ECOPLUS SYSTEMS

FasTLock®

SUSPENDED CEILING GRID

Seismic Design Manual

VER 1.0 NOV 2013

FASTLOCK SUSPENDED CEILING GRID

Introduction

It is important that suspended ceilings are properly restrained against earthquake shaking. This is to reduce the risk of injury to people, cutting off exit routes from buildings and damage to property.

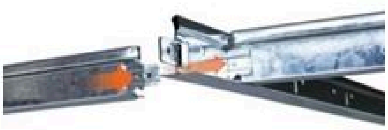
The major Canterbury earthquakes of 2010 and 2011 highlighted how vulnerable suspended ceilings were to the forces induced from shaking during an earthquake. While some buildings suffered little damage to their structural systems, non-structural components such as ceilings were severely damaged. Any damage to the suspended ceilings sustained during the earthquake meant that building operations were effectively shut down until repair or removal of the ceilings had taken place.

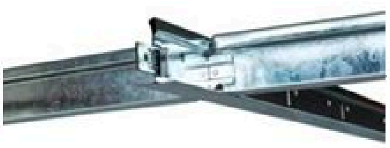
Ceiling damage can be attributed to:

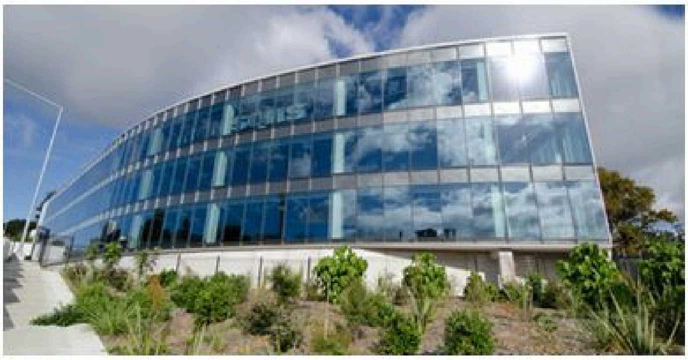
- Ceiling grid not perimeter fixed at one end or back braced.
- Ceiling grid tees being used with insufficient capacity under seismic tension or compression loads.
- Support structures or bulkheads with insufficient capacity to receive the seismic load from the ceiling grid.
- Differential movement of the main building structure.
- Engineering systems within the ceiling space not having independent seismic restraint.
- Partitions that are not independently braced.

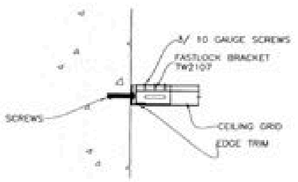
All suspended ceilings in New Zealand need to be designed for earthquake forces in accordance with AS/NZS2785:2000. Seismic actions should be calculated to section 8 of NZS1170.5:2004 – Requirements For Parts And Components.

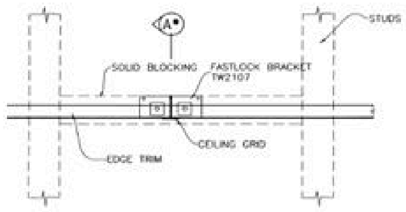
This design manual for the seismic restraint of ceilings is intended to be used as a generic guide, by non-specialist people who have responsibility to ensure the capacity of a suspended ceiling is adequate in a seismic event. For ceilings that fall outside the scope of this manual, advice should be obtained from a suitably qualified structural engineer.











Contents

Seismic Design Statement

Pont Consultants Ltd has been engaged by Ecoplus Systems Ltd to provide assistance with the preparation of a seismic design manual to ensure that installation of the FasTLock™ Suspended Ceiling Systems will meet the requirements of Clause B1 of the New Zealand Building Code with respect to seismic design.

Testing of the ceiling grids and perimeter fixings was undertaken in 2013 by SGS New Zealand Ltd to determine compression and tension capacities. Appropriate reduction factors have been applied to determine the design capacity of the tees in accordance with section 8 of AS/NZS4600:2005, Section 8:Testing.

This manual is designed to be used by non-specialist persons, who are nevertheless experienced in the installation of suspended grid ceilings or are well trained in the principles of seismic design of ceilings. Interpretation and application of this generic seismic design guide for specific applications outside the scope of this manual is the user's responsibility.

Assumptions

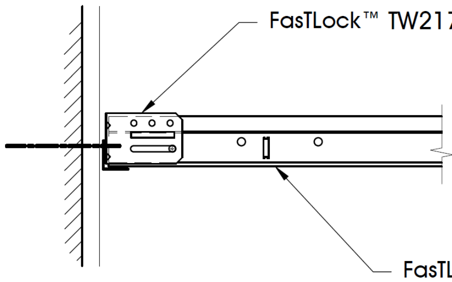
- Ceiling is designed as a Category P7 part under section 8 of NZS1170.5:2011.
- Limit State design is for SLS1 (Serviceability Limit State, 1-25 year return period), as required for category P7 parts.
- Assumed ceiling grid ductility μ = 1.0.
- Ceiling period (T) assumed to be less than 0.75s.
- Importance level of building assumed to be level 3 or less. For importance level 4 buildings (such as hospitals, critical facilities), advice is required from a suitably qualified structural engineer.

Limitations

- This design manual must only be used for Ecoplus FasTLock™ 24mm suspended ceiling grids.
- The building must be located within New Zealand.
- The building height must be 24m or less.
- The spacing of the ceiling grid tees must be a maximum of 1.2m in either direction.
- Ceiling must be non-trafficable.
- Ceiling must not be used as part of a structural system.
- Ceiling systems should not be suspended from building services such as ducts.
- Any equipment exceeding 10kg in the ceiling space must be independently fixed to the structure in accordance with NZS4219:2009.
- Fire sprinkler heads should be separated from ceiling tiles by independently bracing each dropper and providing a 10mm clearance all around or using a flexible dropper.
- Ceiling tiles should be restrained by fitting 4 hold down clips attached to the main tee where possible.
- Ceilings must be designed and installed in accordance with AS/NZS2785:2000.
- Installation of the ceiling must be carried out by competent ceiling installers experienced in the installation of suspended ceiling systems.
- Ceiling is designed to Serviceablility Limit State 1 (SLS1). For design to Ultimate Limit State (ULS), advice should be obtained from a suitably qualified structural engineer.
- Continuous nogging is required at the level of perimeter fixing to ensure sufficient lateral strength at the perimeter connection.
- The support structure for the ceiling grid must have adequate strength and stiffness to withstand the design loads imposed by the ceiling under earthquake and gravity loading.
- Partitions must not rely on the ceiling grid for bracing, unless designed by a suitably qualified structural engineer.
- Ceilings must be installed in accordance with the FasTLock™ suspended ceiling grid manual.

Design Considerations

- Ceiling grid should not have fixed perimeter connections at both ends to two opposite walls, unless a suitable seismic gap has been provided between them.
- Ceiling grid should not be both perimeter fixed and back braced as differential movements could attract greater loads.
- Generally, the ceiling grid is be installed with 2 adjacent fixed perimeters connections and 2 adjacent sliding perimeter connections, or 4 sliding perimeter connections in the case of back bracing.
- Where any doubt exists, seek specialist advice from the manufacturer or a suitably qualified structural engineer.
- A separate seismic design should be carried out for each separate floor of a building or each significant area.



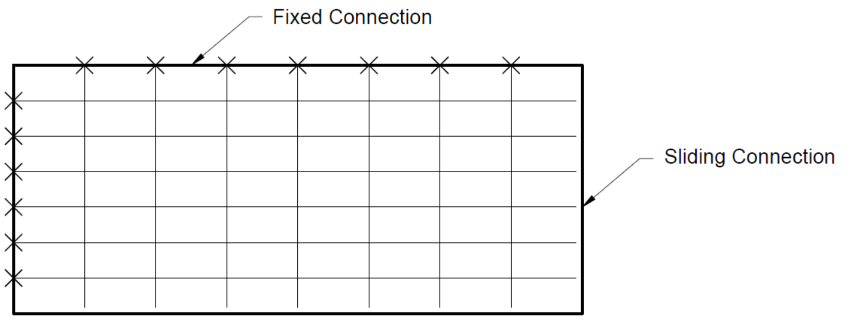
Seismic Design Steps

1	Identify the appropriate Z-value corresponding to the building location based on the map and table provided.
2	Identify the correct ceiling height factor from table provided.
3	Calculate the total ceiling weight. Ensure the total services weight is a minimum of 3kgs/m^2.
4	Input Z-value, total ceiling weight and ceiling height factor to calculate the seismic force.
5	Input the seismic force, tee lengths and tee spacing to determine the total design force.
6	Check with building structural engineer that perimeter can take the design force.
7	Compare the total design force to load capacity of FasTLock™ tee. If load capacity is greater than the design force, proceed to next step. If not, try a different bracing layout option.
8	If bracing layout options 1 and 2 do not work, proceed with back bracing design. Otherwise a structural engineer should be consulted.
9	If layout option 1 and 2 work, proceed with design to compare total design force to load capacity of tee and perimeter fixings.
10	Fill in the summary sheet on page 15.

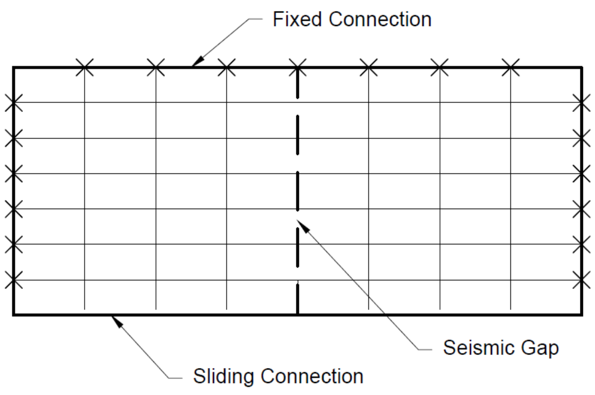
Bracing Layout Options

- The choice of a suitable bracing layout will depend on the shape of the ceiling, the magnitude of the seismic force and suitability of the supports at the perimeter or structure above.

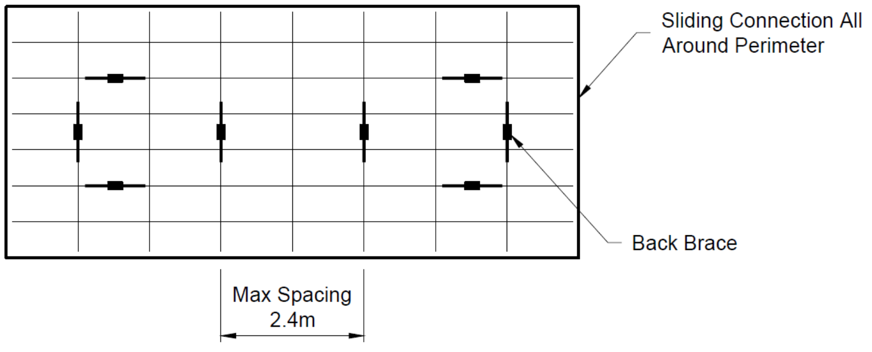
Option 1 – Grid perimeter fixed on two adjacent sides with sliding connections on opposite



Option 2 – Grid perimeter fixed on opposite sides with seismic gap separation between

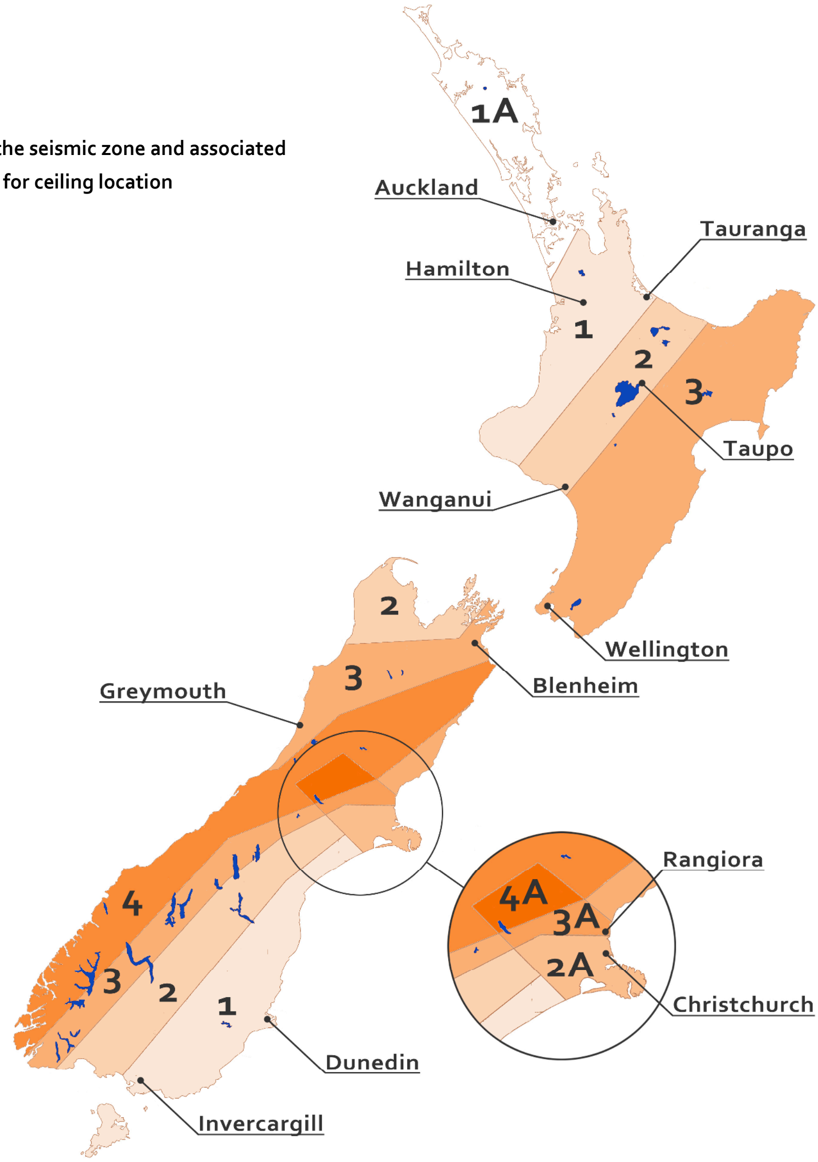


Option 3 – Back bracing to structure above with sliding perimeter connection



Seismic Loading

SEISMIC ZONE – Select the seismic zone and associated z-value for ceiling location



Zone	Z value ≤
1A	0.13
1	0.20
2	0.30
2A*	0.396
3	0.50
4	0.60
3A*	0.66
4A*	0.792

* Z-value has been modified to account for greater return period factor ($R_s \geq 0.33$) in the Canterbury earthquake region. This includes the Selwyn and Waimakariri Districts and Christchurch City

CEILING WEIGHT – Calculate total ceiling weight

Ceiling	Tile		kg/m²
	Grid		kg/m²
Services (minimum 3kg/m²)	Lighting		kg/m²
	Insulation		kg/m²
	Other		kg/m²
	Total Ceiling Weight =		**kg/m²**

CEILING HEIGHT FACTOR – Select appropriate ceiling height factor (circle one)

Ceiling Support Height (m)	0-3	3-6	6-9	9-24
Ceiling Height Factor	1.00	1.33	1.66	2.00

Seismic Design

SEISMIC FORCE – Insert the appropriate values from previous page to determine the seismic force on the ceiling

Z-Value		Ceiling Weight (kg/m²)		Height Factor		Seismic Force (kgf/m²)
	x		x		=	

DESIGN LOAD – Determine the spacing and corresponding maximum tee lengths of the main and cross tees. Tee length will be maximum wall to wall span for layout option 1, or wall to seismic gap span for layout option 2 in direction of tee being considered

Seismic Force (kgf/m²)		Tee Spacing (m)			Tee Length (m)			Total Horizontal Design Load (kgf)	
	x	Main Tee		x	Main Tee		=	Main Tee	
	x	Cross Tee		x	Cross Tee		=	Cross Tee	

CHECK GRID CAPACITY – Choose an appropriate grid type with capacity greater than the total design load. If no grid type sufficient, consider an alternative layout or back bracing option

Grid Type	Tee	Load Capacity (kgf)	≥ Design Load?
FasTLock™ 24	Main Tee	120	
	Cross Tee	90	

Tee Fixings to Perimeter

Fixed Connection (Perimeter Fixed Only)	Load Capacity (kgf)	≥ Design Load?
3.2mmØ Rivet (x1)	42	
3.2mmØ Rivet (x2)	95	
4.0mmØ Rivet (x1)	67	
4.0mmØ Rivet (x2)	134	
Perimeter Clip	105	

Note: 1. Aluminium Rivets shall be type 73AS Al. Alloy 5056
2. For perimeter fixing to steel framing, refer adjacent table for additional maximum load capacities

Perimeter Fixings to Steel Framing (if applicable)

Fixing	Steel Gauge	Load Capacity (kgf)	≥ Design Load?
10g-16 (x2)	0.55mm	74	
	0.75mm	100	
	1.15mm	156	

BACK BRACING REQUIRED?

Main Tee Direction	*Cross Tee Direction*	*None*

MAXIMUM ALLOWABLE LENGTHS – Calculate the maximum allowable spans for the main and cross tees

Load Capacity (Tees and Connections, kgf)*			Tee Spacing (m)		Seismic Force (kgf/m²)		Maximum Allowable Length (m)	
Main Tee		÷		÷		=	Main Tee	
Cross Tee		÷				=	Cross Tee	

* Minimum of: (Tee Capacity, Tee Fixings, Perimeter Fixings)

Perimeter Connection Details

FIXED CONNECTION

The fixed perimeter connection is an integral part of the suspended ceiling system during the event of an earthquake. It provides a rigid point of fixity to the building structure to enable horizontal seismic forces to be transferred into the structure.

A fixed connection can be made with either the 3.2Ømm rivets, 4.0Ømm rivets or the Perimeter Clip. The choice of which connection to use will depend on the magnitude of seismic forces and aesthetic requirements. Details of rivet connection and Perimeter Clip options are shown on the following page with the necessary requirements to ensure a solid fixed connection.

SLIDING CONNECTION

The sliding perimeter connection is critical to eliminate additional forces caused by the differential movement between support structures in a building.

The sliding connection can be made with either a seismic channel or the Perimeter Clip, as shown on the following page. It is essential that the ceiling tee is able to move freely and a 10mm gap is located between the perimeter and tee end.

PERIMETER FIXINGS

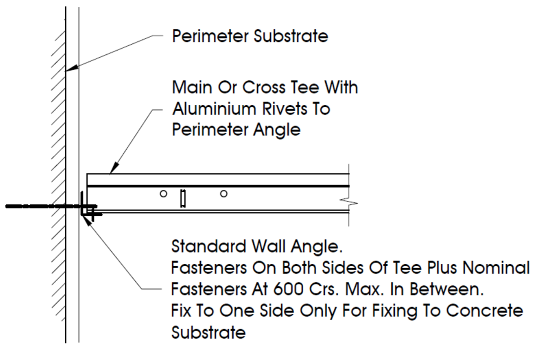
Perimeter Substrate	Nominal Fastener @ 600 crs. max.
Concrete	Hilti, DBZ 6/35 Anchor
Steel > 1.15mm	14g-12 Teks screw
Steel Framed Wall (0.55 – 1.15mm thickness)	10g-16 Teks screw
Timber Framed Wall	8 Gauge x 51mm r/head screw
Timber Batten to Concrete	Ramset M6 x 75mm Split Drive Anchor

*Nominal fasteners stated for perimeter connection may be substituted with an alternative fastener that has a rated working load of 150kgf or greater, that is suitable for seismic loading.

Perimeter Connection Details

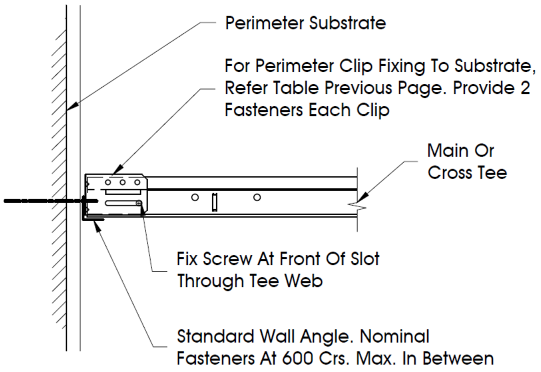
Fixed Connection

Rivet Connection Option



- Aluminium rivets to be installed on one or both sides of tee to wall angle.
- 10mm minimum edge distance for fixings.
- Wall angle must be fixed to perimeter substrate within 20mm of tee.
- Wall angle fixed to perimeter substrate with fasteners on both sides of tee plus nominal fasteners at 600mm maximum in between. Fix to one side only for fixing to concrete substrate.
- Ensure continuous line of nogging at perimeter connection.

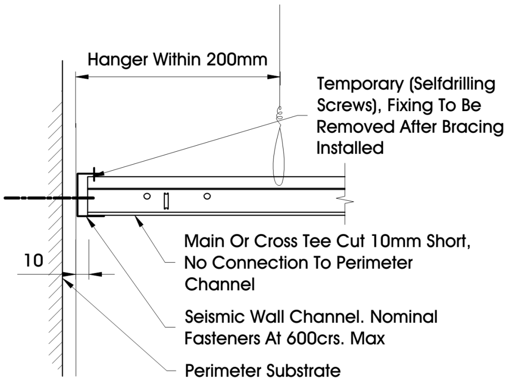
Perimeter Clip Option



- FasTLock™ TW2170 Perimeter Clip fixed to perimeter substrate with nominal perimeter fastener each side.
- Ensure tee end is firm against perimeter angle.
- Fix screw at front of slot through tee web.
- Wall angle fixed to perimeter substrate with nominal fasteners at 600mm crs. maximum.
- Ensure continuous line of nogging at perimeter connection.

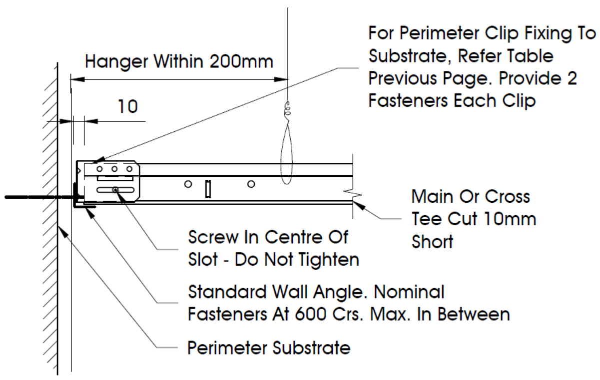
Sliding Connection

Seismic Wall Channel Option



- Cut tee 10mm short from perimeter end and place in seismic wall channel to allow movement.
- Ensure <u>no</u> connection between tee and seismic wall channel.
- Seismic wall channel fixed to perimeter substrate with nominal fasteners at 600mm crs. maximum
- 10mm minimum edge distance for fixings
- Hanger to be installed within 200mm of perimeter to support tee vertically

Perimeter Clip Option



- Cut tee 10mm short from perimeter end and fix to FasTLock™ TW2170 Perimeter Clip with single screw in centre of slot to allow movement.
- Ensure <u>no</u> connection between tee and perimeter angle.
- Perimeter Clip fixed to perimeter substrate with nominal perimeter fastener each side.
- Wall angle fixed to perimeter substrate with nominal fasteners at 600mm crs. maximum.

*For nominal fasteners to perimeter fixings refer pg 8.

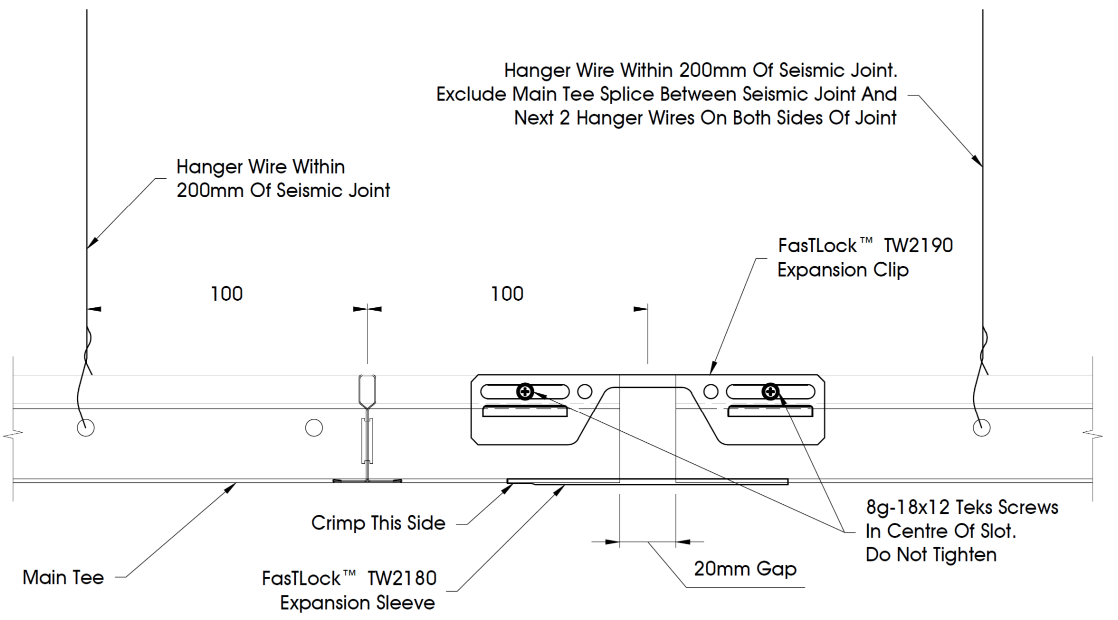
Seismic Gap

Seismic gaps are to be used with layout option 2 where ceiling is perimeter fixed opposites sides and separation is required between. Use FasTLock™ TW2190 Expansion Clips for the main tee and FasTLock™ TW2170 Perimeter Clips both sides for the cross tee, as shown.

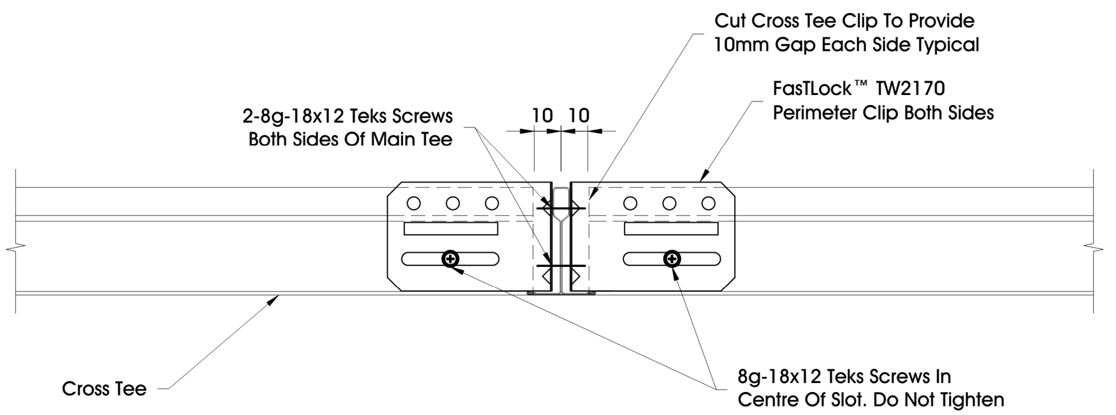
- Permits up to ±20mm movement.
- Can also be fixed on one side for ±10mm movement.

Alternatively a foam strip seismic gap can be adopted, as shown on next page.

Main Tee Seismic Joint



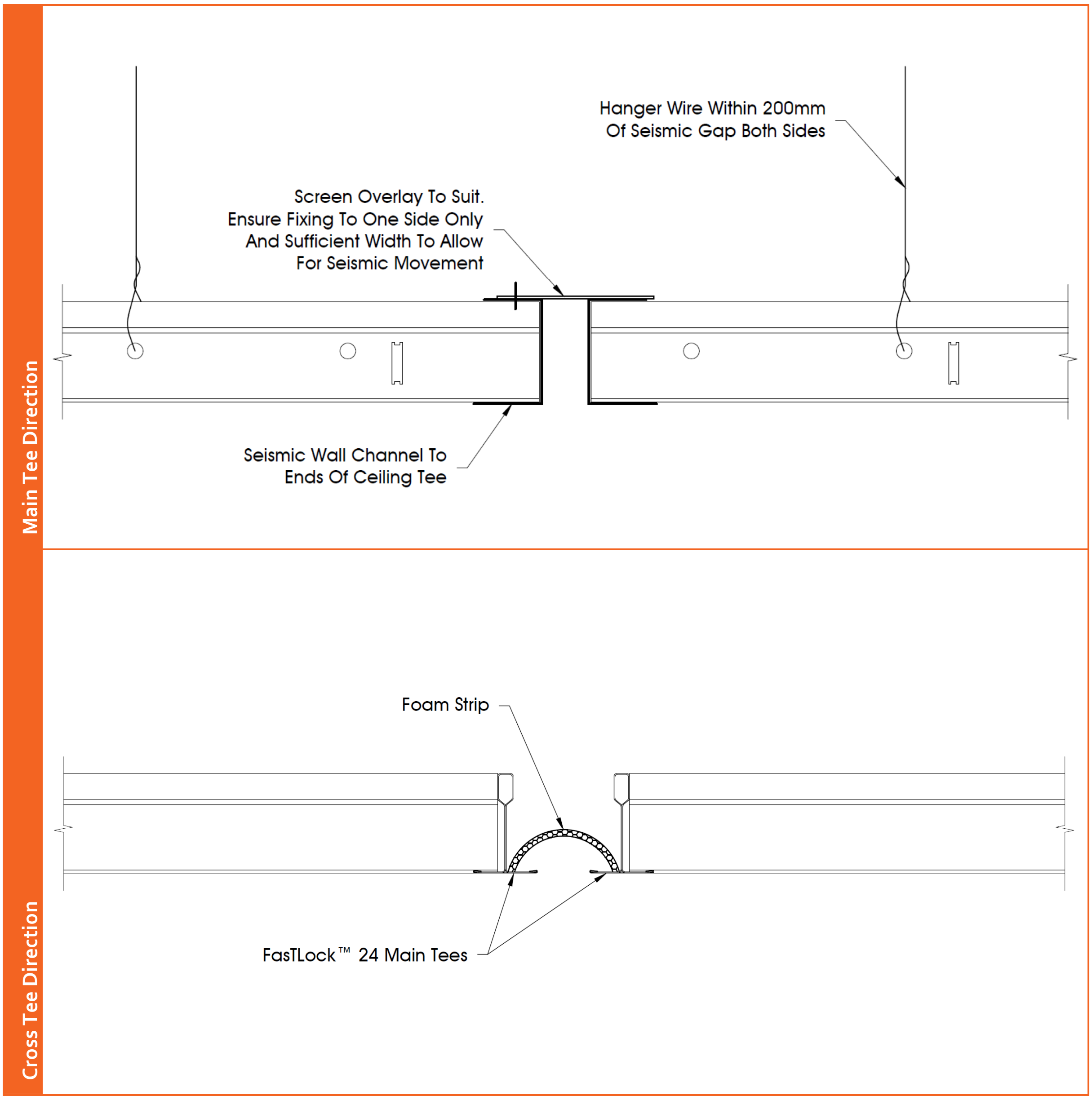
Cross Tee Seismic Joint



Seismic Gap – Alternative

Where greater seismic movements are required and aesthetics allow, the alternative seismic gap options can be used.

- Permits greater movements between tees.
- Alternative to using seismic expansion clips.



Back Bracing Layout Design

This section aids with the selection and design of a back bracing layout. Generally, the back bracing layout option will be used where the tee spans exceed ceiling grid capacity. Five options are available to choose from to suit a variety of plenum depths and loading demands: DF, K1, K2, K3 and WS Brace.

While the suspended grid may act as a partial diaphragm to transfer loadings from adjacent tees, this force however still needs to be transferred into the one tee that is connected to the back brace. Therefore the strength of this tee will govern the design of the back brace. This reflects a realistic situation where the weakest link will break first.

NOTE: Ceiling grid should **not** be both back braced and perimeter fixed in same direction. A ceiling grid however may be back braced in one direction yet perimeter fixed in the other. This situation can arise with large narrow rooms where the cross tee may exceed the maximum span, yet the main tee be ok, or vice versa. If there are any doubts, a structural engineer must be consulted.

BACK BRACE TYPE *(circle one)*

Choose a brace type depending on the plenum depth of the ceiling: Plenum Depth (m) [ ]

- Direct Fix (DF) – 1.15mm Folded Plate - **For plenum depths ≤ 0.18m**
- K-Brace (K1) – Perimeter Trim Diagonal Brace - **For plenum depths ≤ 0.50m**
- K-Brace (K2) – 40x40x1.15 Angle Diagonal Brace - **For plenum depths 0.50 – 1.2m**
- K-Brace (K3) – 64x35x0.55 Steel Stud Diagonal Brace - **For plenum depths 1.2 – 1.8m**
- Wire/Strut Brace (WS) – Steel Stud with Tension Wires - **For plenum depths 1.8 – 2.4m**

MAXIMUM LENGTH SUPPORTED BY BRACE – *MAIN TEE DIRECTION*

Brace	Allowable Plenum Depth	Capacity (kgf)
DF	≤0.18m	170
K1	≤0.50m	34
K2	0.50m - 1.2m	130
K3	1.2m - 1.8m	180
WS	1.8m – 2.4m	160

÷ Brace Spacing Across Tees (≤ 2.4m) [ ] ÷ Seismic Force (kgf/m²) [ ] = Max Length Supported Along Tee (m) [ ]

MAXIMUM LENGTH SUPPORTED BY BRACE – *CROSS TEE DIRECTION*

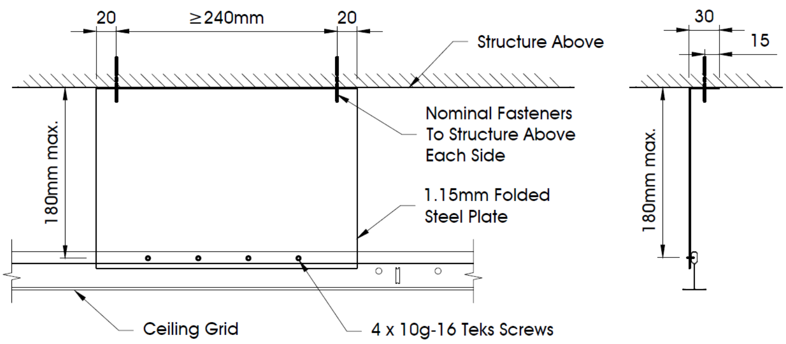
Brace	Allowable Plenum Depth	Capacity (kgf)
DF	≤0.18m	170
K1	≤0.50m	34
K2	0.50m - 1.2m	130
K3	1.2m - 1.8m	180
WS	1.8m – 2.4m	160

÷ Brace Spacing Across Tees (≤ 2.4m) [ ] ÷ Seismic Force (kgf/m²) [ ] = Max Length Supported Along Tee (m) [ ]

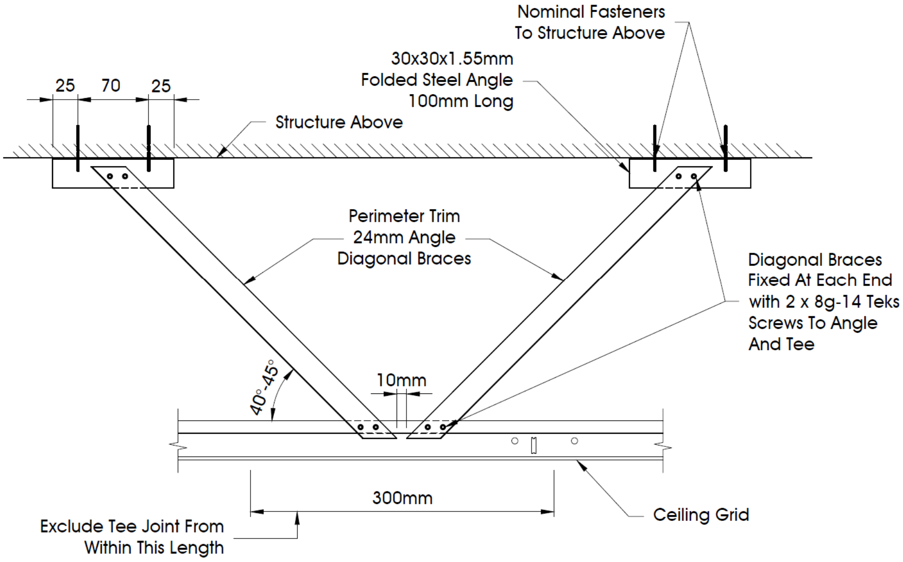
Back braces must be positioned as evenly as possible across the ceiling, at a spacing not exceeding 2.4m, with braces placed at a minimum of half the supported length distance from the perimeter end.

Back Brace Details

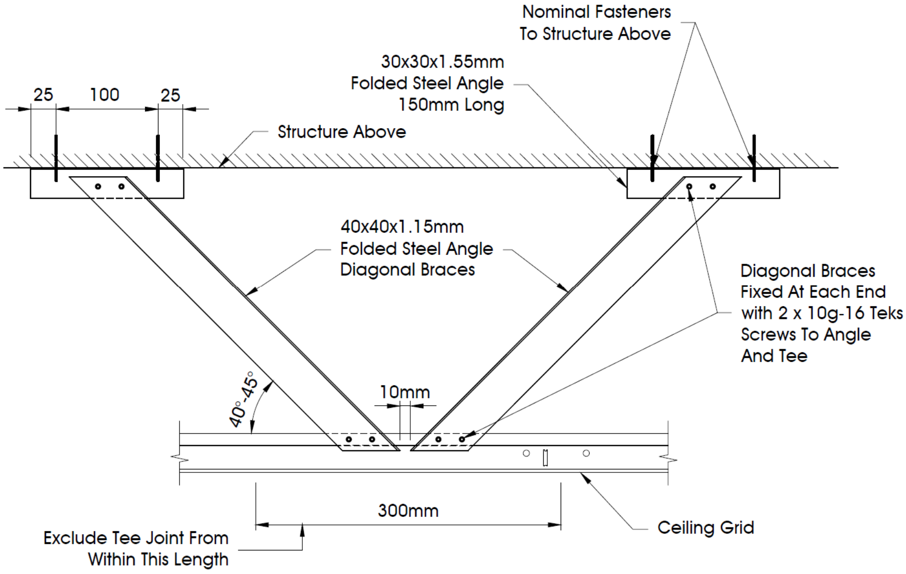
Direct Fix (DF)



K-Brace with Perimeter Trim (K1)

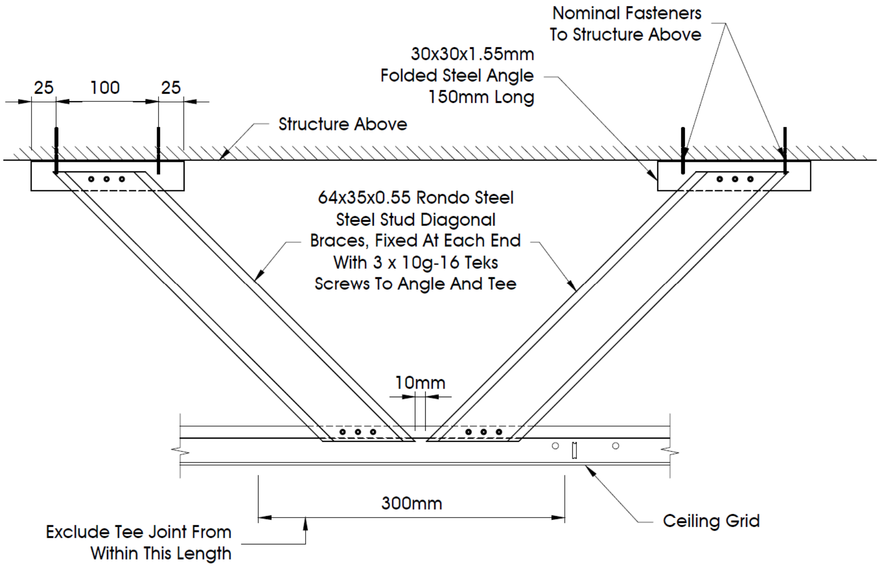


K-Brace with 40x40x1.15 Angle (K2)

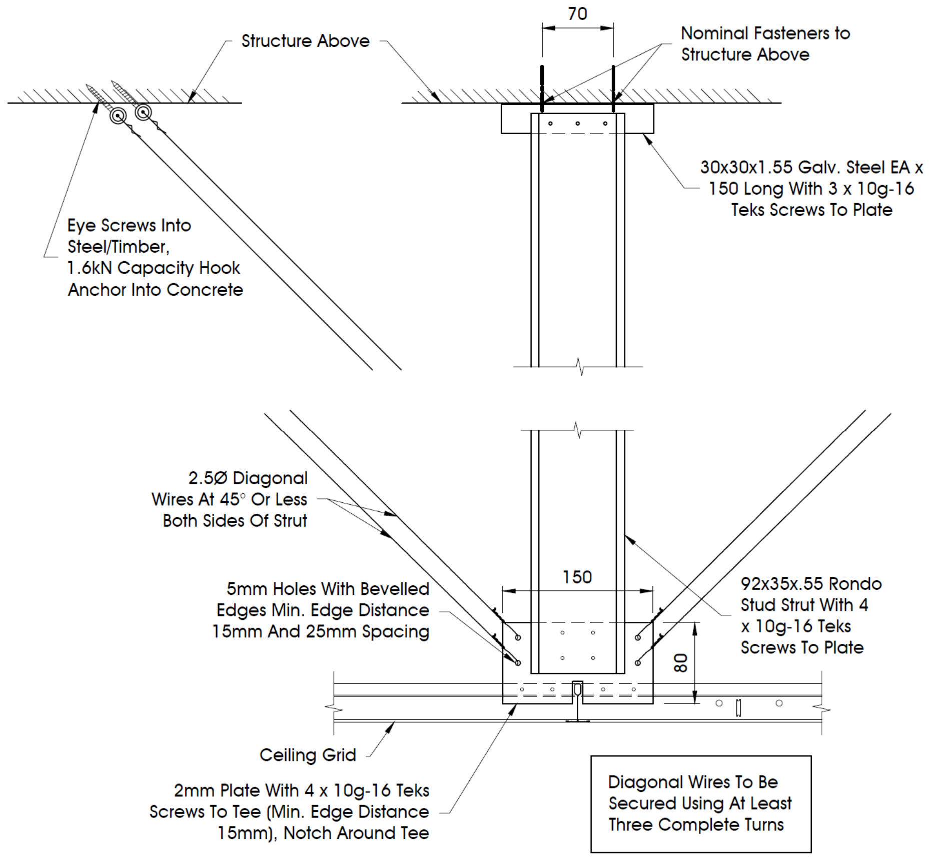


Back Brace Details (cont.)

K-Brace with 64x35x0.55 Stud (K3)



Wire/Strut Brace (WS)



	Nominal Fastener
Concrete	Ramset M6 Split Drive Anchor 50mm
Steel > 1.15mm	14g -12 Teks screw
Timber	10 Gauge x 51mm r/head screw

SUMMARY PAGE

PROJECT NAME:		**PROJECT No. :**	
DESIGNER:		**CEILING LEVEL:**	

Fill in and circle ceiling design information from previous pages

CEILING GRID

	Grid Type		Tee Spacing			
Main Tee:	*FasTLock™ 24*	@		m	*Running in Direction*	
Cross Tee:	*FasTLock™ 24*	@		m	*Running in Direction*	

Fixed Perimeter Connection:	*3.2mmØ Rivet (x1)*	*3.2mmØ Rivet (x2)*	*FasTLock™ TW2170 Perimeter Clip*
	4.0mmØ Rivet (x1)	*4.0mmØ Rivet (x2)*	*None*

Free Perimeter Connection:	*FasTLock™ TW2170 Perimeter Clip*	*Seismic Channel*

Seismic Gap:	*FasTLock™ Seismic Joint*	*Main Tee*	*Cross Tee*	*None*
	Foam Option	*Main Tee*	*Cross Tee*	*None*

BACK BRACING - **(If Applicable)**

Plenum Depth: ____ m

	Brace Type for Tee						Spacing Across Tee		Spacing Along Tee	
Main Tee:	*None*	*DF*	*K1*	*K2*	*K3*	*WS*		m		m
Cross Tee:	*None*	*DF*	*K1*	*K2*	*K3*	*WS*		m		m

CEILING LAYOUT PLAN ATTACHED?

YES	*NO*

List of Towns – Z-value

Town/City	Z-value
Akaroa	0.396*
Alexandra	0.21
Arrowtown	0.30
Arthurs Pass	0.60
Ashburton	0.20
Auckland	0.13
Balclutha	0.13
Blenheim	0.33
Bluff	0.15
Bulls	0.31
Cambridge	0.18
Cheviot	0.40
Christchurch	0.396*
Cromwell	0.24
Dannevirke	0.42
Darfield	0.396*
Dargaville	0.13
Dunedin	0.13
Eastbourne-Point Howard	0.40
Fairlie	0.24
Feilding	0.37
Fox Glacier	0.44
Foxton/Foxton Beach	0.36
Franz Josef	0.44
Geraldine	0.19
Gisborne	0.36
Gore	0.18
Greymouth	0.37
Hamilton	0.16
Hanmer Springs	0.55
Harihari	0.46
Hastings	0.39
Hawera	0.18
Hokitika	0.45
Huntly	0.15
Hutt Valley	0.40
Inglewood	0.18
Invercargill	0.17
Kaikohe	0.13
Kaikoura	0.42
Kaitaia	0.13
Kawerau	0.29
Levin	0.40

Town/City	Z-value
Mangakino	0.21
Manukau City	0.13
Marton	0.30
Masterton	0.42
Matamata	0.19
Mataura	0.17
Milford Sound	0.54
Morrinsville	0.18
Mosgiel	0.13
Motueka	0.26
Mount Maunganui	0.20
Mt Cook	0.38
Murchison	0.34
Murupara	0.30
Napier	0.38
Nelson	0.27
New Plymouth	0.18
Ngaruawahia	0.15
Oamaru	0.13
Oban	0.14
Ohakune	0.27
Opotiki	0.30
Opunake	0.18
Otaki	0.40
Otira	0.60
Otorohanga	0.17
Paeroa	0.18
Pahiatua	0.42
Paihia/Russell	0.13
Palmerston	0.13
Palmerston North	0.38
Paraparaumu	0.40
Patea	0.19
Picton	0.30
Porirua	0.40
Pukekohe	0.13
Putaruru	0.21
Queenstown	0.32
Raetihi	0.26
Rangiora	0.4356*
Reefton	0.37
Riverton	0.20
Rotorua	0.24

Town/City	Z-value
Ruatoria	0.33
Seddon	0.40
Springs Junction	0.45
St Arnaud	0.36
Stratford	0.18
Taihape	0.33
Takaka	0.23
Taumarunui	0.21
Taupo	0.28
Tauranga	0.20
Te Anau	0.36
Te Aroha	0.18
Te Awamutu	0.17
Te Kuiti	0.18
Te Puke	0.22
Temuka	0.17
Thames	0.16
Timaru	0.15
Tokoroa	0.21
Turangi	0.27
Twizel	0.27
Upper Hutt	0.42
Waihi	0.18
Waikanae	0.40
Waimate	0.14
Wainuiomata	0.40
Waiouru	0.29
Waipawa	0.41
Waipukurau	0.41
Wairoa	0.37
Waitara	0.18
Waiuku	0.13
Wanaka	0.30
Wanganui	0.25
Ward	0.40
Warkworth	0.13
Wellington	0.40
Wellington CBD	0.40
Westport	0.30
Whakatane	0.30
Whangarei	0.13
Winton	0.20
Woodville	0.41

* Z-value has been modified to account for greater return period factor ($R_s \geq 0.33$) in the Canterbury earthquake region. This includes the Selwyn and Waimakariri Districts and Christchurch City

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