SEISMIC EXPECTATIONS
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Manager Professional & Advisory Services

Department Planning, Transport & Infrastructure
What tonight's about,
Earthquake Risk
DPTI Expectations
Seismic Compliance
Ministers Recommendations
Importance Level requirements
Special Study
Earthquake Risk

- By world standards Australia’s earthquake risk is low to moderate.
Earthquake Risk

- Seismologists advise earthquakes up to M7.5 can occur in Australia.
- Australia has been subject to 17 earthquakes registering 6 or more on the Richter scale in the last 80 years.
- A number of earthquakes of note have occurred in South Australia.
- Adelaide has suffered damage from earthquakes on three occasions,
- Adelaide has the highest earthquake risk of all Australian capital cities.
Earthquake Risk

Earthquakes of note 1980-2010

• 1986 Marryat Creek M6.0 (Far North)

• 1997 Burra M5.0

• 2010 Mt Barker M3.8 (Largest earthquake within 50km of Adelaide since 1954 M5.5)

• 2010 Quorn M4.5

• 2010 Cleve M4.8
So why do we do it?
Nonstructural damage

Northridge USA 1994 – Failed Chiller Mounts
Nonstructural damage

Chile 2010 - Failed Pump Plinth
Nonstructural damage

Northridge USA 1994 – Failed Compressor Mounts
Nonstructural damage

Failed A/C Mounts

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Nonstructural damage

Northridge USA 1994 – Failed Tank Mounts
Nonstructural damage

Hot water system failures
Nonstructural damage

San Fernando M6.6
1971 – Pipe failure

Chile 2010 – Pipe failure
Nonstructural damage

Northridge USA 1994
Nonstructural damage

Northridge USA 1994
Failed lighting mounts
Nonstructural damage

Mexico M8.0 1985

Izmit, Turkey M7.4 1999
Nonstructural damage

PortauPrince, Haiti M7.0 2010
Nonstructural damage

Christchurch M7.1 2010
Nonstructural damage

Christchurch M7.1 2010

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Nonstructural damage

Northridge USA 1994
Nonstructural damage

Northridge USA 1994
Nonstructural damage

Christchurch M7.1 2010
So why do we do it?

GET PEOPLE OUT SAFELY
DPTI Expectations

Earthquake Codes
DPTI Guide Notes
Design Guides
DPTI Expectations

Earthquake Codes
Earthquake Codes

- The first Earthquake Code AS2121 was published in 1979 and referenced in the South Australian Building Regulations in 1983.
- A Section on “Minimum Earthquake Forces for Parts of Buildings” was included.
- It required the design of fixings for tanks, storage racks, equipment or machinery to resist earthquake loads.
- The standard was a life-protection code – equipment required for life safety systems or for continued operation of essential facilities must be able to withstand the design earthquake event.
Earthquake Codes

- In 2007 the code was revised and reissued as “Earthquake Actions in Australia”.
- This is the current code, effective 1 May 2009.
- Section 8 covers “Design for Parts and Components”.
- Where required by Section 8 architectural, mechanical, electrical and other similar components shall have their fastenings designed to resist earthquake forces.
Specification A1.3
DOCUMENTS ADOPTED BY REFERENCE

AS1170 Part 4 2007
Structural Design Actions
Earthquake Actions in Australia
DPTI Expectations

DPTI Guide Notes
What is in the DPTI Guidenote?

- Background to the earthquake hazard in South Australia
- Design responsibility recommendations
- A design methodology using AS1170.4 – 2007 Section 8 including:
  - Advice on service clearances
  - Advice on spacing of bracing
  - Example calculation
  - Force diagrams
  - Safety wire requirements for components in T-bar ceiling systems
  - Two drawing sheets with restraint examples
Why a DPTI Guidenote?

To assist and promote compliance with AS1170.4 Section 8 as:

- It forms part of the National Construction Code.
- Our clients are increasingly aware of a gap in compliance.
- The Earthquake Code is a loading code, it provides information on calculating loads but provides no examples of how to comply.
Why a DPTI Guidenote?

- Engineering services make up a significant proportion of the cost of constructing a building.
- In some cases equipment within a building can be significantly more valuable than the building itself.
- The cost of repairing services after an earthquake can be significant.
- In future should a major earthquake occur there will be less persons injured by falling services, less obstructions to evacuation and less interruption to the use of buildings immediately afterwards.
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.

- Allow contractors guidance to achieve compliance to the codes.
Seismic Compliance
### Table 1: Design responsibilities for restraint of engineering services to comply with AS1170.4-2007

(Extract from FEMA 464 table 0-3)

<table>
<thead>
<tr>
<th>Engineering Service</th>
<th>Architect</th>
<th>Structural Engineer</th>
<th>Electrical Engineer</th>
<th>Mechanical Engineer</th>
<th>Other Design Professional</th>
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</thead>
<tbody>
<tr>
<td>HVAC systems</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing systems</td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing equipment</td>
<td>2</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Communication and data systems</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
<td>May consider a specialty consultant</td>
</tr>
<tr>
<td>Electrical equipment</td>
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<td>2</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Vertical transportation systems</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Emergency power supply</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Fire protection systems</td>
<td>2</td>
<td></td>
<td>2</td>
<td>1</td>
<td>May consider a specialty consultant</td>
</tr>
<tr>
<td>Kitchen systems</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>May consider a specialty consultant</td>
</tr>
<tr>
<td>Lighting systems</td>
<td>2</td>
<td></td>
<td></td>
<td>1</td>
<td>May consider a specialty consultant</td>
</tr>
<tr>
<td>Medical systems</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>May consider a specialty consultant</td>
</tr>
<tr>
<td>Tanks and vessels</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended ceilings</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Seismic Restraint Design

1 – Establish the Building’s Importance Level (1 – 4) as per NCC

<table>
<thead>
<tr>
<th>Importance Level</th>
<th>Building Type</th>
<th>Example building types</th>
<th>Earthquake probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Buildings presenting a low degree of hazard to life and other property in the case of failure.</td>
<td>Farm buildings Minor temporary facilities</td>
<td>1 in 250 years ($k_p = 0.75$)</td>
</tr>
<tr>
<td>2</td>
<td>Buildings not included in IL 1, 3 and 4.</td>
<td>Low rise residential construction. Buildings and facilities below the limits set for IL3.</td>
<td>1 in 500 years ($k_p = 1.0$)</td>
</tr>
<tr>
<td>Importance Level</td>
<td>Building Type</td>
<td>Example building types</td>
<td>Earthquake probability</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>3</td>
<td>Buildings designed to contain a large number of people</td>
<td>Building where &gt;300 people can congregate in one area.&lt;br&gt;College or university for &gt;500 students&lt;br&gt;Health care for &gt; 50 beds&lt;br&gt;Jails and detention facilities&lt;br&gt;Any occupancy of &gt;5000</td>
<td>1 in 1000 years&lt;br&gt;(k_p = 1.3)</td>
</tr>
<tr>
<td>4</td>
<td>Buildings essential to post disaster recovery or associated with hazardous facilities.</td>
<td>Buildings having post disaster functions.&lt;br&gt;Designated emergency shelters.&lt;br&gt;Buildings and facilities containing hazardous materials capable of causing hazardous conditions beyond the property boundary</td>
<td>1 in 1500 years&lt;br&gt;(k_p = 1.5)</td>
</tr>
</tbody>
</table>
NOT exempted from compliance
AS1170.4 part 8 IL2 & IL3

Mechanical, electrical and similar components that need to have **seismic supports, fixings and bracing**

- Smoke control systems, emergency electrical systems
- Fire and smoke detection systems
- Fire suppression systems including sprinklers
- Life safety system components
- Boilers, furnaces, water heaters, flues, pressure vessels
- Communication systems
- Reciprocating or rotating equipment, machinery (manufacturing)
- Utility and services interfaces, lift machinery, escalators
- Lighting fixtures, electrical panel boards, conveyor systems
Exempted from compliance
AS1170.4 part 8 IL2 & IL3

Mechanical, electrical and similar components that do not need to have seismic supports, fixings but still require bracing

• Gas piping less than 25mm ID
• Piping in boiler and mechanical rooms less than 32mm ID
• Other piping less than 64mm diameter
• Rectangular air handling ducts less than 0.4m² in cross section
• Round air handling ducts less than 0.7m diameter
• Ducts and piping suspended by individual hangers 300mm or less in length from top of pipe to bottom of support for hanger

If the support is sufficient to eliminate the sway or swing bracing is not required
Seismic Restraint Design

Ensure that services are designed to have appropriate clearance between them, whether braced or not, to reduce the chance of damage in an earthquake.

<table>
<thead>
<tr>
<th>Condition being considered</th>
<th>Minimum clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal</td>
</tr>
<tr>
<td>Unrestrained component to unrestrained component (where allowed by AS1170.4 - 2007)</td>
<td>250mm</td>
</tr>
<tr>
<td>Unrestrained component to restrained component</td>
<td>150mm</td>
</tr>
<tr>
<td>Restrained component to restrained component</td>
<td>50mm</td>
</tr>
<tr>
<td>Penetration through structure such as walls or floor</td>
<td>50mm</td>
</tr>
<tr>
<td>Unrestrained services passing through the ceiling</td>
<td>25mm</td>
</tr>
<tr>
<td>Sprinkler heads with flexible droppers</td>
<td>nil</td>
</tr>
</tbody>
</table>

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.
Seismic Restraint Design

Determine the location of bracing
The recommended maximum spacing of seismic bracing for piping, conduit, cable trays and ductwork is as follows:
- 9m for transverse bracing of ductile materials;
- 18m for longitudinal bracing of ductile materials;
Seismic Restraint Design

Determine the location of bracing

The spacing of bracing may need to be reduced, for example:

• Brace both sides of piping, conduit or ductwork at flexible connections;
• Brace to avoid collisions between piping, conduit or ductwork and adjacent other non-structural components;
• Brace within 600mm of changes in direction, whether it be horizontal or vertical changes (note that offsets of less than 600mm along a run are not considered a change of direction);
• Brace where components penetrate floors or ceilings;
• Brace in both directions at the top of all risers where risers exceed 900mm.
• Brace at 45 deg or as close to it
Seismic Restraint Design

- All supports and bracing must have seismic approved fixings;
- The support and the bracing must be independent to each other;
- Know the integrity of the structure that bracing is to be fixed to;
- Ensure bracing doesn’t impede any accessibility of other services that require maintenance.

BEAM CLAMPS ARE NOT A SEISMIC APPROVED FIXING.
Design considerations

- Type of bracing
- Type of anchors
- Compression in suspension rods
- Interaction with ceilings
- Transmission of vibration to structure
- Thermal movements
- Services crossing structural separations.
- Service plinth reinforcement and dowels to structural slab.
Types of bracing

• Wire cable – tension only so required both sides, cable must be strength rated.
• Steel angle – compression and tension, check length for buckling, consider vibration transmission.
• Unistrut - compression and tension, check length for buckling, consider vibration transmission.
• Threaded rod – limited compression strength.
Anchors

- Some fixing types are vulnerable to the dynamic nature of seismic forces such that they might shift, slip or jump out of place.

- Use only anchors rated for seismic loads by their manufacturer.
Compression in suspension rods

- Where horizontal forces are large enough the typical tension force in hanger rods can change to compression.

- In that case loads might exceed the compression strength of the rod depending on its size and length.

- Stiffening may be required

- Or replace with steel angle
Services and Ceilings

- Overhead light fixtures in T-bar ceiling grids have often been damaged in past earthquakes with fixtures becoming dislodged and falling.
- Damage to light fixtures in flush plasterboard ceilings has been less common.
- The attachment of safety wires to light fixtures and cushion head boxes ensures that while they may fall from the ceiling grid and dangle from the safety wire after an earthquake they will not threaten occupants.
- The splaying of the safety wires from the fixtures or box provides some lateral restraint.
Services and Ceilings

Safety wires are not required where:
• Light fittings or cushion head boxes are in flush plasterboard ceilings.
• Light fixtures and cushion boxes are supported and braced independently of the ceiling.
• The ceiling grid has been specifically designed to provide vertical and lateral restraint to the light fixtures and cushion head boxes and fixings are provided to transmit the seismic force from the lights and boxes to the ceiling grid.
Restraint examples

There are many techniques available to reduce potential nonstructural earthquake damage including;

• Using anchor bolts to provide rigid anchorage to a structural floor or wall,
• Bracing the item to a structural floor or wall,
• Providing a tether or safety cable to limit the range of movement if the item falls or swings,
• Providing stops or bumpers to limit the range of movement if the item is on vibration isolators or can slide or swing,
• Providing flexible connections for piping and conduit where they cross seismic joints or connect to rigidly mounted equipment.
Restraint examples

Pipework restraint
Restraint examples

Gas bottle restraint

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Restraint examples

Lateral bracing and strutting of ceilings

Project Services - Building Management Division

Government of South Australia
Department of Planning, Transport and Infrastructure
Restraint examples

Bracing of battery racks

FIGURE 6.4a  Bracing of existing battery racks.

Bracing of rectangular ducting

FIGURE 6.2c  Lateral and longitudinal braces for rectangular ducting.
Restraint examples

Vibration mount with seismic stops

Seismic restraints

Equipment anchorage

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Restraint examples

Stud wall restraint

Figure 6.3.2.2-6 Partial height nonbearing stud wall (ER).
Restraint Examples

Restraint of non-structural components and services is not done well in Australia, if at all, so ensure the requirements of AS1170.4 are being discussed, designed for and then installed on site.

Further information is available through;

- FEMA E-74, 2011, Reducing the Risks of Nonstructural Earthquake Damage
WARNING

KNOW YOUR PRODUCT

“For use in seismic application where approved by an engineer”

“Restraint system must be approved for compliance”

“not suitable for earthquake prone areas”

“makes no representation or warranty, expressed or implied, with respect to the sufficiency or fitness of this product in a seismic application”
PART 1 PRELIMINARY

PART 2 STRUCTURAL SAFETY

PART 3 FIRE SAFETY

PART 4 HEALTH, AMENITY & ACCESSIBILITY

PART 5 CHANGES TO BUILDING CLASSIFICATION
PART 1 PRELIMINARY

PART 2 STRUCTURAL SAFETY

PART 3 FIRE SAFETY

PART 4 HEALTH, AMENITY & ACCESSIBILITY

PART 5 CHANGES TO BUILDING CLASSIFICATION
Primary building elements in an existing building must continue to be able to withstand the combination of loads and/or actions that they were designed to resist and to which they may reasonably be expected to be subjected.

Where an existing building undergoes a change of use, change of Importance level, or alterations, primary building elements must be able to withstand the combination of any changed loads and/or actions to which they may reasonably be expected to be subjected.
Where an existing building undergoes a change of use, a change in its Importance Level or alterations, potential high seismic hazards and vulnerable building elements that could fall and injure occupants who may be evacuating the building during an earthquake must be identified and strengthened at the earliest opportunity to reduce the risk of them falling appropriate to-

(a) the degree of risk to occupants;
(b) the extent of alterations being undertaken; and
(c) the technical feasibility of undertaking upgrading or strengthening work; and
(d) the Importance Level of the building.
A rapid seismic assessment of the building undertaken by a professional engineer or other suitably qualified person outlined in accordance with the process outlined in Appendix A1. Results from the rapid seismic assessment process must be submitted with the application for building approval, together with details of proposed remedial work.
Importance Level requirements
<table>
<thead>
<tr>
<th>Importance Level</th>
<th>Examples of building types</th>
</tr>
</thead>
</table>
| 1                | Farm buildings and farm sheds  
Isolated minor storage facilities  
Minor temporary facilities.  |
| 2                | Low rise residential construction  
Buildings and facilities below the limits set for Importance Level 3.  |
| 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.  |
| 4                | Buildings and facilities designated as essential facilities  
Buildings and facilities with special post disaster functions  
Medical emergency or surgery facilities  
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 LEVEL 4 (IL4)
The following items are excluded from the scope of all DPTI 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).
What is a Special Study?

When does it need to be done?

What does a special study have to inform us of?
What is a Special Study?

• The need for a special study will inform the client of the key limitations surrounding their ability to resume services after an event.
• The study will look at the environment that the construction is to occur and how the structure will fair in the event of an earthquake.
• Prepare designers to ensure all known risks are evident and acknowledged.
When does it need to be done?

- The special study must be developed at concept phase prior to any formal design work.
- The study needs to ensure all stakeholders are advised and allowed to communicate to the formation of the study.
- Final acceptance of the study must be from the client owner.
What does a special study have to inform us of?

- All known risks to operation
- Environmental concerns
- Business continuity
- Resources location and supply
- Time frames for resuming service
- Limitations
- Client approval
QUESTIONS