to figure 8B. The grinding cut adjacent to the edge of the diagonal was made in preparation for removal of a fractured portion of the gusset plate. Also see figure 13.



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Figure 12. Photograph of the portion of the U10E east gusset plate attached to the U10E end of diagonal L9/U10E. The V-shaped tip portion of the plate above the end of the diagonal has been folded back over the east side plate of the diagonal. Compare to figure 8B.

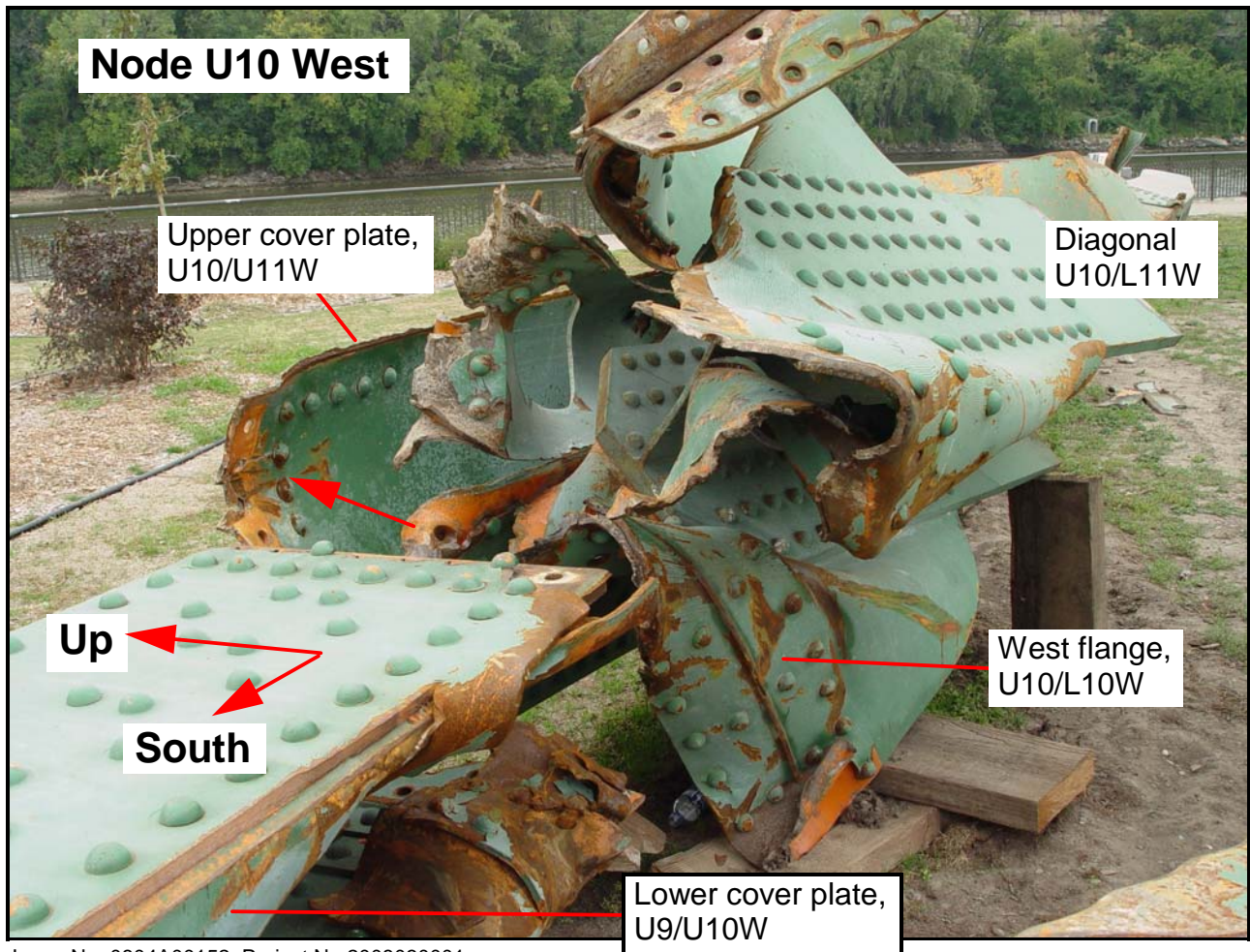


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Figure 13. Photograph of the upper (U10W) end of diagonal L9/U10W showing the V-shaped tips of the gusset plates folded to the east. Photograph taken after removal of a piece of the east gusset plate for laboratory examination. The north, south, and up directions marked on the west gusset plate are oriented for the folded piece of the plate.



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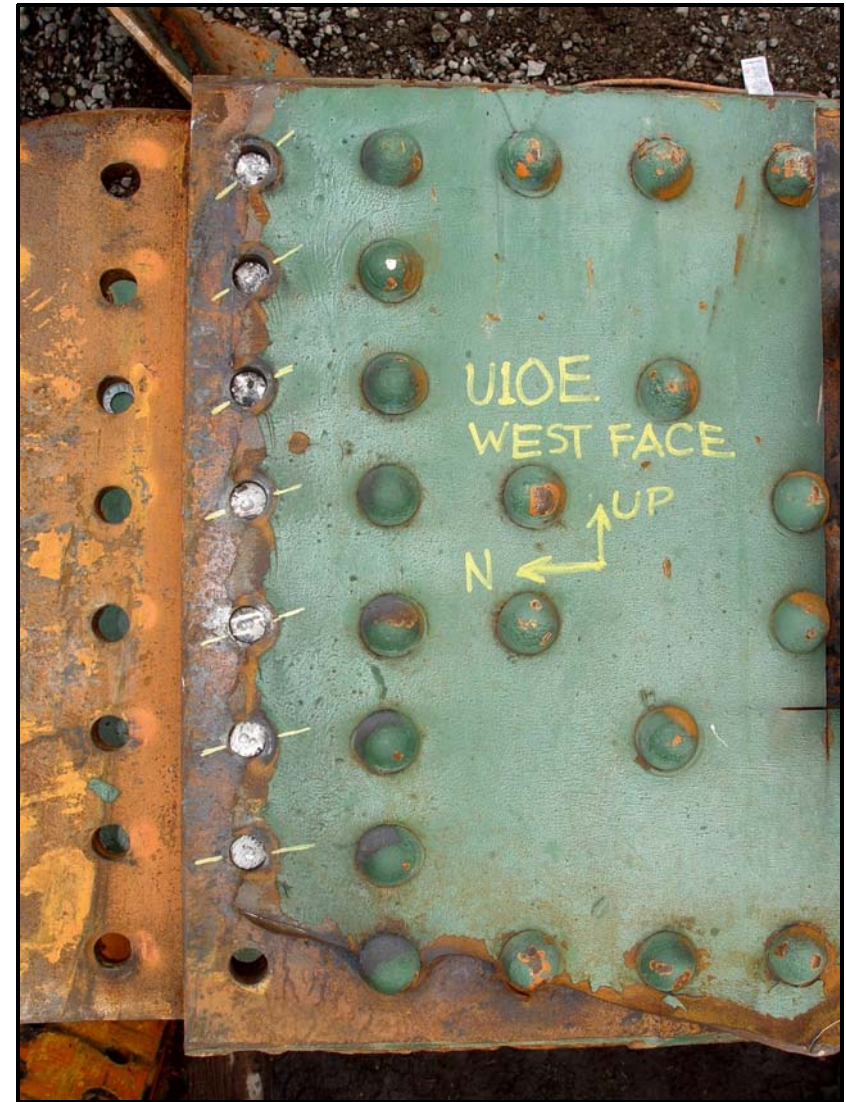


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Figure 14. Lower photograph shows an overall view of the pieces from node U10 West, with an arrow indicating an impact mark visible on the lower surface of the upper cover plate of U10/U11W. The deformed west flange of vertical U10/L10W is also indicated. Upper photograph shows a closer view of the impact mark.



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Figure 15. View of the deformation pattern associated with the node U10 gusset plate fractures at the upper chord. The left photograph shows the east gusset plate of node U10W, and the right photograph shows the west gusset plate of node U10E (after grinding off the heads of the rivets adjacent to the fracture). Markings that indicate the tensile loading direction have been added through the rivet holes adjacent to the fracture.

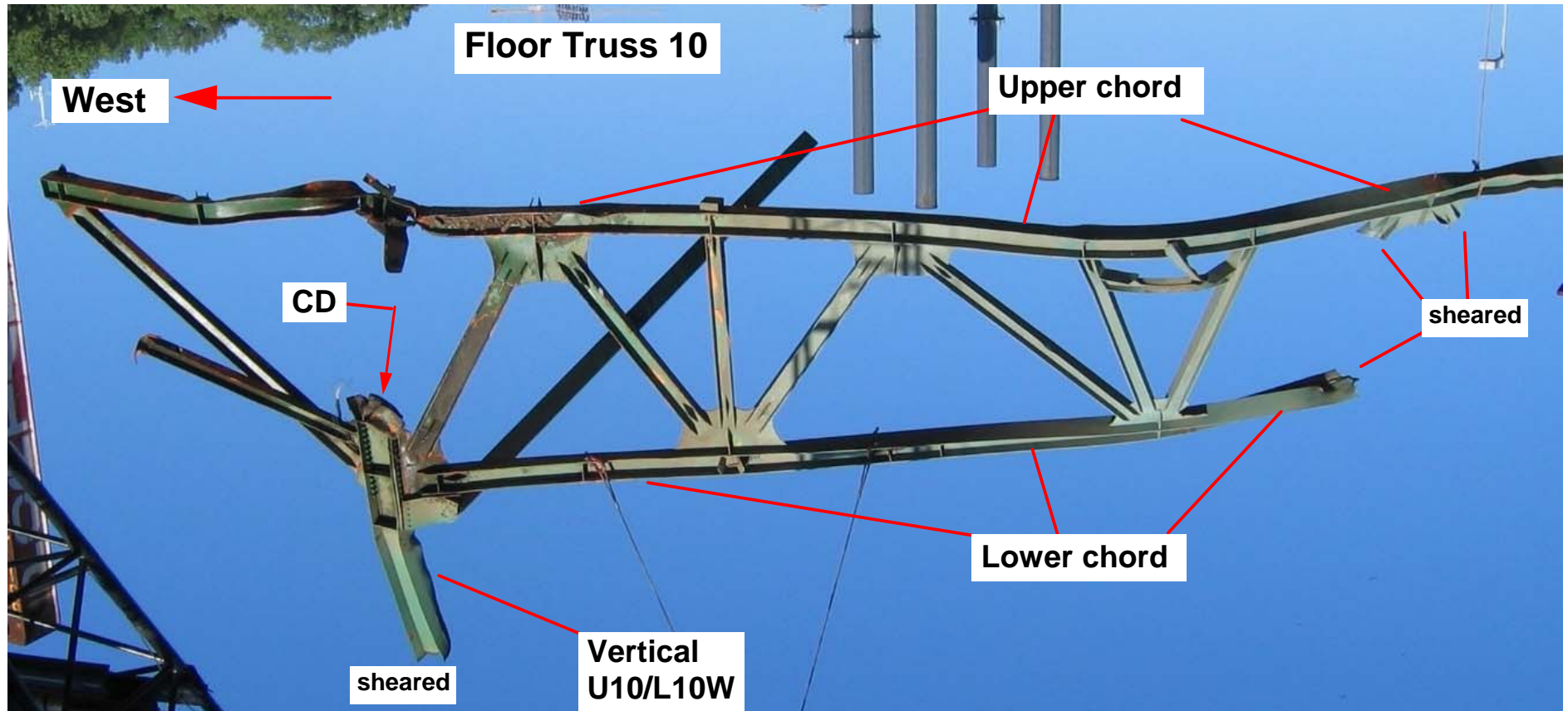
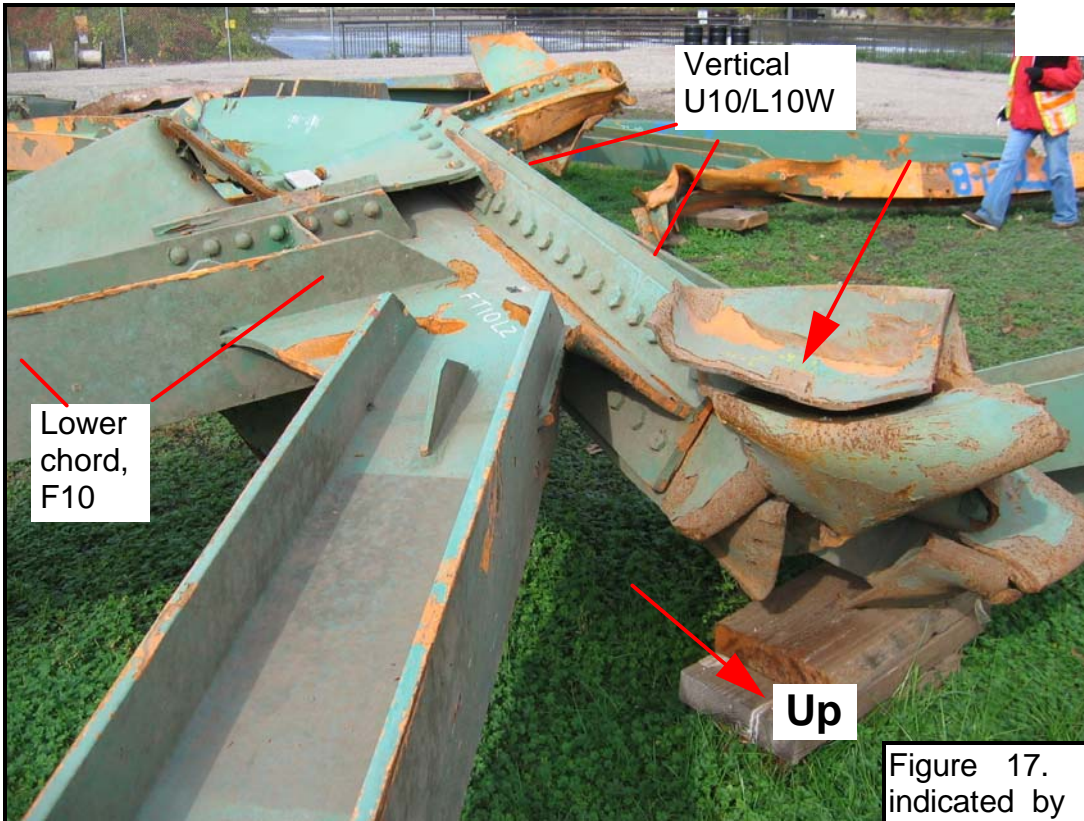
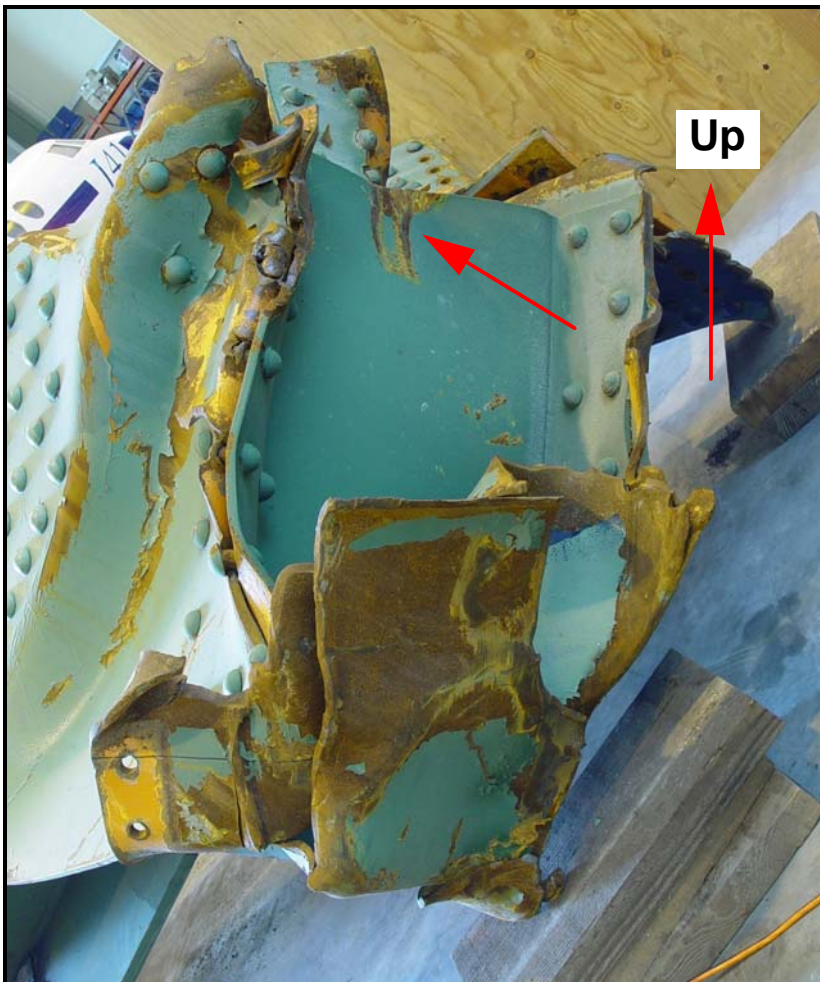


Figure 16. West and central portion of floor truss 10 as it was being removed from the river. The photograph has been turned upside down from the way it was taken to show the floor truss in its normal orientation, viewed looking north. Arrow "CD" indicates severe compression damage to the portion of vertical U10/L10 West above the lower chord of the floor truss. Ends sheared during the recovery process are also indicated.



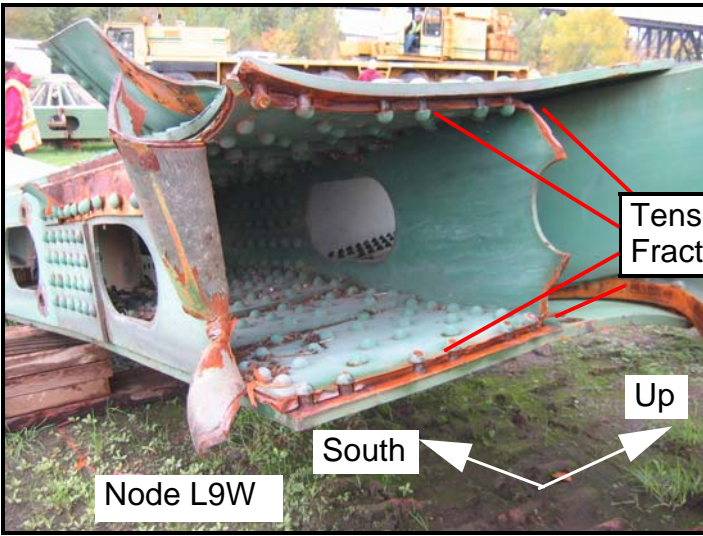
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Figure 17. View of the area indicated by arrow "CD" in figure 16, showing the compression damage to the portion of U10/L10 West above the lower chord of floor truss 10. The arrow indicates the impact mark where diagonal L9/U10W contacted the upper end of the web of the vertical.

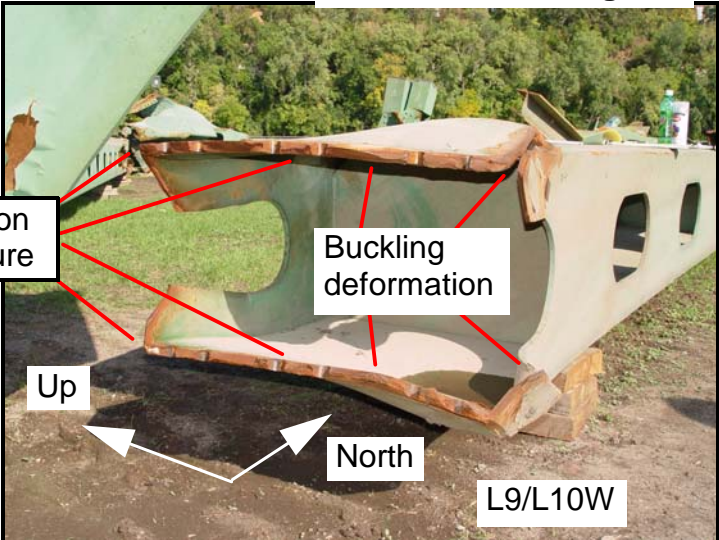


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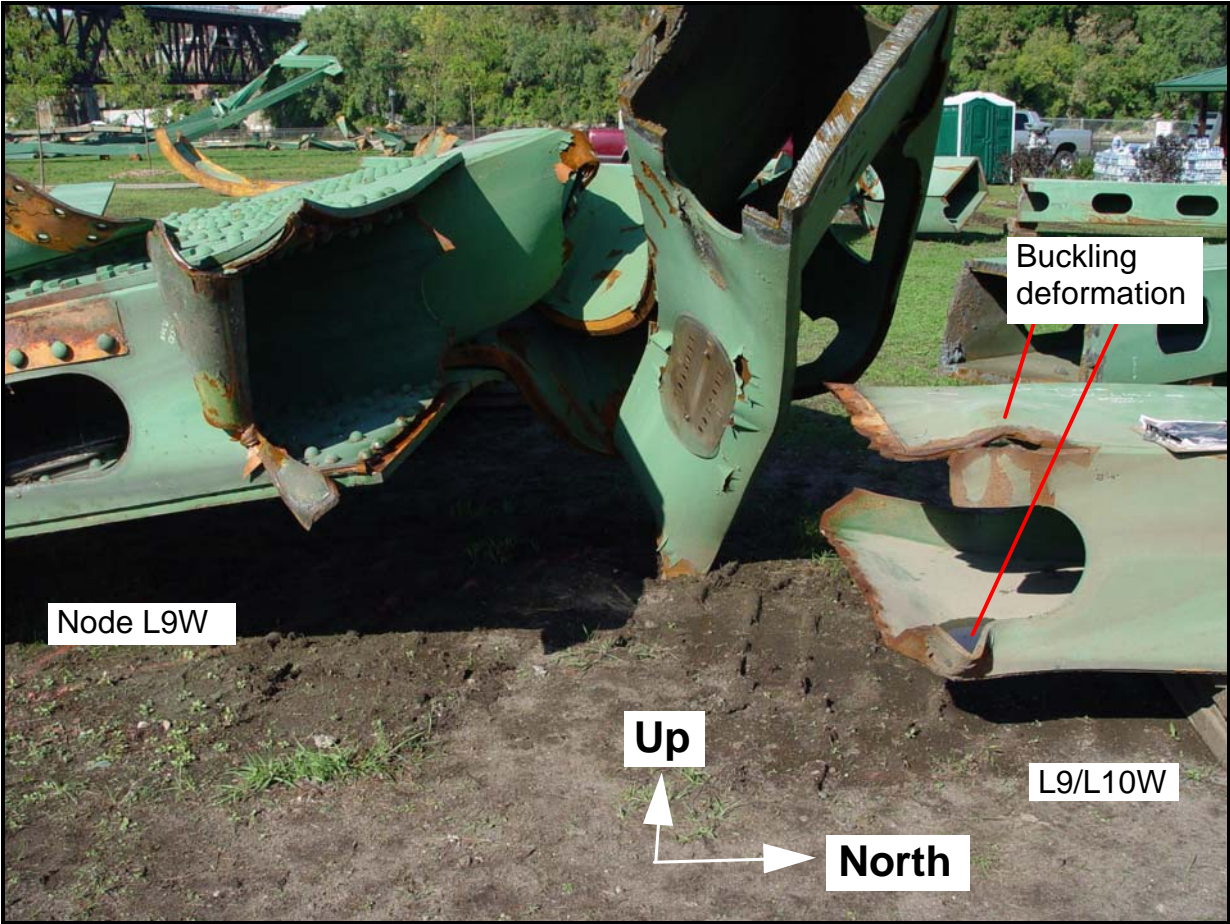
Figure 18. View of the main portion of node U10 East, showing the folding and compression damage on the web of the vertical. The arrow indicates the impact mark where diagonal L9/U10 East contacted the upper end of the web of the vertical.



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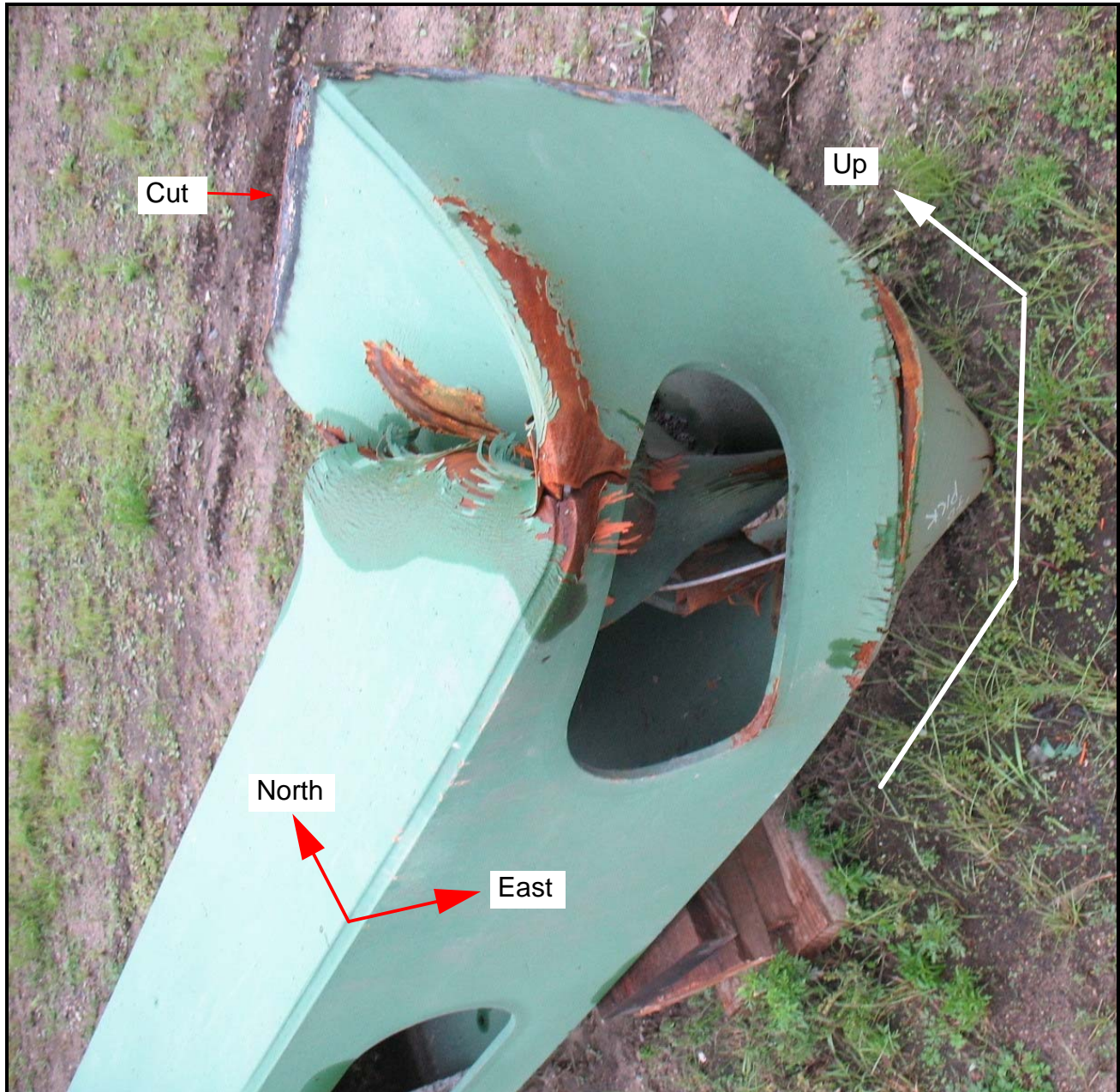


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Figure 19. Node L9W and lower chord member L9/L10W showing the fracture area in the lower chord. Lower photograph looking mainly up, upper right photograph looking mainly north, and upper left photograph looking mainly south. Tension fracture areas and compression buckling deformation areas are noted.



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Figure 20. Vertical member U9/L9 East showing the bent area below the floor truss lower chord. The member was cut at the indicated location during the removal process.

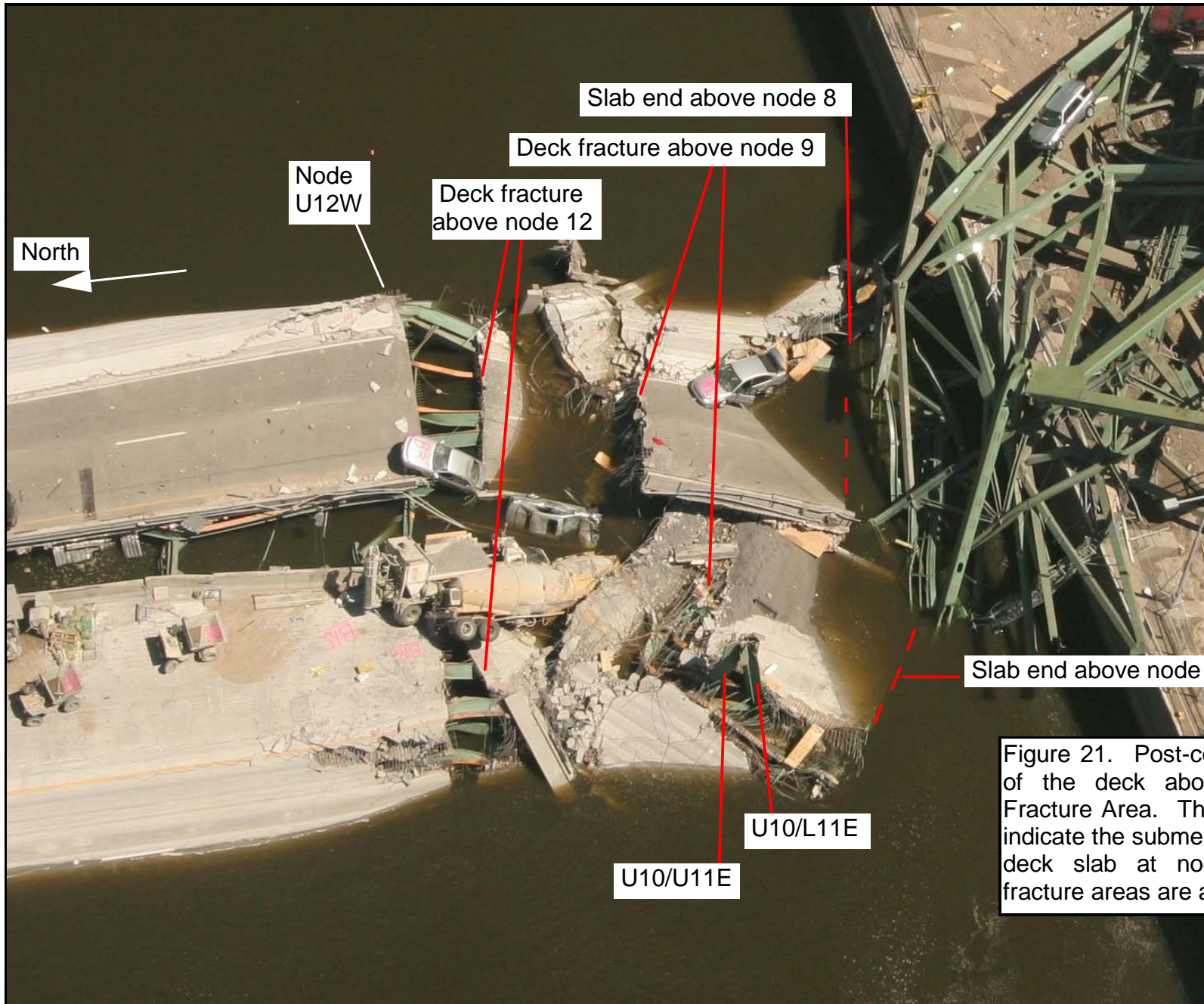
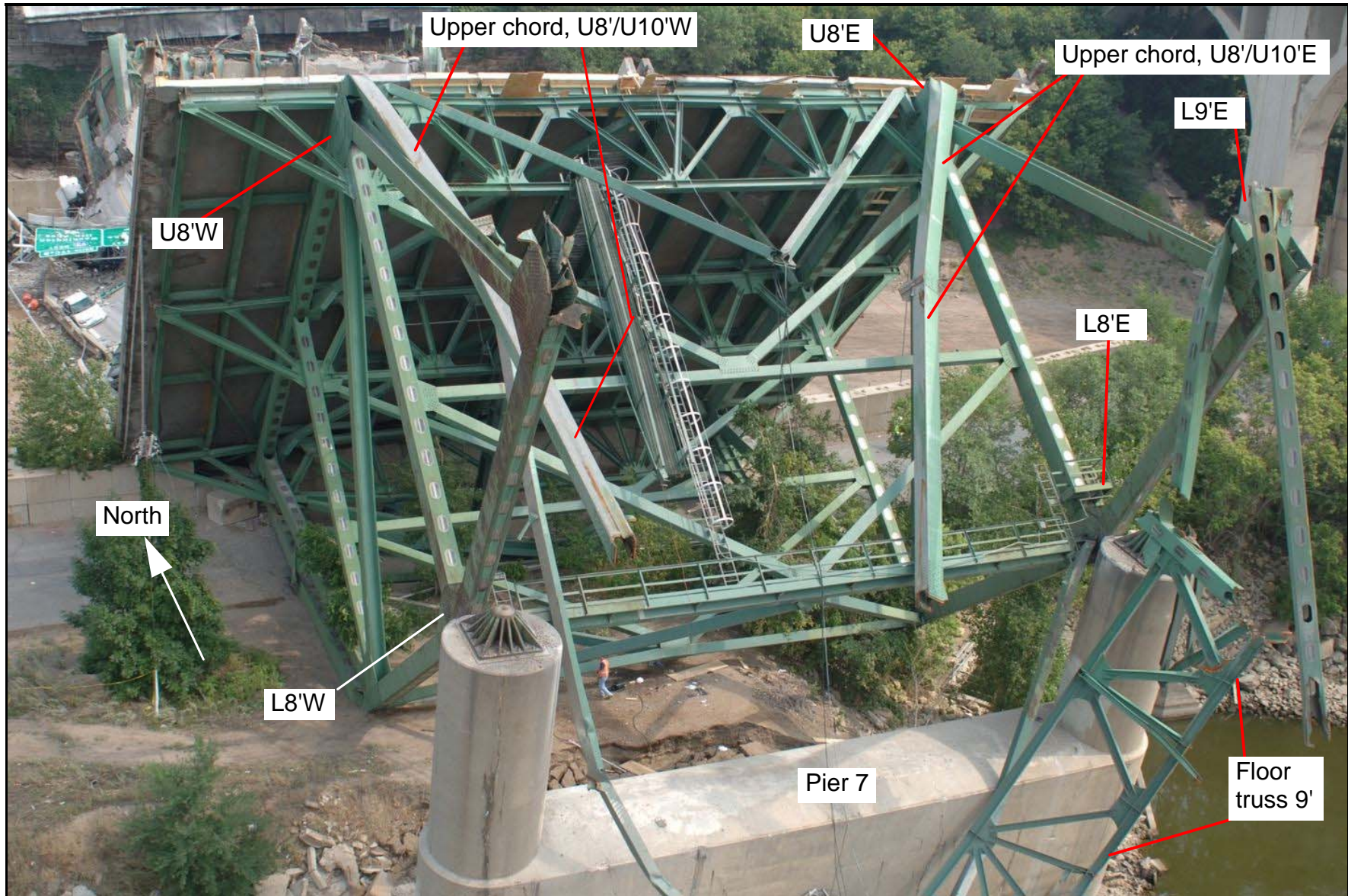


Figure 21. Post-collapse position of the deck above the South Fracture Area. The dashed lines indicate the submerged end of the deck slab at node 8. Deck fracture areas are also indicated.



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Figure 22. Overall view of a large portion of the deck truss above and north of pier 7 that rotated to the north as a rigid body. View is looking north and slightly east and shows most of the fractured members in the North Fracture Area.



Figure 24. View of the deformation pattern associated with the fracture in the west gusset plate at node U10' East in the area of the upper chord (after grinding off the heads of the rivets adjacent to the fracture). Markings that indicate the tensile loading direction have been added through the rivet holes adjacent to the fracture. Compare to the left photograph in figure 15.

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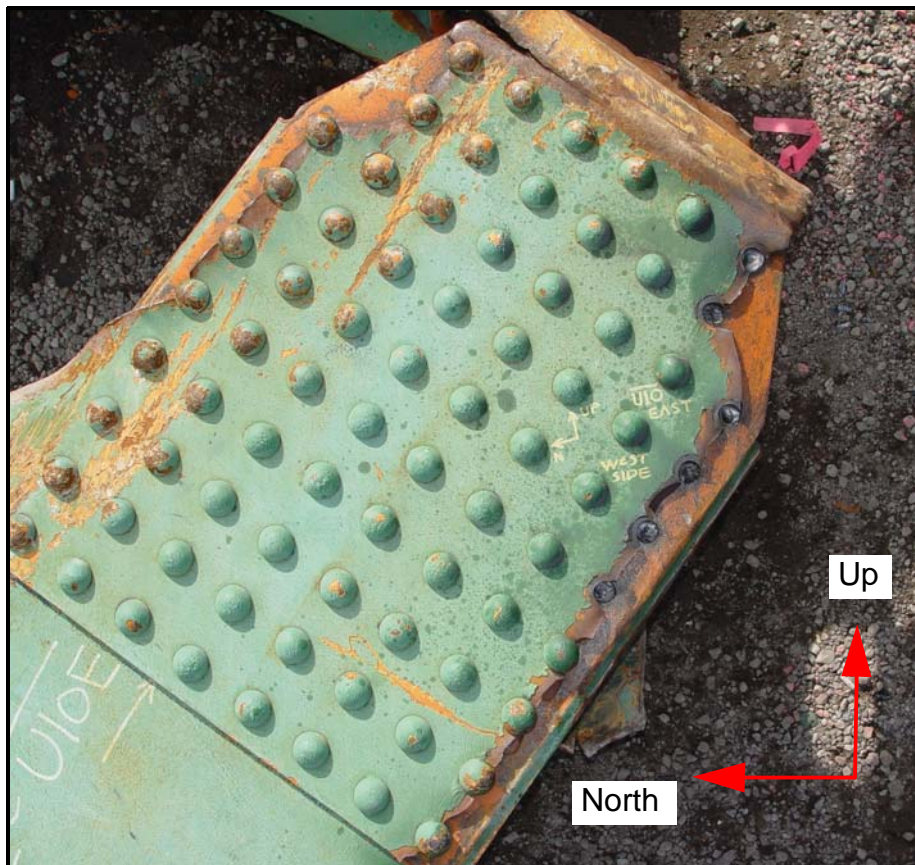
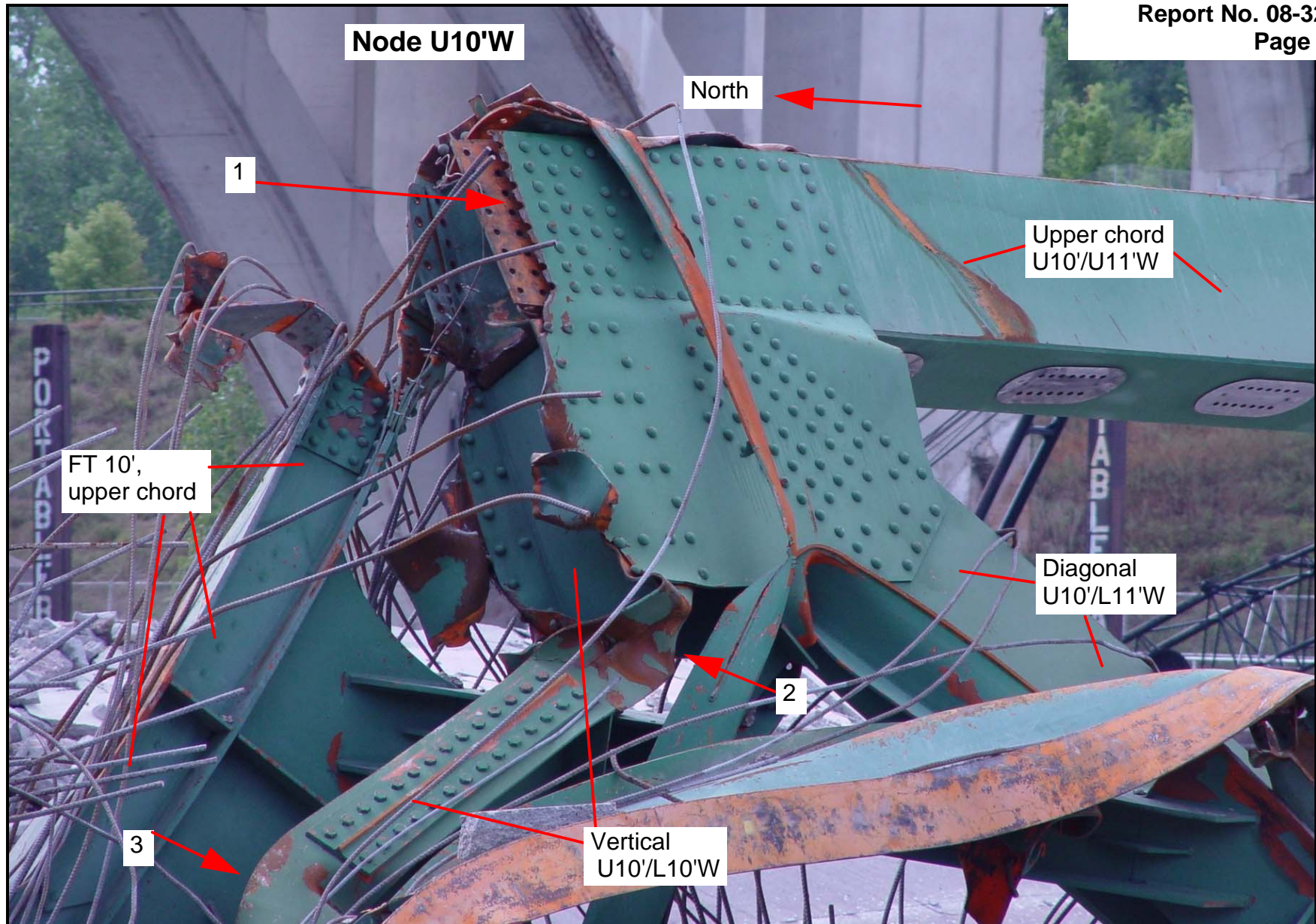


Figure 23. Fractured and deformed west gusset plate on node U10' East.

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Figure 25. Overall view of the west side of main portion of node U10' West in the post-collapse position. Arrow "1" indicates the fracture in the gusset plate through the upper chord. Arrows "2" and "3" indicate bending/buckling damage in vertical U10'/L10' West.



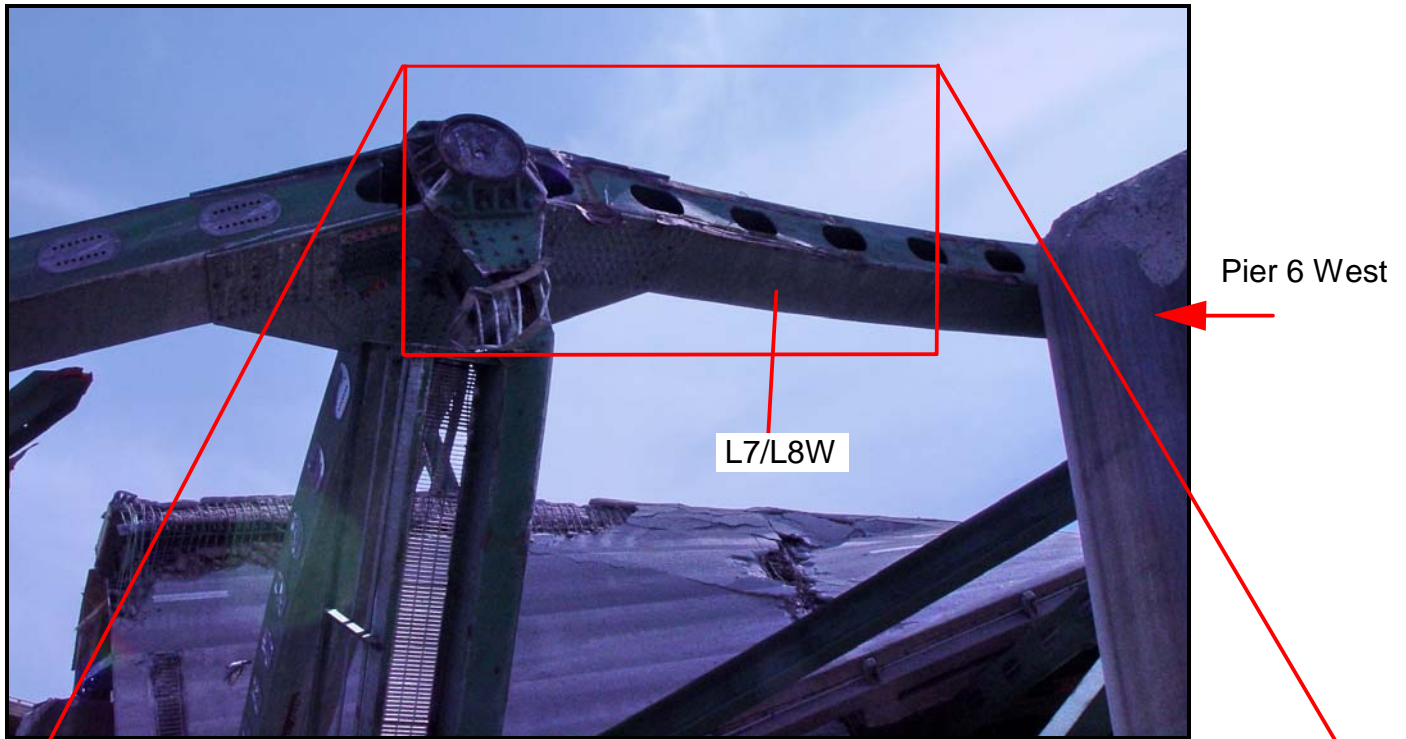
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Figure 26. View of lower chord member L10'/L11'E adjacent to node L11' East, showing the compression buckling deformation in the area indicated by the arrows. Direction of view is mainly looking up.

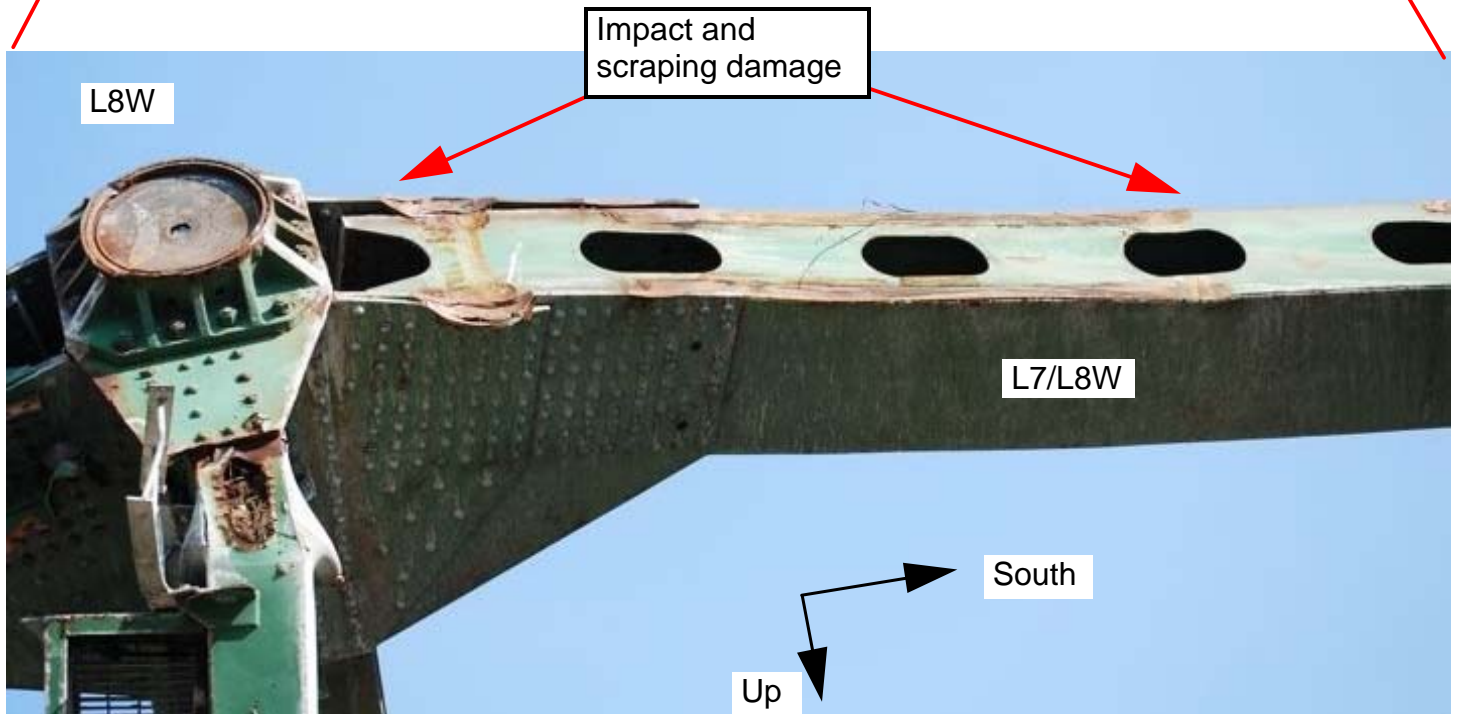


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Figure 27. View of lower chord member L10'/L11'W adjacent to node L11' West, showing the compression buckling deformation in the area indicated by the arrows. Direction of view is mainly looking up.



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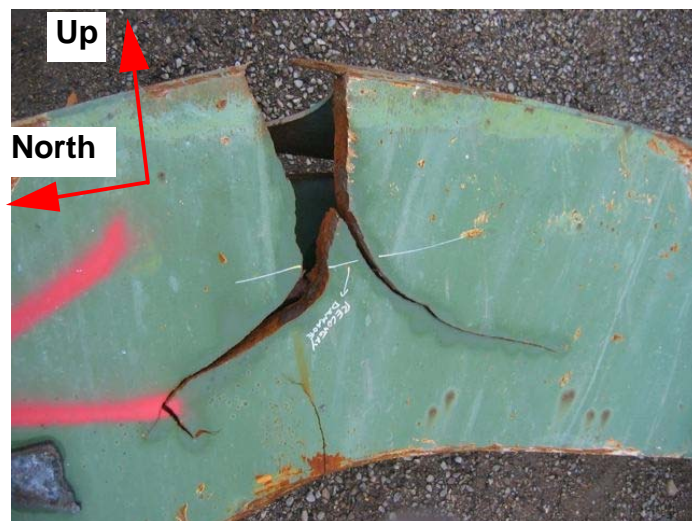
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Figure 28. View of the lower surface of node L8 West and lower chord member L7/L8W before removal from the accident site, showing the impact and scraping damage on the lower chord.



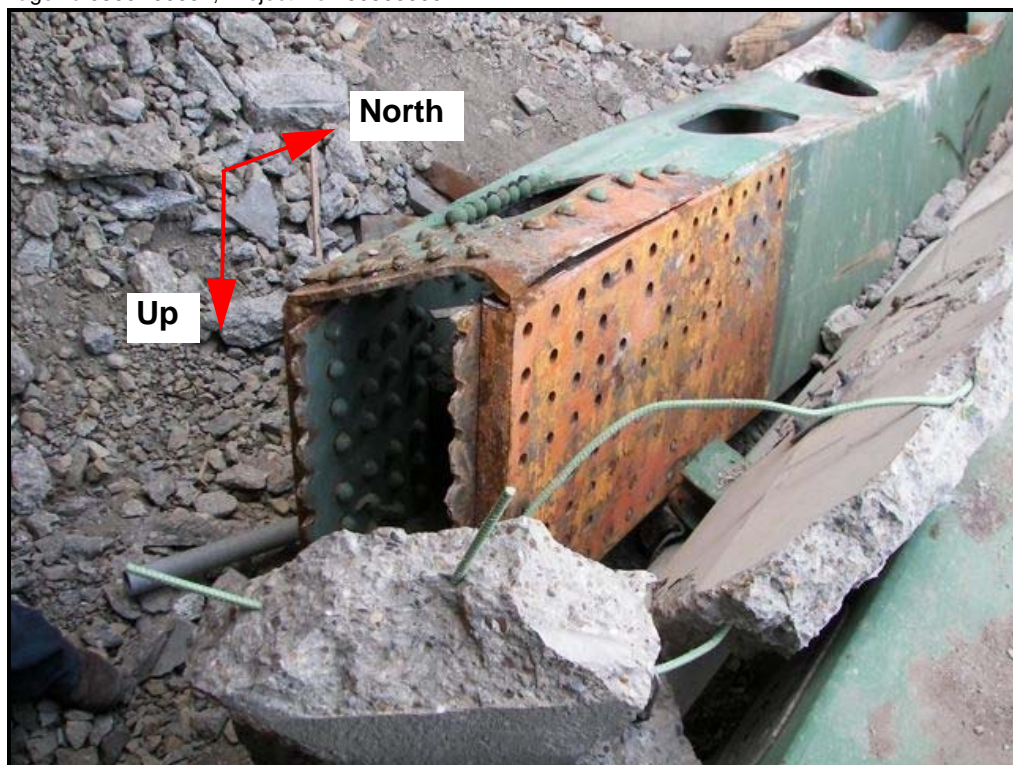
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Figure 29. View of the lower side of lower chord member L7/L8E showing the scraping damage from contact with the pier and bearings at pier 6. View is looking north along the member, but west geographically. The unlabeled arrow indicates the partial fracture shown in figure 30.



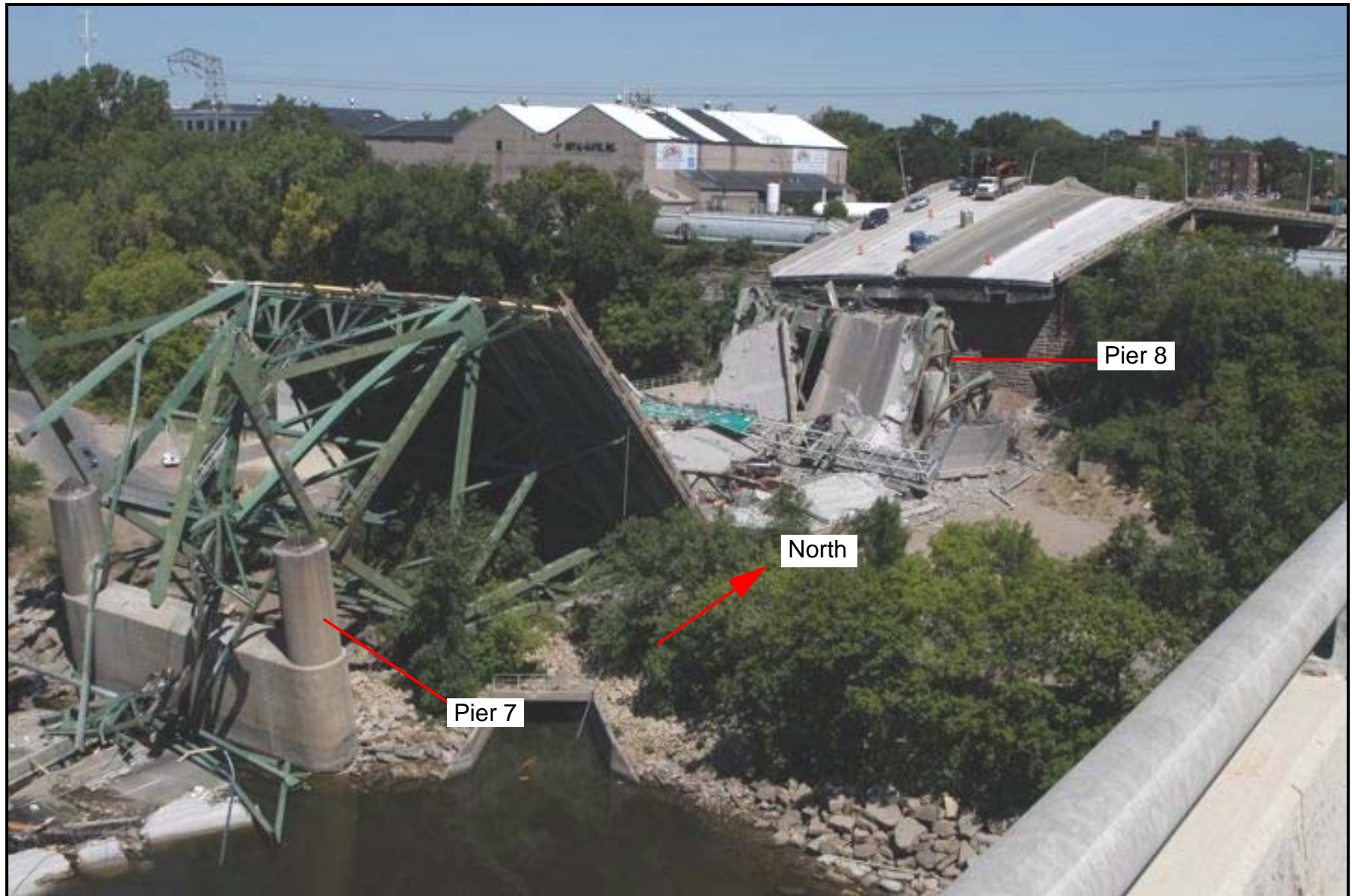
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Figure 30. View of the partial fracture in lower chord member L7/L8E.



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Figure 31. View of the L7E end of lower chord member L7/L8E in its post-collapse position, showing the locations of sheared rivets between the side plate of the lower chord and the gusset plate at node L7 East.



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Figure 32. Overall view of the north portion of the deck truss after the collapse. View is looking northwest.

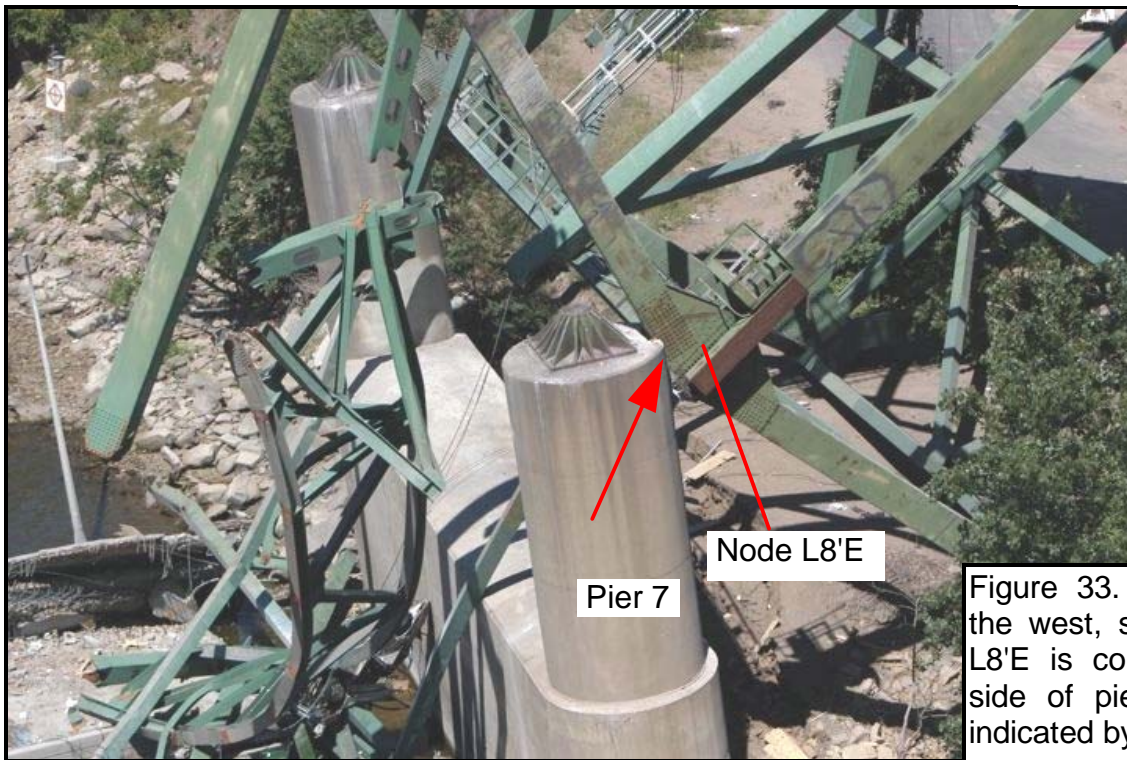
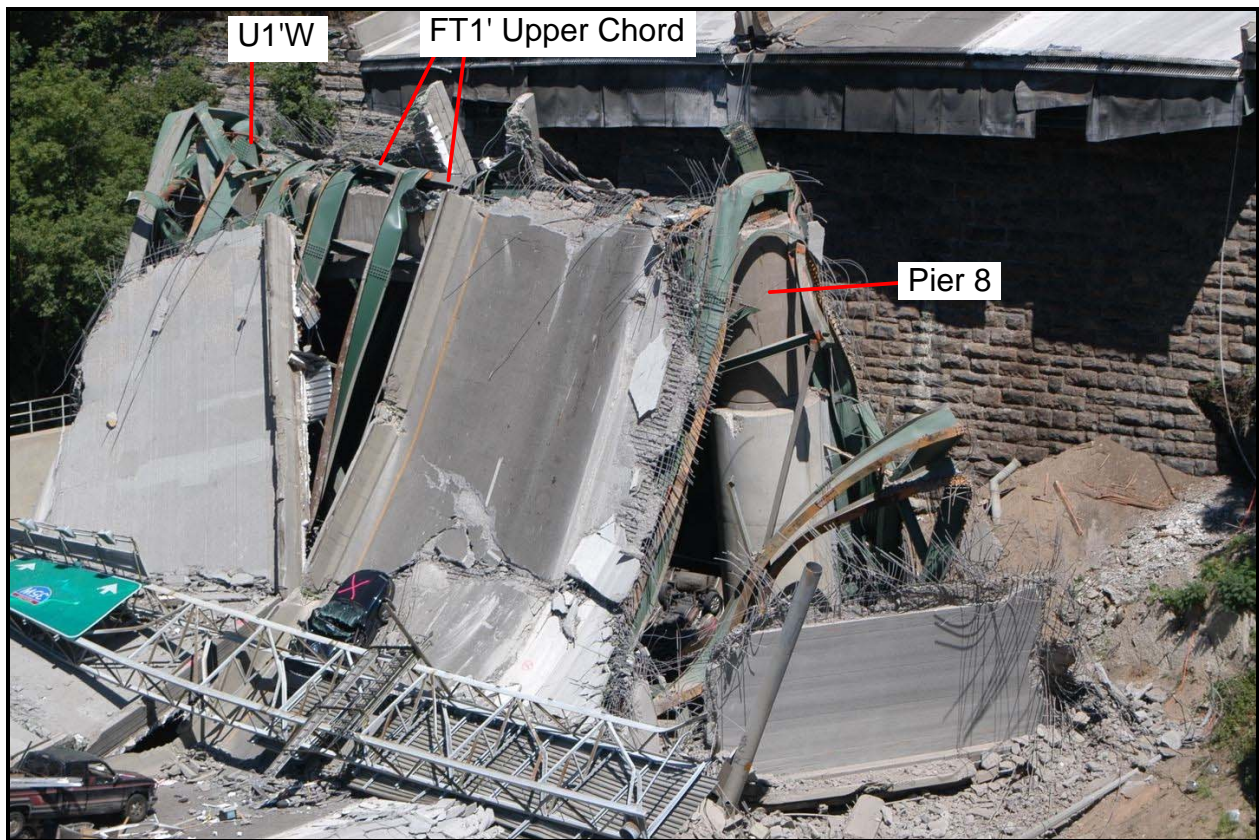


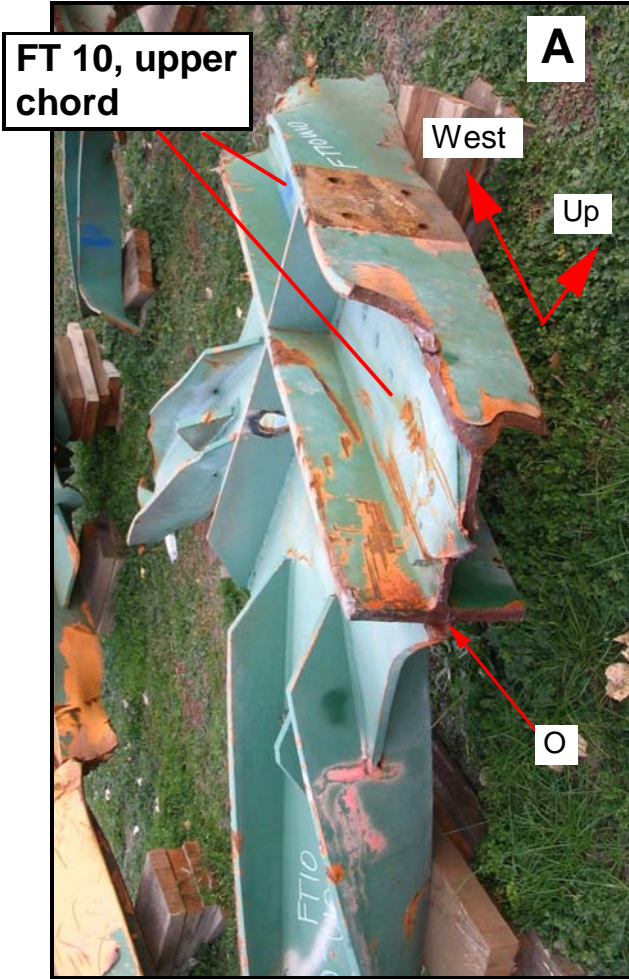
Figure 33. View looking to the west, showing how node L8'E is contacting the north side of pier 7, at the area indicated by the arrow.

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ImageNo: 0803A00812, Project No:2008030001

Figure 34. Deck truss at pier 8 after the collapse. The upper chord of FT1' and a portion of node U1' West are indicated. View is looking northwest. The unsupported southern end of the north approach spans is visible at the top of the photograph.



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Figure 35. Fracture in the upper chord of FT 10 near node U10 East. All views are looking primarily west. Overall view in photograph A, closer view of the fracture in photograph B, and closer view of the origin area in photograph C. Arrow "O" indicates the origin area.

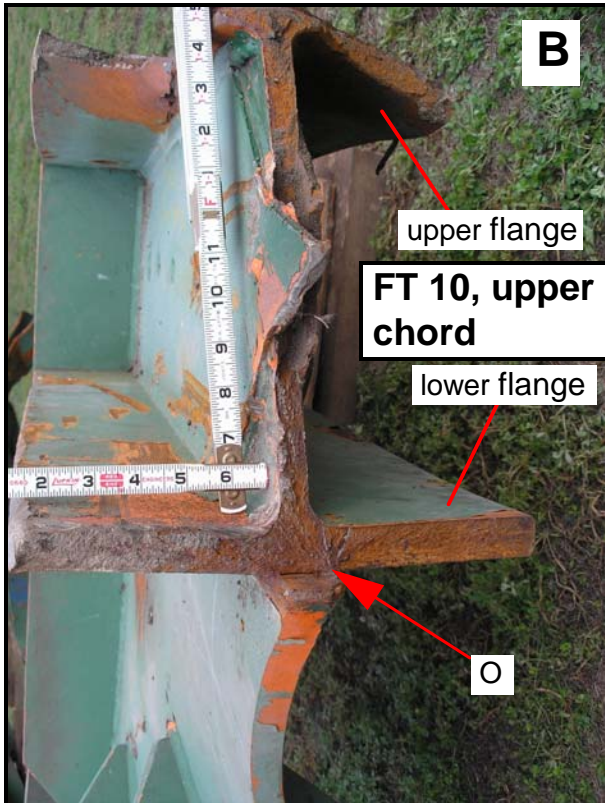
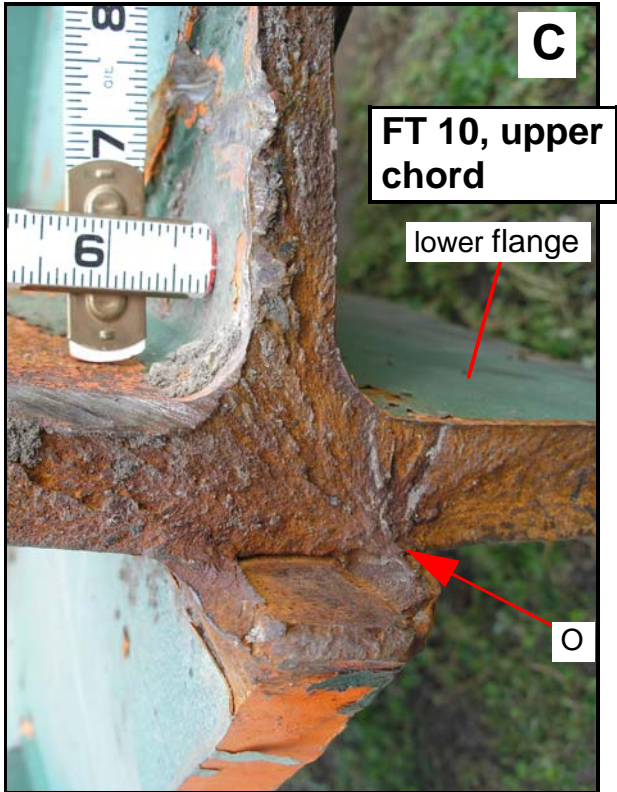


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