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PRT ED
PMD 940603

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AS 3600—1988

AMDT 1 / 1990-06-04
Supplements 1, 2, 3

PRT ED

Standards
Association of
Australia

Australia
1788-1988

Australian Standard®
3600—1988

CONCRETE STRUCTURES

AS 3600—1994
Concrete structures
(In Professional Packages 21A, 30A, 58A, 62A-69A)
146pp *HH*

Sets out minimum requirements for the analysis, design and construction of concrete structures and members which contain reinforcing steel, or prestressing tendons or both, and requirements for plain concrete structures and members. The Standard applies to concrete with a characteristic compressive strength in the range of 20 MPa to 50 MPa and a density in the range 1800 kg/m³ to 2800 kg/m³. Although intended mainly for building structures and members, it may also be applied to pedestrian, road and railway bridges unless otherwise required by the relevant authority. It does not apply to mass concrete structures. Design requirements are given for the limit-states of stability, strength, serviceability, durability and for resistance to fire and earthquakes. Rules are also given for assessing the compliance of concrete supplied by a manufacturer and for prototype or proof testing of finished members and structures.

(BD/2): Superseden AS 3600—1988 (which is to be made Available Superseded): Publication date 1994-10-10.

This Australian Standard was prepared by Committee BD/2, Concrete Structures. It was approved on behalf of the Council of the Standards Association of Australia on 29 January 1988 and published on 14 March 1988.

The following interests are represented on Committee BD/2:

Association of Consulting Engineers Australia
Australian Precast Concrete Manufacturers Association
Building Management Authority, W.A.
Bureau of Steel Manufacturers of Australia
Cement and Concrete Association of Australia
Commonwealth Department of Administrative Services
Concrete Institute of Australia
CSIRO, Division of Building Research
Department of Housing and Construction, S.A.
Hydro-electric Commission, Tas.
Institution of Engineers, Australia
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National Ash Association of Australia
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National Building Technology Centre
National Ready Mixed Concrete Association
N.S.W. Institute of Technology
Public Works Department, N.S.W.
Steel Reinforcement Promotion Group
University of Adelaide
University of New South Wales
University of Sydney
Water Board, Sydney

This Standard was issued in draft form for comment as DR 85137.

STANDARDS AUSTRALIA

Amendment No 1
to
AS 3600—1988
Concrete structures

REVISED TEXT

The 1988 edition of AS 3600 is amended as follows; the amendment(s) should be inserted in the appropriate place.

SUMMARY: This Amendment applies to Clauses 1.1.2, 1.6.3, 1.7, 2.3, 2.4.2, 3.3.1, 3.4, 3.5, 4.10.1, 4.10.3.2, 5.2, 5.4.1, 5.4.2, 5.6.1, 5.6.2, 5.7.1, 5.7.2, 5.7.4, 5.8.2.3, 5.9, 5.10.1.3, 5.10.2, 6.2.1, 6.3.1, 6.4.3.3, 7.2.2, 7.2.4, 7.3.2, 7.5.6, 8.1.3, 8.1.4.1, 8.1.4.2, 8.1.6, 8.2.5, 8.2.12.2, 8.3.4, 8.4.1, 8.5.4, 8.6.3, 8.9.4, 9.1.1, 9.2.1, 9.3.4.1, 9.7, 10.5.1, 10.5.3, 11.2.1, 11.2.4, 11.4.2, 12.3, 15.3, 15.5, 19.1.7.4 and 21.1.3, Appendix A, Appendix B, and the Index.

Published on 4 June 1990.

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Page 8. Clause 1.1.2.

(a) In paragraph (b), *delete* '2600 kg/m^3' and *substitute* '2800 kg/m^3'.

(b) *Delete* the NOTE at the end of the Clause and *substitute* the following:

NOTES:

1. It is intended that the design of a structure or member to which this Standard applies, be carried out by, or under the supervision of, an engineer as defined in Clause 1.6.2.
2. Consideration is being given to extending the application of the Standard to structures in which the characteristic compressive strength of the concrete (f'_c) is greater than 50 MPa. However, before such an extension could be incorporated, current research data indicates that some requirements of the Standard would need to be more stringent than those presently given and others appropriately modified.

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Page 9. Clause 1.6.3.

(a) In the definition of 'Cover', second last line, *delete* 'cover' and *substitute* 'position of reinforcement and tendons'.

(b) After the definition of 'Fire-resistance period', *insert* 'Fire-separating function—See Clause 5.2'.

(c) After the definition of 'Limit state' *delete* definitions of 'Live-load factor for serviceability'.

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Page 10. Clause 1.7.

(a) In the meanings of 'A_m' and 'b_w', *change* the cross-references to '(see Clause 8.3.3).'

(Page 11.)

(b) *Delete* 'L_{ef}' and its meaning and *substitute* the following:

'L_{ef} = the effective span of a member, taken as the lesser of $(L_n + D)$ and L for a beam or slab; or
= $L_n + D/2$ for a cantilever.'

(Page 12.)

(c) *Delete* the meaning of 'M_u' and *substitute* 'the ultimate strength in bending at a cross-section of an eccentrically loaded compression member.'

(d) *Delete* the meaning of 'M_{ub}' and *substitute* 'the particular ultimate strength in bending when $k_u = 0.6$'.

(e) *Delete* the meaning of 'M_{ud}' and *substitute* 'the reduced ultimate strength in bending without axial force, at a cross-section (see Clause 8.1.3 (c))'

(f) After the meaning of 'M_{ud}', *insert* the following:

'M_{uo} = the ultimate strength in bending without axial force, at a cross-section.'

(g) *Delete* the meaning of 'N_u' and *substitute*;

'the ultimate strength in compression, or tension, at a cross-section of an eccentrically loaded compression or tension member respectively.'

(h) *Delete* the meaning of 'N_{ub}' and *substitute* 'the particular ultimate strength in compression of a cross-section where $k_u = 0.6$'

(i) *Delete* the meaning of 'N_{uo}' and *substitute* 'the ultimate strength in compression without bending, of an axially loaded cross-section'.

(j) After 'N_{uo}', *insert* the following:

N_{uot} = the ultimate strength in tension without bending, of an axially loaded cross-section.

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(Page 13.)

(k) In the meaning of 'β_d', *change* the cross-reference *to* '(see Clause 10.4.3)'.

(l) In the meaning of 'σ_{ci}', *change* the cross-reference *to* '(see Clause 6.4.3.3)'.

(m) *Delete* 'T_{umax}', 'V_{umax}' and 'V_{umin}' and *substitute* '$T_{u.max}$', '$V_{u.max}$' and '$V_{u.min}$'

(n) *Delete* 'W' and its meaning.

(Page 14.)

(o) In the meaning of 'σ_{pa}', *change* the cross-reference *to* '(see Clause 6.4.2.3)'.

(p) In the meaning of 'ϕ', to the end *add* '(see Clause 2.3)'

(q) In the meaning of '$\phi_{cc.b}$', *change* the cross-reference *to* 'Clause 6.1.8.1'.

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Page 15. Table 2.3 *Delete* the contents of the Table and *substitute* the following Table.

TABLE 2.3
STRENGTH REDUCTION FACTORS

Type of action effect	Strength reduction factor (ϕ)
(a) Axial force without bending	
(i) tension	0.8
(ii) compression	0.6
(b) Bending without axial tension or compression where:	
(i) $k_u \leq 0.4$	0.8
(ii) $k_u > 0.4$	$0.8\ M_{ud}/M_{uo} \geq 0.6$
(c) Bending with axial tension	$\phi + [(0.8-\phi)(N_u/N_{uot})]$ and ϕ is obtained from (b)
(d) Bending with axial compression where:	
(i) $N_u \geq N_{ub}$	0.6
(ii) $N_u < N_{ub}$	$0.6 + [(\phi-0.6)(1-N_u/N_{ub})]$ and ϕ is obtained from (b)
(e) Shear	0.7
(f) Torsion	0.7
(g) Bearing	0.6
(h) Compression and tension in strut and tie action	0.7
(i) Bending shear and compression in plain concrete	0.6
(j) Bending shear and tension in fixings	0.6

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Page 16. Table 2.4.2. In the second column, last row *insert* ')' after 'impact'.

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Pages 17 and 18. SECTION 3. *Delete* all after the Section Title and *substitute* the following:

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3.1. LOADS AND OTHER ACTIONS.

3.1.1 Loads. The design of a structure for stability, strength and serviceability shall take account of the action effects directly arising from the following loads:

(a) Dead, live, wind and snow loads specified in AS 1170.1, AS 1170.2, and AS 1170.3.

(b) For the design of bridges, loads specified in the NAASRA Bridge design specification, or the ANZRC Railway bridge design manual, if applicable.

(c) Earthquake loading in accordance with Appendix A, if applicable.

(d) Earth pressure and liquid pressure, if applicable.

(e) Accidental loading, if applicable.

(f) Any additional load that may be required.

3.1.2 Construction loads. Loading conditions which may arise from construction activities and which adversely affect the requirements for stability, strength or serviceability, shall be taken into account. If appropriate, the values assumed for design purposes shall be specified (see also Clause 19.6.2).

3.1.3 Other actions. Any action which may significantly affect the stability, strength or serviceability of the structure, including but not limited to the following, shall be taken into account:

(a) Foundation movements.

(b) Temperature changes and gradients.

(c) Axial shortening.

(d) Dynamic effects.

(e) Shrinkage or expansion of concrete during setting or subsequently.

(f) Creep of concrete.

The value of any of the above actions shall be appropriate to the design state being considered.

3.2 LOAD COMBINATIONS FOR STABILITY DESIGN. The design action effects and the design resistance effects for stability design shall be determined as follows:

(a) The loads and other actions determined from Clause 3.1 shall be subdivided into components tending to cause instability and components tending to resist instability.

(b) The design action effect shall be calculated from the components of the loads and other actions tending to cause instability, factored and combined in accordance with Clause 3.3.

(c) The design resistance effect shall be calculated from 0.8 times the components of the unfactored loads and other actions tending to resist instability.

3.3. LOAD COMBINATIONS FOR STRENGTH DESIGN.

3.3.1 Structures other than bridges. The design load for strength design of structures other than bridges, shall be determined from the load combinations for the strength limit states given in AS 1170.1, except that the combination

$1.25G + W_u + \Psi_c Q$

may be replaced by the more severe of—

$1.4G$; and

$1.1G + W_u + \Psi_c Q$.

Where applicable, the prestressing force, P, shall be included with a load factor of unity in each load combination, except for the case of dead load plus prestress at transfer, when the more severe of—

$1.15G + 1.15P$; and

$0.8G + 1.15P$

shall apply (see also Clause 7.6.7).

3.3.2 Bridges. The design load combinations for strength design of bridges shall be determined from the NAASRA Bridge design specification, or the ANZRC Railway bridge design manual, as appropriate.

3.4 LOAD COMBINATIONS FOR SERVICEABILITY DESIGN. The design load for serviceability design for deflection shall be taken from the appropriate combinations of factored loads for short-term and long-term effects given in AS 1170.1. Where applicable, the prestressing force, P, shall be included with a load factor of unity in all load combinations (see also Clause 7.6.7).

3.5 LOAD COMBINATIONS FOR FIRE-RESISTANCE DESIGN. The combination of factored loads to be used for fire resistance in conjunction with Clauses 5.8 and 5.9 shall be as given in AS 1170.1 for the fire limit state.

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Page 22. Clause 4.10.1. In the third line, *delete* 'Clauses 4.10.2 to 4.10.4' and *substitute* 'Clauses 4.10.2 and 4.10.3'.

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Page 23. Table 4.10.3.2. *Delete* the 'Note' following the table and *substitute*—

'NOTES:

1. Bracketed figures are the appropriate covers when the concession given in Clause 4.3.2, relating to the strength grade permitted for a particular exposure classification, is applied.
2. Increased values are required if Clause 4.10.3.3 applies.'

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Page 24. Clause 5.2.

(a) After definition of '*Fire resistance period*' insert—

'*Fire-separating function*—the function served by the boundary elements of a fire compartment, which are required to have a fire-resistance level, of preventing a fire in that compartment from spreading to adjoining compartments.

NOTES:

1. When tested in accordance with AS 1530.4, prototypes of such members are exposed to fire from only one direction at a time and are assumed to be similarly exposed for the purpose of interpreting this Section.
2. Roofs, walls and floors may serve this function.'

(b) In the definition of '*Hollow-core slab or wall*', second last line, before 'effective', *insert* 'required'.

(c) In the definition of '*Loadbearing member*', *add* to the end, 'and where the design axial force at mid-height of the member is greater than $0.03f'_cA_g$.'

(d) In the definition of '*Ribbed slab*', second line, *change* '1200' *to* '1500'.

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Page 25. Clause 5.4.1. *Add* to the end, 'but where required, are met by satisfying the corresponding resistance periods for structural adequacy.'

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Page 25. Figure 5.4.2(B). On the vertical axis, *delete* 'REINFRCEMENT' and *substitute* 'REINFORCEMENT'.

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Page 27. Clause 5.6.1. In sub-paragraph (a) (ii), *delete* 'that does not have' and *substitute* 'not capable of serving'

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Page 27. Clause 5.6.2.

(a) In the second and third lines, *delete* 'are not relevant' and *substitute* 'do not apply'; and

(b) *Add* the following new sentence;

'Where a column serves a fire-separating function and Clause 5.6.1(a) is not applicable, the fire resistance periods for insulation and integrity shall be determined in accordance with Clauses 5.7.2 and 5.7.3.'

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Page 28. Clause 5.7.1 *Delete* all the text in paragraph (b) and *substitute* 'Clause 5.6 in all other instances.'

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Page 28. Clause 5.7.2 In paragraph (b), second line, *delete* 'width' and *substitute* 'length'.

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Page 29. Clause 5.7.4. *Delete* the entire text and Figure 5.7.4 and *substitute* the following:

'A laterally supported wall has the required fire-resistance period for structural adequacy if (a) to (d) of the following are satisfied.

(a) The wall complies with the requirements of Clauses 11.2.

(b) Its effective thickness is not less than the thickness required by Clause 5.7.2 for that period.

(c) If $N^* \leqslant 0.03f'_cA_g$, H_{we}/t_w is not greater than 50.

(d) If $N^* > 0.03f'_cA_g$;

(i) H_{we}/t_w is not greater than 20; and

(ii) the cover from the fire-exposed face to the vertical reinforcement or tendons is not less than the corresponding cover given in Table 5.7.4 for that period.

For the purpose of (c) and (d) above, the following apply:

(e) N^* is the design axial force at the mid-height of the wall.

(f) If the wall is laterally supported top and bottom only, H_{we} shall be taken as;

(i) 1.0 H_{wu} if neither support is rotationally restrained;

(ii) 0.85 H_{wu} if one support is rotationally restrained; or

(iii) 0.70 H_{wu} if both supports are rotationally restrained,

where the rotational restraint at the support, if any, is provided by a member outside the fire compartment (including a continuation of the wall itself).

(g) If the wall is laterally supported on all four sides, H_{we} shall be determined;

(i) in accordance with (f) if $H_{wu} \leqslant L_l$; or

(ii) by substituting L_l for H_{wu} in (f) if $H_{wu} > L_l$, the rotational restraint provided being determined for the supports in the direction of L_l.'

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Page 29. Table 5.7.4. In the title, last line, *delete* 'FIRE'.

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Page 29. Clause 5.8.2.3 In paragraph (b), third line, *insert* 'by more than 20%,' after 'exceed' and in the last line, *delete* 'by more than 20%.'

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Page 29. Clause 5.9. In the third line, after 'BS 8110.2', insert 'ACI 216R-81,'

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Page 31. Clause 5.10.1.3. *Delete* all the text after the fourth line and *substitute* the following new paragraph:

'In the absence of such testing and only for the materials specified in Clause 5.10.1.2, the minimum thickness of insulating material to be added may be taken as the difference between the required cover or effective thickness specified in this Section and the actual cover or effective thickness, whichever governs, multiplied by;

(a) 0.75, for materials specified in Clause 5.10.1.2.(a) and (b); or

(b) an appropriate factor for materials specified in Clause 5.10.1.2(c), where the factor is derived from tests in which the difference calculated above lies within the range of insulation thicknesses tested;

and the thickness thus calculated rounded to the nearest 5 mm above.'

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Page 31. Clause 5.10.2 In the definition of 't_d', first line, *insert* 'effective' before 'thickness.'

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Page 35. Table 6.2.1. In the heading of the last column *delete* 'MPA' and *substitute* 'MPa'.

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Page 35. Clause 6.3.1. In paragraph (b);

(a) *delete* 'shall be assumed to be as follows' and *substitute* 'may either be taken as—'; and

(b) at the end, *add* 'or be determined by test.'

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Page 37. Clause 6.4.3.3. In the last line, *delete* 'Clause 3.4(b)' and *substitute* 'Clause 3.4.'

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Page 38. Clause 7.2.2. In sub-paragraph (c) (ii), *delete* 'F_n', and *substitute* 'F_d'.

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Page 40. Clause 7.2.4. In sub-paragraph (a) (iii), delete 'L_d', and *substitute* 'L_n'.

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Page 40. Table 7.3.2. In the first column, last row, *delete* '(one short edge discontinuous)'.

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Page 43. Clause 7.5.6. In the second paragraph, last line, *delete* 'Clause 8.3.6', and *substitute* 'Clause 8.3.7'.

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Page 46. Clause 8.1.3.

(a) At the end of the first paragraph, *delete* 'ϕM_u' and *substitute* 'ϕM_{uo}';

(b) *Delete* paragraph (c), and *substitute* the following:

'(c) The design strength in bending shall be taken as ϕM_{uo}, where ϕ is determined from (b) (ii) of Table 2.3.

In the determination of ϕ, M_{ud} is the reduced ultimate strength of the cross-section in bending where $k_u = 0.4$ and the tensile force has been reduced to balance the reduced compressive force.

M_{ud} may be calculated by assuming that—

(i) there are no axial forces acting on the cross-section;

(ii) the concrete strain at the extreme compression fibre is 0.003;

(iii) the effective depth, d, is calculated for M_{uo};

(iv) k_u is reduced to 0.4; and

(v) the resultant of the tensile forces in the reinforcement and tendons is equal to the reduced compressive force calculated on the above assumptions'.

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Page 46. Clause 8.1.4.1. In the second line, *delete* 'M_u' and *substitute* 'M_{uo}'.

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Page 46. Clause 8.1.4.2. In the second last line, *delete* 'compresive' and *substitute* 'compressive'.

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Page 46. Clause 8.1.6. In paragraph (b), right hand side of the equation, *delete* '$\sigma_{pu.ef}$', and *substitute* '$\sigma_{p.ef}$'.

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Page 48. Clause 8.2.5. Amend Clause as follows:

(a) *Delete* the second paragraph of sub-paragraph (b) and *substitute* the following new sub-paragraph:

'(c) The minimum shear reinforcement requirements of (a) and (b) may be waived—

(i) for beams, if $V^* \leqslant \phi V_{uc}$ and D does not exceed the greater of 250 mm and half the width of the web; and

(ii) for slabs to which this Clause applies, if $V^* \leqslant \phi V_{uc}$.'

(b) *Make* sub-paragraph (c) a new sub-paragraph, (d)

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Page 49. Clause 8.2.12.2. In the last line of the Clause, *delete* 'beam' and *substitute* 'member'.

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Page 50. Clause 8.3.4. In sub-paragraph (a) (iii), first line, *delete* 'for beams for which' and in the third line, after 'web', *insert* 'and'.

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Page 50. Clause 8.4.1. *Delete* the entire text, and *substitute* the following:

'This Clause applies to the transfer of longitudinal shear forces, across interface shear planes through webs and flanges of composite beams, and across shear planes through flanges cast monolithically.'

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Page 52. Clause 8.5.4. In the definition of $F_{d.ef}$, last line, *delete* 'Table 3.4' and *substitute* 'AS 1170.1'.

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Page 52. Clause 8.6.3. *Delete* the entire text and *substitute* the following:

'For crack control in side faces of beams where the overall depth exceeds 750 mm, longitudinal reinforcement, consisting of Y12 bars at 200 mm centres, or Y16 bars at 300 mm centres, shall be placed in each side face'.

AMDT No 1 JUNE 1990

Page 53. Clause 8.9.4. In paragraph (a), *delete* 'Clause 8.2.5 (d)' and *substitute* 'Clause 8.2.8'.

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Page 54. Clause 9.1.1. In the third line, *delete* 'continuous'.

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Page 57. Figure 9.2.1(B). *Make* left hand edge of the figure a broken line to indicate continuity of the slab past that point.

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Page 59. Clause 9.3.4.1. In the definition of $F_{d.ef}$, last line, *delete* 'Table 3.4' and *substitute* 'AS 1170.1'.

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Page 60. Clause 9.7.

(a) In the title, *insert* 'COMPOSITE' before 'SLABS'.

(b) In the last line, after 'shear', *insert* 'at the interfaces between components,'.

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Page 62. Clause 10.5.1.

(a) In the first paragraph, last line, *delete* 'or 10.5.7.'

(b) In the second paragraph, third line, *insert* 'in accordance with Clause 7.8' after 'out'.

(c) *Reverse* the order of the two paragraphs.

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Page 63. Figure 10.5.3(A). In the heading over the first three shapes *delete* 'columm' and *substitute* 'column'.

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Page 64. Figure 10.5.3(C). On the curve above $k = 1.5$, *delete* '1.8' and *substitute* '1.6'.

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Page 68. Clause 11.2.1. At the end of the second line, *delete* 'as' and *substitute* 'if'.

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Page 68. Clause 11.2.4.

(a) In the fourth line, insert 'at mid-height' after 'N^*,'.

(b) In the fifth line, delete '0.05' and substitute '0.03'.

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Page 68. Clause 11.4.2.

(a) In the third line, *insert* 'design' before 'axial'.

(b) In the second last line, *insert* 'at mid-height' after 'N^*,' and *substitute* '0.03' for '0.05'.

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Page 71. Clause 12.3. At the beginning of the text, *insert* 'Unless special confinement reinforcement is provided,' and *delete* the sentence at the bottom of the page.

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Page 77. Clause 15.3. *Delete* both occurrences of 'M_u' and *substitute* 'M_{uo}'.

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Page 77. Clause 15.5. *Delete* both occurrences of 'N_u' and *substitute* N_{uo}.

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Page 81. Clause 19.1.7.4. In sub-paragraph (a) (v), second and third lines, *delete* 'fly ash or slag or both' and *substitute* 'both fly ash and slag'.

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Page 90. Clause 21.1.3. In paragraph (a), *delete* the line after sub-paragraph (i) and *substitute*—

'(ii) for cantilevers, $L_n^2/5000\ D$; or'

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Page 92. Appendix A, Paragraph A5.1. In the last line of the NOTE, *delete* 'Clause 7.1.7' and *substitute* 'Clause 7.1.1'.

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Page 92. Appendix A, Paragraph A5.2. In the first paragraph, third line, *delete* all after 'determined from' and *substitute* 'AS 1170.1'.

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Page 96. Appendix A, Paragraph A10.3. In the last line, *delete* 'of'.

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Page 98. Appendix B,.

(a) In the title of AS 1170, Part 1, after 'loads', *add* 'and load combinations'.

(b) In the title of AS 1170, Part 2, *delete* 'forces' and *substitute* 'loads'.

(c) After 1170.2 *insert* 'Part 3: Snow/loads'.

(d) In the title of AS 1303, delete 'Hard-drawn'.

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Page 103. Index. After the references for 'rectangular stress block assumption', *insert*—

'reduction factor for strength, 2.3, Table 2.3'.

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Page 104. Index. Under the reference for 'strength', before 'ultimate' *insert* 'reduction factor, 2.3, Table 2.3'.

AUSTRALIAN STANDARD

CONCRETE STRUCTURES

AS 3600—1988

AS 1480
First published as AS CA2 together with AS A26—1934.
CA2 and A26 revised and amalgamated as AS CA2—1958.
Third edition 1963.
Fourth edition 1973.
Metricated and redesignated AS 1480—1974.
AS CA2—1973 withdrawn 1976.
Second edition 1982.

AS 1481
First published as AS CA35—1963.
Second edition 1973.
Metricated and redesignated AS 1481—1974.
AS CA35—1973 withdrawn 1976.
Second edition 1978.

AS 1480—1982 and AS 1481—1978 revised, amalgamated and redesignated AS 3600—1988.

PRECAST CONCRETE UNITS ARE NOT COVERED IN AS 3600 EVEN THOUGH THEY WERE IN AS 1480. NO STANDARD AVAILABLE OR PLANNED. CEO. MAR 94.

PUBLISHED BY THE STANDARDS ASSOCIATION OF AUSTRALIA
STANDARDS HOUSE, 80 ARTHUR ST, NORTH SYDNEY, N.S.W.
ISBN 0 7262 4883 5

PREFACE

This Standard was prepared by the Association's Committee on Concrete Structures. It amalgamates and supersedes AS 1480—1982, *SAA Concrete Structures Code*, and AS 1481—1978, *SAA Prestressed Concrete Code*.

In preparing this Standard, the Committee referred to AS 1480—1982 and AS 1481—1978; BS 8110—1985, *Structural Use of Concrete*; ACI 318M-83, *Building Code Requirements for Reinforced Concrete*; FIP Draft 1982, *Recommendations on the Practical Design of Reinforced and Prestressed Concrete Structures* and ISO 3898—1976, *Bases for the Design of Structures—Notations*. Other technical documents considered or referred to by the Committee in preparing the individual sections and clauses are noted in the Commentary, which will be published separately as a companion document to this Standard.

Although AS 1480—1982 and AS 1481—1978 form the main basis of the Standard, it differs markedly from them in both format and content. The following brief outline gives some indication of the nature and extent of the differences to be found.

1 Limit-state format. In keeping with current SAA and ISO policy on structural design Standards, the appropriate functional states and the corresponding performance limits are presented generally in the format of design action effects and corresponding design resistances. This represents an advancement in the probabilistic approach to structural design, which began with the introduction of the ultimate-strength method in the 1974 edition of AS 1480.

2 General application. Requirements of the Standard have been broadened and modified where necessary, to ensure that generally they apply to reinforced members with or without some degree of prestressing. Requirements are given separately for unreinforced (plain) concrete while requirements which apply only to prestressing are now included as separate clauses in the appropriate sections.

The relevant provisions of the Standard have also been widened so that it is now suitable for bridge design in conjunction with the NAASRA *Bridge design specification* or the ANZRC *Railway bridge design manual*. However, additional or more stringent provisions for some aspects of bridge design may still be required by the relevant Authority in particular instances.

3 New inclusions. A tiered approach to member design rules has been introduced to allow the designer more flexibility in choice of design methods to suit a particular project. Simplified rules, for common applications within prescribed limits, are generally presented first, with more complex rules having wider applications following.

Durability and fire-resistance provisions have been included as independent considerations within the body of the Standard. Previously they have been either implied in various design rules, or given only as recommendations in appendices.

Provision has also been made for the use of the 'truss analogy' where non-flexural behaviour of members occurs.

Rules for concrete structures subject to seismic actions, previously given in various appendices throughout AS 2121, *SAA Earthquake Code*, are now gathered together in Appendix A and are additional to the other provisions of the Standard.

4 Major technical revisions. Major technical revisions have been made in the areas of load combinations, shear in beams and slabs, the design of columns and walls, stress development in reinforcement and the assessment of concrete quality. These changes reflect recent advances in material technology, research into structural behaviour, and computerized methods of analysis and design. The basis for each technical change is covered in the Commentary together with selected references from the published technical literature.

5 Construction and workmanship. A considerable number of provisions relating to construction practices and good workmanship, previously contained in AS 1480—1982 and AS 1481—1978, have been omitted from this Standard. Omitted material was considered to be either inappropriate, because it had contractual implications, or inadequate because it was too specific to cover the likely variety of project situations and the variety of acceptable alternative practices for each. The committee felt that these matters could be dealt with far more effectively in project specifications or manuals of good practice currently published by recognised authoritative organisations. The remaining provisions have been expressed in terms of required end results rather than by prescribing methods for achieving those results.

6 Editorial changes. Advantage has been taken of the current revision to rearrange the material contained in the Standard so that it is more readily usable by the practising design engineer. In this regard the usual steps in the design process, rather than the checking process, have been taken as the guiding criterion.

In line with the Association's editorial policy, the words 'shall' and 'may' are used consistently throughout the Standard to indicate respectively, a mandatory provision and an acceptable or permissible alternative.

Since this Standard is the forerunner of similar structural-design Standards currently being revised or prepared by the Association, suggestions for improvements are welcomed.

CONTENTS

STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard
CONCRETE STRUCTURES

SECTION 1. SCOPE AND GENERAL

1.1 SCOPE AND APPLICATION.

1.1.1 Scope. This Standard sets out minimum requirements for the design and construction of concrete structures and members which contain reinforcing steel, or tendons, or both. It also sets out minimum requirements for plain concrete members.

1.1.2 Application. This Standard is intended to apply to structures made of concrete—

(a) with a characteristic compressive strength at 28 days, f'_c, in the range of 20 MPa to 50 MPa; and

(b) of saturated, surface-dry density in the range of 1800 kg/m^3 to ~~2600 kg/m^3~~. 2500 kg/m^3 (AMDT 1, 1990)

This Standard is generally intended to apply to concrete roadway, railway, or pedestrian bridges. However, the specifications of the relevant Authority shall be used where applicable.

The general principles of concrete design and construction embodied in this Standard may be applied to concrete other than that specified above, or to concrete structures or members not specifically mentioned herein.

This Standard is not intended to apply to the design of mass concrete structures. It is also not intended that the requirements of this Standard should take precedence over those of other Australian Standards.

NOTE: ~~It is intended that the design of a structure or member to which this Standard applies, be carried out by, or under the supervision of, an engineer as defined in Clause 1.6.2.~~ SEE AMDT 1, 1990.

1.2 REFERENCED DOCUMENTS. The Standards and other documents referred to in this Standard are listed in Appendix B.

1.3 USE OF ALTERNATIVE MATERIALS OR METHODS.

1.3.1 General. Provided that the requirements of Section 2 are met, this Standard shall not be interpreted so as to prevent the use of materials or methods of design or construction not specifically referred to herein.

1.3.2 Use of other materials or methods. If it is desired to seek the opinion of the SAA Committee on Concrete Structures as to whether materials other than those specified, or methods of design or construction not covered herein, are deemed to comply with the intention of this Standard, details of these materials or methods, including relevant test results, shall be submitted to the Committee.

1.3.3 Existing structures. Where the strength or serviceability of an existing structure is to be evaluated, the general principles of this Standard may be applied. (See also Clauses 21.1 and 21.4.)

1.4 DESIGN.

1.4.1 Design data. The following design data shall be shown in the drawings:

(a) Reference number and date of issue of applicable design Standards.

(b) Live loads used in design.

(c) Exposure classification for durability.

(d) Fire-resistance rating, if applicable.

(e) Class and where appropriate, grade designation of concrete.

(f) Grade and type of reinforcement and tendons.

1.4.2 Design details. The drawings or specification for concrete members and structures should include, as appropriate, the following:

(a) The shape and size of each member.

(b) The finish and method of control for unformed surfaces.

(c) Class of formwork for the surface finish specified in accordance with AS 1510.1.

(d) The size, quantity and location of all reinforcement, tendons and structural fixings and the cover to each.

(e) Any required properties of the concrete (see Clauses 19.1.7 and 19.1.8).

(f) The curing procedure.

(g) The force required in each tendon, the maximum jacking force to be applied and the order in which tendons are to be stressed.

(h) The location and details of planned construction or movement joints, connections and splices, and the method to be used for their protection.

(j) The minimum period of time before stripping of forms and removal of shores.

(k) Any constraint on construction assumed in the design.

(l) Any other requirements.

1.5 CONSTRUCTION. All concrete structures, designed in accordance with this Standard, shall be constructed to ensure that all the requirements of the design as contained in the drawings and specifications are achieved.

1.6 DEFINITIONS.

1.6.1 General. The definitions below apply to this Standard. Definitions peculiar to a particular clause or section are given in that clause or section and referred to below.

1.6.2 Administrative definitions.

Approved—except as may be otherwise stated, approved by the Authority.