RIGID FRAME STUDIES

Progress Report

FULL SCALE FRAME TESTS
STR 60 12/15 10/25

Submitted to

Star Manufacturing Company
Oklahoma City, Oklahoma

by

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and

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INTRODUCTION

A series of tests was conducted in the Fears Structural Engineering Laboratory, School of Civil Engineering and Environmental Science, University of Oklahoma, using standard rigid frames produced and erected by Star Manufacturing Company, Oklahoma City, Oklahoma. The purpose of these tests was to determine the structural strength and stiffness of rigid frames designated by Star Manufacturing Company as STR 60 12/15 10/25. The frames, referred to herein as STR 60, are normally used in pre-engineered buildings with the following design parameters:

Clear Span	60 ft.
Design Live Load	12 psf
Design Wind Load	15 psf
Eave Height	10 ft.
Frame Spacing	25 ft.
Roof Slope	½:12

The STR series consists of clear span rigid frames with prismatic columns and rafters of shop-welded steel plate. A roof slope of ½:12 is used for frames of this series.

The tests specimens were fabricated as part of standard production runs. The test set-up and testing procedures were developed using details and descriptions found in the literature. The test set-up consisted of two frames spaced 24 ft. 0 in. apart, with connecting simple span purlins, standard flange brace angles, and rod braces as shown in Figure 1. Simulated live load was applied using gravity load simulators similar to

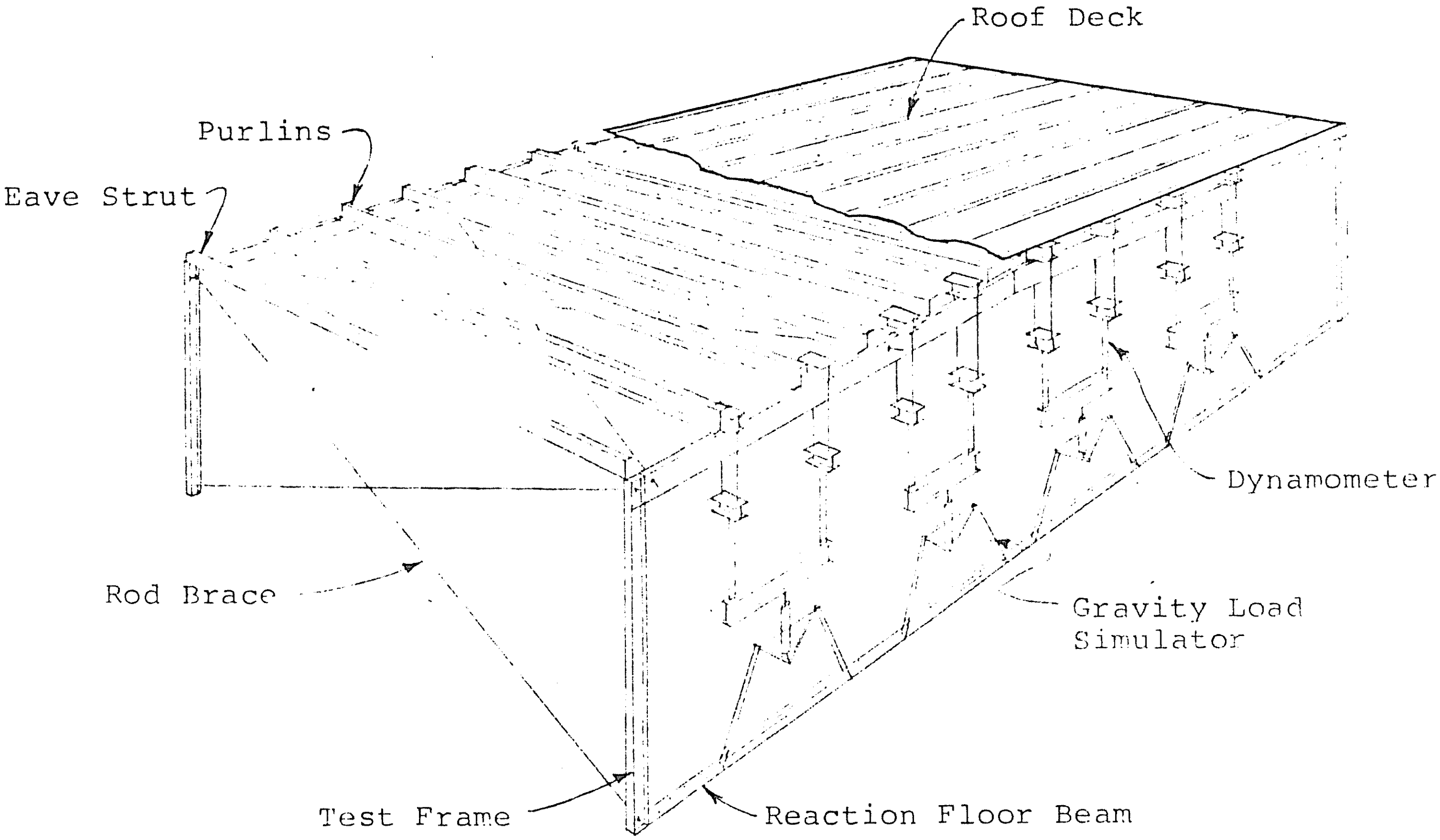


Figure 1. Overall View of Test Set-up

those described in Reference 1. Full live load tests of complete frames with both standard and nonstandard flange brace spacings were conducted. In addition, a test was conducted on a rafter-column portion of one frame to determine the strength and stiffness of the knee area of the frame. The method used for the latter test was similar to that reported in Reference 2.

The purpose of the testing was twofold: 1) to verify existing design procedures used by Star Manufacturing Company to predict deflections and strength, and 2) to verify a proposed method for determining the lateral torsional buckling load of an unbraced span. This report provides a detailed description of the testing procedures, instrumentation, and results. Comparisons are made with the standard Star Manufacturing Company design procedures and preliminary comparisons are made to the proposed method.

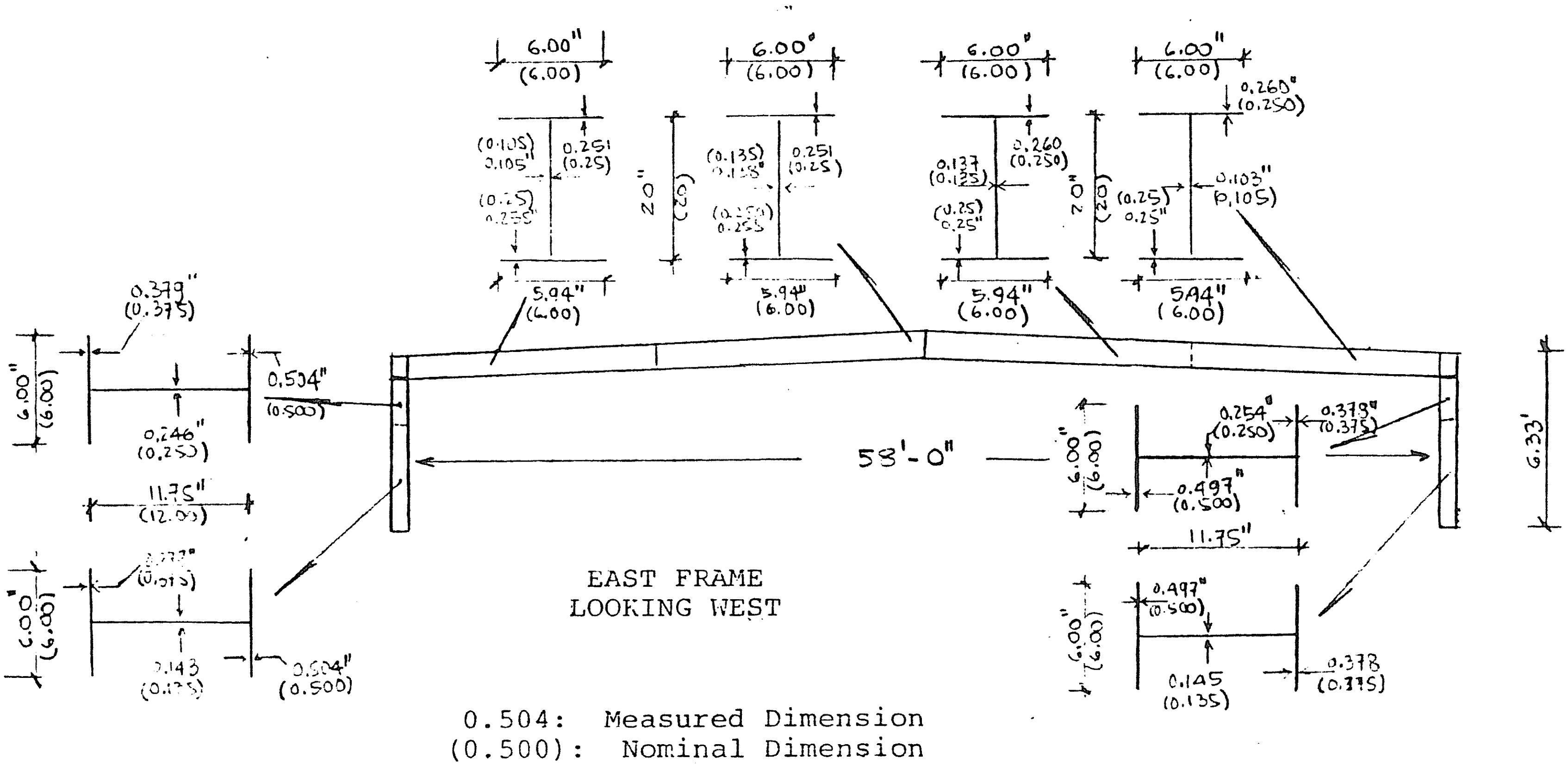
FRAME TEST DETAILS

Description of Specimens

Details and dimensions of the test specimens are shown in Figure 2 and points of load application are shown in Figure 3. The specimens were fabricated from A572 Gr 50 Steel. The only modification made to the specimens compared to standard production frames was the addition of holes in the top flanges of the rafters to permit installation of loading devices.

Test Set-up

The frames were erected inside the Fears Structural Engineering Laboratory on the laboratory reaction floor. The floor is a concrete slab 30 ft. by 60 ft. by 3 ft. 6 in. deep with four W 36 x 150 steel beams embedded in concrete. The slab weighs one million pounds and is capable of reacting 320,000 lb. in any one location. The frames were erected directly over two of the embedded W36 beams, spaced 24 ft. 0 in. apart. Purlins at standard bracing spacing were connected between the frames along with standard rod bracing in both the roof and side walls. The standard end wall girt was not used. Compression flange braces at the standard locations were connected between the purlins and the bottom flanges of the rafters. These braces were later moved to nonstandard locations for additional tests to evaluate a proposed analytical method for predicting lateral buckling strength of rafters. The entire roof area was sheeted



FRAME 5
STR 60 12/15 10/25

Figure 2a. Details and Dimensions of Test Specimens, East Frame

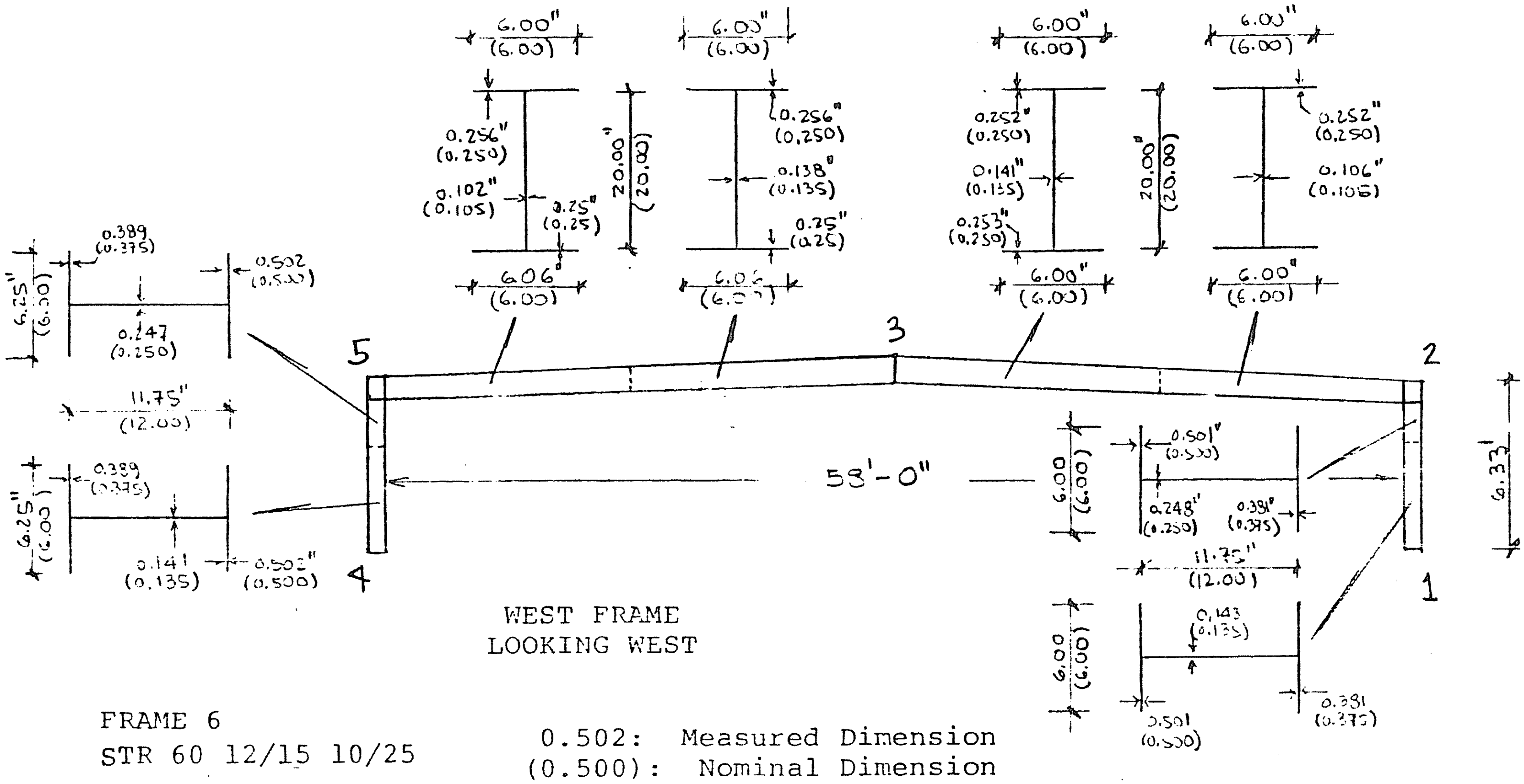


Figure 2b. Details and Dimensions of Test Specimens, West Frame (Frame 6)

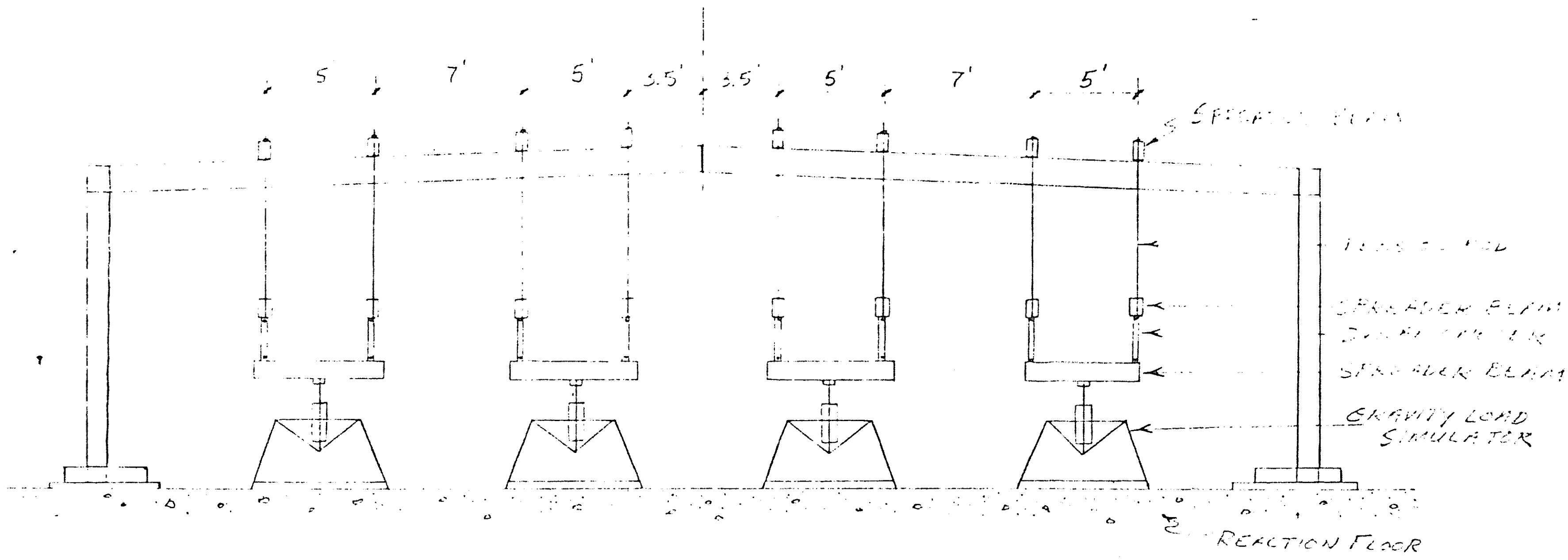


Figure 3. Simulated Live Load Loading

using standard roof deck and fasteners.

The column base plates were bolted to beam sections which were bolted to channel sections which in turn were bolted to the reaction floor beams as shown in Figure 4. Six, 1 in. diameter, A325 bolts were used at the rafter to column connection, six, 3/4 in. diameter, A325 bolts were used at the peak splice connection, and 1/2 in. diameter by 1 1/4 in. hex screws were used to connect all cold-formed parts to the frames. The erection procedure was thought to be representative of standard practice and was performed by erection crews supplied by Star Manufacturing Company. However, after initial testing of the east frame, it was determined that the bolts at both the knee and peak splices had not been sufficiently tightened. In addition, the west frame rafter was erected with the centerline of the lower flange approximately 1 in. outside the theoretical plane of the web. Effects of this erection are discussed subsequently.

Simulated live load was applied using the loading apparatus shown in Figure 3 which consists of a gravity load simulator (Figure 5), a 35 kip tension compression hydraulic cylinder, a spreader beam, two calibrated dynamometers, and spreader beams and tension rods attached to the frame. The simulator is a device which permits horizontal movement of the point of load application while maintaining a vertical line of action of the applied load. For the simulator used in these tests, the point of application of the load can move left or right a maximum of 10 in. and the hydraulic ram will remain vertical.

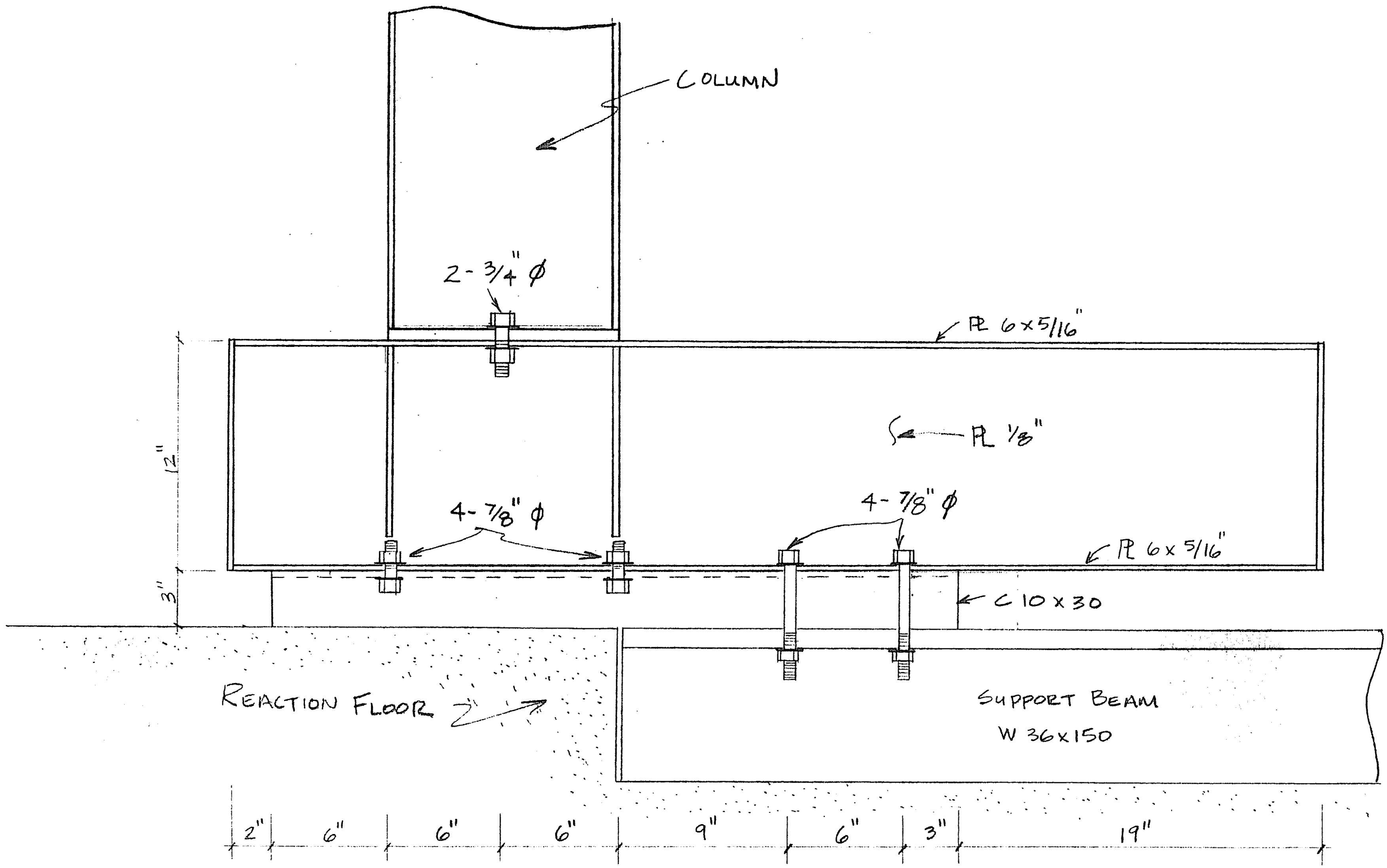


Figure 4. Details of Column to Reaction Floor Connection

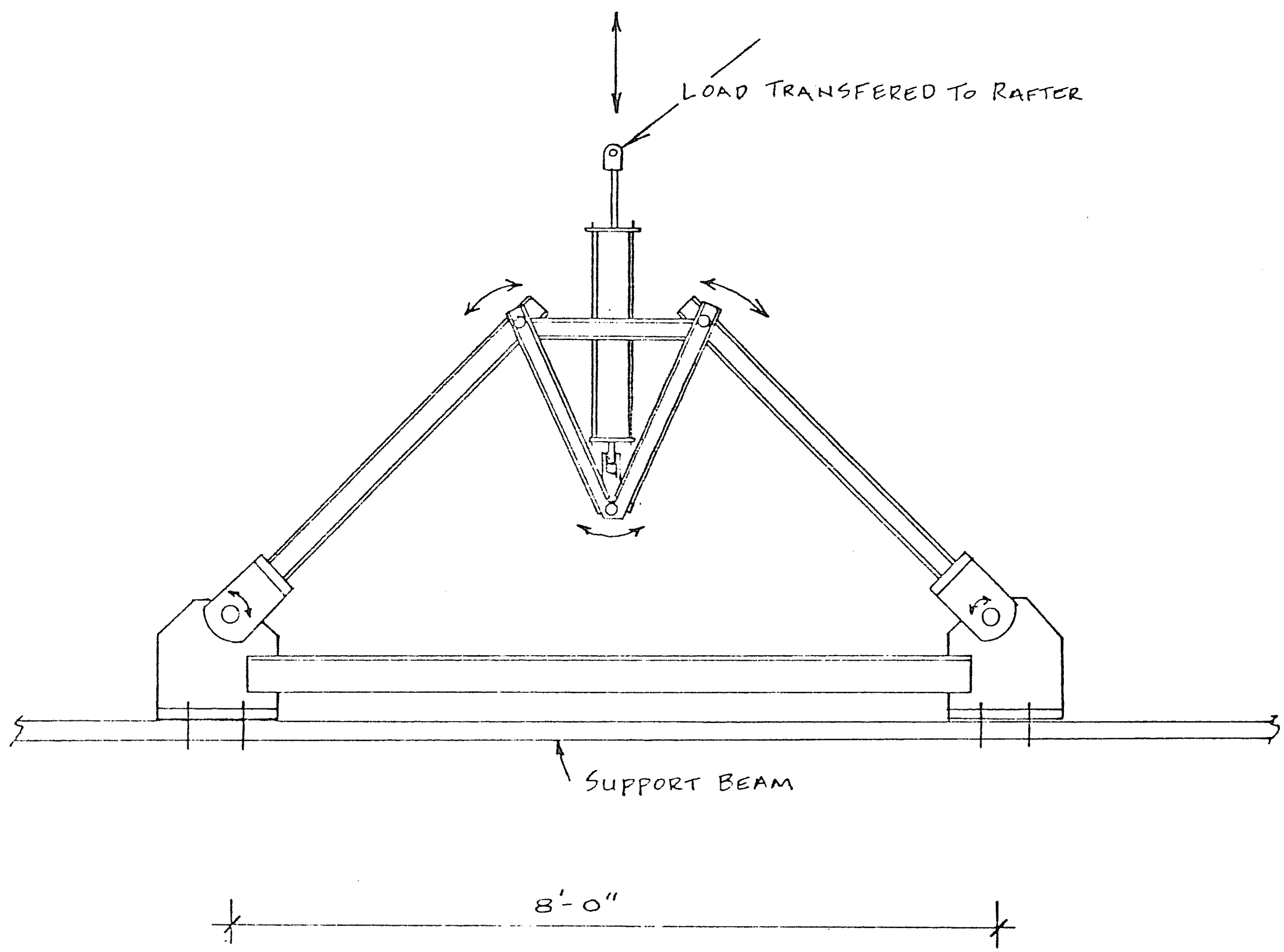


Figure 5. Gravity Load Simulator

Instrumentation

Instrumentation of the frames consisted of calibrated dynamometers, strain gages, dial gages, and horizontal deflection gages. Gravity load was measured using the dynamometers positioned as shown in Figure 3. Vertical deflection of the centerline of the frames was measured using either a taut wire and a dial gage (Figure 6a), or a weighted scale and fixed level (Figure 6b). The former was used for the east frame and the latter for the west frame. Lateral movement of the column and rafter flanges was measured by means of a transit set in a fixed position with the telescope free to move only in a vertical plane. Graduated scales (0.1 in.) were attached perpendicular to the plane of the web at the flange locations shown in Figure 7. The locations shown on the rafters are midway between purlin attachment points. The locations shown on the columns were arbitrarily selected.

Wire strain gages were positioned on both frames at critical locations, as shown in Figure 8. Gages on the same side of the web but on opposite sides of a flange were wired so that the average strain at a particular location was recorded. An electronic data acquisition system was used to record all strain gage data.

Testing Procedure

Prior to any actual testing, an overall check of the testing apparatus and instrumentation was made and zero readings were recorded. In general, load was applied in increments of 0.5 or

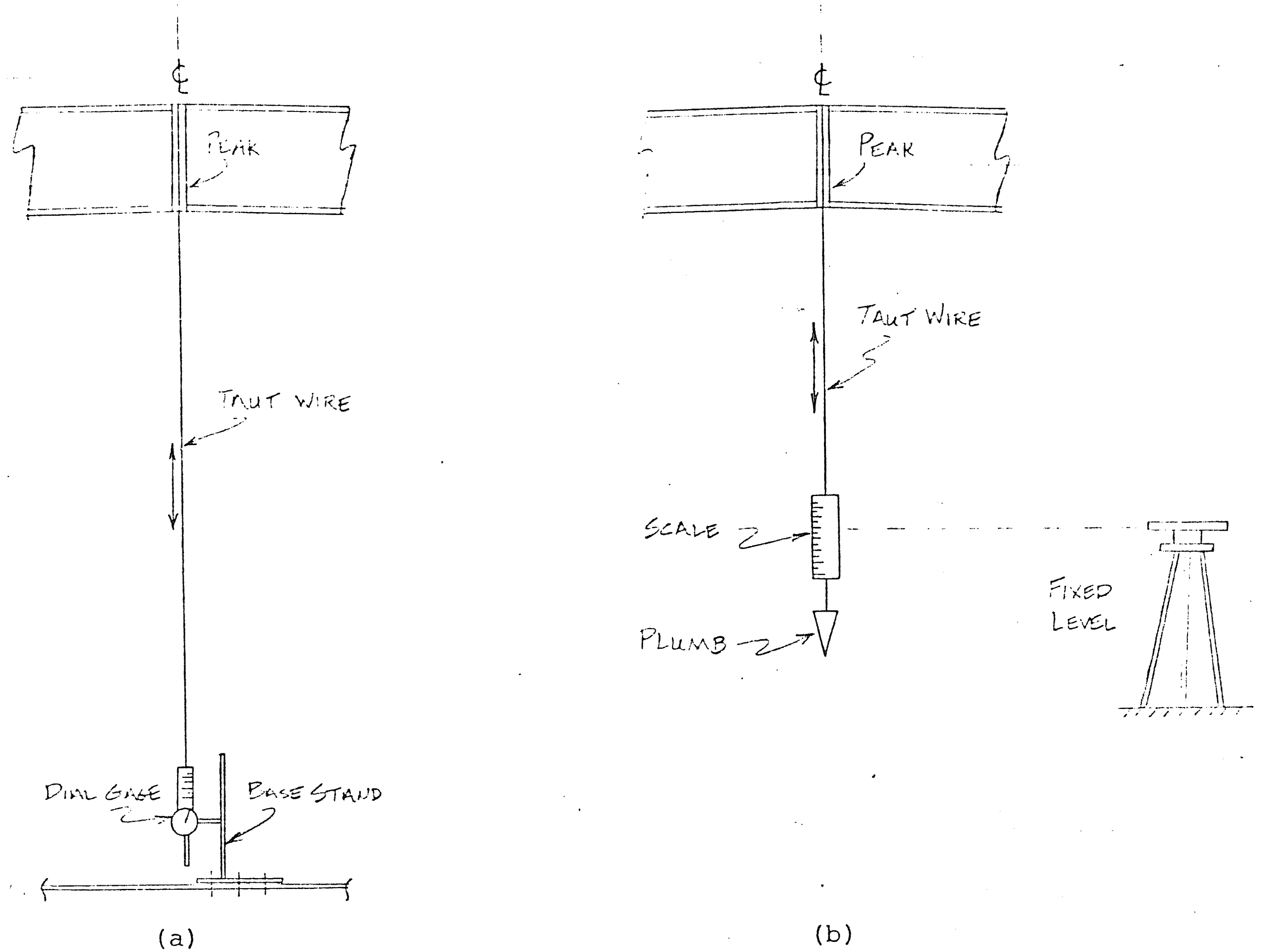


Figure 6. Measurement of Vertical Deflections

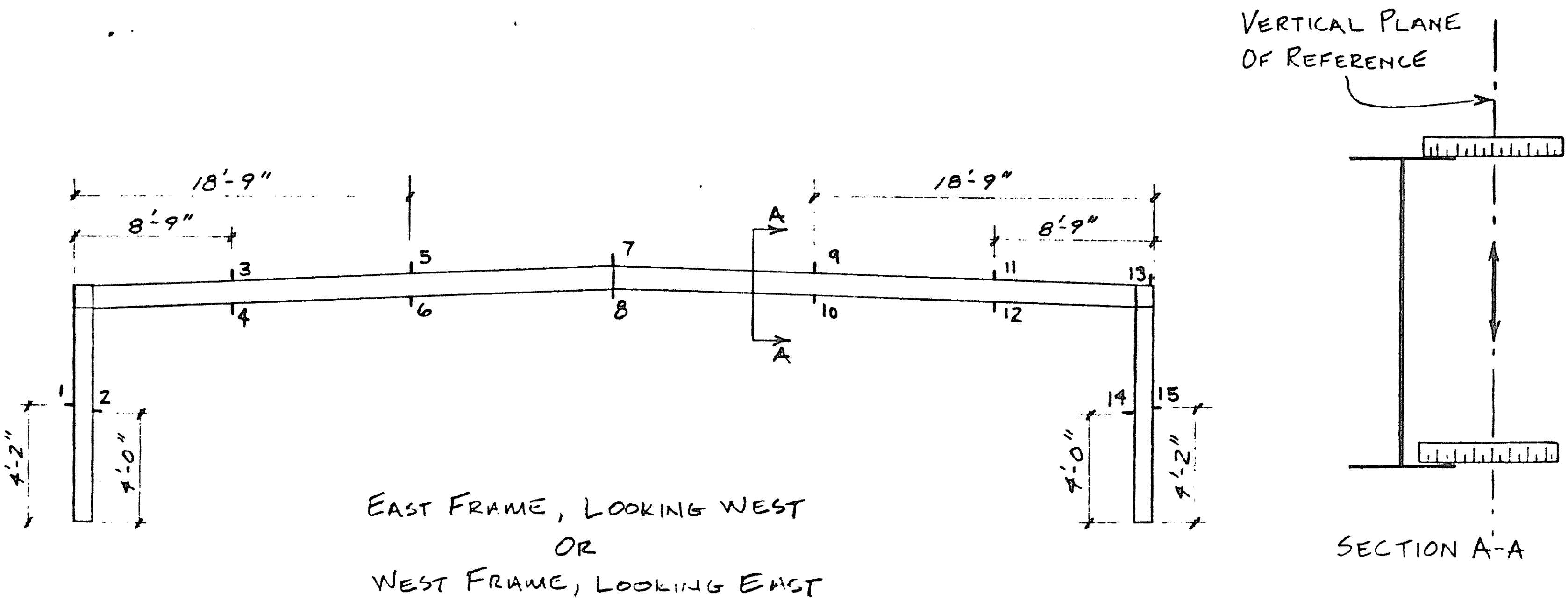


Figure 7. Measurement of Lateral Deflections

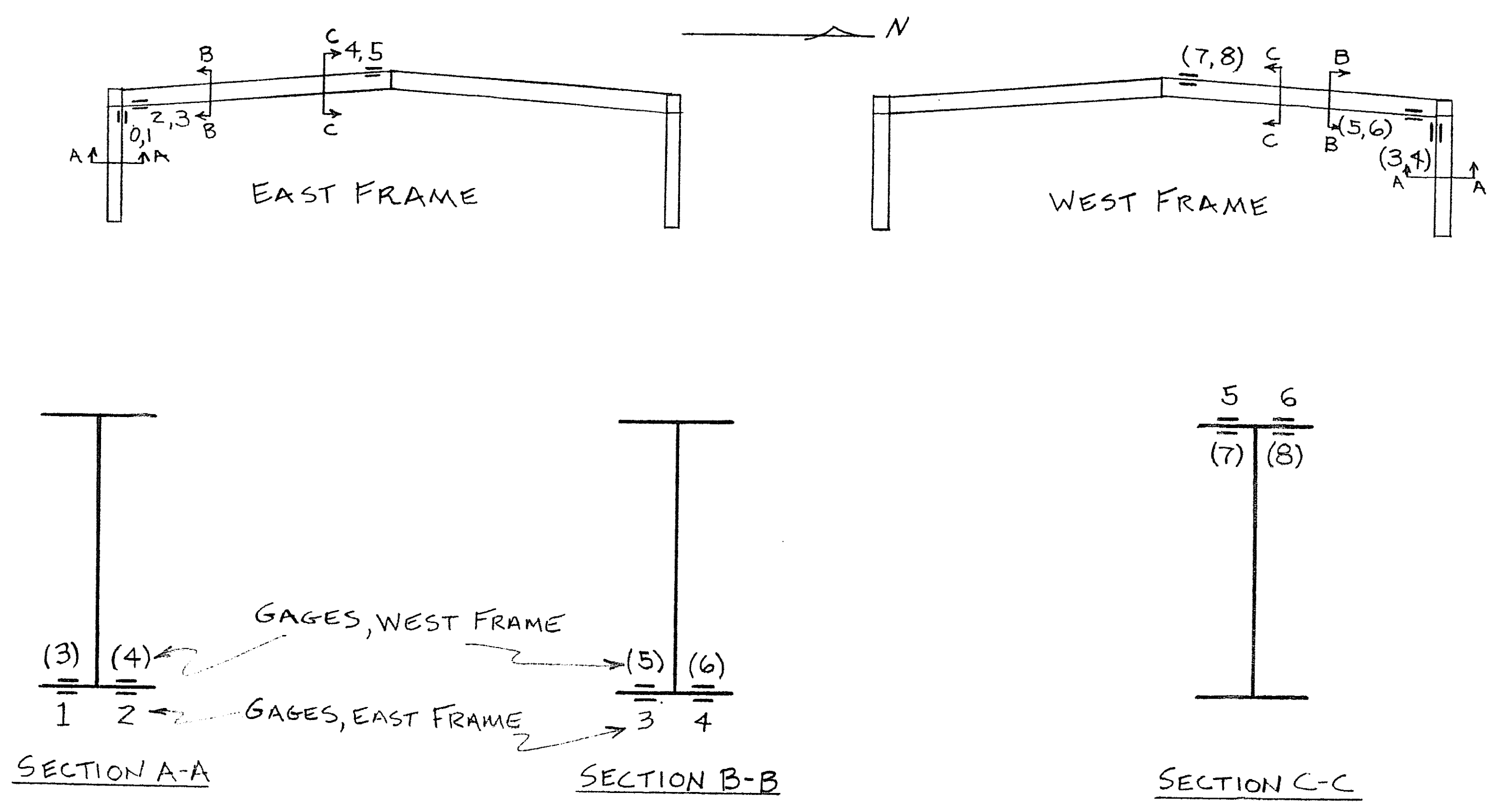


Figure 8. Strain Gage Locations

APPENDIX B

Full Live Load - East Frame

Test Date, July 3, 1980

1.0 kip until near the failure load when the increment was decreased. After each load increment, deflection and strain gage readings were recorded and the specimens were checked for signs of yielding. Yielding was detected by flaking of mill scale under the whitewash coat on the frame. When the specimens were no longer able to resist any additional loading, the maximum load was recorded and the load was then removed.

Three series of tests were conducted: initial tests to verify the performance of the frames relative to analytical predictions; tests to determine the lateral buckling strength of the rafters under nonstandard flange brace spacings; and a final test to determine the strength and stiffness of the knee portion of the frame. The latter tests is discussed in detail in the following section.

KNEE TEST DETAILS

Description of Specimen

The specimen selected for this test was the north rafter-column combination of the east test frame. Details and dimensions of the test specimen was selected are shown in Figure 9 and the test set-up and instrumentation are shown in Figure 10. The configuration of the test specimen was selected such that the moment, shear, and thrust at the column-rafter connection were as close as possible to the actual frame design values with those obtained in the test set-up. The design values were obtained from a computer analysis provided by Star Manufacturing Company.

TABLE 1

Knee Test - Design and Test Forces and Moments

Force	Design Live Load = 1 kip	Test Jack Force = 6 kips
Shear	3.81 kips	3.81 kips
Thrust	4.63 kips	4.64 kips
Moment	36.4 ft-kips	36.45 ft-kips

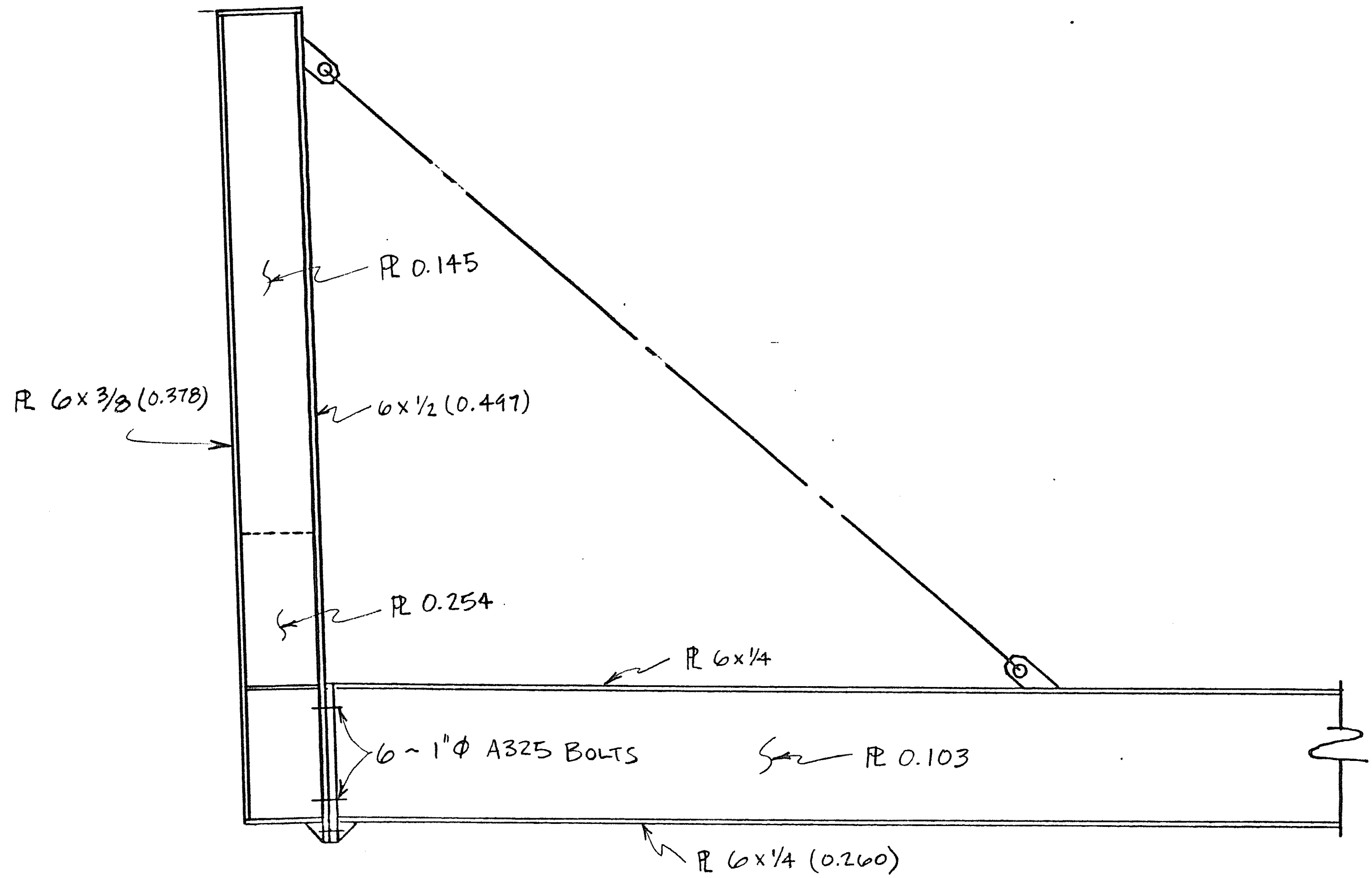


Figure 9. Details of Knee Test

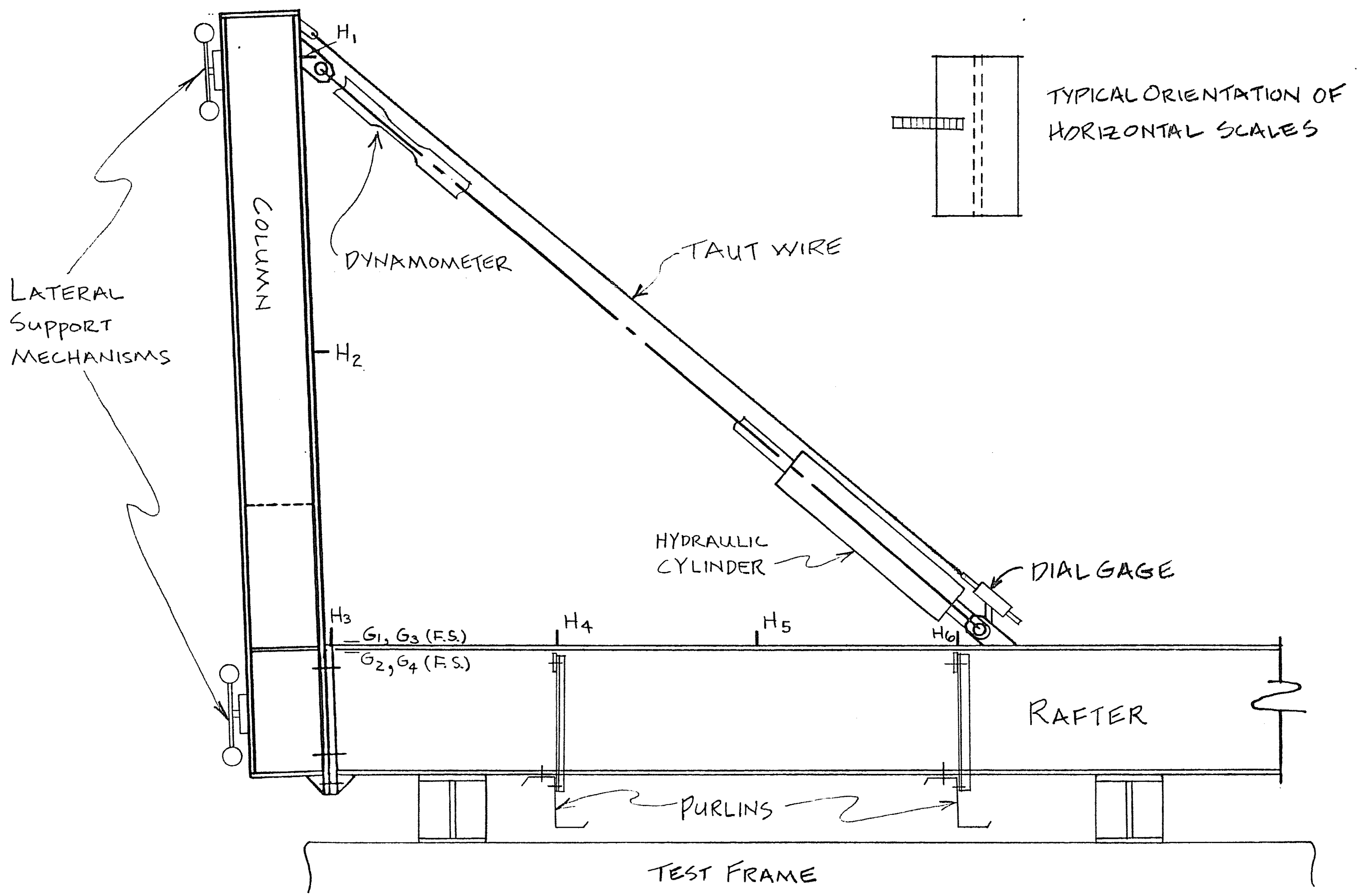


Figure 10. Knee Test Set-up and Instrumentation

Test Set-up

To facilitate loading and support, the specimen was tested in a rotated position relative to use in a building as shown in Figure 10. The actual rafter is the horizontal leg and the actual column is the vertically inclined leg. Load was applied along a diagonal line joining the base of the column and the inflection point of the rafter. A dynamometer and two steel bars were placed in series with a hydraulic cylinder for load application and monitoring. A standard strain indicator was used to control the load.

Star Manufacturing Company standard zee sections were attached to the rafter and to the test framework as shown in Figure 10. The sections and locations were identical with the sections and locations of purlins in the standard building. All purlin connections were made with 1/2 in. x 1 1/4 in. hex screws and nuts. The test frame ends of the purlins were connected to the support beams by means of moveable bolted clamps.

Lateral support mechanisms, similar to those described in Reference 1, were attached to the column as shown in Figure 10. These mechanisms were used to stabilize the specimen and are designed so as not to restrain the specimen in the direction of hydraulic cylinder movement. The attachment is not considered to affect the test results.

Instrumentation

In addition to the previously mentioned dynamometer, deformation measurements were used to determine flexural deflections and lateral movement.

The flexural deflections were determined by measuring the movement between the end of the specimen along the line of action of the applied load. This displacement was measured using a dial gage with a 4 in. stroke and a taut wire as shown in Figure 10.

Lateral movement was measured by means of a tranist set in a fixed position with the telescope free to move only in a vertical plane. Graduated scales (0.1 in.) were attached, perpendicular to the plane of the web, to the compression flanges at locations H_1 to H_6 in Figure 10. Lateral movement was determined from transit readings on the scales.

Strain gages were attached to the compression flange of the rafter at the knee splice (Figure 10). Strains were measured with a standard strain indicator.

Testing Procedure

Prior to actual testing an overall check of testing apparatus and instrumentation was made and zero readings recorded. Load increments of 3 kips were applied until approximately 60% of the design load was reached; the load increments were then reduced to 1 kip and the specimen loaded to failure. After each load increment, deflection readings were recorded and the specimen checked for signs of yielding. Yielding was detected by flaking of mill scale under the whitewash coat on the specimen. When the specimen was no longer able to resist addition loading, the maximum load was recorded and the load was then removed.

ANALYTICAL PROCEDURES

In the section following, test results are compared to two analytical procedures. Star Manufacturing Company's standard computer design program was used to obtain theoretical frame stiffness and failure predictions. This program uses a standard stiffness analysis to determine internal axial forces, shears and moments and external deflections. For analysis purposes, non-prismatic members are divided into a number of segments each with uniform properties. The stiffness matrix is then developed and solutions obtained. Stresses at the end of all segments are calculated and standard AISC interaction equations (Formulas 1.6-1a, 1.6-1b or 1.6-2) are used to determine allowable or service loads. The interaction equations are checked at each analysis point and the location with a maximum value of less than 1.0 (unity check) is used as a criterion for determining maximum service load. In addition, local buckling and shear failure is checked using AISC provisions.

The basic factor of safety in the AISC specification is 1.67. To determine the ultimate load of the frames from the Star Manufacturing Company design procedure, the service loading was increased until a unity check value of approximately 1.67 was attained for at least one analysis point in the frame. Computer output showing geometry and section property data and the analysis for ultimate load is found in Appendix A.

The design check procedures used in the Star Manufacturing Company computer program are based on standard AISC design procedures which were developed specifically for prismatic, doubly symmetrical sections. The column and rafter sections used to construct the STR 60 frames are doubly symmetric. An analytical procedure, currently under development, for singly symmetrical, non-prismatic members was also used to predict the failure loads. This procedure is described in Reference 3 and is summarized as follows.

For the case of non-prismatic member subjected to end moments which cause a varying flange stress along the member and without transverse load, the elastic critical moment at the small end is given by

$$(M_e)_S = C_b C_a M_e \tag{1}$$

and at the large end by

$$(M_e)_L = C_b R C_a M_e \tag{2}$$

where C_a = a modifying factor to account for taper, C_b = a modifying factor to account for stress variations due to unequal compressive flange stresses at the beam ends, R = ratio of the section moduli to the extreme fiber of the compression flange at the large end to that at the small end, and M_e = the critical elastic moment for a prismatic beam with small end section properties subjected to equal but opposite end moments, single curvature bending. (See Reference 3 for complete details and formulas for all terms.) Since the members in these frames are prismatic, C_a and R are taken as 1.0 in equations (1) and (2). To account for inelastic effects the CRC formula is used

$$M_{cr} = M_y - \frac{M_y^2}{4(M_e)} \tag{3}$$

where M_{cr} = inelastic critical moment, M_y = first yield moment referenced to the compression flange and (M_e) = elastic critical moment.

Using the computer program described in Reference 3, a failure analysis was conducted for critical rafter sections of the west frame with modified compression flange brace locations and subjected to full live load.

TEST RESULTS

Results of Frame Tests

East Frame. Tests results for the east frame loaded with full live load are shown in Appendix B. The frame was loaded to 2.95 kips at which time yielding was observed in the compressive flange of the rafter near the peak. Upon inspection of the frame, it was noticed that the bolts at both the knee and peak splices had not been sufficiently tightened. The bolts were tightened and the frame reloaded to an ultimate failure load of approximately 3.4 kips. Failure was manifested by local buckling of the compressive flange of the rafter near the peak. The failure load attained and the location of failure are not in good agreement with Star Manufacturing Company's design program. Output is shown in Figure A.2 and the expected ultimate load was 4.17 kips with the critical location being in the south rafter at the knee.

The low failure load and unexpected critical location can best be explained by the following logic. When the frame was loaded the first time, the bolts were not tightened sufficiently and thus the ends were free to rotate (i.e., act as pinned-ends). If a simple beam analysis of the rafter is done assuming simple supports, it is found that the location of maximum bending stress is between the two centermost loading points. Through this analysis, the stress in the aforementioned region would be approximately 65 ksi at a load of 2.95 kips. This could explain the yielding that occurred in the first loading sequence. Since 65 ksi is greater than the yield stress of the material, residual stresses must have remained after the unloading of the frame. Thus, after the bolts were tightened and the frame loaded for the second time, the residual stresses combined with the loading stresses, resulting in premature failure of the frame.

Test results given in Appendix B are for the second loading sequence. As shown in Figure B.1, measured centerline vertical deflections were higher than those predicted. Lateral deflections of the outside and inside flanges are shown in Figures B.2 and B.3 respectively. The maximum lateral deflection was 0.15 in. near the southeast knee. This deflection is not considered to be of significance.

Load versus stress with stress calculated from measured strain data is shown in Figure B.4 for the south column near the knee, Figure B.5 for the south rafter near the knee, and Figure B.6 for the south rafter near the peak. Experimentally obtained stresses were generally lower than predicted stresses. However, the stress measured on one side of the peak was in close agreement with the predicted stress at that point.

Results of this test indicate that premature failure of the east frame was predicated by shortcomings in the erection procedure rather than inaccuracies in the design procedure.

West Frame, Standard Bracing. Tests results for the west frame with standard flange bracing loaded with full live load are shown in Appendix C. The frame was loaded to 3.0 kips at which time areas of yielding were observed on the compressive flange of the rafter near the peak. Upon further inspection it was noticed that local buckling of the inside (compressive) flange of the southwest rafter had occurred near the knee. The failure load of 3.0 kips did not compare well with Star Manufacturing Company's design program. Output is shown in Figure A.2 and the critical location was shown in the southwest column at the knee.

As shown in Figure C.1, reasonable agreement was attained between measured and predicted centerline vertical defelction. However, the measured deflections tended to be slightly greater than predicted after a load of 1.5 kips was attained. Lateral deflections of the outside and inside flanges are shown in Figures C.2 and C.3, respectively. The maximum lateral deflection was 0.19 in. at the peak. This deflection is not considered to be of significance.

Load versus predicted stress and stress calculated from strain data is shown in Figure C.4 for the north column near the knee, Figure C.5 for the north rafter near the knee, and Figure C.6 for the north rafter near the peak. All experimentally obtained stresses were lower than those predicted by Star Manufacturing Company's design program.

As was pointed out previously, the west frame rafter was erected with the centerline of the lower flange approximately 1 in. outside the theoretical plane of the web. The resulting eccentricity of vertical load with respect to the centroid created torsional stresses in the rafter which are not considered in Star's design program. This could account for the discrepancies between the experimental and predicted results.

West Frame, Nonstandard Bracing Scheme 1. This test was designed to investigate the adequacy of the proposed design method and the brace forces introduced at the ends of the unbraced span. Test results can be found in Appendix D. Figure D.1a shows the bracing pattern which was tested. This bracing scheme was designed so that the expected failure mode would be lateral buckling of the 20 ft. unbraced span.

According to the proposed design method of Reference 4, the critical moment for the unbraced span is approximately 66.4 ft-kips. This corresponds to a live load of 2.21 kips.

The frame was loaded to a failure load of 3.1 kips. The failure mode was torsional buckling of the unbraced span rather than the lateral buckling which had been expected. Reference to Figures D.2 and D.3, load versus the lateral deflection of the top and bottom flanges, respectively, show that the flanges moved laterally in an almost equal but opposite manner. This suggests that the rafter failed by twisting about a vertical axis. However, since the rafter web was initially out of its vertical plane, the system probably would not have failed by torsional buckling had this initial eccentricity been minimized. Therefore, it could be assumed that the lateral buckling load of the system would probably exceed the 3.1 kip load attained. The failure load attained shows that the proposed design method is conservative.

Reference to Figure D.4 shows that measured centerline vertical deflections were higher than those predicted by Star Manufacturing Company's design program. Figure D.5, load versus lateral deflection of the center of the unbraced span, clearly shows the rotation of the rafter and the torsional buckling that occurred at failure.

Load versus brace force, measured at both ends of the unbraced span, is shown in Figure D.6. The braces used at these positions were dynamometers calibrated to measure brace force.

West Frame, Nonstandard Bracing Scheme 2. This test was the second of two tests which were designed to investigate the adequacy of the proposed design method and the brace forces introduced at the ends of the unbraced span. Tests results can be found in Appendix E. Figure E.1 shows the bracing pattern which was tested. This bracing scheme was designed such that the expected failure mode would be lateral buckling of the 25 ft. unbraced span.

According to the proposed design method discussed in Reference 4, the critical moment for the unbraced span is approximately 28.1 ft-kips which corresponds to a load of 0.94 kips at each load location.

The frame was loaded to a failure load of 3.0 kips. As in the previous tests, the failure mode was torsional buckling of the unbraced span rather than lateral buckling as was expected. Reference to Figures E.2 and E.3, load versus lateral deflection of the top and bottom flanges respectively, show, as in the previous test, that the rafter twisted about its vertical axis thus failing by torsional buckling. As was mentioned for the previous test, the rafter would not have failed in this manner if the web had been initially vertical. It is probable that the frame could have attained a higher failure load if the resulting torsional moment had not been present. However, the failure load reached was still much greater than that predicted by the proposed method.

Reference to Figure E.4 shows that measured centerline vertical deflections were higher than those predicted by Star Manufacturing Company's design program. Figure E.5, load versus lateral deflection at a point on the unbraced span, clearly shows the rotation of the rafter and the torsional buckling that occurred at failure.

Load versus brace force, measured at both ends of the unbraced span, is shown in Figure E.6. The braces used at these positions were dynamometers calibrated to measure brace forces.

Results of Knee Test

Test data for the knee test, performed on the northeast rafter-column combination, is given in Appendix F. Load versus flexural deflection is shown in Figure F.1, together with the theoretical deflections. Measured flexural deflections were slightly higher than those predicted and are consistent with the flexural deflections measured in the full-scale frame tests.

Load versus lateral deflection is presented in Figure F.2. Reference to Figure F.2 indicates that the lateral bracing system was adequate and that insignificant lateral movement, less than 0.15 in., occurred during the loading.

The specimen failed at a dynamometer force of 22 kips which corresponds to an equivalent live load of 3.67 kips at each load location on the frame.

The specimen attained a failure load of approximately 88% of the 4.17 kips ultimate load predicted by Star Manufacturing Company's design program (see Figure A.2). Failure was by local buckling of the rafter compressive flange at the knee, showing good agreement with the failure location predicted by Star's design program (see Figure A.2). However, this is consistent with the full live loading of the west frame in which local buckling of the rafter compressive flange occurred near the knee.

Stress versus load for the rafter compressive flange at the knee is shown in Figures F.3 and F.4. Reference to Figure F.4, load versus stress calculated for the rafter compressive flange (the location of failure), shows excellent agreement between measured and theoretical stresses. The theoretical stresses were calculated from Star Manufacturing Company's design program by converting the jackforce (diagonal load) into the equivalent full live load for the full-scale frame. The tests stresses were calculated from measured strains assuming a modulus of elasticity of 29,000 ksi.

Reference to Figure F.4 shows higher stresses on the outside of the compressive flange than those measured on the inside. However, Figure F.3 shows that the reverse is true for the comparable point on the opposite side of the web. At this location, the stress calculated for the outside of the compressive flange is lower than that calculated for the inside. This stress variation is typical for the mode of failure observed.

Coupon Tests

Upon completion of the testing of the east frame, two samples of the plate material used to fabricate the frame were removed from the following locations: 1) Coupon No. 1 was removed from the upper flange of the southeast rafter approximately midway between the peak and knee connections; 2) Coupon No. 2 was removed from the lower flange of the notheast rafter approximately midway between the peak and rafter connections. These locations were chosen to minimize the effects of possible yielding due to test loading. Standard ASTM E-8-47T tensile coupons were then machined and tested. Results are shown in Table 2. Measurement of the yield stress of Coupon No. 1 was impossible due to premature failure of the attached strain gages. The measured yield stress of Coupon No. 2 was 55.2 ksi. For the Star Manufacturing Company computer analyses, a yield stress of 55 ksi was used in all cases, Appendix A. A yield stress of 50 ksi was used for the proposed analyses.

TABLE 2

Results of Coupon Tests

No.	Location	Yield Stress ksi	Ultimate Stress ksi	Elongation %
	Upper Flange Southeast Rafter	N.A.	65.6	31
	Lower Flange Northeast Rafter	55.2	72.6	45

SUMMARY AND CONCLUSIONS

A series of tests was conducted on standard pre-engineered metal building frames fabricated and erected by Star Manufacturing Company, Oklahoma City. The frames tested are designated by the manufacturer as STR 60 12/15 10/25. The test set-up consisted of two frames forming a single bay, 24 ft. by 60 ft. Standard roof deck, purlins, eave struts, flange braces, and rod braces were used to construct the test set-up. The frames were independently subjected to full live load. Additional tests were done on the west frame with nonstandard flange bracing. Experimentally determined results were compared to predicted values using Star Manufacturing Company's design program and, in the latter tests, to a proposed design method. A final test was conducted on a rafter-column portion of one frame to determine the strength and stiffness of the knee area of the frame.

Failure loads predicted by the design program were not in close agreement with the experimentally determined failure loads. Premature failure of both frames was predicated by erection or fabrication errors. Premature failure of the east frame was caused by insufficient tightening of the bolts at both the knee and peak connections. Early failure of the west frame was due to the out-of-plane position in which the rafter was erected. The results of these tests do not indicate shortcomings in Star Manufacturing Company's design program but they do emphasize the importance of accurate erection procedures.

The experimental results of the nonstandard flange bracing tests indicate that the proposed design method gives conservative estimates of the lateral-torsional buckling load of unbraced spans.

LIST OF REFERENCES

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2. Baldwin, B.N., and Murray, T.M., "Econostor Knee Tests", Research Report submitted to Star Manufacturing Company, June, 1977.

3. Yazdani, N. and Murray, T.M., "Design Methodology for Tapered Beams", Research Report submitted to Star Manufacturing Company, May, 1980.

APPENDIX A

Star Manufacturing Company

Computer Analyses

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB EASTFRA
STR 60 3/3 10/25 FILE
DESIGN DIMENSIONS AND PROPERTIES REPORT PAGE 3

MEMBER NO. 1- 2 LENGTH= 8.54 FT ANGLE=-89.95 DEG FYF=55.KSI FYW=55.KSI
SECTION 1 LENGTH= 6.00 FT OF= 6.00 X 0.3780 WEB=0.1450 IF= 6.00 X 0.4970
SECTION 2 LENGTH= 1.72 FT OF= 6.00 X 0.3780 WEB=0.2540 IF= 6.00 X 0.4970

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
1*	0.00	0.00	11.75	6.83	181.3	5.15	1.52	28.2	34.1	1.630	1.668
101	0.00	0.75	11.75	6.83	181.3	5.15	1.52	28.2	34.1	1.630	1.668
102	0.00	2.25	11.75	6.83	181.3	5.15	1.52	28.2	34.1	1.630	1.668
103	0.00	3.75	11.75	6.83	181.3	5.15	1.52	28.2	34.1	1.630	1.668
104	0.00	5.25	11.75	6.83	181.3	5.15	1.52	28.2	34.1	1.630	1.668
105*	0.00	6.00	11.75	6.83	181.3	5.15	1.52	28.2	34.1	1.630	1.668
105*	0.00	6.00	11.75	8.01	193.3	4.91	1.40	30.5	35.7	1.567	1.623
106	0.00	6.43	11.75	8.01	193.3	4.91	1.40	30.5	35.7	1.567	1.623
107	-0.01	7.29	11.75	8.01	193.3	4.91	1.40	30.5	35.7	1.567	1.623
108*	-0.01	7.72	11.75	8.01	193.3	4.91	1.40	30.5	35.7	1.567	1.623

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB EASTFRA
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DESIGN DIMENSIONS AND PROPERTIES REPORT PAGE 4

MEMBER NO. 2- 3 LENGTH= 29.50 FT ANGLE= 2.36 DEG FYF=55.KSI FYW=55.KSI
SECTION 1 LENGTH= 15.50 FT OF= 6.00 X 0.2600 WEB=0.1370 IF= 5.94 X 0.2500
SECTION 2 LENGTH= 13.55 FT OF= 6.00 X 0.2600 WEB=0.1030 IF= 5.94 X 0.2500

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
111*	0.44	8.56	19.88	5.70	375.9	8.12	1.26	38.3	37.4	1.531	1.503
112	2.38	8.64	19.88	5.70	376.2	8.12	1.26	38.3	37.4	1.531	1.503
113	6.25	8.80	19.90	5.70	376.9	8.13	1.26	38.4	37.4	1.531	1.503
114	10.12	8.96	19.92	5.70	377.7	8.14	1.26	38.4	37.5	1.531	1.503
115	13.99	9.12	19.93	5.71	378.4	8.14	1.26	38.4	37.5	1.531	1.502
116*	15.93	9.20	19.94	5.71	378.7	8.15	1.26	38.5	37.5	1.531	1.502
116*	15.93	9.20	19.94	5.05	357.9	8.42	1.34	36.4	35.4	1.574	1.547
117	17.62	9.27	19.95	5.05	358.2	8.42	1.34	36.4	35.4	1.574	1.547
118	21.01	9.40	19.96	5.05	358.8	8.43	1.34	36.5	35.4	1.574	1.547
119	24.39	9.54	19.98	5.05	359.4	8.44	1.34	36.5	35.5	1.574	1.547
120	27.77	9.68	19.99	5.05	360.0	8.44	1.34	36.5	35.5	1.574	1.547
3*	29.46	9.75	20.00	5.05	360.2	8.44	1.34	36.5	35.5	1.574	1.547

a) East Frame

Figure A.1 Geometry and Section Properties

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB EASTFRA
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DESIGN DIMENSIONS AND PROPERTIES REPORT PAGE 5

MEMBER NO. 3- 5 LENGTH= 29.50 FT ANGLE= -2.39 DEG FYF=55.KSI FYW=55.KSI
SECTION 1 LENGTH= 13.55 FT OF= 6.00 X 0.2510 WEB=0.1050 IF= 5.94 X 0.2550
SECTION 2 LENGTH= 15.50 FT OF= 6.00 X 0.2510 WEB=0.1380 IF= 5.94 X 0.2550

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
3*	29.46	9.75	20.25	5.09	369.3	8.52	1.33	36.4	36.5	1.562	1.548
121	31.16	9.68	20.24	5.09	368.8	8.51	1.33	36.4	36.5	1.562	1.548
122	34.54	9.53	20.21	5.09	367.6	8.50	1.33	36.3	36.4	1.562	1.548
123	37.92	9.39	20.18	5.09	366.4	8.49	1.33	36.3	36.4	1.562	1.548
124	41.31	9.25	20.15	5.08	365.2	8.48	1.33	36.2	36.3	1.563	1.548
125*	43.00	9.18	20.13	5.08	364.6	8.47	1.33	36.2	36.3	1.563	1.548
125*	43.00	9.18	20.13	5.73	385.4	8.20	1.25	38.2	38.3	1.519	1.505
126	44.93	9.10	20.12	5.73	384.7	8.20	1.25	38.2	38.3	1.519	1.506
127	48.81	8.94	20.08	5.72	383.3	8.18	1.25	38.1	38.2	1.520	1.506
128	52.68	8.78	20.05	5.72	381.8	8.17	1.25	38.0	38.1	1.520	1.506
129	56.55	8.62	20.02	5.71	380.4	8.16	1.25	38.0	38.1	1.520	1.506
130*	58.49	8.54	20.00	5.71	379.7	8.15	1.25	37.9	38.0	1.520	1.507

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB EASTFRA
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DESIGN DIMENSIONS AND PROPERTIES REPORT PAGE 6

MEMBER NO. 4- 5 LENGTH= 8.52 FT ANGLE= 89.95 DEG FYF=55.KSI FYW=55.KSI
SECTION 1 LENGTH= 1.71 FT OF= 6.00 X 0.3790 WEB=0.1430 IF= 6.00 X 0.5040
SECTION 2 LENGTH= 6.00 FT OF= 6.00 X 0.3790 WEB=0.2460 IF= 6.00 X 0.5040

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
4*	58.93	0.00	11.75	6.85	182.2	5.16	1.52	28.2	34.4	1.631	1.670
132	58.93	0.43	11.75	6.85	182.2	5.16	1.52	28.2	34.4	1.631	1.670
133	58.93	1.28	11.75	6.85	182.2	5.16	1.52	28.2	34.4	1.631	1.670
134*	58.93	1.71	11.75	6.85	182.2	5.16	1.52	28.2	34.4	1.631	1.670
134*	58.93	1.71	11.75	7.97	193.6	4.93	1.41	30.4	36.0	1.571	1.628
135	58.93	2.46	11.75	7.97	193.6	4.93	1.41	30.4	36.0	1.571	1.628
136	58.93	3.96	11.75	7.97	193.6	4.93	1.41	30.4	36.0	1.571	1.628
137	58.93	5.46	11.75	7.97	193.6	4.93	1.41	30.4	36.0	1.571	1.628
138	58.93	6.96	11.75	7.97	193.6	4.93	1.41	30.4	36.0	1.571	1.628
139*	58.93	7.71	11.75	7.97	193.6	4.93	1.41	30.4	36.0	1.571	1.628

a) East Frame Continued

Figure A.1 Geometry and Section Properties Continued

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK.
STR 60 12/15 10/25
DESIGN DIMENSIONS AND PROPERTIES REPORT

JOB WESTFRA
FILE OUTST. TMP. 2
PAGE 3

MEMBER NO. 1- 2 LENGTH= 8.52 FT ANGLE=-89.95 DEG FYF=55. KSI FYW=55. KSI
SECTION 1 LENGTH= 6.00 FT OF= 6.00 X 0.3810 WEB=0.1430 IF= 6.00 X 0.5010
SECTION 2 LENGTH= 1.71 FT OF= 6.00 X 0.3810 WEB=0.2470 IF= 6.00 X 0.5010

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
1*	0.00	0.00	11.75	6.85	182.2	5.16	1.52	28.3	34.3	1.632	1.670
101	0.00	0.75	11.75	6.85	182.2	5.16	1.52	28.3	34.3	1.632	1.670
102	0.00	2.25	11.75	6.85	182.2	5.16	1.52	28.3	34.3	1.632	1.670
103	0.00	3.75	11.75	6.85	182.2	5.16	1.52	28.3	34.3	1.632	1.670
104	0.00	5.25	11.75	6.85	182.2	5.16	1.52	28.3	34.3	1.632	1.670
105*	0.00	6.00	11.75	6.85	182.2	5.16	1.52	28.3	34.3	1.632	1.670
105*	0.00	6.00	11.75	7.98	193.7	4.93	1.41	30.5	35.8	1.572	1.626
106	0.00	6.43	11.75	7.98	193.7	4.93	1.41	30.5	35.8	1.572	1.626
107	-0.01	7.28	11.75	7.98	193.7	4.93	1.41	30.5	35.8	1.572	1.626
108*	-0.01	7.71	11.75	7.98	193.7	4.93	1.41	30.5	35.8	1.572	1.626

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK.
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DESIGN DIMENSIONS AND PROPERTIES REPORT

JOB WESTFRA
FILE OUTST. TMP. 2
PAGE 4

MEMBER NO. 2- 3 LENGTH= 29.50 FT ANGLE= 2.40 DEG FYF=55. KSI FYW=55. KSI
SECTION 1 LENGTH= 15.50 FT OF= 6.00 X 0.2520 WEB=0.1410 IF= 6.00 X 0.2530
SECTION 2 LENGTH= 13.55 FT OF= 6.00 X 0.2520 WEB=0.1050 IF= 6.00 X 0.2530

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
111*	0.44	8.54	20.00	5.78	382.5	8.14	1.25	38.2	38.3	1.517	1.518
112	2.38	8.62	20.00	5.78	382.5	8.14	1.25	38.2	38.3	1.517	1.518
113	6.25	8.78	20.00	5.78	382.5	8.14	1.25	38.2	38.3	1.517	1.518
114	10.12	8.94	20.00	5.78	382.5	8.14	1.25	38.2	38.3	1.517	1.518
115	13.99	9.10	20.00	5.78	382.5	8.14	1.25	38.2	38.3	1.517	1.518
116*	15.93	9.18	20.00	5.78	382.5	8.14	1.25	38.2	38.3	1.517	1.518
116*	15.93	9.18	20.00	5.08	360.2	8.42	1.34	36.0	36.1	1.564	1.565
117	17.62	9.26	20.00	5.08	360.2	8.42	1.34	36.0	36.1	1.564	1.565
118	21.01	9.40	20.00	5.08	360.2	8.42	1.34	36.0	36.1	1.564	1.565
119	24.39	9.54	20.00	5.08	360.2	8.42	1.34	36.0	36.1	1.564	1.565
120	27.77	9.68	20.00	5.08	360.2	8.42	1.34	36.0	36.1	1.564	1.565
3*	29.46	9.75	20.00	5.08	360.2	8.42	1.34	36.0	36.1	1.564	1.565

b) West Frame

Figure A.1 Geometry and Section Properties Continued

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB WESTFRA
STR 60 12/15 10/25 FILE OUTST.TMP.2
DESIGN DIMENSIONS AND PROPERTIES REPORT PAGE 5

MEMBER NO. 3- 5 LENGTH= 29.50 FT ANGLE= -2.38 DEG FYF=55.KSI FYW=55.KSI
SECTION 1 LENGTH= 13.55 FT OF= 6.06 X 0.2560 WEB=0.1020 IF= 6.00 X 0.2500
SECTION 2 LENGTH= 15.50 FT OF= 6.06 X 0.2560 WEB=0.1380 IF= 6.00 X 0.2500

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
3*	29.46	9.75	19.88	5.03	355.4	8.41	1.36	36.1	35.4	1.590	1.567
121	31.16	9.68	19.88	5.03	355.7	8.41	1.36	36.1	35.4	1.590	1.567
122	34.54	9.55	19.90	5.03	356.3	8.42	1.36	36.2	35.5	1.590	1.567
123	37.92	9.41	19.91	5.03	356.9	8.42	1.36	36.2	35.5	1.590	1.567
124	41.31	9.27	19.93	5.03	357.5	8.43	1.36	36.2	35.5	1.590	1.567
125*	43.00	9.20	19.93	5.03	357.7	8.43	1.36	36.3	35.5	1.590	1.567
125*	43.00	9.20	19.93	5.73	379.8	8.14	1.27	38.4	37.8	1.543	1.519
126	44.93	9.11	19.94	5.73	380.1	8.14	1.27	38.5	37.8	1.543	1.519
127	48.81	8.95	19.96	5.74	380.8	8.15	1.27	38.5	37.8	1.543	1.519
128	52.68	8.79	19.97	5.74	381.5	8.15	1.27	38.5	37.9	1.543	1.518
129	56.55	8.63	19.99	5.74	382.3	8.16	1.27	38.6	37.9	1.543	1.518
130*	58.48	8.55	20.00	5.74	382.6	8.16	1.27	38.6	37.9	1.543	1.518

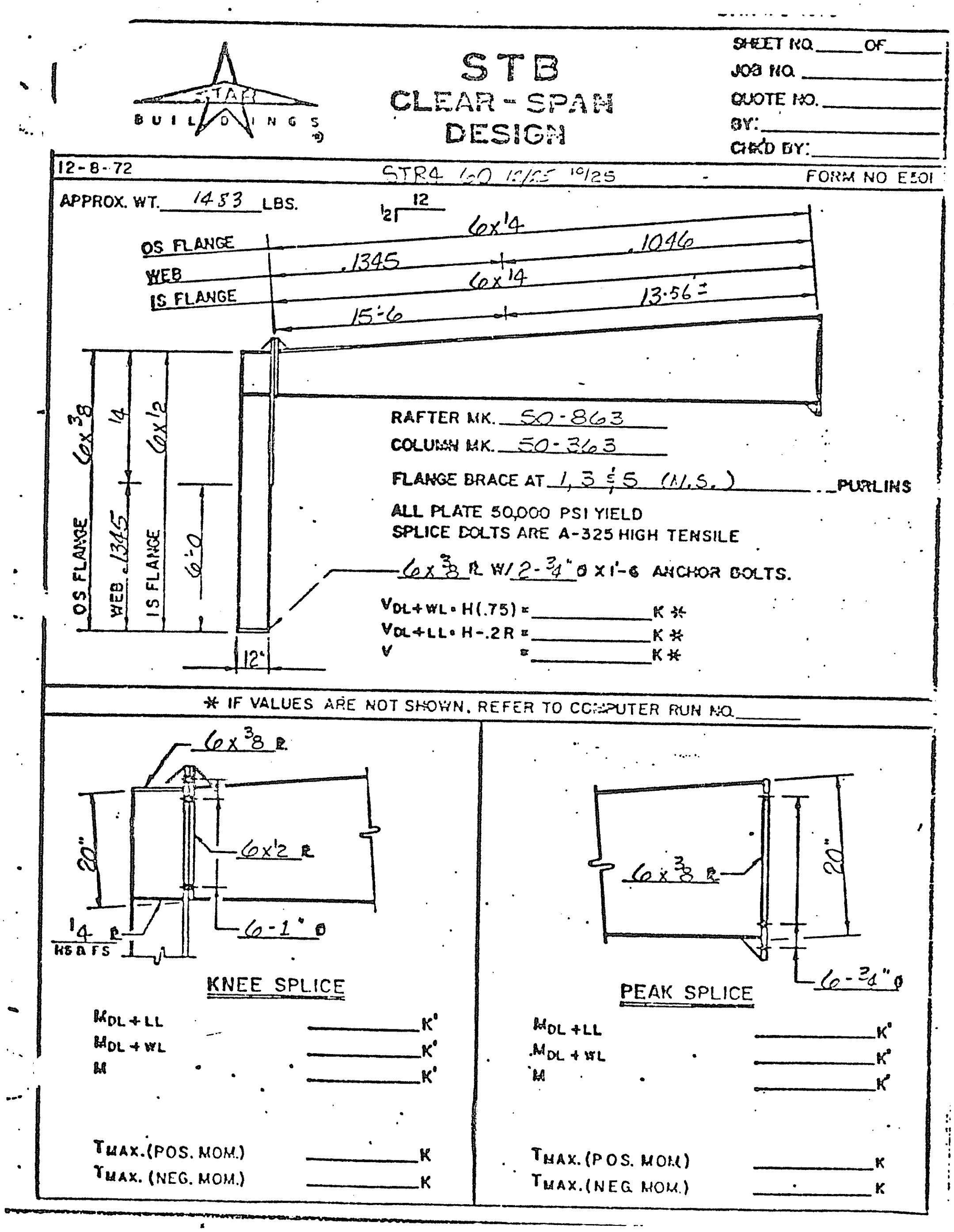
STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB WESTFRA
STR 60 12/15 10/25 FILE OUTST.TMP.2
DESIGN DIMENSIONS AND PROPERTIES REPORT PAGE 6

MEMBER NO. 4- 5 LENGTH= 8.53 FT ANGLE= 89.95 DEG FYF=55.KSI FYW=55.KSI
SECTION 1 LENGTH= 6.00 FT OF= 6.00 X 0.3890 WEB=0.1410 IF= 6.00 X 0.5020
SECTION 2 LENGTH= 1.71 FT OF= 6.00 X 0.3890 WEB=0.2470 IF= 6.00 X 0.5020

POINT NO.	X (FT)	Y (FT)	DEPTH (IN)	AREA (IN2)	IX (IN4)	RX (IN)	RY (IN)	SOX (IN3)	SIX (IN3)	RTO (IN)	RTI (IN)
4*	58.93	0.00	11.75	6.88	183.8	5.17	1.53	28.7	34.3	1.636	1.670
132	58.93	0.75	11.75	6.88	183.8	5.17	1.53	28.7	34.3	1.636	1.670
133	58.93	2.25	11.75	6.88	183.8	5.17	1.53	28.7	34.3	1.636	1.670
134	58.93	3.75	11.75	6.88	183.8	5.17	1.53	28.7	34.3	1.636	1.670
135	58.93	5.25	11.75	6.88	183.8	5.17	1.53	28.7	34.3	1.636	1.670
136*	58.93	6.00	11.75	6.88	183.8	5.17	1.53	28.7	34.3	1.636	1.670
136*	58.93	6.00	11.75	8.03	195.5	4.93	1.41	31.0	36.0	1.576	1.626
137	58.94	6.43	11.75	8.03	195.5	4.93	1.41	31.0	36.0	1.576	1.626
138	58.94	7.28	11.75	8.03	195.5	4.93	1.41	31.0	36.0	1.576	1.626
139*	58.94	7.71	11.75	8.03	195.5	4.93	1.41	31.0	36.0	1.576	1.626

b) West Frame Continued

Figure A.1 Geometry and Section Properties Continued

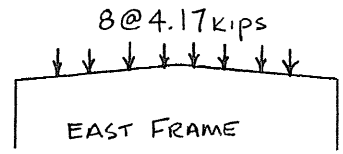


c) Nominal Dimensions

Figure A.1 Geometry and Section Properties Continued

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. — JOB EASTFRA
STR 60 3/3 10/25 — FILE
FORCE, MOMENT, AND STRESS REPORT — PAGE 7
MEMBER 1 - 2 LOAD CONDITION 1 - DL + IMPOSED

POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
1*	17.25	0.0	-19.12	24.91	33.00	33.00	23.31	NONE	0.10	0.00	0.00	0.10	0.0000	0.0000
101	17.25	-14.3	-19.12	24.91	33.00	33.00	23.31	NONE	0.10	0.18	0.15	0.25	-0.0723	-0.0008
102	17.25	-43.0	-19.12	24.91	33.00	33.00	23.31	NONE	0.10	0.55	0.46	0.56	-0.2063	-0.0025
103	17.25	-71.7	-19.12	24.91	33.00	33.00	23.31	NONE	0.10	0.92	0.77	0.87	-0.3086	-0.0042
104	17.25	-100.4	-19.12	24.91	33.00	33.00	23.31	NONE	0.10	1.29	1.07	1.22	-0.3577	-0.0058
105*	17.25	-114.7	-19.12	24.91	33.00	33.00	23.31	NONE	0.10	1.48	1.22	1.40	------	------
105*	17.22	-114.7	-19.15	23.95	33.00	33.00	60.77	NONE	0.09	1.37	1.17	1.30	------	------
106	17.22	-122.9	-19.15	23.95	33.00	33.00	60.77	NONE	0.09	1.47	1.25	1.40	-0.3459	-0.0070
107	17.22	-139.4	-19.15	23.95	33.00	33.00	60.77	NONE	0.09	1.66	1.42	1.60	-0.3047	-0.0077
108*	17.22	-147.6	-19.15	29.48	36.30	36.30	60.77	NONE	0.07	1.60	1.37	1.53	------	------



STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. — JOB EASTFRA
STR 60 3/3 10/25 — FILE
FORCE, MOMENT, AND STRESS REPORT — PAGE 8
MEMBER 2 - 3 LOAD CONDITION 1 - DL + IMPOSED

POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
111*	19.81	-155.8	16.45	25.25	33.00	32.73	16.45	1.24	0.14	1.48	1.53	1.67	------	------
112	19.81	-123.9	16.45	25.25	33.00	32.73	16.45	1.24	0.14	1.18	1.22	1.35	-0.1760	-0.3650
113	19.80	-60.5	16.35	15.75	33.00	24.04	16.35	1.25	0.22	0.57	0.72	0.94	-0.1486	-1.1631
114	19.63	-2.1	12.08	15.75	33.00	24.04	12.08	2.78	0.22	0.02	0.02	0.24	-0.1153	-2.1062
115	19.45	44.6	7.82	15.76	32.73	33.00	11.01	NONE	0.22	0.38	0.43	0.59	-0.0817	-3.0578
116*	19.45	59.7	7.82	15.75	32.73	33.00	11.00	NONE	0.22	0.51	0.58	0.72	------	------
116*	19.44	59.7	7.83	16.41	31.81	33.00	7.83	1.05	0.23	0.55	0.61	0.79	------	------
117	19.44	73.0	7.83	16.41	31.80	33.00	7.83	1.05	0.23	0.67	0.75	0.91	-0.0541	-3.8594
118	19.27	99.1	3.57	16.41	31.80	33.00	4.67	NONE	0.23	0.91	1.02	1.15	-0.0346	-4.4658
119	19.27	111.0	3.47	21.98	31.80	33.00	4.67	NONE	0.17	1.02	1.14	1.20	-0.0227	-4.8870
120	19.10	115.3	-0.70	21.99	31.79	33.00	4.66	NONE	0.17	1.06	1.18	1.23	-0.0194	-5.0990
3*	19.09	114.0	-0.78	21.98	31.79	33.00	4.66	NONE	0.17	1.05	1.17	1.22	-0.0211	-5.1236

a) East Frame

Figure A.2 Stress and Deflection Data

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB EASTFRA
STR 60 3/3 10/25 FILE
FORCE, MOMENT, AND STRESS REPORT PAGE 9
MEMBER 3 - 5 LOAD CONDITION 1 - DL + IMPOSED

POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
3*	19.09	114.0	0.80	21.89	31.73	33.00	4.88	NONE	0.17	1.05	1.13	1.22	-0.0211	-5.1236
121	19.09	115.3	0.73	21.89	31.74	33.00	4.88	NONE	0.17	1.06	1.15	1.24	-0.0225	-5.0938
122	19.27	111.2	-3.44	21.88	31.75	33.00	4.89	NONE	0.17	1.03	1.11	1.20	-0.0188	-4.8751
123	19.27	99.3	-3.54	16.27	31.75	33.00	4.89	NONE	0.23	0.92	0.99	1.15	-0.0065	-4.4517
124	19.45	73.3	-7.80	16.27	31.76	33.00	7.80	1.12	0.24	0.68	0.73	0.92	0.0133	-3.8465
125*	19.45	60.1	-7.80	16.27	31.77	33.00	7.80	1.13	0.24	0.56	0.60	0.79	------	------
125*	19.45	60.1	-7.82	15.61	32.71	33.00	11.13	NONE	0.22	0.51	0.57	0.73	------	------
126	19.45	44.9	-7.82	15.62	32.71	33.00	11.14	NONE	0.22	0.38	0.43	0.60	0.0412	-3.0484
127	19.62	-1.8	-12.09	15.62	33.00	24.09	12.09	3.00	0.22	0.02	0.02	0.24	0.0752	-2.1014
128	19.80	-60.2	-16.35	15.63	33.00	24.09	16.35	1.27	0.22	0.58	0.70	0.92	0.1089	-1.1620
129	19.80	-123.6	-16.46	25.26	33.00	32.73	16.46	1.26	0.14	1.18	1.19	1.33	0.1367	-0.3652
130*	19.80	-155.5	-16.46	25.26	33.00	32.74	16.46	1.26	0.14	1.49	1.50	1.64	------	------

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB EASTFRA
STR 60 3/3 10/25 FILE
FORCE, MOMENT, AND STRESS REPORT PAGE 10
MEMBER 4 - 5 LOAD CONDITION 1 - DL + IMPOSED

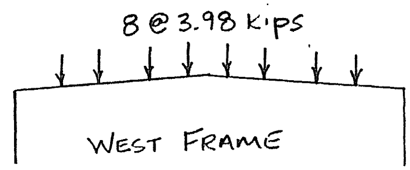
POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
4*	17.22	0.0	19.15	24.94	33.00	33.00	22.37	NONE	0.10	0.00	0.00	0.10	0.0000	0.0000
132	17.22	-8.2	19.15	24.94	33.00	33.00	22.37	NONE	0.10	0.11	0.09	0.19	0.0381	-0.0005
133	17.22	-24.5	19.15	24.94	33.00	33.00	22.37	NONE	0.10	0.32	0.26	0.36	0.1124	-0.0014
134*	17.22	-32.7	19.15	24.94	33.00	33.00	22.37	NONE	0.10	0.42	0.35	0.45	------	------
134*	17.25	-32.7	19.12	24.04	33.00	33.00	58.81	NONE	0.09	0.39	0.33	0.42	------	------
135	17.25	-47.0	19.12	24.04	33.00	33.00	58.81	NONE	0.09	0.56	0.48	0.57	0.2042	-0.0026
136	17.25	-75.7	19.12	24.04	33.00	33.00	58.81	NONE	0.09	0.90	0.77	0.86	0.2905	-0.0040
137	17.25	-104.3	19.12	24.04	33.00	33.00	58.81	NONE	0.09	1.25	1.06	1.18	0.3244	-0.0054
138	17.25	-133.0	19.12	24.04	33.00	33.00	58.81	NONE	0.09	1.59	1.35	1.52	0.2860	-0.0067
139*	17.25	-147.4	19.12	29.50	36.30	36.30	58.81	NONE	0.07	1.60	1.35	1.54	------	------

a) East Frame Continued

Figure A.2 Stress and Deflection Data Continued

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB WESTFRA
STR 60 12/15 10/25 FILE OUTST.TMP.2
FORCE, MOMENT, AND STRESS REPORT PAGE 7
MEMBER 1 - 2 LOAD CONDITION 1 - DL + IMPOSED

POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
1*	17.26	0.0	-18.90	22.93	32.22	33.00	22.37	NONE	0.11	0.00	0.00	0.11	0.0000	0.0000
101	17.25	-14.2	-18.90	22.93	33.00	33.00	22.37	NONE	0.11	0.18	0.15	0.26	-0.0700	-0.0003
102	17.23	-42.5	-18.90	22.93	33.00	33.00	22.37	NONE	0.11	0.55	0.45	0.56	-0.1995	-0.0025
103	17.21	-70.9	-18.90	22.93	33.00	33.00	22.37	NONE	0.11	0.91	0.75	0.86	-0.2977	-0.0041
104	17.19	-99.2	-18.90	22.93	33.00	33.00	22.37	NONE	0.11	1.27	1.05	1.20	-0.3437	-0.0057
105*	17.17	-113.4	-18.90	22.93	33.00	33.00	22.37	NONE	0.11	1.46	1.20	1.38	------	------
105*	17.15	-113.4	-18.93	21.77	33.00	33.00	59.06	NONE	0.10	1.35	1.15	1.29	------	------
106	17.12	-121.5	-18.93	21.77	33.00	33.00	59.06	NONE	0.10	1.45	1.23	1.38	-0.3304	-0.0069
107	17.08	-137.6	-18.93	21.77	33.00	33.00	59.06	NONE	0.10	1.64	1.40	1.57	-0.2889	-0.0076
108*	17.06	-145.7	-18.93	21.77	33.00	33.00	59.06	NONE	0.10	1.74	1.48	1.67	------	------



STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB WESTFRA
STR 60 12/15 10/25 FILE OUTST.TMP.2
FORCE, MOMENT, AND STRESS REPORT PAGE 8
MEMBER 2 - 3 LOAD CONDITION 1 - DL + IMPOSED

POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
111*	19.59	-153.7	16.28	25.47	33.00	32.82	16.28	1.44	0.13	1.46	1.47	1.60	------	------
112	19.58	-122.3	16.20	25.47	33.00	32.82	16.20	1.45	0.13	1.16	1.17	1.30	-0.1612	-0.3612
113	19.58	-59.8	16.05	15.71	33.00	24.30	16.05	1.48	0.22	0.57	0.68	0.90	-0.1336	-1.1468
114	19.40	-2.4	11.92	15.72	33.00	24.30	11.96	NONE	0.21	0.02	0.03	0.24	-0.1001	-2.0737
115	19.23	43.4	7.79	15.72	32.82	33.00	11.96	NONE	0.21	0.37	0.41	0.58	-0.0663	-3.0096
116*	19.23	58.4	7.71	15.72	32.82	33.00	11.96	NONE	0.21	0.50	0.55	0.71	------	------
116*	19.23	58.4	7.70	16.42	31.81	33.00	7.70	1.16	0.23	0.54	0.59	0.78	------	------
117	19.23	71.4	7.63	16.42	31.81	33.00	7.63	1.17	0.23	0.67	0.72	0.90	-0.0385	-3.7999
118	19.06	96.9	3.52	16.43	31.81	33.00	4.94	NONE	0.23	0.90	0.98	1.13	-0.0187	-4.3996
119	19.05	108.5	3.38	22.04	31.81	33.00	4.94	NONE	0.17	1.01	1.09	1.18	-0.0065	-4.8190
120	18.88	112.6	-0.73	22.06	31.81	33.00	4.94	NONE	0.17	1.05	1.14	1.22	-0.0028	-5.0344
3*	18.88	111.3	-0.80	22.05	31.81	33.00	4.94	NONE	0.17	1.04	1.12	1.21	-0.0042	-5.0626

b) West Frame

Figure A.2 Stress and Deflection Data Continued

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB WESTFRA
STR 60 12/15 10/25 FILE OUTST.TMP.2
FORCE, MOMENT, AND STRESS REPORT PAGE 9
MEMBER 3 - 5 LOAD CONDITION 1 - DL + IMPOSED

POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
3*	18.88	111.3	0.78	22.13	31.79	33.00	4.56	NONE	0.17	1.03	1.14	1.20	-0.0042	-5.0626
121	18.88	112.6	0.71	22.13	31.79	33.00	4.55	NONE	0.17	1.05	1.16	1.22	-0.0059	-5.0369
122	19.05	108.5	-3.40	22.11	31.78	33.00	4.55	NONE	0.17	1.01	1.11	1.18	-0.0024	-4.8245
123	19.05	96.7	-3.53	16.63	31.78	33.00	4.55	NONE	0.23	0.90	0.99	1.13	0.0097	-4.4060
124	19.22	71.2	-7.65	16.62	31.78	33.00	7.65	1.05	0.23	0.66	0.73	0.89	0.0293	-3.8057
125*	19.23	58.2	-7.71	16.62	31.77	33.00	7.71	1.04	0.23	0.54	0.60	0.77	-----	-----
125*	19.23	58.2	-7.70	15.96	32.76	33.00	11.25	NONE	0.21	0.49	0.56	0.70	------	-----
126	19.23	43.2	-7.78	15.96	32.76	33.00	11.24	NONE	0.21	0.37	0.42	0.58	0.0568	-3.0140
127	19.41	-2.6	-11.91	15.95	33.00	24.30	12.17	3.00	0.21	0.02	0.03	0.24	0.0905	-2.0764
128	19.58	-59.9	-16.04	15.93	33.00	24.30	16.04	1.32	0.21	0.57	0.69	0.91	0.1237	-1.1481
129	19.59	-122.4	-16.20	25.34	33.00	32.74	16.20	1.30	0.13	1.15	1.18	1.32	0.1511	-0.3617
130*	19.59	-153.8	-16.28	25.34	33.00	32.73	16.28	1.29	0.13	1.45	1.49	1.62	-----	------

STAR MANUFACTURING CO. 8600 S. I-35 OKLAHOMA CITY, OK. JOB WESTFRA
STR 60 12/15 10/25 FILE OUTST.TMP.2
FORCE, MOMENT, AND STRESS REPORT PAGE 10
MEMBER 4 - 5 LOAD CONDITION 1 - DL + IMPOSED

POINT NO.	AXIAL FORCE (KIP)	MOMENT (KIP-FT)	SHEAR FORCE (KIP)	-ALLOWABLE STRESS- FA (KSI)	FBO (KSI)	FBI (KSI)	ALLOW SHEAR (KIP)	A/H RATIO	-UNITY CHECK- UCA	BEND (OF)	BEND (IF)	MAX. COMB UC	DEFLECTIONS DELTA-X (IN)	DELTA-Y (IN)
4*	17.26	0.0	18.90	22.96	32.24	33.00	21.46	NONE	0.11	0.00	0.00	0.11	0.0000	0.0000
132	17.25	-14.2	18.90	22.96	33.00	33.00	21.46	NONE	0.11	0.18	0.15	0.26	0.0687	-0.0003
133	17.23	-42.5	18.90	22.96	33.00	33.00	21.46	NONE	0.11	0.54	0.45	0.56	0.1957	-0.0025
134	17.21	-70.9	18.90	22.96	33.00	33.00	21.46	NONE	0.11	0.90	0.75	0.86	0.2916	-0.0041
135	17.18	-99.2	18.90	22.96	33.00	33.00	21.46	NONE	0.11	1.26	1.05	1.18	0.3359	-0.0057
136*	17.17	-113.4	18.90	22.96	33.00	33.00	21.46	NONE	0.11	1.44	1.20	1.36	------	------
136*	17.15	-113.4	18.93	21.78	33.00	33.00	59.01	NONE	0.10	1.33	1.15	1.27	------	------
137	17.12	-121.5	18.93	21.78	33.00	33.00	59.01	NONE	0.10	1.43	1.23	1.36	0.3216	-0.0068
138	17.08	-137.6	18.93	21.78	33.00	33.00	59.01	NONE	0.10	1.62	1.39	1.55	0.2798	-0.0076
139*	17.06	-145.7	18.93	21.78	33.00	33.00	59.01	NONE	0.10	1.71	1.47	1.65	-----	-----

b) West Frame Continued

Figure A.2 Stress and Deflection Data Continued

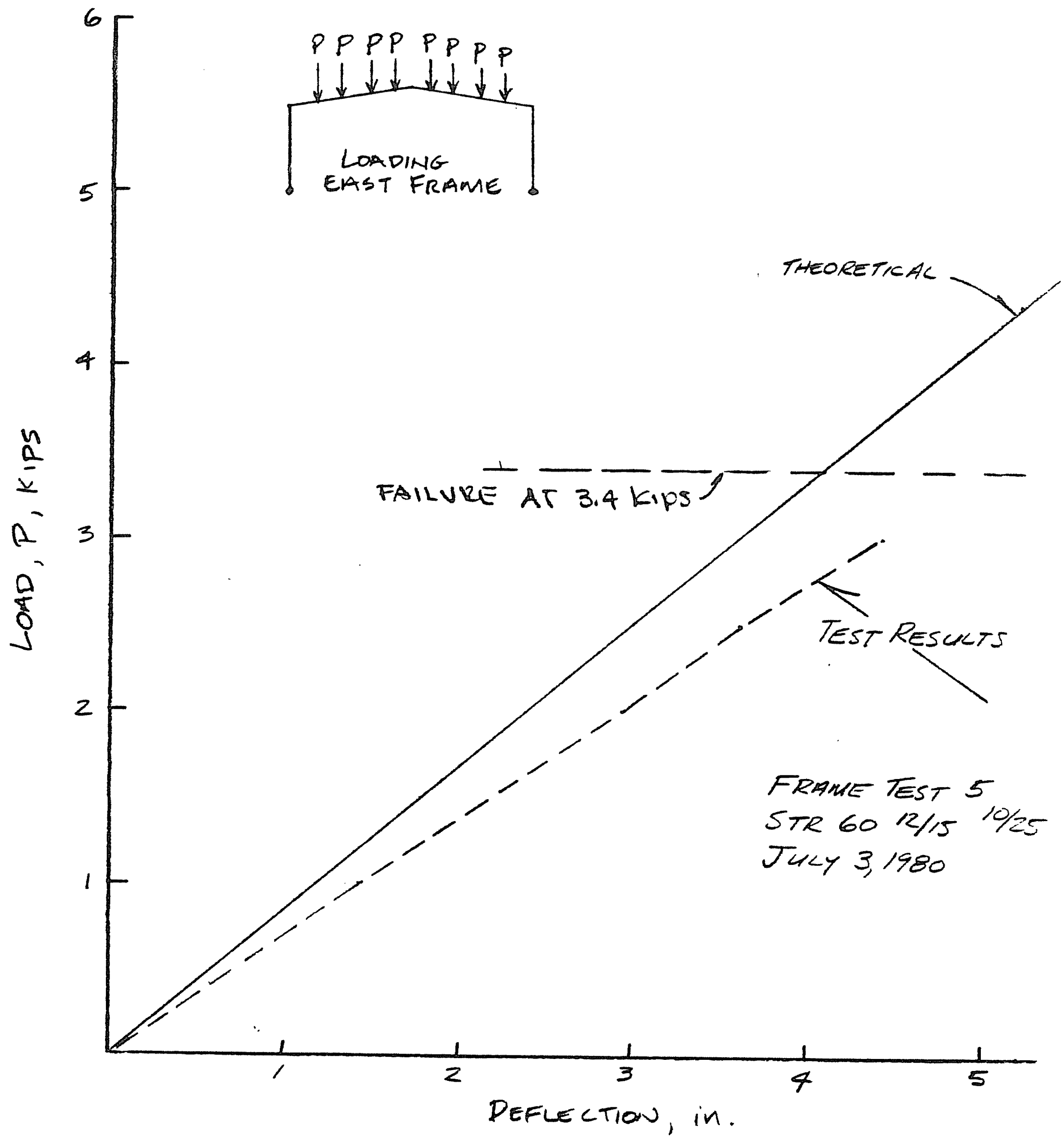


Figure B.1 Load vs. Centerline Vertical Deflection

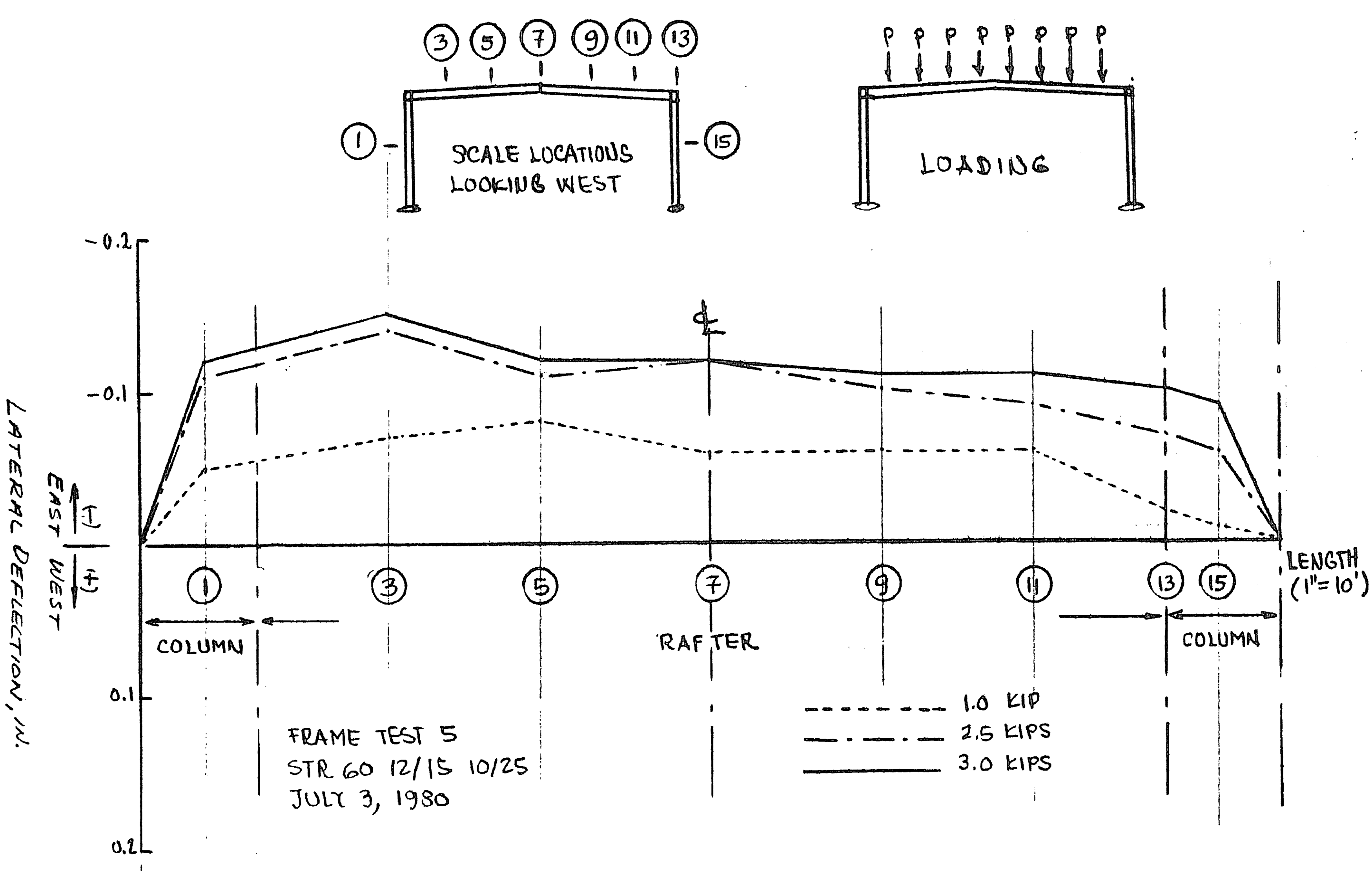


Figure B.2 Load vs. Lateral Deflection of Outside Flange

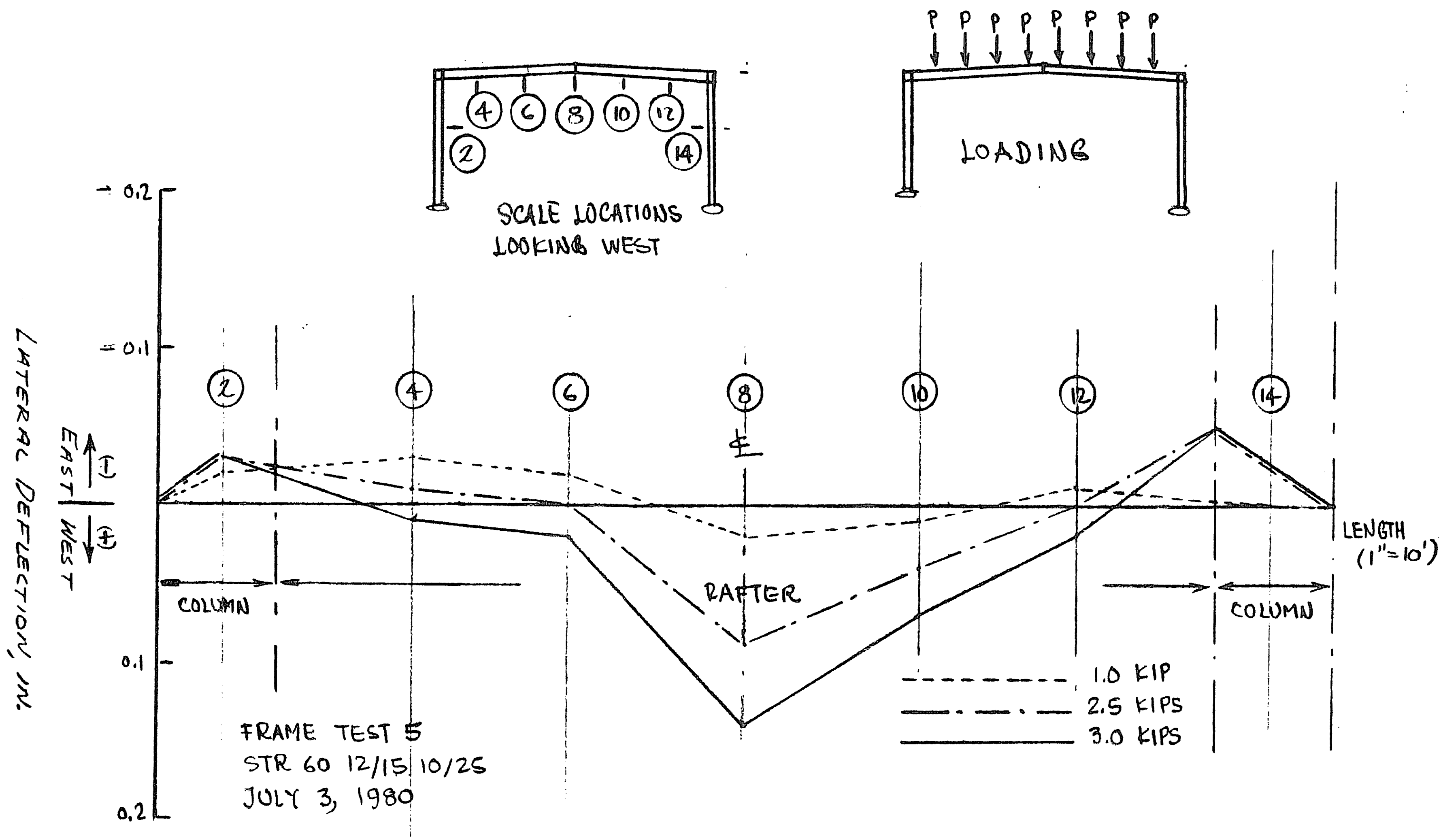


Figure B.3 Load vs. Lateral Deflection of Inside Flange

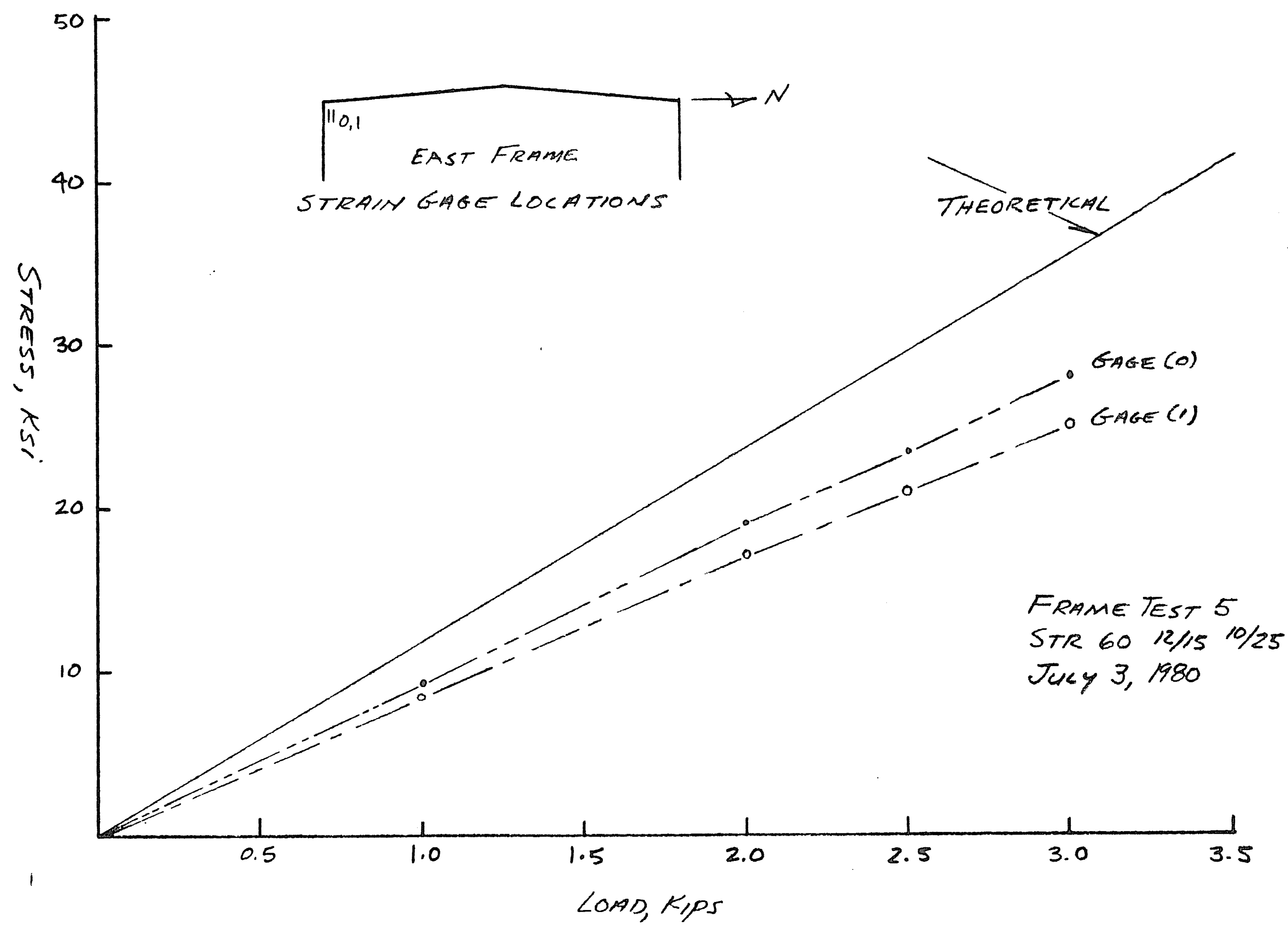


Figure B.4 Load vs. Stress, South Column at Knee

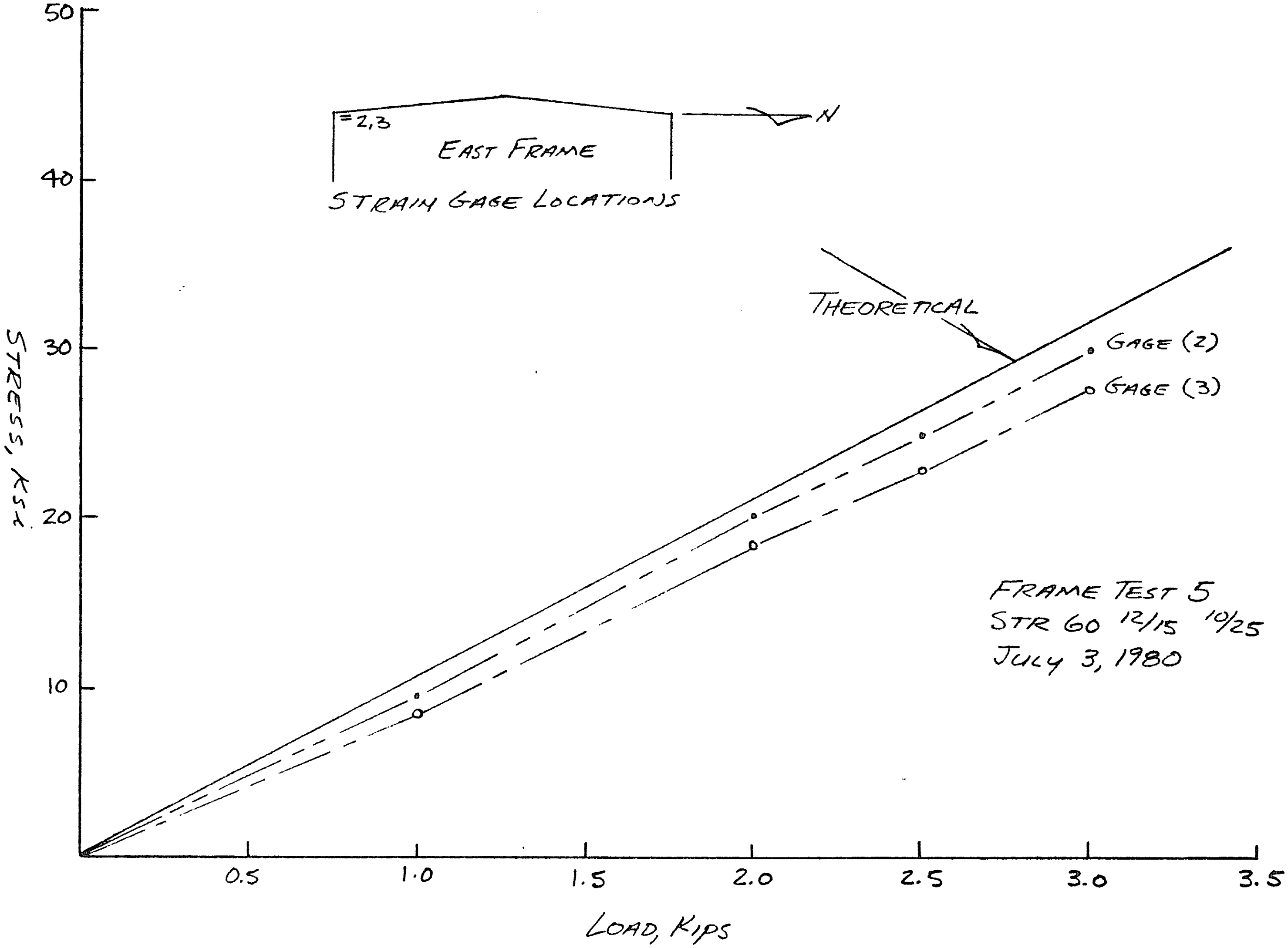


Figure B.5 Load vs. Stress, South Rafter at Knee

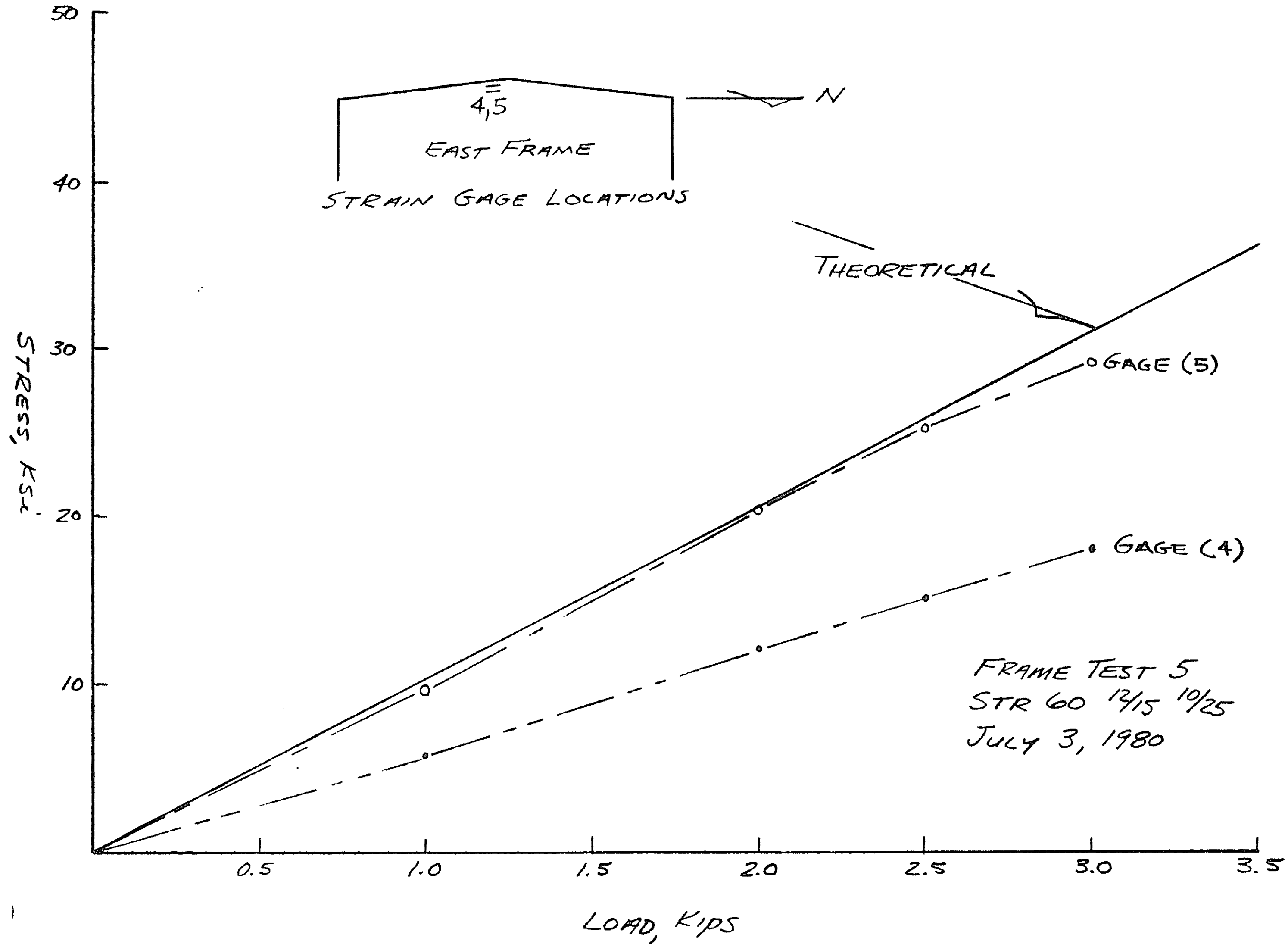


Figure B.6 Load vs. Stress, South Rafter at Peak

APPENDIX C

Full Live Load - West Frame

Test Date, July 21, 1980

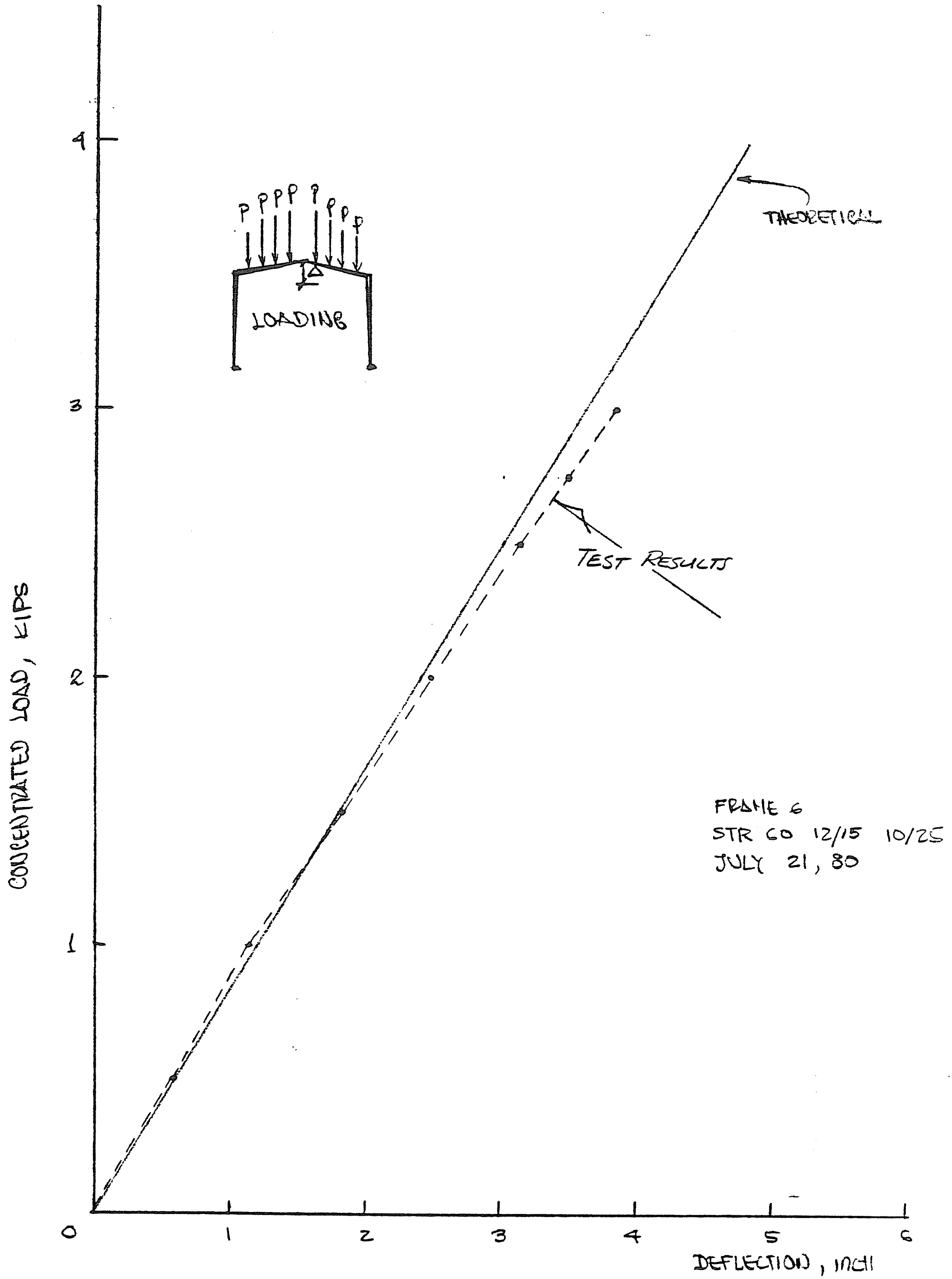


Figure C.1 Load vs. Centerline Vertical Deflection

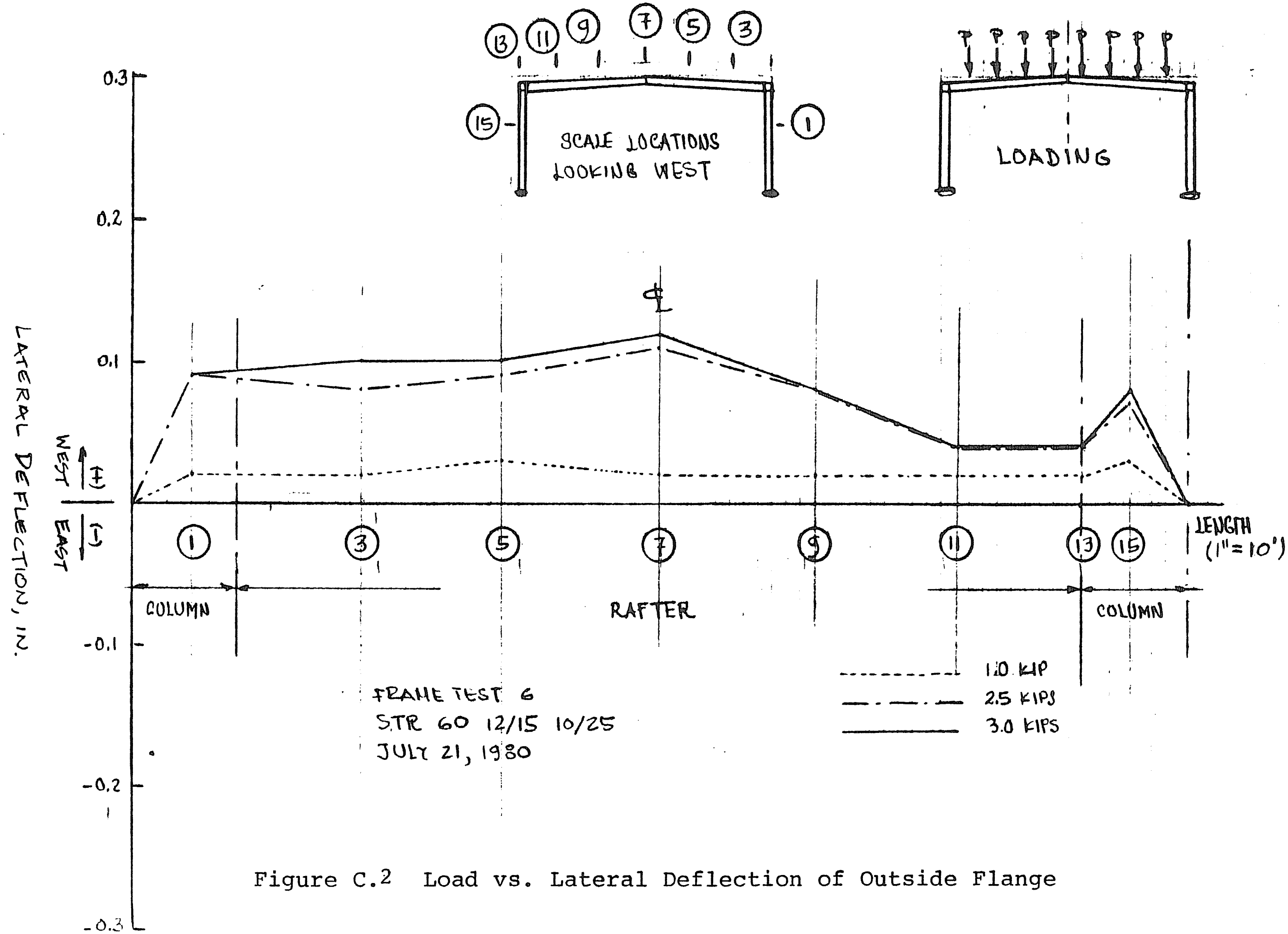


Figure C.2 Load vs. Lateral Deflection of Outside Flange

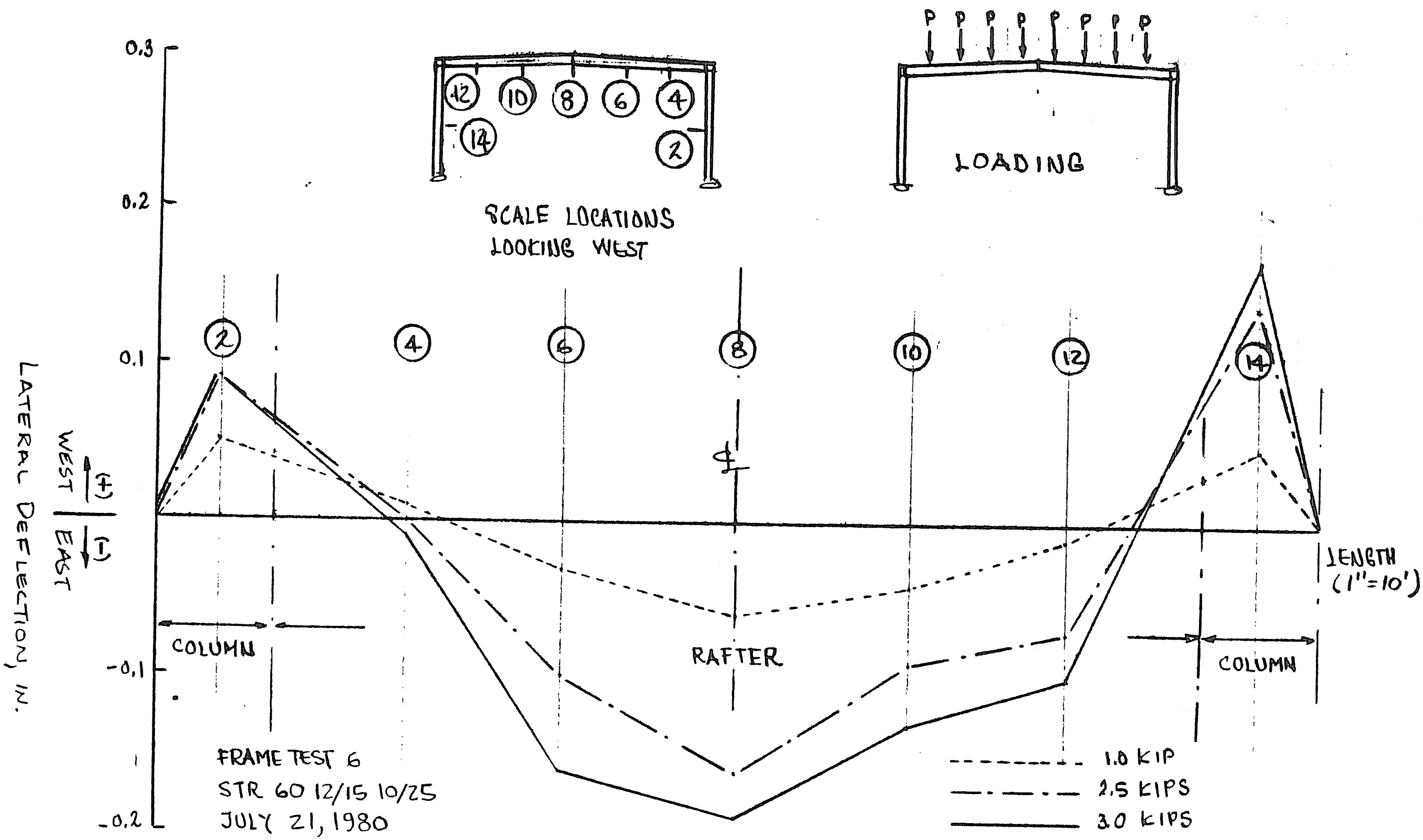


Figure C.3 Load vs. Lateral Deflection of Inside Flange

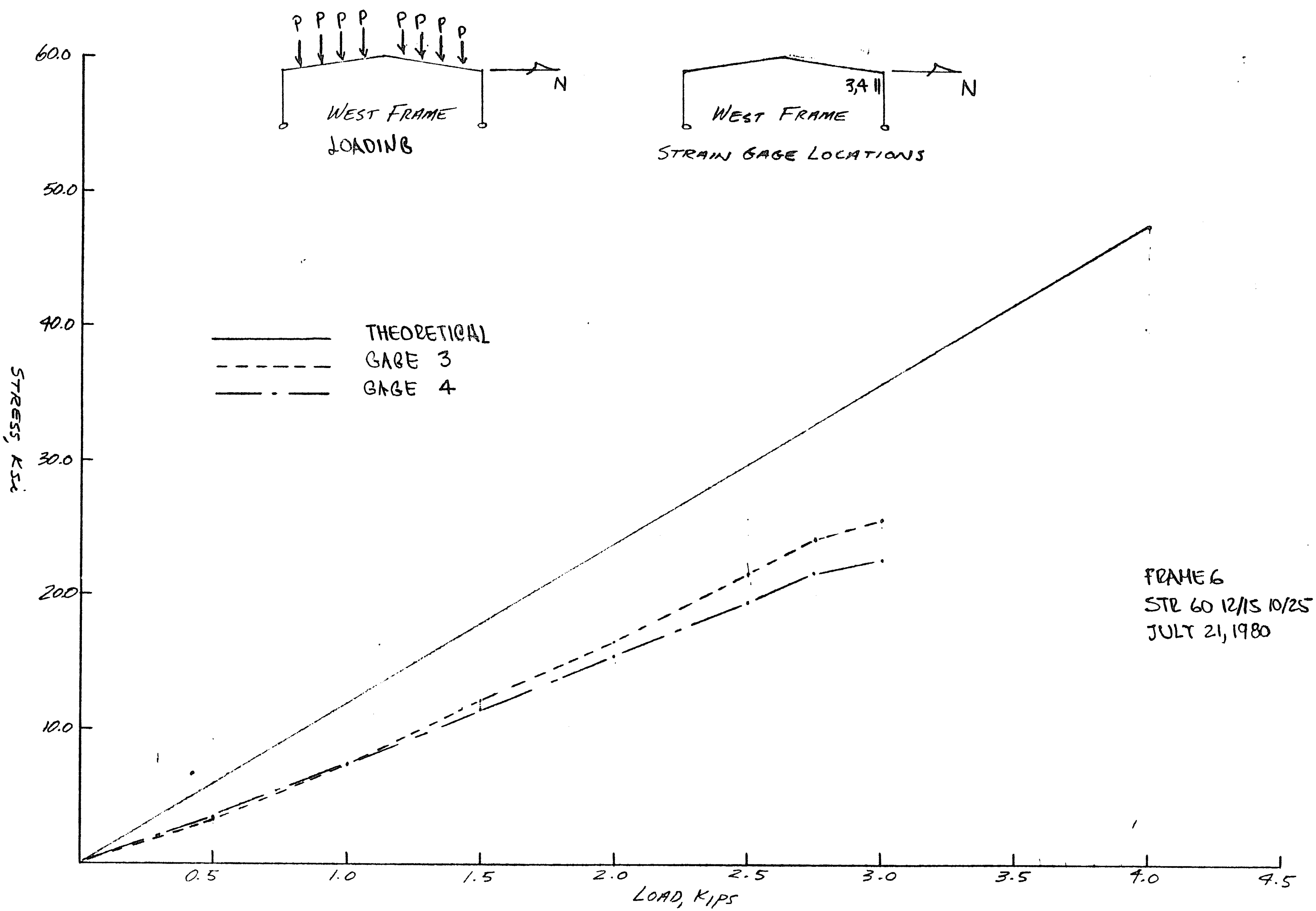


Figure C.4 Load vs. Stress, North Column at Knee

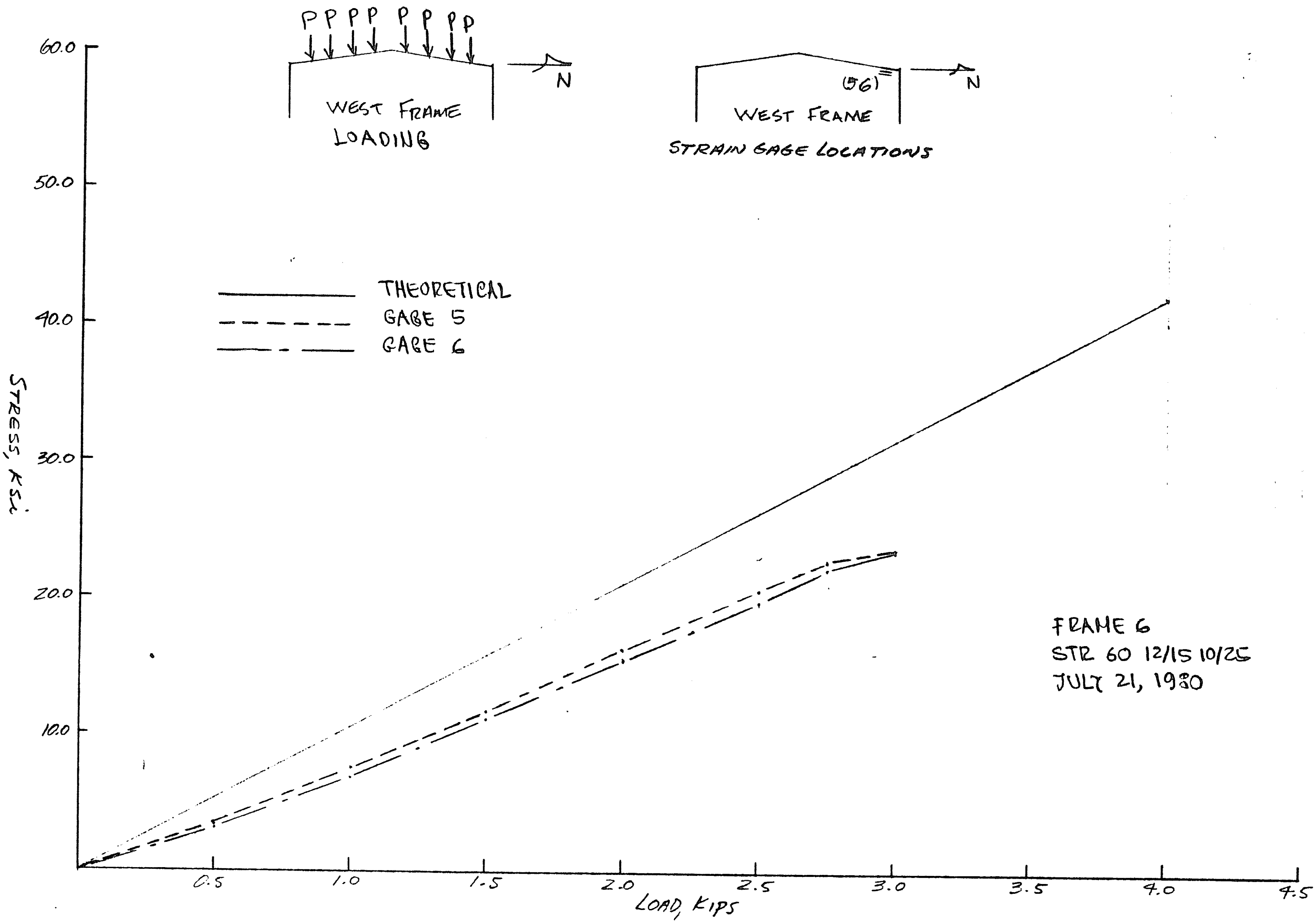


Figure C.5 Load vs. Stress, North Rafter at Knee

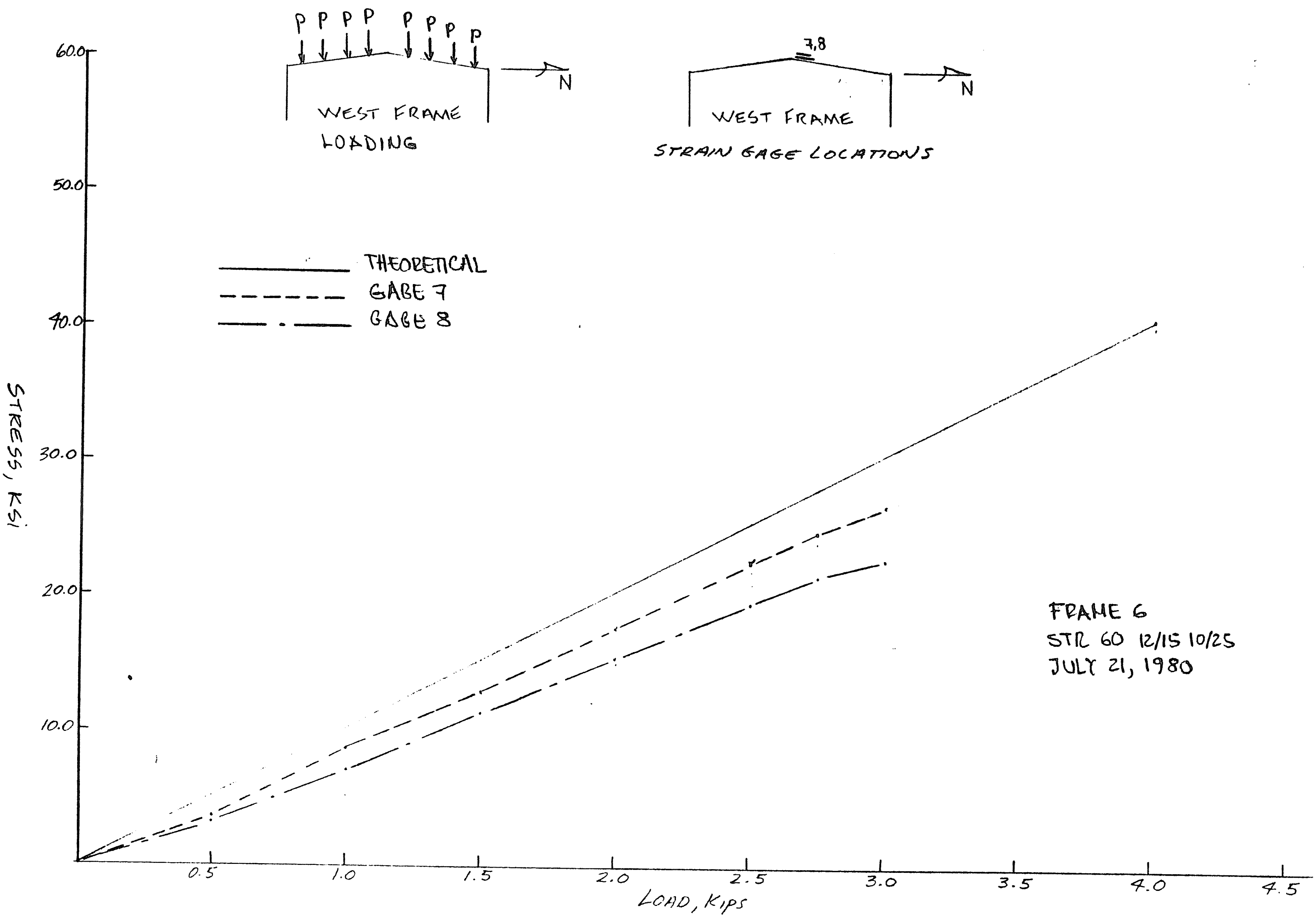


Figure C.6 Load vs. Stress, North Rafter at Peak

APPENDIX D

Full Live Load, West Frame, Bracing Scheme 1

Test Date, October 30, 1980

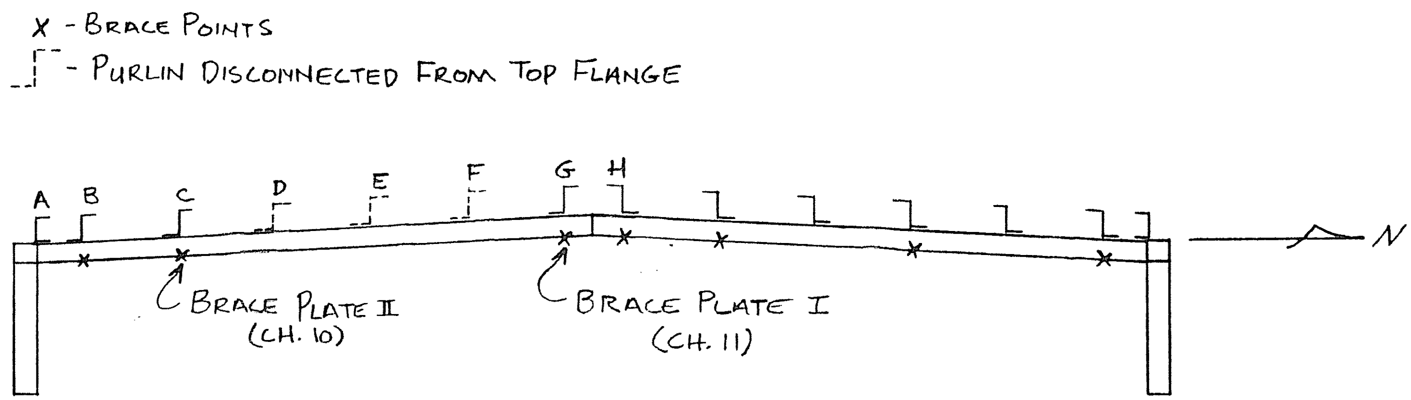


Figure D.1a Bracing Scheme 1, 20 ft. Unbraced Span (Span CG)

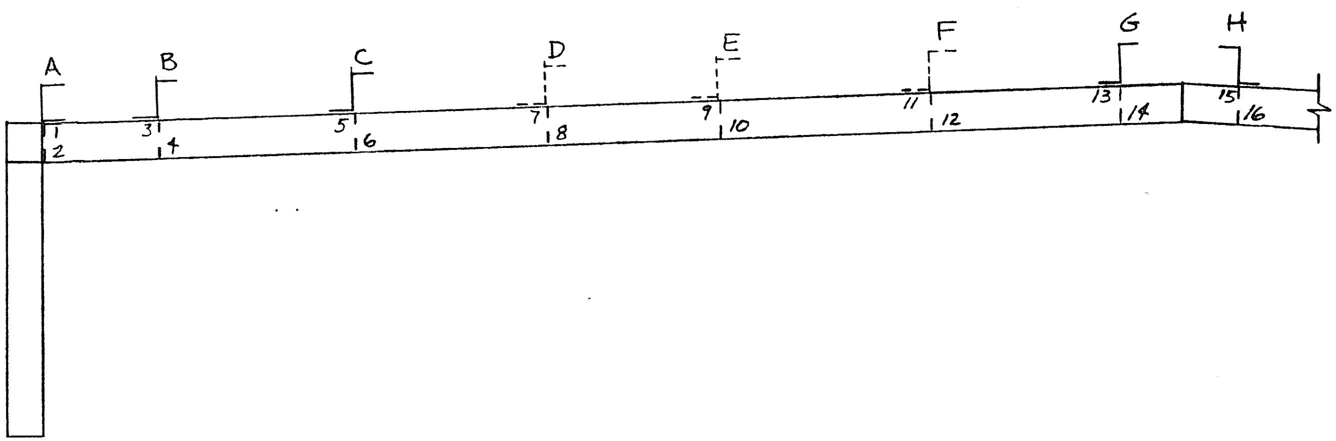


Figure D.1b Location of Lateral Deflection Scales

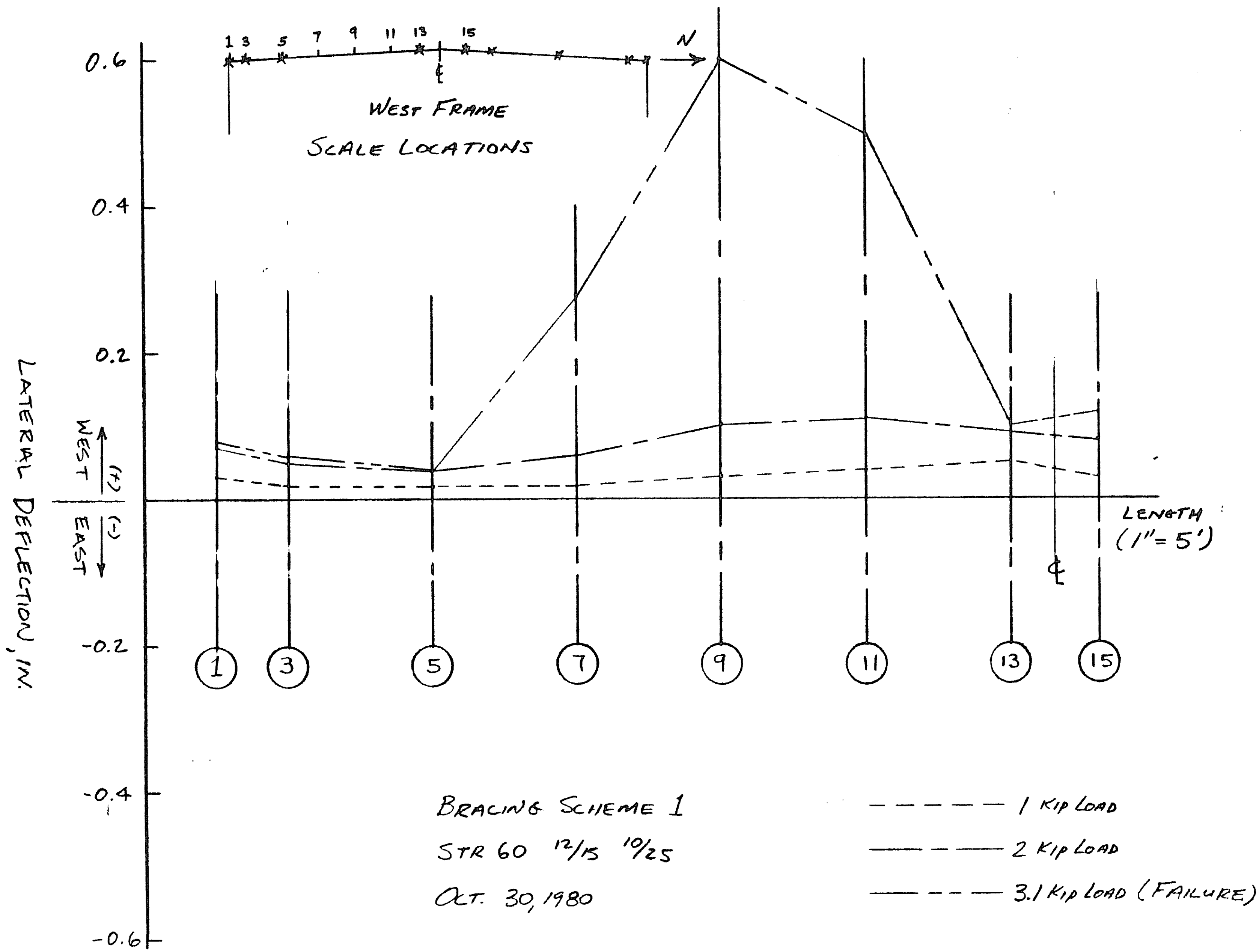


Figure D.2 Load vs. Lateral Deflection of Top Flange

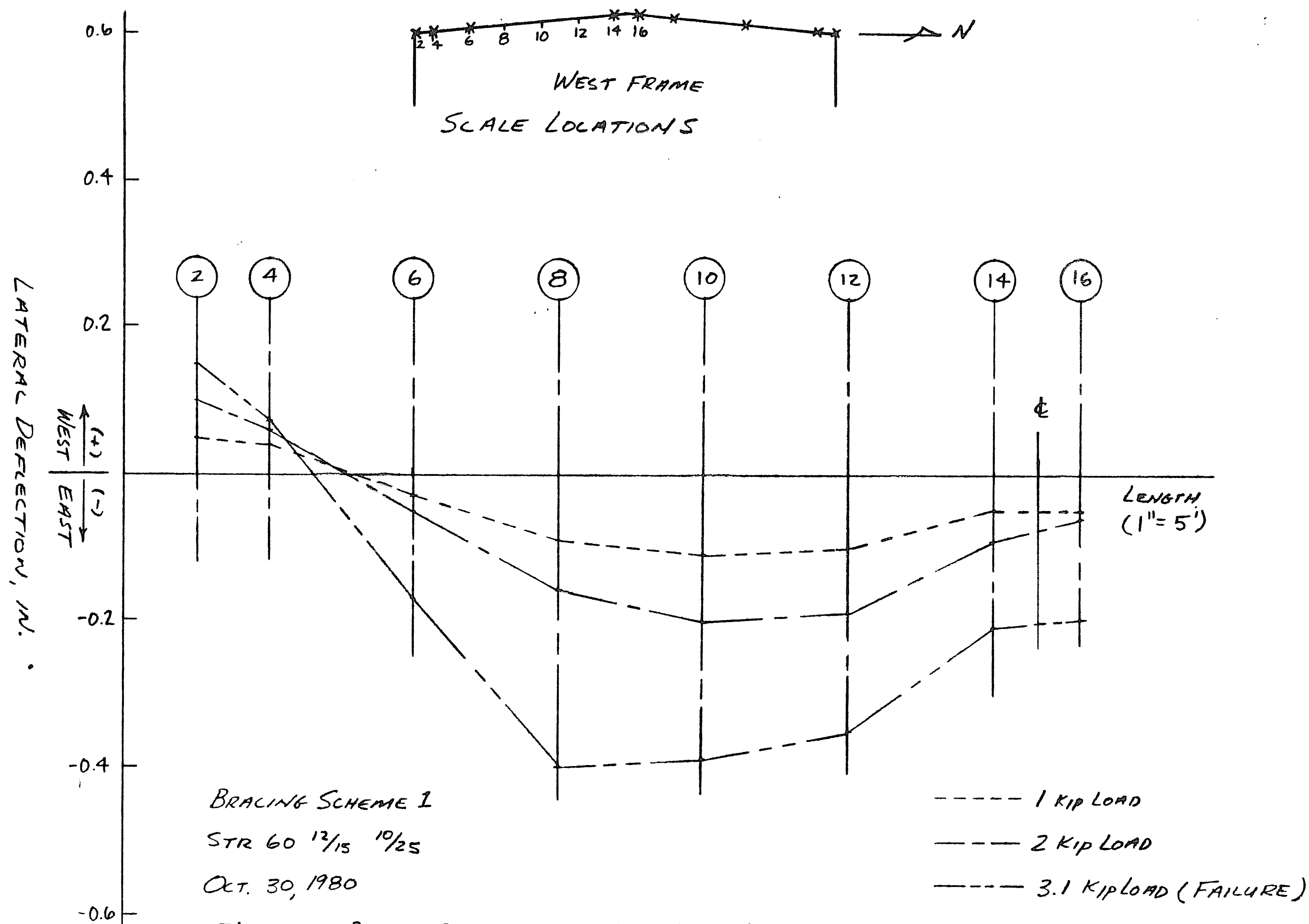


Figure D.3 Load vs. Lateral Deflection of Bottom Flange

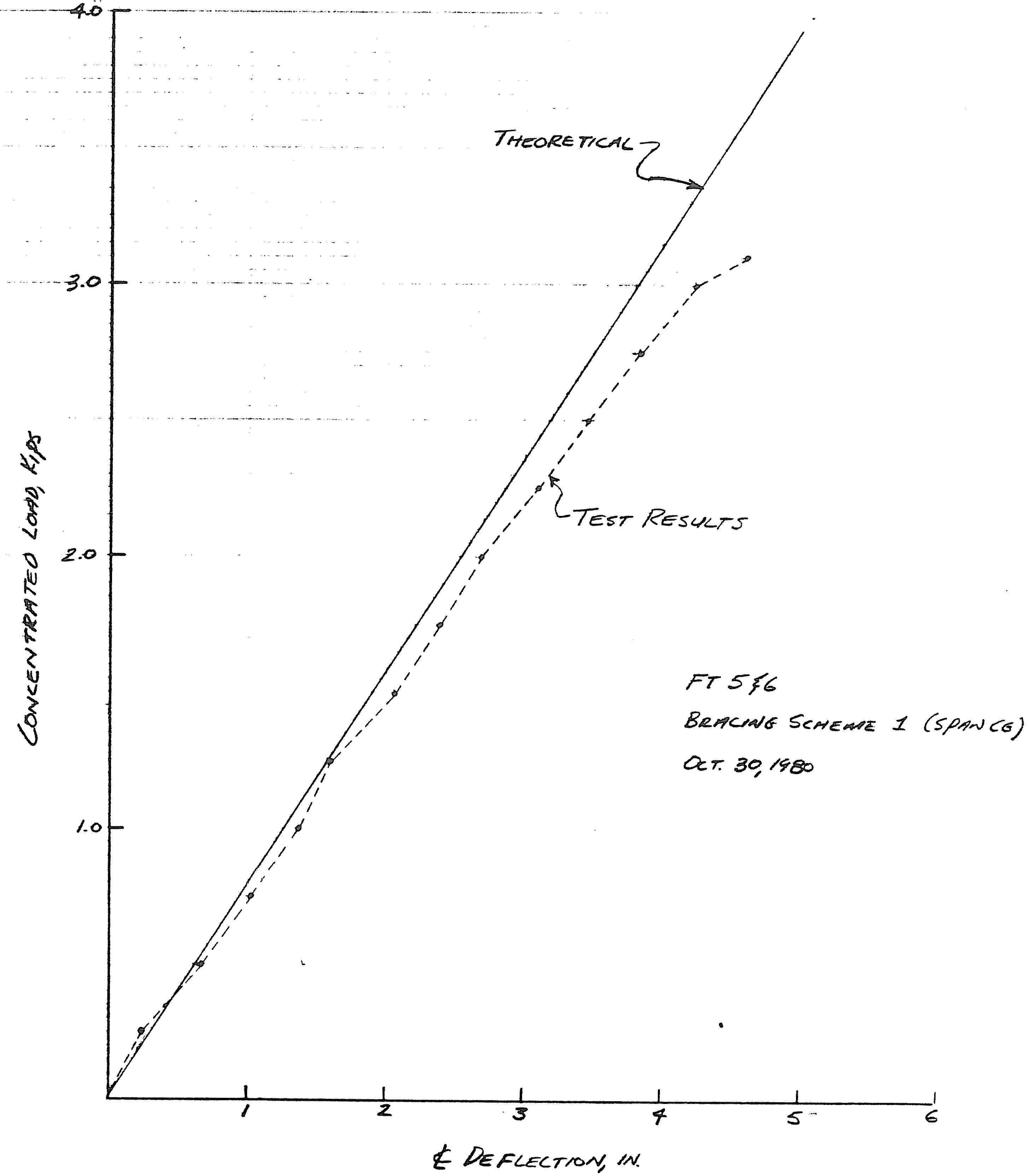


Figure D.4 Load vs. Centerline Vertical Deflection

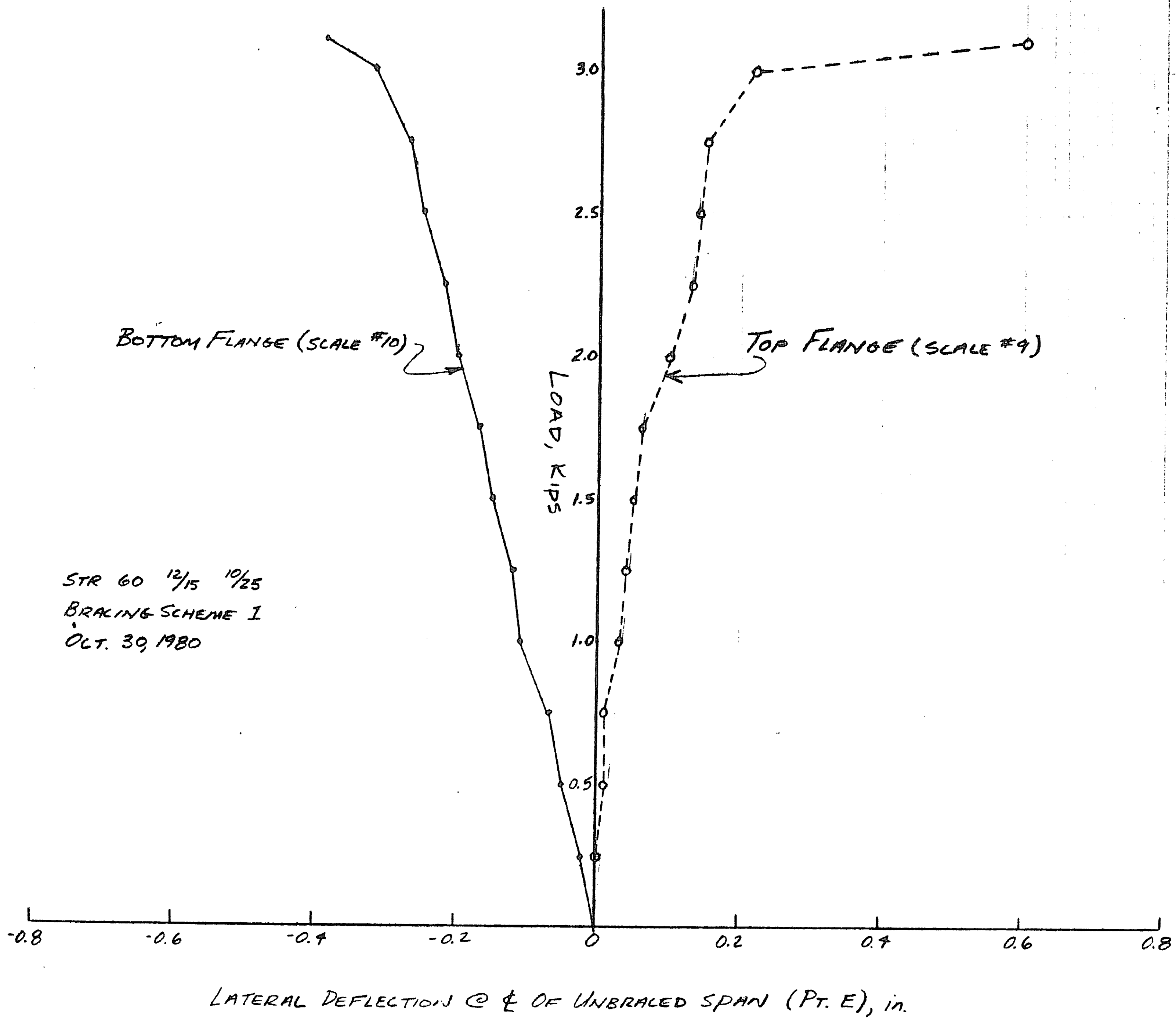


Figure D.5 Load vs. Lateral Deflection

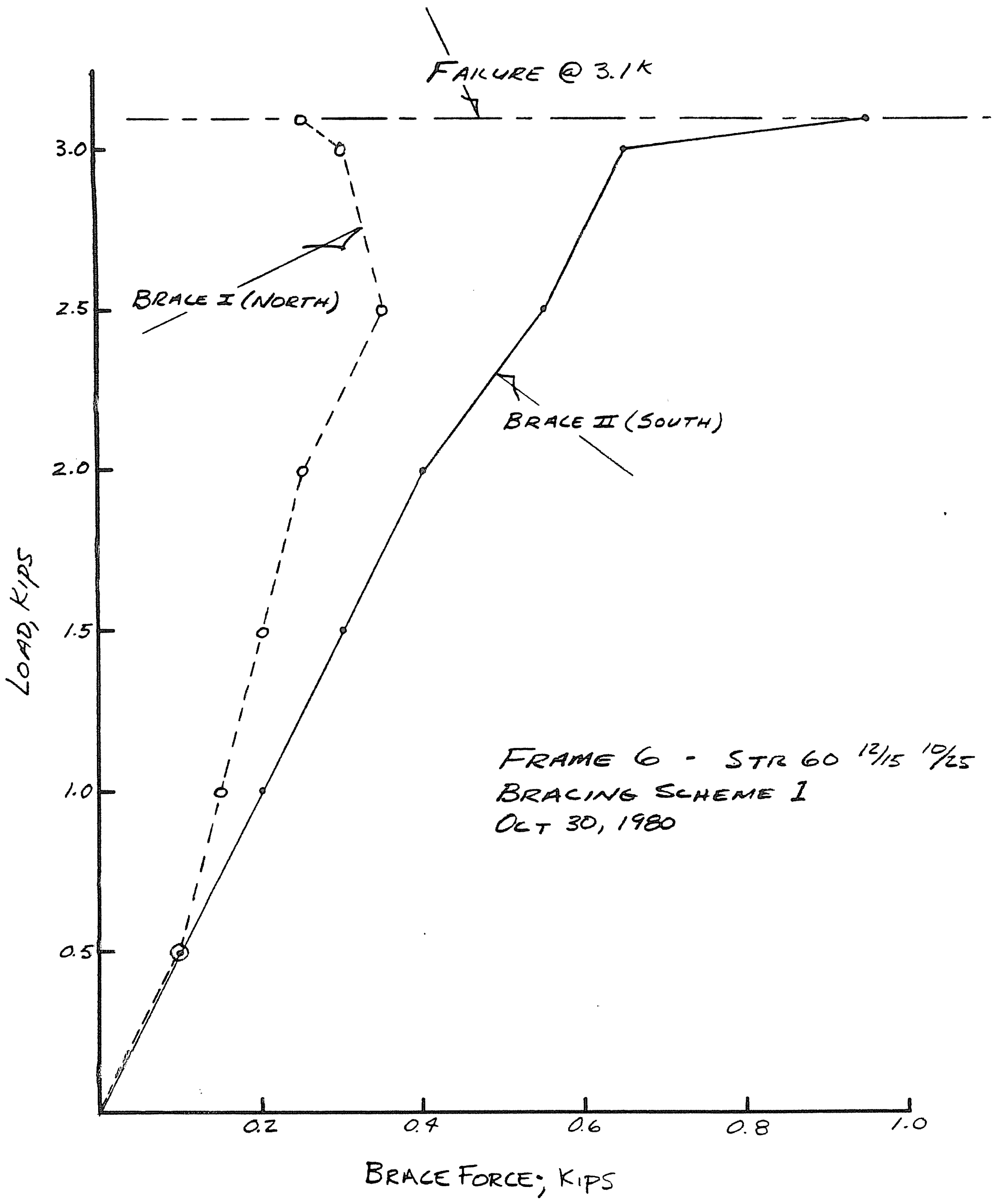


Figure D.6 Load vs. Brace Force

APPENDIX E

Full Live Load, West Frame, Bracing Scheme 2

Test Date, November 11, 1980

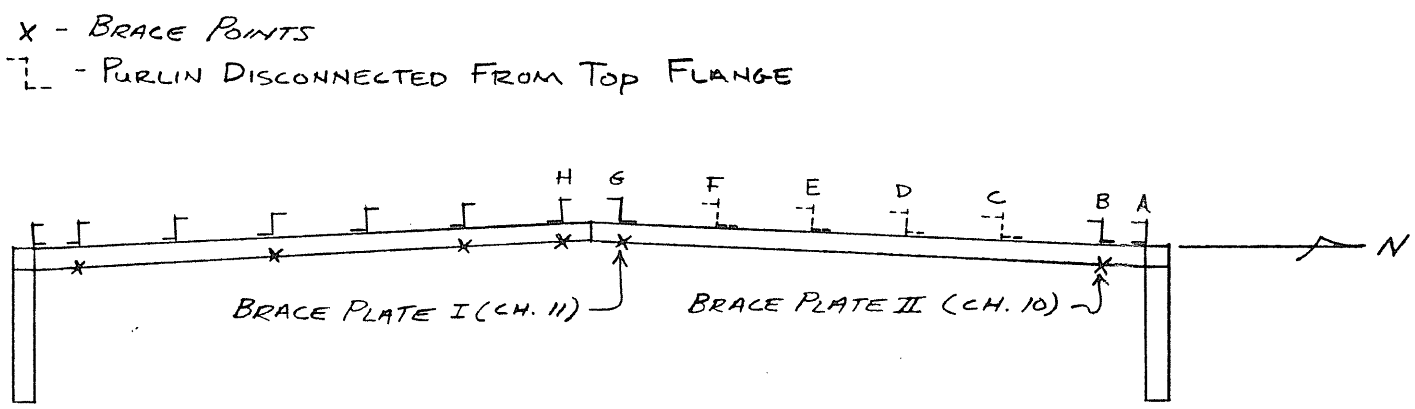


Figure E.1a Bracing Scheme 2, 25 ft. Unbraced Span (Span BG)

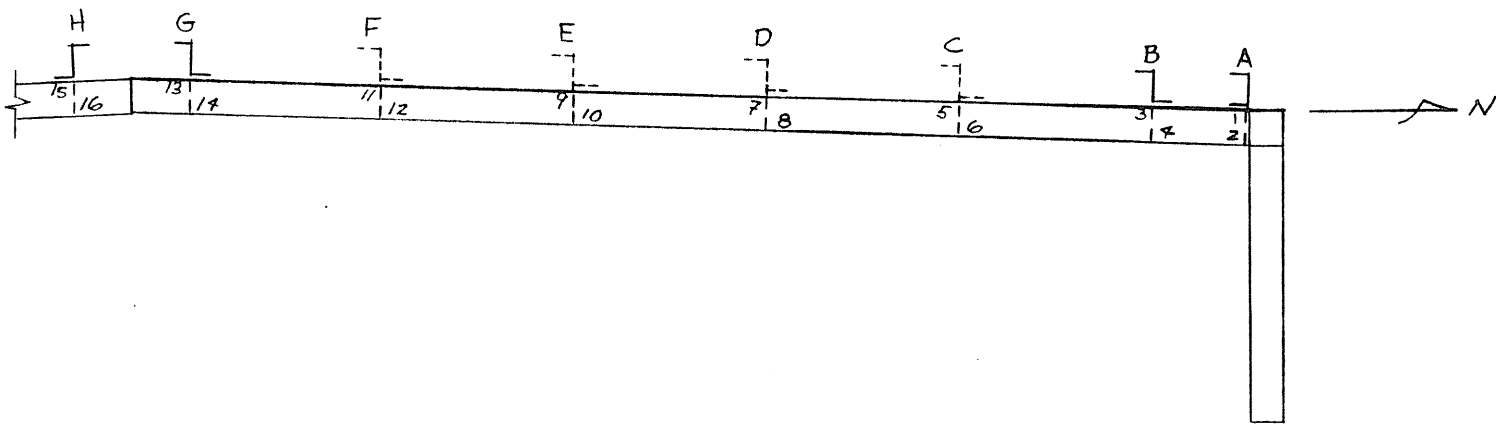


Figure E.1b Location of Lateral Deflection Scales

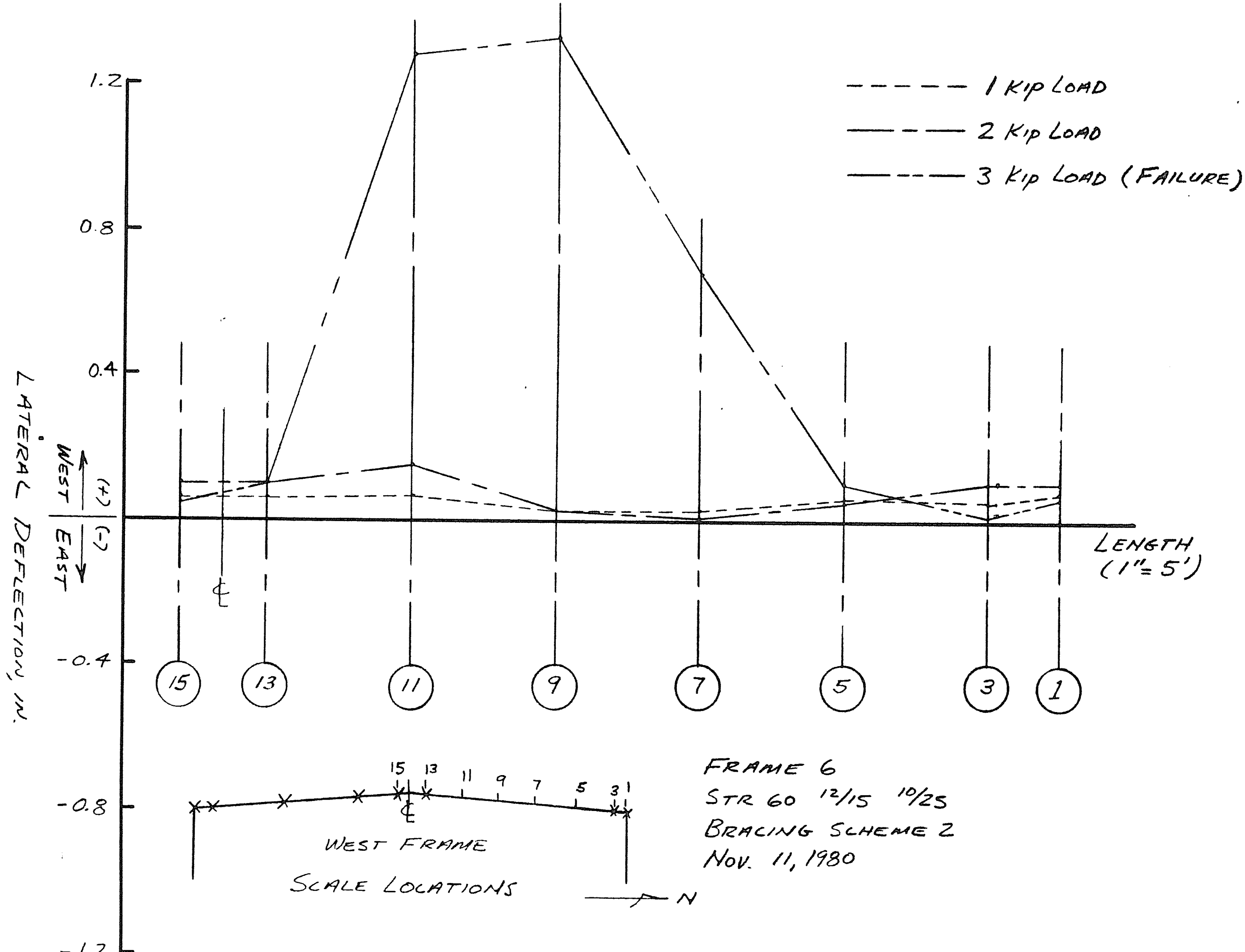


Figure E.2 Load vs. Lateral Deflection of Top Flange

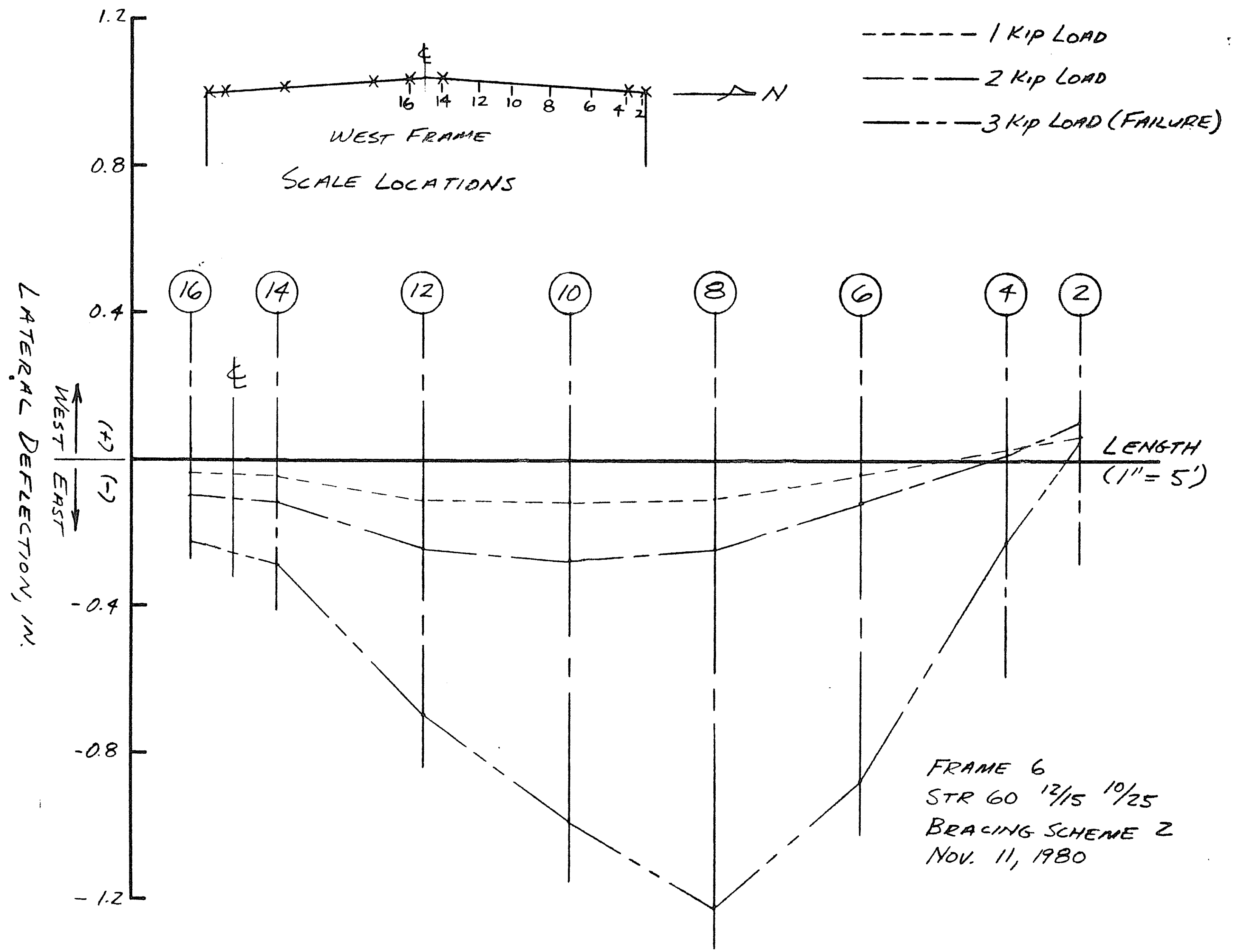


Figure E. 3 Load vs. Lateral Deflection of Bottom Flange

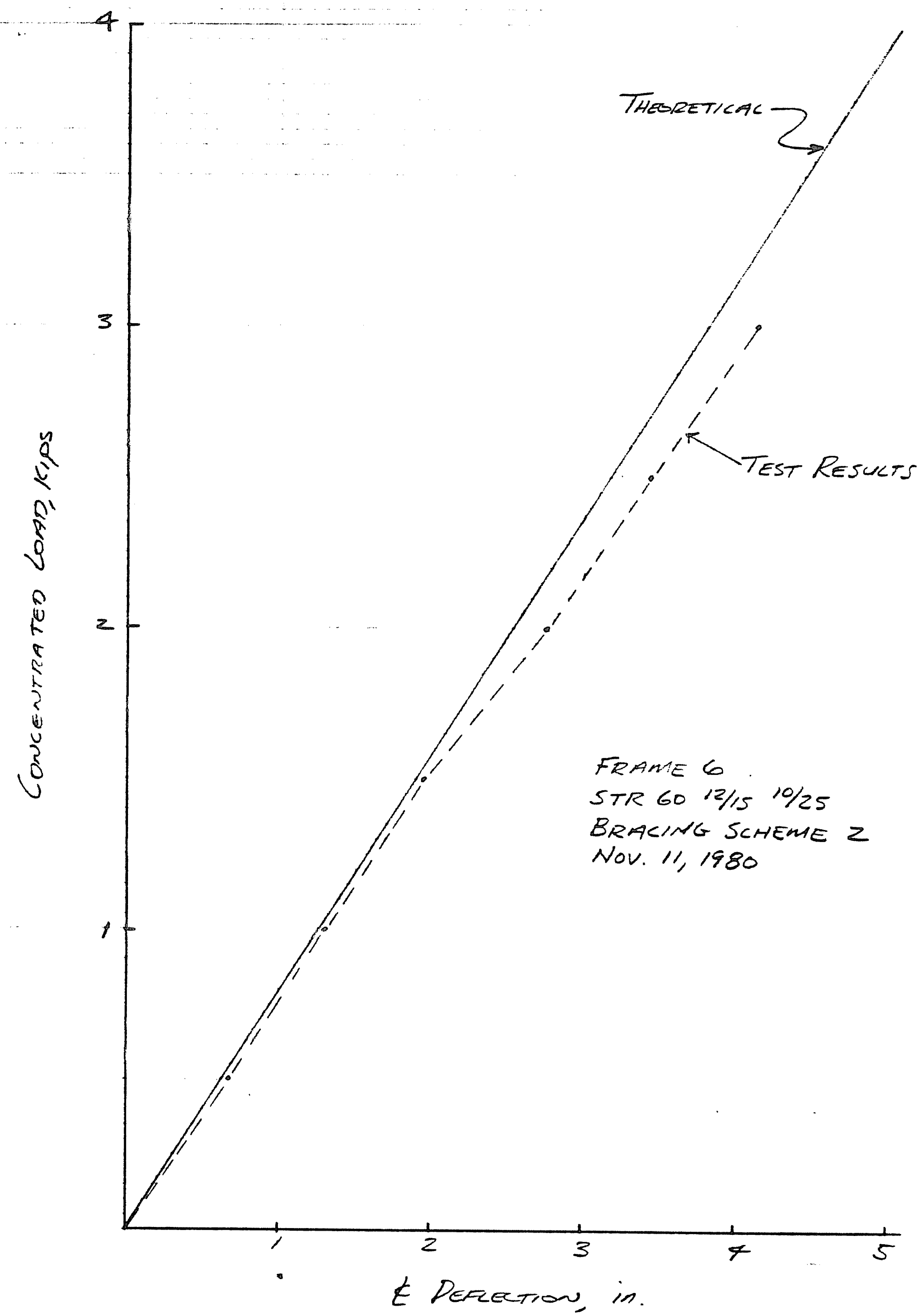


Figure E.4 Load vs. Centerline Vertical Deflection

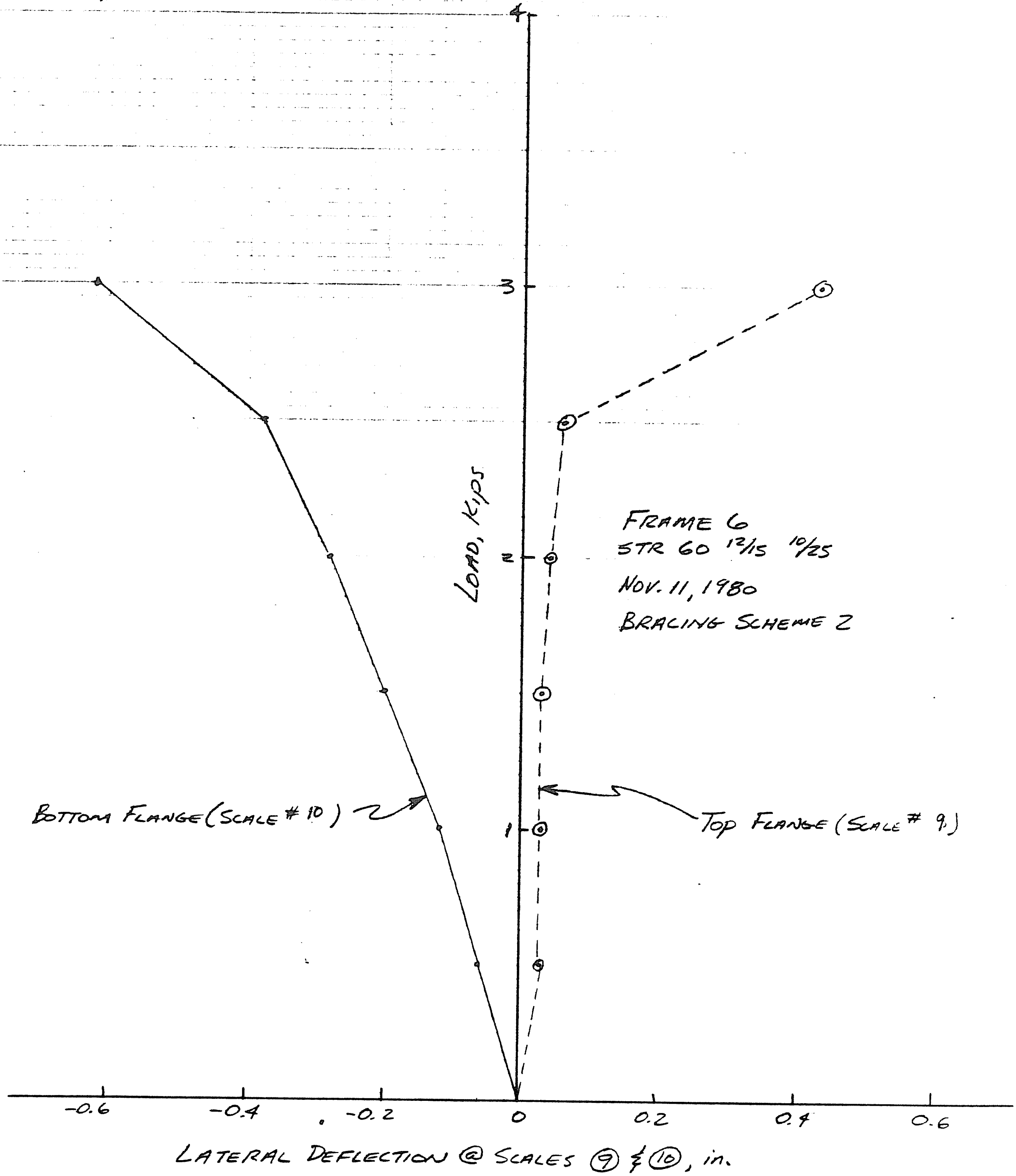


Figure E.5 Load vs. Lateral Deflection at Scales 9 and 10

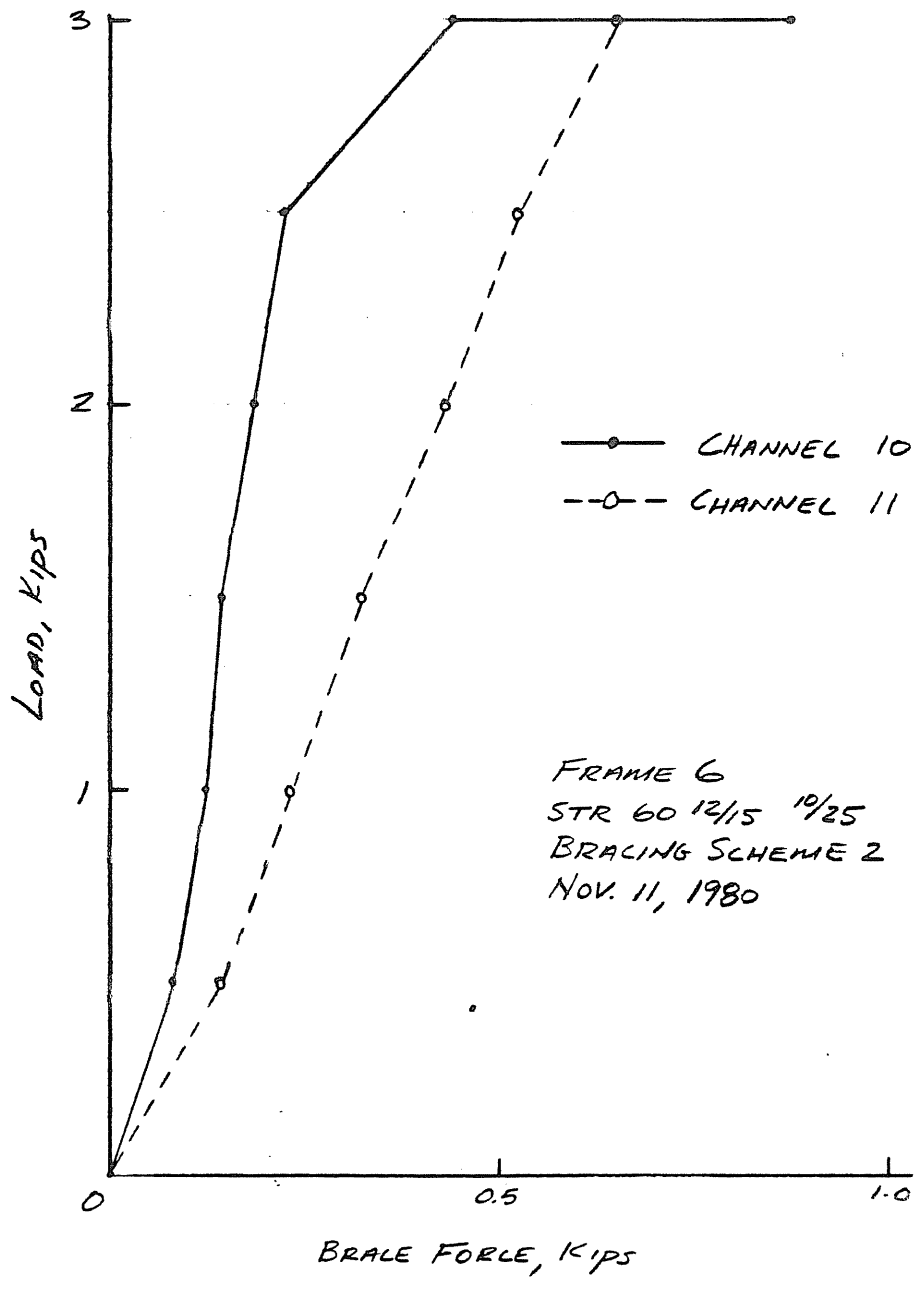


Figure E.6 Load vs. Brace Force

APPENDIX F

Knee Test, East Frame

Test Date, December 12, 1980

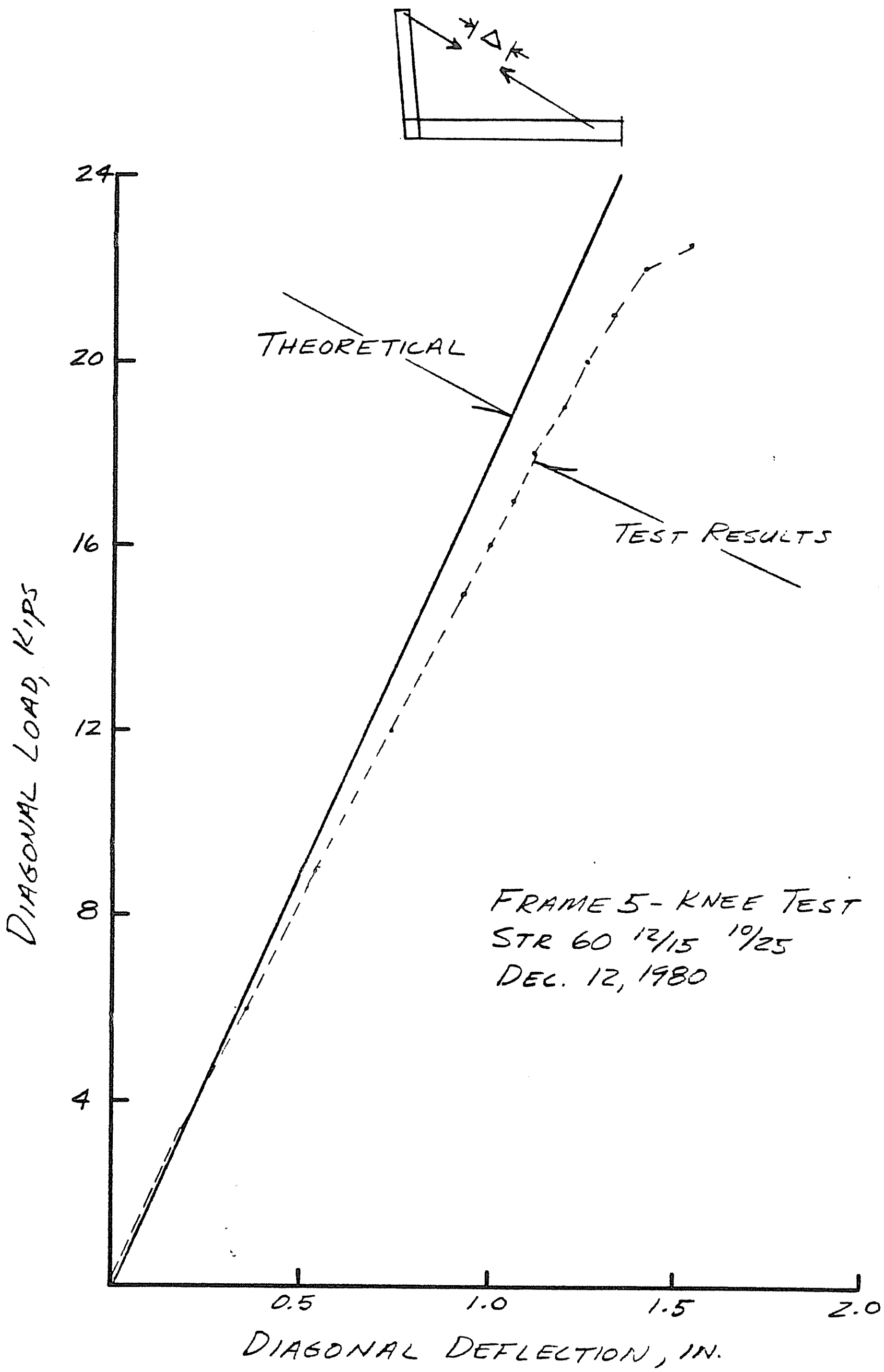


Figure F.1 Load vs. Diagonal Deflection

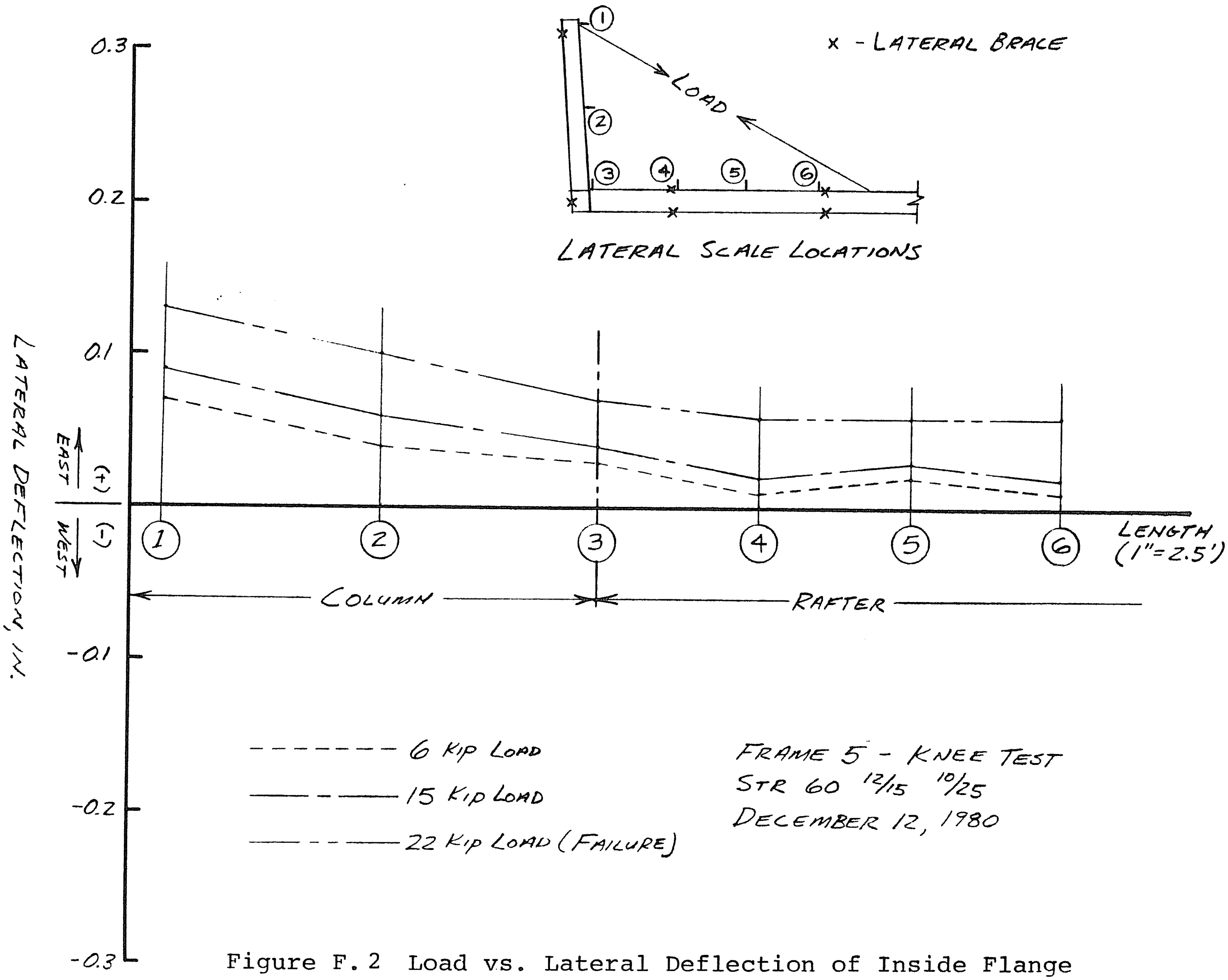


Figure F.2 Load vs. Lateral Deflection of Inside Flange

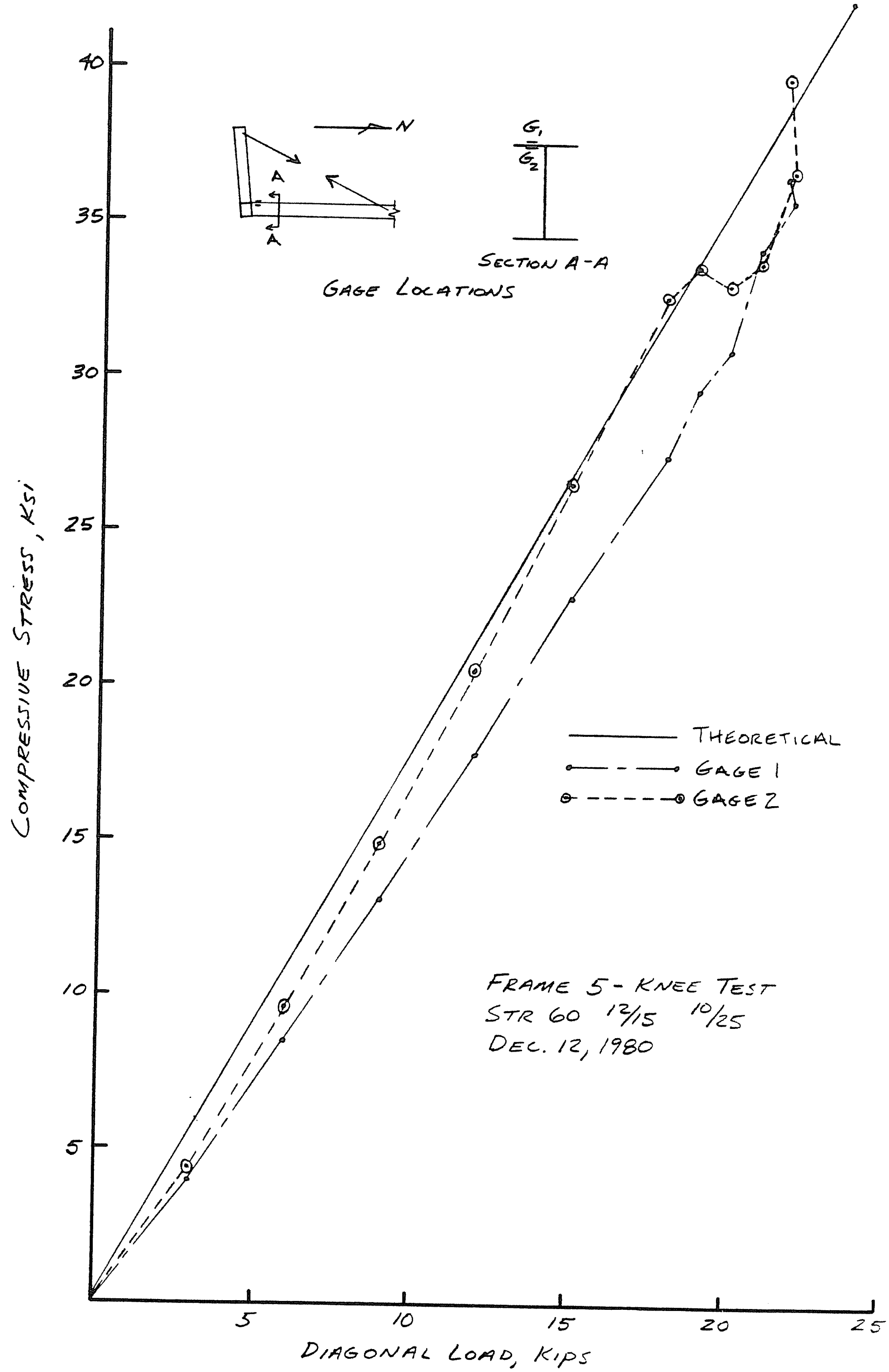


Figure F.3 Load vs. Stress, Rafter at Knee (East Side)

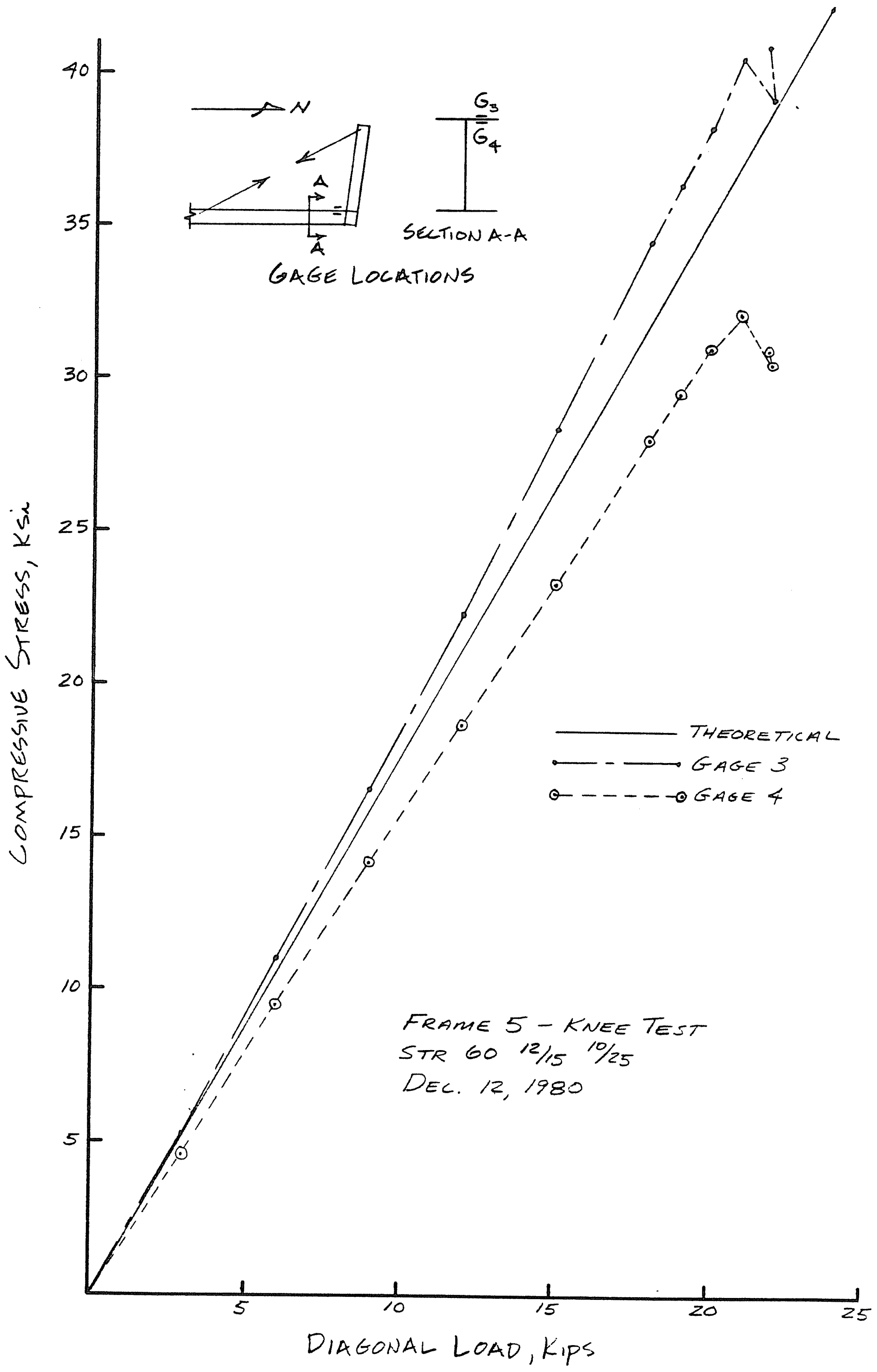


Figure F.4 Load vs. Stress, Rafter at Knee (West Side)