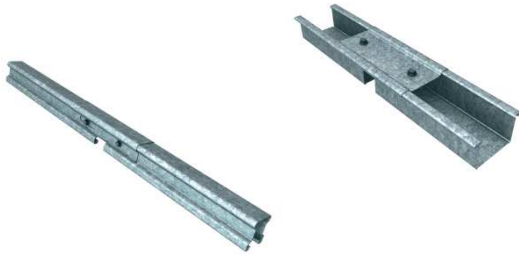


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# Seismic in Suspended Ceilings



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**Time allowance:** 1 hour

**CPD Points:** 10

## Contents – Topic of discussion

- Codes and Compliances
- Seismic & suspended ceilings: the basics
- Seismic concepts: suspended grid ceilings
- Seismic concepts: plasterboard grid ceilings
- Seismic Design – an integrated approach
- Industry design tools and support

# Codes & Compliances

- NZS 1170.5 Structural Design Actions – Earthquake Loads
  - Primary document used to assess/calculate seismic requirements of structural/non-structural elements
- NZS 2785 – Suspended Ceilings, Design and Installation
  - Covers materials, ceiling types, design requirements and installation
- NZS 4541 – Automatic Fire Sprinkler Systems
  - Covers the design of fire systems – defines bracing requirements for sprinkler system pipe work
- NZS 4219 – Seismic Performance of Engineering Systems in Buildings
  - Specifies interaction between components – covers the seismic restraint of services



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# Seismic & Suspended Ceilings




- Various changes to NZS 1170.5 have been implemented to ensure safer construction
- Design considerations:
  - Geographical Location
  - Soil conditions
  - Building usage
  - Building importance level (rated 1 to 4)
  - Construction materials
  - Ceiling weight
  - Ceiling height (from ground level)
  - Plenum depth
  - Ceiling size

JOB NAME: \_\_\_\_\_ JOB NUMBER: \_\_\_\_\_

### Seismic Loading

**SEISMIC ZONE**  
Choose a seismic zone from the adjacent map.  
Alternatively select Z Value from town/city list on page 16






Zone	Z Value ≤
1	0.13
2	0.20
3	0.30
4*	0.396*
5	0.50
6	0.60

\* Christchurch earthquake zone requires a higher return period factor. The Z value has been modified to account for this.

# Seismic & Suspended Ceilings



- Documentation associated with seismic design
  - **PS1:** Issued by certified engineer
  - **PS2:** Design peer review – certified engineer
  - **PS3:** issued by contractor (installation signoff)
  - **PS4:** review of construction – certified engineer




 Building Code Clause(s) B1, B2

**PRODUCER STATEMENT – PS1 – DESIGN**  
(Guidance notes on the use of this form are printed on the reverse side)

ISSUED BY: KNOWLES CONSULTING LTD  
(Design Firm)

TO: FORMAN CEILING  
(Owner/Developer)

TO BE SUPPLIED TO: CHRISTCHURCH CITY COUNCIL  
(Building Consent Authority)

IN RESPECT OF: SEISMIC BRACING OF SUSPENDED CEILING, GROUND FLOOR & FIRST FLOOR  
(Description of Building Work)

AT: \_\_\_\_\_  
(Address)

LOT \_\_\_\_\_ DP \_\_\_\_\_ SO \_\_\_\_\_

We have been engaged by the owner/developer referred to above to provide SEISMIC BRACING SOLUTION FOR THE SUSPENDED CEILING OF GROUND FLOOR & FIRST FLOOR services in respect of the requirements of Clause(s) \_\_\_\_\_ of the Building Code for

☐ All or ☒ Part only (as specified in the attachment to this statement), of the proposed building work.

The design carried out by us has been prepared in accordance with:

☒ Compliance Documents issued by Department of Building & Housing B1/VM1, B2/AS1  
(verification method / acceptable solution)

☐ Alternative solution as per the attached schedule

The proposed building work covered by this producer statement is described on the drawings titled KCL SKETCHES and numbered \_\_\_\_\_ together with the specification, and other documents set out in the schedule attached to this statement.

On behalf of the Design Firm, and subject to:

(i) Site verification of the following design assumptions \_\_\_\_\_  
 (ii) All proprietary products meeting their performance specification requirements;

I believe on reasonable grounds the building, if constructed in accordance with the drawings, specifications, and other documents provided or listed in the attached schedule, will comply with the relevant provisions of the Building Code.

I, LAWRIE RANKS am ☒ CPEng 142563 # \_\_\_\_\_  
(Name of Design Professional)

I am a Member of: ☒ IPENZ ☐ NZIA and hold the following qualifications BE (Hons) # \_\_\_\_\_

The Design Firm issuing this statement holds a current policy of Professional Indemnity Insurance no less than \$200,000\*. The Design Firm is a member of ACENZ ☒ YES ☐ NO

SIGNED BY LAWRIE RANKS ON BEHALF OF KNOWLES CONSULTING LTD  
(Design Firm)

Date 21/02/15 (signature) [Signature]

Note: This statement shall only be relied upon by the Building Consent Authority named above. Liability under this statement accrues to the Design Firm only. The total maximum amount of damages payable arising from this statement and all other statements provided to the Building Consent Authority in relation to this building work, whether in contract, tort or otherwise (including negligence), is limited to the sum of \$200,000\*.

This form is to accompany Form 2 of the Building (Forms) Regulations 2004 for the application of a Building Consent.

# Seismic Concepts – Suspended Grid Ceilings

- Grid manufacturers performed extensive seismic tests to assess mechanical performance of grid components in a seismic event

- Perimeter connection strength
- Grid connection pull capacity
- Grid compression capacity
- Grid torsional performance



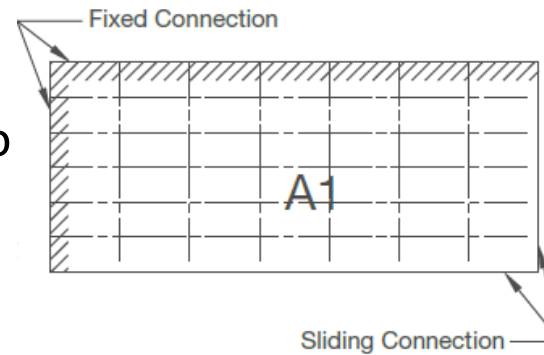
- Test data are then used by engineers to calculate fundamental seismic design capabilities of the grid system



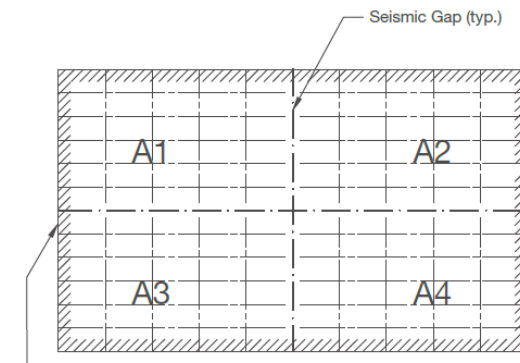
# Seismic Concepts – Suspended Grid Ceilings

- 3 Fundamental bracing layout concepts

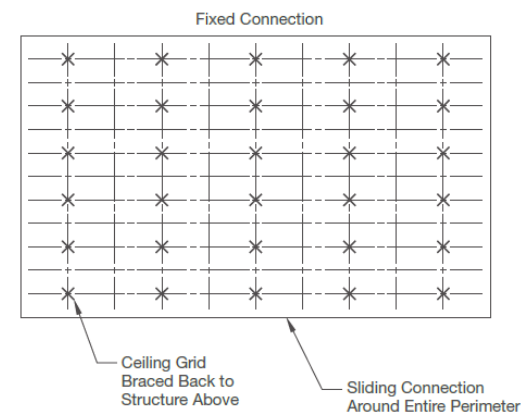
- Perimeter connected on two adjacent walls



- Perimeter connected on all four sides with “seismic separation”



- Disconnected at perimeter on all four sides and braced to roof structure above





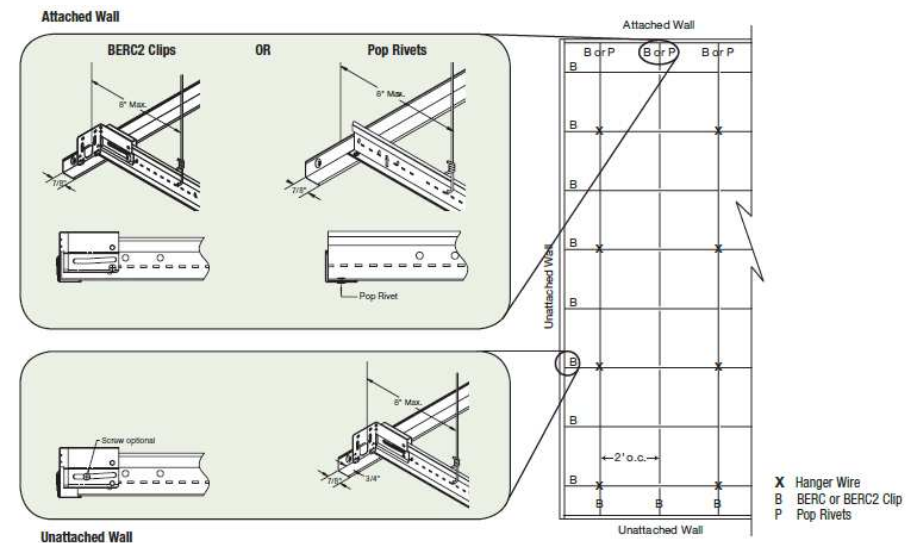
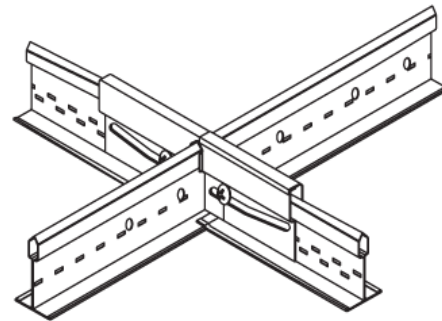
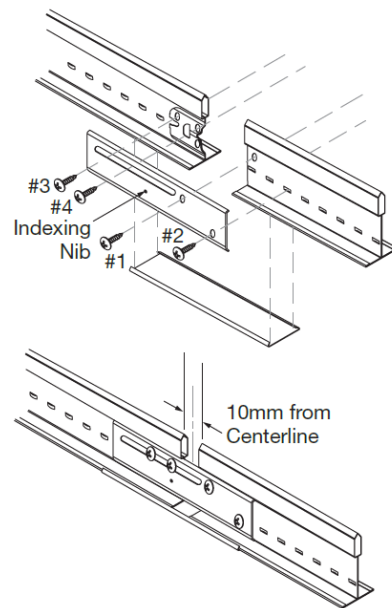


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# Seismic Concepts – Suspended Grid Ceilings



- Various manufactures have developed proprietary seismic clips systems designed to introduce “movement” within the grid module
- Seismic systems are generally fully concealed not to penalise aesthetics







# Seismic Concepts – Suspended Grid Ceilings



- How can we determine which bracing option to use?

- Assess geographical area of the project (seismic zone)
- Calculate ceiling height (from ground level)
- Calculate ceiling weight (tile-grid-services-other)
- Assess ceiling slope factor


- **Seismic Force** is established from above

- Now we assess ceiling size/dimensions and “benchmark” it to seismic force against maximum allowable forces on grid (from manufacturer tests)

JOB NAME: \_\_\_\_\_ JOB NUMBER: \_\_\_\_\_

### Seismic Loading

**SEISMIC ZONE**  
Choose a seismic zone from the adjacent map. Alternatively select Z Value from town/city list on page 16



Zone	Z Value ≤
1	0.13
2	0.20
3	0.30
4*	0.396*
5	0.50
6	0.60

\* Christchurch earthquake zone requires a higher return period factor. The Z value has been modified to account for this.

**CEILING HEIGHT FACTOR**  
The height the ceiling is supported at affects the magnitude of the Seismic Forces. Select the appropriate ceiling height factor from the table below.

Ceiling Support Height	Ceiling Height Factor, H
0 - 3m	1.0
3 - 6m	1.33
6 - 9m	1.66
> 9m	2.0

**CEILING WEIGHT**  
Calculate the total ceiling weight. All elements that are supported by the ceiling grid must be included. Note that no individual element may weigh more than 10kg each. The total service load must be taken as at least 3kg/m<sup>2</sup>. See example for calculation of lighting weight.

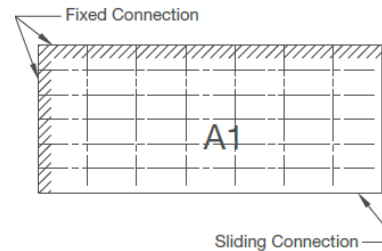
Ceiling Tile		kg/m <sup>2</sup>
Grid		kg/m <sup>2</sup>
Service Load*	Lighting	kg/m <sup>2</sup>
	Insulation	kg/m <sup>2</sup>
	Other	kg/m <sup>2</sup>
	Subtotal	kg/m <sup>2</sup>
Total Wp =		kg/m <sup>2</sup>

\*Minimum services load is 3kg/m<sup>2</sup>

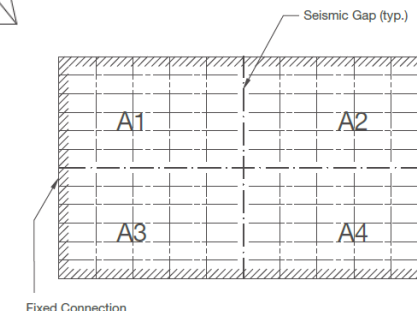
Light Weight = 4 kg  
Light Spacing = 2.4 x 2.4m = 5.76m<sup>2</sup>  
Lighting Load = 4 ÷ 5.76 = 0.7 kg/m<sup>2</sup>

# Seismic Concepts – Suspended Grid Ceilings

- These design assessments and calculations allow to determine if a perimeter connection can exist. (bracing option 1 or 2 depending on size of the ceiling)
- Option 1: continues grid span with two perimeter side fixed and two perimeter sides disconnected



- Option 2: perimeter fixed on all four sides with seismic brake

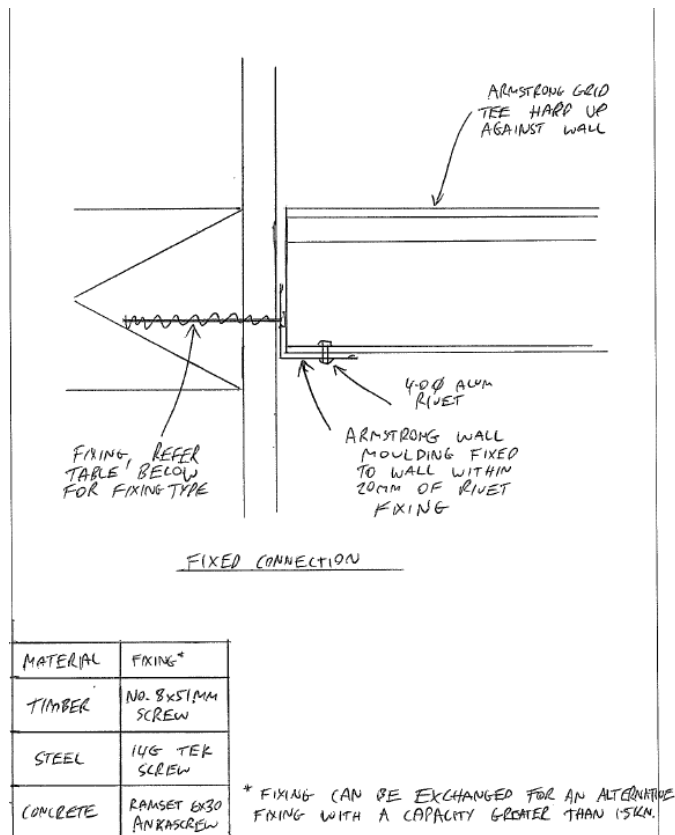


- **Limiting factor? Can the perimeter wall take line load? (transfer grid forces) \*\*\* wall framing needs to have nog at perimeter level\*\*\***

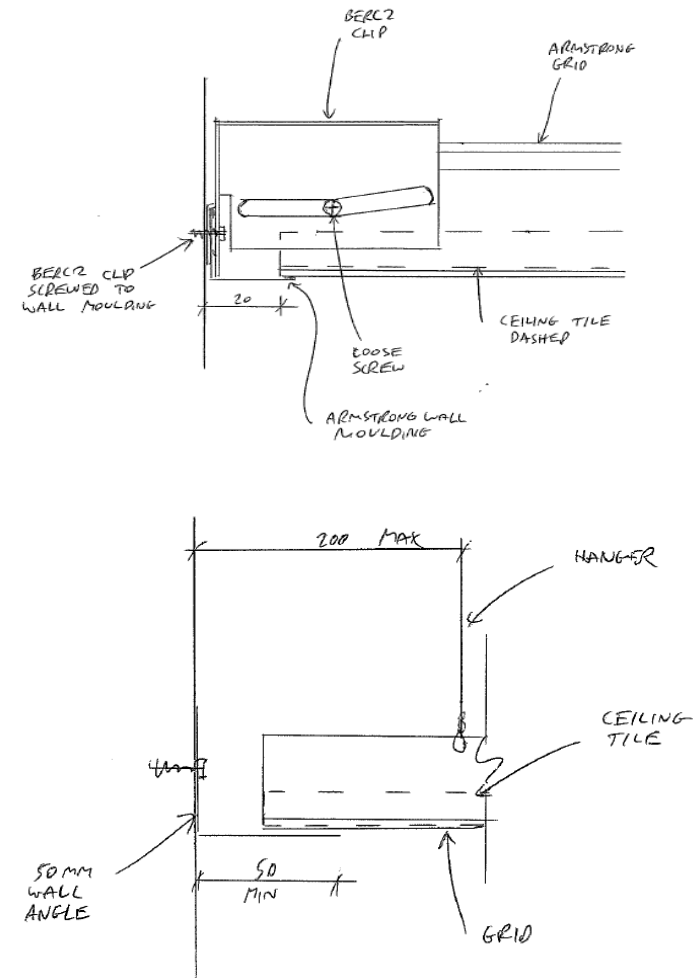


# Seismic Concepts – Suspended Grid Ceilings

## Perimeter fixing option

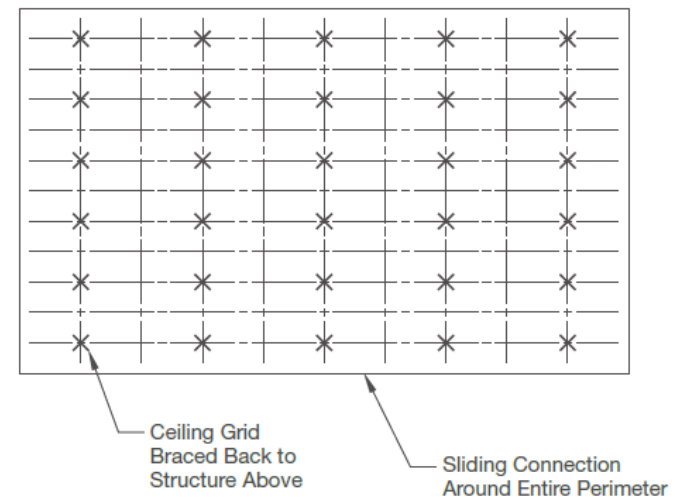
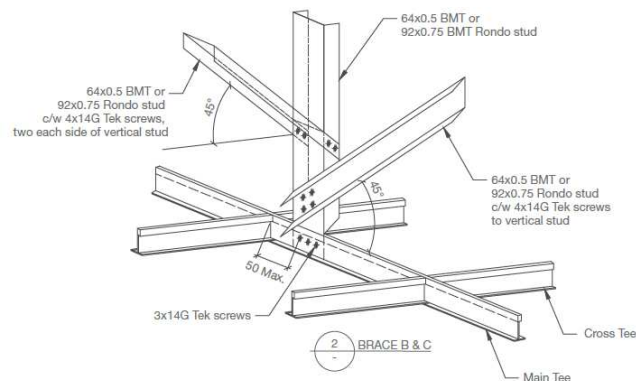


## Disconnected perimeter options



# Seismic Concepts – Suspended Grid Ceilings

- If seismic forces are too high for a perimeter connection to exist (or wall/perimeter details can't take line load), then we must revert to bracing option 3
- Ceiling is fully disconnected at perimeter level and braced to the roof structure above
  - We must now calculate roof bracing requirements
  - Plenum depth directly affects bracing formant/type
  - Calculate maximum allowable area per brace
  - Co-ordinate bracing layout & services layout



# Seismic Concepts – Plasterboard Grid Ceilings

## Design Considerations:

- likely magnitude of seismic design events for a given building location
- accelerations and movements of the primary building structure during an earthquake.
- interaction with other building parts, including the support structure as well as other building attachments
- capacity of the system to transfer seismic inertia loads back to the support structure
- design of restraints to the system and resulting capacities of connections to transfer loads to the support structure

# Seismic Concepts – Plasterboard Grid Ceilings

## Design Considerations:

- accommodating appropriate differential support structure movements between points of attachments, including inter-storey drifts
- limiting damage through the careful selection of restraint type fixings (e.g. fixed, sliding or free)
- capability of systems to deform, including deformations of individual components, joints and connections
- relative stiffness of the system to the support structure

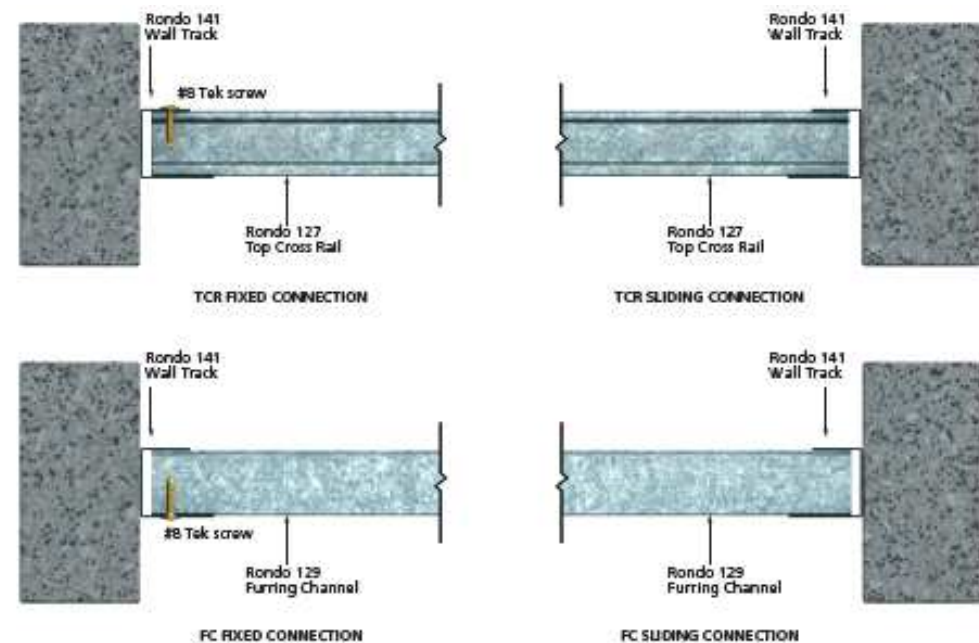
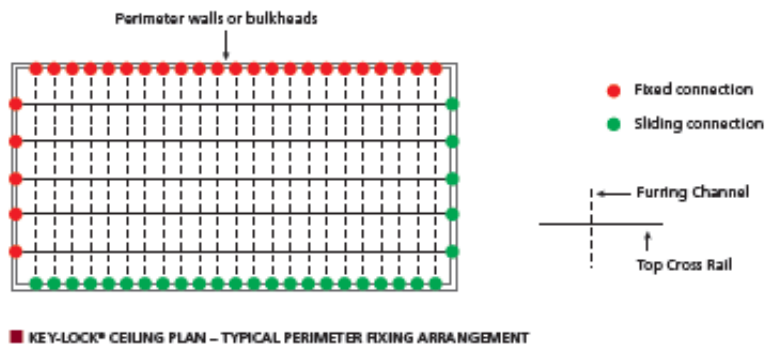
## Seismic Concepts – Plasterboard Grid Ceilings

- Designs assume that the supporting structures have sufficient capacity to withstand all loads (and load combinations) applied from ceiling and partition wall framing, including those for seismic. Support structures must be both strong enough and stiff enough to resist lateral seismic loads without suffering significant damage. This should be checked by the project / structural engineer.
- Ceilings and wall systems are not considered sensitive to vertical accelerations experienced during earthquake events, hence only horizontal accelerations have been considered.
- Suspended ceilings and partition wall systems have not been designed to act as primary building frames, hence they should not be included as a part of the seismic load resisting system or to transfer loads between structural elements.



# Seismic Concepts – Plasterboard Grid Ceilings

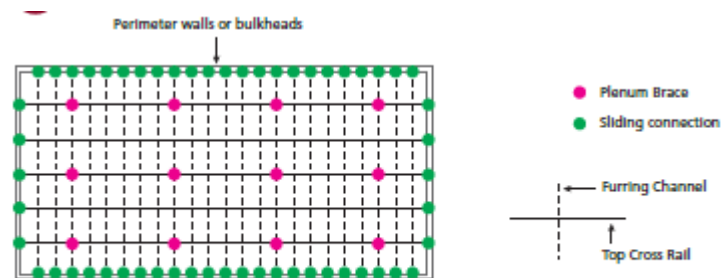
- 2 Bracing Concepts
  - Fixing to perimeter and bulkheads



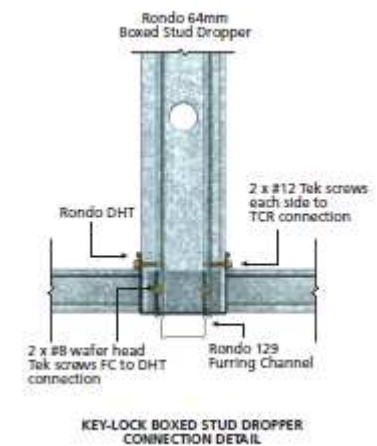
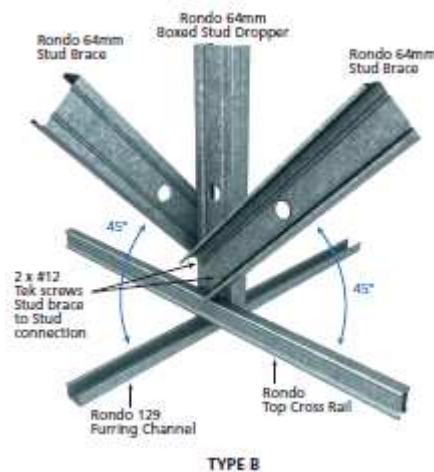
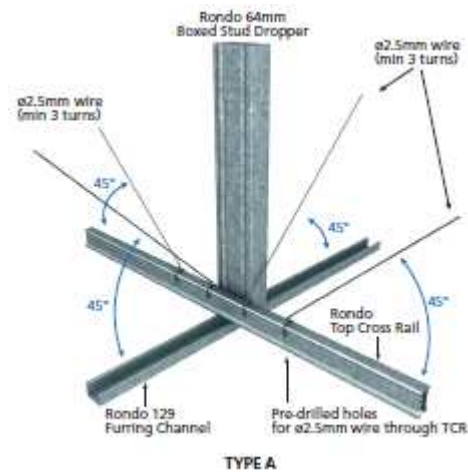
■ KEY-LOCK® FIXED AND SLIDING PERIMETER CONNECTION DETAILS

# Seismic Concepts – Plasterboard Grid Ceilings

- Plenum Bracing



■ KEY-LOCK® CEILING PLAN – TYPICAL PLENUM BRACING ARRANGEMENT



## Seismic Design – an **Integrated Approach**

- CHCH and WLG quakes provided a key lesson: integrated design approach
- Ceiling failures caused by serviced in the plenum were overwhelming
- Mech. services, sprinkler systems, electrical and suspended ceilings all need to be designed with a “holistic” approach to minimise failure



## Seismic Design – an **Integrated Approach**

- Separation of components (ceiling- lights – services) is required by code
- Separation of services allows for relative movements between services and ceiling during an earthquake
- Failure to provide adequate clearance could result in the ceiling failure during a seismic event
- Services within the ceiling can be either braced or unbraced
- Different clearances are required between braced and unbraced services

# Seismic Design – an **Integrated Approach**

- **NZS 4541 – Automatic Fire Sprinkler Systems**

- This code covers the design of fire systems

- Defines bracing requirements for sprinkler system pipe work

- Does not specify clearance requirements





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## Seismic Design – an **Integrated Approach**

- AS/NZS 2785 Suspended Ceilings, Design and Installation

-This code covers material, ceiling types, design requirements and installation

AS/NZS 2785:2000

-Does not specify clearances between ceiling structure and services within the ceiling void

**Suspended ceilings—  
Design and installation**

# Seismic Design – an **Integrated Approach**

## NZS 4219 – Seismic Performance of Engineering Systems in Buildings

-Specifies interaction between components  
(services)

-Covers the seismic restraint of services  
including:

- Pipes Systems
- Ducting
- Non-essential electrical services  
(cable trays)
- Suspended Ceilings
- Luminaries (lights)

**NZS 4219:2009**

New Zealand Standard

### **Seismic Performance Of Engineering Systems In Buildings**

Superseding NZS 4219:1983



# Seismic Design – an **Integrated Approach**

## Interaction between components

- Section 5.2, Table 15 lists interaction clearances between components
- Clearances between restrained and unrestrained components:
  - **Horizontal Clearance: 150mm**
  - **Vertical Clearance: 50mm**
- Clearances between restrained components:
  - **Horizontal Clearance: 50mm**
  - **Vertical Clearance: 50mm**
- Clearances for components with flexible connections may have reduced clearances

### 5.2 INTERACTION BETWEEN COMPONENTS

#### 5.2.1 Clearances

Unless otherwise specified, clearances shall be provided in accordance with table 15.

Table 15 – Clearances

Condition being considered	Minimum clearance (mm)	
	Horizontal	Vertical
Unrestrained component to unrestrained component	250	50
Unrestrained component to restrained component	150	50
Restrained component to restrained component	50	50
Penetration through structure (such as walls and floor)	50	50
NOTE – Ceiling hangers and braces are considered to be restrained components for the purposes of this table.		

#### C5.2.1

*Flexible connections within the service may allow penetration clearances to be reduced.*

# Seismic Design – an **Integrated Approach**

## Piped Systems

- No specific seismic restraint required for piping less than 50mm diameter
- NZS 4541 requires **all** sprinkler pipework to be seismically restrained
- NZS 4219 requires any braced component within the ceiling to have 25mm clearance
- Sprinkler heads typically do not have this available tolerance
- Recommended flexible droppers where clearances cannot be achieved
- Failure to provide adequate clearance through the ceiling can cause the ceiling to fail





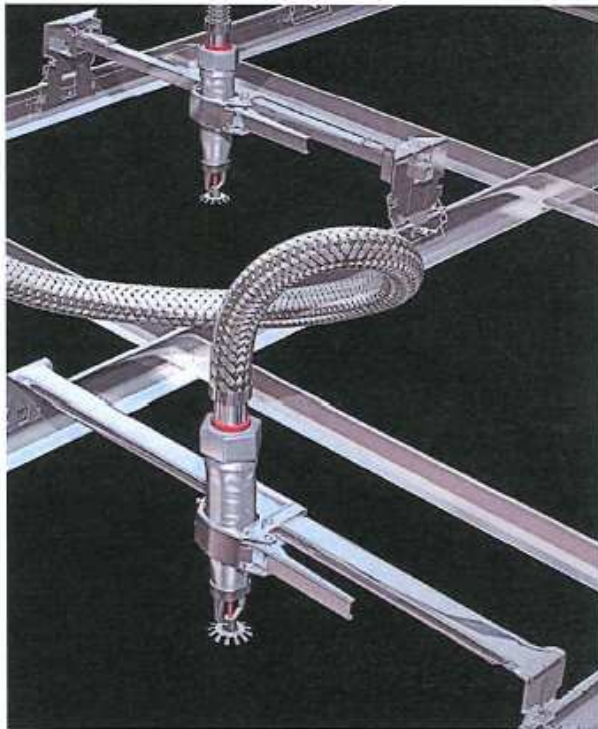
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# Seismic Design – an **Integrated Approach**

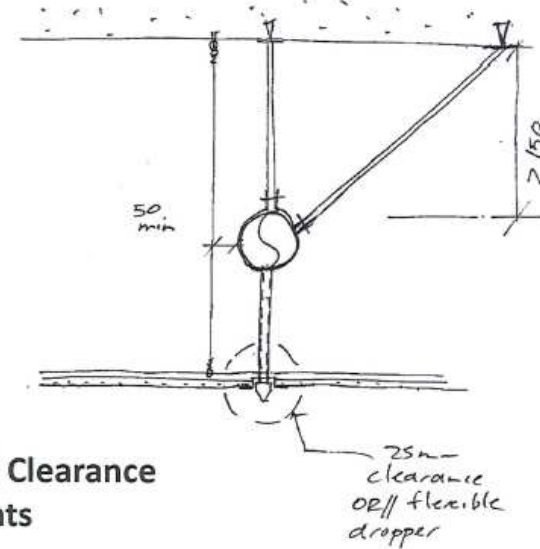
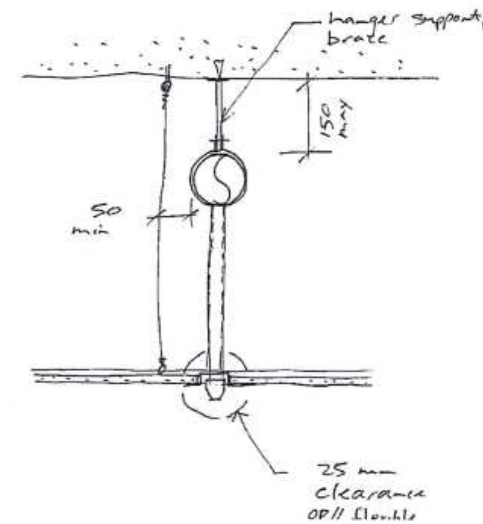
**RONDO**



## Piped Systems



**Flexible Sprinkler Droppers**



**Bracing and Clearance Requirements**

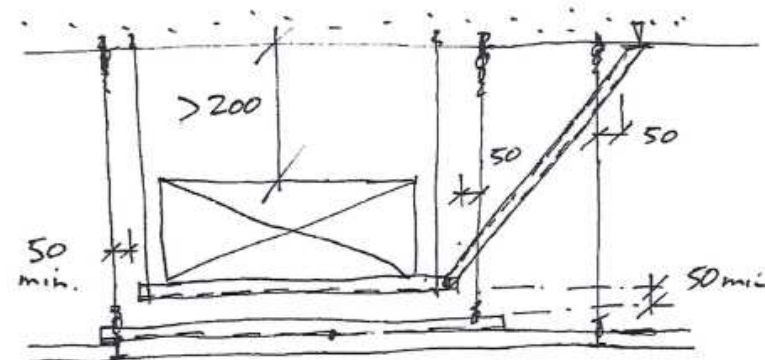
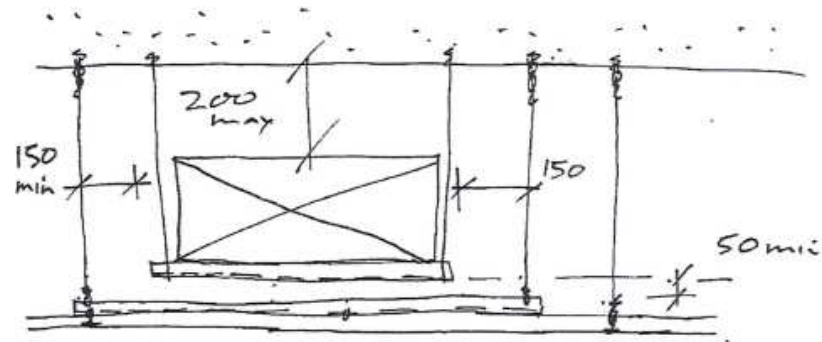
# Seismic Design – an **Integrated Approach**

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**F**  
FORMAN

## Ducting

- In accordance with NZS 4219
  - Ducting within 200mm of soffit requires no seismic bracing
- Flexible ducting requires support at 1.5mt centres



**Bracing and Clearance Requirements**





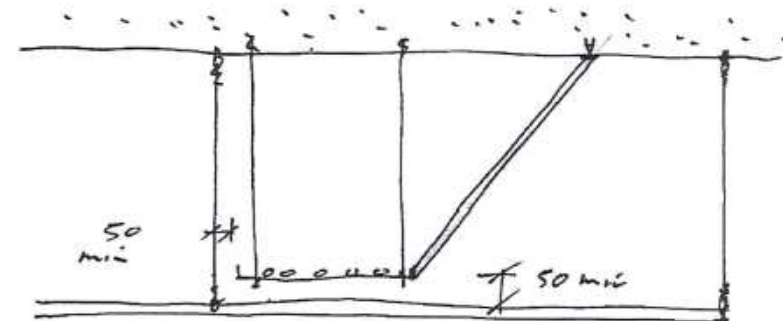
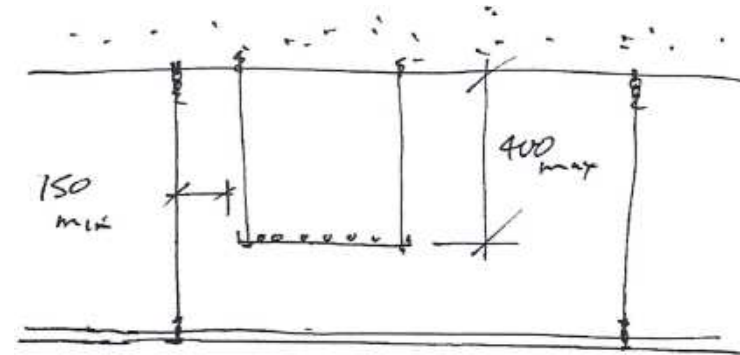
# Seismic Design – an **Integrated Approach**

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## Non-Essential Electrical Services (cable trays)

- In accordance with NZS 4219
  - Cable trays within 400mm of the soffit require no seismic bracing



**Bracing and Clearance Requirements**



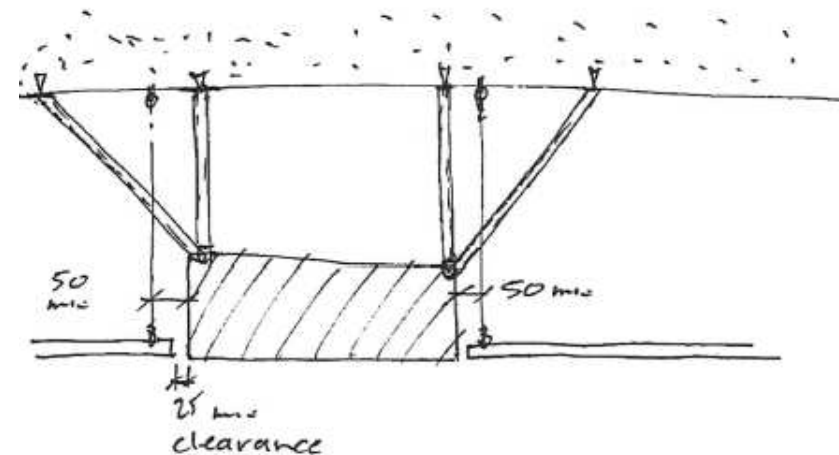
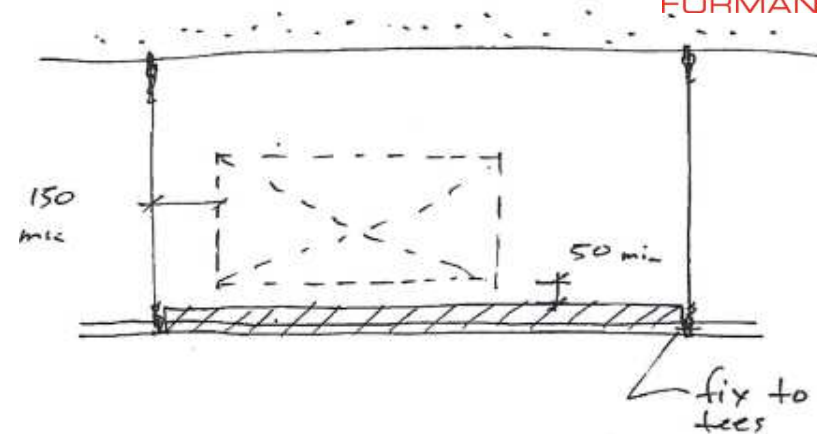
# Seismic Design – an Integrated Approach

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## Luminaries (Lights)

- In accordance with NZS 4219
  - Lights not exceeding 10Kg within the ceiling grid, require no independent support, but require to be positive fixed to the grid
  - Lights greater than 10Kg in weight shall be independently supported, braced and separated by 25mm from the ceiling



Bracing and Clearance Requirements



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# Seismic Design – an **Integrated Approach**

## Summary

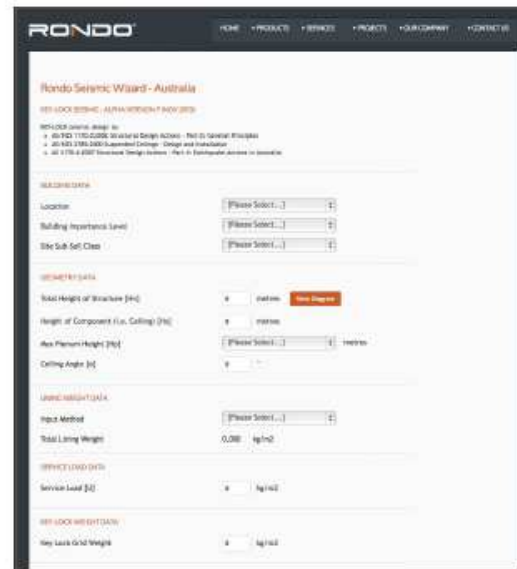
- For simplicity it is recommended that the following minimum clearances are adopted:
  - **Vertical clearance: 50mm**
  - **Horizontal Clearance: 150mm**
- Recommendation that all sprinkler dropper are all flexible
- Ceiling installers need to notify site managers if clearances and component bracing do not comply and tag producer statements to limit future liability in event of a failure caused by clashes in a seismic event



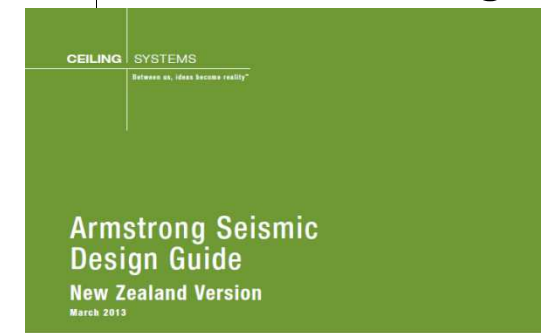


# Seismic Design Tools and Support

- Major ceiling manufacturers have invested resources in creating seismic design tools for industry professional
- These tools do not replace producer statements
- Provide assistance in assessing design requirements and costs of installing code compliant ceilings



SEISMIC DESIGN WIZARD ONLINE



## Suspended Ceiling Systems

