

Australian Standard[®]

Bridge design

**Part 6: Steel and composite
construction**



This Australian Standard® was prepared by Committee BD-090, Bridge Design. It was approved on behalf of the Council of Standards Australia on 2 December 2003. This Standard was published on 23 April 2004.

The following are represented on Committee BD-090:

- Association of Consulting Engineers Australia
 - Australasian Railway Association
 - Austroads
 - Bureau of Steel Manufacturers of Australia
 - Cement and Concrete Association of Australia
 - Institution of Engineers Australia
 - Queensland University of Technology
 - Steel Reinforcement Institute of Australia
 - University of Western Sydney
-

This Standard was issued in draft form for comment as DR 00379.

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through the public comment period.

Keeping Standards up-to-date

Australian Standards® are living documents that reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued.

Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments that may have been published since the Standard was published.

Detailed information about Australian Standards, drafts, amendments and new projects can be found by visiting www.standards.org.au

Standards Australia welcomes suggestions for improvements, and encourages readers to notify us immediately of any apparent inaccuracies or ambiguities. Contact us via email at mail@standards.org.au, or write to Standards Australia, GPO Box 476, Sydney, NSW 2001.

AS 5100.6—2004
AP-G15.6/04
(Incorporating Amendment Nos 1 and 2)

Australian Standard[®]

Bridge design

Part 6: Steel and composite construction

Originated as HB 77.6—1996.
Revised and redesignated as AS 5100.6—2004.
Reissued incorporating Amendment No. 1 (May 2010).
Reissued incorporating Amendment No. 2 (December 2010).

COPYRIGHT

© Standards Australia Limited

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968.

Published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001, Australia

ISBN 0 7337 5650 6

PREFACE

This Standard was prepared by the Standards Australia Committee BD-090, Bridge Design, to supersede HB 77.6—1996, *Australian Bridge Design Code*, Section 6: *Steel and composite construction*.

This Standard incorporates Amendment No. 1 (May 2010) and Amendment No. 2 (December 2010). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The AS 5100 series represents a revision of the 1996 HB 77 series, *Australian Bridge Design Code*, which contained a separate Railway Supplement to Sections 1 to 5, together with Section 6, *Steel and composite construction*, and Section 7, *Rating*. AS 5100 takes the requirements of the Railway Supplement and incorporates them into Parts 1 to 5 of the present series, to form integrated documents covering requirements for both road and rail bridges. In addition, technical material has been updated.

This Standard is also designated as AUSTROADS publication AP-G15.6/04.

The objectives of AS 5100 are to provide nationally acceptable requirements for—

- (a) the design of road, rail, pedestrian and bicycle-path bridges;
- (b) the specific application of concrete, steel and composite construction, which embody principles that may be applied to other materials in association with relevant Standards; and
- (c) the assessment of the load capacity of existing bridges.

These requirements are based on the principles of structural mechanics and knowledge of material properties, for both the conceptual and detailed design, to achieve acceptable probabilities that the bridge or associated structure being designed will not become unfit for use during its design life.

Whereas earlier editions of the *Australian Bridge Design Code* were essentially administered by the infrastructure owners and applied to their own inventory, an increasing number of bridges are being built under the design-construct-operate principle and being handed over to the relevant statutory authority after several years of operation. This Standard includes clauses intended to facilitate the specification to the designer of the functional requirements of the owner to ensure the long-term performance and serviceability of the bridge and associated structure.

Significant differences between this Standard and HB 77.6 are the following:

- (i) *Classification of sections* For the purpose of determining bending moment resistance, the classifications of sections have been changed to be either compact or not compact. Not-compact sections now include the previous classification of slender section, as well as non-compact.
- (ii) *Analysis for bending moment resistance* For compact sections, the bending moment resistance is determined using plastic analysis; for not-compact sections, the bending moment resistance is determined using elastic analysis.
- (iii) *Deflection limits for beams* Deflection limits for beams in road bridges is now covered by AS 5100.2. Where deflections exceed the guideline limits given in AS 5100.2, the onus is on the designer to demonstrate that the serviceability of the bridge or related structure is not adversely affected.

- (iv) *Steel reinforcement in composite deck slabs* The requirements for minimum longitudinal concrete deck reinforcement to control heat of hydration and differential shrinkage effects in steel/concrete composite bridge decks have been expanded. The requirements in this Standard allow for a rigorous analysis procedure based on limiting crack widths, in addition to the existing deemed to comply rules.

In line with Standards Australia policy, the words ‘shall’ and ‘may’ are used consistently throughout this Standard to indicate respectively, a mandatory provision and an acceptable or permissible alternative.

Statements expressed in mandatory terms in Notes to tables are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE AND APPLICATION.....	8
1.2 REFERENCED DOCUMENTS	8
1.3 NOTATION	10
SECTION 2 MATERIALS	
2.1 YIELD STRESS AND TENSILE STRESS USED IN DESIGN.....	30
2.2 STRUCTURAL STEEL	30
2.3 CONCRETE, REINFORCING AND PRESTRESSING STEELS.....	31
2.4 FASTENERS.....	31
2.5 WELDS	31
2.6 WELDED STUD SHEAR CONNECTORS.....	31
2.7 STEEL CASTINGS.....	31
2.8 WROUGHT IRON	31
2.9 RIVETS.....	31
2.10 CAST IRON	32
SECTION 3 GENERAL DESIGN REQUIREMENTS	
3.1 GENERAL	36
3.2 DESIGN FOR STRENGTH.....	36
3.3 DESIGN FOR SERVICEABILITY	38
3.4 DESIGN FOR STRENGTH AND SERVICEABILITY BY LOAD TESTING	39
3.5 BRITTLE FRACTURE	39
3.6 FATIGUE.....	39
3.7 CORROSION RESISTANCE AND PROTECTION	39
3.8 DESIGN FOR FIRE RESISTANCE.....	39
3.9 PARTICULAR DESIGN REQUIREMENTS.....	40
SECTION 4 METHODS OF STRUCTURAL ANALYSIS	
4.1 METHODS OF DETERMINING ACTION EFFECTS	42
4.2 ELASTIC ANALYSIS	42
4.3 MEMBER BUCKLING ANALYSIS.....	47
4.4 ANALYSIS OF COMPOSITE BEAMS, GIRDERS AND COLUMNS	50
4.5 ANALYSIS OF BOX GIRDERS.....	51
4.6 STAGED CONSTRUCTION	52
4.7 CONNECTIONS	53
4.8 LONGITUDINAL SHEAR.....	55
4.9 SHRINKAGE AND DIFFERENTIAL TEMPERATURE EFFECTS	55
4.10 RIGOROUS STRUCTURAL ANALYSIS	56

Page

SECTION 5 STEEL BEAMS

5.1	DESIGN FOR BENDING MOMENT	57
5.2	SECTION MOMENT CAPACITY FOR BENDING ABOUT A PRINCIPAL AXIS	63
5.3	MEMBER CAPACITY OF SEGMENTS WITH FULL LATERAL RESTRAINT ...	63
5.4	RESTRAINTS	65
5.5	CRITICAL FLANGE	68
5.6	MEMBER CAPACITY OF SEGMENTS WITHOUT FULL LATERAL RESTRAINT	68
5.7	BENDING IN A NON-PRINCIPAL PLANE	76
5.8	DESIGN OF WEBS.....	76
5.9	ARRANGEMENT OF WEBS	77
5.10	SHEAR CAPACITY OF WEBS.....	78
5.11	INTERACTION OF SHEAR AND BENDING	81
5.12	COMPRESSIVE BEARING ACTION ON THE EDGE OF A WEB	82
5.13	DESIGN OF LOAD-BEARING STIFFENERS.....	86
5.14	DESIGN OF INTERMEDIATE TRANSVERSE WEB STIFFENERS.....	88
5.15	DESIGN OF LONGITUDINAL WEB STIFFENERS	90

SECTION 6 COMPOSITE BEAMS

6.1	GENERAL	91
6.2	DESIGN FOR BENDING MOMENT	93
6.3	SECTION MOMENT CAPACITY	94
6.4	BEAM MOMENT CAPACITY	95
6.5	VERTICAL SHEAR CAPACITY	96
6.6	LONGITUDINAL SHEAR.....	96

SECTION 7 COMPOSITE BOX GIRDERS

7.1	DESIGN OF COMPOSITE BOX GIRDERS.....	107
7.2	COMPOSITE BOX GIRDERS WITHOUT LONGITUDINAL STIFFENERS	107
7.3	FLANGES IN BEAMS WITH LONGITUDINAL STIFFENERS.....	107
7.4	WEBS IN BEAMS WITH LONGITUDINAL STIFFENERS.....	113
7.5	TRANSVERSE MEMBERS IN STIFFENED FLANGES.....	123
7.6	DIAPHRAGMS AT SUPPORTS.....	127
7.7	LONGITUDINAL SHEAR.....	147
7.8	GEOMETRIC REQUIREMENTS FOR LONGITUDINAL STIFFENERS	148

SECTION 8 TRANSVERSE MEMBERS AND RESTRAINTS

8.1	GENERAL	152
8.2	DEFINITIONS	152
8.3	PARTICULAR REQUIREMENTS	152
8.4	DESIGN OF RESTRAINTS TO FLEXURAL MEMBERS.....	153
8.5	SEPARATORS AND DIAPHRAGMS.....	156
8.6	DESIGN OF RESTRAINTS TO COMPRESSION MEMBERS.....	156

SECTION 9 MEMBERS SUBJECT TO AXIAL TENSION

9.1	DESIGN FOR AXIAL TENSION	158
9.2	NOMINAL SECTION CAPACITY	158
9.3	TENSION MEMBERS WITH TWO OR MORE MAIN COMPONENTS	160
9.4	MEMBERS WITH PIN CONNECTIONS.....	161

SECTION 10 MEMBERS SUBJECT TO AXIAL COMPRESSION	
10.1 DESIGN FOR AXIAL COMPRESSION.....	162
10.2 SECTION CAPACITY.....	162
10.3 NOMINAL MEMBER CAPACITY.....	164
10.4 LACED AND BATTENED COMPRESSION MEMBER.....	168
10.5 COMPRESSION MEMBERS BACK-TO-BACK.....	170
10.6 COMPOSITE COMPRESSION MEMBERS.....	172
SECTION 11 MEMBERS SUBJECT TO COMBINED ACTIONS	
11.1 GENERAL.....	177
11.2 DESIGN ACTIONS.....	177
11.3 SECTION CAPACITY.....	177
11.4 MEMBER CAPACITY.....	179
11.5 CAPACITY OF COMPOSITE COMPRESSION MEMBERS.....	183
SECTION 12 CONNECTIONS	
12.1 GENERAL.....	186
12.2 DEFINITIONS.....	186
12.3 PARTICULAR REQUIREMENTS FOR CONNECTIONS.....	187
12.4 DEDUCTIONS FOR FASTENER HOLES.....	188
12.5 DESIGN OF BOLTS, RIVETS AND PINS.....	190
12.6 DESIGN OF WELDS.....	196
SECTION 13 FATIGUE	
13.1 GENERAL.....	206
13.2 FATIGUE LOADING.....	210
13.3 DESIGN SPECTRUM.....	210
13.4 EXEMPTION FROM ASSESSMENT.....	211
13.5 DETAIL CATEGORY.....	211
13.6 FATIGUE STRENGTH.....	220
13.7 FATIGUE ASSESSMENT.....	222
13.8 PUNCHING LIMITATION.....	222
SECTION 14 BRITTLE FRACTURE	
14.1 GENERAL.....	224
14.2 METHODS.....	224
14.3 NOTCH-DUCTILE RANGE METHOD.....	224
14.4 DESIGN SERVICE TEMPERATURE.....	224
14.5 MATERIAL SELECTION.....	225
14.6 FRACTURE ASSESSMENT.....	227
SECTION 15 TESTING OF STRUCTURES OR ELEMENTS	
15.1 GENERAL.....	228
15.2 DEFINITIONS.....	228
15.3 TEST REQUIREMENTS.....	228
15.4 PROOF TESTING.....	228
15.5 PROTOTYPE TESTING.....	229
15.6 REPORT OF TESTS.....	230

	<i>Page</i>
APPENDICES	
A ELASTIC RESISTANCE TO LATERAL BUCKLING	231
B STRENGTH OF STIFFENED WEB PANELS UNDER COMBINED ACTIONS..	236
C SECOND ORDER ELASTIC ANALYSIS	238
D ECCENTRICALLY LOADED DOUBLE-BOLTED OR WELDED SINGLE ANGLES IN TRUSSES.....	239
E NOMINAL SECTION MOMENT CAPACITY FOR COMPOSITE SECTIONS UNDER SAGGING MOMENTS	241
F INTERACTION CURVES FOR COMPOSITE COLUMNS.....	245
G FABRICATION	247
H ERECTION	257
I MODIFICATION OF EXISTING STRUCTURES	261

STANDARDS AUSTRALIA

Australian Standard
Bridge design

Part 6: Steel and composite construction

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE AND APPLICATION**1.1.1 Scope**

This Standard sets out minimum requirements for the design of the structural steelwork in bridges. Wrought and cast iron structures may be checked in accordance with this Standard, using the appropriate material properties and capacity reduction factors.

In addition, this Standard applies to the design of other steel components of bridges including steel piers, steel railings and sign structures.

In the design of composite steel and concrete members, the general requirements of AS 5100.5 pertaining to the design of concrete shall apply, where relevant, in addition to the requirements of this Standard.

This Standard does not cover the steelwork of the following structures, members and materials:

- (a) Bridges with orthotropic plate decks.
- (b) Cold-formed members other than those complying with AS 1163.
- (c) Steel members for which the value of yield stress (f_y) used in design exceeds 450 MPa.
- (d) Steel elements, other than packers, less than 3 mm thick.

1.1.2 Application

The requirements for bridges, members and materials specified in Items (a) to (d) of Clause 1.1.1, and for new and unusual bridge types shall be designated by the relevant authority.

The design of structural elements using non-ferrous metals such as aluminium alloys is not covered in this Standard. Where such components are to carry calculated stress, the applicable specification to be used in their design shall be designated by the relevant authority.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

AI	1110	ISO metric hexagon bolts and screws—Products A and B—Bolts
	1111	ISO metric hexagon bolts and screws—Product C—Bolts
	1112	ISO metric hexagon nuts
	1112.1	Part 1: Style 1—Product grades A and B