CEILING | SYSTEMS

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Armstrong Seismic Design Guide

New Zealand Version

March 2013

Suspended Ceiling Systems

Armstrong®

Suspended Ceiling - Seismic Design

All structures and parts of structures including suspended ceilings shall be designed to resist earthquake actions as set out in NZS 1170.5. In previous earthquakes throughout history, suspended ceilings have shown a tendency to perform poorly. This may be due to the fact that they are often overlooked and the code requirements for seismic design are low. It is important that suspended ceilings are designed suitably to ensure they perform in a seismic event. The failure of suspended ceilings can cause evacuation paths to be blocked which could be a hazard to life safety. Failure can also cause unnecessary delays in resuming business especially if the rest of the structure has sustained no damage.

The purpose of this guide is to provide a method for the seismic design of suspended grid and tile ceiling systems. It has been designed to meet the requirements of NZS 1170.5 – Structural Design Actions – Earthquake actions. From this guide, a grid type, bracing requirements and fixing types can be designed. Please note that this guide is not suitable for all suspended ceilings and those which fall outside its' scope must be designed by a suitably qualified structural engineer.

Table of Contents

Design Statement

Knowles Consulting Limited (KCL) has been engaged by Forman Building Systems to provide a suspended ceiling seismic design guide which is accurate and easy to follow. The guide has been prepared to meet the requirements of the NZ building code

Testing of the grids was undertaken to determine the compression and tension capacities. Testing of the perimeter fixings was also undertaken. The values from this testing have been used in this guide.

KCL Engineering Services

Limitations and Assumptions

LIMITATIONS

- This guide may only be used to design suspended ceilings with Armstrong Prelude XL and Suprafine XL ceiling grids.
- This guide may only be used for buildings in New Zealand.
- The ceiling system must meet both gravity and seismic load requirements.
- All other Forman & Armstrong brochures, manuals and codes must be adhered to.
- All individual objects weighing over 10kg shall be braced separately unless specifically designed by a structural engineer. Similarly ceiling tile must weigh less than 10kg each unless a structural engineer is consulted.
- The perimeter shall be nogged continuously at ceiling level if ceiling is fixed at perimeter. This is to ensure that the loads can be transferred from the ceiling into the perimeter support. If the perimeter is not continuously nogged, the perimeter fixing option may NOT be used.
- A structural engineer for the building must check all lateral loads can be resisted by the support structure. The support structure must be both strong enough and stiff enough.
- Ceiling grid tees must be spaced at a maximum of 1.2m centres.
- Partition walls must not be braced by the ceiling grid unless designed by a qualified structural engineer.
- The ceiling must not be a structural component of the building. It may not be used to transfer loads between structural elements of the building.
- For a Level 4 importance building (e.g. hospital or police station) a qualified structural engineer must be consulted.
- For ceilings with a plenum of less than 300mm back bracing cannot be used without consulting a qualified structural engineer.

ASSUMPTIONS

- The period of the ceiling is assumed to be $T \leq 0.75s$
- Assume ceiling grid ductility $\mu = 1.0$

Design Considerations

- Ceilings should not be attached to two opposite walls unless there is a seismic gap between them. This is because of the forces that can be induced in the ceiling grid if differential displacements occur between the perimeter structures.
- Ceilings should not be braced to both a wall and the roof/structure above due to differential movement.
- If the building is importance level 4 (hospital, police station etc.) a qualified structural engineer must be consulted in the design of the ceiling.

How to Use This Document

1. Determine the seismic zone Z value using the map or using the town/city list found at the back of the document.
2. Determine the ceiling height factor H, from the tables.
3. Input values to determine the total ceiling weight. All elements which are supported by the ceiling need to be included.
4. Determine ceiling slope factor from tables.
5. Calculate seismic force, Fp using the tables.
6. Calculate total force, Ft using bracing layout option 1.
7. Check with the building engineer to see if the perimeter structure can be used to brace the ceiling.
8. Choose a grid and connection type. If the grid or connection type does not work try bracing layout option 2. If neither perimeter fixing option works proceed to step 8 and use back bracing layout (option 3). **Follow steps 8-9 only for back bracing option.**
9. Choose a back bracing type.
10. Choose the back bracing spacing so that the maximum area allowed and maximum brace spacing is not exceeded.
11. Fill in the Summary Sheet.

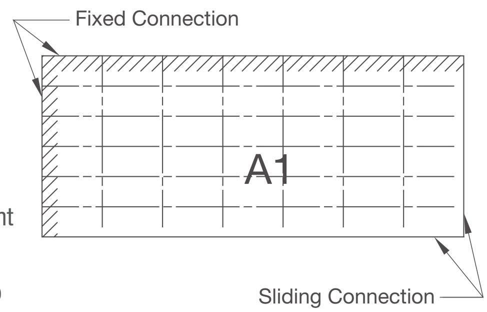
Bracing Layout Options

There are three different options for bracing the ceiling against lateral loading. Options 1 and 2 involve bracing the ceiling to the perimeter and option 3 involves bracing back to the structure above. Option 1 is for smaller ceilings with lower lateral loads, option 2 is for larger ceilings and option 3 is for ceilings where options 1 and 2 do not work.

PERIMETER FIXING

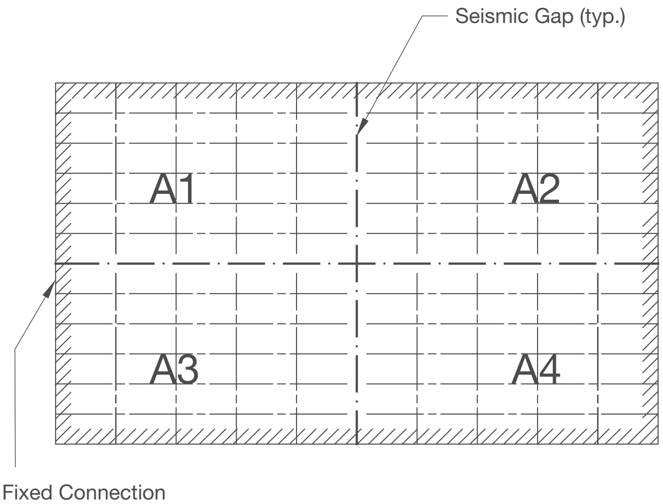
Option 1
(Perimeter fixing on adjacent edges)

Ceiling is fixed to the perimeter on two adjacent sides and a seismic sliding joint is used on the opposite sides. Lateral loads are transferred from the ceiling to the perimeter through a perimeter fixing.



Option 2
(Perimeter fixing on more than two edges)

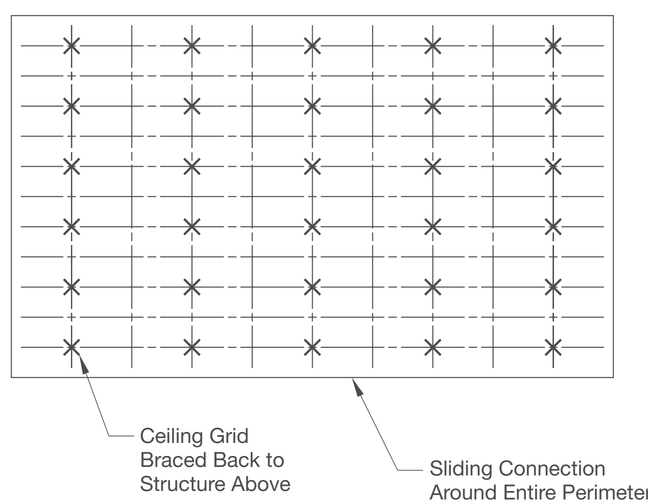
The ceiling is split up into smaller sections using seismic joints. The ceiling can then be fixed to the perimeter on opposite sides. Lateral loads are transferred from the ceiling to the perimeter through perimeter fixings.



BACK BRACING

Option 3
(Back bracing)

The ceiling is braced back to the structure above with compression struts and tension wire braces or diagonal tension/compression struts. A seismic sliding joint around the entire perimeter is required as the ceiling may not be braced to both the structure above and the perimeter.



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^2. See example for calculation of lighting weight.

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

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

*Minimum services load is 3kg/m^2

JOB NAME: JOB NUMBER:

CEILING SLOPE

In the case of a sloping ceiling the seismic forces carried by the grid are increased due to the angle of the ceiling. Choose a ceiling slope factor from the table.

Ceiling Slope	Slope Factor
0°	1.000
10° or less	1.015
20° or less	1.064
30° or less	1.155
40° or less	1.305

SEISMIC FORCE

Insert the relevant choices and multiply them together to find the seismic force. If there is any doubt a structural engineer should be consulted.

Seismic Zone Z value		Height Factor*, H		Ceiling Slope Factor		Ceiling Weight, Wt		Seismic Force, Fp
	X		X		X		=	
	X		X		X		=	

*Height of ceiling bracing from ground level. If the ceiling is braced to the perimeter use the ceiling height, if the ceiling is braced to the roof/structure above use the roof height.

Bracing Option Layouts 1 & 2 (Perimeter Fixing)

GRID AND CONNECTION TYPE

Enter the values below and multiply them together to calculate the maximum force in the main and cross tees. This calculation is only required for option 1 or 2 bracing.

Seismic Force, Fp =		Tee Spacing (m)			Tee Length* (m)			Total Force Ft =	
	X	Main Tee		X	Main Tee		=	Main Tee	
	X	Cross Tee		X	Cross Tee		=	Cross Tee	

*Tee Length - Option 1 (Fixed on one side) = Length from wall to wall.
- Option 2 (Fixed on two sides with seismic gap in middle) = Maximum length from wall to seismic gap.

GRID AND CONNECTION TYPE

Choose a grid type from the options below so that the force on the grid is less than the grid capacity, i.e. Ft ≤ Fg. If none of the grid types work a different bracing option will need to be used.

Grid Type	Tee	Allowable Force, Fg =	OK?
Suprafine XL 15mm	Main Tee	100	
	Cross Tee	60	
Prelude XL 24mm	Main Tee	100	
	Cross Tee	60	

Fixed Connection Type	Allowable Force, Fc =	OK*?
3.2Φ Alum Rivet	70	
4.0Φ Alum Rivet	100	
BERC2 Clip	60	

* Is the Maximum Total Force, Ft ≤ Fc, Allowable Force?

FREE CONNECTION TYPE (CIRCLE ONE)

BERC2 Clip	Seismic Channel	None

CALCULATE THE MAXIMUM ALLOWABLE LENGTH OF MAIN AND CROSS TEES

Allowable Force (Tees and Connections)*			Tee Spacing (m)		Seismic Force, Fp =		Maximum Allowable Length (m)	
Main Tee		÷		÷		=	Main Tee	
Cross Tee							Cross Tee	

*Minimum allowable force from chosen grid connection and tee type above.

JOB NAME: JOB NUMBER:

Perimeter Connection Details

FIXED CONNECTION

It is very important that the grid is fixed to the perimeter properly so that the loads can be transferred from the ceiling into the building structure. The following criteria must be followed when attaching to the perimeter:

- The wall angle must be fixed to the building structure within 20mm of the grid fixing.
- The wall angle must be fixed at 600mm centres minimum. See table below for fixing type.
- When using BERC2 clips for fixing option ensure it is screwed to BOTH the wall angle and tee.
- Required edge distances must be followed when fixing rivets.
- Ensure building perimeter structure has been reviewed by the building engineer to check that it can resist lateral loads.

SLIDING CONNECTION

It is important that the sliding connection is built properly so that additional loads are not experienced by the grid.

- The BERC2 Clip must be screwed to the wall angle. The screw connecting the grid and clip must not be tightened and placed centrally in the sliding slot.
- The end of the grid must be located 19mm away from the wall angle.
- When using a seismic channel a hanger must be placed within 200mm of the perimeter.

WALL ANGLE PERIMETER FIXING TYPE

Perimeter Material	Fixing Type*
Timber	No. 8 x 51mm screw
Steel	14G Tek screw
Concrete	Ramset 6x30mm Dynabolt or equivalent

*The fixing types in the table above may be exchanged for an alternative fixing with a safe working strength of greater than 1.5kN that is suitable for seismic loading. (e.g. Concrete Screw Anchors are not suitable for seismic loadings)

Bracing Layout Option 3 (Back Bracing)

This section is to be used only for bracing option 3 where the grid is braced back to the structure above. This option is required when the forces in the grid are too high to allow perimeter fixing. Choose a brace type from the options below and calculate the maximum ceiling area allowed per brace. Any Armstrong grid may be used as the back-bracing strengths govern the design.

BRACING TYPE

Brace A – Rondo 64x0.50 BMT Stud Strut with 4/2.5 dia wire diagonals.

Brace B – Rondo 64x0.50 BMT Strut with 2/64x0.50 BMT Stud diagonals.

Brace C – Rondo 92x0.75 BMT Strut with 2/92x0.75 BMT Stud diagonals.

MAXIMUM AREA PER BRACE

Calculate the maximum ceiling area allowed per brace for a chosen brace and plenum height. If the max area per brace is too small a stronger bracing type may need to be chosen.

Plenum Depth (m)	Brace A	Brace B	Brace C
0-0.6	90	250	300
0.6-1.0	90	250	300
1.0-1.4	90	250	300
1.4-1.8	90	160	300
1.8-2.4	90	90	170

÷

Seismic Force, Fp =

=

Max Area Per Brace (m²)

AREA PER BRACE

Choose the spacing of braces and multiply the numbers together to get the area of ceiling per brace. At least every second main tee should be braced to avoid the ceiling having to perform as a diaphragm. The area per brace must be less than the maximum area calculated above. The spacing of the braces in both directions is governed by the spacing of tees and also the spacing of structural elements in the roof above (i.e. purlin spacing). If the spacing of braces seems too close use a stronger brace.

	Brace Spacing Along Main Tee	X	Brace Spacing Along Cross Tee*	=	Area Per Brace (m²)	OK?
Area =		X		=		

*Braces should be spaced a maximum of every second main tee (typically 2.4m) and a maximum of 12m along the main tees.

BRACE FIXING TYPES

The table below gives the minimum connection for the different bracing types.

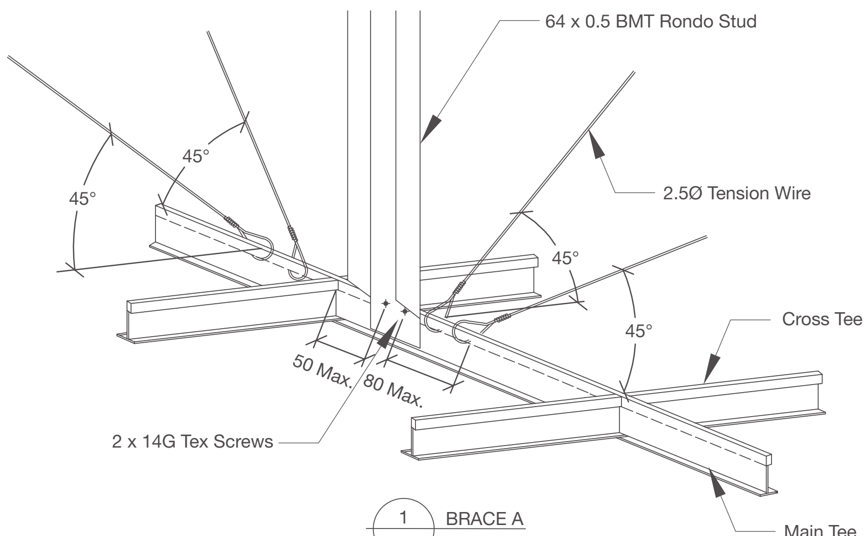
	Brace A	Brace B	Brace C
Steel	2x 14G Tek Screw	4x 14G Tek Screw	4x 14G Tek Screw
Concrete	2x M6x30 Dynabolt	2x M6x30 Dynabolt	2x M6x30 Dynabolt
Timber	2x No 8x51 screw	4x No 8x51 screw	4x No 8x51 screw
Grid Tee	2x14G Tek screw	3x14G Tek screw	3x14G Tek screw

JOB NAME: JOB NUMBER:

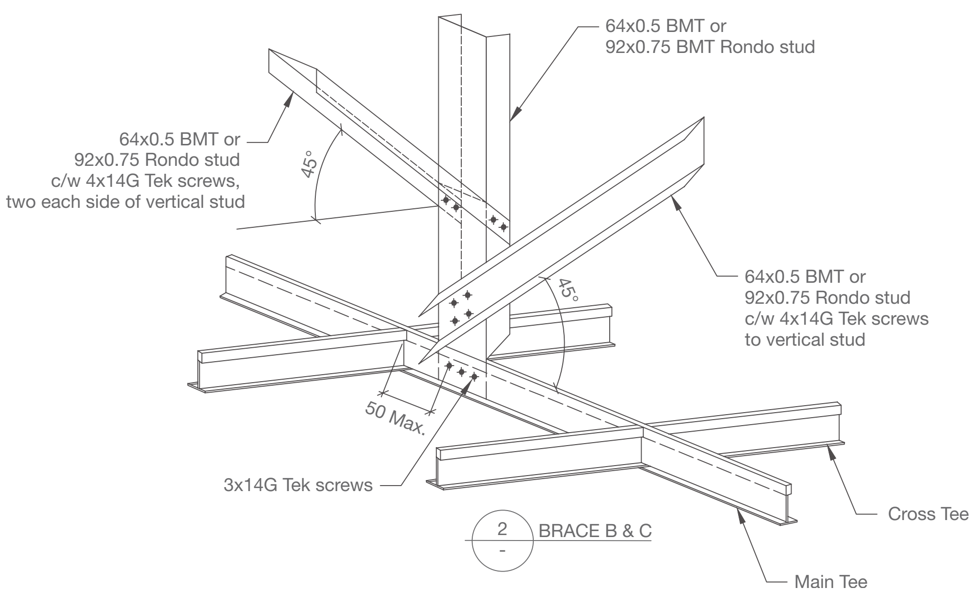
Installation of Bracing

It is important that once the brace type is chosen it is properly installed. The following criteria must be met when installing the bracing to the roof:

- The compression strut must be connected to the Main Tee only and be within 50mm of a Cross Tee connection. See table on page 11 for fixing types.
- The diagonal wires are to be angled at no more than 45° from the plane of the ceiling.
- Braces must be placed a minimum of half the spacing distance from the perimeter.
- At least every second main tee should be back braced. The first Main Tee from the edge of the ceiling should always be braced. Back braces should be installed in a staggered formation for stability (refer example ceiling layout). It is preferable if every main tee is back braced.
- A ceiling may not be both back braced and fixed to the perimeter.
- Tension wires are to be fixed to web holes not bulb slots and tied with a minimum of 3 turns.
- Plenum depths greater than 1.4m may need a perimeter gap of greater than 19mm provided by the BERC2 clip. Speak to the buildings structural engineer to determine the gap required.
- Required edge distances must be followed when fixing rivets, screws etc.



1 - BRACE A



2 - BRACE B & C

Summary Sheet

JOB NAME: JOB NUMBER:

SITE LOCATION:

CEILING LEVEL:

Fill out the Summary sheet below from the types chosen in the preceding sheets.

GRID TYPE

Main Tee	Suprafine XL 15mm	Prelude XL 24mm	@		m centres. Max Length =		m
Cross Tee	Suprafine XL 15mm	Prelude XL 24mm	@		m centres. Max Length =		m

PERIMETER FIXING

Fixed Connection	3.2Φ Rivet	4.0Φ Rivet	BERC2 Clip
Free Connection	BERC2 Clip	Sliding Joint (Hanger ≤ 200mm)	

SEISMIC GAP (CIRCLE ONE)

Seismic Joint Clip SJMR15 24mm grid	Seismic Joint Clip SJMR9 15mm grid	None

BACK BRACING TYPE (BRACING LAYOUT OPTION 3 ONLY)

Plenum Depth: ______________________________

Brace Spacing: Between Main Tees ____________________ m

Between Cross Tees ____________________ m

Brace Type (circle one)	Bracing Description	Fixing to Structure Above (see fixing type table)	Fixing to Tee (see fixing type table)
Brace A	Rondo 64x0.50 BMT Stud Strut with 2.5 dia wire diagonals.		
Brace B	Rondo 64x0.50 BMT Strut with 2/64x0.50 BMT Stud diagonals.		
Brace C	Rondo 92x0.75 BMT Strut with 2/92x0.75 BMT Stud diagonals.		

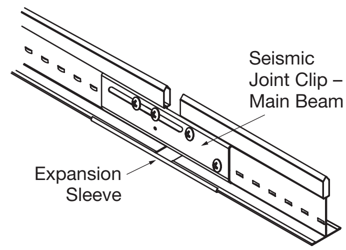
MARKUP PLAN ATTACHED? (CIRCLE ONE)

Yes No

Seismic GAP Options

- BERC2 Clip
- Seismic Joint Clip – Main Tee
- Seismic Joint Clip – Cross Tee

Seismic Joint Clip – Main Beam



PRODUCT DESCRIPTION

MATERIALS

A. General: Commercial-quality cold rolled hot dipped galvanized steel, chemically cleansed

B. Components:

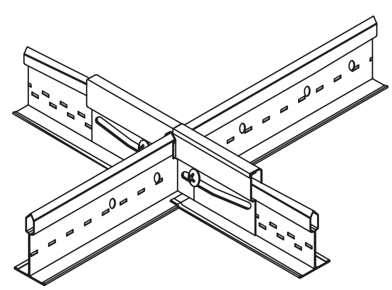
a. Seismic Joint Clip, stamped, unfinished, single-piece unit with slots and screw holes

b. Expansion Sleeves, stamped, exposed face prefinished in baked polyester paint

Note: Not suitable for use with Vector® panels.

Bucket #	Description	Dimension	Color/Finish
SJMR15	Seismic Joint Clip – Main Beam for 24mm grid	100mm x 25mm nominal	Unpainted
ES4	100mm Expansion Sleeve for Prelude 24mm Main Beam	100mm x 24mm nominal	White
SJMR9	Seismic Joint Clip – Main Beam for 19mm grid	100mm x 25mm nominal	Unpainted
ES49	100mm Expansion Sleeve for Suprafine® 19mm Main Beam	100mm x 19mm nominal	White

Seismic Joint Clip – Cross Tee



PRODUCT DESCRIPTION

MATERIALS

A. General: Commercial-quality cold rolled hot dipped galvanized steel, chemically cleansed

B. Components:

Seismic Joint Clip, stamped, unfinished, two-piece unit with slots

Item #	Description	Dimension	Color/Finish
SJCG	Seismic Joint Clip 2 pcs required/joint	125mm x 38mm nominal	Unpainted

Simple to Install with these Easy Steps

HOW TO INSTALL THE SEISMIC JOINT CLIP – MAIN BEAM

Step 1: Determine which splices will receive the separation joint by dividing the total area into sections not greater than 250m^2. Attach a hanger wire within 75mm of the splice that will receive the clip.

Step 2: Install complete grid system. Follow typical procedures except that all main beam splices must line up across the space.

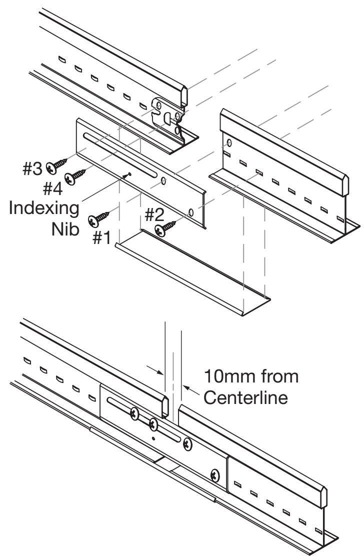
Step 3: Prepare the main beam splice to receive the separation joint clip by cutting the locking tab from the left side of the connection and removing 19mm from the end of the beam on the right.

Step 4: Install the clip using the screws provided. Screws #1 and #2 install through the holes in the clip and into the right-hand main beam.

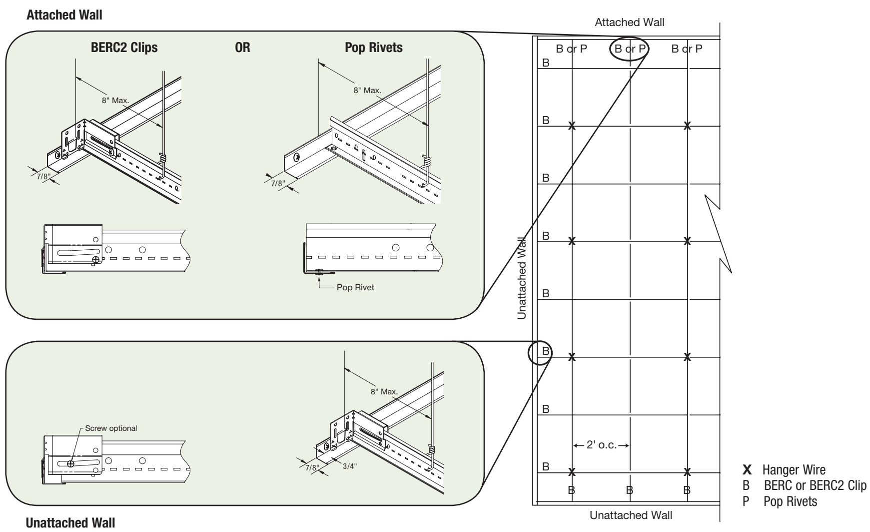
Step 5: Align the indexing nib with the lower hole on the left-hand main beam and insert screws #3 and #4 into the upper holes.

Step 6: Snap ES4 or ES49 expansion sleeve over the gap at the face of the main beam and crimp the four corners with a pair of pliers.

Step 7: Install SJCG cross tee separation joint clips at one end of every cross tee that spans the area of main beam separation.

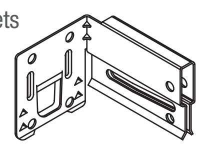


Seismic Rx® Approach



SEISMIC RX CODE COMPLIANT SOLUTIONS AND BENEFITS (ESR-1308)

- Narrow, sleek aesthetic with standard 22mm molding
- Eliminates installation and aesthetic problems associated with 50mm wall angle
- Lower cost solution
- Better access to the plenum
- Eliminates stabilizer bars
- Eliminates visible pop rivets through the wall angle
- More profiles from which to choose
- Perimeter Support wires within 400mm
- Attached grid on two adjacent walls with the BERC2 clip or pop rivets
- BERC2 clip with 19mm clearance on unattached walls
- Allows for minimum 19mm movement of cross tee or main beam towards and away from the wall (total movement of 38mm)



List of seismic factors for specific towns/cities.

City/Town	Z
Akaroa	0.3
Alexandra	0.21
Arrowtown	0.3
Arthurs Pass	0.6
Ashburton	0.2
Auckland	0.13
Balclutha	0.13
Blenheim	0.33
Bluff	0.15
Bulls	0.31
Cambridge	0.18
Cheviot	0.4
Christchurch	0.396*
Cromwell	0.24
Dannevirke	0.42
Darfield	0.396*
Dargaville	0.13
Dunedin	0.13
Eastbourne-Point Howard	0.4
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	0.4
Inglewood	0.18
Invercargill	0.17
Kaikohe	0.13
Kaikoura	0.42
Kaitaia	0.13
Kawerau	0.29
Levin	0.4

City/Town	Z
Mangakino	0.21
Manukau City	0.13
Marton	0.3
Masterton	0.42
Matamata	0.19
Mataura	0.17
Milford Sound	0.54
Morrinsville	0.18
Mosgiel	0.13
Motueka	0.26
Mount Maunganui	0.2
Mt Cook	0.38
Murchison	0.34
Murupara	0.3
Napier	0.38
Nelson	0.27
New Plymouth	0.18
Ngaruawahia	0.15
Oamaru	0.13
Oban	0.14
Ohakune	0.27
Opotiki	0.3
Opunake	0.18
Otaki	0.4
Otira	0.6
Otorohanga	0.17
Paeroa	0.18
Pahiatua	0.42
Paihia/Russell	0.13
Palmerston North	0.38
Palmerston	0.13
Paraparaumu	0.4
Patea	0.19
Picton	0.3
Porirua	0.4
Pukekohe	0.13
Putaruru	0.21
Queenstown	0.32
Raetihi	0.26
Rangiora	0.4356*
Reefton	0.37
Riverton	0.2
Rotorua	0.24

City/Town	Z
Ruatoria	0.33
Seddon	0.4
Springs Junction	0.45
St Arnaud	0.36
Stratford	0.18
Taihape	0.33
Takaka	0.23
Taumarunui	0.21
Taupo	0.28
Tauranga	0.2
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	0.4
Waimate	0.14
Wainuiomata	0.4
Waiouru	0.29
Waipawa	0.41
Waipukurau	0.41
Wairoa	0.37
Waitara	0.18
Waiuku	0.13
Wanaka	0.3
Wanganui	0.25
Ward	0.4
Warkworth	0.13
Wellington	0.4
Wellington CBD	0.4
Westport	0.3
Whakatane	0.3
Whangarei	0.13
Winton	0.2
Woodville	0.41

* Denotes Z value has been adjusted to account for higher return period required in these areas.

FOR MORE INFORMATION

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