the PROFESSIONAL series

SERIES NZ B1: CEILING DESIGN DATA

V1

RONDO®

CONTENTS

Version 1: First released March 27, 2024

INTRODUCTION

B1.1.1 OVERVIEW

Rondo is renowned for delivering high-quality ceiling systems that meet the diverse needs of projects throughout New Zealand. Our commitment to excellence is underpinned by an unwavering focus on innovation, sustainability, and reliability. Over the years, Rondo has pioneered advancements in ceiling technology, setting new standards that ensure greater durability, safety, and efficiency. With a reputation for technical expertise and customer support, we remain at the forefront of the industry, driving progress and equipping builders and designers with the tools needed to bring their visions to life. This manual provides comprehensive guidance on our latest ceiling systems, enabling users to leverage the full potential of Rondo's solutions for outstanding performance and longevity.

Rondo has a wide range of either direct fixed or suspended concealed and exposed grid systems. Rondo ceiling systems are highly innovative, of superior quality and are designed to meet acoustic, fire, wind and seismic requirements where appropriate. All Rondo ceiling systems are designed and manufactured to comply with all relevant New Zealand standards and codes, as nominated.

Table B1.1.1(A) provides a summary of the various Rondo Ceiling grid Systems and their applications.

TABLE B1.1.1(A): RONDO CEILING SYSTEMS

CEILING SYSTEM	KEY-LOCK®	XPRESS®	STEEL STUD	DONN®
CONCEALED OR EXPOSED GRID SYSTEM	Concealed	Concealed	Concealed	Exposed
DIRECTLY FIX OR SUSPENDED CEILING APPLICATIONS	Direct Fix & Suspended	Direct Fix & Suspended	Direct Fix	Direct Fix & Suspended
FIRE-RATED APPLICATIONS	Yes	Yes	Yes	-
ACOUSTIC APPLICATIONS	Yes	Yes	Yes when used with acoustic lining / panels etc	Yes when used with acoustic tiles
SEISMIC DESIGNS AVAILABLE	Yes	Yes	Yes	Yes
BULKHEAD DESIGNS AVAILABLE	Yes	Yes	Yes	Yes

The following flowchart shows a quick overview of using this manual to obtain a preliminary celling design for your project.

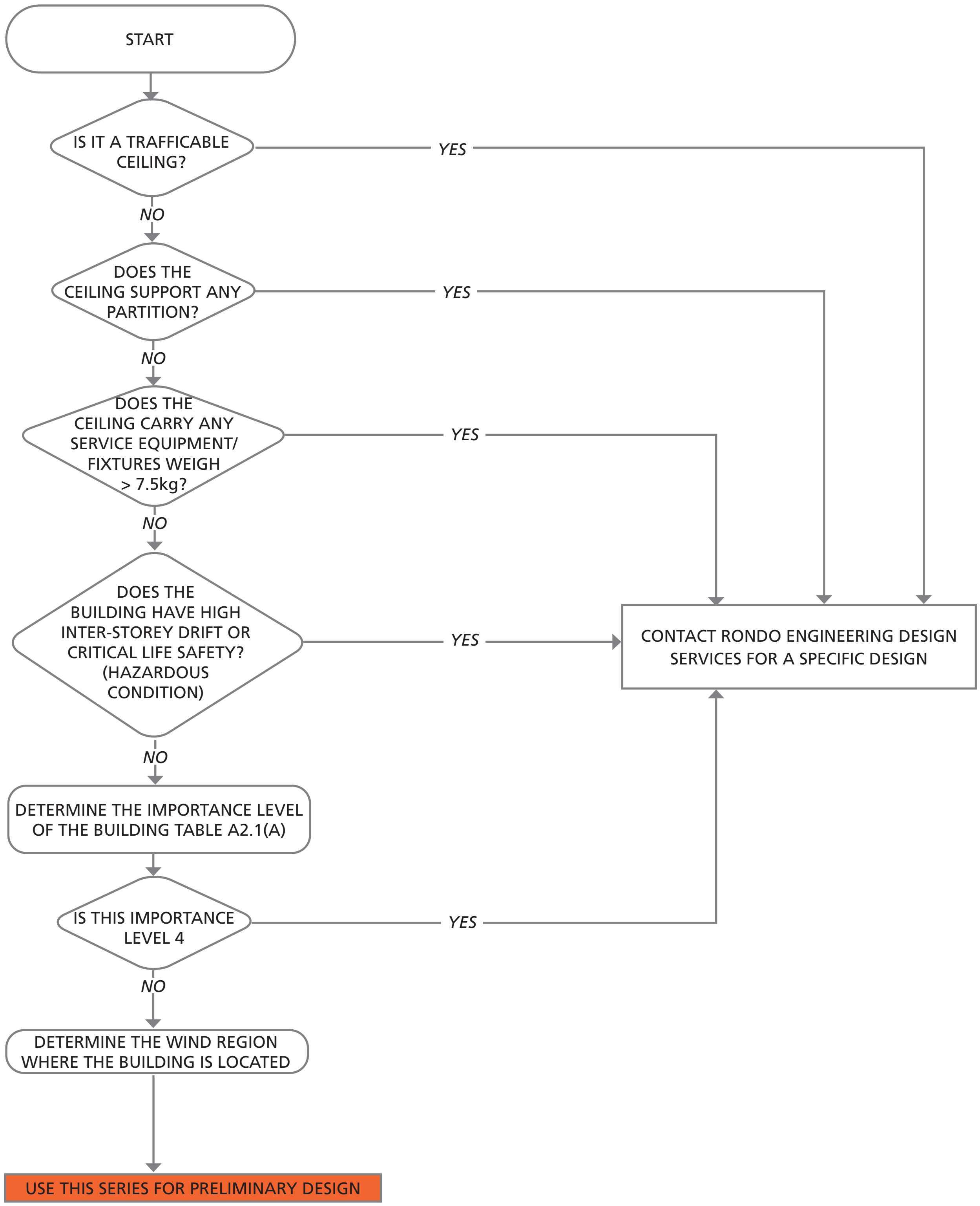

FIGURE B1.1.1(B): APPLICABILITY OF PROFESSIONAL SERIES FOR PRELIMINARY DESIGN

B1.2 GENERAL NOTES

- Refer to Series A : Design Data for Standards of reference for the ceiling systems herein
- The Rondo ceiling systems detailed in this section are only applicable for internal applications
- Ceiling systems discussed in this professional series are non-trafficable.
- Rondo ceiling systems, except where specifically noted otherwise, **are not** designed to support the weight of personnel, construction materials, plant, services, storage of goods or other like loading situations.
- In any instances of low-height wall framing to the underside of the ceiling structure, best practice is to laterally restrain the wall independent of the ceiling.
- For design scenario's outside the scope of this series refer to Rondo for a specific design.

B1.2.2 CEILING JOINTS

Control Joints

Control joints are installed in ceiling systems to accommodate differential movement due to changes in ambient temperature, normal building movement, changes in substrate or the like.

Generally, control joints should be installed in the ceiling in the following scenarios:

- In large continuous ceiling areas control joints should be installed at not more than 12m centers in both directions.*
- Intersection of large and small ceiling areas and at re-entrant corners.
- Any intersection of ceiling framing direction changes, framing changes or lining changes.
- At the location coinciding with control joints in the supporting structure.
- In locations where light fixtures, air conditioners, air diffusers, access panels or vents intersect.

As control joints are an aesthetic consideration the designer should specify the control joint locations based on the project specific requirements.

Note:
** = Control joint spacing limitations may vary for different lining types and per manufacturers recommendations. Refer to GIB for further information.*

Seismic Joints

Seismic joints are typically installed in large ceiling areas to accommodate the earthquake actions.

The seismic joint locations will be dependent upon the seismic actions, the capacity of the ceiling grid, and other project specific limitations.

Accordingly, Rondo Engineering Design Services should be consulted for a project specific seismic design.

Building Movement Joints

Building movement joints are installed within the primary structure to accommodate seismic or wind induced deflections, thermal expansion or contraction, shrinkage of concrete and the like. Generally, these joints require a specific design solution for the ceiling system as standard ceiling control joints or seismic joints are unable to accommodate the required movements.

Joints shall be installed within the ceiling system at all building movement joints as they occur in the primary structure and shall be designed to accommodate the nominated lateral and vertical movements.

No ceiling system, including suspension points, shall cross a building movement joint without having the appropriate movement allowance.

B1.2.3 CEILING AND SERVICES INTERACTION

Clear distances between the ceiling grid, its suspension components and services within the buildings shall be in accordance with AS/NZS 2785:2020 (Suspended Ceilings-Design and Installation) and the table below:

TABLE B1.2.3(A): REQUIRED CELLING CLEARANCES TO SERVICES

CONDITION BEING CONSIDERED	MINIMUM CLEARANCE (mm)	
	HORIZONTAL	VERTICAL
Unrestrained ceiling to unrestrained service	250	50
Restrained ceiling to unrestrained service, or vice versa	150	50
Restrained ceiling to restrained service	50	50
Sprinkler heads with flexible droppers	50	50

Notes:

1. Ceiling hangers and bracing shall be assessed as restrained components, with respect to the table above.

2. Structural columns and the like, that penetrate through the ceiling, can be considered as restrained services with respect to the table above.

3. Plenum height shall not exceed 1200mm. For heights greater than 1200mm further design consideration shall be required

4 Duct work, cable trays, mechanical plant, pipework and electrical conduits and the like shall be independently supported from the primary structure and not supported or braced from the ceiling system.

5 Suspension hangers and bracing locations should be coordinated with the services for an effective solution.

6 Attachment of other items to the ceiling grid is not considered in this manual and will require a specific design.

7 Any service over 7.5kg must be independently suspended.

8 No service that has moving parts can be attached to the ceiling grid.

9 This table is applicable for New Zealand only. Clearances to services shall be in accordance with NZS 4219 or NZS 4541.

B1.3 DESIGN ACTIONS

The basic design actions are discussed in Series NZ:A - Section A3: Design Actions and only further actions specific to ceilings are discussed in this section.

B1.3.1 PERMANENT ACTIONS

Refer A3.2 for minimum permanent actions.

Ceiling permanent action will be the sum of the following:

- The mass of the ceiling tile or linings.
- Grid weight (generally 1.2kg/m^2 except stud ceilings)
- Insulation weight (generally 1kg/m^2 minimum)
- Surface mounted luminaires or similar. (for recessed lightings check the difference in weight and add as appropriate)

B1.3.2 IMPOSED ACTIONS

Refer A3.3 for the minimum imposed actions.

The ceilings herein have been designed for the imposed actions per clause 2.2.2 from AS/NZS 2785:2020 which requires consideration of an imposed live action of not less than 0.03kPa (3 Kg/m^2) in all ceilings, to account for incidental loading. Pattern loading need not be considered with this action, unless applicable.

Rondo Engineering Design Services will need to be consulted if imposed actions outside of that nominated above need to be considered.

Key-Lock is designed to be a non-trafficable ceiling system with access hatches being use for maintenance and inspection of services and other items. As the ceiling is non-trafficable, access hatches shall not be used for complete entry of a person into the ceiling plenum space, and at no point should a person's weight be put onto the ceiling.

Where access hatches are present, an imposed action equal to 0.2kN shall be applied in addition to all other actions, to the members providing direct support to the access hatch. The point action shall be positioned for worst case. Strengthening for the members around the hatch might be necessary

Rondo Engineering Design Services should be consulted for a specific design, as necessary.

B1.3.3 WIND ACTIONS

Refer Section A3.4 to determine the basic wind pressure applicable for the building.

Internal pressures specific to the ceiling design are discussed in this section.

The design wind action (p) on a ceilings surface can be determined using the following basic formula:

$p_{i,u} = p_u \, C_{pi,n} \, K_{c,i} \, K_v$ (Refer Section A3.4.3.1)

where;

p_u = Basic ultimate design wind pressure in pascals

$C_{pi,n}$ = Net internal pressure coefficient $= C_{pi,1} - C_{pi,2}$

$K_{c,i}$ = Combination factor for internal pressure

K_v = Open area/volume factor for internal pressures

However, in some instances the pressure in the ceiling plenum space should also be considered in combination with the internal pressure in the room, as depicted in Figures B1.3.3(A) and (B) below.

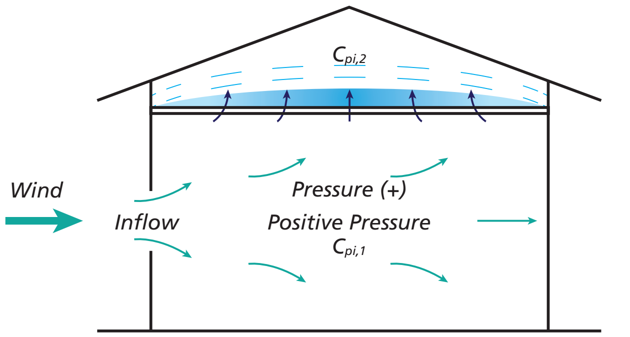

FIGURE B1.3.3(A): POSITIVE INTERNAL PRESSURE

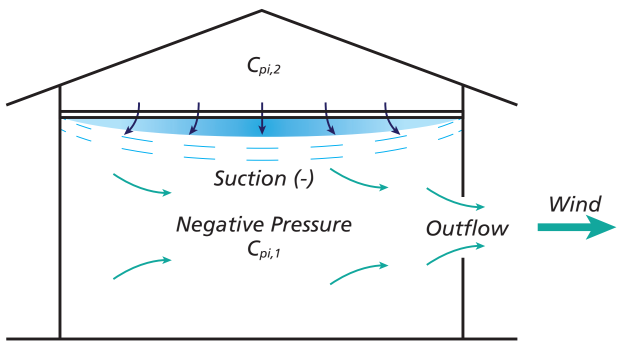

FIGURE B1.3.3(B): NEGATIVE INTERNAL PRESSURE

Where pressures on two contributing surfaces act together in combination to produce a structural action effect, and $|C_{pi,n}| \geq 0.4$ $K_{c,i}$ can be taken as 0.9.

Otherwise, K_{ci} = 1.0.

The K_v factor will be taken as 1.0 if the facade is effectively sealed and 1.085 for dominant openings. Refer Section A3.4.3.1 in Series A for more clarification.

Vented Ceilings

Venting is a means of reducing the pressure differential across the ceiling, and in some instances, venting is already in place. Below are some examples where venting can be applied.

When the ceiling plenum space is used as a Return Air conduit, venting is typically achieved via dummy air registers or physical separation joints around the ceiling perimeter. These allow the pressure in the ceiling plenum to equalize with the room internal pressure.

Shared plenums allow for venting as well, and in Figure B1.3.3.(C) it shows the situation where a concealed ceiling shares a plenum space with an exposed grid ceiling. In this instance, a positive internal pressure is likely to cause the ceiling tiles to lift and subsequently equalize the pressure between the plenum and the room, thus negating any uplift pressure on the ceiling.

Typically, it is assumed that ceiling tiles would not form a pressure seal against the grid as the capacity of the tile to span under even a relatively low internal pressure would be marginal. Additionally, the exposed grid does not have a flat surface for the tile to seal against so there would be pressure leakage.

The wind code AS/NZS1170.2 is not absolute in its definition of venting, and there is limited published information. Accordingly, it is likely engineering judgement will need to be applied in those situations where it is not clear one way or the other.

Pressure Resisting Sealed Ceilings

Internal ceilings that are designed to provide an effective seal between the plenum space and the building space / room shall be considered as pressure sealed and clause 5.3.3 of AS/NZS 1170.2 shall be applied.

These would include, but not limited to, the following:

- Fire rated ceiling systems
- Smoke plenums
- Clean rooms, isolation rooms and the like

Pressure sealed ceilings are subjected to differential pressures resulting from the room internal pressure in combination with the pressure coefficient of ±0.2 applied to the plenum space, to create the worst-case scenario.

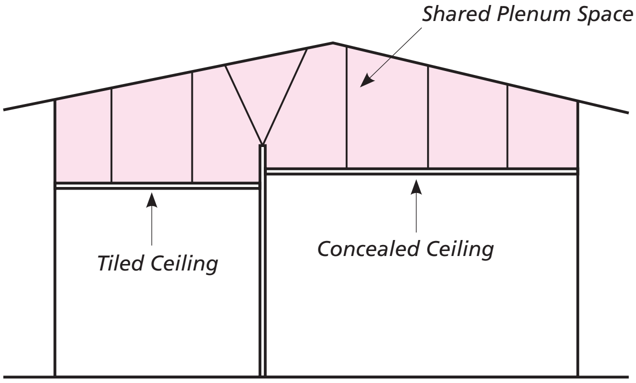

FIGURE B1.3.3(C): SHARED PLENUM SPACE

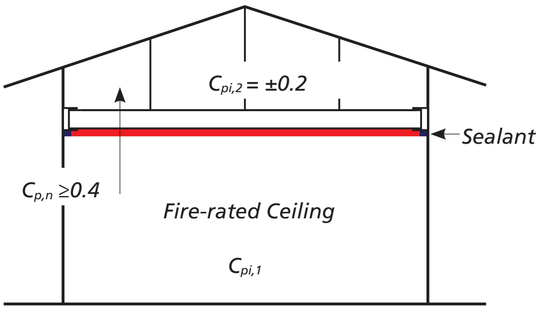

FIGURE B1.3.3(D): PRESSURE SEALED CEILING

Above figure provides a representation of the wind codes intent as it is to be applied to pressure sealed ceilings.

$$C_{p,n} = C_{pi,1} - C_{pi,2} \geq 0.4$$

In the above example, $K_{c,i}$ =0.9 is permitted

Conversely, the capacity of the ceiling tiles to form a pressure seal under suction pressures would need to be determined to assess the negative internal pressure case.

Pressure Resisting Non-Pressure Sealed Ceilings

Where the ceilings are not designed to form or maintain a permanent seal then differential pressures derived using a net pressure coefficient $C_{pi,n}$ of ±0.3 should be applied in accordance with Clause 5.3.3 of AS/NZS 1170.2

Sometimes partial venting could be considered to reduce the differential pressures on these ceilings where appropriate.

The following figure provides an overview of determining net internal pressure coefficient ($C_{pi,n}$) as above.

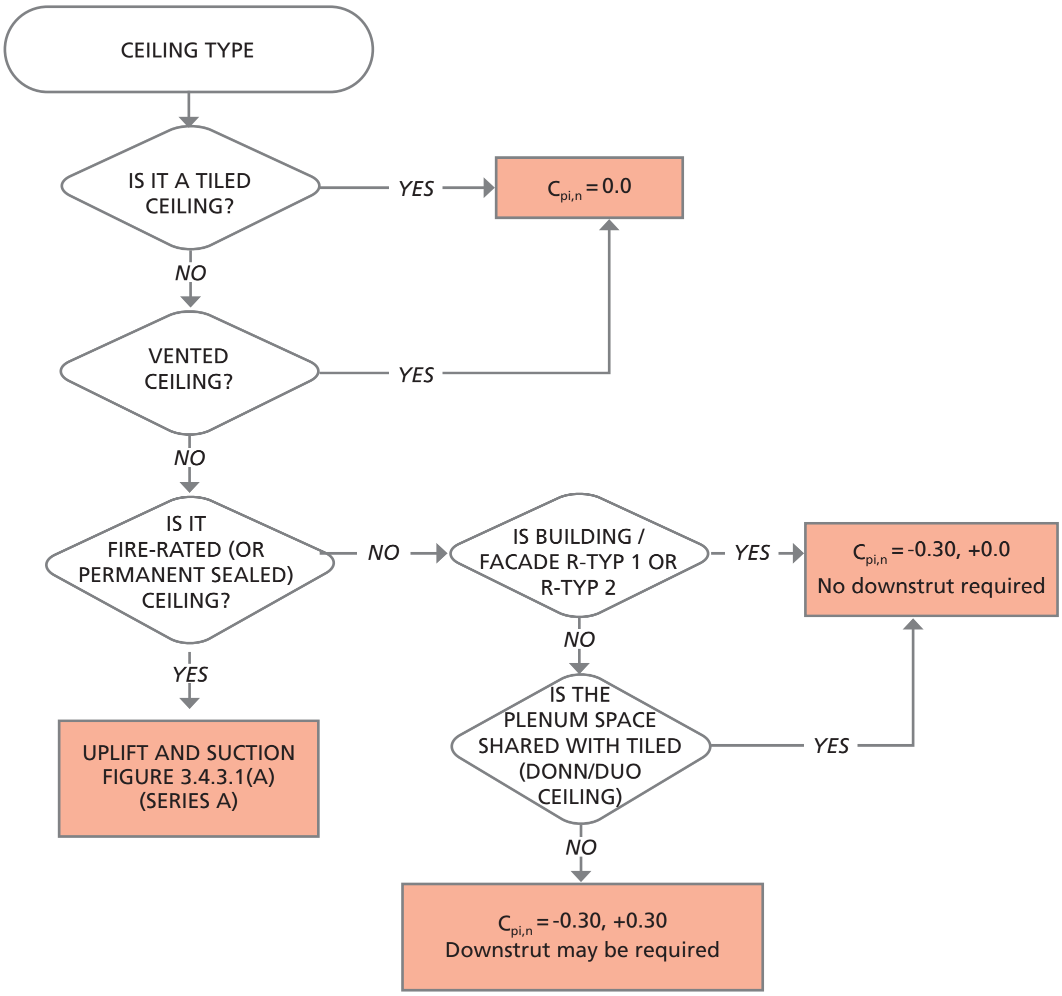

FIGURE B1.3.3(E): INTERNAL CEILING PRESSURE COEFFICIENT

Notes:

1. *R-TYP refers to Rondo facade types. Refer figure A3.4.3.1 of Series A for more clarification.*
2. *Negative Cp,i values result in a suction pressure on the ceiling, conversely positive Cp,i values result in a positive (uplift) pressure on the ceiling.*

B1.3.3.1 INTERNAL PRESSURES

Before the Ceiling Design Tables can be utilised the internal design pressure needs to be calculated using the below formula:

$$p_{i,u} = p_u \, C_{pi,n} \, K_{c,i} \, K_v$$

Where;

p_u = basic pressure

The basic pressure p_u shall be determined in accordance with AS/NZS1170.2 or Section A3.4.2 of Series A as applicable.

The tables below present the net internal design pressures for a given $C_{pi,n}$ with K_{ci} and K_v set to 1.0

TABLE B1.3.3.1(A): REGION NZ1 TO NZ2 IL2 INTERNAL PRESSURES

REGION NZ1 TO NZ2 - IMPORTANCE LEVEL 2												
FLOOR HEIGHT z (m)	TERRAIN CATEGORY 1				TERRAIN CATEGORY 2				TERRAIN CATEGORY 3			
	$C_{pi,n}$				$C_{pi,n}$				$C_{pi,n}$			
	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5
10	0.283	0.425	0.567	0.709	0.243	0.365	0.486	0.608	0.167	0.251	0.335	0.419
20	0.316	0.474	0.632	0.790	0.283	0.425	0.567	0.709	0.215	0.322	0.429	0.537
30	0.338	0.508	0.677	0.846	0.305	0.457	0.610	0.762	0.243	0.365	0.486	0.608
40	0.356	0.534	0.712	0.889	0.327	0.490	0.654	0.817	0.263	0.394	0.526	0.657
50	0.368	0.551	0.735	0.919	0.338	0.508	0.677	0.846	0.278	0.417	0.556	0.696
60	0.377	0.566	0.755	0.943	0.348	0.521	0.695	0.869	0.289	0.433	0.577	0.722
70	0.387	0.581	0.774	0.968	0.357	0.535	0.714	0.892	0.299	0.449	0.599	0.749
80	0.397	0.595	0.794	0.992	0.364	0.546	0.728	0.910	0.309	0.464	0.618	0.773
90	0.407	0.610	0.814	1.017	0.369	0.553	0.738	0.922	0.318	0.477	0.636	0.795
100	0.417	0.626	0.834	1.043	0.374	0.560	0.747	0.934	0.327	0.490	0.654	0.817
110	0.423	0.635	0.847	1.059	0.377	0.566	0.755	0.943	0.333	0.499	0.665	0.832
120	0.430	0.645	0.860	1.075	0.381	0.571	0.762	0.952	0.338	0.508	0.677	0.846
130	0.436	0.654	0.873	1.091	0.385	0.577	0.769	0.961	0.344	0.516	0.688	0.860
140	0.443	0.664	0.886	1.107	0.388	0.582	0.776	0.971	0.350	0.525	0.700	0.875
150	0.449	0.674	0.899	1.124	0.392	0.588	0.784	0.980	0.356	0.534	0.712	0.889
160	0.453	0.680	0.907	1.134	0.394	0.592	0.789	0.986	0.359	0.539	0.719	0.898
170	0.457	0.686	0.915	1.144	0.397	0.595	0.794	0.992	0.363	0.544	0.726	0.907
180	0.461	0.692	0.923	1.154	0.399	0.599	0.799	0.998	0.366	0.550	0.733	0.916
190	0.465	0.698	0.931	1.164	0.402	0.603	0.804	1.005	0.370	0.555	0.740	0.925
200	0.470	0.704	0.939	1.174	0.404	0.607	0.809	1.011	0.374	0.560	0.747	0.934
Service Ratio	0.751	0.751	0.751	0.751	0.751	0.751	0.751	0.751	0.751	0.751	0.751	0.751

■ TABLE B1.3.3.1(B): REGION NZ1 TO NZ2 IL3 INTERNAL PRESSURSE

REGION NZ1 TO NZ2 - IMPORTANCE LEVEL 3												
FLOOR HEIGHT z (m)	TERRAIN CATEGORY 1				TERRAIN CATEGORY 2				TERRAIN CATEGORY 3			
	$C_{pi,n}$				$C_{pi,n}$				$C_{pi,n}$			
	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5
10	0.296	0.444	0.592	0.740	0.254	0.381	0.508	0.635	0.175	0.262	0.350	0.437
20	0.330	0.495	0.660	0.825	0.296	0.444	0.592	0.740	0.224	0.337	0.449	0.561
30	0.354	0.530	0.707	0.884	0.319	0.478	0.637	0.796	0.254	0.381	0.508	0.635
40	0.372	0.558	0.744	0.929	0.342	0.513	0.683	0.854	0.275	0.412	0.549	0.687
50	0.384	0.576	0.768	0.960	0.354	0.530	0.707	0.884	0.291	0.436	0.581	0.727
60	0.394	0.591	0.788	0.986	0.363	0.545	0.726	0.908	0.302	0.453	0.603	0.754
70	0.404	0.607	0.809	1.011	0.373	0.559	0.746	0.932	0.313	0.469	0.626	0.782
80	0.415	0.622	0.829	1.037	0.380	0.571	0.761	0.951	0.323	0.485	0.646	0.808
90	0.425	0.638	0.850	1.063	0.385	0.578	0.771	0.964	0.332	0.498	0.665	0.831
100	0.436	0.654	0.872	1.089	0.390	0.586	0.781	0.976	0.342	0.513	0.683	0.854
110	0.442	0.664	0.885	1.106	0.394	0.591	0.788	0.986	0.348	0.521	0.695	0.869
120	0.449	0.674	0.898	1.123	0.398	0.597	0.796	0.995	0.354	0.530	0.707	0.884
130	0.456	0.684	0.912	1.140	0.402	0.603	0.804	1.005	0.360	0.539	0.719	0.899
140	0.463	0.694	0.926	1.157	0.406	0.609	0.811	1.014	0.366	0.548	0.731	0.914
150	0.470	0.704	0.939	1.174	0.410	0.614	0.819	1.024	0.372	0.558	0.744	0.929
160	0.474	0.711	0.948	1.185	0.412	0.618	0.824	1.030	0.375	0.563	0.751	0.939
170	0.478	0.717	0.956	1.195	0.415	0.622	0.829	1.037	0.379	0.569	0.758	0.948
180	0.482	0.723	0.964	1.205	0.417	0.626	0.835	1.043	0.383	0.574	0.766	0.957
190	0.486	0.730	0.973	1.216	0.420	0.630	0.840	1.050	0.387	0.580	0.773	0.967
200	0.491	0.736	0.981	1.226	0.423	0.634	0.845	1.056	0.390	0.586	0.781	0.976
Service Ratio	0.719	0.719	0.719	0.719	0.719	0.719	0.719	0.719	0.719	0.719	0.719	0.719

■ TABLE B1.3.3.1(C) – REGION NZ3 IL2 INTERNAL PRESSURES

REGION NZ3 - IMPORTANCE LEVEL IL2												
FLOOR HEIGHT z (m)	TERRAIN CATEGORY 1				TERRAIN CATEGORY 2				TERRAIN CATEGORY 3			
	$C_{pi,n}$				$C_{pi,n}$				$C_{pi,n}$			
	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5
10	0.393	0.590	0.786	0.983	0.337	0.506	0.674	0.843	0.232	0.348	0.464	0.581
20	0.438	0.657	0.876	1.095	0.393	0.590	0.786	0.983	0.298	0.447	0.596	0.745
30	0.469	0.704	0.939	1.173	0.423	0.634	0.846	1.057	0.337	0.506	0.674	0.843
40	0.494	0.740	0.987	1.234	0.454	0.680	0.907	1.134	0.365	0.547	0.729	0.911
50	0.510	0.765	1.020	1.275	0.469	0.704	0.939	1.173	0.386	0.579	0.772	0.965
60	0.523	0.785	1.047	1.308	0.482	0.723	0.964	1.205	0.400	0.601	0.801	1.001
70	0.537	0.805	1.074	1.342	0.495	0.743	0.990	1.238	0.415	0.623	0.831	1.038
80	0.551	0.826	1.101	1.376	0.505	0.758	1.010	1.263	0.429	0.643	0.858	1.072
90	0.564	0.847	1.129	1.411	0.512	0.767	1.023	1.279	0.441	0.662	0.882	1.103
100	0.578	0.868	1.157	1.446	0.518	0.777	1.037	1.296	0.454	0.680	0.907	1.134
110	0.587	0.881	1.175	1.468	0.523	0.785	1.047	1.308	0.461	0.692	0.923	1.154
120	0.596	0.894	1.193	1.491	0.528	0.793	1.057	1.321	0.469	0.704	0.939	1.173
130	0.605	0.908	1.211	1.513	0.533	0.800	1.067	1.334	0.477	0.716	0.955	1.193
140	0.614	0.921	1.229	1.536	0.539	0.808	1.077	1.346	0.485	0.728	0.971	1.213
150	0.623	0.935	1.247	1.559	0.544	0.816	1.087	1.359	0.494	0.740	0.987	1.234
160	0.629	0.943	1.258	1.572	0.547	0.821	1.094	1.368	0.498	0.748	0.997	1.246
170	0.635	0.952	1.269	1.586	0.551	0.826	1.101	1.376	0.503	0.755	1.007	1.258
180	0.640	0.960	1.280	1.600	0.554	0.831	1.108	1.385	0.508	0.762	1.017	1.271
190	0.646	0.968	1.291	1.614	0.557	0.836	1.115	1.394	0.513	0.770	1.027	1.283
200	0.651	0.977	1.303	1.628	0.561	0.841	1.122	1.402	0.518	0.777	1.037	1.296
Service Ratio	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754

TABLE B1.3.3.1(D): REGION NZ3 IL3 INTERNAL PRESSURES

REGION NZ3 - IMPORTANCE LEVEL IL3												
FLOOR HEIGHT z (m)	TERRAIN CATEGORY 1				TERRAIN CATEGORY 2				TERRAIN CATEGORY 3			
	$C_{pi,n}$				$C_{pi,n}$				$C_{pi,n}$			
	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5
10	0.408	0.612	0.816	1.020	0.350	0.525	0.700	0.875	0.241	0.362	0.482	0.603
20	0.455	0.682	0.910	1.137	0.408	0.612	0.816	1.020	0.309	0.464	0.618	0.773
30	0.487	0.731	0.974	1.218	0.439	0.658	0.878	1.097	0.350	0.525	0.700	0.875
40	0.512	0.768	1.025	1.281	0.471	0.706	0.942	1.177	0.378	0.568	0.757	0.946
50	0.529	0.794	1.059	1.323	0.487	0.731	0.974	1.218	0.401	0.601	0.801	1.002
60	0.543	0.815	1.087	1.358	0.501	0.751	1.001	1.251	0.416	0.624	0.831	1.039
70	0.557	0.836	1.115	1.393	0.514	0.771	1.028	1.285	0.431	0.647	0.862	1.078
80	0.572	0.857	1.143	1.429	0.524	0.786	1.048	1.311	0.445	0.668	0.890	1.113
90	0.586	0.879	1.172	1.465	0.531	0.797	1.062	1.328	0.458	0.687	0.916	1.145
100	0.600	0.901	1.201	1.501	0.538	0.807	1.076	1.345	0.471	0.706	0.942	1.177
110	0.610	0.915	1.219	1.524	0.543	0.815	1.087	1.358	0.479	0.719	0.958	1.198
120	0.619	0.928	1.238	1.547	0.549	0.823	1.097	1.371	0.487	0.731	0.974	1.218
130	0.628	0.942	1.257	1.571	0.554	0.831	1.108	1.384	0.496	0.743	0.991	1.239
140	0.638	0.957	1.275	1.594	0.559	0.839	1.118	1.398	0.504	0.756	1.008	1.260
150	0.647	0.971	1.294	1.618	0.564	0.847	1.129	1.411	0.512	0.768	1.025	1.281
160	0.653	0.979	1.306	1.632	0.568	0.852	1.136	1.420	0.517	0.776	1.035	1.294
170	0.659	0.988	1.317	1.647	0.572	0.857	1.143	1.429	0.523	0.784	1.045	1.306
180	0.664	0.997	1.329	1.661	0.575	0.863	1.150	1.438	0.528	0.792	1.055	1.319
190	0.670	1.005	1.341	1.676	0.579	0.868	1.157	1.447	0.533	0.799	1.066	1.332
200	0.676	1.014	1.352	1.690	0.582	0.873	1.165	1.456	0.538	0.807	1.076	1.345
Service Ratio	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725

TABLE B1.3.3.1(E): REGION NZ4 IL2 AND IL3 INTERNAL PRESSURES

REGION NZ4 - IMPORTANCE LEVEL IL2 & IL3												
FLOOR HEIGHT z (m)	TERRAIN CATEGORY 1				TERRAIN CATEGORY 2				TERRAIN CATEGORY 3			
	$C_{pi,n}$				$C_{pi,n}$				$C_{pi,n}$			
	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5
10	0.350	0.525	0.700	0.875	0.300	0.450	0.600	0.750	0.207	0.310	0.413	0.517
20	0.390	0.585	0.780	0.975	0.350	0.525	0.700	0.875	0.265	0.398	0.530	0.663
30	0.418	0.627	0.835	1.044	0.376	0.564	0.753	0.941	0.300	0.450	0.600	0.750
40	0.439	0.659	0.878	1.098	0.404	0.606	0.807	1.009	0.324	0.487	0.649	0.811
50	0.454	0.681	0.908	1.135	0.418	0.627	0.835	1.044	0.343	0.515	0.687	0.859
60	0.466	0.699	0.932	1.164	0.429	0.644	0.858	1.073	0.356	0.535	0.713	0.891
70	0.478	0.717	0.956	1.194	0.441	0.661	0.881	1.102	0.370	0.554	0.739	0.924
80	0.490	0.735	0.980	1.225	0.449	0.674	0.899	1.124	0.382	0.573	0.763	0.954
90	0.502	0.753	1.005	1.256	0.455	0.683	0.911	1.138	0.393	0.589	0.785	0.982
100	0.515	0.772	1.030	1.287	0.461	0.692	0.923	1.153	0.404	0.606	0.807	1.009
110	0.523	0.784	1.045	1.307	0.466	0.699	0.932	1.164	0.411	0.616	0.821	1.027
120	0.531	0.796	1.061	1.327	0.470	0.705	0.941	1.176	0.418	0.627	0.835	1.044
130	0.539	0.808	1.077	1.347	0.475	0.712	0.950	1.187	0.425	0.637	0.850	1.062
140	0.547	0.820	1.094	1.367	0.479	0.719	0.959	1.198	0.432	0.648	0.864	1.080
150	0.555	0.832	1.110	1.387	0.484	0.726	0.968	1.210	0.439	0.659	0.878	1.098
160	0.560	0.840	1.120	1.399	0.487	0.730	0.974	1.217	0.444	0.665	0.887	1.109
170	0.565	0.847	1.129	1.412	0.490	0.735	0.980	1.225	0.448	0.672	0.896	1.120
180	0.570	0.854	1.139	1.424	0.493	0.740	0.986	1.233	0.452	0.679	0.905	1.131
190	0.575	0.862	1.149	1.437	0.496	0.744	0.992	1.240	0.457	0.685	0.914	1.142
200	0.580	0.869	1.159	1.449	0.499	0.749	0.998	1.248	0.461	0.692	0.923	1.153
Service Ratio	0.810	0.810	0.810	0.810	0.810	0.810	0.810	0.810	0.810	0.810	0.810	0.810

Note: Wind speed of 50m/s for IL2 (V500) & IL3 (V1000) at region 4 is same.

Notes:

1. Importance Level 4 buildings require a specific design and will need to be referred to Rondo.

2. Values may be proportioned for $K_{c,i}$ K_v values other than 1.0

3. Wind speed and Annual Probability of Exceedance in accordance with Tables A3.4.2.1(A) and A2.1(B)respectively.

B1.3.4 EARTHQUAKE ACTIONS

Refer A3.5 of Series A for the general minimum earthquake actions to be considered.

Seismic Restraint of the Ceiling

Gravity loading of ceilings is well understood, however seismic actions generate horizontal (lateral) actions within the grid and accommodating these is not so well understood.

All ceiling systems should be restrained against seismic actions or any other actions resulting in lateral loading to the ceiling grid. These restraints can prevent tiles from becoming dislodged, plasterboard from falling, uncontrolled impact of the ceiling with the structure and potentially the failure of the ceiling.

The following four options are typically used to restrain the ceiling under seismic actions. These options shall not be mixed within the same ceiling area except the one-way braced ceiling systems (Option 3).

These four options do not preclude the possibility that other options exist; however, these options have been found to cover the majority of applications likely to be encountered.

It should also be noted that IL4 buildings require a specific design and therefore are not covered in this Professional Manual.

Option 1: Perimeter Restrained Ceilings

This option is typically used for small rooms with lightweight ceiling systems and full height walls on all sides of the ceiling.

In this instance, the seismic actions developed within the ceiling grid during a seismic event are transferred through the ceiling grid to the perimeter walls, and ultimately back to the primary structure. This option depends on the following factors.

1. The capacity of the ceiling grid to carry the seismic actions to the perimeter walls.

2. The connection capacity of the ceiling grid members to the perimeter walls

3. The capacity of the perimeter connections to accommodate the lateral movement

4. The capacity of the perimeter walls to transfer the seismic action back to the structure.

Care in design should be taken when adopting this design methodology to ensure both the wall and ceiling contractors are aware of their individual responsibilities, particularly if they are different contractors.

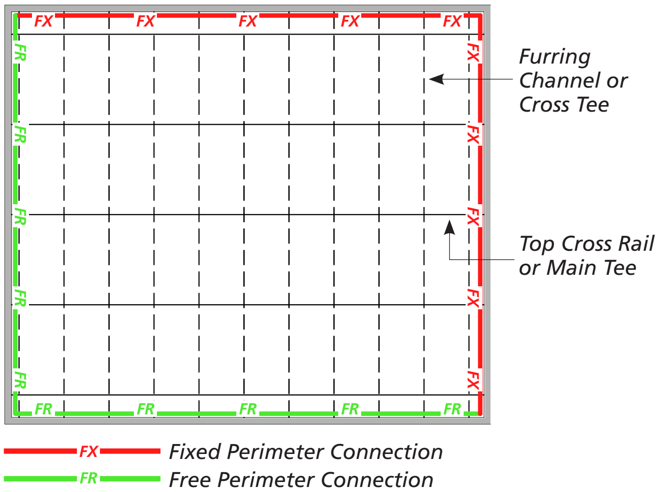

FIGURE B1.3.4(A): PERIMETER RESTRAINED CEILING

This option requires a fixed (or rigid) connection between the ceiling grid members and the perimeter wall along two adjacent sides of the ceiling, coupled with a free (or slotted) connection along the two opposite sides.

This requires only limited coordination between the ceiling suspension and services within the plenum space, a particular beneficial feature in hospitals and prisons where there are large amounts of services in the plenum.

The free end of the ceiling needs to have sufficient clearance to ensure the differential movement, resulting from the inter-storey drift, is adequately accommodated such that there is no impact of the ceiling grid against the perimeter wall.

Option 2: Seismic Jointed Ceilings

This is an extension of the perimeter restraint design method discussed above. By introducing seismic joints within the ceiling grid, the maximum room size can potentially be doubled in size before plenum bracing is required.

This option requires fixed connections to all four perimeter walls, combined with seismic joints within the ceiling to accommodate the expected differential movement during the seismic event.

Figure B1.3.4(B) below provides a simple overview of the design methodology.

This option requires design coordination with the project team for acceptance of the seismic joints within the ceiling.

The specific detailing of these joints is covered under the various ceiling systems to follow.

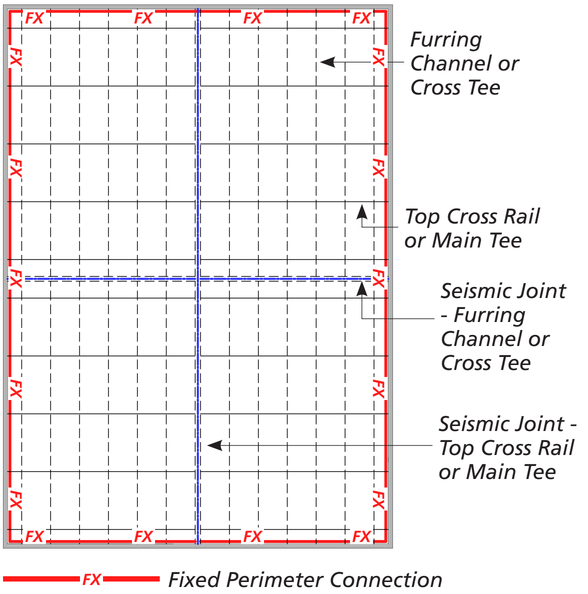

FIGURE B1.3.4(B): SEISMIC JOINTED CEILING

Again, this ceiling installation method only requires coordination of the traditional ceiling suspension points with the services located within the plenum space.

Option 3: One-Way Braced Ceilings

This option is a mixed solution of perimeter restraint with bracing in one direction, typically along the ceiling long direction.

Ceilings will have bracing aligned in one direction and restrained by the perimeter wall in the other orthogonal direction. This is more suitable for long corridors and similar areas where it is difficult to coordinate the bracing in two directions.

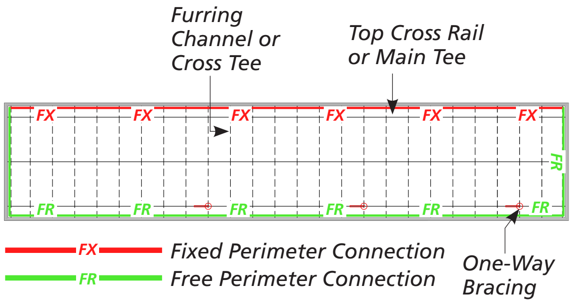

FIGURE B1.3.4(C): ONE-WAY BRACED CEILING

Notes:
1. *1.All bracing systems should be evenly distributed.*
2. *Install one way bracing closer to the free perimeter connection*

Figure B1.3.4(C) above provides a simple overview of this design methodology.

The bracing is typically orientated as far from the restrained wall as possible as this mitigates any torsional effects through the ceiling grid under seismic actions.

Option 4: Two-way Braced Ceilings

In this option the ceiling is rigidly braced back to the structure above, and as such, moves in tandem with the structure.

Ceilings can and do move independently of the perimeter walls, whilst the horizontal seismic actions are progressively transferred to the supporting structure through the bracing members in two orthogonal axes.

This option requires free or slotted connections between the ceiling grid members and the perimeter walls at all locations. The systematic nature of this solution means that it can be easily applied to different designs, can be efficiently installed and parts of the ceiling grid can be individually replaced without significant impact.

This design methodology has no physical limitations on room sizes and therefore is ideally suited to large open plan areas within the building. Although it requires initial coordination between the ceiling bracing system and any services located in the ceiling plenum, the bracing set out can be adjusted to accommodate these services and there is no differential movement between the bracing and services, provided the services are also braced (as should be the case).

Additionally, this system does not rely on seismic actions being transferred to the perimeter walls, so it can be employed irrespective of the type of perimeter walls to be installed.

Perimeter fixing clips are still required for fully braced exposed grid ceilings as these prevent grid spread and the possibility of tiles dislodging under seismic actions.

Figure B1.3.4(D) below provides a simple overview of this design methodology.

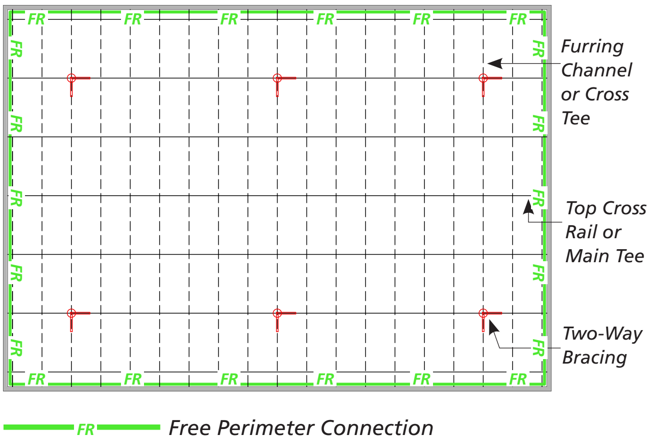

FIGURE B1.3.4(D): TWO-WAY BRACED CEILING

Notes:
1. All bracing systems should be evenly distributed.

Seismic jointing can be utilised within a two way fully braced ceiling to accommodate vertical or horizontal (plan) ceiling irregularities.

B1.3.4.1 CEILING PERIMETER CONNECTION

Perimeter connection can be either fixed end or free end connection based on the ability of the connection to transfer the seismic action into the perimeter walls.

Fixed Perimeter Connection

Fixed perimeter connections are where the ceiling grid members, abutting the perimeter walls, are positively connected to the perimeter walls using a clip, bracket or shear connector, capable of transferring the seismic actions to the perimeter walls.

The load transfer to the perimeter wall can be assessed using the following formula:

$F_w = F_c * L_g * Sgm$

Where;

F_w = seismic action into the perimeter wall (kN/m)

F_c = seismic action in the ceiling (kPa or kN/m^2)

L_g = length of the grid abutting the wall (m)

Sgm = spacing of the grid member (m)

For perimeter restrained ceilings, this action will be both tension and compression because the opposite end of the ceiling is free.

The seismic action can be assessed in accordance with Section A3.5.2 of Series A or NZS1170.5 as applicable.

Free Perimeter Connection

Free perimeter connection is where the ceiling grid members, abutting the perimeter walls and connected in such a way that no axial action is transferred between the ceiling system and the perimeter walls.

This connection requires sufficient clearance between the ceiling member and the perimeter wall to accommodate the resulting deflection from the inter-storey drift. Refer Section A6.1.1 of Series A for inter-storey drift allowances.

The ceiling grid member is to be installed with sufficient end bearing on the perimeter trim so as to prevent accidental dislodgement or alternatively, may be suspended within 200mm of the wall to prevent drop off.

Seismic Joints

Seismic joints create a free / floating edge and can be used to separate one area of the ceiling from the another.

Seismic joints can be installed to provide separation between large areas of ceilings and corridors or at re-entrant corners and the like. The seismic joints need to be sized to accommodate the expected movements, at the ceiling height, resulting from the inter-storey drift.

It should be noted that the expected movement at the ceiling height is likely to be different to the inter-storey drift.

B1.3.4.2 BRACING OPTIONS

Bracing is used to transfer the seismic horizontal actions back to the primary structure.

Bracing can be either one or two directional, depending on the design requirements. That is, when the diagonal bracing is installed in two directions at 90° to each other, it is two-way bracing.

For one-way bracing, the diagonal brace is installed in the direction of the required bracing line.

The GRIDLOK products can be used in conjunction with the Rondo ceiling systems.

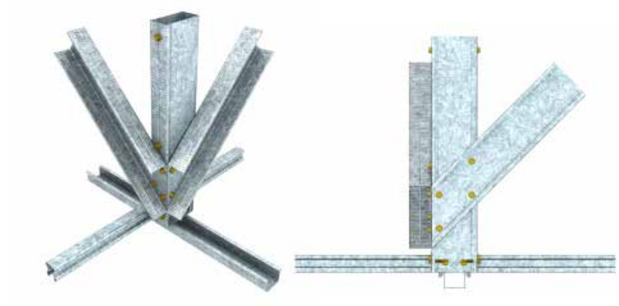

FIGURE B1.3.4(E): SITE FABRICATED TWO-WAY BRACING

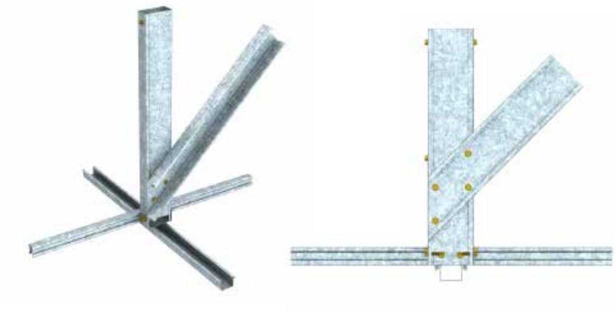

FIGURE B1.3.4(F): SITE FABRICATED ONE-WAY BRACING

FIGURE B1.3.4(H) GRIDLOK TWO-WAY BRACING

FIGURE B1.3.4(G) GRIDLOCK ONE-WAY BRACING

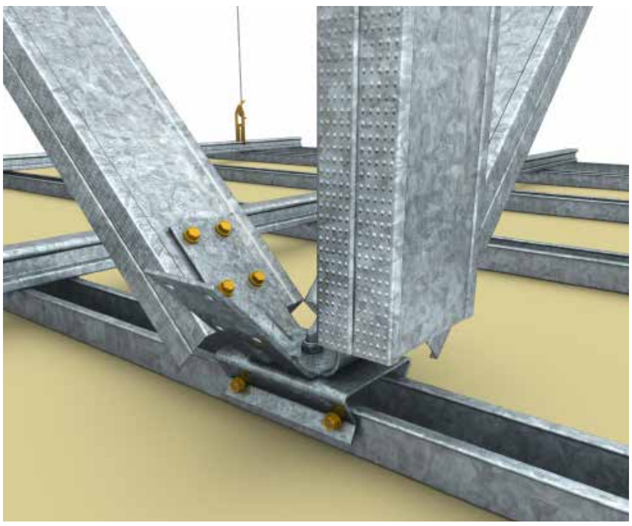

FIGURE B1.3.4(I) GRIDLOCK TWO-WAY BRACING

B1.3.4.3 SEISMIC IRREGULARITIES

Quite often ceilings are designed with architectural features to enhance their aesthetic appeal, or even sometimes just to accommodate services or the like.

These features can lead to seismic irregularities, which disturb the load path of the seismic actions through the ceiling, and can lead to premature failure of the ceiling in the worst case.

Similar to the buildings themselves, these irregularities can be classified as:

- Stiffness irregularity
- Mass irregularity
- Geometrical irregularity

Typically, these irregularities present as a potential detrimental impact to the ceiling performance and should be remedied as follows:

- Design the irregularity out
- Develop an analytical approach
- Resolve the irregularity back to a regular form

Designing out the irregularity is unlikely to be palatable to the project design team, and is not considered here.

An analytical approach can be used in some instances, depending on the required aesthetics and magnitude of the actions.

However, generally the most simple and effective solution is to resolve the irregularity back to a regular form and this is typically achieved using seismic joints.

Some examples of seismic irregularities are discussed below:

Vertical ceiling irregularities can occur at bulkheads, coffered ceilings or atriums and the like. When these irregularities are relatively small, they can be accommodated within the design. However, these irregularities are likely to become a problem when the plenum depth increases significantly and / or coupled with heavy weight linings.

Similarly, horizontal or plan irregularities can occur at hallway junctions where the ceiling continues through without a bulkhead or separation means. The analytical approach would be to install a bulkhead and design it to accommodate the seismic actions, or it could be resolved with the introduction of a seismic joint if the ceiling does not require a fixed end.

Because of the potential endless variations, seismic irregularities have not been considered within this Manual and should be discussed with your Rondo representative.

B1.4 LOAD COMBINATION

Refer Section A4 for load combinations used to determine the worst case design action for the ultimate and serviceability limit states.

If the load combinations change for a particular ceiling the change will be noted within the individual system.

B1.5 DEFLECTION LIMITS

B1.5.1 VERTICAL DEFLECTION LIMITS

The vertical deflection of the ceiling systems throughout this manual, under serviceability actions, have been limited to the values given in Table B1.5.1(A).

Should these limits not be acceptable for your specific project contact Rondo Engineering Design Services to discuss alternative project specific requirements.

TABLE B1.5.1(A): VERTICAL DEFLECTION LIMITS

CEILING FINISH	SERVICEABILITY LOAD CASE	DEFLECTION LIMIT
Matt or textured	G	Span/360
	G+Ws	Span/200
Gloss or brittle finish	G	Span/500
	G+Ws	Span/360

For Level 5 finish ceilings, critical lighting situations or ceilings to finished with Gloss or brittle finishes refer to Rondo for a specific design solution.

B1.5.2 HORIZONTAL DISPLACEMENT LIMITS

Horizontal displacement of the ceiling is different to that of the building, and it is possible that the ceiling will move at a different rate, direction or magnitude than the structure to which it is attached.

Section A6.1.3 provides guidance as to the horizontal building movements considered in this manual and Tables B1.5.2(A) and (B) provides the horizontal displacement of the ceiling systems, under serviceability actions as applicable.

Should these limits not be acceptable for your specific project contact Rondo Engineering Design Services to discuss alternative project specific requirements.

TABLE B1.5.2(A): HORIZONTAL DEFLECTION LIMITS FOR IL2 BUILDINGS

DEFLECTION SCENARIO	SEVICEABILITY LOAD CASE		DEFLECTION LIMIT
	SLS1	SLS2	
Braced ceiling	$0.250E_U$	$0.375E_U$	6mm
Differential displacement of perimeter fixed ceilings	$0.250E_U$	$0.375E_U$	±10mm

TABLE B1.5.2(B): HORIZONTAL DEFLECTION LIMITS FOR IL3 BUILDINGS

DEFLECTION SCENARIO	SEVICEABILITY LOAD CASE		DEFLECTION LIMIT
	SLS1	SLS2	
Braced ceiling	$0.192E_U$	$0.433E_U$	6mm
Differential displacement of perimeter fixed ceilings	$0.192E_U$	$0.433E_U$	±10mm

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