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

LITERATURE SURVEY ON
LONGITUDINALLY STIFFENED PLATES

by
Peter B. Cooper

Lehigh University
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1. INTRODUCTION

When web buckling is used as a criterion for plate girder design, reinforcing a slender web plate with stiffening members is usually more economical than using a stockier web. Transverse stiffeners, oriented perpendicular to the longitudinal axis of the girder, are commonly used to increase the shear strength while longitudinal stiffeners, oriented parallel to the longitudinal axis, are primarily used to increase bending strength.

The purpose of this report is to summarize the research which has been conducted on longitudinally stiffened plate girders or on longitudinally stiffened plates in general. The literature survey is limited in scope to the behavior of rectangular steel plates subjected to static in-plane loading. Longitudinally stiffened plates is the main topic but in some cases reports on transverse stiffeners in combination with longitudinal stiffeners have been included. The results of some theoretical and experimental work on light alloy plates have also been included if they are generally applicable to steel plates. The bibliography has been made as complete and up to date as possible.

Following a brief historical survey and a discussion of the literature survey with recommendations for additional research, references which have been reviewed are listed in the appendices. Appendix A contains general references on plate stability which include information on longitudinally stiffened plates (Refs. i-viii). In Appendix B are listed some specifications which provide for the use of longitudinal stiffeners in plate girder design

(Refs. a-f). Appendix C contains the main body of references which are listed according to the year in which they were published and alphabetically by authors for each year. A brief summary follows each reference in Appendix C. To facilitate use of the survey, the theoretical papers are classified by loading condition in Table I and experimental results are listed in Table II. For ease of summarizing the various papers, a short list of nomenclature has been introduced. An author index has also been provided at the end of the report.

2. HISTORICAL SURVEY

The stability of longitudinally stiffened plates has been investigated only in the past 42 years (1921-1963). Timoshenko's paper, published in 1921⁽¹⁾, is notable not only because it represents one of the first on the subject, but also because the energy method was used in the paper for the first time to obtain approximate solutions to stability problems of stiffened rectangular plates. Many other authors have since used the energy method to analyze various longitudinally stiffened plate problems.

The loading cases considered by Timoshenko (pure compression and pure shear) have their most common application in aircraft and ship design. Barbré^(5,9) was the first of a long list of German investigators to make additional contributions to our knowledge of the elastic stability of longitudinally stiffened plates under uniform compression. Most of the work done in the United States on this topic has been published in the NACA Technical Notes and a good survey of the subject may be found in Ref. iii.

In the design of longitudinally stiffened plate girders, the loading cases of pure bending or combined bending and shear are of most interest. Chwalla published two papers in 1936 which considered a single, symmetrical longitudinal stiffener located at $\eta_1 = 1/4$ (See Nomenclature), one dealing with pure bending⁽⁶⁾ and the other with pure bending as well as combined bending and shear⁽⁷⁾. These same loading conditions were also studied by Hampl⁽¹²⁾ for the case of the stiffener at middepth ($\eta_1 = 1/2$).

In 1941 Massonnet⁽¹⁸⁾ published a detailed discussion of the elastic stability of simply supported rectangular plates subjected to pure bending and reinforced with a longitudinal stiffener at $\eta_1 = 1/4$. This paper also introduced the concept of optimum stiffener rigidity. Minimum stiffness requirements for plate stiffeners were later defined more precisely by Kromm⁽²⁶⁾ and Chwalla⁽²³⁾, both of whom considered a longitudinally stiffened plate under pure bending.

Milosavljevitch⁽²⁸⁾ has presented a general treatment of the elastic stability of a simply supported rectangular plate subjected to combined bending, axial force and shear and reinforced with two transverse stiffeners and one longitudinal stiffener. The solution was obtained by analyzing the differential equation of the plate using a series method. The special cases of pure bending and bending with shear were solved for the transverse stiffeners at the 1/3 width points and the longitudinal stiffener at $\eta_1 = 1/4$. One year later, Dubas⁽³⁰⁾ showed that the optimum position of a longitudinal stiffener on a simply supported plate subjected to pure bending is at $\eta_1 = 1/5$. This position has since been adopted by the American and British Specifications. (See Appendix B).

More recently, a series of papers by Klöppel and Sheer^(44,45,48,52) have treated a multitude of combinations of stiffener arrangements and loading conditions for simply supported, rectangular plates. This work ultimately led to the publication of a handbook which presents tables and charts covering almost any elastic stability problem for a stiffened, simply-supported, rectangular plate^(v). A digital computer was used to solve the buckling determinants for the various problems in this handbook.

The effect of varying boundary conditions on the elastic stability of rectangular plates in pure bending has been studied by both Massonnet and Rockey since 1960. Massonnet determined the effects of full fixity of the longitudinal edges and of torsional rigidity of the longitudinal stiffener⁽⁵⁹⁾. Rockey studied the same problem and showed that the optimum stiffener position for these boundary conditions is $\eta_1 = 0.21$ ⁽⁶⁴⁾ and that a 30% increase in the buckling coefficient results due to the torsional strength of the stiffener. In 1962, Rockey showed that for the longitudinal edges fixed both flexurally and torsionally, the optimum stiffener position is $\eta_1 = 0.22$ ⁽⁶⁵⁾. Also, it was found that the required flexural rigidity of the longitudinal stiffener is decreased owing to the torsional rigidity of the flanges.

Experimental studies of longitudinally stiffened plate girders have been limited to the work of a few investigators.. Madsen concluded from one bending test on a steel box girder that longitudinal stiffeners are very effective in preventing web buckling⁽²⁰⁾. Gaber tested 10 steel girder models in bending to obtain data for stiffener design⁽²⁵⁾. Symmetrical stiffeners were found to be far more efficient than one-sided stiffeners. The longitudinal stiffener provisions of the British Specifications^(d,e) were checked

experimentally by Longbottom and Heyman through tests on two model girders and two full-sized girders⁽⁴⁶⁾.

The most extensive experimental data on longitudinal stiffeners has been presented by Massonnet and Rockey. Massonnet conducted six ultimate load tests on two steel girders using various locations and sizes of longitudinal stiffeners⁽⁴⁰⁾. From these tests he concluded that the theoretical minimum stiffener rigidity is inadequate. Rockey has conducted over 140 buckling tests on webs of bolted aluminum girders⁽⁵⁰⁾. Design rules for proportioning longitudinal stiffeners were suggested based on these tests.

3. DISCUSSION

Many investigators have studied the elastic stability of longitudinally stiffened plates and a great deal is known about the theoretical influence of various loading conditions, different boundary conditions and various locations and sizes of stiffeners. For the loading cases of pure bending or bending with shear, most of this work has been limited to the elastic range. Bleich⁽ⁱ⁾ and Moisseiff and Lienhard^(vii) are among those who have suggested methods of extending the elastic analyses to the case of critical stresses above the proportional limit.

It has been verified both analytically^(61,63) and experimentally⁽⁵⁸⁾ that the bending strength of transversely stiffened plate girders depends primarily on the stability of the compression flange column rather than on the stability

of the stiffened web. In addition, the shear strength depends only partly on the web buckling load; the post-buckling strength is developed by means of tension field action⁽⁶²⁾. Although all of the specifications listed in Appendix B contain provisions for longitudinally stiffened plate girders based on web buckling, in light of the above mentioned research on transversely stiffened girders it would seem logical to assume that web buckling of a longitudinally stiffened girder does not limit the strength of the girder.

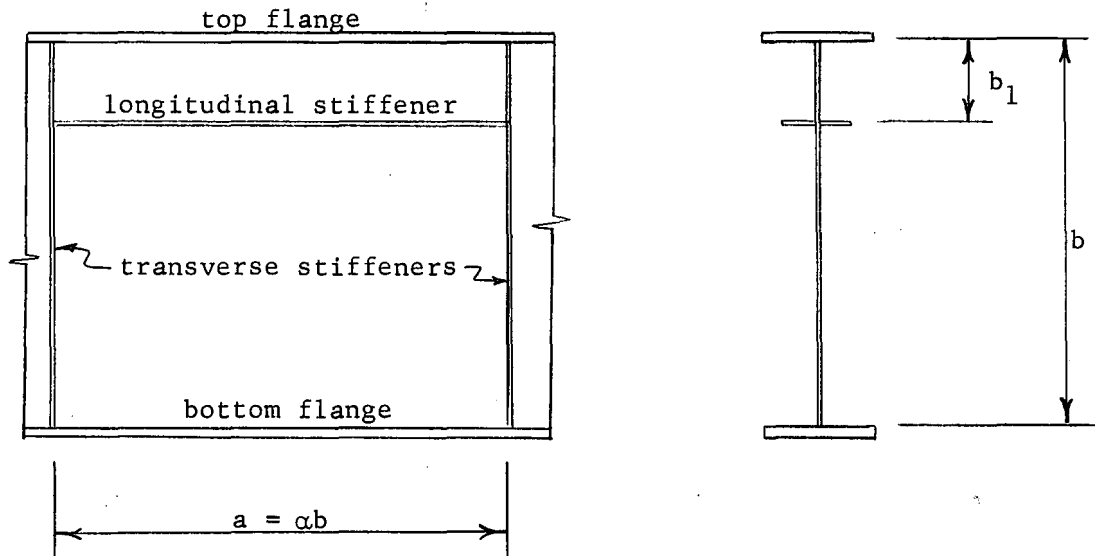
Information is needed on the contribution that longitudinal stiffeners can make to the strength of a plate girder. Based partly on the literature survey which is presented in this report, a research program has been initiated at Lehigh University to study the problem⁽⁶⁷⁾. This program will include a theoretical and experimental investigation of the influence of longitudinal stiffeners on vertical buckling of the compression flange, on shear strength of a panel and on control of web deflections. It is hoped that the investigation will result in the formulation of design recommendations for longitudinally stiffened plate girders with provisions for positioning, proportioning and detailing longitudinal stiffeners.

4. ACKNOWLEDGMENTS

This literature survey has been prepared as the first phase of a research project on longitudinally stiffened plate girders at Fritz Engineering Laboratory, Department of Civil Engineering, Lehigh University, Bethlehem, Pennsylvania, of which Professor W. J. Eney is the Head.

Plate girder research at Lehigh is sponsored by the Pennsylvania Department of Highways, the U. S. Department of Commerce - Bureau of Public Roads, the American Iron and Steel Institute, the American Institute of Steel Construction, and the Welding Research Council and is supervised by the Lehigh University Welded Plate Girder Subcommittee of the Welding Research Council. The financial support of the sponsors and encouragement of the Committee are gratefully acknowledged.

The author expresses his thanks to Dr. Lynn Beedle, Project Director, and Dr. T. V. Galambos and Mr. B. T. Yen for their suggestions, to Mr. M. A. D'Apice for proof-reading the report, and to Miss Marilyn Courtright for typing the report.

5. NOMENCLATURE

- a - clear distance between transverse stiffeners or plate width
- b - clear distance between flanges or plate depth
- b_i - distance from top of web plate to centroid of longitudinal stiffener (b_1 is for first stiffener, b_2 for second, etc.)
- t - plate thickness
- α - aspect ratio (a/b)
- β - slenderness ratio (b/t)
- γ_i - ratio of rigidity (EI) of longitudinal stiffener to rigidity of plate. The latter is defined as $Ebt^3/12(1-\nu^2)$.
- δ_i - ratio of area of longitudinal stiffener to area of web
- η_i - non-dimensionalized location of longitudinal stiffener (b_i/b)

6. TABLES

TABLE I THEORETICAL SOLUTIONS




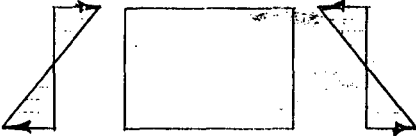
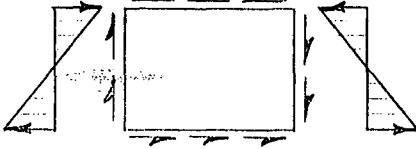
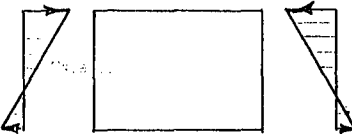
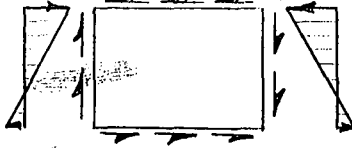
Loading Condition	References
	1, 10, 12, 29, 35, 45, 48, 49, 52, 56, 66
	1, 3, 5, 7, 8, 9, 11, 14, 15, 16, 19, 23, 26, 27, 31, 33, 34, 36, 37, 45, 48, 57
	6, 7, 55
	6, 7, 12, 13, 18, 21, 23, 24, 26, 28, 30, 35, 39, 45, 48, 49, 51, 52, 54, 56, 59, 64, 65
	7, 12, 13, 28, 49, 55
	45, 48, 52, 56
	32, 44, 45, 55

TABLE IIa PANEL TESTS

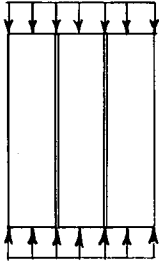
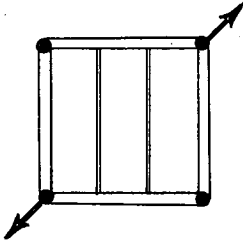
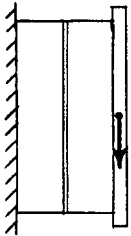
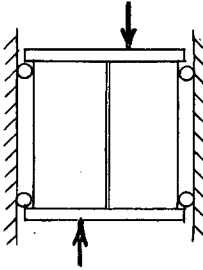
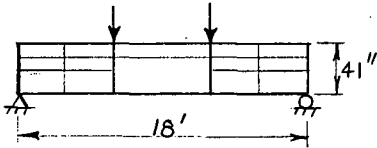
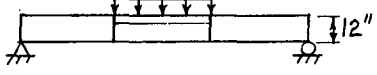
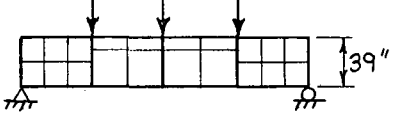
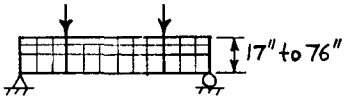
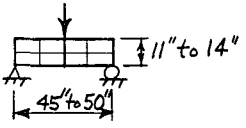
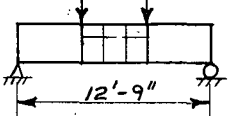
Test Arrangement	Reference No. and Remarks
	<p>Ref. 2, 3, 15, 17</p> <p>Compression tests of riveted aluminum alloy panels.</p>
	<p>Ref. 2</p> <p>Shear tests of riveted aluminum alloy panels.</p>
	<p>Ref. 29</p> <p>Shear tests of long, riveted aluminum alloy panels.</p>
	<p>Ref. 22</p> <p>Combined compression and shear tests of riveted aluminum alloy panels.</p>

TABLE IIb GIRDER TESTS

Test Arrangement	Reference No. and Remarks
	Ref: 20 One welded steel box girder test
	Ref. 25 Ten welded steel girders, 8 with a span of 9'-10" and 2 with a span of 19'-8".
	Ref. 40 Six ultimate load tests on two welded steel girders. Spans varied from 18' to 32'-10".
	Ref. 46 16 tests on 4 welded steel girders with spans from 5'-10" to 31'-2".
	Ref. 50 41 tests on 8 bolted aluminum alloy girders. Very strong flanges used to obtain shear failures.
	Ref. 53 About 45 tests on bolted aluminum alloy girders.

7. APPENDICES

APPENDIX A GENERAL REFERENCES

- i Bleich, F.
BUCKLING STRENGTH OF METAL STRUCTURES, McGraw-Hill, 1952
- ii Column Research Council
GUIDE TO DESIGN CRITERIA FOR METAL COMPRESSION MEMBERS,
Engineering Foundation, 1960
- iii Gerard, G. and Becker, H.
HANDBOOK OF STRUCTURAL STABILITY, NACA TN 3781-3786, 1957-1958
- iv Japanese Column Research Council
HANDBOOK OF ELASTIC STABILITY, 2nd Edition, Korona Publishing
Co., Tokyo, 1959 (in Japanese)
- v Klöppel, K. and Scheer, J.
BEULWERTE AUSGESTEIFTER RECHTECKPLATTEN, Verlag von Wilhelm
Ernst & Sohn, Berlin, 1960 (BUCKLING VALUES FOR STIFFENED
RECTANGULAR PLATES)
- vi Kollbrunner, C. F. and Meister, M.
AUSBEULEN, Springer,-Verlag, Berlin, 1958 (PLATE BUCKLING)
- vii Moisseiff, L. S. and Lienhard, F.
THEORY OF ELASTIC STABILITY APPLIED TO STRUCTURAL DESIGN,
Trans. ASCE, Vol. 106, 1941, p. 1052
- viii Timoshenko, S. P. and Gere, J. M.
THEORY OF ELASTIC STABILITY, McGraw-Hill, 1961

APPENDIX B SPECIFICATIONS

- a. American Association of State Highway Officials
STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 1961
- b. American Railway Engineering Association
SPECIFICATIONS FOR STEEL RAILWAY BRIDGES, Part 4, Rigid-Frame
Steel Bridges and Continuous Steel Bridges, 1962
- c. Association of Iron and Steel Engineers
SPECIFICATIONS FOR ELECTRIC OVERHEAD TRAVELING CRANES FOR
STEEL MILL SERVICE, AISE Standard No. 6, 1949
- d. British Standards Institution
STEEL GIRDER BRIDGES, British Standard 153, Parts 3B and 4, 1958
- e. British Standards Institution
THE USE OF STRUCTURAL STEEL IN BUILDINGS, British Standard 449,
1959
- f. Deutscher Normenausschuss
! DIN 4114, BLATT 1 UND 2, Beuth-Vertrieb G.m.b.H., Berlin W15
und Köln, 1952 (German Buckling Specifications)

APPENDIX C BIBLIOGRAPHY1921

- 1 Timoshenko, S. P.
 ÜBER DIE STABILITÄT VERSTEIFTER PLATTEN, Eisenbau, Vol. 12,
 1921, p. 147
 (ON THE STABILITY OF STIFFENED PLATES)

The energy method is used to analyze the stability of simply supported plates loaded in their plane. Among the cases considered are : (1) $\eta_1 = 1/2$, pure compression; (2) $\eta_1 = 1/3$ and $\eta_2 = 2/3$, pure compression; and (3) one longitudinal stiffener, pure shear. k-values are tabulated for various values of α , γ , and δ .

1930

- 2 Newell, J. S.
 THE STRENGTH OF ALUMINIM ALLOY SHEETS, Airway Age, Vol. 11,
 1930, p. 1420

The results of a series of compression tests on small, longitudinally stiffened, light gage aluminum alloy panels are summarized. Channel and U-shaped stiffener sections were used.

1933

- 3 Lundquist, E. E.
 COMPARISON OF THREE METHODS FOR CALCULATING THE COMPRESSIVE STRENGTH OF FLAT AND SLIGHTLY CURVED SHEET AND STIFFENER COMBINATIONS, NACA TN 455, 1933

Three methods for calculating the compressive strength of longitudinally stiffened sheets are compared with available experimental data. It is concluded that for stiffeners which do not fail locally but by bending of the stiffener and sheet normal to the plane of the sheet, a method which assumes that the stiffener and an effective width of sheet act together as a column gives the best agreement between observed and predicted loads.

1934

- 4 Scheicher, F.
 STABILITÄTSPROBLEME VOLLWANDIGER STAHLTRAGWERKE. ÜBERSICHT UND AUSBLICK, Bauing, Vol. 15, 1934, p. 505
 (STABILITY PROBLEMS OF PLATE STRUCTURES. SURVEY AND OUTLOOK)

A good summary is presented of the solutions available in 1934 to problems of elastic stability of unstiffened and stiffened rectangular plates. Some of the problems which had not been solved at that time are listed.

1936

5 Barbré, R.

BUCKLING STRESSES OF RECTANGULAR PLATES WITH LONGITUDINAL STIFFENERS UNDER UNIFORM COMPRESSION, Translation 78, The David W. Taylor Model Basin, Washington 7, D. C., 1943 (Originally appeared in Bauing, Vol. 17, 1936, p.268)

The "exact" values of the required minimum rigidities for a central longitudinal stiffener and two equally spaced longitudinal stiffeners are determined from derived expressions for the buckling conditions. The effect of clamping the longitudinal edges of the plate on the minimum stiffener rigidity is also investigated.

6 Chwalla, E.

BEITRAG ZUR STABILITÄTSTHEORIE DES STEGBLECHES VOLLWANDIGER TRÄGER, Stahlbau, Vol. 9, 1936, p. 161 (CONTRIBUTION TO THE BUCKLING THEORY OF WEBS OF PLATE GIRDERS)

Simply supported rectangular plates reinforced with one longitudinal stiffener are analyzed using the energy method. The loading cases of pure bending and compression with shear are included.

7 Chwalla, E.

DIE BEMESSUNG DER WAAGERECHT AUSGESTEIFTEN STEGBLECHE VOLLWANDIGER TRÄGER, Pre. Pub. IABSE, and Congress, 1936, p. 957 (THE DESIGN OF LONGITUDINALLY STIFFENED WEBS OF PLATE GIRDERS)

The stability of simply supported rectangular plates reinforced with one longitudinal stiffener at $\eta_1 = 1/4$ and subjected to pure bending or bending with shear, and reinforced with one longitudinal stiffener at $\eta_1 = 1/2$ and subjected to pure compression or compression with shear is discussed. An approximate method of designing longitudinally stiffened web plates is presented.

8 Heck, O. S. and Ebner, H.

METHODS AND FORMULAS FOR CALCULATING THE STRENGTH OF PLATE AND SHELL CONSTRUCTIONS AS USED IN AIRCRAFT DESIGN, NACA TM 785, 1936

A survey of the literature on the strength and stability of plate and shell construction as used in aircraft design is presented. Some information on compressed, longitudinally stiffened plates is included.

1937

- 9 Barbré, R.

STABILITY OF RECTANGULAR PLATES WITH LONGITUDINAL OR TRANSVERSE STIFFENERS UNDER UNIFORM COMPRESSION, NACA TM 904, 1939
(Translated from Ing. Archiv. Vol. 8, 1937, p. 117)

The stability of longitudinally stiffened plates subjected to pure compression is investigated by solving the differential equation. Hinged transverse edges and hinged or clamped longitudinal edges are assumed. Various positions of one or two stiffeners are considered.

- 10 Chwalla, E. and Novak, A.

THEORIE DER EINSEITIG ANGEORDNETEN STEGBLECHSTEIFE, Stahlbau, Vol. 10, 1937, p. 73.
(THEORY OF UNSYMMETRIC WEB STIFFENERS)

The buckling of a simply supported rectangular plate subjected to pure shear with a central unsymmetrical stiffener is investigated using the energy method. The case of the stiffener buckling with the web is considered as well as the case where a nodal line forms along the stiffener.

- 11 Fröhlich, H.

STABILITÄT DER GLEICHMÄSSIG GEDRÜCKTEN RECHTECKPLATTE MIT STEIFENKREUZ, Bauing, Vol. 18, 1937, p. 673
(STABILITY OF A UNIFORMLY COMPRESSED RECTANGULAR PLATE WITH CROSSING STIFFENERS)

A general procedure is presented to investigate the stability of a simply supported rectangular plate subjected to pure compression and reinforced by one longitudinal and one vertical stiffener. The special case where these stiffeners are located at the middle of the plate is examined in detail with the buckling coefficients and minimum stiffener requirements evaluated for various combinations of the parameters.

- 12 Hampl, M.

EIN BEITRAG ZUR STABILITÄT DES HORIZONTAL AUSGESTEIFTEN STEGBLECHES, Stahlbau, Vol. 10, 1937, p. 16
(A CONTRIBUTION TO THE STABILITY OF LONGITUDINALLY STIFFENED WEB PLATES)

The energy method is used to obtain buckling coefficients for a simply supported plate with a longitudinal stiffener at midheight. Pure bending, shear and combined bending and shear are considered.

- 13 Krabbe, F. W.
BEITRAG ZUR BERECHNUNG DER STEGBLECHAUSSTEIFUNGEN VOLLWANDIGER
BLECHTRÄGER, Stahlbau, Vol. 10, 1937, p. 65
(CONTRIBUTION TO THE CALCULATION OF WEB STIFFENERS OF PLATE
GIRDERS)

A general method of designing web stiffeners is derived by considering the principal stresses in the unstiffened web at loads beyond the buckling load and imposing the deformation condition to determine the compressive forces in the stiffeners. Special cases considered include longitudinally stiffened panels subjected to pure bending and subjected to combined bending and shear.

- 14 Schleicher, F. and Barbré, R.
STABILITÄT VERSTEIFTER RECHTECKPLATTEN MIT ANFÄNGLICHER AUSBIEGUNG,
Bauing, Vol. 18, 1937, p. 665
(ON THE STABILITY OF STIFFENED RECTANGULAR PLATES HAVING INITIAL
DEFLECTIONS)

The effect of initial web deflections on the stability of a simply supported rectangular plate reinforced by a central longitudinal stiffener and subjected to uniform compression is investigated. A sinusoidal initial deflection curve is assumed. It is concluded that initial deflections equal to 1/10 of the web thickness have no significant effect on the plate behavior or the critical stress.

- 15 Sechler, E. E.
STRESS DISTRIBUTION IN STIFFENED PANELS UNDER COMPRESSION, Journ.
Aero, Sci., Vol. 4, 1937, p. 320

The compressive strength of longitudinally stiffened sheet metal panels is investigated analytically and experimentally. The effective width of sheeting which acts with a stiffener as a column is determined and a simple design formula for a panel with any number of stiffeners is proposed.

1939

- 16 Schleicher, F.
UNELASTISCHE BEULUNG VERSTEIFTER STEGBLECHE, Bauing, Vol. 20,
1939, p. 217
(INELASTIC BUCKLING OF STIFFENED WEBS)

Inelastic buckling of plates subjected to a uniform stress condition and made of material which is isotropic above the proportional limit is investigated by the use of reduction coefficients. One of the cases discussed is that of a longitudinally stiffened plate loaded in pure compression.

1940

- 17 Dunn, L. G.
AN INVESTIGATION OF SHEET-STIFFENER PANELS SUBJECTED TO COMPRESSION LOADS WITH PARTICULAR REFERENCE TO TORSIONALLY WEAK STIFFENERS, NACA TN 752, 1940

The results of 183 tests on aluminum alloy sheets stiffened longitudinally with bulb-angle sections and subjected to compressive loads are presented and compared with theoretical results. It is concluded that the scope of the tests was insufficient to formulate general design criteria but that the results should be useful as a guide for design.

- 18 Massonnet, C.
LA STABILITÉ DE L'ÂME DES POUTRES MUNIES DE RAIDISSEURS HORIZONTAUX ET SOLlicitÉES PAR FLEXION PURE, Pub. IABSE, Vol. 6, 1940-41, p. 233 (THE WEB STABILITY OF LONGITUDINALLY STIFFENED PLATE GIRDERS SUBJECTED TO PURE BENDING)

The stability of simply supported rectangular plates reinforced with a longitudinal stiffener at $\eta_1 = 1/4$ is investigated using the energy method. Buckling coefficients are given for various combinations of δ and γ and for various values of α .

1941

- 19 Knipp, G.
ÜBER DIE STABILITÄT DER GLEICHMÄSSIG GEDRÜCKTEN RECHTECKPLATTE MIT STEIFENROST, Bauing, Vol. 22, 1941, p. 257 (ON THE STABILITY OF A UNIFORMLY COMPRESSED RECTANGULAR PLATE STIFFENED BY A GRILLAGE SYSTEM)

Approximate values of the buckling coefficients and minimum required stiffener rigidities corresponding to various stiffener areas are given for five different cases of plates having both longitudinal and transverse stiffeners and subjected to uniform compression. The energy method is used and simply supported plate edges, equal sizes of sub-panels and equal sections for parallel stiffeners are assumed.

- 20 Madsen, I.
REPORT OF CRANE GIRDER TESTS, Iron and Steel Engineer, Vol. II, Nov. 1941, p. 47

A brief account is given of one bending test on an 18 ft. longitudinally stiffened box girder with $\alpha = 1.8$, $\beta = 320$, $\eta_1 = 1/4$. The test was not taken to failure but it is concluded that longitudinal stiffeners are very effective in preventing web buckling.

- 21 Stiffel, R.
 BIEGUNGSBEULUNG VERSTEIFTER RECHTECKPLATTEN, Bauing, Vol. 22,
 1941, p. 367
 (BUCKLING OF STIFFENED RECTANGULAR PLATES UNDER BENDING)

The stability of simply supported rectangular plates subjected to pure bending is studied using the energy method. The following cases are included: (1) $\eta_1 = 1/2$; (2) $\eta_1 = 1/4$; and (3) $\eta_1 = 1/4$ and $\eta_2 = 1/2$.

1943

- 22 Scott, M. and Weber, R. L.
 REQUIREMENTS FOR AUXILIARY STIFFENERS ATTACHED TO PANELS UNDER
 COMBINED COMPRESSION AND SHEAR, NACA TN 921, 1943

Light gage aluminum panels with $\alpha = 1, 2$ and 3 and with a central longitudinal stiffener on one side were tested under combined compression and shear. The moments of inertia of the rectangular stiffeners were varied from test to test and limiting values calculated from measured stiffener deflections.

1944

- 23 Chwalla, E.
 ÜBER DIE BIEGEBEULUNG DER LÄNGSVERSTEIFTEN PLATTE UND DAS PROBLEM
 DER "MINDESTSTEIFIGKEIT", Stahlbau, Vol. 17, 1944, p. 84
 (ON THE BUCKLING PROBLEM OF A LONGITUDINALLY STIFFENED PLATE UNDER
 BENDING MOMENTS AND THE PROBLEM OF OPTIMUM STIFFNESS)

An investigation which supplements that of Ref. 26 is presented. The stability of a longitudinally stiffened plate under pure bending is discussed in detail and it is shown that no "minimum stiffness" of the stiffener exists in this case. A longitudinally stiffened plate subjected to pure compression is also discussed.

- 24 Gaber, E.
 ÜBER DIE ASSTEIFUNG VON VOLLWANDTRÄGERN AUS STAHL, Stahlbau,
 Vol. 17, 1944, p. 1
 (ON THE STIFFENING OF STEEL PLATE GIRDERS)

Based on DIN 4114, a method of designing longitudinal and transverse stiffeners for a plate girder subjected to bending is presented. The following cases are considered: a single longitudinal stiffener with transverse stiffeners; and two longitudinal stiffeners with transverse stiffeners. Numerical examples are included.

- 25 Gaber, E.
 BEULBERSUCHE AN MODELLTRÄGERN AUS STAHL, Bautechnik, Vol. 22,
 1944, p. 6
 (BUCKLING TESTS ON MODEL STEEL GIRDERS)

Results of tests on 8 girders with a span length of 3 m and 2 with a span length of 6 m are briefly described. Both longitudinal and vertical stiffeners were used and a line loading was applied to the top flange. It is concluded that symmetrical stiffeners are much more efficient than one-sided stiffeners.

- 26 Kromm, A.
 ZUR FRAGE DER MINDESTSTEIFIGKEITEN VON PLATTENAUSSTEIFUNGEN,
 Stahlbau, Vol. 17, 1944, p. 81
 (ON THE PROBLEM OF OPTIMUM RIGIDITY OF STIFFENED PLATES)

The problem of minimum stiffness of plate girders is investigated. Two types of minimum stiffness are defined, γ_I , and γ_{II} . For $\gamma > \gamma_I$, the buckling load does not increase; for $\gamma > \gamma_{II}$, the buckling load increases at a much slower rate than for $\gamma < \gamma_{II}$. The concepts are illustrated by examples which include longitudinally stiffened plates subjected to pure bending or pure compression.

- 27 Torre, K.
 VORSCHLAG ÜBER DIE PRAKTISCHE BEULBERECHNUNG VERSTEIFTER RECHTECK-
 PLATTEN, Stahlbau, Vol. 17, p. 45, 1944
 (SUGGESTIONS FOR THE PRACTICAL CALCULATION OF CRITICAL LOADS OF
 RECTANGULAR PLATES)

A method is presented for designing a uniformly compressed rectangular plate reinforced with any number of equally spaced longitudinal stiffeners with equal section. Two cases are considered: (1) the stiffeners are elastic; (2) the stiffeners do not bend with the plate. Numerical examples are included.

1947

- 28 Milosavljevitch, M.
 SUR LA STABILITÉ DES PLAQUES RECTANGULAIRES RENFORCÉES PAR DES
 RAIDISSEURS ET SOLLICITÉES À LA FLEXION ET AU CISAILLEMENT,
 Pub. IABSE, Vol. 8, 1947, p. 141
 (ON THE STABILITY OF RECTANGULAR PLATES REINFORCED BY STIFFENERS
 AND SUBJECTED TO BENDING AND SHEAR)

The differential equation of the elastic surface of a simply supported rectangular plate subjected to combined bending, axial force and shear and reinforced with two transverse stiffeners and one longitudinal stiffener is analyzed. For the transverse stiffeners at the 1/3 width points and the longitudinal stiffener at $\eta_1 = 1/4$, the separate loading conditions of pure bending and bending with shear are solved.

1948

29. Crate, H. and Lo, H.

EFFECT OF LONGITUDINAL STIFFENERS ON THE BUCKLING LOAD OF LONG FLAT PLATES UNDER SHEAR, NACA TN 1589, 1948

A theoretical solution of the problem of shear buckling of long plates reinforced by equally spaced longitudinal stiffeners is presented. Both fixed and simply-supported longitudinal edges are considered. Fair agreement is obtained between theory and the results of 20 tests on light-gage, aluminum-alloy panels with one or two stiffeners and $\alpha = 8$.

30. Dubas, C.

CONTRIBUTION À L'ÉTUDE DU VOILEMENT DES TÔLES RAIDIES, Publications de L'Institut De Statique Appliquée, No. 23, École Polytechnique Fédérale De Zurich, 1948
(CONTRIBUTIONS TO THE PROBLEM OF BUCKLING OF STIFFENED PLATES)

The optimum position for a longitudinal stiffener on a simply supported rectangular plate subjected to bending is found to be $\eta_1 = 1/5$. Buckling coefficients for various combinations of δ and γ are given for this stiffener position.

1949

31. Seide, P. and Stein, M.

COMPRESSIVE BUCKLING OF SIMPLY SUPPORTED PLATES WITH LONGITUDINAL STIFFENERS, NACA TN 1825, 1949

Charts are presented for the analysis of the stability under compression of simply supported rectangular plates with one, two, three, and an infinite number of identical equally spaced longitudinal stiffeners that have zero torsional stiffness. The energy method is used in deriving the charts.

1952

32. Heilig, R.

ALLGEMEINE BEULGLEICHUNGEN DES VERSTEIFTEN, RECHTECKIGEN STEGBLECHFELDES, Bauing, Vol. 27, 1952, p. 398
(GENERAL BUCKLING EQUATIONS FOR STIFFENED, RECTANGULAR WEB PLATE PANELS)

Using the energy method, the buckling determinant is derived for a simply supported rectangular plate subjected to normal and shear stresses and reinforced with one longitudinal and one transverse stiffener. Variation of the normal stress magnitude along the plate length is also considered.

- 33 Wang, C. T. and Zuckerberg, H.
 INVESTIGATION OF STRESS DISTRIBUTION IN RECTANGULAR PLATES WITH
 LONGITUDINAL STIFFENERS UNDER AXIAL COMPRESSION AFTER BUCKLING,
 NACA TN 2671, 1952

The elastic post-buckling behavior of a rectangular plate reinforced with equally spaced longitudinal stiffeners and subjected to uniform compression is studied. Two possible buckling modes are considered: the stiffeners buckle with the plate or nodal lines form along the stiffeners. A modified variational procedure is used.

1953

- 34 Falconer, B. H. and Chapman, J. C.
 COMPRESSIVE BUCKLING OF STIFFENED PLATES, Eng., Vol. 195, 1953, p. 789

The stability of infinitely long plates under uniform compression is examined using the energy method. Effects of transverse and longitudinal stiffeners as well as of initial deflections are considered.

- 35 Sheer, J.
 NEUE BEULWERTE AUSGESTEIFTER RECHTECKPLATTEN, Stahlbau, Vol. 22,
 1953, p. 280
 (NEW BUCKLING VALUES OF STIFFENED RECTANGULAR PLATES)

Three cases are analyzed using the energy method: (1) equal longitudinal stiffeners at $\eta_1 = 1/4$ and $\eta_2 = 1/2$, pure bending; (2) $\eta_1 = 1/2$ and a transverse stiffener at mid-width of the panel, pure shear; and (3) equal longitudinal stiffeners at $\eta_1 = 1/4$ and $\eta_2 = 1/2$, pure shear.

- 36 Seide, P.
 THE EFFECT OF LONGITUDINAL STIFFENERS LOCATED ON ONE SIDE OF A PLATE
 ON THE COMPRESSIVE BUCKLING STRESS OF THE PLATE-STIFFENER COMBIN-
 ATION, NACA TN 2873, 1953

The buckling of uniformly compressed, simply supported rectangular plates with equally spaced longitudinal stiffeners on one side is investigated. One, two, three or infinitely many stiffeners of equal cross section are considered. With an effective flexural stiffness ratio of the stiffeners which is defined in the paper, buckling charts of the type presented in Ref. 31 can be used.

- 37 Sievers, H. and Bornscheuer, E.
 ÜBER DIE BEULSTABILITÄT DURCHLAUFENDER PLATTEN MIT DREHSTEIFEN
 LÄNGSSTEIFEN, Stahlbau, Vol. 22, 1953, p. 149
 (ON THE STABILITY OF CONTINUOUS PLATES WITH LONGITUDINAL
 STIFFENERS HAVING TORSIONAL RIGIDITY).

A method is developed to include the torsional stiffness of the stiffeners in the buckling analysis of longitudinally stiffened plates subjected to pure compression. As one example, the stability of the plates of a longitudinally stiffened box column is analyzed.

1954

- 38 Chwalla, E.
 ANSPRACHE UND VORTRAG ANLÄSSLICH DER EHRENPROMOTION AN DER
 TECHNISCHEN UNIVERSITÄT BERLIN-CHARLOTTENBURG, Veröffentlichungen
 des deutschen Stahlbau-Verbandes, No. 3, Köln, 1954
 (LECTURE TO THE TECHNICAL UNIVERSITY OF BERLIN ON THE OCCASION OF
 HIS PROMOTION TO AN HONORARY PH.D. DEGREE)

A number of possible research topics are outlined, including the buckling of web plates reinforced by arbitrarily inclined stiffeners, by stiffeners which follow the lines of principal stress or by stiffening corrugations which may or may not be parallel to the panel edges.

- 39 Dubas, C.
 LE VOILEMENT DE L'ÂME DES POUTRES FLÉCHIES ET RAIDIES AU CINQUIÈME
 SUPÉRIEUR, Pub. IABSE, Vol. 14, 1954, p. 1
 (THE WEB BUCKLING OF FLEXURALLY LOADED PLATE GIRDERS, STIFFENED
 HORIZONTALLY AT THE UPPER FIFTH POINT OF THE DEPTH)

The study contained in the 1948 paper (Ref. 30 is supplemented with the presentation of values and graphs for the use of the designer. It is concluded that the required stiffener rigidities of DIN 4114^(f) are too conservative.

- 40 Massonnet, C.
 ESSAIS DE VOILEMENT SUR POUTRES À ÂME RAIDIE, Pub, IABSE, Vol. 14,
 1954, p. 125
 (BUCKLING EXPERIMENTS ON GIRDERS WITH STIFFENED WEB)

The results of six ultimate load tests on two welded plate girders are summarized and discussed. Girder depth was 1 meter and spans varied from 5.5 to 10 meters. $0.35 \leq \alpha \leq 1.25$ and $255 \leq \beta \leq 425$. Horizontal stiffeners of various sized were tested at $\eta_1 = 1/5, 1/4, 1/3$ and $1/2$. It is concluded that the theoretical minimum stiffener rigidity is inadequate.

1955

- 41 Young, J. M. and Landau, R. E.
A RATIONAL APPROACH TO THE DESIGN OF DEEP PLATE GIRDERS, Proc.
Inst. Civ. Engs., Vol. 4, Part I, 1955, p. 299

The available theoretical and experimental work on plate girder web design is reviewed and design procedures for stiffened web plates are proposed. It is suggested that larger transverse stiffeners are required when used with longitudinal stiffeners on webs subjected to pure shear.

1956

- 42 Deutschen Stahlbauverband
STAHLBAU, EIN HANDBUCH FÜR STUDIUM UND PRAXIS, Stahlbau-Verlags-
G.m.b.H., Köhn, Vol. 1, 1956, p. 284
(STEEL STRUCTURES, A HANDBOOK FOR STUDY AND PRACTICE)

The design of stiffened plates according to DIN 4114^(f) is briefly outlined. The concept of different kinds of minimum stiffness (developed in Ref. 23 and 26) is explained.

- 43 Kerensky, O. A, Flint, A. R. and Brown, W. C.
THE BASIS FOR DESIGN OF BEAMS AND PLATE GIRDERS IN THE REVISED
BRITISH STANDARD 153, Proc. Inst. Civ. Engs., Vol. 5, Part III,
1956, p. 396

New design procedures for plate girders are proposed and compared with various specifications. The use of longitudinal stiffeners is recommended and rules for locating and proportioning them are suggested. Results of the tests reported in Ref. 46 are discussed in light of the proposed design rules and design examples are given. The British Specification provisions for longitudinal stiffeners are based on this paper.

- 44 Klöppel, K. and Scheer, J.
DAS PRAKTISCHE AUFSTELLEN VON BEULDETERMINANTEN FÜR RECHTECKPLATTEN
MIT RANDPARALLELEN STEIFEN BEI NAVIERSCHEN RANDBEDINGUNGEN,
Stahlbau, Vol. 25, 1956, p. 117
(THE DERIVATION OF BUCKLING DETERMINANTS OF RECTANGULAR PLATES WITH
STIFFENERS, THE PLATE BEING SIMPLY SUPPORTED AND THE STIFFENERS
PARALLEL TO THE EDGES)

Buckling determinants are derived using the energy method for simply supported rectangular plates subjected to linearly varying normal stresses and shear stresses. Longitudinal and transverse stiffeners at intervals of $1/6$, $1/5$, $1/4$, $1/3$ and $1/2$ of the panel depth and panel width, respectively, are considered.

- 45 Klöppel, K. and Scheer, J.
 BEULWERTE DER DURCH ZWEI GLEICHE LÄNGSSTEIFEN IN DEN DRITTELPUNKTEN
 DER FLEDBREITE AUSGESTEIFTEN RECHTECKPLATTE BEI NAVIERSCHEN
 RANDBEDINGUNGEN, Stahlbau, Vol. 25, 1956, p. 265 and Vol. 26, 1957,
 p. 246
 (BUCKLING VALUES OF SIMPLY SUPPORTED RECTANGULAR PLATE WITH TWO
 LONGITUDINAL STIFFENERS SUBDIVIDING THE PANEL INTO THREE EQUAL
 PARTS)

The stability of simply supported rectangular plates with two equal longitudinal stiffeners at $\eta_1 = 1/3$ and $\eta_2 = 2/3$ is investigated using the energy method. The loading cases of linearly varying normal stresses, shear stresses and combined normal and shear stresses are analyzed.

- 46 Longbottom, E. Heyman, J.
 EXPERIMENTAL VERIFICATION OF THE STRENGTHS OF PLATE GIRDERS
 DESIGNED IN ACCORDANCE WITH THE REVISED BRITISH STANDARD 153:
 TESTS ON FULL SIZE AND ON MODEL PLATE GIRDERS, Proc. Inst.
 Civ. Engs., Vol. 5, Part III, 1956, p. 462

One model girder test and one full-size girder test are reported for each of the following cases: (1) $\beta = 300$, $\eta_1 = 1/5$; (2) $\beta = 400$, $\eta_1 = 1/5$, $\eta_2 = 1/2$. The test results were used as a basis for B.S. 153. (See Ref. 43).

1957

- 47 Erickson, E. L. and Van Eenam, N.
 APPLICATION AND DEVELOPMENT OF AASHO SPECIFICATIONS TO BRIDGE
 DESIGN, Proc. ASCE, Vol. 83 (ST4), 1957, p. 1320

The AASHO longitudinal stiffener provisions are discussed briefly. The assumptions made in deriving the AASHO formula for minimum moment of inertia of a longitudinal stiffener from an equation in Ref. vii are explained.

- 48 Klöppel, K. and Scheer, J.
 BEULWERTE DER DURCH EINE LÄNGSSTEIFE IM DRITTELPUNKT DER
 FELDBREITE ASUGESTEIFTEN RECHTECKPLATTE BEI NAVIERSCHEN
 RANDBEDINGUNGEN, Stahlbau, Vol. 26, 1957, p. 364
 (BUCKLING VALUES OF A SIMPLY SUPPORTED RECTANGULAR PLATE WITH
 ONE LONGITUDINAL STIFFENER LOCATED AT THE THIRD-POINT OF THE
 PANEL DEPTH)

The solution is presented for the buckling of a simply supported rectangular plate subjected to linearly varying normal stresses and shear stresses and reinforced with a longitudinal stiffener at $\eta_1 = 1/3$.

- 49 Massonnet, C. and Greisch, R.
 BEULSICHERHEITSBERECHNUNG ENTSPRECHEND DER DIN 4114 MIT HILFE
 EINES NOMOGRAMMS, Stahlbau, Vol. 26, 1957, p. 228
 (CALCULATION OF THE BUCKLING SAFETY FACTOR ACCORDING TO DIN 4114
 WITH THE HELP OF A NOMOGRAM)

Nomographs are presented for determining the buckling safety factor for simply supported rectangular plates according to the German buckling specifications.^(f) The cases of a longitudinal stiffener at $\eta_1 = 1/2$ or $1/4$ in a panel subjected to pure bending, pure shear or combined bending and shear are included.

- 50 Rockey, K. C.
 SHEAR BUCKLING OF A WEB REINFORCED BY VERTICAL STIFFENERS AND A
 CENTRAL HORIZONTAL STIFFENER, Pub. IABSE, Vol. 17, 1957, p. 161

The results of over 140 buckling tests on webs of bolted aluminum girders with one-sided transverse stiffeners and a one-sided longitudinal stiffener are reported. Design rules are suggested for the spacing and proportioning of vertical stiffeners and for the proportioning of longitudinal stiffeners.

- 51 Stüssi, F., Dubas, C. and Dubas, P.
 LE VOILEMENT DE L'ÂME DES POUTRES FLÉCHIES, AVEC RAIDISSEUR AU
 CINQUIÈME SUPÉRIEUR, Pub. IABSE, Vol. 17, 1957, p. 217
 (THE BUCKLING DUE TO BENDING OF WEBS OF BEAMS HAVING STIFFENERS
 IN THE TOP FIFTH OF THE WEB)

Additional results on the buckling of a simply supported rectangular plate reinforced with one longitudinal stiffener at $\eta_1 = 1/5$ and subjected to pure bending are presented. It is shown that the method of "applied statics" used in the previous two papers (Ref. 30 and 39) leads to very accurate results without excessive work.

1958

- 52 Klöppel, K. and Scheer, J.
 BEULWERTE DER DURCH EINE LÄNGSSTEIFE IM VIERTELSPUNKT DER
 FELDBREITE AUSGESTEIFTEN RECHTECKPLATTE BEI NAVIERSCHEN
 RANDBEDINGUNGEN, Stahlbau, Vol. 27, 1958, p. 206
 (BUCKLING VALUES OF A SIMPLY SUPPORTED RECTANGULAR PLATE WITH
 ONE LONGITUDINAL STIFFENER LOCATED AT THE QUARTER-POINT OF THE
 PANEL DEPTH)

A simply supported rectangular plate reinforced with a longitudinal stiffener at $\eta_1 = 1/4$ and subjected to linearly varying normal stresses or shear stresses is analyzed. Buckling coefficients are given for various combinations of γ and δ .

- 53 Rockey, K. C.
WEB BUCKLING AND THE DESIGN OF WEBPLATES, Struct. Eng., Vol. 36,
1958, p. 45

Theoretical and experimental work is summarized and design procedures recommended for light alloy girders and for steel girders. Results of many bending tests on longitudinally stiffened, riveted aluminum girders are summarized. It is suggested that the working load be 1.5 times the buckling load for the sake of appearance of the web.

- 54 Stüssi, F., Dubas, C. and Dubas, P.
LE VOILEMENT DE L'ÂME DES POUTRES FLÉCHIES, AVEC RAIDISSEUR AU CINQUIÈME SUPÉRIEUR. ETUDE COMPLÉMENTAIRE, Pub. IABSE, Vol. 18,
1958, p. 215
(THE BUCKLING DUE TO BENDING OF WEBS OF BEAMS HAVING STIFFENERS IN THE TOP FIFTH OF THE WEB. FURTHER STUDY)

The work of the three earlier papers (Ref. 30, 39 and 51) is summarized with tables and graphs. A numerical example is discussed in detail.

1959

- 55 Barth, W., Börsch-Supan, W. and Scheer, J.
BEULSICHERHEIT AUSGESTEIFTER RECHTECKPLATTEN BEI ZUSAMMENGESETZTER BEANSPRUCHUNG, Stahlbau, Vol. 28, 1959, p. 68
(SAFETY AGAINST BUCKLING OF STIFFENED RECTANGULAR PLATES SUBJECTED TO COMBINED LOADING CASES)

The results of an investigation of simply supported rectangular plates subjected to combined normal and shearing stresses and reinforced by longitudinal stiffeners at $\eta_1 = 1/3$, $\eta_1 = 1/4$ or $\eta_1 = 1/3$ and $\eta_2 = 2/3$ is presented. Tables are given to determine the buckling factor of safety for these cases.

- 56 Börsch-Supan, W.
BERECHNUNG VON BEULWERTEN VERSTEIFTER PLATTEN AUF RECHENAUTOMATEN: MATHEMATISCHE GRUNDLAGEN UND PRAKTISCHES VORGEHEN, Stahlbau, Vol. 28, 1959, p. 37
(THE COMPUTATION OF BUCKLING VALUES FOR STIFFENED PLATES ON COMPUTERS: MATHEMATICAL BASIS AND PRACTICAL PROCEDURE)

A procedure for solving problems of stability of stiffened rectangular plates on a digital computer is outlined. Resulting k -values for various combinations of stiffeners and loadings are tabulated.

- 57 Kusuda, T.
BUCKLING OF STIFFENED PANELS IN ELASTIC AND STRAIN-HARDENING RANGE, Report No. 39, Transportation Technical Research Institute, Tokyo, 1959

The buckling of longitudinally or transversely stiffened rectangular plates subjected to uniform compression is analyzed in the elastic and strain-hardening range by application of the integral equation. The minimum required bending rigidity of a stiffener is obtained and the effect of torsional resistance of a stiffener is investigated.

1960

- 58 Basler, K., Yen, B. T., Mueller, J. A and Thurlimann, B.
WEB BUCKLING TESTS ON WELDED PLATE GIRDERS, Bulletin No. 64, Welding Research Council, Sept., 1960

Although the tests did not include longitudinally stiffened girders, they provided experimental verification of the ultimate strength theories developed in Ref. 60, 61 and 62 for transversely stiffened plate girders.

- 59 Massonnet, C., Mazy, G. and Tanghe, A.
THÉORIE GÉNÉRALE DU VOILEMENT DES PLAQUES RECTANGULAIRES ORTHOTROPES, ENCHAÎTRÉES OU APPUYÉES SUR LEUR CONTOUR, MUNIES DE RAIDISSEURS PARALLÈLES AUX BORDS À GRANDES RIGIDITÉS FLEXIONNELLE ET TORSIONNELLE, Pub. IABSE, Vol. 20, 1960, p. 223
(GENERAL THEORY OF THE BUCKLING OF ORTHOTROPIC, RECTANGULAR PLATES, CLAMPED OR FREELY SUPPORTED AT THE EDGES, PROVIDED WITH STIFFENERS, PARALLEL TO THE EDGE, HAVING CONSIDERABLE FLEXURAL AND TORSIONAL RIGIDITIES)

The effects of full fixity of the longitudinal edges and of torsional rigidity of the longitudinal stiffener on the stability of rectangular plates subjected to pure bending are determined. The longitudinal stiffener is located at the optimum position and has the minimum required rigidity.

- 60 Massonnet, C.
STABILITY CONSIDERATIONS IN THE DESIGN OF STEEL PLATE GIRDERS, Proc. ASCE, Vol. 86 (ST1), 1960, p. 71

A design procedure for longitudinally stiffened plates subjected to combined bending and shear is proposed. The results of a series of tests on girders with one and two-sided longitudinal stiffeners are discussed. A buckling safety factor of more than one is recommended.

1961

- 61 Basler, K. and Thurlimann, B.
STRENGTH OF PLATE GIRDERS IN BENDING, Proc. ASCE, Vol. 87
(ST6), Aug. 1961, p. 153
- 62 Basler, K.
STRENGTH OF PLATE GIRDERS IN SHEAR, Proc. ASCE, Vol. 87
(ST7), Oct., 1961, p. 151
- 63 Basler, K.
STRENGTH OF PLATE GIRDERS IN COMBINED BENDING AND SHEAR,
Proc. ASCE, Vol. 87 (ST7), Oct., 1961, p. 181

Methods of evaluating the ultimate strength of transversely stiffened plate girders are presented in Ref. 61, 62, and 63. Experimental verification of these methods is reported in Ref. 58. An extension of the research which is summarized in these reports to include longitudinal stiffened girders is proposed in Ref. 67.

- 64 Rockey, K. C.
BUCKLING UNDER PURE BENDING OF STIFFENED WEBPLATES--SINGLE
LONGITUDINAL STIFFENER HAVING BOTH TORSIONAL AND FLEXURAL
STRENGTH, Brown University, Oct., 1961

The increase in the buckling coefficient due to the use of torsionally strong longitudinal stiffener on a plate clamped along transverse edges and subjected to pure bending is examined analytically using the energy method. The optimum position for the stiffener is $\eta_1 = 0.21$ and for this position a 30% increase in the k-value results from the torsional strength of the stiffener.

1962

- 65 Rockey, R. C. and Leggett, D. M. A.
THE BUCKLING OF A PLATE GIRDER WEB UNDER PURE BENDING WHEN
REINFORCED BY A SINGLE LONGITUDINAL STIFFENER, Proc. Inst.
Civ. Engs., Vol. 21, 1962, p. 161

Energy methods are used to examine the stability of a longitudinally reinforced web plate under pure bending. Transverse edges are assumed to be simply supported while longitudinal edges are assumed to be flexurally and torsionally clamped. The optimum position for the stiffeners is found to be $\eta_1 = 0.22$ and the required flexural rigidity of the stiffener to force a nodal line at the buckling load is much lower than that when no torsional rigidity of the girder flanges is assumed.

- 66 Rockey, K. C. and Cook, I. T.
SHEAR BUCKLING OF CLAMPED AND SIMPLY-SUPPORTED INFINITELY LONG
PLATES REINFORCED BY TRANSVERSE STIFFENERS AND A CENTRAL
LONGITUDINAL STIFFENER, Aeronautical Quarterly, Vol. 13,
1962, p. 95

The results of an investigation of the stability of an infinitely long plate subjected to shear and reinforced with equally spaced transverse stiffeners and a longitudinal stiffener at $\eta_1 = 0.5$ are presented. The cases $\alpha = 1, 2, \text{ or } 5$ are considered. It is concluded that for a specified value of transverse stiffener rigidity, the required rigidity of the longitudinal stiffener to attain a certain buckling stress is little affected by fixing the longitudinal plate edges.

- 67 Cooper, P. B.
PRELIMINARY REPORT AND PROPOSAL ON LONGITUDINALLY STIFFENED PLATE
GIRDERS, Fritz Engineering Laboratory Report No. 304.1, Lehigh
University, July 1963

Specification provisions for longitudinally stiffened plate girders which are based on theoretical buckling strength are reviewed and discussed. It is suggested that an investigation should be conducted to evaluate the ultimate strength of such girders. A proposed research program with this objective is outlined.

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