Earthquake design of Fire Safety Systems

think. change.

Jordan Bartlett
Proactive Design
BBus BApSc GC-RMGT MDRSD

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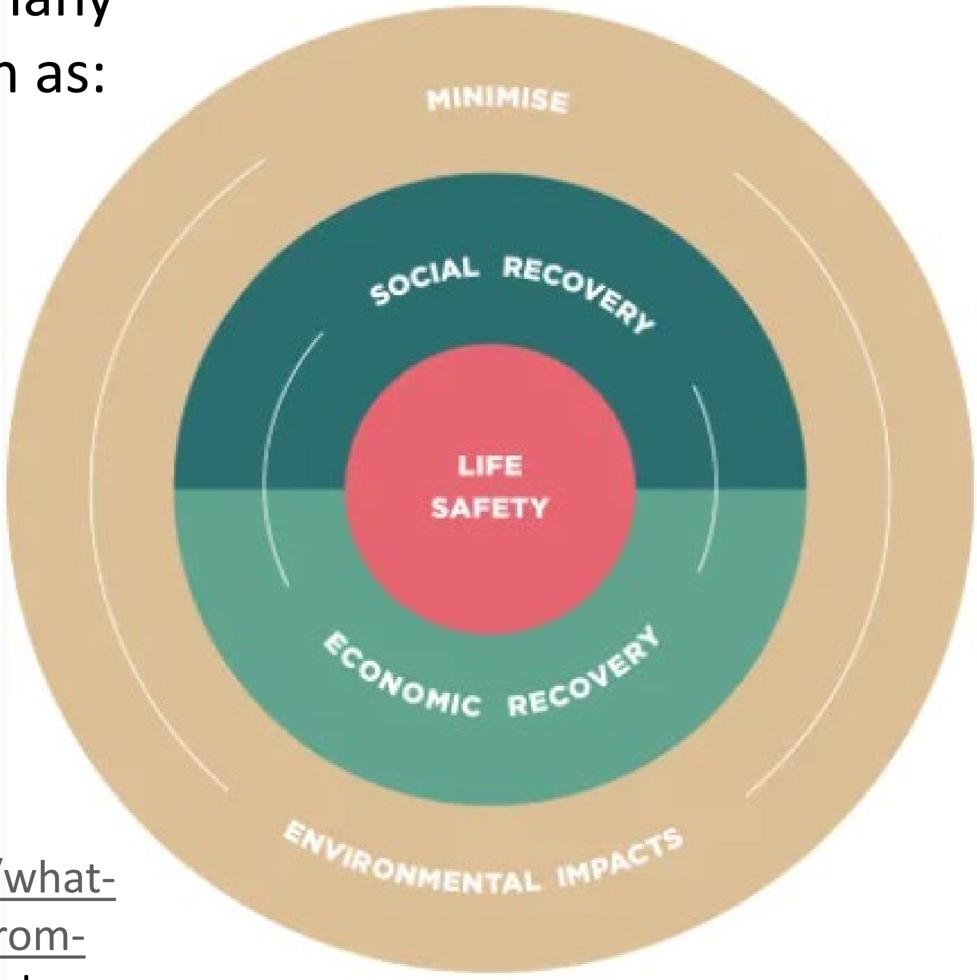
Table of Contents

Community expectations & Risk Based approach

This could apply to many natural hazards, such as:

- Cyclone
- Bushfire
- Flood
- Building Fire



1: LIFE SAFETY

Avoid mass casualty events
Protect vulnerable persons
Ensure safety at mass gathering points
Preserve high value skills and resources
Support immediate response activities
Maintain a perception of safety

2: SOCIAL RECOVERY

Ensure equitable access to essential goods and services
Enable effective governance
Have places to connect
Return sense of normalcy
Retain sense of place and cultural identity

3: ECONOMIC RECOVERY

Restore enabling services and industries
Enable people to work
Build business confidence

4: MINIMISE ENVIRONMENTAL IMPACT

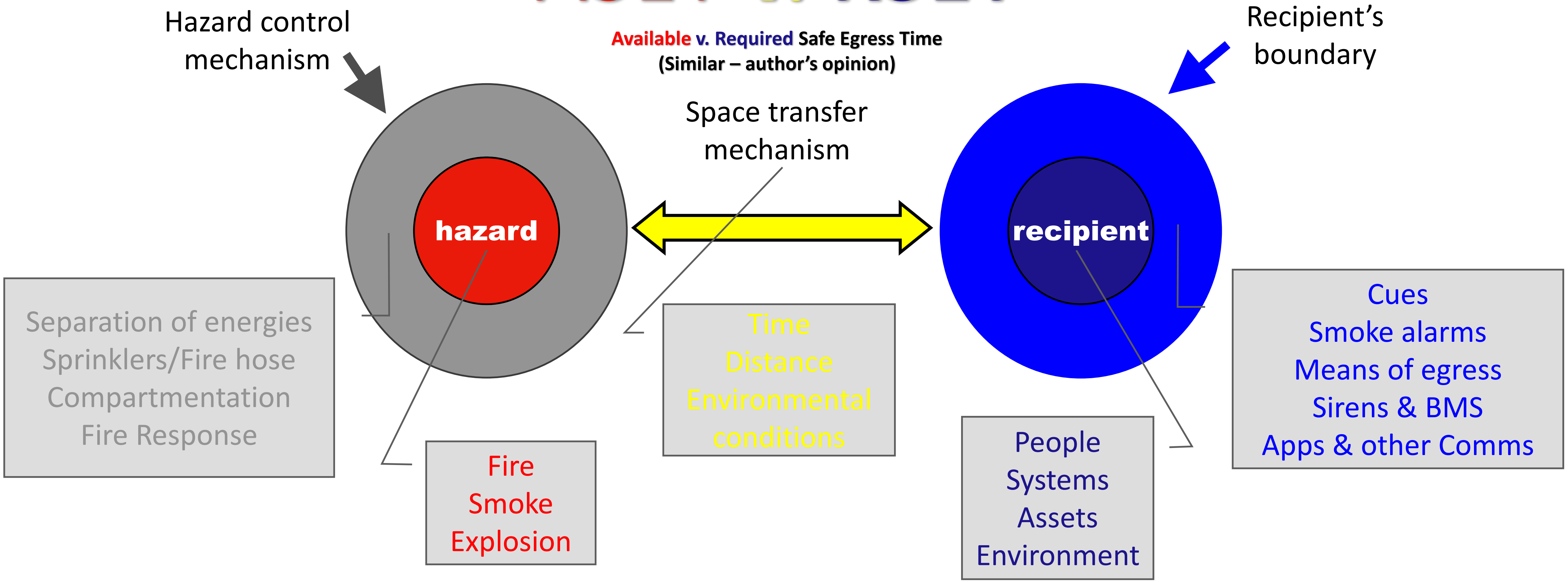
Minimise waste generation
Avoid hazardous waste or potential public health risks
Reduce embodied carbon

https://www.resorgs.org.nz/what-do-new-zealanders-want-from-their-buildings/, captured 24/06/2025

Viner. D. 1991, - Extended Energy Damage Model

ASET v. RSET

Available v. Required Safe Egress Time
(Similar – author's opinion)



Historical EQ design

- 1970 - Olive View Medical Center, CA
- ‘Earthquake-proof’ hospital

- 1971 - San Fernando EQ (M6.5) Feb 9
- Building badly damaged
- No fatalities in hospital
- No services available & required evacuation

- 1981 - Olive View Hospital (New)
- 1989 - Newcastle Earthquake
    - AS1170.4:1993 (from AS2121:1979)
- 1994 Northridge earthquake (M6.7)
    - Olive View Hospital
    - Structure survived
    - Collapse prevented
    - No fatalities
- **Failure of non-structural components**

1. Ceilings torn from walls

2. Support failure

3. Ceilings pulling walls down

4. Ceiling connections failing

5. Ceilings crushed

6. Dislodged supported services

1. Essential Services

2. Loss of hygienic environment

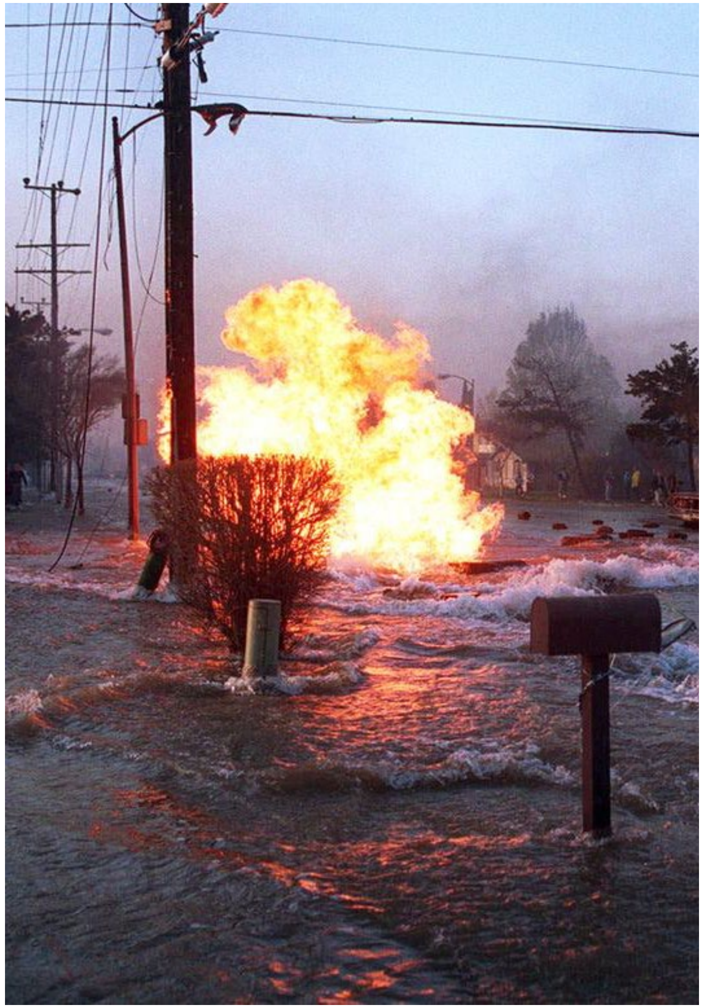
3. Storage systems failing

4. Lab & Sterilisation Services

5. Lift services

6. Data storage & essential controls

Building services failures



Community disruption

A checklist can help identify property loss prevention measures.

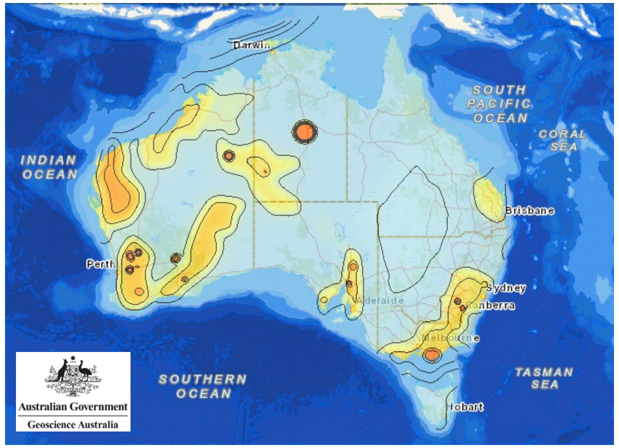
Preparing for an earthquake before the event occurs can dramatically decrease the level of damage and associated losses. Businesses adequately prepared with defined plans and trained employees are better placed to restore business operations quickly. Below is a check-list of possible pre-earthquake risk mitigation actions for business.[21]

- Develop/train an Earthquake Emergency Response Team to initiate pre- and post-earthquake recovery actions.
- Develop plans for the protection and maintenance of fire protection systems in service.
- Develop business continuity plans for rapidly resuming operations after an earthquake, including sourcing restoration / remediation companies/ critical spare parts inventory.
- Establish a list of contractors to aid in earthquake preparedness and recovery. Place contractors on alert.
- Develop procedures for safe shutdown of utilities and operations (electricity, gas, flammable liquids operations, etc).
- Provide anchorage, clearance, and flexibility for machinery and equipment.
- Provide bracing, clearance, and flexibility for liquid filled piping systems including domestic water, fire protection water, other liquids and gases.
- Provide Earthquake Actuated Automatic Seismic Shutoff Valves for flammable gas systems and flammable liquid dispensing systems.
- Retrofit structural elements to adequately resist seismic forces under the direction of licensed engineers and contractors.
- Ensure emergency gear and equipment are ready and accessible.
- Maintain an adequate inventory of materials such as mops, brooms, squeegees, portable generators, etc.

Australian EQ story

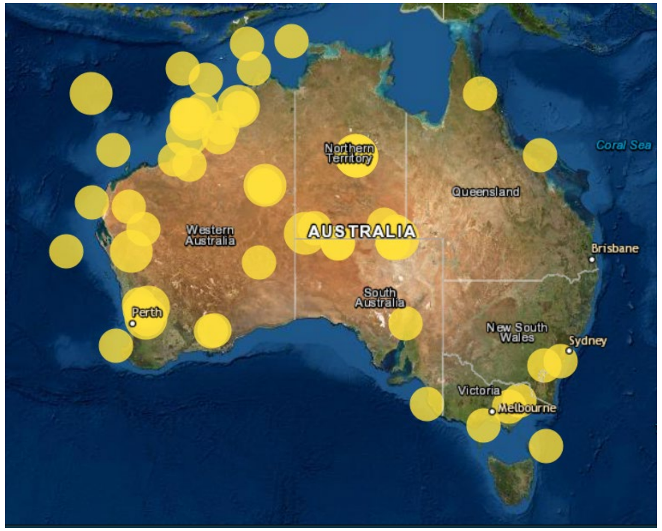
On average 100 earthquakes of magnitude 3 or more are recorded in Australia each year. Earthquakes above magnitude 5.0, such as the destructive 1989 Newcastle earthquake, occur on average every one-to-two years. About every ten years Australia experiences a potentially damaging earthquake of magnitude 6.0 or more such as the magnitude 6.5 Meckering earthquake in October 1968.

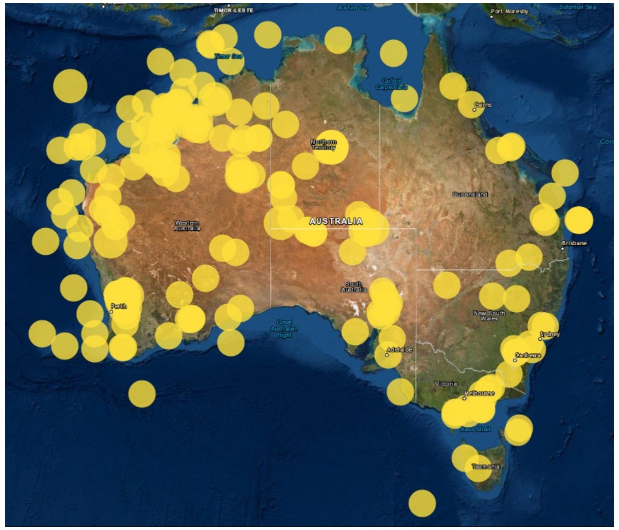
https://www.ga.gov.au/education/classroom-resources/hazards/natural-hazards/earthquake, 29/02/2024



Illustrations – 5.6ML (116) & 5ML (364)

- M6.5 Beachport SA 1896
- M6.5 Meckering 1968 (MI IX Violent)
- M5.4 Morwell 2012 felt in MEL
- M5, 5.1 & 5.3 QLD 2015 ** (SCUH)
- M6.1 NT (Sth West) 20/05/16 (*20yrs)
- M5.9 Woods Point 2021 (Mansfield/MEL)
- Adelaide 1954 – Close to Magnitude 6 according to the Seismological Society of Australia https://earthquake.net.au/index.php/2024/02/29/1954-adelaide/





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Australia – Low seismic risk, not no risk

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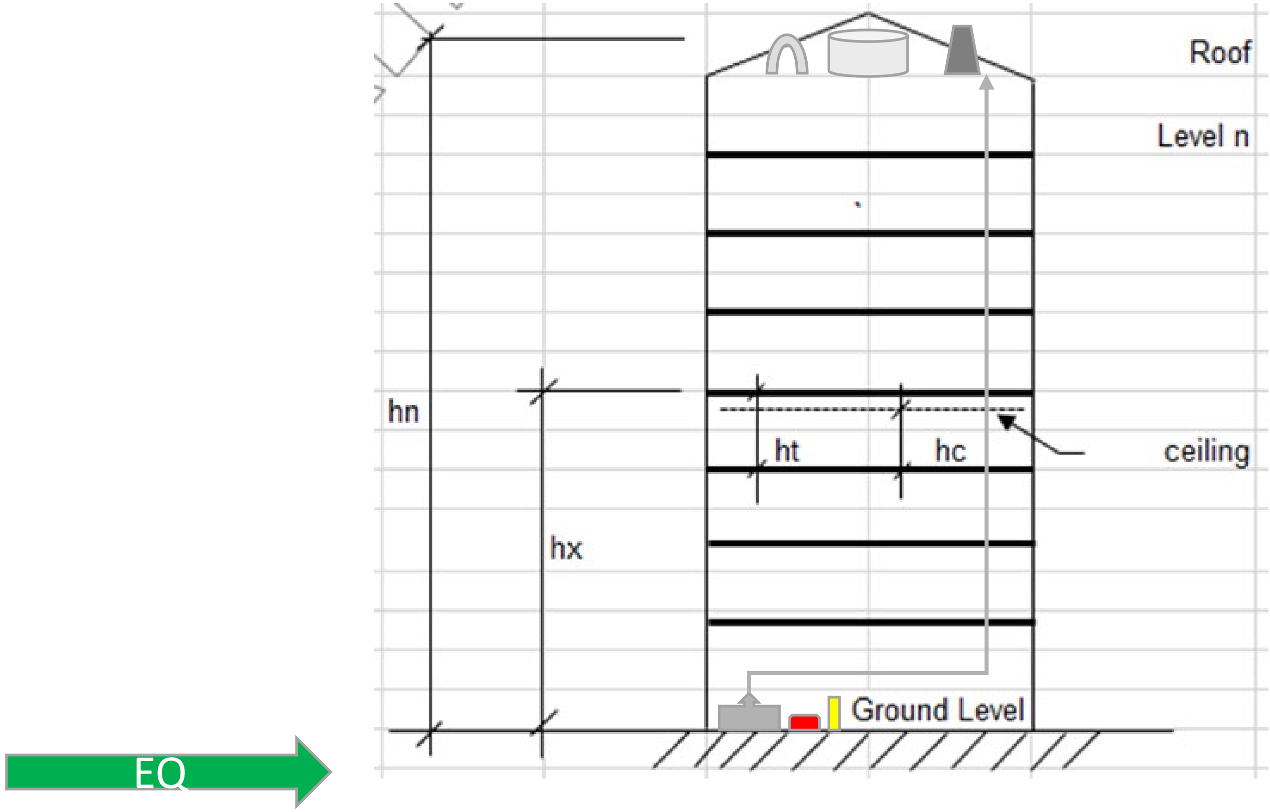

IL2/3

IL4(5)

Performance Target

- Life-safety
- Egress

- Ingress
- Business Continuity
- Recovery for Critical Infrastructure

‘ambiguous references’ are over-ridden by AS1170.4, although dangerously misunderstood:

- 'and any likely seismic loading (refer to AS1170.4)' AS1940:2017 – Storage Flammable & Combustible liquids
- ‘Acceleration Coefficient below 0.1’ AS2304:2019 – (M-Fire water storage)
- 'in a Zone A or Zone 2 location as defined in AS1170.4' AS1894:1997 (CRYO) & AS3961:2017 - LNG
- 'in areas which seismic events are likely to occur' AS2118.1:2017 – (M-F Sprinkler)
- 'in areas of seismic activity' AS2419:2017 – (M-F Hydrant)
- 'in areas with significant risk of seismic activity' AS/NZS3084:2017 – (E-Comms)
- 'seismically active region' AS2067:2016 – (E-HV & Subs)
- 'situated in a seismic environment’ AS2067:2016 – (E-HV & Subs)
- 'in areas with possible risk of earthquake' AS/NZS5149.3:2016 (M-Ref)
- 'where earthquakes are anticipated' AS/NZS5149.3:2016 (M-Ref)
- 'in areas subject to earthquake' AS/NZS4994:2018 – Temp Edge Protection

Correction of these should be: **In accordance with AS1170.4 Section 8**

General advice

From: "Victorian Building Authority" <communications@vba.vic.gov.au>
Date: 20 July 2018 at 11:13:27 am AEST
Subject: Carbon monoxide testing, July building reforms, draft plumbing regulations and much more

Important information about professional indemnity insurance

Designing ceiling installations for earthquake action

The VBA is aware that ceilings in buildings may not be designed to meet the requirements of AS 1170.4 – 2007 *Structural design actions* Part 4: Earthquake actions in Australia.

Volume One, Clause B1.2 (c) (ii) and Volume Two, Clause 3.11.3 (c) (iv) of the *National Construction Code* require buildings to be designed to resist seismic loads calculated to AS 1170.4 - 2007 *Structural design actions* Part 4: Earthquake actions in Australia as appropriate.

Section 8 of the Standard requires ceilings to be designed to resist earthquake forces, except where they are located within domestic structures less than 8.5m tall and "Importance Level One" structures. The Standard also applies to walls, partitions and other non-structural elements.

Designers, contractors, installers, builders and building surveyors are reminded that the requirements of AS 1170.4 – 2007 need to be considered when designing ceilings, walls, partitions and other non-structural elements within a building.

VBA Website | Contact Us | eToolbox – Plumbing | eToolbox – Building | Find a Practitioner

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abcb.gov.au/Connect/Articles/2019/03/12/Design-of-nonstructural-building-elements-for-earthquake-forces

ABCB CONNECT

NCC | Consultation | Resources | Initiatives | Product Certification | ABCB | NCBP

ABCB Connect > National Construction Code > Design of nonstructural building elements for earthquake forces

Design of non-structural building elements for earthquake forces

27/03/2019

The following provides guidance about the application of AS 1170.4 and in particular the required performance of certain non-structural building elements (including walls and partitions; ceilings and services) to resist earthquake forces.

National Construction Code
- Documents considered as part of a Performance Solution (Update 1: NCC 2022)
- Restricting the spread of smoke within buildings through Zone Pressurization
- Lead in Plumbing Products Forum

Browse By Category >

Important Announcements

National Construction Code

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qbcc.qld.gov.au/blog/tradie-talk/designing-building-accommodate-earthquake-loads

qbcc | QUEENSLAND BUILDING AND CONSTRUCTION COMMISSION

› Contractors › Home owners › myQBCC › New Laws

Home > QBCC Blog > Tradie Talk > Designing and building to accommodate earthquake loads

Designing and building to accommodate earthquake loads

Posted 07 Mar 2019

Share to

Compliance with relevant standards

Recent devastating earthquakes around the world should remind all building industry practitioners of the importance of ensuring that our buildings in Australia comply with the National Construction Code and Australian Standard AS1170.4 'Earthquake actions in Australia'.

Let's not forget the fact that Australia has experienced the devastation caused by an earthquake on the morning of 28 December 1989 at Newcastle where 13 people were killed and more than 160 were hospitalised.

Generally speaking, all buildings need to be designed and constructed in accordance with AS1170.4 unless they are not captured under its scope such as buildings that are:

- domestic structures of class 1a or 1b that are 8.5m or less in height
- Importance Level 1 structures (e.g. farm buildings and sheds, isolated minor storage facilities, minor temporary facilities).

Non-structural components need to be considered

A common misconception in the building industry is that only the primary structural frame of a building needs to be considered for earthquake actions, this is not the case. Non-structural components of a building and their fastenings need to be designed for earthquake forces as required by AS1170.4.

Additionally, on multi-storey buildings 'inter-storey drift', which is the amount of potential movement that could occur between floor slabs above one another in any given storey of a building during an earthquake event, needs to be considered.

AS1170.4 Clause 8.1.4 provides a comprehensive list of architectural (non-structural) components that require consideration for earthquake loads being:

- (i) Walls that are not part of the seismic-force-resisting system
- (ii) Appendages, including parapets, gables, verandas, awnings, canopies, chimneys, roofing components (tiles, metal panels) containers and

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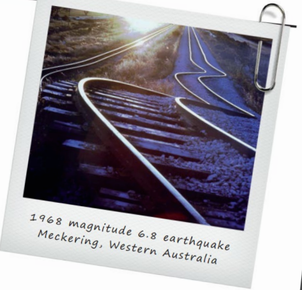
AS 1170.4-2007 Commentary
Structural Design Actions
Part 4: Earthquake Actions in Australia
2nd Edition (2021)



1968 magnitude 6.8 earthquake
Meckering, Western Australia

ENGINEERS AUSTRALIA

AUSTRALIAN EARTHQUAKE ENGINEERING SOCIETY

Government of South Australia
Department of Planning, Transport and Infrastructure

Seismic Restraint of Engineering Services

Introduction

Despite Australia's seemingly low seismic risk, being in the middle of one of the earth's larger tectonic plates, we have been subjected to 17 earthquakes registering 6 or more on the Richter Scale in the last 80 years. There have been six major earthquakes recorded in South Australia;

- 1897 Beachport M6.5
- 1902 Warooka M6.0
- 1954 Adelaide (Darlington) M5.5
- 1986 Marryat Creek M6.0
- 2012 & 2013 Ernabella M5.7

Seismologists advise that based on local geology earthquakes of up to Richter magnitude M7.5 can occur in South Australia however earthquakes of such a magnitude are very rare.

Experience from around the world shows that failure of engineering services as a result of an earthquake can have a significant effect on life safety and economic loss. The seismic loads that engineering services must be designed to resist are calculated using Section 8 of AS 1170.4 - 2007 Structural design actions Part 4: Earthquake actions in Australia. The standard requires that engineering services be designed to resist earthquake forces except where the services are located in domestic structures less than 8.5m tall and "Importance Level One" structures. The Standard is applicable to equipment mounted on structures as well as on the ground, such as high voltage circuit breakers, transformers and tanks.

The aim of this guidenote is to make designers aware of the:

- Requirement to restrain engineering services against seismic forces in accordance with Section 8 of AS 1170.4 - 2007;
- Requirement that the seismic bracing of engineering services be documented in detail in the tender drawings and specification on DPTI projects and that the Lead Professional Service Contractor is required to co-ordinate this work across all disciplines;
- Technical information available to assist in designing and detailing the seismic restraint of engineering services.

The following items are excluded from the scope of this guidenote:

- The restraint of engineering services in an importance level 4 building as a special study is required to be carried out to ensure they remain serviceable for immediate use following the design event for importance level 2 structures (1 in 500 year earthquake).
- Suspended ceilings.
- Building contents including portable appliances.

Definitions

- Anchor – A fastener installed into concrete used to transfer seismic forces.
- Brace – An element of the restraint system used to transfer seismic force from a component to the supporting structure.
- Domestic structure – Single dwelling or one or more detached dwellings complying with Class 1a or 1b as defined in the National Construction Code.
- Ductile material – flexible and tough material, eg: steel, copper, aluminium.

Seismic Restraint of Engineering Services bp19 v1.3
Created in April 2019

Government of South Australia
Department of Planning, Transport and Infrastructure

NSW GOVERNMENT | Health Infrastructure

DESIGN GUIDANCE NOTE No. 024
Rev A_21 October 2016
Page **1** of **7**

IMPORTANCE LEVELS FOR HOSPITAL BUILDINGS

PURPOSE

The purpose of this note is to provide guidance and consistency with regard to Building Importance Levels as defined by the BCA and AS1170.

BACKGROUND

The **BCA Section B Table B1.2a** requires a selection of a Building Importance Level (IL) based on the proposed use of the building. For Health projects this generally requires a decision as to whether the building is **IL3** (Buildings or structures that are designed to contain a large number of people), or **IL4** (Buildings or structures that are essential to post-disaster recovery or associated with hazardous facilities).

The **NCC2016 Guide to the BCA Volume One** provides further detail and examples in respect of the IL and goes on to state, in relation to health care facilities:

> **IL3:** Health care facilities with a capacity of 50 or more residents but not having surgery or emergency medical treatment facilities;
>
> **IL4:** Medical emergency or surgery facilities; Emergency service facilities: fire, rescue, police station and emergency vehicle garages.

It is generally accepted that the majority of HI's hospital buildings will fall into the IL4 category, the exceptions being regional MPS facilities and the like.

HI DIRECTION

For all HI projects, confirmation is to be sought from the HI Project Director as to the IL category proposed to be adopted before any design commences. Note that this IL is to apply to all building elements, including structure, façade, services, fitout and so on.

AS1170

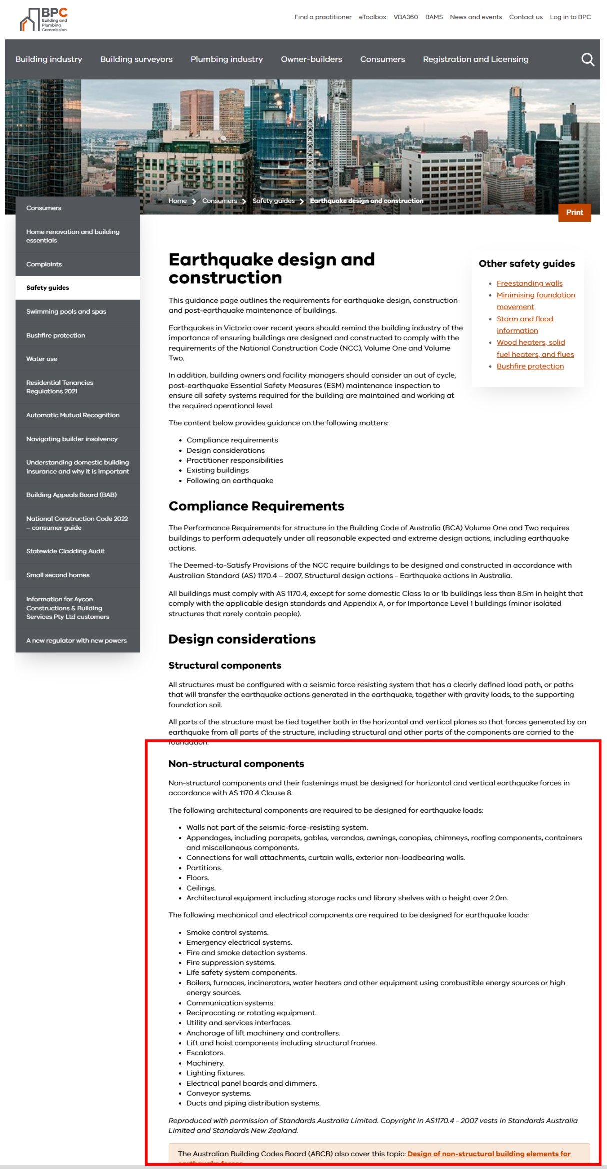
The categorisation of a building's IL then feeds into the Australian Standards for Structural Design Actions (AS1170.0 to 1170.4). These standards adopt the Importance Level for a building or structure and the associated Annual Probability of Exceedance for wind, snow and earthquakes.

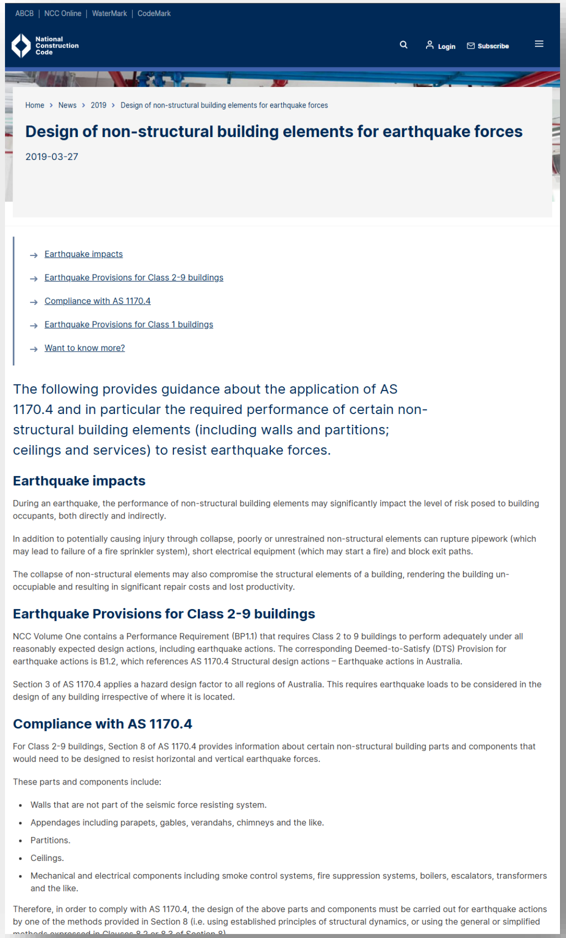
With respect to earthquakes, along with the geographical location, soil conditions and other factors, AS1170.4 (Earthquake Actions in Australia) determines the horizontal forces that the structural engineer will need to design the building for in its ultimate state.

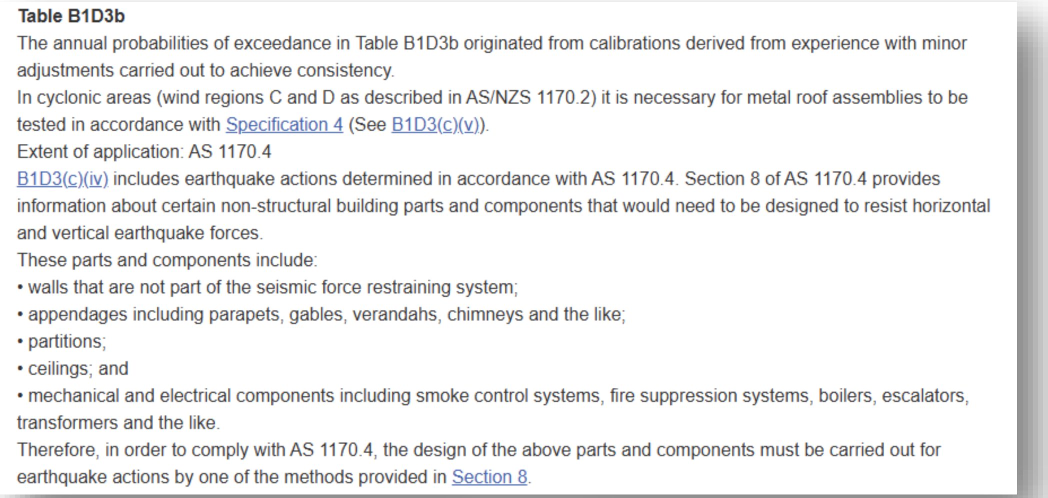
In addition, the structural engineer will need to advise the building design category to the services designers, and other designers such that appropriate localised support for other building elements such as services pipes, ducts, ceilings, walls etc. is provided. These elements are all listed in Section 8.1 of AS1170.4 and must be complied with for both IL3 and IL4 buildings. This may require the addition of bracing elements to services, where not exempt under the code. Examples of bracing details are appended to this guidance note. These are provided as examples only - designers are required to engineer their own solutions that comply with the BCA and AS1170.

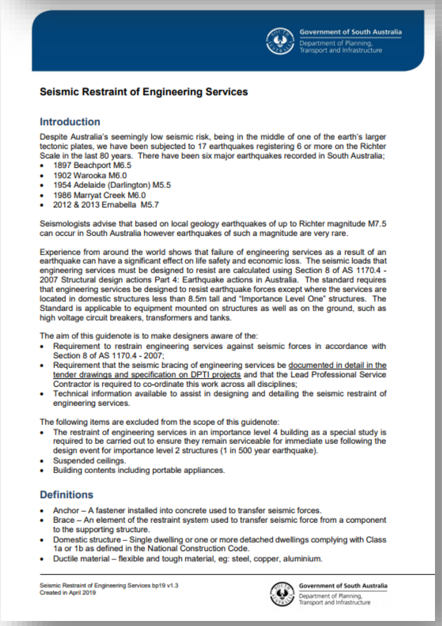
SERVICEABILITY POST DISASTER

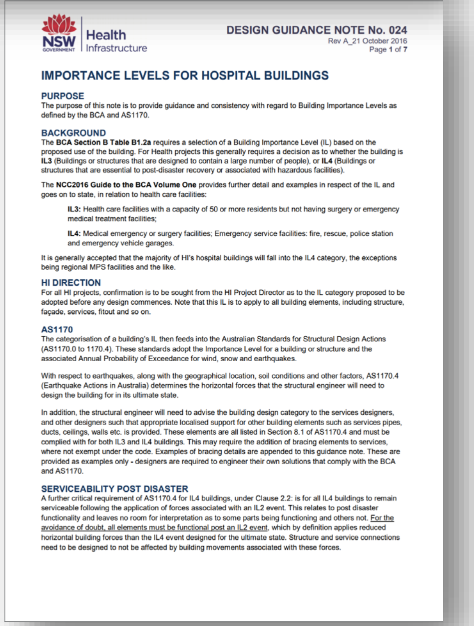
A further critical requirement of AS1170.4 for IL4 buildings, under Clause 2.2: is for all IL4 buildings to remain serviceable following the application of forces associated with an IL2 event. This relates to post disaster functionality and leaves no room for interpretation as to some parts being functioning and others not. For the avoidance of doubt, all elements must be functional post an IL2 event, which by definition applies reduced horizontal building forces than the IL4 event designed for the ultimate state. Structure and service connections need to be designed to not be affected by building movements associated with these forces.











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AS1170.4 Section 8 – Confirmations ABCB, NCC, Guide, VBA & Dept.

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SECTION 8 DESIGN OF PARTS AND COMPONENTS

8.1 GENERAL REQUIREMENTS

8.1.1 General

Non-structural parts and components and their fastenings, as listed in Clause 8.1.4, shall be designed for horizontal and vertical earthquake forces as defined in Clauses 8.1.2 and 8.1.3,
A1 and accommodate the design inter-storey drift.

Base isolation may be used to reduce the forces on a component. Where flexible mounting devices (such as spring mountings) are used, they shall be fitted with restraining devices to limit the horizontal and vertical motions, to inhibit the development of resonance in the flexible mounting system, and to prevent overturning.

Update: AS 1170.4:2024

8.1.1 General

Non-structural parts and components and their fastenings for EDC I, EDC II and EDC III facilities, as listed in Clause 8.1.4, shall:

(a) be designed for horizontal and vertical earthquake forces as defined in Clauses 8.1.2 and 8.1.3, and

(b) accommodate the design ~~inter-~~storey drift (see Clause 6.7.2).

Base isolation may be used to reduce the forces on a component. Where flexible mounting devices (such as spring mountings) are used, they shall be fitted with restraining devices to limit the horizontal and vertical motions, to inhibit the development of resonance in the flexible mounting system, and to prevent overturning.

A special study shall be carried out for importance level 4 facilities to demonstrate that the relevant parts and components will remain serviceable and operational for immediate use following the design event associated with importance level 2 structures.

Architectural Components

(a) *Architectural components*:

(i) Walls that are not part of the seismic-force-resisting system.

(ii) Appendages, including parapets, gables, verandas, awnings, canopies, chimneys, roofing components (tiles, metal panels) containers and miscellaneous components.

(iii) Connections (fasteners) for wall attachments, curtain walls, exterior non-loadbearing walls.

(iv) Partitions.

(v) Floors (including access floor systems, where the weight of the floor system shall be determined in accordance with Clause 6.2.2).

(vi) Ceilings.

(vii) Architectural equipment including storage racks and library shelves with a height over 2.0 m.

'Their Connections'

(The weakest link) a product can be conforming, but only if the installation is compliant!

MEPF Components

(b) *Mechanical and electrical components*:

(i) Smoke control systems.

(ii) Emergency electrical systems (including battery racks).

(iii) Fire and smoke detection systems.

(iv) Fire suppression systems (including sprinklers).

(v) Life safety system components.

(vi) Boilers, furnaces, incinerators, water heaters, and other equipment using combustible energy sources or high-temperature energy sources, chimneys, flues, smokestacks, vents and pressure vessels.

(vii) Communication systems (such as cable systems motor control devices, switchgear, transformers, and unit substations).

(viii) Reciprocating or rotating equipment.

(ix) Utility and service interfaces.

(x) Anchorage of lift machinery and controllers.

(xi) Lift and hoist components including structural frames providing support for guide rail brackets, guide rails and brackets, car and counterweight members.

(xii) Escalators.

(xiii) Machinery (manufacturing and process).

(xiv) Lighting fixtures.

(xv) Electrical panel boards and dimmers.

(xvi) Conveyor systems (non-personnel).

(xvii) Ducts, cabling and piping distribution systems.

8.1.4(b)(xviii) Restraint Exemption Clarification

(xvii) Ducts, cabling and piping distribution systems.

(xviii) Supports for ducts, cabling and piping distribution systems, except individually supported services, in the following situations:

(A) In structures classified as being in EDC I.

(B) For gas piping less than 25 mm inside diameter.

(C) For piping in boiler and mechanical rooms less than 32 mm inside diameter.

(D) For all other piping less than 64 mm inside diameter.

(E) For all electrical conduit less than 64 mm inside diameter.

(F) For all rectangular air-handling ducts less than 0.4 m^2 in cross-sectional area.

(G) For all round air-handling ducts less than 700 mm in diameter.

(H) For all ducts and piping suspended by individual hangers 300 mm or less in length.

- Applying these require SED knowledge, and noteworthy:
  - The exemptions only apply to IL2 & IL3 structures, not IL4.
  - The exceptions only apply to 'individually supported services'.
  - Straight run of service should remain restrained if beginning – ie no exemption @ changes in size, drop, etc.
  - Where below threshold items are supported on a trapeze or multi-service hanger exemption is no longer valid
  - "All other components similar to those listed" - Items not specifically mentioned in AS1170.4 section 8.1.4 are considered to require restraint ….. plinths, fuel storage systems, batteries and UPS.

Update: AS 1170.4:2024

Mechanical, hydraulic and electrical components, except for those in Importance Level 4 facilities or those required to remain operational immediately following an earthquake, are exempted as follows:

Draft

(A) Pipes carrying flammable or hazardous substances that have an internal diameter of 25 mm or less;

(B) Fire ~~sprinkler systems~~service pipes that have an internal diameter of 50 mm or less;

(C) Individually supported discrete components with an operating weight less than 10 kg;

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

(E) Individually supported components classified in items (xvii), (xviii) and (xix), not covered in Items (A) and (B), with an operating weight less than 30 kg per metre and vertical supports that are ~~located~~ less than 300 mm long from the soffit.

Force Calculation (8.3 Simple*)

$$F_c = [k_p Z C_h(0)] a_x [I_c a_c / R_c] W_c \qquad \text{but} > 0.05 W_c$$

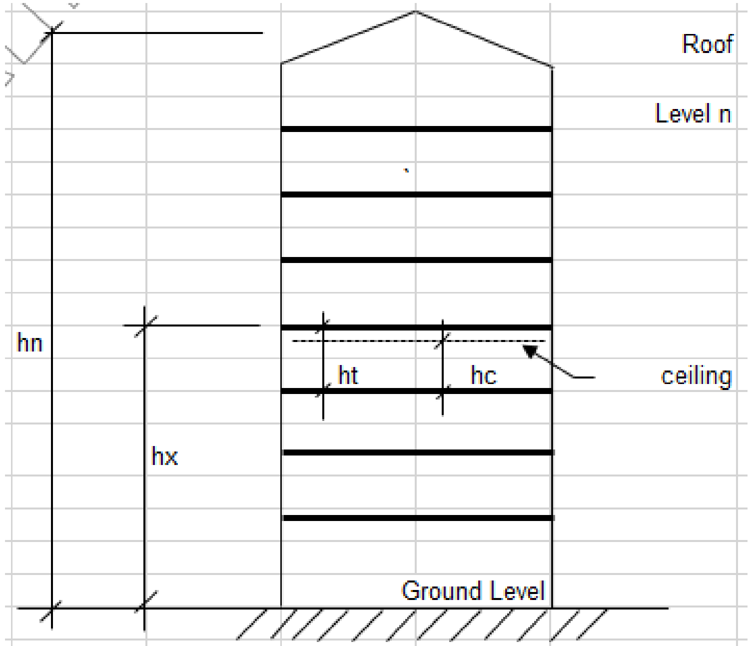
Design Considerations

Structural Engineer

- **Building Usage (IL1-4) - k_p**
- **Geographical Location - Z (min 0.08)**
- **Site Subsoil Type $C_h(0)$**
- **Building/Attachment height - a_x**

Specific Engineering Design

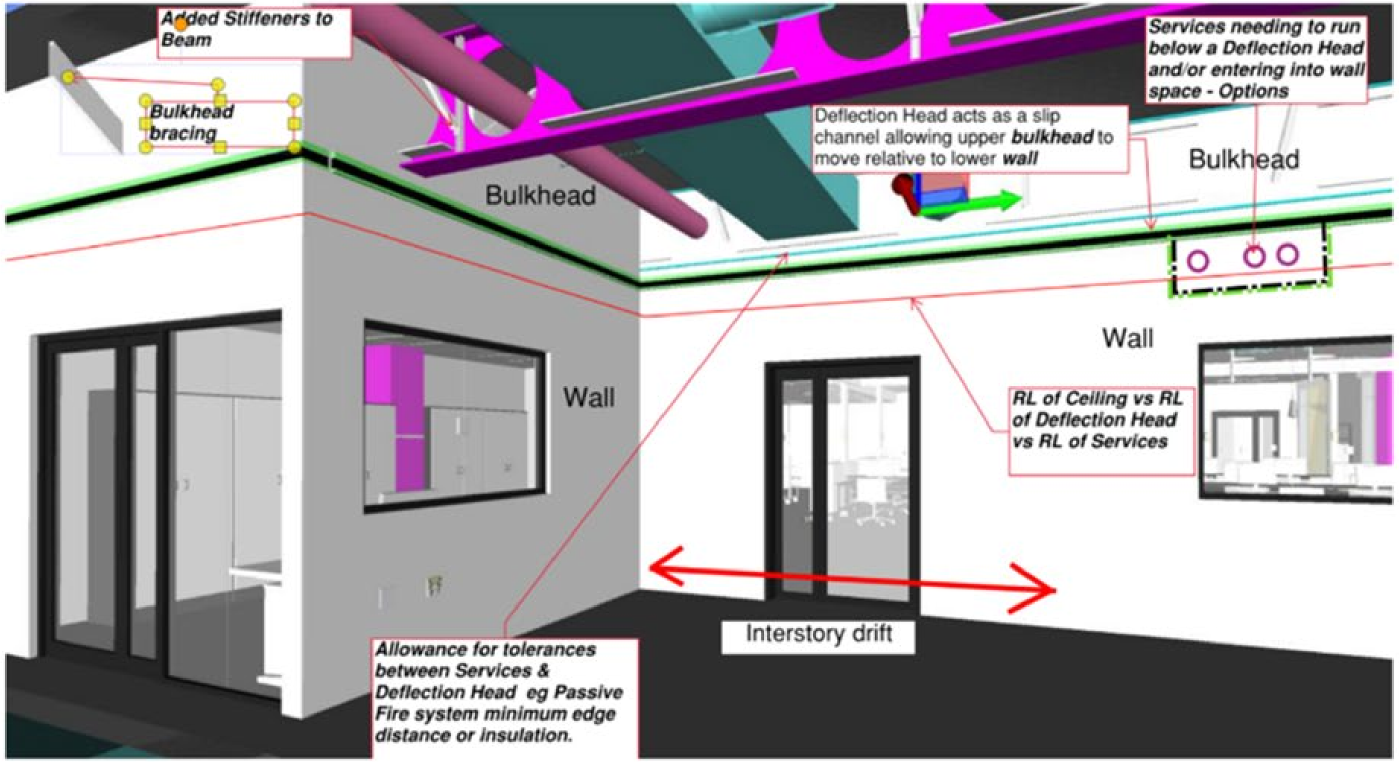
- **Component Importance Factor - I_c**
- **Construction materials – a_c / R_c (capacities/ductility)**
- **Ceiling/Pipe/Finishes Weights - W_c**
- **Attachment Point/Height/Plenum depth**
- **Lateral Length/Area**



Opportunity - Consider Tolerance in the design/model space

Opportunities

RL of Ceiling
vs
RL of Deflection Head
vs
Acoustic Detailing
vs
Passive Fire (Edge Distances)
vs
Services passing under the deflection head into the wall.



HAWKINS

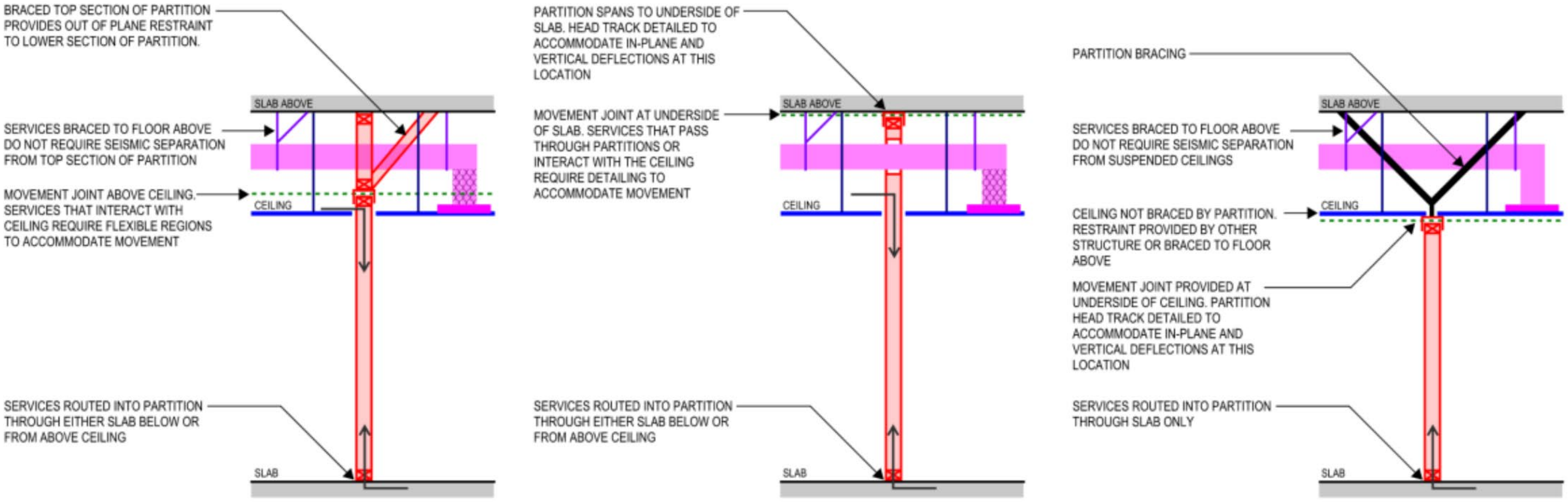


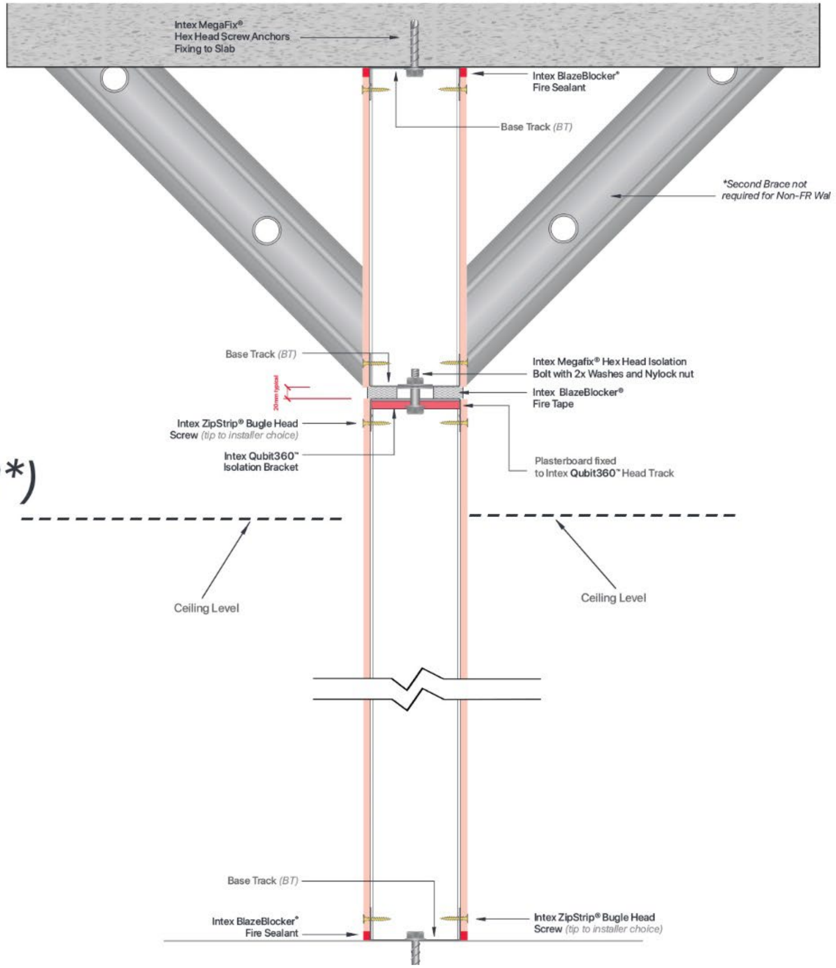
Figure 5. Example of seismic restraint partition strategies for discussion and coordination with architects and building service engineers

Testing – Theoretical v tested

Concept Only

Plenum Bulkhead Wall *(FR*)*

(Testing subject to market demand)



- Minimum clearances for services shall apply for Seismic Restraint of Engineering Services (table pictured below).
- Result: pathways may require adjustment and communication to other trades.

Table 4: Minimum clearances *(Part extract from NZS 4219:2009 Table15)*

Condition being considered	Minimum clearance	
	Horizontal	Vertical
Unrestrained component to unrestrained component (where allowed by AS1170.4 - 2007)	250mm	50mm
Unrestrained component to restrained component	150mm	50mm
Restrained component to restrained component	50mm	50mm
Penetration through structure such as walls or floor	50mm	50mm
Unrestrained services passing through the ceiling	25mm	25mm
Sprinkler heads with flexible droppers	nil	nil
Note: Ceiling hangers and braces are considered to be restrained components for the purpose of this table, hence 150mm horizontal clearance is required between ceiling hangers and unrestrained services. Where multiple services are attached by the same support (ceiling hanger from mechanical plant supports) then this must be an engineered solution from the primary support consultant. No hangers will be attached to any plant that can vibrate or has the potential to move.		

Table 4.4 — Minimum clearances between ceiling and services

Condition being considered	Minimum clearance, mm	
	Horizontal	Vertical
For Australia		
Unrestrained ceiling to unrestrained service (see Note 2)	250	25
Unrestrained ceiling to restrained service, or vice versa	100	25
Restrained ceiling to restrained service	35	25
Sprinkler heads with flexible droppers	Nil	Nil

NOTE 1 Ceiling hangers and braces shall be assessed as restrained components for interpretation of this Table.

NOTE 2 The centre of mass of any service, directly suspended from above, shall be located within 250 mm of the primary supporting structure, for it to be considered as "restrained".

NOTE 3 Columns and other penetrations through the ceiling can be considered as restrained "services" within this Table as required.

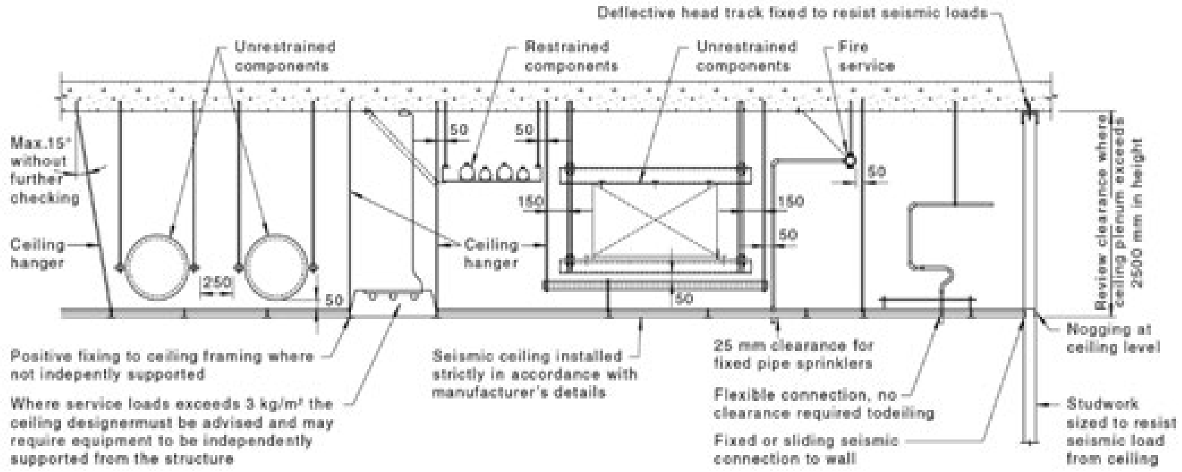


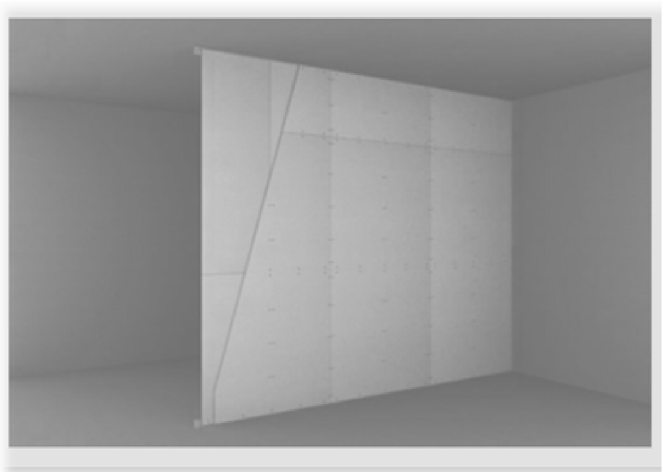
Figure 4.3 — Minimum component clearances for services

TRAFALGAR FIRE
Trafalgar Head Office:
PO BOX 545
Chester Hill NSW 2162
T: 1800 888 714
F: 1800 201 500
E: technical@tgroup.com.au
W: www.tfire.com.au

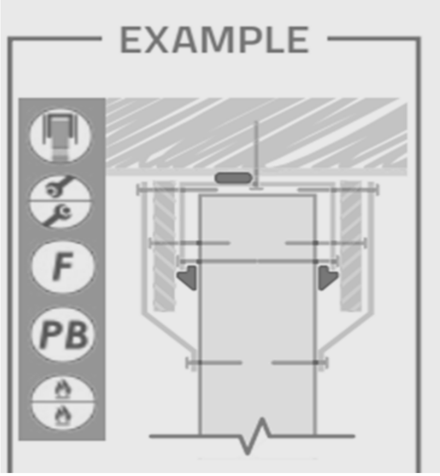
Item Number	Service type A	Service type B	Separation required	Standard reference
1	Power	Gas	25mm **AND** as per AS 5610	AS 3000 3.9.8.4(b)
2	Power	Water	25mm **AND** as per AS 3500	AS 3000 3.9.8.4(b)
3	Power	Comms	50mm (unless in a conduit) **AND** as per AS/CA S009	AS 3000 3.9.8.4(c)
4	Safety Service (i.e. fire cables)	Any other cables including other safety services	50mm (unless in a conduit)	AS 3000 7.2.2.2.2
5	Comms	Power	50mm (unless in a conduit)	AS/CA S009 16.3.1(a)
6	Comms	Gas	Recommended 25mm ##	AS/CA S009 9.2.2(a)
7	Comms	Water (Cold <60°C)	50mm (unless in a conduit)	AS/CA S009 9.2.1
8	Comms	Water (Hot >60°C)	Recommended 25mm ##	AS/CA S009 9.2.2(a)
9	Cold water	Gas	25mm	AS 3500 5.2.2
10	Cold water	Power and comms	25mm	AS 3500 5.2.2
11	Potable water	Non-potable water	25mm	AS 3500 9.3.2.1
12	Gas	Power	25mm (unless in a conduit)	AS 5601 5.3.4
13	Heated water piping	any other service	25mm separation	AS3500.4:2021 Clause 4.3.2.2
14	Stormwater drainage	any other service	100mm separation	AS3500.3 Clause 6.2.6(d)
15	Sanitary drainage	any other service	100mm separation	AS3500.2 Clause 3.6.2
16	uPVC pipes	Building element	minimum 6mm annular space and filled with flexible material	AS2032 Clause 6.2.3 as referenced in AS3500.2 Clause 10.7
17	Copper or alloy pipe	Building element	minimum 6mm annular space and filled with flexible material	AS3500.2 Clause 10.6.4 and PCA CP1.1

Minimum clearances between services – Enforceable

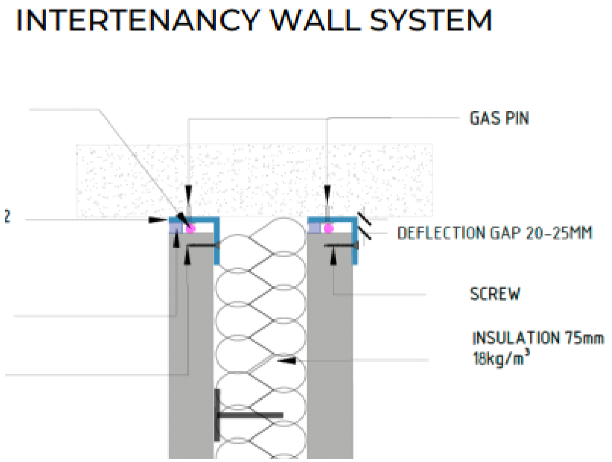
Compartmentation & Passive Fire



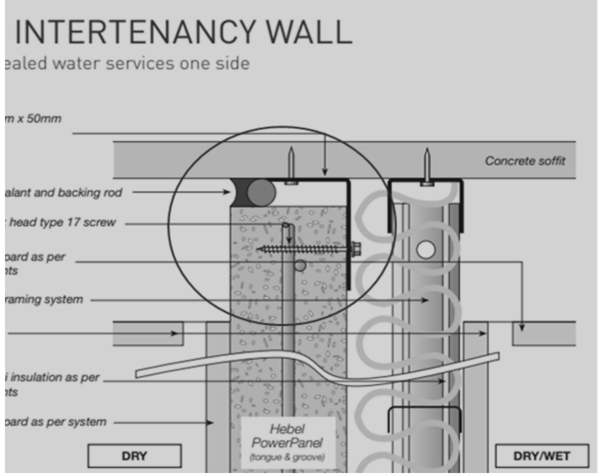
Frameless Partitions



Aerated concrete w metal skin

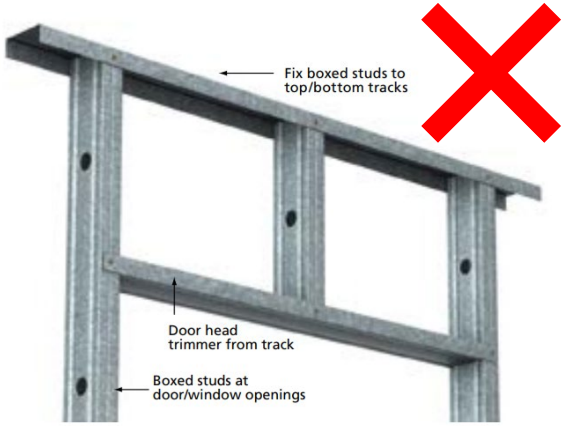


GFR concrete panel



RAAC Panel

- All become loadbearing – lack of capacity or by design (error).
- Are they tested for these structural or fire performance conditions?
- Earthquake – due to load/friction part of the force-resisting system?



DETAIL A: DOOR/WINDOW HEAD DETAIL

Design Parameters and Assumptions

Preparation of the Shelf load Tables have been based on the following assumptions.

1. Max Stud Spacing - 600mm.
2. Top and bottom wall tracks are mechanically fixed to floor and ceiling framing.
3. Studs are mechanically fixed to top and bottom wall tracks.
4. Studs and track sections are manufactured by [illegible] Building Systems.
5. Shelves are evenly distributed over 2/3 the wall height.
6. The tables are applicable to shelves on one side of the wall.
7. [illegible] takes no responsibility for the shelf design or the attachment methods unless specifically requested to carry out checks on particular systems.
8. The tables have been designed for a deflection limit of wall height/480.
9. Wall studs are clad both sides with 13mm plasterboard or thicker.
10. Noggings are provided in accordance with minimum requirements as specified for wall construction.
11. Studs are to be continuous, not spliced.

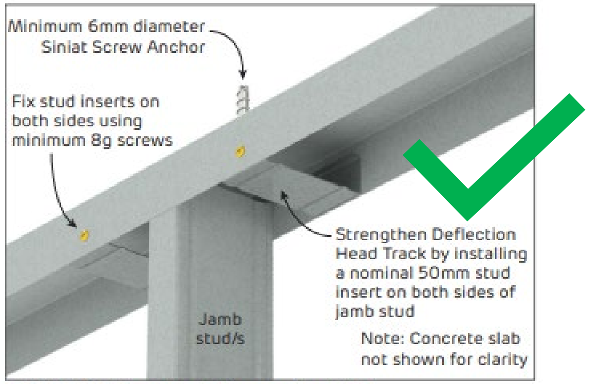
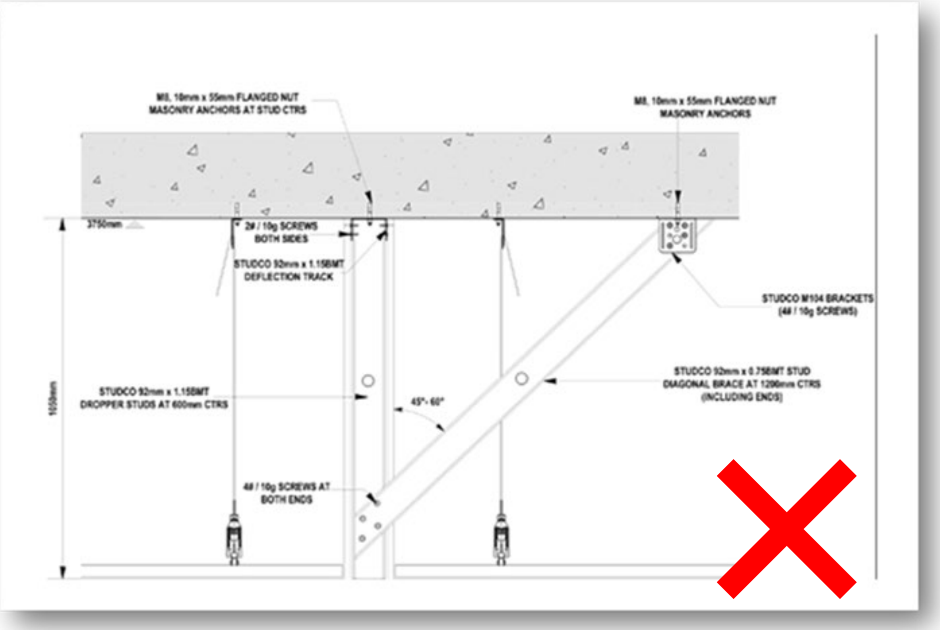


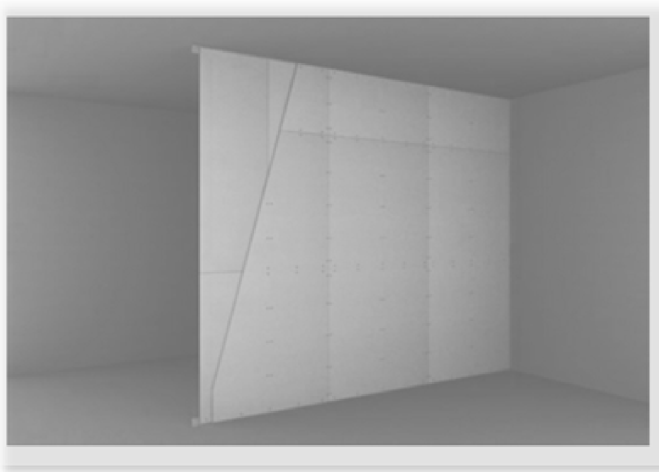
FIGURE 16a Head Track Connection HC5
Medium Duty Connection
Perspective



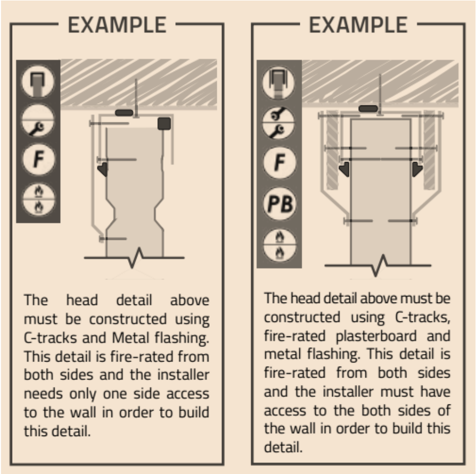
think. change.

AS/NZS1170.0 – 20mm mid-span slab deflection

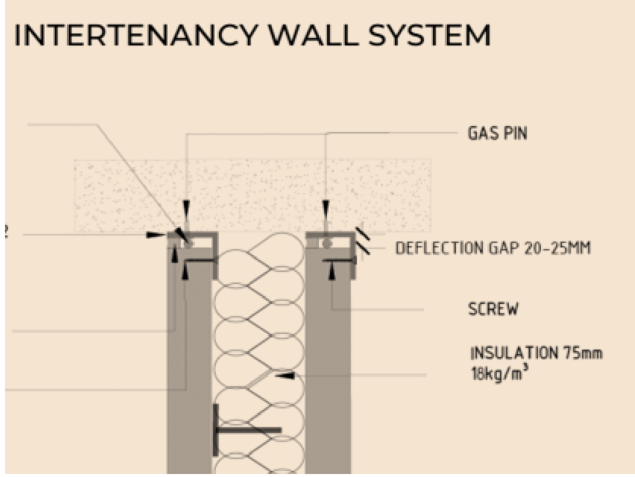
proactive design
think. change.



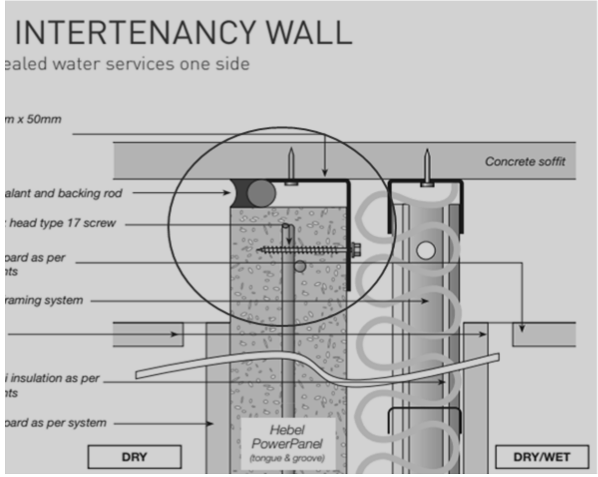
Frameless Partitions



Aerated concrete w metal skin



GFR concrete panel



RAAC Panel

- No drift: either a direct fixed or a vertical slot in the top member
- Not tested for these structural or fire performance conditions.
- Earthquake – part of the force-resisting system as no ‘*design inter-storey drift accommodation*’ *(AS1170.4 s8.1)*

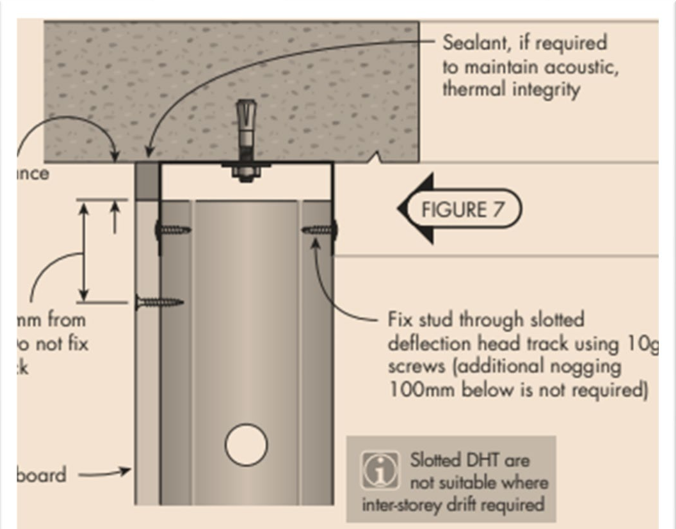


FIGURE 8 Wall Head
Slotted Deflection Head Track
Section

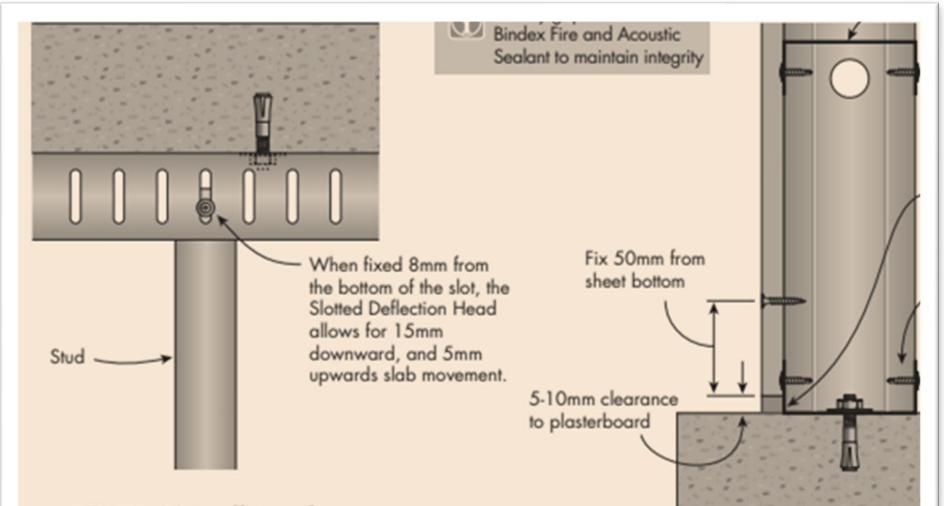


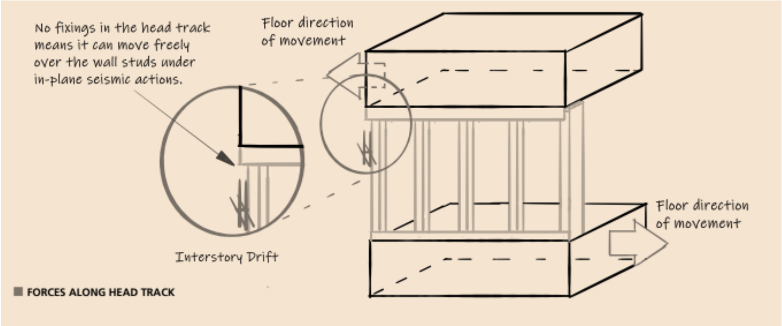
FIGURE 32 Wall Head
Slotted Deflection Head Track
Elevation

FIGURE 33 Wall Base - Lined
Section

Always check that the building solution you have selected complies with the requirements of the National Construction Code (NCC).

At all times refer to the Serviceability Limit State Load Tables for the appropriate fixing dimensions on page 230 and ensure the Project Engineer has signed off on your proposal.

- *'Slotted DHT are not suitable where inter-storey drift required.'*
- Commonly used for all FR external stud walls and multiple internal FR walls, including the latest *Telescopic (FR) stud walls.*
- Earthquake – now part of force-resisting system as they have no '*design inter-storey drift accommodation' (AS1170.4 s8.1)*



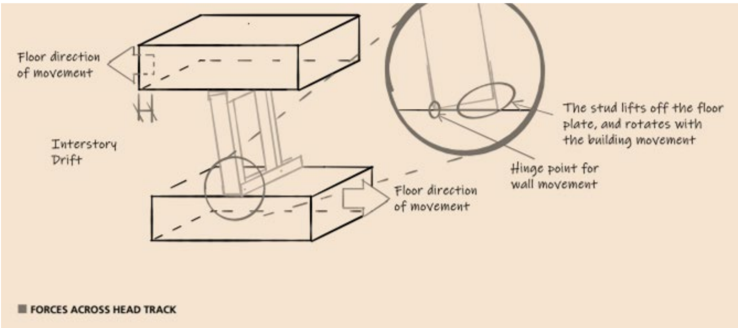
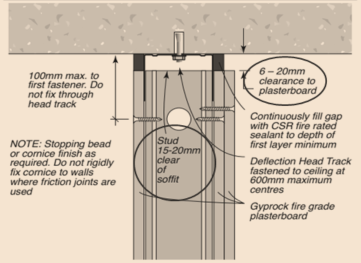


FIG Z46: DEFLECTION HEAD
(Maintains the FRL of the wall system in which it is installed).



Slotted DHT are not suitable where inter-storey drift required

Centre for Smart Infrastructure and Digital Construction, Swinburne University of Technology

Table 4.1: High level summary of the structural behaviour of the test specimens.

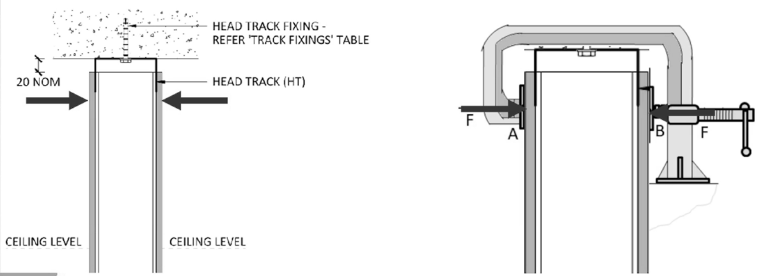
Specimen	S-A-1	S-A-2	S-B-1	S-B-2	S-C-1
System	Industry standard (type1)	Industry standard (type2)	Traxx MFS Slotted Head Track	Traxx MFS FlexiStud and FlexiHead	Traxx MFS 360 Flexi Bracket
Cycle 1 5 mm (0.17%)	Corners* (1)	Screws† (L)	No damage or cracking	No damage or cracking	No damage or cracking
Cycle 2 10 mm (0.33%)	Corners* (2)	Corners* (2) Screws† (M) Panels‡ (M)			
Cycle 3 20 mm (0.67%)	Corners* (3) Screws† (M)	Corners* (3) Screws† (S) Panels‡ (S)	Corners* (1)		
Cycle 4 35 mm (1.2%)	Corners* (4) Screws† (S) Panels‡ (L)	Corners* (4) Screws† (S) Panels‡ (S)	Corners* (2)	Corners* (1)	
Cycle 5 50 mm (1.7%)	Corners* (4) Screws† (S) Panels‡ (M)	Corners* (4) Screws† (S) Panels‡ (S)	Corners* (2)	Corners* (2)	
Cycle 6 65 mm (2.2%)	NA	NA	Corners* (2)	Corners* (2)	
Cycle 7 90 mm (3.0%)	NA	NA	NA	Corners* (2) Cracking§ (1) Panels‡ (L)	Denting of slot in head track (refer discussion in Section 4.5)
Cycle 8 120 mm (4.0%)	NA	NA	NA	Corners* (3) Cracking§ (3) Panels‡ (M)	

* "Corners" denotes vertical cracking along the inside corners/wall junctions and/or damage/cracking to the external corners of the specimen.
† "Screws" denotes the heads of the screws being pulled through the plasterboard (i.e. the initiation of delimitation of plasterboard panels).
‡ "Panels" denotes the delamination of plasterboard panels.
§ "Cracking" denotes cracking in a plasterboard sheet away from an internal or external corner.

- In-plane – head track smashes adjoining wall
- Out-of-plane – wall cycles tearing away and crushing in-plane wall and damaging FR substrate bracing the stud frame.
- Corner junctions are split from top-down and excessive noise.
- Earthquake – corner forms part of force-resisting system as no *'design inter-storey drift accommodation' (AS1170.4 s8.1)*

Laboratory Testing

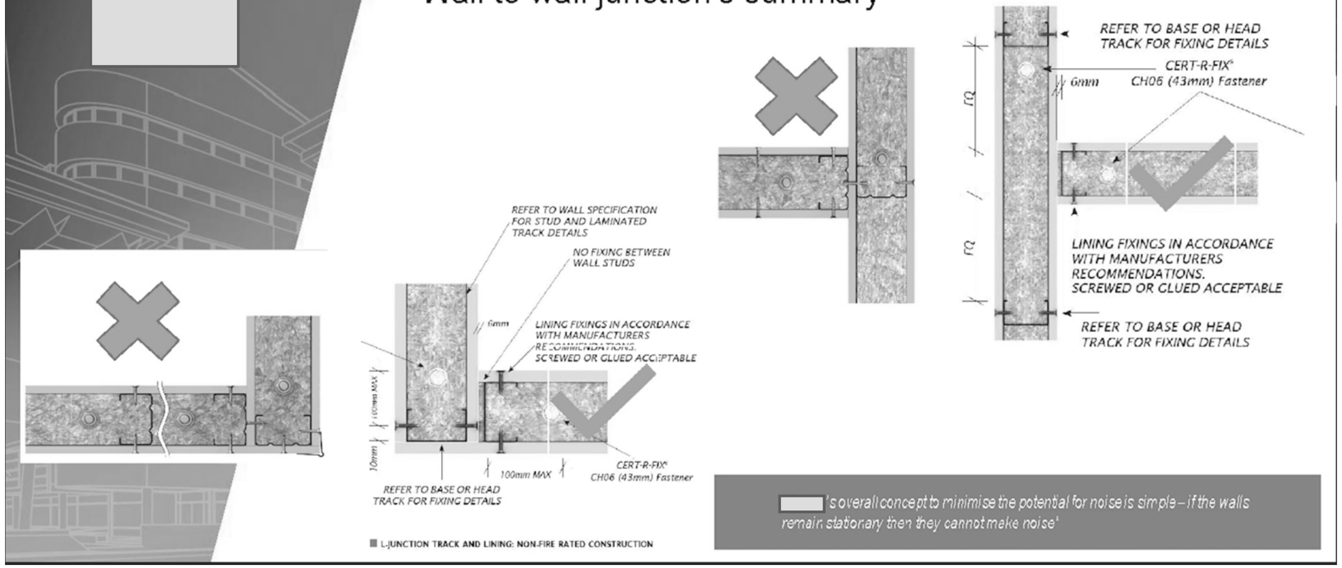
Friction forces at head track (clamping)



Laboratory Testing

Noise sources observed from testing:

- Wall to wall junction's summary

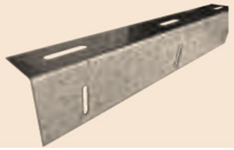


's overall concept to minimise the potential for noise is simple – if the walls remain stationary then they cannot make noise'

SLOTTED ANGLE CONNECTIONS

For positioning and restraining (with added screw fixings) the top and bottom of the panels. See Table 1.2.2 for typical intertenancy and corridor walls. See Table 1.2.3 for typical shaft and services walls.

- Slotted galvanised steel angle for head, vertical and base connections for H > 3300mm and/ or for 2 hour rated systems. 75 x 50 x 1.15mm BMT.



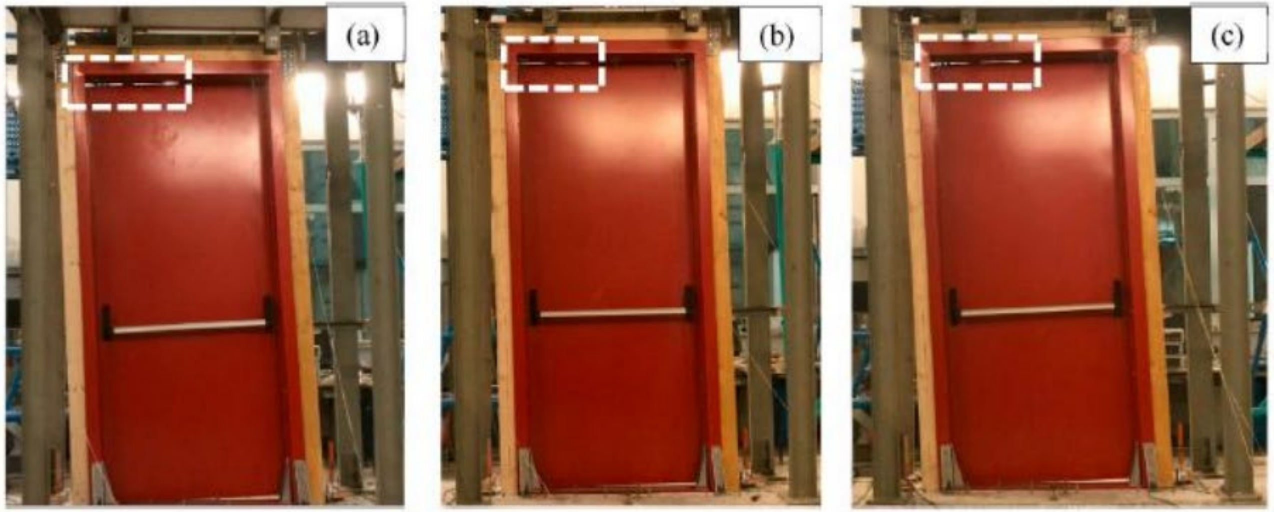
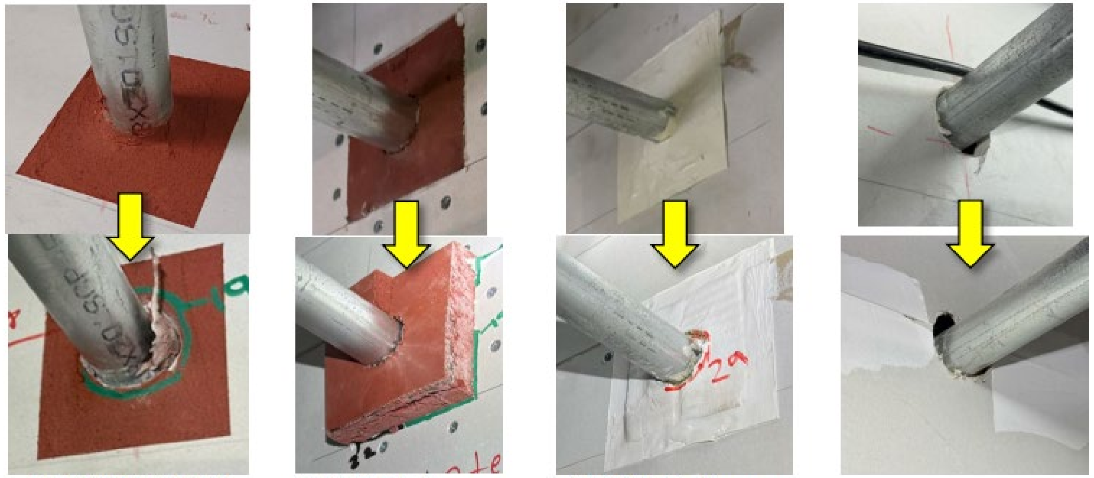
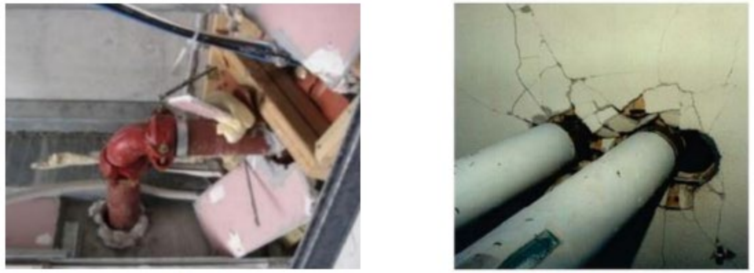


Figure 2. Observed damage to fire door sets under lateral drift [Calayir et al., 2022]: (a–c) Permanent distortion of three 90-min fire door specimens at their failure inter-story drifts (~1.9–2.3% IDR) – note large gap openings at top corners and tearing near the locks



(a) FS-ONE MAX sealant
(b) CFS-BL firestop block
(c) CFS-BL firestop block
(d) No fire stopper

Figure 10: Damage to penetration sealants at start (top row) and end of testing (bottom row)

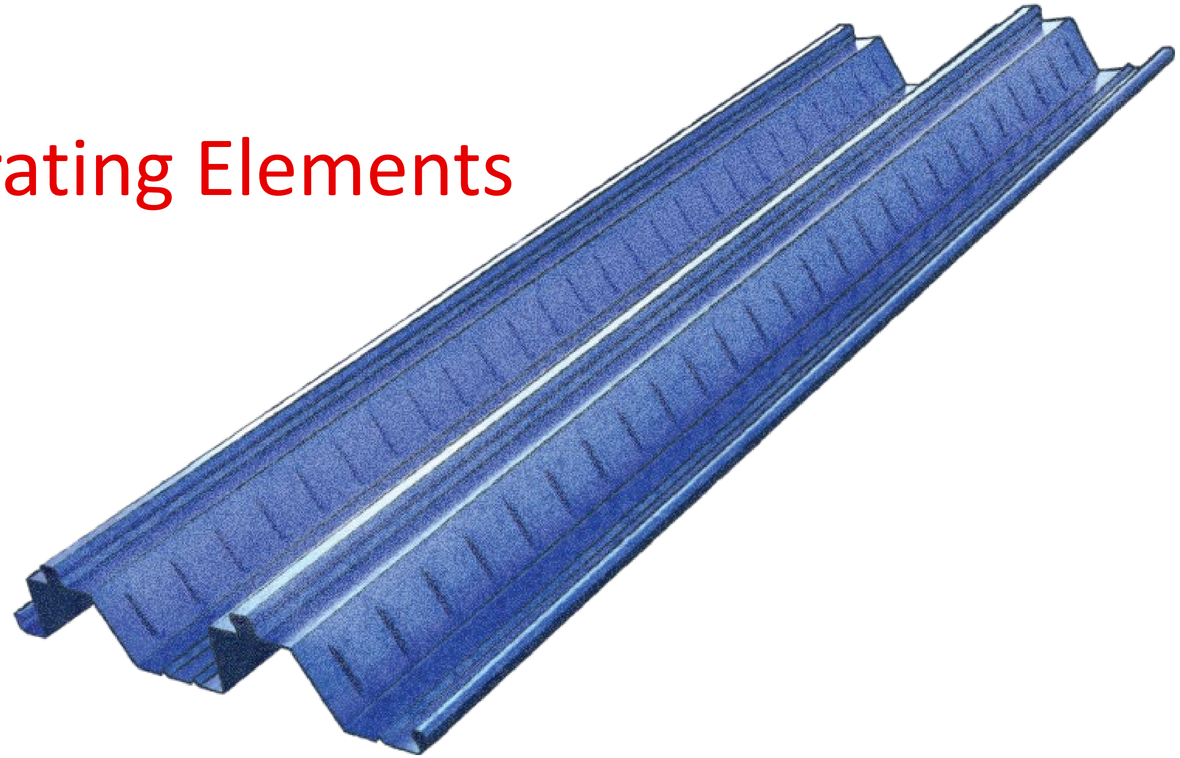


(a) (b)

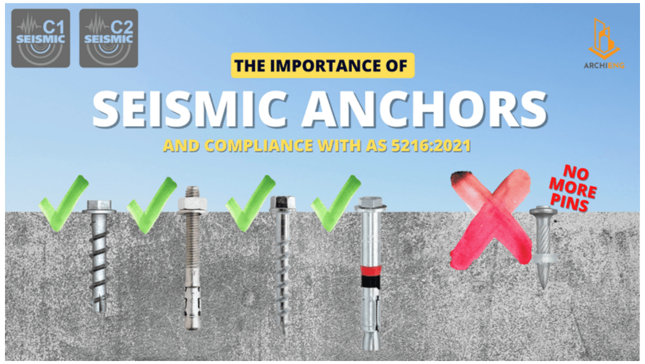
Figure 2. Voids created around penetrations in fire rated walls after: (a) the 2011 Christchurch earthquake [Abu, 2012]; (b) the 1994 Northridge Earthquake [Perry et al., 2017]

Egress Pathways & Compartmentation penetrations

Floors…. Horizontal (plane) Separating Elements



- What are we building?
  - 40mm steel reinforcement
  - Hollow-core slabs
  - PT slabs (vulnerabilities)
  - Composite (concrete/metal deck)
  - Bubble-deck slabs



Structural-Safety

SCOSS and CROSS

The Institution of Structural Engineers | ice | HSE

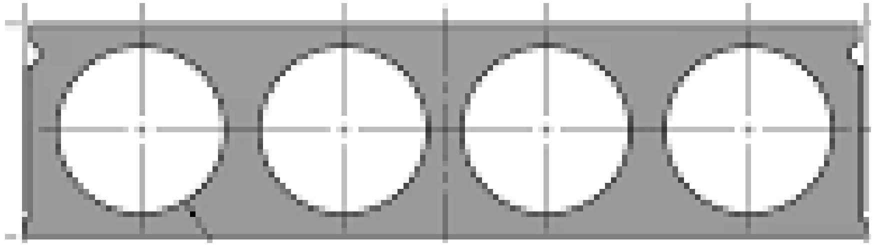
SCOSS

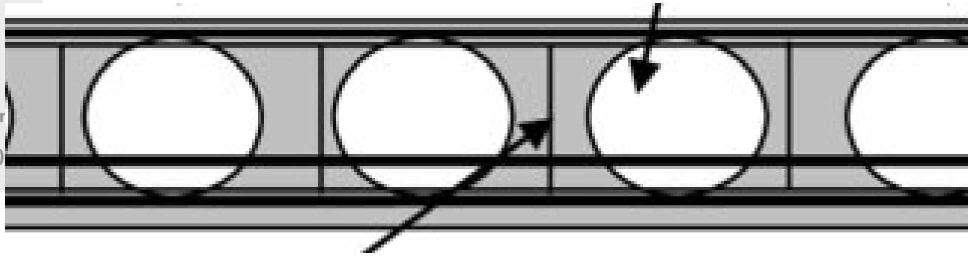
Standing Committee on Structural Safety

SCOSS Alert | May 2019

FAILURE OF REINFORCED AUTOCLAVED AERATED CONCRETE (RAAC) PLANKS

In late 2018, the Local Government Association (LGA) and the Department for Education (DfE) contacted all school building owners› to draw attention to a recent failure involving a flat roof constructed using Reinforced Autoclaved Aerated Concrete (RAAC) planks. There was little warning of the sudden collapse.





- AS1530.4 – One pass needed, (w/o limit) w minor changes.
  - **Tested: 3m x 3m** sample
  - concrete frame fixed
  - vertical joint free & filled with non-combustible material.
- Now: **Unlimited** innovations, multiple soffits, typologies, BMTs, heights, stud widths, etc.
- **Never tested**: corner junctions, face loads, deflection applied, post drift, repaired panels/substrate(**), connections to FR ceilings, across movement joints, etc. (But many assessments made).

Active Fire Suppression

(a) (b)

Figure 1. Failure of a flanged joint from FEMA E-74 [2012] (a); failure of a pipe-to-tank connection from Jain et al. [2002] (b)

(a)

Rooftop diesel generator – vibration mounts without lateral restraint capacity.

Figure 4. Failure to fire sprinkler heads

Figure 7. Rupture of sprinkler head

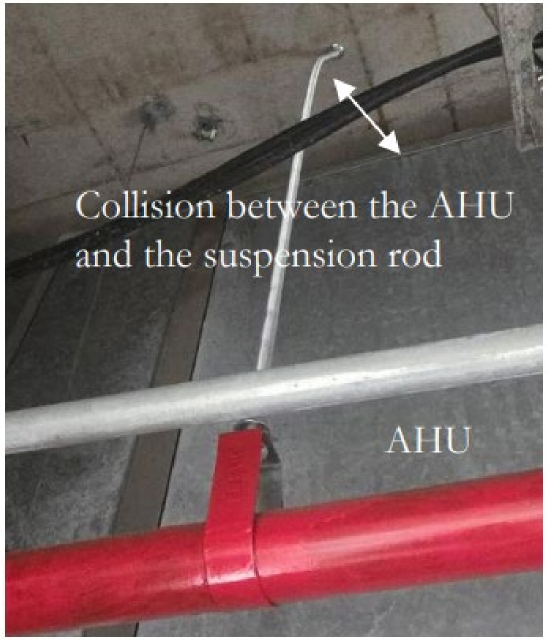


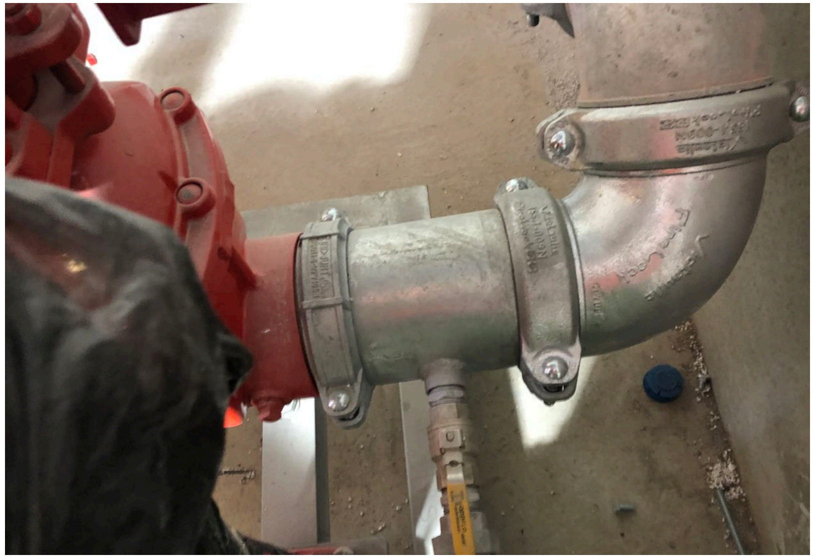
Figure 8. Suspension rod

think. change.

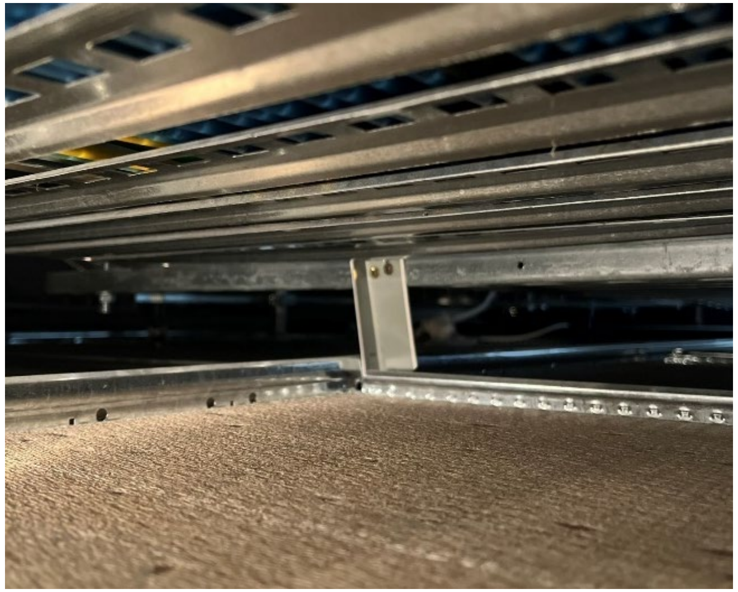
Loss of fire suppression system

(multiple single points of failure)

proactive design
think. change.





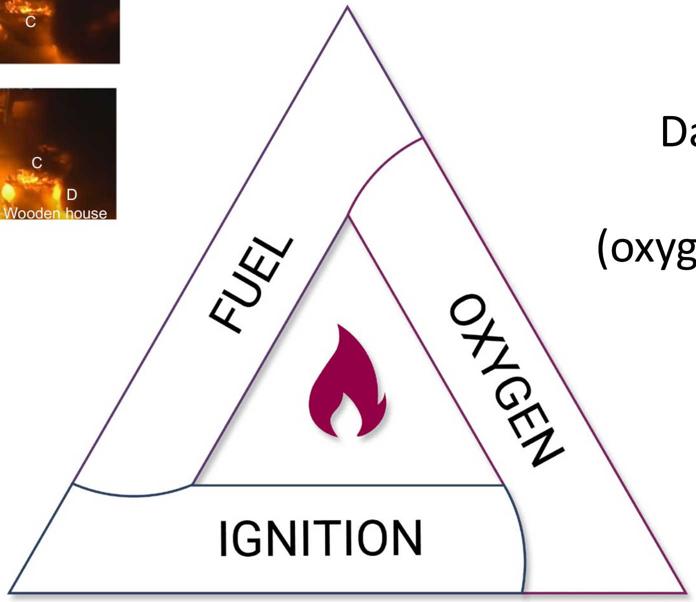



Vulnerabilities to earthquake actions

- Fire water supply - no continuity following EQ (pressure loss)
- Fire water storage tanks – AS2304 s4.6 EQ is generally ignored.
  - Forces – design & anchoring (AS5216 – C2 Life Safety)
  - Displacement/interactions – punching
- Fire pumps – specific design:
  - Anchoring/Mounts/specific design
  - Connections - 'Vibration failure'
- Distribution (piping) systems
  - Restraint 'Fire suppression' with minor exemptions.
  - Clearances from services (later slide).
- Sprinklers – when integrated into substrates
  - Inadequate clearance from displacing services
  - Ceiling integration - Flexible hose preference
  - Inadequate substrate for operational forces.

Ignition sources & fuels

Ignition of subterranean methane: unveiling a new geohazard in Japan following 2024 Noto Peninsula Earthquake



Damaged to façade or compartment (oxygen leak within hospital)

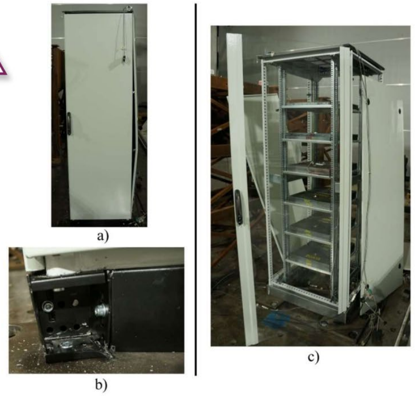


Figure 6. Damage observed to the electrical cabinet specimens during the shake table tests: a) Permanent bending of one of the lateral walls of Specimen 1; b) Failure of the attachment structure of Specimen 1; c) Collapse of the lateral walls of Specimen 2.

Ignitions sources post-earthquake

IL4 – Post-disaster & Hazardous Facilities

Table B1D3a: Importance Levels of buildings and structures

Importance level	Building Types
1	Buildings or structures presenting a low degree of hazard to life and *other property* in the case of failure.
2	Buildings or structures not included in Importance Level 1, 3 and 4.
3	Buildings or structures that are designed to contain a large number of people.
4	Buildings or structures that are essential to post-disaster recovery or associated with hazardous facilities.

NCC 2022 (& not AS/NZS 1170.0)

Guide to NCC 2022 (Online only)

Table B1D3b Design events for safety

Importance level	Annual probability of exceedance for non-cyclonic wind	Annual probability of exceedance for cyclonic wind	Annual probability of exceedance for snow	Annual probability of exceedance for earthquake
1	1:100	1:200	1:100	1:250
2	1:500	1:500	1:150	1:500
3	1:1000	1:1000	1:200	1:1000
4	1:2000	1:2000	1:250	1:1500

Importance levels

A generic description of building types has been provided to which Importance Levels have been assigned. The "Importance Level" concept is applicable to building structural safety only. More specific examples are provided below. The examples are not exhaustive.

Importance Level 1:
- Farm buildings and farm sheds.
- Isolated minor storage facilities.
- Minor temporary facilities.

Importance Level 2:
- Low rise residential construction.
- Buildings and facilities below the limits set for Importance Level 3.

Importance Level 3:
- Buildings and facilities where more than 300 people can congregate in one area.
- Buildings and facilities with a primary school, a secondary school or day care facilities with a capacity greater than 250.
- Buildings and facilities with a capacity greater than 500 for colleges or adult educational facilities.
- Health care facilities with a capacity of 50 or more residents but not having surgery or emergency treatment facilities.
- Jails and detention facilities.
- Any occupancy with an occupant load greater than 5000.
- Power generating facilities, water treatment and waste water treatment facilities, any other public utilities not included in Importance Level 4.
- Buildings and facilities not included in Importance Level 4 containing hazardous materials capable of causing hazardous conditions that do not extend beyond property boundaries.

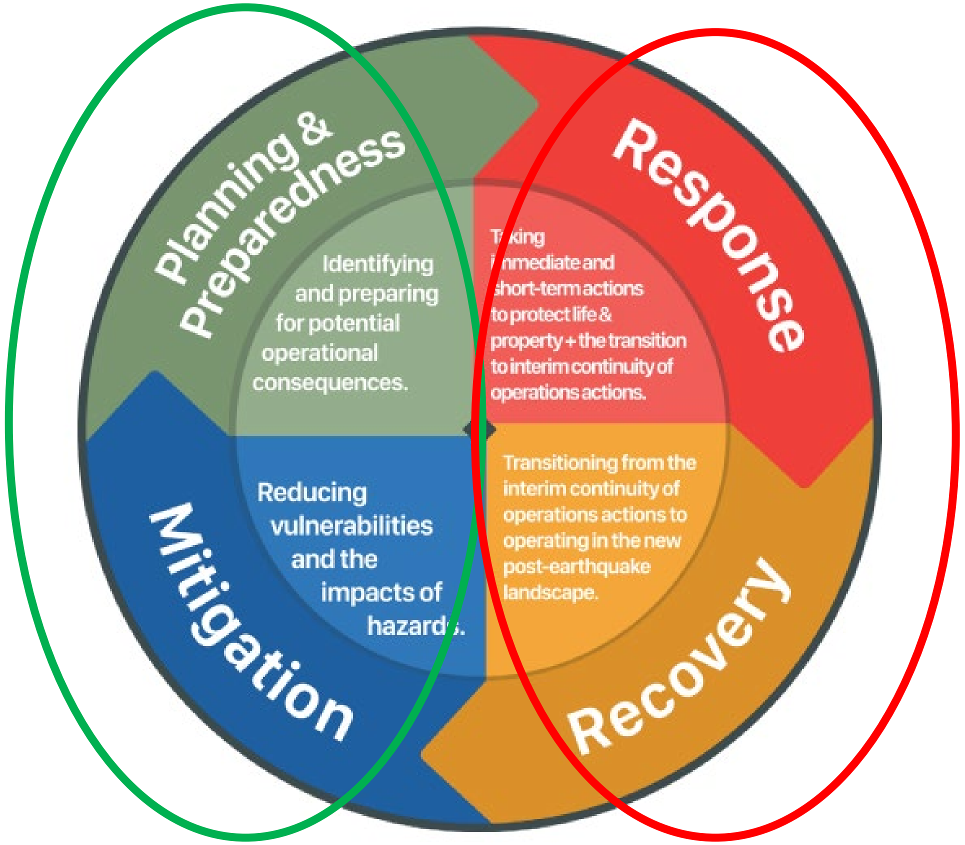
Importance Level 4:
- Buildings and facilities designated as essential facilities.
- Buildings and facilities with special post disaster functions.
- Medical emergency or surgery facilities. Medical buildings essential to post-disaster recovery that contain emergency facilities and/or operating theatres.
- Emergency service facilities: fire, rescue, police station and emergency vehicle garages.
- Utilities required as backup for buildings and facilities of Importance Level 4.
- Designated emergency shelters.
- Designated emergency centres and ancillary facilities.
- Buildings and facilities containing hazardous materials capable of causing hazardous conditions that extend beyond property boundaries.

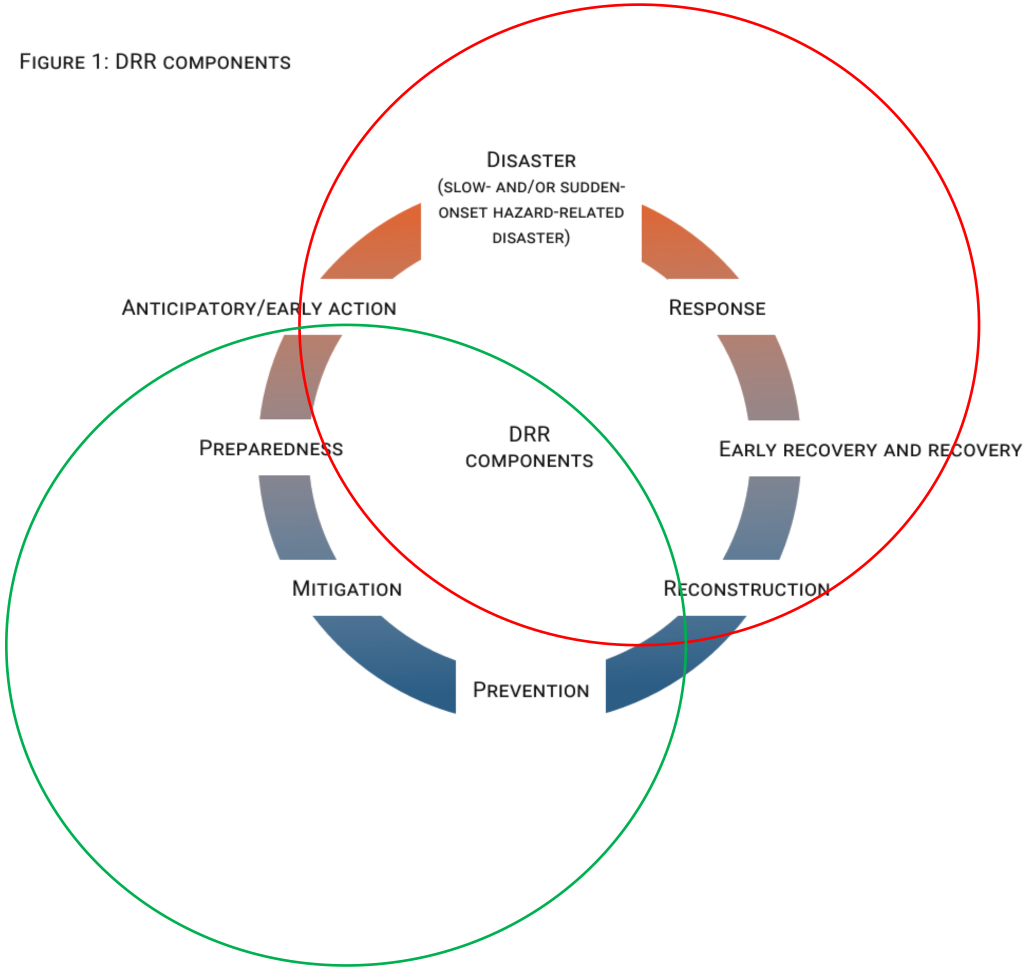
Importance Levels must be assigned on a case-by-case basis.

APPENDIX F

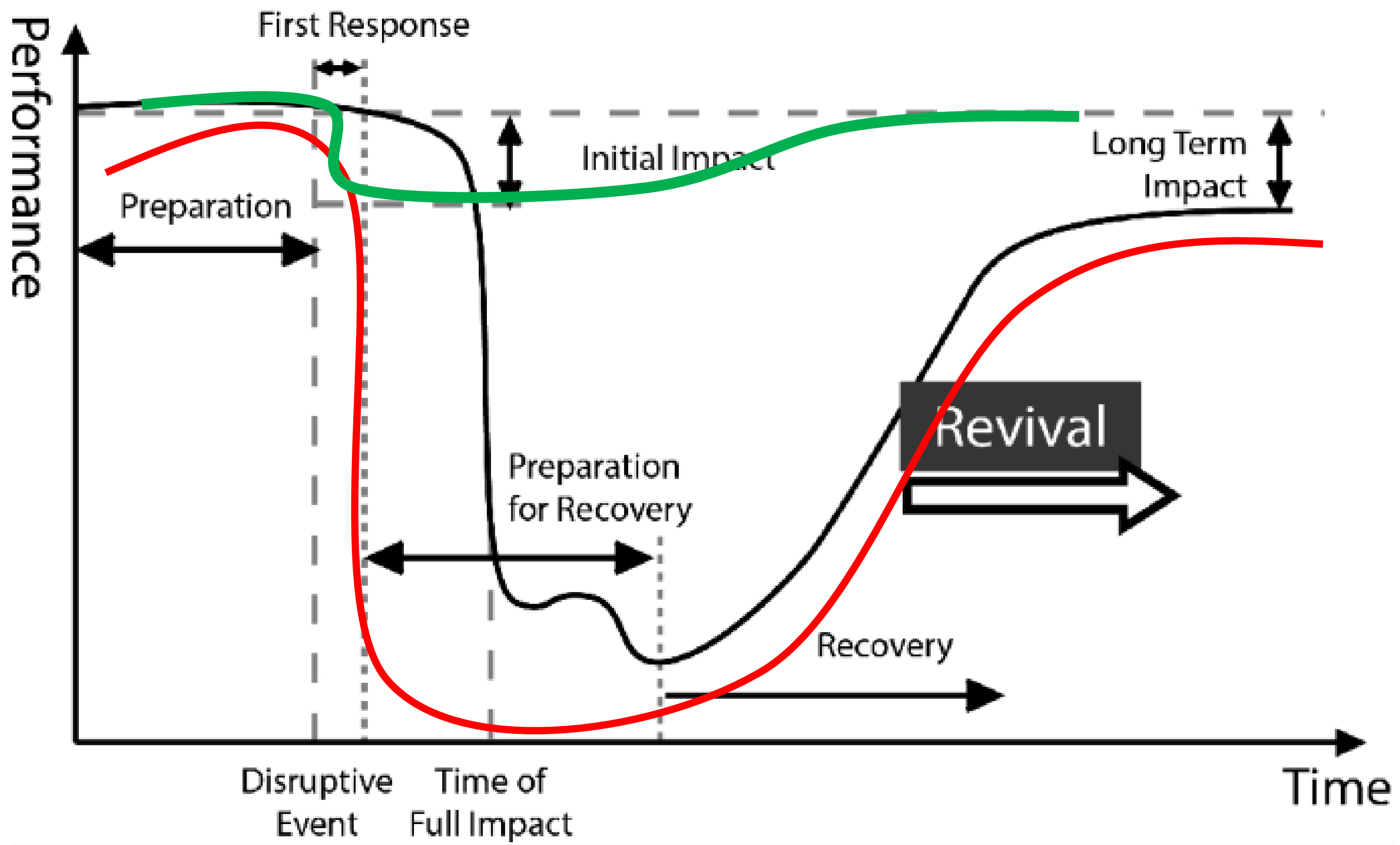
ANNUAL PROBABILITY OF EXCEEDANCE
(FOR AUSTRALIAN USE ONLY—STRUCTURES FOR WHICH DESIGN EVENTS ARE NOT GIVEN ELSEWHERE)

(Normative)





Disaster Management Cycle & UN Augmented version



Ivanov et al, *Handbook of Ripple Effects in the Supply Chain,* 2019, Springer Cham
https://doi.org/10.1007/978-3-030-14302-2

Example responses

- 1st – MAKE SAFE
  - Stabilise active processes
  - Protect integrity
- 2nd - EVALUATE
  - Triage
  - Safely shut down unnecessary services.
- 3rd – PD PERFORM
  - Scale/adapt
  - Planned recovery

Key Risk Management Concepts

Responsibility and Authority

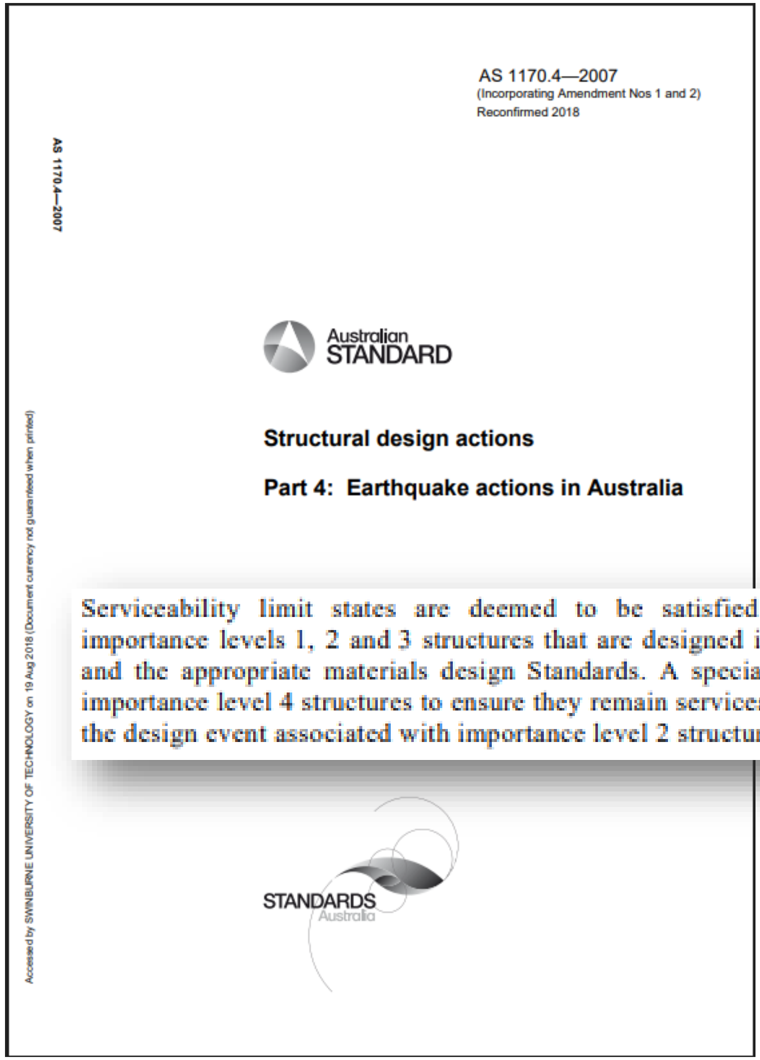
The responsibility, authority and the interrelationship of personnel who perform and verify work affecting risk management shall be defined and documented

Documentation

Each stage of the risk management process should be documented. The documentation should include assumptions, methods, data sources and results

Data

Robust and credible data sources are required to establish a sound basis for risk assessment and management. Data is required to either directly establish the consequence and likelihood of identified risks or as input to a numerical model or set of calculations that quantify risk.



AS 1170.4—2007
(Incorporating Amendment Nos 1 and 2)
Reconfirmed 2018

AS 1170.4—2007

Australian STANDARD

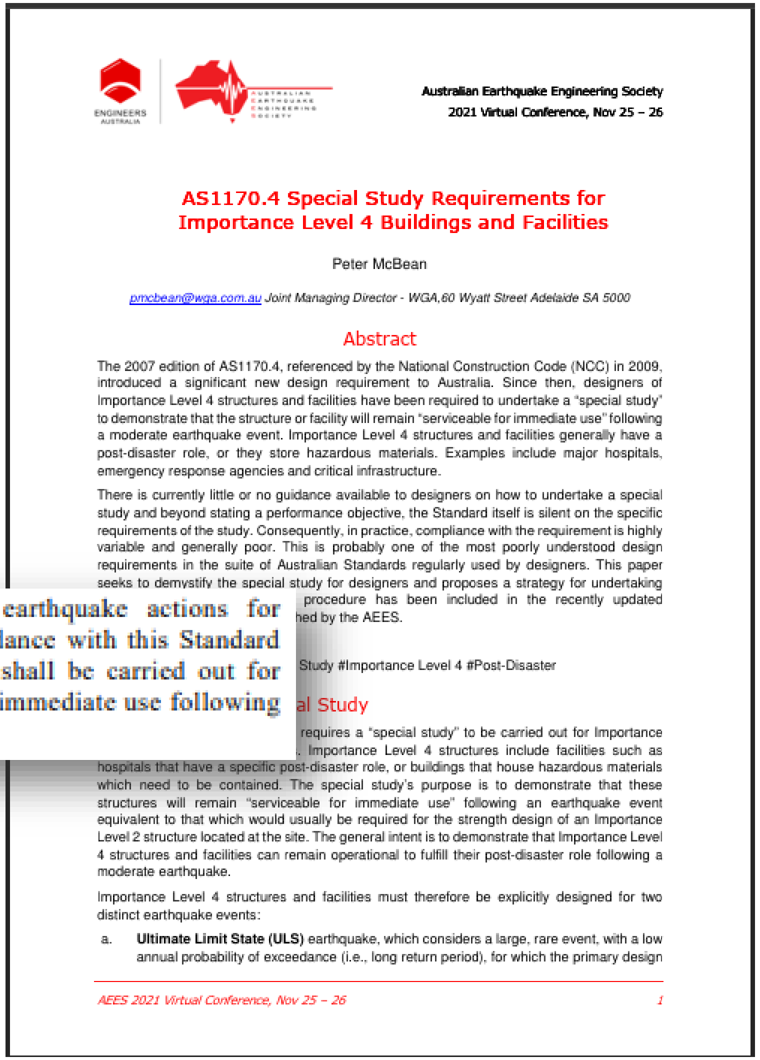
Structural design actions

Part 4: Earthquake actions in Australia

Serviceability limit states are deemed to be satisfied under earthquake actions for importance levels 1, 2 and 3 structures that are designed in accordance with this Standard and the appropriate materials design Standards. A special study shall be carried out for importance level 4 structures to ensure they remain serviceable for immediate use following the design event associated with importance level 2 structures.

STANDARDS Australia

Accessed by SWINBURNE UNIVERSITY OF TECHNOLOGY on 19 Aug 2018 (Document currency not guaranteed when printed)



ENGINEERS AUSTRALIA

Australian Earthquake Engineering Society
2021 Virtual Conference, Nov 25 – 26

AS1170.4 Special Study Requirements for Importance Level 4 Buildings and Facilities

Peter McBean

pmcbean@wga.com.au *Joint Managing Director - WGA,60 Wyatt Street Adelaide SA 5000*

Abstract

The 2007 edition of AS1170.4, referenced by the National Construction Code (NCC) in 2009, introduced a significant new design requirement to Australia. Since then, designers of Importance Level 4 structures and facilities have been required to undertake a "special study" to demonstrate that the structure or facility will remain "serviceable for immediate use" following a moderate earthquake event. Importance Level 4 structures and facilities generally have a post-disaster role, or they store hazardous materials. Examples include major hospitals, emergency response agencies and critical infrastructure.

There is currently little or no guidance available to designers on how to undertake a special study and beyond stating a performance objective, the Standard itself is silent on the specific requirements of the study. Consequently, in practice, compliance with the requirement is highly variable and generally poor. This is probably one of the most poorly understood design requirements in the suite of Australian Standards regularly used by designers. This paper seeks to demystify the special study for designers and proposes a strategy for undertaking ... procedure has been included in the recently updated ...hed by the AEES.

...Study #Importance Level 4 #Post-Disaster

...al Study

... requires a "special study" to be carried out for Importance ... Importance Level 4 structures include facilities such as hospitals that have a specific post-disaster role, or buildings that house hazardous materials which need to be contained. The special study's purpose is to demonstrate that these structures will remain "serviceable for immediate use" following an earthquake event equivalent to that which would usually be required for the strength design of an Importance Level 2 structure located at the site. The general intent is to demonstrate that Importance Level 4 structures and facilities can remain operational to fulfill their post-disaster role following a moderate earthquake.

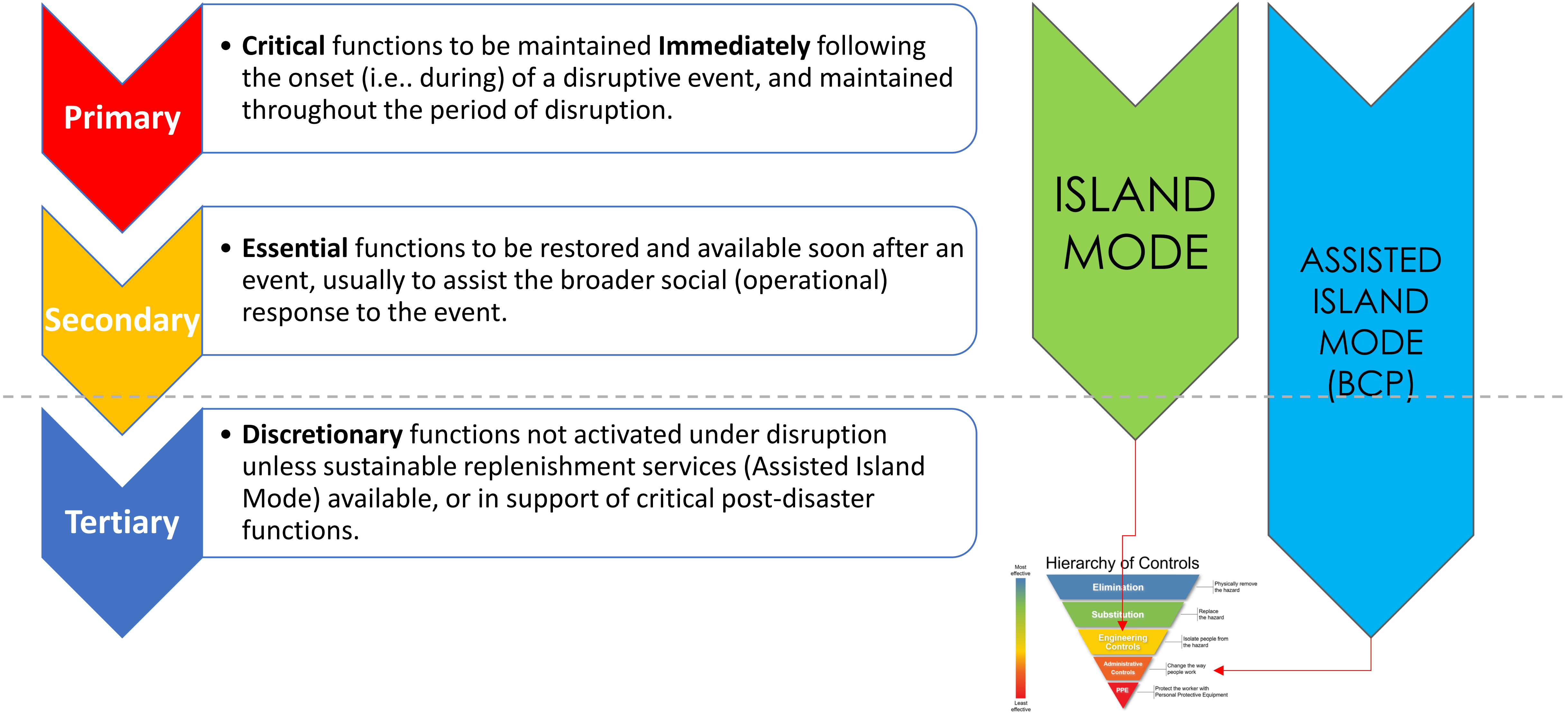
Importance Level 4 structures and facilities must therefore be explicitly designed for two distinct earthquake events:

a. **Ultimate Limit State (ULS)** earthquake, which considers a large, rare event, with a low annual probability of exceedance (i.e., long return period), for which the primary design

AEES 2021 Virtual Conference, Nov 25 – 26 1

McBean suggested:
* Outlined the Purpose and Content.

- A Role:
  - Designated person to capture the Special Study requirements.
- Process:
  - PD Operational req.
  - Structural perform.
  - NSE perform.
  - Procurement
  - Construction
  - Final Report



think. change.

Figure 2 – Minimum Business Continuity Objective (MBCO) categories and definitions.

proactive design
think. change.

Stakeholder Engagement

Post-disaster functions (MBCOs)

Multi-hazard

Vulnerable Elements

Dangerous Elements

Performance Objectives

Time (Island mode)

Serviceability Events

Ultimate Limits

BCP expectations

Design Criteria

Resilience time (calcs)

Earthquake

Wind

Other events

Design Response (P1)

As per Design Criteria/limits

P2 if needed.

Roles/Responsibility

Procurement

Test Evidence (3rd party testing)

Updated Design (p1)

Construction Monitoring

Designated IL4 checks

Install certification (P3)

Install verification (P4 by other)

Audit and Documentation

Constructor to submit all evident

IL4 consultant to witness stress testing.

Inform BCP preparation

Primary

Critical Functions – *Required during event onset and period of disruption.*

- Life Safety (facility occupant) & Dangerous Goods Safety.
- Existing Services Protection - *Data, Processes and Equipment.*
- Facility Security (physical) & Access.

Secondary

Essential Functions – *Required soon after a disruption event*

- Incident Control Centre (incident dependent).
- Triage & Emergency medicine
- Intensive Care
- Existing patient triage

Tertiary

Discretionary Functions – *to be activated as required.*

- Renal dialysis
- Maternal care
- Vaccinations
- Etc.

Technology Outage (Power)

48 hrs

Regular operations

Natural Hazard (Earthquake serviceability)

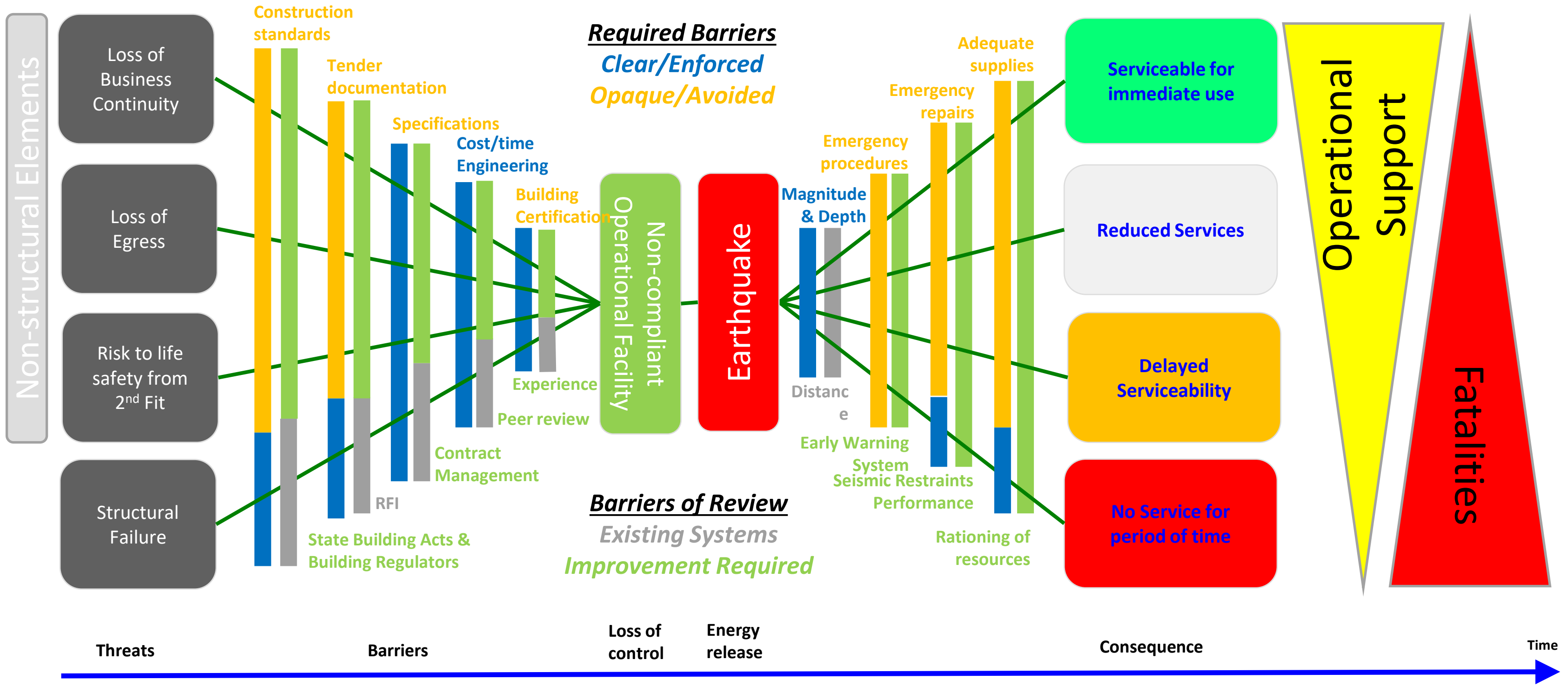
72 hrs

Administrative Controls to track usage, shed loads, etc

Utility Service	Island Mode System, Duration, and Capacity	Capacity basis	Storage Redundancy	Specific System	System Documentation	Method of replenishment	SAFC BCP Considerations
Power	Generators & diesel storage 48 O/L 43kL of Diesel	Supporting 48 hours of full building load through a permanent generator system.	3 x 1,000L day tank for each permanent Generator (3) 2 x 20,000L in-ground tanks (pumped up to rooftop generators)	3 x permanent Generators on lv-2 configured in N+1 arrangement. Provision for mobile Generator on Lv-0 (direct connection to MSB). Diesel fuel system delivery system Switchover transfer function from Mains to generator supplies within the electrical infrastructure.	Building Services - Resilience Brief. Design Report Electrical Schematics.	Fuel truck (max size?) access to the filling station (where?)	Establish a process and timing for refuelling requests. Supply agreement with backup supply options during disruptions. Supplier resilience: * generator-backed filling station. * earthquake design of filling station (unlikely). * redundancy of filling facilities.
Potable Water	Storage tanks above ground 72 PD 120kL water	Hydraulic water Load 1 x 24kL/day (full load) 2 x 21kL/day (Primary and Secondary increased function) = 66kL (1-day full load provided as a small safety to allow the wind-down of operations) 12 hours of Mechanical Cooling tower water load = 55kL (provided as a safety if the BMS control does not work at all, or straight away, or if Manual intervention is required)	1x 120,000L above ground tank (2 x 60,000L sections)	Facility load reductions: Mechanical cooling tower off while heat pump assist mode is on (via BMS or manual intervention) The Cooling tower shutdown/switchover should be quick, so the spare water also serves as spare capacity for DVI usage, which is unknown. No irrigation load (Closed via BMS). Toilet RW supply valve closed and switchover to potable cold-water supply from tank – via BMS controls Water use is monitored via BMS and visually on the water tank indicator. Once the utility system is re-established, the tanks should automatically refill.	Building Services – Resilience Brief Design Report. Hydraulic 70% Design drawing – Resilience Requirement (Sheet HY-0004) Hydraulic plant schematic and Site part plan – Fire and hydraulic service yard	Water truck (max size?) access to the filling station (where?)	Establish a process and timing for refilling requests, with special consideration for water quality control. Supply agreements with backup supply options during disruptions. Supplier resilience: * generator-backed filling station. * earthquake design of filling station (unlikely). * redundancy of filling facilities. Potable water replenishment may need to be notified within the first 24 hours of Island Mode operations to allow service preparation, or sooner if needed. When reconnecting to external supply, consideration should be given for incoming water quality after infrastructure disruption and recharge debris.
Sewer	Storage tank below ground 72PD 100kL storage capacity	68 staff with 4x multiplier on the mortuary for DVI Hydraulic Sewer Load 1 x 24kL/day (full load) 2 x 21kL/day (Primary and Secondary increased function) = 66kL (1-day full load provided as a small safety to allow the wind-down of operations) 12 hours of Mechanical Cooling tower water load = 55kL (provided as a safety if the BMS control does not work at all, or straight away, or if Manual intervention is required)	4x 25,000L inground sewer holding tanks *two access hatches per tank. * passive activation through network backup * monitored by BMS. *one fills, before overflowing to next, and so on.	Facility load reductions: Mechanical cooling tower off while heat pump assist mode is on (via BMS or manual intervention). No irrigation load (Closed via BMS). Tank volume to be monitored via BMS. Evacuation of the storage tank should be requested within the first 24 hours of Island Mode operations, or sooner if needed. Once sewer service from the utility is restored: * The mechanical switch will require a change back to utility service. * Sewer storage should be evacuated, and the re-establishment process should be requested.	Building Services – Resilience Brief Design Report. Hydraulic 70% Design drawing – Resilience Requirement (Sheet HY-0004) Hydraulic site plans.	Sewer suction truck (max size?) access to the suction point (where?)	Establish a process and timing for: * sewer suction requests to contractor. * mechanical switching to sewer and back. * re-establishment of sewer tank by independent licensed contractor. Service agreements with backup service options during disruptions, and post-disruption sewer tank re-establishment. Supplier resilience: * generator-backed filling station. * earthquake design of filling station (unlikely). * redundancy of filling facilities.
Waste water	nil	Trade waste pre-treated and discharge to sewer. Depend on sewer storage.					

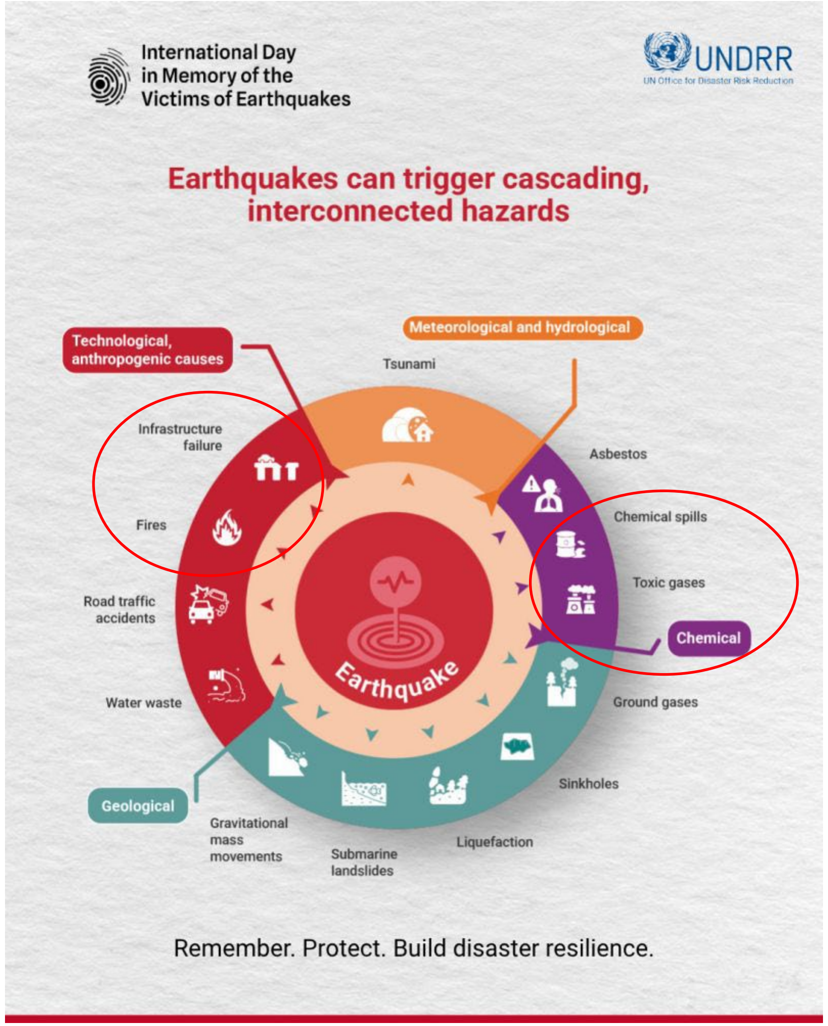
Threat Barrier Diagram – Emergency Facility v. Earthquake

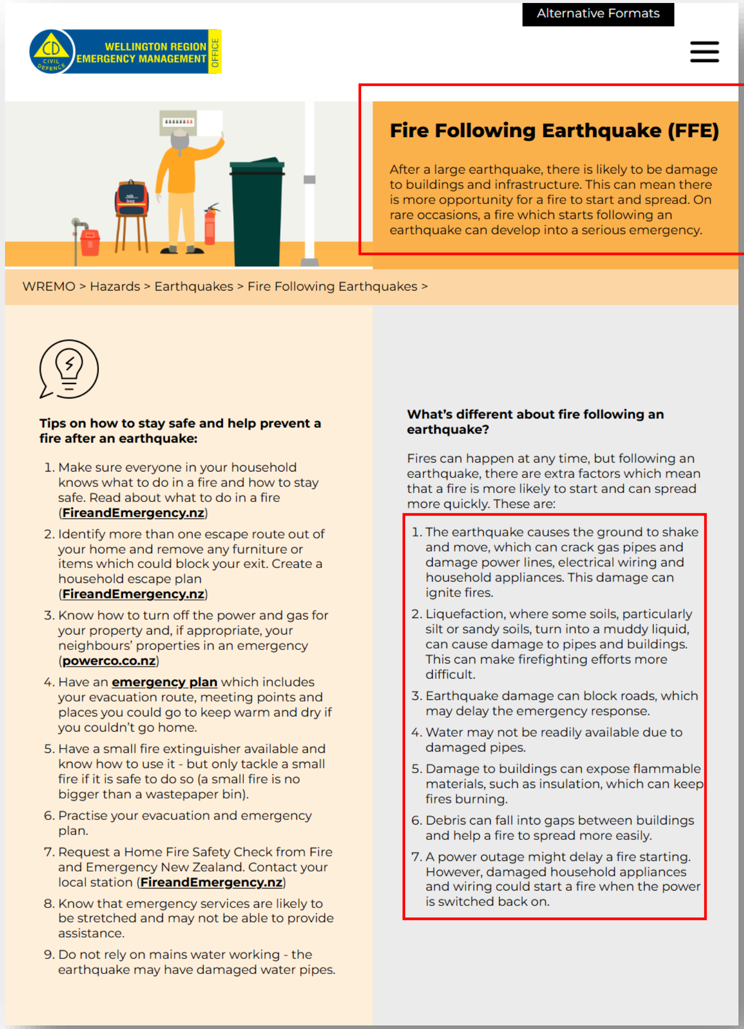
Bartlett, 2018



Project Risk 2-3y | Community Risk 50y

Fire Safety Story





Alternative Formats

WELLINGTON REGION EMERGENCY MANAGEMENT OFFICE

Fire Following Earthquake (FFE)

After a large earthquake, there is likely to be damage to buildings and infrastructure. This can mean there is more opportunity for a fire to start and spread. On rare occasions, a fire which starts following an earthquake can develop into a serious emergency.

WREMO > Hazards > Earthquakes > Fire Following Earthquakes >

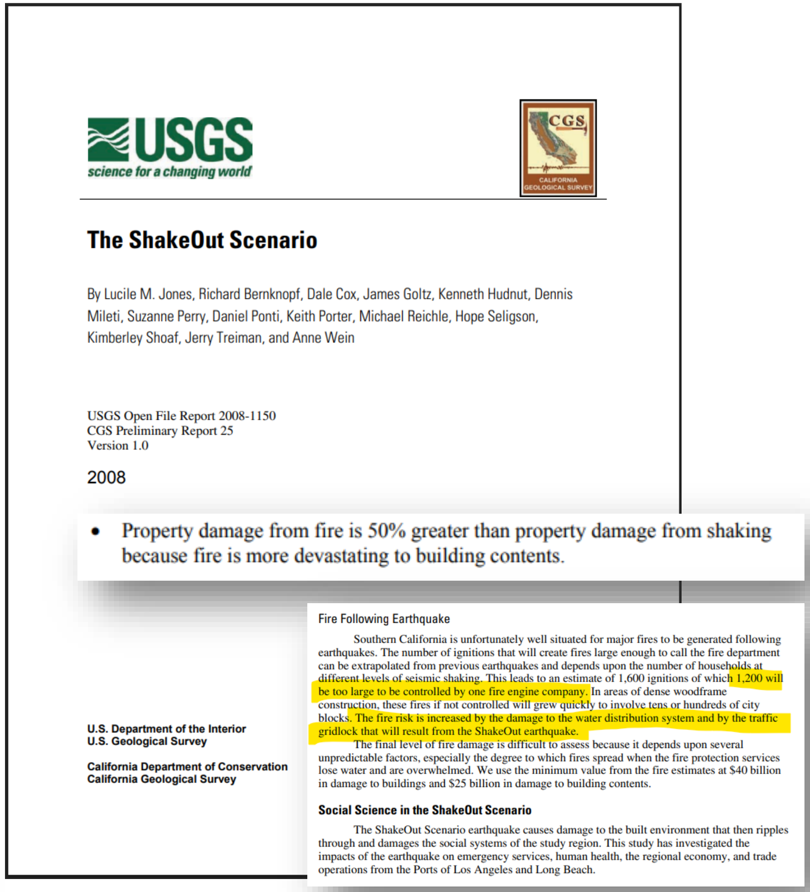
Tips on how to stay safe and help prevent a fire after an earthquake:

1. Make sure everyone in your household knows what to do in a fire and how to stay safe. Read about what to do in a fire (**FireandEmergency.nz**)
2. Identify more than one escape route out of your home and remove any furniture or items which could block your exit. Create a household escape plan (**FireandEmergency.nz**)
3. Know how to turn off the power and gas for your property and, if appropriate, your neighbours' properties in an emergency (**powerco.co.nz**)
4. Have an **emergency plan** which includes your evacuation route, meeting points and places you could go to keep warm and dry if you couldn't go home.
5. Have a small fire extinguisher available and know how to use it - but only tackle a small fire if it is safe to do so (a small fire is no bigger than a wastepaper bin).
6. Practise your evacuation and emergency plan.
7. Request a Home Fire Safety Check from Fire and Emergency New Zealand. Contact your local station (**FireandEmergency.nz**)
8. Know that emergency services are likely to be stretched and may not be able to provide assistance.
9. Do not rely on mains water working - the earthquake may have damaged water pipes.

What's different about fire following an earthquake?

Fires can happen at any time, but following an earthquake, there are extra factors which mean that a fire is more likely to start and can spread more quickly. These are:

1. The earthquake causes the ground to shake and move, which can crack gas pipes and damage power lines, electrical wiring and household appliances. This damage can ignite fires.
2. Liquefaction, where some soils, particularly silt or sandy soils, turn into a muddy liquid, can cause damage to pipes and buildings. This can make firefighting efforts more difficult.
3. Earthquake damage can block roads, which may delay the emergency response.
4. Water may not be readily available due to damaged pipes.
5. Damage to buildings can expose flammable materials, such as insulation, which can keep fires burning.
6. Debris can fall into gaps between buildings and help a fire to spread more easily.
7. A power outage might delay a fire starting. However, damaged household appliances and wiring could start a fire when the power is switched back on.



USGS science for a changing world

CGS CALIFORNIA GEOLOGICAL SURVEY

The ShakeOut Scenario

By Lucile M. Jones, Richard Bernknopf, Dale Cox, James Goltz, Kenneth Hudnut, Dennis Mileti, Suzanne Perry, Daniel Ponti, Keith Porter, Michael Reichle, Hope Seligson, Kimberley Shoaf, Jerry Treiman, and Anne Wein

USGS Open File Report 2008-1150
CGS Preliminary Report 25
Version 1.0

2008

- Property damage from fire is 50% greater than property damage from shaking because fire is more devastating to building contents.

U.S. Department of the Interior
U.S. Geological Survey

California Department of Conservation
California Geological Survey

Fire Following Earthquake

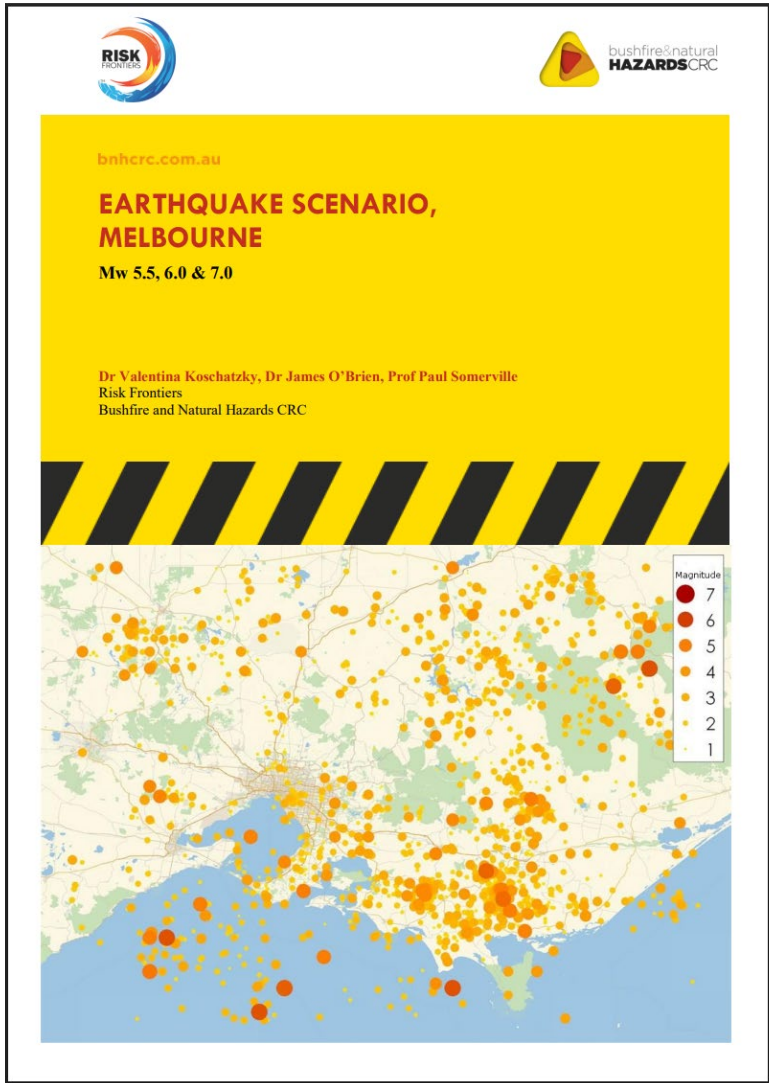
Southern California is unfortunately well situated for major fires to be generated following earthquakes. The number of ignitions that will create fires large enough to call the fire department can be extrapolated from previous earthquakes and depends upon the number of households at different levels of seismic shaking. This leads to an estimate of 1,600 ignitions of which 1,200 will be too large to be controlled by one fire engine company. In areas of dense woodframe construction, these fires if not controlled will grew quickly to involve tens or hundreds of city blocks. The fire risk is increased by the damage to the water distribution system and by the traffic gridlock that will result from the ShakeOut earthquake.

The final level of fire damage is difficult to assess because it depends upon several unpredictable factors, especially the degree to which fires spread when the fire protection services lose water and are overwhelmed. We use the minimum value from the fire estimates at $40 billion in damage to buildings and $25 billion in damage to building contents.

Social Science in the ShakeOut Scenario

The ShakeOut Scenario earthquake causes damage to the built environment that then ripples through and damages the social systems of the study region. This study has investigated the impacts of the earthquake on emergency services, human health, the regional economy, and trade operations from the Ports of Los Angeles and Long Beach.

For Australians these are 'Unknown Knowns'


bnhcrc.com.au

EARTHQUAKE SCENARIO, MELBOURNE

Mw 5.5, 6.0 & 7.0

Dr Valentina Koschatzky, Dr James O'Brien, Prof Paul Somerville
Risk Frontiers
Bushfire and Natural Hazards CRC

- **Water supply:** Major water facilities such as pumping stations and reservoirs may experience extensive damage with a probability of 7% (event 1), 16% (event 2) and 46% (event 3), which implies a downtime of 40 days (FEMA, 2004). Minor damage may occur across the network, with a downtime of 3 days (if no major system was completely damaged). In case of liquefaction, breakage of pipes is likely to be widespread in the hot coloured regions in Figure 11, and concerns over contamination may render the water not suitable to drinking. This is supported by the experience in Christchurch (Koschatzky et al., 2015).

- **Transport:** Roads may be blocked as a consequence of debris from fallen buildings. Roads may also be shut where there is the potential for surrounding building to fail during aftershocks, even if no debris has yet fallen. As a result, and as observed in Christchurch, areas of the CBD may be cordoned off for a minimum of 7 days following the event. This is described further in the Adelaide Earthquake Scenario Technical Note (Koschatzky et al., 2015).

Table 3: Median total casualties by severity level and time of the day (Number of People).

	Event 1		Event 2		Event 3	
Severity	Day	Night	Day	Night	Day	Night
1	4,039	4,037	12,581	12,875	101,947	103,937
2	1,252	1,285	3,741	3,860	31,576	31,412
3	104	93	412	381	4,631	4,190
4	197	181	779	744	8,690	8,159

6.3 Essential facilities

Essential facilities comprise hospitals, fire and police stations, emergency operation centres and schools – all are essential to provide support in the event of an earthquake (schools provide evacuation centres). Such buildings are designed to withstand higher levels of shaking than ordinary buildings.

Melbourne Specific HAZUS-based estimation

Key Terminology

Risk

Lifesafety, loss of egress, loss of safety systems, untennable conditions, fire-following-earthquake.

Risk management

Building Acts, regulations, NCC, Standards, CoP, etc.

Risk management process

Design, construction, verification, maintenance

Risk management framework

NCC - Holistic design (Part A) for:

- Structural Provisions (Part B), incl. EQ, Wind, etc.
- Fire Resistance (Part C)

Key Terminology

Event

Earthquake – building accelerations & displacements

Consequence

Untreated systems damaged, no fire safety systems, loss of tenability, displacement (camping).

Probability

Low, although extremely high consequence.

- No warning.
- M6+ occur in Australia (CHCH M_w6.2)
- Our code requirements are far lower than CHCH (Previously 40%, now 27% of their Hazard factor).

Ranking of ignition source

- Fire Incident Data Coding Guide

The general classification of form of heat of ignition is as follows:

FHI 1	Heat from fuel fired, fuel powered object
FHI 2	Heat from electrical equipment arcing, overload
FHI 3	Heat from smoking material
FHI 4	Heat from open flame, spark
FHI 5	Heat from hot object
FHI 6	Heat from explosive, fireworks
FHI 7	Heat from natural source
FHI 8	Heat spreading from another fire (exposure)
FHI 9	Other, unknown, etc

Fire Incident Data Coding Guide*

The general classification of means of extingushment is as follows:

ME 1	Self-extinguished
ME 2	Make-shift aids (included are garden hoses, sand, rakes, shovels, baking soda, and the like)
ME 3	Portable extinguisher
ME 4	Automatic extinguishing system
ME 5	Preconnected hose line(s) with water carried in apparatus tanks
ME 6	Preconnected hose line(s) with water from hydrant, draft, standpipe (included are preconnected hose lines on standpipe systems)
ME 7	Hand-laid hose line(s) with water from standpipe, hydrant, draft
ME 8	Master stream device(s) with or without hand line(s)
ME 9	Unknown, etc

Effectiveness

Effectiveness = Efficacy x Reliability

Efficacy – scale 0 to 1 (depends on objective)

1 = totally effective, 0 = totally ineffective

Reliability – scale 0 to 1 (independent of objective)

1 = always operates when required, inversely related to probability of failure

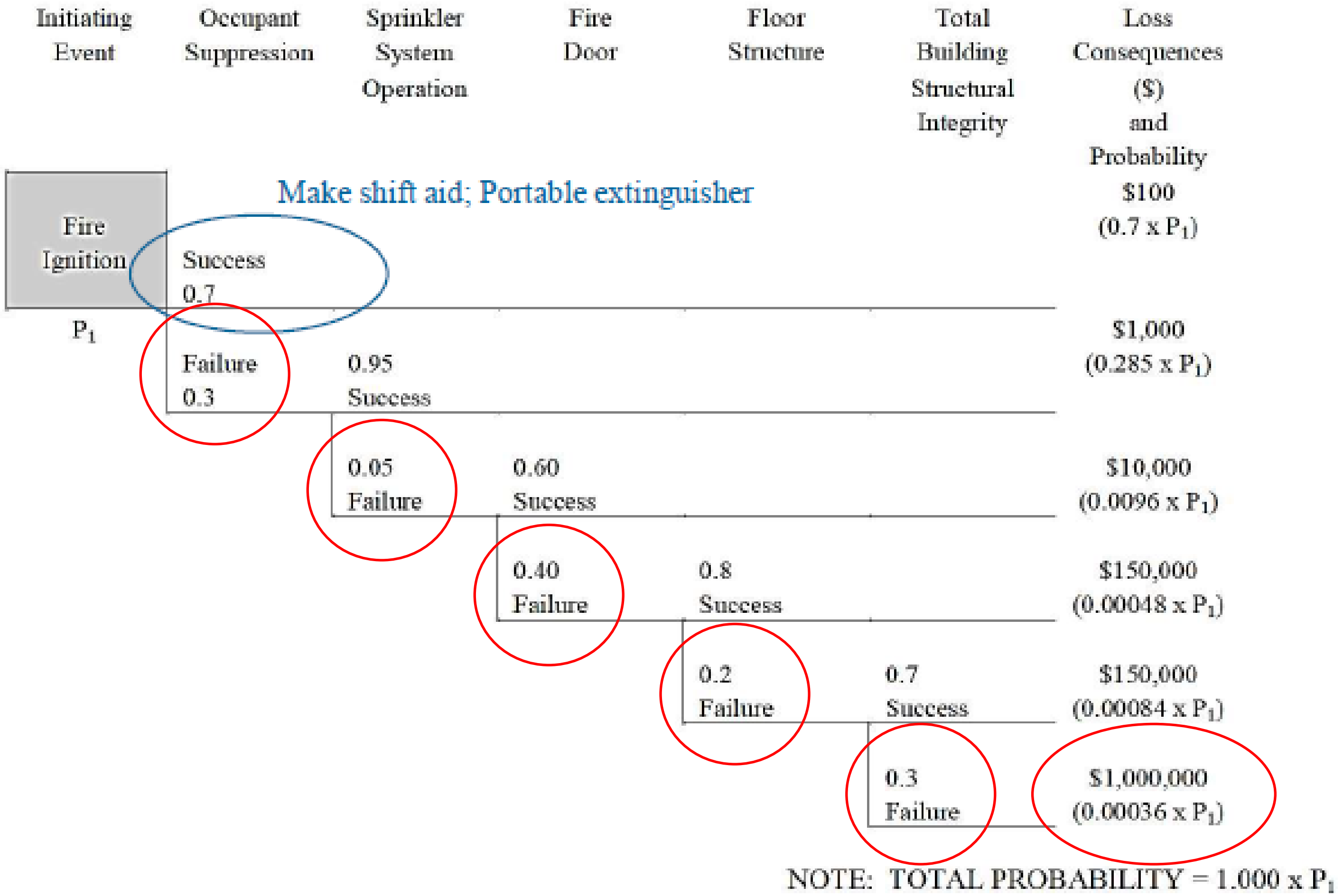
Effectiveness – scale 0 to 1 (depends on objective)

Extent of Flame Damage

Extent of flame damage (EFD) is a measure of the degree of development and spread of a fire:

EFD 1	Confined to the object of origin
EFD 2	Confined to the part of room or area of origin
EFD 3	Confined to the room of origin
EFD 4	Confined to the fire-rated compartment of origin
EFD 5	Confined to the floor of origin
EFD 6	Confined to the structure of origin
EFD 7	Extended beyond the structure of origin

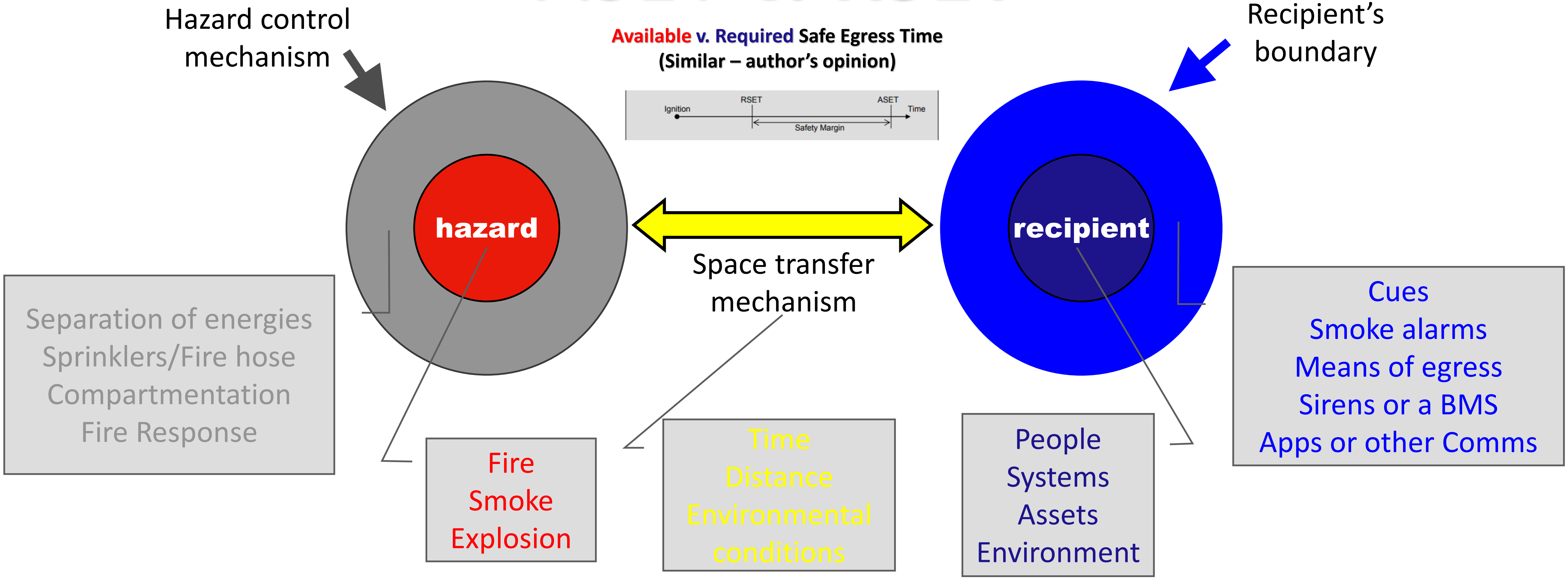
Occupant suppression



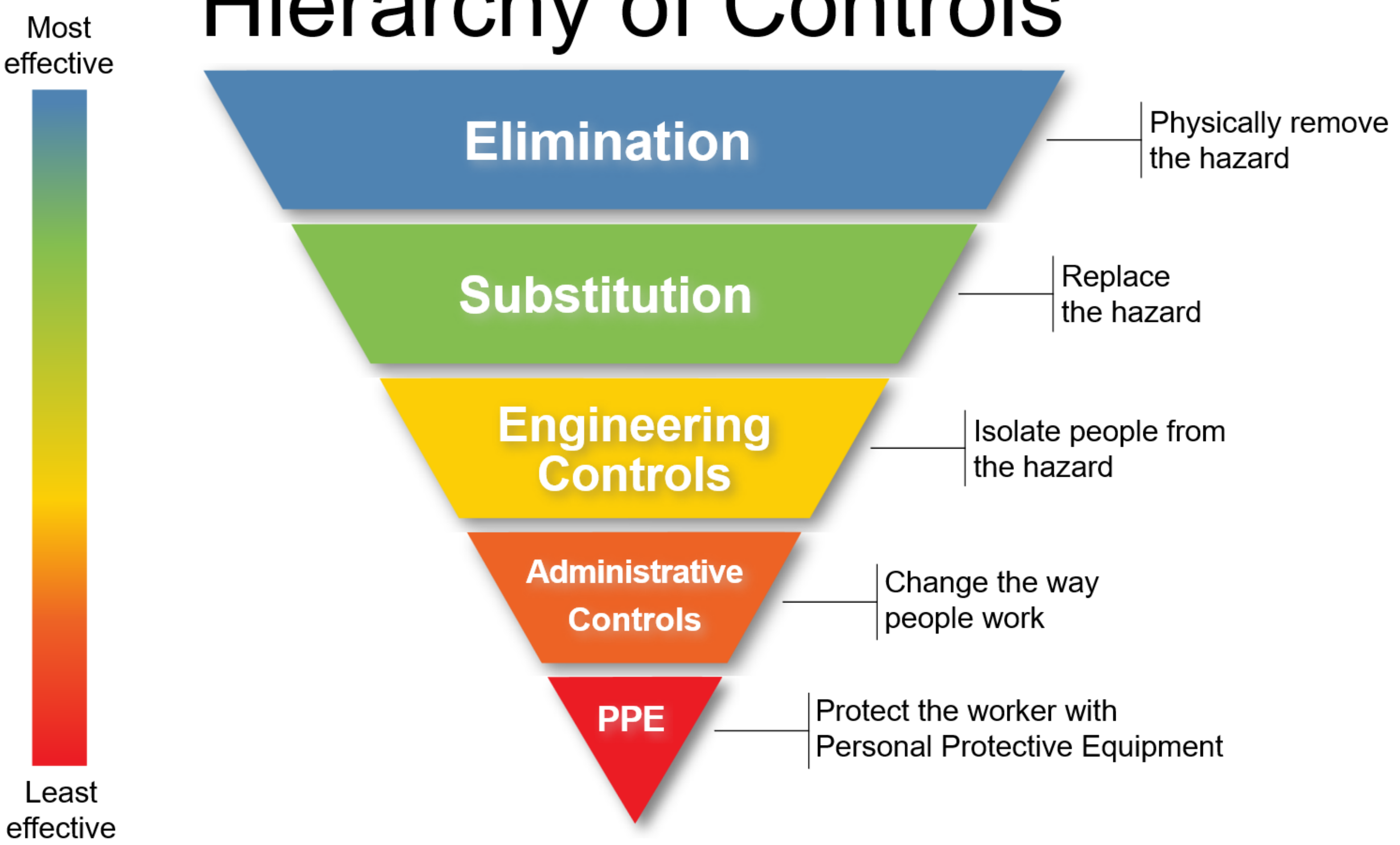
Viner. D. 1991, - Extended Energy Damage Model

ASET v. RSET

Available v. Required Safe Egress Time
(Similar – author's opinion)



Hierarchy of Controls



$$\text{Disaster Risk} = \frac{Hazard\ x\ Exposure\ x\ Vulnerability}{Capacity}$$

Decisions of Agency/Enterprise:

- What is your risk appetite?
- What is your client's or MP's risk appetite?
- What are your post-disaster obligations?
  - Security of Critical Infrastructure Act 2018 (SOCI Home Affairs)
  - National or State Emergency Management Plan (SEMP)
    - Responsibilities: Risk Reduction? Response Coordinator? Supporting Agency?
  - Duty of Care to vulnerable peoples?

Key Risk Management Concepts

Risk Treatment

A process that is intended to change or create controls.

Controls

Controls are used to modify risk. The objective is to decrease the likelihood and or consequence to effectively reduce risk to an acceptable level.

Residual risk

The remaining level of risk after risk treatments have been completed and controls implemented.

Key Risk Management Concepts

Responsibility and Authority

The responsibility, authority and the interrelationship of personnel who perform and verify work affecting risk management shall be defined and documented

Documentation

Each stage of the risk management process should be documented. The documentation should include assumptions, methods, data sources and results

Data

Robust and credible data sources are required to establish a sound basis for risk assessment and management. Data is required to either directly establish the consequence and likelihood of identified risks or as input to a numerical model or set of calculations that quantify risk.

Conclusions

1. Earthquake design of fire safety systems has been a requirement since BCA 2010.
2. Fire safety systems get specific primary mention for seismic treatment.
3. There is much more research to be done to refine the values.
4. Compartmentation & Passive Fire are highly vulnerable: ask your supplier for holistic solutions.
5. Fire Suppression: due to pressurisation, failure under medium event can lead to excessive loss.
6. Ignition sources & fuel are challenging elements to allow for: needs everyone to do their part.
7. Fire Safety Story is presently quite vulnerable to any install quality or single point of failure (active fire)
8. Post-disaster & Hazardous Facilities require an IL4 Special Study to ensure they ‘remain serviceable/operational for immediate use’ following a 1/500 APE earthquake.

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proactive design
think. change.