AN ABSTRACT OF THE THESIS OF

WILLIAM BROOKS LANDERS (Name) for the DOCTOR OF PHILOSOPHY (Degree)

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Title: EXPERIMENTAL INVESTIGATION OF STRESSES IN STEEL I-BEAMS WITH RECTANGULAR HOLES IN THE WEBS

Abstract approved: Redacted for Privacy

The object of this investigation was to develop an analytical method for the calculation of stresses in I-beams with rectangular holes in the web. Two fabricated steel I-beams of the same dimensions and material, one with a solid web and the other with five rectangular holes cut in the web, were instrumented identically. Similar load tests were performed on the two beams in order to assess the change in stress caused by the rectangular holes in the web.

The results of the first series of tests produced a variation in strain pattern, but no rational theory was found to explain the change. It was decided that the concentrated loads in the immediate proximity of the holes were adding another variable in addition to the shear and bending moment on the section and therefore at least one of these effects should be eliminated.

For the second series of tests the beams were loaded with the

loads so far removed from the instrumented holes that their effect on the strains around the instrumented holes was negligible. The measured strain readings in all instances showed reasonable agreement with calculated strains.

The calculated strains above and below the holes were obtained by adding algebraically the strain caused by each of the following two loadings (11, p. 145, 146):

(1) The strain calculated from the formula $\varepsilon = \frac{MY}{EI}$

where ε is the required strain;

M is the bending moment at the point of inflection which for rectangular holes, as were used in these tests, is at the center of the hole;

Y is the distance from the neutral axis to the point in question;

E is Young's Modulus for the beam material;

I is the moment of inertia of the beam cross-section at the line of inflection which for these tests was at the center of the hole.

(2) The strain resulting from one-half the shear at the section acting at the center of the span of the hole. This results in a cantilever beam, whose length is one-half the width of the hole and which has a force equal to one-half the shear at that section acting on the end of the cantilever. The proper

direction of the shear force must be assigned to each cantilever. The formula used to calculate the strain is the same as (1) but in this instance,

ε is the required strain;

M is the product of one-half the shear and the distance the section in question is from the center of the hole;

Y is the distance from the point in question from the neutral axis of the Tee-section;

E is Young's Modulus of the material in the beam;

I is the moment of inertia of the Tee-section.

The following are the conclusions gathered from the test results:

(1) The algebraic sum of the strains calculated as described above proved good estimations of the actual strains in the portion of a beam above or below the rectangular holes in the steel I-beams tested.

(2) The strain in the immediate vicinity of the vertical sides of the hole is small and it increases as the distance from the hole increases. Therefore, instead of reinforcing the vertical sides of the hole, this reinforcing material should be added to the horizontal reinforcing to extend from the edge of the hole back onto the solid web of the beam to give

extra material to carry the load caused by the shear on the cantilever beam.

Experimental Investigation of Stresses in Steel I-Beams with Rectangular Holes in the Webs

by

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Professor of Civil Engineering
in charge of major

Redacted for Privacy

Head of Department of Civil Engineering

Redacted for Privacy

Dean of Graduate School

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EXPERIMENTAL INVESTIGATION OF STRESSES IN STEEL I-BEAMS WITH RECTANGULAR HOLES IN THE WEBS

INTRODUCTION

This dissertation is an account of experiments with two I-beams fabricated from A-36 steel, one of which had five rectangular holes cut in the web. The aim of the experiments was to find the magnitude of the stresses caused by the presence of the holes and to formulate a method for calculating these stresses.

The solid web I-beam has many advantages which explains its wide application in structures. They are economical to fabricate and have considerable flexibility because (1) the flange width and thickness can be varied and (2) the web thickness and depth can be varied. There is also the advantage that holes may be cut in the web at desired locations to accommodate ducts or mechanical pipes. This last advantage has been greatly abated because of the common practice of reinforcing around these holes. By calculating the stress increases caused by the holes, only the areas where the total stresses are above the allowable need to be reinforced.

To the author's knowledge the following are the principal investigations and hypothesis related to steel I-beams with rectangular holes in the webs. Roark (11, p. 145, 146) assumed that the tee beams above and below the hole had a point of inflection at midspan

of the hole due to the moment resulting from the shear. Therefore he hypothesized that the total stress at points in the tee sections above and below the hole is equal to the algebraic sum of two stresses; (1) the flexural stress at midspan of the hole calculated from the total moment acting on the net section (i. e. excluding the hole); and (2) the flexural stress at the point in question calculated from the moment on the cantilever tee beam whose length is one half the span of the hole with a concentrated load equal to one half the shear acting at the free end). Roark's hypothesis is commonly referred to as the Vierendeel method.

Some research has been done by the Texas Engineering Experiment Station; Texas A and M College, on beams with reinforced holes. This research was primarily concerned with the amount of reinforcing required around the holes in order that the load carrying capacity of the beam at a section through the hole was not reduced because of the hole. The procedure followed was to reinforce the holes and then test the beam to failure. The reinforcing was considered adequate if the section supported a load equal to a similar section without the hole.

J. E. Bower (9) carried out tests and did a theoretical elasticity analysis on 16 WF 36 beams. The stresses in the elasticity analysis are computed as the sum of stresses occurring in the beam when there is no hole, basic stresses, and the stresses occurring in

the beam as a result of forces applied to the boundary of the hole, perturbated stresses. These latter forces are applied so that the resulting perturbated stresses and the basic stresses satisfy a required boundary condition of zero resultant force at the hole.

The radius of the fillets at the corners of the holes was one quarter of an inch. This small radius accentuates the effect of the corner as a stress riser.

Mr. Bower found good agreement with experimental results and the elasticity analysis at the corners of the holes. The experimental bending stresses at the low-moment edge of the holes agree better with stresses predicted by the elasticity analysis than with the predictions of the Vierendeel analysis, except at the flange. He concluded that the predictions of the Vierendeel analysis provided a reasonably accurate prediction of the stresses in the vicinity of a rectangular hole. He also suggests that better agreement could be achieved if the point of inflection was assumed slightly closer to the high-moment side of the hole instead of at the center of the hole.

Richard G. Redwood and John O. McCutcheon (15) investigated the effect of rectangular holes in the webs of 8 WF 17 beams. The beams were coated with whitewash in the region around the openings to indicate yielding. The flanges and the webs were reinforced in order to ensure failure at the holes. The beams were tested to

failure. The moment at the opening was plotted against the deflection at the midpoint of the beam in each instance.

Their conclusions are as follows:

1. Under pure bending the moment capacity of the beams with one or two openings can be calculated based on the plastic modulus of the net section through an opening.

2. The presence of shear reduces the moment capacity of the beam at the opening below that for pure bending. The reduction is a function of opening shape, dimensions, the spacing of openings, and the shear/moment ratio. The influence of a second opening at a given spacing also depends upon the rate at which the moment capacity decreases as the shear/moment ratio increases for a single opening of that particular type.

3. A single rectangular opening reduces the capacity to 40% of Mp at shear/moment ratio = 0.425. The presence of an identical adjacent opening produces a very small reduction in strength when it is spaced a distance equal to the opening depth from the more heavily loaded opening. When the spacing is half the depth of the opening there is a significant decrease in strength at the higher shear/moment ratios which results from buckling or tearing, or both, of the web between the openings.

OBJECT OF TESTS

The object of these tests is to develop an analytical method for the calculation of stresses in steel I-beams with rectangular holes cut in the webs. The stress distributions are studied with the purpose of predicting if reinforcing is required around a hole, and if reinforcing is required, where it would be most advantageously located.

One present practice is to place reinforcing around the perimeter of the hole. The quantity of reinforcing is calculated from empirical formulae.

TEST SPECIMENS

Description of Specimens

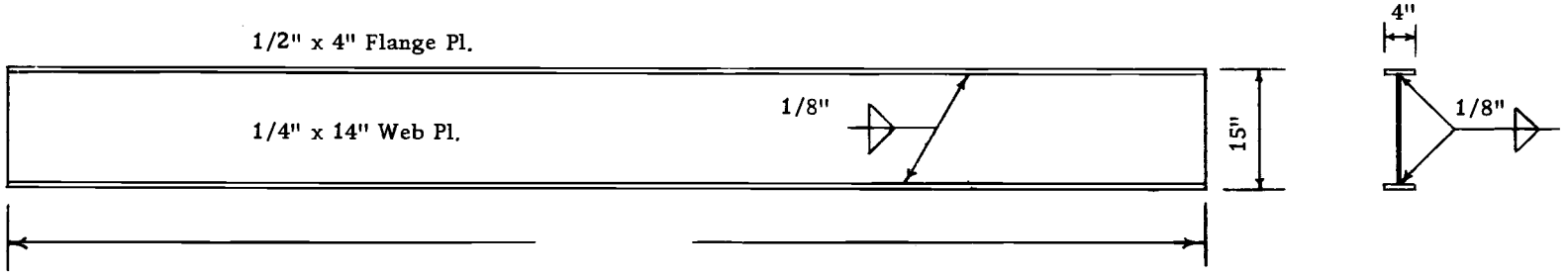
The two beams used were fabricated by continuous machine fillet welding of 1/2" x 4" flange plates to 1/4" x 14" web plates as shown in Figure 1. The beams were 12'6" long. The beams were chosen in proportions such that the "ld/bt" ratio of the unsupported length always remained close to 600. The span of 12'0" and the maximum load required were chosen in order that they could be accommodated in the space provided for the experiments and by the testing machine assigned to provide the load.

The over-all specimens are 15" high and 12'6" long. Dimensions of the web holes are as shown in Figure 1.

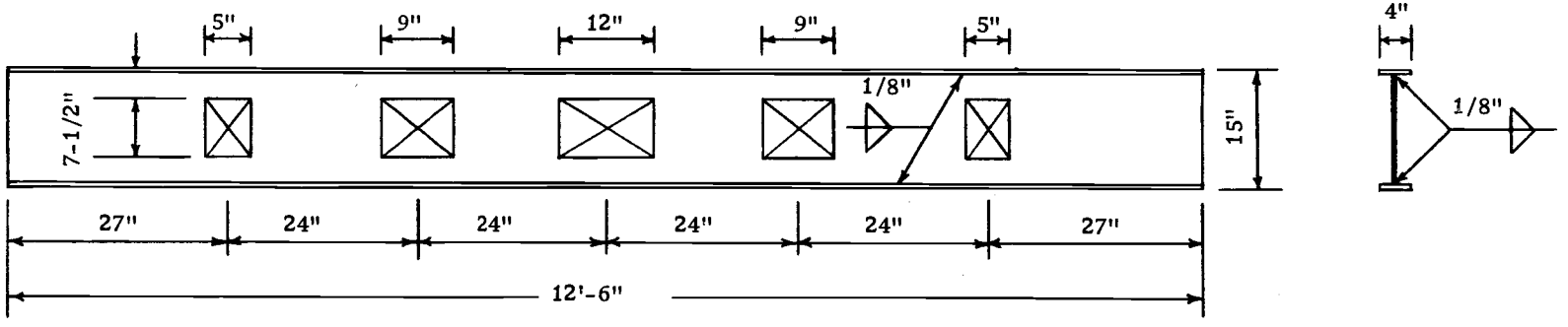
Properties of Specimen

All beam material is ASTM A-36 steel.

Modulus of elasticity of steel	$E = 29 \times 10^6$ psi
Moment of inertia of section	$I = 268.25$ in^4
Area of section	$A = 7.50$ in^2
Area of web	$A_w = 3.50$ in^2
Web thickness	$t_w = 1/4$ in.
Flange thickness	$t_f = 1/2$ in.
Flange width	$w_f = 4$ in.



Solid Web Test Beam



Test Beam With Holes

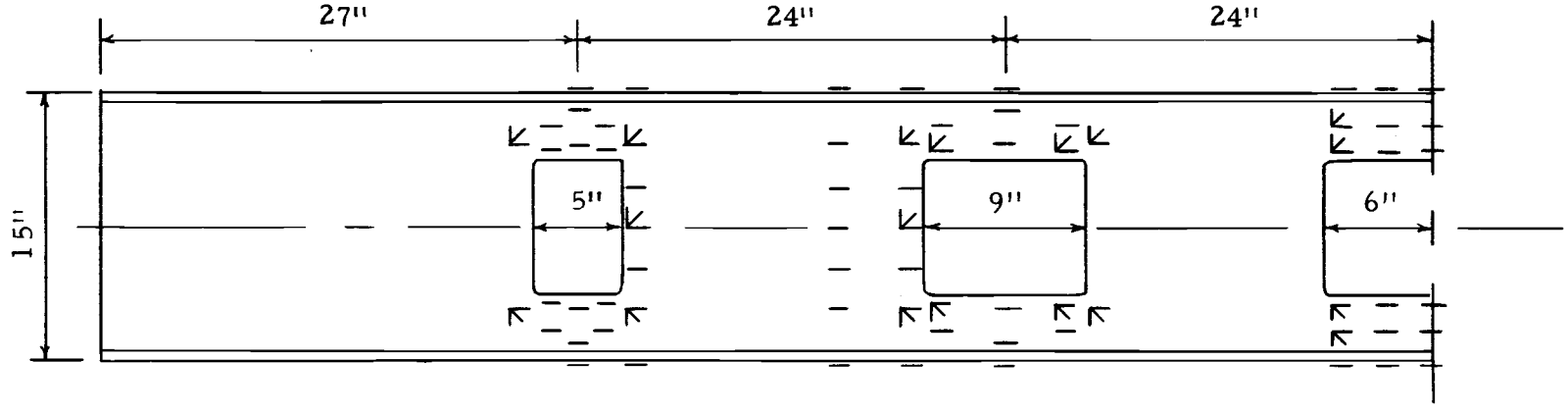
Note: All holes - 1" rad. fillet

Figure 1. Details of two test beams.

Total depth of I-beam	d = 15 in.
Clear distance between flanges	h = 14 in.
Moment of inertia of cross-section through a hole	$I = 259.46 \text{ in}^4$
Moment of inertia of tee-cross-section above and below a hole	$I = 2.79 \text{ in}^4$

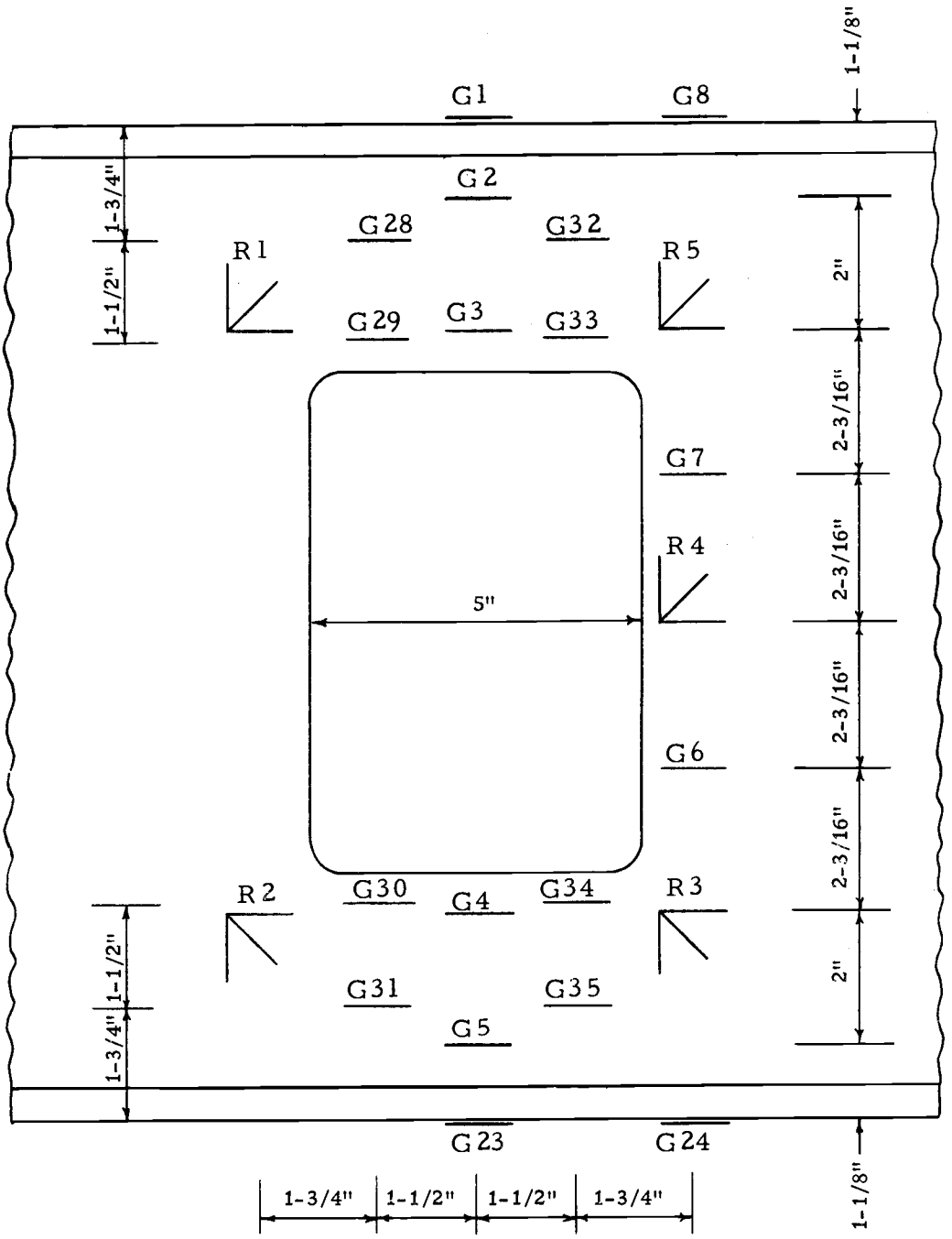
Instrumentation of Specimen

As stated previously, this investigation is to establish an analytical method for the calculation of stresses in I-beams with holes cut in the webs. The location and number of gages was chosen to obtain a record of the stresses in the areas most affected by the presence of the holes in the web. To evaluate the change in stress caused by the holes more realistically, gages were placed on the solid beam in the same locations and with the same designation. The locations and identification markings of the gages on the perforated beam and the solid beam are shown in Figures 2, 3, 4, 5 and 6 respectively. After preliminary tests were run and an hypothesis of the behavior was formulated, additional gages were placed in the vicinity of the holes to further substantiate the conclusions. The location of these gages is shown in Figure 3. Baldwin SR-4 gages, type A-12, and Rosettes, type AR-3, were used.



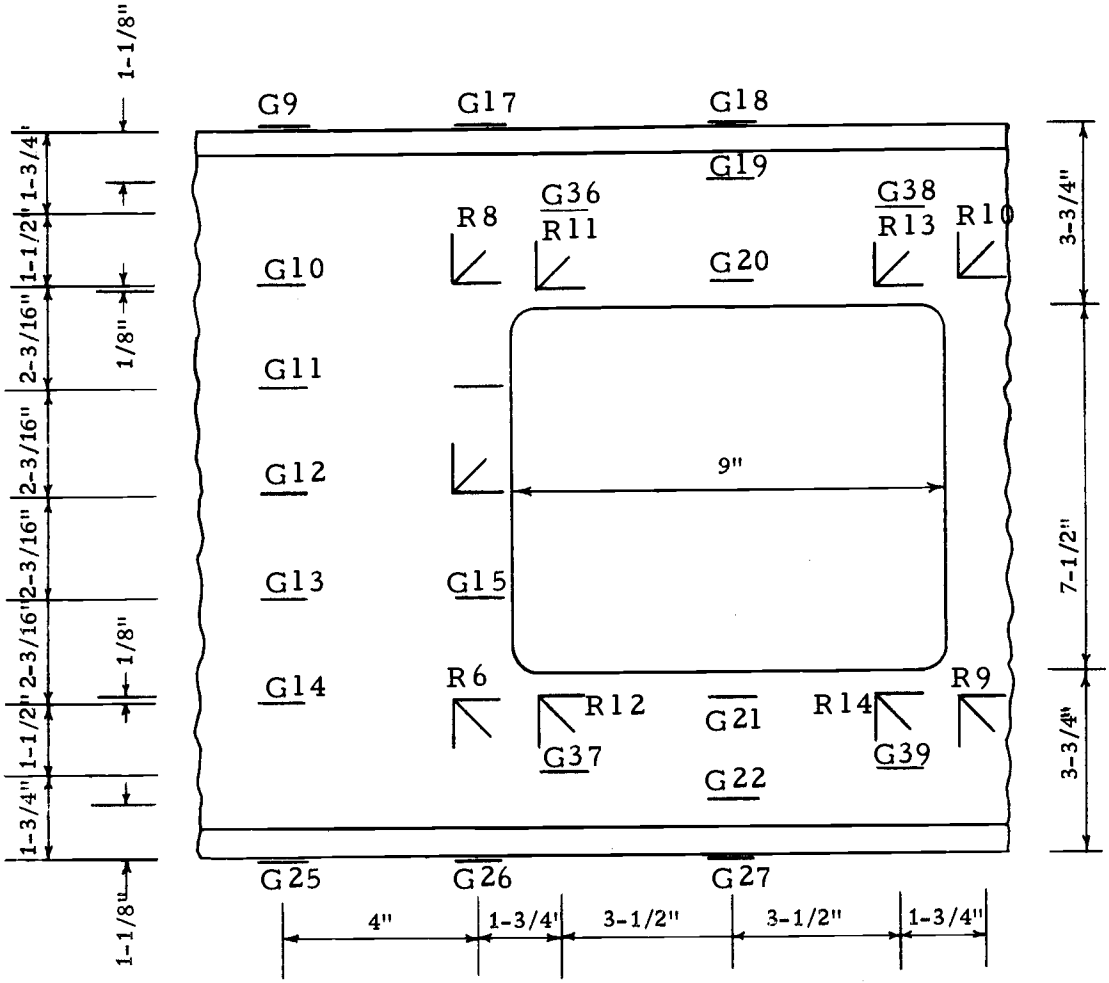
Note: For location of gages and rosettes, see Figures 3, 4 and 5.

Figure 2. One-half of beam with holes showing all gages and rosettes.



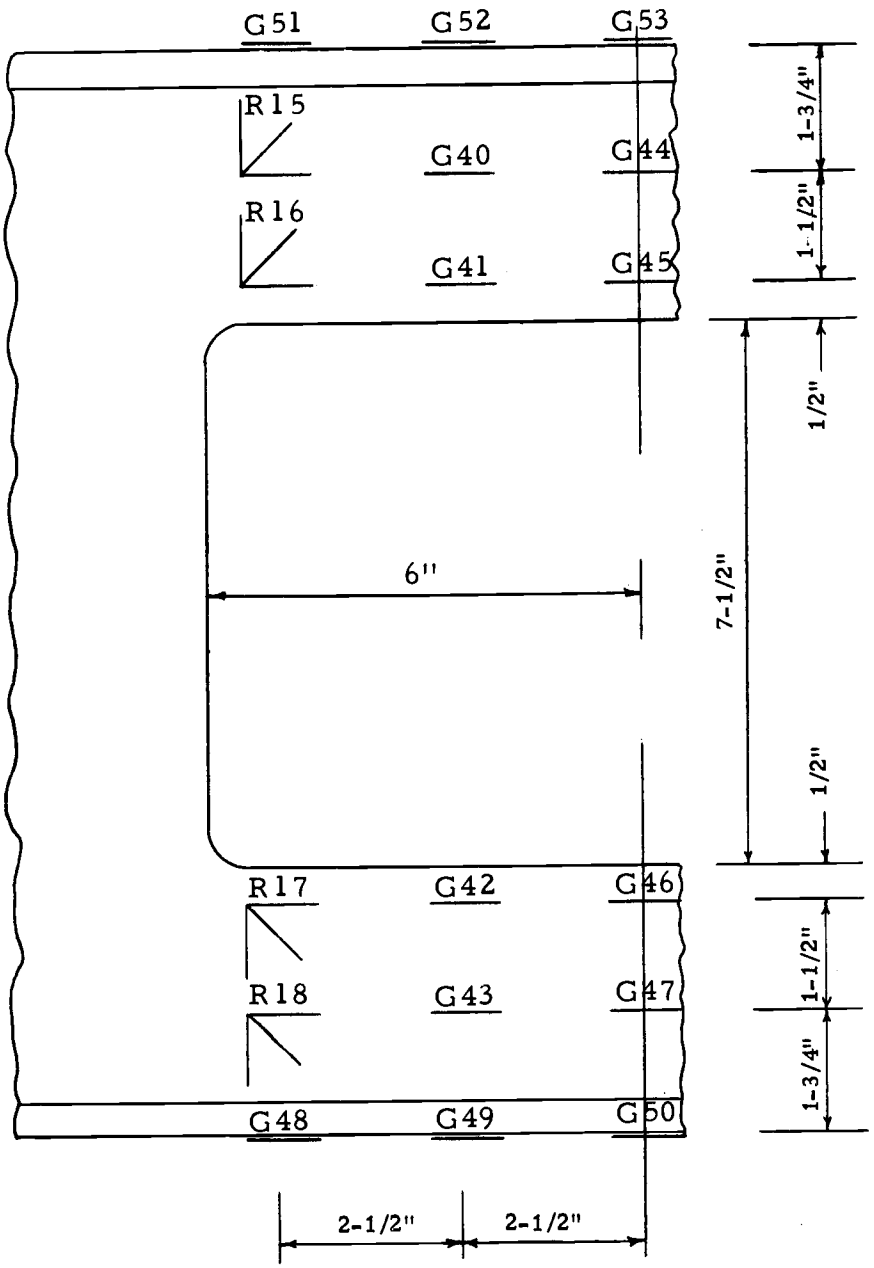
Scale - 3/8" = 1"

Figure 3. Location of gages and rosettes around the 5" hole.



Scale - 1/4" = 1"

Figure 4. Location of gages and rosettes around the 9" hole.



Scale - 3/8" = 1"

Figure 5. Location of gages and rosettes around the 12" hole.

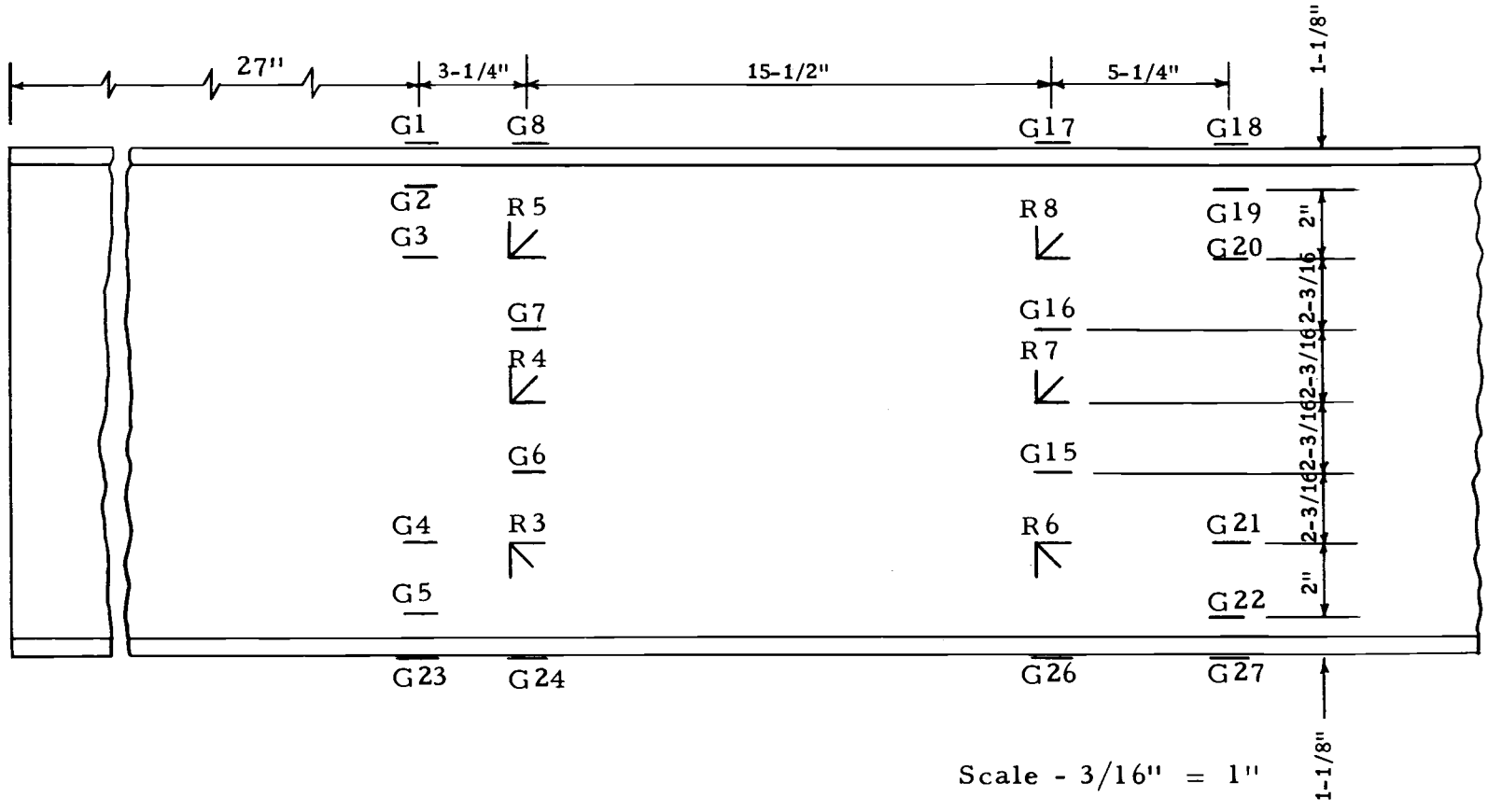


Figure 6. Location of gages and rosettes on solid web beam.

APPARATUS

All gaging elements were connected through three 20-point switch-balancing units to Baldwin Type K and Type N strain indicators. Figure 7 indicates instrumentation, wiring, switching and indicators.

Loading was performed on a Rhiele 150,000 lb. mechanical testing machine with a beam arm. Figures 8 and 9 show the two beams in place for testing. Deflection measurements were made with a detached level telescope arranged to read midspan deflections as shown in Figure 10.

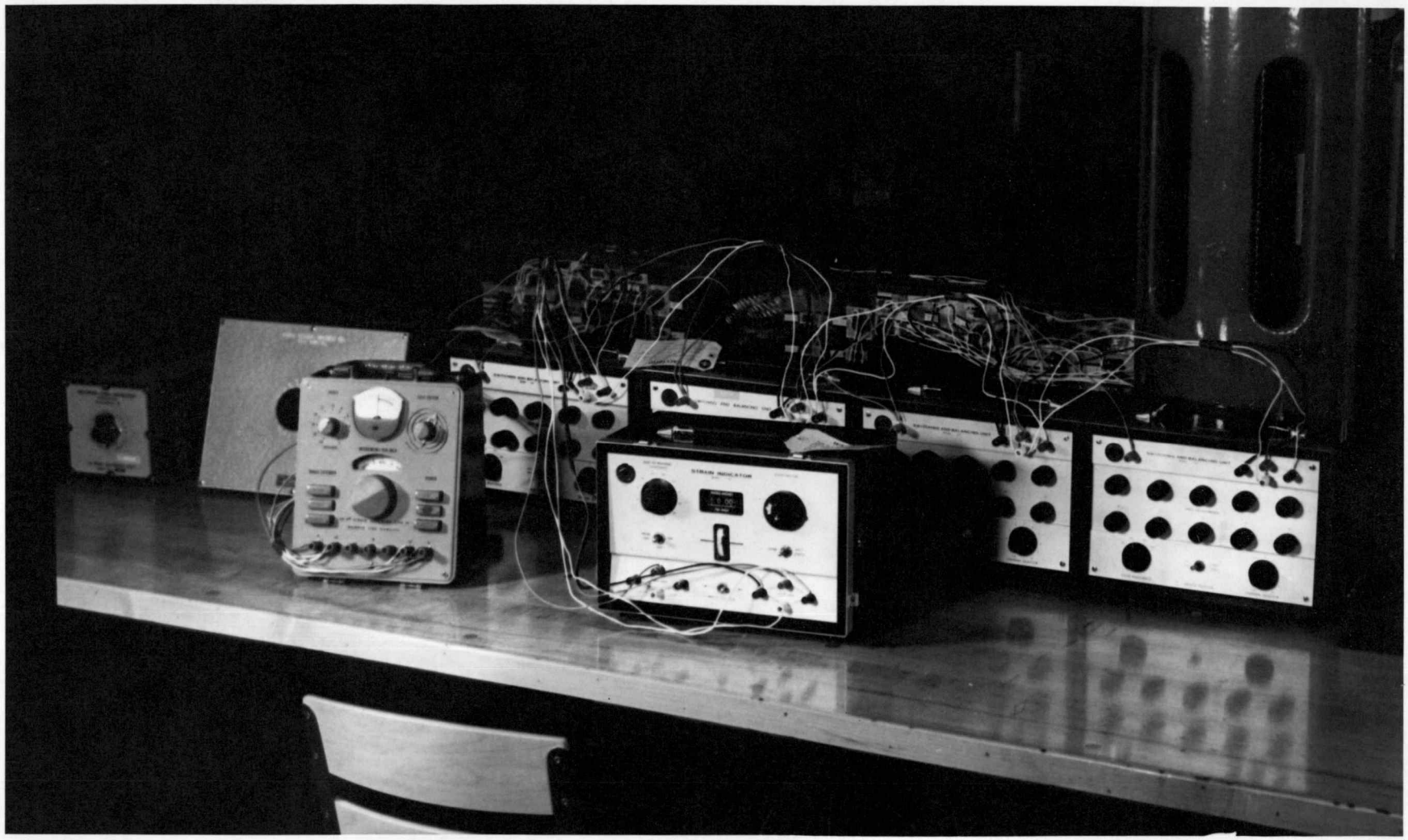


Figure 7. Switch-balancing units and strain indicators.

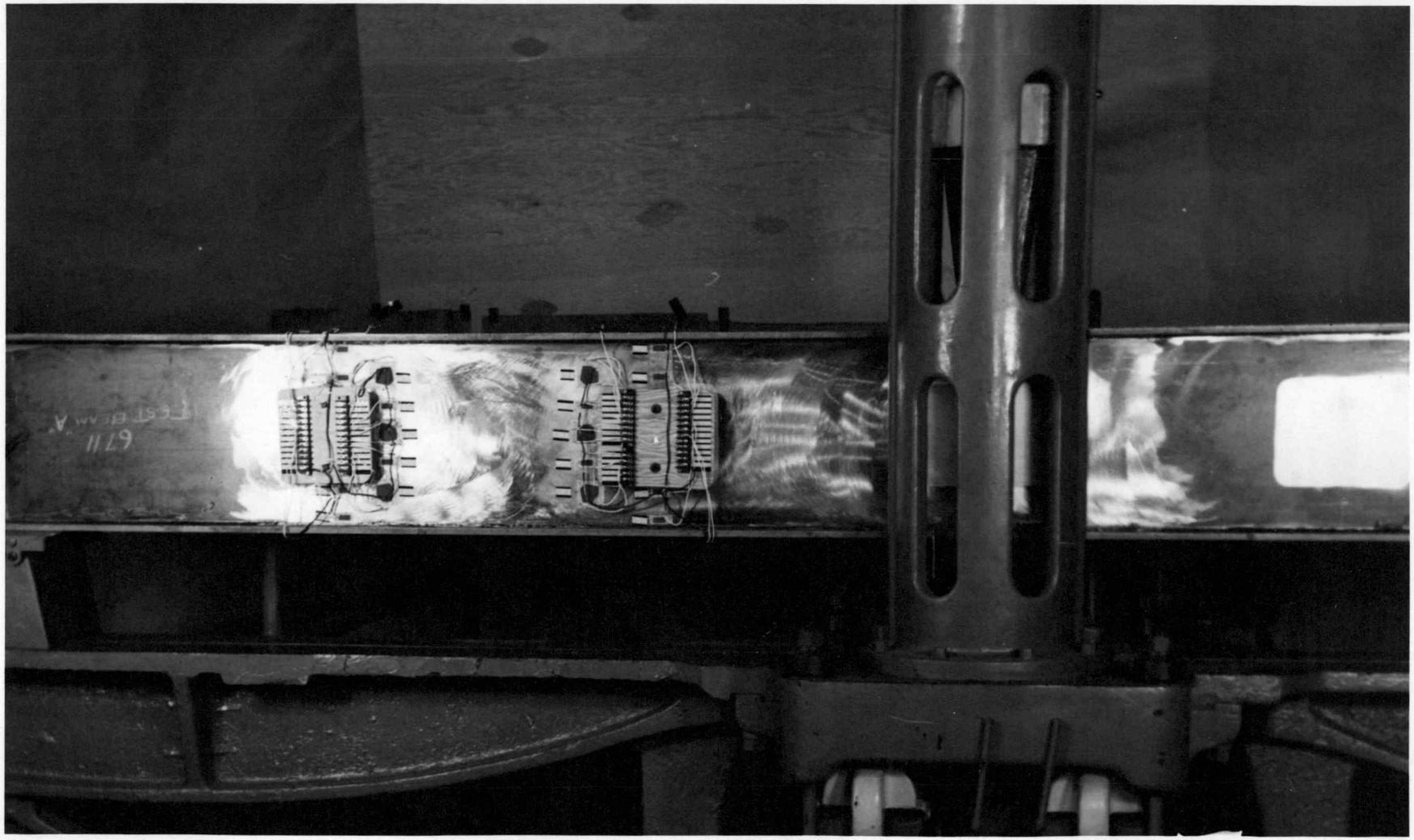


Figure 8. Solid-web I-beam in position in Rhiele Testing Machine.

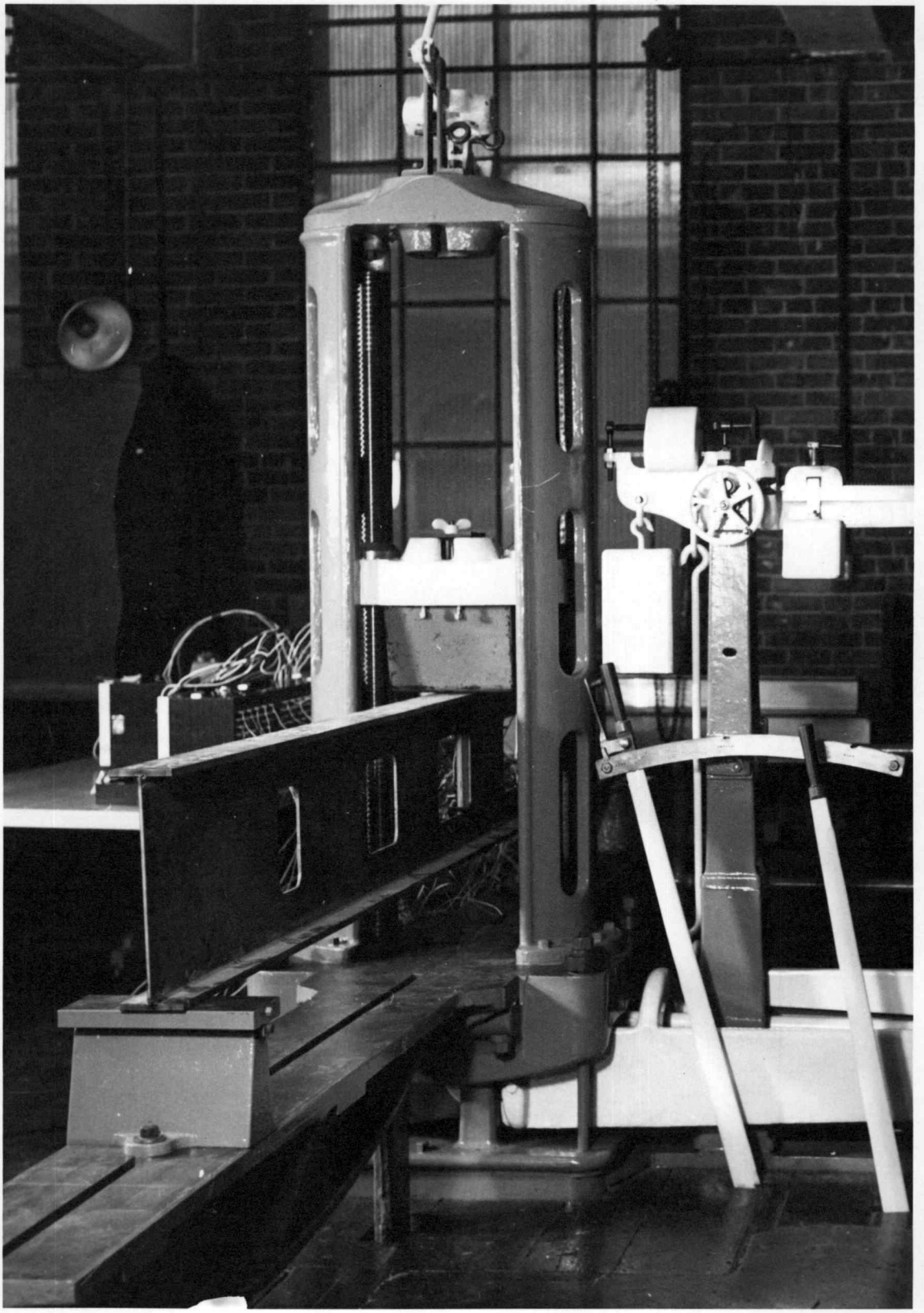


Figure 9. Beam with holes in position in Rhiele Testing Machine.

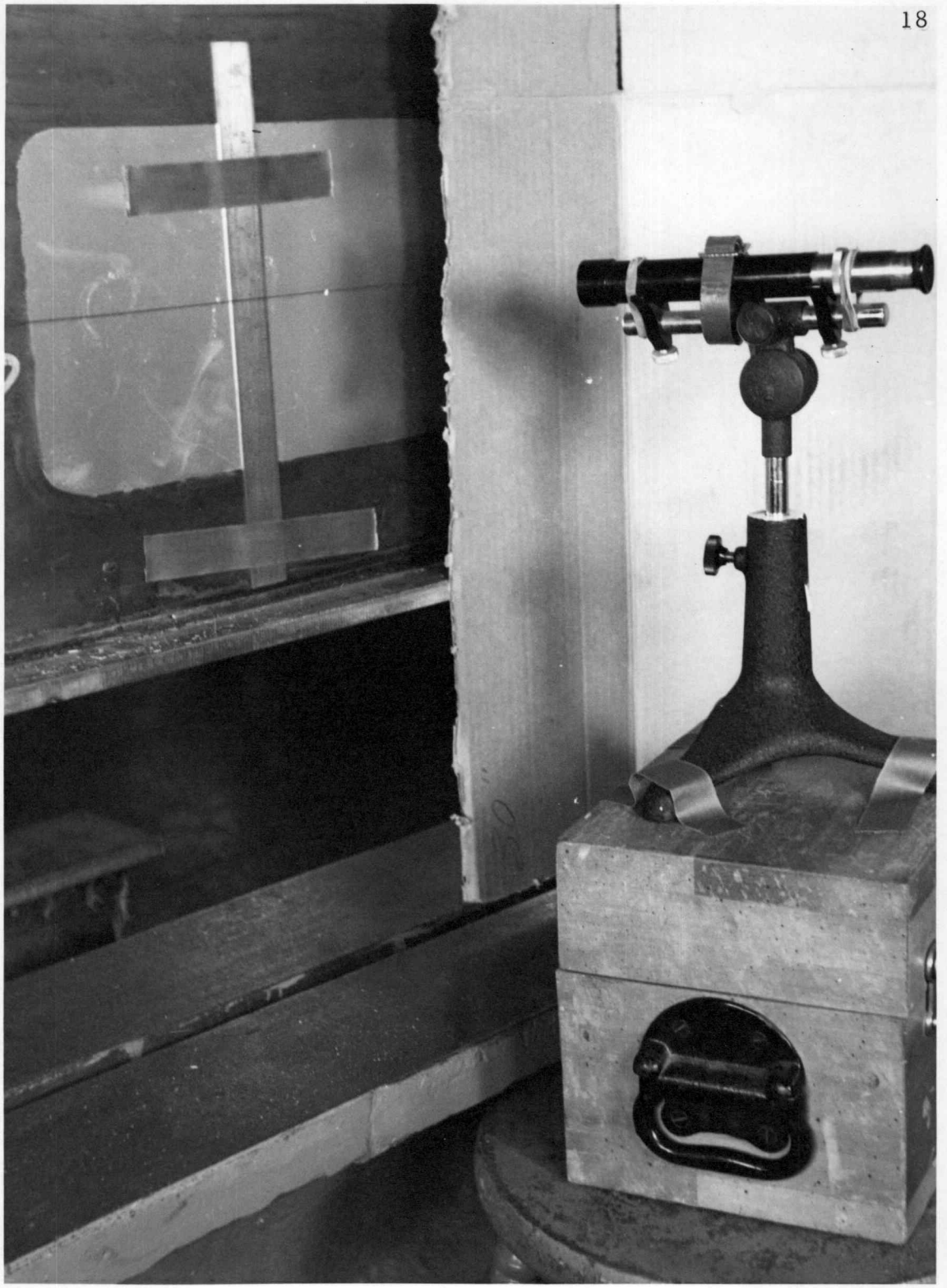


Figure 10. Method used for measurement of deflection at center of beam.

TEST PROCEDURE

Preliminary Test

The beams were placed in the testing machine, the control beam first then the perforated beam. Zero readings were taken for the strain gages. The loading was applied as follows: (1) a 1,000-lb. increment, (2) a 3,000-lb. increment, (3) 4,000-lb. increments to the nearest load below the maximum load that was evenly divisible by 4,000 required to bring load to the maximum allowable. The loads were held constant between increments and strain gage readings were taken. The deflection on the center point of the beam was also taken.

Final Test

The final test procedure was similar to the preliminary tests except that extra gages were added and the location of the application of the load was changed in order that the load influence on the strain readings on the gages would be minimized. In each test the predicted strain of the gage was calculated and compared to the strain recorded by the gage. The perforated beam was loaded to failure on the final test run.

DISCUSSION OF RESULTS

Solid Beam

Tables 1 to 36, inclusive (Appendix A) list the strain readings for each of the load increments on the solid beam. Tables 1, 2 and 3 illustrate the general agreement of the values of strains calculated using the formula $\varepsilon = \frac{My}{EI}$ with the strains measured for the same loads. Location of the gages is shown in Figure 6.

The strain readings with the loads at 38 in. and 35 in. from the supports as listed in Tables 2 and 3, respectively, were somewhat influenced by the proximity of the load. The strain readings in Table 1 with the load applied at the center of the span would be affected very little because of the greater distance the gages were removed from the load.

The discrepancies between the calculated strain and the measured strains are not proportional to the magnitude of the strains but are a unique percentage of the strain at each gage which indicates an error in the measuring equipment and/or a change in the response of the portion of the beam where the gage is located. These differences between the measured and calculated strains will be referred to again when discussing the perforated beam.

Table 1. Solid Beam - Load at Centerline.

Gage No.	Calculated Strain ($\times 10^{-6}$ in/in)	Run No. 1 Strain ($\times 10^{-6}$ in/in)	Run No. 3 Strain ($\times 10^{-6}$ in/in)
G-1	-215	-187	-183
G-2	-183	-162	-160
G-3	-125	-104	-103
G-4	+125	+ 96	+ 98
G-23	+215	+182	+177
G-8	-244	-210	-214
R-5-H	-142	-120	-124
G-7	- 71	- 70	- 63
R-4-H	0	0	- 12
G-6	+ 71	+ 57	+ 57
R-3-H	+142	+122	+122
G-24	+244	+205	+203
G-17	-383	-354	-348
R-8-H	-223	-200	-203
G-16	-111	-112	-105
R-7-H	0	0	- 12
G-15	+111	+ 82	+ 90
R-6-H	+223	+177	+190
G-26	+383	+333	+342
G-18	-429	-400	-391
G-19	-366	-353	-347
G-20	-250	-249	-242
G-21	+250	+197	+200
G-22	+366	+322	+328
G-27	+429	+380	+384

Table 2. Solid Beam - Load 38 in. From Each Support.

Gage No.	Calculated Strain ($\times 10^{-6}$ in/in)	Run No. 1 Strain ($\times 10^{-6}$ in/in)	Run No. 3 Strain ($\times 10^{-6}$ in/in)
G-1	-418	-362	-359
G-2	-355	-317	-318
G-3	-244	-209	-212
G-4	+244	+193	+193
G-5	+355	+303	+303
G-23	+418	+363	+365
G-8	-475	-409	-409
R-5-H	-277	-262	-260
G-7	-138	-140	-143
R-4-H	0	- 37	- 28
G-6	+138	+104	+105
R-3-H	+277	+208	+217
G-24	+475	+414	+417
G-17	-661	-562	-557
R-8-H	-386	-375	-381
G-16	-193	-182	-179
R-7-H	0	8	- 15
G-15	+193	+161	+165
R-6-H	+386	+325	+310
G-26	+661	+596	+600
G-18	-661	-587	-585
G-19	-562	-522	-522
G-20	-386	-371	-370
G-21	+386	+308	+310
G-22	+562	+502	+500
G-27	+661	+613	+600

Table 3. Solid Beam - Load 35 in. From Each Support.

Gage No.	Calculated Strain ($\times 10^{-6}$ in/in)	Run No. 1 Strain ($\times 10^{-6}$ in/in)	Run No. 3 Strain ($\times 10^{-6}$ in/in)
G-1	-452	-392	-400
G-2	-385	-343	-353
G-3	-264	-227	-240
G-4	+264	+210	+209
G-5	+385	+330	+329
G-23	+452	+397	+397
G-8	-515	-440	-450
R-5-H	-300	-288	-300
G-7	-150	-153	-163
R-4-H	0	- 27	- 35
G-6	+150	+120	+117
R-3-H	+300	+240	+240
G-24	+515	+454	+457
G-17	-660	-579	-571
R-8-H	-384	-376	-390
G-16	-192	-194	-193
R-7-H	0	- 29	- 17
G-15	+192	+154	+153
R-6-H	+384	+312	+323
G-26	+660	+593	+605
G-18	-660	-589	-587
G-19	-560	-522	-520
G-20	-384	-367	-360
G-21	+384	+305	+301
G-22	+560	+495	+495
G-27	+660	+590	+592

Beam With Holes - First Set of Tests

Tables 37 to 76, inclusive (Appendix A), list the strain readings for each of the load increments on the perforated beam with the loads applied 35 in. and 38 in. from the supports. A study of the strains measured on the beam produced no analytic approach to predict the measured values. It was decided that the concentrated loads in the immediate vicinity of the holes were adding another variable in addition to the shear and bending moment on the section and therefore at least one of these effects should be minimized or eliminated.

Tables 77 to 100, inclusive (Appendix A) list the strain readings for each load increment with the load applied at the center of the span. Table 4 shows the strains calculated from the formula $\varepsilon = \frac{My}{EI}$ and the measured strains for the three test runs with the above loading. Location of the gages is shown in Figures 3 and 4.

Gages G-1, G-23, G-18 and G-27, located on the top and bottom flanges on the centerlines of the 5-in. and 9-in. holes, respectively, show good agreement between the solid beam and the perforated beam.

This was predictable because the gages are located on the hypothesized line of inflection at mid-point of the tee sections spanning the hole as shown in Figure 11. Therefore the shear will cause no bending moment at this section and the total strain will result from the bending moment caused by the applied load. This is the same condition

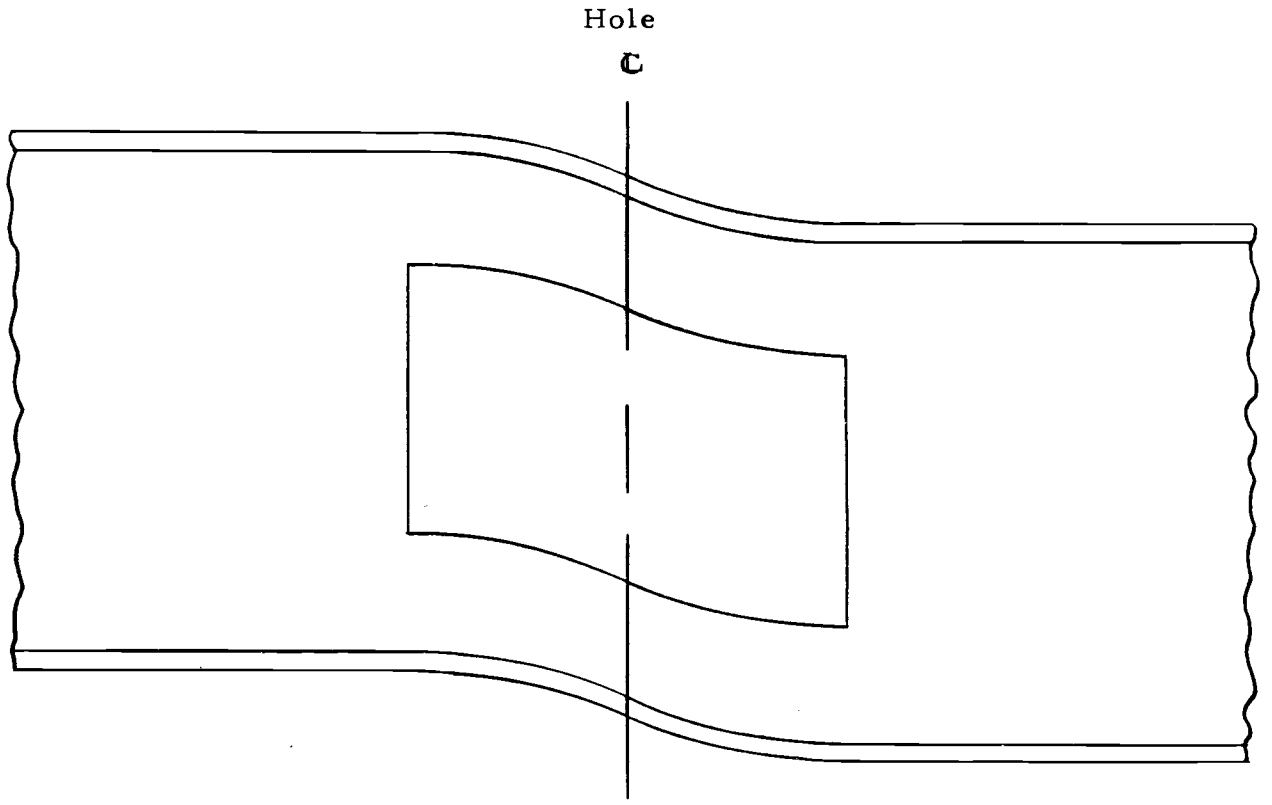


Figure 11. Assumed deflected shape (exaggerated) of the hole caused by shear. The centerline marks the inflection line of the curve.

as for similar gages on the solid beam and the strains should differ only in proportion to the reduction in the moment of inertia of the section caused by the hole. The moment of inertia of the solid beam is 268.25 in.^{4} and the perforated beam is 259.46 in.^{4} which is a reduction equal to 3.28% of the moment of inertia of the solid beam.

Gages G-2, G-5, G-19 and G-22 (see Table 4) also show similar agreement with calculated values on the two beams. As stated above, these gages are also located on the hypothesized line of inflection and therefore are only affected by the bending moment produced by the applied loads.

Gages G-3, G-4, G-20 and G-21 show no greater differences between the calculated and the measured strains on the perforated beam than on the solid beam. These gages are again located on the assumed line of inflection. They are located further from the neutral axis of the tee section than the two other gages discussed above and therefore would be more sensitive to the effect of the hole if the line of inflection were not directly on the centerline of the hole as was assumed. A slight change in the inflection line could be caused by the permitted variations in the dimensions of the beam and/or by the irregularities in the surface around the hole. This is common when an oxygen cutting torch is used.

Gages G-8 and G-24 on the solid beam show agreement between calculated and measured strain values similar to many of the other

gages on this beam. On the contrary, these gages on the perforated beam show measured values greater than the calculated values. This is rationalized as being caused by the effect of the shear acting at the center of the hole which in this instance would cause added compression on G-8 and added tension on G-24. An analytic method for predicting these strains is not presented because the gages are located in the area where the effective section is transforming from the tee section above and below the hole to the solid web section at some distance removed from the hole. There were not enough strain readings to plot the strain pattern in this transformation area.

Gages R-5-H and R-3-H, which are the horizontal arms of the respective rosettes, show similar discrepancies between the calculated and measured strain values. These discrepancies were predicted as it was hypothesized that the shear acting at the center of the hole would cause tension on R-5-H, cancelling a portion of the tension caused by the bending moment. The measured strains of R-5-H show a slight predominance of the bending moment effect as the measurement was negative (average measurement was -16×10^{-6} in./in.) and the measured strains of R-3-H show the shear effect to be the largest as the measurement was also negative (average measurement was -40×10^{-6} in./in.). In these instances, as above, the hypothesis of the cause of these strains is supported by the measured values.

Gages R-1-H and R-2-H were not on the solid beam. The

measured strains on the perforated beam further confirm that the shear acting at the point of inflection at the center of the hole is the second contributing cause to the total strain. The first is the total bending moment on the section. Gage R-1-H would have compression strain caused by the bending moment and compression strain caused by the shear. The measured strain was much larger than the strain calculated from the bending moment on the section (calculated strain was -105×10^{-6} in./in. and the average measured strain was -225×10^{-6} in./in.). Gage R-2-H would have both the strain caused by bending moment and the strain caused by shear as tension. The measured strain in this instance also was much greater than the strain calculated from the bending moment (calculated strain was -109×10^{-6} in./in. and the average measured strain was -209×10^{-6} in./in.).

Gages G-7 and G-6 show comparable values for the calculated and measured strains on the solid beam. On the other hand, these gages measured very nearly zero on the perforated beam. This was attributed to their proximity to the vertical edge of the hole. The strain conditions of these points are similar to the conditions in the web material adjacent to the vertical edge at the free end of a beam.

Gages R-4-H and R-7-H are at the neutral axis of the beam and therefore the calculated strain for both beams was zero. The measured strains in all instances were zero or very small.

Gages G-9 and G-25 were placed only on the perforated beam. They are located 4. 75 in. from the edge of the 9-in. hole. In all instances, the measured strain values differ from the strain values calculated for a solid beam such that the differences could be explained by the Vierendeel theory (11, p. 145, 146).

Gages G-10 and G-13 were also placed only on the perforated beam. The measured strains on both these gages also could be explained as being caused by the bending moment and the shear applied at the center of the hole length. The gages are also in the transformation area and therefore no strain was calculated.

Gages G-11 and G-13 were placed only on the perforated beam. Both gages indicate measured strain values which could be explained by the application of the shear force as described above.

The remainder of the gages listed in Table 4 conform well to the hypothesis described previously for gages in similar locations relative to the holes. Because most of these gages were located in the area of the beam where the effective section was somewhere between the tee section above and below the holes and the solid web of the beam no strains were calculated.

Beam With Holes - Second Set of Tests

Inspection of the strains of the first set of tests indicated that two loading conditions could be used to calculate the strains in an

Table 4. Beam With Holes - Load at Centerline.

Gage No.	Calculated Strain ($\times 10^{-6}$ in/in)	Run No. 1 Strain ($\times 10^{-6}$ in/in)	Run No. 2 Strain ($\times 10^{-6}$ in/in)	Run No. 3 Strain ($\times 10^{-6}$ in/in)
G-1	-215	-180	-181	-183
G-2	-183	-155	-162	-163
G-3	-126	-142	-145	-139
G-4	126	133	138	139
G-5	183	149	156	158
G-23	215	158	168	167
R-1-H	-105	-230	-216	-230
R-2-H	109	203	217	208
G-8	-236	-295	-300	-302
R-5-H	-138	- 15	- 16	- 17
G-7	- 69	- 16	- 17	- 17
R-4-H	0	- 13	- 19	- 13
G-6	69	- 3	- 2	- 4
R-3-H	138	- 45	- 35	- 40
G-24	236	269	285	288
G-9	-336	-284	-284	-284
G-10	-196	-262	-260	-267
G-11	- 98	-137	-140	-139
G-12	0	3	0	3
G-13	98	137	150	146
G-14	196	245	252	257
G-25	336	265	272	275
G-17	-371	-218	-224	-224
R-8-H	-216	-458	- 50	-459
G-16	-108	- 40	- 41	- 43
R-7-H	0	- 20	- 10	- 22
G-15	108	23	28	27
R-6-H	216	439	443	447
G-26	371	192	200	200
G-18	-431	-361	-359	-364
G-19	-366	-340	-341	-341
G-20	-252	-290	-288	-289
G-21	252	245	254	255
G-22	366	339	340	338
G-27	431	367	368	373
R-10-H	-269	- 8	- 3	- 9
R-9-H	269	-103	- 90	-102

I-beam with holes cut in the web (11, p. 145, 146). The following are descriptions of the two calculations:

(1) First, the strain at any point caused by the bending moment at the center of the hole can be calculated from the formula,

$$\varepsilon = \frac{My}{EI},$$

where ε -horizontal strain at that point caused by the bending moment;

M -the bending moment at that center of the hole;

y -distance of point from the neutral axis of the beam;

E -Young's Modulus for the material;

I -the moment of inertia of the section about the neutral axis.

(2) Second, the strain at the point caused by the shear across the span of the hole. The following hypotheses are made: (a) Because the cross-sections above and below the holes are identical, one-half of the shear at the section will be carried by each of the top and bottom tee-beams, respectively. (b) Because the tee-sections are uniform along the span of the holes, the point of inflection will be at the center of the span of the hole in each instance. (c) Each

section of the tee beams above and below the holes is considered a cantilever beam whose length is one-half the span of the hole with a force equal to one-half the shear on the section acting at the free end. The proper direction of the shear force in each instance is assigned to each of the four cantilever beams. This theory was presented by Roark (11, p. 145, 146).

To check this thoery, strain gages G-28 to G-39, inclusive and rosettes R-11 to R-14, inclusive, were placed on the perforated beam in the locations shown in Figures 2, 3 and 4. The load was applied at midspan.

The following is a sample calculation of the predicted total horizontal strain at G-29 for a load of 20 kips at the centerline. The strain attributed to the bending moment on the section $\varepsilon_1 = \frac{M_1 y}{EI_2}$,

where ε_1 = the strain;

M_1 = the bending moment at the centerline of the hole;

y = the distance from the neutral axis of the I-beam to G-29;

I_2 = the moment of inertia of the I-beam through the hole;

E = Young's Modulus for the steel = 29×10^3 ksi.

$$\varepsilon_1 = \frac{225 \text{ kip in.} \times 4.25 \text{ in.}}{29.00 \times 10^3 \frac{\text{kips}}{\text{in.}^2} \times 259.46 \text{ in.}^4} = 127.0 \times 10^{-6} \frac{\text{in.}}{\text{in.}}$$

ε_1 is the compression and therefore is negative.

$\varepsilon_1 = .127.0 \times 10^{-6}$ in./in.

The strain attributed to the shear on the section $\varepsilon_2 = \frac{M_2 y}{EI_3}$

where ε_2 - the strain;

M_2 - the bending moment in the tee section above the hole caused by the shear, whose value is the product of one-half the shear at this section of the beam multiplied by the distance from the centerline of the gage to midspan of the hole;

y - the distance from the neutral axis of the tee section above the hole to G-29;

I_3 - the moment of inertia of the tee section above the hole;

E - Young's Modulus for the steel = 29×10^3 ski.

$$\varepsilon_2 = \frac{5.0 \text{ kips} \times 1.5 \text{ in.} \times 2.46 \text{ in.}}{29 \times 10^3 \frac{\text{kips}}{\text{in.}^2} \times 2.79 \text{ in.}^4} = -228 \times 10^{-6} \frac{\text{in.}}{\text{in.}}$$

Therefore calculated horizontal strain at G-29 equals the algebraic sum of $\varepsilon_1 + \varepsilon_2$

$$= -127 - 228 = -355.0 \times 10^{-6} \frac{\text{in.}}{\text{in.}}$$

The strains measured for G-29 were as follows

Run #1, -33×10^{-6} in./in.

Run #2, -333×10^{-6} in./in.

Tables 101 to 120, inclusive (Appendix A), list the strain readings of the gages on the perforated beam with the load at the centerline. Table 5 shows a comparison of the strains calculated using the procedure described for G-29 and the measured strains taken from the tables for the two test runs.

The following is a discussion of the calculated and measured strains for each of the gages listed in Table 5. The calculated and measured strains of gages G-29, G-30, G-33, G-34 and the horizontal arm of rosettes R-11-H, R-12-H and R-13-H and R-14-H, check within the tolerance achieved with the solid beam. This agreement was hypothesized to result from gages being located such that the tee beams above and below the holes acted as true cantilever beams.

The remainder of the gages were affected by their close proximity to the solid portion of the web. In each case the strain caused by the shear was reduced indicating that a greater section than that of the tee was resisting the secondary moment due to shear at these points.

To verify this supposition, gages G-40 to G-53, inclusive, and rosettes R-15 to R-18, inclusive, were placed around the center hole as shown in Figure 5. Tables 121 to 132, inclusive (Appendix A), list the strains on these gages for three test runs. Table 106 shows a comparison of calculated and measured strains.

From the results of the previous tests, it was predicted that

Table 5. Beam With Holes - Load at Centerline.

Gage No.	Calculated Strain ($\times 10^{-6}$ in/in)	Run No. 1 Strain ($\times 10^{-6}$ in/in)	Run No. 2 Strain ($\times 10^{-6}$ in/in)
G-28	-261	-170	-170
G-29	-355	-333	-333
G-30	+355	+353	+354
G-31	+261	+150	+149
G-32	-106	-185	-185
G-33	+ 84	+ 38	+ 35
G-34	- 84	- 90	- 81
G-35	+106	+155	+153
G-36	-548	-443	-436
G-37	+548	+400	+400
G-38	-186	-273	-278
G-39	+186	+243	+238
R-11-H	-794	-748	-748
R-12-H	+784	+793	+803
R-13-H	+241	+163	+156
R-14-H	-241	-227	-232

gages R-15-H and R-18-H would show large discrepancies between calculated and measured values as these gages are in the transformation area and therefore something greater than the assumed tee section would be resisting the secondary moment due to shear. This proved to be true for both cases.

Previous tests indicated that the above theory should give reasonably accurate results for gages G-51 and G-48. Table 6 shows this to be the case as the difference between thecalculated and measured values are within the range of differences on the solid beam.

Gages G-52, G-40, G-41, G-42, G-43 and G-49 are all 3-1/2 in. from the end of the cantilever beam and therefore the section acting in each instance should be the cross-section of the tee, as is assumed in the calculations. Table 6 shows agreement between calculated and measured strains within the expected limits in all instances.

Gages G-53, G-44, G-45, G-46, G-47 and G-50 are all located along the centerline of the hole and are therefore assumed to be on the line of inflection. The strains are assumed to be caused only by the bending moment resulting from the applied loads. Table 6 lists the calculated and measured strains for two test runs. Gages G-53 and G-50 show a slightly greater discrepancy between the calculated and measured strains than gages in similar locations

Table 6. Beam With Holes - Load 4 Ft. From Right End.

Gage No.	Calculated Strain ($\times 10^{-6}$ in/in)	Run No. 1 Strain ($\times 10^{-6}$ in/in)	Run No. 2 Strain ($\times 10^{-6}$ in/in)	Run No. 3 Strain ($\times 10^{-6}$ in/in)
G-51	-295	-263	-260	-260
R-15-H	-562	-431	-431	-429
R-16-H	-791	-702	-708	-702
R-17-H	+791	+752	+747	+752
R-18-H	+562	+439	+435	+442
G-48	+295	+248	+251	+253
G-52	-398	-341	-342	-339
G-40	-473	-480	-486	-476
G-41	-538	-562	-572	-559
G-42	+538	+527	+523	+533
G-43	+473	+448	+441	+446
G-49	+398	+342	+344	+341
G-53	-500	-439	-436	-432
G-44	-383	-358	-367	-358
G-45	-283	-316	-328	-316
G-46	+283	+286	+286	+290
G-47	+383	+364	+364	+366
G-50	+500	+434	+436	+438

on the solid beam. This was attributed to the possibility that the actual point of inflection was slightly off the centerline. The holes and the one inch radius corners were burned and there were slight imperfections in the surface of the cut. These could cause the inflection point to vary slightly from the assumed centerline of the span of the hole. Gages G-44 and G-47 show agreement between calculated and measured values within the discrepancies obtained on the solid beam. The horizontal arms of rosettes R-16-H and R-17-H also show discrepancies between the calculated and measured strains no greater than some of the gages on the solid beam with strains of similar magnitude. This indicates that the aforedescribed theory can be used to predict strains in the area at the edge of the hole where the effect of the shear is a maximum.

Tables 133 to 143, inclusive (Appendix A), list the strains for the final test run on the perforated beam. The load was applied four feet from the right support and was increased until the beam failed. The beam failed by lateral buckling of the compression flange as can be seen in Figure 12. The failure did not occur until much of the beam was in the state of yield as is shown by the strain readings.

The gage readings and the calculated strains, using the aforedescribed theory, showed no greater discrepancies than similar readings on the solid beam and in other tests on the perforated one while all the strains were within the limits permitted in design. The

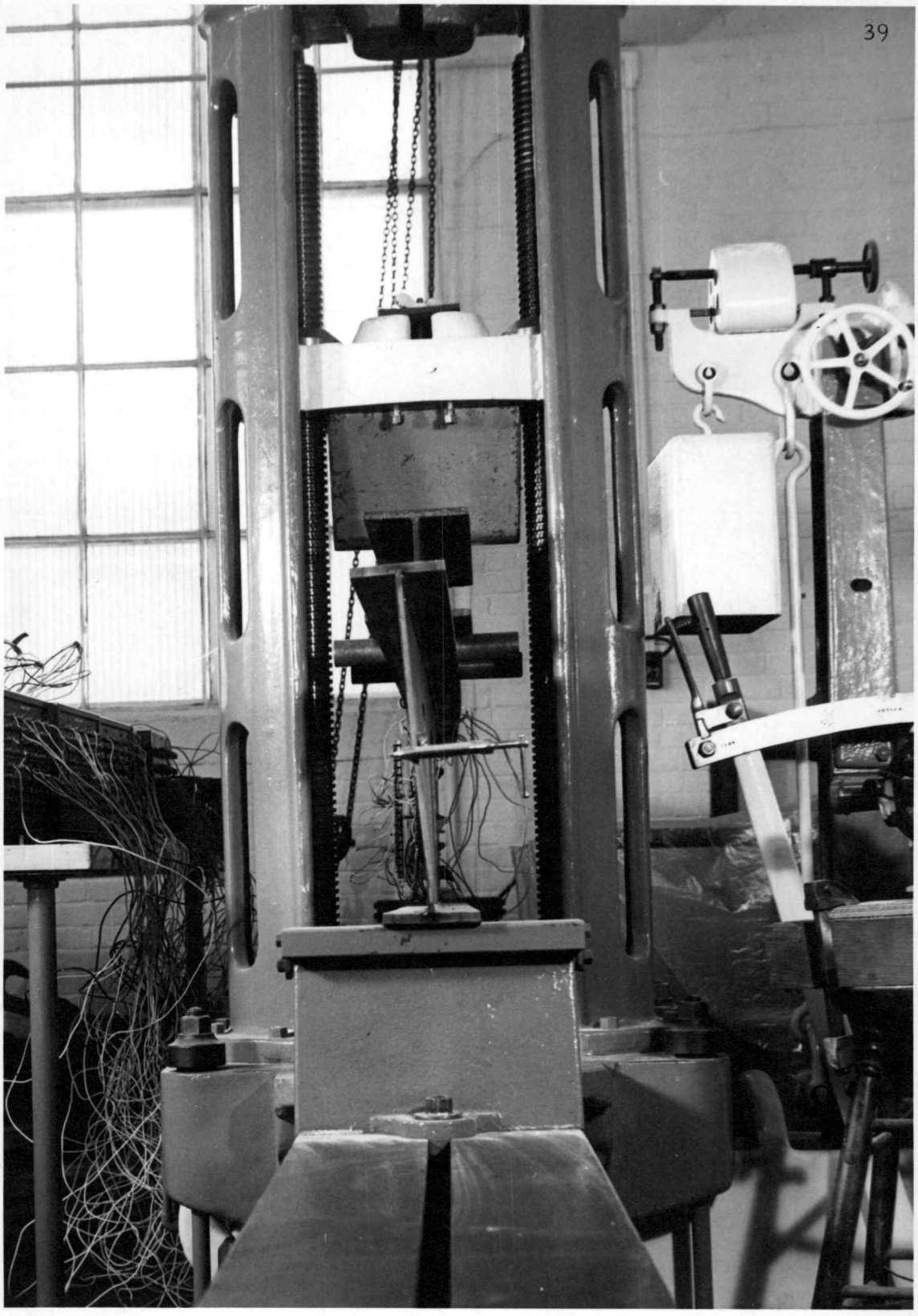


Figure 12. Beam with holes showing buckling of the top flange at failure load.

applied load and the strains maintained close to a straight line relationship up to a load of 26, 500 lbs. When the load reached 26, 500 lbs., the increase in strain became larger in proportion to the increase in load. The measured strain of R-16-H at this load was 1095. x 10^{-6} in/in. The comparable calculated strain was 1007. x 10^{-6} in/in. The measured strain of R-16-H at an applied load of 26, 000 lbs. was 919. x 10^{-6} in. /in.

The yield point for the A-36 steel used in the beam is at a strain of 1241. x 10^{-6} in. /in. Therefore it was rationalized that at a load of 26, 500 lbs., a portion of the web in the immediate vicinity of the corners of the hole closest to R-16-H reached this yield value. The calculated strain at the edge of the hole below R-16-H and at three-quarters of an inch from the vertical face of the hole (see Figure 5), was 1143. x 10^{-6} in. /in.

The increase in strain per increment increase in load became larger as the yield strain was reached and exceeded. After the material at R-16-H had yielded to approximately 2000. x 10^{-6} in. /in., the proportion of strain per load increment decreased. This was attributed to an increase in the strength of the steel due to strain hardening.

When the section through R-16-H began to yield, the following effects were hypothesized: (1) The line of inflection moved away

from the centerline of the hole toward R-16-H. (2) This movement of the line of inflection decreased the stiffness of the upper tee section and thus increased the proportion of the shear carried by the lower tee section.

These hypotheses were supported by the strain readings of R-17-H. Before R-16-H began to yield, the strain of R-16-H and R-17-H were, except for proportional discrepancies as were found on other gages, the same. After R-16-H began to yield, the strain of R-17-H did not increase as quickly as the strain of R-16-H, but increased faster than before R-16-H reached the yield strain. The comparative values of strain for gages R-16-H and R-17-H at a load of 40,000 lbs. were 5080. x 10^{-6} in./in. and 1675. x 10^{-6} in./in., respectively.

When the material at the bottom of the tee section through R-16-H began to yield, it was rationalized that the neutral axis of the tee section would tend to move up which would increase the proportional strain increase of R-15-H. This proved to be true as the rate of strain per unit of load increased after yielding began at the section.

R-11-H and R-12-H were in similar locations around the 9-in. hole as were R-16-H and R-17-H around the 12-in. hole. (See Figures 4 and 5.) R-11-H began to yield at a load of 35,000 lbs. The calculated strain at a point at the edge of the hole three-quarters of an inch from the vertical edge of the hole, was 1058. x 10^{-6} in./in.

The strain at the same relative point below R-16-H when it began to yield was 1143. x 10^{-6} in./in. The calculated and measured strains at R-11-H with a load of 33,000 lbs. were 884. x 10^{-6} in./in. and 976. x 10^{-6} in./in., respectively. The calculated and measured strains with a load of 35,000 lbs. were 937. x 10^{-6} in./in., and 1490. x 10^{-6} in./in., respectively.

The discrepancies between the calculated and measured strains for R-11-H and R-16-H are similar; i.e. at a load of 33,000 lbs. the difference between the calculated and measured strains for R-11-H is 92. x 10^{-6} in./in. and at a load of 26,500 lbs. the difference between the calculated and measured strains for R-16-H is 88. x 10^{-6} in./in. It was rationalized that changes in the line of inflection, due to dimension variations in the material and/or imperfections around the edge. of the hole, would produce an error independent of the width of the hole; i.e., proportional only to the distance the actual inflection line was from the centerline of the hole.

As was hypothesized with R-16-H when the section at R-16-H began to yield, there should have been an increase in the strain at R-13-H per increment of load. An inspection of the strains in Tables 139 and 141 (Appendix A), shows this to be the case. Also, an increase in the strain load increment ratio was predicted for R-12-H and R-14-H. Tables 141 and 142 (Appendix A) show this prediction supported by the strain readings.

Vertical Deflections of Beams at Midspan

Figure 10 shows the telescope used to measure the deflection of the beams at midspan. The steel rule mounted on the centerline of the beam was graduated in hundredths of an inch; therefore the deflection readings were limited to this accuracy.

Tables 7, 8 and 9 list the calculated deflection for the solid beam, the measured deflection for the solid beam, and the measured deflection for the perforated beam. All three deflection values show close agreement in most instances. Where there is a discrepancy the deflection of the perforated beam is the greater. This was expected because of the increased strains recorded on the perforated beam. The effect of the holes in the web on the deflection was not verified by calculating the deflection using the hypothesized theory because the significant figures of the measured deflection were not sufficient to show the increased deflection caused by the holes.

Table 7. Deflection of Beam at Midspan - Load at 35" from Each of the Supports.

Load (lbs.)	Deflections Calculated (in.)	Solid Beam		Beam with Holes	
		Run No. 1 (in.)	Run No. 2 (in.)	Run No. 1 (in.)	Run No. 2 (in.)
0	0.0000	0.00	0.00	0.00	0.00
1,000	0.0054	0.01	0.01	0.01	0.01
4,000	0.214	0.02	0.02	0.02	0.02
8,000	0.0428	0.04	0.04	0.04	0.04
12,000	0.0642	0.06	0.06	0.06	0.06
16,000	0.0856	0.08	0.08	0.08	0.08
20,000	0.1070	0.10	0.11	0.10	0.10
24,000	0.1284	0.12	0.12	0.12	0.12
28,000	0.1498	0.15	0.15	0.15	0.15
32,000	0.1712	0.17	0.17	0.17	0.17
36,000	0.1926	0.19	0.19	0.19	0.19
40,000	0.2140	0.21	0.21	0.21	0.22

Table 8. Deflection of Beam at Midspan - Load Applied at Centerline of Beam.

Load (lbs.)	Deflections Calculated (in.)	Solid Beam		Beam With Holes	
		Run No. 1 (in.)	Run No. 2 (in.)	Run No. 1 (in.)	Run No. 2 (in.)
0	0.0000	0.00	0.00	0.00	0.00
2,000	0.0160	0.01	0.01	0.02	0.02
4,000	0.320	0.03	0.02	0.04	0.04
6,000	0.0480	0.05	0.04	0.06	0.06
8,000	0.0640	0.06	0.06	0.07	0.08
10,000	0.0800	0.08	0.08	0.09	0.09
12,000	0.0960	0.10	0.10	0.11	0.11
14,000	0.1120	0.12	0.12	0.13	0.13
16,000	0.1280	0.13	0 14	0.15	0.15
18,000	0.1440	0.15	0.16	0.17	0.17

Table 9. Deflection of Beam at Midspan - Load at 38" from Each of the Supports.

Load (lbs.)	Deflections Calculated (in.)	Solid Beam		Beam With Holes	
		Run No. 1 (in.)	Run No. 2 (in.)	Run No. 1 (in.)	Run No. 2 (in.)
1,000	0.0000	0.00	0.00	0.00	0.00
4,000	0.0172	0.02	0.02	0.02	0.02
8,000	0.0402	0.04	0.04	0.04	0.04
12,000	0.0632	0.07	0.07	0.07	0.07
16,000	0.0862	0.09	0.09	0.09	0.09
20,000	0.1092	0.11	0.11	0.12	0.11
24,000	0.1322	0.14	0.14	0.14	0.14
28,000	0.1552	0.16	0.16	0.16	0.16
32,000	0.1782	0.18	0.18	0.19	0.19
36,000	0.2012	0.21	0.21	0.21	0.21
37,000	0.2069	0.21	0.21	0, 22	0.22
1,000	0.0000	0.00	0.00	0.00	0.00

CONCLUSIONS

The results of the experiments support the following theory for predicting the strains in an I-beam with holes cut in the web.

The calculated strains above and below the holes can be obtained by adding algebraically the strain caused by each of the following two loadings (11, p. 145, 146).

(1) The strain calculated from the formula $\varepsilon = \frac{My}{EI}$, where

ε is the required strain;

M is the bending moment at the point of inflection which for these tests is at the center of the span of the rectangular holes;

y is the distance from the neutral axis to the point in question;

E is Young's Modulus for the beam material;

I is the moment of inertia of the beam cross-section through the above point about the neutral axis.

(2) The strain resulting from one-half the shear at the section acting at the center of the span of the hole. This results in a cantilever beam whose length is one-half the width of the hole and which has a force equal to one-half the shear at that section acting on the end of the cantilever. The proper direction of the shear force must be assigned to each

cantilever. The formula used to calculate the strain is the same as (1) but in this instance,

ε is the required strain;

M is the bending moment caused by the appropriate proportion of the shear force acting at the point of inflection above or below the hole which for these tests is the product of one-half the shear and the horizontal distance the section in question is from the center of the hole;

y is the distance of the point in question from the neutral axis of the tee section;

E is Young's Modulus of the material in the beam;

I is the moment of inertia of the tee section.

The investigation showed that the strain in the immediate vicinity of the vertical sides of holes is negligible and therefore no reinforcing is required in this area. The area of increased strain is the sections above and below the holes and adjacent to the fixed ends of the cantilever beams described above. Therefore if reinforcing is required around a hole, it should be attached along the edge of the cantilever sections adjacent to the hole and should extend onto the solid web of the beam where the cantilever effect has increased the strain.

Figure 13 shows a suggested location of the above reinforcing. The bars extend a distance equal to one-half the width of the hole

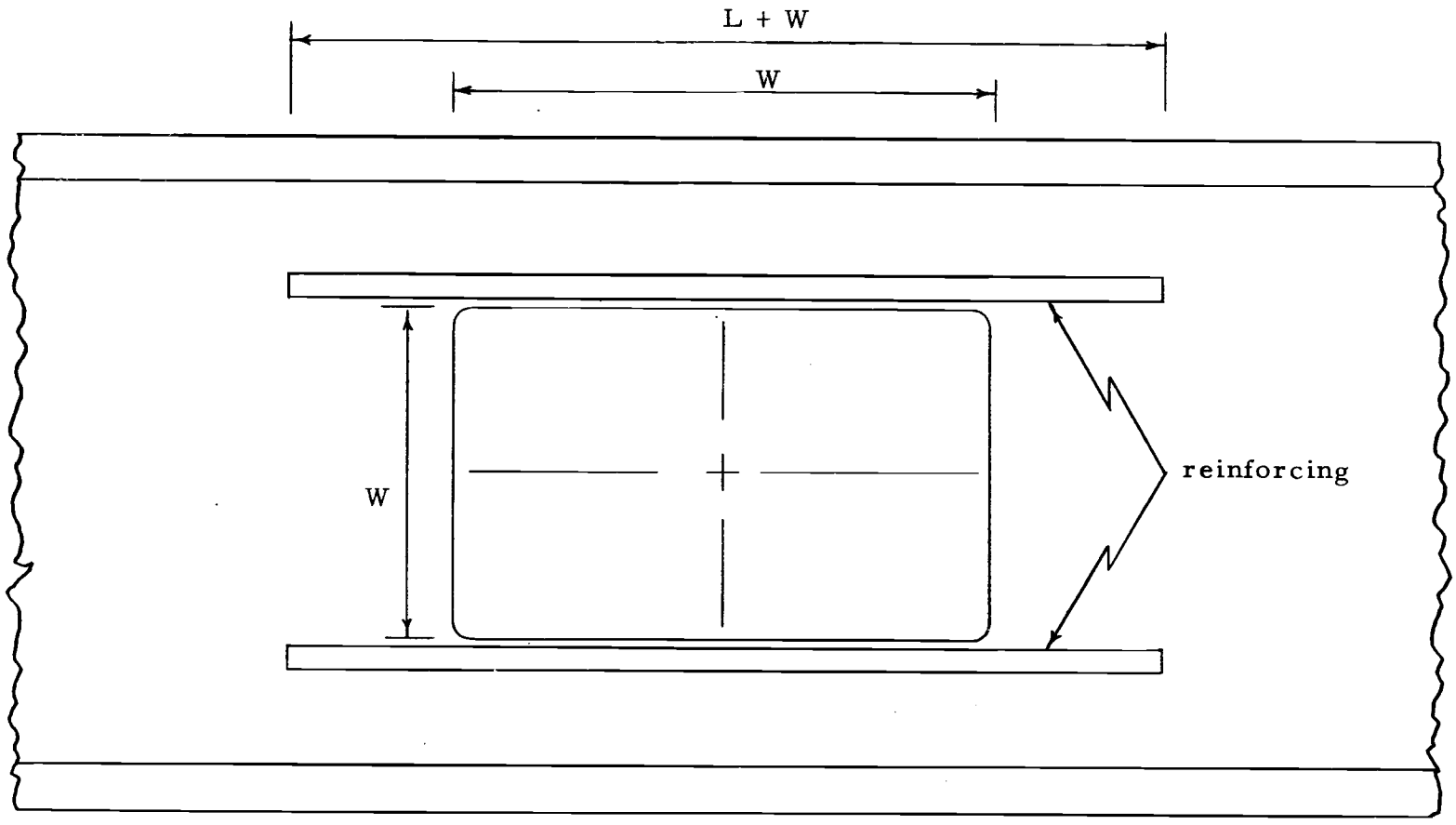


Figure 13. Location and length of suggested reinforcing around a hole in the web of an I-beam.

beyond the edges of the hole. Square bars were used in this example. The size of the reinforcing should be chosen so that the hole does not reduce the carrying capacity of the beam. Verification of the reinforcing required around rectangular holes in I-beams is outside the scope of this investigation. However, two investigations were undertaken to assess the most effective location of reinforcing around rectangular holes in steel I-beams (see 9 and 12).

It was expected that the corners of the holes would act as strain risers but the one inch radius fillets must have compensated for this effect. None of the gages located in the closest proximity of the corners reflected the expected increase. Bower (9) and Redwood (15) noted the strain increase in the proximity of the corners but the radii of the fillets at the corners of the holes in the webs of their test beams were one quarter inch and three sixteenths of an inch respectively.

The following are suggested investigations that could be conducted to learn more about strains in the proximity of the corners of holes. I-beam shapes made of lucite could be tested to study the strain patterns using photoelasticity. Then steel I-beams could be instrumented and tested to confirm the strain patterns and establish more precise magnitudes.

A suggested procedure for predicting stresses caused by unsymmetrical holes in I-beams is described under 'Recommendations' in Appendix A.

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APPENDIX

APPENDIX A

RECOMMENDATIONS

A suggested procedure for predicting stresses caused by unsymmetrical holes in I-beams is as follows. The theory assumes that there is a point of inflection in the span of the hole and at this point the shear acts on the cantilever beams of remaining material spanning the hole. This theory is reasonably supported by all the tests run in this investigation. If the horizontal centerline of the hole is coincident with the centerline of the I-beam and if the remaining portions above and below the hole are uniform and identical, as is the case in this investigation, the inflection point should be at the center of the hole and each of the top and bottom tee beams should carry one-half the shear at the section.

For the condition that the top and bottom sections are not uniform over the length of the hole and that the top and bottom sections are not identical, a suggested approach to the solution is as follows:

(1) Because it is known that at the point of inflection the angle change, representing the rotation of the vertical cross-section of the beam, will be equal when the change is calculated from either fixed end, this equality can be used to find the point of inflection. It is assumed in this analysis, as is assumed in the prior investigation, that the ends of the cantilever beams are fixed at the solid web section. The angle change considered is that caused by the moment due to

the shear acting across the span of the hole. The value of the shear force acting on the cantilever beams cancels out when equating the two angle changes and therefore its value does not have to be known at this point. See the example at the end of this section.

(2) To find the proportion of the total shear at the section carried by each of the remaining portions of the beam above and below the hole, respectively, consider the total deflection of the remaining portions of the beam above and below the hole to be equal. When calculating the deflections, let the shear force acting on the sections above and below the hole equal P and V, respectively. Equate the two deflections and calculate the value of P in terms of V. Next, the values of P and V, the shear force carried by the sections above and below the hole, respectively, can be found.

(3) Apply the values of the shear found in (2) at the inflection points found in (1) and thus find the additional flexure stress caused by the hole.

(4) Algebraically add the stress found in (3) to the stress caused by the bending moment resulting form the external loads.

The following example illustrates an application of the above procedure. Figure 14 shows the dimensions of the hole in a 15-in.

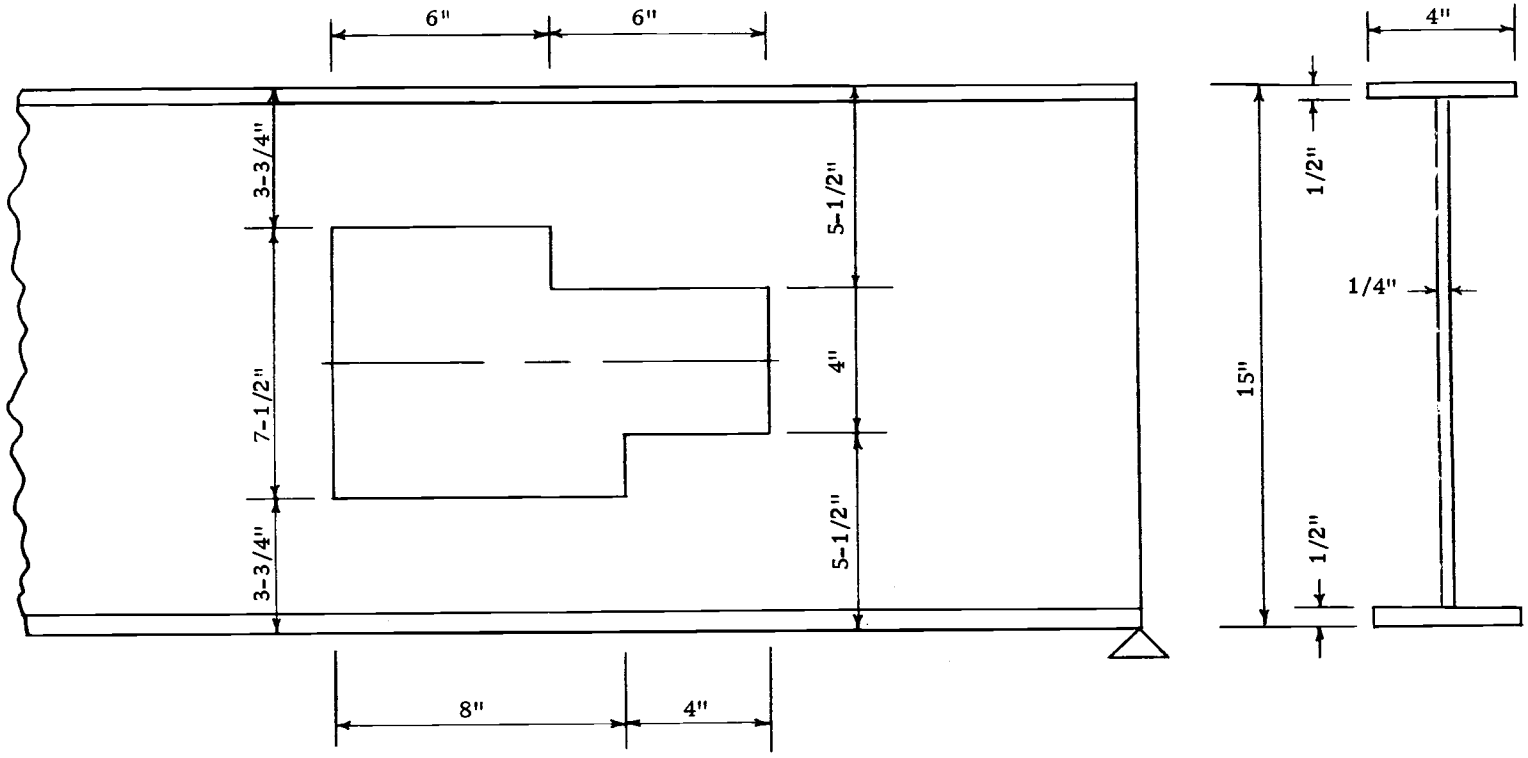

Figure 14. Dimensions of the unsymmetrical hole in the web.

I-beam identical to the two beams used in the tests. Let the total shear on the section across the span of the hole equal 10 kips. Let the portion of the shear carried by the tee section above the hole equal P kips and the portion carried by the tee section below the hole equal V kips. Use this relationship as the first equation, $P + V = 10$.

Figure 15 shows the load, shear, bending moment and angle change diagrams for the tee section above the hole with only the shear force acting at the inflection point considered as the load. The inflection point is assumed to be located x in. from the left end of the hole as shown in the diagram. Solve for the value of x by equating the total angle change of the cantilever beam to the left of x and the cantilever to the right of x. As shown in the diagram, the shear force, P, acts down on the cantilever beam to the left of x and up on the cantilever to the right of x. The angle change is equal to the area of the angle change diagram between the two points. (See Figure 15.)

Angle change to the left of x = angle change to the right of x.

$$\frac{1}{2} \times \frac{P(x)(x)}{EI_1} = \frac{1}{2} \times \frac{P(6-x)(6-x)}{EI_1} + \frac{P(6-x)(6)}{EI_2} + \frac{1}{2} \times \frac{P(6)(6)}{EI_2}$$

where I_1 is 2.79 $in.^4$

I_2 is 8.46 $in.^4$

E is the Modulus of Elasticity (29,000 ksi)

P is the shear carried by the tee section above the hole.

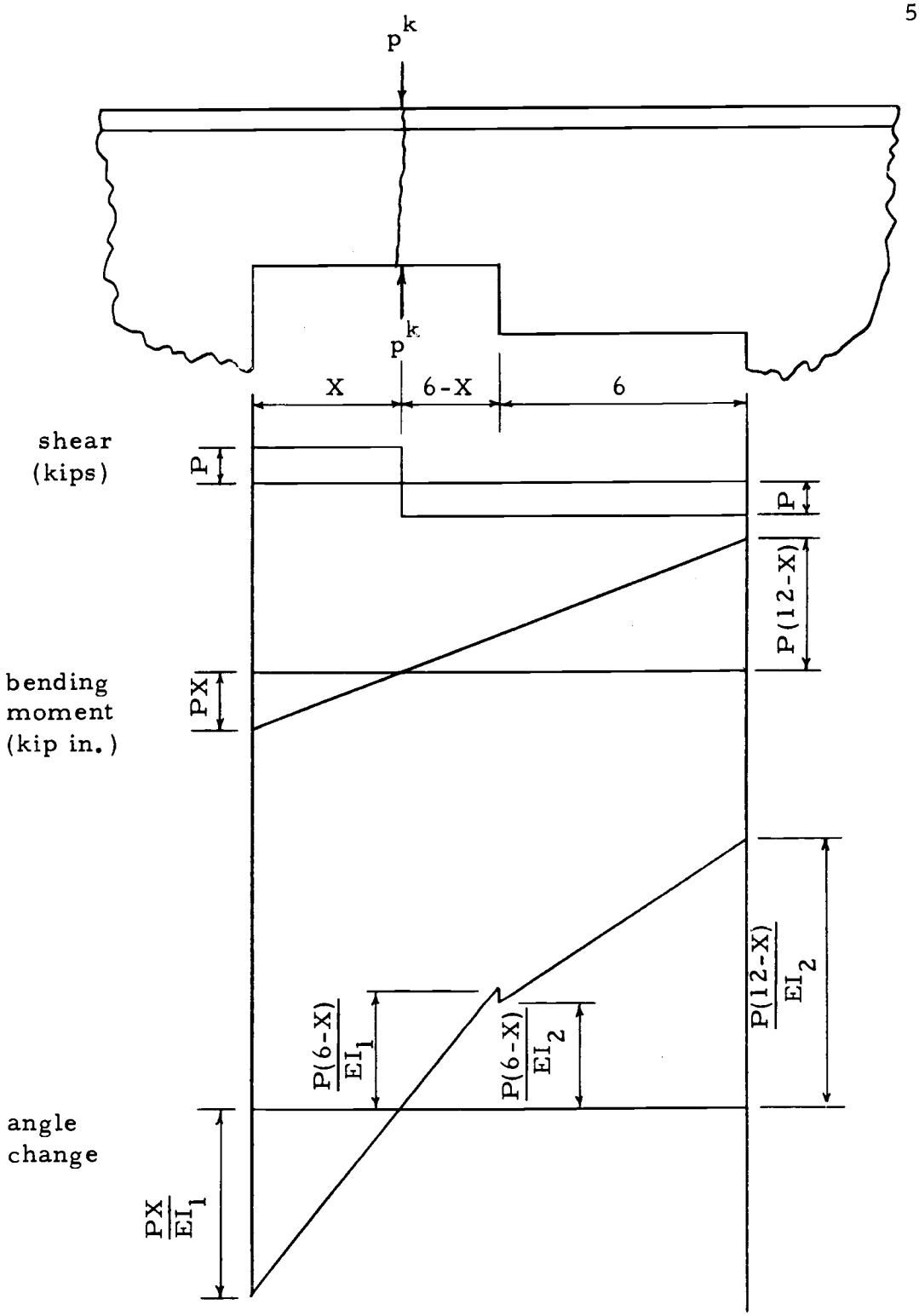

Figure 15. The shear, bending moment and angle change diagrams for the tee beam above the hole.

Substitute these values and solve for x.

$$x = 4.48 \text{ in.}$$

Figure 16 shows the load, shear, bending moment and the angle change diagrams for the tee section below the hole with only the shear force acting at the point of inflection considered as the load. The inflection point is assumed to be located x in. from the left end of the hole as shown in the diagram. As with the tee section above the hole, solve for the value of x by equating the angle changes to the left and to the right of the inflection point. (See Figure 16.)

$$\frac{1}{2}\frac{(Vx)(x)}{EI_1} = \frac{1}{2}\frac{(V)(8-x)(8-x)}{EI_1} + \frac{V(8-x)(4)}{EI_2} + \frac{1}{2}\frac{(V)(4)(4)}{EI_2}$$

where I_1 is 2.79 in.^{4}

I_2 is 8.46 in.^{4}

E is the Modulus of Elasticity (29,000 ksi)

V is shear carried by the tee section below the hole.

Substitute these values and solve for x.

$$x = 4.85 \text{ in.}$$

Obtain a second equation containing the shear values, P and V, by equating the total deflection of the tee beams above and below the hole with only the respective shear force as the load. Let the deflection of the left cantilever beam of the top tee beam (see Figure 15)

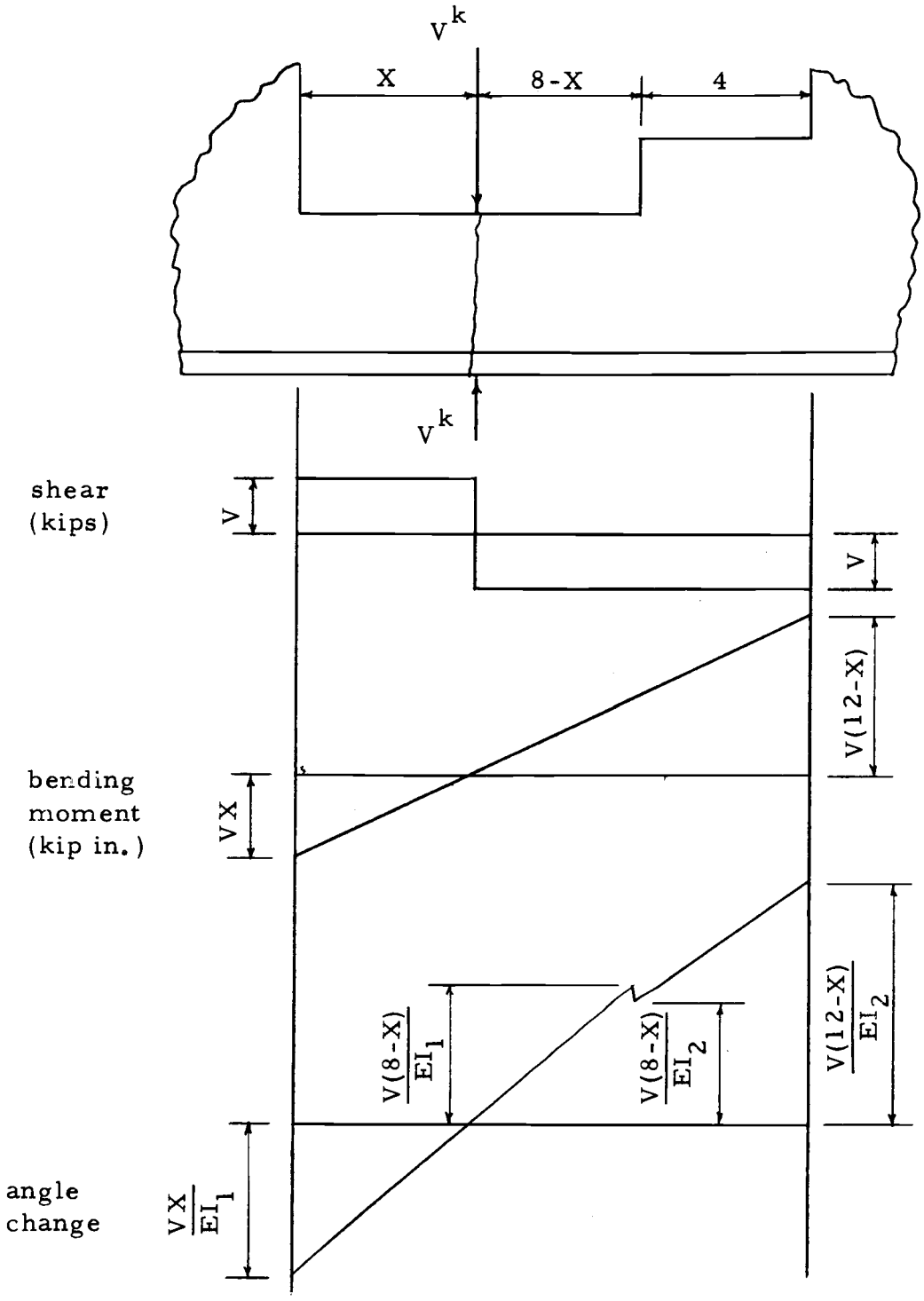

Figure 16. The shear, bending moment and angle change diagrams for the tee beam below the hole.

equal e_1.

$$e_1 = (\frac{1}{2}) \frac{(4.48P)(4.48)}{2.79E} (\frac{2}{3}) (4.48)$$

$$e_1 = \frac{10.75P}{E}$$

Let the deflection of the right cantilever beam of the top tee beam equal e_2.

$$e_2 = (\frac{1}{2}) \frac{(1.52P)(1.52)}{2.79E} (\frac{2}{3}) (1.52) + \frac{(1.52P)(6)(4.52)}{8.46E}$$

$$+ (\frac{1}{2}) \frac{(6P(6)(5.52)}{8.46E}$$

$$e_2 = \frac{11.03P}{E}$$

The total deflection of the top tee beam

$$= e_1 + e_2$$

$$= \frac{10.75P}{E} + \frac{11.03P}{E}$$

$$= \frac{21.78P}{E}$$

Let the deflection of the left cantilever beam of the bottom tee beam (see Figure 16) equal e_3.

$$e_3 = \left(\frac{1}{2}\right) \frac{(4.85V)(4.85)}{2.79E} \left(\frac{2}{3}\right) (4.85)$$

$$e_3 = \frac{13.63V}{E}$$

Let the deflection of the right cantilever beam of the bottom tee equal e_4.

$$e_4 = \left(\frac{1}{2}\right) \frac{(3.15V)(3.15)}{2.79E} \left(\frac{2}{3}\right) (3.15)$$

$$+ \frac{(3.15V)(4.00)(5.15)}{8.46E} \left(\frac{1}{2}\right) \frac{(4.00V)(4.00)(5.82)}{8.46E}$$

$$e_4 = \frac{16.91V}{E} \text{ in.}$$

The total deflection of the bottom tee beam

$$= e_3 + e_4$$

$$= \frac{13.63V}{E} + \frac{16.91V}{E}$$

$$= \frac{30.54V}{E} \text{ in.}$$

Equate the total deflections to obtain second equation containing P and V.

(2) $$\frac{2178P}{E} = \frac{30.54V}{E}$$

or $$P = 1.41V$$

Substitute this value for P in equation (1) and solve for V.

(1) $P + V = 10$ or $1.41V + V = 10$

$V = 4.15K$ and $P = 5.85K$

Apply the respective value of shear at the point of inflection and calculate the stress caused by the shear at any point above or below the hole as described in (3). Finally, algebraically add the stress found above to the stress caused by the bending moment resulting from the external loads, as described in (4) and thus establish the total stress at the point.

A suggested method for calculating the strain, when the normal loads and the strain increase because of the proximity of a corner are necessary considerations, is to superimpose the strains resulting from the following:

(a) the bending moment caused by external loads as described in this dissertation;

(b) the appropriate shear force applied at the line of inflection as described in this dissertation;

(c) the normal effects of the loads and reactions which requires further research;

(d) the strain increase resulting from the proximity of the corner which requires further research.

Table 1. Solid Beam -Load at Centerline.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-21	Gage No. G-22	Gage No. G-26	Gage No. G-27
1,000	11,495	11,227	10,952	9,840	10,187	10,377
2,000	11,475	11,207	10,957	9,847	10,190	10,383
4,000	11,432	11,178	10,977	9,882	10,228	10,427
6,000	11,395	11,150	10,995	9,913	10,260	10,464
8,000	11,357	11,127	11,018	9,953	10,305	10,508
10,000	11,320	11,100	11,037	9,983	10,333	10,540
12,000	11,278	11,072	11,058	10,018	10,373	10,588
14,000	11,245	11,045	11,082	10,052	10,407	10,627
16,000	11,203	11,017	11,103	10,088	10,445	10,668
18,000	11,168	10,994	11,123	10,123	10,477	10,708
19,500	11,138	10,972	11,140	10,152	10,510	10,744
1,000	11,485	11,214	10,940	9,824	10,168	10,360
			Total Strain x 10^{-6} in./in.			
	-347	-242	200	328	342	384

Table 2. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. G-6	Gage No. G-7	Gage No. G-17	Gage No. G-16	Gage No. G-15	Gage No. G-18
1,000	0	0	11,358	10,114	10,034	10,852
2,000	0	- 7	11,337	10,100	10,030	10,825
4,000	7	-11	11,295	10,085	10,037	10,778
6,000	13	-21	11,255	10,073	10,045	10,736
8,000	18	-27	11,217	10,062	10,055	10,695
10,000	23	-34	11,180	10,050	10,062	10,650
12,000	32	-40	11,140	10,035	10,072	10,606
14,000	38	-48	11,106	10,025	10,082	10,565
16,000	43	-55	11,063	10,012	10,088	10,523
18,000	50	-60	11,030	10,002	10,100	10,480
19,500	57	-70	11,000	9,995	10,107	10,447
1,000	0	0	11,348	10,100	10,017	10,838
			Total Strain x 10^{-6} in./in.			
	57	-70	-348	-105	90	-391

Table 3. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. G-2	Gage No. G-3	Gage No. G-4	Gage No. G-5	Gage No. G-23	Gage No. G-24
1,000	0	0	0	0	0	0
2,000	- 8	- 7	2	3	7	10
4,000	- 24	-18	13	22	26	30
6,000	- 42	-27	23	38	45	53
8,000	- 60	-40	34	53	64	73
10,000	- 78	-50	45	70	82	98
12,000	- 93	-60	60	90	107	120
14,000	-110	-72	68	100	123	142
16,000	-130	-84	78	120	142	164
18,000	-146	-97	90	137	162	188
19,500	-160	-103	98	150	177	203
1,000	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.			
	-160	-103	98	150	177	203

Table 4. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. R-7-H	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V	Gage No. G-1	Gage No. G-8
1,000	0	0	0	0	0	0
2,000	-7	0	0	-11	- 8	- 10
4,000	-7	27	20	-18	- 28	- 30
6,000	-10	40	32	-27	- 47	- 55
8,000	- 2	67	55	-30	- 70	- 80
10,000	- 8	82	68	-27	- 88	-100
12,000	-10	102	88	-43	-108	-122
14,000	-10	120	102	-53	-130	-147
16,000	-10	143	128	-55	-152	-171
18,000	-17	160	140	-65	-170	-193
19,500	-12	177	152	-70	-183	-210
1,000	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.			
	-12	177	152	-70	-183	-210

Table 5. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-7-V	Gage No. R-7-45
1,000	0	0	0	0	0	0	0
2,000	- 3	- 3	- 15	- 11	0	- 8	0
4,000	0	0	- 32	- 32	0	-10	10
6,000	-10	-10	- 58	- 58	0	-13	17
8,000	-15	-11	- 77	- 68	12	-12	30
10,000	-22	-11	-100	- 90	18	-12	40
12,000	-23	-16	-122	-110	22	-12	52
14,000	-18	-27	-147	-127	30	-18	60
16,000	-10	-28	-160	-143	35	-18	74
18,000	-20	-32	-190	-177	33	-23	80
19,500	-23	-32	-203	-185	38	-26	90
1,000	23	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	-46	-32	-203	-185	38	-26	90

Table 6. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H	Gage No. R-3-H
1,000	0	0	0	0	0	0	0
2,000	0	3	- 3	2	- 2	- 8	0
4,000	3	13	- 15	4	- 17	- 8	20
6,000	12	20	- 28	4	- 24	- 7	30
8,000	12	22	- 43	0	- 37	- 8	40
10,000	13	30	- 60	- 3	- 57	-10	52
12,000	14	37	- 72	- 3	- 70	-10	67
14,000	18	40	- 82	- 3	- 80	-10	97
16,000	20	50	-102	-10	- 98	-10	120
18,000	20	50	-117	-13	-114	-18	129
19,500	23	60	-124	-13	-120	-12	142
1,000	0	0	0	0	6	0	20
			Total Strain x 10^{-6} in./in.				
	23	60	-124	-13	-126	-12	122

Table 7. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-23	Gage No. G-24	Gage No. G-6	Gage No. G-7
1,000	0	0	0	0	0	0
2,000	10	12	14	14	6	0
4,000	20	30	32	36	10	- 8
6,000	30	42	53	58	18	-14
8,000	43	63	77	83	30	-18
10,000	52	76	90	105	30	-30
12,000	62	92	110	127	37	-37
14,000	72	109	130	148	42	-42
16,000	83	128	152	170	50	-50
18,000	97	144	173	196	57	-57
19,500	104	160	190	213	60	-60
1,000	8	8	8	8	3	3
			Total Strain x 10^{-6} in./in.			
	96	152	182	205	57	-63

Table 8. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. G-26	Gage No. G-27	Gage No. G-1	Gage No. G-8	Gage No. G-2	Gage No. G-3
1,000	10,140	10,327	0	0	0	0
2,000	10,165	10,353	- 4	- 8	- 4	- 3
4,000	10,205	10,403	- 27	- 30	- 23	- 14
6,000	10,245	10,445	- 46	- 54	- 40	- 27
8,000	10,283	10,493	- 60	- 70	- 54	- 34
10,000	10,330	10,540	- 83	-100	- 73	- 48
12,000	10,360	10,577	-104	-122	- 90	- 60
14,000	10,408	10,628	-130	-147	-110	- 70
16,000	10,447	10,672	-145	-170	-125	- 80
18,000	10,490	10,717	-166	-190	-142	- 92
19,500	10,515	10,748	-183	-210	-158	-100
1,000	10,182	10,368	4	4	4	4
			Total Strain x 10^{-6} in./in.			
	333	380	-187	-214	-162	-104

Table 9. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. G-15	Gage No. G-18	Gage No. G-19	Gage No. G-20	Gage No. G-21	Gage No. G-22
1,000	9,992	10,815	11,460	11,185	10,912	9,974
2,000	10,000	10,793	11,440	11,177	10,925	9,817
4,000	10,015	10,760	11,415	11,157	10,953	9,858
6,000	10,025	10,715	11,375	11,128	10,977	9,895
8,000	10,042	10,682	11,347	11,113	11,007	9,936
10,000	10,055	10,642	11,308	11,087	11,030	9,977
12,000	10,063	10,600	11,270	11,064	11,050	10,007
14,000	10,077	10,560	11,238	11,038	11,078	10,053
16,000	10,093	10,524	11,205	11,018	11,105	10,093
18,000	10,105	10,485	11,170	10,995	11,130	10,128
19,500	10,110	10,448	11,142	10,975	11,145	10,157
1,000	10,028	10,848	11,495	11,224	10,948	9,835
			Total Strain x 10^{-6} in./in.			
	82	-400	-353	-249	197	322

Table 10. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. R-7-H	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V	Gage No. G-17	Gage No. G-16
1,000	0	0	0	0	11,326	10,075
2,000	0	10	8	- 4	11,305	10,067
4,000	0	37	27	- 6	11,277	10,064
6,000	5	60	44	-10	11,237	10,057
8,000	0	73	57	-24	11,208	10,050
10,000	-3	90	70	-37	11,172	10,040
12,000	-8	107	86	-43	11,136	10,028
14,000	-3	130	113	-50	11,100	10,023
16,000	-8	147	122	-60	11,068	10,015
18,000	-3	170	142	-60	11,033	10,005
19,500	0	190	160	-68	11,003	9,998
1,000	0	0	0	0	11,357	10,110
			Total Strain x 10^{-6} in./in.			
	0	190	160	-68	-354	-112

Table 11. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-7-V	Gage No. R-7-45
1,000	0	0	0	0	0	0	0
2,000	7	7	- 3	- 10	0	0	3
4,000	0	3	- 23	- 24	10	0	20
6,000	12	12	- 40	- 40	20	0	30
8,000	- 7	- 7	- 74	- 72	12	-10	34
10,000	- 8	- 8	- 95	- 90	20	-10	43
12,000	-20	-17	-120	-110	22	-12	53
14,000	-23	-15	-142	-130	30	-13	70
16,000	-22	-22	-162	-150	33	-20	77
18,000	-23	-20	-180	-160	47	-18	90
19,500	-27	-27	-200	-180	48	-18	100
1,000	20	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	-47	-27	-200	-180	48	-18	100

Table 12. Solid Beam - Load at Centerline.

Load (lbs.)	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H	Gage No. R-3-H
1,000	0	0	0	0	0	0	0
2,000	0	13	10	12	0	6	10
4,000	12	23	- 10	13	- 4	8	25
6,000	17	30	- 20	12	- 10	15	52
8,000	17	30	- 43	0	- 38	0	52
10,000	17	36	- 52	3	- 48	4	68
12,000	17	40	- 67	- 3	- 70	- 3	73
14,000	17	42	- 90	- 3	- 83	- 3	90
16,000	26	55	- 97	- 3	- 90	0	110
18,000	23	60	-108	- 4	-103	0	130
19,500	23	68	-120	- 10	-115	0	142
1,000	0	0	0	0	0	0	20
			Total Strain x 10^{-6} in./in.				
	23	68	-120	-10	-115	0	122

Table 13. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-21	Gage No. G-22	Gage No. G-26	Gage No. G-27
1,000	11,495	11,218	10,943	9,825	10,167	10,355
4,000	11,452	11,192	10,970	9,868	10,226	10,412
8,000	11,395	11,150	11,003	9,923	10,288	10,475
12,000	11,333	11,108	11,037	9,983	10,362	10,545
16,000	11,277	11,065	11,075	10,035	10,427	10,615
20,000	11,220	11,026	11,108	10,097	10,500	10,685
24,000	11,162	10,987	11,143	10,148	10,562	10,748
28,000	11,103	10,943	11,177	10,207	10,634	10,817
32,000	11,046	10,904	11,213	10,260	10,695	10,880
36,000	10,988	10,865	11,248	10,320	10,766	10,950
37,000	10,975	10,855	11,256	10,335	10,778	10,963
1,000	11,497	11,226	10,948	9,833	10,178	10,350
			Total Strain x 10^{-6} in./in.			
	-522	-371	308	502	600	-613

Table 14. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-6	Gage No. G-7	Gage No. G-17	Gage No. G-16	Gage No. G-15	Gage No. G-18
1,000	0	0	11,355	10,107	10,022	10,848
4,000	10	-10	11,312	10,090	10,035	10,803
8,000	23	-23	11,250	10,065	10,053	10,738
12,000	32	-39	11,184	10,047	10,072	10,673
16,000	45	-54	11,124	10,028	10,094	10,605
20,000	58	-70	11,065	10,012	10,113	10,543
24,000	72	-83	11,002	9,992	10,130	10,476
28,000	83	-100	10,937	9,974	10,150	10,408
32,000	100	-112	10,878	9,953	10,168	10,345
36,000	107	-130	10,816	9,936	10,187	10,285
37,000	110	-134	10,805	9,933	10,193	10,268
1,000	6	6	11,362	10,112	10,028	10,855
			Total Strain x 10^{-6} in./in.			
	104	-140	-557	-179	165	-587

Table 15. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-2	Gage No. G-3	Gage No. G-4	Gage No. G-5	Gage No. G-23	Gage No. G-24
1,000	0	0	0	0	0	0
4,000	- 23	- 16	17	28	30	34
8,000	- 57	- 38	40	60	72	80
12,000	- 93	- 60	60	93	112	128
16,000	-130	- 83	82	130	153	177
20,000	-160	-105	105	162	195	222
24,000	-198	-128	128	198	237	270
28,000	-230	-150	152	233	280	320
32,000	-266	-170	175	270	320	368
36,000	-303	-197	194	300	360	410
37,000	-312	-203	200	310	370	420
1,000	5	6	7	7	7	6
			Total Strain x 10^{-6} in./in.			
	-317	-209	193	303	363	414

Table 16. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-7-H	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V	Gage No. G-1	Gage No. G-8
1,000	0	0	0	0	0	0
4,000	- 5	22	10	- 15	- 24	- 30
8,000	-10	57	22	- 32	- 62	- 72
12,000	- 8	90	36	- 48	-107	-120
16,000	-12	125	53	- 62	-145	-165
20,000	-13	160	60	- 82	-183	-208
24,000	-10	197	80	- 94	-224	-257
28,000	-15	232	90	-112	-260	-300
32,000	- 7	275	118	-118	-303	-344
36,000	-10	307	128	-140	-333	-392
37,000	-15	310	128	-147	-357	-404
1,000	0	0	0	0	5	5
			Total Strain x 10^{-6} in./in.			
	-15	310	128	-147	-362	-409

Table 17. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-7-V	Gage No. R-7-45
1,000	0	0	0	0	0	0	0
4,000	- 8	- 8	- 38	- 23	-28	- 23	-12
8,000	- 16	-10	- 80	- 42	-42	- 42	-25
12,000	- 30	-20	-120	- 57	-52	- 60	-30
16,000	- 41	-27	-163	- 86	-68	- 78	-38
20,000	- 56	-37	-203	-103	-75	- 97	-48
24,000	- 68	-43	-243	-117	-78	-108	-50
28,000	- 88	-58	-290	-138	-80	-122	-57
32,000	- 96	-60	-323	-150	-80	-130	-53
36,000	-108	-65	-368	-170	-82	-148	-63
37,000	-113	-70	-381	-182	-88	-155	-70
1,000	0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	-113	-70	-381	-182	-88	-155	-70

Table 18. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H	Gage No. R-3-H
1,000	0	0	0	0	0	0	0
4,000	-20	3	- 20	-10	- 23	- 8	12
8,000	-23	12	- 50	-20	- 50	- 8	40
12,000	-30	20	- 80	-30	- 83	-10	60
16,000	-33	30	-107	-37	-112	-17	84
20,000	-30	40	-134	-44	-143	-20	108
24,000	-30	48	-163	-63	-172	-20	132
28,000	-40	52	-200	-68	-210	-33	152
32,000	-37	62	-230	-70	-238	-33	180
36,000	-38	78	-257	-74	-267	-33	202
37,000	-40	80	-262	-78	-280	-37	208
1,000	0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	-40	80	-262	-78	-280	-37	208

Table 19. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-21	Gage No. G-22	Gage No. G-26	Gage No. G-27
1,000	11,525	11,250	10,970	9,850	10,200	10,385
4,000	11,485	11,224	10,995	9,985	10,255	10,438
8,000	11,430	11,183	11,035	9,953	10,323	10,507
12,000	11,370	11,143	11,067	10,010	10,395	10,575
16,000	11,315	11,100	11,105	10,065	10,460	10,643
20,000	11,255	11,063	11,140	10,124	10,532	10,710
24,000	11,200	11,018	11,175	10,180	10,593	10,775
28,000	11,135	10,975	11,210	10,238	10,665	10,845
32,000	11,082	10,935	11,245	10,295	10,732	10,915
36,000	11,020	10,895	11,276	10,350	10,800	10,980
37,000	11,013	10,888	11,292	10,367	10,814	11,000
1,000	11,535	11,258	10,982	9,867	10,218	10,400
			Total Strain x 10^{-6} in./in.			
	-522	-370	310	500	596	600

Table 20. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-6	Gage No. G-7	Gage No. G-17	Gage No. G-16	Gage No. G-15	Gage No. G-18
1,000	0	0	11,385	10,135	10,055	10,877
4,000	10	- 10	11,348	10,124	10,068	10,835
8,000	23	- 25	11,285	10,100	10,087	10,773
12,000	33	- 38	11,225	10,083	10,107	10,705
16,000	48	- 55	11,162	10,063	10,125	10,643
20,000	58	- 70	11,100	10,045	10,145	10,578
24,000	70	- 86	11,036	10,023	10,163	10,513
28,000	80	-100	10,973	10,005	10,182	10,448
32,000	98	-117	10,914	9,987	10,203	10,382
36,000	107	-132	10,850	9,967	10,220	10,316
37,000	110	-138	10,838	9,966	10,228	10,305
1,000	5	5	11,400	10,148	10,067	10,890
			Total Strain x 10^{-6} in./in.			
	105	-143	-562	-182	161	-585

Table 21. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-2	Gage No. G-3	Gage No. G-4	Gage No. G-5	Gage No. G-23	Gage No. G-24
1,000	0	0	0	0	0	0
4,000	- 23	- 17	18	27	30	33
8,000	- 57	- 38	40	58	70	80
12,000	- 90	- 60	60	92	115	130
16,000	-127	- 85	82	128	153	177
20,000	-162	-108	105	160	196	223
24,000	-200	-130	127	196	236	270
28,000	-232	-156	-50	230	278	320
32,000	-268	-178	170	267	320	364
36,000	-303	-200	193	300	360	412
37,000	-313	-207	198	308	370	422
1,000	5	5	5	5	5	5
			Total Strain x 10^{-6} in./in.			
	-318	-212	193	303	365	417

Table 22. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-7-H	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V	Gage No. G-1	Gage No. G-8
1,000	0	0	0	0	0	0
4,000	0	30	17	- 7	- 26	- 26
8,000	0	65	32	- 20	- 61	- 71
12,000	0	100	49	- 20	-105	-118
16,000	5	143	65	- 43	-145	-152
20,000	0	177	80	- 60	-184	-210
24,000	0	210	90	- 78	-228	-256
28,000	0	250	110	- 90	-270	-300
32,000	6	290	130	-100	-310	-348
36,000	3	324	142	-120	-348	-394
37,000	0	335	147	-124	-357	-404
1,000	8	10	3	5	2	5
			Total Strain x 10^{-6} in./in.			
	-8	325	144	-129	-359	-409

Table 23. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-7-V	Gage No. R-7-45
1,000	0	0	0	0	0	0	0
4,000	5	5	- 22	- 10	-23	- 20	0
8,000	0	0	- 63	- 40	-40	- 38	-10
12,000	-10	- 3	-103	- 54	-50	- 50	-17
16,000	-20	- 8	-135	- 70	-52	- 63	-20
20,000	-37	-20	-187	- 80	-57	- 80	-28
24,000	-48	-28	-227	-120	-68	-100	-37
28,000	-60	-30	-267	-130	-67	-110	-38
32,000	-70	-40	-308	-140	-68	-120	-40
36,000	-80	-40	-348	-160	-70	-133	-43
37,000	-90	-47	-363	-162	-70	-140	-50
1,000	15	12	12	12	12	8	8
			Total Strain x 10^{-6} in./in.				
	-105	-59	-375	-174	-82	-148	-58

Table 24. Solid Beam - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H	Gage No. R-3-H
1,000	0	0	0	0	0	0	0
4,000	-20	7	- 18	-10	- 23	0	22
8,000	-20	20	- 45	-15	- 50	0	50
12,000	-20	30	- 73	-23	- 80	- 3	72
16,000	-20	40	-100	-30	-103	0	103
20,000	-23	50	-127	-37	-138	-10	125
24,000	-20	55	-160	-43	-167	-10	150
28,000	-23	67	-190	-53	-192	-10	180
32,000	-23	77	-220	-60	-228	-18	200
36,000	-20	90	-243	-63	-253	-18	230
37,000	-23	93	-250	-67	-266	-18	232
1,000	9	10	10	10	10	10	15
			Total Strain x 10^{-6} in./in.				
	-32	83	-260	-77	-276	-28	217

Table 25. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-23	Gage No. G-24	Gage No. G-6	Gage No. G-7
1,000	0	0	0	0	0	0
4,000	15	23	30	30	6	- 15
8,000	34	56	68	77	17	- 30
12,000	57	90	108	124	30	- 47
16,000	77	122	148	170	40	- 60
20,000	100	153	190	217	55	- 80
24,000	121	190	230	264	68	- 90
28,000	144	225	272	313	80	-107
32,000	168	262	316	360	90	-122
36,000	190	297	354	407	106	-140
40,000	210	330	397	454	120	-153
1,000	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.			
	210	330	397	454	120	-153

Table 26. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-26	Gage No. G-27	Gage No. G-1	Gage No. G-8	Gage No. G-2	Gage No. G-3
1,000	10,235	10,422	0	0	0	0
4,000	10,287	10,467	- 28	- 32	- 25	- 17
8,000	10,343	10,520	- 70	- 77	- 60	- 40
12,000	10,407	10,583	-108	-123	-100	- 67
16,000	10,465	10,646	-150	-170	-130	- 90
20,000	10,535	10,710	-187	-210	-165	-113
24,000	10,585	10,763	-228	-256	-200	-135
28,000	10,652	10,827	-268	-300	-235	-160
32,000	10,707	10,887	-310	-348	-273	-183
36,000	10,775	10,952	-347	-393	-308	-205
40,000	10,833	11,010	-392	-440	-343	-230
1,000	10,240	10,420	0	0	0	- 3
			Total Strain x 10^{-6} in./in.			
	593	590	-392	-440	-343	-227

Table 27. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-15	Gage No. G-18	Gage No. G-19	Gage No. G-20	Gage No. G-21	Gage No. G-22
1,000	10,085	10,915	11,562	11,285	11,008	9,885
4,000	10,097	10,867	11,522	11,258	11,030	9,922
8,000	10,110	10,805	11,465	11,217	11,060	9,975
12,000	10,126	10,740	11,405	11,175	11,090	10,023
16,000	10,142	10,683	11,357	11,137	11,120	10,068
20,000	10,160	10,622	11,302	11,102	11,152	10,125
24,000	10,173	10,558	11,245	11,062	11,183	10,173
28,000	10,192	10,500	11,193	11,025	11,215	10,226
32,000	10,208	10,438	11,137	10,987	11,245	10,275
36,000	10,226	10,384	11,092	10,953	11,278	10,333
40,000	10,243	10,326	11,040	10,918	11,313	10,385
1,000	10,089	10,915	11,562	11,285	11,008	9,890
			Total Strain x 10^{-6} in./in.			
	154	-589	-522	-367	305	495

Table 28. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-7-H	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V	Gage No. G-17	Gage No. G-16
1,000	0	0	0	0	11,428	10,170
4,000	0	27	0	- 10	11,380	10,155
8,000	-10	49	3	- 33	11,318	10,132
12,000	-10	80	18	- 30	11,256	10,110
16,000	-15	113	30	- 58	11,195	10,093
20,000	-20	143	36	- 72	11,137	10,073
24,000	-23	173	47	- 88	11,075	10,050
28,000	-23	210	60	- 93	11,016	10,033
32,000	-20	247	80	-104	10,958	10,010
36,000	-20	280	90	-114	10,902	9,988
40,000	-17	320	108	-120	10,845	9,978
1,000	12	8	8	8	11,424	10,172
			Total Strain x 10^{-6} in./in.			
	-29	312	100	-128	-579	-194

Table 29. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-7-V	Gage No. R-7-45
1,000	0	0	0	0	0	0	0
4,000	0	0	- 25	0	0	0	0
8,000	- 10	- 8	- 67	- 28	-18	-30	-23
12,000	- 26	-23	-110	- 48	-20	-40	-27
16,000	- 37	-30	-146	- 60	-13	-43	-30
20,000	- 48	-34	-184	- 83	-18	-53	-38
24,000	- 63	-48	-227	-105	-12	-60	-43
28,000	- 76	-53	-260	-123	- 8	-63	-43
32,000	- 90	-60	-300	-133	0	-70	-45
36,000	-100	-68	-335	-145	0	-72	-43
40,000	-107	-70	-376	-164	10	-76	-40
1,000	0	0	0	8	8	8	8
			Total Strain x 10^{-6} in./in.				
	-107	-70	-376	-172	2	-84	-48

Table 30. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H	Gage No. R-3-H
1,000	0	0	0	0	0	0	0
4,000	0	7	- 15	- 3	- 12	0	23
8,000	-22	12	- 47	-21	- 47	- 6	42
12,000	-27	12	- 83	-34	- 83	-10	63
16,000	-25	25	-110	-43	-112	-13	90
20,000	-30	33	-140	-53	-142	-16	116
24,000	-35	40	-173	-63	-178	-23	133
28,000	-38	55	-200	-70	-206	-25	160
32,000	-42	62	-233	-82	-240	-28	187
36,000	-38	74	-260	-88	-268	-30	210
40,000	-35	90	-288	-93	-297	-27	240
1,000	0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	-35	90	-288	-93	-297	-27	240

Table 31. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-21	Gage No. G-22	Gage No. G-26	Gage No. G-27
1,000	6,572	6,300	6,020	4,900	5,245	5,425
4,000	6,529	6,270	6,038	4,932	5,289	5,466
8,000	6,478	6,237	6,070	4,983	5,352	5,522
12,000	6,420	6,196	6,100	5,032	5,411	5,590
16,000	6,370	6,160	6,130	5,082	5,470	5,650
20,000	6,310	6,115	6,153	5,123	5,523	5,708
24,000	6,265	6,084	6,191	5,182	5,598	5,770
28,000	6,210	6,049	6,218	5,320	5,658	5,830
32,000	6,160	6,013	6,250	5,278	5,715	5,890
36,000	6,109	5,977	6,278	5,327	5,770	5,948
40,000	6,055	5,938	6,306	5,373	5,828	6,000
1,000	6,573	6,297	6,022	4,900	5,240	5,428
			Total Strain x 10^{-6} in./in.			
	-518	-359	284	473	588	572

Table 32. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-6	Gage No. G-7	Gage No. G-17	Gage No. G-16	Gage No. G-15	Gage No. G-18
1,000	0	0	6,432	5,180	5,096	5,932
4,000	10	- 10	6,390	5,165	5,108	5,889
8,000	11	- 35	6,329	5,143	5,121	5,832
12,000	29	- 48	6,268	5,121	5,135	5,772
16,000	37	- 68	6,208	5,100	5,150	5,710
20,000	45	- 87	6,147	5,078	5,160	5,648
24,000	55	-105	6,091	5,062	5,180	5,590
28,000	60	-128	6,035	5,041	5,195	5,532
32,000	70	-145	5,982	5,022	5,210	5,474
36,000	78	-164	5,927	5,002	5,222	5,418
40,000	86	-185	5,868	4,985	5,240	5,360
1,000	-22	- 25	6,432	5,183	5,100	5,938
			Total Strain x 10^{-6} in./in.			
	108	-160	-564	-198	140	-578

Table 33. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-2	Gage No. G-3	Gage No. G-4	Gage No. G-5	Gage No. G-23	Gage No. G-24
1,000	0	0	0	0	0	0
4,000	- 23	- 16	17	27	30	37
8,000	- 69	- 49	30	50	60	71
12,000	-100	- 70	55	88	108	123
16,000	-140	- 95	71	118	143	167
20,000	-176	-121	90	148	180	210
24,000	-213	-150	110	180	220	253
28,000	-258	-180	125	206	250	294
32,000	-291	-202	146	240	290	340
36,000	-330	-230	160	264	322	378
40,000	-370	-260	177	292	360	420
1,000	- 27	- 27	- 27	- 22	- 22	- 23
			Total Strain x 10^{-6} in./in.			
	-343	-233	204	314	382	443

Table 34. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-7-H	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V	Gage No. G-1	Gage No. G-8
1,000	0	0	0	0	0	0
4,000	2	27	10	- 4	- 28	- 30
8,000	-10	50	10	- 29	- 77	- 84
12,000	-10	90	30	- 35	-110	-125
16,000	-15	119	35	- 50	-155	-172
20,000	-20	147	42	- 68	-200	-220
24,000	-23	177	52	- 80	-240	-270
28,000	-31	200	60	-100	-288	-320
32,000	-32	235	70	-110	-326	-366
36,000	-40	260	80	-128	-370	-413
40,000	-44	291	90	-140	-414	-462
1,000	-25	- 22	-30	- 28	- 27	- 27
			Total Strain x 10^{-6} in./in.			
	-19	313	120	-112	-387	-435

Table 35. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-7-V	Gage No. R-7-45
1,000	0	0	0	0	0	0	0
4,000	3	3	- 25	- 9	- 3	- 10	- 2
8,000	- 14	-11	- 74	- 38	-20	- 32	-20
12,000	- 20	-15	-110	- 52	-18	- 38	-20
16,000	- 37	-26	-150	- 68	-17	- 45	-30
20,000	- 50	-35	-190	- 90	-18	- 53	-38
24,000	- 69	-48	-230	-108	-14	- 63	-41
28,000	- 84	-60	-277	-130	-20	- 78	-52
32,000	-100	-63	-312	-149	-11	- 82	-52
36,000	-117	-77	-357	-170	-13	- 94	-60
40,000	-130	-87	-397	-188	-13	-100	-68
1,000	- 20	-20	- 20	- 20	-20	- 30	-25
			Total Strain x 10^{-6} in./in.				
	-110	-67	-377	-168	7	-70	-43

Table 36. Solid Beam - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H	Gage No. R-3-H
1,000	0	0	0	0	0	0	0
4,000	- 8	10	- 17	- 5	- 18	2	25
8,000	-22	10	- 52	- 27	- 57	-10	40
12,000	-28	20	- 80	- 32	- 86	-10	70
16,000	-30	28	-110	- 40	-115	-10	90
20,000	-33	37	-140	- 52	-150	-20	112
24,000	-40	43	-177	- 65	-186	-25	135
28,000	-49	50	-213	- 80	-221	-35	155
32,000	-45	60	-240	- 90	-253	-38	180
36,000	-54	70	-277	-102	-293	-48	197
40,000	-60	75	-310	-120	-330	-52	220
1,000	-20	-20	- 20	- 20	- 20	-20	- 20
			Total Strain x 10^{-6} in./in.				
	-40	95	-290	-100	-310	-32	240

Table 37. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-1	Gage No. G-8	Gage No. G-23	Gage No. G-24	Gage No. G-7	Gage No. G-6
1,000	11,806	10,464	8,980	9,254	8,938	9,907	9,017	9,838
4,000	11,820	10,483	8,956	9,208	8,966	9,950	9,010	9,842
8,000	11,850	10,515	9,917	9,140	9,003	10,017	9,006	9,845
12,000	11,878	10,557	8,875	9,078	9,043	10,083	9,007	9,845
16,000	11,906	10,593	8,838	9,015	9,077	10,145	9,007	9,847
20,000	11,932	10,623	8,800	8,950	9,115	10,212	9,003	9,850
24,000	11,962	10,663	8,764	8,887	9,157	10,274	9,000	9,853
28,000	11,990	10,696	8,723	8,822	9,194	10,344	8,997	9,860
32,000	12,015	10,733	8,685	8,756	9,235	10,406	8,994	9,863
36,000	12,046	10,766	8,647	8,692	9,273	10,475	8,992	9,865
40,000	12,076	10,802	8,605	8,625	9,310	10,542	8,987	9,865
1,000	11,818	10,467	8,988	9,264	8,948	9,920	9,027	9,848
				Total Strain x 10^{-6} in./in.				
	258	335	-383	-639	362	622	-40	17

Table 38. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14	Gage No. G-15	Gage No. G-2	Gage No. G-3
1,000	9,337	10,544	10,527	10,210	10,287	10,256	11,206
4,000	9,337	10,552	10,552	10,243	10,295	10,232	11,184
8,000	9,330	10,553	10,550	10,270	10,292	10,202	11,153
12,000	9,322	10,560	10,566	10,296	10,293	10,166	11,120
16,000	9,316	10,562	10,587	10,326	10,295	10,133	11,087
20,000	9,307	10,567	10,595	10,355	10,296	10,095	11,055
24,000	9,303	10,575	10,606	10,388	10,302	10,063	11,023
28,000	9,293	10,577	10,624	10,416	10,302	10,027	10,988
32,000	9,286	10,584	10,640	10,445	10,305	9,993	10,955
36,000	9,275	10,585	10,653	10,477	10,305	9,957	10,926
40,000	9,268	10,590	10,665	10,500	10,305	9,922	10,893
1,000	9,345	10,550	10,533	10,222	10,294	10,265	10,217
			Total Strain x 10^{-6} in./in.				
	-77	40	132	278	11	-343	676

Table 39. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-9	Gage No. G-17	Gage No. G-18	Gage No. G-10
1,000	11,002	10,827	9,930	10,976	9,686	10,365	9,397
4,000	10,965	10,788	9,928	10,938	9,652	10,335	9,385
8,000	10,907	10,746	9,924	10,880	9,585	10,275	9,355
12,000	10,848	10,697	9,918	10,825	9,523	10,218	9,325
16,000	10,794	10,653	9,917	10,768	9,463	10,160	9,297
20,000	10,735	10,605	9,912	10,714	9,398	10,103	9,265
24,000	10,683	10,566	9,910	10,660	9,338	10,046	9,238
28,000	10,626	10,517	9,906	10,603	9,276	9,990	9,207
32,000	10,573	10,474	9,903	10,548	9,216	9,933	9,178
36,000	10,517	10,430	9,898	10,493	9,155	9,874	9,150
40,000	10,462	10,385	9,895	10,437	9,093	9,816	9,118
1,000	11,013	10,827	9,940	10,987	9,700	10,384	9,405
			Total Strain x 10^{-6} in./in.				
	-551	-442	-45	-550	-607	-568	-287

Table 40. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-9-45	Gage No. R-9-V	Gage No. G-21	Gage No. G-22	Gage No. G-27	Gage No. G-26	Gage No. G-25
1,000	0	0	11,422	11,734	10,626	11,643	10,213
4,000	18	0	11,446	11,776	10,675	11,693	10,256
8,000	45	0	11,485	11,828	10,734	11,756	10,317
12,000	62	- 8	11,523	11,883	10,792	11,816	10,375
16,000	77	-22	11,558	11,935	10,848	11,875	10,438
20,000	90	-37	11,597	11,990	10,907	11,934	10,497
24,000	105	-47	11,640	12,046	10,967	12,002	10,562
28,000	132	-37	11,683	12,100	11,030	12,066	10,624
32,000	151	-50	11,723	12,154	11,087	12,127	10,685
36,000	160	-70	11,762	12,205	11,146	12,188	10,745
40,000	172	-84	11,803	12,260	11,205	12,250	10,805
1,000	0	0	11,425	11,745	10,635	11,650	10,220
			Total Strain x 10^{-6} in./in.				
	172	-84	378	515	570	600	585

Table 41. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-8-V	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H
1,000	0	0	0	0	0	0	0
4,000	30	0	- 30	10	- 3	- 3	18
8,000	61	0	- 60	28	0	0	53
12,000	80	- 15	- 97	30	- 6	- 3	82
16,000	102	- 26	-137	34	-13	-10	108
20,000	120	- 47	-180	30	-25	-15	133
24,000	132	- 60	-214	33	-30	-15	162
28,000	164	- 69	-240	50	-24	- 3	208
32,000	180	- 78	-273	58	-27	- 3	240
36,000	190	-100	-320	50	-42	-15	262
40,000	200	-123	-363	49	-53	-23	288
1,000	0	0	4	- 4	0	0	0
			Total Strain x 10^{-6} in./in.				
	200	-123	-367	53	-53	-23	288

Table 42. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-4-H	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H
1,000	0	0	0	0	0	0	0
4,000	- 4	- 10	3	19	23	- 10	- 25
8,000	0	- 12	20	53	50	- 14	- 63
12,000	- 3	- 26	30	80	67	- 30	-100
16,000	- 3	- 37	41	108	83	- 43	-135
20,000	-10	- 48	51	138	98	- 57	-172
24,000	-14	- 61	61	164	110	- 71	-205
28,000	-18	- 78	72	195	125	- 80	-226
32,000	- 8	- 78	92	238	158	- 84	-264
36,000	-18	-100	100	257	159	-110	-300
40,000	-19	-108	110	285	174	-125	-347
1,000	0	0	0	0	4	10	7
			Total Strain x 10^{-6} in./in.				
	-19	-108	110	285	170	-135	-354

Table 43. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45
1,000	0	0	0	0	0	0	0
4,000	- 22	- 3	40	29	- 3	14	- 4
8,000	- 50	- 8	90	77	- 0	30	- 10
12,000	- 84	-18	127	108	- 3	33	- 27
16,000	-117	-23	170	133	-10	40	- 38
20,000	-150	-30	206	176	-13	43	- 58
24,000	-186	-42	240	190	-23	40	- 77
28,000	-220	-51	275	237	-28	41	- 96
32,000	-255	-57	312	260	-26	56	-100
36,000	-293	-70	344	300	-37	50	-125
40,000	-327	-77	380	318	-40	54	-143
1,000	5	5	5	10	10	0	0
			Total Strain x 10^{-6} in./in.				
	-332	-82	375	308	-50	54	-143

Table 44. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-1-H	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V
1,000	0	0	0	0	0	0	0
4,000	- 33	- 18	13	35	38	8	- 22
8,000	- 78	- 47	30	90	97	30	- 40
12,000	-128	- 88	30	138	147	40	- 68
16,000	-187	-136	26	185	197	53	- 97
20,000	-230	-177	30	238	250	62	-113
24,000	-297	-230	20	280	297	70	-160
28,000	-347	-274	18	330	350	80	-188
32,000	-401	-323	18	384	401	90	-217
36,000	-458	-374	11	424	450	98	-250
40,000	-513	-423	11	477	500	107	-280
1,000	5	5	5	5	5	5	5
			Total Strain x 10^{-6} in./in.				
	-518	-428	6	472	495	102	-285

Table 45. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-1	Gage No. G-8	Gage No. G-23	Gage No. G-24	Gage No. G-7	Gage No. G-6
1,000	11,804	10,456	8,977	9,252	8,936	9,897	9,015	9,836
4,000	11,816	10,483	8,952	9,205	8,965	9,946	9,007	9,835
8,000	11,844	10,516	8,914	9,140	9,003	10,015	9,005	9,838
12,000	11,873	10,557	8,875	9,075	9,054	10,080	9,007	9,840
16,000	11,903	10,693	8,834	9,013	9,080	10,143	9,003	9,844
20,000	11,928	10,622	8,800	8,947	9,120	10,212	9,000	9,845
24,000	11,957	10,663	8,758	8,883	9,157	10,274	8,997	9,855
28,000	11,985	10,690	8,720	8,815	9,195	10,343	8,994	9,856
32,000	12,007	10,728	8,680	8,752	9,233	10,405	8,993	9,853
36,000	12,043	10,766	8,640	8,685	9,272	10,473	8,988	9,855
40,000	12,070	10,802	8,602	8,622	9,313	10,538	8,984	9,857
1,000	11,813	10,464	8,987	9,262	8,944	9,907	9,024	9,850
				Total Strain x 10^{-6} in./in.				
	257	338	-385	-640	369	631	-40	7

Table 46. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-20	Gage No. G-16	Gage No. G-9	Gage No. G-17	Gage No. G-18	Gage No. G-2	Gage No. G-3
1,000	10,832	9,933	10,978	9,690	10,368	10,257	11,206
4,000	10,788	9,922	10,930	9,638	10,323	10,230	11,178
8,000	10,746	9,917	10,874	9,575	10,266	10,196	11,150
12,000	10,700	9,908	10,814	9,512	10,202	10,165	11,117
16,000	10,655	9,905	10,755	9,447	10,145	10,130	11,084
20,000	10,612	9,904	10,705	9,387	10,090	10,095	11,054
24,000	10,567	9,900	10,647	9,327	10,032	10,060	11,020
28,000	10,530	9,903	10,598	9,270	9,980	10,023	10,096
32,000	10,477	9,890	10,536	9,205	9,918	9,987	10,955
36,000	10,432	9,983	10,478	9,137	9,858	9,954	10,922
40,000	10,390	9,984	10,427	9,082	9,803	9,918	10,890
1,000	10,828	9,937	10,982	9,694	10,375	10,265	11,215
			Total Strain x 10^{-6} in./in.				
	-438	-53	-555	-612	-572	-347	-325

Table 47. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-15	Gage No. G-21	Gage No. G-22	Gage No. G-27	Gage No. G-26	Gage No. G-25	Gage No. G-19
1,000	10,285	11,424	11,736	10,628	11,648	10,212	11,007
4,000	10,282	11,435	11,766	10,665	11,688	10,252	10,958
8,000	10,285	11,477	11,823	10,726	11,752	10,314	10,904
12,000	10,286	11,522	11,880	10,785	11,813	10,370	10,847
16,000	10,293	11,560	11,934	10,848	11,875	10,432	10,788
20,000	10,286	11,595	11,987	10,907	11,938	10,496	10,733
24,000	10,290	11,637	12,040	10,964	12,000	10,555	10,678
28,000	10,297	11,680	12,095	11,026	12,064	10,620	10,625
32,000	10,295	11,713	12,145	11,090	12,122	10,673	10,566
36,000	10,294	11,755	12,200	11,134	12,180	10,733	10,506
40,000	10,298	11,798	12,255	11,203	12,247	10,800	10,457
1,000	10,288	11,418	11,736	10,632	11,648	10,215	11,005
			Total Strain x 10^{-6} in./in.				
	10	380	519	571	599	585	-548

Table 48. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-9-45	Gage No. R-9-V	Gage No. G-10	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14
1,000	0	0	9,402	9,338	10,547	10,530	10,214
4,000	10	- 6	9,377	9,327	10,542	10,528	10,228
8,000	28	- 12	9,350	9,325	10,548	10,545	10,262
12,000	40	- 26	9,318	9,315	10,555	10,556	10,293
16,000	45	- 47	9,288	9,308	10,556	10,577	10,323
20,000	61	- 58	9,263	9,303	10,562	10,585	10,342
24,000	72	- 75	9,233	9,296	10,568	10,605	10,380
28,000	90	- 80	9,205	9,287	10,577	10,622	10,416
32,000	98	-100	9,168	9,277	10,574	10,628	10,436
36,000	120	-103	9,138	9,262	10,574	10,640	10,467
40,000	131	-117	9,114	9,262	10,585	10,662	10,500
1,000	- 35	- 35	9,403	9,344	10,544	10,525	10,220
			Total Strain x 10^{-6} in./in.				
	166	- 82	-289	-82	41	137	280

Table 49. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-8-V	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H
1,000	0	0	0	0	0	0	0
4,000	24	- 4	- 37	8	- 8	- 8	10
8,000	57	- 10	- 78	17	-13	-17	37
12,000	75	- 28	-120	18	-27	-26	63
16,000	81	- 52	-167	12	-40	-33	80
20,000	97	- 71	-210	12	-50	-40	108
24,000	109	- 90	-250	9	-60	-47	133
28,000	137	-100	-280	18	-67	-45	165
32,000	132	-126	-333	10	-81	-60	186
36,000	160	-133	-360	22	-80	-53	223
40,000	170	-158	-402	19	-88	-57	253
1,000	- 35	- 35	- 35	-35	-35	-35	-35
			Total Strain x 10^{-6} in./in.				
	205	-123	-367	54	-53	-22	288

Table 50. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-4-H	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H
1,000	0	0	0	0	0	0	0
4,000	0	- 4	8	18	26	- 7	- 38
8,000	- 3	- 17	18	45	50	- 12	- 77
12,000	-14	- 38	22	68	60	- 33	-110
16,000	-22	- 51	29	92	70	- 56	-162
20,000	-30	- 72	30	113	80	- 73	-202
24,000	-38	- 92	36	137	90	- 92	-240
28,000	-40	-103	48	165	106	-104	-268
32,000	-51	-123	52	190	118	-124	-323
36,000	-54	-134	61	218	135	-126	-350
40,000	-56	-145	73	248	140	-153	-383
1,000	-27	- 27	-27	- 27	- 27	- 27	- 40
			Total Strain x 10^{-6} in./in.				
	-29	-123	100	275	167	-126	-343

Table 51. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45
1,000	0	0	0	0	0	0	0
4,000	- 23	- 10	41	30	0	15	- 4
8,000	- 60	- 18	85	60	-11	23	- 17
12,000	-100	- 30	126	86	-24	24	- 38
16,000	-140	- 42	154	130	-27	25	- 57
20,000	-184	- 60	184	144	-53	20	- 83
24,000	-224	- 77	215	168	-56	16	-103
28,000	-260	- 84	253	204	-59	20	-122
32,000	-300	- 97	288	218	-73	13	-145
36,000	-337	-109	312	243	-78	16	-162
40,000	-368	-113	355	274	-83	20	-180
1,000	- 34	- 34	- 38	- 27	-27	-27	- 27
			Total Strain x 10^{-6} in./in.				
	-334	- 79	393	301	-56	47	-153

Table 52. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-1-H	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V
1,000	0	0	0	0	0	0	0
4,000	- 40	- 14	20	38	40	12	- 18
8,000	-100	- 62	20	82	86	21	- 50
12,000	-160	-110	19	130	136	28	- 83
16,000	-210	-150	18	170	181	30	-118
20,000	-270	-205	4	211	224	36	-158
24,000	-336	-262	- 5	252	268	39	-192
28,000	-385	-309	- 8	300	318	47	-226
32,000	-446	-360	-12	340	363	55	-255
36,000	-510	-417	-22	390	414	58	-293
40,000	-555	-454	-16	447	472	74	-317
1,000	- 40	- 40	-40	- 34	- 34	-34	- 34
			Total Strain x 10^{-6} in./in.				
	-515	-414	24	481	506	108	-283

Table 53. Beam With Holes - Load 35 in. From Supports.

Load (lbs.)	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H	Gage No. R-9-45	Gage No. R-9-V
1,000	0	0	0	0	0	0	0	0
4,000	0	- 25	16	0	0	17	20	0
8,000	- 10	- 72	23	-10	-10	40	30	-12
12,000	- 23	-112	25	-18	-17	70	50	-23
16,000	- 32	-145	30	-23	-20	100	65	-33
20,000	- 36	-177	43	-20	-10	137	90	-37
24,000	- 60	-220	40	-33	-20	160	100	-50
28,000	- 78	-260	40	-42	-25	186	114	-64
32,000	- 90	-297	47	-46	-27	217	130	-75
36,000	-108	-338	48	-56	-30	244	145	-84
40,000	-124	-380	50	-60	-30	275	160	-93
1,000	- 23	- 20	-20	-20	-20	- 20	- 20	-20
				Total Strain x 10^{-6} in./in.				
	-101	-360	70	-40	-10	295	180	-73

Table 54. Beam With Holes - Load 35 in. From Supports.

Load (lbs.)	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H	Gage No. R-8-V
1,000	0	0	0	0	0	0	0
4,000	- 8	3	18	26	- 8	- 23	34
8,000	- 20	17	47	49	- 13	- 60	57
12,000	- 32	22	73	67	- 30	-113	80
16,000	- 45	31	102	83	- 44	-140	105
20,000	- 62	43	128	103	- 57	-174	132
24,000	- 73	58	160	115	- 72	-218	140
28,000	- 88	61	185	127	- 89	-257	153
32,000	-101	73	214	143	-100	-290	178
36,000	-118	80	240	153	-120	-322	193
40,000	-128	90	267	168	-133	-365	210
1,000	- 24	-23	- 23	- 18	- 18	- 23	- 23
			Total Strain x 10^{-6} in./in.				
	-104	113	290	186	-115	-342	233

Table 55. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H
1,000	0	0	0	0	0	0	0
4,000	- 3	43	22	- 8	12	- 8	- 4
8,000	- 12	86	55	-18	20	- 22	-10
12,000	- 24	123	87	-23	22	- 38	-15
16,000	- 32	168	120	-28	30	- 51	-17
20,000	- 43	197	148	-37	30	- 72	-22
24,000	- 50	233	180	-38	32	- 88	-24
28,000	- 60	273	207	-50	30	-108	-30
32,000	- 73	307	237	-55	33	-122	-31
36,000	- 85	343	265	-62	36	-143	-37
40,000	-100	383	300	-66	40	-160	-37
1,000	- 27	- 27	- 24	-24	-24	- 24	-24
			Total Strain x 10^{-6} in./in.				
	-73	410	324	-42	64	-136	-13

Table 56. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V	Gage No. R-3-45
1,000	0	0	0	0	0	0	0
4,000	- 10	22	42	44	17	- 17	- 23
8,000	- 55	23	86	90	20	- 56	- 60
12,000	- 98	23	132	138	27	- 89	-100
16,000	-144	23	180	190	38	-115	-137
20,000	-190	20	227	237	42	-150	-173
24,000	-230	20	277	290	55	-176	-203
28,000	-282	18	323	340	62	-211	-247
32,000	-333	12	370	388	67	-244	-285
36,000	-383	12	417	437	76	-280	-324
40,000	-440	8	467	490	84	-311	-365
1,000	- 36	-24	- 24	- 24	-24	- 27	- 27
			Total Strain x 10^{-6} in./in.				
	-404	32	491	514	108	-284	-338

Table 57. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-10	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14	Gage No. G-15	Gage No. R-1-H
1,000	9,406	9,343	10,546	10,524	10,217	10,294	0
4,000	9,383	9,336	10,552	10,540	10,237	10,295	- 31
8,000	9,357	9,334	10,556	10,552	10,270	10,295	- 86
12,000	9,326	9,326	10,564	10,570	10,303	10,296	-143
16,000	9,295	9,307	10,557	10,575	10,316	10,285	-195
20,000	9,266	9,300	10,570	10,595	10,358	10,297	-250
24,000	9,240	9,300	10,572	10,608	10,386	10,297	-302
28,000	9,210	9,293	10,573	10,625	10,414	10,300	-357
32,000	9,182	9,285	10,583	10,637	10,445	10,300	-423
36,000	9,155	9,276	10,586	10,655	10,477	10,300	-480
40,000	9,118	9,265	10,585	10,670	10,504	10,304	-540
1,000	9,402	9,346	10,547	10,530	10,222	10,294	- 27
			Total Strain x 10^{-6} in./in.				
	-284	-81	38	140	282	10	-513

Table 58. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-25	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-9	Gage No. G-17	Gage No. G-18
1,000	10,210	11,017	10,835	9,933	10,976	9,702	10,373
4,000	10,256	10,977	10,800	9,927	10,935	9,657	10,332
8,000	10,318	10,920	10,757	9,922	10,877	9,595	10,272
12,000	10,378	10,862	10,713	9,917	10,820	9,532	10,215
16,000	10,435	10,802	10,658	9,905	10,757	9,458	10,146
20,000	10,500	10,750	10,622	9,907	10,706	9,405	10,096
24,000	10,560	10,695	10,577	9,905	10,652	9,342	10,037
28,000	10,623	10,635	10,532	9,897	10,595	9,282	9,982
32,000	10,684	10,583	10,485	9,895	10,543	9,222	9,924
36,000	10,745	10,525	10,545	9,887	10,485	9,155	9,862
40,000	10,805	10,463	10,397	9,887	10,434	9,086	9,807
1,000	10,220	11,008	10,833	9,937	10,984	9,695	10,377
			Total Strain x 10^{-6} in./in.				
	585	-545	-436	-50	-550	-609	-570

Table 59. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-24	Gage No. G-7	Gage No. G-6	Gage No. G-21	Gage No. G-22	Gage No. G-27	Gage No. G-26
1,000	9,897	9,020	9,836	11,420	11,733	10,626	11,646
4,000	9,945	9,013	9,835	11,445	11,773	10,673	11,696
8,000	10,010	9,010	9,842	11,485	11,830	10,736	11,758
12,000	10,073	9,002	9,838	11,526	11,885	10,795	11,822
16,000	10,138	9,004	9,842	11,560	11,937	10,848	11,878
20,000	10,207	9,000	9,850	11,607	11,995	10,913	11,945
24,000	10,270	8,997	9,853	11,644	12,047	10,968	12,007
28,000	10,335	8,995	9,856	11,685	12,100	11,030	12,065
32,000	10,405	8,992	9,852	11,723	12,155	11,087	12,130
36,000	10,467	8,987	9,853	11,762	12,205	11,144	12,193
40,000	10,536	8,983	9,860	11,797	12,255	11,205	12,248
1,000	9,907	9,025	9,848	11,424	11,744	10,633	11,648
			Total Strain x 10^{-6} in./in.				
	629	-42	12	373	511	572	600

Table 60. Beam With Holes - Load at 35 in. From Supports.

Load (lbs.)	Gage No. G-2	Gage No. G-3	Gage No. G-4	Gage No. G-5	Gage No. G-1	Gage No. G-8	Gage No. G-23
1,000	10,260	11,203	11,797	10,464	8,983	9,265	8,936
4,000	10,232	11,178	11,823	10,487	8,954	9,217	8,967
8,000	10,197	11,148	11,840	10,523	8,916	9,150	9,007
12,000	10,166	11,116	11,872	10,564	8,876	9,087	9,045
16,000	10,128	11,086	11,900	10,595	8,837	9,022	9,085
20,000	10,095	11,054	11,930	10,636	8,797	8,957	9,123
24,000	10,060	11,022	11,955	10,665	8,760	8,893	9,158
28,000	10,027	10,988	11,985	10,698	8,720	8,826	9,197
32,000	9,987	10,955	12,012	10,735	8,682	8,763	9,235
36,000	9,955	10,924	12,037	10,772	8,643	8,695	9,275
40,000	9,918	10,893	12,065	10,800	8,602	8,623	9,312
1,000	10,263	11,213	11,813	10,472	8,987	9,264	8,948
			Total Strain x 10^{-6} in./in.				
	-345	-320	252	328	-385	-641	364

Table 61. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-1	Gage No. G-8	Gage No. G-23	Gage No. G-24	Gage No. G-7	Gage No. G-6
1,000	11,753	10,410	8,945	9,213	8,887	9,864	8,973	9,606
4,000	11,778	10,435	8,918	9,167	8,915	9,907	8,977	9,608
8,000	11,807	10,485	8,885	9,105	8,963	9,983	8,983	9,622
12,000	11,840	10,520	8,847	9,037	9,000	10,046	8,985	9,626
16,000	11,873	10,554	8,817	8,977	9,046	10,117	8,985	9,626
20,000	11,905	10,588	8,775	8,917	9,084	10,185	8,987	9,634
24,000	11,937	10,626	8,745	8,853	9,125	10,254	8,986	9,636
28,000	11,968	10,665	8,700	8,788	9,163	10,317	8,988	9,643
32,000	12,005	10,710	8,667	8,725	9,203	10,387	8,990	9,645
36,000	12,025	10,745	8,627	8,663	9,242	10,450	8,987	9,645
37,000	12,035	10,748	8,620	8,647	9,250	10,467	8,993	9,645
1,000	11,784	10,440	8,968	9,235	8,914	9,888	9,00	9,635
				Total Strain x 10^{-6} in./in.				
	251	308	-348	-588	336	579	-7	10

Table 62. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14	Gage No. G-15	Gage No. G-2	Gage No. G-3
1,000	9,284	10,500	10,477	10,176	10,246	10,206	11,145
4,000	9,278	10,500	10,488	10,198	10,247	10,187	11,119
8,000	9,273	10,510	10,507	10,230	10,260	10,156	11,093
12,000	9,277	10,522	10,526	10,272	10,266	10,127	11,058
16,000	9,270	10,526	10,545	10,307	10,272	10,094	11,027
20,000	9,267	10,533	10,558	10,340	10,277	10,057	10,993
24,000	9,267	10,547	10,578	10,375	10,285	10,025	10,965
28,000	9,263	10,545	10,595	10,405	10,287	9,995	10,930
32,000	9,263	10,555	10,615	10,445	10,290	9,965	10,905
36,000	9,257	10,563	10,633	10,473	10,300	9,927	10,866
37,000	9,256	10,565	10,635	10,483	10,303	9,922	10,860
1,000	9,307	10,517	10,495	10,188	10,264	10,236	11,174
			Total Strain x 10^{-6} in./in.				
	-51	48	140	295	39	-314	-314

Table 63. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-9	Gage No. G-17	Gage No. G-18	Gage No. G-10
1,000	10,952	10,773	9,883	10,917	9,610	10,325	9,344
4,000	10,914	10,730	9,886	10,875	9,564	10,278	9,323
8,000	10,857	10,685	9,896	10,817	9,497	10,217	9,298
12,000	10,797	10,640	9,898	10,762	9,436	10,160	9,277
16,000	10,740	10,595	9,907	10,705	9,373	10,097	9,255
20,000	10,682	10,545	9,907	10,645	9,305	10,035	9,232
24,000	10,624	10,500	9,914	10,588	9,245	9,980	9,210
28,000	10,567	10,454	9,915	10,530	9,184	9,918	9,185
32,000	10,507	10,405	9,922	10,473	9,122	9,857	9,166
36,000	10,450	10,358	9,923	10,405	9,058	9,794	9,140
37,000	10,435	10,345	9,925	10,390	9,044	9,780	9,135
1,000	10,985	10,795	9,907	10,940	9,637	10,350	9,365
			Total Strain x 10^{-6} in./in.				
	-550	-450	18	-550	-593	-570	-230

Table 64. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-9-45	Gage No. R-9-V	Gage No. G-21	Gage No. G-22	Gage No. G-27	Gage No. G-26	Gage No. G-25
1,000	0	0	11,373	11,697	10,583	11,600	10,175
4,000	16	- 9	11,405	11,746	10,635	11,657	10,227
8,000	30	- 23	11,455	11,807	10,703	11,728	10,297
12,000	43	- 37	11,505	11,875	10,774	11,803	10,367
16,000	57	- 50	11,551	11,937	10,845	11,875	10,438
20,000	73	- 63	11,598	11,998	10,908	11,945	10,505
24,000	100	- 70	11,647	12,065	10,977	12,017	10,574
28,000	104	- 90	11,696	12,125	11,046	12,085	10,645
32,000	120	-104	11,745	12,185	11,115	12,158	10,706
36,000	130	-121	11,785	12,245	11,175	12,224	10,776
37,000	131	-123	11,797	12,258	11,194	12,243	10,795
1,000	- 18	- 18	11,395	11,725	10,607	11,625	10,200
			Total Strain x 10^{-6} in./in.				
	149	-105	402	533	587	618	595

Table 65. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-3-V	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H
1,000	0	0	0	0	0	0	0
4,000	- 3	- 20	- 25	- 10	- 10	0	20
8,000	-10	- 45	- 60	- 25	- 25	0	50
12,000	-19	- 70	- 90	- 40	- 40	0	77
16,000	-19	- 87	-120	- 50	- 45	0	110
20,000	-20	-107	-153	- 62	- 58	2	140
24,000	- 8	-116	-170	- 60	- 57	15	187
28,000	-22	-148	-214	- 84	- 78	7	208
32,000	-21	-170	-248	- 95	- 90	7	240
36,000	-27	-193	-282	-112	-103	3	267
37,000	-25	-197	-291	-113	-104	4	275
1,000	-12	- 18	- 22	- 16	- 22	-22	- 22
			Total Strain x 10^{-6} in./in.				
	-13	-179	-269	-97	-82	26	297

Table 66. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-4-H	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H
1,000	0	0	0	0	0	0	0
4,000	8	0	16	30	13	- 13	- 24
8,000	0	- 23	25	58	23	- 38	- 67
12,000	0	- 37	40	90	33	- 57	-110
16,000	- 3	- 57	58	128	47	- 77	-145
20,000	-10	- 77	65	158	55	-100	-180
24,000	-14	- 97	78	193	70	-100	-212
28,000	-10	-107	100	230	85	-132	-265
32,000	-17	-127	110	260	90	-153	-303
36,000	-20	-145	120	293	100	-174	-340
37,000	-25	-152	122	300	100	-180	-352
1,000	-12	- 12	- 12	- 12	- 3	- 3	- 22
			Total Strain x 10^{-6} in./in.				
	-13	-140	134	312	103	-177	-330

Table 67. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45
1,000	0	0	0	0	0	0	0
4,000	- 11	3	30	30	7	11	0
8,000	- 47	-10	56	50	- 3	7	- 24
12,000	- 80	-20	83	78	-10	8	- 40
16,000	-115	-30	115	115	-12	5	- 60
20,000	-150	-40	143	133	-21	0	- 80
24,000	-187	-52	174	160	-27	0	-100
28,000	-217	-56	210	195	-25	7	-113
32,000	-252	-70	240	220	-27	5	-132
36,000	-290	-80	260	248	-37	0	-153
37,000	-302	-86	269	252	-40	0	-160
1,000	- 11	-11	- 10	0	-13	-10	- 10
			Total Strain x 10^{-6} in./in.				
	-291	-75	279	252	-27	10	-150

Table 68. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-1-H	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V
1,000	0	0	0	0	0	0	0
4,000	- 24	- 20	10	48	48	21	- 7
8,000	- 83	- 73	0	90	90	30	- 37
12,000	-135	-123	-10	140	140	37	- 67
16,000	-188	-173	-20	186	186	43	-100
20,000	-244	-227	-30	231	233	47	-130
24,000	-300	-280	-40	280	285	55	-163
28,000	-350	-323	-40	330	338	68	-185
32,000	-403	-377	-54	377	385	75	-214
36,000	-456	-435	-65	420	430	80	-250
37,000	-470	-445	-67	428	440	80	-257
1,000	- 11	- 7	- 7	- 7	- 7	-11	- 11
			Total Strain x 10^{-6} in./in.				
	-459	-438	-60	435	447	91	-246

Table 69. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-1	Gage No. G-8	Gage No. G-23	Gage No. G-24	Gage No. G-7	Gage No. G-6
1,000	11,794	10,440	8,976	9,240	8,916	9,895	9,008	9,638
4,000	11,816	10,476	8,953	9,195	8,945	9,945	9,010	9,643
8,000	11,845	10,515	8,915	9,134	8,987	10,015	9,013	9,653
12,000	11,878	10,546	8,875	9,066	9,026	10,077	9,008	9,646
16,000	11,912	10,590	8,840	9,008	9,074	10,145	9,013	9,658
20,000	11,936	10,618	8,803	8,943	9,112	10,215	9,013	9,655
24,000	11,964	10,655	8,763	8,875	9,156	10,283	9,008	9,666
28,000	11,993	10,694	8,725	8,810	9,185	10,340	9,005	9,663
32,000	12,025	10,725	8,685	8,748	9,228	10,410	9,003	9,670
36,000	12,054	10,764	8,647	8,684	9,265	10,474	9,006	9,668
37,000	12,055	10,773	8,636	8,665	9,272	10,485	9,005	9,667
1,000	11,805	10,463	8,990	9,255	8,934	9,910	9,023	9,653
				Total Strain x 10^{-6} in./in.				
	250	310	-354	-590	338	575	-18	14

Table 70. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14	Gage No. G-15	Gage No. G-2	Gage No. G-3
1,000	9,320	10,535	10,506	10,206	10,278	10,245	11,183
4,000	9,315	10,540	10,520	10,233	10,285	10,223	11,157
8,000	9,315	10,547	10,543	10,265	10,290	10,195	11,127
12,000	9,306	10,550	10,553	10,296	10,294	10,157	11,095
16,000	9,303	10,555	10,566	10,335	10,297	10,124	11,064
20,000	9,295	10,565	10,590	10,365	10,305	10,090	11,030
24,000	9,293	10,567	10,605	10,400	10,307	10,050	11,964
28,000	9,285	10,572	10,617	10,430	10,311	10,018	10,960
32,000	9,285	10,580	10,638	10,463	10,318	9,985	10,928
36,000	9,277	10,584	10,654	10,494	10,323	9,953	10,895
37,000	9,277	10,585	10,658	10,498	10,320	9,945	10,885
1,000	9,328	10,543	10,515	10,215	10,287	10,265	11,194
			Total Strain x 10^{-6} in./in.				
	-51	42	143	283	33	-320	-309

Table 71. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-9	Gage No. G-17	Gage No. G-18	Gage No. G-10
1,000	10,994	10,807	9,917	10,948	9,657	10,360	9,377
4,000	10,948	10,773	9,923	10,906	9,608	10,315	9,360
8,000	10,888	10,724	9,925	10,850	9,945	10,250	9,335
12,000	10,825	10,674	9,924	10,788	9,475	10,184	9,306
16,000	10,767	10,627	9,925	10,732	9,413	10,126	9,285
20,000	10,704	10,582	9,930	10,673	9,345	10,058	9,260
24,000	10,646	10,532	9,930	10,613	9,280	10,000	9,235
28,000	10,585	10,480	9,928	10,547	9,213	9,937	9,207
32,000	10,525	10,435	9,932	10,488	9,150	9,878	9,185
36,000	10,465	10,385	9,933	10,424	9,084	9,814	9,164
37,000	10,450	10,368	9,934	10,405	9,058	9,798	9,157
1,000	11,003	10,816	9,933	10,964	9,655	10,372	9,385
			Total Strain x 10^{-6} in./in.				
	-553	-448	1	-559	-597	-574	-228

Table 72. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-9-45	Gage No. R-9-V	Gage No. G-21	Gage No. G-22	Gage No. G-27	Gage No. G-26	Gage No. G-25
1,000	0	0	11,407	11,735	10,616	11,635	10,206
4,000	10	- 12	11,443	11,784	10,665	11,688	10,263
8,000	33	- 20	11,488	11,845	10,735	11,758	10,333
12,000	47	- 35	11,533	11,907	10,795	11,825	10,395
16,000	56	- 55	11,580	11,967	10,864	11,897	10,464
20,000	80	- 60	11,630	12,033	10,935	11,970	10,534
24,000	83	- 85	11,672	12,085	10,994	12,035	10,594
28,000	100	-100	11,715	12,145	11,060	12,105	10,663
32,000	120	-108	11,764	12,205	11,127	12,175	10,728
36,000	137	-118	11,805	12,265	11,194	12,240	10,795
37,000	136	-123	11,815	12,278	11,207	12,257	10,808
1,000	- 11	- 20	11,417	11,748	10,627	11,645	10,223
			Total Strain x 10^{-6} in./in.				
	147	-103	398	530	580	612	585

Table 73. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-8-V	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H
1,000	0	0	0	0	0	0	0
4,000	- 8	- 20	- 26	- 10	-10	0	20
8,000	0	- 30	- 48	- 18	-17	7	60
12,000	- 3	- 55	- 84	- 30	-27	7	90
16,000	-13	- 83	-120	- 48	-43	0	114
20,000	- 3	- 92	-145	- 50	-42	10	157
24,000	-17	-123	-185	- 72	-65	0	175
28,000	-11	-141	-214	- 80	-75	3	210
32,000	- 7	-157	-244	- 88	-80	8	247
36,000	0	-170	-275	- 93	-84	10	280
37,000	0	-180	-288	-100	-90	10	288
1,000	-20	- 18	- 10	- 23	-18	-18	- 11
			Total Strain x 10^{-6} in./in.				
	20	-162	-278	- 77	-72	28	299

Table 74. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-4-H	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H
1,000	0	0	0	0	0	0	0
4,000	- 8	- 15	7	20	0	- 23	- 30
8,000	0	- 27	28	60	23	- 37	- 60
12,000	0	- 40	44	97	36	- 53	-103
16,000	-20	- 73	44	119	37	- 83	-137
20,000	-10	- 80	70	166	62	- 90	-176
24,000	-26	-110	71	188	63	-120	-231
28,000	-20	-120	90	228	80	-131	-270
32,000	-20	-132	110	267	100	-145	-300
36,000	-20	-150	125	300	115	-160	-323
37,000	-26	-160	123	300	111	-170	-353
1,000	-15	- 15	- 15	- 12	- 13	- 12	- 8
			Total Strain x 10^{-6} in./in.				
	-11	-145	138	312	124	-158	-345

Table 75. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45
1,000	0	0	0	0	0	0	0
4,000	- 27	-10	20	20	-10	- 4	- 18
8,000	- 52	-10	58	58	- 3	3	- 28
12,000	- 80	-17	91	80	-10	0	- 44
16,000	-125	-35	114	97	-27	-10	- 76
20,000	-153	-37	154	144	-19	0	- 80
24,000	-203	-60	172	168	-37	-10	-112
28,000	-230	-60	211	205	-30	0	-120
32,000	-263	-70	247	224	-33	3	-134
36,000	-295	-73	280	250	-37	7	-153
37,000	-305	-80	286	260	-40	0	-162
1,000	0	0	- 8	- 6	-10	-20	- 18
			Total Strain x 10^{-6} in./in.				
	-305	-80	294	266	-30	20	-144

Table 76. Beam With Holes - Load at 38 in. From Supports.

Load (lbs.)	Gage No. R-1-H	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V
1,000	0	0	0	0	0	0	0
4,000	- 38	- 38	- 4	30	30	0	- 22
8,000	- 85	- 76	0	90	90	23	- 40
12,000	-117	-111	0	147	147	37	- 65
16,000	-186	-174	-19	180	180	31	-106
20,000	-230	-218	-20	240	244	51	-130
24,000	-311	-290	-45	267	273	40	-175
28,000	-350	-328	-42	327	332	57	-196
32,000	-400	-374	-45	380	390	70	-222
36,000	-450	-420	-45	433	440	80	-250
37,000	-483	-447	-54	438	449	80	-260
1,000	3	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	-486	-447	-54	438	449	80	-260

Table 77. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H	Gage No. R-9-45	Gage No. R-9-V
0	0	0	0	0	0	0	0	0
2,000	- 27	- 57	8	0	-10	- 21	- 22	- 10
4,000	- 57	-110	13	5	-18	- 38	- 43	- 22
6,000	- 84	-157	23	14	-18	- 44	- 60	- 32
8,000	-128	-220	18	10	-27	- 60	- 83	- 52
10,000	-163	-273	17	12	-37	- 78	-109	- 70
12,000	-203	-331	17	17	-40	- 90	-133	- 88
14,000	-235	-381	20	20	-43	-102	-151	- 98
16,000	-276	-437	20	22	-49	-120	-174	-113
18,000	-312	-487	20	30	-50	-130	-197	-127
0	- 28	- 28	-28	-28	-28	- 28	- 28	- 28
				Total Strain x 10^{-6} in./in.				
	-284	-459	48	58	-22	-102	-169	- 99

Table 78. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H	Gage No. R-8-V
0	0	0	0	0	0	0	0
2,000	3	38	42	30	15	0	20
4,000	0	68	83	57	30	- 8	24
6,000	0	108	134	94	58	-10	34
8,000	0	143	180	110	64	-20	30
10,000	- 4	178	230	130	79	-28	30
12,000	-10	210	271	146	90	-35	30
14,000	-16	250	323	172	108	-27	37
16,000	-16	287	370	193	123	-37	38
18,000	-15	322	420	215	138	-37	40
0	-31	- 27	- 27	- 31	- 28	-28	-28
			Total Strain x 10^{-6} in./in.				
	16	349	447	246	166	- 9	68

Table 79. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45	Gage No. R-4-H
0	0	0	0	0	0	0	0
2,000	- 4	19	12	- 3	9	- 4	- 4
4,000	-21	30	20	-18	0	-22	-18
6,000	-20	50	30	-13	0	-28	-20
8,000	-28	60	55	-22	3	-38	-26
10,000	-40	68	53	-33	- 3	-58	-36
12,000	-48	83	60	-38	- 3	-70	-38
14,000	-56	98	84	-38	- 4	-78	-43
16,000	-63	108	86	-47	- 3	-88	-44
18,000	-71	121	112	-48	0	-93	-44
0	-31	- 31	- 31	-31	-31	-31	-31
			Total Strain x 10^{-6} in./in.				
	-40	152	143	-17	31	-62	-13

Table 80. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V	Gage No. R-3-45
0	0	0	0	0	0	0	0
2,000	- 18	7	27	22	12	- 8	- 8
4,000	- 38	- 2	38	41	13	- 25	- 27
6,000	- 58	0	66	67	28	- 37	- 38
8,000	- 88	- 9	80	84	26	- 53	- 57
10,000	-111	-10	100	108	30	- 70	- 78
12,000	-150	-23	118	128	30	- 88	-100
14,000	-173	-26	136	148	30	-103	-114
16,000	-207	-37	153	170	32	-123	-138
18,000	-230	-40	177	192	36	-138	-156
0	- 31	-31	- 31	- 31	-31	- 31	- 31
			Total Strain x 10^{-6} in./in.				
	-199	- 9	208	223	67	-107	-125

Table 81. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-10	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14	Gage No. G-15	Gage No. R-1-H
0	9,398	9,325	10,523	10,493	10,163	10,278	0
2,000	9,370	9,310	10,525	10,513	10,191	10,284	- 22
4,000	9,343	9,300	10,525	10,528	10,220	10,287	- 57
6,000	9,316	9,287	10,527	10,542	10,254	10,288	- 83
8,000	9,284	9,270	10,524	10,560	10,283	10,294	-108
10,000	9,255	9,255	10,524	10,578	10,306	10,294	-136
12,000	9,228	9,236	10,527	10,595	10,340	10,300	-177
14,000	9,197	9,222	10,524	10,614	10,367	10,305	-204
16,000	9,167	9,208	10,528	10,630	10,393	10,307	-234
18,000	9,138	9,193	10,528	10,643	10,424	10,312	-261
0	9,405	9,332	10,525	10,497	10,167	10,285	- 31
			Total Strain x 10^{-6} in./in.				
	-267	-139	3	146	257	27	-230

Table 82. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-25	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-9	Gage No. G-17	Gage No. G-18
0	10,137	11,045	10,848	9,930	11,050	9,725	10,404
2,000	10,173	11,010	10,817	9,927	11,023	9,703	10,367
4,000	10,204	10,973	10,787	9,923	10,990	9,683	10,328
6,000	10,238	10,935	10,755	9,918	10,960	9,655	10,288
8,000	10,270	10,898	10,725	9,915	10,930	9,628	10,250
10,000	10,300	10,858	10,692	9,912	10,897	9,605	10,208
12,000	10,330	10,824	10,658	9,905	10,865	9,582	10,170
14,000	10,362	10,785	10,628	9,905	10,835	9,557	10,130
16,000	10,390	10,747	10,596	9,898	10,804	9,530	10,088
18,000	10,422	10,712	10,565	9,895	10,774	9,508	10,050
0	10,147	11,053	10,854	9,938	11,058	9,732	10,414
			Total Strain x 10^{-6} in./in.				
	275	-341	-289	-43	-284	-224	-364

Table 83. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-24	Gage No. G-7	Gage No. G-6	Gage No. G-21	Gage No. G-22	Gage No. G-27	Gage No. G-26
0	9,707	9,097	10,027	11,367	11,697	10,562	11,583
2,000	9,737	9,097	10,033	11,398	11,737	10,612	11,607
4,000	9,770	9,097	10,027	11,427	11,776	10,650	11,630
6,000	9,807	9,095	10,032	11.457	11,820	10,695	11,655
8,000	9,845	9,095	10,032	11,487	11,857	10,737	11,680
10,000	9,873	9,088	10,036	11,517	11,896	10,780	11,700
12,000	9,900	9,090	10,033	11,545	11,934	10,820	11,725
14,000	9,935	9,092	10,033	11,573	11,970	10,864	11,747
16,000	9,967	9,088	10,037	11,600	12,007	10,905	11,770
18,000	10,002	9,085	10,034	11,628	12,043	10,945	11,788
0	9,714	9,102	10,038	11,373	11,705	10,572	11,588
			Total Strain x 10^{-6} in./in.				
	288	-17	-4	255	338	373	200

Table 84. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-2	Gage No. G-3	Gage No. G-4	Gage No. G-5	Gage No. G-1	Gage No. G-8	Gage No. G-23
0	10,274	10,808	11,728	10,530	9,147	9,386	8,937
2,000	10,262	10,797	11,750	10,547	9,128	9,353	8,963
4,000	10,245	10,783	11,767	10,570	9,113	9,322	8,980
6,000	10,228	10,770	11,788	10,593	9,095	9,290	9,000
8,000	10,213	10,756	11,805	10,610	9,074	9,257	9,022
10,000	10,194	10,738	11,820	10,622	9,052	9,223	9,038
12,000	10,173	10,722	11,835	10,644	9,032	9,187	9,056
14,000	10,158	10,706	11,850	10,660	9,014	9,156	9,077
16,000	10,140	10,690	11,864	10,676	8,992	9,122	9,092
18,000	10,120	10,675	11,877	10,694	8,972	9,090	9,112
0	10,283	10,814	11,738	10,536	9,155	9,392	8,945
			Total Strain x 10^{-6} in./in.				
	-163	-139	139	158	-183	-302	167

Table 85. Beam With Holes - Load at Centerline

Load (lbs.)	Gage No. G-17	Gage No. G-18	Gage No. G-10	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14	Gage No. G-15
0	9,725	10,403	9,397	9,326	10,524	10,491	10,160	10,283
2,000	9,704	10,370	9,373	9,312	10,525	10,512	10,190	10,285
4,000	9,678	10,328	9,342	9,297	10,525	10,525	10,223	10,287
6,000	9,655	10,288	9,312	9,285	10,527	10,542	10,250	10,287
8,000	9,631	10,250	9,287	9,267	10,523	10,560	10,275	10,294
10,000	9,607	10,213	9,257	9,254	10,523	10,578	10,308	10,298
12,000	9,580	10,170	9,225	9,240	10,527	10,588	10,335	10,300
14,000	9,557	10,130	9,200	9,226	10,527	10,606	10,360	10,305
16,000	9,530	10,093	9,168	9,212	10,528	10,628	10,390	10,307
18,000	9,508	10,052	9,144	9,193	10,524	10,642	10,420	10,312
0	9,732	10,411	9,404	9,333	10,524	10,492	10,168	10,284
				Total Strain x 10^{-6} in./in.				
	-224	-359	-260	-140	0	150	252	28

Table 86. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-27	Gage No. G-26	Gage No. G-25	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-9
0	10,563	11,583	10,138	11,047	10,846	9,933	11,052
2,000	10,607	11,608	10,173	11,012	10,816	9,927	11,025
4,000	10,648	11,630	10,205	10,975	10,787	9,924	10,992
6,000	10,692	11,653	10,235	10,937	10,754	9,921	10,960
8,000	10,737	11,673	10,265	10,900	10,724	9,917	10,930
10,000	10,773	11,700	10,295	10,863	10,693	9,912	10,900
12,000	10,818	11,722	10,327	10,823	10,660	9,907	10,867
14,000	10,860	11,744	10,357	10,786	10,626	9,907	10,837
16,000	10,900	11,767	10,390	10,750	10,595	9,900	10,805
18,000	10,940	11,787	10,418	10,713	10,564	9,897	10,774
0	10,572	10,587	10,146	11,054	10,852	9,938	11,058
			Total Strain x 10^{-6} in./in.				
	368	200	272	-341	-288	-41	-284

Table 87. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-8	Gage No. G-23	Gage No. G-24	Gage No. G-7	Gage No. G-6	Gage No. G-21	Gage No. G-22
0	9,392	8,944	9,708	9,102	10,015	11,367	11,696
2,000	9,353	8,958	9,742	9,097	10,010	11,397	11,737
4,000	9,327	8,980	9,777	9,097	10,010	11,425	11,777
6,000	9,293	8,998	9,800	9,097	10,012	11,453	11,816
8,000	9,260	9,018	9,838	9,096	10,012	11,483	11,853
10,000	9,226	9,038	9,867	9,096	10,015	11,513	11,894
12,000	9,193	9,057	9,898	9,088	10,015	11,540	11,928
14,000	9,160	9,075	9,934	9,094	10,017	11,566	11,967
16,000	9,128	9,095	9,967	9,093	10,025	11,596	12,005
18,000	9,095	9,116	10,000	9,090	10,028	11,626	12,043
0	9,395	8,948	9,715	9,107	10,030	11,372	11,703
			Total Strain x 10^{-6} in./in.				
	-300	168	285	-17	-2	254	340

Table 88. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-9-45	Gage No. R-9-V	Gage No. G-2	Gage No. G-3	Gage No. G-4	Gage No. G-5	Gage No. G-1
0	0	0	10,280	10,815	11,728	10,527	9,152
2,000	- 16	- 3	10,260	10,794	11,747	10,552	9,137
4,000	- 37	- 17	10,243	10,784	11,767	10,570	9,117
6,000	- 58	- 30	10,225	10,768	11,785	10,582	9,094
8,000	- 80	- 42	10,210	10,753	11,798	10,602	9,075
10,000	-100	- 60	10,195	10,737	11,816	10,620	9,057
12,000	-120	- 68	10,177	10,722	11,830	10,642	9,036
14,000	-142	- 83	10,157	10,706	11,847	10,660	9,015
16,000	-185	-120	10,143	10,692	11,862	10,678	8,996
18,000	-197	-126	10,125	10,675	11,878	10,696	8,976
0	- 40	- 40	10,287	10,820	11,740	10,540	9,157
			Total Strain x 10^{-6} in./in.				
	-157	- 86	-162	-145	138	156	-181

Table 89. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-8-V	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H
0	0	0	0	0	0	0	0
2,000	18	- 22	- 56	13	0	-10	- 13
4,000	17	- 53	-110	13	3	-17	- 32
6,000	22	- 90	-165	20	10	-20	- 45
8,000	30	-122	-218	23	10	-24	- 60
10,000	30	-160	-273	23	12	-30	- 72
12,000	42	-187	-317	32	23	-30	- 80
14,000	38	-230	-376	30	30	-38	- 96
16,000	23	-288	-450	10	10	-60	-130
18,000	32	-316	-490	20	23	-50	-130
0	-40	- 40	- 40	-40	-40	-40	- 40
			Total Strain x 10^{-6} in./in.				
	72	-276	-450	60	63	-10	-90

Table 90. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-4-H	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H
0	0	0	0	0	0	0	0
2,000	0	6	40	42	42	28	- 2
4,000	-10	10	77	90	70	37	-17
6,000	-16	6	112	136	98	52	-22
8,000	-20	0	144	180	120	68	-18
10,000	-25	0	184	230	143	81	-26
12,000	-30	0	220	278	167	110	-23
14,000	-30	0	260	330	187	118	-32
16,000	-55	-27	275	357	190	110	-50
18,000	-51	-20	318	411	218	133	-43
0	-32	-32	- 32	- 32	- 32	- 32	-40
			Total Strain x 10^{-6} in./in.				
	-19	12	350	443	250	165	- 3

Table 91. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45
0	0	0	0	0	0	0	0
2,000	- 5	- 5	23	13	- 7	9	0
4,000	- 18	-10	40	27	-10	10	-10
6,000	- 33	-17	60	38	-17	10	-20
8,000	- 50	-23	72	48	-22	10	-30
10,000	- 67	-28	86	64	-24	10	-40
12,000	- 83	-38	100	72	-32	3	-56
14,000	-100	-43	112	110	-33	8	-61
16,000	-145	-71	105	80	-52	-10	-93
18,000	-145	-67	144	108	-48	- 3	-95
			Total Strain x 10^{-6} in./in.				
	-113	-35	176	140	-16	29	-63

Table 92. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-1-H	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V
0	0	0	0	0	0	0	0
2,000	- 23	- 10	10	28	28	14	- 5
4,000	- 53	- 40	3	43	47	22	- 17
6,000	- 77	- 60	8	68	70	31	- 27
8,000	-107	- 83	3	90	96	36	- 42
10,000	-134	-110	0	110	120	42	- 54
12,000	-160	-130	- 3	132	147	48	- 70
14,000	-184	-155	- 8	153	170	52	- 86
16,000	-238	-210	38	150	166	30	-127
18,000	-248	-220	-32	185	200	43	-134
0	- 32	- 32	-32	- 32	- 32	-32	- 32
			Total Strain x 10^{-6} in./in.				
	-216	-188	0	217	232	75	102

Table 93. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-1	Gage No. G-8	Gage No. G-23	Gage No. G-24	Gage No. G-7	Gage No. G-6
0	11,717	10,533	9,177	9,390	8,945	9,683	9,098	9,948
1,000	11,732	10,542	9,156	9,377	8,957	9,700	9,095	9,954
2,000	11,745	10,563	9,147	9,364	8,965	9,717	9,097	9,957
4,000	11,758	10,573	9,127	9,333	8,985	9,747	9,095	9,957
6,000	11,778	10,587	9,110	9,300	9,003	9,780	9,095	9,957
8,000	11,787	10,600	9,095	9,265	9,024	9,813	9,100	9,964
10,000	11,806	10,622	9,070	9,230	9,035	9,845	9,107	9,966
12,000	11,820	10,637	9,057	9,203	9,060	9,877	9,093	9,972
14,000	11,835	10,655	9,035	9,167	9,075	9,915	9,090	9,980
16,000	11,850	10,668	9,010	9,134	9,090	9,945	9,088	9,988
18,000	11,865	10,684	8,978	9,098	9,106	9,986	9,092	10,002
0	11,732	10,535	9,158	9,393	8,948	9,717	9,108	10,005
				Total Strain x 10^{-6} in./in.				
	133	149	-180	-295	158	261	-16	-3

Table 94. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-11	Gage No. G-12	Gage No. G-13	Gage No. G-14	Gage No. G-15	Gage No. G-2	Gage No. G-3
0	9,307	10,505	10,482	10,147	10,283	10,287	10,760
1,000	9,304	10,513	10,493	10,166	10,284	10,287	10,762
2,000	9,297	10,510	10,498	10,180	10,288	10,283	10,756
4,000	9,285	10,515	10,517	10,210	10,293	10,278	10,742
6,000	9,270	10,517	10,535	10,238	10,294	10,280	10,730
8,000	9,255	10,518	10,550	10,268	10,298	10,230	10,713
10,000	9,240	10,518	10,568	10,297	10,305	10,215	10,696
12,000	9,225	10,517	10,580	10,323	10,307	10,195	10,680
14,000	9,215	10,520	10,603	10,355	10,308	10,178	10,667
16,000	9,203	10,525	10,620	10,382	10,310	10,150	10,665
18,000	9,193	10,528	10,637	10,410	10,310	10,130	10,670
0	9,330	10,525	10,500	10,165	10,287	10,285	10,812
			Total Strain x 10^{-6} in./in.				
	-137	3	137	245	23	-155	-142

Table 95. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-9	Gage No. G-17	Gage No. G-18	Gage No. G-10
0	11,037	10,745	9,330	11,062	9,708	10,438	9,385
1,000	11,023	10,735	9,930	11,050	9,697	10,425	9,377
2,000	11,006	10,720	9,925	11,034	9,685	10,405	9,365
4,000	10,970	10,688	9,925	11,008	9,667	10,368	9,935
6,000	10,932	10,657	9,920	10,975	9,637	10,330	9,307
8,000	10,895	10,625	9,914	10,945	9,617	10,292	9,280
10,000	10,858	10,595	9,912	10,914	9,592	10,250	9,248
12,000	10,820	10,573	9,907	10,878	9,570	10,207	9,222
14,000	10,784	10,566	9,907	10,845	9,550	10,155	9,190
16,000	10,748	10,557	9,900	10,810	9,528	10,105	9,168
18,000	10,715	10,563	9,900	10,774	9,512	10,054	9,140
0	11,055	10,853	9,940	11,058	9,730	10,415	9,402
			Total Strain x 10^{-6} in./in.				
	-340	-290	-40	-284	-218	-361	-262

Table 96. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-9-45	Gage No. R-9-V	Gage No. G-21	Gage No. G-22	Gage No. G-27	Gage No. G-26	Gage No. G-25
0	0	0	11,333	11,687	10,568	11,600	10,120
1,000	- 10	0	11,353	11,707	10,597	11,617	10,140
2,000	- 18	- 8	11,365	11,725	10,615	11,628	10,155
4,000	- 30	- 10	11,395	11,765	10,660	11,650	10,187
6,000	- 52	- 25	11,425	11,804	10,702	11,674	10,218
8,000	- 70	- 30	11,455	11,842	10,740	11,695	10,250
10,000	- 90	- 46	11,483	11,878	10,783	11,717	10,280
12,000	-108	- 60	11,515	11,915	10,816	11,738	10,315
14,000	-140	- 80	11,548	11,952	10,850	11,753	10,353
16,000	-157	- 90	11,580	11,988	10,893	11,768	10,383
18,000	-200	-114	11,615	12,033	10,935	11,780	10,410
0	- 30	- 22	11,370	11,694	10,568	11,588	10,145
			Total Strain x 10^{-6} in./in.				
	-170	- 92	245	339	367	192	265

Table 97. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-8-V	Gage No. R-8-45	Gage No. R-8-H	Gage No. R-7-V	Gage No. R-7-45	Gage No. R-7-H	Gage No. R-9-H
0	0	0	0	0	0	0	0
1,000	2	- 17	- 32	3	3	- 3	-10
2,000	12	- 25	- 57	10	10	- 3	-18
4,000	20	- 55	-108	20	12	-10	-30
6,000	27	- 85	-160	23	20	-10	-42
8,000	40	-117	-210	34	28	-10	-50
10,000	42	-157	-266	34	34	-12	-60
12,000	48	-208	-323	38	38	-22	-72
14,000	38	-262	-362	42	42	-27	-92
16,000	40	-300	-390	54	54	-27	-103
18,000	30	-343	-418	58	53	-40	-133
0	-47	- 60	40	3	-10	-20	-30
			Total Strain x 10^{-6} in./in.				
	77	-283	-458	55	63	-20	-103

Table 98. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-4-H	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H
0	0	0	0	0	0	0	0
1,000	- 7	- 2	13	13	13	0	-11
2,000	-10	0	38	42	42	17	-11
4,000	-10	7	77	90	72	37	-17
6,000	-10	10	116	140	100	57	-20
8,000	-13	12	154	190	130	77	-15
10,000	-13	12	193	238	152	93	-20
12,000	-18	12	232	288	173	110	-18
14,000	-20	10	274	344	193	130	-13
16,000	-18	13	318	403	217	157	0
18,000	-33	0	348	447	214	173	12
0	-20	-20	0	8	-30	6	20
			Total Strain x 10^{-6} in./in.				
	-13	-20	348	439	244	167	- 8

Table 99. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-3-45	Gage No. R-3-H	Gage No. R-5-V	Gage No. R-5-45	Gage No. R-5-H	Gage No. R-4-V	Gage No. R-4-45
0	0	0	0	0	0	0	0
1,000	- 13	-11	8	0	-10	0	- 7
2,000	- 17	-17	18	10	-10	3	-10
4,000	- 26	-20	33	22	-12	10	-13
6,000	- 38	-23	50	37	-13	12	-22
8,000	- 53	-30	70	44	-17	20	-26
10,000	- 68	-33	83	66	-18	20	-33
12,000	- 83	-38	100	90	-16	20	-43
14,000	-100	-40	118	103	-22	20	-57
16,000	-116	-48	132	108	-18	18	-58
18,000	-145	-72	128	120	-15	0	-83
0	- 18	-27	-27	-20	0	-28	-24
			Total Strain x 10^{-6} in./in.				
	-127	-45	155	140	-15	-28	-59

Table 100. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-1-H	Gage No. R-1-45	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-V
0	0	0	0	0	0	0	0
1,000	- 12	- 12	0	0	10	- 3	-10
2,000	- 23	- 20	0	15	22	2	-10
4,000	- 50	- 37	3	42	50	18	-20
6,000	- 82	- 60	0	60	73	28	-30
8,000	-110	- 87	0	80	97	32	-42
10,000	-136	-110	0	105	120	37	-57
12,000	-160	-140	- 8	128	143	42	-70
14,000	-188	-160	- 8	150	170	50	-80
16,000	-220	-188	-10	174	197	60	-96
18,000	-230	-220	-18	193	223	62	-118
0	0	- 28	-20	- 10	- 10	-18	- 18
			Total Strain x 10^{-6} in./in.				
	-230	-192	2	203	233	80	-100

Table 101. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-H	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-5-H
0	0	0	0	0	0	0	0	0
5,000	12	62	71	32	-11	- 20	- 20	0
10,000	10	137	144	59	-12	- 53	- 44	3
15,000	7	202	217	76	-23	- 86	- 73	3
20,000	4	264	284	93	-28	-121	-103	0
0	10	10	10	10	10	10	10	10
				Total Strain x 10^{-6} in./in.				
	-6	254	274	83	-38	-131	-113	-10

Table 102. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-9-H	Gage No. R-9-45	Gage No. R-1-H	Gage No. R-1-45
0	0	0	0	0	0	0	0
5,000	-129	86	16	-33	- 45	- 62	- 57
10,000	-252	-166	46	-49	- 88	-132	-113
15,000	-360	-245	64	-71	-130	-195	-176
20,000	-504	-321	74	-94	-176	-257	-233
0	10	0	10	10	10	10	10
			Total Strain x 10^{-6} in./in.				
	-514	-321	64	-104	-186	-267	-243

Table 103. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-12-45	Gage No. R-12-V	Gage No. R-5-45	Gage No. R-5-V	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V
0	0	0	0	0	0	0	0
5,000	190	- 3	49	52	140	114	12
10,000	377	- 5	98	98	274	212	21
15,000	562	-16	147	156	413	331	34
20,000	753	-26	193	205	546	428	28
0	10	10	10	10	10	10	10
			Total Strain x 10^{-6} in. /in.				
	743	-36	183	195	536	418	18

Table 104. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-10-H	Gage No. R-10-45	Gage No. R-10-V	Gage No. R-11-H	Gage No. R-11-45	Gage No. R-11-V	Gage No. R-12-H
0	0	0	0	0	0	0	0
5,000	0	44	69	-181	-157	17	206
10,000	10	98	137	-368	-305	45	418
15,000	3	145	206	-554	-472	57	617
20,000	16	192	273	-738	-639	74	813
0	3	0	2	10	10	10	10
			Total Strain x 10^{-6} in./in.				
	13	192	271	-748	-649	64	803

Table 105. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-13-H	Gage No. R-13-45	Gage No. R-13-V	Gage No. R-14-H	Gage No. R-14-45	Gage No. R-14-V	Gage No. R-9-V
0	0	0	0	0	0	0	0
5,000	42	92	22	- 61	- 96	- 2	- 24
10,000	77	182	38	-121	-202	-13	- 43
15,000	125	282	52	-172	-304	-16	- 74
20,000	166	376	73	-232	-410	-23	-105
0	10	0	10	0	0	10	0
			Total Strain x 10^{-6} in./in.				
	156	376	63	-232	-410	-33	-105

Table 106. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-31	Gage No. G-39	Gage No. G-21	Gage No. G-22	Gage No. R-7-H	Gage No. R-7-45	Gage No. R-7-V
0	13,205	9,535	10,800	11,190	0	0	0
5,000	13,167	9,605	10,875	11,285	0	18	18
10,000	13,130	9,665	10,945	11,385	0	32	32
15,000	13,095	9,720	11,065	11,477	0	58	58
20,000	13,056	9,780	11,085	11,572	4	78	62
0	13,205	9,542	10,806	11,195	10	10	10
			Total Strain x 10^{-6} in./in.				
	149	238	279	377	6	68	52

Table 107. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-29	Gage No. G-28	Gage No. G-32	Gage No. G-33	Gage No. G-34	Gage No. G-35	Gage No. G-30
0	14,395	13,207	13,675	13,390	12,685	11,370	12,265
5,000	14,483	13,248	13,722	13,377	12,705	11,330	12,176
10,000	14,565	13,293	13,767	13,372	12,727	11,294	12,088
15,000	14,645	13,330	13,815	13,365	12,748	11,255	12,000
20,000	14,717	13,375	13,860	13,355	12,766	11,217	11,912
0	14,384	13,205	13,675	13,390	12,685	11,370	12,266
			Total Strain x 10^{-6} in./in.				
	-333	-170	-185	35	-81	153	354

Table 108. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-6	Gage No. G-7	Gage No. G-8	Gage No. G-23	Gage No. G-24
0	11,255	11,225	11,990	12,600	13,515	12,730	11,773
5,000	11,218	11,185	12,000	12,615	13,600	12,688	11,695
10,000	11,180	11,142	11,995	12,615	13,685	12,637	11,610
15,000	11,143	11,095	11,993	12,615	13,770	12,590	11,533
20,000	11,105	11,045	11,980	12,607	13,855	12,538	11,444
0	11,255	11,215	11,980	12,595	13,517	12,722	11,763
			Total Strain x 10^{-6} in./in.				
	150	170	0	-12	-338	184	319

Table 109. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-27	Gage No. G-36	Gage No. G-38	Gage No. G-37	Gage No. G-1	Gage No. G-2	Gage No. G-3
0	15,923	8,565	6,767	9,712	12,670	11,415	10,465
5,000	16,026	8,460	6,695	9,815	12,733	11,475	10,512
10,000	16,129	8,345	6,630	9,917	12,780	11,522	10,550
15,000	16,232	8,240	6,565	10,015	12,825	11,561	10,585
20,000	16,335	8,137	6,495	10,115	12,867	11,597	10,622
0	15,923	8,573	6,773	9,715	12,667	11,415	10,455
			Total Strain x 10^{-6} in./in.				
	412	-436	-278	400	-200	-182	-167

Table 110. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-17	Gage No. G-18	Gage No. G-15	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-26
0	9,200	9,995	9,832	10,525	10,393	9,537	11,232
5,000	9,140	9,893	9,844	10,430	10,305	9,527	11,285
10,000	9,075	9,785	9,855	10,335	10,223	9,520	11,345
15,000	9,020	9,695	9,858	10,244	10,146	9,513	11,405
20,000	8,960	9,590	9,865	10,148	10,060	9,505	11,465
0	9,205	9,995	9,827	10,530	10,397	9,544	11,235
			Total Strain x 10^{-6} in./in.				
	-245	-405	38	-382	-337	-39	230

Table 111. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-1-V	Gage No. R-2-H	Gage No. R-2-45	Gage No. R-2-V	Gage No. R-3-H	Gage No. R-3-45	Gage No. R-3-V	Gage No. R-5-H
0	0	0	0	0	0	0	0	0
4,000	6	55	60	28	0	- 14	- 8	0
8,000	5	107	114	46	- 5	- 36	- 29	- 4
16,000	0	216	232	81	-15	- 87	- 68	6
20,000	3	267	284	96	-21	-122	-105	- 4
0	10	10	10	10	10	10	10	10
				Total Strain x 10^{-6} in./in.				
	-7	257	274	86	-31	-132	-115	-14

Table 112. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-8-H	Gage No. R-8-45	Gage No. R-8-V	Gage No. R-9-H	Gage No. R-9-45	Gage No. R-1-H	Gage No. R-1-45
0	0	0	0	0	0	0	0
4,000	-104	- 56	30	-10	- 10	- 40	- 28
8,000	-207	-124	49	-27	- 50	- 95	- 80
16,000	-407	-264	77	-60	-131	-205	-178
20,000	-514	-335	70	-81	-165	-261	-227
0	- 13	- 24	7	19	19	10	10
			Total Strain x 10^{-6} in./in.				
	-501	-316	63	-100	-184	-271	-237

Table 113. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-12-45	Gage No. R-12-V	Gage No. R-5-45	Gage No. R-5-V	Gage No. R-6-H	Gage No. R-6-45	Gage No. R-6-V
0	0	0	0	0	0	0	0
4,000	146	2	29	41	116	83	16
8,000	308	7	67	82	221	164	21
16,000	603	-19	148	163	441	334	31
20,000	746	-30	177	197	547	412	26
0	4	4	4	4	4	4	4
			Total Strain x 10^{-6} in./in.				
	742	-34	173	193	543	408	22

Table 114. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-10-H	Gage No. R-10-45	Gage No. R-10-V	Gage No. R-11-H	Gage No. R-11-45	Gage No. R-11-V	Gage No. R-12-H
0	0	0	0	0	0	0	0
4,000	0	43	70	-153	-118	14	151
8,000	22	102	138	-305	-255	35	319
16,000	20	167	222	-608	-520	51	641
20,000	27	207	280	-760	-650	60	797
0	12	12	12	- 12	- 7	4	4
			Total Strain x 10^{-6} in./in.				
	15	195	268	-748	-643	56	793

Table 115. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. R-13-H	Gage No. R-13-45	Gage No. R-13-V	Gage No. R-14-H	Gage No. R-14-45	Gage No. R-14-V	Gage No. R-9-V
0	0	0	0	0	0	0	0
4,000	0	82	26	-39	- 67	0	-16
8,000	67	162	42	- 82	-145	0	-13
16,000	127	312	64	-170	-310	-13	-73
20,000	175	394	81	-215	-394	-30	-97
0	12	12	12	12	12	1	12
			Total Strain x 10^{-6} in./in.				
	163	382	69	-227	-406	-31	-109

Table 116. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-31	Gage No. G-39	Gage No. G-21	Gage No. G-22	Gage No. R-7-H	Gage No. R-7-45	Gage No. R-7-V
0	13,445	9,533	10,803	11,183	0	0	0
4,000	13,415	9,576	10,853	11,262	0	23	0
8,000	13,385	9,625	10,905	11,335	0	41	41
16,000	13,325	9,723	11,033	11,487	0	70	60
20,000	12,295	9,775	11,082	11,565	0	87	74
0	13,445	9,532	10,795	11,184	6	12	12
			Total Strain x 10^{-6} in./in.				
	150	243	287	381	-6	75	62

Table 117. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-29	Gage No. G-28	Gage No. G-32	Gage No. G-33	Gage No. G-34	Gage No. G-35	Gage No. G-30
0	14,416	13,207	13,675	13,638	12,954	11,373	12,505
4,000	14,475	13,241	13,712	13,625	12,975	11,342	12,435
8,000	14,545	13,275	13,749	13,615	12,977	11,311	12,363
16,000	14,675	13,343	13,823	13,605	13,025	11,249	12,225
20,000	14,748	13,377	13,860	13,607	13,045	11,218	12,152
0	14,415	13,207	13,675	13,645	12,955	11,373	12,505
			Total Strain x 10^{-6} in./in.				
	-333	-170	-185	38	-90	155	353

Table 118. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-4	Gage No. G-5	Gage No. G-6	Gage No. G-7	Gage No. G-8	Gage No. G-23	Gage No. G-24
0	10,564	11,235	12,057	12,610	12,916	12,738	11,780
4,000	10,534	11,195	12,056	12,615	12,984	12,703	11,715
8,000	10,504	11,160	12,057	12,615	13,052	12,662	11,645
16,000	10,444	11,095	12,057	12,625	13,188	12,587	11,518
20,000	10,414	11,065	12,072	12,640	13,256	12,564	11,468
0	10,565	11,243	12,062	12,625	12,916	12,750	11,793
			Total Strain x 10^{-6} in./in.				
	151	178	-10	-15	-340	186	-333

Table 119. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-27	Gage No. G-36	Gage No. G-38	Gage No. G-37	Gage No. G-1	Gage No. G-2	Gage No. G-3
0	15,672	8,685	6,745	9,693	12,695	11,440	10,476
4,000	15,754	8,595	6,690	9,766	12,726	11,475	10,505
8,000	15,837	8,506	6,635	9,842	12,765	11,505	10,540
16,000	16,002	8,334	6,525	10,005	12,845	11,580	10,607
20,000	16,084	8,246	6,477	10,085	12,890	11,625	10,643
0	15,672	8,689	6,750	9,695	12,695	11,445	10,484
			Total Strain x 10^{-6} in./in.				
	412	-443	-273	400	-195	-180	-159

Table 120. Beam With Holes - Load at Centerline.

Load (lbs.)	Gage No. G-17	Gage No. G-18	Gage No. G-15	Gage No. G-19	Gage No. G-20	Gage No. G-16	Gage No. G-26
0	9,185	9,992	9,812	10,512	10,336	9,522	11,228
4,000	9,135	9,913	9,814	10,438	10,268	9,515	11,275
8,000	9,085	9,832	9,822	10,364	10,200	9,505	11,322
16,000	8,985	9,666	9,838	10,206	10,070	9,495	11,416
20,000	8,935	9,584	9,843	10,125	10,008	9,495	11,465
0	9,190	9,992	9,815	10,515	10,348	9,530	11,228
			Total Strain x 10^{-6} in./in.				
	-255	-408	28	-390	-340	-35	237

Table 121. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-48	Gage No. G-49	Gage No. G-50	Gage No. G-51	Gage No. G-52	Gage No. G-53
0	0	0	0	0	0	0
5,000	60	82	106	- 64	- 85	-106
10,000	123	165	209	-127	-163	-210
15,000	177	240	309	-188	-244	-308
20,000	239	326	417	-248	-324	-411
21,000	253	341	438	-260	-339	-432
0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.			
	253	341	438	-260	-339	-432

Table 122. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-42	Gage No. G-43	Gage No. G-44	Gage No. G-45	Gage No. G-46	Gage No. G-47
0	0	0	0	0	0	0
5,000	132	105	- 88	- 71	74	89
10,000	259	216	-173	-155	143	179
15,000	379	320	-258	-230	206	258
20,000	506	421	-342	-302	275	347
21,000	533	446	-358	-316	290	366
0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.			
	533	446	-358	-316	290	366

Table 123. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-17-45	Gage No. R-17-H	Gage No. R-18-V	Gage No. R-18-45	Gage No. R-18-H	Gage No. G-40	Gage No. G-41
0	0	0	0	0	0	0	0
5,000	166	182	3	88	105	-116	-133
10,000	327	362	4	176	211	-231	-265
15,000	483	535	4	261	312	-342	-399
20,000	644	715	3	346	419	-454	-535
21,000	675	752	3	365	442	-476	-559
0	2	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	673	752	3	365	442	-476	-559

Table 124. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-15-V	Gage No. R-15-45	Gage No. R-15-H	Gage No. R-16-V	Gage No. R-16-45	Gage No. R-16-H	Gage No. R-17-V
0	0	0	0	0	0	0	0
5,000	7	-21	-104	10	- 30	-171	0
10,000	13	-36	-205	16	- 56	-338	- 2
15,000	22	-50	-305	25	- 79	-502	- 8
20,000	25	-62	-406	31	-100	-666	-15
21,000	26	-69	-427	31	-105	-700	-17
0	2	0	2	0	2	2	2
			Total Strain x 10^{-6} in./in.				
	24	-69	-429	31	-107	-702	-19

Table 125. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-48	Gage No. G-49	Gage No. G-50	Gage No. G-51	Gage No. G-52	Gage No. G-53
0	0	0	0	0	0	0
5,000	59	83	105	- 61	- 78	-100
10,000	124	169	209	-121	-157	-203
15,000	183	250	314	-182	-237	-303
20,000	239	328	416	-231	-318	-410
21,000	252	347	439	-238	-336	-430
0	1	3	3	22	6	6
			Total Strain x 10^{-6} in./in.			
	251	344	436	-260	-342	-436

Table 126. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-42	Gage No. G-43	Gage No. G-44	Gage No. G-45	Gage No. G-46	Gage No. G-47
0	0	0	0	0	0	0
5,000	125	110	- 89	- 83	63	79
10,000	249	211	-174	-158	133	170
15,000	376	319	-259	-234	202	256
20,000	507	425	-335	-290	274	344
21,000	537	451	-351	-301	289	364
0	14	10	16	27	9	10
			Total Strain x 10^{-6} in./in.			
	523	441	-367	-328	280	354

Table 127. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-17-45	Gage No. R-17-H	Gage No. R-18-V	Gage No. R-18-45	Gage No. R-18-H	Gage No. G-40	Gage No. G-41
0	0	0	0	0	0	0	0
5,000	166	181	8	91	107	-118	-143
10,000	331	360	16	188	219	-229	-277
15,000	501	544	23	281	327	-343	-411
20,000	668	734	29	372	437	-467	-522
21,000	706	777	30	393	463	-494	-541
0	33	30	33	33	28	- 8	31
			Total Strain x 10^{-6} in./in.				
	673	747	-3	360	435	-486	-572

Table 128. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-15-V	Gage No. R-15-45	Gage No. R-15-H	Gage No. R-16-V	Gage No. R-16-45	Gage No. R-16-H	Gage No. R-17-V
0	0	0	0	0	0	0	0
5,000	11	-16	-103	16	-23	-171	4
10,000	22	-23	-197	31	-41	-332	13
15,000	29	-34	-295	39	-59	-496	7
20,000	38	-71	-419	37	-42	-624	5
21,000	44	-71	-458	38	-47	-640	3
0	26	- 3	- 27	9	55	68	23
			Total Strain x 10^{-6} in./in.				
	18	-68	431	29	-102	-708	-20

Table 129. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-48	Gage No. G-49	Gage No. G-50	Gage No. G-51	Gage No. G-52	Gage No. G-53
0	0	0	0	0	0	0
5,000	52	75	101	- 68	- 87	-108
10,000	117	160	207	-130	-165	-210
15,000	178	239	308	-190	-246	-312
20,000	237	322	413	-252	-326	-413
21,000	248	342	434	-263	-341	-435
0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.			
	248	342	434	-263	-341	-435

Table 130. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-42	Gage No. G-43	Gage No. G-44	Gage No. G-45	Gage No. G-46	Gage No. G-47
0	0	0	0	0	0	0
5,000	130	112	- 90	- 80	68	87
10,000	253	216	-176	-156	137	175
15,000	378	316	-261	-230	203	261
20,000	502	426	-346	-303	273	344
21,000	527	448	-358	-316	286	364
0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.			
	527	448	-358	-316	286	364

Table 131. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-17-45	Gage No. R-17-H	Gage No. R-18-V	Gage No. R-18-45	Gage No. R-18-H	Gage No. G-40	Gage No. G-41
0	0	0	0	0	0	0	0
5,000	165	182	4	85	104	-116	-138
10,000	326	359	3	175	210	-230	-271
15,000	488	537	3	257	311	-344	-405
20,000	645	716	2	347	419	-456	-536
21,000	675	752	1	364	439	-480	-562
0	0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	675	752	1	364	439	-480	-562

Table 132. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-15-V	Gage No. R-15-45	Gage No. R-15-H	Gage No. R-16-V	Gage No. R-16-45	Gage No. R-16-H	Gage No. R-17-V
0	0	0	0	0	0	0	0
5,000	7	-22	-105	11	- 31	-173	- 2
10,000	14	-38	-210	13	- 57	-340	- 7
15,000	18	-54	-310	24	- 78	-506	-11
20,000	20	-67	-410	28	-100	-668	-16
21,000	23	-67	-431	30	-103	-702	-18
0	0	0	0	0	0	0	0
			Total Strain x 10^{-6} in./in.				
	23	-67	-431	30	-103	-702	-18

Table 133. Beam With Holes - Load at 4 Ft. From Right Supports.

Load (lbs.)	Gage No. G-38	Gage No. G-39	Gage No. G-40	Gage No. G-41	Gage No. G-42	Gage No. G-43	Gage No. G-44	Gage No. G-45
0	7,355	10,095	7,300	8,285	8,265	7,700	8,265	8,285
10,000	7,265	10,175	7,055	8,005	8,535	7,925	8,085	8,127
20,000	7,175	10,260	6,817	7,727	8,787	8,135	7,908	7,975
24,000	7,146	10,295	6,725	7,615	8,890	8,225	7,845	7,915
25,000	7,135	10,303	6,697	7,585	8,915	8,245	7,825	7,900
25,500	7,130	10,307	6,685	7,573	8,933	8,255	7,817	7,888
26,000	7,126	10,310	6,673	7,560	8,945	8,265	7,810	7,885
26,500	7,125	10,315	6,673	7,557	8,960	8,277	7,805	7,890
27,000	7,118	10,317	6,656	7,556	8,975	8,295	7,800	7,895
29,000	7,105	10,335	6,585	7,555	9,060	8,347	7,777	7,907
31,000	7,085	10,350	6,507	7,547	9,134	8,400	7,755	7,920
33,000	7,077	10,365	6,445	7,550	9,215	8,455	7,745	7,937
35,000	7,073	10,380	6,355	7,555	9,290	8,515	7,725	7,955
38,000	7,054	10,395	6,277	7,555	9,410	8,605	7,675	7,990
40,000	7,040	10,415	6,237	7,545	9,482	8,665	7,645	8,015

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 134. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-31	Gage No. G-32	Gage No. G-33	Gage No. G-34	Gage No. G-35	Gage No. G-36	Gage No. G-37
0	8,707	8,395	8,527	9,235	10,555	9,105	10,260
10,000	8,760	8,335	8,543	9,214	10,615	8,967	10,394
20,000	8,804	8,275	8,555	9,185	10,665	8,823	10,525
24,000	8,828	8,255	8,557	9,177	10,693	8,765	10,583
25,000	8,835	8,245	8,557	9,173	10,693	8,748	10,595
25,500	8,836	8,245	8,563	9,175	10,697	8,737	10,600
26,000	8,840	8,243	8,563	9,174	10,695	8,735	10,602
26,500	8,845	8,237	8,565	9,167	10,700	8,725	10,615
27,000	8,846	8,237	8,563	9,167	10,704	8,723	10,620
29,000	8,855	8,225	8,565	9,167	10,715	8,695	10,645
31,000	8,865	8,213	8,565	9,160	10,718	8,660	10,670
33,000	8,875	8,200	8,573	9,157	10,738	8,545	10,693
35,000	8,885	8,185	8,575	9,155	10,754	8,420	10,725
38,000	8,903	8,167	8,577	9,148	10,765	8,067	10,764
40,000	8,915	8,155	8,585	9,150	10,773	7,945	10,800

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 135. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-52	Gage No. G-53	Gage No. G-26	Gage No. G-27	Gage No. G-28	Gage No. G-29	Gage No. G-30
0	13,203	13,963	11,345	10,245	8,702	7,745	9,715
10,000	13,375	14,183	11,207	10,168	8,645	7,635	9,835
20,000	13,545	14,395	11,075	10,095	8,593	7,525	9,955
24,000	13,613	14,485	11,023	10,066	8,575	7,483	10,003
25,000	13,627	14,507	11,006	10,060	8,570	7,470	10,013
25,500	13,635	14,515	11,002	10,045	8,565	7,467	10,015
26,000	13,645	14,525	10,995	10,050	8,555	7,462	10,023
26,500	13,657	14,542	10,990	10,050	8,560	7,452	10,027
27,000	13,670	14,555	10,987	10,047	8,555	7,450	10,035
29,000	13,725	14,613	10,955	10,027	8,545	7,425	10,060
31,000	13,878	14,675	10,930	10,015	8,535	7,405	10,080
33,000	13,845	14,745	10,905	10,005	8,525	7,383	10,105
35,000	13,895	14,815	10,878	9,997	8,510	7,357	10,133
38,000	14,037	14,957	10,838	9,985	8,495	7,325	10,165
40,000	14,118	15,073	10,815	9,982	8,484	7,305	10,185

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 136. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-16	Gage No. G-17	Gage No. G-18	Gage No. G-19	Gage No. G-20	Gage No. G-21	Gage No. G-22
0	11,925	12,315	11,580	10,960	11,065	10,675	10,323
10,000	11,938	12,395	11,715	11,085	11,170	10,574	10,193
20,000	11,948	12,475	11,845	11,210	11,275	10,475	10,068
24,000	11,955	12,505	11,897	11,263	11,317	10,435	10,018
25,000	11,955	12,510	11,913	11,275	11,328	10,425	10,013
25,500	11,955	12,515	11,920	11,280	11,335	10,425	10,005
26,000	11,955	12,520	11,926	11,286	11,338	10,415	9,998
26,500	11,955	12,525	11,933	11,294	11,345	10,415	9,994
27,000	11,955	12,525	11,944	11,298	11,350	10,407	9,994
29,000	11,955	12,540	11,967	11,325	11,367	10,390	9,965
31,000	11,965	12,558	12,003	11,352	11,395	10,365	9,945
33,000	11,965	12,575	12,037	11,374	11,378	10,352	9,923
35,000	11,965	12,597	12,077	11,393	11,357	10,326	9,896
38,000	11,960	12,605	12,137	11,423	11,323	10,295	9,863
40,000	11,957	12,595	12,175	11,445	11,305	10,270	9,843

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 137. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. G-3	Gage No. G-4	Gage No. G-48	Gage No. G-49	Gage No. G-50	Gage No. G-51	Gage No. G-15
0	10,345	9,825	13,173	13,255	13,784	14,695	11,657
10,000	10,403	9,775	13,045	13,085	13,565	14,825	11,647
20,000	10,457	9,723	12,925	12,920	13,355	14,950	11,635
24,000	10,477	9,705	12,875	12,855	13,267	15,005	11,633
25,000	10,485	9,696	12,863	12,838	13,245	15,015	11,627
25,500	10,490	9,695	12,855	12,830	13,235	15,020	11,630
26,000	10,493	9,695	12,853	12,825	13,225	15,026	11,628
26,500	10,495	9,695	12,847	12,816	13,218	15,025	11,628
27,000	10,495	9,687	12,845	12,810	13,205	15,025	11,626
29,000	10,505	9,680	12,835	12,784	13,165	15,025	11,625
31,000	10,523	9,675	12,823	12,755	13,125	15,025	11,625
33,000	10,535	9,665	12,807	12,730	13,065	15,035	11,625
35,000	10,545	9,648	12,797	12,695	13,005	15,058	11,623
38,000	10,557	9,628	12,775	12,642	12,925	15,065	11,627
40,000	10,567	9,613	12,767	12,594	12,875	15,080	11,633

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 138. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-9-45	Gage No. R-9-H	Gage No. R-10-V	Gage No. R-10-45	Gage No. R-10-H	Gage No. G-46	Gage No. G-47
0	0	0	0	0	0	14,410	13,533
10,000	- 44	- 16	80	68	16	14,265	13,350
20,000	- 82	- 24	147	147	35	14,126	13,177
24,000	-105	- 26	175	175	41	14,068	13,105
25,000	-107	- 30	186	178	57	14,055	13,087
25,500	-108	- 26	183	183	51	14,050	13,080
26,000	-108	- 24	196	184	53	14,040	13,073
26,500	-108	- 24	193	193	58	14,035	13,065
27,000	-105	- 18	198	198	62	14,025	13,055
29,000	-114	- 17	215	215	74	13,985	13,010
31,000	-121	- 17	224	234	80	13,948	12,973
33,000	-131	- 21	226	257	96	13,900	12,925
35,000	-150	- 34	230	277	122	13,855	12,870
38,000	-180	- 78	242	307	155	13,785	12,787
40,000	-200	-110	242	340	180	13,748	12,735

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 139. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-11-45	Gage No. R-11-H	Gage No. R-18-V	Gage No. R-18-45	Gage No. R-18-H	Gage No. R-8-H	Gage No. R-9-V
0	0	0	0	0	0	0	0
10,000	- 214	- 241	18	184	227	-168	- 50
20,000	- 427	- 478	23	361	434	-329	- 92
24,000	- 513	- 571	22	432	520	-396	-107
25,000	- 541	- 596	32	454	544	-406	-114
25,500	- 552	- 612	30	460	556	-419	-116
26,000	- 562	- 618	38	470	567	-426	-115
26,500	- 565	- 628	34	485	581	-430	-116
27,000	- 577	- 641	42	493	593	-431	-115
29,000	- 620	- 687	49	546	645	-462	-129
31,000	- 674	- 734	54	591	698	-500	-138
33,000	- 762	- 976	50	637	746	-518	-155
35,000	-1,088	-1,490	42	681	808	-521	-173
38,000	-1,669	-2,200	5	705	912	-657	-195
40,000	-1,717	-2,240	-26	831	1,007	-822	-200

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 140. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-6-V	Gage No. R-6-45	Gage No. R-6-H	Gage No. R-16A-V	Gage No. R-16A-45	Gage No. R-16A-H	Gage No. R-11-V
0	0	0	0	0	0	0	0
10,000	4	129	170	31	- 302	- 376	28
20,000	12	268	350	70	- 548	- 742	45
24,000	20	326	425	90	- 677	- 892	52
25,000	17	343	440	98	- 700	- 935	56
25,500	21	343	446	103	- 717	- 961	59
26,000	21	354	459	119	- 743	- 995	63
26,500	30	362	474	189	- 852	-1,142	65
27,000	26	369	485	255	- 951	-1,293	68
29,000	33	398	520	553	-1,376	-1,970	76
31,000	36	432	556	763	-1,873	-2,700	65
33,000	34	462	594	1,004	-2,420	-3,395	105
35,000	41	489	625	1,157	-2,975	-3,930	228
38,000	70	556	688	1,354	-3,455	-4,570	491
40,000	102	618	728	1,501	-3,840	-5,110	514

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 141. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-13-45	Gage No. R-13-H	Gage No. R-14-V	Gage No. R-14-45	Gage No. R-14-H	Gage No. R-8-V	Gage No. R-5-H
0	0	0	0	0	0	0	0
10,000	133	67	-15	-115	- 56	32	- 4
20,000	271	138	-30	-236	-108	47	4
24,000	324	166	-30	-277	-127	55	3
25,000	342	171	-28	-292	-138	55	7
25,500	344	179	-31	-297	-134	61	7
26,000	356	186	-25	-301	-133	70	6
26,500	369	192	-23	-303	-134	70	10
27,000	381	200	-24	-304	-138	73	10
29,000	411	218	-22	-323	-140	80	15
31,000	445	235	-28	-345	-146	74	23
33,000	485	272	-28	-377	-159	78	11
35,000	524	316	-33	-414	-189	66	19
38,000	576	380	-30	-459	-233	71	29
40,000	615	435	-22	-474	-272	96	25

Note: Increased strain per increment of load began at 26, 500 lb load. Failure load was 42, 000 lbs. - beam failed by lateral buckling of the top flange.

Table 142. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-17-45	Gage No. R-17-H	Gage No. R-8-45	Gage No. R-12-V	Gage No. R-12-45	Gage No. R-12-H	Gage No. R-13-V
0	0	0	0	0	0	0	0
10,000	330	367	-111	-17	241	268	25
20,000	650	728	-230	-15	482	527	42
24,000	780	874	-282	-17	582	638	51
25,000	814	908	-289	-18	604	664	54
25,500	835	924	-295	-17	618	679	60
26,000	847	947	-298	-16	630	694	61
26,500	876	972	-301	-15	650	712	70
27,000	901	999	-300	-18	663	718	72
29,000	992	1,107	-325	- 8	711	775	78
31,000	1,060	1,211	-355	-15	757	824	77
33,000	1,142	1,328	-285	-24	818	884	81
35,000	1,214	1,437	-405	-24	880	953	74
38,000	1,290	1,600	-344	-40	947	1,029	66
40,000	1,482	1,675	-328	-45	1,002	1,105	60

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.

Table 143. Beam With Holes - Load at 4 Ft. From Right Support.

Load (lbs.)	Gage No. R-15-V	Gage No. R-15-45	Gage No. R-15-H	Gage No. R-16-V	Gage No. R-16-45	Gage No. R-16-H	Gage No. R-17-V
0	0	0	0	0	0	0	0
10,000	16	- 34	- 207	29	- 45	- 345	0
20,000	20	- 57	- 413	44	- 71	- 687	- 2
24,000	28	- 65	- 493	45	- 93	- 830	- 3
25,000	25	- 64	- 513	46	- 94	- 864	- 5
25,500	31	- 68	- 521	50	- 98	- 884	- 1
26,000	27	- 71	- 530	60	- 98	- 919	- 5
26,500	52	-124	- 656	111	-140	-1,095	0
27,000	62	-172	- 792	154	-183	-1,294	7
29,000	46	-379	-1,255	356	-335	-2,110	- 6
31,000	45	-444	-1,525	510	-428	-2,687	- 15
33,000	27	-515	-1,815	707	-506	-3,320	- 40
35,000	17	-560	-1,990	850	-540	-3,850	- 62
38,000	45	-674	-2,585	1,044	-577	-4,555	-105
40,000	45	-722	-2,990	1,172	-610	-5,080	-121

Note: Increased strain per increment of load began at 26,500 lb. load. Failure load was 42,000 lbs. - beam failed by lateral buckling of the top flange.