



Reinforced Autoclaved Aerated Concrete

Part 2: Design



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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.

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Australian Standard®

Reinforced Autoclaved Aerated Concrete

Part 2: Design

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PREFACE

This Standard was prepared by Standards Australia Committee BD-106, Autoclaved Aerated Concrete to supersede AS 5146.2:2015.

The objective of this Standard is to provide minimum requirements for the determination of the characteristic properties of Reinforced Autoclaved Aerated Concrete (AAC) members, for use in design in accordance with the requirements of AS 5146.1, *Reinforced autoclaved aerated concrete*, Part 1: *Structures*.

Statements expressed in mandatory terms in notes to tables and figures 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 appendices to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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FOREWORD

This Standard is to be read in conjunction with AS 5146.1 and AS 5146.3.

The members used in design may be—

- (a) mass-produced members for incorporation into structures in accordance with common practice and details, the basic characteristic capacities of which are determined in accordance with Sections 2 to 8 and reported in accordance with Section 1 of this Standard; or
- (b) customized members for incorporation into structures in a manner requiring particular design and detailing, the characteristic capacities of which are relevant to the particular structure and are determined in accordance with Sections 2 to 8.

The characteristic properties of Reinforced AAC may be determined in accordance with this Standard by either calculation (using basic properties of AAC and reinforcement) or by test.

Such values are typically the 95 percentile characteristic values, determined with at least 75 percent confidence, before the application of capacity reduction factors.

The capacity reduction factors are specified in AS 5146.1. Factors for design actions (commonly called load factors), for use when designing Reinforced AAC structures, are also specified in AS 5146.1.

This Standard specifies methods for determining characteristic values or mean values, which are similar to the methods set out in European Standard EN 12602:2008+A1:2013, *Prefabricated reinforced components of autoclaved aerated concrete*, with the following exceptions:

- (i) This Standard does not permit the use of thermal prestress to enhance capacity.
- (ii) This Standard does not permit the use of bond between AAC and steel reinforcement to enhance reinforcement anchorage.
- (iii) This Standard requires design that differentiates between brittle failure bending capacity and ductile failure bending capacity.

This Standard has been written in a format compatible with Australian Standards that are in common use in Australia for determining design actions and other common materials. Some parts of this Standard (e.g. most of the nomenclature, formulae and detailed design) are the same as EN 12602:2008+A1. This has been done intentionally, to ensure that Reinforced AAC designs in accordance with EN 12602:2008+A1:2013 and this Standard may be used interchangeably. This ensures that Reinforced AAC members designed to one of the Standards can be verified relatively easily for use in locations where the other Standard is in common use. This similarity to EN 12602:2008+A1 is acknowledged by Standards Australia.

It has been necessary to prepare a suite of Australian Standards for Reinforced AAC, including this Standard, for the following reasons:

- (A) EN 12602:2008+A1 includes European design actions and materials, which are not applicable in Australia. It is necessary to include reference to Australian Standards and Australian/New Zealand Standards for design principles, design actions, load factors, capacity reduction factors and materials testing.
- (B) EN 12602:2008+A1 includes a partial capacity reduction factor approach, which is not compatible with the current approach common in Australian Standards.
- (C) Additional formulae for the design for bending and definitions of ductile and brittle behaviour have been provided.

- (D) Thermal prestress and bond between reinforcement and AAC have been excluded.
- (E) Test details have been included in this Standard.
- (F) The tests have been modified to suit referenced Australian Standards, Australian laboratory practice and the requirements of AS 5146.1 for certain design information. This Standard also provides for testing to the equivalent EN standards, with suitable modification of the reporting where necessary.
- (G) This Standard has been written in a format compatible with Australian Standards and Australian/New Zealand Standards that are in common use in Australia for determining design actions and other common materials.

STANDARDS AUSTRALIA

Australian Standard

Reinforced Autoclaved Aerated Concrete

Part 2: Design

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements and sets out methods for the determination of the characteristic properties of Reinforced Autoclaved Aerated Concrete members (Reinforced AAC), with a thickness not less than 50 mm, for use in structures where the design and construction conform with AS 5146.1.

NOTES:

- 1 This Standard uses the term AAC (autoclaved aerated concrete material) and Reinforced AAC (wall, floor or roof panels or other members, consisting of AAC into which steel reinforcement has been cast).
- 2 Typical uses of Reinforced AAC include loadbearing and non-loadbearing wall panels for both internal and external use, fascias and cladding, roofs, floors, beams, lintels, piers, noise barriers and earth retaining structures.
- 3 This Standard does not cover the design or use of unreinforced AAC blocks.
- 4 This Standard does not cover the use of Reinforced AAC subject to dynamic loads, except loads due to earthquake.
- 5 This Standard does not cover finishes such as render, tiling, plasterboard and the like, fixings or supporting structures.
- 6 This Standard applies only to cases where—
 - (a) the design has been performed by an experienced structural engineer and design actions, material properties, section properties, bending moments, shears and deflections have been determined in accordance with the provisions of this Standard; and
 - (b) the execution of such work is carried out under the direction of appropriately qualified persons who are experienced in Reinforced AAC construction and who understand the structural requirements specified herein.
- 7 This Standard should not be interpreted in a way that prevents design using alternative materials or methods not specifically referred to herein. However, the design of such members is outside the scope of this Standard.

Means for demonstrating conformance with this Standard are given in Appendix AA.

1.2 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard.

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

AS

- | | |
|--------|---|
| 1530 | Methods for fire tests on building materials, components and structures |
| 1530.4 | Part 4: Fire-resistance test for elements of construction |
| 2193 | Calibration and classification of force-measuring systems |
| 2702 | Acoustics—Methods for the measurement of road traffic noise |

AS	
5146	Reinforced Autoclaved Aerated Concrete
5146.1	Part 1: Structures
AS ISO	
140	Acoustics—Measurement of sound insulation in buildings and of building elements
140.6	Part 6: Laboratory measurements of impact sound insulation of floors
717	Acoustics—Rating of sound insulation in buildings and of building elements
717.2	Part 2: Impact sound insulation
AS/NZS	
4671	Steel reinforcing materials
4859	Materials for the thermal insulation of buildings
4859.1	Part 1: General criteria and technical provisions
AS/NZS ISO	
717	Acoustics—Rating of sound insulation in buildings and of building elements
717.1	Part 1: Airborne sound insulation
ISO	
7976	Tolerances for building—Methods of measurement of buildings and building products
7976-1	Part 1: Methods and instruments
8302	Thermal insulation—Determination of steady-state thermal resistance and related properties—Guarded hot plate apparatus
10456	Building materials and products—Hygrothermal properties—Tabulated design values and procedures for determining declared and design thermal values
EN	
678	Determination of the dry density of autoclaved aerated concrete
679	Determination of the compressive strength of autoclaved aerated concrete
680	Determination of the drying shrinkage of autoclaved aerated concrete
990	Test methods for verification of corrosion protection of reinforcement in autoclaved aerated concrete and lightweight aggregate concrete with open structure
991	Determination of the dimensions of prefabricated reinforced components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure
1351	Determination of flexural strength of autoclaved aerated concrete
1352	Determination of static modulus of elasticity under compression of autoclaved aerated concrete or lightweight aggregate concrete with open structure
1353	Determination of moisture content of autoclaved aerated concrete
1355	Determination of creep strains under compression of autoclaved aerated concrete or lightweight aggregate concrete with open structure
1356	Performance test for prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure under transverse load
1737	Determination of the shear strength of welded joints of reinforcement mats or cages for prefabricated components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure

EN

- 1738 Determination of steel stresses in unloaded reinforced components made of autoclaved aerated concrete
- 1739 Determination of shear strength for in-plane forces of joints between prefabricated components of autoclaved aerated concrete or lightweight aggregate concrete with open structure
- 1740 Performance test for prefabricated components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure under predominantly longitudinal load (vertical components)
- 1741 Determination of shear strength for out-of-plane forces of joints between prefabricated components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure
- 1742 Determination of shear strength between different layers of multilayer components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure
- 15304 Determination of the freeze-thaw resistance of autoclaved aerated concrete
- 15361 Determination of the influence of the corrosion protection coating on the anchorage capacity of the transverse anchorage bars in prefabricated reinforced components of autoclaved aerated concrete

EN ISO

- 7500 Metallic materials—Calibration and verification of static uniaxial testing machines
- 7500-1 Part 1: Tension/compression testing machines—Calibration and verification and calibration of the force-measuring system

1.3 DEFINITIONS

For the purposes of this Standard, the definitions below apply.

1.3.1 Autoclaved Aerated Concrete (AAC)

Material manufactured from binders such as cement and/or lime combined with fine siliceous-based material, cell generating material and water.

NOTES:

- 1 The raw materials are mixed together and cast into moulds where the mix is allowed to rise and set into cakes. After this part of the process, the cake is cut into members of the required size and cured with high-pressure steam in autoclaves.
- 2 It is assumed that the manufactured AAC material will not have a detrimental effect on the durability of materials it comes in contact with.

1.3.2 Built-in components for Reinforced AAC construction

Metal items used for connecting Reinforced AAC to its supporting structure including, but not limited to, the following:

- (a) Anchors.
- (b) Connectors.
- (c) Shelf angles.
- (d) Lintel bars.
- (e) Bolts and fixings.

1.3.3 Characteristic value

Characteristic values are as follows:

- (a) For strength properties, the value of the material property that is exceeded by 95% of the material.
- (b) For coefficients of expansion and contraction, the value that is exceeded by 5% of the material.

1.3.4 Connectors

Bolts, nuts, screws, screwed rod, brackets, straps and the like, used to fix Reinforced AAC members to supporting elements in the structure.

1.3.5 Design documents

Drawings and specifications that set out the work to be executed.

1.3.6 Declared value

The value of a particular property of Reinforced AAC, determined in accordance with one of the methods in this Standard.

1.3.7 Exposure environments

1.3.7.1 *Severe marine*

Areas up to 100 m from a non-surf coast and up to 1 km from breaking surf.

NOTE: The distances specified are from the mean high-water mark.

1.3.7.2 *Marine*

Areas from 100 m up to 1 km from a non-surf coast and from 1 km up to 10 km from breaking surf.

NOTE: The distances specified are from the mean high-water mark. Sheltered bays such as Port Phillip Bay and Sydney Harbour are considered to be non-surf coast.

1.3.7.3 *Industrial*

Areas within 1 km of major industrial complexes producing significant acidic pollution.

NOTE: There are only a few such regions in Australia; for example, around Port Pirie.

1.3.7.4 *Moderate*

Areas with light industrial pollution or very light marine influence, or both.

NOTE: Moderate areas include built-up areas within 50 km of the coast and more than 1 km from a non-surf coast and more than 10 km from breaking surf coast, including suburban areas of cities such as Melbourne, Adelaide and Hobart, many areas of Sydney, Perth and Brisbane, and many inland cities.

1.3.7.5 *Mild*

Areas more than 50 km from the coast, and not classed as industrial, which are subdivided as follows:

- (a) *Mild-tropical* Areas more than 50 km from the coast and falling within the tropical climatic zone shown in Figure 1.3.7.
- (b) *Mild-temperate* Areas more than 50 km from the coast and falling within the temperate climatic zone shown in Figure 1.3.7.
- (c) *Mild-arid* Areas more than 50 km from the coast and falling within the arid climatic zone shown in Figure 1.3.7.

1.3.7.6 Special

Areas that are not defined in Clauses 1.3.7.1 to 1.3.7.5, which have durability requirements different to those set out in Table 2.1 of AS 5146.1.

NOTE: Special environments are often more aggressive than severe marine environments, thus requiring greater protection of some or all of the components than would be afforded by conformance with the requirements of Table 2.1 of AS 5146.1 for a severe marine environment.

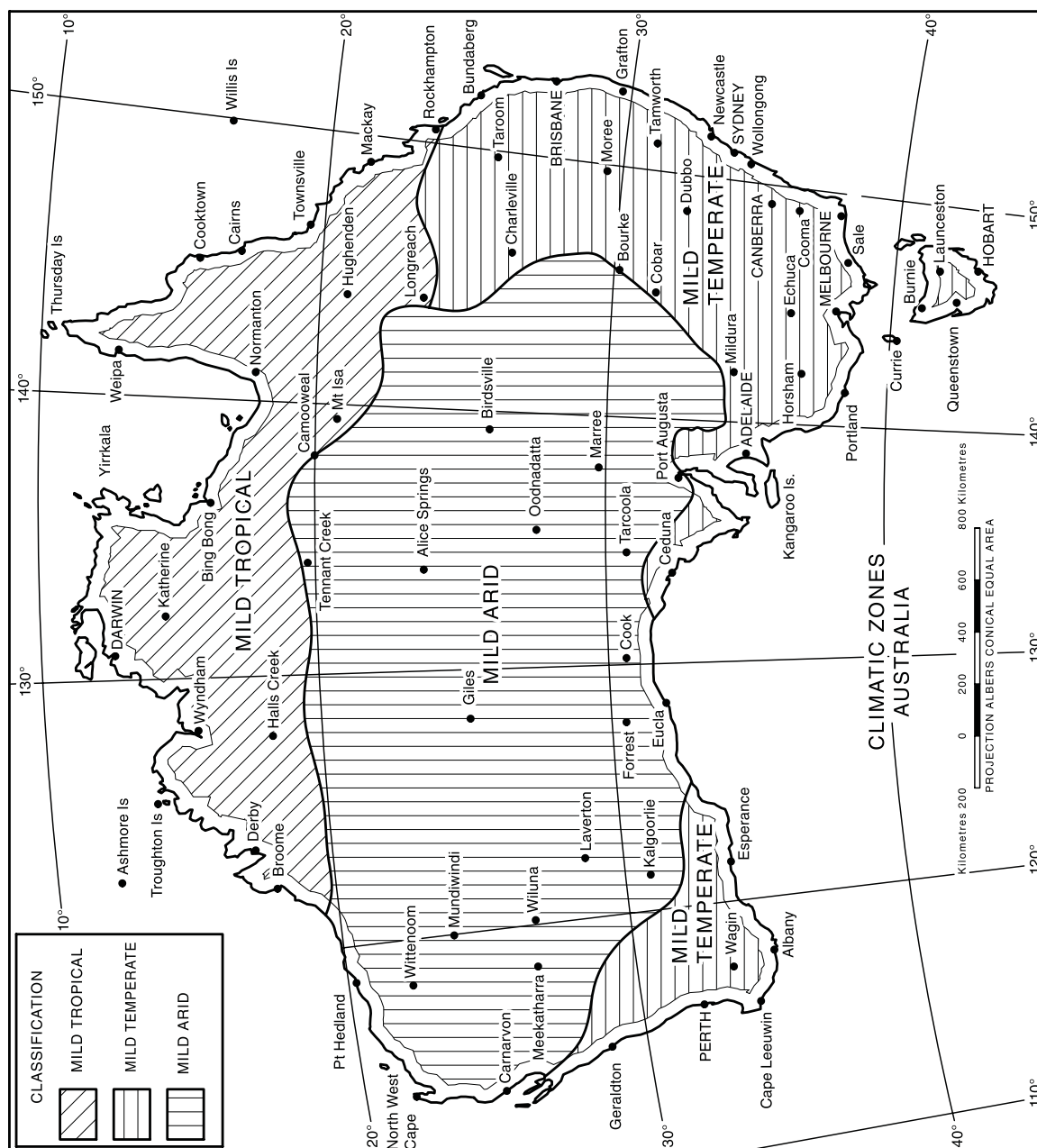


FIGURE 1.3.7 CLIMATIC ZONES FOR MILD EXPOSURE ENVIRONMENTS

1.3.8 Fire resistance level (FRL)

The fire resistance level that a member can provide, in terms of structural adequacy, integrity and insulation, as defined in the NCC.

1.3.9 Lateral support

The support (i.e. a column, buttress, cross-wall, footing, beam, stud, batten, floor, braced roof structure or the like) that effectively restrains a Reinforced AAC wall or isolated pier in the direction of its thickness, except that an isolated pier may also have lateral support in the direction of its width.

1.3.10 Reinforced AAC

Member consisting of AAC into which reinforcement has been cast.

1.3.11 Reinforcement

Steel mesh, cages and/or bars conforming with AS/NZS 4671 incorporated into AAC to form Reinforced AAC members.

1.4 NOTATION

The symbols used in this Standard, including their definitions, are listed below.

Unless a contrary intention appears, the following applies:

- (a) The symbols used in this Standard shall have the meanings ascribed to them, with respect to the structure, or member, or condition to which a clause is applied.
- (b) Where non-dimensional ratios are involved, both the numerator and denominator shall be expressed in identical units.
- (c) The dimensional units for length, force and stress, in all expressions or equations, shall be taken as millimetres (mm), newtons (N) and (MPa) respectively, unless noted otherwise.
- (d) An asterisk (*) placed after a symbol as a superscript (e.g. M_y^*) denotes a design action effect due to the design load.

A_c	= total cross-sectional area of concrete
	= area of the compression zone of the cross-section
	= area of AAC within the tensile zone
A_{crit}	= critical area, as presented in Figures 4.4.3(A), 4.4.3(B) and 4.4.3(C)
A_{c0}	= loaded area
A_{c1}	= maximum distribution area
A_k	= area defined by longitudinal reinforcement
A_s	= cross-sectional area of tensile reinforcement
A_{smin}	= minimum cross-sectional area of the reinforcement
A_{swmin}	= minimum cross-sectional area of shear reinforcement within a length equal to the spacing of fitments s
A_{sw}	= cross-sectional area of vertical or inclined shear reinforcement
A_{sl}	= cross-sectional area of the reinforcing bar with the larger diameter of the connection
	= cross-sectional area of tension reinforcement
a	= dimension of support perpendicular to the plane of a wall
	= shear span
	= larger dimension of a rectangular loaded area

a_b	= dimension of rectangular loaded area perpendicular to the span of a slab
a_0	= minimum support length
a_1	= horizontal displacement of the envelope of the design bending moment distribution
b	= width of a member = smaller dimension of a rectangular loaded area
b'	= centre distance of longitudinal reinforcement (see Figure 4.8.2)
b_w	= minimum width of the web section
c	= concrete cover = a value, in MPa, representing the difference between the characteristic compressive strength and the permissible minimum individual value of the compressive strength
d	= effective depth of a member = design thickness of a member, for a solid wall $d = h$ = diameter of a circular loaded area
d_{load}	= diameter of loading plate in punching shear test
$E_{c,eff}$	= effective modulus of elasticity of AAC
E_{cm}	= mean value of the modulus of elasticity of AAC
E_s	= modulus of elasticity of reinforcing steel
$(EI)_k$	= stiffness in bending of a section in the 'semi-cracked' state
$(EI)_0$	= stiffness of a section in the uncracked state, assuming $E = E_{cm}$
$(EI)_1$	= stiffness of a section in the uncracked state
$(EI)_2$	= stiffness of a section in the cracked state
e	= distance of the axis of the transverse bars in the anchorage zone to the nearest surface of the member = distance of the centroid of the longitudinal bars from the adjacent side face of the AAC member = basis of natural logarithms
e_a	= additional eccentricity of the longitudinal force due to geometrical imperfections
e_b	= eccentricity in the plane of a wall, $e_b = M/N + e_N$
e_{cr}	= eccentricity e_{c0} of the vertical action including the geometrical imperfections
e_m	= first order eccentricity caused by bending due to horizontal load
e_N	= eccentricity of the vertical axial force in the plane of a wall
e_o	= eccentricity of the longitudinal force at the top of the member
e_t	= first order eccentricity perpendicular to the plane of a wall, taken as the sum of e_o and e_m
e_0	= first order eccentricity of loads perpendicular to the plane of a component
F_b	= long-term anchorage capacity
F_c	= compression force in the AAC in the direction of the longitudinal axis

F_{ld}	= design tensile force in the longitudinal reinforcement to be anchored
F_s	= tensile force in the longitudinal reinforcement
F_{sl}	= tensile force in each of the longitudinal bars
F_{RA}	= ultimate anchorage resistance due to welded cross-bars
F_{pk}	= characteristic punching shear capacity
F_{Rdu}	= concentrated compressive design force
F_{wg}	= declared shear strength of a welded joint
f_{bl}	= long-term bond strength
f_{cd}	= design value of the compressive strength of AAC
$f_{c,edge}$	= compressive strength of AAC at the edge of a wall or pier
f_{ck}	= characteristic compressive strength of AAC = declared characteristic compressive strength of AAC
f_{cflk}	= characteristic flexural strength of AAC = declared characteristic flexural strength of AAC
$f_{cflk,eff}$	= 'effective' characteristic flexural strength of AAC
f_{co}	= contact stress
f_{ctk}	= characteristic axial tensile strength of AAC = declared characteristic flexural strength of AAC
f_{ctm}	= mean value of axial tensile strength of AAC
f_{ld}	= characteristic bearing strength of AAC
f_{st}	= tensile strength of reinforcing steel
f_{yk}	= characteristic yield strength of reinforcing steel
f_{yd}	= design value of yield strength of reinforcing steel
f_{ywk}	= characteristic yield strength of steel fitments
$f_{0,2k}$	= characteristic 0.2% proof stress of reinforcing steel
h	= overall depth of a cross-section
h'	= centre distance of longitudinal reinforcement
h_c	= distance between A_{c0} and A_{c1}
h_k	= thickness of a fictitious box section
h_w	= (total) thickness of a wall
I_c	= moment of gyration of compression zone of a cross-section
i_c	= radius of gyration of the compression zone of a cross-section, i.e. $\sqrt{I_c/A_c}$
K_c	= factor for maximum AAC bearing strength depending on the bond class
K_1	= reduction factor for reduced AAC cover
K_2	= spacing factor of fitments
K_3	= factor taking into account the type of fitments

k	= coefficient for minimum reinforcement which takes into account the nature of the stress distribution
	= column factor
	= factor relating the compressive and tensile strains in bending
	= distribution coefficient for calculation of deflections
k_h	= factor used to calculate bending capacity
k_n	= factor used to calculate the depth to the neutral axis in bending
	= depth to the neutral axis from the compression face/effective depth
	= x/d
k_s	= column factor
k_w	= welding strength factor
k_1	= factor for the support strength
	= reduction factor for the design bond strength taking into account geometrical influences
k_2	= reduction factor for long-term and temperature effects
L	= span length between the centre points of the supports
l	= span length
l_b	= basic anchorage length of reinforcement
$l_{b,net}$	= required anchorage length of reinforcement
$l_{h,eff}$	= effective horizontal length of a wall or pier
l_{hs}	= horizontal length of a support in a plane of a wall
l_{ht}	= horizontal length of a (stiffening) transverse wall
$l_{k,test}$	= length of the member in function testing
l_s	= shear span
l_w	= height of a wall measured between centres of restraint
l_0	= effective length of a member (with respect to buckling)
M	= mean ultimate bending capacity of a test sample
M_i	= mean ultimate bending capacity of a test specimen
M_k	= declared characteristic bending capacity
	= calculated characteristic bending capacity
M_{cr}	= moment that will initiate cracking
M_s	= mean serviceability bending capacity of a test sample
M_{si}	= serviceability bending capacity of a test specimen
M_{sk}	= declared characteristic serviceability bending capacity
	= calculated characteristic serviceability bending capacity
M^*	= bending moment due to the total design load
M_a^*	= bending moment at the section concerned due to a horizontal displacement a_1
M_f^*	= bending moment due to the most frequent combination of loads

M_h^*	= bending moment due to horizontal actions
M_l^*	= bending moment due to transverse load
m	= factor for consideration of existing transverse compression in the anchorage zone
N	= mean ultimate axial capacity of a test sample
N_i	= mean ultimate axial capacity of a test specimen
N_k	= declared characteristic axial capacity = calculated characteristic axial capacity (compressive positive)
N^*	= axial force due to the total design load (compression positive)
n	= number (e.g. test results) = modular ratio (E_s/E_c)
n_p	= number of welded transverse bars available for anchorage within the zone of transverse compression
n_t	= number of welded transverse bars in the anchorage zone
p, p_I, p_{II}	= parameters
q_p	= sum of permanent and quasi-permanent loads
q_v	= sum of variable loads
r	= radius of curvature due to bending moment = coefficient for the calculation of effective height of door or window piers
r_{c0}	= radius of loaded area
r_{c1}	= radius of maximum distribution area
s	= spacing of shear reinforcement = spacing of vertical fitments = spacing of inclined shear reinforcement measured along the longitudinal axis of a member
s_{11}	= centre distance of the bars of longitudinal tensile reinforcement
s_{12}	= centre distance of the bars of required compressive reinforcement
s_s	= spacing of shear reinforcement along the longitudinal axis of the member
s_t	= centre distance of transverse reinforcing bars
$s_{t,min}$	= minimum centre distance of transverse reinforcing bars
T_{k1}	= resisting torsional moment of a section without torsional reinforcement
T_{k3}	= resisting torsional moment of a section with torsional reinforcement
T_k	= characteristic torsional resistance
T^*	= torsional moment
t_t	= total effective length of transverse anchorage bars
V	= volume of member
V	= mean ultimate shear capacity of a test sample
V_i	= mean ultimate shear capacity of a test sample

V_k	= declared characteristic shear capacity
	= calculated characteristic shear capacity
V_{k1}	= characteristic shear resistance of a section without shear reinforcement
V_{k2}	= characteristic shear force that can be carried without crushing of the notional concrete compressive struts
V_{k3}	= characteristic shear resistance of a section with shear reinforcement
V_{k4}	= characteristic in-plane shear resistance
V_{cd}	= contribution of the concrete to shear resistance
V_d	= characteristic loadbearing capacity in shear of a joint
V_{pk}	= declared characteristic punching shear capacity
	= calculated characteristic punching shear capacity
V_k	= declared characteristic value of shear capacity
V_{wd}	= contribution of shear reinforcement to shear resistance
V^*	= shear force per unit of length
	= shear force
v	= reduction factor for the design compressive strength of AAC used for the calculation of maximum design shear force (V_{k2}) that can be carried without crushing of the notional concrete compressive struts
W_T	= section modulus for torsion
$\bar{x}$	= mean value of the compressive strength of a test series
$x_{\min}$	= minimum individual value of the compressive strength of a test series
y_{el}	= short-term deflection
y_k	= deflection under total design load, assuming a section stiffness of $(EI)_k$
y_v	= instantaneous deflection caused by variable load
y_0	= camber due to prestress
y_1	= instantaneous deflection due to loads occurring before construction of adjoining members, assuming a section in the uncracked state and $E = E_{cm}$
y_{∞}	= long-term deflection under the quasi-permanent combination of loading
z	= lever arm of internal longitudinal forces
α	= a factor defining the compressive force in the AAC
α_c	= factor accounting for long-term reduction of compressive strength due to sustained and/or unfavourable loading, and shall be taken as 0.85
α_s	= angle of shear reinforcement with the longitudinal axis
β	= coefficient for the determination of effective height of a wall or pier, depending on the stiffness of lateral support
	= factor defining the distance of the force in the AAC from the extreme compressive fibre
	= reduction factor to account for the reduction of shear force close to a support
γ_c	= partial factor for AAC
γ_{comp}	= partial factor for component

γ_F	= partial factor for actions
γ_M	= partial factor for material properties
γ_n	= multiplication factor for the partial factor γ_c for AAC
γ_s	= partial factor for reinforcing steel
ε_c	= strain of AAC
$\varepsilon_c(t_0)$	= initial (elastic) strain of AAC
ε_{cc}	= creep strain of AAC
ε_{cfl}	= flexural (tensile or compressive) strain of AAC at the opposite side of ε_c
ε_{cflu}	= ultimate flexural strain of AAC in the tensioned zone
ε_{su}	= elongation of reinforcing steel at maximum load
ε_{suk}	= characteristic elongation of the reinforcing steel at maximum load
ε_{syfl}	= tensile or compressive strain of the reinforcing steel at the opposite side of ε_c
ε_{yd}	= design yield strain of reinforcing steel
ε_0	= short-term prestrain
η_d	= conversion factor for design by testing
θ	= angle of concrete struts with the longitudinal axis
κ	= curvature
	= coefficient for determination of 'effective' elastic modulus and 'effective' flexural tensile strength of AAC
	= factor taking into account increased strength of partially loaded areas
λ	= factor describing the compressive stress block in bending
λ_{10dry}	= thermal conductivity in the dry state at a mean test temperature of 10°C
λ_d	= design thermal conductivity in the moist state, at a moisture content μ_m
μ	= design coefficient of friction
μ_m	= mass related moisture content
ρ	= dry density of AAC
$\rho_{d,inf}$	= design value of the density of AAC members (including reinforcement) in the moist state, in case weight acts favourably
$\rho_{d,sup}$	= design value of the density of AAC members (including reinforcement) in the moist state, in case weight acts unfavourably
ρ_k	= characteristic dry density of AAC (95% – quantile)
ρ_m	= mean value of the dry density of AAC
ρ_{sound}	= density to be used for the determination of acoustic behaviour
$\rho_{T,l}$	= reinforcement ratio of the longitudinal reinforcement resisting torsion
$\rho_{T,s}$	= reinforcement ratio of fitments resisting torsion
$\rho_{thermal}$	= density to be used for the determination of thermal properties
ρ_{trans}	= density to be used for calculation of transportation weight of AAC members
ρ_l	= reinforcement ratio

φ_a	= factor used to reduce a characteristic value to give an approximate design shear force
σ_c	= stress of AAC
σ_{cd}	= edge stress of AAC on the compressive side
σ_d	= compressive stress
σ_{sld}	= tensile stress in the longitudinal torsion reinforcement
σ_{swd}	= tensile stress in shear reinforcement
σ_{td}	= design edge stress on the tensile side
τ_k	= characteristic shear strength of ACC
φ	= final creep coefficient
ϕ_d	= diameter of a circular loaded area
ϕ_{sl}	= diameter of a longitudinal bar
ϕ_{sw}	= diameter of a fitment
ϕ_t	= diameter of transverse bars in the anchorage zone
$d_{b,eff}$	= declared effective outer diameter of the transverse bar with corrosion protection coating
$d_{b,m}$	= measured mean outer diameter of the transverse bar with corrosion protection coating
φ_α	= factor used to reduce a characteristic value to give an approximate design shear force, for purposes of determining whether or not the characteristic capacity should be calculated on the basis of including shear reinforcement or torsional shear reinforcement (see Clause 4.3.2(b)(ii))

1.5 INFORMATION TO BE PROVIDED IN DESIGN DOCUMENTS

Design documents showing the following information shall be available in accordance with AS 5146.1:

- (a) Characteristic properties of the Reinforced AAC members, including the following:
 - (i) Designation and size of each principal Reinforced AAC member, including the following:
NOTE: For example, this requirement applies to the length, thickness and width of the principal Reinforced AAC panels, but not to make-up pieces.
 - (ii) Characteristic bending capacity (kN.m per metre width of each type of member) subject to uniform out-of-plane bending moment.
 - (iii) Characteristic shear capacity (kN per metre width of each type of member) subject to uniform out-of-plane shear.
 - (iv) Characteristic axial load capacity (kN per metre width of each type of member) subject to uniform axial concentric compression.
 - (v) Characteristic basic shear strength (kN of each type of member) subject to uniform out-of-plane punching load.

- (vi) FRLs (minutes/minutes/minutes of each type of member) subject to the conditions of a loadbearing fire test in accordance with AS 1530.4 and the specified method of installation.

NOTE: The test conditions defined by AS 1530.4 for determining FRLs of a Reinforced AAC member are more adverse than the conditions likely to occur in practice. For Reinforced AAC members that are non-loadbearing and supported at centres closer than 3.0 m, higher FRLs for structural adequacy may be predicted using this Standard.

- (vii) Other structural capacities relevant to the particular design.
 - (viii) Limitations on cutting and holes.
- (b) Characteristic properties of the AAC and reinforcement, including the following:
- (i) AAC mean dry density or density class.
 - (ii) AAC characteristic compressive strength or compressive strength class.
 - (iii) Longitudinal steel reinforcement details, including number of bars, bar diameter, yield strength, location, cover and coating.
 - (iv) Transverse steel reinforcement details, including number of bars, bar diameter, yield strength, location, cover and coating.

SECTION 2 MATERIAL AND MEMBER PROPERTIES

2.1 GENERAL

2.1.1 Determination of properties

The characteristic properties of AAC, reinforcement and Reinforced AAC shall be determined by calculation or by test, as set out in this section.

NOTES:

- 1 Design requirements for structures incorporating reinforced autoclaved aerated concrete members are set out in AS 5146.1.
- 2 The properties of customized members for incorporation into structures, in a manner requiring particular design and detailing, are determined in accordance with Sections 3, 4, 5, 6 and 7.

2.1.2 Mean properties

Unless specified otherwise, the dimensions, densities and FRLs of Reinforced AAC members shall be reported as mean values, determined with 50 percent confidence (i.e. the best estimate). The mean values shall be determined in accordance with Appendix A.

2.1.3 Characteristic strengths

Unless specified otherwise, the strengths of AAC, reinforcement and Reinforced AAC members shall be reported as 95 percentile characteristic strengths, determined with at least 75 percent confidence, in accordance with Appendix B.

NOTE: AS 5146.1 specifies the relevant capacity reduction factors to be applied to the characteristic values for purposes of ultimate limit state and serviceability limit state design of particular structures.

2.2 AAC DENSITY

The mean dry density of the AAC component of Reinforced AAC members shall be determined by test in accordance with either—

- (a) Appendix C; or
- (b) EN 678.

2.3 AAC CHARACTERISTIC COMPRESSIVE STRENGTH

The characteristic compressive strength of the AAC component of Reinforced AAC members shall be determined by test in accordance with either—

- (a) Appendix D; or
- (b) EN 679.

2.4 AAC CHARACTERISTIC FLEXURAL STRENGTH

The characteristic flexural strength of the AAC component of Reinforced AAC members shall be determined—

- (a) by calculation of a default value in accordance with Section 3 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix E; or
 - (ii) EN 1351.

2.5 AAC MODULUS OF ELASTICITY

The mean static elastic modulus of the AAC component of Reinforced AAC members shall be determined—

- (a) by calculation in accordance with Section 3 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix F; or
 - (ii) EN 1352.

2.6 AAC CREEP

The mean value for creep of the AAC component of Reinforced AAC members under sustained static compressive load shall be determined—

- (a) by calculation in accordance with Section 3 of this Standard; or
- (b) by test in accordance with, either—
 - (i) Appendix G; or
 - (ii) EN 1355.

2.7 AAC MOISTURE CONTENT

The mean value for the moisture content of the AAC component of Reinforced AAC members shall be determined by test in accordance with either—

- (a) Appendix H; or
- (b) EN 1353.

2.8 AAC DRYING SHRINKAGE

The mean drying shrinkage of the AAC component of Reinforced AAC members shall be determined—

- (a) by calculation in accordance with Section 3 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix I; or
 - (ii) EN 680.

2.9 AAC THERMAL EXPANSION

The mean thermal expansion of the AAC component of Reinforced AAC members shall be determined in accordance with Section 3 of this Standard.

2.10 AAC FREEZE-THAW PROPERTIES

The mean loss of density and compressive strength of the AAC component of Reinforced AAC members due to free-thaw conditions shall be determined by test in accordance with either—

- (a) Appendix J; or
- (b) EN 15304.

2.11 STEEL REINFORCEMENT STRENGTHS AND ELONGATION

The characteristic yield strength, ultimate tensile strength and elongation at rupture of the steel reinforcement component of Reinforced AAC members shall be determined by test in accordance with AS/NZS 4671.

2.12 DIMENSIONS OF REINFORCED AAC MEMBERS

The dimensions of Reinforced AAC members shall be determined by measurement in accordance with Appendix A and either—

- (a) Appendix K; or
- (b) EN 991.

2.13 CORROSION PROTECTION OF STEEL REINFORCEMENT

Corrosion protection of the steel reinforcement is provided by the coating applied to the reinforcement, as follows:

- (a) Steel shall be free from corrosion prior to coating.

This shall be determined by test in accordance with either—

- (i) Appendix L and M; or
 - (ii) EN 990 and EN 15361.
- (b) Corrosion protection shall provide total protection to the steel reinforcement.
- (c) Corrosion protection shall be compatible with all surrounding materials.

NOTE: This standard assumes that there is no bond between the reinforcement coating and the AAC. Should bond occur additional protection of the AAC may be required.

2.14 STRENGTH OF WELDED JOINTS IN STEEL REINFORCEMENT

The characteristic strengths of welded joints in the steel reinforcement component of Reinforced AAC members shall be determined by test in accordance with either—

- (a) Appendix N and Appendix O; or
- (b) EN 1737 and EN 1738.

2.15 CHARACTERISTIC BENDING CAPACITY OF REINFORCED AAC MEMBERS

The characteristic bending capacity of Reinforced AAC members shall be determined—

- (a) by calculation in accordance with Section 4 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix P; or
 - (ii) EN 1356.

2.16 CHARACTERISTIC OUT-OF-PLANE SHEAR CAPACITY OF REINFORCED AAC MEMBERS AND JOINTS

The characteristic out-of-plane shear capacity of Reinforced AAC members and joints shall be determined—

- (a) by calculation in accordance with Section 4 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix Q; or
 - (ii) EN 1741.

2.17 CHARACTERISTIC IN-PLANE SHEAR CAPACITY OF REINFORCED AAC MEMBERS

The characteristic in-plane shear capacity of Reinforced AAC members shall be determined—

- (a) by calculation in accordance with Section 4 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix R; or
 - (ii) EN 1739.

2.18 CHARACTERISTIC IN-PLANE SHEAR CAPACITY BETWEEN LAYERS OF REINFORCED AAC MEMBERS

The characteristic in-plane shear capacity between layers of multilayered Reinforced AAC members shall be determined—

- (a) by calculation in accordance with Section 4 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix S; or
 - (ii) EN 1742.

2.19 CHARACTERISTIC PUNCHING SHEAR CAPACITY OF REINFORCED AAC MEMBERS

The characteristic punching shear capacity of Reinforced AAC members shall be determined—

- (a) by calculation in accordance with Section 4 of this Standard; or
- (b) by test in accordance with Appendix T.

2.20 CHARACTERISTIC AXIAL LOAD CAPACITY OF REINFORCED AAC MEMBERS

The characteristic axial load capacity of Reinforced AAC members shall be determined—

- (a) by calculation in accordance with Section 4 of this Standard; or
- (b) by test in accordance with either—
 - (i) Appendix U; or
 - (ii) EN 1740.

2.21 FIRE RESISTANCE LEVELS (FRLs) OF REINFORCED AAC MEMBERS

The FRLs of Reinforced AAC shall be determined—

- (a) by calculation in accordance with Section 6 and Appendix V; or
- (b) by test in accordance with AS 1530.4.

2.22 AAC THERMAL CONDUCTIVITY AND THERMAL RESISTANCE

The mean thermal conductivity and thermal resistance of Reinforced AAC shall be determined—

- (a) by calculation in accordance with Section 7 of this Standard; or
- (b) by test in accordance with AS/NZS 4859.1, ISO 8302 and ISO 10456.

2.23 AAC SOUND ATTENUATION

The sound attenuation properties of Reinforced AAC shall be determined—

- (a) by test in accordance with AS ISO 140.6, AS/NZS ISO 717.1 and AS ISO 717.2; or
- (b) by test in accordance with AS 2702 for the sound absorption of road traffic noise by barriers.

SECTION 3 DETERMINATION OF AAC AND REINFORCEMENT PROPERTIES BY CALCULATION

3.1 GENERAL

Where the properties of AAC and reinforcement are determined by calculation, the relevant requirements of this section shall apply.

3.2 AAC DENSITY

3.2.1 General

The mean dry density of the AAC component of Reinforced AAC members shall be—

- (a) determined by test in accordance with Clause 2.2; and
- (b) declared as a mean dry density or as a density class.

3.2.2 Declared mean dry density

Where declared, the mean dry density shall conform with the following:

- (a) The mean dry density of any test sample shall be within $\rho_{m,g} \pm \Delta\rho_g$.
- (b) The dry density of any individual test specimen shall be within $\rho_{m,g} \pm 15\%$

where

$\rho_{m,g}$ = declared mean value of the dry density

$\Delta\rho_g$ = declared tolerance of the dry density (not more than 10%)

3.2.3 Declared density class

Where declared, the density class shall conform with the following:

- (a) The mean dry density of any sample shall be greater than the corresponding lower limit given in Table 3.2.3.
- (b) The mean dry density of any sample shall be not greater than the corresponding upper limit given in Table 3.2.3.
- (c) The dry density of any individual test specimen shall not be more than 25 kg/m³ outside the range defined by the upper and lower limits.

TABLE 3.2.3
DECLARED DENSITY CLASS

Declared density class	Mean dry density (ρ_m), kg/m ³		
	Lower limit	Average dry density	Upper limit
300	250	275	300
350	300	325	350
400	350	375	400
450	400	425	450
500	450	475	500
550	500	525	550
600	550	575	600
650	600	625	650
700	650	675	700
750	700	725	750
800	750	775	800
850	800	825	850
900	850	875	900
950	900	925	950
1000	950	975	1000

3.2.4 Density for structural design

The density of AAC for use in determining structural design actions shall be derived using the following equations:

$$\rho_{d,\text{sup}} = \rho_{d,\text{sup}} = (\rho_{m,g} + \Delta\rho_g) \times \left(1 + \frac{\mu_m}{100}\right) + \frac{m_s}{V} \quad \dots 3.2.4(1)$$

$$\rho_{d,\text{inf}} = \rho_{d,\text{inf}} = (\rho_{m,g} - \Delta\rho_g) \times \left(1 + \frac{\mu_m}{100}\right) + \frac{m_s}{V} \quad \dots 3.2.4(2)$$

where

$\rho_{d,\text{sup}}$ = design value of the density of the AAC members (including reinforcement) in the moist state (moisture content μ_m), in case weight acts unfavourably, in kilograms per cubic metre

$\rho_{d,\text{inf}}$ = design value of the density of the AAC members (including reinforcement) in the moist state (moisture content μ_m), in case weight acts favourably, in kilograms per cubic metre

$\rho_{m,g}$ = declared mean value of dry density of AAC, in kilograms per cubic metre

$\Delta\rho_g$ = declared tolerance of dry density of AAC, in kilograms per cubic metre

μ_m = expected mass related moisture content of AAC under service conditions, as a percentage

m_s = mass of reinforcement, in kilograms

V = volume of member, in cubic metres

In the case of declared density class, the expression $(\rho_{m,g} + \Delta\rho_g)$ shall be taken as the upper limit and the expression $(\rho_{m,g} - \Delta\rho_g)$ as the lower limit of the mean dry density (ρ_m), as specified in Table 3.2.3.

3.2.5 Density for determining thermal properties

The thermal properties shall be derived from the declared mean dry density or the average value of the declared density class.

NOTE: The presence of moisture in the AAC affects the thermal conductivity and thermal resistance. This Standard provides the method for determining the thermal conductivity for AAC at its dry density, and converting this to the thermal conductivity for density at the ambient moisture content, which may then be used to determine the ambient thermal resistance of a member.

3.2.6 Density for determining sound attenuation properties

The acoustic properties shall be derived from the declared mean dry density or the average value of the declared density class.

NOTE: The presence of moisture in the AAC affects the acoustic properties.

3.2.7 Density for determining transport and construction loads

The gravitational design actions for transport, lifting and placement of Reinforced AAC members shall be those derived using the density for transport (ρ_{trans}) as follows:

$$\rho_{\text{trans}} = 1.4\rho_{\text{m,g}} + \rho_{\text{reinf}} \quad \dots 3.2.7$$

where

ρ_{trans} = density of Reinforced AAC for transport, lifting and placement, in kg/m³

$\rho_{\text{m,g}}$ = declared dry density or the 'average dry density' from Table 3.2.3

ρ_{reinf} = for members other than beams, 40 kg/m³; or
for beams, a value determined by calculation for the mass of reinforcement specified in the design

NOTE: For temporary loading in wind uplift situations, the mean dry density of the AAC panel, ignoring the mass of steel reinforcement, should be used.

3.3 AAC CHARACTERISTIC COMPRESSIVE STRENGTH

3.3.1 General

The characteristic compressive strength of the AAC component of Reinforced AAC members shall be—

- (a) determined by test in accordance with Clause 2.3; and
- (b) declared as a characteristic compressive strength or as a compressive strength class.

3.3.2 Declared characteristic compressive strength

Where declared, the characteristic compressive strength of AAC (f_{ck}) shall be the value exceeded by 95 percent of the compressive strengths of any sample, with a confidence level of 75 percent.

3.3.3 Declared compressive strength class

Where declared, the compressive strength class of AAC shall conform with the following:

- (a) The characteristic compressive strength of all tested specimens shall be not less than the declared compressive strength class given in Table 3.3.3.
- (b) The mean compressive strength of any sample of three specimens shall be not less than 0.9 times the declared compressive strength class given in Table 3.3.3.

NOTE: There is no maximum limit on the characteristic compressive strength calculated from the test results for any particular declared compressive strength class.

TABLE 3.3.3
DECLARED COMPRESSIVE STRENGTH
CLASS

Declared compressive strength class	Lower limit of characteristic compressive strength (f_{ck}), MPa
AAC 1.5	1.5
AAC 2	2.0
AAC 2.5	2.5
AAC 3	3.0
AAC 3.5	3.5
AAC 4	4.0
AAC 4.5	4.5
AAC 5	5.0
AAC 6	6.0
AAC 7	7.0
AAC 8	8.0
AAC 9	9.0
AAC 10	10.0

3.4 AAC CHARACTERISTIC FLEXURAL STRENGTH AND CHARACTERISTIC TENSILE STRENGTH

The characteristic flexural strength and characteristic tensile strength of AAC shall be the value, in MPa, exceeded by 95 percent of the AAC with a confidence level of 75 percent.

When determined by calculation, the following applies:

- (a) The 5% characteristic flexural strength ($f_{cflk\ 0.05}$) shall be taken as $0.18f_{ck}$.
- (b) The 5% characteristic tensile strength ($f_{ctk\ 0.05}$) shall be taken as $0.10f_{ck}$.
- (c) The 50% mean flexural strength (f_{cflm}) shall be taken as $0.27f_{ck}$.
- (d) The 50% mean tensile strength (f_{ctm}) shall be taken as $0.17f_{ck}$.
- (e) The 95% quantile flexural strength ($f_{cflk\ 0.95}$) shall be taken as $0.36f_{ck}$.
- (f) The 95% quantile tensile strength ($f_{ctk\ 0.95}$) shall be taken as $0.24f_{ck}$.

3.5 AAC MODULUS OF ELASTICITY AND POISSON'S RATIO

3.5.1 General

When determined by calculation, the mean static elastic modulus of AAC in compression shall be determined from the idealized stress-strain relationship specified in Clause 3.5.2.

3.5.2 Stress-strain relationship

The compressive strain and compressive stress shall be related as follows:

$$f_c = E_c \varepsilon_c \text{ for strains from zero to } -0.002 \quad \dots 3.5.2(1)$$

and

$$f_c = \frac{\alpha_c f_{ck}}{\gamma_c} \text{ for strains between } -0.002 \text{ and } -0.003 \quad \dots 3.5.2(2)$$

where

f_c = stress in the AAC

E_c = elastic modulus of AAC for strains from zero to -0.002

ε_c = strain in the AAC

f_{ck} = characteristic design compressive strength of AAC

α_c = factor accounting for long-term reduction of compressive strength due to sustained and/or unfavourable loading, and shall be taken as 0.85

γ_c = factor accounting for the difference in reliability between AAC and steel reinforcement, and shall be taken as 1.25 for ductile bending failure and 1.5 for brittle failure

3.5.3 Static elastic modulus

The static elastic modulus of the AAC shall conform with the following:

- (a) The mean static elastic modulus of any test sample shall be within $E_{cm,g} \pm \Delta E_g$.
- (b) The static elastic modulus of any individual test specimen shall be within $E_{cm,g} \pm 20\%$

where

$E_{cm,g}$ = declared mean value of the static elastic modulus

ΔE_g = declared tolerance of the static elastic modulus

In the absence of test results, the mean value of the static elastic modulus shall be obtained using the following equation:

$$E_{cm} = 5(\rho_m - 150) \quad \dots 3.5.3$$

where

E_{cm} = mean value of the elastic modulus of AAC, in MPa

ρ_m = mean value of the dry density of AAC, in kilograms per cubic metre

3.5.4 Poisson's ratio

Poisson's ratio shall be taken as—

- (a) 0.2 in the range of elastic strain; and
- (b) zero where cracking is permitted.

3.6 AAC CREEP

3.6.1 General

When declared, the creep coefficient of AAC under sustained static compressive load shall be declared as a creep coefficient or as a creep class.

3.6.2 Creep coefficient

When declared, the creep coefficient $\varphi(t_0, \infty)$ shall conform with one of the following:

- (a) Where test data is not available, $\varphi(t_0, \infty) = 1.0$.
- (b) Where test data is available, $\varphi(t_0, \infty)$ shall be determined as follows:

$$\begin{aligned} \varphi(t_0, \infty) &= (t_0, t) \text{ where the data is extrapolated to } t = \infty \\ \varphi(t_0, t) &= \frac{\varepsilon_{cc}(t_0, t)}{\varepsilon_c(t_0)} \quad \dots 3.6.2 \end{aligned}$$

where

$\varepsilon_{cc}(t_0, t)$ creep strain from time t_0 until time, t (where t is taken as ∞ for declared creep coefficients)

$\varepsilon_c(t_0)$ initial (elastic) strain at a given time t_0

3.6.3 Declared creep class

When declared, the creep class shall conform with the following:

- The mean value of creep coefficient of any test sample shall be within $\phi(t_0, \infty)$ as shown in Table 3.6.3 + 10%.
- The calculated final creep coefficient of any individual test specimen shall be within $\phi(t_0, \infty)$ as shown in Table 3.6.3 + 20%.

TABLE 3.6.3
DECLARED CREEP CLASS

Declared creep class [$\phi(t_0, \infty)$]	Mean creep coefficient [$\phi(t_0, \infty)$]	
	Lower limit	Upper limit
0.5	0.4	0.5
0.6	0.5	0.6
0.7	0.6	0.7
0.8	0.7	0.8
0.9	0.8	0.9
1.0	0.9	1.0

3.7 AAC DRYING SHRINKAGE

3.7.1 General

When declared, the mean drying shrinkage of the AAC component of Reinforced AAC shall be declared as a shrinkage coefficient or as a shrinkage class.

3.7.2 Declared shrinkage coefficient

When declared, the shrinkage coefficient (ε_{cs}), shall be taken as $0.5\varepsilon_{cs,tot}$, where $\varepsilon_{cs,tot}$ = total value of drying shrinkage of the AAC.

NOTES:

- The reduction factor, 0.5, accounts for the dimensional changes of whole Reinforced AAC members due to drying shrinkage or wetting swelling, considering change in moisture content, size of the members and amount and position of reinforcement.
- ε_{cs} = drying shrinkage coefficient.
 $\varepsilon_{cs,tot}$ = total value of the drying shrinkage.
 ε_{csF} = the value of the final shrinkage used in design.
 S = notional size of the AAC member = $2 A_c/u$ (Clause 3.7.4).
 u = perimeter of an AAC member in contact with atmosphere.
 R = relative humidity (RH), in the range of 50% to 80%.

3.7.3 Declared shrinkage class

When declared the shrinkage class shall conform with the following:

- The declared shrinkage class shall be in accordance with Table 3.7.3.
- The mean value of creep coefficient of any test sample of AAC shall be not greater than twice the declared shrinkage class.

TABLE 3.7.3
DECLARED SHRINKAGE CLASS

Declared shrinkage class (ϵ_{cs})	Mean shrinkage coefficient ($0.5\epsilon_{cs,tot}$)
	Upper limit
0.15	0.15
0.20	0.20
0.25	0.25
0.30	0.30
0.35	0.35
0.40	0.40

3.7.4 Final shrinkage used in design

The value of final shrinkage used for the design of Reinforced AAC members (ϵ_{csF}) shall be determined in accordance with Equation 3.7.4:

$$\epsilon_{csF} = 0.3 - 0.001S + (R-50)(-0.125 + 0.0005S)/30 \quad \dots 3.7.4$$

where

S = notional size

= $2 A_c/u$, in the range of 50 to 150, as given in Table 3.7.4

A_c = cross-sectional area of an AAC member

u = perimeter of an AAC member in contact with atmosphere

R = relative humidity (RH), in the range of 50% to 80%

NOTE: Table 3.7.4 conforms with Equation 3.7.4.

TABLE 3.7.4
FINAL SHRINKAGE USED IN DESIGN

Relative humidity (RH) %	Final shrinkage used in design, %	
	Notional size $2 A_c/u$	
	50	150
50	0.25%	0.15%
80	0.15%	0.10%

A_c = the cross-sectional area of AAC member.

u = the perimeter of AAC member in contact with atmosphere.

NOTE: Linear interpolation may be used.

3.8 AAC THERMAL EXPANSION

The mean thermal expansion of Reinforced AAC shall be taken as $8 \times 10^{-6}/K$.

3.9 STEEL REINFORCEMENT PROPERTIES

The characteristic yield strength, ultimate tensile strength and elongation at rupture of the steel reinforcement component of Reinforced AAC members shall be—

- (a) determined by test in accordance with Clause 2.11; or
- (b) determined from the idealized stress-strain relationship of steel reinforcement in tension, taken as linearly proportional to stress up to the characteristic yield strength or characteristic 0.2% proof stress of the steel using the following equation:

$$f_s = E_s \varepsilon_s, \text{ for stresses from zero to } f_{yk} \quad \dots 3.9$$

where

f_s = stress in the steel

ε_s = strain in the steel

f_{yk} = characteristic yield strength of the steel

E_s = elastic modulus of the steel

SECTION 4 DETERMINATION OF REINFORCED AAC MEMBER ULTIMATE CAPACITIES BY CALCULATION

4.1 GENERAL

4.1.1 Determination and reporting of capacities

Where the characteristic capacities of Reinforced AAC members are determined by calculation, the relevant requirements of this section shall apply.

This section applies to the calculation of the characteristic capacities of—

- (a) mass-produced Reinforced AAC members; and
- (b) custom-designed Reinforced AAC members.

4.1.2 Ductility—Compatibility of structures and Reinforced AAC members

The ductility of Reinforced AAC members shall be compatible with the ductility requirement of the structures into which they are incorporated.

4.1.3 Limited use of non-ductile Reinforced AAC members

Reinforced AAC members, whose bending capacity is achieved as a result of non-ductile (brittle) behaviour, shall not be used in structures where the flexural behaviour of the members is required to be ductile.

NOTE: See Clause 4.2.5(b)(ii) for bending capacity of reinforced AAC members achieved as a result of non-ductile (brittle) behaviour.

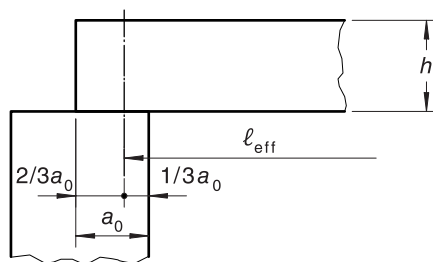
4.1.4 Ductile Reinforced AAC members

Reinforced AAC members shall be ductile in the following applications:

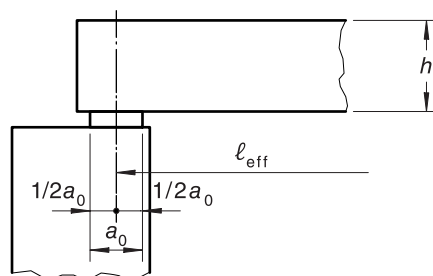
- (a) Reinforced AAC floors.
- (b) Reinforced AAC beams and lintels.
- (c) Reinforced AAC walls or columns that form part of the horizontal load-resisting structure.

4.1.5 Effective span

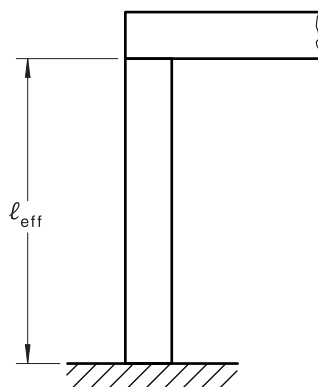
The effective span of Reinforced AAC members in bending or compression shall be in accordance with Figure 4.1.5.



(a) Horizontal AAC component supported without bearing pad



(b) Horizontal AAC component supported with bearing pad



(c) Vertical AAC component

LEGEND:

- a_0 Support length
- h Slab thickness
- l_{eff} Effective span

FIGURE 4.1.5 EFFECTIVE SPAN OF REINFORCED AAC MEMBERS IN BENDING OR COMPRESSION

4.1.6 Second order effects and deformations

Second order effects and deformations shall be determined using the design value of the dimensions and the mean values of the relevant material properties.

4.1.7 Strain compatibility in steel reinforcement and surrounding AAC

If AAC and longitudinal reinforcement act together to resist design actions, the strain in the reinforcement shall be taken to be the same as the strain in the surrounding AAC.

4.1.8 Bond between steel reinforcement and adjacent AAC to be ignored

Any bond between the steel reinforcement and adjacent AAC shall be ignored when determining the structural capacities of Reinforced AAC members. All requisite anchorage shall be provided by the incorporation of transverse reinforcement welded to the longitudinal reinforcement.

4.1.9 Effective diameter of coated transverse reinforcement

When determining anchorage capacity by calculation, the diameter of coated transverse reinforcement shall be taken as the measured mean outer diameter of the transverse reinforcement including its corrosion protection coating ($d_{b,m}$), provided

$$d_{b,m} \geq d_{b,eff} \quad \dots 4.1.9$$

where

$d_{b,eff}$ = measured mean outer diameter of the transverse bar with corrosion protection coating

$d_{b,eff}$ = declared effective outer diameter of the transverse bar with corrosion protection coating

4.1.10 Properties of non-structural reinforcement

If required, the mechanical properties of the non-structural reinforcement shall be declared.

4.2 CHARACTERISTIC BENDING CAPACITY OF REINFORCED AAC MEMBERS

4.2.1 General

The characteristic bending capacity of Reinforced AAC members shall be determined in accordance with Clauses 4.2.2 to 4.2.5.

4.2.2 Stress-strain relationships for Reinforced AAC members

For Reinforced AAC members, the calculations for design strength of cross-sections shall be based on equilibrium and strain compatibility and shall be consistent with the following:

- (a) Plane sections normal to the axis shall be assumed to remain plane.
- (b) The tensile strength (including flexural strength) of the AAC shall be taken as zero.
- (c) For members subject to longitudinal compression across the whole of the section, the compressive strain of the AAC shall not exceed -0.002 .
- (d) For members not subject to longitudinal compression across the whole of the section, the compressive strain of the AAC shall not exceed -0.003 . At a position one-third of the depth of the section from the most compressed face, the compressive strain of the AAC shall not exceed -0.002 .
- (e) Members required to be ductile shall be proportioned such that a strain of 0.001 occurs in the tensile reinforcement before the limits on compressive strain are reached.
- (f) Longitudinal reinforcement in the compression zone shall not be considered as contributing to axial compressive capacity unless restrained to the main tensile reinforcement by fitments or the like.
- (g) Longitudinal compressive stress that does not exceed $0.08f_{ck}$ can be neglected in members designed principally to resist bending.
- (h) The bending capacities of members shall be based on the effective depth, taking into consideration any local reductions.

4.2.3 Minimum tensile reinforcement

A Reinforced AAC member shall include sufficient tensile reinforcement to ensure that there is no brittle failure at the initiation of the first crack.

The characteristic bending capacity of the cracked cross-section of the reinforced member shall be greater than the characteristic cracking bending capacity of the uncracked section, determined using the characteristic tensile strength of AAC determined in accordance with Clause 2.4.

The minimum area of tensile reinforcement necessary to achieve this shall be determined by either of the following:

- (a) A_{smin} determined as follows:

$$A_{smin} = kA_c f_{cflm} / f_{yk} \text{ for pure bending without normal compressive reinforcement; or} \quad \dots 4.2.3(1)$$

$$A_{smin} = kA_c f_{ctm} / f_{yk} \text{ for pure tension across the entire section} \quad \dots 4.2.3(2)$$

where

A_{smin} = required minimum area of tensile reinforcement

k = 1.0 for pure tension across the entire cross-section; or
0.4 for pure bending without normal compressive force

A_c = area of AAC within the tensile zone

f_{cflm} = mean flexural strength of AAC

f_{ctm} = mean flexural strength of AAC

f_{yk} = characteristic tensile strength of the reinforcement

- (b) Calculation by a more rigorous method.

4.2.4 Characteristic bending strength

The characteristic bending strength, M_k , of Reinforced AAC members shall be determined in accordance with the following:

- The maximum strain in the extreme AAC compression fibre at characteristic bending capacity shall not exceed -0.003
- The maximum strain in steel tensile reinforcement at characteristic bending capacity shall not exceed 0.005 .
- Bending moment capacity shall be provided by a couple exerted by a compressive force, $C = \alpha(\alpha_c f_{ck} / \gamma_c) \beta k_n d$, acting at a location $\beta k_n d$ from the extreme compressive fibre, and a tensile force, $T = f_s A_s$, acting at the centroid of the tensile steel reinforcement.
- Factors α and β shall be determined taking into account the proportion and position of steel reinforcement, the stresses and strains in AAC and steel reinforcement and the resulting position of the neutral axis. See also Clause 4.2.2.
- The static elastic modulus of the AAC (E_c) for characteristic bending design, for strains from zero to -0.002 , shall be taken as—

$$E_c = (\alpha_c f_{ck} / \gamma_c) / 0.002 \quad \dots 4.2.4$$

4.2.5 Characteristic bending strength without axial compression

Unless a more precise method is used, in applications where—

- (a) the compressive stress due to axial compression is less than $0.08 f_{ck}$; and

(b) compression reinforcement is not used to provide bending resistance, the characteristic bending strength of Reinforced AAC members shall be determined in accordance with the following:

(i) In applications where $0.286 < k_n \leq 0.375$

$$M_k = k_h(\alpha_c f_{ck}/\gamma_c) b d^2 \alpha k_n (1 - \beta k_n) \quad \dots 4.2.5(1)$$

(ii) In applications where brittle failure is permitted and where:

$0.375 < k_n \leq 0.545$ (for reinforcement yield stress of 500 MPa)

$0.375 < k_n \leq 0.724$ (for reinforcement yield stress of 500 MPa)

$$M_k = k_h(\alpha_c f_{ck}/\gamma_c) b d^2 \alpha_{\max} k_n (1 - \beta_{\max} k_n) \quad \dots 4.2.5(2)$$

where

M_k = characteristic bending capacity at characteristic limit state

k_h = 0.8 for member thickness less than 75 mm

= 1.0 for member thickness equal to and greater than 75 mm

α_c = factor accounting for long-term reduction of compressive strength due to sustained and/or unfavourable loading, and shall be taken as 0.85

f_{ck} = characteristic compressive strength of AAC

γ_c = factor accounting the difference in reliability between AAC and steel reinforcement, and shall be taken as 1.25 for ductile bending failure and 1.5 for brittle failure

b = width of section

d = effective depth from compression face to centroid of tensile reinforcement

k_n = factor (depth to neutral axis/effective depth) used to calculate the depth to the neutral axis, determined by considering the stress and corresponding strain in the reinforcement

= minimum of $\varepsilon_c/(\varepsilon_c + \varepsilon_s)$ and 0.724

ε_s = steel reinforcement strain

ε_c = AAC strain

k = factor relating the compressive and tensile strains in bending

= $\varepsilon_c/(\lambda \varepsilon_s)$

λ = factor describing the compressive stress block in bending

= 2 for a triangular stress distribution, 3 for parabolic stress distribution

α = factor defining the compressive force in the AAC

= $1 - (1 - k_n)\varepsilon_c/(2\varepsilon_{skn})$

$\alpha_{\max}$ = 0.667

β = factor defining the distance of the force in the AAC from the extreme compressive fibre

= $\{2k(1 - k_n)[-1 + 2k(1 - k_n)/(3kn)] + k_n\}/[2x - 2k(1 - k_n)]$

$\beta_{\max}$ = 0.361

NOTE: The determination of forces, stresses, strains, effective depth, bending factors and the resulting value of M_k may be determined iteratively for particular combinations of design actions.

4.3 CHARACTERISTIC OUT-OF-PLANE SHEAR CAPACITY OF REINFORCED AAC MEMBERS

4.3.1 General

The characteristic out-of-plane shear capacity of Reinforced AAC members of constant depth shall be determined in accordance with Clauses 4.3.2 to 4.3.6.

NOTE: When determining the out-of-plane shear forces (V^*) to be resisted by a Reinforced AAC member, loads that are applied within a distance of $x < 2.5d$ from the face of the support may be multiplied by a reduction factor (β)

$$\beta = 0.3 + 0.28x/d \leq 1 \quad \dots 4.3.1$$

where

x = distance from the point of application of the load to the face of the support

d = effective depth of the member

Where part of the out-of-plane shear force acts on a support in direct compression, the design shear force to be resisted by the section may be reduced. This reduction is ignored when checking V_{k2} .

The design shear force (V^*) due to a continuously distributed load may be evaluated at a distance (d) from the face of the support.

4.3.2 Determination of characteristic shear capacity

The characteristic shear capacity of a Reinforced AAC member shall be determined on the following basis:

- (a) Reinforced AAC beams shall include shear reinforcement, and the characteristic shear capacity determined on this basis.
- (b) The characteristic shear capacity of Reinforced AAC members other than beams shall be determined on the basis of whether or not shear reinforcement is included, based on the following:
 - (i) If shear reinforcement is not included, the characteristic shear capacity shall be limited to V_{k1} , determined in accordance with Equation 4.3.5.
Reinforced AAC members that do not include shear reinforcement shall not be used in applications where the characteristic shear capacity (V_{k1}) is less than V^*/φ_α .
 - (ii) If shear reinforcement is included, the characteristic shear capacity shall be limited to the lesser of V_{k3} and V_{k2} , determined in accordance with Equations 4.3.6.1(1) and 4.3.6.3 respectively.

where

V_{k1} = characteristic shear resistance of a section without shear reinforcement

V_{k2} = characteristic shear force that can be carried without crushing of the notional concrete compressive struts

V_{k3} = characteristic shear resistance of a section with shear reinforcement

φ_α = factor used to reduce a characteristic value to give an approximate design shear force, for purposes of determining whether or not the characteristic capacity should be calculated on the basis of including shear reinforcement or torsional shear reinforcement

$$= 0.85$$

NOTE: $\varphi_\alpha = 0.85$ corresponds to the value of capacity reduction factor, φ , given in AS 5146.1

NOTE: Reinforced AAC roof, floor and wall members and members of minor structural importance are not required to contain a specified minimum quantity of shear reinforcement unless demonstrated otherwise.

4.3.3 Extent and anchorage of longitudinal reinforcement

The longitudinal reinforcement necessary to resist transverse shear forces shall be extended in accordance with Clause 8.3.5 to provide sufficient anchorage to achieve V_{k1} and V_{k2} .

4.3.4 Minimum shear reinforcement in beams

Reinforced AAC beams shall include shear reinforcement, determined using the following equation:

$$A_{swmin} = \min[1.1 \tau_k (1 - 0.83d/1000)(1 + 240\rho_1)b_w s / (\sigma_{swd}(1 + \cot\alpha_s)\sin\alpha_s) \quad \dots 4.3.4$$

$$1.1 V^* s / (d \sigma_{swd}(1 + \cot\alpha_s) \sin\alpha_s)]$$

where

A_{swmin} = required minimum area of shear reinforcement within the length (s)

τ_k = characteristic shear strength of AAC

d = effective depth

ρ_1 = reinforcement ratio

$$= A_s / b_w d$$

b_w = minimum width of the web section

s = spacing of shear reinforcement

σ_{swd} = tensile stress in steel shear reinforcement

α_s = angle between the shear reinforcement and the longitudinal axis

V^* = design shear force

4.3.5 Members not incorporating shear reinforcement

The characteristic shear resistance (V_{k1}) for members not incorporating shear reinforcement and loaded by out-of-plane forces shall be determined using the following:

$$V_{k1} = \max \left\{ \begin{array}{l} \tau_k \left(1 - \frac{0.83d}{1000} \right) (1 + 240\rho_1) b_w d \\ 0.5 \frac{f_{ctk}}{\gamma_c} b_w d \end{array} \right\} \quad \dots 4.3.5$$

where

V_{k1} = characteristic shear resistance, in Newtons

τ_k = characteristic shear strength of AAC = $0.063 f_{ck}^{0.5} / \gamma_c$

f_{ctk} = characteristic axial tensile strength of AAC

γ_c = partial factor for brittle failure of AAC, taken as 1.0

d = effective depth of the section, in millimetres ($d \leq 400$ mm)

ρ_1 = reinforcement ratio, defined as follows:

$$A_{sl} / b_w d \leq 0.005$$

where

A_{sl} = cross-sectional area of tension reinforcement

b_w = minimum width of the section over the effective depth

4.3.6 Members incorporating design shear reinforcement

4.3.6.1 Shear resistance

The characteristic shear resistance (V_{k3}) for members incorporating shear reinforcement and loaded by out-of-plane forces shall be determined in accordance with this Clause (4.3.6.1).

The equations for inclined shear reinforcement provided in this clause are intended for fitments that are welded to the upper and lower longitudinal reinforcement.

Where the load is not acting at the top of the member, or when the support is not at the bottom of the member, suspension reinforcement shall be provided to transfer the load to the top of the member.

For shear design, the structure shall be assumed to consist of a compressive zone and a tensile zone separated by a distance equal to the internal lever arm (z). The shear zone shall have a depth equal to z and a width equal to b_w . The internal lever arm shall be calculated perpendicular to the longitudinal reinforcement.

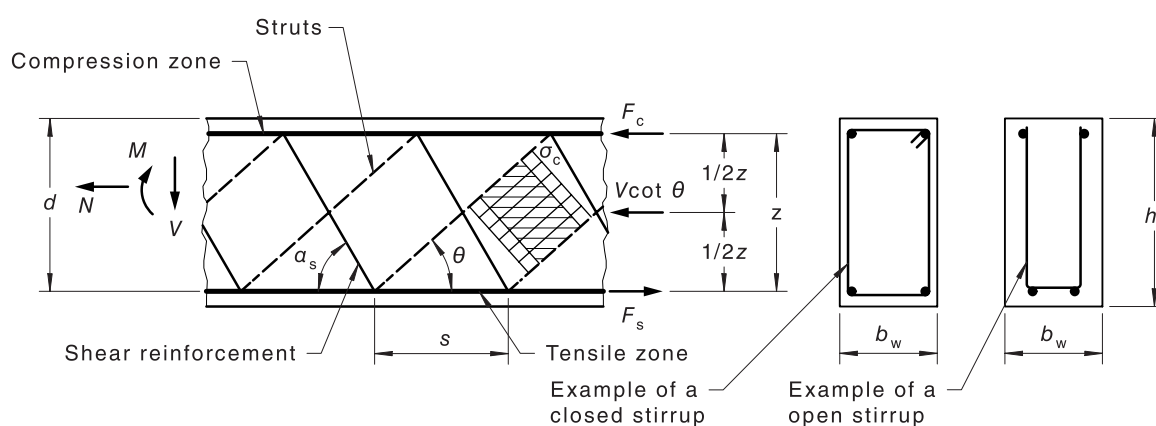


FIGURE 4.3.6.1 NOTATION FOR MEMBERS SUBJECTED TO SHEAR

The parameters given in Figure 4.3.6.1 are as follows:

- V = shear force
- M = bending moment
- N = axial force
- α_s = angle of the shear reinforcement with the longitudinal axis
- θ = angle of the AAC struts with the longitudinal axis, assumed to be 45°
- σ_c = AAC stress in the struts
- F_s = tensile force in the longitudinal reinforcement
- F_c = compression force in the AAC in the direction of the longitudinal axis
- V' = vertical component of force in shear reinforcement
- $V' \cot \theta$ = horizontal component of force in shear reinforcement
- b_w = minimum width of the section
- z = denotes, for a member with constant depth, the internal lever arm corresponding to the maximum bending moment in the member under consideration. In shear analysis, an approximate value $z = 0.9d$ can normally be used for members with a slenderness $l/h_t > 5$, where

- d = effective depth
 l = span length
 h_t = overall depth of the cross-section

The shear resistance of a section with shear reinforcement shall be determined using Equation 4.3.6.1(1):

$$V_{k3} = V_{cd} + V_{wd} \quad \dots 4.3.6.1(1)$$

where

V_{cd} = contribution of the AAC and is equal to V_{k1}

V_{wd} = contribution of the shear reinforcement

The contribution of vertical shear reinforcement shall be determined using Equation 4.3.6.1(2):

$$V_{wd} = \frac{A_{sw}}{s} z \sigma_{swd} \quad \dots 4.3.6.1(2)$$

where

A_{sw} = area of the vertical shear reinforcement in the considered cross-section

s = spacing of the shear reinforcement

σ_{swd} = tensile stress in the shear reinforcement

The contribution of inclined shear reinforcement shall be determined using Equation 4.3.6.1(3):

$$V_{wd} = \frac{A_{sw}}{s} z \sigma_{swd} (1 + \cot \alpha_s) \sin \alpha_s \leq \frac{d}{\sin \alpha_s} \sqrt{\frac{v f_{ck}}{\gamma_c} \frac{b_w \sigma_{swd} A_s}{2s}} \quad \dots 4.3.6.1(3)$$

where

A_{sw} = area of the inclined shear reinforcement in the considered cross-section

s = spacing of the shear reinforcement measured along the longitudinal axis (see Figure 4.3.6.1)

σ_{swd} = design tensile stress in the shear reinforcement

d = effective depth

b_w = minimum width of the section

f_{ck} = characteristic compressive strength of AAC

γ_c = partial factor for brittle failure of AAC, taken as 1.0

v = effectiveness factor, taking into account the reduction of compressive strength f_{ck} in the web of the member

= 0.56

4.3.6.2 Design steel stress in the shear reinforcement

The design tensile stress in shear reinforcement shall be determined using Equation 4.3.6.1(1) for closed fitments at any angle, Equation 4.3.6.1(2) for open fitments at any angle, or Equation 4.3.6.1(3) for open or closed fitments that are vertical.

$$\sigma_{\text{swd}} = \frac{250}{\gamma_s} \left(1 - 0.02 \frac{l}{d} \right) \left(1.2 - 60 \frac{A_{\text{sw}}}{sb_w} \right) \leq \frac{f_{\text{ywk}}}{\gamma_s} \leq 300 \text{ MPa, for closed fitments} \dots 4.3.6.2(1)$$

$$\sigma_{\text{swd}} = \frac{150}{\gamma_s} \left(1 - 0.02 \frac{l}{d} \right) \left(1.2 - 60 \frac{A_{\text{sw}}}{sb_w} \right) \leq \frac{f_{\text{ywk}}}{\gamma_s} \leq 300 \text{ MPa, for open fitments} \dots 4.3.6.2(2)$$

$$\sigma_{\text{swd}} = 0.45 K_1 K_2 f_{\text{co}} \frac{\phi_{\text{sl}}^2 + (K_3 \phi_{\text{sw}})^2}{\phi_{\text{sw}}^2} \leq \frac{f_{\text{ywk}}}{\gamma_s} \leq 200 \text{ MPa} \dots 4.3.6.2(3)$$

NOTE: Equations 4.3.6.2(1) and 4.3.6.2(2) give better predictions for slender beams than Equation 4.3.6.2(3).

where

l = span length

d = effective depth

f_{ywk} = characteristic yield strength of steel fitments

γ_s = partial factor for steel, taken as 1.0

f_{co} = contact stress

= $2.4 f_{\text{ck}} / \gamma_C$ for welded shear reinforcement

= f_{ck} / γ_C for non-welded shear reinforcement

f_{ck} = characteristic compressive strength of the AAC

γ_C = partial factor for brittle failure of AAC, taken as 1.0

ϕ_{sl} = diameter of the top or bottom longitudinal bars, whichever is the smallest

ϕ = diameter of the fitments

K_3 = 1 for closed fitments

= 0 for open fitments

K_1 = reduction factor for reduced AAC cover

= 1 for closed fitments

= $0.33e / \phi_{\text{sl}} \leq 1$ for open fitments

K_2 = spacing factor for fitments

= $s / \phi_{\text{sl}} \leq 14$

e = distance of the centroid of the longitudinal bars at the open ends from the adjacent side face of the AAC member

s = spacing of the fitments

4.3.6.3 Design shear resistance

The design shear resistance for crushing of the AAC in compression (V_{k2}) shall be determined using the Equation 4.3.6.3:

$$V_{k2} = b_w z v f_{ck} \gamma_c \left(\frac{\cot \theta + \cot \alpha_s}{1 + \cot^2 \theta} \right) \quad \dots 4.3.6.3$$

where

- v = effectiveness factor, taking into account the reduction of compressive strength f_{ck} in the web of the member
= 0.56 for ACC
- f_{ck} = characteristic compressive strength of the AAC
- γ_c = partial factor for brittle failure of AAC, taken as 1.0
- α_s = angle of inclined shear reinforcement to longitudinal axis
- b_w = minimum width of the section
- θ = angle of the AAC struts with the longitudinal axis, taken as 45°
(see Figure 4.3.6.1)
- z = for a member with constant depth, the internal lever arm corresponding to the maximum bending moment in the member under consideration
(see Figure 4.3.6.1)

4.4 CHARACTERISTIC BEARING CAPACITY AND PUNCHING SHEAR CAPACITY OF REINFORCED AAC MEMBERS

4.4.1 General

The characteristic bearing capacity and punching shear capacity of Reinforced AAC members shall be determined in accordance with Clauses 4.4.2 to 4.4.5.

The punching shear resistance shall be checked within the critical area.

4.4.2 Loaded area

The following method applies where—

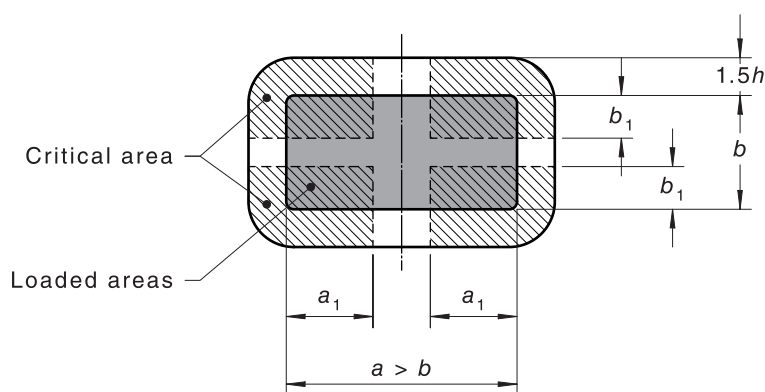
- (a) concentrated loaded areas are separated from each other such that their critical areas do not intersect; and
- (b) concentrated loaded areas are—
 - (i) circular, where the diameter of the loaded area does not exceed $3.5h$;
 - (ii) rectangular, where the perimeter of the loaded area does not exceed $11h$ and the ratio of the length to width is in the range of 2.0 to 0.5; or
 - (iii) any other shape with dimensions such that the effect is similar to either case (i) or (ii),

where—

h = the thickness of the member subject to the punching shear.

For other cases, more rigorous analysis shall be used, including the case where a rectangular concentrated load area is near an unsupported edge of a member.

NOTE: For an example of the above, see Figure 4.4.2.



$$a_1 \leq \begin{cases} a/2 \\ b \\ 2.8h - b_1 \end{cases} \quad b_1 \leq \begin{cases} b/2 \\ 1.4h \end{cases}$$

FIGURE 4.4.2 PUNCHING SHEAR IN NON-STANDARD APPLICATIONS

4.4.3 Critical perimeter

The following shall apply to the determination of the critical perimeter:

- Except where the loaded area is close to an unsupported edge or opening, the critical perimeters corresponding to circular, rectangular and tee-shaped concentrated loads shall be determined in accordance with Figure 4.4.3(A).
- Where the loaded area is close to an opening, the critical perimeter shall be determined such that the parts of the perimeter intersected by the opening are not included, as shown in Figure 4.4.3(B).
- Where the loaded area is close to an unsupported edge, the critical perimeter shall be determined such that the parts of the perimeter intersected by the free edge are not included, as shown in Figure 4.4.3(C).

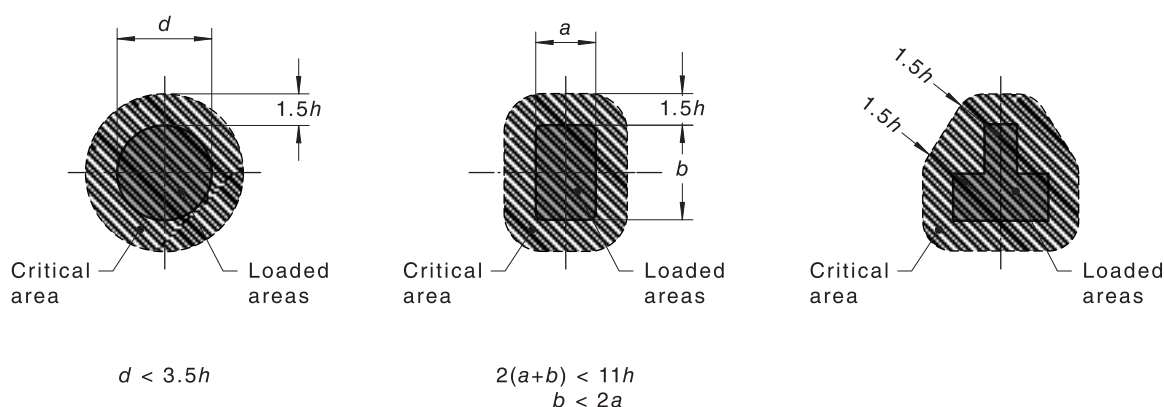


FIGURE 4.4.3(A) CRITICAL PERIMETER AT CIRCULAR, RECTANGULAR AND TEE-SHAPED CONCENTRATED LOADS (EXCEPT AT UNSUPPORTED EDGES OR OPENINGS)

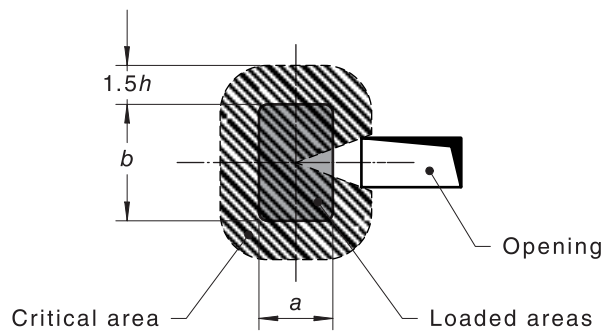


FIGURE 4.4.3(B) TYPICAL CRITICAL PERIMETER AT AN OPENING

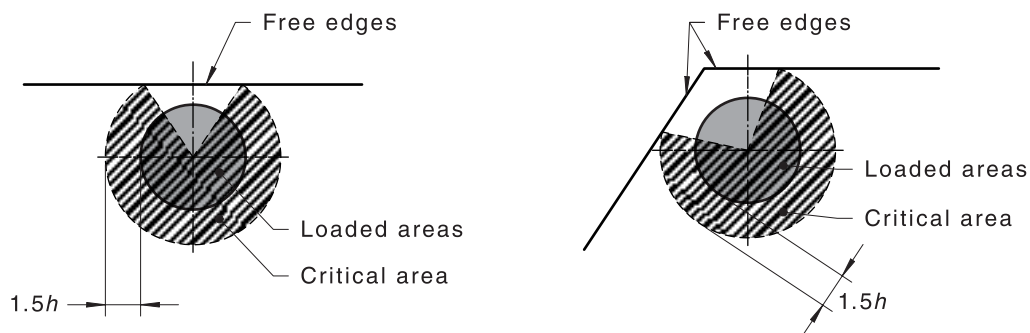


FIGURE 4.4.3(C) TYPICAL CRITICAL PERIMETER AT A FREE EDGE

4.4.4 Bearing capacity

When Reinforced AAC members are subject to concentrated compressive forces, the characteristic bearing capacity (F_{pk}) can be increased by distributing the forces over an area greater than the loaded area as follows:

$$F_{pk} = A_{c0} \alpha (f_{ck} / \gamma_c) \sqrt[3]{A_{c1} / A_{c0}} \quad \dots 4.4.4$$

where

$\kappa = 2.0$, not taking into account local indentations

$\alpha_c =$ factor accounting for long-term reduction of compressive strength due to sustained and/or unfavourable loading, and shall be taken as 0.85

$\kappa = 3.3$, taking into account local indentations

$f_{ck} =$ characteristic compressive strength of the AAC

$\gamma_c =$ partial factor for brittle failure of AAC, taken as 1.0

$A_{c0} =$ loaded area

$A_{c1} =$ maximum distribution area of load in AAC taking into account that the distribution of forces in AAC follows the principle presented in Figure 4.4.4

$h_c =$ distance between A_{c0} and A_{c1} :

$$h_c \geq 3(r_{c1} - r_{c0})$$

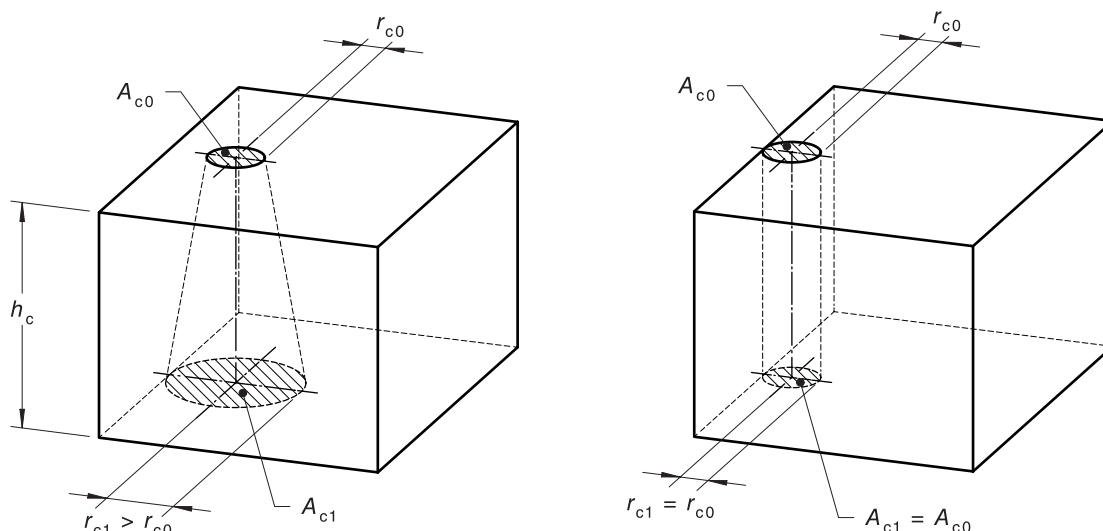


FIGURE 4.4.4 AREAS USED FOR CALCULATING THE DISTRIBUTION OF CONCENTRATED LOADS

4.4.5 Punching shear capacity

The punching shear capacity shall satisfy Equation 4.4.5:

$$V_k = 0.42 A_{crit} \tau_{pk} \quad \dots 4.4.5$$

where

A_{crit} = critical area, as presented in Figures 4.4.3(A), 4.4.3(B) and 4.4.3(C)

τ_{pk} = characteristic punching shear strength

$$= 0.063 f_{ck}^{0.5} / \gamma_c$$

γ_c = partial factor for brittle failure of AAC, taken as 1.0

NOTE: The punching shear capacity is based on shear strength of unreinforced AAC, and does not include any contribution by reinforcement.

4.5 PRIMARY TORSION AND COMBINED PRIMARY TORSION AND SHEAR

4.5.1 General

A Reinforced AAC member shall be deemed to have sufficient torsional capacity (T_{k1}) to resist a design torsional moment (T^*) provided one of the following conditions is fulfilled:

$$\frac{T^*}{\phi_\alpha T_{k1}} \leq 0.2 \quad \text{and} \quad \frac{V^*}{\phi_\alpha V_{k1}} \leq 0.95 \quad \dots 4.5.1(1)$$

$$\frac{V^*}{\phi_\alpha V_{k1}} \leq 0.2 \quad \text{and} \quad \frac{T^*}{\phi_\alpha T_{k1}} \leq 0.95 \quad \dots 4.5.1(2)$$

$$\frac{T^*}{\phi_\alpha T_{k1}} + \frac{V^*}{V_{k1}} \leq 1.2 \quad \dots 4.5.1(3)$$

where

V^* = design shear force

V_{k1} = characteristic shear resistance

T_{k1} = characteristic resisting torsional moment, to be taken as $0.06 f_{cd} W_T$