Final report on project 304, longitudinally stiffened plate - girders, July 1966

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LONGITUDINALLY STIFFENED PLATE GIRDERS

FINAL REPORT ON PROJECT 304,
LONGITUDINALLY STIFFENED PLATE GIRDERS

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Peter B. Cooper
Alexis Ostapenko

Fritz Engineering Laboratory Report No. 304.11
FINAL REPORT ON PROJECT 304,
LONGITUDINALLY STIFFENED PLATE GIRDER

Submitted to the
Welding Research Council Subcommittee
on Welded Plate Girders - Lehigh University

Peter B. Cooper
Alexis Ostapenko

Lehigh University
Department of Civil Engineering
Fritz Engineering Laboratory Report No. 304.11

July 1966
INTRODUCTION

The research project "Longitudinally Stiffened Plate Girders", which was initiated at Lehigh University on August 1, 1963, was terminated on July 31, 1966. While the termination does not indicate that all the problems related to longitudinally stiffened plate girders have been solved, most of those pertaining to the static strength have been investigated, and satisfactory results obtained. This final report briefly summarizes development, phases of work and results and conclusions of the project.

DEVELOPMENT OF THE PROJECT

The project was initiated as a logical extension of an earlier research project concerned with the static strength of transversely stiffened plate girders. The general objective was to determine the influence of longitudinal stiffeners on the static behavior and load-carrying capacity of plate girders.

Two loading conditions were studied experimentally and theoretically: pure bending and high shear. In the experimental work, six full-size girders were tested in pure bending and four in shear. Using the previous work on transversely stiffened girders as a starting point and utilizing the observed behavior of the test girders, methods were developed to predict the static strength of longitudinally stiffened plate girders for the two loading conditions considered. Requirements for proportioning stiffeners were
also established. The status of the various phases of the project at the time of termination is given below.

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RESULTS AND CONCLUSIONS

Some of the more important results of this research work are the following:

1) Longitudinal stiffeners control lateral web deflections and thereby reduce or modify the redistribution of stresses in the web which
takes place in a transversely stiffened girder when the buckling load is exceeded.

2) For girders subjected to pure bending, the redistribution of stress from the compressed portion of the web to the compression flange, observed in transversely stiffened plate girders with high slenderness ratios, can be eliminated by a longitudinal stiffener.

3) In girders subjected to pure bending, longitudinal stiffeners do not significantly increase the stress at which lateral or torsional buckling of the compression flange occurs. The compression flange cannot buckle vertically until the flange is completely yielded; therefore longitudinal stiffeners influence the load at which vertical buckling occurs indirectly by eliminating the stress redistribution.

4) Because of the control of stress redistribution by longitudinal stiffeners, the ultimate bending moment can be predicted using beam theory. Predictions based on this method are in very good agreement with test results.

5) The increase in bending strength due to longitudinal stiffeners depends on the ratio of the area of the web to the area of the compression flange and on the web slenderness ratio.

6) For girders subjected to high shear, longitudinal stiffeners influence the stress redistribution in the web by forcing separate tension fields in the subpanels formed by the longitudinal stiffeners.
A tension field model was developed to predict the shear strength of longitudinally stiffened plate girders. Comparison of predicted ultimate loads based on the model with test results indicates that the model provides a reliable but somewhat conservative estimate of the actual shear strength of longitudinally stiffened plate girders.

The increase in shear strength due to longitudinal stiffeners depends on the web slenderness ratio, the panel aspect ratio, and the yield strain of the steel.

For bending, it was suggested that longitudinal stiffeners located one-fifth of the web depth from the compression flange are effective in controlling stress redistribution. The optimum longitudinal stiffener position for shear varies with the web slenderness ratio, moving from mid-depth toward the compression flange as the web slenderness ratio increases.

Three requirements for proportioning longitudinal stiffeners were proposed: a) a minimum width-thickness ratio to prevent premature local buckling, b) a minimum stiffener rigidity to force a nodal line in the deflected web and c) a minimum column strength to avoid premature lateral buckling.

These results and conclusions are presented in various reports which are listed at the end of this final report.
SPONSORSHIP AND PERSONNEL

The financial sponsorship of the project was shared by the American Iron and Steel Institute through the Welding Research Council and the Pennsylvania Department of Highways in conjunction with the U. S. Department of Commerce--Bureau of Public Roads.

Technical guidance was provided by the Subcommittee on Welded Plate Girders - Lehigh University of the Structural Steel Committee of the Welding Research Council, with the following membership:

E. L. Erickson  J. A. Gilligan  W. B. McLean
A. Amirikian  C. D. Jensen  E. Pisetzner
Lynn S. Beedle  Knud Jensen  E. J. Ruble
M. Deuterman  B. G. Johnston  B. Thurlimann
F. H. Dill  R. L. Ketter  J. Vasta
J. L. Durkee  M. L. Koehler  Ivan M. Viest
G. F. Fox  K. H. Koopman  G. Winter
                   C. F. Larson

Those who were engaged in the research work of the project were:

Lynn S. Beedle  D. J. Fielding  B. T. Yen
P. B. Cooper  T. V. Galambos
M. A. D'Apice  A. Ostapenko

IDEAS FOR ADDITIONAL RESEARCH

The project work was limited to the study of the static bending and shear strength of steel plate girders with rectangular
panels reinforced with a single longitudinal stiffener. A number of related topics remain to be investigated:

1) the effect of interaction between bending moments and shear forces on the carrying capacity of longitudinally stiffened plate girders;
2) the use of multiple longitudinal stiffeners on a girder web;
3) the effect of longitudinal stiffeners on the strength of non-rectangular panels (curved or straight haunches);
4) the effect of longitudinal stiffeners on the behavior and strength of unsymmetrical girders;
5) the fatigue strength of longitudinally stiffened girders.

Two research projects have been initiated at Lehigh University which will be concerned with the latter two items:

Welded Plate Girders - Design Recommendations (Project 327)

Unsymmetrical Plate Girders (Project 328)
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<td>M. A. D'Apice, D. J. Fielding and P. B. Cooper STATIC TESTS ON LONGITUDINALLY STIFFENED PLATE GIRDER, May, 1966</td>
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