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GIRDERS WITH INCLINED STIFFENERS

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INTRODUCTION

Ever since studying Dean Turneaure's paper "Experimental Determination of Stresses in Web Plates and Stiffeners in Plate Girders" in the 1907 Journal of the Western Society of Engineers, the first of the above authors has been obsessed with the idea that stiffeners in a girder should be inclined to be more effective and that now that welding gives us a new tool for performing the operation, the procedure is entirely practicable.

Six years ago two models girders of cardboard were made and subjected to load. The girder having inclined stiffeners was so much stronger than the one with vertical stiffeners that the problem appeared worthy of more research. The actual work began in 1934 with a thesis by Wm. Allen Robinson, a student at Lehigh University, who had time but for a polarized-light study of "Stress Distribution in Thin Webs of Girders". The work was continued in 1936 by Wm. Lotz, who made and tested two steel girders with dimensions as shown in Fig. 1.

NOTES ON DESIGN OF THE GIRDERS

In order to keep the size of the steel girders within reason and yet use the limits set by Robinson in his work, a web material of 1/8 inch structural grade steel was chosen. Using a depth to thickness ratio of 102 to 1, the same ratio as used by Robinson in the construction of his celluloid girders, a web-depth of 12.75 inches was obtained. Next the approximate length of girders between supports was found by using Robinson's 6 to 1 ratio of length to depth. This choice was made assuming that we were designing a short member which was to be used to support a heavy concentrated load at its mid-point. The resulting length was 76.5 inches. Later this was decreased a few inches in order that the inclined stiffeners might be placed at exactly 30 degrees. The design load of 31,880 lbs. was found by multiplying the web area (12.75 x 0.125= 1.595 sq. inches) by the allowable stress in shear (10,000 psi.). The flanges were overdesigned by 167% in order ~~that~~ to insure web failure. Each flange consisted of two plates- one, 6" x 1/4" and one, 7"x 1/2". The use of two plates was to facilitate the welding of the web to the flange. If this had not been done there was the definite possibility of burning the 1/8 inch web material before the comparatively thick flange material was hot enough to alloy with the weld metal. Joining the web to the flanges were 3/16 inch fillet welds. The inclined stiffeners were designed assuming that the girders would act as trusses. The four center stiffeners were assumed to carry their components of the load as direct stresses. The web was then assumed to carry the tension to the top of the next set of stiffeners and so on to the support points. The direct stress under ~~xxx~~ working load in each inclined stiffener was calculated to be 7970 lb., and from this it was computed, by using an allowable stress of 12,000 psi. that the required area was 0.768 sq. in. However, since the area required for the vertical stiffeners was a little less and since it was desired to use one size of stiffener for the two girders, 2-3/4 x 1/4 inch plates were adopted giving an area of 0.69 sq. inches. It was assumed in the case of the inclined stiffeners that the web could be depended on to carry some of the stress, thus making up the deficiency in area. The design of the welding ~~that~~ to fasten the stiffeners to the web and flanges was carried out to develop the full strength of the stiffeners at each end. ~~This was done by welding continuously~~ In addition a few tack welds were provided between web and stiffeners.

The total length of stiffening material required by the inclined stiffener layout was 177.5 inches for six pairs of stiffeners. For the other girder seven pairs of vertical stiffeners were used on 12.32 inches centers, giving a total length practically identical with that of the first.

RESULTS

It is not the intention in this brief paper to give all of the details of the investigation, which include the testing of tensile coupons cut from the webs of the girders, the exploration of stresses in the webs of the girders with Huggenberger tensometers, and the testing of the girders before the stiffeners were placed. The summary of the unit stresses measured at one of the test loads, Fig.2, gives in condensed form the essential information obtained from the tests.

Stiffener Stresses: It will be noted that all stiffeners in the second girder (the one with inclined stiffeners) have been put to work and that the stiffeners in the first girder carry practically no load, the exception being the pair under the load. It should also be noted that more research is needed in determining the most favorable inclination of stiffeners, since they are only carrying about half load.

Flange Stresses: Maximum flange stresses in the second girder were consistently higher than in the first one. More investigation is needed to verify this point.

Web Stresses: In the first girder the tensile and compressive stresses were approximately equal whereas in the second girder the tensile stresses were considerably greater than the compressive xxxxxx stresses. Strictly speaking a comparison is impossible since (see Fig.1) the gage lines in the two girders were not in the same direction. However, if we may theorize a little in the matter of reserve strength we should like to point out that it is more favorable to have the tensile stresses exceed the compressive stresses in the web. If the stresses were the same, then, at yield point load the web would begin buckling in the direction of the compressive stresses, whereas, in the tensile direction the web would still have a good deal of reserve strength. If on the other hand buckling is delayed, greater loads can be carried.

Web Buckling: The first signs of buckling in the girder with vertical stiffeners was noticed at about 44,500 pounds as compared with 60,000 pounds for the girder with inclined stiffeners. Pronounced buckling was noted at loads of 46,000 and 63,000 pounds for the two girders respectively.

Comparative Deflections: Load-deflection curves are given in Fig.3 and tell the story more vividly than can be told by words.

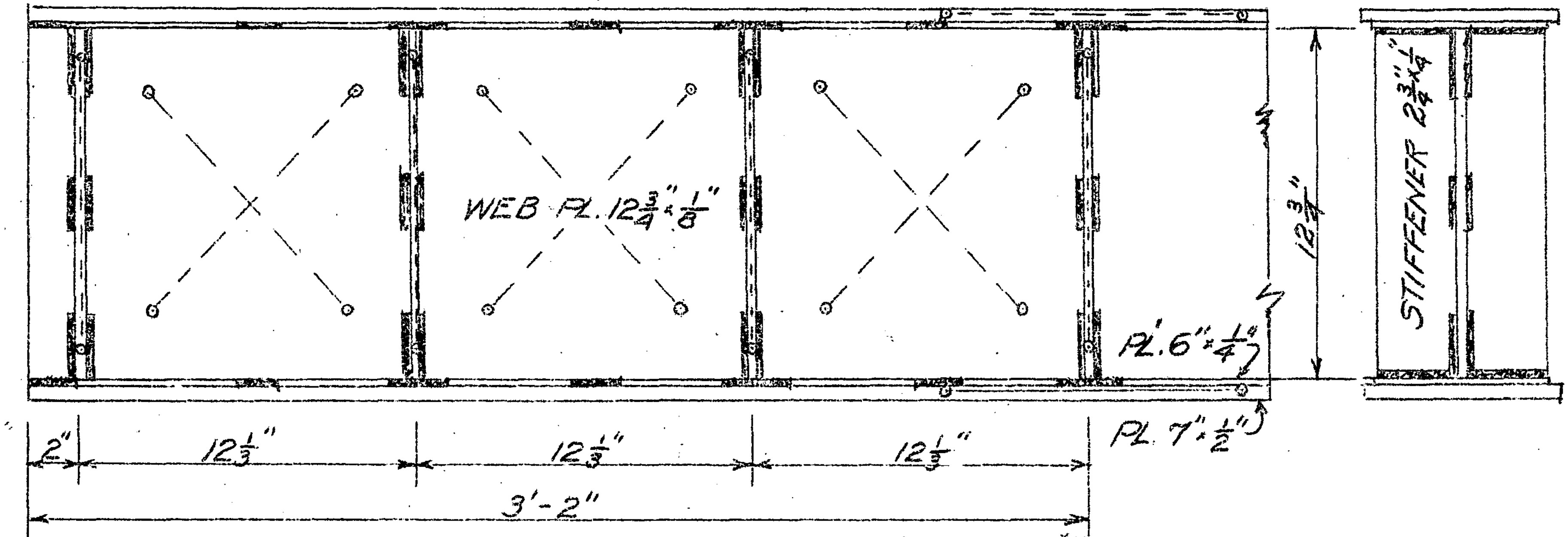
Fabrication: There appear to be no difficulties in the fabrication of the girders with inclined stiffeners. In fact a reasonable tolerance in length of xxx stiffener would be permitted where such would not be the case for tight-fitting vertical stiffeners.

<u>Application</u>: In thinking of this research from the practical standpoint we see a chance for a variety of application among which are deck-girder bridges, and certain girders ~~in buildings~~ which may span openings in buildings and which carry one or more columns from above.

CONCLUSIONS

In conclusion we wish to state that this investigation is but the first step in a larger project. It has been proven that putting the stiffeners to work by inclining them in the direction of the compressive stresses in the web of the girder increases materially the strength of the girder. What still remains to be determined is the best angle of inclination for the stiffeners, and a suitable method for design of this new type of girder

GIRDER WITH VERTICAL STIFFENERS



GIRDER WITH INCLINED STIFFENERS

ABOUT ℄

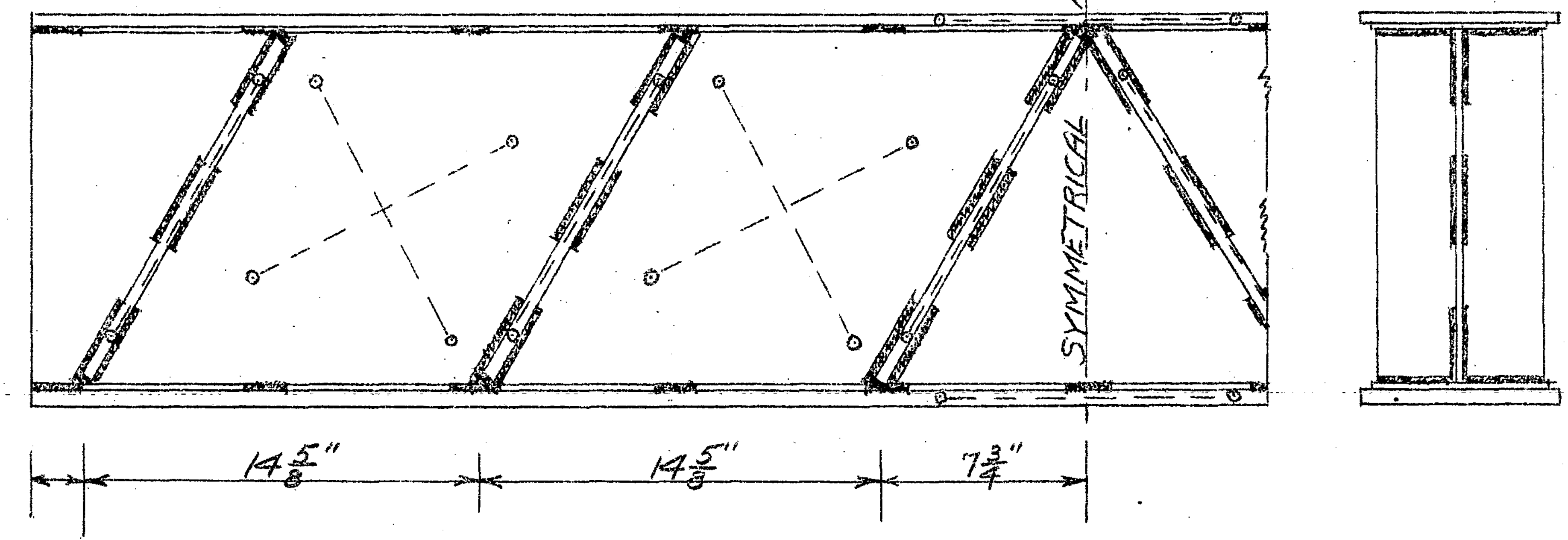
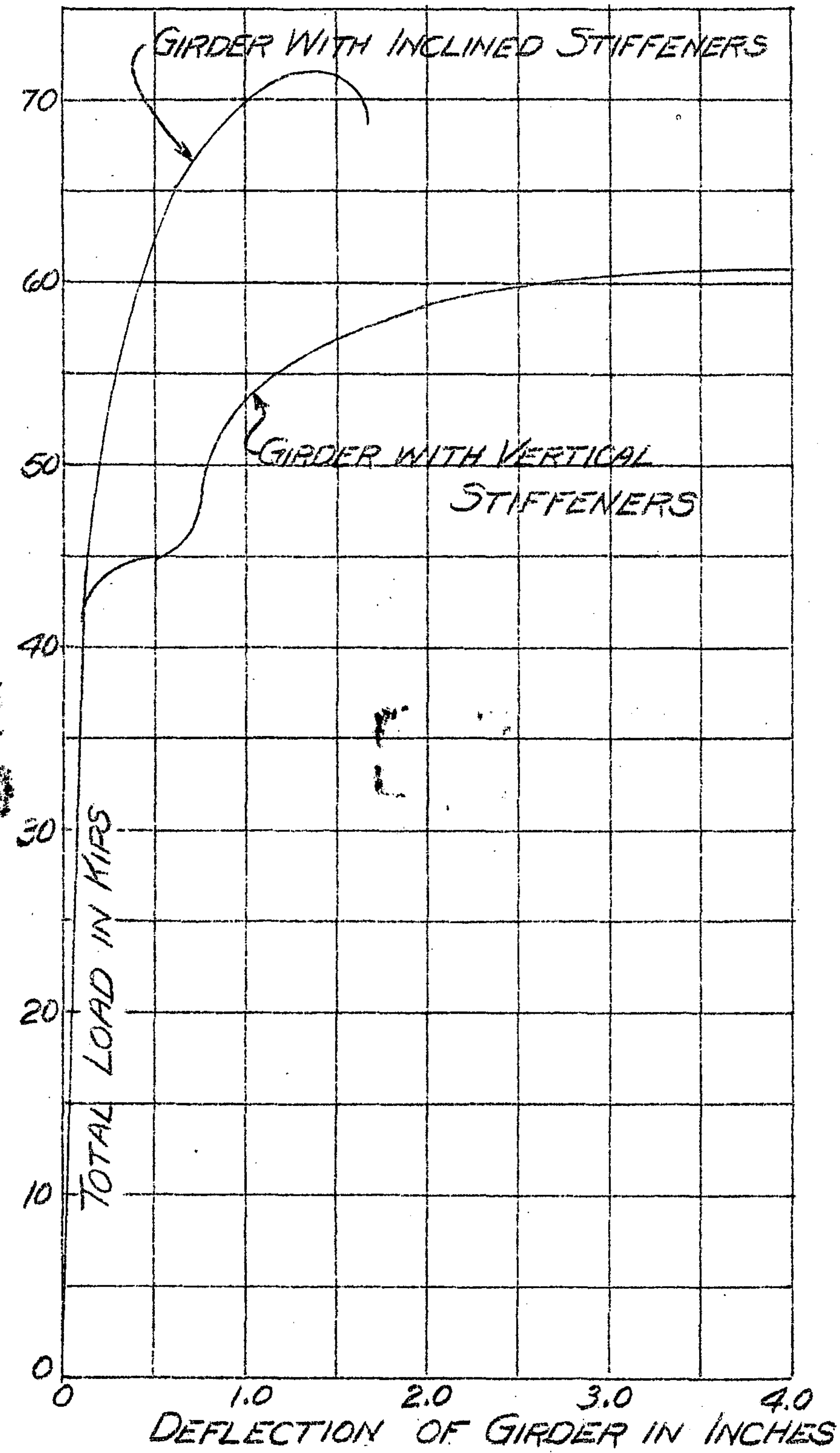


FIG.2 UNIT STRESSES (in psi) AT LOAD 33,000 LB.

		GIRDER WITH:	
		VERTICAL STIFFENERS	INCLINED STIFFENERS
Stiffener Stresses	A	-1350	-5250
	B	-1800	-5250
	C	-1350	-6450
	D	-5100	
Flange Stresses At Midspan	Top	-6300	-9300
	Bottom	8400	9000
Web Stresses See Fig.1	Panel 1	21,500 & -15,300	20,700 & -17,400
	" 2	15,600 & -13,200	19,650 & -13,500
	" 3	15,300 & -14,100	


GIRDER WITH INCLINED STIFFENERS
GIRDER WITH VERTICAL STIFFENERS
70
60
50
40
30
20
10
0
TOTAL LOAD IN KIPS
0
1.0
2.0
3.0
4.0
DEFLECTION OF GIRDER IN INCHES