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HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY

CCH/for

WAR DEPARTMENT OBSERVERS BOARD

APD 887
23 May 1945

SUBJECT: ASF Report No. 126 - Collapse of Remagen Bridge.

TO : Commanding General, Army Service Forces,
Pentagon Building, Washington 25, D. C.,
(Attn: Brig. Gen. L. D. WORSHAM)

Inclosure No. 1 (RESTRICTED) (in triplicate) report on Collapse
of Remagen Bridge, submitted by Colonel CHESTER C. HOUGH, C.E., is attached.

1 Incl.
As indicated above.



CHESTER C. HOUGH,
Colonel, Corps of Engineers,
President, WD Observers Board.

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HEADQUARTERS III CORPS
Office of the Engineer
APO 303

*
* ~~SECRET~~
* AUTH: CG, III CORPS
* DATE: 19 March 45
* INIT:

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19 March 45

Report on the Collapse of the Ludendorf Bridge, 17 March 1945

JUN 21 1965

1. General: The Ludendorff Bridge across the Rhine River at Remagen, Germany was captured by the Ninth Armored Division on 7 March 1945. The bridge, when captured, was damaged as shown in Enclosure No. 3. Explosives placed by the enemy were immediately removed by the Ninth Armored Engineer Battalion. Amounts and locations of this explosive are shown in Enclosure No. 4. A later check by the 276th Engineer Combat Battalion disclosed explosives in the manholes of the piers and these were removed. The bridge carried practically continuous one way traffic from the time of its capture until 12 March at which time two other bridges in the immediate vicinity made it possible to close traffic on the bridge and repair it. The 276th Engineer Combat Battalion was assigned the task of repairing the bridge with the assistance of a Technical Team from the 1058th P. C. and R Gp. This work was nearing completion when the bridge collapsed on 17 March 1945.

2. Condition of the Bridge at Time of Collapse: At the time of the collapse of the bridge, flooring of the west side of the deck had been completed, several hangers had been spliced, and several floor members replaced. Repairs at two points still remained to be made. These repairs were the replacing of stringers adjacent to the south abutment and repair of the broken lower chord of the upstream arch truss adjacent to the north abutment.

Although there were damaged parts to the bridge throughout its length, the only unrepaired portion which might have been a serious effect on the load carrying capacity of the bridge, was the broken lower chord of the upstream arch truss. This damage had been accomplished by enemy demolition and had completely torn apart the lower chord, diagonal, and vertical of the truss at the first panel point south of the north pier. As a result of this, the upstream arch truss had dropped at the north end over one foot below the level of the downstream arch truss at the corresponding point. The side plates of the top chord of this upstream truss directly above the point where the lower chord was cut were slightly buckled. It is apparent from these facts that that part of the load of the main span of the bridge which was originally carried by the east or upstream truss had been redistributed when the lower chord of the upstream truss was cut. At the time of the collapse the load originally supported by the upstream truss was being supported in three ways as follows: first, by the upstream truss by cantilever action over the south pier due to the original continuous construction; second, by the partial support afforded the north end of the upstream arch truss by the slightly buckled top chord; and third, by the downstream truss through the floor and bracing system. Serious stresses could have been set up in the members of the downstream truss due to the additional load it was required to carry combined with the twisting action resulting from the eccentricity of this load.

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.

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EXHIBIT A

5 JUN 1945

acc# PAR-47020
PO Ref 1731625

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3. How the Bridge Collapsed: From the reports of eye witnesses attached hereto as Enclosure No. 2, it is possible to reconstruct the actual collapse of the bridge approximately as follows: Without apparent immediate cause, at about 1500 hours on 17 March 1945 the main span of the bridge suddenly gave way near the north pier. Whether because some part of the members still carrying stress in the upstream truss failed or whether the west truss suddenly failed under the tremendous twisting forces applied to it by the possibly useless upstream truss is not known. Once this initial failure occurred the main span twisted with its top falling upstream. This caused the members of the main arch trusses to buckle laterally and the whole span dropped into the river pulling the two side spans with it.

4. Factors Contributing to the Collapse: Available evidence does not show any one specific cause for the collapse. Unless further evidence is found, it must be assumed that the bridge collapsed from a combination of causes which, when added together finally provided the straw to "break the camels back". Common civil practice would indicate that the bridge should have collapsed when the charge which cut the lower chord of the east truss was blown, yet the bridge had carried traffic equivalent to an infantry division with attached tanks and was still standing. The various factors which might have contributed to the collapse are discussed below.

a. The Broken Lower Chord of the Upstream Arch Truss: This is, of course, the basic reason that the bridge collapsed. The effect of cutting this chord on the remainder of the structure was twofold. First, it forced the downstream truss to carry a good portion of the load which had previously been carried by the upstream truss. Neglecting the effects of any twisting action, this could cause the members of the downstream truss to be overstressed by 100% if the upstream truss were completely severed. Second, it subjected the downstream truss to a twisting action for which the structure was never designed.

b. Additional Dead Load of Added Flooring: This additional load added gradually during the repair of the bridge was doubtless a contributing factor. Exactly how much added weight this involves is not known, but a four inch flooring, 15 feet wide over the 515 foot center span would represent an additional load of approximately 50 tons. This is equivalent to 7 loaded $2\frac{1}{2}$ ton trucks.

c. Cable used to Straighten Part of the Lower Chord: At the time the bridge collapsed attempts were being made to align the broken chord of the upstream truss with a cable attached to a crane. The crane was on the bridge over the north pier with a cable attached which ran through a block on the downstream side of the bridge, through the deck to another block and across under the deck to the part of the bottom chord of the upstream truss which framed into the pier. Attempts to take up on this cable were made once, the clamps slipped, and the crane was standing idle at the time the bridge collapsed.

d. Vibration by Machinery and Equipment: Throughout the period during which the bridge was being repaired, there was constant hammering and air compressors, electric welding machines, crane and trucks were operating on the bridge floor. All of these could set up vibrations within the structures.

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e. Vibrations set up by Artillery Firing: During the period that the bridge was being repaired, several heavy artillery units moved into the area. The continued vibration and shock effect from the firing of hundreds of rounds is not negligible. 1087 rounds of 8" howitzer were fired from positions approximately 2000 yards from the bridge during the period. A V-2 bomb also exploded in the town of Remagen during this period.

f. Continued Shelling by the Enemy: Although very few of the 601 rounds fired at the bridge by the enemy during its use by our forces actually struck the bridge, this number of close rounds could have damaging effect on a structure on the verge of collapse.

g. Traffic on the Bridge: Before the bridge was closed to traffic for repairs it carried continuous one way traffic for five days. Some of the vehicles crossing were tanks. Such traffic might have brought the structure near to collapse.

5. Casualties: The 276th Engineer Combat Battalion maintained and repaired the Ludendorf Bridge from 8 March 1945 until its collapse on 17 March 1945. Casualties suffered by this unit during this period, exclusive of those resulting from the collapse were as follows:

Killed	- - - - -	1
Missing	- - - - -	2
Seriously Wounded	- - - - -	3
Lightly Wounded	- - - - -	8

Casualties suffered as a result of the collapse by the two units working on the bridge at the time were as follows:

276th Engineer Combat Battalion

Killed	- - - - -	6
Missing	- - - - -	11
Died of Wounds	- - - - -	3
Wounded	- - - - -	57

1058th P. C. and R. Unit

Killed	- - - - -	1
Missing	- - - - -	7
Wounded	- - - - -	6

F. RUSSEL LYONS
Col. CE
Engineer

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5 Incls:

- 1 - Sketch Showing General Layout of Bridge and approaches and position of Observers.
- 2 - Summary of Statements of Witnesses.
- 3 - Sketch Showing Damage to Ludendorf Bridge and Repairs Made Prior to Collapse.
- 4 - Engineer Reconnaissance of Ludendorf R.R. Bridge (by 9th Armd. Engr. Bn.)
- 5 - Photographs of the Ludendorf Bridge before and after Collapse.

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Lt. Csendes
T/Sgt. Humphreys

Cpl. McGroth

Pfc. Reilly

Pvt. Burant

Capt. Goodwin

Pfc. Kief

M/Sgt. Thompson

RHINE

RIVER

Lt. Col. Rust

Present position of
collapsed structure

Lt. Moffat
T/4 Gazaway

INCLOSURE NO.
REPORT ON COLLAPSE OF THE
LUDENDORF BRIDGE

SKETCH SHOWING GENERAL
LAYOUT OF BRIDGE AND
APPROACHES AND POSITION
OF OBSERVERS

1159th Engr C Gp.

18 Mar. 1945

Auth: CG, III Corps

Date: 18 Mar. 1845

Init: Hale

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Inclosure No. 2 to Report on
the Collapse of the Ludendorf
Bridge. Statement of Witnesses.

SUMMARY OF STATEMENTS OF WITNESSES

CAPT FRANCIS E. GOODWIN 01 101 011
S-4 1159th Engineer Combat Group

I arrived at the east side of the Ludendorf Bridge at approximately 1345 hours, 17 March 1945. I walked back into the railroad tunnel intending to investigate some German water supply equipment I had previously seen in the far end of the tunnel. I did not have a flashlight with me and there was no one in the tunnel with a light I could borrow so I returned to the entrance and walked out onto the railroad bridge.

I walked straight across making a mental note of how much lumber would be needed to complete the flooring and treading. The flooring was almost complete except for two gaps; one where the bridge had been blown and the other at a point near the west abutment. I walked as far as the Bailey Bridge on the west approach and then started back over the main bridge.

A squad of men were policing up the odd pieces of lumber and loading them onto a truck (2½ Ton). They were stacking the heavier timbers (6 x 6) along the curbing. I stopped at the point where Major CARR and his men from the 1058th P. C. & R. unit were repairing the blown section of the bridge. I inquired from Major CARR as to how long it would take to bridge the blown gap. He said everything was coming along fine and he expected to have the gap repaired in one more day, but he estimated there was a month's work if all the damaged parts were to be restored.

I then questioned one of the welders concerning the supply of gas for cutting and welding, and he assured me that the supply was adequate.

There was a crane parked on the downstream side of the bridge opposite the blown section. A cable was attached to the front of the crane and from there it was reeved through a snatch block attached to one of the downstream bridge members. From the snatch block the cable was threaded down through the bridge floor. I questioned the Sergeant who appeared to be in charge as to what they were doing. From his explanation, I gathered that the other end of the cable was attached to a broken beam that they were going to pull into line before attempting to fill in the blown section. I did not make any further investigation. I remained in the vicinity of the bridge until approximately 1445 hours.

Then I rode a motorcycle down and around the east abutment on my way to the treadway bridge. Just prior to crossing the treadway bridge, I heard an unusual sound and looking up saw that the arch of the bridge had just crumbled and the abutment section settling to the ground. The time was 1500 hours.

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I proceeded to cross the treadway bridge and instructed the men on the west bank to get all available power boats to pick up survivors and to clear the treadway bridge of any debris floating from the collapsed bridge. I continued on through Remagen and sent three or four ambulances to the bridge site. I arrived at the 1159th forward CP in Kripp and instructed T/Sgt Subkowsky to get all available Medical aid sent down to the bridge site and to notify the rear CP of what happened. I proceeded down to the Ponton Bridge and informed the officer in charge (Capt BISHOP, 552d Heavy Ponton Battalion) that the Ludendorf Bridge had collapsed. I rode across the Heavy Ponton Bridge and instructed the MP's to have all available power boats sent downstream to aid in rescue work. I proceeded on down to the Ludendorf Bridge where I met Lt. Col. FIELDS and Capt. OEHMANN.

LT COL CLAYTON A. RUST 022 916
Commanding Officer, 276th Engineer Combat Battalion

I was on the Ludendorf Bridge at a point just south of center of the center span with Capt SERGI proceeding to the north bank to make an inspection of the progress of the work on the new approach, at the time the bridge collapsed. The first idea I had of any trouble was a sharp report like a rivet head shearing and I noticed a vertical hanger which had been spliced by two turnbuckles was breaking loose and one turnbuckle was dangling, having come loose at the top of turnbuckle. It appeared as though the bolt holding the turnbuckle to the web of the vertical member had sheared through the web. At that instant I heard another sharp report of a rivet shearing off from my left rear followed by a trembling sensation of the whole deck. Quickly glancing down the bridge the whole deck seemed to be vibrating and dust was coming off the surface. I knew instantly that the bridge was collapsing and I turned toward the south bank and ran as fast as I could. While I was running, the east side of the bridge seemed to settle first and I found myself running, in effect, "on a side hill". The next instant I was engulfed in water. I had no sensation of falling at all. Capt SERGI and I were pulled out together at the treadway bridge, both badly shaken but neither of us badly injured.

No one alive can say why the bridge collapsed. It had previously been stated and reported that the bridge was very weak and would little more than support its own weight. Only a thorough analysis by a competent engineer will come close to giving the reason why. The bridge was rotten throughout, many members not cut had internal fractures from the bombing (our own) artillery fire, and the deliberate demolitions themselves.

The bridge was extremely weak. The upstream truss was actually useless. The entire load of traffic, equipment and dead load was supported by the good downstream truss. On the surface it was healthy; in fact it was carrying almost

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the entire dead load including the sister truss except an infinitesimal amount carried by the already buckled top cord of the upstream truss. That infinitesimal support was apparently the sole difference between support and falling. It is my opinion as an engineer that vibrations caused by numerous possible sources, i.e., air compressors, one crane, a few trucks, several electric arc welders, hammering, and finally but important, the not insignificant concussion of heavy artillery recently emplaced in the town of Remagen. Although at the time of collapse the guns were not firing. I believe that as the vibration continued, the condition of the previously buckled top cord was aggravated to such an extent that it buckled completely under a load which of course, it was not designed to carry.

We were making wonderful progress in bridge repairs. I am confident that nothing in the way of engineer work caused the accident. The Commanding Officer of the 1058 P.C.&R. unit had complete charge of repairs on the major members of the bridge. If he were still alive, he might qualify my last remark to give it a more concrete basis.

1ST LT F. E. CSENDES 01 111 006
Asst S-3 1058th P C & R Unit

At the time of the collapse I was in the tunnel when I heard someone yell. I turned around and looked out and saw the center span of the bridge twisting counter-clock-wise and buckling. The center span fell into the river and the two adjacent spans fell with it.

Prior to the collapse a crane had been placed on the bridge with a cable fastened to it. This cable was run through block and tackle over the west side of the bridge, down under the floor system and across to that part of the lower chord of the main truss on the east side which framed into the pier. I believe that the crane was sitting on the deck on the north side of the north pier.

1ST LT EUGENE A. MOFFAT 01116313
276th Engineer Combat Battalion

I had just walked off the south end of the bridge and was standing about 20 feet south of the edge of the abutment when something caused me to look at the bridge. There was no explosion or unusual noise. The center span was rolling to my right as I looked at the bridge and the arch on the left side buckled and the midspan collapsed. As this span collapsed it pulled the short span near me off the abutment and it crashed below.

M/SGT EDWIN A. THOMPSON 42031281
1058th P C & R Unit

I was on the bridge over the north pier at the time of the collapse of the

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bridge. I heard timber cracking and saw the main span twisting to the left as I faced it. I hit the water on the north side of the north pier and pulled myself out on the steel girders.

The crane which was on the bridge was standing still at the time of the collapse because clamps had been sent for to fasten the cable more securely. The cable ran from the crane through a block above the floor of the bridge on the west side, down through the floor system to another block and across to that part of the lower chord of the east arch truss which still remained attached to the pier. No strain had been put on this cable as yet.

T/SGT GORDON HUMPHREYS 39336548
1058th P C & R Unit

I had just gone into the tunnel at the time the bridge collapsed to pick up some clamps. I did not see what happened. The crane was over the north pier and was not moving at the time. The clamps were to be used to rig a set of falls to pull the lower part of the east arch truss chord into line. The pull was to be put on that part of the chord framing into the pier. An attempt to pull this member into line had just been made but the clamps were not sufficiently strong and the operation had stopped while better clamps were secured. There was not noticeable change in wind on that day over any other days.

CORPORAL PATRIC McGRATH 31041770
"C" Battery, 639th AAA Bn

I was cleaning my rifle in an Antiaircraft gun emplacement about 75 yards west of the entrance to the tunnel which is just north of the north abutment of the Ludendorf Bridge at the time the bridge collapsed. I saw the center span drop down and the top of it fall toward the upstream (east) side of the bridge. There was no explosion or other unusual occurrence prior to the collapse. There was no wind.

PVT FRED BURANT 35923192
"C" Battery, 639th AAA Bn

At the time the bridge collapsed, I was manning an AA machine gun located in a tunnel under the railroad about 75 yards west of the north abutment of the bridge. I heard a peculiar noise and saw the bridge fold in the center and roll toward the upstream (east). As it fell it twisted back somewhat toward a vertical position.

PFC JOHN REILLY 33134828
"A" Battery, 639th AAA Bn

I was digging a gun emplacement at the edge of the road which was under the bridge on the north side of the river. I was about 100 yards east of the bridge.

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The bridge appeared to give way first over the north pier, then the main span toppled into the river, the top falling toward the upstream side of the bridge and the remainder of the bridge followed. There were no explosions or unusual occurrences prior to the collapse.

PFC EARL KIEF 13070797
"A" Battery, 639th AAA Bn

I was manning a gun in an emplacement beside the road on the north side of the Rhine River about 100 yards east of the bridge when it collapsed. The bridge appeared to give away first over the north pier, then over the south pier, then the north side span fell, followed by the south side span. The center span turned over as it fell with the top falling upstream. There was no unusual noise for at least two hours prior to the collapse of the bridge.

TEC 4 HARMAN GAZAWAY 38564435
1058th P. C. & R Unit

I was standing on the south abutment of the bridge at the time of the collapse. I had just finished welding some floor beams near the south end of the bridge. The whole bridge started to collapse and the rear span (south span) dropped into the river. There was not wind at the time.

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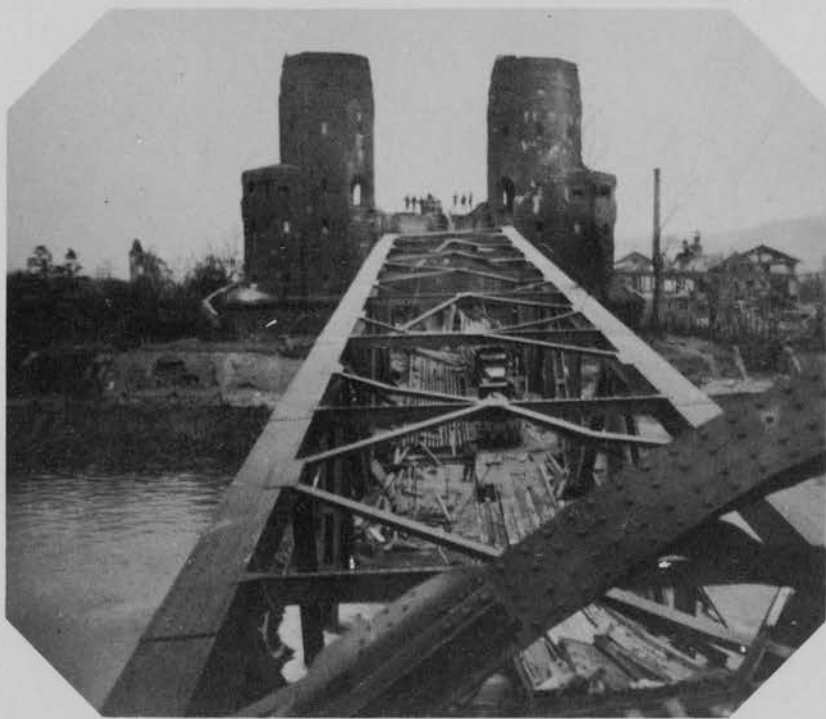


Views of Wreckage from a Point just
downstream from the south abutment

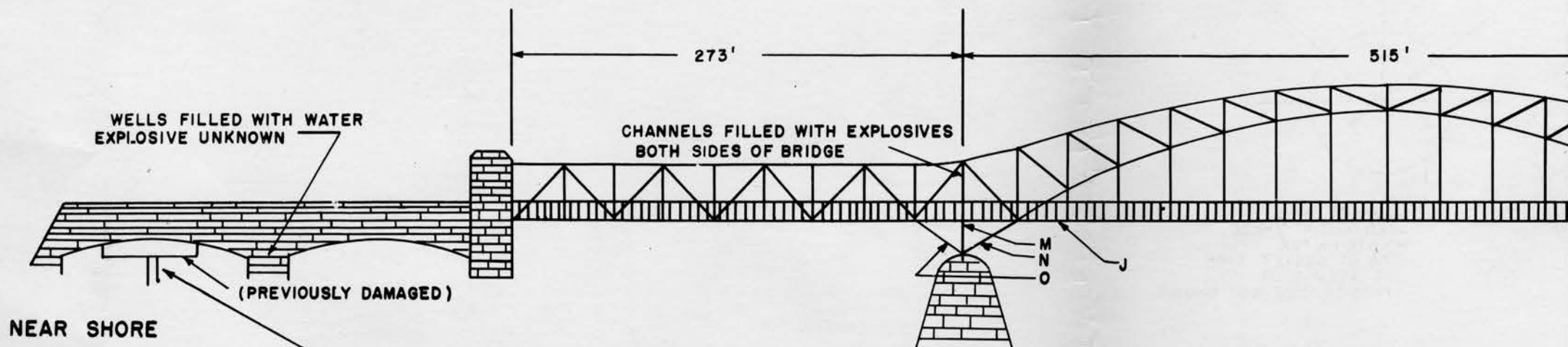
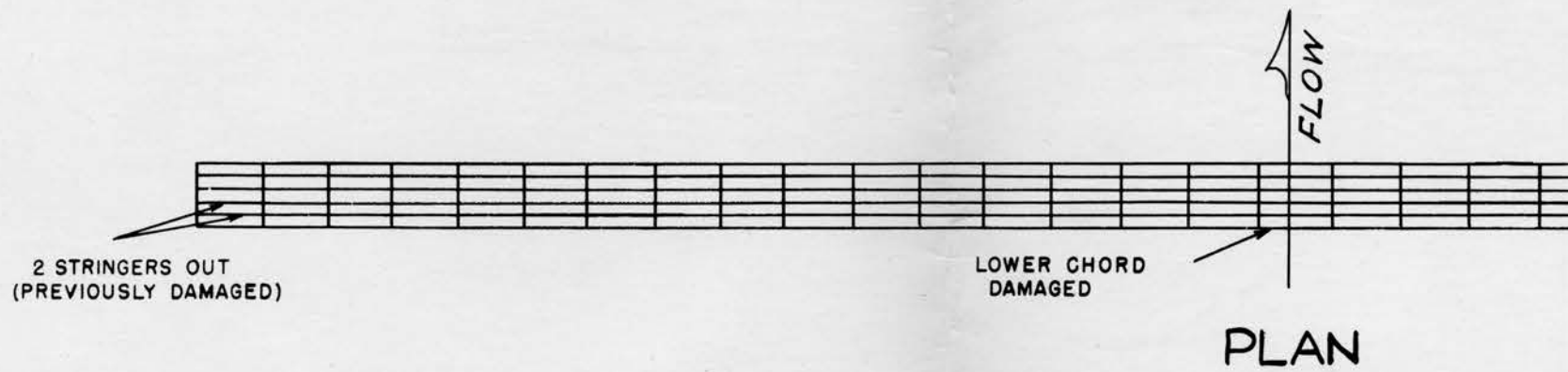
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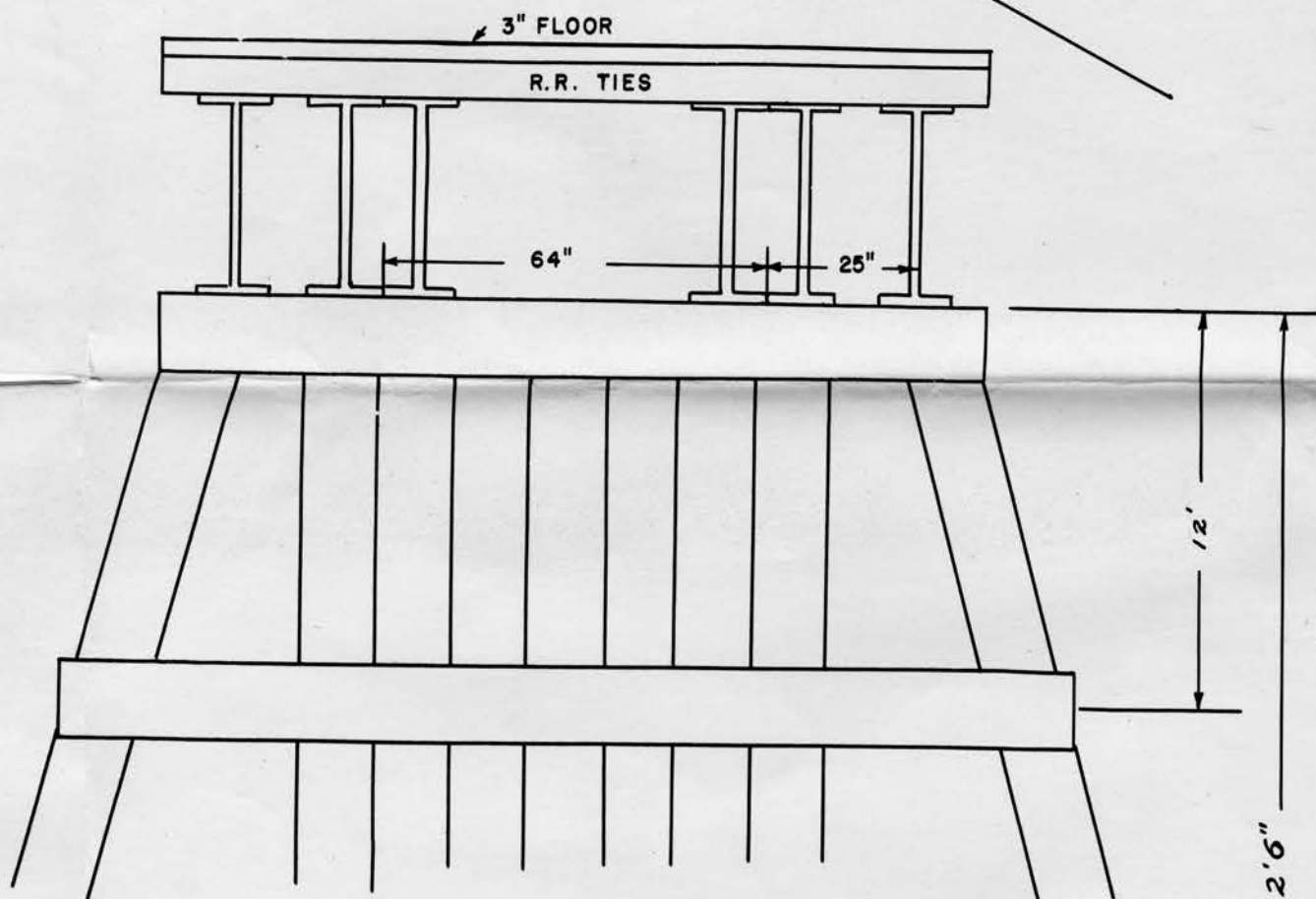
View of Collapsed North Span with
North Pier in the Distance



View of Collapsed South Span from
South Pier

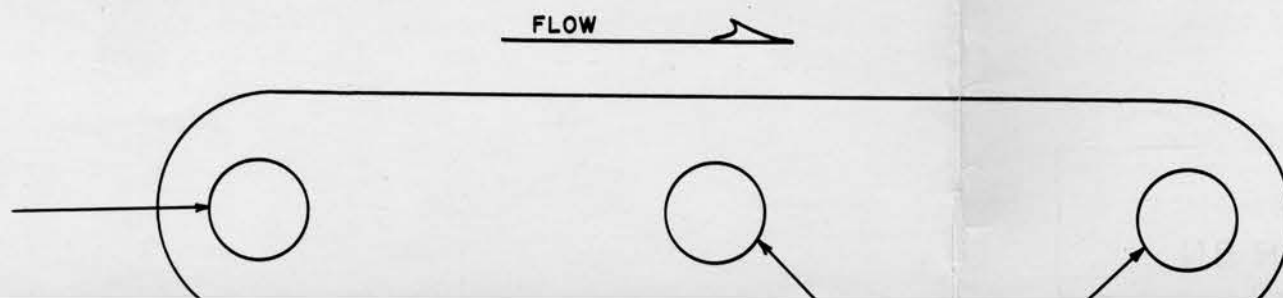


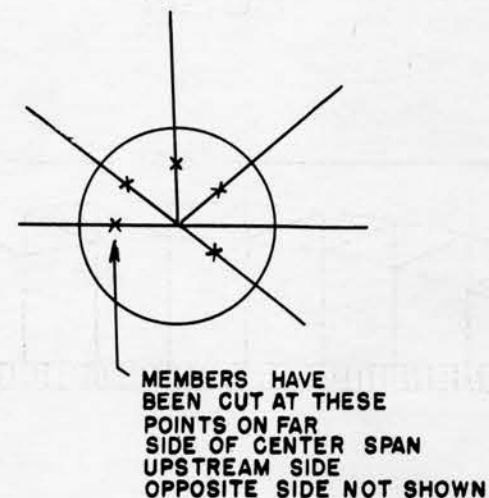
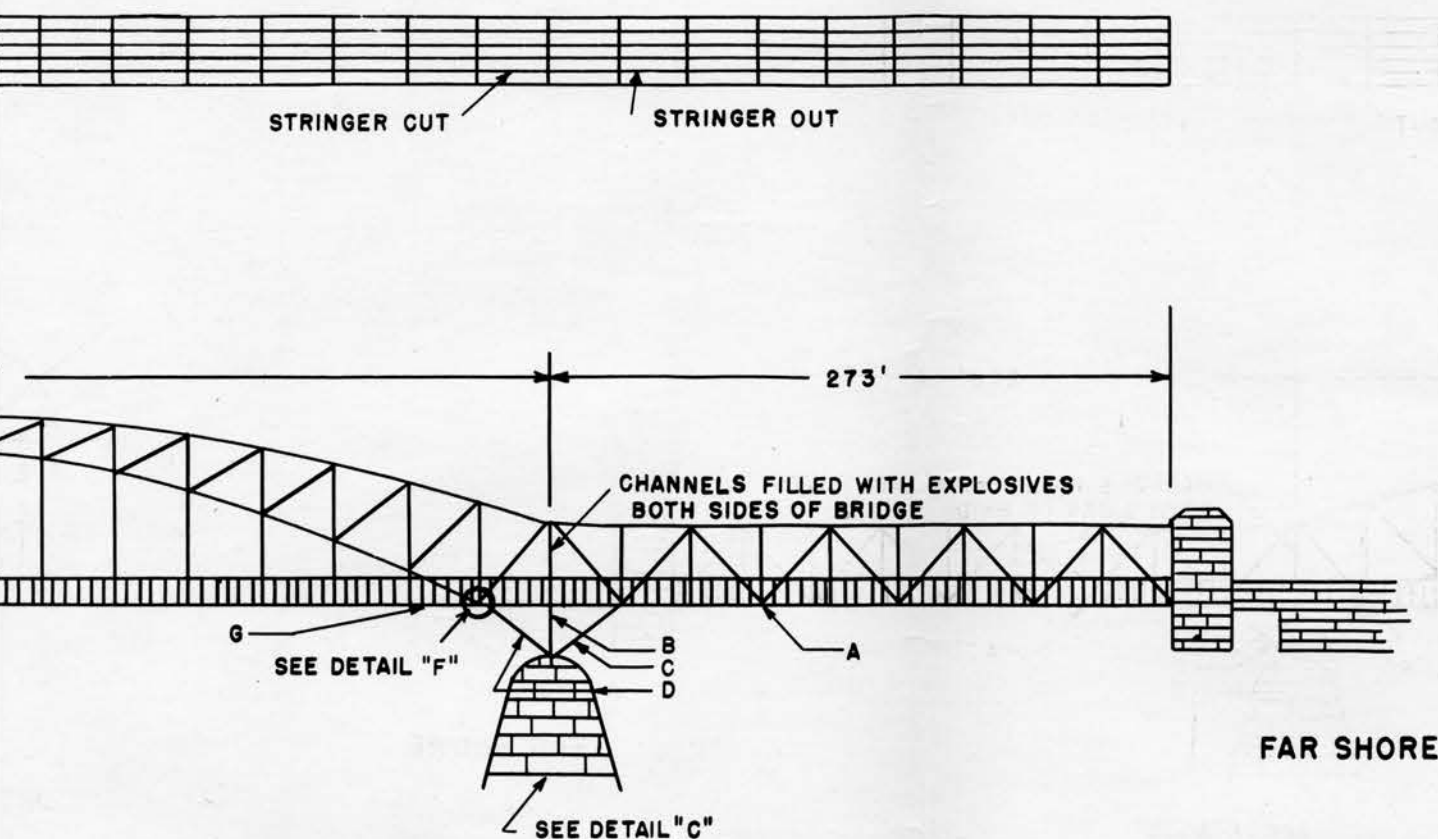
SKETCH SHOWING DAMAGE & DEM



CONSTRUCTION REINFORCING DAMAGED STONE ARCH

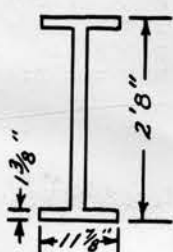
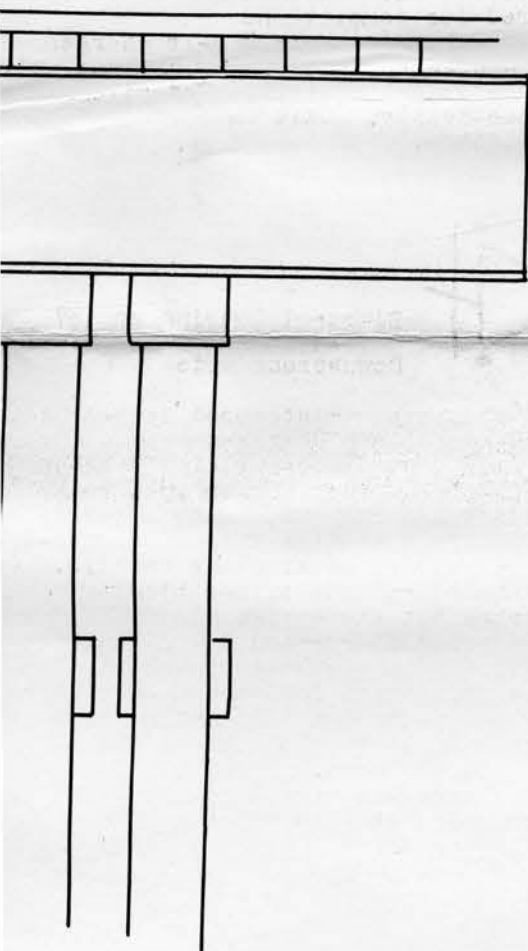
THIS WELL CONTAINED 1 CHARGE
APPROX. 2-V2' DIA. 1' HIGH





DETAIL "F"

AGE & DEMO.



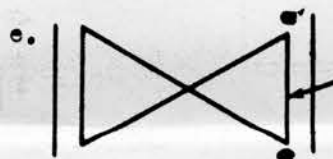
The charges used on the bridge were all tailored to fit the particular member they were to destroy. They consisted of TNT packed in thin metal boxes and the sizes are all estimates.

a. One 8-lb. charge was located at the junction of the floor beam and the downstream vertical chord at (a). Four other similar charges were spaced along the floor beam at this point. No charge was placed on the upstream chord. Each charge contained an electric cap. Since there were no electrical outlets here it is assumed they were wired with a direct line to the main switch.

b. On each open channel side of member (b) downstream there were 6 - 8-lb charges. Each 8-lb charge contained an electric cap with leads connected to a central outlet box. This member on the upstream side of the bridge was not prepared for demolition.

c. Spaced along member (c) were 2 8-lb charges and 9 - 1 Kilogram charges. Each 8-lb charge was prepared with an electric cap with leads going to separate electrical outlets. The kilogram charges were placed to detonate sympathetically. This member on the upstream side was not prepared for demolition.

d. Same as (c)



Diagonal bracing at (b)
Downstream side

At points e and e' there was strapped an 8-lb charge. No electrical outlets were found near these charges.

f. There was an estimated 600-lbs of TNT stacked on all the members which join at point (f). The charges were packed in cardboard boxes whose exact dimensions are unknown. They appeared to be hastily placed and were to be exploded with time fuze and a non-electric cap. The charges upstream detonated and severed the members. On the downstream charge the cap exploded and the primer block was shattered and neighboring blocks disturbed but the charge did not detonate.

g. 1 - 3' x 12" x 10" charge and 1 - 3' x 10" x 6" charge was located on the upstream side of the downstream chord at point (g). 1 - 3' x 12" x 10" charge was on the downstream side of this chord. 1 - 3' x 6" x 12" charge was placed on each stringer. These charges had leads connected to electrical outlets located on the same members. There were no charges on the upstream chord.

A 2' x 12" x 6" charge was placed at the cross point of the sway braces under the stringers at this point.

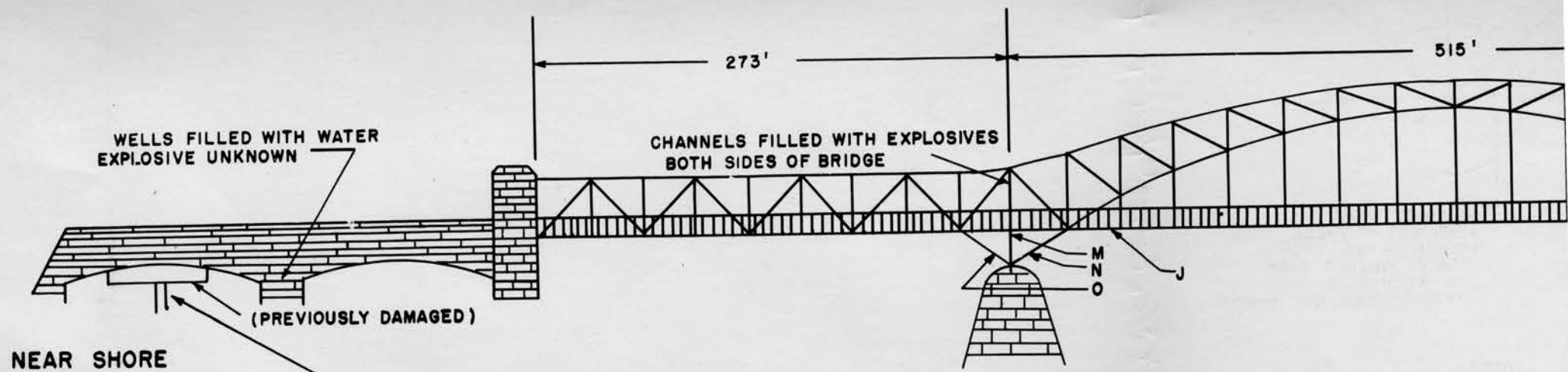
- j) Same as (g)
- m) Same as (b)
- n) Same as c
- o) Same as c

Various charges were also scattered on the far shore span, the location of which cannot be determined. These appeared to have been placed in great haste and seemingly without scheme or plan.

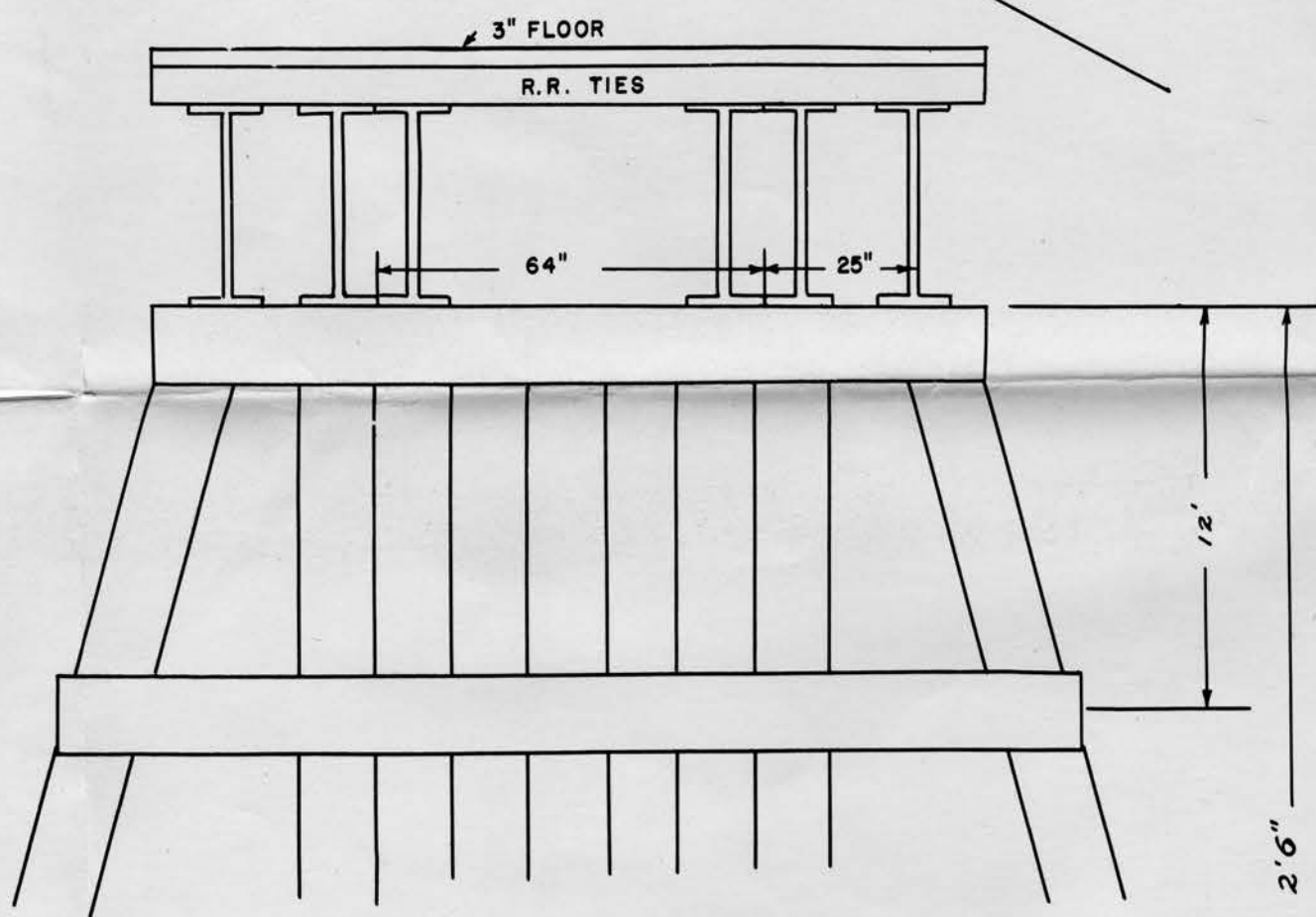
NOTE: The above information has been obtained by questioning the men who actually removed the explosives from the bridge. Because of enemy action at the time of removal there is doubt about the exact size and location of some of the charges.

When the engineers first arrived on the bridge the master switch, located on the endmost vertical of the far shore span, downstream side was closed. This was opened and the main cable severed before the charges were removed.

HEADQUARTERS
9TH ARMORED ENGR BN



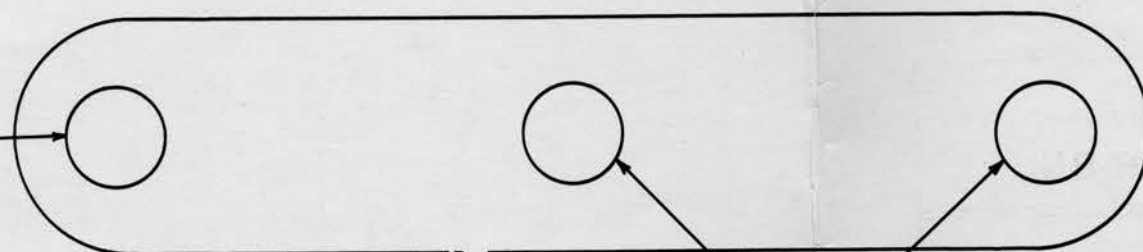
SKETCH SHOWING DAMAGE &



CONSTRUCTION REINFORCING DAMAGED STONE ARCH

THIS WELL CONTAINED 1 CHARGE
APPROX. 2-1/2' DIA. 1' HIGH

FLOW

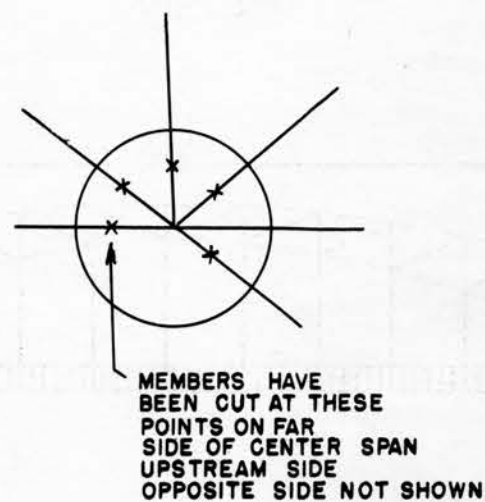
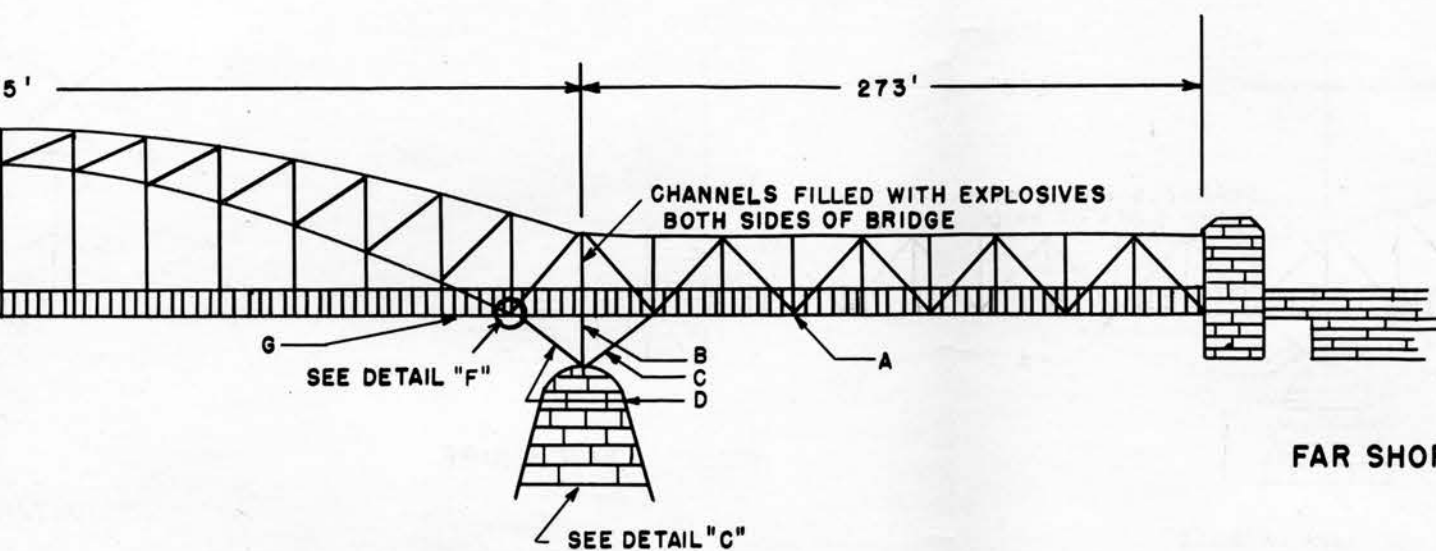


THESE TWO WELLS HAVE NOT
BEEN OPENED, NO WIRES LEAD TO THESE WELLS.

NOTE

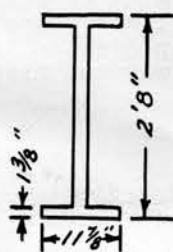
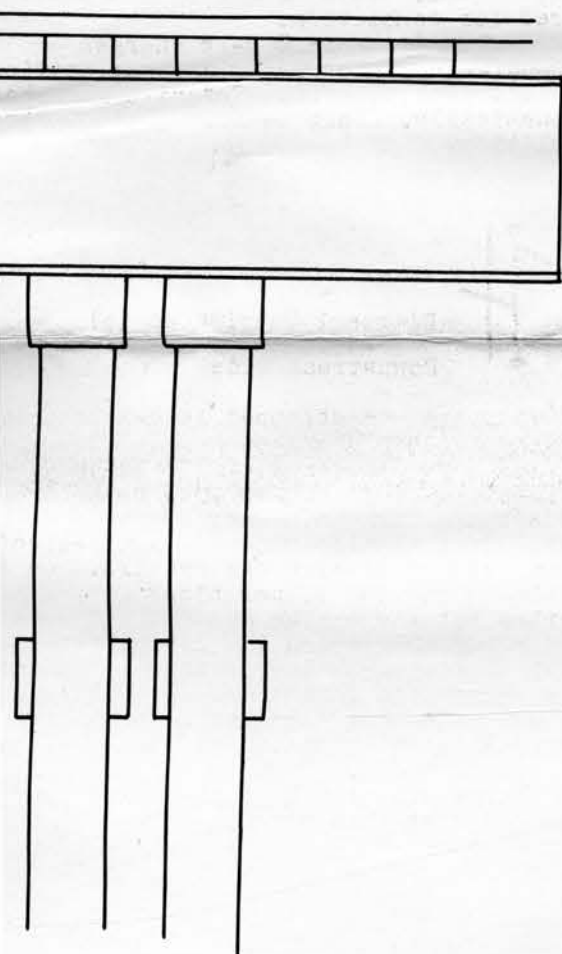
SIMILAR PIER, NEAR SHORE
HAS IDENTICAL WELLS WHICH ARE SEALED. NO WIRES.

DETAIL "C"



DETAIL "F"

IMAGE & DEMO.



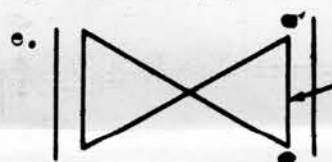
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Diagonal bracing at (b)

Downstream side

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f. There was an estimated 600-lbs of TNT stacked on all the members which join at point (f). The charges were packed in cardboard boxes whose exact dimensions are unknown. They appeared to be hastily placed and were to be exploded with time fuze and a non-electric cap. The charges upstream detonated and severed the members. On the downstream charge the cap exploded and the primer block was shattered and neighboring blocks disturbed but the charge did not detonate.

g. 1 - 3' x 12" x 10" charge and 1 - 3' x 10" x 6" charge was located on the upstream side of the downstream chord at point (g). 1 - 3' x 12" x 10" charge was on the downstream side of this chord. 1 - 3' x 6" x 12" charge was placed on each stringer. These charges had leads connected to electrical outlets located on the same members. There were no charges on the upstream chord.

A 2' x 12" x 6" charge was placed at the cross point of the sway braces under the stringers at this point.

j) Same as (g)

m) Same as (b)

n) Same as c

o) Same as c

Various charges were also scattered on the far shore span, the location of which cannot be determined. These appeared to have been placed in great haste and seemingly without scheme or plan.

NOTE: The above information has been obtained by questioning the men who actually removed the explosives from the bridge. Because of enemy action at the time of removal there is doubt about the exact size and location of some of the charges.

When the engineers first arrived on the bridge the master switch, located on the endmost vertical of the far shore span, downstream side was closed. This was opened and the main cable severed before the charges were removed.

HEADQUARTERS	
9TH ARMORED ENGR BN	
ENGR. RCN.	
LUDENDORF R.R. BRIDGE	
REMAGEN GERMANY	
SHEET 1 OF 2 SHEETS	S-2 SEC
DRAWN BY RJB	CHECKED BY
DATE Mar. 11 1945	