DEPARTMENT OF ENGINEERING RESEARCH
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

TESTS OF STRAN STEEL JOISTS AS ERECTED AND BRIDGED FOR USE IN FLOOR CONSTRUCTION

By

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Purpose of Tests

The tests outlined in this report were made for the purpose of determining the behavior under concentrated loading, of Stran Steel Joists and Standard Bridging, as used in floor construction. The tests were made on November 24, 1945, in the laboratories of the University of Detroit, and were under the personal supervision of James H. Cissel, Professor of Structural Engineering of the University of Michigan. Assisting in the conduct of the test and in the analysis of test data were Professor H. E. Mayrose, of the University of Detroit; also Professor L. C. Maugh, A. F. Haven, and W. E. Quinsey, of the University of Michigan.

Test Specimens

The joists sections and bridging used for the tests were furnished from stock by the Stran Steel Division of Great Lakes Steel Corporation, for whom the tests were made. Three sizes of joist were supplied by the sponsor, the depths being 6 inch, 8 inch, and 9 inch, respectively. All joists were of 16 gage thickness material.

Bridging consisted of cold formed channel sections made from 18 gage material with 11/16 inch deep web and 9/16 inch wide flanges, and of lengths conforming with the depth and spacing of joists. One flange and the web were cut away at opposite sides on each end, for a length of 2-1/8 inches, to provide for bending the section around the joist flange at the designated joist spacing.

Test Panels

Test panels for each size of joist consisted of three parallel joists spaced 24 inches apart with standard bridging installed in accordance with recommended Stran Steel practice for floor construction. The two outside joists are in each case referred to as joists A and C, respectively, and the middle joist, to which the load was applied, is referred to as joist B. The joists were mounted on test frames consisting of a 12 inch x 31.8 lb. standard I-Beam serving as a supporting beam at the ends of the joists. The supporting beam was welded at each end to a vertical 10 x 10 H-Section and was also supported at its middle by another vertical H-Section. The vertical legs at the ends of the supporting beam were continued upward to another transverse beam above and parallel to the supporting beam. These higher level transverse beams in turn supported a longitudinal beam parallel to and above joist B of the test panel assembly. The purpose of this arrangement was to permit a hydraulic jack to be insterted at any point of the span, between the longitudinal overhead beam of the testing frame and joist B of the test panel. The joists had a 5 inch bearing on the top flange of the supporting beam and simply rested on this beam with no positive attachment. A standard plate as used in Stran Steel Construction was attached across the tops of the joists at the support to serve as a spacer and to furnish lateral support to the top flange at the support. This plate consists of a 16 gage channel section, 3-3/16 inches wide with 1-5/8 inch flanges, and was attached to the top flanges by means of two metal screws at each joist. It was free from contact or attachment to the testing frame. Fig. 1 is a photograph of the testing frame used for the 6 inch joists and shows the manner of assembly of a test panel.

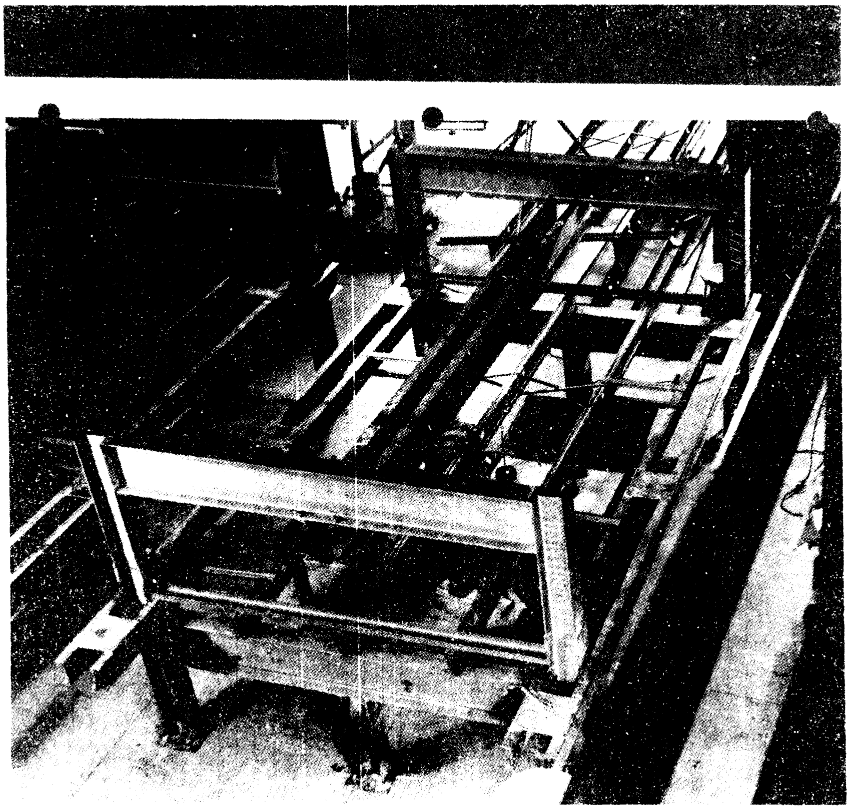

Fig. 1. General View of Testing Frame and Test Panel - 6" Joists.

Testing frames for the 8 inch and 9 inch joists differed from this only in the spacing of the beams supporting the ends of the joists. Fig. 2 is a general view of the three testing frames.

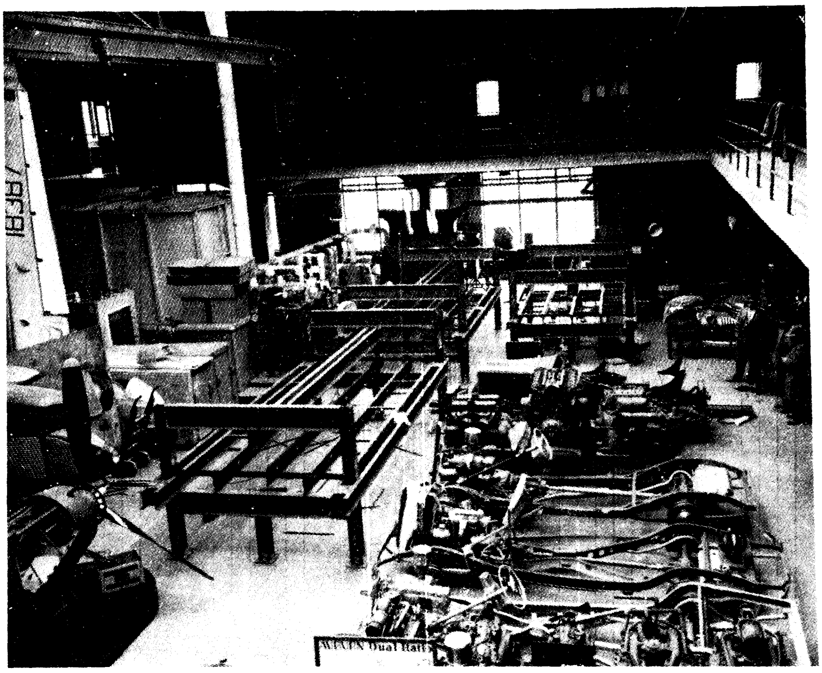

Fig. 2. General View of Testing Frames.

Description of Tests

For the 9 inch x 16 gage joists, the supporting beams of the test frame were spaced so as to provide a clear span of 18 feet, or 24 times the depth of joist. The three joists comprising the test panel were spaced at 24 inches, center to center, and standard Stran Steel bridging was installed at the center and quarter points of the span. Simulated bridging was provided from joists A and C to the adjacent sides of the test frame. By means of a hydraulic jack, a concentrated load of 800 pounds was then applied to joist B at the three transverse lines of bridging and at points approximately midway between lines of bridging. (See Fig.3) Deflections of all joists at lines of bridging and at the center of span of joist B were measured by means of dials located under the bottom flange of the joist. (See Fig.4)

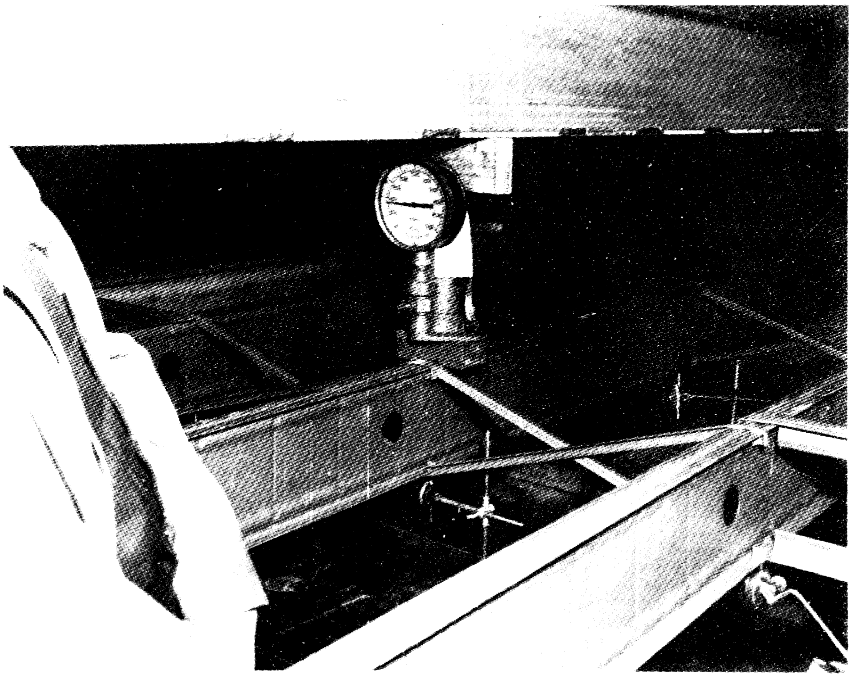

Fig. 3. Concentrated Load Applied to Test Panel by Hydraulic Jack.

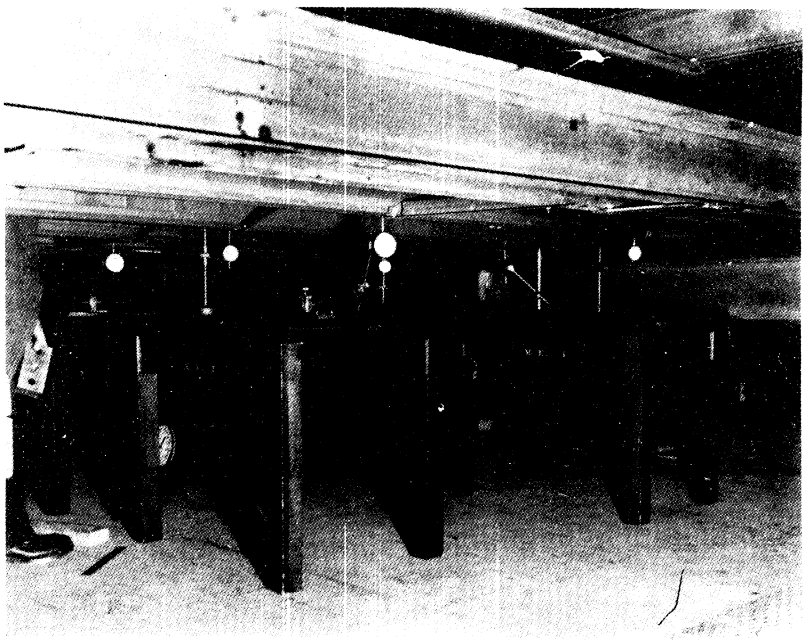

Fig. 4. Dials Used to Measure Deflections.

The deflection of other points was measured by means of a surveyor's level. Test results are given in Table I.

For the 8 inch by 16 gage joists the supporting beams of the testing frame were spaced to provide a clear span of 16 feet, or 24 times the depth of the joist. Except for this difference in span, the arrangement and procedure was identical with that used for the 9 inch joists. Test results are given in Table II.

In the case of the 6 joists the supporting beams of the testing frames were spaced to provide a clear span of 12 ft., or 24 times the depth of joist. The bridging was arranged in two lines located at approximately the third points of the span, and simulated bridging was provided at these points between joists A and C and the adjacent side channels of the testing frame. By means of a hydraulic jack, a concentrated load of 800 pounds was applied to joist B at the third points of the span, corresponding to the location of bridging, and at the center of the span. Deflections of all joists were measured by means of dials located at lines of bridging and at the center of joist B. Test results are recorded in Table III.

Table I - 9 inch - 16 Ga. Stran Steel Joists - 18 ft. span

Three parallel joists at 24 inch centers bridged at quarter points of span with standard Stran Steel Bridging. Middle joist (Joist B) loaded with a concentrated load of 800 lbs. Deflections are recorded in inches.

Distance Load to Support (inches)	Joist A			Joist B			Joist C		
	1/4 Span	Center of Span	3/4 Span	1/4 Span	Center of Span	3/4 Span	1/4 Span	Center of Span	3/4 Span
27	.039	.045	.031	.078	.138	.140	.035	.044	.031
56	.072	.094	.065	.143	.247	.214	.065	.085	.058
81	.093	.127	.084	.195	.325	.253	.087	.114	.074
111	.103	.139	.089	.231	.353	.234	.097	.125	.077
135	.120	.134	.084	.243	.327	.203	.090	.110	.067
161	.102	.106	.065	.208	.243	.146	.069	.092	.048
189	.053	.057	.036	.130	.140	.081	.047	.053	.029

Table II - 8 inch - 16 Ga. Stran Steel Joists - 16 ft. span

Three parallel joists at 24 inch centers bridged at quarter points of span with standard Stran Steel Bridging. Middle joist (joist B) loaded with a concentrated load of 800 lbs. Deflections are recorded in inches.

Distance Load to Support (inches)	Joist A			Joist B			Joist C		
	1/4 Span	Center of Span	3/4 Span	1/4 Span	Center of Span	3/4 Span	1/4 Span	Center of Span	3/4 Span
24	.037	.049	.037	.101	.155	.150	.042	.056	.046
49.5	.069	.088	.063	.184	.276	.244	.071	.092	.080
72	.090	.112	.081	.247	.358	.276	.087	.113	.089
98	.097	.116	.082	.280	.381	.256	.096	.120	.099
123	.092	.110	.076	.287	.348	.219	.090	.110	.082
145	.080	.092	.063	.248	.266	.163	.071	.087	.062
168	.048	.054	.037	.163	.164	.095	.043	.051	.033

Table III - 6 inch - 16 Ga. Stran Steel Joists - 12 ft. span

Three parallel joists at 24 inch centers, bridged at third points of span with standard Stran Steel Bridging. Middle joist (joist B) loaded with a concentrated load of 800 lbs. Deflections are recorded in inches.

Distance Load to Support (inches)	Joist A			Joist B			Joist C.		
	1/3 Span	Center of Span	2/3 Span	1/3 Span	Center of Span	2/3 Span	1/3 Span	Center of Span	2/3 Span
48	.077	.084	.077	.225	.302	.267	.058	.059	.044
72	.093	.099	.091	.275	.345	.264	.068	.082	.046
96	.094	.087	.077	.259	.270	.192	.113	.076	.043

A test to determine the capability of the bridging to transfer load to adjacent joists was conducted on the panel of 9 inch beams in the following manner. All lines of bridging were removed and joist B was moved lengthwise until one end was clear of the supporting beam of the test frame, (note testing frame in foreground of Fig. 2, which has been arranged for this test). New bridging was then installed at this point between Joist B and the side joists A and C, in such a manner that Joist B was supported only by this bridging at one end and by the supporting beam of the testing frame at the other. There were no other attachments of any kind to Joist B. By means of a hydraulic jack, a concentrated load of 500 pounds was applied to joist B directly on the line of bridging which supported one end of the joist. (See Fig. 5). After observing the behavior of bridging under such loading, the load was increased until failure of the bridging occurred.

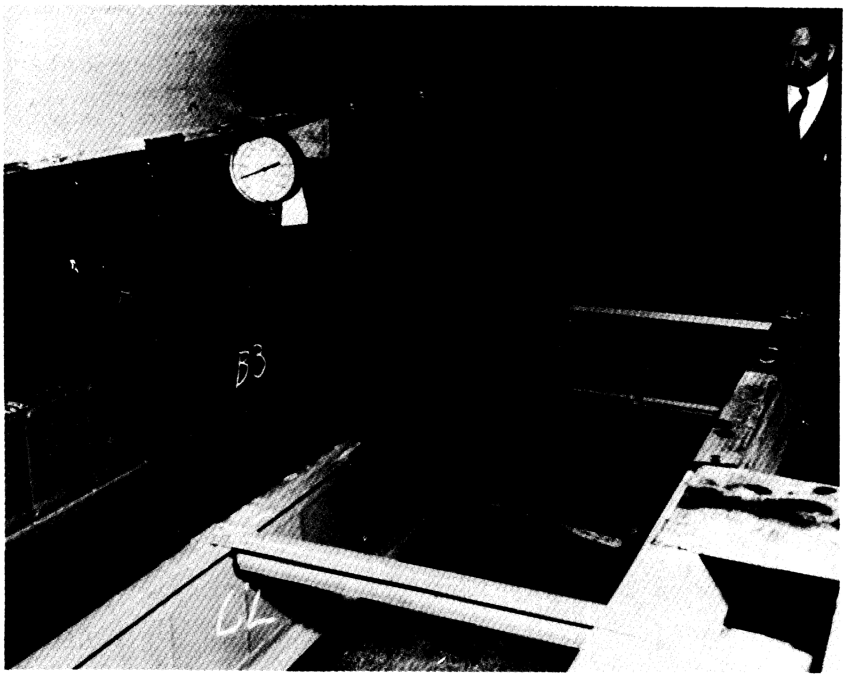

Fig. 5. Bridging Test.

The hydraulic jack used in applying concentrated loading to the joists was calibrated by Professor Mayrose of the University of Detroit immediately preceeding the test. A copy of his certification of the calibration of this jack is appended to this report.

Discussion of Test Results

The physical properties of the joists are as follows:

6" x 16 Ga. joist; $I = 3.928$ $S = 1.309$

8" x 16 Ga. joist; I = 8.219 S = 2.055

9" x 16 Ga. joist; I = 10.992 S = 2.443

Based upon steel having a yield point of 37000 p.s.i., the allowable unit stress on the tension flange would be 20000 p.s.i., according to the proposed American Iron and Steel Institute Specification for the Design of Light Gage Steel Members. (September, 1945). The ratio of the outstanding flange width to flange thickness is 14.25, hence the allowed unit stress on the compression flange, as given by these specifications, would be limited to 18500 p.s.i., where the flange is fully supported, and to a value given by the formula:

$$f = \frac{24615}{1 + \frac{(L/r)^2}{11700}}, \text{ where}$$

L = distance between lateral flange supports

r = radius of gyration of compression flange.

In each of the beams tested, r = 0.576 inches, and the compression flange is supported laterally by bridging at the third points in the case of the 6 inch joists, and at the quarter points for the others. In accordance with this specification, therefore, the allowed working stress in the compression flange would be 15500 p.s.i. in the case of the 6 and 8 inch joists; and 14000 p.s.i. for the 9 inch joists. Based upon the limitations of the A.I.S.I. Specification, which governs the use of these joists, the safe working concentrated load at the midpoint of the span would in each case be as follows:

6" x 16 Ga. joist; 12 ft. span P = 560 lbs.

8" x 16 Ga. joist; 16 ft. span P = 660 lbs.

9" x 16 Ga. joist; 18 ft. span P = 630 lbs.

The 800 pound concentrated load, which was adopted in compliance with the requirements of the New York City Building Code (C26-519.0e), is therefore 20 to 40 percent greater than the working load of similar character which would be permitted on these joists.

Under the test load the joists showed no signs of distress and remained in true alignment throughout. The top flange showed no tendancy to deflect laterally and it was obvious that the test load was considerably less than that which would produce failure.

The maximum deflection of the loaded joist occurred in each case when the load was placed at the center of the span. The maximum deflection in each case was as follows:

6" joist, Deflection = 0.345 = L/417

8" joist, Deflection = 0.381 = L/502

9" joist, Deflection = 0.353 = L/610

These deflections are 81%, 78%, and 68%, respectively, of the theoretical deflections of unbridged joists.

Under the test loading, the estimated transfer of load from the loaded joist to the adjacent joists through the bridging is shown on Figures 6, 7, and 8.

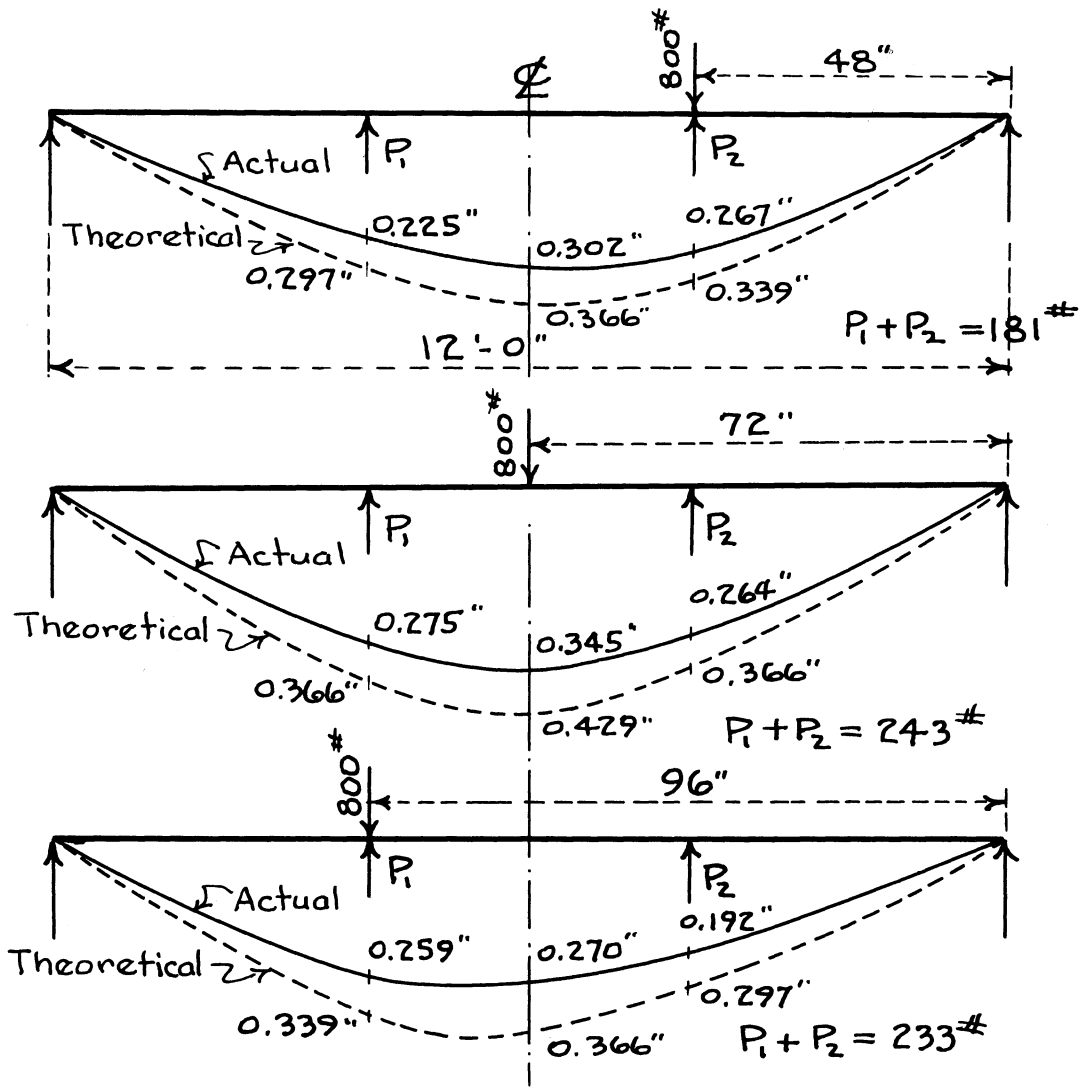

Fig. 6. Deflection Curves for 6" Joists

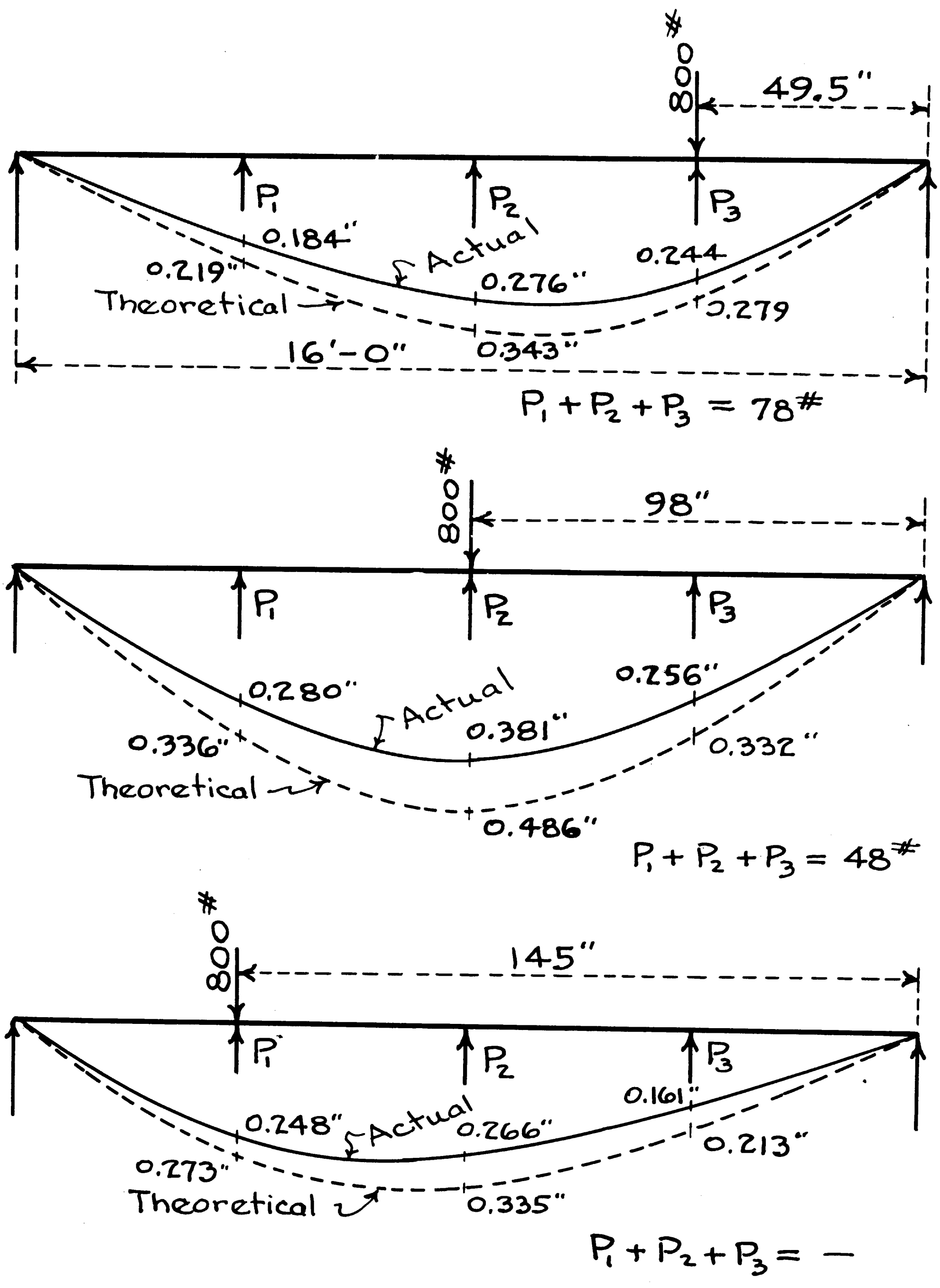

Fig. 7. Deflection Curves for 8" Joists

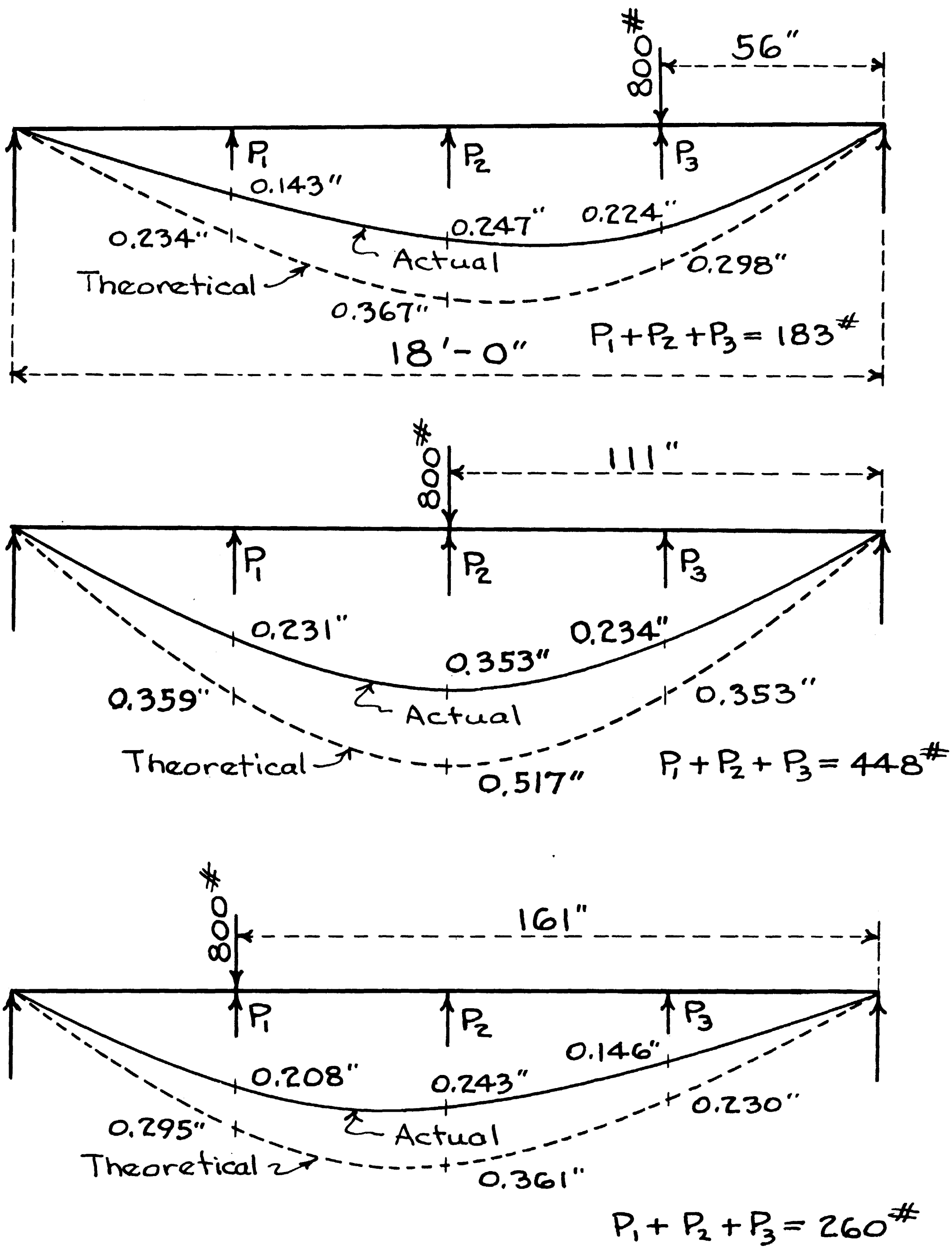

Fig. 8. Deflection Curves for 9" Joists

These computations are based on the assumption that the difference between the theoretical deflection curve of the loaded joist and the observed deflection curve of this joist is produced by resistances offered by the several lines of bridging.

The test of the ability of bridging to transfer the load to adjoining joists was made in such a manner as to leave no doubt as to the result, since the entire load was supported by bridging. At an applied load of 500 pounds, no distress was noted, and the load was increased to a total of 740 pounds before failure occurred. Failure consisted in the straightening out of one bridging strut, (See Fig. 9), which was placed in tension by the action of the load, where it was bent over the flange of the loaded joist.

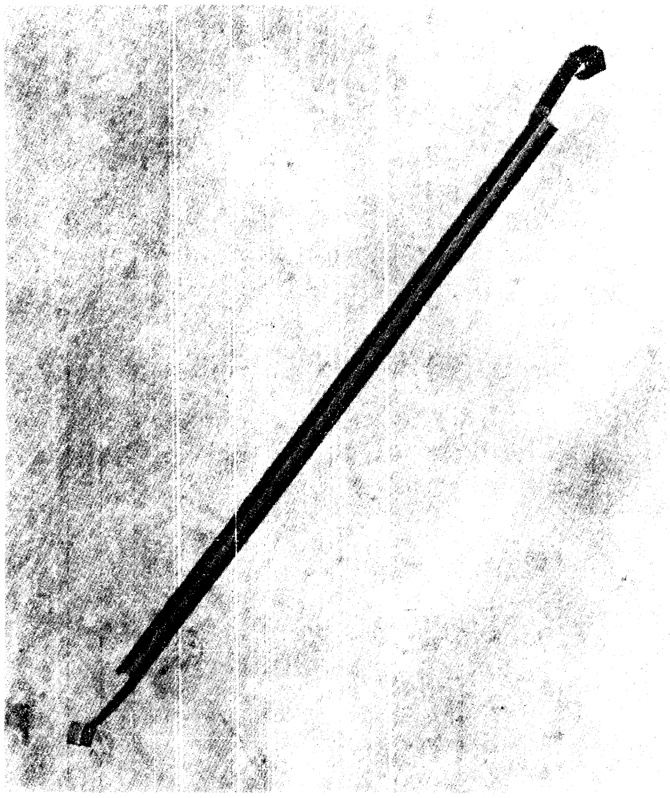

Fig. 9. Bridging Strut which Failed when at Transfer Load of 740 Lbs.

Conclusions:

The spans used for these tests were in each case 24 times the joist depth and therefore represented the longest span for which it is permissible to use joists of the given depth under such a span limitation. Since the joists tested were in each case the lightest section of each depth produced by Stran Steel, it is obvious that the conclusions given below apply also to joists made of heavier gage material. Subject to the foregoing span limitations, therefore, it has been concluded that:

1. Stran Steel joists, when properly bridged, are capable of sustaining a concentrated load of 800 pounds, applied at any point in the span.
2. The deflection of Stran Steel joists, when properly erected and bridged, will not exceed 1/360 of the span, when a concentrated load of 800 lbs. is applied at any point in the span.
3. The bridging supplied by Stran Steel Joist Floors, is a satisfactory rigid type of bridging and is capable of transmitting at least 500 lbs. from the loaded joist to the adjoining joists on either side.
4. Stran Steel joist construction, together with the bridging erected in the manner recommended for such material, fully complies with the requirements of C26-519e of the New York City Building Code.

Respectfully submitted,

J. H. Cissel
Consulting Engineer

Registered Professional Engineer
State of Michigan
Certificate No. 249

University of Detroit
Detroit, Mich.

Nov. 26,1945.

TO WHOM IT MAY CONCERN:

This is to certify that immediately before the tests of STRAN STEEL JOISTS for the New York City Building Department on Saturday, November 24th,1945 THE HYDRAULIC JACK which was used in the tests was calibrated under my personal supervision and that the equipment used for the application of loads was checked so that the forces applied to the joists would be accurate and according to those prescribed.

This calibration and check showed that when the gauge of the hydraulic jack registered eight hundred seventy(870) pounds the force applied to the joist was exactly eight hundred pounds(800 lbs).

An accurate universal testing machine with beam graduated to read in one pound increments was used for the calibration. This machine had been calibrated with dead weights from zero load to 1500 pounds.

Herman E. Mayrose
Herman E. Mayrose,
Registered Professional
Engineer - Michigan.

Prof. Eng. Mechanics,
College of Engineering
University of Detroit.