ASSOCIATION OF AMERICAN RAILROADS

RESEARCH AND TEST DEPARTMENT

REPORT NO. LT-327

STATIC, DYNAMIC AND SPIKE-PULL-OUT TESTS ON CONCRETE BRIDGE TIES

SEPTEMBER 1972

AAR RESEARCH CENTER
Chicago, Illinois

INTRODUCTION

AREA Committee 8 - Masonry - requested the testing and evaluation of 9 in. x 10-1/2 in. cross section prestressed concrete bridge ties by the Association of American Railroads Research and Test Department. The work was done by the AAR in cooperation with the Portland Cement Association and AREA Committee 8 studies on design of concrete bridge ties.

BACKGROUND

After testing three (3) similar specimens of prestressed concrete bridge ties at the AAR laboratory in 1967 - which yielded inconclusive results - the PCA redesigned the ties in 1968 and 1969. The new design ties were cast by Vulcan Materials Company on September 30, 1970, and delivered to AAR laboratory for testing. The quantity and size of the ties were as follows:

5 ties 9 in. by 10-1/2 in. - 11 ft. long (type "A")

5 ties 9 in. by 10-1/2 in. - 12 ft. long (type "B")

1 tie 9 in. by 10-1/2 in. - 11 ft. long (Special)

The testing of the specimens was under the direction of K. W. Schoeneberg, Executive Research Engineer. This report was written by C. Somogy, Assistant Research Engineer, Structures, who also assisted in the conduct of the tests.

DESCRIPTION OF TESTS

Type "A" ties were identified as Numbers 2 through 6 and type "B" ties were identified as the Numbers 7 through 11. The "Special" tie, containing six various types of spiking inserts, was identified as Number 1.

Tie Number 3 and 4 were selected for static load test, Number 6 for repeated load (fatigue) test and Number 1 and Number 7 for spike-pull-out tests.

STATIC AND REPEATED LOAD TESTS

Figure 1 and Figure 6 show the general set-up for static and dynamic loading. The east end of the tie rested on a fixed bearing (Figure 7), and the west end on a roller bearing (Figure 8). Figures 2 and 3 illustrate the location and extent of the first significant cracks on ties Number 3, 4 and 6 as indicated during testing.

Tie Number 3 was tested on November 2, 1970 in the Amsler* loading press on an 8.0 ft. support span with the two loading jacks, placed 5.0 ft. apart and symmetrical to the center of the tie. The P/2 jack load was increased to 25,000 lb. in 5,000 lb. increments. Loading was then increased to 27,000 lb. (design load), and then

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* A description of the Amsler jacks and pulsator can be found in AREA Proceedings, Volume 61, 1960, p. 601.

to 34,500 lb. (cracking load) and again in 5,000 lb. increments to failure. The deflection of the tie was measured at the center line at each increment of loading and micrometer dials applied on two strands at either end of the tie measured any slippage of the strands.

Tie Number 3, whose 28 day cylinder strength was 8,830 psi, showed the first cracks at P/2 jack load of 36,000 lb. and did not fail under 65,000 lb. load. The load was released to 0 and then loaded up again to 65,000 lb. and beyond in slow 5,000 lb. increments. Failure occurred at 72,500 lb. load.

Also on November 2, 1970, tie Number 4, whose 28 day cylinder strength was 7,900 psi was loaded similarly to tie Number 3 and the first cracks appeared at 36,000 lb. on opposite faces of the tie. The load after 65,000 lb. was continuously increased. The tie failed at 71,000 lb. per jack.

The corresponding crushing moments were 1,300,000 in. lb. for tie Number 3 and 1,280,000 in. lb. for tie Number 4.

Tie Number 6 was subjected to static testing and then dynamic testing on November 3, 1970. Under static testing, and at 34,500 lb. design cracking load, no cracks appeared, however, at 37,000 lb. and 38,000 lb. loads several were visible. For dynamic testing, it was decided to set the subsequent fatigue load range between a maximum of 38,000 lb. and a minimum of 4,000 lb. per jack. After 3,000,000 cycles between November 3rd and 19th, (200 cycles per minute) the tie did not show damage; the cracks did not open up or grow in length. It was then decided to load the tie statically from 30,000 lb. in 5,000 lb. increments, until failure, which occurred at P/2 of 73,600 lb. (See Figures 9 through 14).

To illustrate the test results of static loading, a comparison of calculated and measured values of ties Number 3, 4 and Number 6 are shown on Table 1.

SPIKE-PULL-OUT TEST

The spike-pull-out test was conducted in two parts.

On November 2, 1970, after driving standard cut spikes into the twenty (20) various insert type holes of tie Number 1, 9 of the 20 were selected to measure the force in pounds needed to move and then pull the spike out by means of a Simplex hydraulic jack. The various types of insert holes are shown on Figure 4. The results of these tests are listed on Table 2. On November 18, 1970, tie Number 7 was used to investigate the holding power of one-bend and two-bend spike inserts and also the relative holding power of subsequent spikes driven into the same (re-used) insert hole. The results of these tests are shown on Table 3.

TEST RESULTS AND CONCLUSIONS

The test results indicate that the ties, as designed and manufactured, performed satisfactorily. Cracks developed at a higher load than the design cracking load for each tie tested. Ultimate capacity was more than 50 percent higher than calculated.

In dynamic testing, the one tie tested sustained 3 million cycles without failure. The final ultimate crushing strength was higher than on the two ties subjected to static test only, and 60 percent higher than the calculated ultimate strength.

On Figure 5, corresponding load and deflection values of the above ties are plotted. It can be noted that ties Number 3 and Number 6 follow the same pattern in a continuous, unbroken line. The load-deflection curve of tie Number 4 shows a break at cracking load and the deflection increased more rapidly with respect to load for this tie as compared to tie Number 3 and Number 6.

Test results of the spike-pull-out test show that on tie Number 1, the pull-out force varied between a minimum of 6,300 lbs. to a maximum of 15,800 lbs. (See Table 2.) The spike-pull-out test results, as shown on Table 3 when tie Number 7 was used, show that the holding power of a two-bend spike (8,064 lb. and 10,710 lb) is appreciably greater than that of a one-bend spike (3,150 lb. and 5,292 lb).

When the same insert hole was used the second and third time in driving new spikes, the holding power of the successive spikes decreased from 10,710 lb. to 7,245 lb. to 5,670 lb. or from 100 percent to 67 percent to 53 percent. It was noted that the concrete cracked radially from the inserts when spikes were driven.

SUMMARY

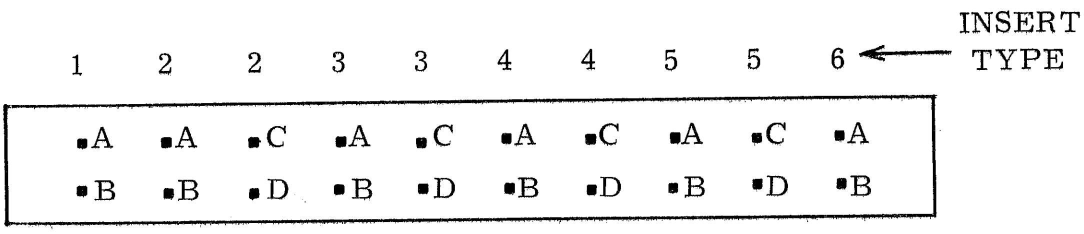
The concrete bridge ties tested met the initial design criteria. At the present time there are no testing or performance specifications covering concrete bridge ties, therefore no comparison or recommendations can be made.

Executive Research Engineer

Approved: Manager of Tests

PRESTRESSED CONCRETE BRIDGE TIE

TIE #1



INSERT TYPE	OIL GAUGE DIAL INITIAL	OIL GAUGE DIAL ULTIMATE	PULL-OUT FORCE INITIAL	PULL-OUT FORCE ULTIMATE
	Pounds Per Square Inch		Pounds	
6A	610	980	7700	12300
6B	690	980	8700	12300
5C	740	890	9300	11200
5D	650	650	8200	8200
5A				
5B				
4C	650	800	8200	10100
4D				
4A				
4B				
3C				
3D				
3A	540	500	6800	6300
3B				
2C	530	1250	6700	15800
2D	440	1000+	5500	12600+
2A				
2B				
1A	640	800	8100	10100
1B				

TABLE 2

SPIKE-PULL-OUT TEST

PRESTRESSED CONCRETE BRIDGE TIES

TIE NO. 7 - REGULAR SPIKE INSERTS, TYPE 7

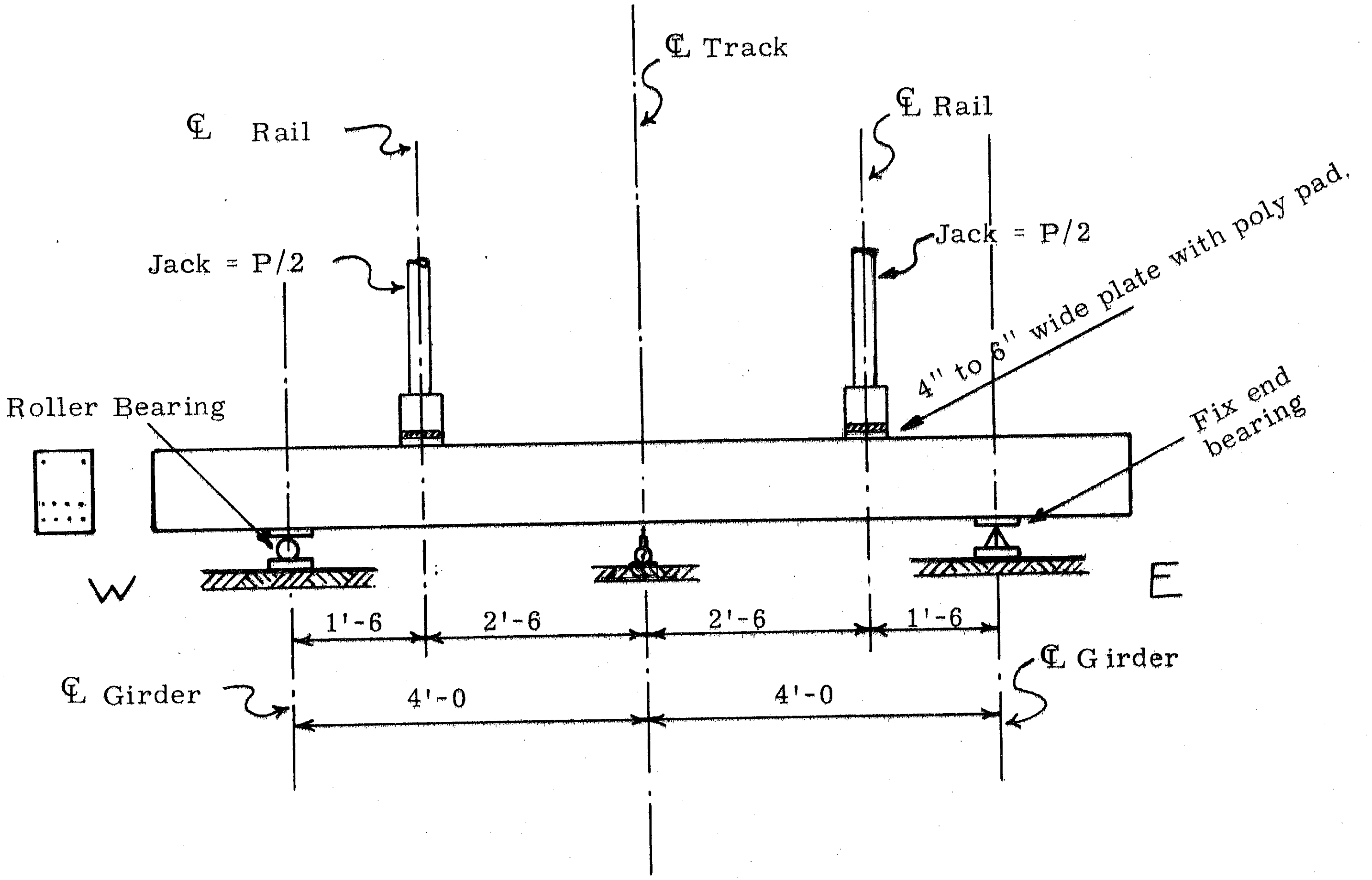
INSERT	FORCE IN LBS.	REMARKS
1.	8,064 lbs.	Two bend
2.	10,710 lbs.	Two bend
3.	5,292 lbs.	One bend (3-1/2 inches penetration into insert)
4.	3,150 lbs.	One bend
2 (a)	7,245 lbs.	New Spike in hole 2
2 (b)	5,670 lbs.	New Spike in hole 2

Note: 2 (a) = Second time hole No. 2 was used.

2 (b) = Third time hole No. 2 was used.

TABLE 3

TEST SET UP FOR PRESTRESSED CONCRETE BRIDGE TIE



Design Load Moment = 432,000 in. lb; P/2 = 24,000 lb.

Calculated Cracking Moment = 620,000 in. lb; P/2 = 34,500 lb.

Calculated Ultimate Moment = 830,000 in. lb; P/2 = 46,000 lb.

Two 50,000 lb. Amsler jacks actuated by a single pulsator were used.

FIGURE 1

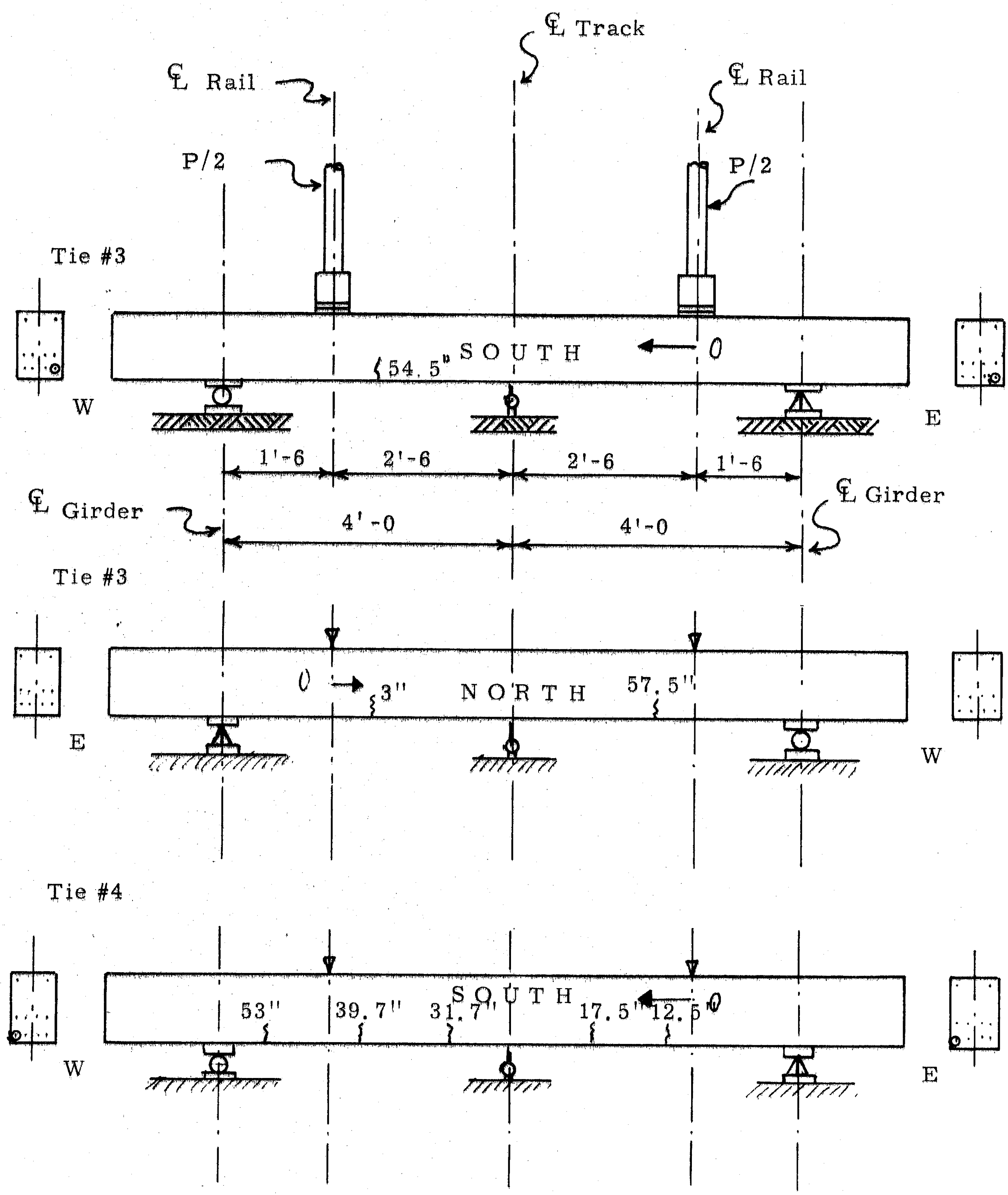

℄ Track
℄ Rail
℄ Rail
P/2
P/2
Tie #3
SOUTH
0
54.5"
W
E
1'-6
2'-6
2'-6
1'-6
℄ Girder
℄ Girder
4'-0
4'-0
Tie #3
0
3"
NORTH
57.5"
E
W
Tie #4
SOUTH
53"
39.7"
31.7"
17.5"
12.5"
0
W
E

FIGURE 2

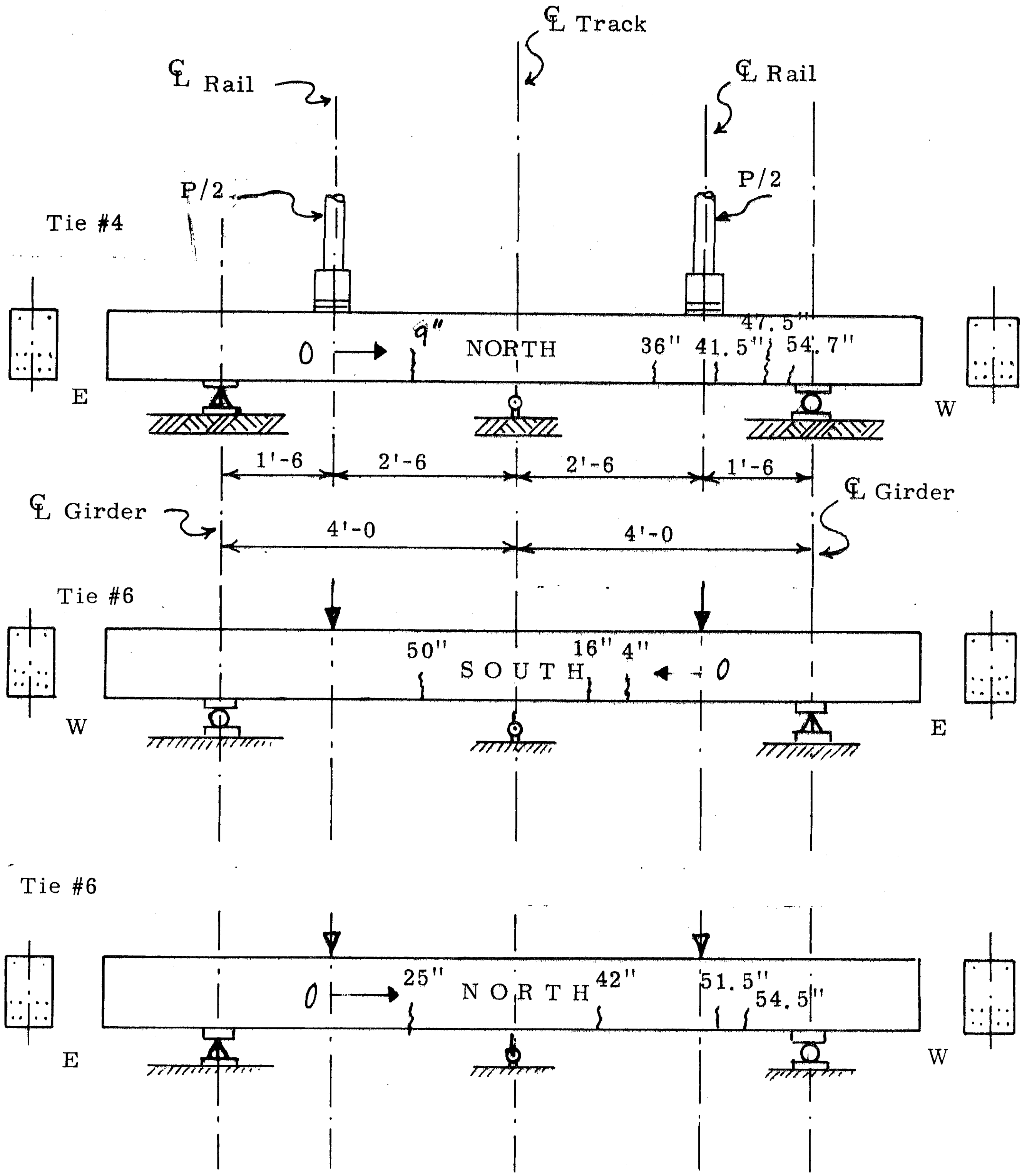
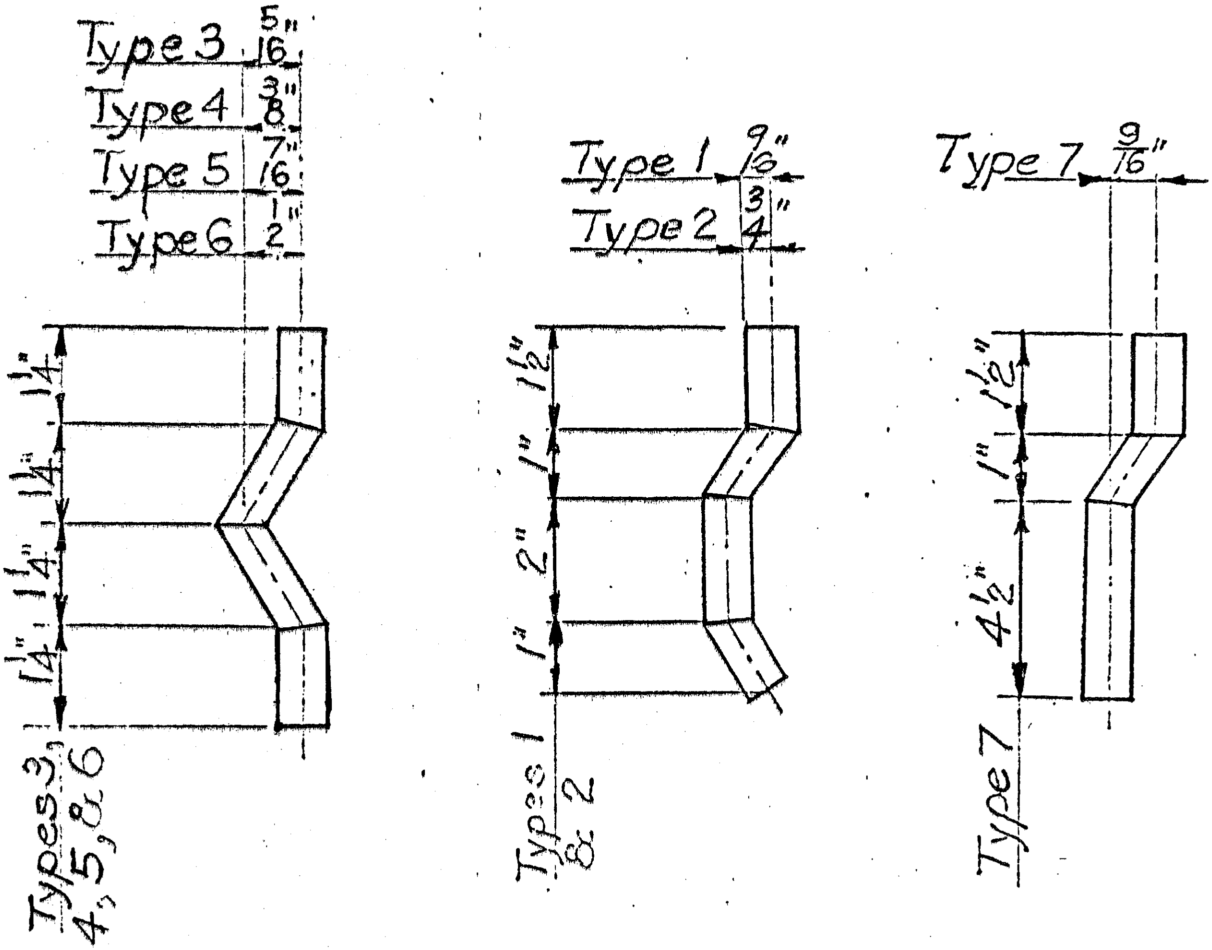

℄ Track
℄ Rail
℄ Rail
P/2
P/2
Tie #4
0
9"
NORTH
36"
41.5"
47.5"
54.7"
E
W
1'-6
2'-6
2'-6
1'-6
℄ Girder
℄ Girder
4'-0
4'-0
Tie #6
50"
S O U T H
16"
4"
0
W
E
Tie #6
0
25"
N O R T H
42"
51.5"
54.5"
E
W

FIGURE 3



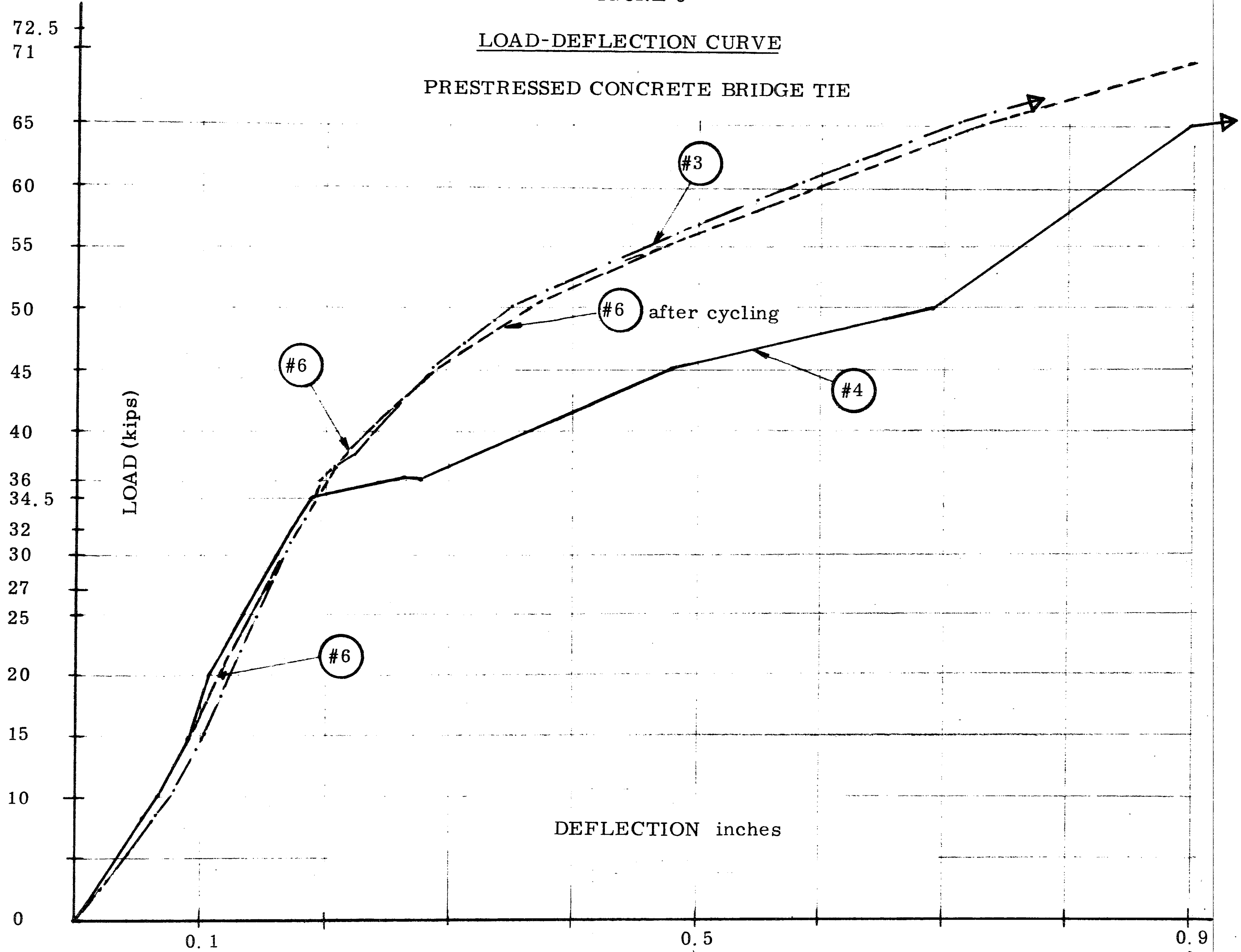
¾" square steel tubing, 11 gage, Inserts.

FIGURE 4

FIGURE 5

LOAD-DEFLECTION CURVE

PRESTRESSED CONCRETE BRIDGE TIE



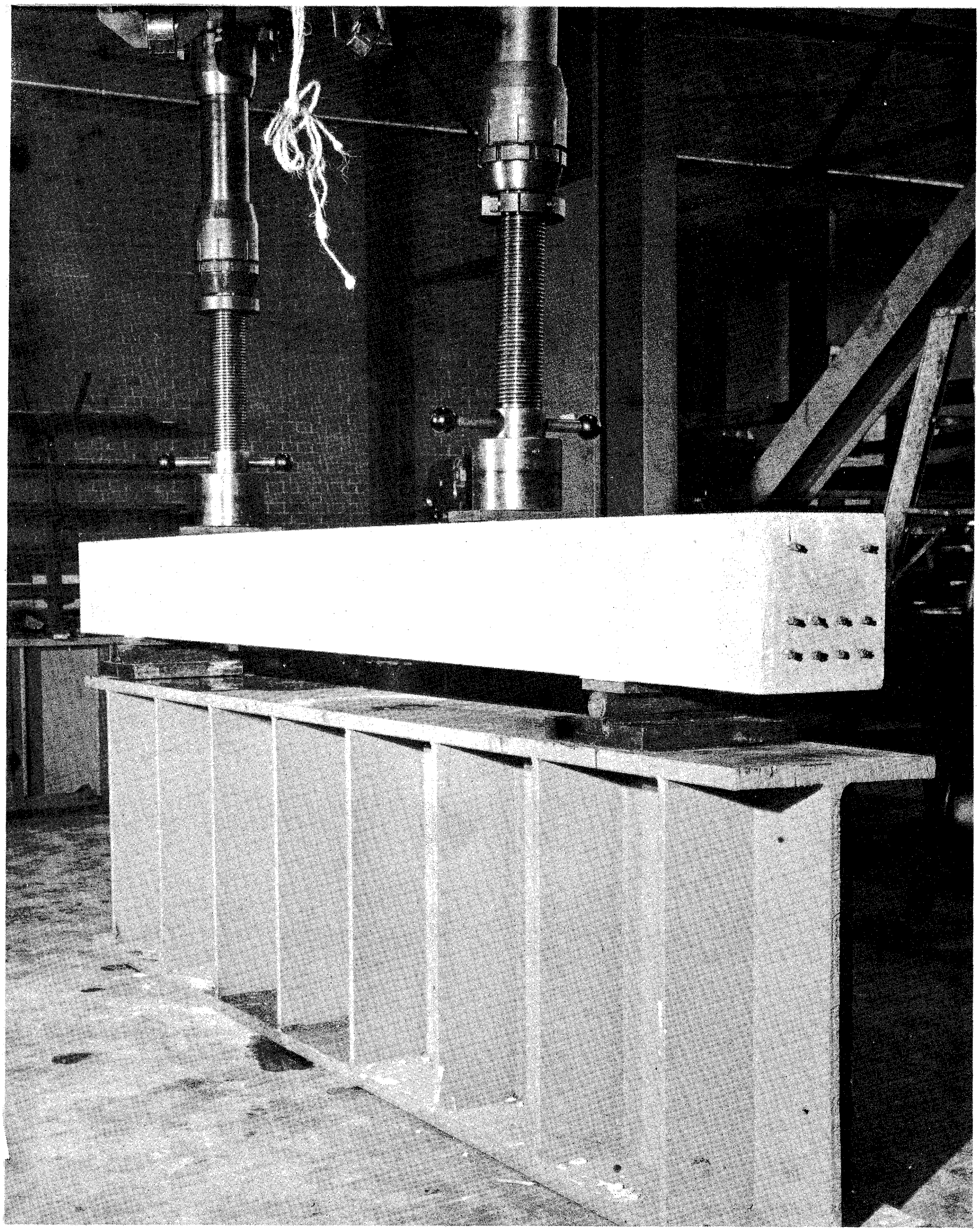


Figure 6. Static and Dynamic Test Set-Up.

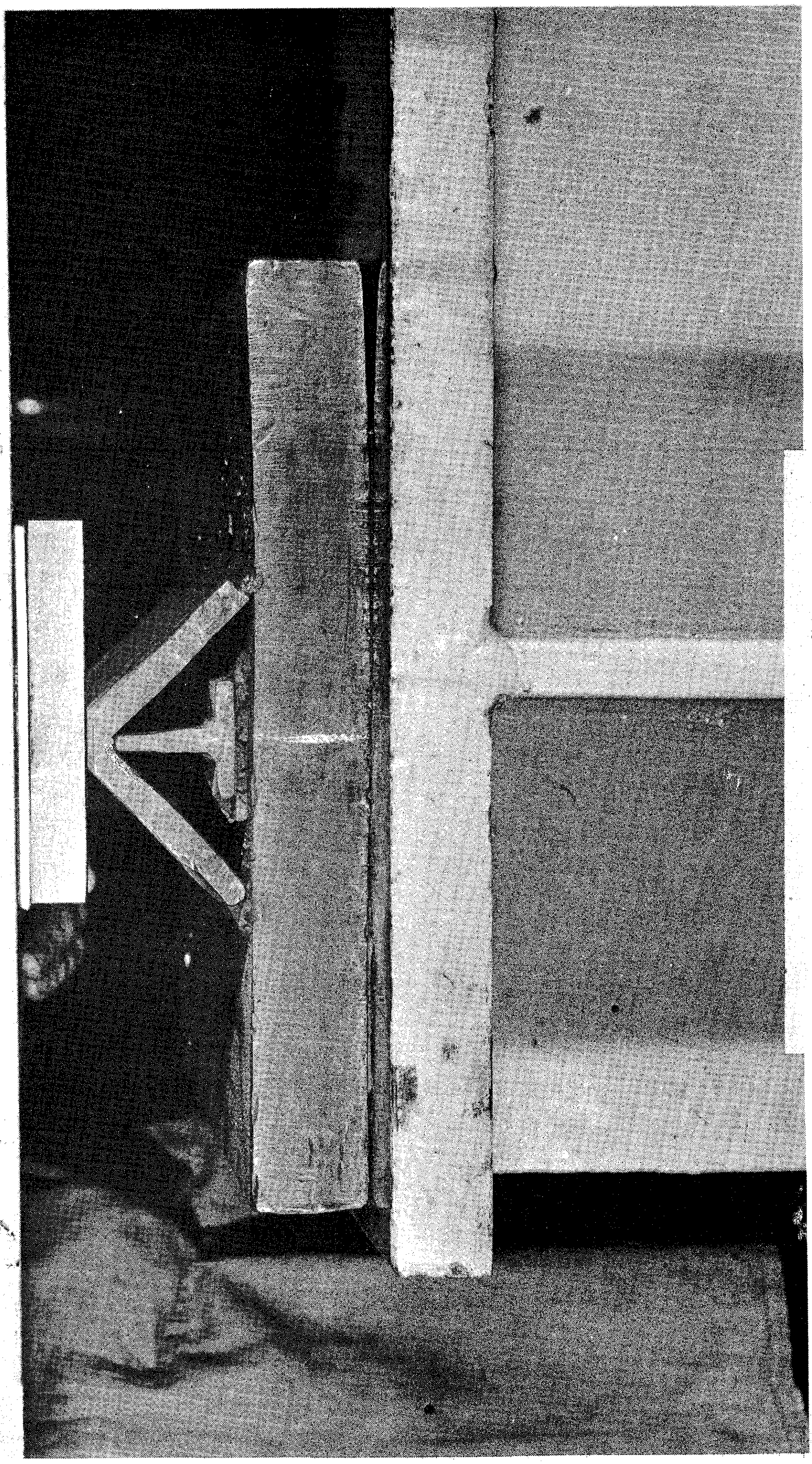


Figure 7. Fixed (E End) Bearing.

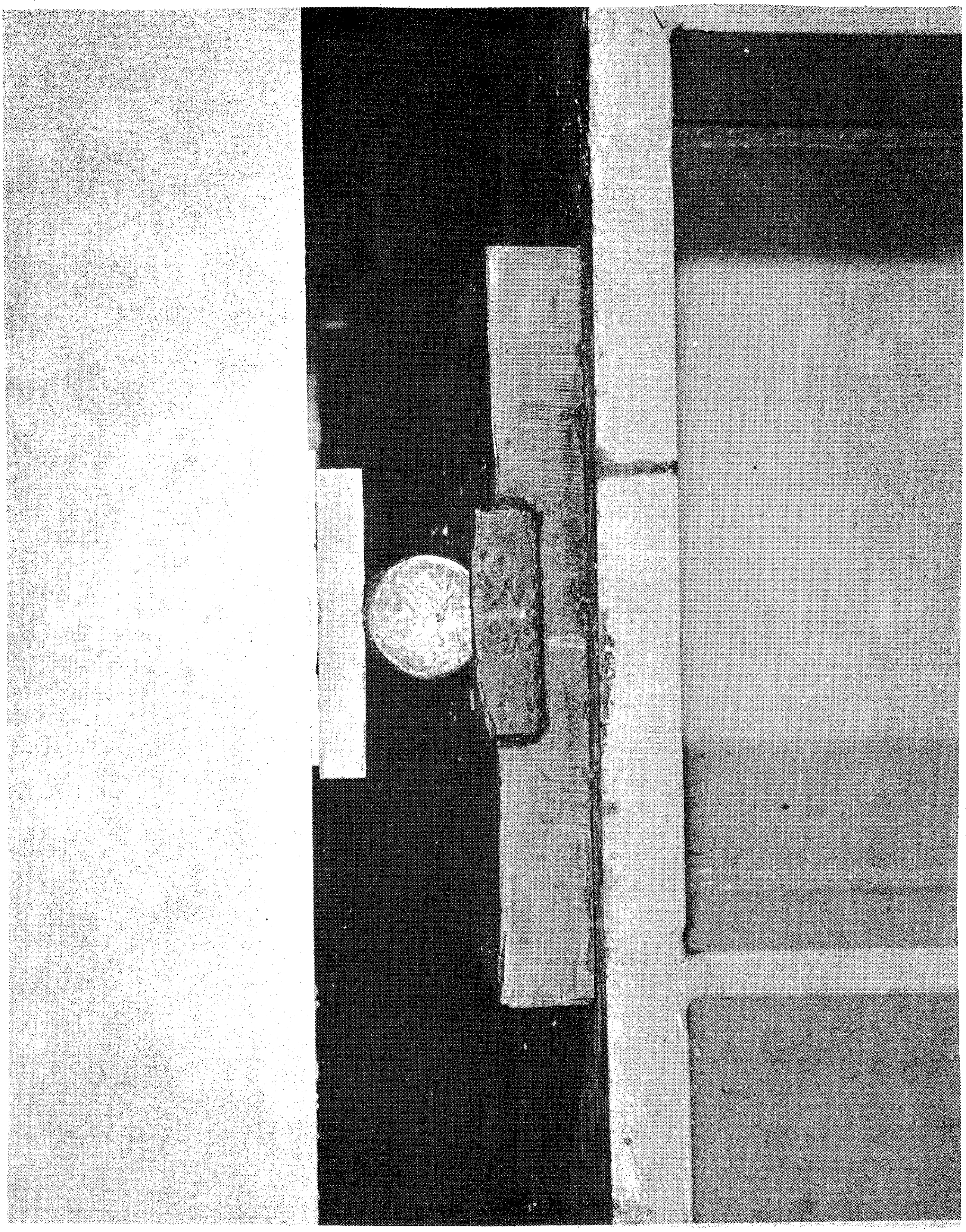


Figure 8. Roller (W End) Bearing

Figure 9. Tie No. 6 After Failure (North Side)

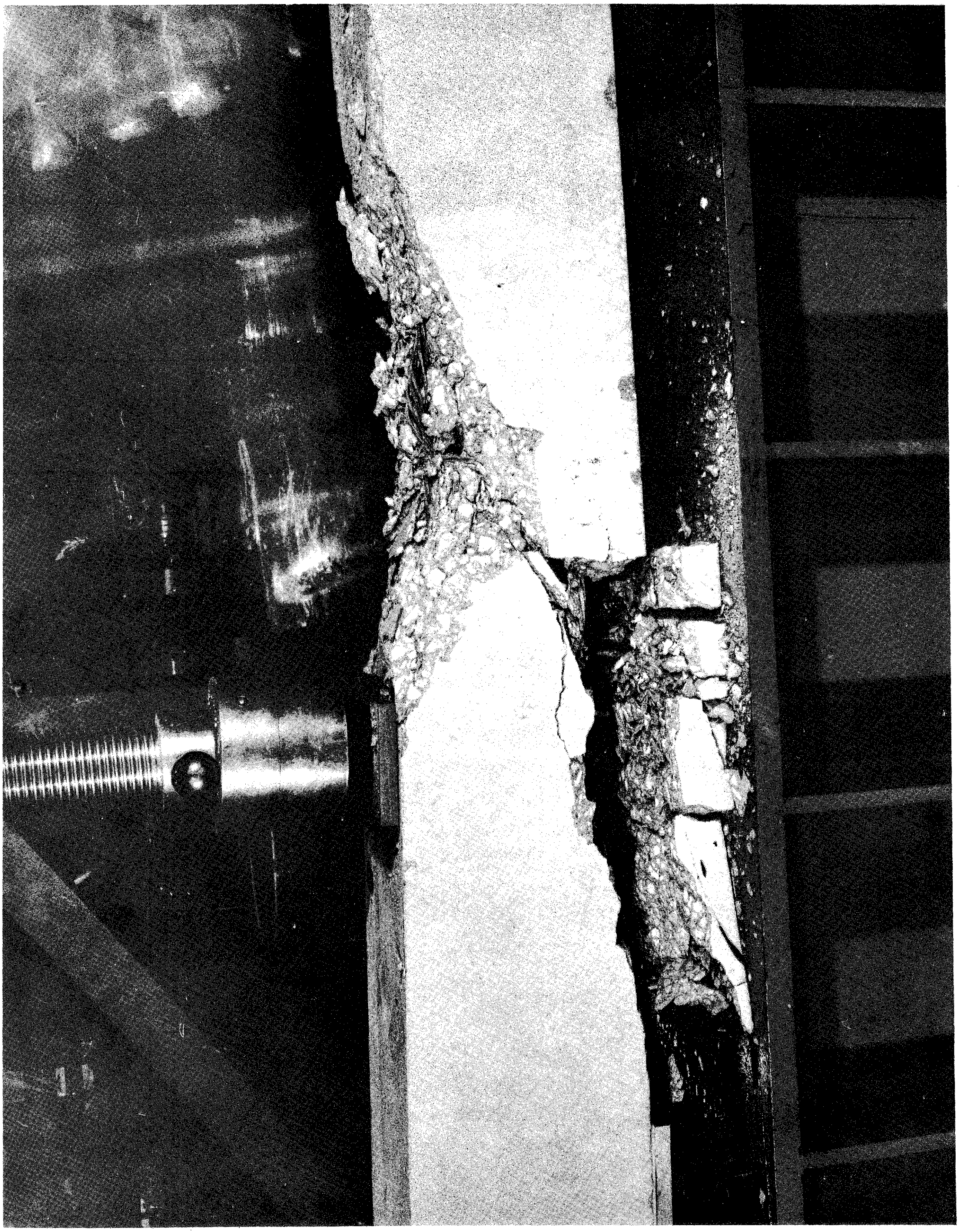


Figure 10. Tie No. 6 After Failure (North Side)

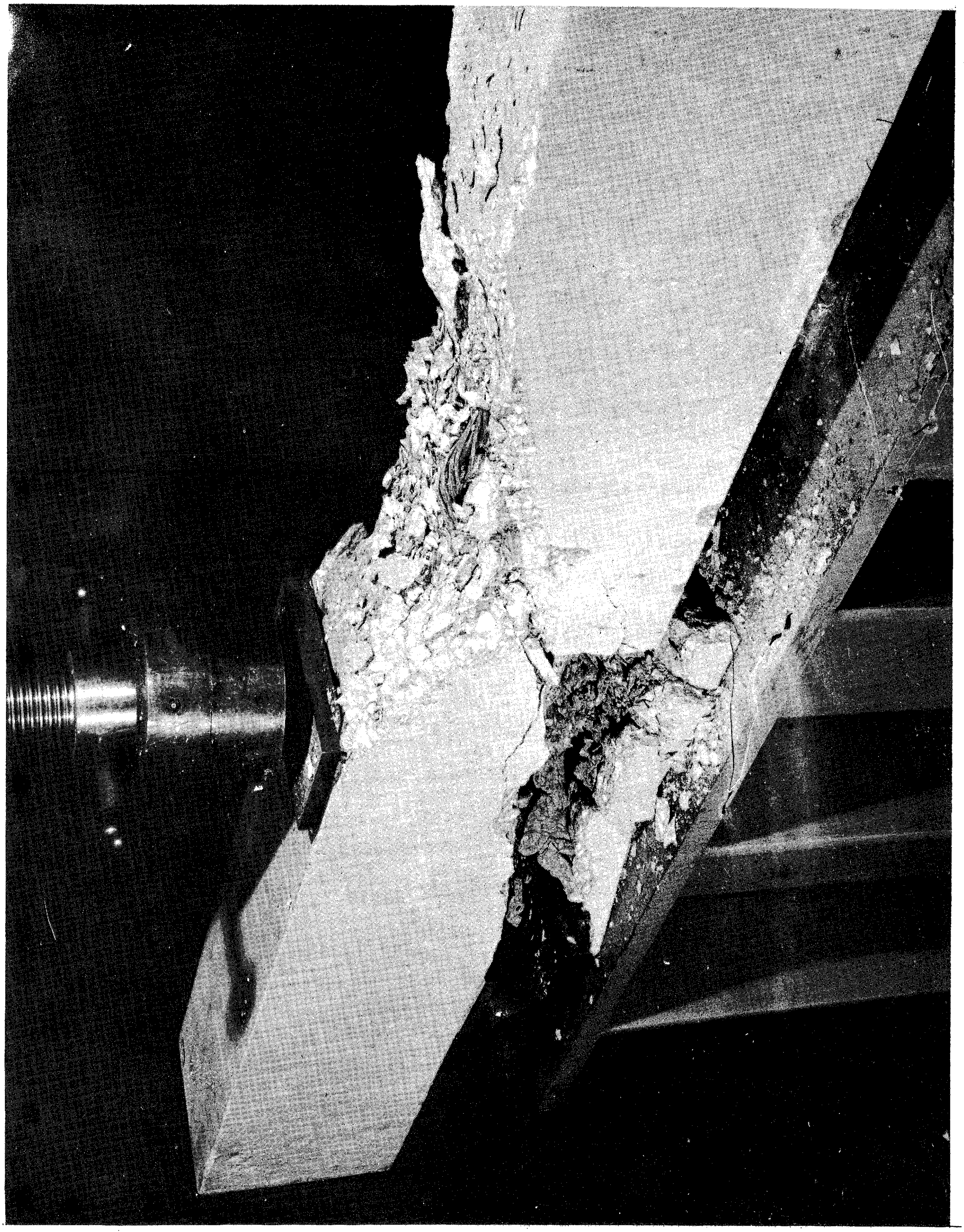


Figure 11. Tie No. 6 After Failure (North Side)

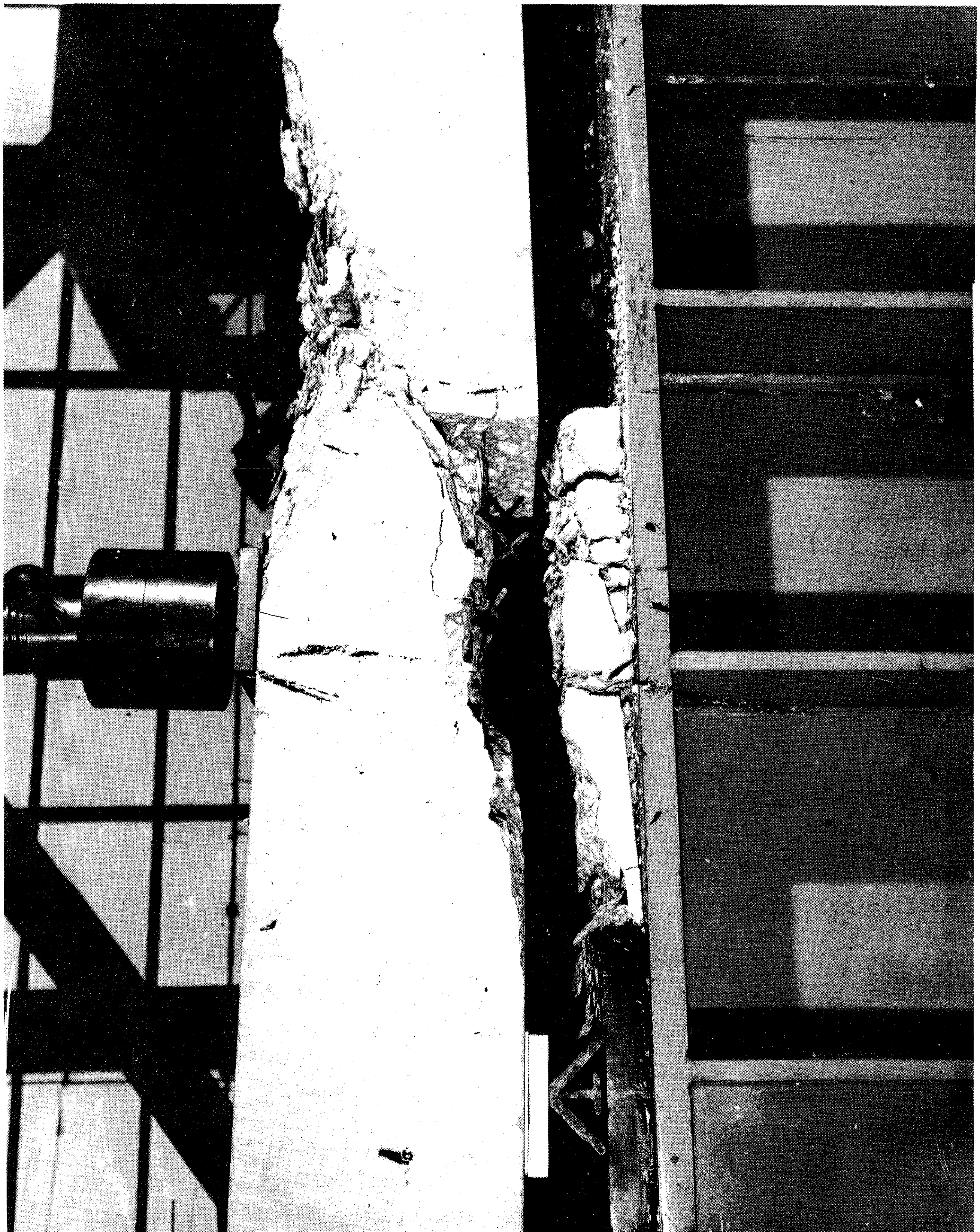


Figure 12. Tie No. 6 After Failure (North Side)

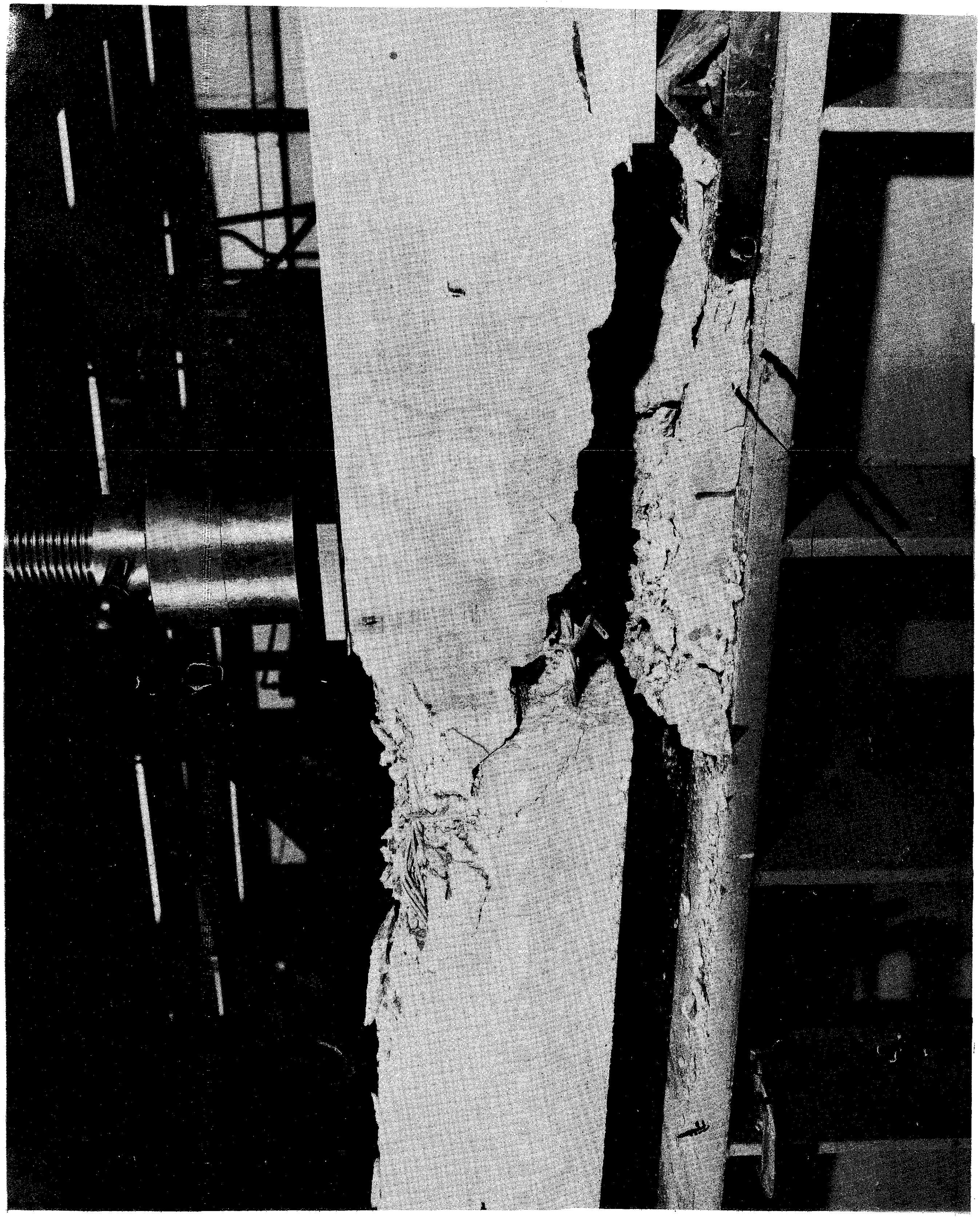


Figure 14. Tie No. 6 After Failure (South Side)