PROPOSAL FOR FATIGUE TESTING
OF WELDED PLATE GIRDER
UNDER THE INTERACTION OF BENDING AND SHEAR

Submitted to the
Welded Plate Girder Project Subcommittee
of the Welding Research Council

by

B. T. Yen
J. A. Mueller

Lehigh University
Department of Civil Engineering
Fritz Engineering Laboratory Report 303.8
January 1965
1. INTRODUCTION

In the investigation of the static strength of welded plate girders with slender webs, specimens were subjected to pure bending moment, high shear, or combined bending and shear for examining the effects of each type of loading. The failure of a girder under each loading condition was characterized by failure of a specific component of the girder: the flange in bending and the web in shear \(^{(1)}\). Subsequent investigations on the fatigue strength of girders followed the same loading patterns \(2,3,4,5,6\). The results indicated that a "shear girder" with a slender web would most likely develop fatigue cracks in the web along its boundaries \(2,3\) and a "bending girder" would probably fail at a flange \(4,6\) -- similar to a welded beam with transverse stiffeners. Since these modes of failure seem to agree well with those under static loads, it might be expected that a girder under repeated loads causing interaction between bending and shear would develop fatigue cracks simultaneously in the web and at the flanges. Whether this is true may be revealed by an experimental investigation. Such an investigation is proposed here.

Because interaction only occurs at panels with high shear plus high moment, the test girders for interaction often have some of their panels governed either by shear or by bending. Therefore, an investigation of girders under interaction between bending and shear also provides opportunities for the examination of other loading conditions. To further study shear and bending panels is another purpose of this proposed investigation.
2. DESIGN OF SPECIMENS

Two identical girders are proposed. To conform to the previous test girders' panel configuration for comparison of results, it was decided that the web depth of 50 inches and the aspect ratio of 1.0 (square panels) are to be maintained for the two new girders. To avoid any possibility of fatigue failure by transverse butt-weld joints in the web, a web continuous throughout the length of the girder will be used. The thickness of the web, the length of the girder, and the size of the flanges were so chosen that:

(a) The girder deflection at the loading point(s) would be within the stroke limit of the loading jack(s).

(b) The intended test loads would be within the capacity of the loading system.

(c) There would be at least two panels under the interaction of bending and shear (the main test panels), and, if possible,

(d) There would be some panels under pure bending moment or high shear.

Because the basic feature for the investigation is the "slender webs" of girders, the thickness of the webs is preferably 3/16 in. or 1/4 in. For a web depth of 50 in., the web slenderness ratio will then be always higher than the usual limit of 170 for bridge girders. By considering this and all those factors above, and by assuming that the yield stresses of the girder material are about 33 ksi (ASTM-A373), the specimens were designed and are presented in Figure 1. A web thickness of 1/4 in. as well as a difference in flange thickness is
necessary to keep the girder deflection within allowable limits. The flange components will be butt-welded together with a 1 to 2-1/2 taper. Other details such as cutting short transverse stiffeners at the tension side of the girder are also shown in Figure 1. The panels of a girder are numbered for reference.

In Table 1 are summarized the nominal strengths of each panel. As indicated, panels 3 and 5 of each girder are governed by the interaction of bending and shear. The two adjacent panels (2 and 6) are "shear panels" and the panel (4) between the loads is under pure bending. The buckling load of panels 1 and 7 is very high. Thus these panels are expected to be strong enough to anchor the tension fields of the neighboring panels.
3. **LOADS**

Since the static strengths of girder specimens are governed by the interaction of bending and shear, it is difficult to set a stress magnitude as the testing reference. It is proposed to use the static strength ($P_u$) as a guide and subject a girder to a load range of 0-65% of the static strength, as was the case for the bending and shear girders. The magnitudes of the loads are listed in Table 1. (A minimum load of a few kips is needed to stabilize the test set up).

Each girder will be subjected to a static test up to the intended maximum load for inspection and test observations. After that, repeated loads will be applied until a crack occurs. Repairs will then be made and the test continued. The procedure has been employed for the previous girders with good results and is expected to be applicable again if the cracks do not occur in the flanges.

If conditions warrant, static tests to failure will be performed to examine the effects of cracks on the static strength.
4. Equipment, Funds, and Staff

It is expected that the fatigue testing equipment and the testing space at the Fritz Engineering Laboratory will be available to the project in the Fall of 1965. The cost of the specimens and the salaries and wages of the investigating staff have been included in the budgets of the project for the current and the forthcoming fiscal years. The girder specimens, if approved, shall be ordered in the Spring. It is believed that the existing staff of the project is adequate for the investigation. Necessary assisting hands for testing shall be available without difficulty.
<table>
<thead>
<tr>
<th>Girder</th>
<th>F 8</th>
<th>F 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web Slenderness ratio</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Panels (1) and (7)</td>
<td>( \alpha )</td>
<td>Strength Mode</td>
</tr>
<tr>
<td>Panels (2) and (6)</td>
<td>( \alpha )</td>
<td>Strength Mode</td>
</tr>
<tr>
<td>Panel (3) and (5)</td>
<td>( \alpha )</td>
<td>Strength ( (P_u) ) Mode</td>
</tr>
<tr>
<td>Panel (4)</td>
<td>( \alpha )</td>
<td>Strength Mode</td>
</tr>
<tr>
<td>Test Loads</td>
<td>( P_{\text{max}} )</td>
<td>65% ( P_u )</td>
</tr>
<tr>
<td>Test Stresses</td>
<td>( P_{\text{min}} )</td>
<td>5 kips</td>
</tr>
<tr>
<td>Panels (3) and (5)</td>
<td>( \sigma_{\text{max}} )</td>
<td>19.8 ksi</td>
</tr>
<tr>
<td>Panel (4)</td>
<td>( \sigma_{\text{max}} )</td>
<td>19.8 ksi</td>
</tr>
</tbody>
</table>

**NOTE:** Two identical girders; nominal \( \sigma_y = 33 \text{ ksi} \)
Material: ASTM - A373
Two Identical Girders (F8 and F9)

Detail of Butt Weld
5. REFERENCES

1. K. Basler, B. T. Yen, J. A. Mueller, and B. Thurlimann
   WEB BUCKLING TESTS ON WELDED PLATE GIRDERS, Bulletin No. 64,
   Welding Research Council, New York, September 1960

2. B. T. Yen
   ON THE FATIGUE STRENGTH OF WELDED PLATE GIRDERS, Lehigh
   University, Fritz Engineering Laboratory Report No. 303.1,
   November 1963

3. B. T. Yen, and J. A. Mueller
   FATIGUE TESTS OF WELDED PLATE GIRDERS IN SHEAR, Lehigh University,
   Fritz Engineering Laboratory Report No. 303.6, November 1964

4. A. A. Toprac
   FATIGUE STRENGTH OF FULL-SIZE HYBRID GIRDERS - A PROGRESS REPORT,
   University of Texas Report, April 1963

5. L. R. Hall, and J. E. Stallmeyer
   THIN WEB GIRDER FATIGUE BEHAVIOR AS INFLUENCED BY BOUNDARY RIGIDITY,
   Structural Research Series No. 278, University of Illinois,
   January 1964

   FATIGUE TESTS OF WELDED PLATE GIRDERS IN BENDING, Lehigh University,
   Fritz Engineering Laboratory Report No. 303.9, (in preparation).