AS/NZS 1170.1 Supplement 1:2002

Structural design actions—Permanent, imposed and other actions—Commentary (Supplement to AS/NZS 1170.1:2002)

Standards Australia

STANDARDS NEW ZEALAND
Paerewa Aotearoa

AS/NZS 1170.1 Supp 1:2002

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AS/NZS 1170.1 Supplement 1:2002

Structural design actions—Permanent, imposed and other actions—Commentary (Supplement to AS/NZS 1170.1:2002)

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PREFACE

This Commentary was prepared by the Joint Standards Australia/Standards New Zealand Committee BD-006, General Design Requirements and Loading on Structures, as a Supplement to AS/NZS 1170.1, *Structural design actions*, Part 1: *Permanent, imposed and other actions*. This Commentary supersedes in part AS 1170.1—1989, *Minimum design loads on structures*, Part 1: *Dead and live loads and load combinations* and in part NZS 4203:1992, *Code of practice for general structural design and design loadings for buildings (Vol. 2).*

The Commentary provides background material and guidance to the requirements of the Standard.

The clause numbers of this Commentary are prefixed by the letter ‘C’ to distinguish them from references to the Standard clauses to which they directly relate. Where a commentary to certain Clauses is non-existent, it is because no explanation of the Clause is necessary.

ACKNOWLEDGEMENT

Standards Australia wishes to acknowledge and thank the following member who has contributed significantly to this Commentary:

Peter Kleeman

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SECTION C1 SCOPE AND GENERAL

C1.1 SCOPE

This Commentary is intended to be read in conjunction with AS/NZS 1170.1:2002. The commentary includes explanations of the provisions and in some cases suggests approaches that may satisfy the intent of the Standard. Commentary Clauses are not mandatory. Lists of references are also given for further reading.

Construction actions are now specifically covered in AS/NZS 1170.0. Some comment on construction activity is given under Clause C3.1.

C1.2 APPLICATION

C1.3 DETERMINATION OF DESIGN ACTIONS

This Clause reflects the philosophy outlined in AS/NZS 1170.0 that design should be verified using appropriate loads.

C1.4 REFERENCED DOCUMENTS

The following documents are referred to in this Commentary:

AS	
2156	Walking tracks
2156.1	Part 1: Classification and signage
2156.2	Part 2: Infrastructure design
2867	Farm structures—General requirements for structural design
3610	Formwork for concrete
4678	Earth retaining structures
AS/NZS	
1170	Structural design actions
1170.0	Part 0: General principles
1576	Scaffolding
1576.1	Part 1: General requirements
NZS	
4203	Code of practice for general structural design and design loadings for buildings (Volume 1, Code of practice; Volume 2, Commentary)
BS	
6399	Loads for buildings
6399.1	Part 1: Code of practice for dead and imposed loads
EN	
1991	Basis of design and actions on structures (Eurocode 1)
1991-2-1	Part 2.1: Actions on structures—Densities, self-weight and imposed loads

ANSI/ASCE
7-95 Minimum Design Loads for Buildings and Other Structures

ISO
2394 General principles on reliability for structures

9194 Bases for design of structures—Actions due to self-weight of structures, non-structural elements and stored materials—Density

10137 Bases for designs of structures—Serviceability of buildings against vibration

BRANZ
Bulletin 227 Weights and measures of building materials

C1.5 DEFINITIONS

Definitions have been drawn from ISO 2394, where appropriate.

C1.6 NOTATION

Notation follows the guidelines laid out in ISO 3898.

The notation used in this Commentary is as given in AS/NZS 1170.1, together with the following:

F = impact or braking force, in newtons

h = height of handrail, in millimetres

l = length between handrail supports (verticals), in millimetres

m = gross mass of the vehicles, in kilograms

s = mean of the lengths of the adjoining spans of a slab supported by walls, in metres

V = velocity of the vehicles, in metres per second

Δ = deceleration length, in metres

SECTION C2 PERMANENT ACTION

C2.1 GENERAL

The variation in magnitude of the action with time is intended to cover loads where for most of the time the load will remain constant. For example, a tank intended to be kept full with suitable overflow control may be considered a permanent action. Of course the case should also be considered where the tank is emptied in the short term for maintenance.

The permanent equipment may include some machinery items if it is envisaged that the service life of the machinery is of the same order as the design working life of the structure.

C2.2 SELF-WEIGHT

The self-weight values given in this Commentary in Appendix CA are mean values. Unit weights of some materials are given as follows:

(a) For international purposes in Tables CA2(A), CA2(B), and CA2(C) (ISO 9194).

(b) For Australian conditions in Table CA1.

(c) For New Zealand conditions, ‘Weights and measures of building materials’ may be used (BRANZ Bulletin 227).

C2.3 PROVISION FOR PARTITIONS

Movable partitions are included as permanent actions, to ensure that their mass is considered in an earthquake situation. The minimum value of 0.5 kPa is sufficient to provide for most partitions fabricated from studs supporting glass, plywood and plasterboard.

C2.4 REMOVABLE LOADS

Tanks and other receptacles and their contents, service equipment, and the like, are considered as permanent action due to their small variability for the application of a load factor but should not be relied on for resisting overturning or wind uplift.

SECTION C3 IMPOSED ACTIONS

C3.1 GENERAL

The live loads given in this Standard are deemed to be characteristic loads. Where load data were available (mainly for office occupancies), the characteristic values given represent the peak loads over a 50 year life with a 5 percent probability of being exceeded. Otherwise, the characteristic loads given are the traditional loads for each occupancy and are to be regarded as minimum values.

The imposed loads given in Table 3.1 or Appendix B are assumed to take account of the importance and expected life of the structure. The choice of an occupancy takes the place of the choice of an annual probability of exceedance (as defined in Table 2.1 of AS/NZS 1170.0). The importance and life are assumed to be part of the occupancy description. Thus once the occupancy has been chosen, that imposed load is applicable for design regardless of the importance level and design working life defined in AS/NZS 1170.0.

The possibility of increased imposed actions should be considered for importance level 5 (see AS/NZS 1170.0).

Where the loads are not known and the type of occupancy is not covered in this Standard, the loads shall be determined from—

(a) measured load information together with a probability-based analysis; or

(b) an assessment of the loads resulting from—

  (i) assembly of people;

  (ii) accumulation of equipment and furnishings; and

  (iii) storage of materials.

Actions resulting from construction are not covered in this Standard (see AS/NZS 1170.0). Some aspects of these are treated in AS 3610 and AS/NZS 1576.1. Close supervision of the construction process is essential to ensure that overloading does not occur due to building materials and equipment such as cranes or trucks. Where floor-to-floor propping is employed during construction, close control of the propping sequence should be maintained throughout the construction period and the propping system should be approved by an engineer competent in structural design.

For dynamic effects due to human occupancy refer to ISO 10137:1992.

The distributed loads are in agreement with ISO 2633 except for parking of 2.5 t vehicles, which is 2.5 kPa instead of 3 kPa.

The distributed loads are generally equivalent to or higher than those given in ISO 2103.

C3.2 CONCENTRATED ACTIONS

For the determination of bending moments, shear and deflection, concentrated loads may be treated as point loads.

C3.3 PARTIAL LOADING

The Clause implies that pattern loading may have to be considered for live load. Whether pattern loading needs to be considered or not depends on the ratio of the dead to live load and the type of structural component. These parameters vary with the material of construction.

The partial loading provision for continuous beams relaxes the pattern loading often assumed. The relaxed provision is based on the application of Turkstra's Rule to the combination of independent actions that vary randomly in time, in that the maximum lifetime value of one action is taken in combination with 'arbitrary-point-in-time' values of other actions. The value obtained by reducing the imposed load by its long-term factor (ψ_ℓ), provides a reasonable estimate of the 'arbitrary-point-in-time' imposed load. Note that there is no requirement to consider patterned variation of permanent loads by varying the load factor. The factors influencing the variability of permanent loads between spans are generally correlated.

Examples of loading on continuous beams are given in Figure C3.1. Q_1 to Q_7 represent for each area the product of ψ_a and the reference values given in Table 3.1. ψ_a is determined for the tributary area of the span or spans under consideration. It is conservative to take $\psi_\ell = 1.0$, or to take any or all of $\psi_a = 1.0$.

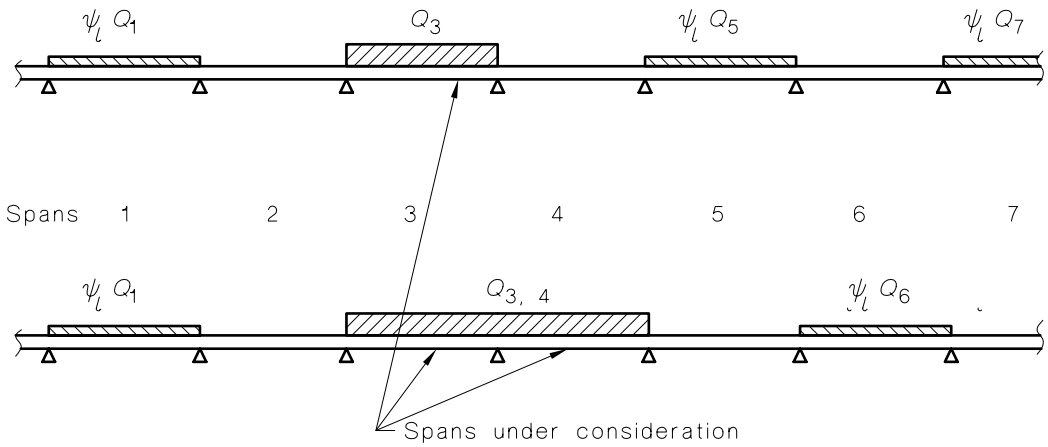

FIGURE C3.1 EXAMPLES OF LOADING ON A CONTINUOUS BEAM

C3.4 FLOORS

C3.4.1 Imposed floor actions

It should be noted that the values given in Table 3.1 are minimum values and the designer should determine if higher values are appropriate. For example, some supermarket floors may need to be treated as a combination of storage areas and areas in which people may congregate instead of as retail areas.

Table 3.1

The values given in Table 3.1 are based on values given in AS 1170.1—1989 and NZS 4203:1992. Where the values were found to be different, the differences were resolved by checking with BS 6399.1:1996 and ENV 1991-2-1:1996. The revised format in the Table follows that adopted in BS 6399.1, which is an expanded version of that in ENV 1991-2-1. The examples given in the second column of the Table may be used for guidance for occupancies not specifically listed.

The philosophy of the Table (based on the European code) is that each area of a floor would fall into one of the activity types. Thus in order to classify an area under consideration, the designer must consider the type of activities that occur in that area.

For example, a corridor in a motel is an area where people may congregate (C), whereas the rooms off the corridor are residential activities (A). Similarly, stairs and landings are areas where the activity is Type C, except where the stairs and landings are wholly contained within a self-contained dwelling of activity Type A.

Some uses will not appear in the specific uses listed in the Table. In these cases, the designer should choose the appropriate activity (A to G) and look for a similar specific use or make a fresh assessment of the likely loading (see Commentary on Clause 3.1).

The concentrated action for stairs and landings in self-contained dwellings has been increased to 2.7 kN due to a re-assessment of impact forces.

'Self-contained dwellings' indicates a range from domestic housing to apartments (covering self-contained occupancy units). The term 'Domestic activities' is intended to indicate structures that fall into the definition of Class 1 buildings given in the Building Code of Australia, or into the definition of housing as given in the New Zealand Building Code. 'Residential activities' includes buildings with areas where people live and sleep, which are covered by other definitions in the building codes.

The term 'wheeled vehicles' refers to trolleys, cleaner's carts, and other small vehicles up to 300 kg gross mass, but not to cars or trucks (see activities F and G).

The value used in activity type F (2.5 kPa) was adopted from New Zealand practice and is equivalent to the value in the British Standard. Lower values have been suggested in a recent paper by Wen et al (Ref. 1). The Committee intends to wait for further developments before reconsidering this value.

C3.4.2 Reduction of uniformly distributed imposed actions

The reduction of uniformly distributed live load is empirically based on the results of load surveys. The factor ψ_a, by which some values given in Table 3.1 may be reduced, is taken from ISO 2103 and differs only slightly in effect from the provision in AS 1170.1—1989. The area used to determine ψ_a is the sum of the tributary areas supported by the member.

Note that for office occupancies, for which a considerable body of data exists, NZS 4203 and AS 1170.1 specified loads of 2.5 kPa and 3.0 kPa respectively, but the reduced loads (reduced for area using ψ_a) converged to similar values for larger areas. The revised rule maintains these similar load levels for the larger areas.

Some linear-type structures have little capacity for transverse distribution of loads. It is not intended that reduction factors should be applied to the combined areas supported by those elements and their neighbours, unless there is capacity in the structural system to share the peaks of imposed load between the various elements that support the loaded area. Where transverse positive and negative moments of resistance are provided to transfer load laterally in slabs supported on two opposite edges, partial loading of the slab with the unreduced load will generally be critical. The critical loading case for the ultimate limit state occurs when an area of 18 m^2 (the maximum area for which $\psi_a = 1.0$) is loaded and adjacent areas are loaded with an arbitrary-point-in-time load. If a 'one-way' system is to be designed by taking account of lateral load transfer, the 'arbitrary-point-in-time' load must be not less than $\psi_\ell Q$ (see AS/NZS 1170.0).

Clause 4.9.2(c) of AS 1170.1—1989 allowed for a 20 percent reduction in live load received by any column, wall or footing for which the uniformly distributed live load exceeded 5 kPa. In the revised Table this reduction would mainly be applied to activity E (warehousing and storage) but has been omitted. In ENV 1991-2-1 and BS 6399.1 there is no reduction allowed for warehousing and storage areas. The omission of this allowance in the Standard leads to some simplification in the overall process of determining imposed floor loads.

Guidance for loads on supporting walls

The following examples illustrate the calculation of tributary areas for imposed action on walls that support a floor (see Clause 3.4.2).

For supporting walls, the area at the relevant floor which, when multiplied by the imposed action per square metre gives the imposed action on the wall (including its supports or footings) for that floor, is the least of the following:

(a) The area supported by the length of wall between supporting cross-walls (see Figure C3.2).

(b) The area supported by the length of wall between the centrelines of major openings in that wall (such as doorways, archways or windows extending to more than half the storey height) with the termination of a wall being treated as the centre-line of an opening (see Figure C3.3).

(c) An area equal to (s) × (s + storey height/2), where s is the mean of the lengths of the adjoining spans (see Figure C3.4).

Walls with only small openings that extend to less than one-half the storey height should be assessed as for Item (a) or Item (c).

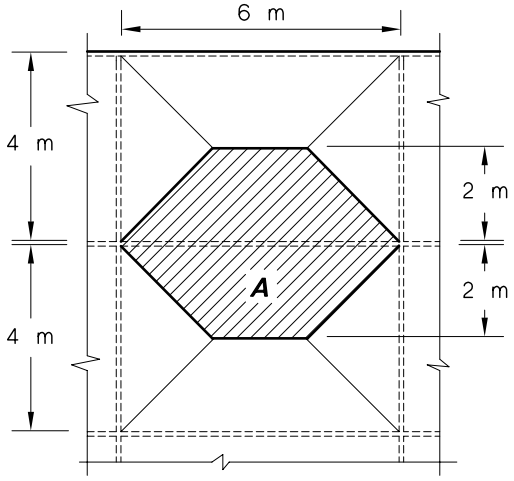

FIGURE C3.2 WALLS BOUNDED BY LOAD-BEARING CROSS-WALLS
(Walls supporting two-way slabs)

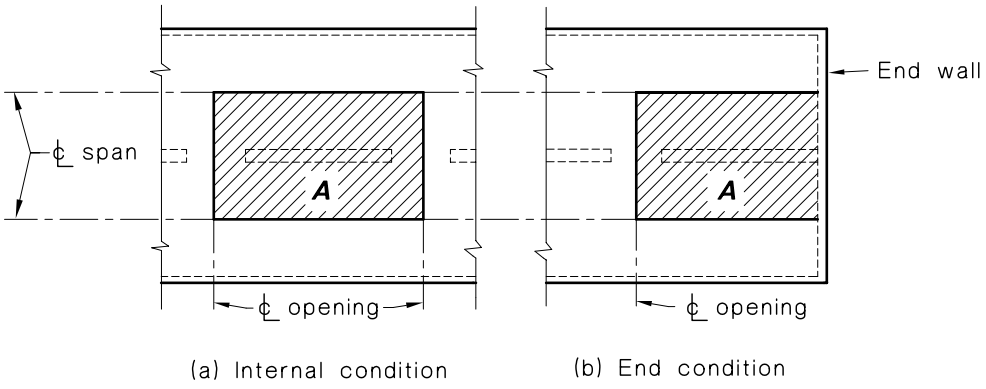

FIGURE C3.3 WALLS WITH MAJOR OPENINGS
(Principal reinforcement in one direction only)

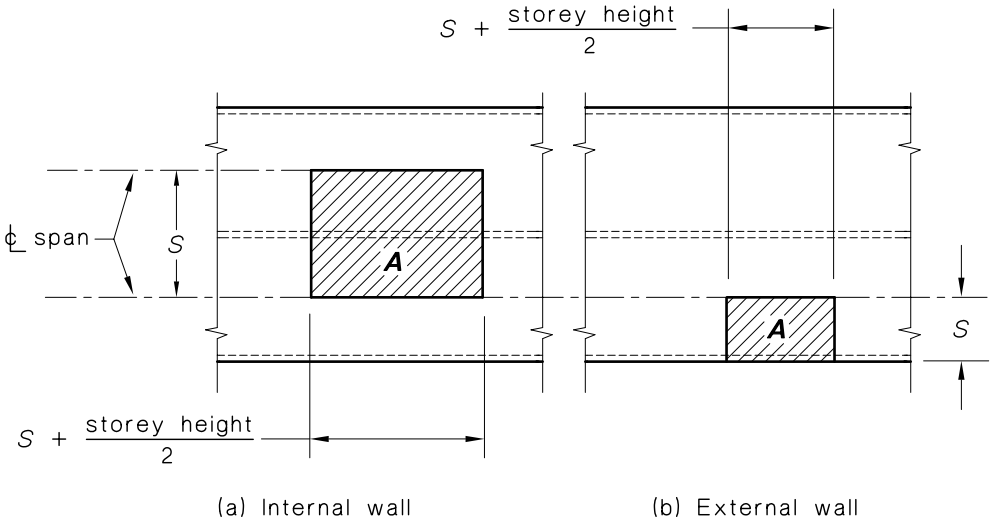

FIGURE C3.4 LONG WALLS WITH SMALL OPENINGS OR WITHOUT OPENINGS
(Principal reinforcement in one direction only)

C3.5 IMPOSED ACTIONS ON ROOFS, AND SUPPORTING ELEMENTS

C3.5.1 Roofs

Roof Category R1 is intended to cover situations where people may gain unauthorized access through their own efforts to a roof not intended for such use. The lower load of 1.0 allows for greater difficulty in gaining access compared to the value of 1.5 where access may be facilitated by adjacent windows, balconies or other awnings. An example is a street awning on a multistorey building with openable windows.

It is not expected that people would walk on glass or other transparent or translucent materials such as plastic sheeting. Therefore, allowance has been made for transparent surfaces to be treated as an area where supports (e.g., boards) would be placed over the surface when access is necessary (usually for maintenance).

The limit of 0.25 kPa in Table 3.2 is intended to cover situations not covered elsewhere in the loading Standards, such as stacking of materials for maintenance or for local accumulations of hail.

C3.5.2 Roof supporting trusses, ceilings, skylights and similar structures

The provision regarding concentrated loads supported by roof trusses or other primary roof members is intended to provide for a common situation for which specific requirements are generally lacking.

C3.6 BARRIERS

The new Table reflects the provisions given in BS 6399.1 and ENV 1991-2-1.

For serviceability, the deflection of handrails may be considered acceptable if they do not exceed $h/60 + l/240$ (horizontal deflection).

C3.7 CRANES, HOISTS, LIFTS AND RECIPROCATING MACHINERY

C3.7.1 General

In general, the designer should refer to the referenced Standards. The alternative factors given in Clause 3.7 are similar to those given in ANSI/ASCE 7-95.

While in most cases the load effects need to be ascertained only for immediate supporting members (e.g., corbels supporting crane rails, beams supporting lift machinery), the load path needs to be pursued further in cases where the operating weight of machinery is the primary load on a structure. It should be appreciated, however, that treating these dynamic loads as static loads will often predict deflections that are unrealistically large.

C3.7.2 Vertical actions

C3.7.3 Horizontal actions on crane rails

C3.8 CAR PARKS

The values given in the Standard are based on the force from one vehicle only.

Braking and horizontal impact forces arising from the movement of vehicles may be calculated as follows:

$$F = \frac{mV^2}{2\Delta} \quad \ldots \text{C3.8}$$

where

F = impact or braking force, in newtons

m = gross mass of the vehicles, in kilograms

V = velocity of the vehicles, in metres per second

Δ = deceleration length, in metres

In calculating the braking force, Δ is taken as the braking distance, and in calculating the impact force on a barrier, Δ is taken as the sum of the deflection of the vehicle and barrier.

The loads given for car park barriers are based on the following:

(a) 1500 kg at 2 m/s and 0.1 m crumple zone.

(b) 2000 kg at 6 m/s and 0.15 m crumple zone.

(c) 2000 kg at 2 m/s and 0.1 m crumple zone.

Wheel stops should not be relied upon to stop a vehicle impacting a barrier except in normal use. The shape and design of wheel stops varies and information is not available on their effectiveness in stopping or reducing the speed of vehicles.

C3.9 GRANDSTANDS

Clause 4.10 of AS 1170.1—1989 INCREASE OF UNIFORMLY DISTRIBUTED LIVE LOAD ON RESTRICTED AREAS

This Clause from the previous Australian edition of the Standard prescribed an increased uniformly distributed load on areas less than 3 m^2. There is no similar provision in BS 6399.1, ENV 1991-2-1, ANSI/ASCE 7-95 nor was there in NZS 4203:1992. The provision has been removed for simplicity, as for small areas the maximum moments are generally reached when the specified concentrated loads are applied. Whilst shear in cantilevers supporting restricted areas may have been controlled by the increased distributed load, the relaxation of this requirement is not considered significant.

REFERENCES

1 WEN, Y.K., YEO, G.L., *Design live loads for Passenger Cars Parking Garages*, Journal of structural engineering, A.S.C.E., March 2001, pp.280-289.

SECTION C4 LIQUID PRESSURE, GROUND WATER, RAINWATER PONDING, MOVEMENT EFFECTS AND EARTH PRESSURE

C4.1 GENERAL

C4.2 LIQUID PRESSURE

C4.3 GROUND WATER

It is unlikely that information will be available on the level of ground water for different annual probabilities of exceedance. Therefore the 1 in 50 value is given as the default value.

Assuming the level to be at ground level is a conservative assumption for most situations. The presence or absence of ground water should be considered for the purposes of combinations, as the absence of hydrostatic water pressure may produce more critical conditions than its presence.

Where flooding, heavy rains, variations in sea level or similar can occur, the additional action of the water above ground level may need to be considered.

It may be necessary to make other provisions to safeguard against the occurrence of excessive pressure or flooding. Tidal charts should give reliable regular tide levels (e.g., spring tides). Added height may be required to account for storm surge. For soil-retaining structures and foundations, effects of ground water need to be considered in conjunction with the effects of soil loads and with soil strength.

C4.4 RAINWATER PONDING

Where secondary drainage such as overflow outlets from gutters is provided, the ‘depth of water that may collect’ may be assumed to be limited to the resulting maximum feasible depth given collection rate versus overflow rate.

C4.5 EARTH PRESSURE

AS 4678 provides methods for determining $F_{e,u}$ for both ultimate and serviceability limit states. These values are appropriate for use with the combinations of actions given in AS/NZS 1170.0. Where other methods of determining the earth pressures are used, different load factors are required.

APPENDIX CA

UNIT WEIGHT OF MATERIALS

(Informative)

The unit weights given in the Standard have been expressed in the form of weights for ease of calculation. Only the most frequently used materials are covered.

Further data is given in Tables CA1 and CA2. Table CA1 includes values of bulk densities drawn from AS 2867—1986.

Tables CA2(A), CA2(B) and CA2(C) are drawn from ISO 9194. As the values given in ISO 9194 are deterministic in nature and represent the range of national mean values submitted for the drafting of that Standard, they do not necessarily reflect Australian and New Zealand conditions. The densities are given in kg/m^3 and the pressures in N/m^2.

Where Tables CA2(A), CA2(B) and CA2(C) give only one density value for a material (or soil), this means that the corresponding nominal values do not normally differ significantly in different countries (up to ±5 percent) and the indicated mean value is the average of the nominal values. The range of two values of densities given in the annexes for one material indicates that the mean values of densities for different countries vary between the indicated ones. The values for angles of repose are similarly expressed except that the ranges are of the order of ±30 percent, therefore, values should be considered as approximations only.

TABLE CA1

BULK DENSITIES OF AGRICULTURAL MATERIALS

Particulars of agricultural material	Minimum design bulk density kg/m^3
Grains	
Barley	670
Oats	550
Rice	550
Wheat	850
Rye	700
Sorghum	730
Maize	800
Oil seeds	
Safflower	550
Canola	750
Linseed	0
Cottonseed	400
Sunflower	400
Soy bean	800
Other field crops	
Lima beans (dry)	700
Soy beans	750
Field peas	750
Peanuts (unshelled)	300
Maize cobs	450

(*continued*)

TABLE CA1 (*continued*)

Particulars of agricultural material	Minimum design bulk density kg/m^3
Hay—rectangular and big round bales	200
Silage (moisture content 70 percent wet basis):	
Stored up to 2 m deep	550
Stored more than 2 m deep	650
Fruit and vegetables	
Apples	600
Beans	400
Carrots	650
Cherries	800
Onions (dry)	750
Potatoes	650
Eggs in cases	200
Tobacco	550
Wool, shearing shed bales	300
Fertilizer (bulk), superphosphate	1200
Manure (faeces and urine mixed)	1000
Feeds	
Lucern meal, dehydrated	350
Lucern pellets	700
Brewers grains, dried	250
Brewers grains, wet	1000
Bonemeal	850
Fish meal	550
Meat meal	600
Linseed oil meal	600
Soy bean oil meal	600
Salt	1150
Wheat, bran	250
Pelleted ration	600
Ground ration	550

TABLE CA2(A)

DENSITY OF MATERIALS AS GIVEN IN ISO 9194—REPRESENTATIVE VALUES OF THE DENSITIES OF STRUCTURAL AND NON-STRUCTURAL ELEMENTS

Material	Density kg/m^3	Material	Density kg/m^3
Wood and substitutes (air-dried, about 15 percent moisture content) (see Note 1)			
Hardwoods		Softwoods	
Beech tree (Fagus sylvatica)	680	Black pine (Pinus laricio)	570
Oak tree (Quercus)	690	Larch tree (Larix decidua)	550
Perpendicular oak (Quercus robur)	640	Norway spruce (Picea)	430
Brazilian rosewood (Dalbergia nigra)	800	Spruce fir (Pinus eccelsa)	380 to 440
Turkey oak (Quercus cerris)	640 to 770	Scotch pine (Pinus silvestris)	490
Yew tree (Taxus baccata)	640	White willow (Salix alba)	330
		Giant poplar (Populus alba)	410
		Trembling poplar (Populus tremula)	450
		Ocume (Ocume)	410
Fibreboard		Extruded chipboard	500 to 750
hard	900 to 1 000	Coreboard	450 to 650
medium-hard	600 to 850		
porous insulating	250 to 400		
Concrete (see Note 2)			
Blast furnace foam slag concrete	1 600 to 1 900	Perlite concrete	350 to 700
Aerated and gas concrete	600 to 1 500	Tuff concrete	1 400 to 1 600
Expanded clay gravel concrete	700 to 1 700	Lightweight aggregate concrete using sintered pulverized fuel ash aggregates	1 600 to 1 850
Heat insulating gas concrete	300 to 900	Heat insulating pearlite brick and pipeshell	260
Aggregates and fillers			
Sand	1 550	Crushed slag stone of 5 to 40 mm grain size	1 500
Sand gravel of 0 to 40 mm grain size	1 700	Pulverized fuel ash (pozzolan) for use as a cementitious component in concrete (bulk density)	800 to 1 050
Gravel	1 500 to 1 600	Blast furnace foam slag	1 700
Aerated silicate	1 000	Blast furnace slag, granulated	1 200
Mortars			
Lime mortar	1 200 to 1 800	Fireclay mortar	1 900
Lime cement mortar	1 750 to 2 000	Pearlite mortar	
Cement mortar (with 2.5 MPa or greater compressive strength)	2 100	lime	340
		gypsum	370
		cement	440
Rock floor mortar	1 600	Bitumen mortar with river sand	1 700
Building bricks and blocks			
Tuff block with 5 MPa compressive strength	1 100	Lime-sand brick	1 700
Glass brick, double-walled	870 to 1 100	Cob brick, adobe	1 600
Acid resistant brick	2 000	Gas silicate block	
		with 2 MPa compressive strength	500
		with 5 MPa compressive strength	700
		with 7, 5 MPa compressive strength	900

(*continued*)

TABLE CA2(A) (*continued*)

Material	Density kg/m^3	Material	Density kg/m^3
Brick masonry			
Walls made from brick with holes or ceramic blocks (depending on the type of brick or blocks used)	1 15 to 1 450	Gas silicate, medium-sized building block	
		with 1.5 to 2.5 MPa compressive strength	600 to 800
Glass brick, double-walled (in cement mortar)	2 000	with 2.5 to 5 MPa compressive strength	800 to 1 100
Glass brick, coupled on one side (in cement mortar)	870	with 5 to 10 MPa compressive strength	900 to 1 300
Acid resistant brick (in bitumen mortar	1 900	with 10 to 20 MPa compressive strength	1 000 to 1 600
Natural building stones			
Sedimentary rocks		Magmatic plutonic rocks	2 650 to 3 000
sandstone	2 700	Magmatic vulcanites	2 500 to 2 850
marl	2 300	Volcanic tuffs	1 400 to 2 000
porous limestone	1 700 to 2 200	Transformed rocks	
fresh-water limestone	2 400	clay slate	2 600
compact limestone	2 650 to 2 800	marble	2 700
dolomite	2 800		
Masonry from natural stones			
Rocks of initial setting		Transformed rocks	
basalt malphir, diorit, gabbro	3 000	gneiss, granulite	3 000
basalt lava	2 400	slate	2 800
diabase	2 900	serpentine	2 700
granite, syngenit, porphyt	2 800	Sedimentary rocks	
trachyt	2 600	graywacke, sandstone, puddingstone	2 700
		volcanic tuff	2 000
Covering and other building material			
Tar (pitch)	1 100 to 1 400	Rubber floor	1 800
Cellulose acetate panel	1 300	Plastic tile	1 100
Soft covering brick		Polyamide (e.g. diamid)	1 100
holed	1 350	Polyester resin, without filler	1 350
solid	1 600		
Epoxy resin		Polyethylene	930
without filler	1 150	Polyisobutylene-base board	1 350
with mineral matter	2 000	Polymethylacrylate	1 150
with fibreglass	1 800		
Fenoplast	1 500	Polypropylene	930

NOTES:

1 The body density of the wood should be increased by 120 kg/m^3 where in a state saturated with water and by 80 kg/m^3 in the case of a structure standing outdoors and not protected against atmospheric humidity.

2 The values given do not include steel reinforcement. Density should be that as given for the appropriate concrete increased by 100 kg/m^3 where the reinforcement percentage is 1.25 or less. Appropriate adjustments should be made for concrete reinforced to higher masses.

TABLE CA2(B)

DENSITY OF MATERIALS AS GIVEN IN ISO 9194—REPRESENTATIVE VALUES IN TERMS OF SURFACE PRESSURE AND WEIGHT FOR ROOFING MATERIALS

Material	Surface pressure N/m^2	Surface density kg/m^2
Roof shells, roofings (see Note)		
Metal plate roofings		
Double-welt copper roof covering, 0.6 mm	60	6
Aluminium sheet roofing		
6 mm thick	20	2
7 mm thick	25	2.5
Lead-plate roofing, 2 mm thick, soldered	240	24
Other plate roofings		
Soft plastic roofing, 1 mm thick		
Bitumenized board roofing	90	9
2 layer, nailed	80	8
3 layer with stuck gravel scattering	250	25

NOTE: The values do not include the fixing and supporting structures.

TABLE CA2(C)

DENSITY OF MATERIALS AS GIVEN IN ISO 9194—REPRESENTATIVE VALUES OF DENSITIES AND ANGLES OF REPOSE FOR STORED MATERIALS

Material	Density (see Note 1) kg/m^3		Angle of repose, degrees
	Natural heap (see Note 2)	Stack or pile (see Note 3)	
Building and construction materials			
Boulder clay	—	2 100	—
Brick sand, brick hardcore, brick chippings, moist earth	1 500	—	25 to 40
Cement	1 100 to 1 200	1 300 to 1 600	18 to 28
Clay			
fluorfine, dry	1 100	—	—
heavy, air-dried	1 600	—	
Cork grit	—	60	—
Coke ash	750	—	25
Crushed foamed slag	900	—	35
Expanded clay gravel			
light	250	—	30 to 35
medium	400	—	30 to 35
heavy	550	—	30 to 35
Fibreglass	—	160 to 180	—
Foamed scoria, crushed, moist earth	1 100	—	35
Glass wool	—	100 to 110	—
Gravel and dry sand or moist earth	1 800	—	30 to 36
Heat-insulating perlite brick	—	260	—

(*continued*)

TABLE CA2(C) (*continued*)

Material	Density (see Note 1) kg/m^3		Angle of repose, degrees
	Natural heap (see Note 2)	Stack or pile (see Note 3)	
Heat-insulating perlite pipe shell	—	260	—
Lime hydrate	500	600	25
Lime, slaked	—	1 300 to 1 400	—
Lime			
lumps	850 to 1 300	—	45
ground	600 to 1 300	1 00 to 1 100	25
Limestone powder	—	1 300	—
Magnesite (caustic magnesite), ground	—	1 200	—
Plastics			
polyethylene, polystyrol, granulated	—	650	—
polyvinylchloride, powdered	—	600	—
polyester resin	—	1 200	—
Perlite	—	70 to 250	—
Read sheet of roofing	—	150 to 220	—
Powdered coal ash	900	1 000 to 1 200	25
Silt	—	1 800	—
Slag wool	—	200 to 300	—
Slag, granulated	1 100	—	30
Trass, ground	—	1 500	—
Wood-wool	—	300 to 380	—
Combustibles and fuels			
Coal			
mineral coal:	900 to 1 200	—	30 to 35
coke	450 to 650	—	35 to 45
briquette:			
egett	800	—	25
cornered coal	700	—	35
brown coal:			
dry	800	—	35
moist earch	1 000	—	30
bridquette	800	—	30
coke	1 000	—	40
brown coal dust	500	—	25
Charcoal	250	—	—
Oils			
fuel, diesel oil	800 to 1 000	—	—
crude oil	980	—	
Petrol (gasoline)	750 to 800	—	—
Petroleum	800	—	—

(*continued*)

TABLE CA2(C) (*continued*)

Material	Density (see Note 1) kg/m^3		Angle of repose, degrees
	Natural heap (see Note 2)	Stack or pile (see Note 3)	
Liquid gas			
propane	500	—	—
butane	580	—	—
Wood (air-dried, about 15% moisture)			
hard wood		—	45
chopped	400 to 600		50
logs	500	600 to 700	
soft wood		400	45
chopped	250	400 to 600	—
logs	300		
firewood	400		45
Brush wood	—	200	—
Peat	300 to 600	500 to 900	—
Foodstuffs and agricultural products			
Alcohol	800	—	—
Beer			
in tanks	1 050	—	—
in barrels	—	900	
Butter			
in barrels	—	550	—
cased or boxed	—	500 to 800	—
Cocoa in bags	—	550	—
Coffee in bags	—	550 to 700	—
Clover-seed in bags	—	750	—
Conserves in bottles or boxes	—	800	—
Dry fodder			
baled	—	350	—
ensiled	1 000	—	—
Edible oil			
in barrels	—	750	—
bottled, in crates	—	550	—
Eggs in egg-stands	—	550	—
Fat, boxed	—	800	—
Fish			
in barrels	—	600	—
cased	—	800	—
Flax in bales	—	1 300	—
Flaxseed in bags	—	700	—
Fruit (stored in prisms)	500 to 700	—	25
Fruit crated in boxes	—	350 to 400	—
Groundnuts	—	400	—

(*continued*)

TABLE CA2(C) (*continued*)

Material	Density (see Note 1) kg/m^3		Angle of repose, degrees
	Natural heap (see Note 2)	Stack or pile (see Note 3)	
Hay (baled)	—	150 to 200	—
Hempseed	500	—	25
Hempseed in bags	—	450	—
Honey			
in tanks	1 300	—	—
in cans	—	1 000	—
bottled	—	600	—
Leguminous plants	850	—	—
Leguminous plants in bags	—	800	—
Maize on ear	450	—	—
Margarine			
in barrels	—	550	—
cased or boxed	—	700	—
Meat, refrigerated	—	400 to 700	—
Milk			
in tanks	950 to 1 000	—	—
in cans	—	850	—
bottled (in crates)	—	700	—
Oat, milled	750 to 800	—	—
Onions			
in bags	—	550	—
crated	—	550	—
Pickled cucumber, bottled in cases	—	700	—
Pimiento	—	500	—
Drinks			
bottled	—	850	—
bottled in cases	—	800	—
bottled in crates	—	750	—
Potatoes in bags	—	500 to 700	—
Rice (unmilled) in bags (hulled)	—	800	—
Salt (rock-salt)			
in piles (milled)	—	2 200	—
in piles, pressed cattlesalt	1 000	—	—
Starch flour in bags	—	170	—
Straw, baled (standard bale)	—	170	—
Straw bales, high-density	—	600	—
Sugar powdered/granulated			
in paper bags	—	600	—
in gunny sacks	—	800	—
Lump sugar			
in paper bags	—	600	—
boxed	—	700	—

(*continued*)

TABLE CA2(C) (*continued*)

Material	Density (see Note 1) kg/m^3		Angle of repose, degrees
	Natural heap (see Note 2)	Stack or pile (see Note 3)	
Tobacco, baled	—	300 to 500	—
Wine			
in tanks	1 000	—	—
in barrels	—	850	—
Other materials (see Note 4)			
Aluminium alloy	2 800	—	—
Bags, baled	—	500	—
Bone splinters	700	—	—
Books and papers in stacks	—	850	
Broadcloth, in bolts	—	400	—
Bronze	8 400	—	—
Carbolineum			
in tanks	1 000	—	—
in barrels	—	800	
Cellulose, baled	—	800	—
Cellulose filiform			
baled	—	750	—
pressed, baled	—	1 200	
Cloth, baled	—	400	—
Chemical fertilizer			
kalimagnesia in bags	—	1 300 to 1 500	—
kalisulfate	1 600	—	28
nitrogenous in bags	—	2 000	—
Compost	1 200	—	45
Cotton, baled	—	700 to 1 300	—
Excrement	1 200	—	—
Felt in piles, baled	—	500	—
Filament in piles, pressed, baled	—	1 200	—
Glass			
bottles, etc.	—	400	—
sheets of glass, crated	—	1 000	—
Hemp, baled	—	400	—
Iron ore	3 000	—	—
Ice (from water), in blocks	—	850 to 900	—
Ice (from carbonic acid), in blocks	—	1 700	—
Jute, baled	—	700	—
Leather, in piles (curried)	—	900 to 1 000	—
Linen, in bolts	—	600	—
Linoleum: rolled-up flooring material	—	1 300	—

(*continued*)

TABLE CA2(C) (*continued*)

Material	Density (see Note 1) kg/m^3		Angle of repose, degrees
	Natural heap (see Note 2)	Stack or pile (see Note 3)	
Magnesium	1 850	—	—
Nickel	8 900	—	—
Oil paint and lacquer, canned or boxed	—	1 100	—
Paper			
in stacks, in sheets	—	1 200	—
in rolls	—	1 100	—
Raw hide			
in piles (dried)	—	350	—
in piles (salted)	—	1 100	—
Rubber			
rolled-up flooring material	—	1 300	—
raw, baled	—	1 000	—
Steel rail	2 600	—	—
Textile, in bolts	1 100	—	
Tin, rolled	—	7 200 to 7 400	—
Wearing apparel, cased	300	—	—
Soils (see Note 5)			
Inorganic cohesive soils			
soft	1 800 to 2 000	—	10 to 24
stiff	1 900 to 2 050	—	12 to 26
semi-solid	2 000 to 2 100	—	17 to 27
Organic clay, soft	1 400	—	15
Organic silt	1 700	—	—
Sand			
moist earth			
loose	1 200 to 1 500	—	30
medium-dense	1 900 to 2 050	—	30
dense	2 000 to 2 100	—	35
saturated			
loose	1 500 to 1 800	—	30
medium-dense	1 700 to 2 000	—	30
dense	1 800 to 2 000	—	35
under uplift			
loose	900 to 1 000	—	30
medium-dense	1 000 to 1 200	—	30
dense	1 100 to 1 200	—	35

(*continued*)

TABLE CA2(C) (*continued*)

Material	Density (see Note 1) kg/m^3		Angle of repose, degrees
	Natural heap (see Note 2)	Stack or pile (see Note 3)	
Gravel			
moist earth			
loose	1 500 to 1 700	—	
medium-dense	1 600 to 1 800	—	
dense	1 900	—	
saturated			
loose	1 900	—	
medium-dense	2 000	—	
dense	2 100	—	
under uplift			
loose	900	—	
medium-dense	1 000	—	
dense	1 100	—	

NOTES:

1 The density of the stack and pile contains data on bales.

2 Heap = disorderly or bulky stored materials and, by agreement, liquids in a tank.

3 Stack or pile = ordered or linked or ordered but not linked materials.

4 The density of stored metal products can be multiplied by a coefficient less than 1.0 according to the real situation.

5 The values given for density and angles of repose of soils (which can differ from geotechnical data) are only to be used if the soils present are similar to the stored materials.

APPENDIX CB

OTHER IMPOSED ACTIONS

(Informative)

The values in this Appendix are separated from Table 3.1 as they do not easily fit into the structure of that Table. The types of activity are also less commonly encountered.

The values for farm structures replace the information given in AS 2867—1986.

Those for non-habitable structures are intended for the design of structures such as viewing platforms and boardwalks constructed on walking tracks as described in AS 2156.1 and AS 2156.2. These are structures that are open and exposed to the weather (i.e., not a hut). The value of the imposed action varies depending on the probability of access by large numbers of people. This is related to the classification of track, which in turn depends on the degree of difficulty of access to the track in practical terms.

For example, Track Classification 2 in AS 2156.1 would normally be applied to easy walking tracks that start near a car park and probably take only an hour or two to finish. Thus for example a number of busses may arrive at the same time, leading to a high likelihood of a particular structure on the track being fully loaded with people. Therefore, this track should be designed for full open space loading (activity type C).

For Track Classification 5, the track would be a long one (maybe a few days to walk), require all supplies to be carried and be difficult to pass (navigation of an unmarked route may require use of a map and compass). A structure on such a track would be less likely to be loaded to the same extent as one on Track Classification 2 (that is, use the values for isolated structures).

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