STEEL STRUCTURES DESIGN HANDBOOK

National Library of Australia
Cataloguing in Publication Data
Steel Structures Design Handbook
Standards Australia
1 The Crescent, Homebush NSW
ISBN 0 7337 2754 9
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First published 1993
Second edition 1999

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Publishers
Standards Australia
1 The Crescent, Homebush
NSW Australia 2140

The first edition of this Handbook was prepared by a consortium of design, construction and research engineers.

This Edition has been reviewed by the Institution of Engineers Australia's National Committee on Structural Engineering.

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(continued overleaf)

PREFACE

This second edition of the Handbook is an update of the 1993 edition to incorporate:

- The amendments to the Steel Structures Standard embodied in AS 4100—1998
- The replacement of BHP Grade 250 steel sections with 300PLUS sections
- Changes to the available range of sizes of BHP steel sections.

As a consequence of 300PLUS becoming the standard grade for hot-rolled steel sections, most rules, tables, design aids and examples relating to sections of grade 250 have been replaced with ones corresponding to grade 300. Designers requiring information relating to grade 250 should consult the 1993 edition.

The preface to the 1993 edition outlines the essential features of the Handbook and is reproduced below. It is unchanged apart from an updating of the recommended publications in the final paragraph.

Preface to the 1993 edition

The first Australian Limit States Design Standard for Steel Structures, AS 4100—1990, incorporates material which permits a more advanced approach to some design problems than is found in most other Standards. It is written in such a way that, in some instances, designers may choose to use simpler options with some penalty in the design capacity of the members in the sense that their design would be more conservative. Incorporating various tiers of design in one Standard may make the total document less convenient than it could be for those designers who wish to do most of their work in the lower tier mode.

To overcome this drawback, this Handbook offers a lower tier design method on its own, providing rules and procedures which will result in designs fulfilling the requirements of AS 4100. The reader will find the appropriate cross-referencing to AS 4100 which may be needed in some circumstances.

The use of AS 4100 may enable the designer to justify a greater capacity in a given member than can be demonstrated by the use of this Handbook. There is therefore a price to be paid for the simplicity of the rules contained herein. In most instances, however, the effect on the combined cost of design and materials will be marginal.

The Handbook contains three parts and each member of the consortium of engineers who wrote it participated as author of the design rules, or author of the worked examples, or as editorial adviser representative of future users. Therefore, the consortium includes research engineers from CSIRO and the universities, and designers from large and small practices, and from the construction and fabrication industries. It is believed that the outcome is a book which is technically sound, and well-suited to use by a designer who wishes to make decisions with minimal design aids and only a hand-held calculator. The users of this Handbook are assumed to be qualified to undertake structural design.

Part I of the book provides advice and rules in a structure similar to that of the first eleven sections of AS 4100. The chapter and paragraph numbers, titles, and notation, are kept as close to those of AS 4100 as possible so that designers can move readily from one document to the other in order to use the tier of their choice.

Chapter 1 sets out the scope and the limitations for the use of this Handbook and Chapter 2 lists the relevant standards with which the materials should comply.

Chapter 3 describes the difference between Working Stress and Limit States Design and describes the classes of Limit States which should be anticipated. It also sets serviceability limits. Chapter 4 defines the methods of analysis for the purposes of obtaining design effects and displacements, the forms of construction, the assumptions for analysis and the limitations to the use of plastic analysis in this Handbook.

Chapters 5 to 8 provide rules and procedures for calculating the strength of members subjected to flexural, compressive, tensile and combined actions. Chapter 9 recognizes the fact that a large part of Australian structural practice uses a very limited and discrete range of fasteners. It therefore also contains simple tables of bolt and weld capacities, and of the relevant geometric data on hole sizes and edge distances.

Chapter 10 identifies circumstances under which brittle fracture is not likely to be a problem. Chapter 11 presents a simplified approach to design against fatigue. Advice is given only on situations where the stress range is constant and material is thin. The form of expression of the S-N curves is simplified by changing the definition of the detail category to reduce the number of 'variables' in the equations. The structure of Chapter 11 is such that the designer will often be able quickly to exempt the detail from fatigue analysis with little or no computation. A more fundamental change in philosophy is that the Handbook enables the designer to calculate the **life** of the detail when it is fatigue-prone.

Part II is a set of design aids in the form of tables and charts derived from the dimensions of standard sections and from the rules in the Chapters of this Handbook. They speed up the design process and reduce the opportunity for computational error.

Part III consists of worked examples of the application of the rules in Part I. The examples are chosen to demonstrate realistic situations and have been worked out by designers in active commercial practice.

Users of the Handbook are expected to have a copy of the tables of section properties (published by BHP under the title *Hot Rolled and Structural Steel Products 1998*), and would find their work expedited even further by having access to *Design Capacity Tables for Structural Steel, 2nd ed, Vol 1: Open Sections* published in 1994 by the Australian Institute of Steel Construction (AISC) and *DuraGal Design Capacity Tables for Steel Hollow Sections* produced in 1996 by Tubemakers Structural and Pipeline Products (now BHP Structural and Pipeline Products). For reference to higher tier methods, designers should use this Handbook together with AS 4100.

NOTATION

A_c	=	minor diameter area of a bolt, as defined in AS 1275
A_g	=	gross area of a cross-section
A_n	=	net area of a cross-section; or
	=	sum of the net areas of the flanges and the gross area of the web
A_o	=	plain shank area of a bolt
A_s	=	tensile stress area of a bolt as defined in AS 1275; or
	=	area of a stiffener or stiffeners in contact with a flange; or
	=	area of an intermediate web stiffener
A_w	=	gross sectional area of a web
a_e	=	minimum distance from the edge of a hole to the edge of a ply measured in the direction of the component of a force plus half the bolt diameter
b	=	width; or
	=	clear width of an element outstand from the face of a supporting plate element; or
	=	clear width of a supported element between faces of supporting plate elements
b_b, b_{bf}	=	bearing widths defined in Para. 2.2.3
b_{es}	=	stiffener outstand from the face of a web
b_f	=	width of an RHS Section
b_s	=	stiff bearing length
b_w	=	depth of an RHS Section
c_m	=	factor for unequal moments
d	=	depth of a section; or
	=	depth of preparation for incomplete penetration butt weld; or
	=	maximum cross-sectional dimension of a member
d_f	=	diameter of a fastener (bolt or pin)
d_h	=	hole diameter
d_o	=	overall section depth including out-of-square dimensions; or
	=	overall section depth of a segment; or
	=	outside diameter of a circular hollow section
d_p	=	clear transverse dimension of a web panel
d_v	=	coped web depth
d_1	=	depth of a web
d_3, d_4	=	depths of preparation for incomplete penetration butt welds
E	=	young's modulus of elasticity, 200×10^3 MPa
F^*	=	total design load on a member between supports
f_u	=	tensile strength used in design
f_{uf}	=	minimum tensile strength of a bolt
f_{up}	=	tensile strength of a ply
f_{uw}	=	nominal tensile strength of weld metal
f_y	=	yield stress used in design
f_{ys}	=	yield stress of a stiffener used in design
f_3	=	detail category fatigue strength at constant amplitude fatigue limit
f^*	=	design stress range
G	=	shear modulus of elasticity, 80×10^3 MPa; or
	=	nominal dead load
G^R	=	part of the dead load tending to resist instability

H^*	=	design horizontal force
h	=	height to the eave of a portal frame
h_s	=	storey height
I	=	second moment of area of a cross-section
I_c	=	I of a column
I_r	=	I of a rafter
I_s	=	I of a pair of stiffeners or a single stiffener about centreline of web
I_w	=	warping constant for a cross-section
I_y	=	I about the cross-section minor principal y-axis
J	=	torsion constant for a cross-section
k	=	modifying factor
k_e	=	member effective length factor
k_f	=	form factor for members subject to axial compression
k_h	=	factor for different hole types
	=	load height effective length factor
	=	factor for pin rotation
	=	effective length factor for restraint against lateral rotation; or
	=	effective length factor for a restraining member; or
k_l	=	load height factor
k_r	=	lateral rotation restraint factor
	=	reduction factor to account for the length of a bolted or welded lap splice connection
k_{ss}	=	factor for type of shear stress distribution
k_t	=	twist restraint effective length factor; or
	=	correction factor for distribution of forces in a tension member
l	=	span; or
	=	member length; or
	=	segment or sub-segment length
l_b	=	length between points of effective bracing or restraint
l_c	=	distance between adjacent column centres
l_e	=	effective length of a compression member = $k_e l$; or
	=	effective length of a laterally unrestrained member
l_e/r	=	geometrical slenderness ratio
l_h	=	slotted hole length
l_j	=	length of a bolted lap splice connection
l_w	=	greatest internal dimension of an opening in a web; or
	=	length of a fillet weld in a welded lap splice connection
M_b	=	nominal member moment capacity
M_{bx}, M_{by}	=	M_b about major principal x-axis, and minor principal y-axis, respectively
M_o	=	nominal out-of-plane member moment capacity; or
	=	reference elastic buckling moment for a member subject to bending
M_{ox}	=	enhanced nominal out-of-plane member moment capacity about major principal x-axis
M_{rbx}, M_{rby}	=	reduced nominal capacity in bending of member about major x-axis and minor y-axis, respectively
M_{rsx}	=	M_s about major principal x-axis reduced by axial force
M_{rsy}	=	M_s about minor principal y-axis reduced by axial force
M_s	=	nominal section moment capacity