

**STEEL STRUCTURES DESIGN HANDBOOK**

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# **STEEL STRUCTURES DESIGN HANDBOOK**

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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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## **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, 2<sup>nd</sup> 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, $200 \times 10^3$ 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, $80 \times 10^3$ 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