# AS 3600 Supplement 1:2014

# Concrete structures—Commentary (Supplement to AS 3600—2009)



This is a preview. Click here to purchase the full publication.

This Australian Standard Supplement was prepared by Committee BD-002, Concrete Structures. It was approved on behalf of the Council of Standards Australia on 6 November 2014.

This Supplement was published on 5 December 2014.

The following are represented on Committee BD-002:

- Australian Building Codes Board
- AUSTROADS
- Bureau of Steel Manufacturers of Australia
- Cement Concrete & Aggregates Australia
- Concrete Institute of Australia
- Consult Australia
- Engineers Australia
- La Trobe University
- Master Builders Australia
- National Precast Concrete Association Australia
- Steel Reinforcement Institute of Australia
- University of Melbourne
- University of New South Wales
- University of Western Sydney

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Supplement through their representation on the Committee.

#### 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Standards may also be withdrawn.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.

This is a preview. Click here to purchase the full publication.

# AS 3600 Supplement 1:2014

# Concrete structures—Commentary (Supplement to AS 3600—2009)

First published in part as MP 28.C4-1975. MP 28.C9 first published 1975. MP 28.C10 first published 1975. MP 28.C26 first published 1975. MP 28.C6 first published 1977. MP 28.C11 first published 1977 MP 28.C12 first published 1977. MP 28.C12 first published 1977. MP 28.C13 first published 1977. MP 28.C14 first published 1977 MP 28.C15 first published 1977. MP 28.C19 first published 1978. MP 28.C21 first published 1978. MP 28.C22 first published 1978. MP 28.C23 first published 1978. MP 28.C25 first published 1978. The preceding Standards revised, amalgamated and redesignated AS 3600 Supplement 1-1990. Second edition 1994. Third edition 2014.

#### 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 978 1 74342 915 0



# PREFACE

This Commentary was prepared by Standards Australia Committee BD-002, Concrete Structures, to supersede AS 3600 Supp 1—1994. It provides detailed background information to the fourth edition of the Concrete Structures Standard, AS 3600–2009. This is the third edition of the Commentary, which was first published in 1990. While it is intended that this Commentary be read in conjunction with AS 3600–2009, it does not form an integral part of that Standard.

The objectives of this Commentary are to-

- (a) provide background reference material to the Clauses of the Standard;
- (b) indicate the origin of particular requirements;
- (c) indicate departures from previous practice; and
- (d) explain the application of certain Clauses.

The paragraph numbers of this Commentary are prefixed with the letter 'C' and refer directly to the respective clause numbers of AS 3600 (e.g. C1.1 refers to Clause 1.1).

To avoid possible confusion between Commentary and Standard Clauses that are crossreferenced within the text, Commentary clauses are referred to as 'Paragraph C...'. This is in accordance with Standards Australia policy.

Where appropriate, each Section of the Commentary concludes with a list of references that are cross-referenced numerically in the text, e.g. (Ref. 6) or (Refs. 6, 7 and 8). In some sections, additional references for further reading, or as a lead to specialist literature, have also been listed.

As noted in the Preface to AS 3600—2009, the new edition of the Standard is a revision of the third edition, AS 3600—2001, which incorporates Amendments published in 2001 and 2004, as well as changes and updates that take account of the significant developments that have occurred over the past decade in construction practice and theory. The main changes are listed in the Preface to AS 3600—2009. Background information on these changes is given in this new edition of the Commentary, as well as on Clauses that have remained largely unchanged from the previous edition of the Standard. The opportunity has also been taken to include improvements suggested in the interim by users.

Like the Standard itself, this Commentary is an ongoing work-in-progress. Suggestions for improvements to both the Standard and to the Commentary, in regard either to content or to clarity of wording, are therefore welcomed by Standards Australia.

## ACKNOWLEDGMENTS

Standards Australia wishes to acknowledge and thank the members of BD-002 and its subcommittees who have contributed significantly to this Commentary:

H. Backes	G McGregor
G. Brock	P. Mendis
T. Cao	R. Munn
J. Forbes	S. Munter
S.J. Foster	M. Patrick
P. Gabor	A. Paul
R.I. Gilbert	R.J. Potter
S. Guirguis	V. Sirivivatnanon
E. Holdsworth	T. Thomas
K. Kavani	B.Uy
A.E. Kilpatrick	I. Vavilov
M. Manning	R.F. Warner
S. Manwarring	
S. Manwarring	

# This is a preview. Click here to purchase the full publication.

# CONTENTS

SECTIO	N C1 SCOPE AND GENERAL	
C1.1	SCOPE AND APPLICATION	8
C1.2	NORMATIVE REFERENCES	9
C1.3	EXISTING STRUCTURES	. 10
C1.4	DOCUMENTATION	. 10
C1.5	CONSTRUCTION	. 10
C1.6	DEFINITIONS	.10
C1.7	NOTATION	. 10
SECTIO	N C2 DESIGN PROCEDURES, ACTIONS AND LOADS	
C2.1	DESIGN PROCEDURES	. 12
C2.2	DESIGN FOR STRENGTH	. 14
C2.3	DESIGN FOR SERVICEABILITY	. 20
C2.4	ACTIONS AND COMBINATIONS OF ACTIONS	. 25
SECTIO	N C3 DESIGN PROPERTIES OF MATERIALS	
C3.1	PROPERTIES OF CONCRETE	. 30
C3.2	PROPERTIES OF REINFORCEMENT	. 44
C3.3	PROPERTIES OF TENDONS	. 47
C3.4	LOSS OF PRESTRESS IN TENDONS	. 49
C3.5	MATERIAL PROPERTIES FOR NON-LINEAR STRUCTURAL ANALYSIS	. 56
SECTIO	N C4 DESIGN FOR DURABILITY	
C4.1	GENERAL	. 60
C4.2	METHOD OF DESIGN FOR DURABILITY	. 60
C4.3	EXPOSURE CLASSIFICATION	. 62
C4.4	REQUIREMENTS FOR CONCRETE FOR EXPOSURE	
	CLASSIFICATIONS A1, A2, B1, B2, C1 AND C2	. 65
C4.5	REOUIREMENTS FOR CONCRETE FOR EXPOSURE CLASSIFICATION U	. 66
C4.6	ABRASION	. 66
C4.7	FREEZING AND THAWING	. 66
C4.8	AGGRESSIVE SOILS	. 67
C4.9	RESTRICTION ON CHEMICAL CONTENT IN CONCRETE	. 68
C4.10	REQUIREMENTS FOR COVER TO REINFORCING STEEL AND TENDONS	. 68
SECTIO	N C5 DESIGN FOR FIRE RESISTANCE	
C5.1	SCOPE	.73
C5.2	DEFINITIONS	.73
C5.3	DESIGN PERFORMANCE CRITERIA	. 74
C5.4	FIRE RESISTANCE PERIODS (FRPs) FOR BEAMS	. 79
C5.5	FIRE RESISTANCE PERIODS (FRPs) FOR SLABS	. 81
C5.6	FIRE RESISTANCE PERIODS (FRPs) FOR COLUMNS	. 82
C5.7	FIRE RESISTANCE PERIODS (FRPs) FOR WALLS.	. 83
C5.8	INCREASE OF FIRE RESISTANCE PERIODS (FRPs) BY USE	
22.0	OF INSULATING MATERIALS	. 85

SECTIC	N C6 METHODS OF STRUCTURAL ANALYSIS	
C6.1	GENERAL	87
C6.2	LINEAR ELASTIC ANALYSIS	
C6.3	ELASTIC ANALYSIS OF FRAMES INCORPORATING SECONDARY	
	BENDING MOMENTS	
C6.4	LINEAR ELASTIC STRESS ANALYSIS	
C6 5	NON-LINEAR FRAME ANALYSIS	92
C6 6	NON-LINEAR STRESS ANALYSIS	93
C6 7	PLASTIC METHODS OF ANALYSIS	95
C6.8	ANALYSIS USING STRUT-AND-TIE MODELS	97
C6.9	IDEALIZED FRAME METHOD OF ANALYSIS	
C6.10	DSIMPLIFIED METHODS OF FLEXURAL ANALYSIS	
SECTIC	NI C7 STRUT AND THE MODELLING	
	CENED AI	106
C7.1	CONCRETE STRUTS	100
C7.2		100
C7.5	NODES	112
C7.4		112
C7.5	ANALYSIS OF STRUT-AND-THE MODELS	114
C/.0	DESIGN BASED ON STRUT-AND-THE MODELLING	114
SECTIC	N C8 DESIGN OF BEAMS FOR STRENGTH AND SERVICEABILITY	
C8.1	STRENGTH OF BEAMS IN BENDING	116
C8.2	STRENGTH OF BEAMS IN SHEAR	125
C8.3	STRENGTH OF BEAMS IN TORSION	138
C8.4	LONGITUDINAL SHEAR IN COMPOSITE AND MONOLITHIC BEAMS	140
C8.5	DEFLECTION OF BEAMS	142
C8.6	CRACK CONTROL OF BEAMS	149
C8.7	VIBRATION OF BEAMS	153
C8.8	T-BEAMS AND L-BEAMS	154
C8.9	SLENDERNESS LIMITS FOR BEAMS	154
SECTIC	NI CO DECIGN OF SI ADS FOD STDENGTH AND SEDVICE ADII ITY	
	STDENGTU OF SLADS FOR STRENGTH AND SERVICEADILIT I	150
C9.1	STRENGTH OF SLADS IN BENDING	159
C9.2	DEELECTION OF SLADS IN SHEAK	101
C9.5	CPACK CONTROL OF SLADS	105
C9.4	VIDDATION OF SLADS	100
C9.5	MOMENT DESISTING WIDTH FOD ONE WAY SI ADS SUDDODTING	172
C9.0	CONCENTRATED LOADS	172
C0.7	LONCITUDINAL SUEAD IN COMPOSITE SLADS	172
09.7	LUNGITUDINAL SHEAR IN COMPOSITE SLABS	173
SECTIC	N C10 DESIGN OF COLUMNS FOR STRENGTH AND SERVICEABILITY	
C10.	1 GENERAL	175
C10.2	2 DESIGN PROCEDURES	177
C10.	3 DESIGN OF SHORT COLUMNS	179
C10.4	4 DESIGN OF SLENDER COLUMNS	179
C10.:	5 SLENDERNESS	183
C10.0	STRENGTH OF COLUMNS IN COMBINED BENDING	
	AND COMPRESSION	184
C10.7	7 REINFORCEMENT REQUIREMENTS FOR COLUMNS	186
C10.3	8 TRANSMISSION OF AXIAL FORCE THROUGH FLOOR SYSTEMS	192

SECTION C11 DESIGN OF WALLS	
C11.1 GENERAL	197
C11.2 DESIGN PROCEDURES	197
C11.3 BRACED WALLS	199
C11.4EFFECTIVE HEIGHT	199
C11.5 SIMPLIFIED DESIGN METHOD FOR BRACED WALLS SUBJECT	
TO VERTICAL COMPRESSION FORCES	199
C11.6DESIGN OF WALLS FOR IN-PLANE SHEAR FORCES	200
C11.7 REINFORCEMENT REQUIREMENTS FOR WALLS	201
SECTION C12 DESIGN OF NON-FLEXURAL MEMBERS, END ZONES AND BEAR	RING
SURFACES	
C12.1 GENERAL	202
C12.2 STRUT-AND-TIE MODELS FOR THE DESIGN OF NON-FLEXURAL	
MEMBERS	202
C12.3 ADDITIONAL REQUIREMENTS FOR CONTINUOUS CONCRETE NIBS	
AND CORBELS	203
C12.4 ADDITIONAL REQUIREMENTS FOR STEPPED JOINTS IN BEAMS	
AND SLABS	204
C12.5 ANCHORAGE ZONES FOR PRESTRESSING ANCHORAGES	206
C12.6BEARING SURFACES	208
C12.7 CRACK CONTROL	209
SECTION C13 STRESS DEVELOPMENT OF REINFORCEMENT AND TENDONS	
C13.1 STRESS DEVELOPMENT IN REINFORCEMENT	211
C13.2 SPLICING OF REINFORCEMENT.	222
C13.3 STRESS DEVELOPMENT IN TENDONS	224
C13.4 COUPLING OF TENDONS	226
SECTION C14 JOINTS EMBEDDED ITEMS AND FIXINGS	
C14 1 IOINTS	228
C14 2 EMBEDDED ITEMS	232
C14 3 FIXINGS	233
	255
SECTION C15 PLAIN CONCRETE PEDESTALS AND FOOTINGS	
C15.1 GENERAL	234
C15.2DURABILITY	234
C15.3 PEDESTALS	234
C15.4FOOTINGS	234
SECTION C16 SLAB-ON-GROUND FLOORS, PAVEMENTS AND FOOTINGS	
C16.1 GENERAL	236
C16.2 DESIGN CONSIDERATIONS	236
C16.3 FOOTINGS	236

Page

SECTION C17 MATERIAL AND CONSTRUCTION REQUIREMENTS	
C17.1 MATERIAL AND CONSTRUCTION REQUIREMENTS FOR CONCRETE	
AND GROUT	237
C17.2 MATERIAL AND CONSTRUCTION REQUIREMENTS FOR REINFORCING	
STEEL	239
C17.3 MATERIAL AND CONSTRUCTION REQUIREMENTS FOR PRESTRESSING	
DUCTS, ANCHORAGES AND TENDONS	241
C17.4 CONSTRUCTION REQUIREMENTS FOR JOINTS AND EMBEDDED	
ITEMS	244
C17.5 TOLERANCES FOR STRUCTURES AND MEMBERS	244
C17.6FORMWORK	245
APPENDICES	
CA REFERENCED DOCUMENTS	249
CB TESTING OF MEMBERS AND STRUCTURES	250
CC REQUIREMENTS FOR STRUCTURES SUBJECT TO	
EARTHQUAKE ACTIONS	250

# STANDARDS AUSTRALIA

# Australian Standard

# Concrete structures—Commentary (Supplement to AS 3600—2009)

# SECTION C1 SCOPE AND GENERAL

## C1.1 SCOPE AND APPLICATION

### C1.1.1 Scope

Most concrete structures in Australia are designed and constructed to comply with the National Construction Code (NCC) (Ref. 1) and for such structures the design requirements are set out in the NCC and in AS/NZS 1170.0 (Ref. 2). The' Concrete structures' Standard, AS 3600—2009, which sets out minimum provisions for the design and construction of concrete structures in Australia, is called up by the NCC so that compliance with the requirements of the BCA is deemed to be satisfied by following the provisions of this Standard.

AS 3600—2009 covers reinforced and prestressed concrete structures. It does not provide rules for all plain concrete structures, as was the case in previous editions; only rules for plain concrete footings and pedestals are given. The exclusion of mass concrete structures recognizes the fact that they are generally outside the range of normal structures. The treatment of plain concrete members in the Standard is thus limited, and other design criteria, not covered therein, will usually need to be considered in the design of plain concrete members and structures.

The first Note to Clause 1.1.1 points out that much of the content of the Standard is based on general principles and, therefore, may be applicable to design situations not specifically covered by the Standard.

In the preparation of a Standard such as this, a certain level of knowledge and competence of the users has to be assumed. As indicated by the second Note, it is assumed that the users would be professionally qualified civil or structural engineers experienced in the design of concrete structures, or equally qualified but less experienced persons working under their guidance. Therefore, it is intended that the Standard be applied and interpreted primarily by such persons. Similarly, it is intended that the construction of the structure be carried out and supervised by suitably qualified persons using appropriate quality control systems.

## C1.1.2 Application

This Clause places various restrictions on the materials that can be used in conjunction with AS 3600–2009.

A lower limit on concrete compressive strength of 20 MPa is imposed because strength grades less than this are not normally suitable for structures. In AS 3600—2009, the upper limit for the concrete compressive strength is 100 MPa, a strength that can be achieved in commercial premix production plants around Australia and for which concrete properties are specified in the Standard. The design procedures in the Standard apply to structures with concrete strengths within these limits. This is not to suggest that concretes with greater strength cannot be produced commercially or not be used in the construction of concrete structures; however, when used in such situations, the applicability of the rules given in the Standard needs to be checked.