NATIONAL BUREAU OF STANDARDS REPORT

2597

TEST OF PRECAST GIRDER WITH WELDED SPLICES

(TEE-HEAD NO. 1)

by

L. F. Skoda and D. Watstein

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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CONTENTS

TEST OF PRECAST GIRDER WITH WELDED SPLICES

(TEE-HEAD NO. 1)

1. INTRODUCTION

The test of the precast girder was made at the request of the Bureau of Yards and Docks for the purpose of evaluating the resistance to shear of the welded splices and the thin web of the hollow girder.

The following report presents the data obtained in the test of the specimen which was designated as Tee-Head No. 1 by the Bureau of Yards and Docks.

2. DESCRIPTION OF TEST SPECIMEN

2.1 General Description of Specimens

The precast Tee-Head was constructed in accordance with the Bureau of Yards and Docks plans and specifications, (see sketch B-1, January 12, 1953, attached). The Tee-Head consisted essentially of two reinforced concrete channels with straight haunches. The two channels, 12 ft 6 in. long and 3 ft 6 in. deep at the mid section, were joined together with welded plate splices along the top and bottom legs of channel. Each channel was stiffened with four ribs, one near each end and one 9 in. each side of the centerline of the specimen. The overall thickness of the assembled specimen was 12 in. and the web thickness was 2 1/2 in. for each channel throughout. The girder ends which were constructed to match the ends of the Tee-Head simulating a girder suspended between two adjoining Tee-Heads as shown in figures 1 and 2.

2.2 Forms

In order to keep the cost of casting the specimens to a minimum, only one set of forms was made and the two halves of the Tee-Head were cast on two different days; the first half of the Tee-Head was cast on March 16 and the second half on March 26.

The forms were fabricated of wood and so constructed that the sides were easily removed. A base of 4-in. by 4-in. timbers was topped by sheets of 1/2-in. plywood. Plywood panels were then bolted to the base to form the inside of the vertical stiffening ribs, the legs of the channels and the inside of the web. The end channel sections were cast in an additional set of two forms. Three coats of spar varnish were applied to all surfaces within the form and prior to casting a mixture of oil and asbestine powder was applied to facilitate stripping. The forms with reinforcing steel in place are shown in figures 3 and 4.

2.3 Concrete

The proportions of the concrete mix were 1:2.48:2.02, by weight. High-early strength cement was used in order to expedite the curing of the specimens. The aggregates were White Marsh, Maryland sand and pea gravel, maximum size of the coarse aggregate being 3/8 in. Three batches of concrete were mixed for each pour and the slump varied from 2 1/2 in. to 5 1/2 in. Six standard 6 in. by 12 in. control cylinders were cast to represent each half of a specimen and the average compressive strength realized at the time of the test of the Tee-Head was 7270 psi. Stress-strain curves were determined for each set of concrete cylinders and are shown in figure 5. All concrete specimens were cured for two days under damp burlap; they were then transferred to a curing chamber until it was necessary to remove them for fabrication into a Tee-Head.

2.4 Reinforcement

The channels composing the Tee-Head were reinforced with bars of intermediate grade and with welded wire fabric. Two No. 9 deformed reinforcing bars were located along the upper leg of each channel and a No. 4 deformed bar was located along the bottom leg of the channel. Both top and bottom reinforcing bars projected four inches beyond each end of the specimen. The purpose of extending the bars was to form a welded joint with the beam end sections. The webs of the channels were reinforced with 2 in. by 2 in. welded wire fabric of No. 6 gage. The fabric extended throughout the web and was bent at a 90° angle to extend into the upper and lower leg of the channel.

The beam end sections were similarly reinforced with a single No. 7 deformed reinforcing bar in the upper and lower legs and were so placed as to permit being welded to the bars projecting from the Tee-Head. Wire fabric of the size used in the Tee-Head was also placed in the same manner in the beam ends.

2.5 Assembly of Specimens

The two halves of the Tee-Head were joined together at six points. Three of these points were located on the upper leg and the remaining three on the lower leg of the channels. These connections were made by welding 1- by 2- by 3/8-in. steel plates to the adjoining 2- by 3- by 3/8-in. plates which were embedded into each half of the specimen. The embedded plates were anchored by being welded to a No. 5 reinforcing bar placed in the leg and web of the specimen. Similar welding plates were also cast into the beam ends at four points on the stiffening ribs.

After the channels and beam end sections were assembled, the welded splices were made by placing all three parts of the Tee-Head so as to form welded lapped joints of the reinforcing bars projecting from the Tee-Head and the two beam ends as shown in the close-up in figure 2. The outer No. 9 reinforcing bars of the Tee-Head were welded to the No. 7 bar of the beam end at the top of the specimen. In the same manner, the No. 4 bar of the Tee-Head was welded to the No.7 bar in the beam end at the bottom of the specimen. In all cases the length of the welded lap joint was 3 inches. After the welding was completed, the gaps between the Tee-Head and the beam ends were filled with a 1:3 mortar.

3. TESTING PROCEDURE AND RESULTS

3.1 Test Set-Up

The Tee-Head was tested to failure in a 600,000 lb capacity testing machine. It was necessary to support the test specimen on a 20-ft length of I-beam since the length of the platen of the testing machine was only 12 ft, whereas a 14-ft span was specified in the test of the Tee-Head. The supporting I-beam was 30-in. deep and was supported at points 12 ft apart by 4- by 4- by 12-in. steel blocks. The Tee-Head was then placed in an inverted position on top of the supporting I-beam as shown in figure 6. At the reaction points 7 feet on either side of the vertical centerline, the Tee-Head was supported by rollers. The top of the Tee-Head was covered with a 14- by 18- by 1-in. steel plate and a 10- by 12- by 4-in. steel bearing block was interposed between the first plate and the crosshead of the testing machine. The load was applied through a 3-in. diameter steel roller which was sandwiched between two steel plates. Neat plaster of Paris was used to assure intimate contact between all steel parts of the assembly.

3.2 Instrumentation

Deflection of the Tee-Head was measured at the center of the specimen by a taut-wire device and also with micrometer dial gages. The taut-wire device consisted of .011 in. diameter wire stretched taut with weights suspended over anchor pins located directly above the reaction points. A scale calibrated in hundredths of an inch was cemented to the specimen along its centerline and readings were taken at the point on the scale intersected by the wire. The micrometer dial gages having one thousandth inch divisions were placed at the centerline and bore against brass angles cemented to the sides of the specimen. The dial gages were mounted on tripods which rested on the platen of the testing machine. A pair of dial gages were mounted over the east and west ends of the test specimen directly over the support in order to detect any settlement of the supporting members in reference to the platen of the testing machine.

3.3 Test Results

The stress-strain curves obtained for the concrete and the mortar used in grouting the girder splices are shown in figure 5. The concrete in the first half of the Tee-Head was 32 days old at the time of test, and the second half of the specimen was 22 days old. The compressive strengths of the cylinders representing the two halves of the specimen were 7100 and 7250 psi, while their tangent moduli were 4,700,000 and 5,400,000 psi, respectively. The mortar grout was 8 days old at the time of test and its compressive strength and tangent modulus were 5700 psi and 3,800,000 psi, respectively.

The properties of the reinforcement used in the Tee-Head are given in the Table on Properties of Materials. All the bars were deformed reinforcing bars of intermediate grade, while the welded wire fabric used as web reinforcement was 2- by 2-in. wire mesh of No. 6 gage.

The Tee-Head was tested in an inverted position as a simple beam having a 14 ft span with a concentrated load applied at the center. The load was applied in increments of 5000 lb up to a load of 10,000 lb and in increments of 10,000 lb until a maximum load of 130,000 lb was reached.

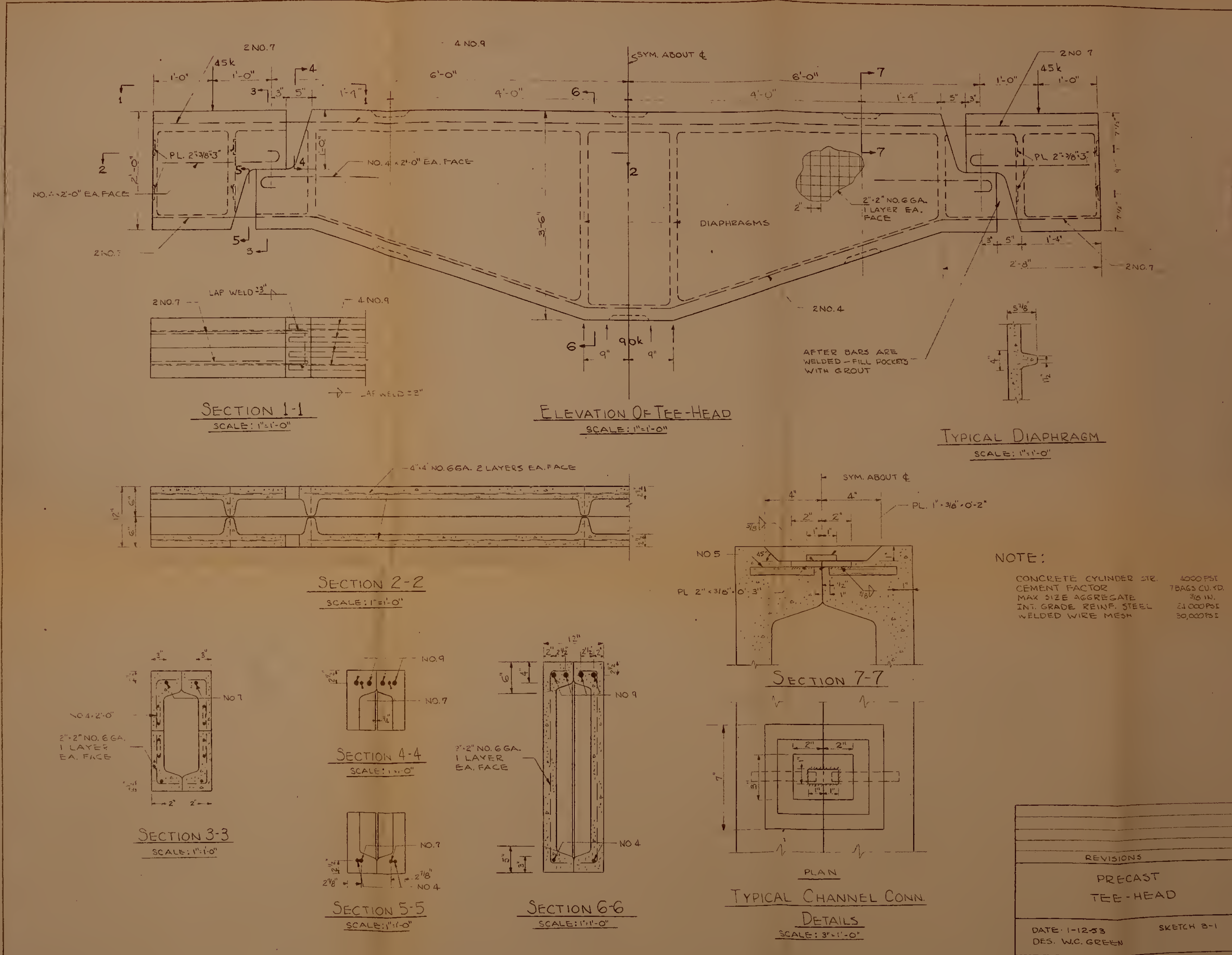
Shrinkage cracks were observed at the start of the test in planes where the mortar in the girder splices was bonded to the concrete. The first visible tensile crack in the concrete appeared at a load of 28,500 lb. In all, a total of 57 cracks appeared throughout the test. These cracks were all carefully marked and numbered and the crack pattern is shown in figure 7. The load-deflection curve shown in figure 3 represents the averaged results obtained with both the taut-wire device and the micrometer dial gages. There was good agreement between the data obtained by the two different methods.

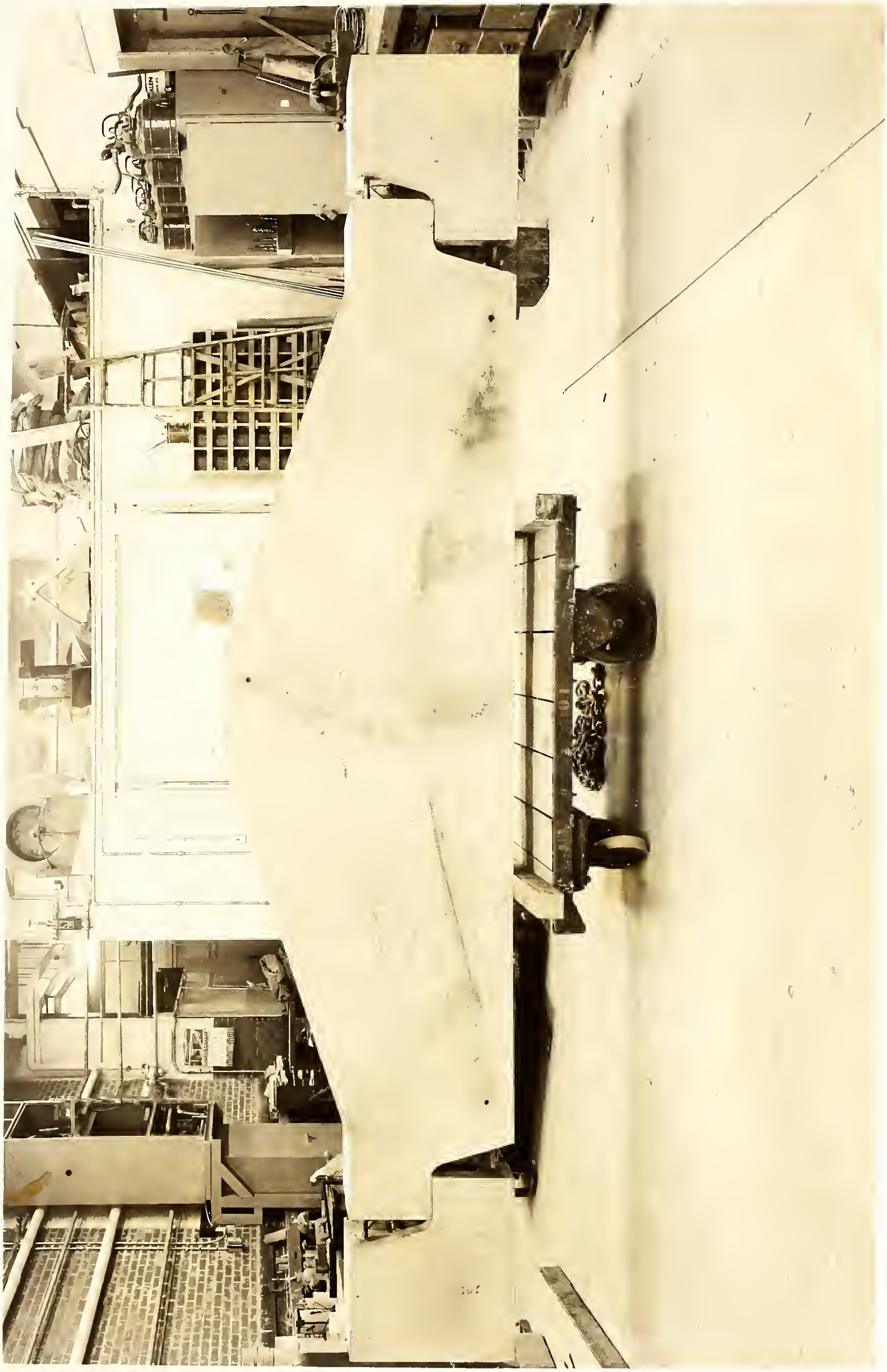
The load-deflection relationship observed in the test of Tee-Head as a simply supported beam was in accord with similar results usually obtained with conventionally reinforced concrete beams. The relatively steep initial portion of the curve corresponds to the load-deflection relationship observed prior to cracking which started at about 30,000 lb. As the number of cracks increased, the beam began to deflect more rapidly. The maximum value of deflection at the center of the Tee-Head was 0.362 in. at 120,000 lb, at which load the last ddflection reading was made.

The width of several cracks was measured with a Brinnell microscope at loads of 60,000 and 90,000 lb. The width of cracks varied from 0.05 to 0.10 mm at the 60,000 lb load, and from 0.09 to 0.6 mm at the 90,000 lb load.

The Tee-Head failed at a load of 130,000 lb. The east end of the Tee-Head appeared to fail in diagonal tension, with the major crack running up and toward the applied load from the center of the girder splice. However, a closer examination of the splice revealed that the lap weld in one half of the east girder splice failed in tension, causing shear failure in the web as a secondary failure. A close-up of the girder splice which failed is shown in the views of the northeast and southeast corners of the specimen, figures 9 and 10.


6'-0"


ELEVATION OF TEE-HEAD
SCALE: 1"=1'-0"
SYM. ABOUT ℄
DIAPHRAGMS
AFTER BARS ARE WELDED — FILL POCKETS WITH GROUT
SECTION 1-1
SCALE: 1"=1'-0"
TYPICAL DIAPHRAGM
SCALE: 1"=1'-0"
SECTION 2-2
SCALE: 1"=1'-0"
SECTION 7-7
SECTION 3-3
SCALE: 1"=1'-0"
SECTION 4-4
SECTION 5-5
SCALE: 1"=1'-0"
SECTION 6-6
SCALE: 1"=1'-0"
PLAN
TYPICAL CHANNEL CONN. DETAILS
SCALE: 3"=1'-0"
NOTE:
CONCRETE CYLINDER STR. 4000 PSI
CEMENT FACTOR 7 BAGS CU. YD.
MAX SIZE AGGREGATE 3/8 IN.
INT. GRADE REINF. STEEL 20,000 PSI
WELDED WIRE MESH 30,000 PSI
REVISIONS
PRECAST TEE-HEAD
DATE 1-12-53
DES. W.C. GREEN
SKETCH 3-1



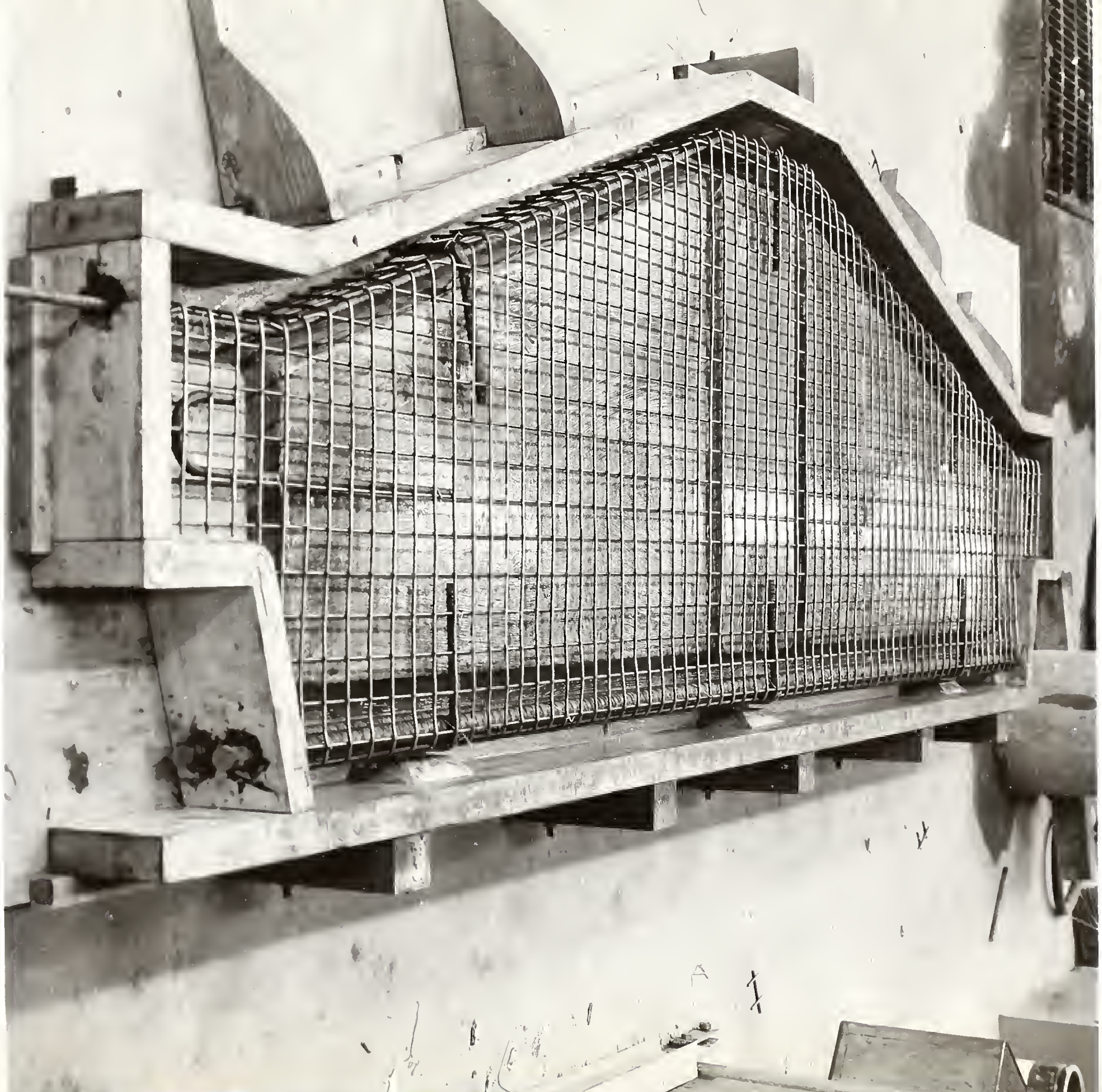


Fig. 3. Form for center portion of Tee-Head, with steel in place.

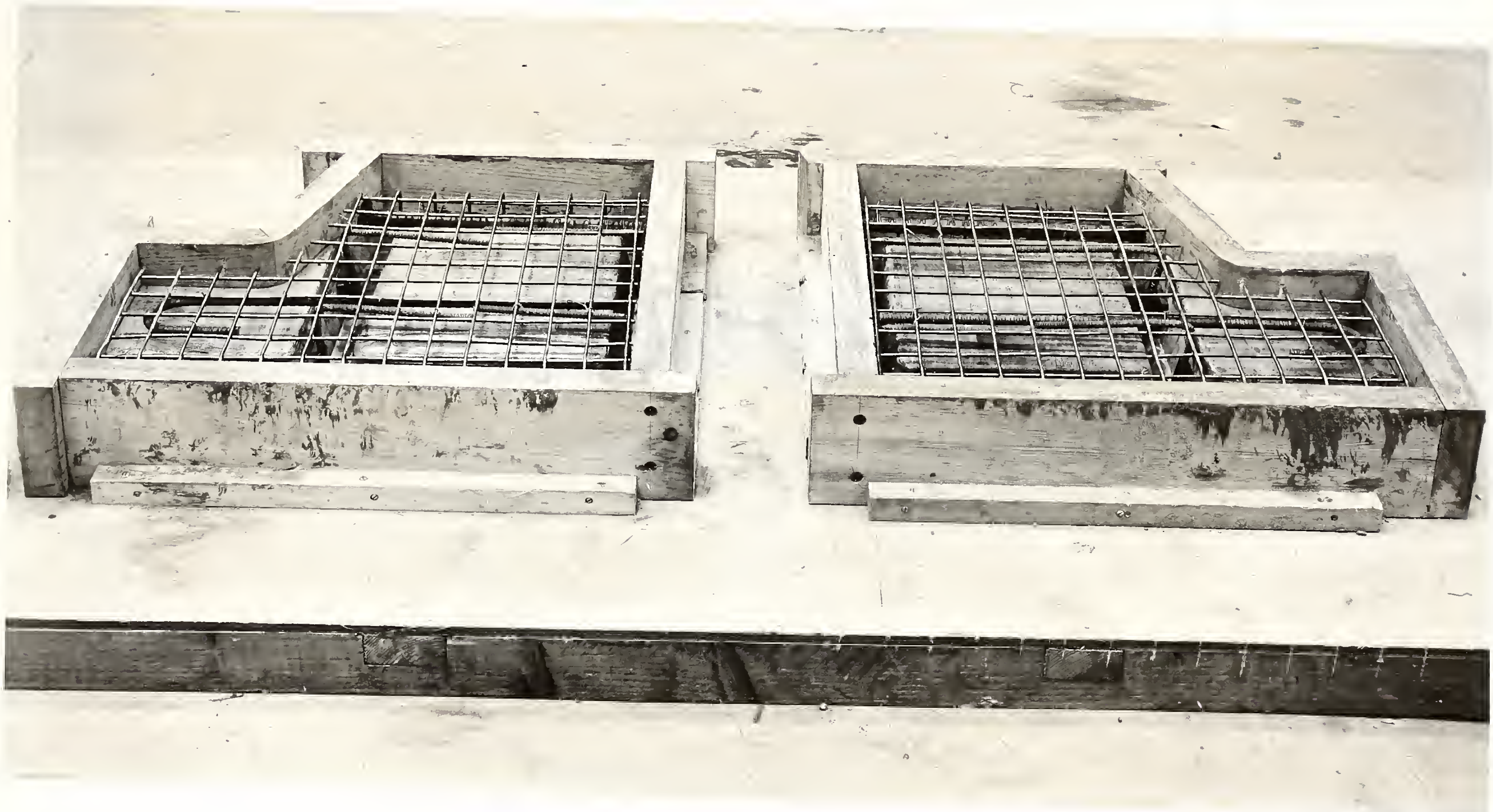
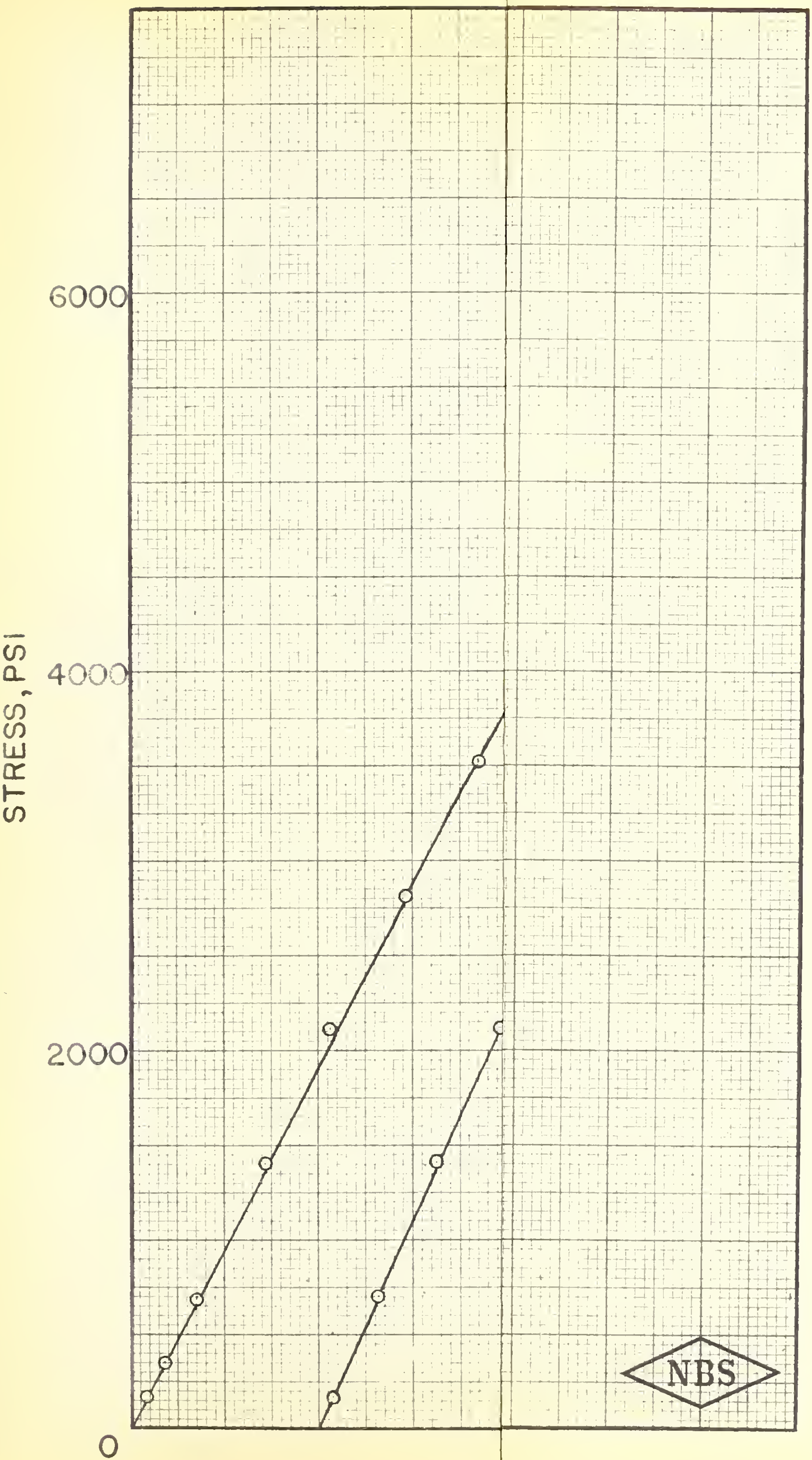


Fig. 4. Forms for girder ends, with steel in place.



STRESS, PSI
6000
4000
2000
0

FIG. 5

STRESS-STRAIN CURVES TEE HEAD NO. 1

COMPRESSIVE TESTS OF CONCRETE AND MORTAR CONTROL CYLINDERS

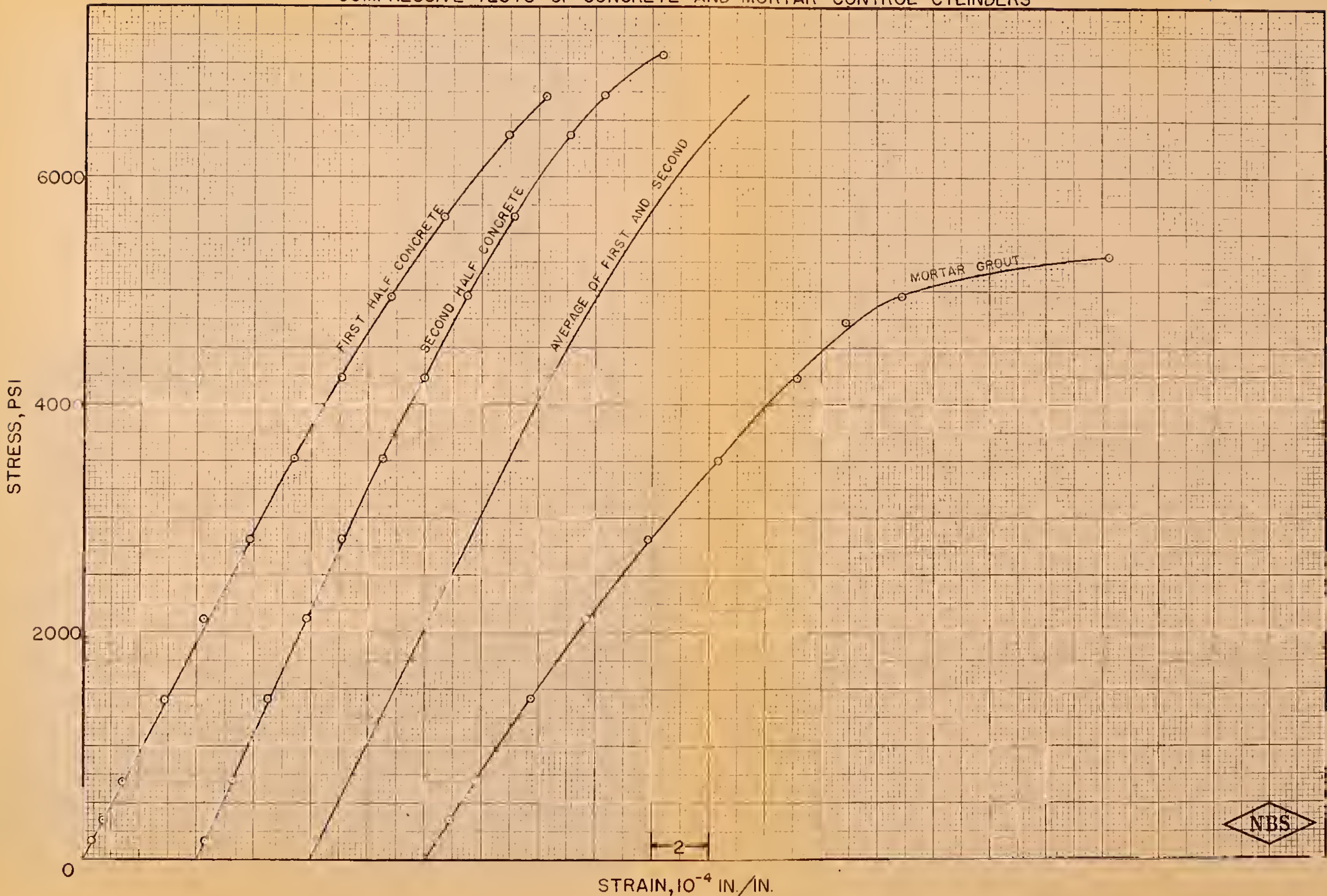


Fig. 6. View of Tee-Head in testing machine.

FIG. 7

CRACK PATTERNS TEE HEAD NO. 1

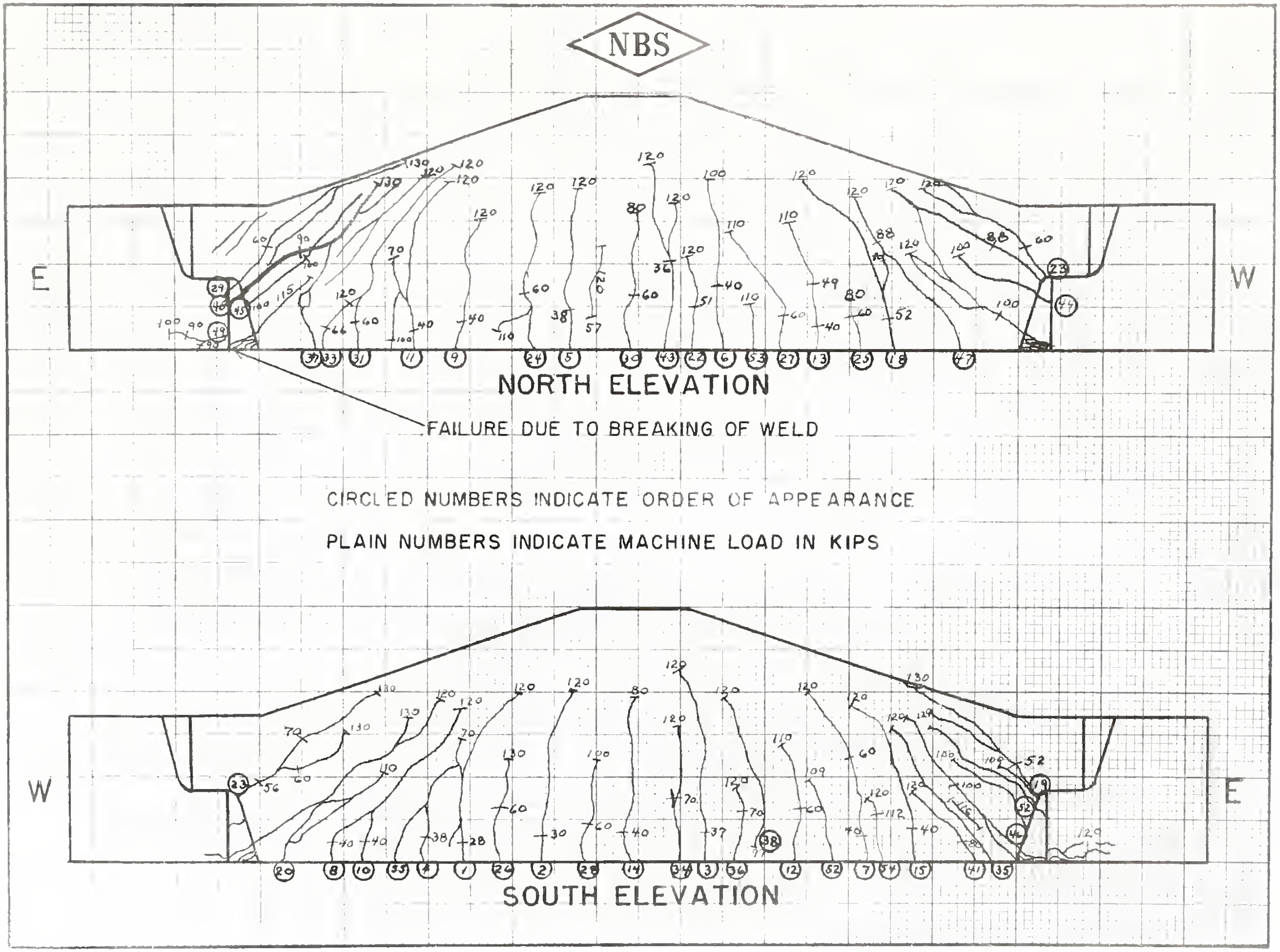


FIG. 8

LOAD DEFLECTION CURVE TEE HEAD NO. 1

AVERAGE OF TAUT WIRE METHOD AND DIAL GAGES

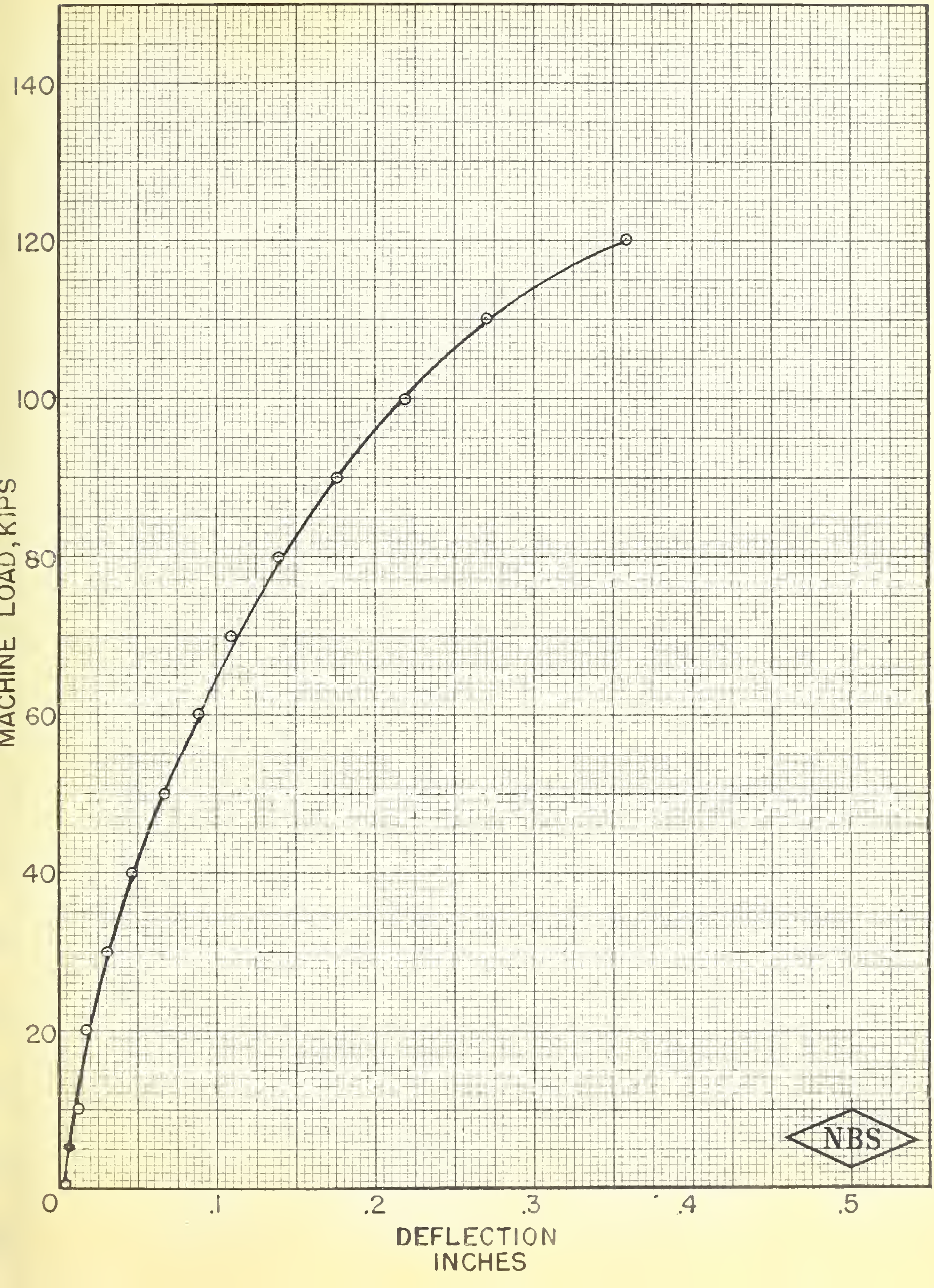


Fig. 9 Close-Up of splice failing in shear (north side).

Fig.10 Close-Up of splice failing in shear (south side).

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