AS 1170.4-2024 Updates for building service designers, consultants and architects

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Abstract

The 2024 updates to AS1170.4 Section 8 bring important changes to Australia's earthquake standards. This paper aims to assist architects and building service consultants to understand these updates and apply them to their project specifications to better inform the market of earthquake action responsibility in design.

We will discuss clear design direction, relevant seismic design criteria, and specific clearance requirements. Additionally, we will outline the responsibilities of seismic design engineers and installers/contractors, as well as product compliance requirements. For Importance Level 4 (IL4) buildings, we will explain the need for a special study.

By learning about these updates, professionals can ensure their designs meet the new standards and contribute to building a safer, more earthquake-resilient Australia.

Keywords: seismic design; building services; project specifications.

1 Introduction

The National Code of Construction (NCC) is Australia's primary set of technical design and construction provisions for buildings[1]. As a performance-based code, it sets the minimum required level of safety, health, amenity, accessibility and sustainability of certain buildings. It primarily applies to the design and construction of new buildings, and may also apply to new building work or new plumbing and drainage work in existing buildings. Each state or territory of Australia determines which NCC amendment or edition applies to this work. This paper provides guidance on NCC 2022 applications, noting that development consent expiry may vary up to 5 years, and construction certificates can exist up to 99 years if significant commencement has been demonstrated, meaning that earlier editions may apply.

[1] NCC 2019 – Contents and Introduction to NCC Page 9

In this paper the term "building" in the NCC and "structure" in AS 1170.4 are given the same definition.

The NCC contains two pathways in compliance, performance solutions and/or deemed to satisfy provisions[2]. Australian Standard 1170.4 – Earthquake Actions is a deemed to satisfy structural provision pathway under Part A2G3, specified in Part B1D3 of NCC 2022. A building may require a combination of both pathways to meet performance-based criteria[3].

2 Purpose and impacts to industry

A 2007 Australian Building Codes Board first highlighted an important observation leading to the introduction of the 2007 edition of AS 1170.4. It stated: 'The current regulations have resulted in market failure in the form of insufficient information. Information failure exists in the sense that consumers do not have sufficient information about the risk of earthquake to make informed choices regarding the level of building protection required. Thus, the market can be said to have failed to adequately deal with the risk of earthquake damage and it is therefore the role of government to intervene. The existing BCA-referenced Standard is 14 years old and requires updating to bring it into line with international practices.'[4]

This paper seeks to continue that narrative by further seeking to inform building service consultants charged with compliant design documentation so that builders, contractors and consumers are aware of important updates to the standard in 2024, 17 years after the ABCB valid commentary in 2009.

3 AS 1170.4 2024 key updates

Australian Standard 1170.4-2025 (published July 1, 2024) includes definition of design storey drift[5], the difference in displacement between each level of a building, affecting vertical service riser shafts that contain pipes, duct or electrical trays. These non-structural elements attached to and supported by the structure are not part of the seismic-force-resisting system but are required to be designed to withstand these displacements.

Light gauge steel material supporting building services and architectural framing require consideration of newly updated Australian New Zealand Standard (AS/NZS) 4600 – Cold formed steel structures, revised 2018 but not captured in AS 1170.4 (R 2018).

Importance level 4 structures, required to function after a disaster event, are now to demonstrate how the structure remains operational, instead of serviceable, immediately after an Importance Level 2 disaster event, in attempt to better equip building service design consultants on documenting designs and specifications[6].

Ductile behaviour definition and capacity, which is the ability to withstand repeated cyclic displacements within elastic and inelastic range, has been altered to more conservative values due to observed overuse of computational software structural designs that generate very ductile joint and component behaviour in building designs, which in turn reduces base shear transfer forces to ground and therefore passing on a reduced footing design and cost to the customer, in competition with other design consultants for structural design tenders.

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[2] Figure 1 NCC 2019, and Figure A2G1 NCC2022 are similar.
[3] Part A2G4 NCC 2022
[4] Final Regulation Impact Statement For Decision RIS 2007-03 Executive Summary recommendation excerpt quotation – Australian Building Codes Board
[5] Part 1.3.7 1.3.7 design storey drift - design storey drift (dst) shall be calculated as the difference of the deflections (di) at the top and bottom of the storey under consideration (see Clause 6.7.2)
[6] AS 1170.4 Part 2.2 NOTE 4: The operational requirements will vary from facility to facility depending on its nature and functionality. Case-by-case assessment is essential.

The design of building parts and components that existed in Sections 5 and 6 of R2018 standard are now compiled into Section 8 only of the new standard to give a single point of resource for designers of non-structural parts and components, therefore making it easier for reference in building design and certification.

Other important design parameters such as probability and geographical hazard factors across Australia were updated to reflect recent research by Geosciences Australia, along with technical committee review of method hierarchy to determine soil factors, with clearer distinction on low amplitude natural site period to distinguish between rock, shallow soil, and deep soil.

4 The deemed to satisfy pathway earthquake design procedure.

AS 1170.4 contains design procedure[7] for determining earthquake actions based on the building classification, structural design, site geotechnical investigation and building consultant input, detailed on cover sheet, design brief, specification, and or drawings. Steps (a) to (g) of Part 2.2 AS 170.4 excerpted below are simplified into steps and table for comprehension:

(a) determine importance level of structure from NCC 2022 Table B1D3a (AS/NZS 1170.0 Appendix F for undefined structures) based on hazard to life or other property, number of people, or post disaster function, either IL1, 2, 3 or 4;

(b) The Annual Probability of Exceedance (APE) of an earthquake occurring (NCC 2022 Table B1D3b) and probability factor (kp) of AS 1170.4 Table 3.1 are directly affected by the importance level adopted, as summarised in Table 1:

Table 1. Correlation of importance level, annual probability of exceedance, and probability factor

Importance Level (IL) NCC 2022 Table BD3	*Annual Probability of Exceedance (APE) NCC 2022 Table B1D3b*	*Probability Factor (kp) AS 1170.4 Table 3.1*
1	1:250	0.75
2	1:500	1.0
3	1:1000	1.3
4	1:2000	1.5
4+	1:2500	1.8

* This is a caption footnote

(c) Determine site specific hazard design factor (Z)[8] identified by geographical location overlain by probabilistic contours of ground motion acceleration[9] across Australia (Figures 3.2(A) to (F) by state and territory and Figure 3.2(G) overall). Minimum Z is 0.8, maximum Z is 0.22 for mainland Australia, maximum Z is 0.3 in Bass Strait.

(d) determine if domestic structures (housing) criteria AS 1170.4 Appendix A allows exemption of assessment, being Class 1a or 1b, as defined in NCC, less than 8.5m height; or use IL2[10].

[7] AS 1170.4 Part 2.2 and Figure 2.2

[8] Part 1.4 Notation and Units Z - earthquake hazard design factor modified from an acceleration coefficient with an annual probability of exceedance of 1/500

[9] Peak ground velocity, an intensity value thought to be the best predictor of damage. The acceleration coefficient is obtained by dividing peak ground velocity, in millimetres per second, by 750.

[10] Housing in Z value 0.30 – refer New Zealand Standard 1170.5.

(e) determine the site sub-soil class (Section 4) that corresponds to function of natural period of structure (amplification of ground motion) founded on A_e strong rock, B_e rock, C_e shallow soil, D_e deep or soft soil, or E_e very soft soil summarised and correlated into spectral shape factor in Table 6.4 specific for architectural and building service non-structural parts and components.

Table 2. Simplified Table 6.4 of AS 1170.4 Spectral Shape Factor C_hT_1 for building service design

Site sub-soil class AS 1170.4 Table 6.4	***Spectral Shape Factor C_hT_1 AS 1170.4 Table 6.4***
A_e	0.8
B_e	1.0
C_e	1:3
D_e	1:1
E_e	1:1

* This is a caption footnote

(f) not specific to design of parts of components, but important in classifying the design category, the above values determined are referred to AS 1170.4 Table 2.1 to determine the earthquake design category (EDC)[11], being EDC I, II, or III, which guides primary structure design supporting parts and components. (Section 5 AS 1170.4)

(g) design parts and components in accordance with the requirements set out in Section 8 by using one of three ways:

   a. established principles of structural dynamics, which can be ISO 3010 or NZS 1170.5 methodologies not covered in this paper: or

   b. forces determined by general method (Clause 8.2), calculating acceleration onto each level supporting component determined from Section 5, 6 and 7 of AS 1170.4; or

   c. forces determined by simplified method (Clause 8.3), calculating acceleration onto component determined by proportion of height from ground to centre of mass of component, to that of overall height of building.

(h) All methods require specific detail on component importance, amplification, ductility and mass. This would require a deep knowledge of method of support, function of component, ability to withstand cyclical actions, and unit mass for both service runs and specific components which should be located easily in plans or specifications produced by the consultant.

5 Project specification and accountability recommendations.

Steps (a) to (h) require many factors sourced from many resources to enable non structural parts and component design. From the above the following recommendation of accountability is detailed below:

[11] Earthquake Design Category (EDC) is a simplified distinction of low, medium and high risk structures, with varying degree of analysis required based on importance level, structure type, height, and soil conditions, determined in Table 2.1 of AS 1170.4.

(a) Importance level is accountable to the building certifier, architect and engineer in that level of hierarchy. It must be clearly stated in the project brief used to determine development consent conditions. It is commonly associated with development consent conditions which is governed by state building legislation rather than national code of construction. This guides the kp factor. Importantly maintenance of existing building assets may or may not trigger a review of consent, where commonly it requires a change of use of the facility, or a significant portion of the facility being altered before considering updates of parts and component support and restraint.

(b) Site location is accountable to client and owner of the site seeking development, guiding hazard factor Z.

(c) Both factors above are multiplied giving a kp*Z value that must be a minimum for certain Importance Levels contained in Table 3.3 of AS 1170.4.

(d) Ground conditions is accountable to geotechnical engineer via client instruction, guiding site sub-soil conditions. In absence of this knowledge conservative value of shallow soil C_e conditions would be required to be stated in specification by the building service consultants to determine seismic weight component acting horizontally and vertically unless verified otherwise as it generates the greatest imposed action to consider and increasing the resilience of the design.

(e) Building services should have their material specifications, and relevant material deemed to satisfy structural provisions of Australian Standards stated and updated to prescribed deemed to satisfy provisions stated in latest Building Code of Australian, or National Code of Construction that was issued in development consent and date.

(f) Further to that and building design and specification must have an understanding of intent of the material use with minimum and maximum stresses applied to the material in design specified, either in units of stress (MPa) or if displacement related, imposed strain elongation, or lateral displacement over a prescribed distance that would cause rupture or plastic deformation to the material or unit used in design. This is particularly very important regarding heat, seismic action and displacement and other factors in long distances, vertical riser shafts and high variance in temperature, or where supports vary from fixed to spring mounted.

(g) All plant and equipment should have overall mass, weight, and centre of mass specified in clear labels on machinery (manufacture and specification), with these aspects clearly labelled on plan design drawings, along with stated method of support, along with clear spatial dimensions to determine actions. If not provided specifically then provide general guidelines on effective centre of mass or support. In Importance Level 4 buildings it is the strong recommendation that testing of the units under such force, either static, or dynamic, or even a shake test of a certain displacement be undertaken to verify the component is fit for purpose.

6 Specification to installation – Coordination and clearances

Technological advances in computer aided design software programs have enabled building service designs to coordinate plant, equipment and service runs in a virtual building model containing all aspects of the build prior to commencing onsite. Industry practice involves a hierarchy of building services in coordination.

Such a process involves meetings, coordination workshops, minimum size and clearance implications and finally a review of any clashes between services within the model.

A building consultant may not be privy to site based instruction or variation to the design by the client. It is therefore important to specify minimum clearances to services to ensure they are not unduly impacted by damage from another component or building component.

Update to standard has including an informative (not mandatory) table of minimum clearances between services stating in Part C.1:

'All parts and components suspended from floor slabs and roof systems should be separated, both horizontally and vertically, from other services and components to prevent collision between services and components during the design earthquake. In the absence of more accurate analysis, the minimum clearances given in Table C1 may be used.'

Table 3. Table C1 introduced into AS 1170.4 – 2024 Appendix C.

Table C1 Minimum clearances between parts and components		
Condition being considered	***Minimum clearance***	
	Horizontal	***Vertical***
Unrestrained component to unrestrained component	150mm	25mm
Restrained component to unrestrained component	75mm	25mm
Restrained component to restrained component	25mm	25mm
Sprinkler heads with flexible droppers	nil	nil

* nil – interpreted as able to be in direct contact with another part or component

Some buildings have a high complexity and congestion of services all within a common roof space such as a hallway or corridor with no choice but to have services literally in direct contact with each other, in other cases it may present as one service being supported by another service due to a lack of coordination.

7 Importance level 4 buildings – What is a special study?

Australian Standard 1170.4 Section 8 non-structural parts and components determines an imposed seismic weight force acting in the horizontal and vertical directions. An IL4 structure has a greater kp value and therefore the action can be increased by 1.5 when comparing to an IL2 structure.

Importance level 4 buildings require a special study. What does that mean for the building service designer? It means two (2) approaches must be considered in design, the part or component must withstand the imposed force under IL4 calculated actions; and the part or component must still function as required during or immediately after an earthquake event under IL2 actions, which is simply recognising the behaviour of the component whether it sways and impacts other services when subjected to reduced force actions of that determined by IL4 by dividing those actions by 1.5.

Building design therefore needs to consider what secondary actions occur when force is applied, and more importantly how it behaves when subjected to repeated actions, differing displacements, or the potential crash impact into other adjacent services.

Each prepared design requires clear detail on the method of support whether it be suspended by rods or wires, anchored into a concrete slab, supported by springs on concrete plinth, frames to ground below, or directly attached to primary structure.

Therefore, it is advised to consider the robust nature and the actual displacement profile of non-structural parts and components, especially those required to continue to function during, or immediately after an earthquake event, to the point that prior manufacturer testing may be required.

For example the level of detailing and design needs to consider the support of spring mounted fans inside an air handling unit to remain functioning, the correct anchor within a cracked concrete substrate to resist imposed actions, and even highlight potential limitations of deformation of sheet metal duct subjected to design lateral displacement in the form of inter storey drift between opposing levels of a building and impact on its installation.

This can be determined by a number of methods. A simplified method that can be adopted is equation 8.2(1) of AS 1170.4

$$F_c = a_{floor}[\, I_c a_c / R_c \,]\, W_c \qquad (1)$$

Where afloor = effective floor acceleration at the level where the component is situated, calculated from the earthquake actions determined for the structure using Sections 5, 6 and 7 divided by the seismic weight, but not less than kpZCh(0), where the values of C(0) are the bracketed values given in Table 6.1 of AS 1170.4

Ic = component importance factor

= 1.5 for all parts and components in importance level 4 structures

= 1.5 for components critical for life safety, which includes parts and components required to function immediately following an earthquake, those critical to containment of hazardous materials, storage racks in public areas, curtain walls, external walls, and walls enclosing stairs, stair shafts, lifts and egress pathways

= 1.0 for all other components

ac = component amplification factor

= 2.5 for flexible spring-type mounting systems for mechanical equipment (unless detailed dynamic analysis is used to justify lower values)

= 1.0 for all other mounting systems, and all other parts and components

Rc = component ductility factor

= 2.5 for flexible ductile components

= 1.0 for rigid components or non-ductile components

= 1.0 for connections (unless a higher value can be justified using capacity design principles)

Wc = seismic weight of the component, in kilonewtons (kilograms x 9.81) (1)

It is strongly recommended to provide a list of these parameters that apply to each of the components used in building service design.

If not sure then the very least nominate the intent of the component, whether it be a life critical design component in a hospital theatre, or just a normal functioning component such as supplementary external air for air conditioning, whether the material used is considered ductile or brittle in nature, and whether support if the component be fixed directly to the primary structure or contain a variable allowance for movement such as spring mounts.

8 Building service specification - Example list of standards

To assist the designer, it is recommended to provide a simplified listing of material and imposed action deemed to satisfy structural provisions, such as Australian Standards in the specification similar to that listed below:

AS/NZS 1170.0:2002 - Structural design actions General principles

AS/NZS 1170.1:2002 - Part 1: Permanent, imposed, and other actions

AS 4100:2020 - Steel structures

AS 3600:2018 (R2022) - Concrete Structures

AS/NZS 4600:2018 - Cold-formed steel structures

AS 1170.4:2024 - Earthquake actions in Australia – Section 8

AS 5216:2021 - Design of post-installed and cast-in fastenings in concrete

9 Required principal engineer (building or facility) requirements to consider in building service design

The following is a list of example parameters required for seismic design of each component:

- Building Importance Level (IL#): Specify the IL according to AS1170.4.
- Earthquake Design Category (EDC): Define the EDC for the project.
- Hazard Design Factor (Z): Provide the seismic hazard factor.
- Site Subsoil Conditions: Describe the subsoil conditions as per AS1170.4.
- Building Height (m): State the height of the building.
- Inter-storey Drift - Ultimate (mm): Provide ultimate inter-storey drift values.
- Inter-storey Drift - Service (mm): Provide serviceability inter-storey drift values.
- Peak Floor Accelerations (α_{floor})*:
- Indicated service design loads or weights on plan, indicating load pathways of seismic actions assumed.
- Scaled drawings (1:10) of how a component is connected to the primary structure.
- Details to be forwarded to the principal structural for verification of capacity.
- Statement of periodic reviews required whenever design changes occur throughout the design, the build and/ or the final occupation of the building or facility, located in an operational manual for each service.
- A Design (Peer) Review by a third party structural engineer on record is also an option for IL4 projects, involving examining the design documents prepared to ensure the proposed building works comply with the nominated action and material

standards in specification, for example Australian Standard 5216 Design of post-installed and cast-in fastenings in concrete, before work commences.

10 Contractor responsibilities in executing building service design

We recommend the following inclusions in specification documents:

The contractor is to:

- Engage a seismic design engineering consultant if the intent of the building design is to be altered in support, so that it can be consistent with intent of the design and the specification.

- Submit workshop details or a bill of material of components with identification of purpose (life safety or normal), level of ductility (brittle or ductile), and method of support (direct fixed or spring mounted).

- Specified fastener type and their capacities for additional bracing support from their preferred supplier of the items to confirm that it meets imposed actions.

- Submit technical data sheets for fastening, supports, framing and bracing.

- Update final seismic bracing design on Issued For Construction (IFC), workshop drawings, and as built drawings.

- Confirm recommended service clearances have been met or advise building designer if this cannot be achieved.

- Arrange installation inspections

- Submit installation certification

- Submit quality control documentation plan on bracing locations

- Submit section details for bracing types, gravity load supports, fastening connections and secondary steel framing requirements

11 Example list of exact components used in design - Electrical

It is recommend building service design specifications clearly identify every component or part in design so that it is explicit in what a contractor installation is to consider. Below listed is for an electrical service design. These can be headings in the specification. Section 8 of AS 1170.4 has a more comprehensive list of components for other services as well.

- Smoke control systems

- Emergency electrical systems (including battery racks)

- Battery storage systems or other energy storage systems.

- Fire and smoke detection systems.

- Fire suppression systems (including sprinklers and piping).

- Life safety systems and components. (Including Alarms and Emergency Lighting)
- Boilers, furnaces, incinerators, water heaters, and other equipment using combustible energy sources or high-temperature energy sources, chimneys, flues, smokestacks, vents and pressure vessels.
- Communication systems (such as cable systems motor control devices, pneumatic systems, switchgear, transformers, and unit substations).
- Reciprocating or rotating equipment. (generators)
- Utility and service interfaces.
- Electrical panel boards and dimmers. (switchboards and distribution boards)
- Cabling distribution systems (including cable tray, busbar etc).
- All other similar components

12 Example list of component exemptions

Included in both specification and design layout plans, the building service designer is advised to describe and detail in scale of 1:10 how potential additional restraint exemptions can apply in design. This does not apply in Importance Level 4 structures. Statement would include similar to listed below, excerpted from Section 8, Clause 8.1.4:

Individually supported components classified in items (xvii), (xviii) and (xix) in Section 8.1.4 of AS1170.4, not covered in Items (A) and (B) in Section 8.1.4 of AS1170.4, with an operating weight less than 10kg per metre; or

Individually supported components classified items (xvii), (xviii) and (xix) in Section 8.1.4 of AS1170.4, not covered in Items (A) and (B) in Section 8.1.4 of AS1170.4, with an operating weight less than 30 kg per metre and are located less than 300 mm from the soffit.

Pipes carrying flammable or hazardous substances that have an internal diameter of 25 mm or less; (e.g. medical gases or flammable liquids)

13 Recommended table of service clearance

All details, plans and specifications should include Table C1 of the new standard as replicated in Table 3.1 of this paper.

14 Recommended inclusion statements in building service specifications

Listed below are inclusion statements recommended for design general notes of a site specific design:

- Verify component and equipment fixings and fasteners to withstand seismic design events

- Mounting and fixing/anchor points to be verified with main structural engineer.
- Anti-vibration and acoustic isolations systems are to work for seismic loads.
- Plinths are required to be designed with adequate depth and edge distances for anchor capabilities and suitably structure connections to prevent overturning
- Post-installed anchors must meet AS5216 requirements.
- All material used for gravity supports, secondary steel framing and additional seismic bracing must meet the relevant Australian Standards.

15 References

Australian Building Codes Board (2007) Final Regulation Impact Statement For Decision Executive Summary Recommendation, pg iv (pg1-56)

Australian Building Codes Board (2019) NCC 2019 Building Code of Australia - Volume One, Contents and Introduction to NCC, Pg 9, Figure 1,

Australian Building Codes Board (2022) NCC 2022 Building Code of Australia - Volume One, Figure A2G1, Part A2G4

Standards Australia (2024) Australian Standard 1170.4-2024 – Earthquake Actions, Part 2.2 Note 4, Part 1.3.7, Part 1.4, Part 2.2, Figure 2.2, Table 6.4, Section 8, Clause 8.1.4, Eq 8.2(1), Part C.1, Table C1.