Steel Frame Design Examples

Steel Frame Design Examples

Ian Robb

A.M.I.Struct.E.

Senior Lecturer in Structural Engineering
Royal College of Technology, Salford

SECOND EDITION

Macmillan Education

© Ian Robb 1961

Softcover reprint of the hardcover 3rd edition 1961 978-0-333-13404-7

First published 1961

Second edition 1965

MACMILLAN AND COMPANY LIMITED

Incorporating Cleaver-Hume Press Limited

Little Essex Street London WC2

also Bombay Calcutta Madras Melbourne

THE MACMILLAN COMPANY OF CANADA LIMITED

70 Bond Street Toronto 2

ST. MARTIN'S PRESS INC

175 Fifth Avenue New York 10010 NY

Foolscap 4to, 216 pages

89 line illustrations

1 folding plate

ISBN 978-1-349-01439-2   ISBN 978-1-349-01437-8 (eBook)

DOI 10.1007/978-1-349-01437-8

Preface

This book is intended for the intermediate student in structural design. The author has assumed that the reader will already have carried out some preliminary work in strength of materials as well as steel design to enable him to appreciate the behaviour of steel when used as a material of construction. In consequence, the sections of the text dealing with elementary design are treated from the point of view of revision, and not from first principles.

The examples which follow are intended to give the student a broad outline of the application of structural design to a variety of structures and to include drawings which are detailed to a high degree.

The drawings given in the text should be regarded as typical details rather than as complete drawings since the scope is confined to the limitations of page size. Students who have little or no industrial experience will find it beneficial to make their own detail drawings from the sketches given in the text. This procedure will enable them to make the transition from the study of theory to the practice of design, a development which many of them find so difficult. Suitable scales for these drawings are $\frac{1}{8}$ in. to 1 ft for layouts and arrangements, and $\frac{1}{2}$ in. or $\frac{3}{4}$ in. to 1 ft for the details.

It is hoped that the present volume will prove useful to those engaged in the following courses of study:

- (a) Diploma in Technology in Civil Engineering,
- (b) Higher National and Post Higher National Certificates,
- (c) intermediate stage of degree courses (e.g. Part II of London University B.Sc. degree),
- (d) the intermediate and final examinations of the professional institutions,
- (e) final examinations in Structural Engineering of the City and Guilds of London Institute.

The examples in the text have been prepared in accordance with the provisions of B.S.449:1959. Many students find difficulty in interpreting this specification mainly because they are not sufficiently experienced in basic design to appreciate the intention behind it. So far as possible an appropriate commentary is given on the application of B.S.449:1959, the critical assessment of which is a perennial source of argument among engineers and other interested parties. Generally speaking, the limitations imposed on the designer by this specification are conservative in character, and this is a proper and reasonable point of view when the large

number of different types of structures to which it is applicable is borne in mind, as well as the varying experience and aptitude of the persons making use of it.

For the above reasons the author has thought it desirable to present some basic design before introducing the requirements of B.S.449:1959. This procedure is not intended to imply that the author's methods are to be preferred to this standard. Young engineers should be encouraged to use the appropriate B.S. specification whatever their field of operation. By so doing they are ensuring a good standard of craftsmanship combining safety with economy of material.

The author is indebted to Mr R. J. Payne B.Sc. A.M.I.C.E. A.M.I.Struct.E. for his critical reading of the manuscript.

Note to Second Edition

Since the first printing in 1961 there have been several amendments to B.S.449:1959. These were issued in July 1960, November 1961, April 1962, January 1964 and February 1965.

An important revision to column design is brought about by amendments (in Amendment No. 4, 1964) to Clause 34, revising eccentricity allowances for columns, and to Appendix B, revising the load factor for column formulae from 2 to 1.7. This latter amendment results in increased values of p_c in Table 17 of B.S. 449.

As an example, revised calculations for Fig. 4.5., Column S5 in this book are shown below:

$$l \div r = 0.85 \times 192 \div 4.46 = 37$$

$$p_{bc} = 10.5 \text{ ton/sq. in.} \quad p_c = 8.97 \text{ ton/sq. in.}$$

$$f_c \div p_c = 135.81 \div (21.18 \times 8.97) = 0.716$$

$$f_{bc} \div p_{bc} = 17.72 \times 9.25^* \div (2 \times 80.1 \times 10.5) = 0.098$$

The section is satisfactory	0.814

*9.25 is obtained from (half column width + 4 in.)

It will be seen that in normal circumstances the amendments do not result in any significant change in the section proposed in the calculations.

In addition, a new specification for high strength friction grip bolts (B.S.3294) has been issued and this should be read in conjunction with Section 52 (a) (iv) of the text.

Marple Bridge
Cheshire, 1965

I. R.

Contents

List of Abbreviations	9
1 Preliminary Considerations of Design	11
1 The Role of the Engineer as a Designer. 2 The Role of the Specification in Design. 3 Design Procedure. 4 Choice of Sections when Designing. 5 Relative Costs of Fabrication. 6 Relation of Strength to Weight in Selecting Sections. 7 Importance of Load Assessment. 8 Use of Tabulated Information.	
2 Elementary Design Definitions	17
9 Relationship between Load, Stress and Strain. 10 Relationship between Shear and Bending. 11 Relationship between Bending Moment and Moment of Resistance. 12 Relationship between Ultimate Stress (or rupture stress), Yield Stress, and Working Stress. 13 Factor of Safety. 14 Fatigue Failure of Material. 15 Brittle Fracture. 16 Deflexion of Structures. 17 Geometrical Properties of Sections.	
3 Elements of Basic Design	22
18 Beam Design. 19 Struts (including columns or stanchions). 20 Roof Trusses. 21 Design of Tension Members.	
4 Design of Multi-storey Shop Premises	28
22 Particulars of Scheme. 23 Layout of Steelwork. 24 Design of Floor Beams. 25 Effect of Wind on Building. 26 Design of Stanchions. 27 Design of Welded Plate Girder. 28 Design of Welded Connexions. 29 Design of Mass Concrete Foundation Block. 30 Design of Grillage Foundation. 31 Note on the Buckling of Joist Webs.	
5 Design of 60-ft Span Shed with Ridge-type Roof Trusses	80
32 Particulars of Scheme. 33 Layout of Steelwork. 34 Roof Purlins. 35 Design of Roof Trusses. 36 Column Design. 37 Design of Concrete Foundation Block to Resist Overturning. 38 Design of Side and Gable Sheeting Rails. 39 Design of Gable Steelwork. 40 Slenderness Ratios of Struts. 41 Note regarding Design Loads. 42 Design of Rain-water Gutters and Downpipes.	
6 Design of a Large-span Industrial Building with Special Reference to Lattice Girders	124
43 General Notes on Lattice Girders. 44 Particulars of Scheme. 45 Layout of Steelwork. 46 Alternative Layout of Roof Steelwork. 47 Design of Roof Purlins. 48 Design of Roof Trusses. 49 Effect of Wind on Building. 50 Design of Wind Bracing Systems. 51 Design of Lattice Girder. 52 Design of Connexions for Lattice Girder. 53 Camber in Lattice Girder. 54 Setting out Roof Trusses and Lattice Girders. 55 Design of	

Main Side Columns. 56 Design of Framing for Sides and Gables. 57 Design of Rain-water Gutters and Pipes. 58 Alternative Condition for Design of the Main Side Columns.

7 Design of Braced Tower Supporting Water Tank	180
59 Particulars of Scheme. 60 Layout of Steelwork. 61 Investigation of Wind Pressures. 63 Design of Tower Members. 64 Design of Foundation. 65 Check on Estimated Data. 66 Design of Connexions. 67 Provision of Access to the Tank. 68 Maintenance of the Structure.	
8 Economical Design	199
69 Costs of Fabrication. 70 Effect of Layout upon Design.	
Exercises	207
Index	213

List of Abbreviations

The following abbreviations have been used in the text and these follow the recommendations of B.S.449:1959 and C.P. 3.

- A Cross-sectional area
- B.S. British Standard as issued by the British Standards Institution
- B.S.B. British Standard Beam (sometimes referred to as a rolled steel joist, or R.S.J., in trade circles)
- b Breadth
- C.P. Code of Practice for buildings as issued by the British Standards Institution on behalf of the Council for Codes of Practice
- D or d Depth
- dia Diameter
- E Young's modulus of elasticity (taken as 13,500 ton/sq. in. for structural steel)
- e Lever arm
- f Stress, in a general sense
- f_c Calculated stress in axial compression
- f_t Calculated stress in axial tension
- f_{bc} Calculated stress in compression induced by bending
- f_{bt} Calculated stress in tension induced by bending
- ft Foot or feet
- ft lb Foot-pound
- H Horizontal reaction
- H_L Horizontal reaction at left-hand support
- H_R Horizontal reaction at right-hand support
- I Moment of inertia (or second moment of area)
- I_x, I_y Moment of inertia measured about the x or y axes
- in. Inch or inches
- L Overall length of column or effective span of beam
- l Effective length of column
- l_x, l_y Effective length of column measured about the x or y axes of the column

LIST OF ABBREVIATIONS

lb	Pound or pounds (weight)
M	Bending moment
P	Load in general sense (used when W would cause confusion)
p_c	Allowable stress in axial compression
p_t	Allowable stress in axial tension
p_{bc}	Allowable stress in compression induced by bending
p_{bt}	Allowable stress in tension induced by bending
p	Unit wind pressure
R	Reaction to a system of loads
R_L	Reaction to a system of loads at a left-hand support
R_R	Reaction to a system of loads at a right-hand support
r	Radius of gyration
r_x, r_y, r_v, r_u	Radius of gyration measured about the x , y , v and u axes respectively
sq. ft	Square foot
sq. in.	Square inch
T	Average thickness of compression flange of a section resisting bending
t	Thickness in a general sense
ton/sq. in.	Tons per square inch
W	Load or force (see also P)
x	Major axis of a section
y	Minor axis of a section, or the distance measured from the y axis to the plane of the section under consideration
z	Section modulus