2295

NATIONAL BUREAU OF STANDARDS REPORT

2295

TEST OF PRECAST PRESTRESSED

ROOF PANEL NO. 1

(TYPE A)

by

C. T. Valenti, Jr., T. W. Reichard

L. F. Skoda and D. Watstein

NBS

U. S. DEPARTMENT OF COMMERCE

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TEST OF PRECAST PRESTRESSED
ROOF PANEL NO. 1
(TYPE A)

1. INTRODUCTION

The study of precast-prestressed concrete roof panels was initiated in the National Bureau of Standards at the request of the Bureau of Yards and Docks for the purpose of establishing design data for prestressed thin shell ribbed panels of various cross-sections.

The following report presents the data obtained in the test of one prestressed roof panel, type A, slab 1.

2. DESCRIPTION OF TEST SPECIMEN

The prestressed roof panel tested was constructed in accordance with Bureau of Yards and Docks plans (Sketch A-1, October 4, 1952) and specifications. The 5 ft by 24 ft panel was essentially a thin slab stiffened by two edge beams and two transverse ribs. The longitudinal edge beams were 8-in. deep and 2 1/2-in. wide at the base. The outer surfaces of the edge beam were plumb; the inner surfaces tapered up at a slope of 1.5 in. in 8 in. and became an integral part of the slab. At a distance of 9 in. in from either end, there were two transverse ribs. The transverse ribs were 7 7/8-in. deep, 2-in. wide at the base, and tapered up at a slope of 1 in. in 7 7/8 in. until they merged into the slab. The portion of the slab enclosed by the longitudinal beams and transverse ribs was 1-in. deep. At the two extremities if the panel, the slab was 3-in. deep.

The slab and the stiffening members were reinforced with 2-in.by 2-in. by 12 ga welded wire fabric. Each transverse rib also included two No. 3 deformed reinforcing bars, one at the top and one at the bottom. These bars met the requirements of A.S.T.M. Specifications A305-50T and A15-50T for deformed reinforcing bars of intermediate grade. Each longitudinal edge beam enclosed one ten wire Freyssinet prestressing unit complete with flexible conduit and placed in a parabolic curve. An overall view of the test slab is shown in figure 7.

3. FABRICATION OF SPECIMEN AND DESCRIPTION OF MATERIALS

3.1 Forms

Since the reinforcement was to be post-tensioned and the specimen had to be supported along its entire length prior to prestressing, the forms were constructed so as to permit stripping of the web and side surfaces of the longitudinal and transverse edge beams while continuing to support the base of the longitudinal edge beams. Therefore, the form was elevated on wooden trestles to permit working beneath the specimen without moving it. Figure 1 shows the overall view of the form. The trestles were joined by 2-in. by 4-in. pieces of Douglas fir and leveled with an engineer's level. The 2-in. by 4-in. struts were then grouted with Hydrocal to assure complete bearing and eliminate deflections of the form under the weight of the concrete. Plywood was used for all cast surfaces of the specimen to assure smooth surfaces. The web of the specimen was supported with wedge shaped 2-in. by 6-in. pieces of Douglas fir spaced 14 in. on center. The wedges were cut so as to permit complete support of the web and inner surfaces of the edge beams. The outer surfaces of the edge beams were supported 14 in. on center as shown in figure 1.

3.2 Prestressing Units

Ten wire Freyssinet prestressing units were used to apply the required prestress in the specimen. The units were obtained from the Intercontinental Equipment Company, Inc. of New York, N. Y. Each unit is complete with two end anchorage cylinders, two end anchorage cones, one flexible steel conduit, and ten 0.196 in. dia high yield point steel wires. To determine the properties of the wire, two samples were tested in tension in a 60,000 lb testing machine. Strain data were obtained using both Tuckerman optical gages and SR-4 bonded wire strain gages. Figure 27 shows the stress strain curve and Table 1 gives the properties of the wire, from data obtained with the Tuckerman gages. Two Freyssinet double acting hydraulic jacks and one five gallon capacity hydraulic pump were obtained from the above mentioned manufacturer to apply the pretensioning force to the specimen. Details of the end anchorage units and the hydraulic jacks in place for prestressing are shown in figure 6.

3.3 Welded Wire Fabric

Two in. by 2-in. by 12 ga welded wire fabric, obtained from the American Steel and Wire Company, Washington, D. C. was used to reinforce the web and edge beams of the specimen. The wire fabric was supported by 1/2-in. slab bolsters. The placement of the reinforcement in the form may be seen in Figure 2. Segments of the wire fabric were measured with micrometer calipers and the average diameter was found to be 0.1051 in. Tensile tests were made on several sections of the wire fabric, using Tuckerman optical gages to measure strain. It was found that the properties of the wire varied greatly among the individual specimens; the data obtained from only one specimen, however, are given in Table 1 and Figure 28.

3.4 Concrete

Proportions of the concrete mix used were 1:2.48:2.02, by weight. The cement factor was seven bags per cu yd. White Marsh, Md. sand and pea gravel were used as fine and coarse aggregates. The pea gravel was passed through a 3/8-in. standard sieve to obtain 3/8-in. top size aggregate. High-early strength Portland cement was used with calcium chloride (2 percent by weight of cement) to permit early stripping and prestressing. Figure 3 shows the slump test made on the preliminary batch of the mix. The five 5 cu ft batches used to fill the form had slumps varying from 1 1/2 in. to 4 1/2 in. The specimen was cured under wet burlap for four days, then air dried for three days to permit attachment of SR-4 bonded wire strain gages. Ten standard 6-in. by 12-in. cylinders were cast at the time the specimen was made. The cylinders were cured in a curing chamber until they were tested. The average compressive strength of four cylinders tested at the time of prestress was 6760 psi. The remaining six cylinders, which were tested at the time the specimen was tested, had an average compressive strength of 6950 psi. Properties of the concrete are given in Table 1 and the stress-strain curve is shown in figure 26. It is noted here that the information in the Table, and the stress-strain curve, are from data obtained from two specimens tested at the time of prestress.

3.5 Prestressing Technique

When the specimen was 20 days old, the first attempt at prestressing was made. The two 10 wire bundles were slipped into their respective flexible conduits which were cast in each edge beam of the specimen. The ends opposite the jacking point were anchored with the manufacturer's end anchorage device. Since it was felt that the pressure gage supplied by the manufacturer would not be sufficiently accurate to measure prestressing forces transmitted to the specimen, dynamometers were inserted between the end anchorage cylinders and the specimen at the jacking point. These dynamometers were used to control the load applied to the specimen. A close up view of the dynamometers and the hydraulic jacks in place for prestressing is shown in figure 6. The first attempt at prestressing was not successful since the load in the two edge beams varied. The variation in the load applied may have been due to frictional losses in the individual jacks. The prestress was released and a second attempt was made the next day. On the second attempt, the load was applied uniformly to the edge beams by manipulating the proper control valve on the pump. The prestress was applied in several increments and indications of micrometer dial gages, SR-4 strain gages on concrete and individual Freyssinet prestressing wires, dynamometers and pressure gages were recorded. Figure 13 shows the changes in total tension in the units after the jacks were removed. It can be seen that 20,050 lb had to be applied to the jacks to obtain a tension in each unit of 18,250 lb. A few minutes later, at the time that final readings were taken on all gages, the tension in each unit dropped to 18,100 lb.

Distribution of deflections under prestressing at various places in the slab are shown in figures 14, 15, and 16. Figures 22, 23, 24, and 25 show longitudinal strain in the concrete and Table 4 gives transverse strains in the concrete under prestressing.

4. TESTING PROCEDURE

4.1 Test Setup

One day after the prestress was applied, the specimen was moved to the testing piers by means of a lifting jig and a three ton bridge crane. Figure 7 shows the overall view of the lifting jig and the testing piers. The specimen was supported at four points by 2- by 2 1/2- by 3/4-in. bearing plates and 2 1/2- by 3/4-in. dia rollers. The span length between the rollers was 22 ft 4 in. The rollers and bearing plates are shown in figure 7. One end of the specimen was set in place by lowering the bridge crane. The other end was then supported by a 5 ton hydraulic jack and lowered gently to its proper position. Hydrocal was used between all bearing surfaces to assure complete bearing of the specimen.

4.2 Method of Loading

Water was used to apply the uniform load to the specimen during test. Since large deflections were anticipated, it was felt that the use of a single tank would cause too uneven a distribution of the water at large deflections. Therefore, four individual 5- by 6- by 2 ft tanks were used to minimize the concentration of load near the center of the slab. The tanks were made of No. 8 treated duck and were coated with a fatty acid pitch material to make them watertight. Each tank was loaded at the same rate and the total quantity of water entering the tanks was measured with individual water meters. The water meters are shown in figure 7. Figure 8 shows the overall view of the test setup with the water tanks in place.

4.3 Instrumentation

Deflections of the slab under load were measured with 0.001 in. micrometer dial gages and taut-wire mirror-scale devices. The dial gages were located on the underside of the slab at the same point at which measurements were made during prestressing at the top of the slab. Five dial gages were placed across the center cross-section of the spans and three were placed at approximately the quarter point sections of the span. A closeup view of some dial gages and some SR-4 gages are shown in figure 4. Dial gages were also placed over the supports to measure any settlement of the supports. Distribution of deflections as measured by the micrometer dial gages are shown in figures 14, 15, and 16. Figure 17 shows the load vs. deflection curves of the edge beams at the center and quarter point sections. Distributions of deflections of the edge beams, as measured by the taut-wire mirror-scale devices are shown in figure 18.

SR-4 bonded wire strain gages were placed both transversely and longitudinally on thespecimen on top and bottom of the slab. A total of 54 gages were used to measure strain in concrete. The gages were placed across the center and quarter-point sections of the specimen. Figures 19 and 20 show the distribution of longitudinal and transverse strain in the specimen under the applied load. Figures 21, 22, 23, and 24 show the applied load vs. longitudinal strain at various points in the concrete and table 4 gives the transverse strain in the concrete through the pretensioning and loading cycles.

In addition, SR-4 bonded wire strain gages were attached to each prestressing wire at the end opposite the jacks so that the distribution of stresses in a given unit might be determined. Some of the gages were damaged before the test began because of the close working space in the conduit. Tables 3 and 4 show the comparison of stresses in each wire where gages were not damaged.

It is noted that the tensile stresses observed in the individual wires were in most cases higher than the average stress indicated by the dynamometers. Arrangement of the SR-4 strain gages on the individual wires of the prestressing units is shown in figure 5. Figure 12 shows the manner in which the lead wires were brought through the end anchorage cones.

4.4 Description of Test

The specimen was loaded in increments of 10 lb/sq ft and readings were taken on all gages. The first noted cracks occurred in both edge beams between 40 and 50 lb/sq ft. Figure 9 shows the first cracks in the east edge beam. The specimen was loaded to 60 lb/sq ft and that load was maintained for 1 1/2 hr at which time additional readings were taken on the gages. The load was continued to 70 lb/sq ft but the micrometer dial gages had to be removed due to excessive deflections of the slab. The load was then removed from the specimen by means of siphons to note the recovery. The transverse centerline of the slab recovered to within 1/4 in. of its original position and the tensile cracks closed up. Figure 10 shows the same cracks as figure 9 with the load removed. The empty tanks were removed from the specimen and the positions of cracks on the top surface and on the under-side of the web were noted. Figure 25 is a sketch of all cracks that were observed on the specimen after the load was removed. The next day, the specimen was reloaded to 60 lb/sq ft and additional measurements were taken until failure occurred at 80 lb/sq ft. It should be noted here that at this load the Freyssinet wires in the west edge beam began slipping through the end anchorage devices and the tensioning force in it was lost completely. The slab rotated and the east edge beam twisted. Figure 12 shows details of the rotation at the north end of the slab. It can be seen that the No. 3 reinforcing bar was all that kept the east edge beam from pulling away from the transverse rib.

TABLE NO. 1 PROPERTIES OF CONCRETE AND REINFORCEMENTS

MATERIAL	AVERAGE DIAMETER	CROSS SECTIONAL AREA	PROPORTIONAL LIMIT	YIELD STRENGTH	E	MAX. STRESS
	IN.	SQ IN.	PSI	PSI	PSI X 10^6	PSI
2- by 2-IN. by 12 GA	.1050	.00866	54,000	68,000	29.0	80,000
PRESTRESSING WIRE	.1962	.0302	132,000	218,000*	29.6	268,000
STANDARD 6- by 12-IN. CONCRETE CYLINDERS	6	28.27	3600	----	4.16	6,760

* Yield point by the 0.2% offset method.

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TABLE NO. 2 COMPARISON OF STRESSES IN EACH WIRE OF EAST FREYSSINET PRESTRESSING UNIT

TOTAL TENSION BY DYNA-MOMETER	STRESS INDICATED BY DYNAMOMETER	STRESS IN WIRE									REMARKS:
		NO. 2	NO. 3	NO. 4	NO. 5	NO. 6	NO. 7	NO. 8	NO. 9	NO. 10	
KIPS	PSI	PSI	PSI	PSI	PSI	PSI	PSI	PSI	PSI	PSI	
5.00	16,540	29,980	25,490	25,570	25,750	22,550	18,020	34,420	18,680	25,430	PRESTRESSING STARTED
10.00	33,080	48,900	46,400	46,200	47,600	42,200	39,000	58,700	40,900	47,300	
15.00	49,620	62,700	58,800	57,800	59,900	53,300	51,100	73,400	56,200	62,300	
18.50	61,200	76,500	72,300	70,900	73,200	66,500	64,500	84,600	70,100	75,500	
18.20	60,210	77,000	72,100	70,100	72,300	69,000	67,200	89,500	73,200	77,500	
17.30	57,230	73,300	69,000	66,000	68,100	65,300	62,500	------	69,400	73,300	BEFORE MOVING TO TEST SITE
16.00	52,930	70,400	65,700	63,000	65,100	62,400	59,700	------	66,400	70,400	START OF TEST
16.20	53,590	70,900	66,300	63,000	65,200	62,400	60,200	------	66,900	71,200	
16.35	53,920	71,780	65,900	63,500	65,900	62,800	61,100	------	67,700	71,780	
16.60	54,910	72,800	66,400	64,200	66,600	63,500	62,000	------	68,500	72,800	
16.80	55,570	74,200	67,000	65,000	67,300	64,500	63,300	------	69,500	73,800	
18.60	61,530	80,300	72,000	64,800	73,000	69,500	69,600	------	75,500	79,800	
21.70	71,780	93,500	83,800	81,700	85,200	80,600	80,700	------	88,100	91,600	
22.60	74,760	93,700	84,300	82,300	85,600	81,200	81,200	------	88,800	92,000	
26.20	86,670	106,300	96,800	94,700	98,700	93,700	93,200	------	102,000	104,700	

NOTE: Stress in wire was computed from $S = E\epsilon$, where $E = 29.6 \times 10^6$ psi and ϵ = strain indicated by SR-4 bonded wire gages on each wire.

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TABLE NO. 3 COMPARISON OF STRESSES IN EACH WIRE OF WEST FREYSSINET PRESTRESSING UNIT

TOTAL TENSION BY DYNAMOMETER	STRESS INDICATED BY DYNAMOMETER	STRESS IN WIRE						REMARKS:
		NO. 12	NO. 13	NO. 17	NO. 18	NO. 19	NO. 20	
KIPS	PSI	PSI	PSI	PSI	PSI	PSI	PSI	
5.00	16,540	25,500	23,500	26,300	22,100	23,600	28,000	PRESTRESSING STARTED
10.00	33,080	45,100	41,500	46,100	41,400	43,700	47,200	
15.00	49,620	55,700	50,900	58,000	53,800	55,400	61,800	
18.20	60,200	68,700	63,900	70,700	66,400	67,800	74,700	
17.90	59,200	92,300	88,600	31,500	86,300	84,400	91,800	
16.90	55,900	88,500	81,900	29,200	81,900	80,700	88,000	BEFORE MOVING TO TEST SITE
15.80	52,300	84,500	78,500	28,200	78,500	77,100	83,800	START OF TEST
16.00	52,900	85,200	79,400	28,800	79,200	77,800	84,600	
16.20	53,600	86,000	79,900	29,600	79,900	78,400	85,400	
16.50	54,600	86,900	80,700	30,500	80,700	79,300	86,300	
16.90	55,900	88,100	81,900	31,500	81,800	80,600	87,500	
18.60	61,500	94,100	88,700	37,900	88,100	86,700	94,100	
21.90	72,400	------	100,800	50,000	99,700	97,900	106,000	
22.60	74,800	------	101,500	51,000	100,400	98,700	106,600	
26.00	86,000	------	113,800	64,300	112,100	109,600	106,300	

NOTE: Stress in wire was computed from $S = E\epsilon$, where $E = 29.6 \times 10^6$ psi and ϵ = strain indicated by SR-4 bonded wire gages on each wire.

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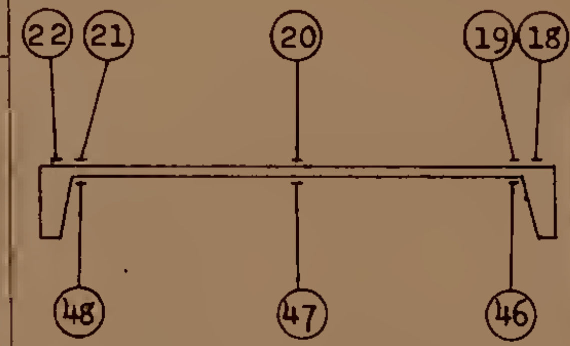
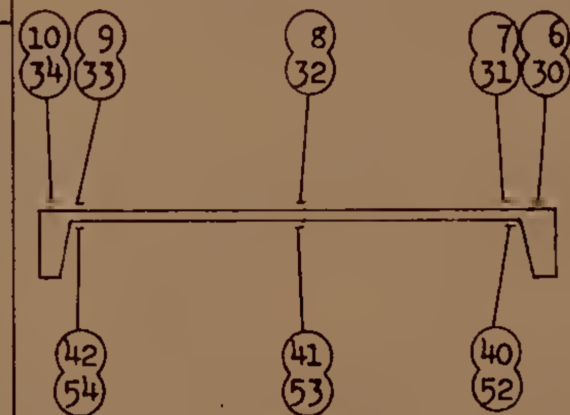
TABLE NO. 4 STRAINS IN TRANSVERSE SECTIONS AT CENTER AND QUARTER POINTS

(MICROINCHES/INCH)

GAGE	PRESTRESS LOAD - KIPS							APPLIED LOAD - PSF								
NO.	5	10	15	18.5	18.05	17.1	16.75	0	10	20	30	40	50	60	70
TRANSVERSE SECTION AT CENTER																
18 & 22	- 7.5	- 3.5	-14.0	-12.5	+ 4.5	+13.5	+71.5	+90.5	+ 92.5	+ 94.0	+ 93.5	+ 93.0	+ 75.0	+ 60.5	- 2.5
19 & 21	-11.5	- 8.5	-20.0	-21.5	- 7.0	+ 1.5	+28.5	+80.5	+ 89.5	+ 78.5	+ 76.5	+ 35.5	- 57.0	------	------
20	-13.0	-12.0	-22.0	-25.0	-10.0	+54.0	+92.0	+92.0	+173.0	+221.0	+252.0	+311.0	+322.0	+368.0	+354.0
46 & 48	- 7.0	-17.5	-22.0	-24.5	-14.0	-33.5	+ 2.5	+44.0	+ 89.5	+107.5	+119.5	+145.5	+244.0	+383.0	+534.0
47	-13.0	-14.0	-22.0	-24.0	-31.0	-24.0	+16.0	+39.0	+ 75.0	+ 62.0	+ 38.0	- 68.0	-110.0	-156.0	-186.0
AVERAGE TRANSVERSE SECTION AT QUARTER POINTS																
10,34 & 6,30	- 9.2	- 8.7	-15.0	-15.2	- 0.7	+16.0	+65.5	+85.0	+ 89.5	+ 88.0	+ 85.5	+ 81.7	+ 83.0	+ 56.7	+ 37.2
9,33 & 7,31	-10.7	-10.5	-13.5	-17.0	- 0.2	+ 7.0	+28.2	+87.5	+ 88.0	+ 77.7	+ 68.7	+ 52.5	- 1.0	- 26.2	------
8 & 32	-15.0	-13.0	-22.0	-22.0	- 6.5	+ 8.0	+62.0	+99.0	+132.5	+146.5	+158.5	+172.0	+179.5	+164.5	+221.0
42, 54 & 40, 52	-30.0	-34.0	-38.5	-41.2	-30.5	-40.5	+ 6.7	+32.7	+ 75.5	+ 95.0	+102.5	+114.7	+152.5	+248.2	+352.0
41 & 53	- 4.0	- 8.0	-11.5	-10.5	0	- 8.0	+46.0	+48.0	+ 81.0	+ 68.0	+ 46.5	- 15.0	-100.0	-120.0	-172.5

LOCATION OF GAGES





NOTE: PLUS VALUES INDICATE COMPRESSION.
MINUS VALUES INDICATE TENSION.

Fig. 1 - Overall View of Form.

Fig. 2 - Placement of Steel in Form.

Fig. 3 - Slump Test of Concrete Mix.

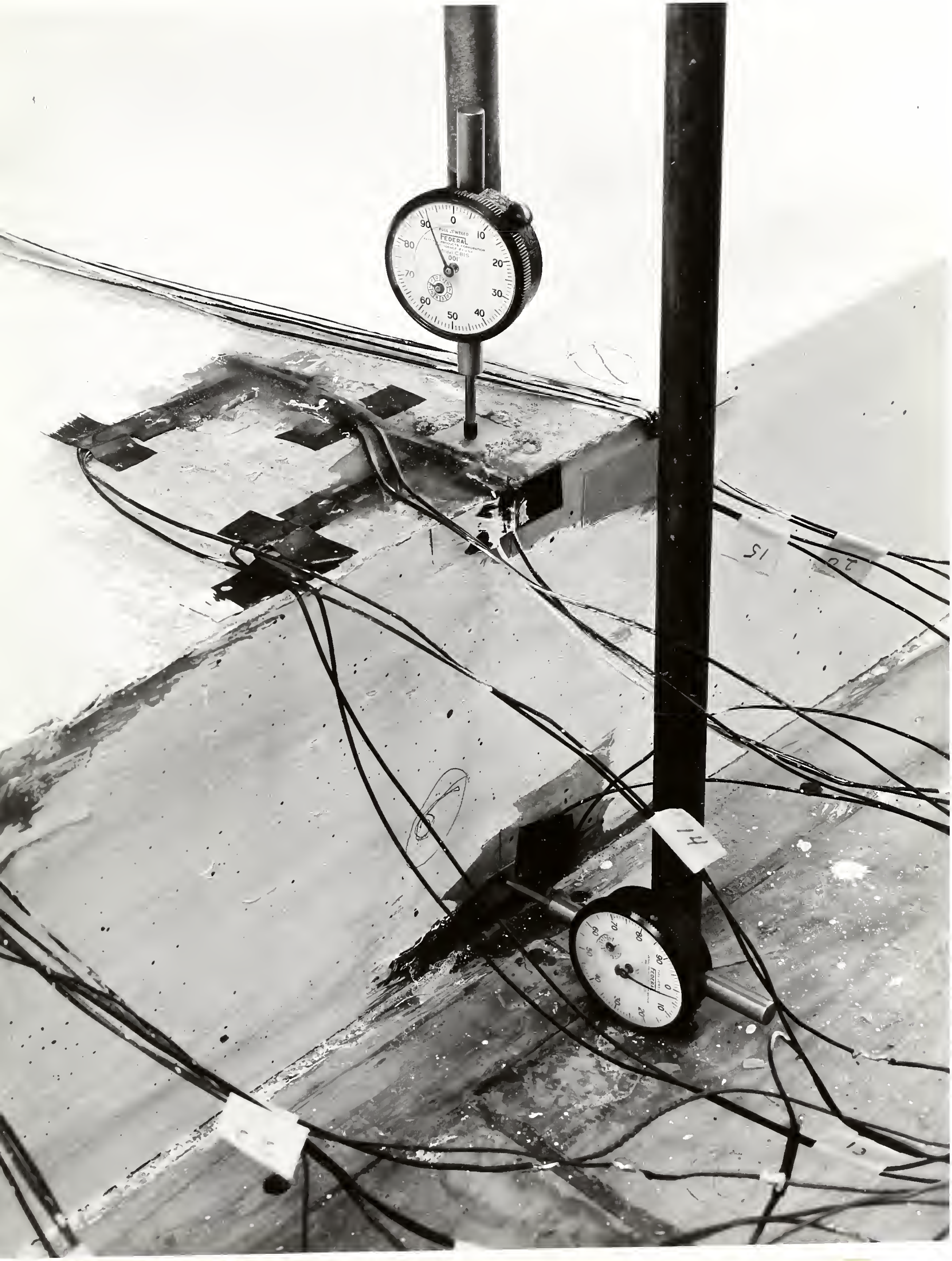


Fig. 4 - Close Up View of Section of Edge Beam Showing Detail of Gages.

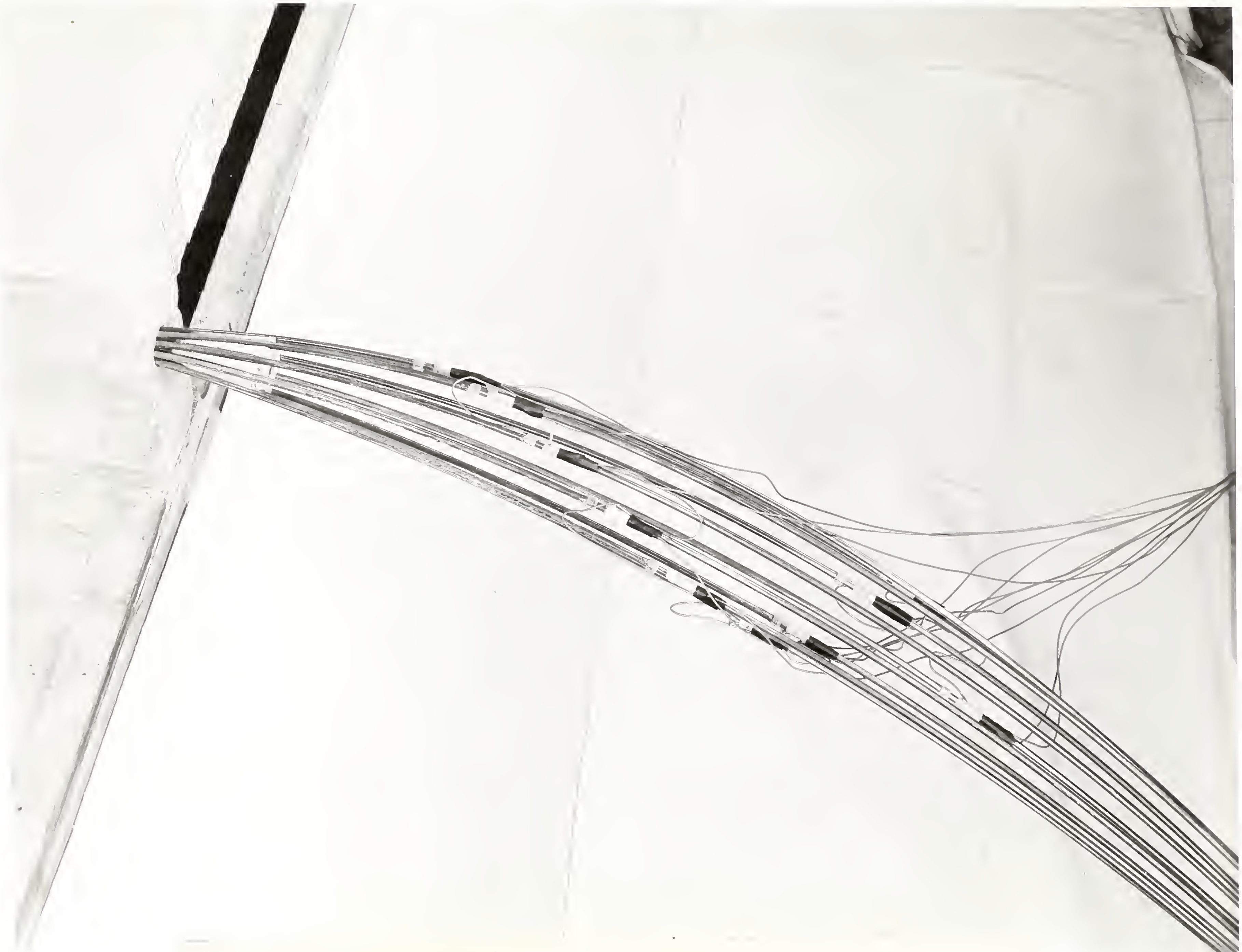


Fig. 5 - Arrangement of SR-4 Strain Gages on Freyssinet Prestressing Unit.

Fig. 6 - Hydraulic Jacks in Place for Prestressing.

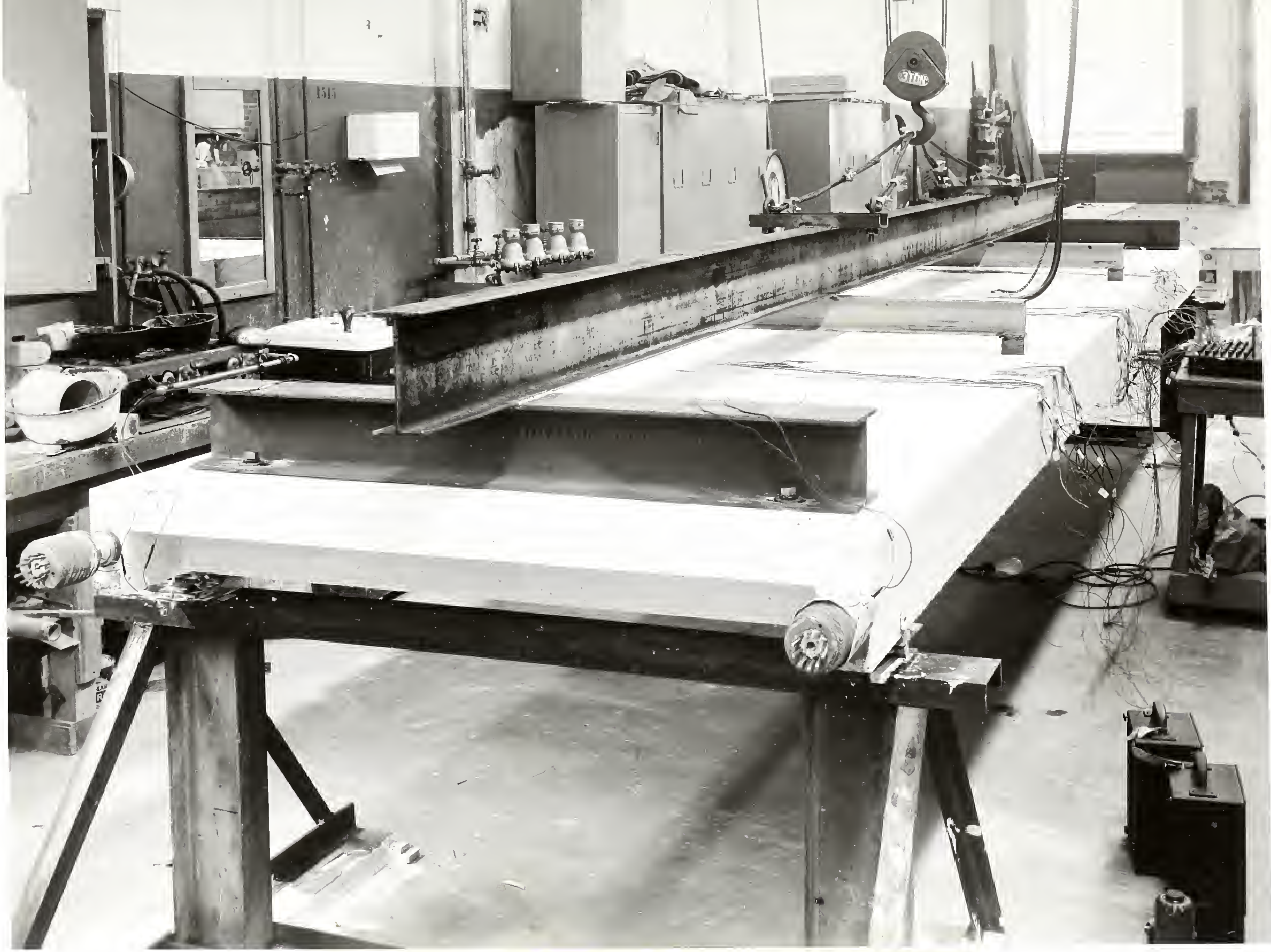


Fig. 7 - Overall View of Lifting Jig and Test Specimen.

Fig. 8 - Overall View of Specimen at Start of Test.

Fig. 9 - Crack Pattern in Section of East Edge Beam - 70 PSF.
(First Crack Opened at Approx. 45 PSF)

Fig. 10 - Same Cracks as Fig. 9 with Load Removed.

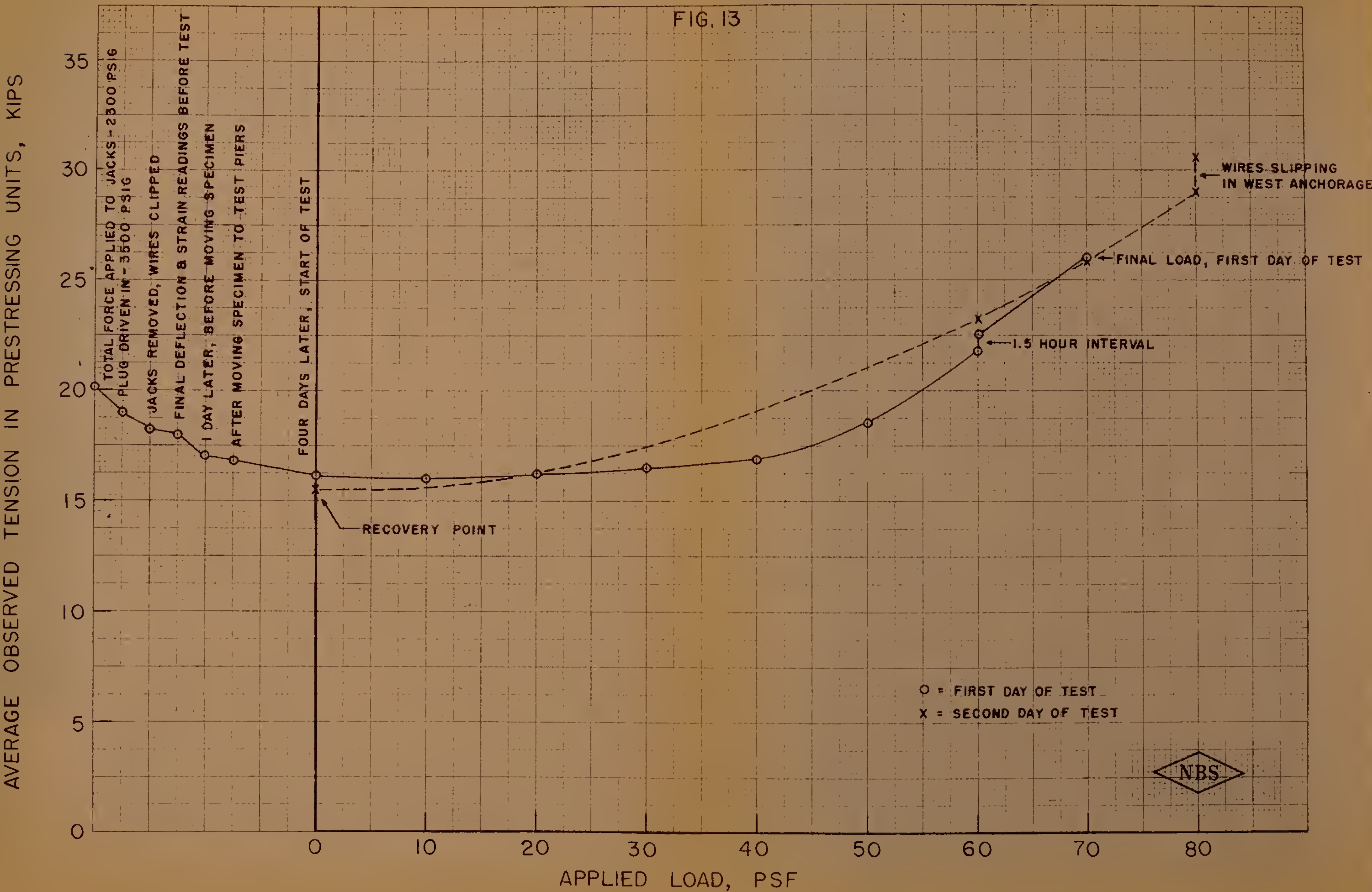
Fig. 11 - Overall View Showing Failure at 80 PSF.

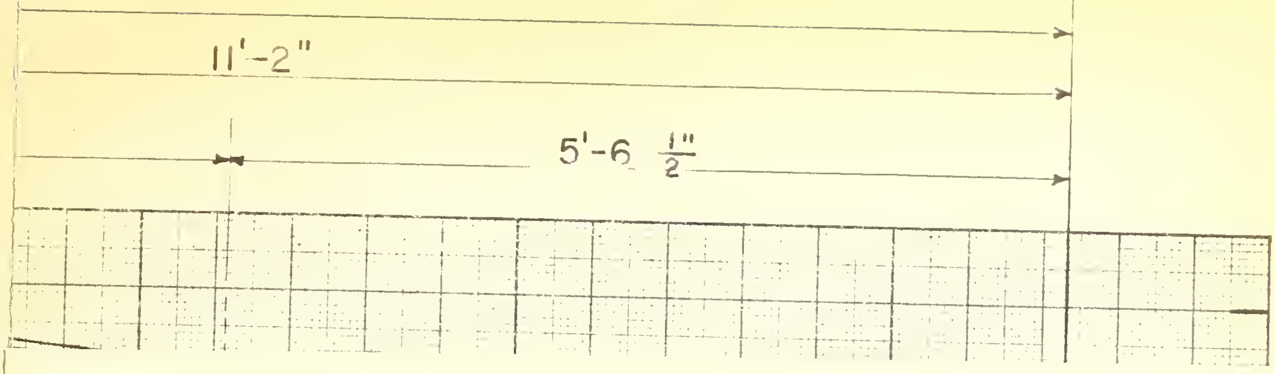
Fig. 12 - Close Up of Secondary Failure in N.E. Corner of Specimen.

AVERAGE OBSERVED TENSION IN PRESTRESSING UNITS, KIPS

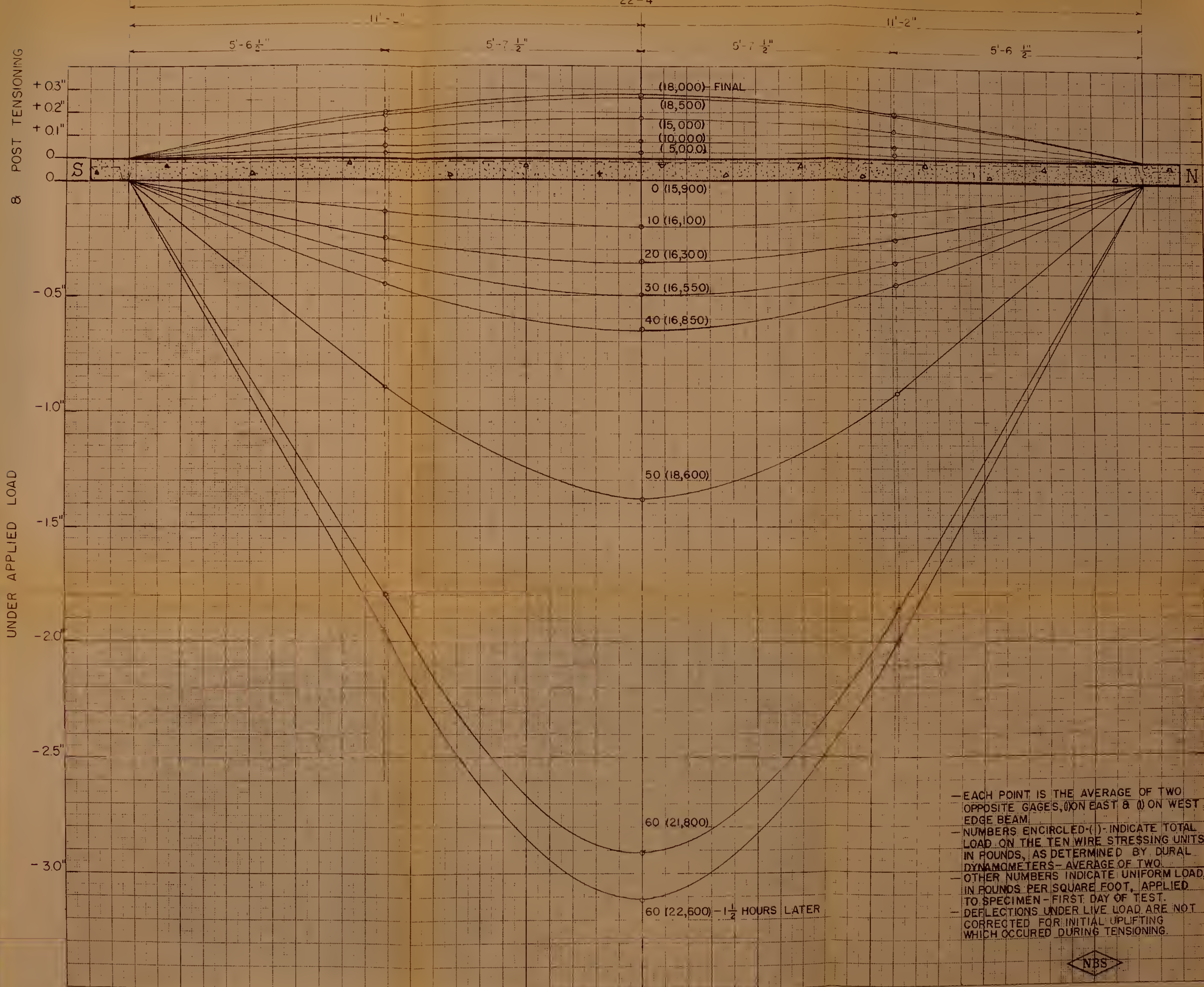
PRESTRESSED SLAB - I

VARIATION OF AVERAGE OBSERVED TENSION IN PRESTRESSING UNITS WITH APPLIED LOAD





DEFLECTIONS

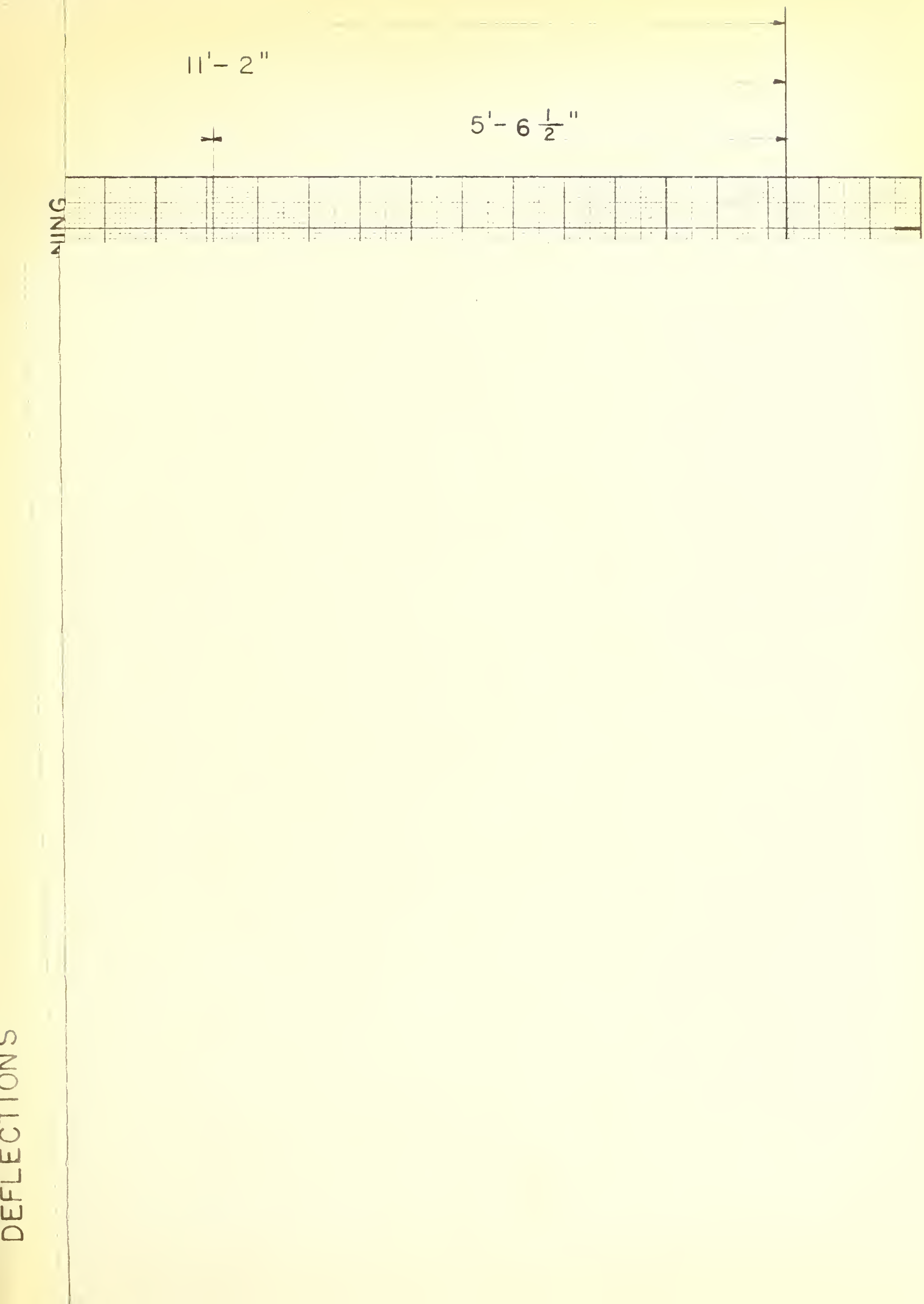


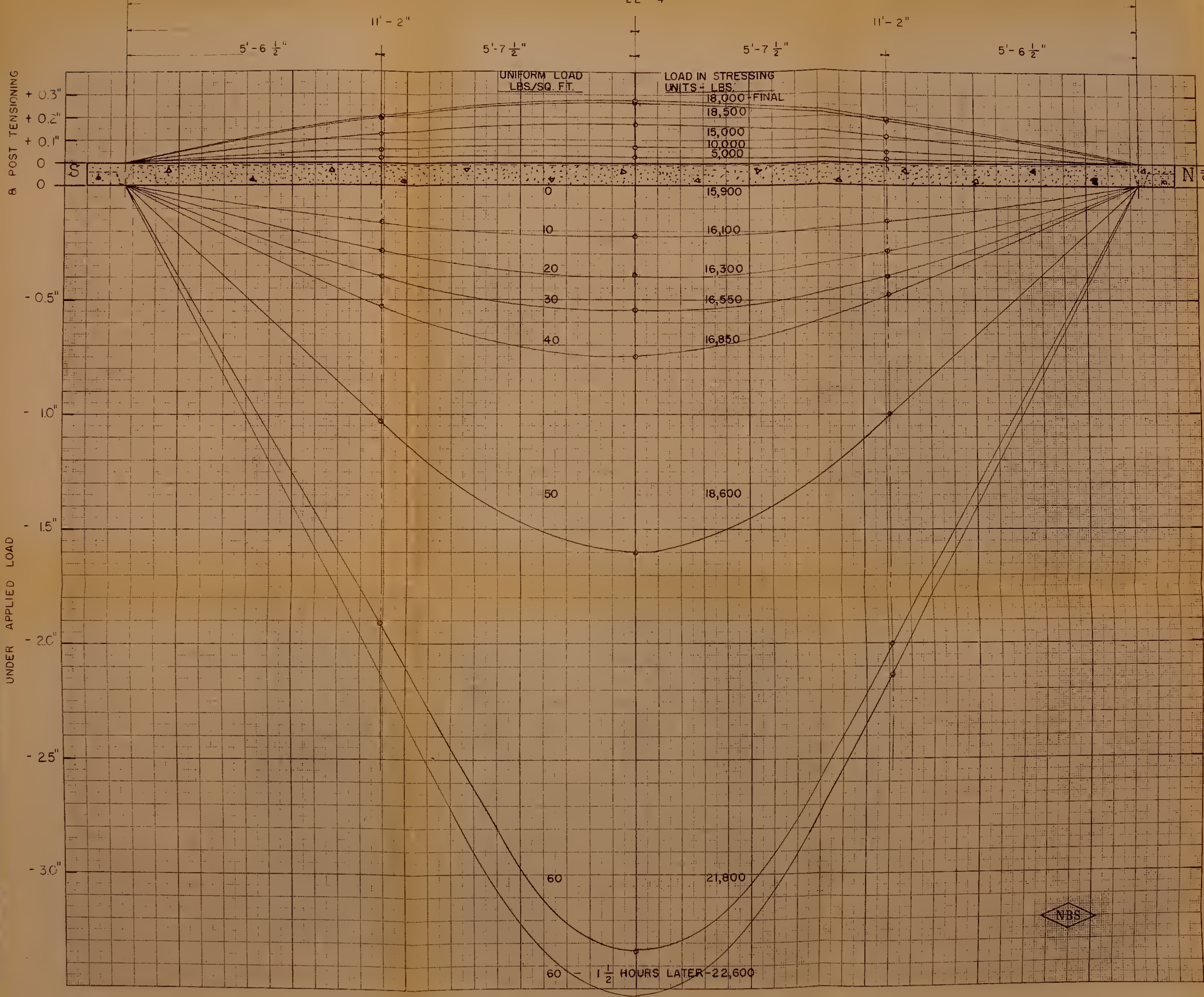
PRECAST-PRESTRESSED SLAB-1

DEFLECTIONS OF EDGE BEAMS UNDER POST TENSIONING & APPLIED LOADS

AS MEASURED BY MICROMETER DIAL GAGES

FIG. 14

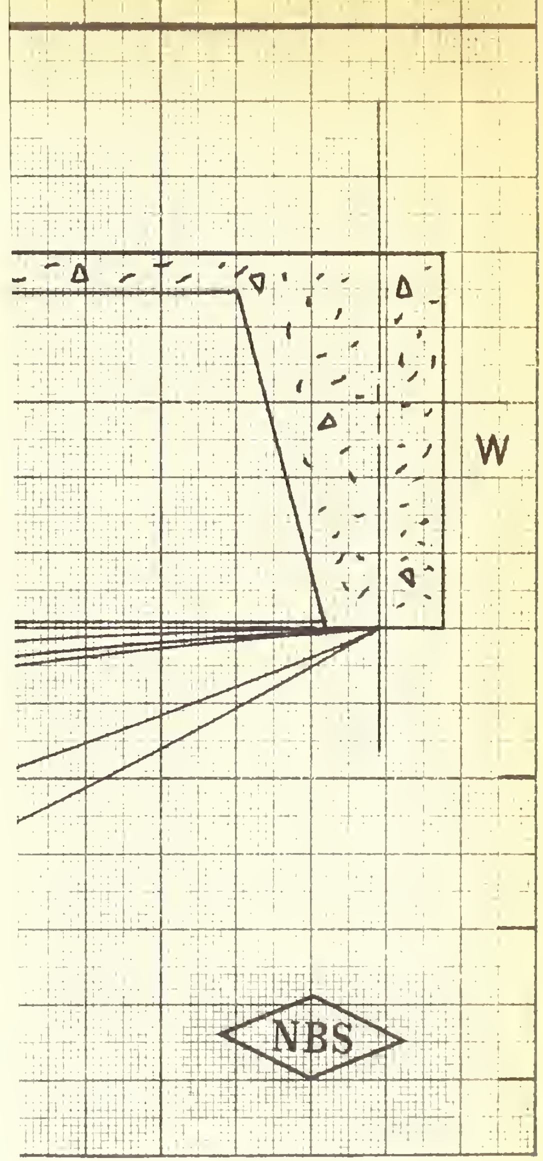

11'- 2"
5'- 6 1/2"
NING
DEFLECTIONS

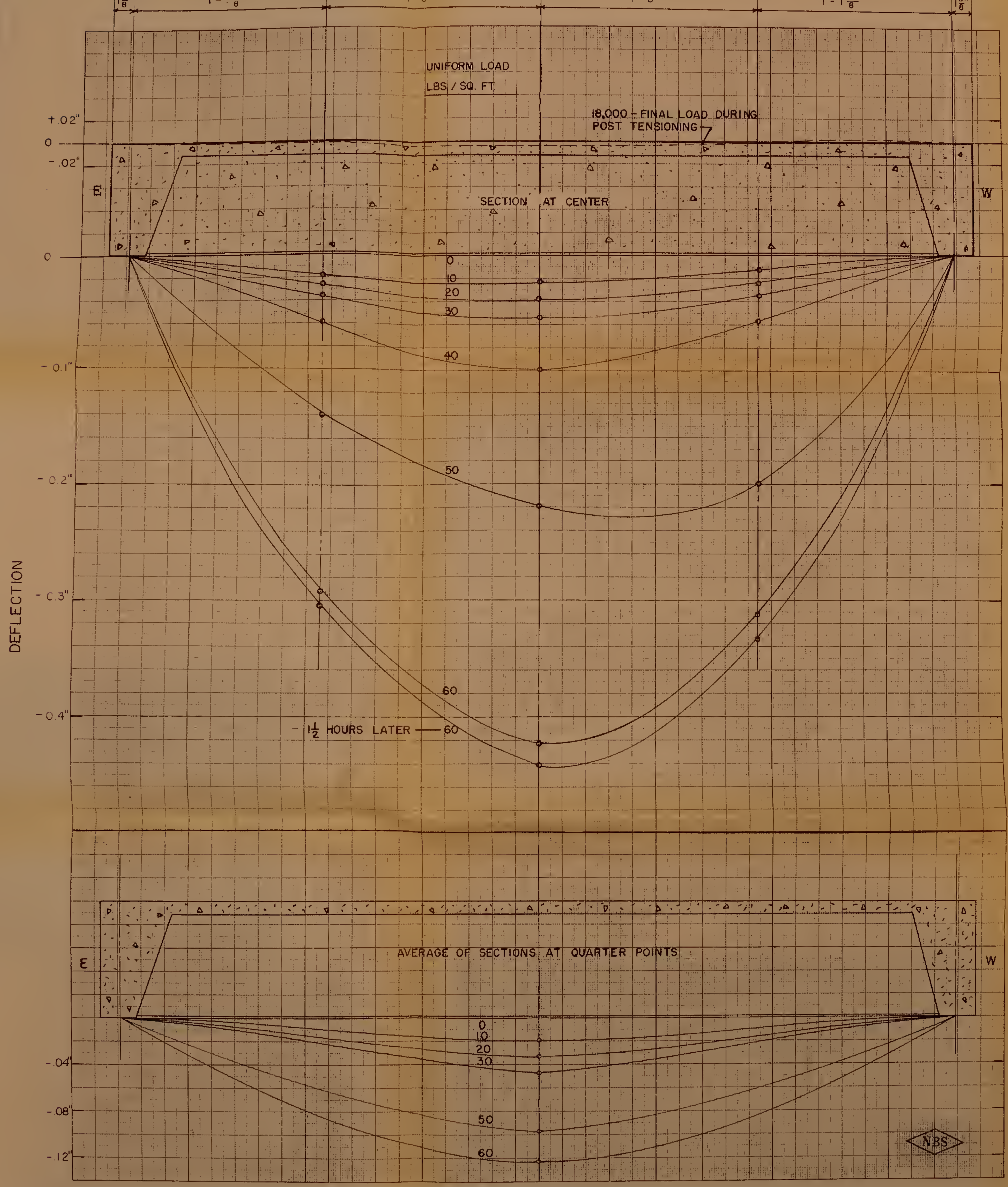


PRECAST-PRESTRESSED SLAB-1

DEFLECTION OF WEB AT CENTERLINE UNDER POST TENSIONING & APPLIED LOAD AS MEASURED BY MICROMETER DIAL GAGES

FIG. 15


W



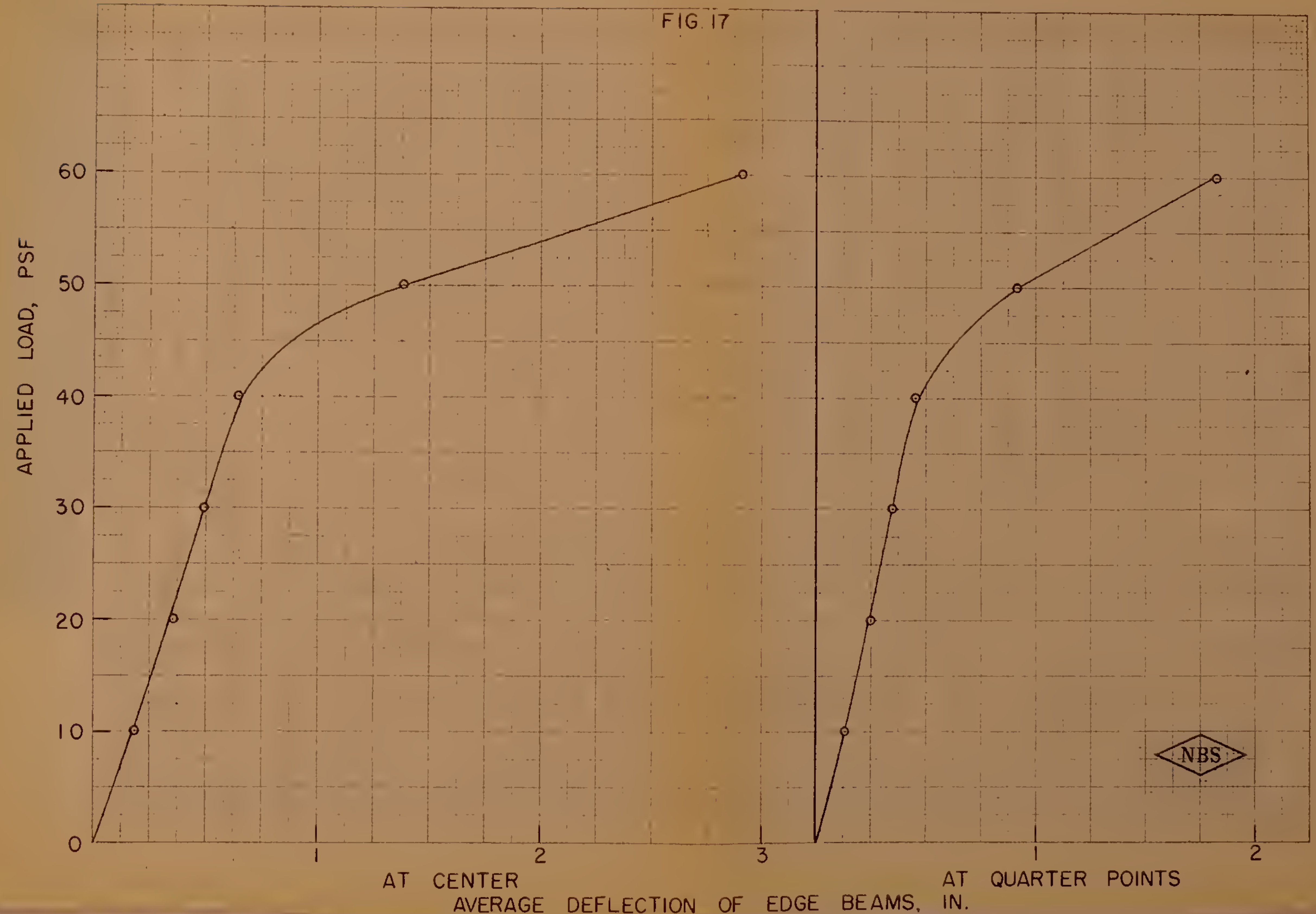
PRECAST - PRESTRESSED SLAB - I
DEFLECTION OF CROSS - SECTIONS UNDER APPLIED LOADS AS MEASURED BY MICROMETER DIAL GAGES
FIG. 16

APPLIED LOAD, PSF

PRESTRESSED SLAB-1

APPLIED LOAD VS. DEFLECTION OF EDGE BEAMS AT CENTER AND QUARTER POINTS

FIG. 17



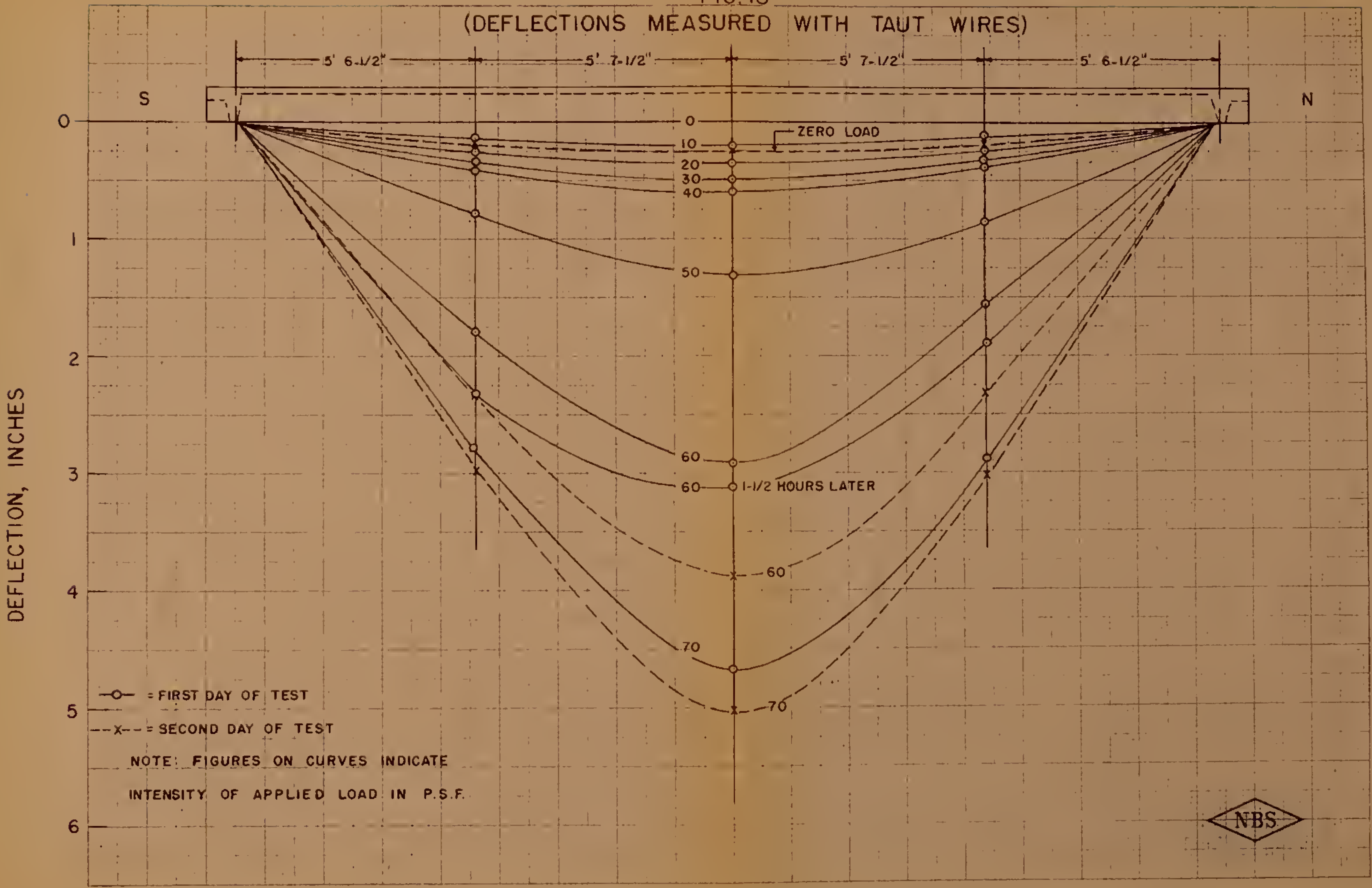
DEFLECTION, INCHES

PRESTRESSED SLAB-1

DISTRIBUTION OF DEFLECTIONS UNDER APPLIED LOAD

FIG. 18

(DEFLECTIONS MEASURED WITH TAUT WIRES)

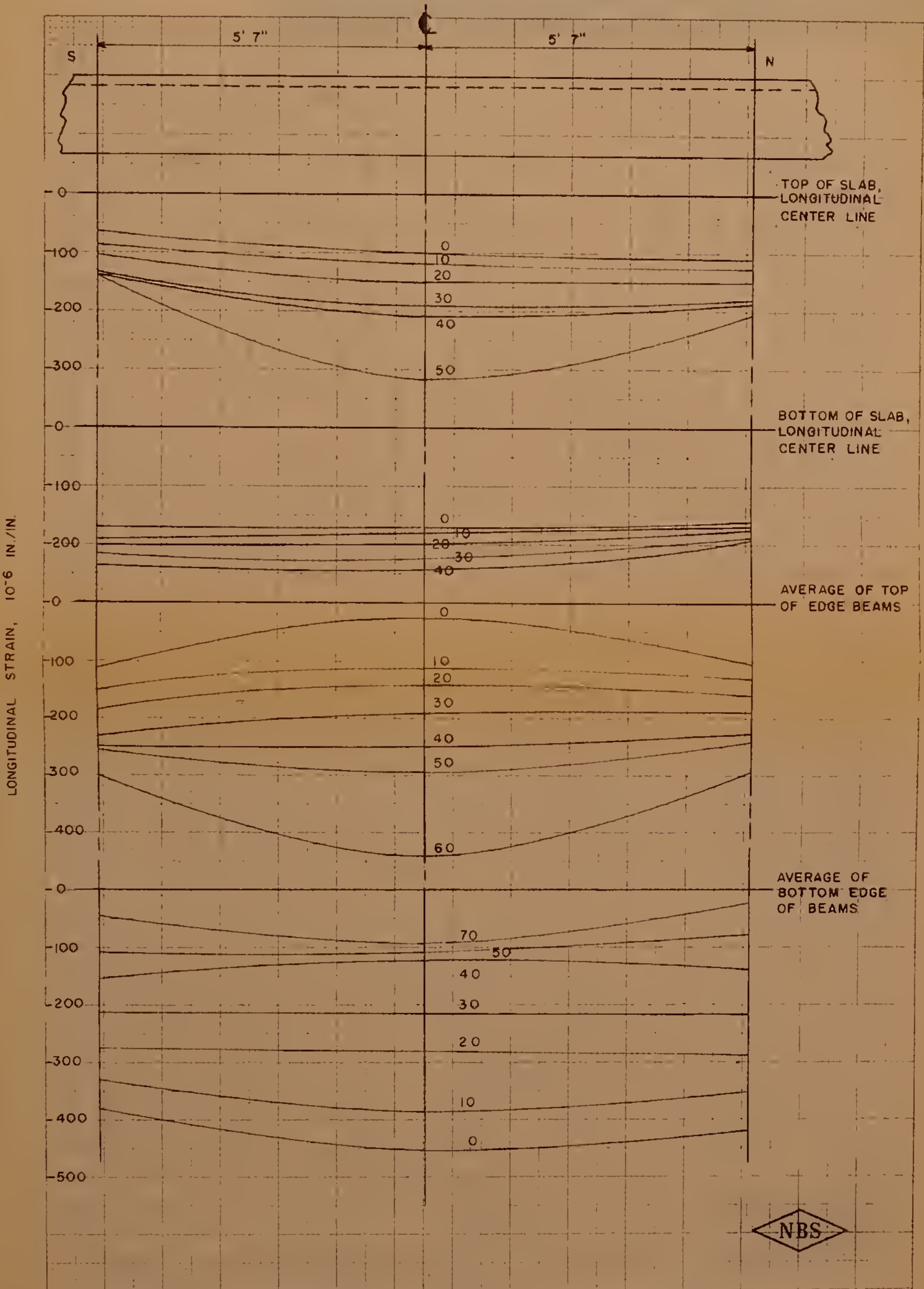


DISTRIBUTION OF TRANSVERSE STRAINS

PRECAST-PRESTRESSED SLAB-1

DISTRIBUTION OF LONGITUDINAL STRAINS

FIG. 19



NOTE: NUMBERS ON CURVES INDICATE LOAD ON SLAB IN LB/SQ FT.
COMPRESSIVE STRAINS ARE PLOTTED BELOW ZERO LINES.

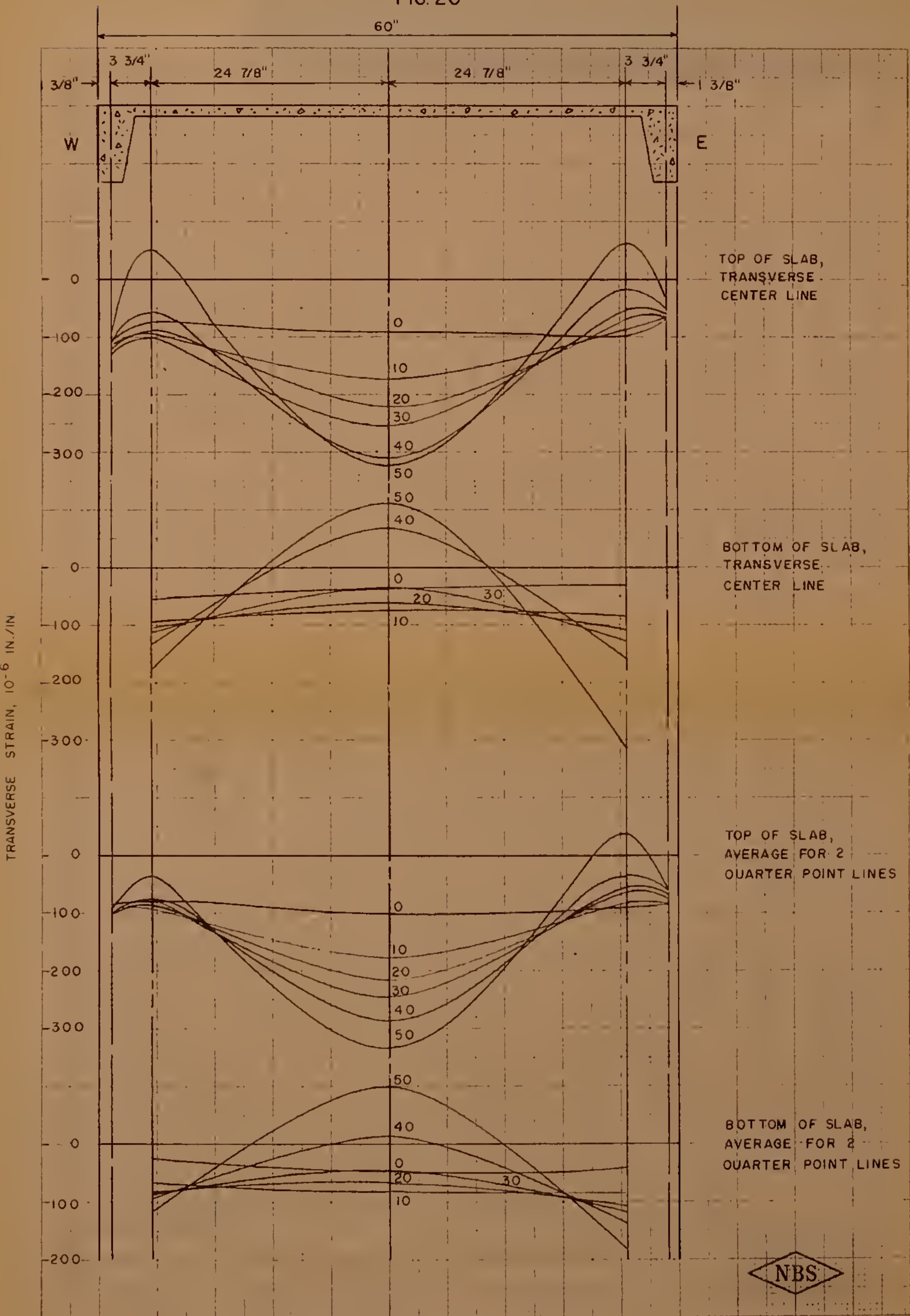
PRESTRESSING FORCE
KIPS

APPLIED LOAD
PSF

PRECAST-PRESTRESSED SLAB-1

DISTRIBUTION OF TRANSVERSE STRAINS

FIG. 20



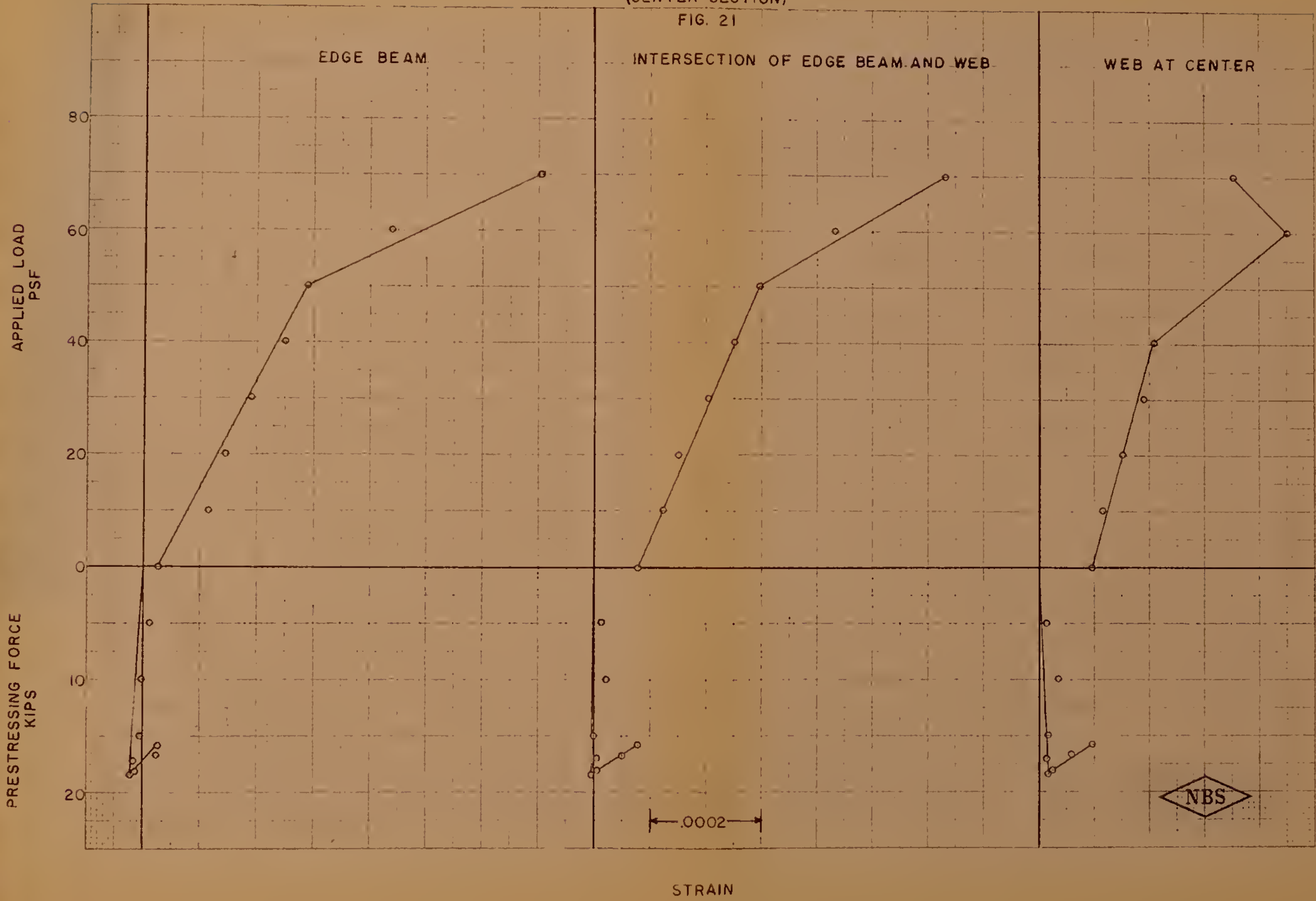
NOTE: NUMBERS ON CURVES INDICATE LOAD ON SLAB IN LB/SQ FT. COMPRESSIVE STRAINS ARE PLOTTED BELOW ZERO LINES.

PRESTRESSING FORCE KIPS	APPLIED LOAD PSF

PRESTRESSED SLAB -I

LONGITUDINAL COMPRESSIVE STRAINS THROUGH TENSIONING AND LOADING CYCLE AT TOP OF SPECIMEN
(CENTER SECTION)

FIG. 21



PRESTRESSING FORCE

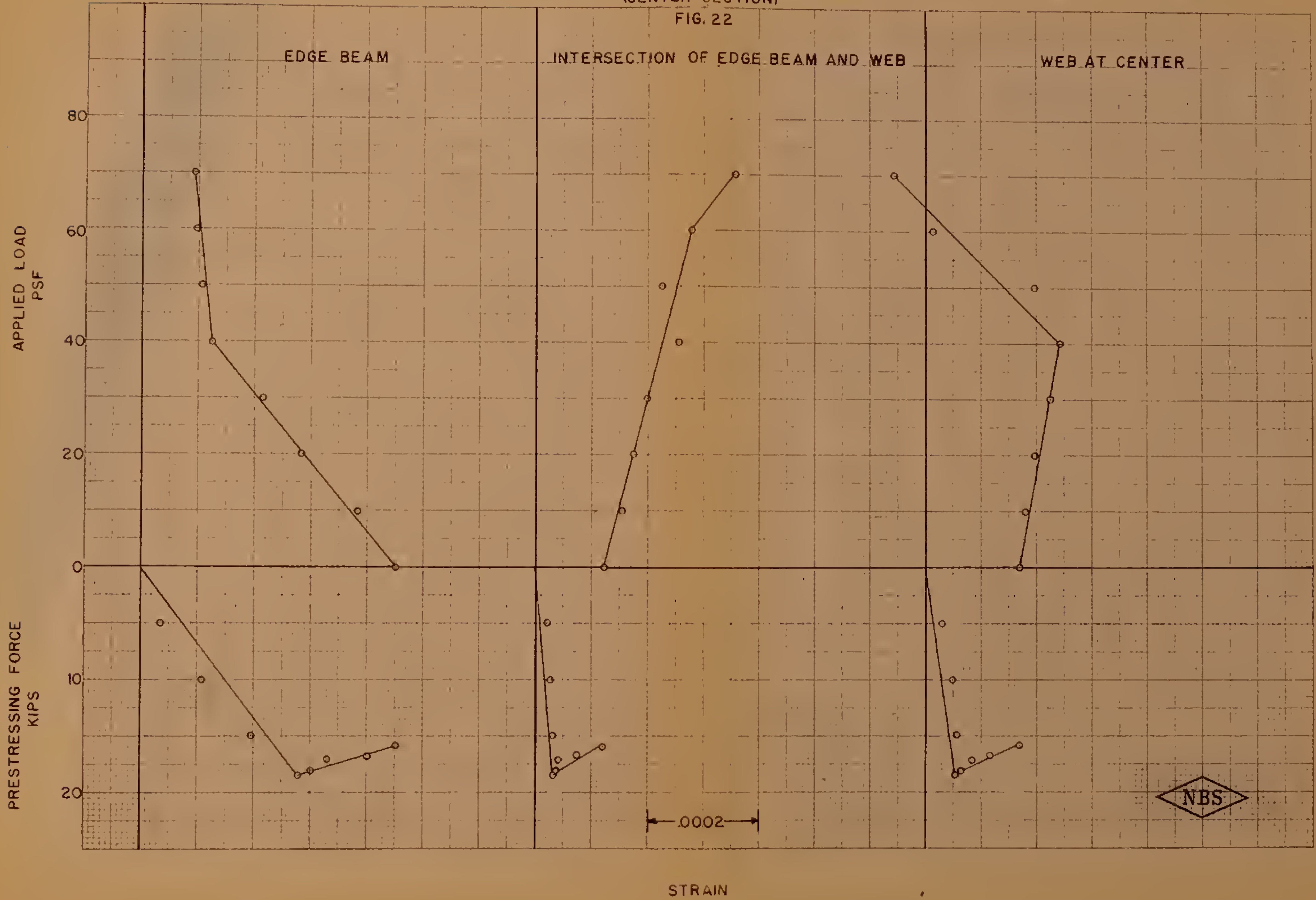
APPLIED LOAD

PRESTRESSED SLAB-I

LONGITUDINAL COMPRESSIVE STRAINS THROUGH TENSIONING AND LOADING CYCLE AT BOTTOM OF SPECIMEN

(CENTER SECTION)

FIG. 22

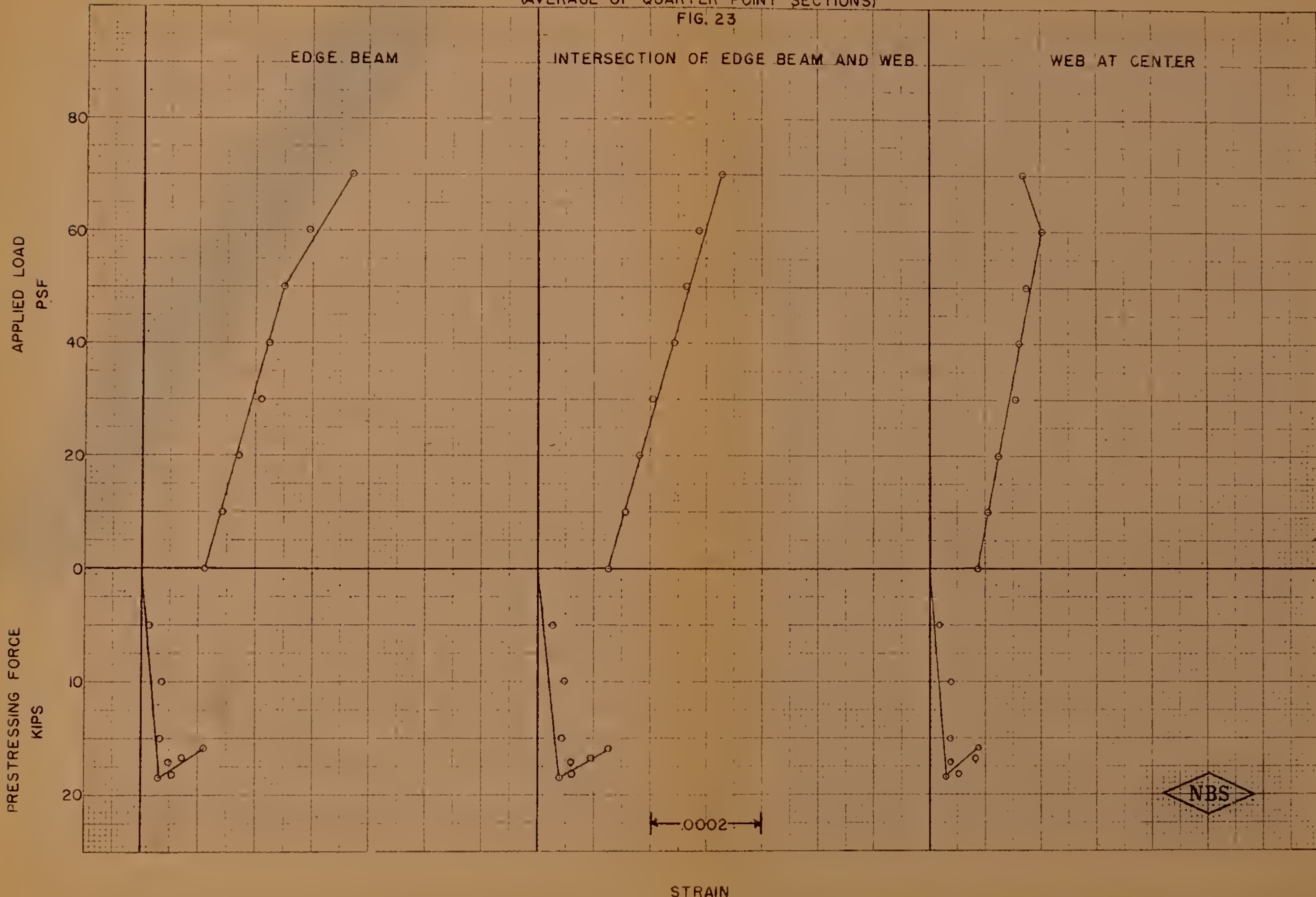


PRESTRESSING FORCE KIPS	APPLIED LOAD PSF

PRESTRESSED SLAB-1

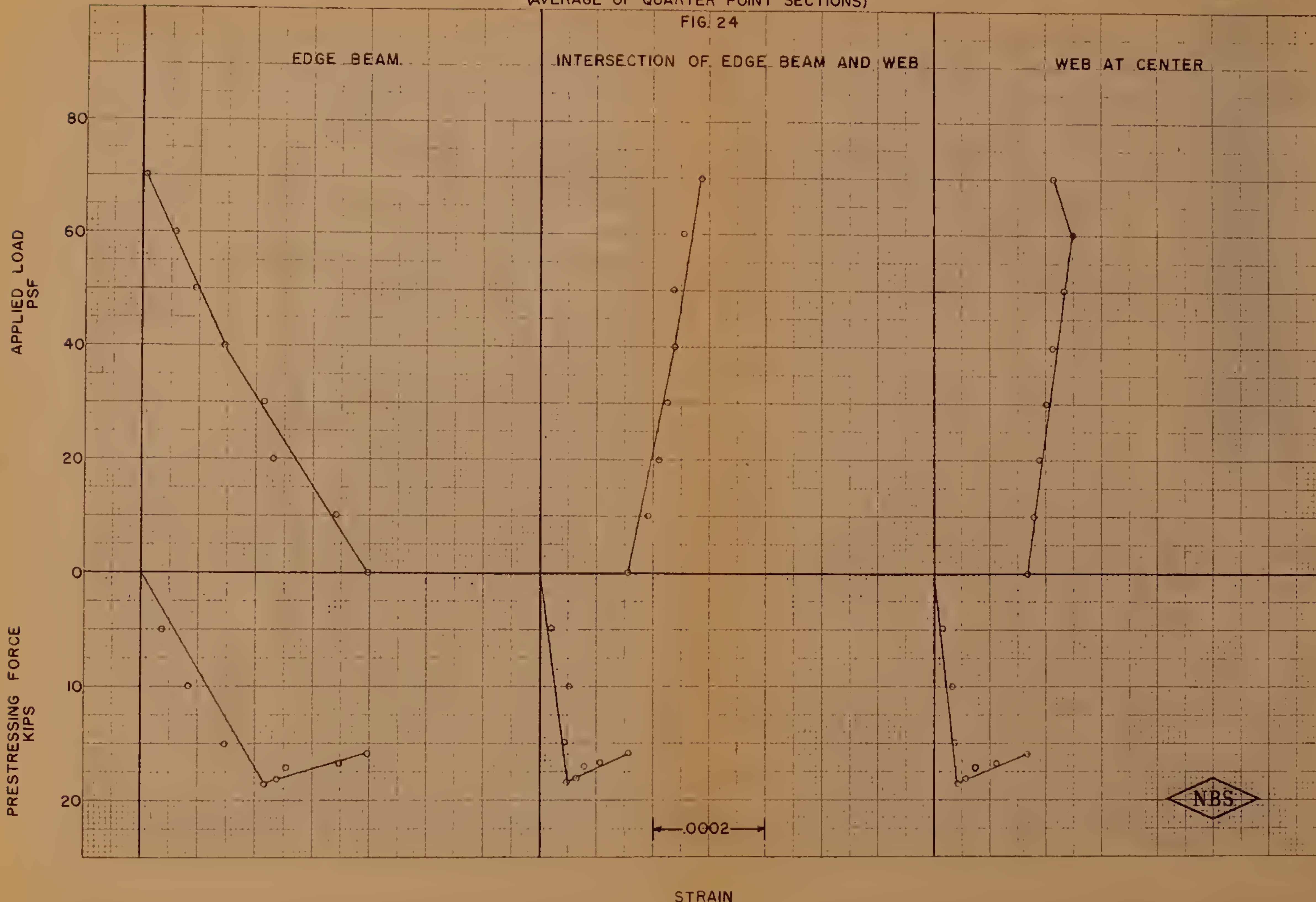
LONGITUDINAL COMPRESSIVE STRAINS THROUGH TENSIONING AND LOADING CYCLE AT TOP OF SPECIMEN
(AVERAGE OF QUARTER POINT SECTIONS)

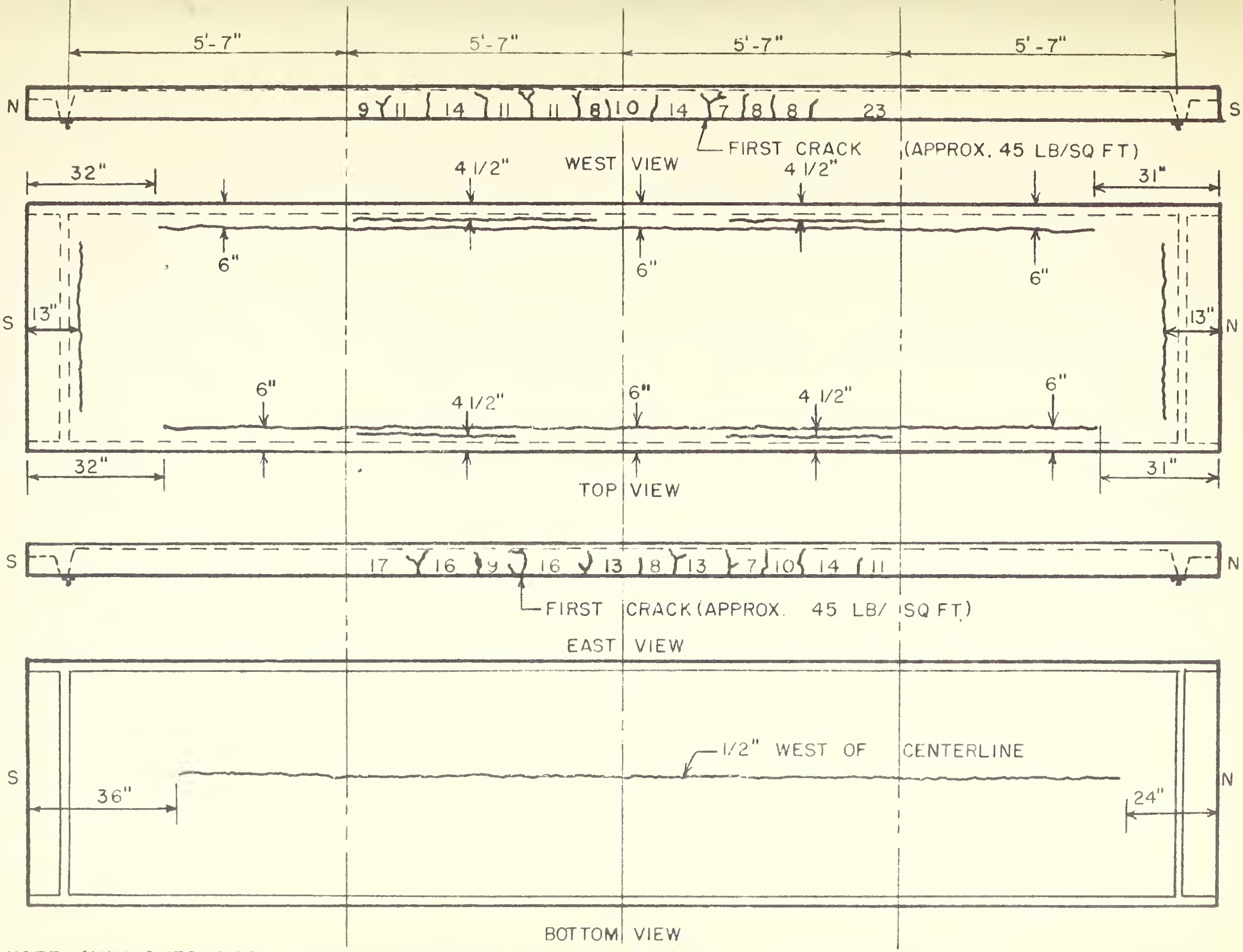
FIG. 23



LONGITUDINAL COMPRESSIVE STRAINS THROUGH TENSIONING AND LOADING CYCLE AT BOTTOM OF SPECIMEN
(AVERAGE OF QUARTER POINT SECTIONS)

FIG. 24





NOTE - UNMARKED NOS. INDICATE **DISTANCE IN INCHES BETWEEN CRACKS OR BETWEEN CRACK & QUARTER POINT**

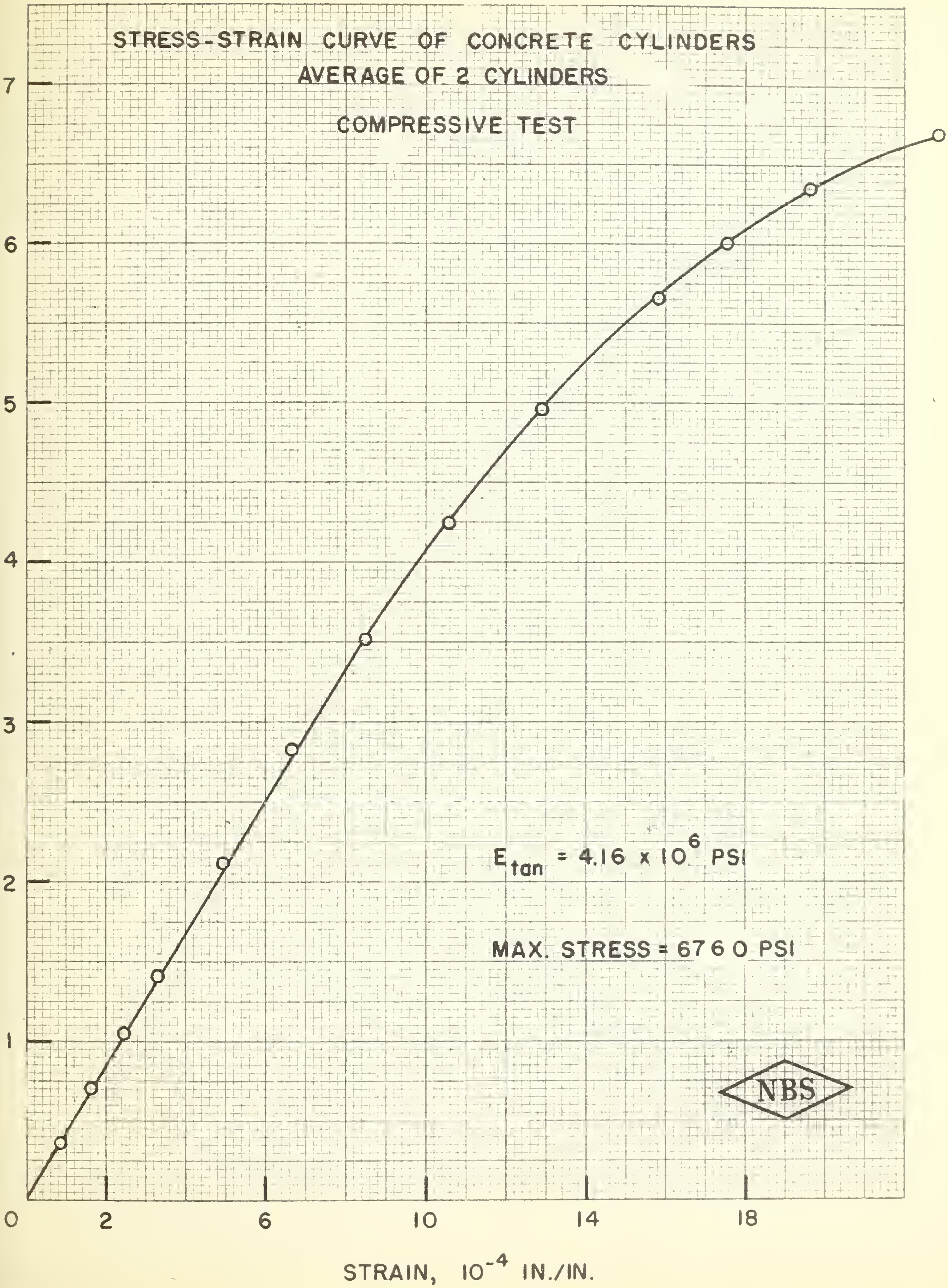
NES

DISTRIBUTION OF CRACKS ON SPECIMEN - FIRST DAY OF TEST

FIG. 25

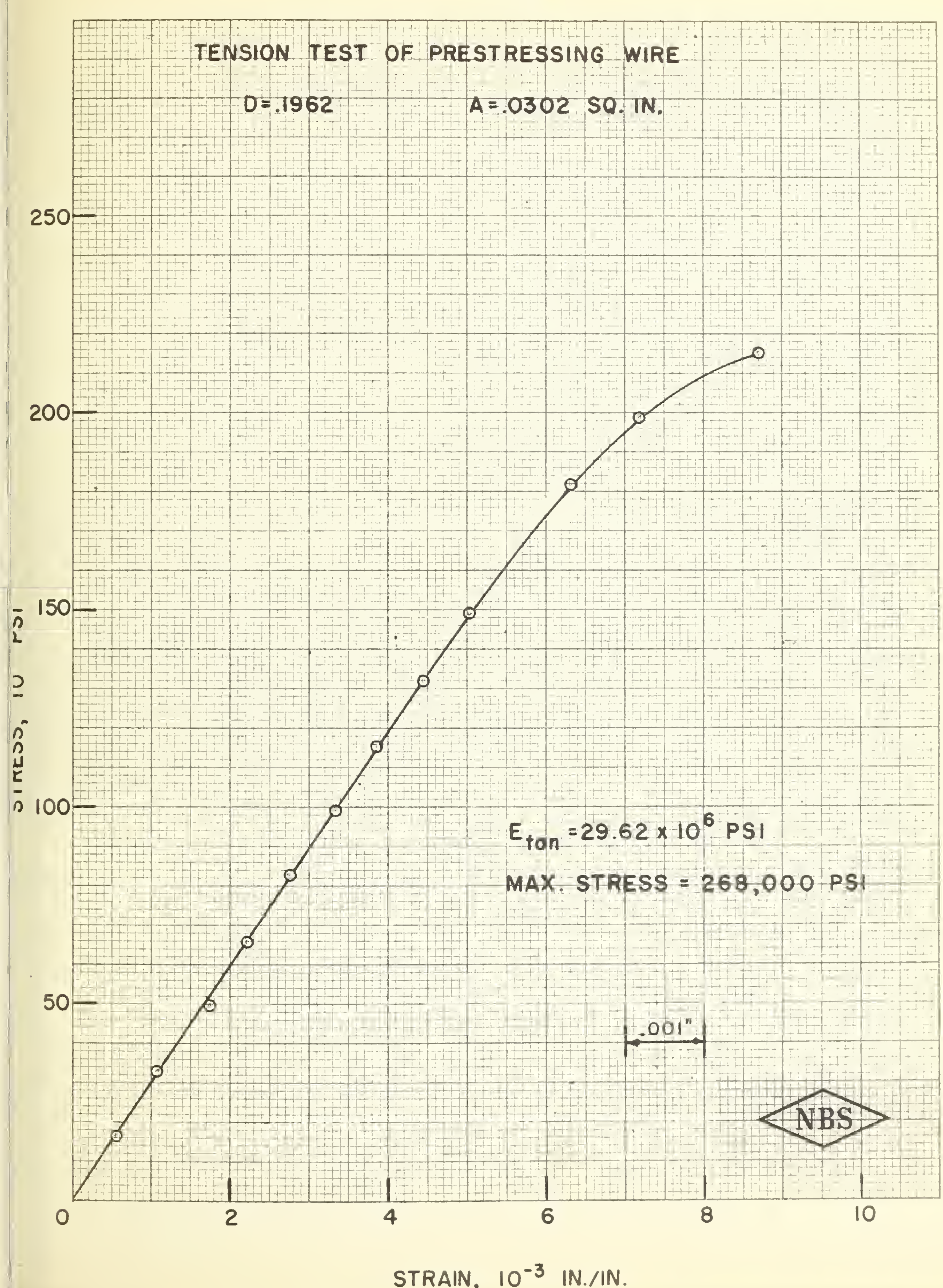
PRESTRESSED SLAB-1

FIG. 26

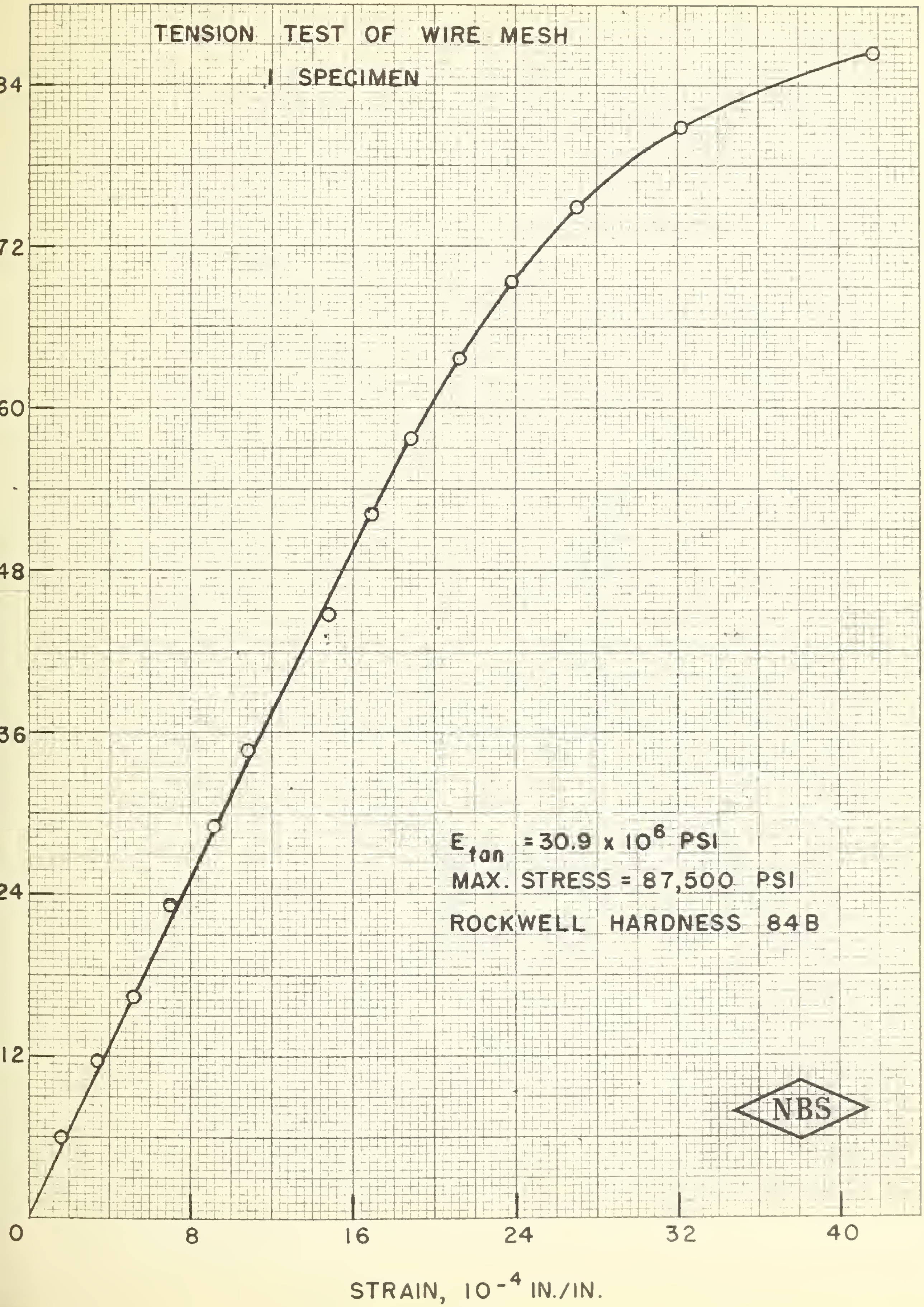


PRESTRESSED SLAB-I

FIG. 27



PRESTRESSED SLAB-I
FIG. 28



THE NATIONAL BUREAU OF STANDARDS

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

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NBS