Submitted to the Welding Research Council Subcommittee on Lehigh University Welded Plate Girder Project

PROPOSAL FOR BENDING TESTS
ON
LONGITUDINALLY STIFFENED PLATE GIRDERS
by
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Introduction

The bending strength of transversely stiffened plate girders has been investigated both theoretically and experimentally.\(^{(1,2)}\) In this investigation it was shown that the bending strength is limited either by yielding or by instability of the compression flange. Compression flange instability can occur by lateral, torsional or vertical buckling. For a given value of yield stress, lateral buckling depends upon the ratio of the unsupported length of the compression flange to the radius of gyration of the section consisting of the flange and one-sixth of the web, torsional (local) buckling is a function of the width-thickness ratio of the compression flange and vertical buckling is governed by the web slenderness or web depth-to-thickness ratio.

The bending strength of a girder reinforced with both transverse and longitudinal stiffeners may also be limited either by yielding or compression flange instability, and for lateral or local (torsional) buckling of the compression flange, the relationships which were developed for transversely stiffened girders can be applied. It is also possible for a longitudinal stiffener to fail laterally or locally for some geometric configurations.

The resistance of a plate girder web to vertical buckling of the compression flange should be significantly increased by the use of a longitudinal stiffener. Thus, a suitably positioned and proportioned longitudinal stiffener should permit the use of a larger web slenderness ratio than would be safe for a girder without the longitudinal stiffener.
The parameters which are involved in the vertical buckling problem are the aspect ratio $\alpha$, the web slenderness ratio $\beta$, the yield strain $\epsilon_y$, the yield stiffness $\eta_y$ and the stiffener rigidity ratio $\gamma_s$. All of these parameters are defined in Fig. 1.

A literature survey has shown that a relatively small amount of experimental work on longitudinally stiffened plate girders subjected to bending has been conducted. Many of the tests reported in the literature were not carried to failure so that little can be learned about the failure modes. Of those tests which were taken to failure, lateral buckling of the compression flange was the most common failure mode. Therefore, very little experimental data on vertical buckling of the compression flange is available. For this reason, bending tests on longitudinally stiffened plate girders are proposed in this report.
Proposed Experimental Program

It is proposed to conduct ultimate load tests on two longitudinally stiffened girders which are designated girders L1 and L2. For each girder a central test section consisting of three panels will be subjected to pure bending (see Fig. 2). Reinforcing of failed panels should permit conducting three tests on each girder. The girders will be fabricated from ASTM A373 steel plates. Nominal values of the basic parameters for each test panel are listed in Table I.

The depth of the girders was determined on the basis that an extreme value of the web slenderness ratio should be tested. Using the thinnest practical web thickness of 1/8 in., a depth of 60 in. was selected which provides a nominal web slenderness ratio of 480.

The flanges were proportioned so that the possibility of lateral or local buckling would be minimized. Lateral support to the compression flange will be provided at each transverse stiffener (Fig. 2). The longitudinal stiffeners were located 1/5 of the web depth from the compression flange and are all one-sided stiffeners. The shear spans, transverse stiffeners, bearing stiffeners and end plates were all designed conservatively to avoid premature failure of these elements.

The test section of girder L1 consists of three panels with an aspect ratio of 1.0. In order to demonstrate conclusively to what extent a longitudinal stiffener can contribute to the resistance of the web to vertical buckling of the compression flange, there is no longitudinal
stiffener in panel B, while panel A has a fairly rigid stiffener (Fig. 3). The third panel (panel C) has a stiffener with a value of $\gamma_s$ which is less than that required by the current AASHO, British or German Specifications. (3,4,5)

Girder L2 was designed to check the influence of panel size on vertical buckling strength, and thus the test section consists of one panel with an aspect ratio of 1.5 (panel A) and two with an aspect ratio of 0.75 (panels B and C). As shown in Fig. 3, $\gamma_s$ for panel B is approximately the same as that required by the AASHO Specifications while the values of $\gamma_s$ for panels A and C are larger than either the AASHO or German Specification requirements and smaller than the British Specification values.

During the tests, ultimate loads and load-deflection behavior of the girders will be measured. In addition to strain measurements at selected locations on the stiffeners and webs, at least one section of each girder will be completely instrumented to measure the stress redistribution above the elastic buckling load. Lateral deflections of the web and stiffeners will also be measured.

In addition to the girders shown in Fig. 2, it is also proposed to order a short section of girder with the same configuration as the test sections and provided with a 2-1/2" x 1/8" longitudinal stiffener. This section will be used to determine the magnitude and distribution of residual stresses using the sectioning method. It is possible that the
influence of residual stresses can be incorporated in analytical expressions to predict the strength of welded, longitudinally stiffened plate girders.
Funds and Staff

It is anticipated that the proposed tests can be conducted by the present project staff. The cost of the specimens, the salaries of the investigators and the wages of the necessary technical assistants will be paid from funds available to the project for the current 1963-1964 fiscal year. Testing equipment will be furnished at Fritz Engineering Laboratory.
References

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5. British Standards Institution
   BRITISH STANDARD 153: STEEL GIRDER BRIDGES, Parts 3B and 4,

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   DIN 4114 (German Buckling Specifications), Blatt 1 und 2,
   Beuth-Vertrieb GmbH, Berlin and Cologne, July, 1952
### GIRDER L1

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### GIRDER L2

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*Table I  Nominal Values of Basic Parameters*
\[ \alpha = \frac{a}{b} = \text{aspect ratio} \]
\[ \beta = \frac{b}{t} = \text{slenderness ratio} \]
\[ \epsilon_y = \frac{\sigma_y}{E} = \text{yield strain} \]
\[ \eta_i = \frac{b_i}{b} = \text{stiffener position} \]
\[ \gamma = 10.92 \frac{I_s}{b t^3} = \text{stiffener rigidity ratio} \]

FIG. 1 - VERTICAL BUCKLING PARAMETERS
FIG. 2 - PROPOSED TEST GIRDERS