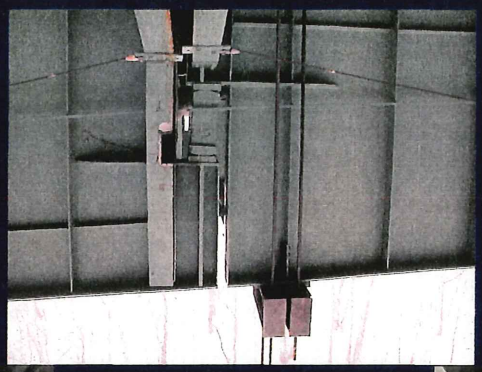

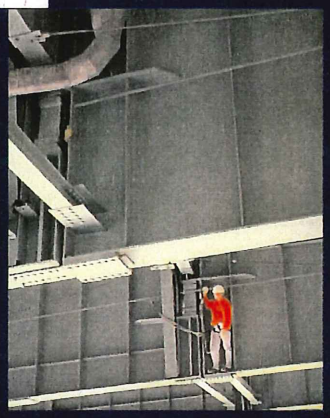

I-480 Bridge Repair

On Saturday, November 11, 2000, the I-480 westbound bridge over the Rocky River was closed for structural reasons. The bridge remained closed for seven days, diverting 48,250 westbound motorists per day to other arterial routes and local secondary roads. After installation of a temporary beam on top of the deck, three out of four lanes were reopened on Sunday, November 19, 2000. Permanent repairs are designed and the bridge is scheduled to be completely opened in March, 2001.

Preliminary Report

Overview of Events Leading Up To Bridge Closing

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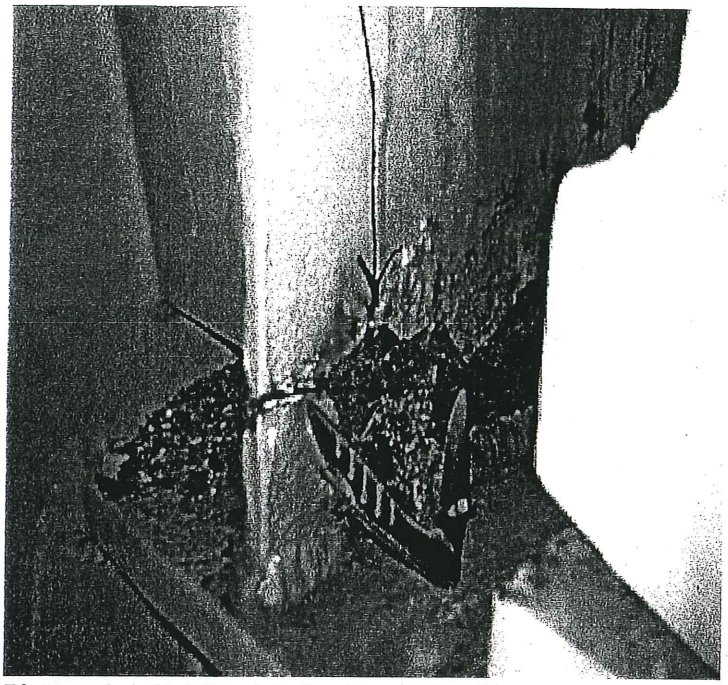

Picture 1- Initial Crack in the Upper Box Plate Photo/ODOT

The Ohio Department of Transportation Central Office, Office of Structures was immediately made aware of the situation. John Wackerly, Central Office Structural Engineer, was on-site acting as the Reachall Operator when the initial crack was found.

Week of October 16-21 Through the preliminary finite element analysis and field inspection, Malloy found that the upper box plate was not functioning as designed (as a non-structural finish plate). The upper box plate was actually in tension, carrying half of the load from the hinge support. The upper box plate, designed as one plate welded at the end of the web, was actually constructed using two plates welded to each side of the web. Thus, if the crack were to grow, it would propagate through the girder web.

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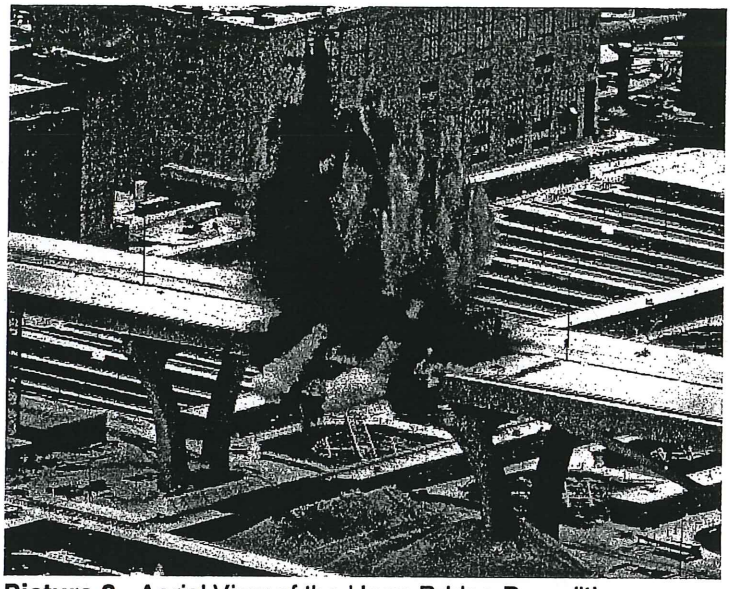
FROM

AT

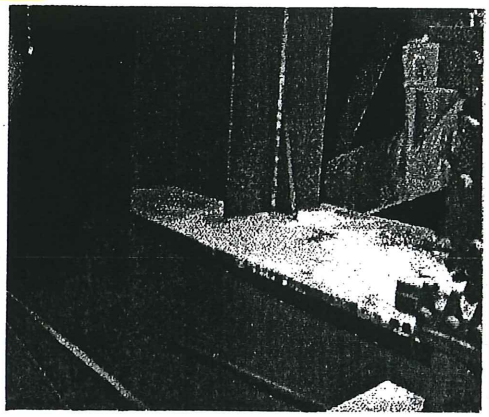
Conclusions and Lessons Learned

The successful incident management of the I-480 bridge is attributed to good communication, cooperation and shared expertise between D-12, the consultant, the contractor, the local police, and the media. After information of the initial incident was quickly relayed, all parties addressed their responsibilities. There was no need to channel every task through a central person or unit. Time was saved and misinformation was avoided. Technologies such as cell phones, alpha-numeric pagers and lap-top computers played an integral role in updating information throughout the network.

Coincidentally, a comparable bridge crisis occurred in Milwaukee, Wisconsin, one month after the I-480 incident. On December 13, 2000, a 216-foot section of the Hoan Bridge in downtown Milwaukee buckled and sagged four feet. Due to the girder failure, the bridge span could not be repaired and had to be demolished (see Picture 8), rerouting eight lanes of interstate traffic until a new structure is designed and built. The I-480 incident rerouted four lanes of interstate traffic for only one week. A major loss in a transportation link has by far, a greater impact on a region than a short term loss.



Picture 8 - Aerial View of the Hoan Bridge Demolition
Photo/Gary Porter



Picture 9 - CUY-480-1842 Hinge Detail
Photo/ODOT

District 12 has reviewed its bridge inventory for similar hinge details. Seventeen bridges in D-12 have seated hinges. Only CUY-480-0647 has three or less girder lines providing minimal redundancy. In the ongoing effort to inspect all of the seated hinges in D-12, hinge details on CUY-480-1842L&R were recently inspected. These structures have four girders instead of three, a triangular web extension, and additional stiffeners which dissipate the stress (see Picture 9). These bridges do not seem to be subject to the same problems as CUY-480-0647. District 12 intends to complete an evaluation of all seated hinge bridges by the end of 2001.

District 12 queried the State Bridge Inventory and forwarded a list of all structures with seated hinges to Central Office (see Appendix B). There are 163 structures with seated hinges, six of

The Emergency Bridge Closing and Repair of I-480 WB over the Rocky River (Bridge CUY-480-0647)

Preliminary Report

Table of Contents

Background

Bridge CUY-480-0647 spans the Rocky River Reservation and is located in Cuyahoga County, Ohio. The Rocky River is the city corporation line between Fairview Park and Cleveland. The Ohio Department of Transportation (ODOT), District 12 (D-12) is responsible for maintaining the structure.

1968 The bridge was designed by Alden E. Stilson and Associates Lmt. and constructed by National Engineering and Contracting Company under Project 670-70. It comprises two structures, one westbound and one eastbound. The twin structures are nine span, three continuous welded plate girder bridges approximately 1,500 feet long. They each carry four 12-foot lanes of traffic with two 12-foot berms.

1980 The bridge was opened to traffic after the completion of the roadway portion of I-480 between Grayton Road and Clague Road.

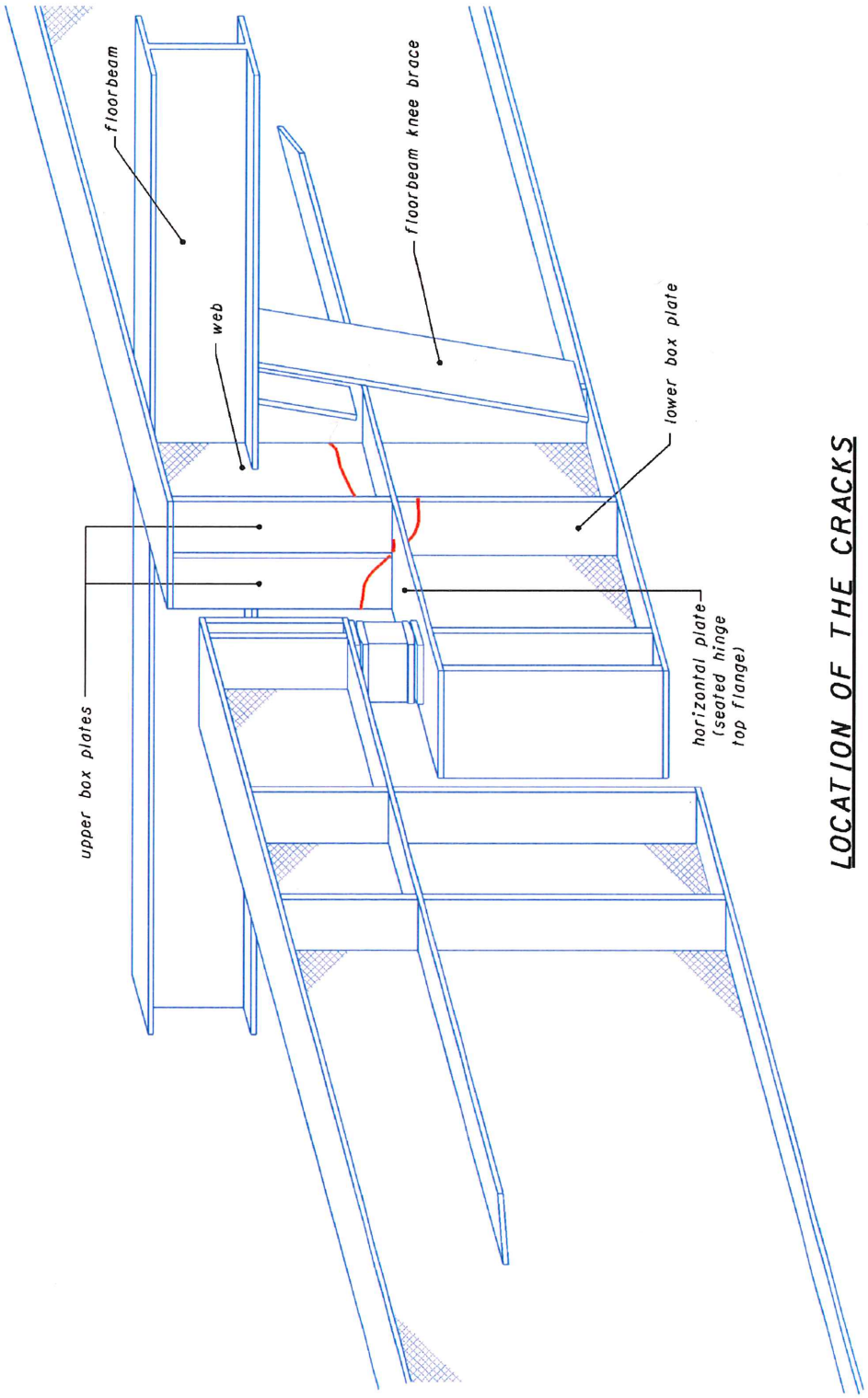
1991 The bridge was painted and some fatigue prone details were retrofitted.

1994 The Ohio Department of Transportation, D-12 Bridge inspector Dave Everett noticed that the backer bars (the steel plate used to assist in welding and normally removed after construction is complete) were left in place after construction at the seated hinge expansion joints, and noted that there was a potential stress concentration which has led to cracks in other structures. No cracks were found at this time. These locations would be monitored during routine inspection to see if any problems develop.

1997 The bridge was analyzed by BARS (AASHTO's bridge rating analysis program), and was found to be HS-19 and 150% legal.

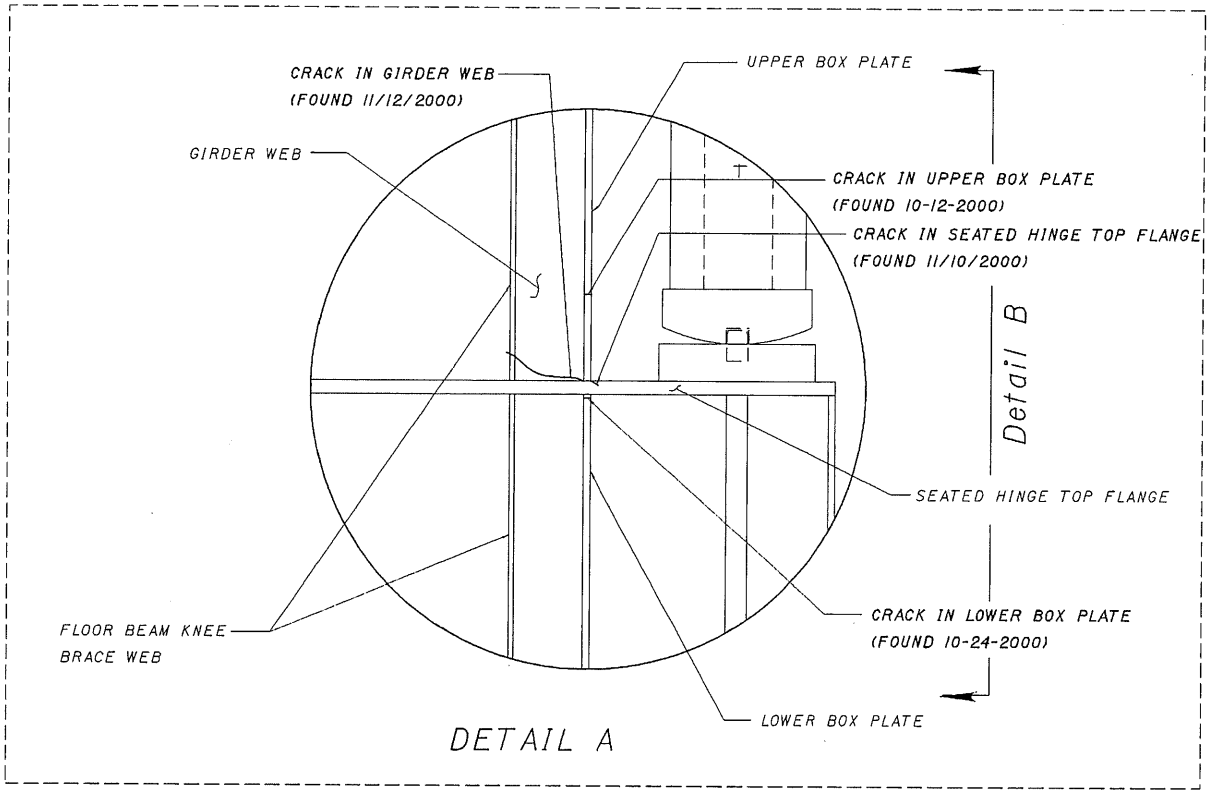
1999 Everett found fatigue cracks in the girder webs near the lower lateral bracing connections, and in the stringer webs where the cross frames connect to support the lower lateral bracing. Fatigue cracks in tension areas were retrofitted by D-12 bridge inspectors. Repair retrofits were programmed to be completed in Project CUY-71-17.91, PID 21562, and scheduled to sell in 2001.

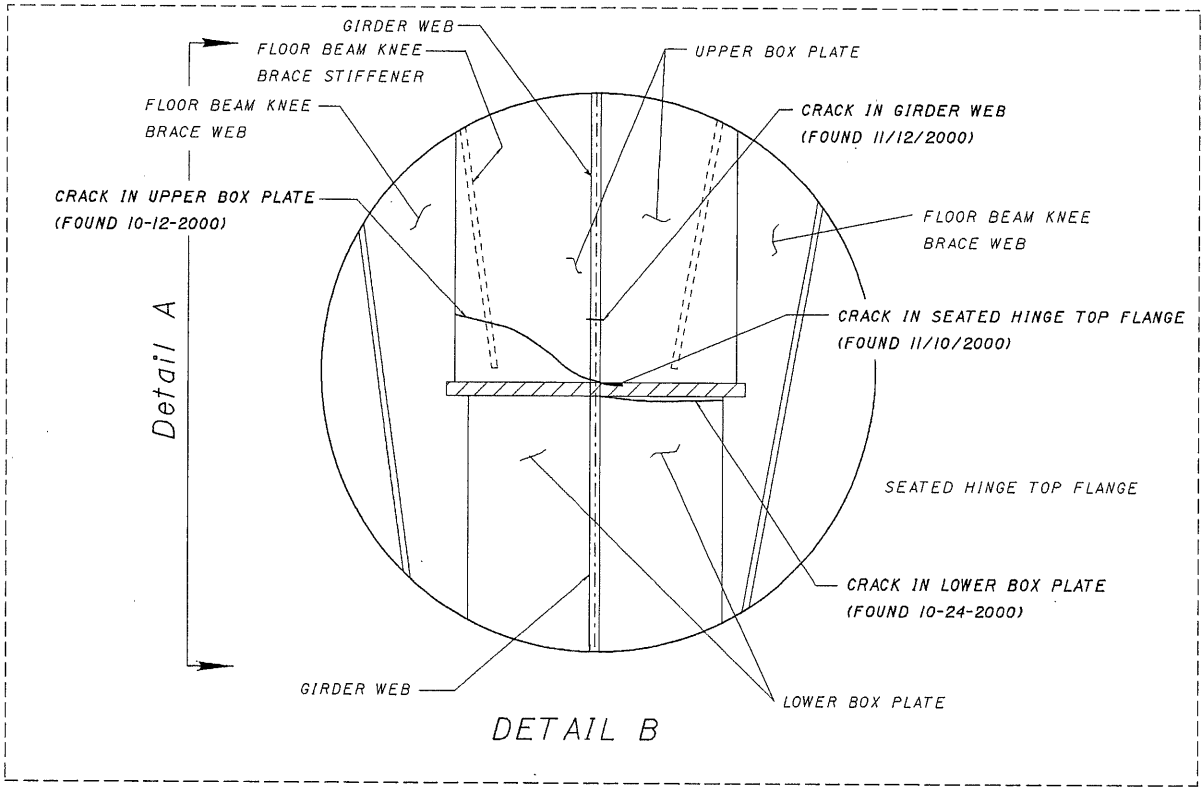
October 2000 Cracks were found in the median facia girder, which led to the temporary closing of this structure. The following is an overview of these events.



LOCATION OF THE CRACKS

(CRACKS SHOWN IN RED)


CRACK IN GIRDER WEB
(FOUND 11/12/2000)
UPPER BOX PLATE
GIRDER WEB
CRACK IN UPPER BOX PLATE
(FOUND 10-12-2000)
CRACK IN SEATED HINGE TOP FLANGE
(FOUND 11/10/2000)
Detail B
SEATED HINGE TOP FLANGE
CRACK IN LOWER BOX PLATE
(FOUND 10-24-2000)
FLOOR BEAM KNEE
BRACE WEB
LOWER BOX PLATE
DETAIL A


GIRDER WEB
FLOOR BEAM KNEE
BRACE STIFFENER
UPPER BOX PLATE
FLOOR BEAM KNEE
BRACE WEB
CRACK IN GIRDER WEB
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LOWER BOX PLATE
DETAIL B

Overview of Events Leading Up To Bridge Closing

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Saturday and Sunday, October 21 and 22 Malloy recommended removing the live load off of the median girder to reduce the stress in the location of the crack. Malloy and Lechak decided to first close the high speed lane (the No. #1 lane) and then re-stripe the bridge,

shifting the remaining three lanes to the north side of the bridge. This configuration would reduce much of the live load from the area in question, reducing the probability of crack growth. Cuyahoga Maintenance crews closed the lane at 6:00p.m. Sunday. There were no delays on I-480 WB related to the lane closure.

Week of October 23 - 27 The situation had now become an ODOT, D-12 team project with expertise required from Dennis O'Neil - Work Zone Traffic Control, Jeff Hebebrand and Scott Slack - Construction, and Jim Mihelich and Bob Wisniewski - Cuyahoga Maintenance.

Inspection in the area of the crack was extremely difficult. There was no easy access. The ODOT Reachall was not able to reach the girder line, so the inspectors had to climb the steel. In addition, the floorbeam knee brace flange and stiffener obstructed the view of the girder web. Banaszak and Everett further probed into location of the crack, this time attempting to remove as much rust and loose paint as possible. At this time, Banaszak found a second crack in the **lower box plate** on the north side of the girder web under the horizontal plate (see Picture 2).

Picture 2 - Second Crack in Lower Box Plate
Photo/ODOT

District 12 forwarded original construction plans and pictures of the crack area to Tom Lefchak and Krishna Verma of FHWA, and the Office of Structural Engineering and requested guidance. FHWA and the Office of Structures came to the site to look at the cracks. District 12 continued to analyze the structure in order to evaluate the severity of the problem and looked for possible repair options.

Friday, November 3 District 12 finished the detailed finite element analysis, and determined that the web plate was overstressed under the structure's own dead load. The web plastically deformed and redistributed the load to the floor beams. The structure remained stable, but repairs were still necessary.

Malloy, Slack and Hebebrand discussed a temporary repair of the girder with steel contractor Tri-State Steel. Inspection and repair access to the crack location had to be made by cutting a hole in the floor beam knee brace. Next, the contractor would have to grind out and re-weld the cracks, drill three retrofit holes in the girder web, and four retrofit holes in the box plates. This would be a temporary fix until a permanent retrofit could be designed and installed in project PID 21562.

Sunday, November 5 The contractor, United Rental, completed the lane shift designed

Picture 3 - Tri-State Worksite Photo/ODOT

by O'Neil. The three westbound lanes were moved to the north side of the bridge.

Tuesday, November 7 District 12 received a permit from the Cleveland MetroParks allowing access to the area under the bridge.

Thursday, November 9 Tri-State commenced the work discussed on November 3 (see Picture 3).

Friday, November 10 As work began, Tri-State found that the crack in the upper box plate extended into the horizontal plate (seated hinge top flange). They notified Malloy, who directed them to re-weld the box plate, and then drill out the end of the crack in the horizontal plate. At this time no cracks were found in the web. Malloy's re-analysis of the structure with the new crack, indicated that the structure was still stable with half of the horizontal plate removed, under the assumption that the crack would only propagate in the north direction, which appeared to be the way the crack was heading. Tri-State started to re-weld the upper box plate crack, but with one weld pass left to go, the weld cracked. After discussions with Malloy, Tri-State tried to re-weld the upper box plate crack starting further away from the web. Tri-State did a partial depth re-weld leaving out the final two passes. The horizontal plate crack was not drilled out.

Saturday, November 11 Malloy realized that the crack in the horizontal plate had a potential to propagate in two directions, thus compromising the integrity of the girder. The structure was re-analyzed assuming the median girder hinge lost its load carrying capacity. From the re-analysis it was concluded that the potential existed for the structure to collapse locally and/or catastrophically. **At 8:30p.m. Malloy and Lechak discussed the situation and determined that the risk to public safety outweighed the repercussions of complete closure of the westbound bridge.**

Synopsis of Incident Management

(The technical bridge repair is shown in *blue italics*.)

The incident management response for bridge CUY-480-0647 was carried out by a network of specialists, not a single individual.

Saturday, November 11 Immediately a web of communications was implemented. Calls were made between Lechak, Malloy, David Ray, Highway Management Administrator, David Coyle, D-12 Deputy Director, O'Neil, Mihelich, Wisniewski, the local police departments, and Barb Gibbons and Billie Jo Baughman, Public Information Officers. All immediately responded to the situation. Through the leadership of O'Neil, Mihelich, and Wisniewski, **the I-480 westbound bridge over the Rocky River was safely and expeditiously closed at 10:30p.m., Saturday, November 11, 2000.** The teamwork between the D-12 Maintenance crews and the local police kept the tense situation from ever being out of control. The closed bridge detoured 48,250 westbound motorists per day.

Gibbons and Baughman contacted the local media. The Cleveland Plain Dealer would run the article on the closure the following day (see Appendix A-1).

Malloy called consulting firm Richland Engineering Limited for a second opinion and to help expedite the repair design process.

Sunday, November 12 Though the day began with some confusion to the motorists, answers to their questions were easily found. The local newspapers, television and radio stations, and portable message boards were constantly updated by the well-informed D-12 incident team. Traffic was detoured onto the parallel State Route 17. Traffic signal timings were adjusted and traffic police were used at intersections. Message boards were placed well in advance of the closure so that other exits, including I-71, could be considered. The public advisory radio was changed to give motorists a delay warning and the option of using I-71 SB to I-80 WB (turnpike) as a bypass. (See the detour in Appendix A-1)

Lechak, Malloy, Richland, and Tri-State sought a solution. Tri-State would cut out the upper box plate above the flange crack in order to get a better idea of what was going on, and possibly drill it out and re-open the bridge. Once Tri-State cut out the upper box plate exposing the girder web, a crack in the girder web was found (see Picture 5). With this discovery, installation of a carrier beam would be necessary before the bridge could be re-opened. Richland was instructed to perform an independent finite element analysis and to start design for a carrier beam. The carrier beam was designed from material available at Tri-State's yard. District 12 began contingency plans that would put both directions of travel on the eastbound structure if the carrier beam was not practical.

Picture 5 - Crack in the Girder Web Photo/ODOT

While engineers assessed the situation, Gibbons and Baughman, were continually briefed on the bridge condition and supplied the media with as much information as possible. By mid-afternoon they had arranged to have Malloy and Lechak interviewed by the local news media (see Appendices A-1, A-2, A-3 and A-4).

Monday, November 13 David Coyle, D-12 Deputy Director, led a meeting Monday morning to bring together the network specialists and discuss a plan of action. Malloy and Lechak could give no definitive time table on when the bridge would be re-opened. Coyle instructed O'Neil, Lechak, and Malloy to be available for daily press briefings at the bridge to answer questions on structural conditions and the traffic situation. Numerous Central Office employees visited the site.

No ideas were ignored. Baughman suggested that since there was no entrance ramp at the interchange west of the bridge (Clague Rd.) the exit ramp could be used as an entrance ramp. Coyle recommended that ODOT pay the tolls for motorists using the turnpike (I-80) detour between Exits 9 and 10. (The Ohio Department of Transportation was later billed $7,093.80 for the tolls.) These ideas and others were implemented.

Tri-State completed preparation of the upper box plate for steel testing. It was found that the horizontal plate crack looked like a "J" which went around a stiffener. It appeared that the upper box plate was actually pulling a divot of steel out of the horizontal plate. This was verified later after a hole was drilled out at the hook in the "J" (see Picture 6).

Picture 6 - Drilled Out "J" Divot Photo/ODOT

The Central Office Reachall had returned with operators Andy Clark and Ed Dodd to help with the inspections.

Armed with additional knowledge of the cracking condition, D-12 bridge inspectors looked more closely at the other hinge locations on the bridge. Everett found cracks in the upper box plates in the eastbound structure's median fascia girder. Ultrasonic testing of this area verified that the ends of the cracks did not penetrate into structurally critical areas.

Tuesday, November 14 District 12 Cuyahoga Maintenance crews and local police maintained the closure and detour. The local detour, SR 17, was less saturated as motorists found other westbound detours. A temporary repair timetable was set and released to the media for completion by Wednesday, November 22, the day before Thanksgiving.

Tri-state cut access holes in the eastbound bridge at the crack for inspection purposes. Richland performed magnetic particle testing that verified the crack in the eastbound bridge was only in the upper box plates, and confirmed that the girder web, horizontal plate, and floor beam knee brace were not cracked. Tri-State then retrofitted the two cracks in the upper box plates by drilling out the ends of the cracks. Tests showed that the web crack in the westbound

structure actually passed through the floor beam knee brace. This knee brace was the last remaining internal redundancy on the bridge. This web crack was drilled out to prevent further propagation.

Janet Bix, ODOT Librarian, performed a literature search, and a request for information from other states. She found that several states have had minor problems with this particular hinge detail. Only one state, Nevada, had a serious problem, where they had to repair two railroad bridges. All information was forwarded to Richland to help them design the retrofit.

Thursday, November 16 *Richland's finite element analysis was completed and confirmed Malloy's results, and that the potential for bridge failure existed. The design of the temporary carrier beam was completed. The temporary carrier beam installation and permanent repair alternatives were discussed at the district.*

Friday, November 17 *All materials were delivered to the project site.*

Saturday, November 18 Installation of the carrier beam was completed late that evening and the calls were made for the maintenance crews to open the bridge by daybreak.

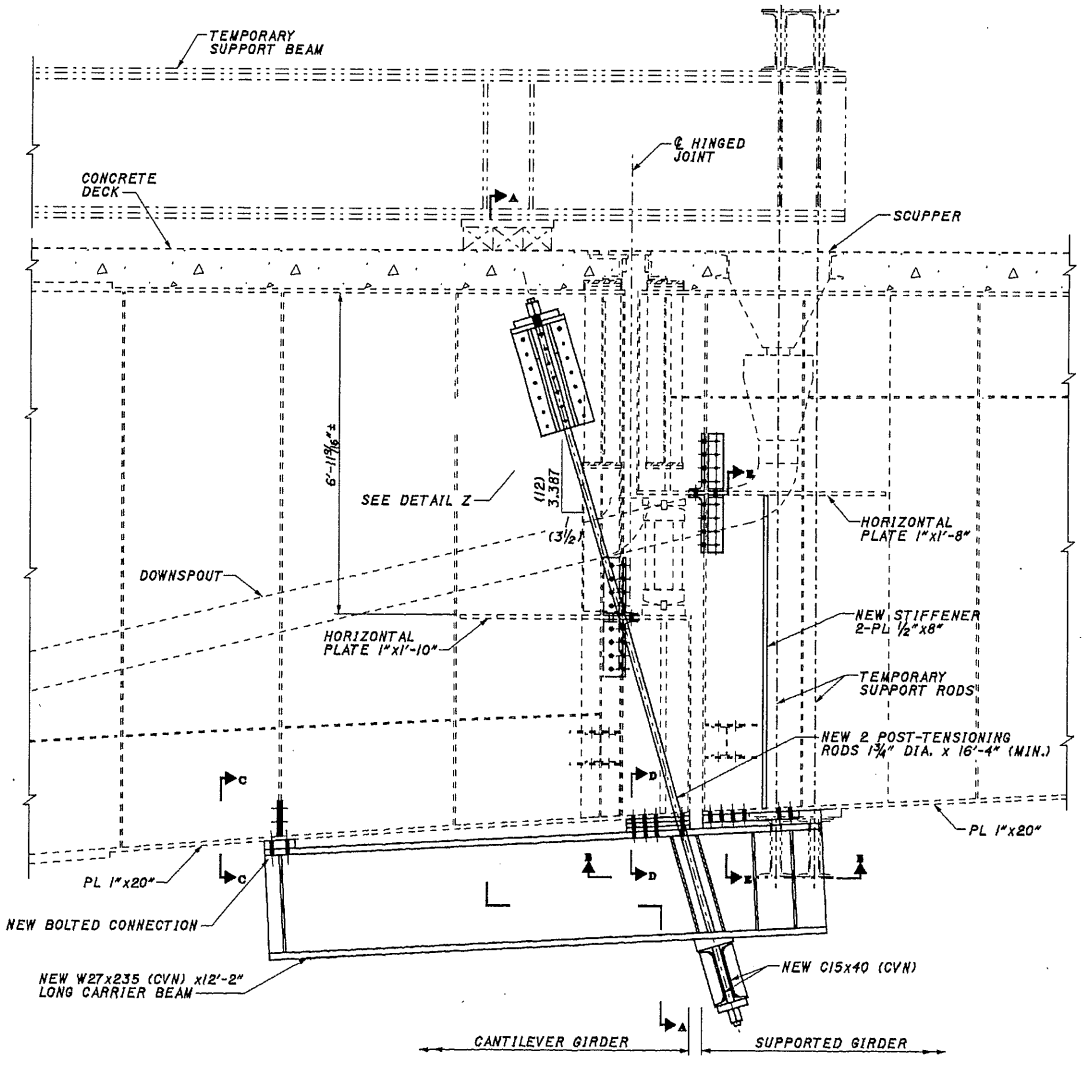
Sunday, November 19 With the temporary repair in place (see Picture 7), three of the four I-480 westbound traffic lanes were opened, three days ahead of schedule.

Picture 7 - Temporary Carrier Beam Installed Photo/ODOT

The Permanent Repairs

Richland Engineering has submitted final emergency repair plans for the two hinges that were cracked. Tri-State has contacted suppliers for materials. It is anticipated that the final repair will be completed in March 2001 (see below). Richland was directed to size the retrofit components for the other ten hinges in order for these girders to be retrofitted in project PID 21562.

Permanent hinge repairs will strengthen the hinge connections and add redundancy to the structure. Long term plans for the structure have not yet been determined. In the near future District 12 will study the I-480/Airport Freeway corridor and evaluate structural rehabilitation alternatives at that time.



GIRDER ELEVATION

Preliminary Cost Breakdown

Construction Costs	
Tri-State Steel - initial emergency repair	$54,860.71
Tri-State Steel - final emergency repair	$130,000.00
United Rental - striping	$3771.10
National Engineering and Contracting - initial emergency repair	$16,357.63
National Engineering and Contracting - final emergency repair	$6,500.00
Consultant Costs	
Richland Engineering (PE/CE = 5.73%)	$52,350.00
Local Agency Support Costs	
City of Cleveland	$10,704.00
City of Fairview Park	$739.18
City of North Olmsted	$1,166.00
Ohio Turnpike Commission	$7,093.80
The Ohio Department of Transportation internal costs	
Labor, equipment, and material	$30,000.00
Sub-Total Emergency Estimate	**$313,542.42**
Costs Still To Be Incurred	
Estimated cost to retrofit the remaining 10 hinge locations (PID 21562)	$600,000.00
Total Emergency Repair Costs (estimated)	**$913,542.42**

Conclusions and Lessons Learned

The successful incident management of the I-480 bridge is attributed to good communication, cooperation and shared expertise between D-12, the consultant, the contractor, the local police, and the media. After information of the initial incident was quickly relayed, all parties addressed their responsibilities. There was no need to channel every task through a central person or unit. Time was saved and misinformation was avoided. Technologies such as cell phones, alpha-numeric pagers and lap-top computers played an integral role in updating information throughout the network.

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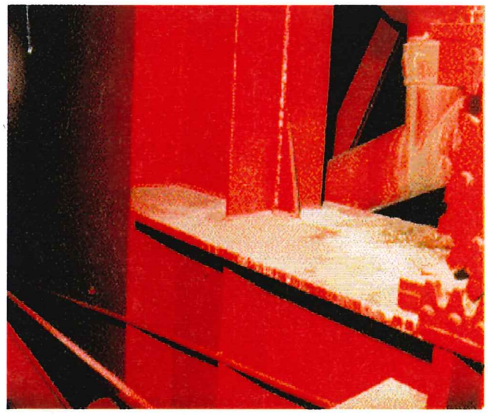

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which have only three girders. District 12 recommends that all districts evaluate their structures with seated hinges.

A statewide **Bridge Emergency Response Team (BERT)** should be formed to help districts who may need extra guidance, expertise, and manpower when an emergency situation such as this arises. In the weeks prior to the closing, many people were contacted and were interested in assisting with the I-480 Emergency; however, time constraints and other priorities took precedence over what was a very serious problem.

BERT would be available without delay, with the emergency taking precedence over other non-emergency activities. BERT would have the ability to perform bridge rating, finite element analysis, test and evaluate materials, and design repair alternatives. BERT would work closely with the response team from the local district.

If the team cannot be staffed from within ODOT, then a consulting firm should be retained for such purposes. Currently, there are no provisions in ODOT's emergency contract protocol to hire a consultant. Just hours after the closing, upon request, Richland Engineering arrived at the site but under no contract. District 12 later had to go to the Controlling Board to justify reimbursement for Richland Engineering's services.

For additional information contact either Michael Malloy, Natalie Conley, or Jeffrey Lechak at 216-581-2100.

APPENDIX A-1

Sunday 11/12/00

Unsafe bridge closes I-480

Crack is found in support beam

The Ohio Department of Transportation indefinitely closed the Interstate 480 westbound bridge over the Rocky River last night after inspectors found a crack in one of the three support beams.

ODOT inspectors and a private engineering consultant had been examining the roadway for several weeks as part of the department's annual bridge inspection. They found a crack in the beam underneath the high-speed lane of the bridge, said ODOT spokeswoman Barb Gibbons.

"We are closing the bridge as a safety precaution," she said. "We will always err on the side of the safety of the motoring public."

A contractor from Richland Engineering Co. of Mansfield will be working today to fix the crack.

Valley Pkwy., which passes under the bridge, was closed between Puritas Rd. and Brookway Dr.

Gibbons said the area was closed to traffic about 10:15 p.m. Cleveland police rerouted motorists, and traffic was backed up for a time.

A detour is available. Drivers should exit I-480 at Grayton Rd., travel south to Brookpark Rd. and then west on Brookpark Rd. to Great Northern Blvd. At Great Northern Blvd., motorists should travel south and follow signs back to I-480 to re-enter the freeway.

THE PLAIN DE

OHIO'S LARGEST NEWSPAPER 35¢ NEWSSTANDS & MACHINES Monday 11/13/00

ME

I-480 span stays closed while crack is inspected

By MICHAEL SANGIACOMO
PLAIN DEALER REPORTER

Interstate 480 westbound will remain closed from Grayton Rd. to Great Northern Blvd. at least through the weekend as state engineers poke and prod the unstable undergirdings of the bridge span over the Rocky River.

That, the Ohio Department of Transportation said yesterday, could cause some frustrating traffic bottlenecks for the roughly 100,000 motorists who use that route and will have to detour.

ODOT officials said yesterday that if the bridge's westbound lanes were still closed by week's end, ODOT would temporarily divide the bridge's eastbound lanes to allow traffic to flow in both directions. Alternatively, if repair work goes well but still isn't done by the weekend, ODOT may reopen all but the high-speed (left-hand) lane on the bridge by the weekend, officials there said.

Until then, all westbound I-480 traffic is being detoured off the Grayton Rd. exit onto Brookpark Rd. west to Great Northern Blvd., where it is directed back onto the interstate. ODOT officials suggested that westbound drivers bound for Lorain County and points west consider taking Interstate 90 or the Ohio Turnpike (Interstate 80).

"Engineers need to get in there and see how severe the crack is and how easily it can be fixed."
MICHAEL MALLOY, *ODOT bridge-design engineer*

ODOT ordered the bridge's westbound lanes closed Saturday night after inspectors scrutinizing a crack in one of three support beams determined that the crack could spread and jeopardize the bridge.

Almost immediately after the 10:15 p.m. bridge closing, traffic along I-480 and the detour route began to clog. Even the light Sunday-afternoon traffic was backed up for more than a mile at the exit yesterday.

ODOT warned that the detour could cause major rush-hour delays, particularly for traffic heading to nearby Cleveland Hopkins International Airport.

Valley Pkwy., which runs under the I-480 bridge through the Rocky River Reservation of the Cleveland Metroparks, was open yesterday after being closed Saturday night.

ODOT bridge-design engineer Michael Malloy expressed hope yesterday that the cracked beam could be repaired quickly. But, he said, it's too soon to determine the severity of the problem.

"Engineers need to get in there and see how severe the crack is and how easily it can be fixed," he said. "If it is one that is not easily corrected, it could take a while, but it's premature to speculate until we see what we have."

Malloy said inspectors first found the crack in the beam during a routine inspection in 1994. Since then, ODOT has regularly inspected it, he said.

SEE I-480/7-A

Westbound I-480 bridge closed, ODOT recommends detours

Nearly 100,000 vehicles that normally cross the Rocky River Bridge on westbound I-480 daily will be forced to detour indefinitely while workers repair a cracked support beam. The Ohio Department of Transportation closed the bridge's westbound lanes Saturday night. Eastbound lanes remain open.

HEADED INTO LORAIN COUNTY? ODOT is predicting heavy traffic on the main detour route. For I-480 westbound drivers headed into Lorain County or beyond, ODOT recommends following I-71 south to the Ohio Turnpike (I-80) in Strongsville, then going west on the turnpike. It rejoins I-480 in North Ridgeville. Another alternative: I-90.

THE PLAIN DEALER

SCOTT SHAW / THE PLAIN DEALER

Workers from Tri-State Construction prepare the westbound Interstate 480 bridge over the Rocky River for inspection yesterday.

APPENDIX A-2

Editorial

8-B **THE PLAIN DEALER**

TUESDAY, NOVEMBER 14, 2000

Taking no chances on I-480

Isn't it typical? Just as Ohio's road builders were putting away orange barrels for the winter, up went the barricades on a heavily used stretch of Interstate 480 near Cleveland Hopkins International Airport.

But far from cussing out Ohio Department of Transportation engineers for closing the affected portion of highway, those who use it on their daily journeys might wish to commend the vigilance and caution of ODOT officials.

The sudden action, ordered late Saturday, resulted from an inspection of the I-480 bridge that crosses the Rocky River. A crack that had been found in one of three support beams looked as if it might spread, endangering the whole structure.

Alarming though that may seem, it may be even more troubling to learn that the existence of the crack was known as early as 1994. But, ODOT says, inspectors have kept an eye on it ever since. On Oct. 12, they decided a closer look was in order, and earlier this month closed the westbound high-speed lane so tests could be conducted.

As of this writing, all lanes of I-480 westbound are closed between Grayton Rd. and Great Northern Blvd., creating potential delays for commuters and airport users. Depending on their destinations, other interstates offer alternative routes. For many, however, a period of inconvenience is in prospect.

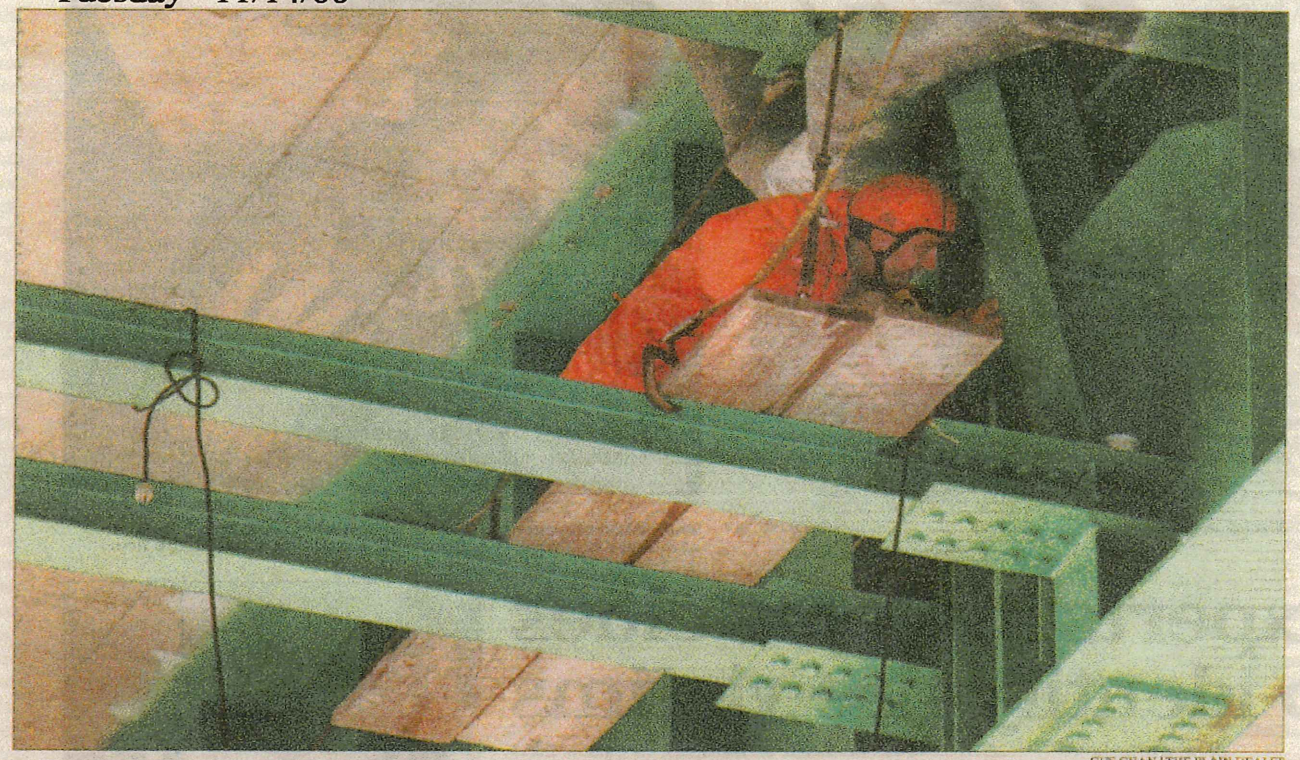
Grumbling is inevitable. But an appreciation of what might have been should keep it within reasonable bounds.

APPENDIX A-3

THE PLAIN DE

OHIO'S LARGEST NEWSPAPER 35¢ NEWSSTANDS & MACHINES MEDINA COUNTY

ME Tuesday 11/14/00



GUS CHAN / THE PLAIN DEALER

Cracks in the steel beams supporting the I-480 westbound bridge over the Rocky River had Dave Everett, an Ohio Department of Transportation bridge inspector, suspended 80 feet above the ground yesterday and stretching to get a closer look.

3 cracks found in I-480 bridge

By ALAN ACHKAR and MICHAEL SANGIACOMO
PLAIN DEALER REPORTERS

Three tiny cracks, none longer than 8 inches, were enough to shut down a highway.

The small cracks, in a steel girder supporting Interstate 480 westbound near Grayton Rd., forced transportation engineers and police departments yesterday to find ways to keep traffic moving smoothly.

The Ohio Department of Transportation expects to keep I-480's four westbound lanes, on a bridge between Grayton and Clague Rd., closed through the end of the week. ODOT hopes to reopen three of the lanes by early next week, after installing support beams around the cracks.

▪ Taking no chances on I-480. An editorial. **8-B**

Warnings by ODOT and news reports apparently kept the challenge of rush-hour traffic yesterday from turning into a nightmare. Cars were slowed for about a mile before the Grayton Rd. exit last night but proceeded smoothly once off the highway.

Several police officers stationed on Brookpark Rd., to which I-480 traffic is being detoured, helped keep the cars moving.

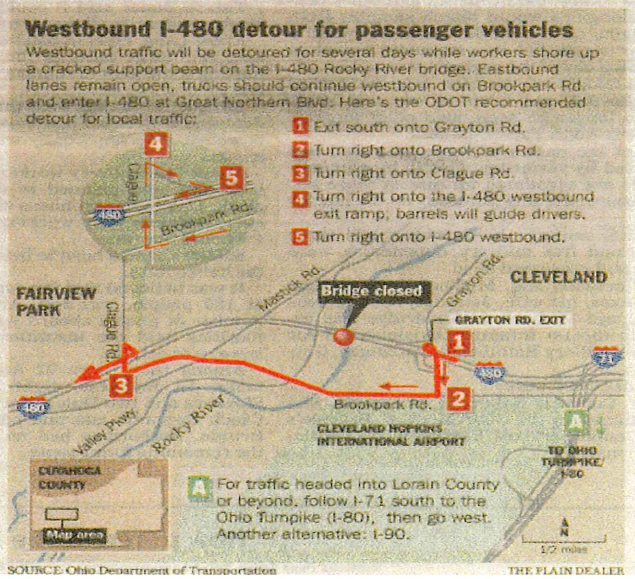
"This isn't bad at all, especially since they have the police out," Jim Janiak, of Garfield Heights, said last night as he maneuvered along Brookpark.

ODOT engineers yesterday used ultrasound equipment to pinpoint the location of the cracks. For now, ODOT inspectors believe they are dealing with three cracks. The problem is not so much that the cracks exist as where they are — at a spot where three joints are welded together. No cracks have been found in the girders underneath the eastbound lanes, he added.

The problem is similar to a tiny tear in a piece of paper, according to Jeff Lechak, an ODOT bridge engineer. The more pressure applied to the tear, the worse it will get, he said. That's why ODOT on Saturday night decided to shut down the bridge, used by about 100,000 drivers a day.

"It's a unique situation," Lechak said. "This is very uncommon."

SEE BRIDGE/4-A



APPENDIX A-4

SCOTT SHAW / THE PLAIN DEALER

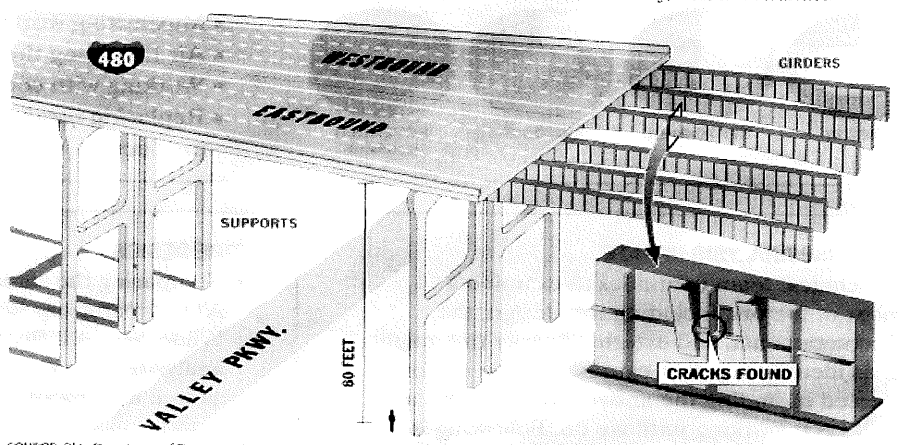
The four westbound lanes of the I-480 bridge over the Rocky River will be closed until next week, as Ohio Department of Transportation engineers repair cracks in steel beams. Below the bridge is Valley Pkwy., a road through the Cleveland Metroparks' Rocky River Reservation.

Tuesday 11/14/00

Cracked girder cripples I-480 traffic

A team of inspectors and engineers from the Ohio Department of Transportation is fixing three cracks in the girder of an I-480 bridge that crosses Valley Pkwy. and the Rocky River. The first two cracks, measuring eight inches and six inches, were discovered last month. The third crack, discovered Sunday, measures six inches.

Six years ago, ODOT inspectors realized that the design could result in cracking. They have inspected the bridge every year since.



SOURCE: Ohio Department of Transportation

STEPHEN J. BEARD / THE PLAIN DEALER

BRIDGE

FROM 1-A

Interstate caught in cracks of time

The bridge was built in 1969, and engineers no longer use its type of joint design, Lechak said. Six years ago, ODOT inspectors realized that the design could result in cracking. They have inspected the bridge every year since.

Last month, an inspector first noticed a 6-inch crack. ODOT shut down one lane of traffic to take pressure off the girder. A second crack, also 6 inches, was found two weeks later. Then, as workers for Tri-State Steel Construction were fixing the girder, they noticed that the first crack was 2 inches longer than expected — raising worries that the problem was more serious than originally thought.

The final alarm bell was a third crack, also about 6 inches, that was discovered on Sunday.

In the next few days, ODOT plans to install support beams around the cracked girder. It can then reopen three of the four westbound lanes while continuing to examine and repair the steel.

In the meantime, ODOT is working with police and the Ohio Turnpike Commission to keep driving headaches to a minimum. The group came up with some solutions yesterday:

■ The exit ramp from westbound I-480 onto Clague Rd. was transformed last night into an entrance to the eastbound lanes. Motorists driving along Brookpark Rd. can re-enter westbound I-480 by going the wrong way up the Clague Rd. exit. Since westbound I-480 is closed at Grayton Rd., there is no danger from oncoming traffic.

"We wanted to keep as much traffic away from the mall on Great Northern Blvd. as possible because that area is always crowded anyway," said North Olmsted police Capt. Kevin Whelan. "This will take up much of the traffic."

Whelan said the Clague Rd. exit ramp would be open only to cars and smaller vehicles. The road is too narrow for trucks to navigate, so truck traffic must take Brookpark Rd. to Great Northern Blvd. to I-480.

■ Traffic lights along Brookpark Rd. have been reset to stay green longer, according to Whelan. Also, a "no turn on red" sign at the intersection of Brookpark Rd. and Clague Rd. has been covered up.

■ Motorists who avoid the area and use the Ohio Turnpike will not be nicked with a toll.

Drivers who take I-71 south to Exit 10 of the toll road, then get off at Exit 9 (Ohio 10), will not have to pay the 50-cent toll.

"Collectors will not charge anyone who gets on at 10 and off at 9," said Lauren Hakos, spokeswoman for the Ohio Turnpike Commission. "We will keep track of the fares and the Ohio Department of Transportation will reimburse the Turnpike Commission for them."

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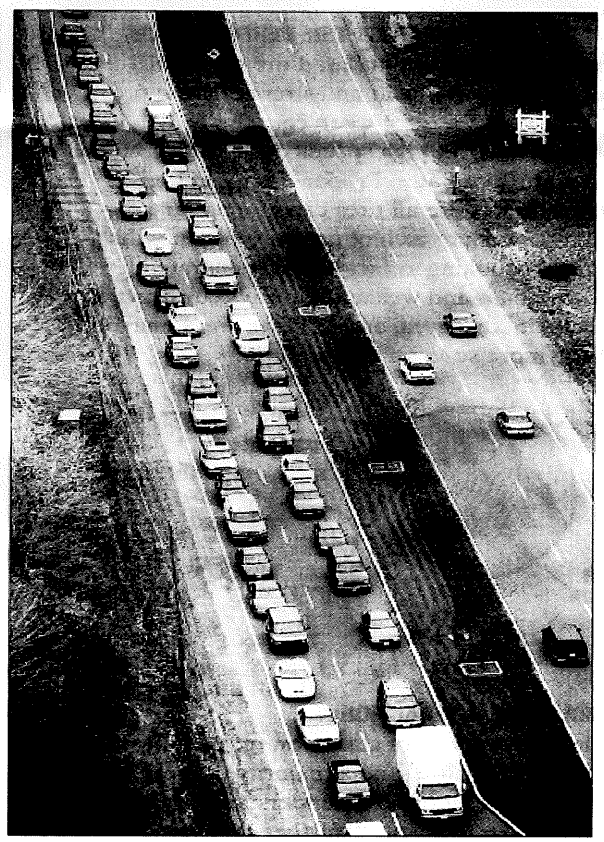
Phone: (216) 999-4814



SCOTT SHAW / THE PLAIN DEALER

APPENDIX B

Bridges with Seated Hinges

Dist.	LMT	County	Route	SLM	SFN	Feature Intersected
2	2	WOO	475R	386	8706751	MAUMEE RIV & S RIVER ROAD
	2	WOO	475R	386	8706786	MAUMEE RIV & S RIVER ROAD
	4	WOO	T003A	1	8730490	JACKSON CUT-OFF CYGNET RD
	4	WOO	T011B	3	8732965	TWOROOT CREEK LUCKEY ROAD
	4	WOO	T023B	1	8736324	N BR PORTAGE R JERRY CITY
	4	WOO	T023E	3	8736537	ROCKYFORDCRK.JERRYCITY RD
	4	WOO	T024B	1	8737150	MID BR PORTAGE HAMMANSBRG
	4	WOO	T177B	3	8753164	NOR BR PORTAGE RIV KRAMER
	4	WOO	C189A	1	8753660	BEAVER CRK.WAPAKONETA RD.
	4	WOO	T201A	1	8753873	BEAVER CRK.WINTERGREEN RD
	4	WOO	T305A	1	8757348	GRASSY CREEK MANDELL ROAD
	4	WOO	T306A	2	8757399	GRASSY CREEK SCHRIER ROAD
	4	WOO	M313A	1	8757720	HENRY DITCH CHERRY STREET
	5	WOO	T025C	2	8737649	2200 RADER BR OIL CENTER
	5	WOO	T043C	2	8741611	N.BR.PRTG.RIV.RANGLINE RD
	5	WOO	T044C	5	8742103	NBRPRTGRIV.PTR.RD(CLOSED)
	5	WOO	T073D	1	8744955	MID BR PORTAGE CLOVERDALE
	5	WOO	T078A	5	8745242	BEAVER CREEK POE ROAD
	5	WOO	C526A	1	8759049	PRTG.RIV(CLOSED)NEWRCHSTR
	N	HEN	006R	1650	3500578	MAUMEE RIVER
	N	LUC	075R	27	4802764	MAUMEE R N&W RR SOUTH AVE
	N	LUC	075R	167	4802942	SWAN CR N&WRR SR25
	N	LUC	075R	167	4802977	SWAN CR N&W RR SR 25
	N	LUC	075R	199	4803000	NEBRASKA AVE
	N	LUC	075R	364	4803272	BANCROFT ST
	N	LUC	075R	577	4803752	BERDAN,OTTAWA R. US24 CRR
	N	LUC	075R	762	4804058	STICKNEY AVE.
	N	LUC	475R	1350	4808193	SECOR ROAD
	N	LUC	475R	1418	4808282	BOWEN ROAD
	N	LUC	475R	1434	4808312	RUSHLAND AVE
	N	LUC	475R	1478	4808401	SHERBROOKE ROAD
	N	LUC	475R	1538	4808460	UPTON AVE
	N	LUC	475R	1595	4808584	AUBURN AVE.-OTTAWA RIVER
	N	LUC	475R	1618	4808673	IR 75 SBL & IR 475 WBL
	N	WOO	075R	3268	8704953	CSX RR
	N	WOO	795R	589	8707413	CEDAR CR-CONRAIL-CO RD 10
	N	WOO	795R	589	8707448	CEDAR CR-CONRAIL-CO RD 10
4	1	SUM	271R	802	7709005	RIVERVIEW RD B&O RR CUY R
	5	SUM	008R	195	7700369	NORTH ST-RRS- L. CUY RIV
	N	MAH	062X	1775	5002052	MAHONING RIV & RR
	N	MAH	080R	125	5002257	OVER MEANDER RESERVOIR
	N	MAH	080R	125	5002281	OVER MEANDER RESERVOIR
	N	MAH	076R	91	5002702	LAKE MILTON
	N	MAH	076R	91	5002737	LAKE MILTON
	N	MAH	193R	72	5004470	CONRAIL & RAYEN AVE
	N	MAH	062D	54	5008514	SOUTH AVENUE

APPENDIX B

Bridges with Seated Hinges

Dist.	LMT	County	Route	SLM	SFN	Feature Intersected
	N	MAH	062D	54	5008522	SOUTH AVENUE
	N	POR	043R	1150	6701132	CUY RIVER, RRS, FRANKLIN
	N	POR	261R	119	6704964	PLUM CK & N&S RR
	N	POR	261R	119	6704972	PLUM CREEK & N&S RR
	N	STA	030R	1493	7600887	RAMP C 30WB TO 77SB
	N	STA	030R	1487	7600941	I77,CONRAIL,CREEK & RAMPS
	N	STA	043R	1339	7601379	CSX;N&S;CONRAIL RR
	N	STA	062R	1876	7602227	RMP G BR OVER I77 TOI77NB
	N	STA	062R	1885	7602235	RMP F(SB 30&62 TO SB 77)
	N	STA	077R	925	7603592	SB RMP B OV I77 TO 30 EB
	N	SUM	008R	566	7700636	PORTAGE TRAIL
	N	SUM	077R	1216	7703007	77 NB OVER JOHNSON ST& RR
	N	SUM	076R	1043	7703155	ON RMP OVER BDWY TO 76 EB
	N	SUM	077R	1547	7703600	OVER HAWKINS AVE
	N	SUM	271R	802	7709064	RIVERVIEW RD B&O RR CUY'R
	N	SUM	619R	77	7711034	TUSCARAWAS RIV, RRS,STS
	N	TRU	080R	191	7803397	PENN CENT B&O ELRR
	N	TRU	080R	191	7803427	PENN CENT B&O ELRR
5	5	FAI	022R	2441	2300427	CONRAIL RR & LIT RUSH CR
	N	GUE	723R	38	3006840	SR 723 OVER I-70
	N	GUE	723R	54	3006875	OVER B&O RR & CROOKED CRK
	N	LIC	C539B	15	4536940	RACOON CREEK BIKE TRAIL
6	N	FRA	070R	1322	2504413	70WB OVER SCIOTO RIVER
	N	FRA	070R	1322	2504448	EB70 OVER SCIOTO RIVER
7	B	CLA	SNYPK	1	1260529	BUCK CREEK
	N	CLA	072R	915	1205528	MT VER BUCK CK PC & DT &I
	N	MOT	035R	1513	5701597	CSRR CRR UND(USR-IR)RAMP
	N	MOT	035R	1516	5701627	CSRR CRR UND(IR-USR)RAMP
	N	MOT	035R	1576	5701929	MOSE BLVD G MM R CRR&STS
	N	MOT	035R	1576	5701937	CRR LONGWORTH STREET
	N	MOT	035R	1758	5702585	BOLTIN STREET
	N	MOT	075R	1044	5707056	CARILLON BLVD GT MIAMI R
	N	MOT	075R	1122	5707145	STEWART STREET
	N	MOT	075R	1164	5707366	ALBANY ST RAMP=I75*S-ST
	N	MOT	075R	1164	5707404	ALBANY ST RAMP=ST-I75*N
	N	MOT	075R	1174	5707447	RAMP=I75*N-US35*W
	N	MOT	075R	1175	5707501	RAMP=I75*S-US35*E
	N	MOT	075R	1180	5707595	RMP=US35*E-I75*N UN RMPS
	N	MOT	075R	1188	5707617	WASHINGTON STREET
	N	MOT	075R	1188	5707625	WASHINGTON ST CSRR CRR
	N	MOT	075R	1188	5707641	WASHINGTON STREET
	N	MOT	075R	1226	5707730	ROBT.,THIRD,GR.MIAMI RIV
	N	MOT	075R	1226	5707749	GRT MIAMI R THIRD ST &ST
	N	MOT	075R	1226	5707773	GRT MIAMI R THIRD ST &ST

APPENDIX B

Bridges with Seated Hinges

Dist.	LMT	County	Route	SLM	SFN	Feature Intersected
	N	MOT	075R	1226	5707781	ROBERT DR.,GR.MIAMI RIV.
	N	MOT	075R	1281	5708133	S49*N GT MIAMI R RVW AVE
	N	MOT	075R	1281	5708141	S49*N
	N	MOT	075R	1281	5708168	S49*N GT MIAMI R RVW AVE
	N	MOT	075R	1371	5708370	RIVERSIDE DR GT MM R &ST
	N	MOT	075R	1979	5708974	C28(LITTLE YORK ROAD)
8	1	HAM	050R	1904	3102785	6TH ST VIADUCT, SR264
	1	HAM	075R	1102	3110443	W FK MIL CR;GALBRAITH RD
	3	HAM	562R	147	3113914	ROSS AVENUE;CSRR
	N	GRE	444R	16	2902524	MAD RIVER
	N	GRE	444R	16	2902559	MAD R;RAMP=S444*S-C149*W
	N	HAM	050R	2239	3103455	PEDESTRIAN CROSSWALK
	N	HAM	052R	2414	3105679	BUTLER STREET
	N	HAM	052R	3083	3105776	RAMP=US52*E-SALEM ROAD*E
	N	HAM	071R	0	3105946	I71*N;3RR;I75*N;9USR;STS
	N	HAM	071R	155	3106616	MUNI RMP=VIA*W-SIXH ST*W
	N	HAM	071R	202	3106683	NB471-US22-TO-W-LIBST
	N	HAM	071R	1712	3107418	C256(CORNELL ROAD)
	N	HAM	074R	69	3107833	C48(NEW BIDDINGER ROAD)
	N	HAM	074R	69	3107868	C48(NEW BIDDINGER ROAD)
	N	HAM	075R	86	3109003	I75*S RAMP;NINTH ST*W
	N	HAM	075R	249	3109453	SPRING GROVE AVENUE
	N	HAM	075R	253	3109488	SPRING GROVE AVENUE
	N	HAM	075R	261	3109518	RMP=I75*N-WES HILS VIA*W
	N	HAM	075R	346	3109577	RAMP C FR HOPPLE TO NB 75
	N	HAM	075R	356	3109631	RMP=I75*N-US27*S(US52*E)
	N	HAM	074R	1908	3109798	I75
	N	HAM	071R	422	3114538	BLAIR AVENUE
	N	HAM	071R	838	3115224	RIDGE AVENUE
	N	HAM	074R	1908	3115720	US27*S;MILL CR;ACCESS DR
	N	HAM	074R	1908	3115739	US27*S;MLCK;2RR;STS;RAMP
	N	HAM	471R	0	3117324	TH ST CONN;EGGLESTON AVE
	N	HAM	471R	0	3117359	1RR;US52;THIRD ST CONN
	N	HAM	471R	0	3117367	1RR;US52;THIRD ST CONN
	N	HAM	471R	0	3117391	RELIEF
	N	HAM	471R	45	3117650	RAMP=PRKWY*W,ST*E-I471*S
	N	HAM	126R	1373	3118525	IR 75
	N	HAM	126R	1373	3118533	IR 75,ANTHONY WAYNE,RR
	N	HAM	126R	1434	3118630	I-75/MILL CREEK
	N	HAM	OLDMT	3403	3160785	MILL CREEK (OLD MITCHELL
	N	HAM	DANA	4071	3161455	PEDESTRIAN BRIDGE O/ DAN
	N	WAR	048R	863	8301085	LITTLE MIAMI R; BIKE PATH
9	N	ROS	035R	2530	7102259	SCIOTO RIVER
	N	SCI	052R	1881	7301359	SCIOTO RIVER
	N	SCI	052R	1881	7301383	SCIOTO RIVER

APPENDIX B

Bridges with Seated Hinges

Dist.	LMT	County	Route	SLM	SFN	Feature Intersected
10	N	WAS	050R	404	8401357	SR 618
11	N	BEL	007R	2006	700541	US40-SR767-I70-WHCR B&ORR
	N	BEL	007J	221	700584	INDIAN RUN,CSX RR, ACCESS
	N	BEL	007J	221	700592	INDIAN RUN,CSX RR, ACCESS
	N	BEL	070R	2618	702978	WEST ST.OVER I70,WHG.CR
	N	BEL	872R	44	705950	T-533A,CONRAIL,OE.RD.OH.R
	N	COL	030R	3661	1502387	ROAD,RR&OHIO R.BACK CHNL
	N	COL	030R	3664	1502395	RAMPS,RR&OHIO R.BACK CHL
	N	COL	039R	2031	1502689	RMP B OVR RMP&RR (OHIO R)
	N	COL	039R	2035	1502697	RMP A OVR CONRAIL(OHIO R)
	N	JEF	007R	166	4100050	WILLIAMS&MAIN,C&P W&LE RR
12	2	CUY	480R	647	1812831	ROCKY RIVER
	3	CUY	480R	1842	1812521	CUYAHOGA RIVER-OHIO CANAL
	3	CUY	480R	1842	1812548	CUYAHOGA RIVER-OHIO CANAL
	3	CUY	490R	100	1811991	CUYAHOGA RIVER
	3	CUY	37	8300	1832344	CR122,CUY,RR/HRVD-DEN #83
	3*	CUY	90	1524	1809393 CUYA	
	N	CUY	008R	226	1801244	SR-14 AND TINKERS CREEK
	N	CUY	071R	1016	1804650	NS,RTA91 AIRPT FRWY
	N	CUY	071R	1016	1804685	NS, RTA91
	N	CUY	071R	1791	1805371	SR 176(1328)JENNINGS FWY
	N	CUY	176J	1334	1805436	IR-71NB (CUY-71-1791R)
	N	CUY	271R	232	1810715	TINKERS CREEK @ MP 24.1
	N	CUY	271R	232	1810774	TINKERS CREEK @ MP 24.1
	N	CUY	480N	129	1811088	I-271 (CUY-271-0556)
	N	CUY	490R	30	1812068	W 14 ST
	N	CUY	422R	398	1812440	NS AT EAST 87TH ST.
	N	CUY	480N	11	1814494	SR-8 (0514) NORTHFIELD R

Total 163

LMT = Longitudinal Bridge Member.

1 = Two Girder Bridge
2 = Three Girder Bridge
3 = Four or more Girder Bridge
N = Not Applicable such as a rolled beam bridge
5 = Two Truss (Riveted)
B = Two or More Arches (Riveted)

* This bridge did not show up in the inventory search because it has more than one type of hinge, so the struts were coated not the seated hinge. This may be The case for other bridges, that may have seated hinges but do not show up on this list. Each district will have to verify this list in their own district.

APPENDIX C

The Emergency Bridge Closing and Repair of I-480 WB over the Rocky River (Bridge CUY-480-0647)

Preliminary Report

Table of Contents

GIRDER HINGE SUPPORT STRUCTURAL ANALYSIS

Bridge No. CUY-480-0647
over Rocky River

December 2000

Introduction

Bridge No. CUY-480-0647 carries eight lanes of Interstate Route 480 traffic over the Cuyahoga County Metroparks Rocky River Reservation, and the Rocky River in Fairview Park and Cleveland. The structure was built in 1970, and opened to traffic in 1980.

The structure consists of a reinforced concrete deck carried by stringers, floorbeams and continuous cantilevered welded steel girders. The eastbound lanes and westbound lanes structures are separated with a three-inch open joint between the median concrete barriers. Each portion of the structure is supported by three lines of steel girders. (See Figures No. 1 and 2.) The nine-span structure has compression hinges at the ends of girder cantilevers in spans four and six. The structure is 142 feet wide with an overall length of 1,571 feet for the eastbound lanes structure and 1,535 feet for the westbound lanes structure. The roadway is about 100 feet above the valley.

On October 12, 2000, a crack in a steel plate was found during a routine inspection. The steel plate was part of the steel girder cantilever supporting a compression hinge in span four of the median girder of the westbound structure. Further inspection discovered more cracks at the same location. (See Figure No. 3.) Welded repairs performed at the same location also cracked. On November 11, 2000, the westbound structure was closed to traffic. A temporary support beam was installed on November 17 and 18, and the westbound structure was reopened on November 19, 2000, with traffic restricted to three lanes.

Structural Analysis

The finite element models were analyzed using STAAD/Pro (Release 3.1) by Research Engineers, Inc., of Yorba Linda, CA.

1. A finite element model was created for Girder GD from floorbeam 25, through floorbeam 26, to the cantilever end of the hinge. (See Figure No. 4.) The wireframe model was rendered using AutoCAD to check for "holes" in the model. (See Figure No. 5.) Dead load stress reached 17.4 ksi (See Figure No. 6.), and the live load stress was 6.7 ksi. This stress was concentrated in the web of the girder under the seat plate, next to the box plate.

2. The model was modified to reflect two cracks through the box plate, one above the seat plate on the outside of the girder and the other below the seat plate on the inside of the girder. This

changed both the locus and the intensity of the maximum stress. The locus changed to the web immediately behind the box plate, just above the seat plate. The dead load stress increased from 17.4 ksi to 23.9 ksi, and the live load stress from 6.7 ksi to 9.2 ksi. The total unfactored stress (33.1 ksi) is close to the yield strength of A-36 steel (36 ksi).

3. The model was again modified to incorporate removal of a portion of the box plate above the seat plate. This changed the locus of the stress concentration to the intersection of the seat plate and the edge of the web immediately above the seat plate, which is where the seat plate transfers the loads into the web. (See Figure No. 8.) The dead load stress increased to 31.0 ksi, and the live load stress to 11.9 ksi. The total unfactored stress (42.9 ksi) exceeds the yield strength of A-36 steel (36 ksi).

4. A through-the-web crack was added to the model. The crack originated in the locus of the previous model, arcing upwards for about two inches, then leveling off and running about horizontally until it reached the knee brace at floorbeam 26, where it essentially stopped. The new locus of the stress concentration is at the end of the crack in the web, with the floorbeam knee brace acting as a box plate, quickly dissipating stresses into the web. The stresses declined slightly, with dead load at 27.5 ksi, and live load at 10.6 ksi. The total unfactored stress (38.1 ksi) exceeds the yield strength of A-36 steel (36 ksi). (See Figure No. 9.)

5. The model was again modified to add a partial-depth crack in the seat plate, representing a weld tear-out by the box plate. The stresses reported were greatly out of line with the other models, so it is suspected that the extreme stresses are located within the depth of the new crack. (See Figures No. 10 and 11.) Comparison of stresses reported in the web of the girder at the end of the web crack are consistent with those in the previous model.

6. The original (uncracked) model was used again, changed to reflect three retrofit considerations:

   a. The web is notched in a two-inch radius quarter-circle centered at the back of the box plate, two inches above the seat. The box plate is removed for two inches in this option. (See Figure No. 12.) The stresses are greatly amplified in this model - dead load, 55.4 ksi; live load, 21.3 ksi. This option was dismissed, since the dead load is at about the ultimate strength of A-36 steel (58 ksi). The locus of the stress concentration is on the radius of the web notch, about 1½ inches above the seat plate.

   b. This retrofit is similar to the previous model, except the web notch is a full semi-circle centered at the same location. (See Figure No. 13.) The locus of the stress concentration is about the same as in the previous model, while the stresses are about ten percent less. Dead load stress is 50.5 ksi, and live load stress is 19.4 ksi.

   c. Using the previous model and adding the box plate back in greatly reduced the stresses in the girder web. (See Figure No. 14.) The locus of the stress concentration stayed about the same, but the dead load stress dropped to about 26.0 ksi, and the live load stress to about 10.0 ksi. The box plate picks up much of the vertical load component, with dead load stress of about 16.3 ksi, and live load stress of about 6.3 ksi. (See Figure No. 15.)

A further examination of the stresses in this scheme is instructive. The majority of the maximum stresses observed occur in the horizontal direction. (See Figures No. 16 and 17.) The dead load stresses are 24.1 ksi horizontal and 17.6 ksi vertical; live load, 9.3 ksi horizontal and 6.8 ksi vertical. This indicates that for this model, the primary stress is shear through the girder web caused by the beam action of the hinge cantilever, where the seat plate is the tension flange of the hinge. This in turn indicates that the web may be too thin to properly disperse the tension/shear field from the seat plate.

Summary and Conclusions

The series of finite element models indicates a possible failure sequence in the hinge cantilever. The stresses in the original (uncracked) model are higher than current design allowables, but not so high as to cause failure by themselves. The combination of forces applied to the weld from the upper box plate to the top of the seat plate likely introduced fatigue cracking into the three-way intersection between the box plate, the seat plate, and the web plate.

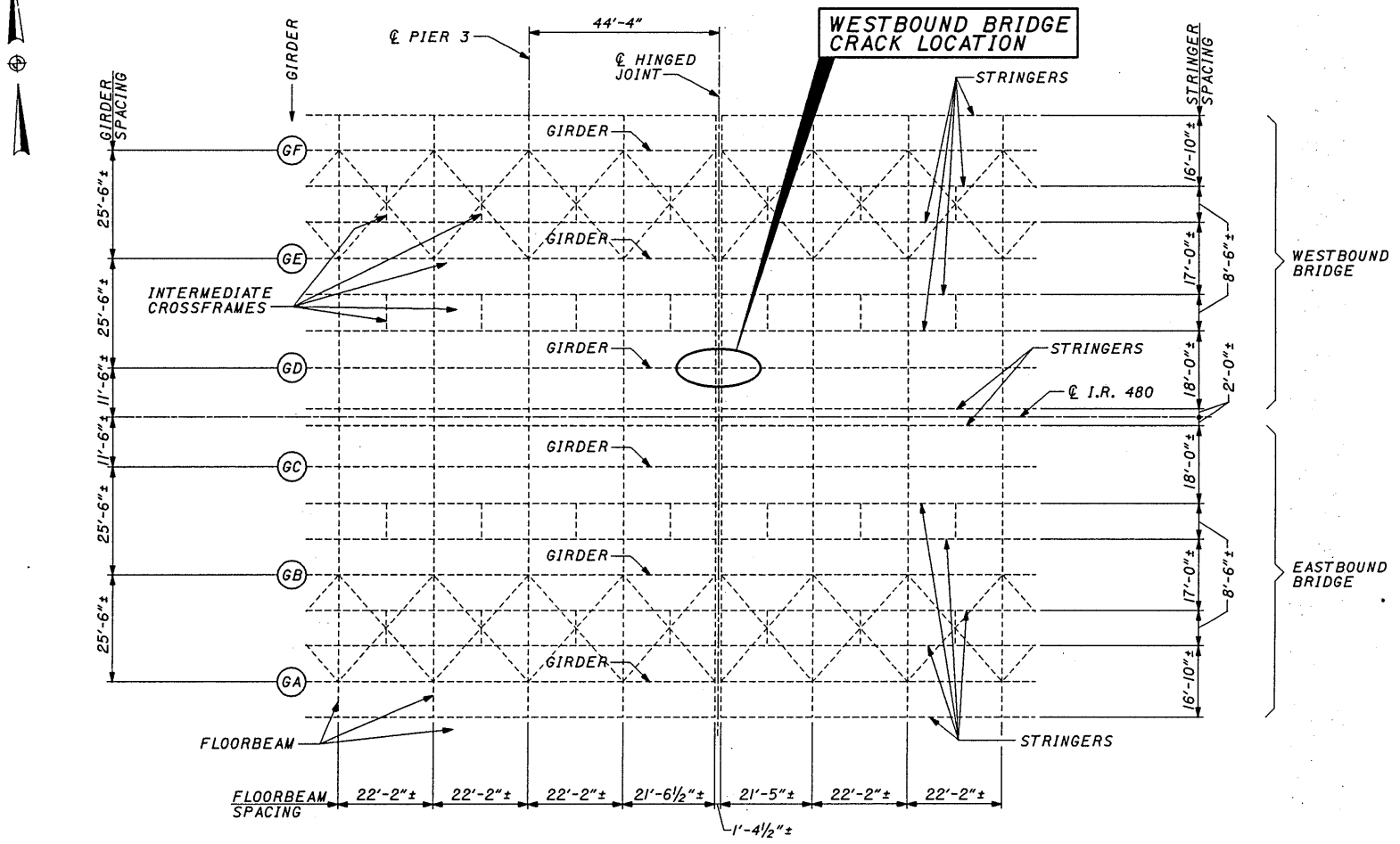
The upper box plate is obviously a tension member. The bending action of the hinge cantilever puts tension into the seat plate at the same time. The tension in the seat plate translates into a shear in the box plate, which produces a twist around the axis of the weld joining them. At the free edges of the box plate, this twisting can be absorbed by the flexibility of the plates. At the web, however, the box plate is restrained, so the stress from the twisting is concentrated in the weld near the web. This concentrated stress, combined with fabrication stresses due to welds intersecting there from three directions, created a major stress concentration in the web and box plate at the seat plate, effectively reducing the fatigue life of the joint. Once the fatigue life was used up, a crack initiated in or near the box plate to seat plate weld at the web. The tension in the box plate allowed the crack to propagate across the box plate width, until the cracks were completely across the plate, similar to the second model.

Once the box plate cracked completely across, the stress was then concentrated in the web. The web probably cracked at the same time the box plate cracked, but did not propagate until the box plate was completely cracked and not carrying the vertical loads. The transfer of the vertical load into the web concentrated the highest stress at the tip of the crack in the web, causing it to crack further and further until it reached the floorbeam knee brace. Once the crack reached the floorbeam knee brace, it stopped, because the stiffener is acting as the box plate, distributing the vertical loads along the height of the web.

Conclusions drawn from this analysis and incorporated into the design of the retrofit plans include:

- The box plate serves to distribute the vertical load from the hinge cantilever into the full depth of the web. Cracks or notches in the box plate need to be repaired.

- Stresses need to be reduced in the web, especially live load stresses at the box plate/seat plate intersection.

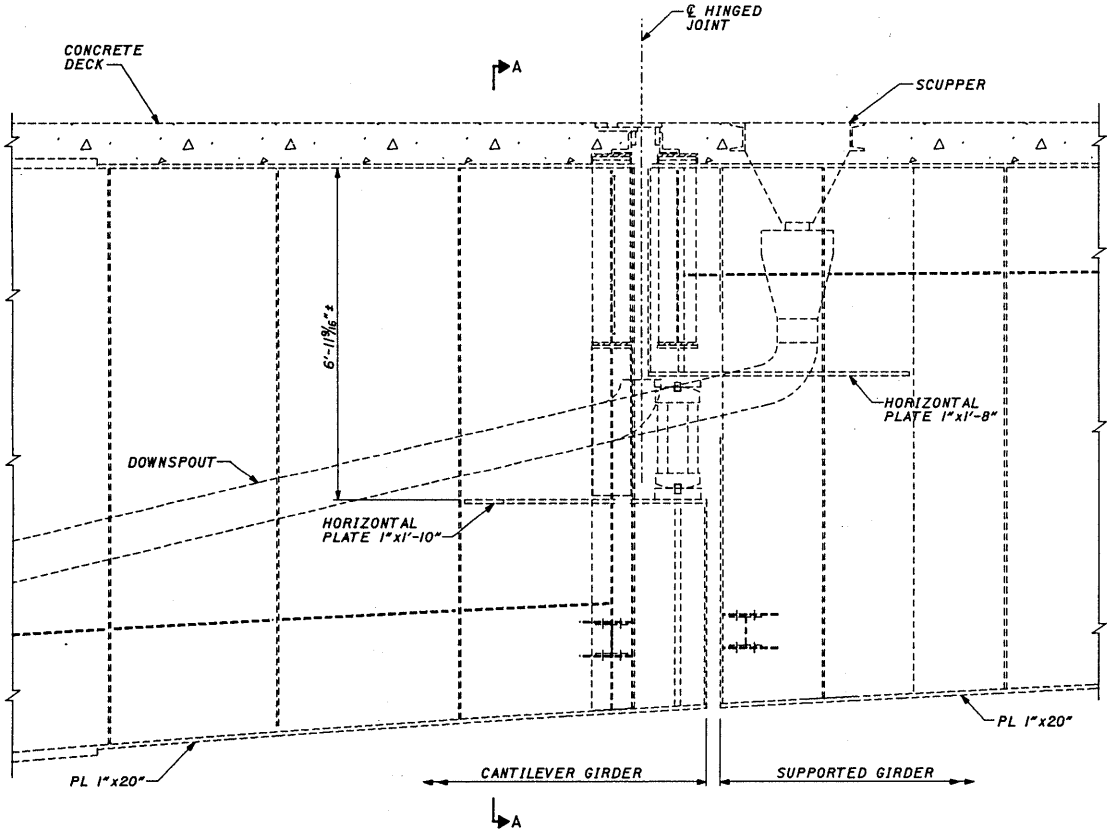


FRAMING PLAN

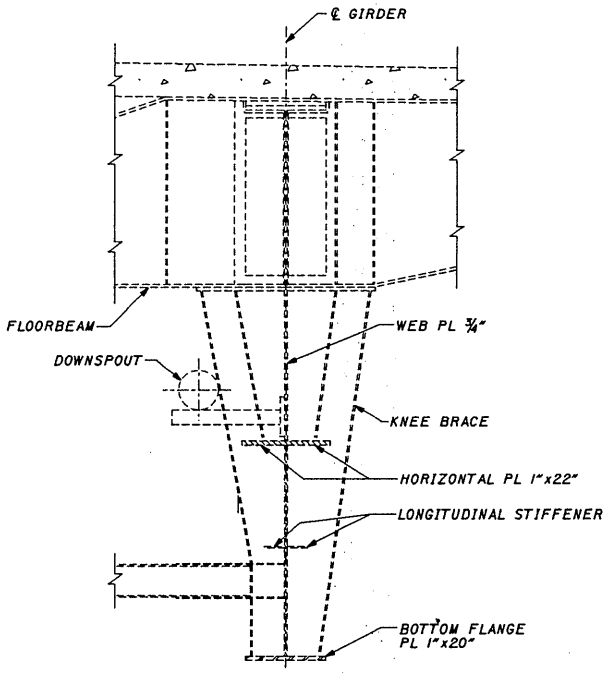
CUY-480-0647

Figure No. 1

RICHLAND ENGINEERING LIMITED



GIRDER ELEVATION

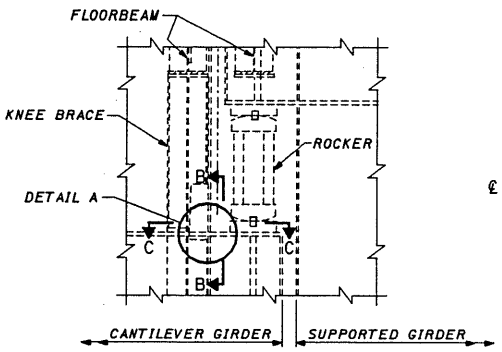


SECTION A-A

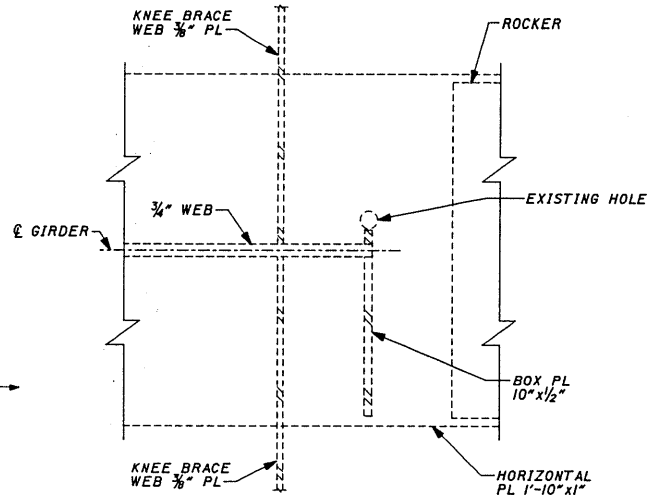
CUY-480-0647

Figure No. 2

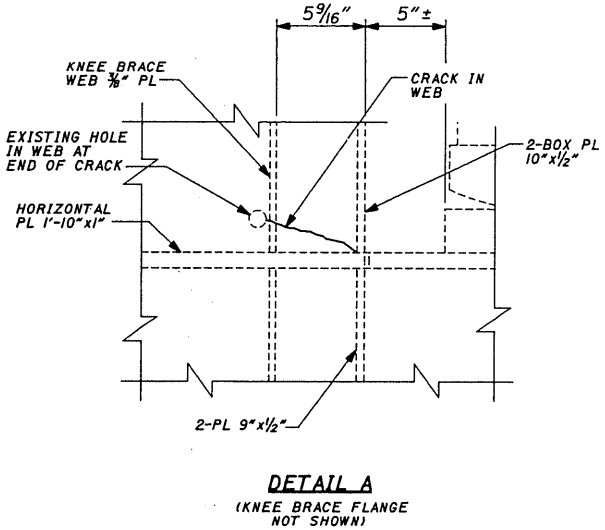
RICHLAND ENGINEERING LIMITED



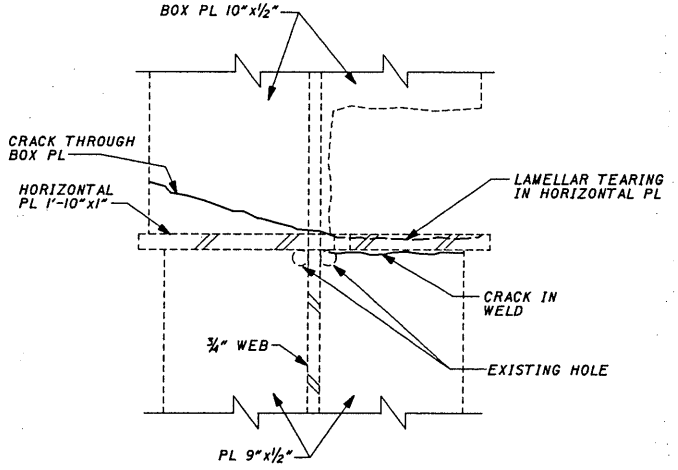
ELEVATION VIEW



SECTION C-C



DETAIL A
(KNEE BRACE FLANGE NOT SHOWN)



SECTION B-B

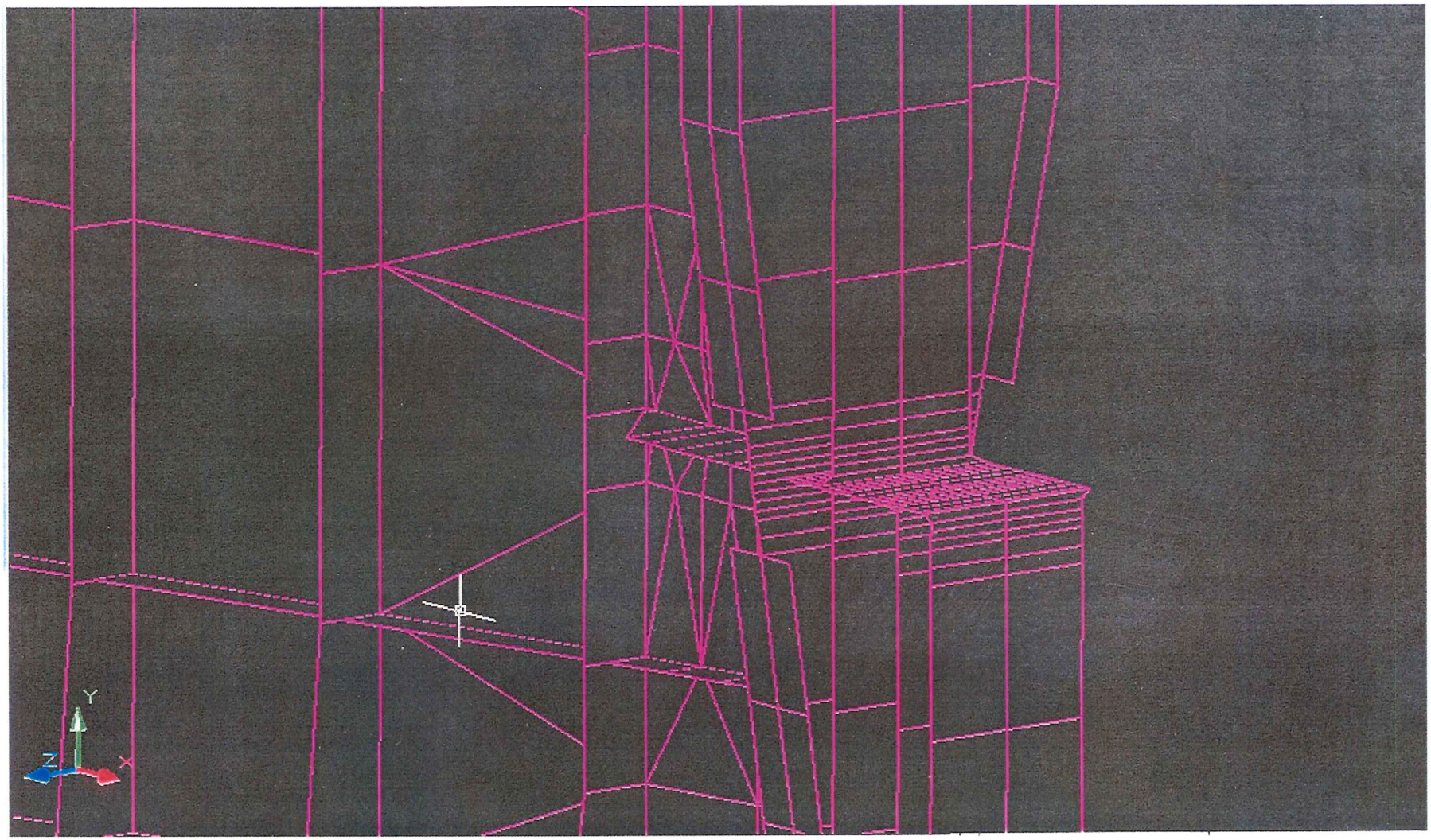


Figure No. 4 - Wireframe rendition of finite element model.

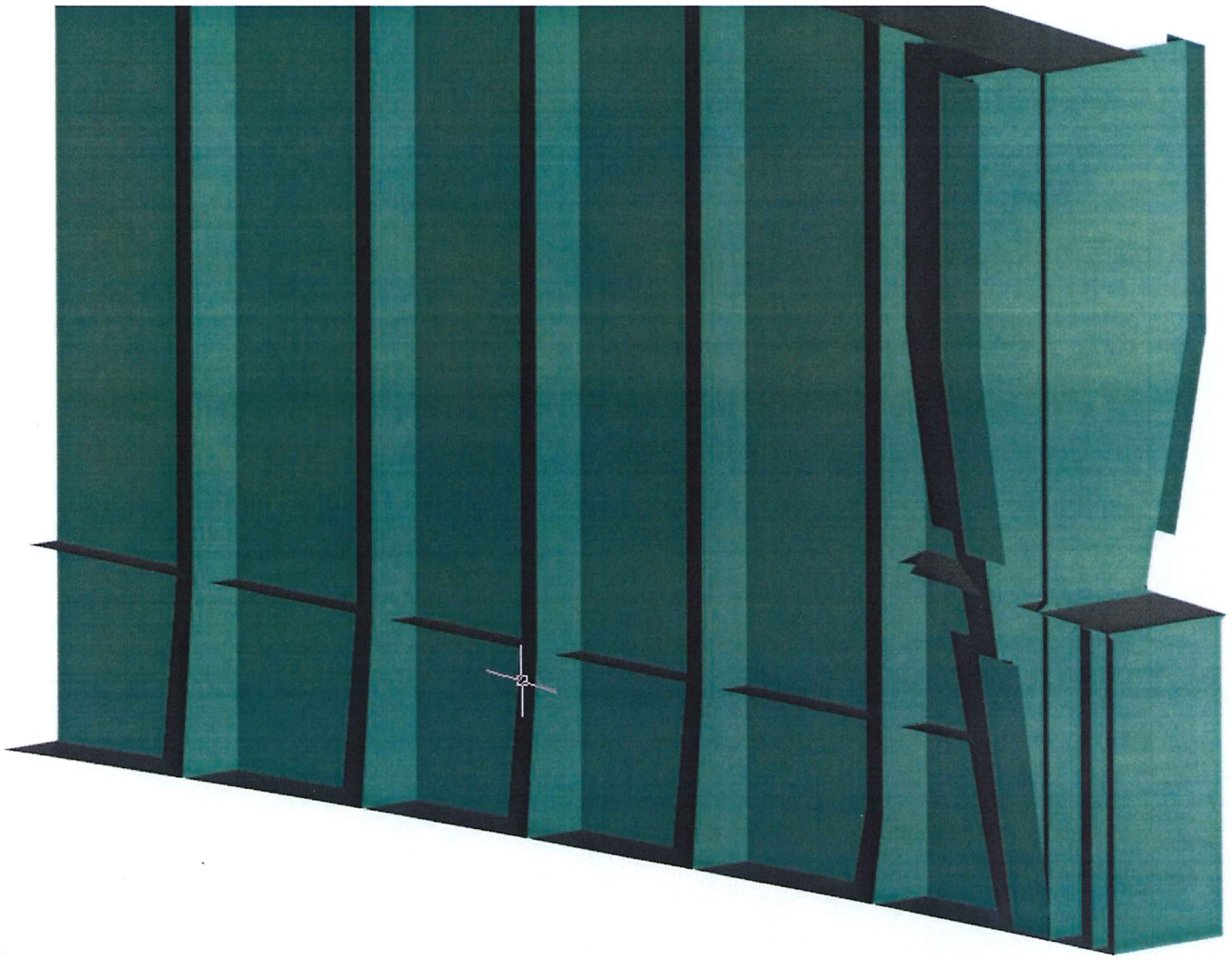


Figure No. 5 - 3-D rendition of finite element model.

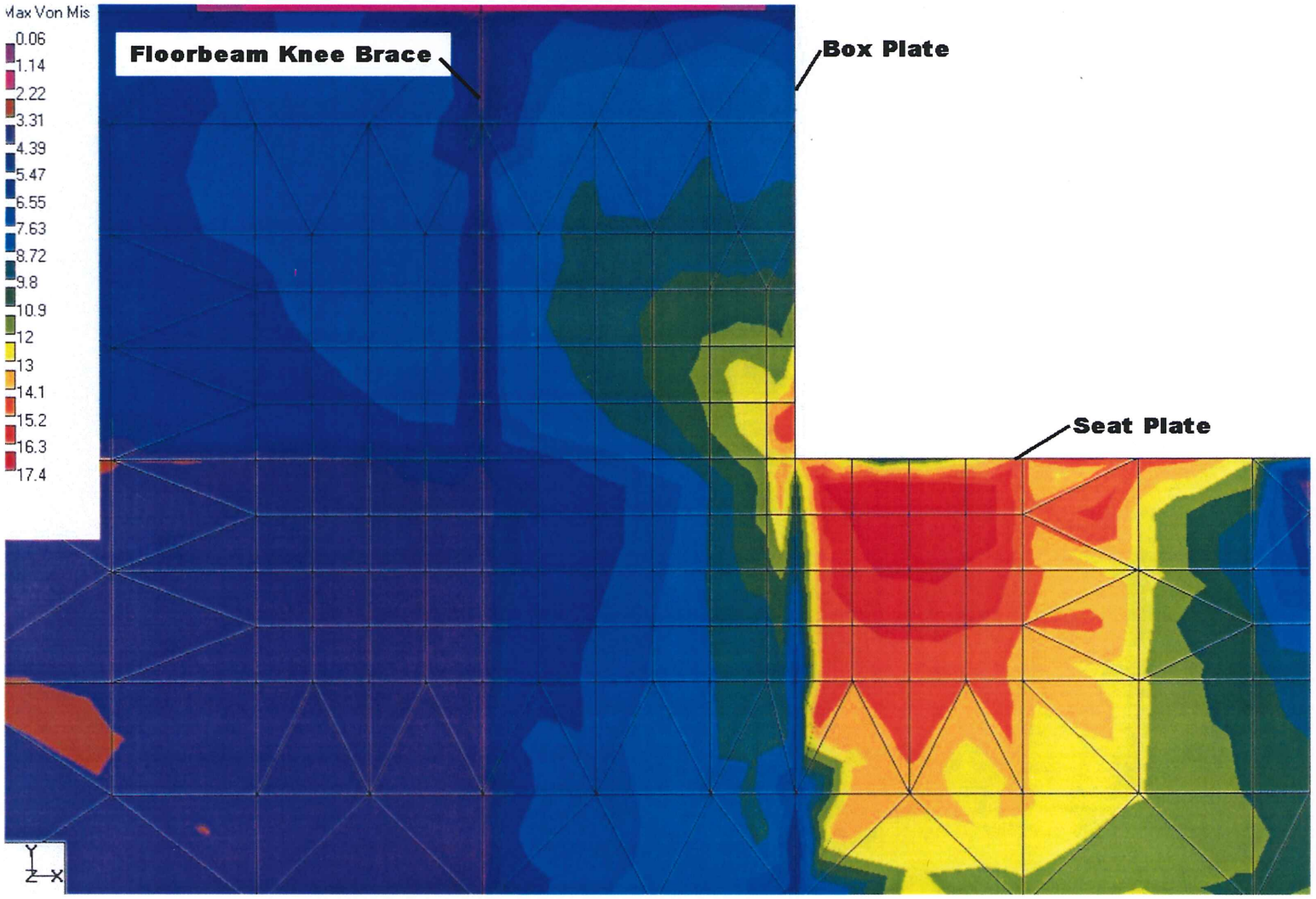


Figure No. 6 - Dead Load stress distribution for web of uncracked model.

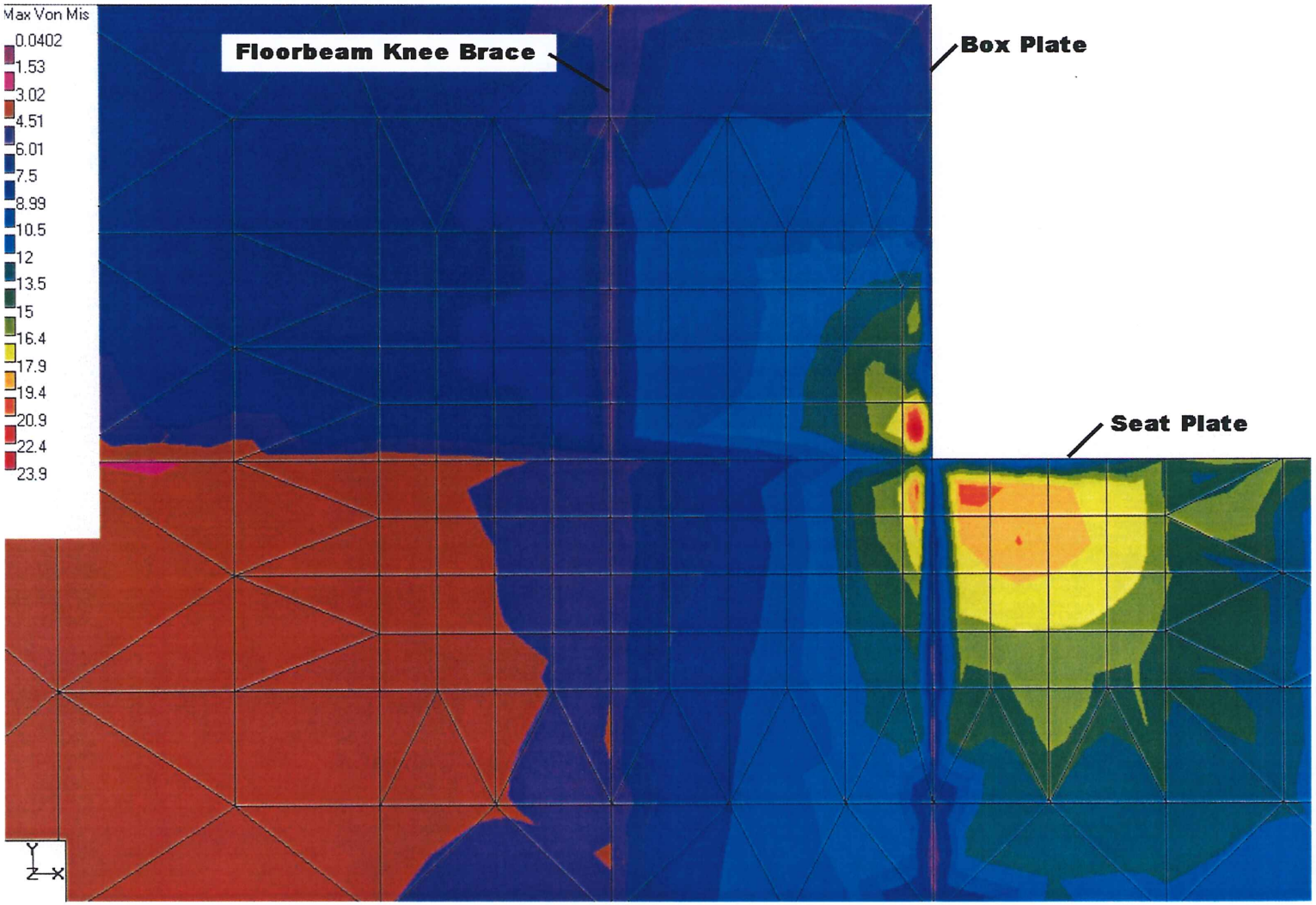


Figure No. 7 - dead load stress distribution in web for model with 2 cracks through box plate.

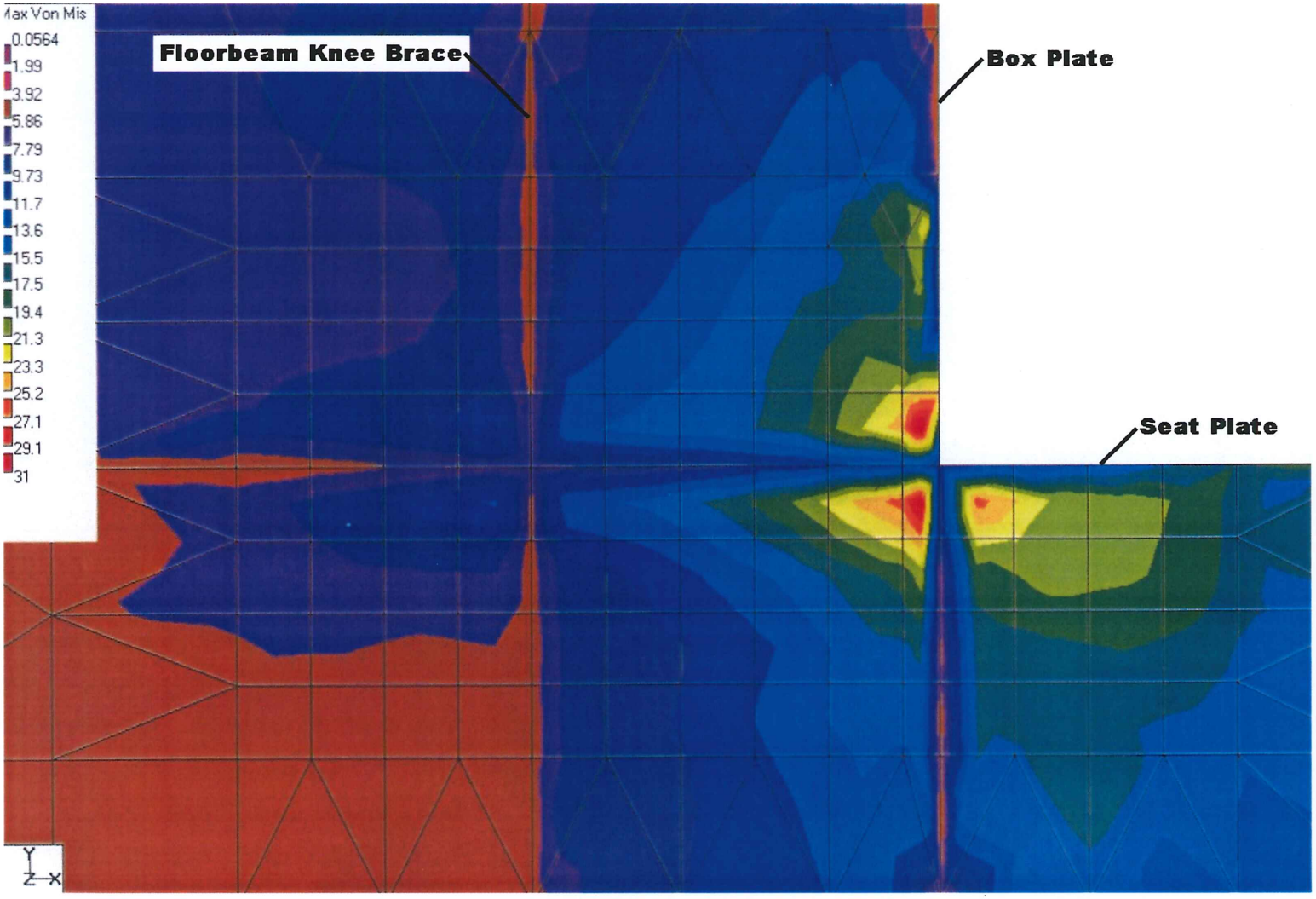


Figure No. 8 - Dead load stress distribution in web for model with 2 cracks through box plate and notch in box plate.

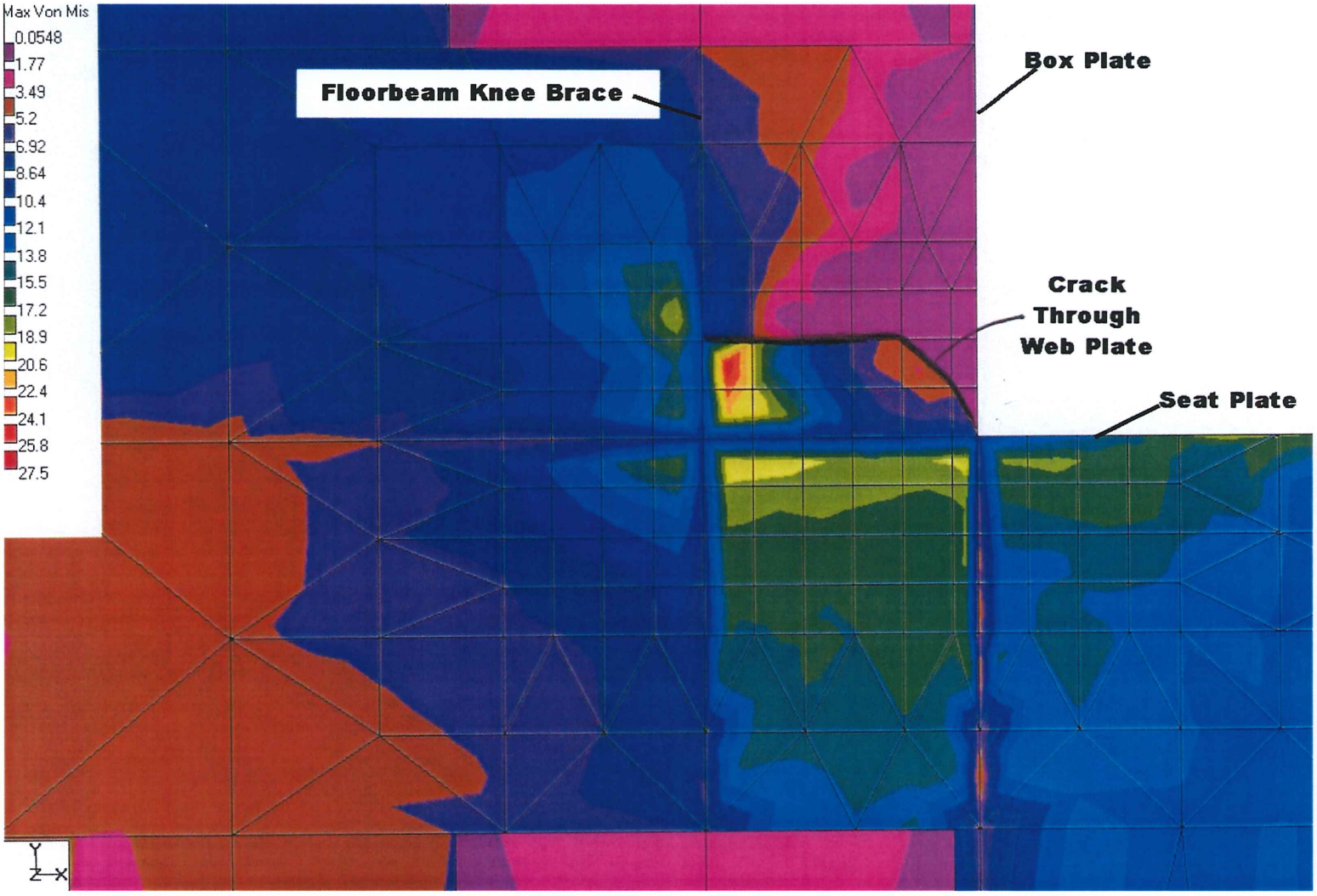


Figure No. 9 - Dead load stress distribution in web for model with 2 cracks and notch in box plate, and crack through web plate.

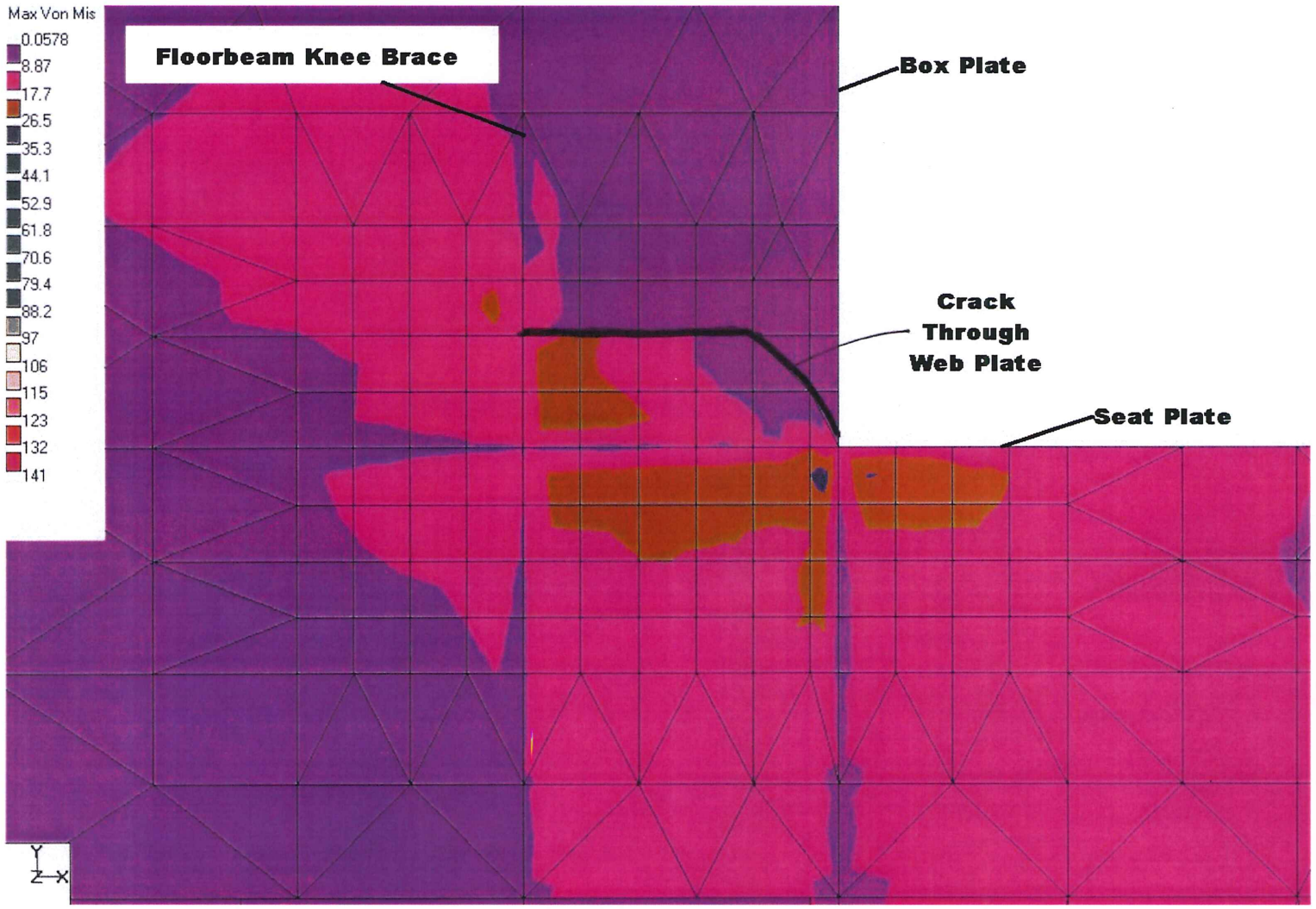


Figure No. 10 - Dead load stress distribution in web for model with 2 cracks and notch in box plate, crack through web, and partial-depth crack in seat plate.

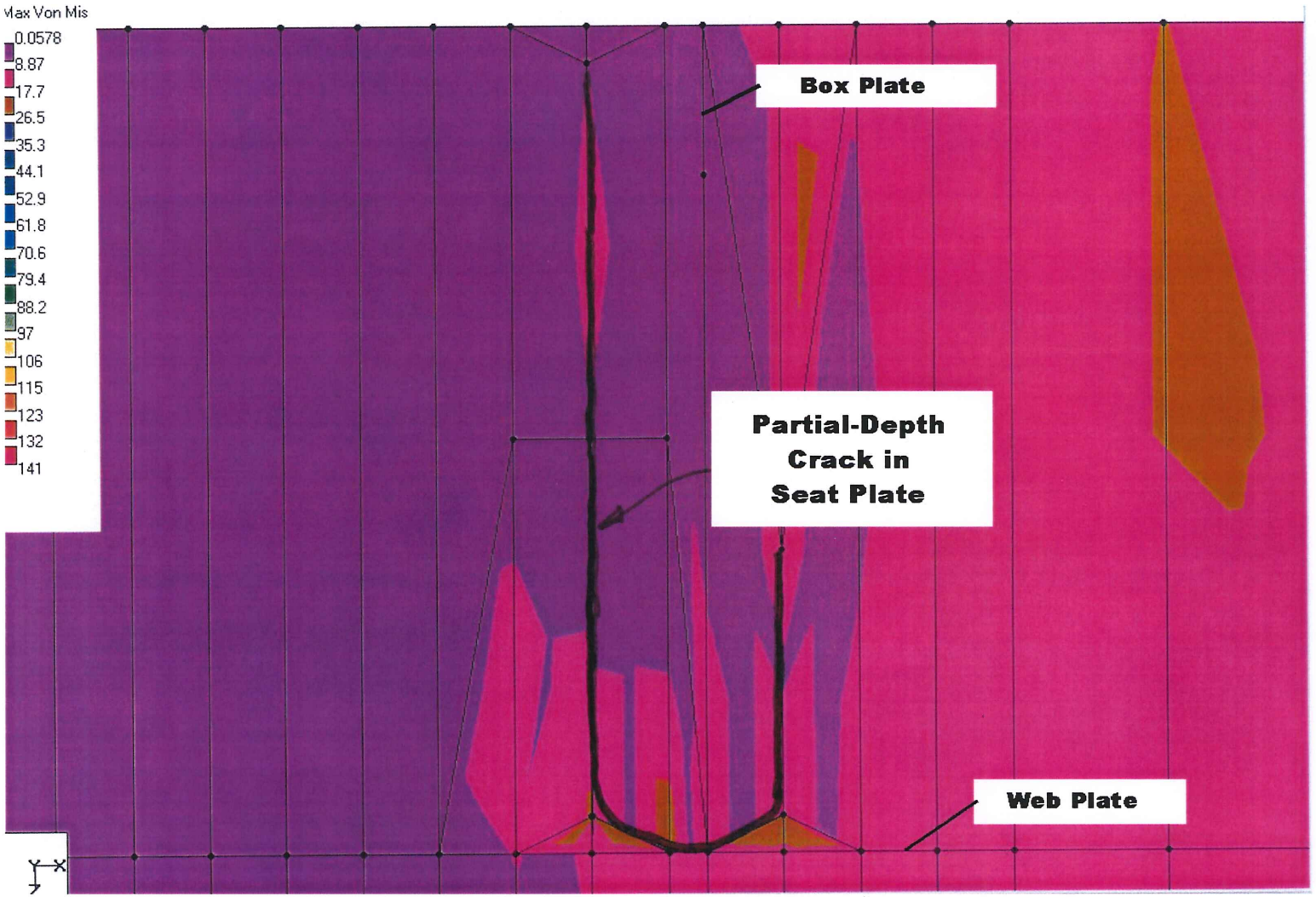


Figure No. 11 - Dead load stress distribution in seat plate for model with 2 cracks and notch in box plate, crack through web, and partial-depth crack in seat plate.

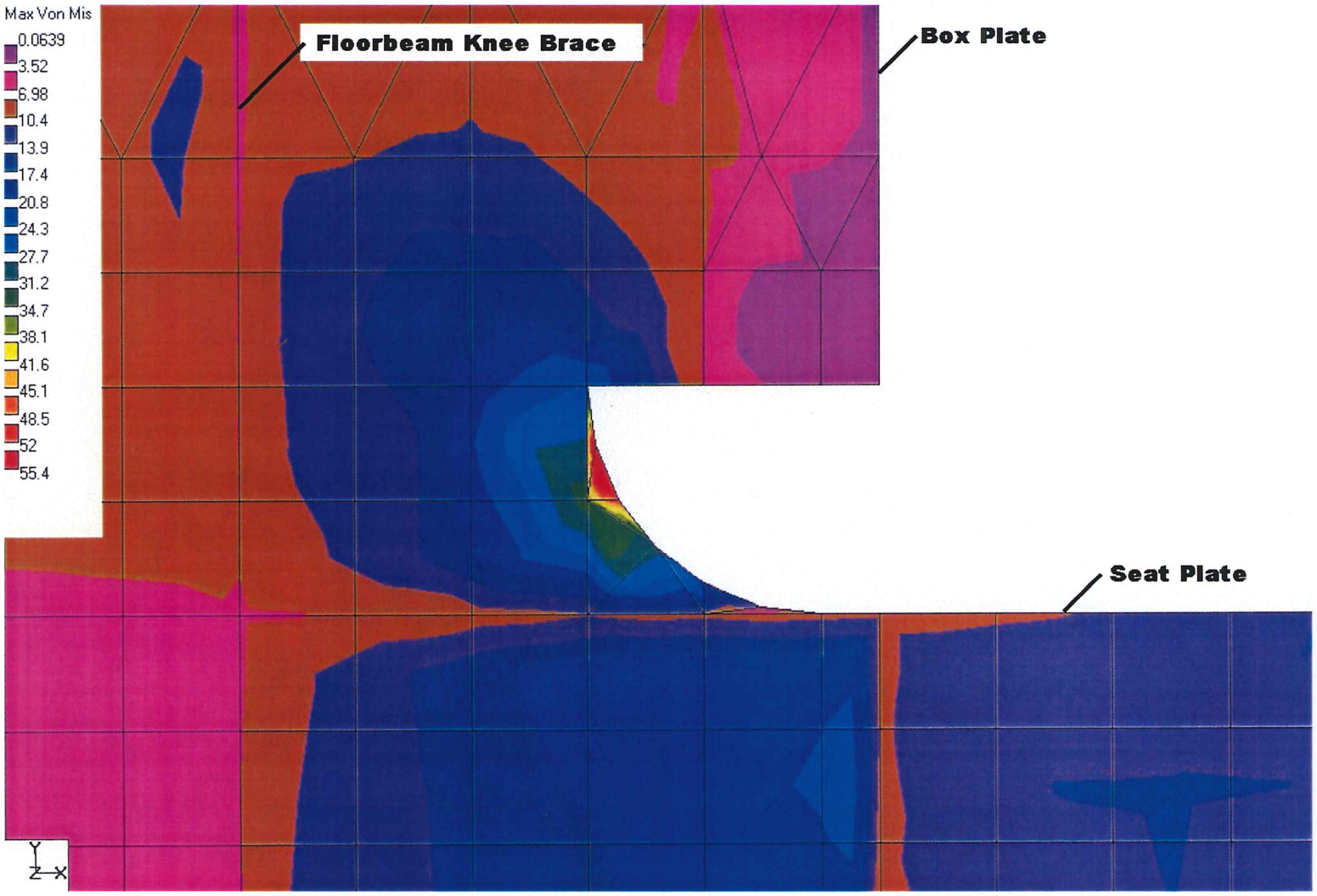


Figure No. 12 - Dead load stress distribution in web for retrofit model with quarter-circle notch.

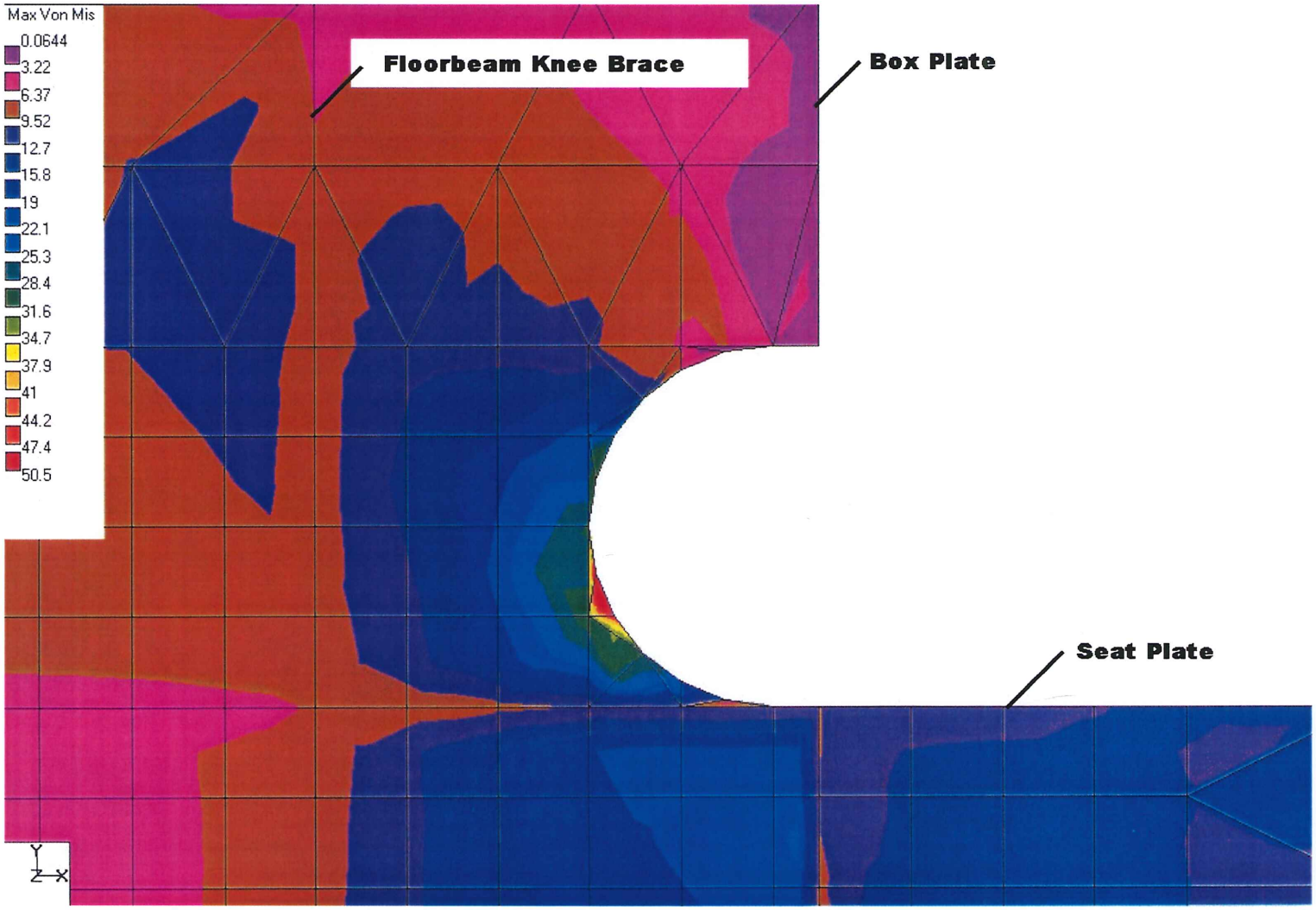


Figure No. 13 - Dead load stress distribution in web for retrofit model with half-circle notch.

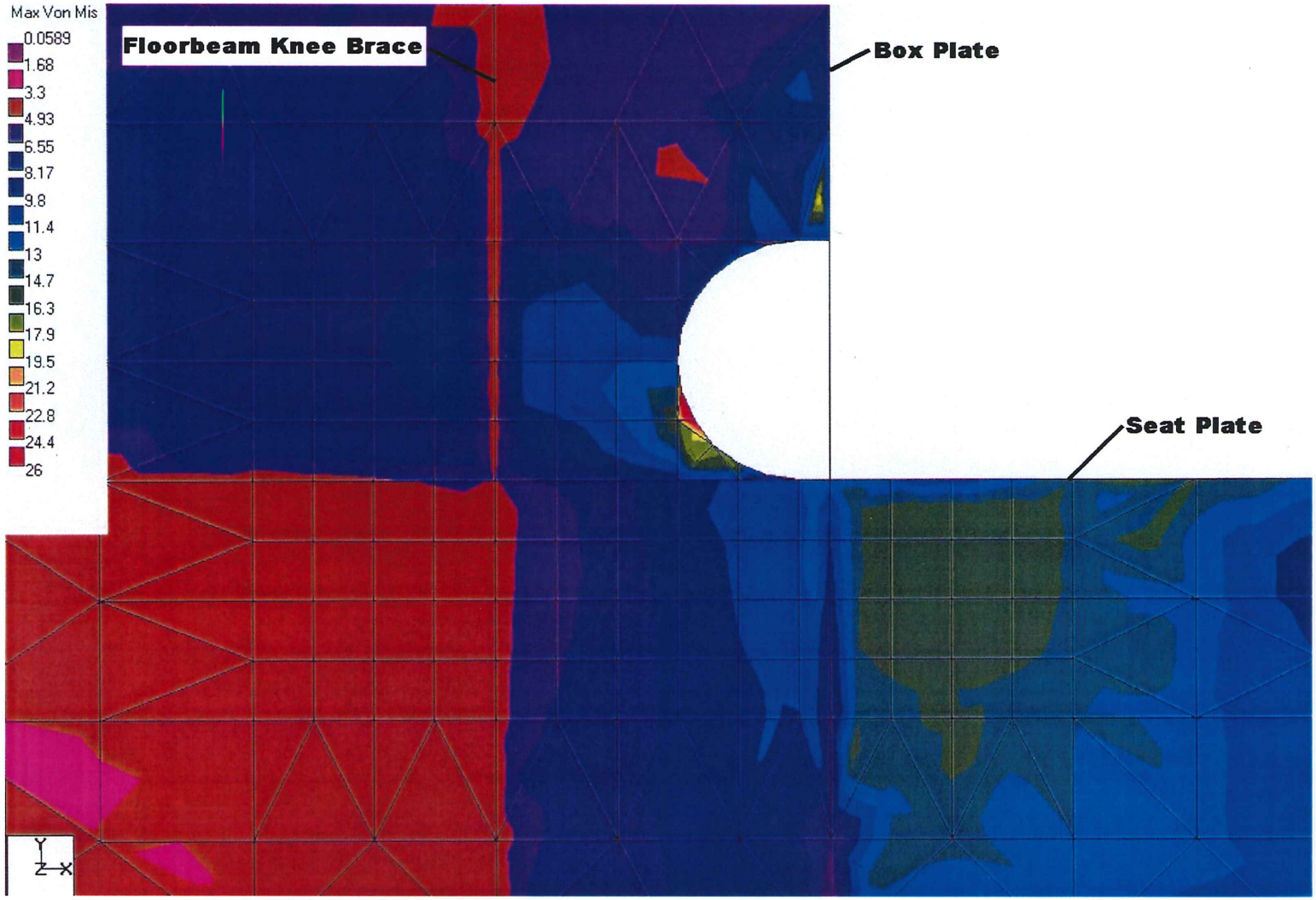


Figure No. 14 - Dead load stress distribution in web for retrofit model with half-circle notch and box plate.

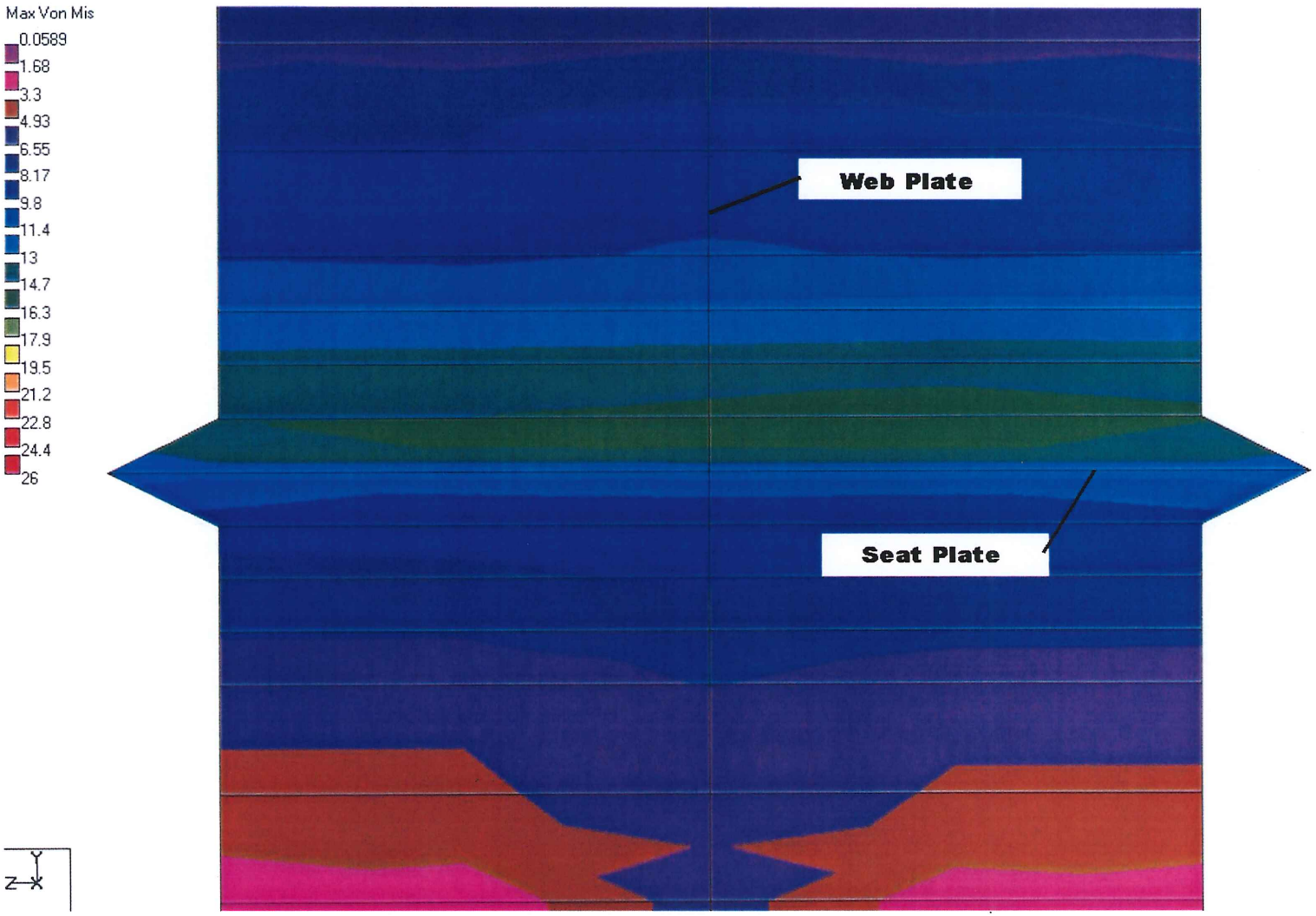


Figure No. 15 - Dead load stress distribution in box plate for retrofit model with half-circle notch and box plate.

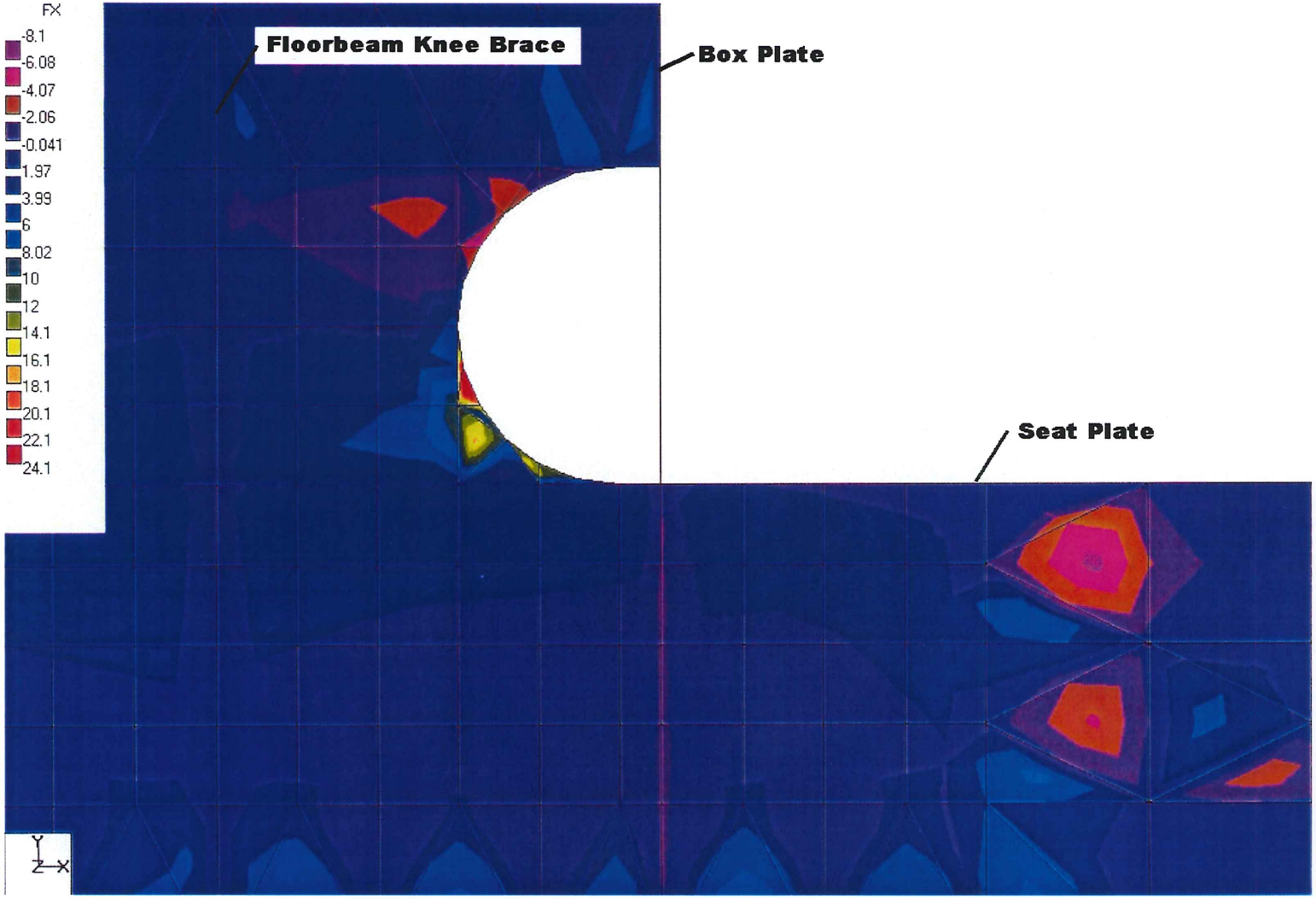


Figure No. 16 - Dead load stress distribution in web for retrofit model with half-circle notch and box plate, showing shear stresses acting in the X (horizontal) direction.

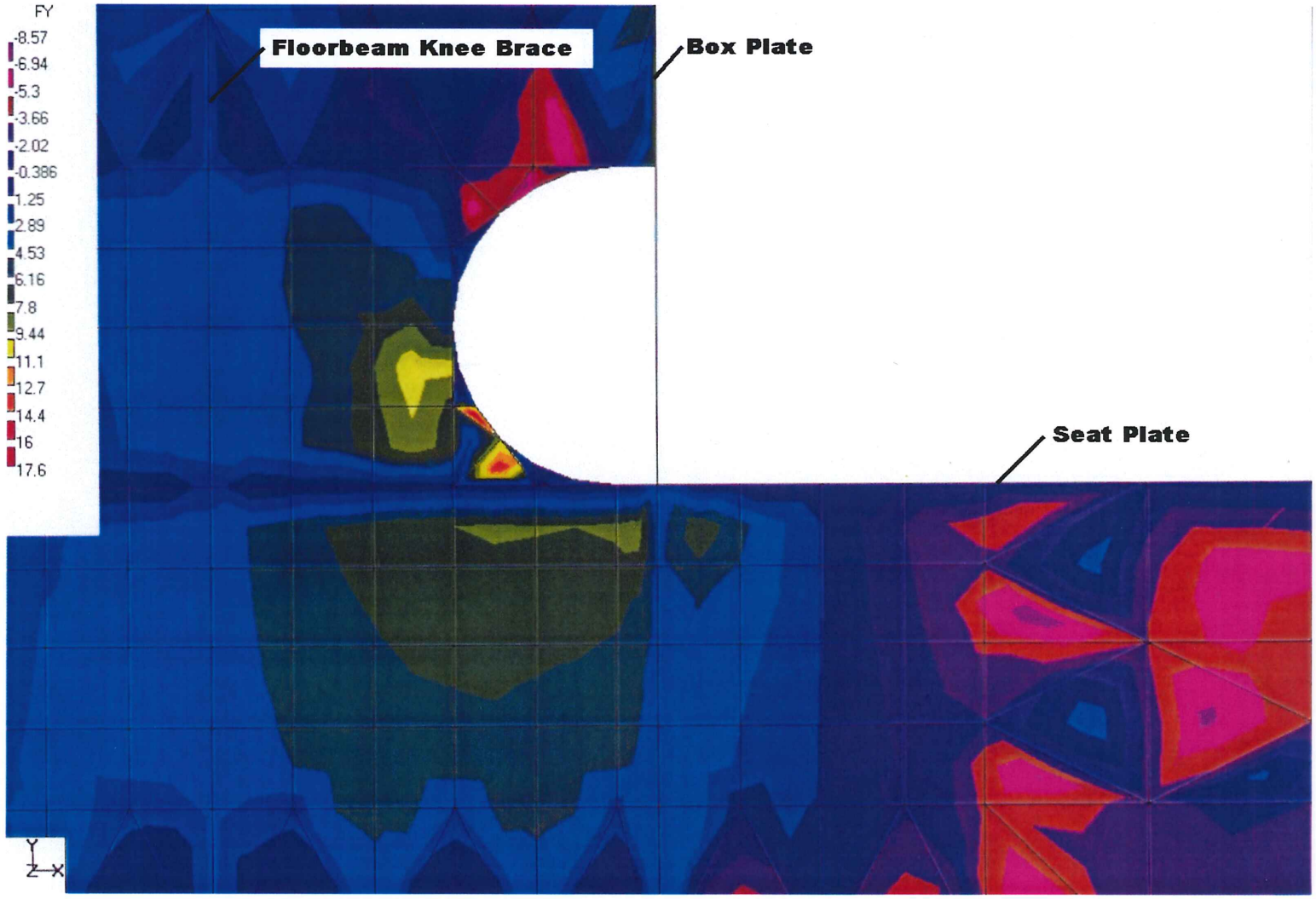
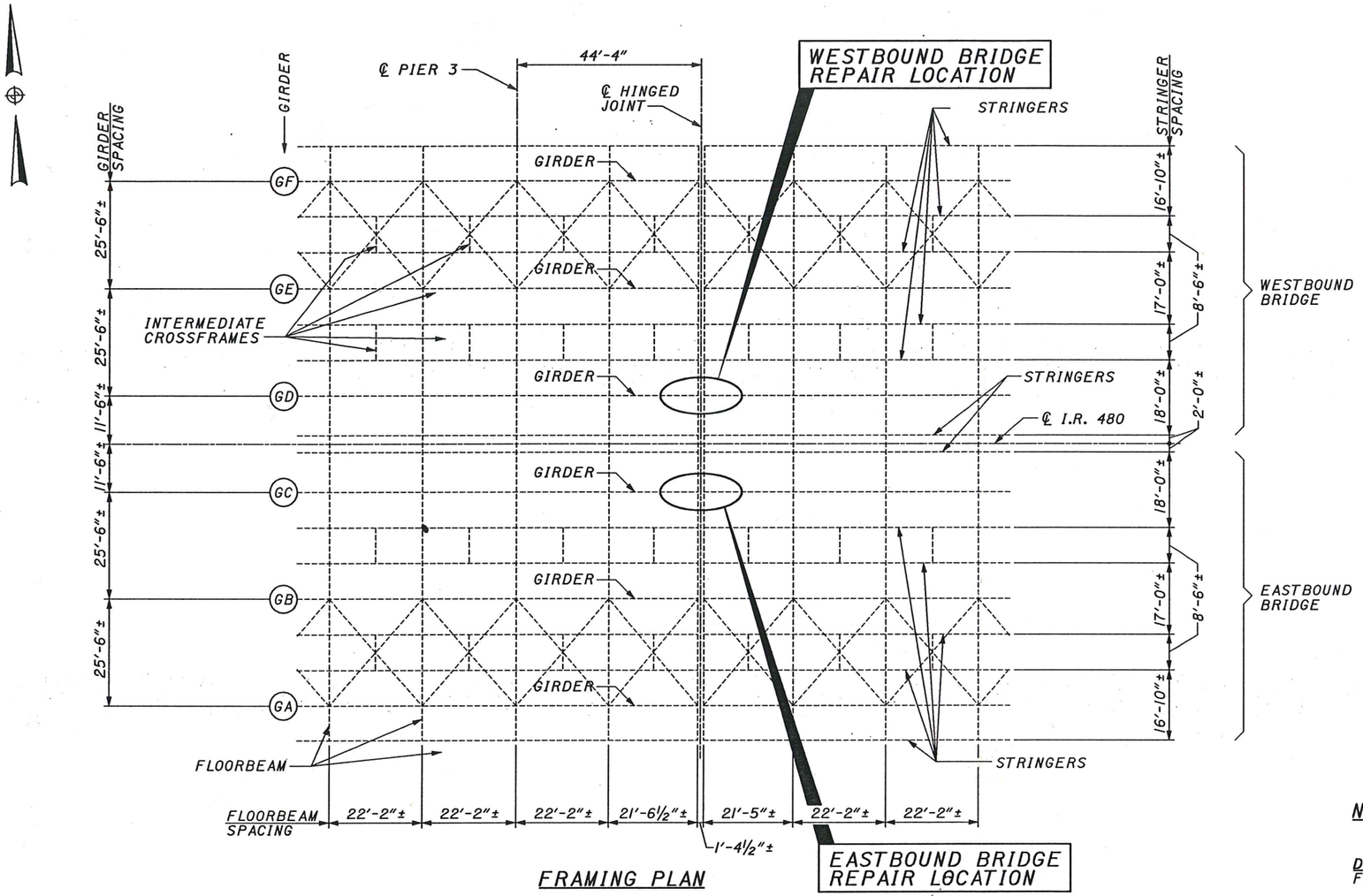
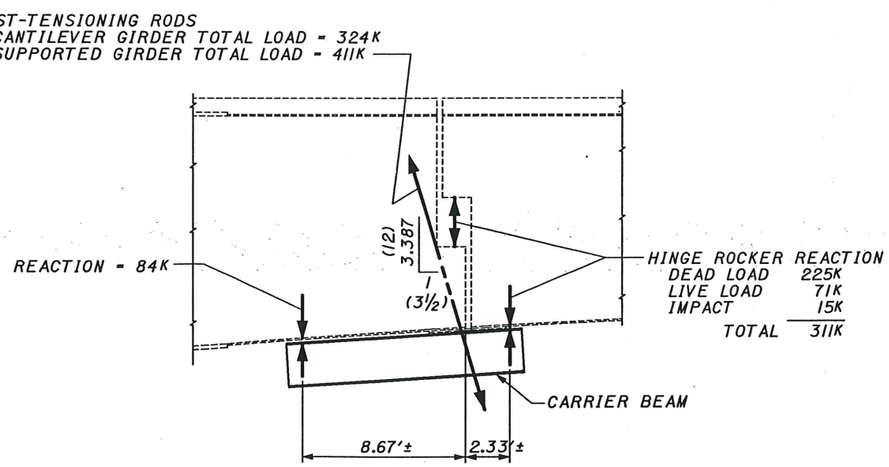


Figure 17 - Dead load stress distribution in web for retrofit model with half-circle notch and box plate, showing shear stresses acting in the Y (vertical) direction.



FRAMING PLAN



LOADING DIAGRAM

NOTES

DESIGN LOADING: HS20-44 AND THE ALTERNATE MILITARY LOADING FOR ADDED NEW MATERIAL. NO FUTURE WEARING SURFACE INCLUDED.

MATERIALS:
STRUCTURAL STEEL - ASTM A572/A709 GRADE 50 - YIELD STRENGTH 50,000 PSI
POST-TENSIONING ROD - ASTM A722 HIGH STRENGTH THREAD BAR - ULTIMATE STRENGTH 150,000 PSI.

CVN: WHERE A SHAPE OR PLATE IS DESIGNATED (CVN) THE MATERIAL SHALL MEET SPECIFIED MINIMUM NOTCH TOUGHNESS REQUIREMENTS AS SPECIFIED IN 711.01.

HIGH STRENGTH BOLTS SHALL BE 1 INCH DIAMETER ASTM A325, GALVANIZED, UNLESS OTHERWISE NOTED.

STRUCTURAL STEEL SHALL BE FABRICATED AND ERECTED IN ACCORDANCE WITH SUPPLEMENTAL SPECIFICATION 863 - STRUCTURAL STEEL MEMBERS.

PAINTING NEW AND EXISTING STEEL: THE EXISTING PAINT SYSTEM IS OZEU APPLIED IN 1990. DAMAGED AND DETERIORATED EXISTING PAINT SHALL BE TOUCHED UP AND COATED IN ACCORDANCE WITH SUPPLEMENTAL SPECIFICATION 815 - FIELD PAINTING OF EXISTING STEEL, SYSTEM OZEU. NEW STRUCTURAL STEEL AND POST-TENSIONING RODS SHALL BE PAINTED IN ACCORDANCE WITH ITEM 816 - FIELD PAINTING OF NEW STEEL, SYSTEM IZEU. MATERIALS SHALL BE IN ACCORDANCE WITH SUPPLEMENTAL SPECIFICATION 910 - OZEU STRUCTURAL STEEL PAINT. THE COLOR OF THE TOP COAT SHALL MATCH THE EXISTING STRUCTURAL STEEL PAINT COLOR. NEW FABRICATED ASSEMBLIES MAY BE SHOP PAINTED WITH ALL COATS.

RICHLAND ENGINEERING LIMITED
29 NORTH PARK STREET
MANSFIELD, OHIO 44902

DESIGNED	DRAWN	REVIEWED	DATE
DAP	JLS	DLR	01/23/01
CHECKED	REVISED	STRUCTURE FILE NUMBER	
KAK		1812831	

GENERAL NOTES AND FRAMING PLAN
BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

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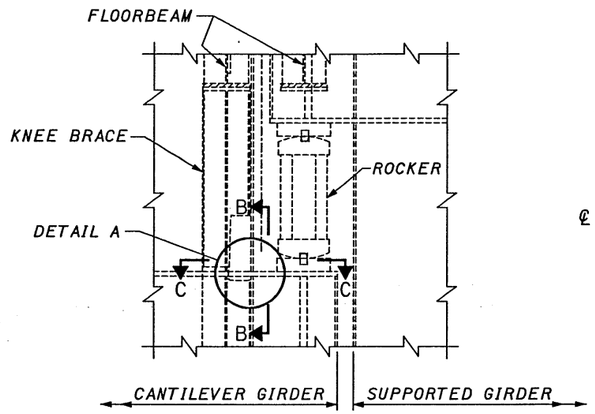
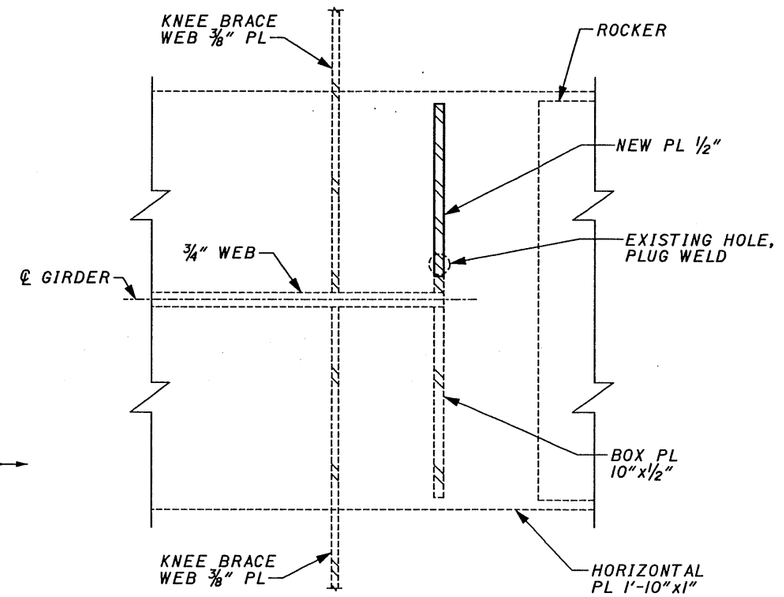
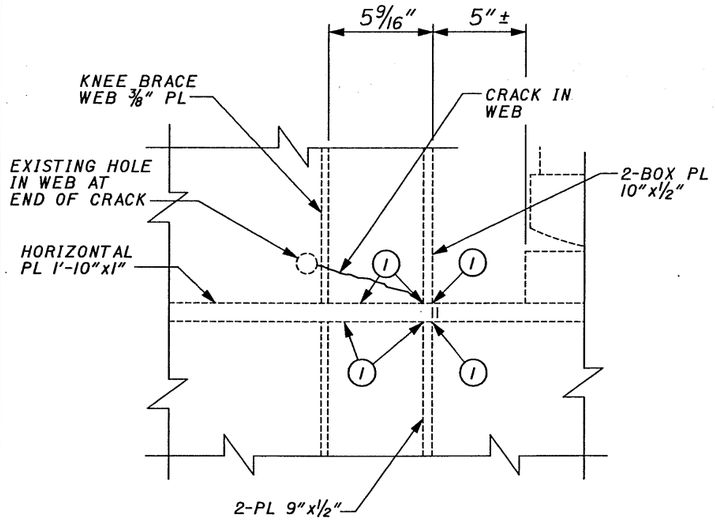
210FRA.DGN 01/23/01 JLS



ELEVATION VIEW

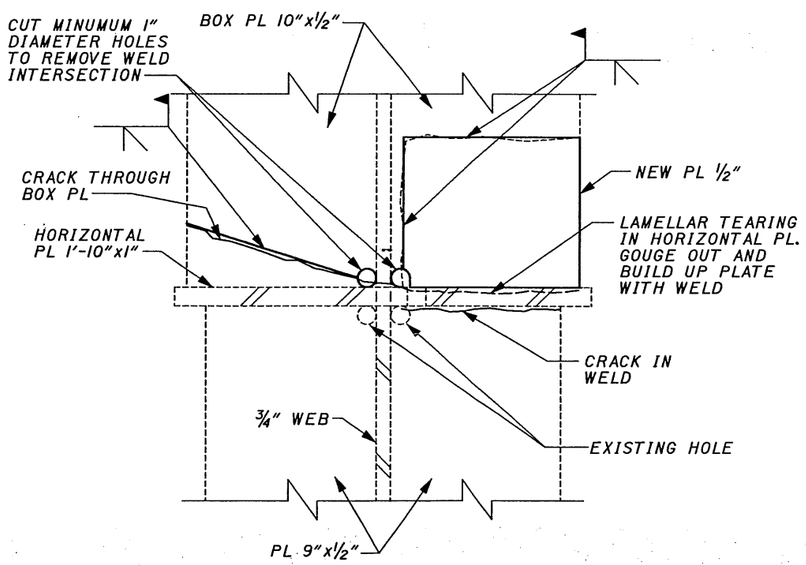


SECTION C-C



DETAIL A

(KNEE BRACE FLANGE NOT SHOWN)

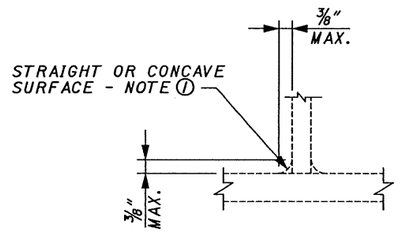


SECTION B-B

PROPOSED WORK - WESTBOUND BRIDGE, SPAN 4, SOUTH GIRDER

EXISTING CONDITIONS: TEMPORARY SUPPORT BEAM IS IN PLACE WITH A SMALL AMOUNT OF TENSION IN THE TEMPORARY SUPPORT RODS. HOLES HAVE BEEN DRILLED AT ENDS OF CRACKS IN BOX PLATES AND WELDS.

1. FABRICATE NEW MATERIALS AND PRIME PAINT.
2. JACK TEMPORARY SUPPORT BEAM TO TAKE LOAD OF HINGE ROCKER. THE CANTILEVER END JACK LOAD SHALL BE INCREASED TO 112 TONS (100% DEAD LOAD).
3. SUBDRILL (CUT) NEW HOLES FOR CONNECTING NEW ANGLE MATERIAL. INSTALL ANCHOR BRACKET TO WEB.
4. GOUGE OUT CRACK IN HORIZONTAL PLATE, WELD AND GRIND TO ORIGINAL PLATE SIZE. PLUG WELD HOLE. PERFORM ULTRASONIC TESTING TO CONFIRM THERE ARE NO FLAWS REMAINING IN THE HORIZONTAL PLATE.
5. REWELD BOX PLATES ABOVE AND BELOW HORIZONTAL PLATE TO ORIGINAL CONDITION (EXCEPT LEAVE GAP AT WEB PER DETAILS).
6. CUT OUT WELD INTERSECTIONS OF BOX PLATES TO WEB AND HORIZONTAL PLATE.
7. INSTALL ANGLES AND REAM HOLES FOR BOLTED CONNECTION TO BOX PLATES, HORIZONTAL PLATES, AND WEB. INSTALL BOLTS AND TIGHTEN.
8. REMOVE TEMPORARY SUPPORT BEAM.
9. INSTALL CARRIER BEAM AND POST-TENSIONING RODS.
10. POST-TENSION RODS TO 80% OF DEAD LOAD, 47 TONS PER ROD.
11. RESTORE 4 LANES OF TRAFFIC TO ORIGINAL LOCATIONS.
12. FINISH PAINT NEW MATERIAL AND TOUCH-UP PAINT EXISTING MATERIAL.



EXISTING FILLET WELD DETAIL

NOTE 1: REMOVE BACKER BARS AND GRIND WELDS TO ACCEPT NEW ANGLE SHAPE MEMBER.

RICHLAND ENGINEERING LIMITED
29 NORTH PARK STREET
MANSFIELD, OHIO 44902

DESIGNED	DRAWN	REVIEWED	DATE
DAP	JLS	DLR	01/23/01
CHECKED	REVISED	STRUCTURE FILE NUMBER	
KAK		181283	

WESTBOUND, SPAN 4, SOUTH GIRDER
EXISTING CONDITIONS - PROPOSED WORK
BRIDGE NO. CUY-480-0647 OVER ROCKY RIVER

CUY-480-6.47

2/8

2/10

210CON.DGN 01/23/01 JLS

NOTES

MATERIALS SHOWN ARE EXISTING UNLESS OTHERWISE NOTED.

DETAILS X AND Y: SEE SHEET 6 / 8 .

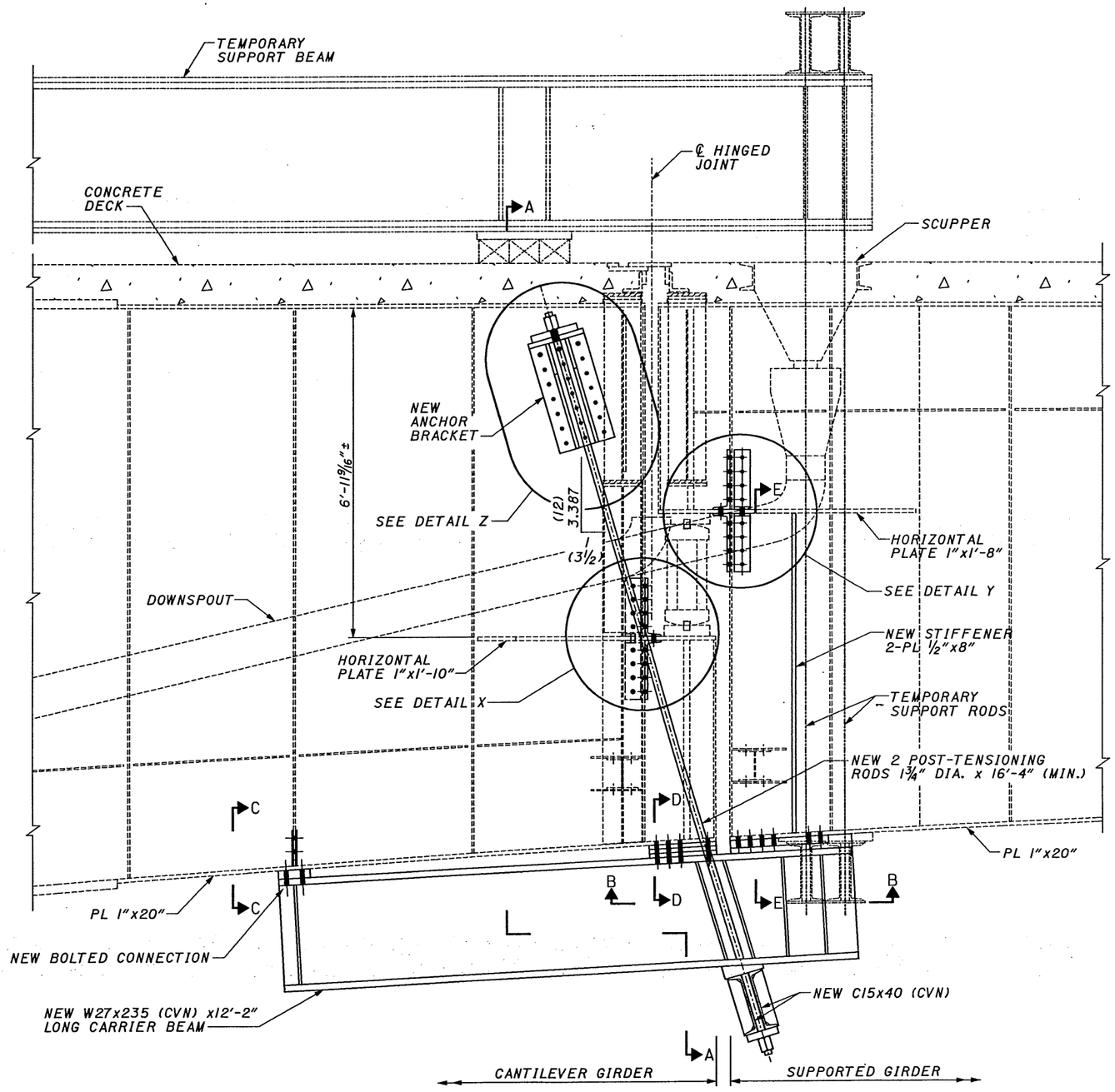
TEMPORARY SUPPORT SYSTEM: SEE SHEETS 9 AND 10 .

ANCHOR BRACKET: SEE SHEET 7 / 8 .

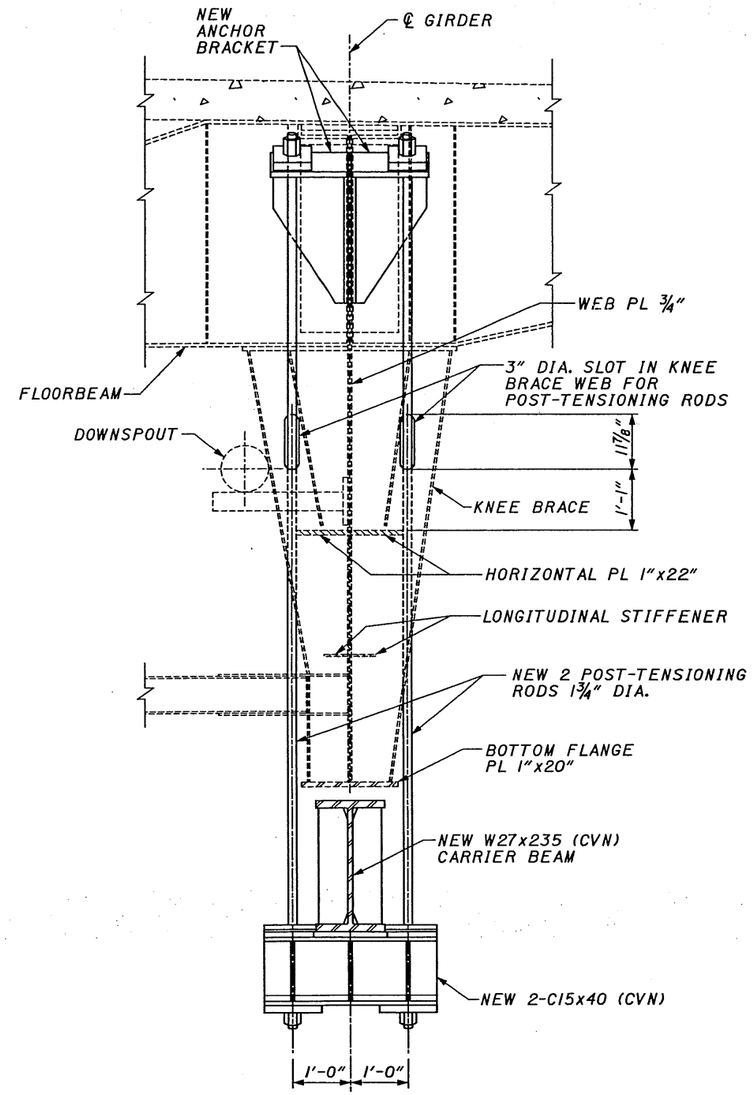
CARRIER BEAM DETAILS: SEE SHEET 8 / 8 .

SECTIONS B-B, C-C D-D & E-E: SEE SHEET 8 / 8 .

DETAIL Z: SEE SHEET 7 / 8 .



GIRDER ELEVATION



SECTION A-A

RICHLAND ENGINEERING LIMITED
29 NORTH PARK STREET
MANSFIELD, OHIO 44902

REVIEWED	DATE
DLR	01/23/01
STRUCTURE FILE NUMBER	
181231	

DRAWN	REVISED
JLS	

DESIGNED	CHECKED
DAP	KAK

WESTBOUND, SPAN 4, SOUTH GIRDER REPAIR DETAILS
BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

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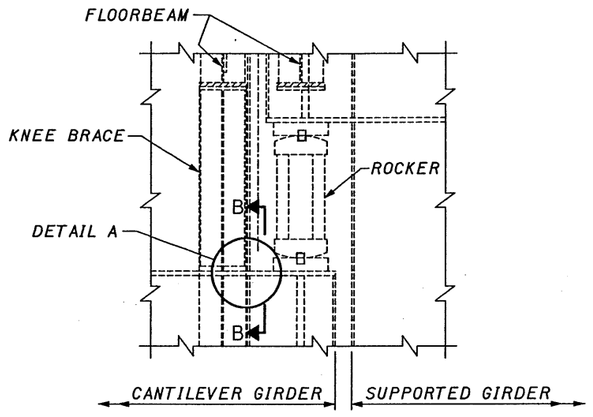
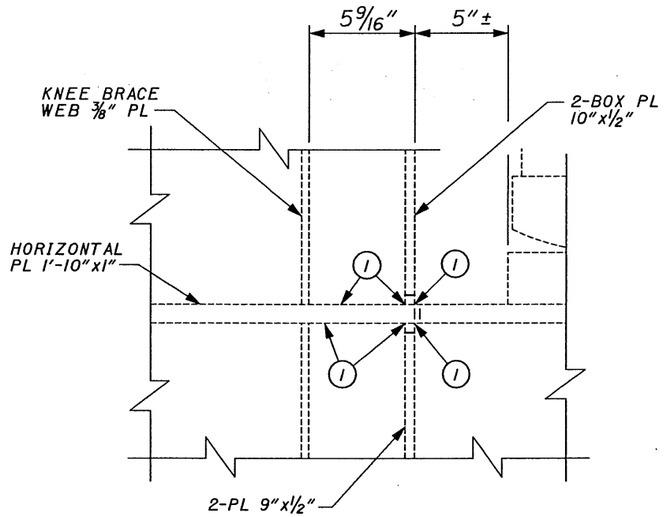
3 / 10

210REP.DGN 01/23/01 JLS

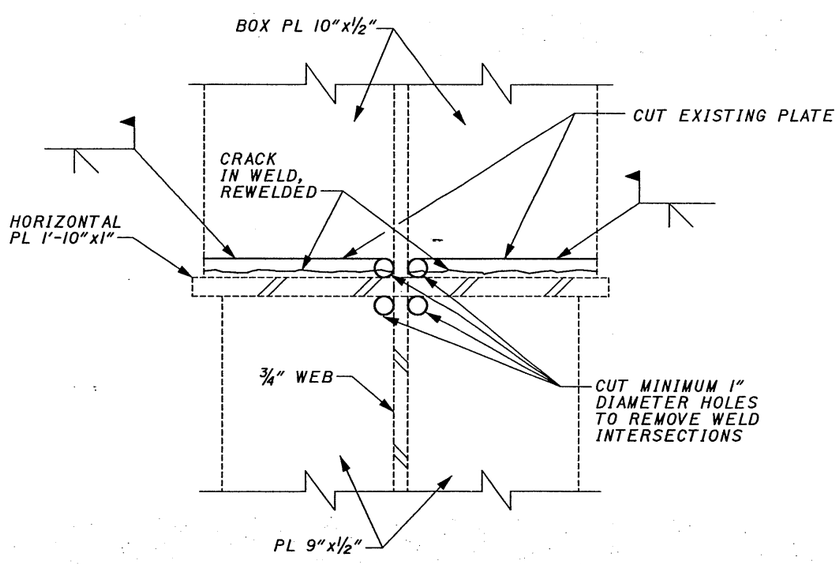


ELEVATION VIEW



DETAIL A

(KNEE BRACE FLANGE NOT SHOWN)

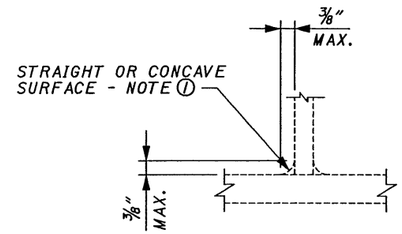


SECTION B-B

PROPOSED WORK - EASTBOUND BRIDGE, SPAN 4, NORTH GIRDER

EXISTING CONDITIONS: CRACKS FOUND IN BOX PLATE WELDS ABOVE HORIZONTAL PLATE HAVE BEEN REWELDED.

1. FABRICATE NEW MATERIALS AND PRIME PAINT.
2. SUBDRILL (CUT) NEW HOLES IN WEB ABOVE LOWER HORIZONTAL PLATE THAT WILL BE BEHIND THE POST-TENSIONING RODS FOR CONNECTING NEW ANGLES. INSTALL ANCHOR BRACKET TO WEB.
3. INSTALL CARRIER BEAM AND POST-TENSIONING RODS.
4. POST-TENSION RODS TO 100% OF DEAD LOAD, 59 TONS PER ROD.
5. CUT BOX PLATES ABOVE HORIZONTAL PLATE AND REWELD (EXCEPT LEAVE GAP AT WEB PER DETAILS).
6. CUT OUT WELD INTERSECTIONS OF BOX PLATES TO WEB AND HORIZONTAL PLATE.
7. SUBDRILL (CUT) NEW HOLES FOR CONNECTING NEW ANGLE MATERIAL. INSTALL ANGLES AND REAM HOLES FOR BOLTED CONNECTION TO BOX PLATES, HORIZONTAL PLATES, AND WEB. INSTALL BOLTS AND TIGHTEN.
8. REDUCE LOAD IN POST-TENSIONING RODS TO 80% OF DEAD LOAD, 47 TONS PER ROD.
9. FINISH PAINT NEW MATERIAL AND TOUCH-UP PAINT EXISTING MATERIAL.



EXISTING FILLET WELD DETAIL

NOTE 1: REMOVE BACKER BARS AND GRIND WELDS TO ACCEPT NEW ANGLE SHAPE MEMBER.

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KAK		1812831	

EASTBOUND, SPAN 4, NORTH GIRDER
EXISTING CONDITIONS - PROPOSED WORK
BRIDGE NO. CUY-480-0647 OVER ROCKY RIVER

CUY-480-6.47

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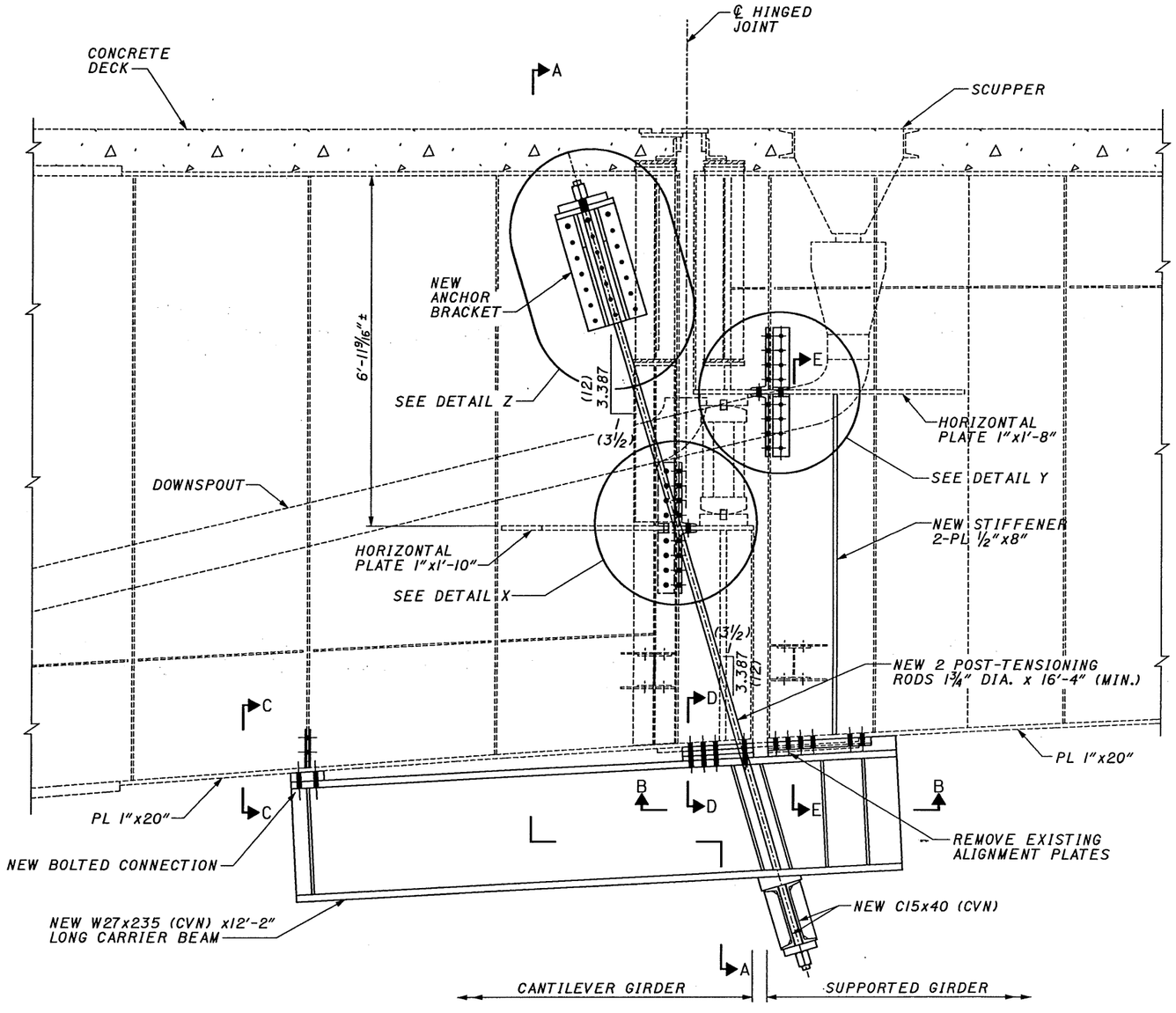
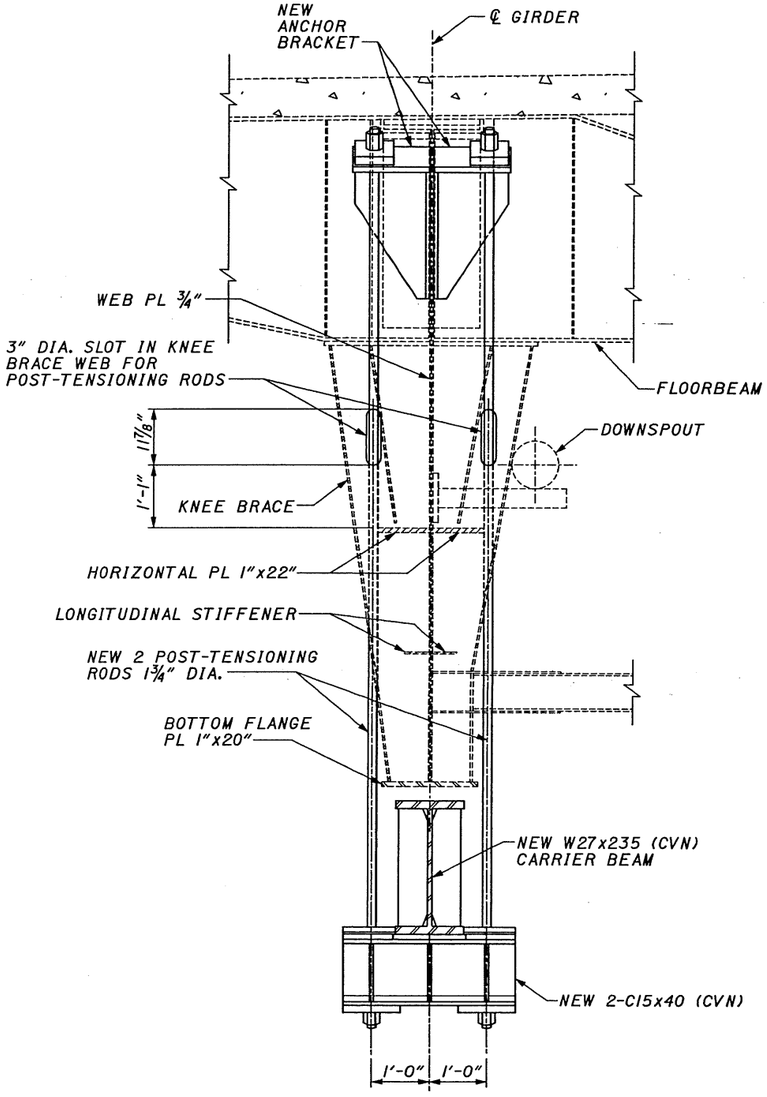
210CON.DGN 01/23/01 JLS



GIRDER ELEVATION



SECTION A-A

NOTES

MATERIALS SHOWN ARE EXISTING UNLESS OTHERWISE NOTED.

DETAILS X AND Y: SEE SHEET 6 / 8 .

ANCHOR BRACKET: SEE SHEET 7 / 8 .

CARRIER BEAM DETAILS: SEE SHEET 8 / 8 .

SECTIONS B-B, C-C D-D & E-E: SEE SHEET 8 / 8 .

DETAIL Z: SEE SHEET 7 / 8 .

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MANSFIELD, OHIO 44902

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REPAIR DETAILS

EASTBOUND, SPAN 4, NORTH GIRDER REPAIR
BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

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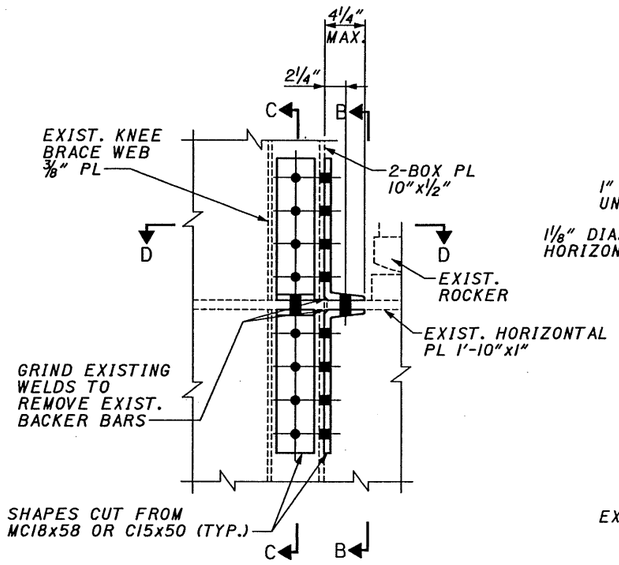
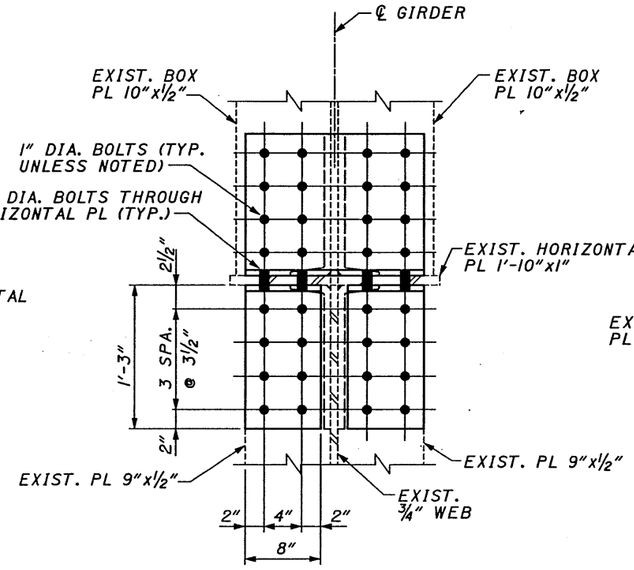
(5 / 10)

210REP.DGN 01/23/01 JLS

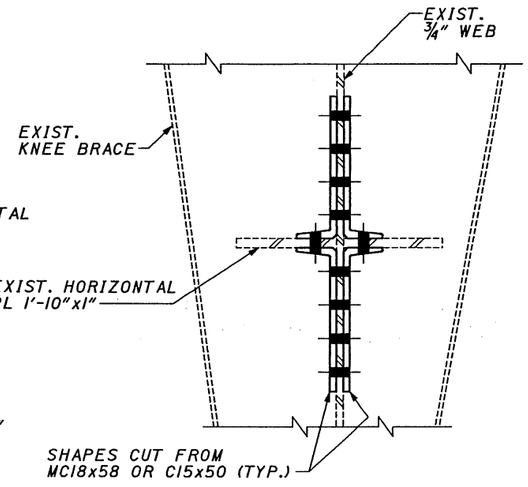


DETAIL X

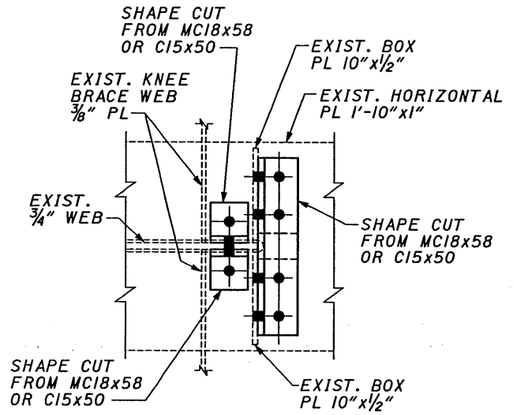
(KNEE BRACE FLANGE NOT SHOWN)



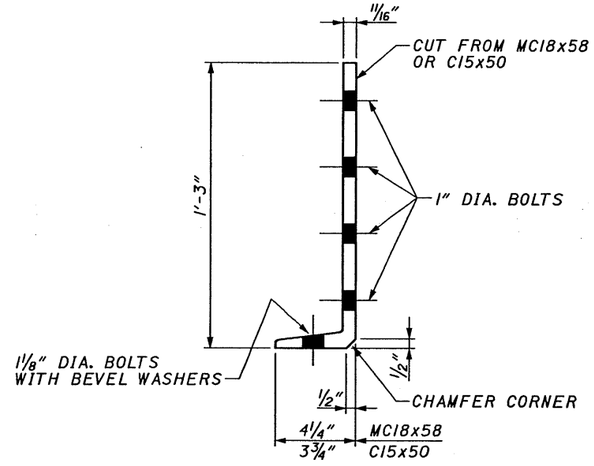
SECTION B-B



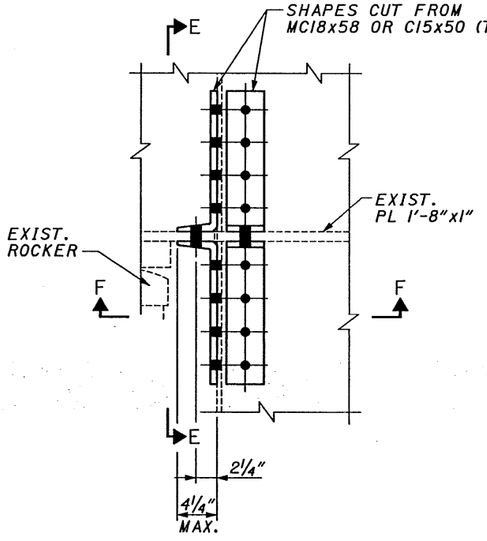
SECTION C-C



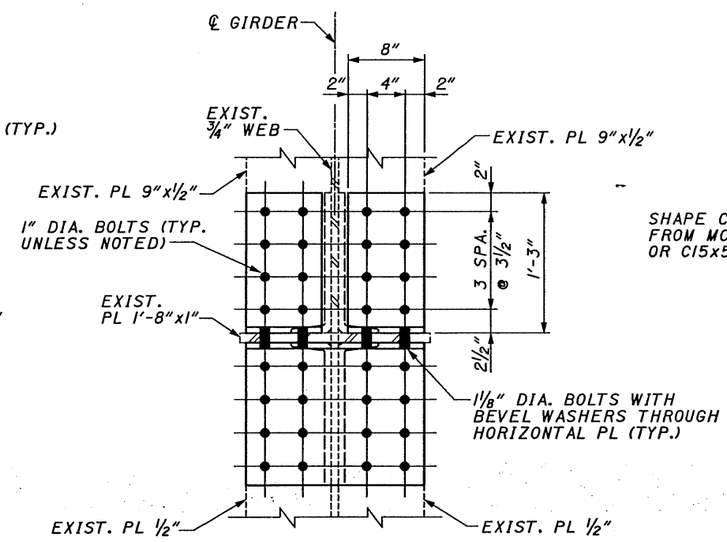
SECTION D-D



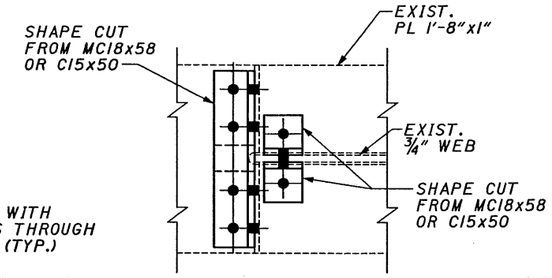
ANGLE SHAPE DETAIL



DETAIL Y



SECTION E-E



SECTION F-F

RICHLAND ENGINEERING LIMITED
29 NORTH PARK STREET
MANSFIELD, OHIO 44902

REVIEWED	DATE
DLR	01/23/01
STRUCTURE FILE NUMBER	
1812831	
DRAWN	REVISED
JLS	
DESIGNED	CHECKED
DAP	KAK

WESTBOUND, SPAN 4, SOUTH GIRDER DETAILS

BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

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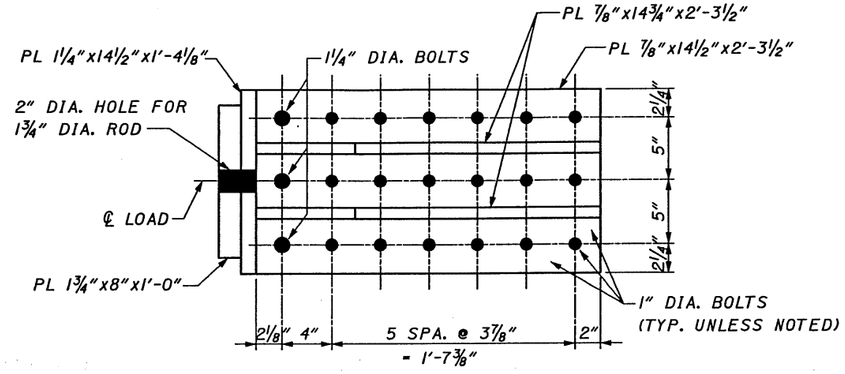
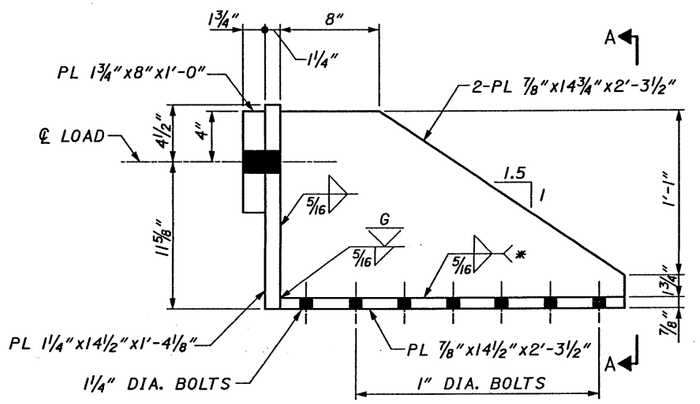
210DET.DGN 01/23/01 JLS

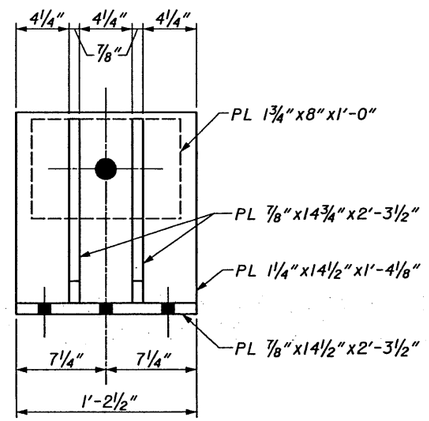


PLAN

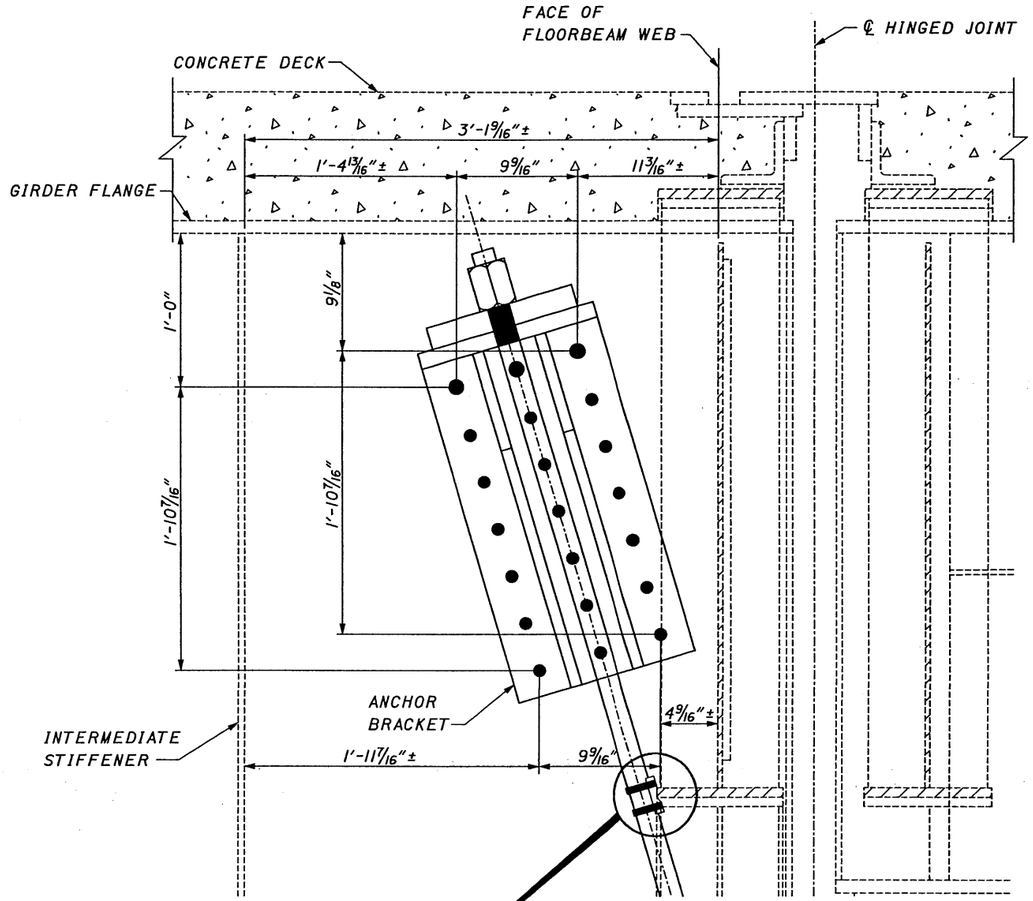


ELEVATION

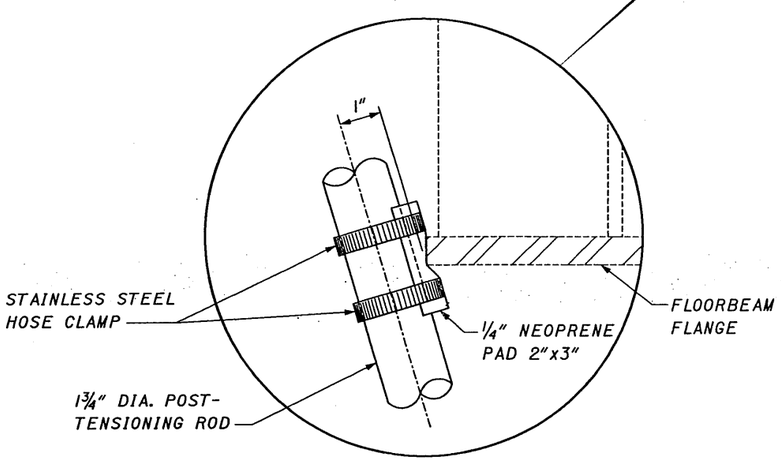
* WELD ENTIRE LENGTH OF BOTH SIDES OF FIRST SUPPORT AND THE ENTIRE LENGTH OF THE OUTSIDE AND AS FAR AS POSSIBLE ON THE INSIDE OF THE SECOND SUPPORT.



VIEW A-A



DETAIL Z



ANCHOR BRACKET DETAILS

210BKT.DGN 01/23/01 JLS

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29 NORTH PARK STREET
MANSFIELD, OHIO 44902

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CHECKED	REVISED	STRUCTURE FILE NUMBER	
KAK		181283	

ANCHOR BRACKET DETAILS
BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

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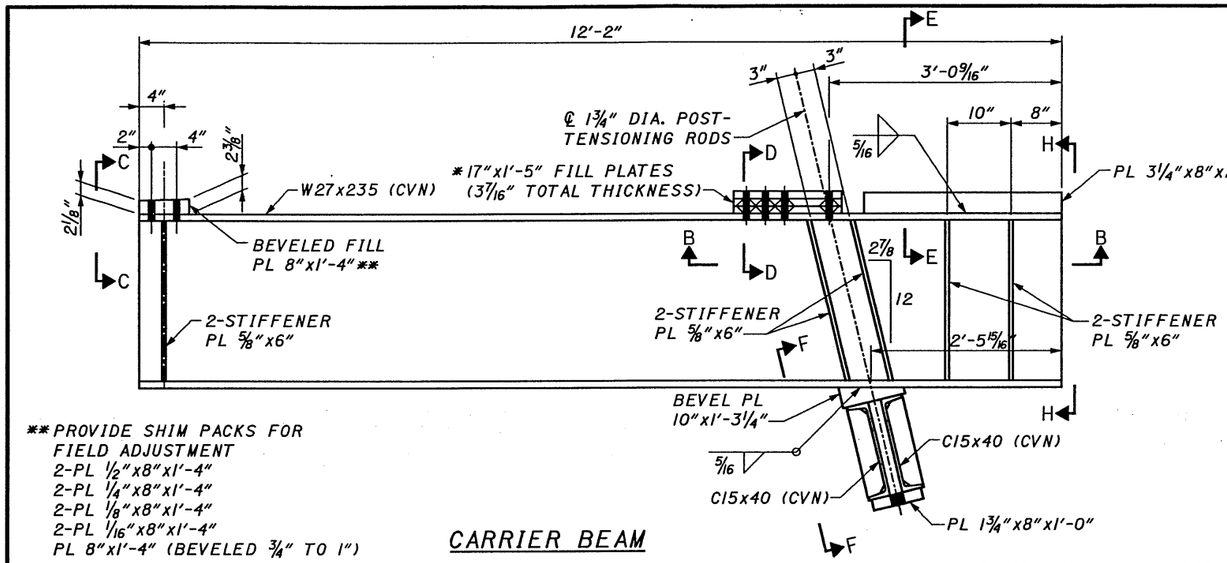
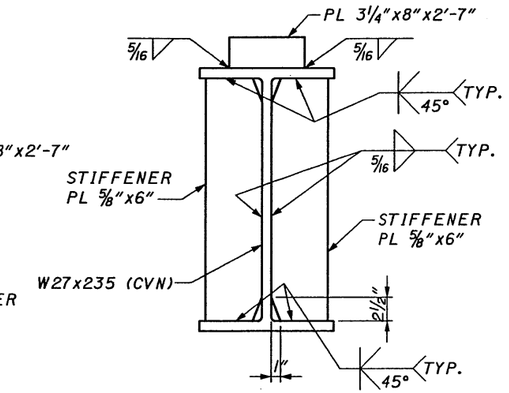


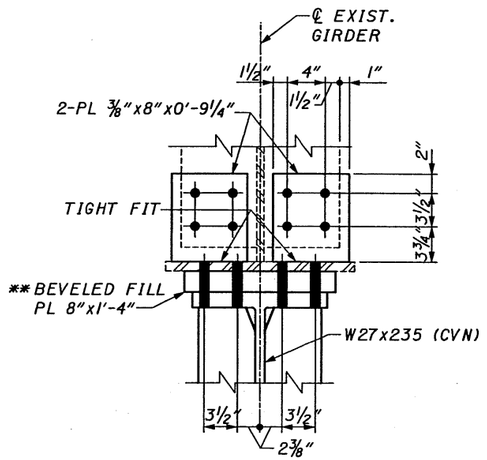
CARRIER BEAM

** PROVIDE SHIM PACKS FOR FIELD ADJUSTMENT
2-PL 1/2"x8"x1'-4"
2-PL 1/4"x8"x1'-4"
2-PL 1/8"x8"x1'-4"
2-PL 1/16"x8"x1'-4"
PL 8"x1'-4" (BEVELED 3/4" TO 1")

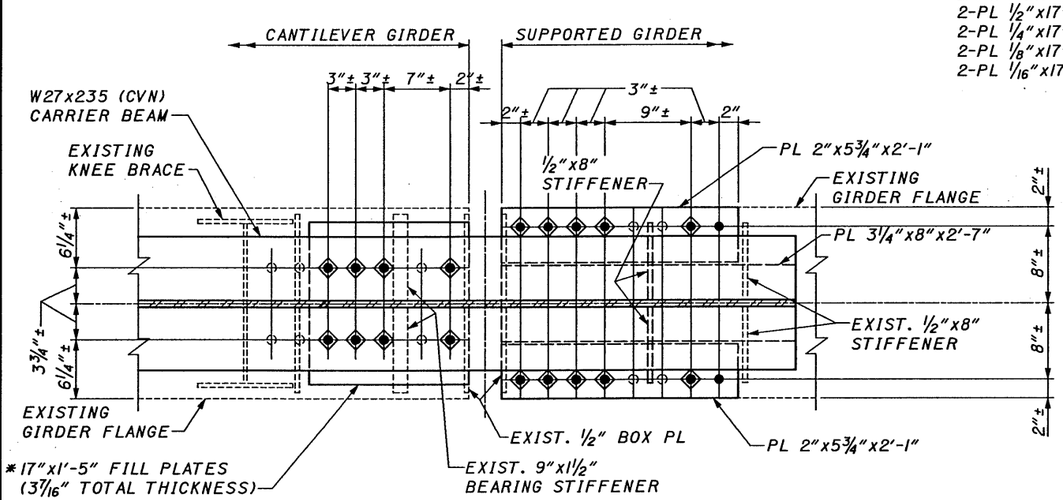
* PROVIDE SHIM PACKS FOR FIELD ADJUSTMENT
2-PL 1"x17"x1'-5"
2-PL 1/2"x17"x1'-5"
2-PL 1/4"x17"x1'-5"
2-PL 1/8"x17"x1'-5"
2-PL 1/16"x17"x1'-5"



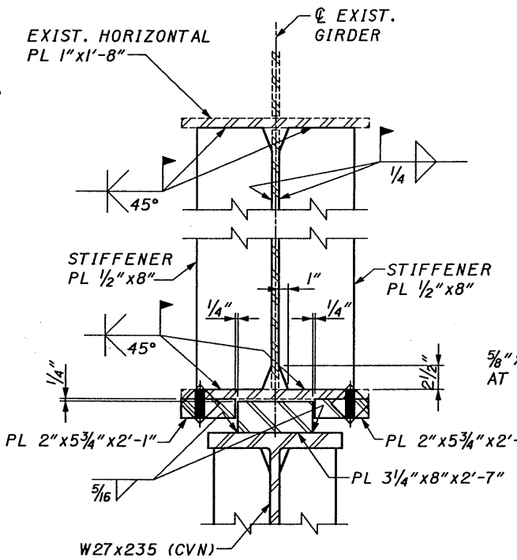
VIEW H-H



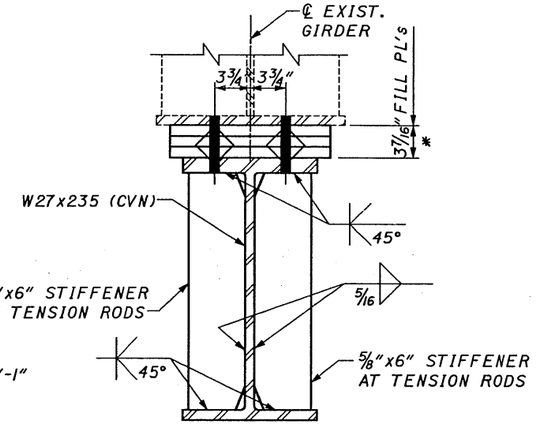
SECTION C-C



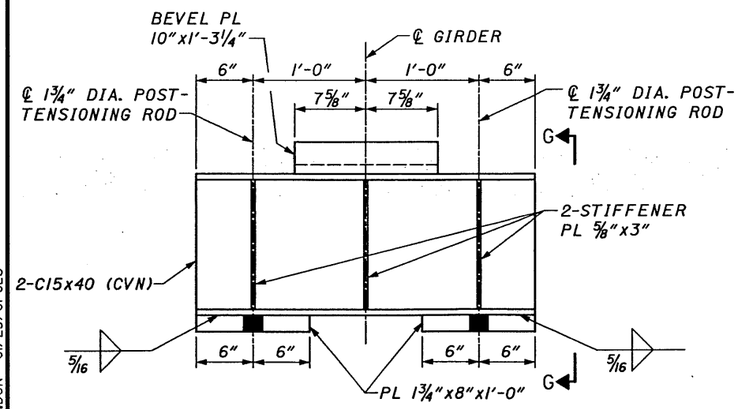
SECTION B-B



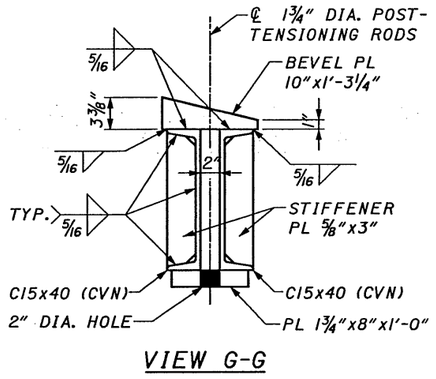
SECTION E-E



SECTION D-D



VIEW F-F



VIEW G-G

BOLT LEGEND

REMOVE EXISTING BOLT AND FILL BOLT HOLE WITH CAULK.

NEW FIELD BOLT AND NUT - NEW MATERIAL TO NEW OR FIELD DRILLED EXISTING MATERIAL.

REMOVE EXISTING BOLT AND INSTALL NEW FIELD BOLT AND NUT - FIELD DRILL NEW MATERIAL TO MATCH EXISTING BOLT HOLE.

NOTES

SECTIONS B-B, C-C, D-D & E-E: FOR LOCATION SEE SHEETS 3 / 8 AND 5 / 8.

ADDITIONAL NOTES: SEE SHEET 1 / 8.

RICHLAND ENGINEERING LIMITED
29 NORTH PARK STREET
MANSFIELD, OHIO 44902

DESIGNED DAP | DRAWN JLS | CHECKED KAK | REVISED | REVISED DLR 01/23/01 | DATE | STRUCTURE FILE NUMBER 181283

CARRIER BEAM DETAILS

BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

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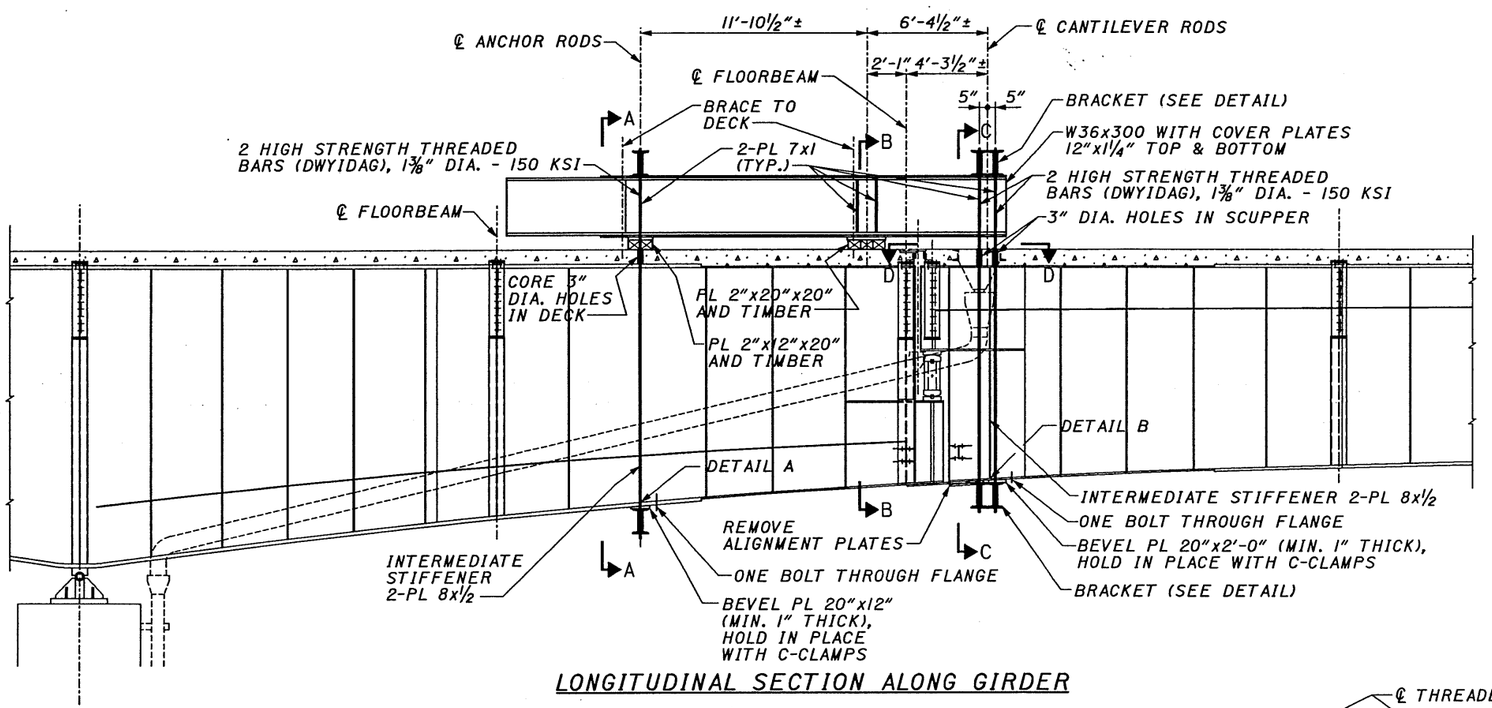
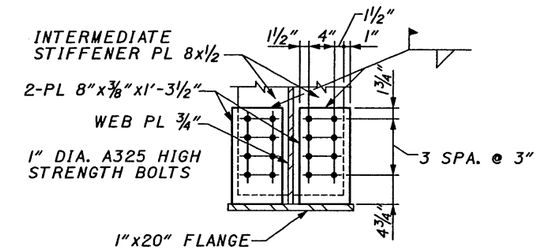
8
10

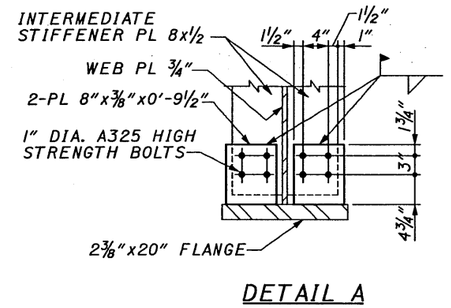
210CAR.DGN 01/23/01 JLS



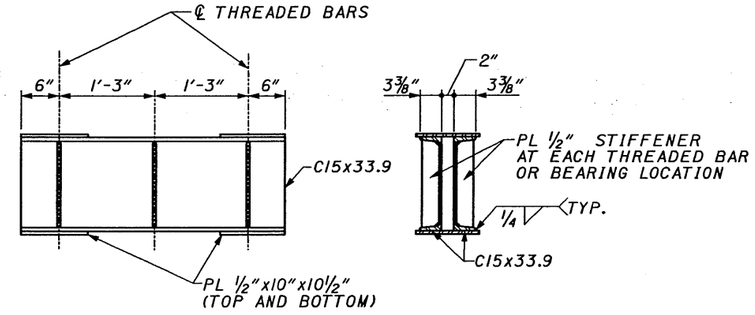
LONGITUDINAL SECTION ALONG GIRDER



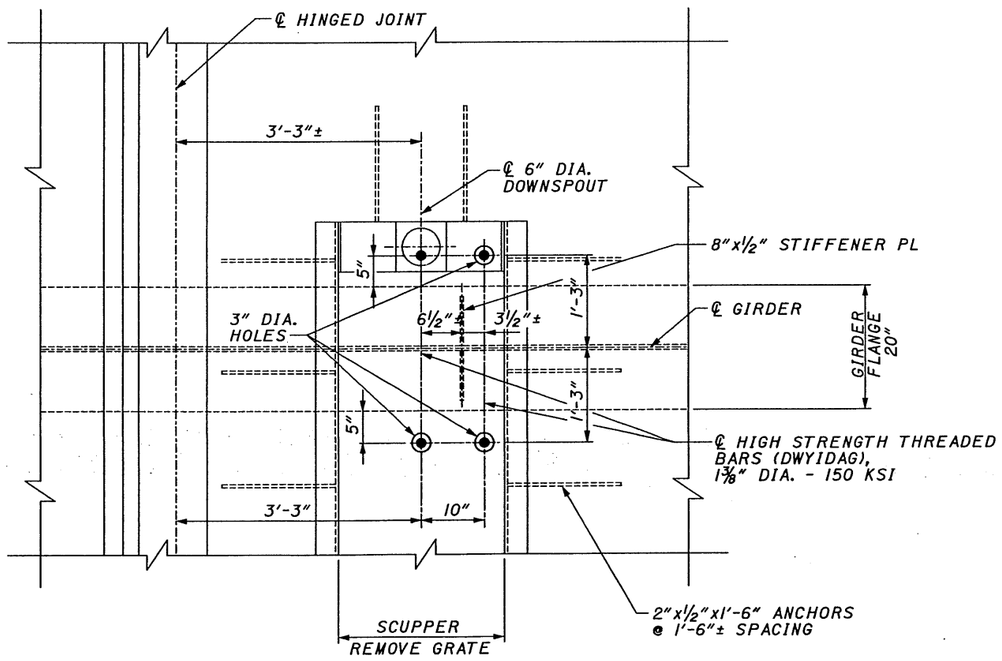
DETAIL B



DETAIL A



BRACKET DETAIL



VIEW D-D

NOTES

DESIGN LOADS:

DEAD LOAD	224 KIPS
LL + I	23 KIPS
TOTAL	247 KIPS

MAXIMUM LOAD ON CANTILEVER RODS - 349 KIPS (175 TONS, 44 TONS/ROD) (INCLUDING 33% INCREASE IN BASIC ALLOWABLE STRESSES)

TEMPORARY SUPPORT BEAM INSTALLATION COMPLETED 11/18/00

GIRDER.DGN 01/05/01 JLS

RICHLAND ENGINEERING LIMITED
29 NORTH PARK STREET
MANSFIELD, OHIO 44902

DESIGNED DAP | DRAWN JLS | REVIEWED DLR | DATE 11/15/00
CHECKED KAK | REVISED 11/17/00 11/20/00 | STRUCTURE FILE NUMBER 1812831

TEMPORARY SUPPORT BEAM - 1
BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

1/2

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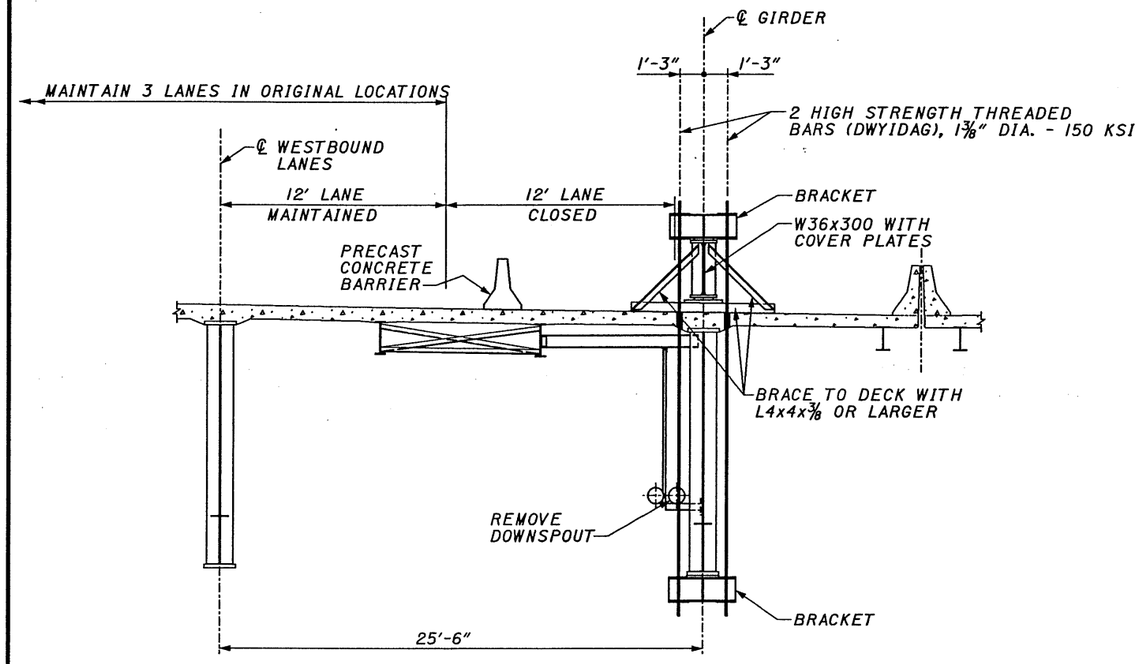
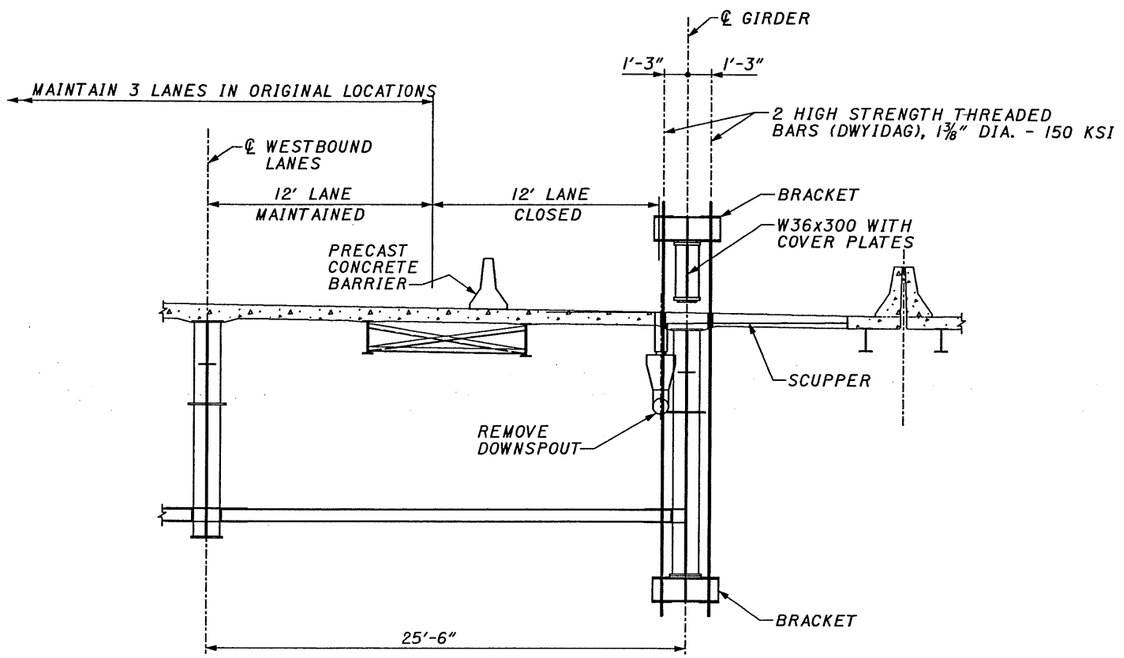
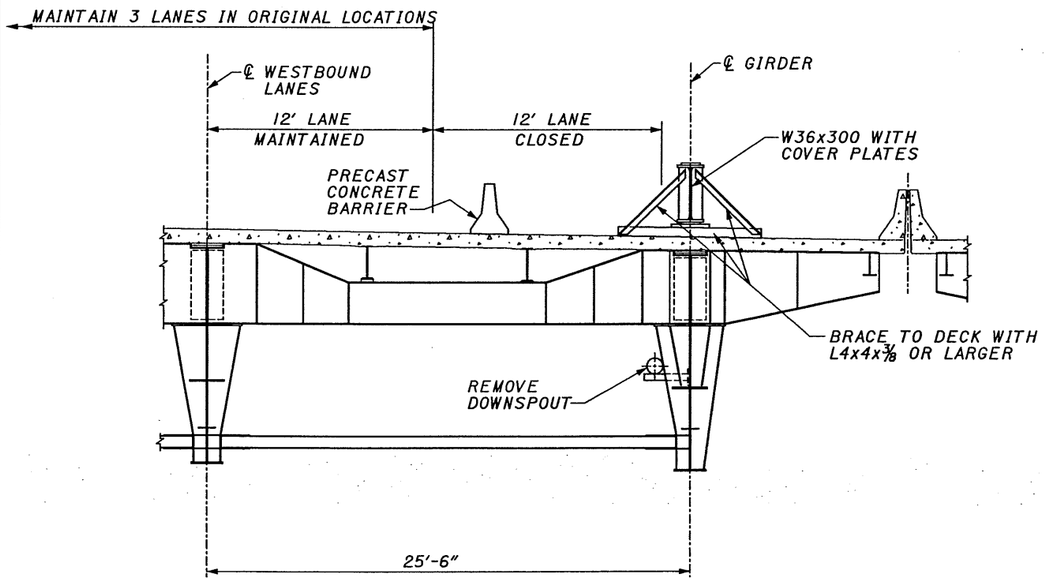


SECTION A-A



SECTION C-C



SECTION B-B

INSTALLATION PROCEDURE

1. CUT HOLES IN DECK AND SCUPPER FOR RODS.
2. REMOVE SCUPPER DOWNSPOUT.
3. REMOVE ALIGNMENT PLATES FROM BOTTOM FLANGE.
4. PLACE TIMBER BLOCKING (HARDWOOD) ON DECK. SHIM TO LEVEL. PLACE STEEL BEARING PLATES.
5. PLACE TEMPORARY BEAM AND BRACKETS.
6. PLACE VERTICAL RODS.
7. INSTALL BOTTOM FLANGE BEVEL PLATES AND BRACKETS.
8. INSTALL BEARING PLATES TO INTERMEDIATE STIFFENERS AT BOTTOM FLANGE.
9. TENSION ANCHOR RODS TO 15 TONS PER ROD.
10. TENSION CANTILEVER RODS TO 15 TONS PER ROD.
11. OPEN BRIDGE TO TRAFFIC.

GIRDER.DGN 01/05/01 JLS

RICHLAND ENGINEERING LIMITED
29 NORTH PARK STREET
MANSFIELD, OHIO 44902

DESIGNED	DRAWN	REVIEWED	DATE
DAP	JLS	DLR	11/15/00
CHECKED	REVISED	STRUCTURE FILE NUMBER	
KAK	11/17/00 11/20/00	18128831	

TEMPORARY SUPPORT BEAM - 2
BRIDGE NO. CUY-480-0647
OVER ROCKY RIVER

CUY-480-6.47

2/2

10/10