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Proposal for an experimental investigation of web-boundary joints of welded plate girders, January 1965

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Proposal

for

AN EXPERIMENTAL INVESTIGATION ON WEB-BOUNDARY JOINTS OF WELDED PLATE GIRDERS

Submitted to the

Welded Plate Girder Project Subcommittee

of the Welding Research Council

by

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1. INTRODUCTION

Fatigue tests on welded large-size and model girders with slender webs indicate that failure may occur by cracks along web panel boundaries(1,2,3,4). The lateral fluctuation of a web under repeated loading has led to the speculation that these cracks at web boundaries are caused by the out-of-plane bending of the web. The fact that cracks first appear only on one side of webs(1,2) seems to substantiate this thinking.

From the few experiments on fillet-welded web stems of carbon steels under bending(5,6,7), it is observed that the fatigue strength of such a weldment under the specific loading condition is quite high. In one case it is in the order of 36 ksi for 4,000,000 cycles with a stress range of zero-to-maximum(7). At some points along the web boundaries of the test girders of Reference 2, the stresses were lower than 30 ksi yet cracks occurred much earlier than 4,000,000 cycles. Thus, the bending of the web stem alone may not be the governing situation in causing fatigue cracks at girder web boundaries.

Actual stresses at web boundaries are not only the result of the web's bending but also the consequence of axial (membrane) straining. This is illustrated with Figure 1 in which is shown the stress distribution across the thickness of a girder web near a stiffener. There are some data on the fatigue strength of such fillet-wedled, web-to-stiffener joints under axial (membrane) stresses alone(8). For the loading condition of complete axial stress reversal, the fatigue strength is in the order of 15 to 18 ksi for 2,000,000 cycles for as-welded specimens of structural carbon steels. Furthermore, a web under combined out-of-plane bending and axial strain would probably have a fatigue strength lower than those of web bending or axial strain alone.

Unfortunately, there seems to be no available fatigue data on the combined bending and axial stress pattern. Neither is there any reliable method to extrapolate from the existing results on bending and axial stresses alone. An experimental investigation on the combined stress pattern is proposed here. The results of the investigation are expected to be of great significance on the study of fatigue strength of welded plate girders.

2. LOADING AND SPECIMENS

Since both the lateral deflection and the axial strain of a web near its boundary change with load from zero to maximum, it would be logical to test specimens with web plate bending stresses proportional to web membrane stresses. In other words, a loading scheme of Figure 2, with the lateral force P proportional to the axial force T, would be ideal. A setup of Figure 2 is relatively simple to achieve by using a gear-and-pinion system and a motor. However, the testing speed of such a mechanical setup is relatively slow. To obtain even a limited amount of data would require an excessive amount of time. In order to speed up the experimentation, it is proposed to adopt the setup of Figure 3a and utilize the high speed vibrophore at the Fritz Engineering Laboratory. Both the magnitude and the eccentricity of the loads will be varied to achieve the desired stresses. The testing speed is estimated to be in the order of 4,000 cycles per minute. Ten million (10,000,000) cycles will be considered as run-out.

Under the proposed testing condition, the specimens will be subjected to a slightly higher moment at the ends than at the "joint" at the middle (Figure 3b). However, it is expected that the reduction of fatigue strength due to fillet-welding will cause failure at the toes of the fillet weld. Thus, straight specimens are proposed. In case failure should occur at the ends, the width of specimens at the middle could be reduced to render that part critical.

Figure 4 shows the configuration of the specimens. Both web-to-stiffener joints (non load-carrying attachments, Figure 4a) and web-to-flange joints (load-carrying attachments, Figure 4b) are included in the program. Preliminarily, each set of specimens will be subjected to the same loading condition of zero to maximum stresses. The stresses at the toes of fillet welds will be evaluated with the help of electrical resistance strain gages. In Table 1 are summarized the testing stresses and the number of specimens. A total of 108 specimens are proposed, three for each particular testing condition. If conditions warrant, the stresses shown in Table 1 will be adjusted to obtain an S-N curve for each web thickness.

3. TIME, EQUIPMENT, FUNDS, AND STAFF

With a testing frequency of 4,000 cycles per minute, the testing time for 10,000,000 cycles is approximately 42 hours. For 108 specimens, the machine running time will be about 6 months, continuously. Change of specimens requires about the same amount of time. Therefore, it is expected that the results of tests should be available to the Committee a year after the tests have been started.

It is anticipated that the testing equipment will be available late February or early March. Except for a very minor expense for maintenance, the use of the equipment will be furnished free at the Fritz Engineering Laboratory.

The cost of the specimens is estimated to be a few hundred dollars, including the electrical resistance gages for strain evaluation. For the attachment of the test specimens to the test machine, a pair of end blocks are necessary which will be made at the Fritz Laboratory. All these costs can be absorbed in the project budget for the current fiscal year (1964-1965). The salaries and the wages of the investigating staff and necessary technical assistants will be covered by available budget funds from the current and the coming fiscal year. The existing project staff shall be adequate for the investigation.

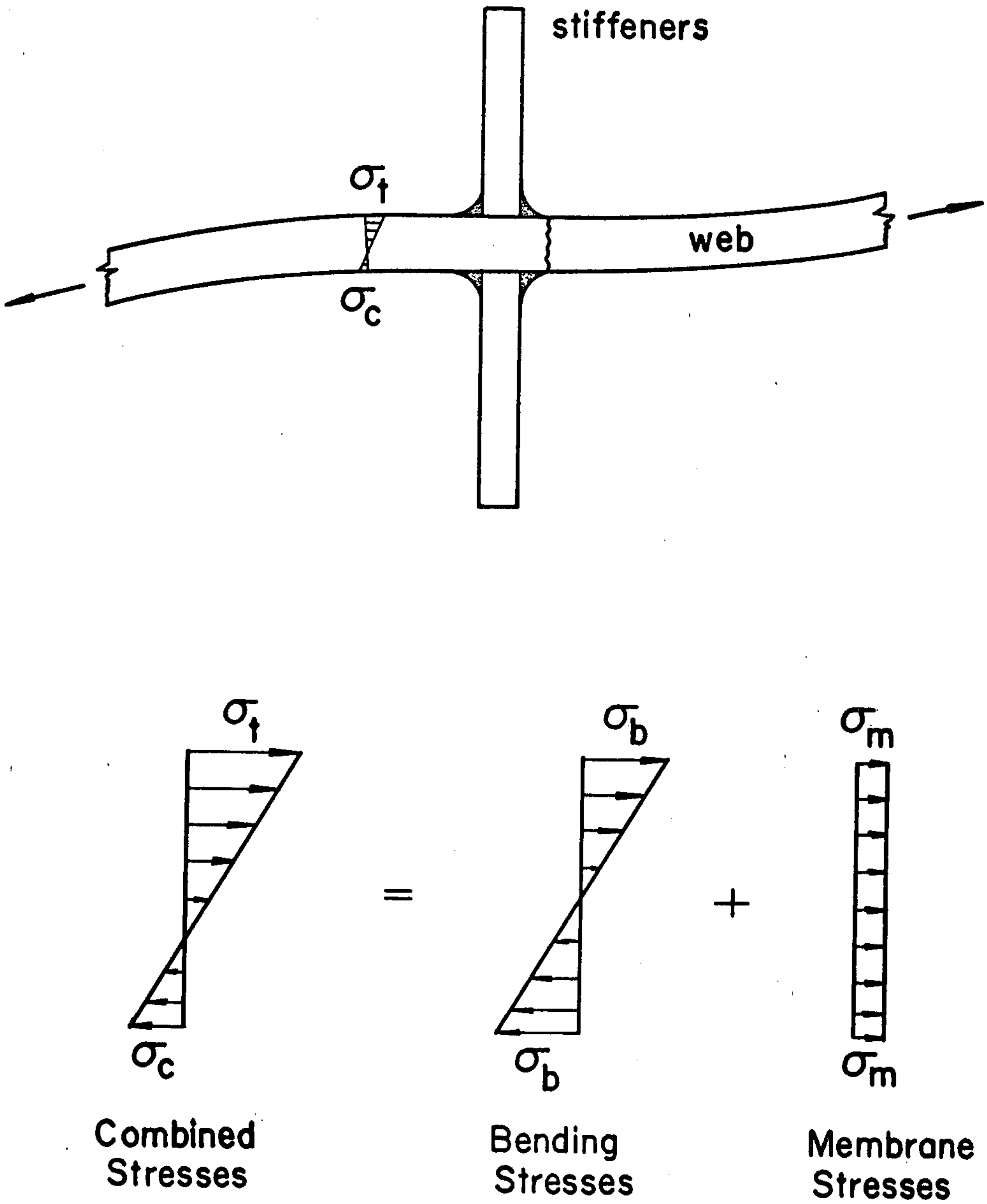

stiffeners
σ_t
web
σ_c
σ_t
σ_b
σ_m
=
+
σ_c
σ_b
σ_m
Combined Stresses
Bending Stresses
Membrane Stresses

Figure 1

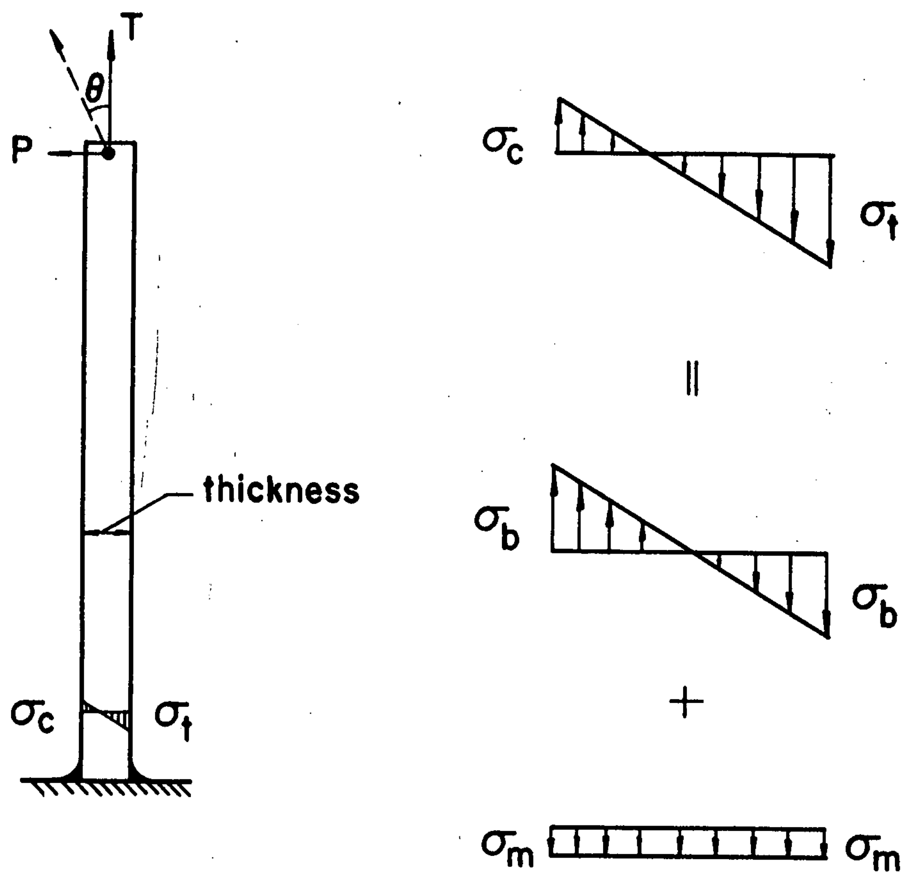


Figure 2

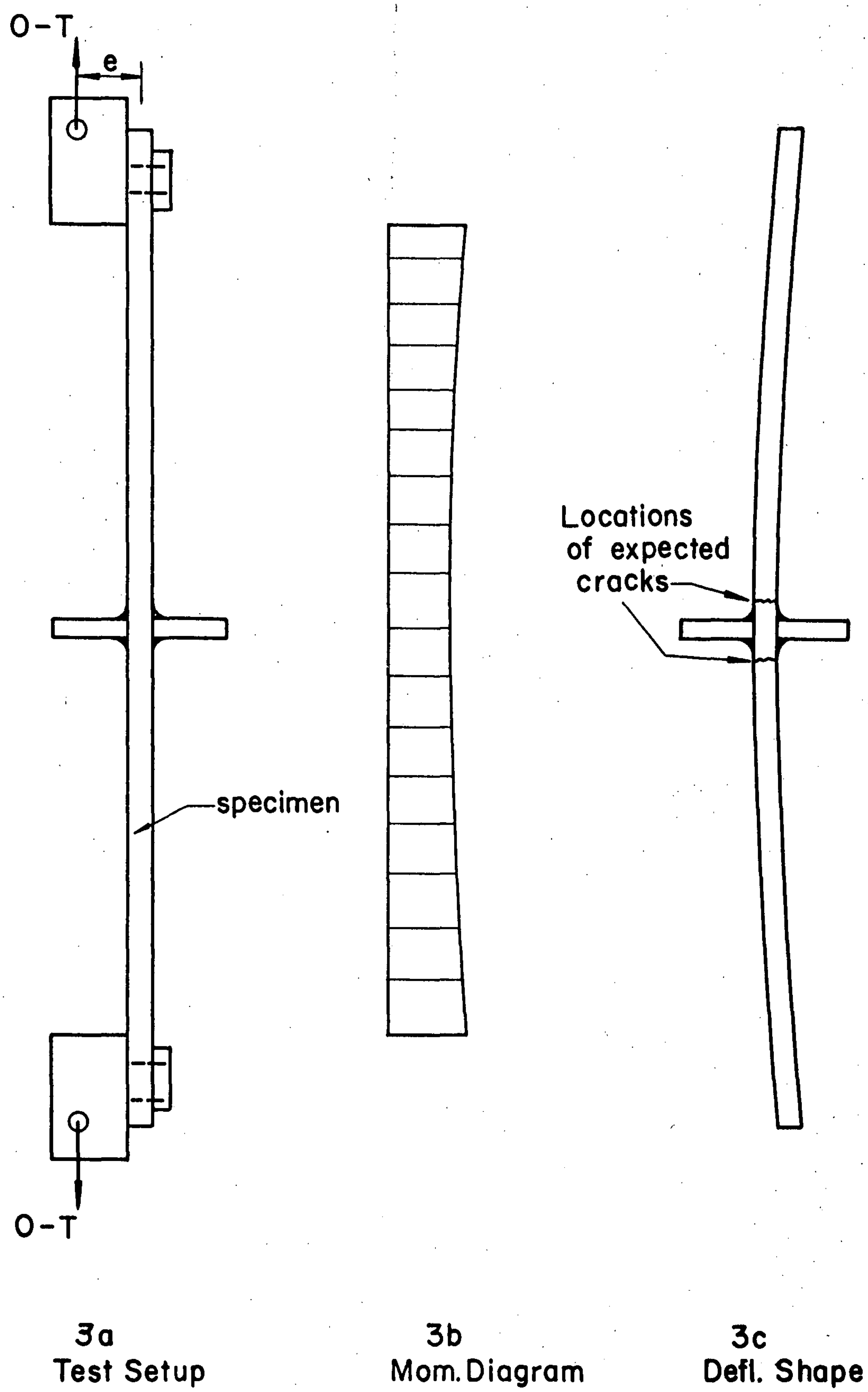
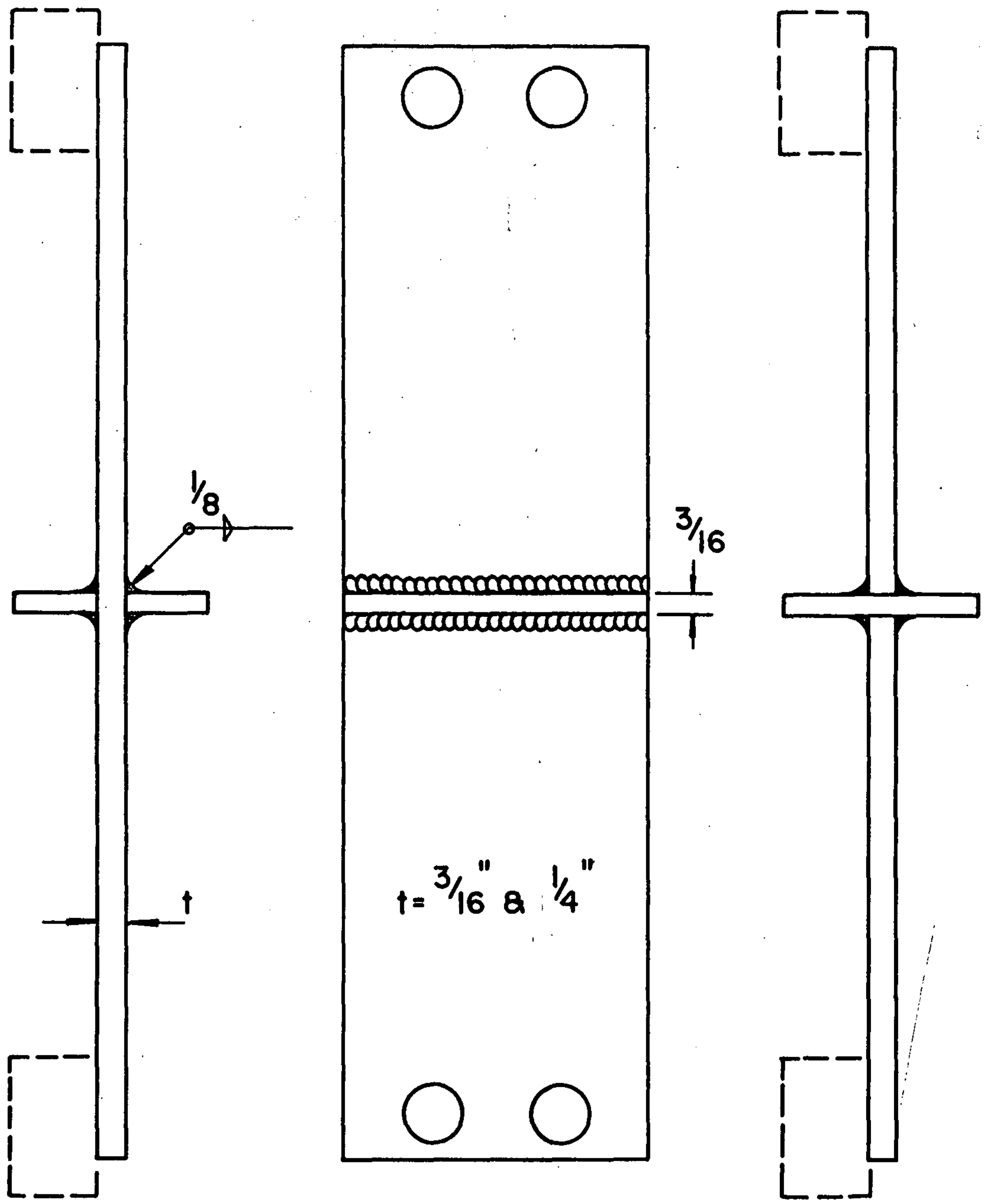

O-T
e
specimen
O-T
Locations
of expected
cracks
3a
Test Setup
3b
Mom. Diagram
3c
Defl. Shape

Figure 3



4a
Web to Stiffener
Joints

4b
Web to Flange
Joints

Figure 4

Table 1

Web Thickness (in.)	Axial Stresses (ksi)	Bending Stresses (ksi)	Number of Specimens	
			Stiffener Joint	Flange Joint
t=3/16	0-10	0-36	3	3
		0-30	3	3
		0-24	3	3
	0-7	0-36	3	3
		0-30	3	3
		0-24	3	3
	0-4	0-36	3	3
		0-30	3	3
		0-24	3	3
t=1/4	0-10	0-36	3	3
		0-30	3	3
		0-24	3	3
	0-7	0-36	3	3
		0-30	3	3
		0-24	3	3
	0-4	0-36	3	3
		0-30	3	3
		0-24	3	3

Total: 108

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