the PROFESSIONAL series

SERIES NZ A: DESIGN DATA

V1

RONDO®

CONTENTS

A1 INTRODUCTION 3

A2 BUILDING DATA 4
- A2.1 Building Importance Level 4

A3 DESIGN ACTIONS 5
- A3.1 Standards Of Reference 5
- A3.2 Permanent Actions 5
- A3.3 Imposed Actions 6
- A3.4 Wind Actions 6
- A3.5 Earthquake Actions 19

A4 LOAD COMBINATIONS 25
- A4.1 Ultimate Limit State 25
- A4.2 Serviceability Limit State 25
- A4.3 Worked Example 25

A5 INSTALLATION 28
- A5.1 Connections 28
- A5.2 Linings 31
- A5.3 Ceiling And Partition Interactions 32

A6 OTHER CONSIDERATIONS 34
- A6.1 Building Movement Allowance 34
- A6.2 Material Specifications 35
- A6.3 Properties Of Steel 35
- A6.4 Early Fire Hazard Properties 35
- A6.5 Durability 35

Version 1: first published in June 2024

A1 DESIGN DATA

A1.1 INTRODUCTION

The Rondo Wall, Ceiling and associated framing systems detailed within this Professional Series are installed in many varied buildings and forms. This section provides an overview of some of the design requirements of these systems, as well as simple tools to assist in the determination of a compliant solution.

Whilst not every design scenario can be considered, the following information covers the majority of situations likely to be encountered in the design process.

TOPICS CONSIDERED

- Wall and Ceiling Linings
- Internal wind actions
- Seismic actions
- Load bearing walls
- Impact actions
- Fire-rated Walls
- Acoustic rated walls
- Durability and Corrosion
- Fasteners

Not all loading actions are covered in this Professional Series. For design situations outside the scope of this Series refer to Rondo for technical assistance and/or clarification.

SPECIAL CONSIDERATION

- Overall system performance can be significantly impacted due to poor installation. Rondo recommends using qualified tradespeople familiar with Rondo systems.
- This Professional Series has been prepared using New Zealand Standards, test data and our design methodology for Rondo wall and ceiling systems only. Mixing of products may mean the system doesn't perform as designed or tested, and therefore, could lead to compliance issues.
- Attachment of FF&E to any wall or ceiling system needs to be carefully considered and is not covered in this Professional Series due to the many variables.
- Design and installation of all Rondo systems must be in accordance with the details herein and the relevant New Zealand Standards.

SUPPORT

Remember, if in doubt, ask. Rondo provides a full design service for their systems and products.

Please refer to Rondo representative should futher assistance be required.

A2 BUILDING DATA

A2.1 BUILDING IMPORTANCE LEVEL

The building Importance Level (IL) needs to be established using Clause A3 of the New Zealand Building Code. Thereafter, Clause A3 can be used to establish the design events for safety including wind, seismic and snow as applicable. Clause A3 has been reproduced here for completeness.

TABLE A2.1(A): BUILDING IMPORTANCE LEVELS

IMPORTANCE LEVEL	BUILDING TYPES
1	Buildings or structures presenting a low degree of hazard to life and other property in the case of failure.
2	Buildings or structures not included in Importance Levels 1, 3 or 4.
3	Buildings or structures designed to contain a large number of people. Refer to NZBC A3.
4	Buildings or structures that are essential to post-disaster recovery or associated with hazardous facilities.

TABLE A2.1(B): DESIGN EVENTS FOR SAFETY IN ACCORDANCE WITH AS/NZS 1170.0

IMPORTANCE LEVEL	ANNUAL PROBABILITY OF EXCEEDANCE			ANNUAL PROBABILITY OF EXCEEDANCE FOR SERVICEABILITY LIMIT STATES	
	Wind	Snow	Earthquake	SLS1	SLS2
1	1:100	1:50	1:100	-	-
2	1:500	1:150	1:500	1:25	-
3	1:1000	1:250	1:1000	1:25	-
4	1:2500	1:500	1:2500	1:25	1:500

Table A2.1(B) provides a summary of the design events for safety for buildings with a design life of 50 years, to be considered for each project. Not all events will be applicable for every project, however wind and seismic events do need to be considered for all projects.

The design events vary according to the IL of the building, with IL4 providing the highest level of safety due to the critical nature of these types of facilities.

The annual probability of exceedance (APE) is a probabilistic measure of the risk associated with the action, for example a 1:100 APE has 1% probability of occurring in any year or 100% probability of occurring in any 100 years. The time period of occurrence is also referred to as the Return Period.

The higher the APE, the higher the corresponding design events.

A3 DESIGN ACTIONS

A3.1 STANDARDS OF REFERENCE

Permanent (G), imposed (Q), wind (W) and earthquake (E) actions on walls and ceilings shall be determined in accordance with the following codes as applicable:

AS/NZS 1170.1	Part 1: Permanent, imposed and other actions
AS/NZS 1170.2	Part 2: Wind actions
AS/NZS 1170.3	Part 3: Snow and ice actions
NZS 1170.5	Part 5: Earthquake actions in New Zealand
AS/NZS 2785	Suspended ceilings – Design and installation

Load combinations shall be considered in accordance with:

AS/NZS 1170.0 General principles

The wall and ceiling designs contained in this Series assume that the supporting structure has sufficient capacity to withstand all actions and combinations thereof resulting from the installed systems. Rondo recommends this be confirmed with the Project Engineer prior to commencing work on site.

Rondo wall and ceiling systems in this Series are not considered part of the primary building frame and should not be included as part of the primary seismic action resisting system or used to transfer loads between structural elements.

Whilst every care has been taken to compile this Series the information provided should be considered as general guidance. Rondo recommends you confirm your specific project requirements if in doubt.

A3.2 PERMANENT ACTIONS (G)

Minimum permanent actions shall be determined in accordance with AS/NZS 1170.1. Total weight will be the sum of all linings, insulation, self-weight of the grid/framing system, fixtures, fittings and any other attachment or the like that is supported by the grid/framing.

Wall and Ceiling linings vary considerably, and the table below provides typical lining weights:

TABLE A3.2(A) TYPICAL LINING WEIGHTS

LINING	WEIGHT (kg/m²)
Plasterboard	
10mm Standard Plasterboard	7.00
13mm Standard Plasterboard	9.00
13mm FR Plasterboard	11.50
13mm Acoustic Grade Plasterboard	12.50
16mm FR Plasterboard	15.30
Fibre Cement	
6mm thickness	9.00
9mm thickness	13.0
Timber or Plywood	
Seasoned Softwood (per 10mm thickness)	7.00
Seasoned Hardwood (per 10mm thickness)	10.0
Metal	
0.42BMT painted	4.40
0.48BMT painted	5.00

Lining weights are important for ceiling systems and when considering seismic actions on both ceilings and wall systems.

Notes to Table A3.2(A):

1. *Refer to lining manufacturers published data for installation details.*
2. *Weights can vary from those published here and the above table are only recommendations where actual design data is not available.*
3. *Rondo partners with different manufacturers of plasterboard and other cladding/linings, using Rondo steel framing systems. The figures are general and manuals should be checked for weights.*

A3.3 IMPOSED ACTIONS (Q)

The minimum imposed actions (Q), for wall and ceiling systems, shall be determined in accordance with AS/NZS1170.1, as applicable.

Imposed actions for ceilings are further discussed in Series NZ:B1 - Section B1.3.2.

Imposed actions for walls are further discussed in Section C1.3.2.

A3.4 WIND ACTIONS

As design experts, we understand that wind loading is complex with many factors that relate to the site and the building including: the façade system on the building and whether there are operable doors and/or windows within the façade.

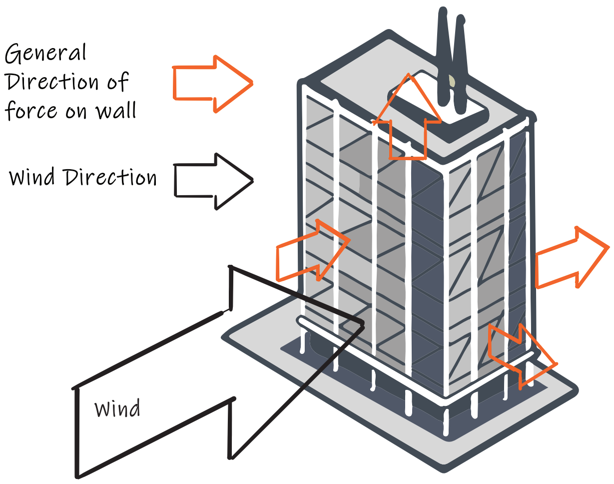


FIGURE A3.4(A) WIND EFFECTS ON A BUILDING

A3.4.1 DESIGN WIND PRESSURE

The design wind pressure for structures and parts of structures is calculated in accordance with AS/NZS1170.2 Equation 2.4.(1) using the project specific design wind speed as follows:

$$\rho = (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{shp}\ C_{dyn}$$

However, because the Rondo Wall and Ceiling systems herein are typically subjected to internal wind pressures and for external walls and soffits, in combination with external pressures, it is easier to address these specific design requirements in the relevant system sections that follow.

Accordingly, the wind pressure derivation herein shall be separated into (1) the basic wind pressure, (2) the aerodynamic shape factor (C_{shp}) and (3) the dynamic response factor (C_{dyn}).

A3.4.2 BASIC WIND ACTIONS

The characteristics of wind pressure on a structure and its elements are specific to that structure and are primarily a function of four main variables:

1. Building Importance Level.
2. Locality of the building.
3. The geometry of the structure under consideration.
4. Disturbance of the approaching wind.

These four primary inputs are used to determine the design wind speed for the site ($V_{des,\theta}$), which is used to calculate the basic wind pressure (ρ_u).

The basic wind pressure is calculated as follows:

$$\rho_u = (0.5\ \rho_{air})\ [V_{des,\theta}]^2$$

where;

ρ_u = basic design wind pressure in pascals

ρ_{air}= taken as 1.2kg/m^3 at sea level

$V_{des,\theta}$= design wind speed

The basic wind pressure does not consider the aerodynamic shape factor (C_{shp}) or the dynamic response factor (C_{dyn}) for the building.

The aerodynamic shape factor is discussed separately under the Internal and External Wind Pressure sections, as applicable.

A3.4 WIND ACTIONS

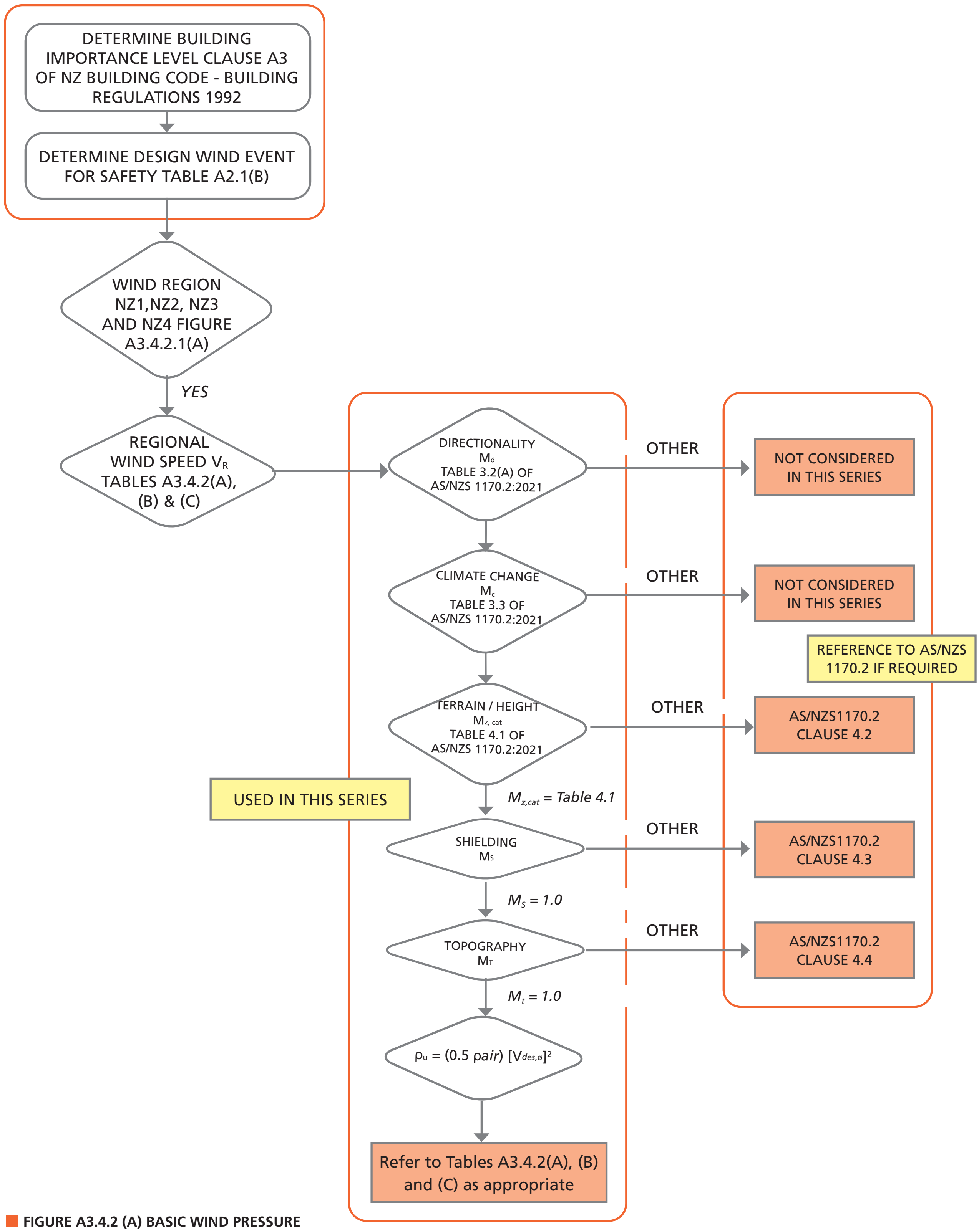


FIGURE A3.4.2 (A) BASIC WIND PRESSURE FLOW CHART

The above flow chart provides a means of checking which basic pressure design table should be used. These pressures are in Ultimate Limit State (ULS) format.

Tables A3.4.2(A), A3.4.2(B) and A3.4.2(C) on pages 9 and 10 provide the basic wind pressures for IL2 and IL3 buildings in Regions NZ1, NZ2, NZ3 and NZ4 across four terrain categories.

BASIC PRESSURE TABLES

TABLE A3.4.2(A): REGION NZ1 & NZ2 - BASIC WIND PRESSURES

REGION NZ1 & NZ2 - BASIC WIND PRESSURES (kPa)								
FLOOR HEIGHT	IMPORTANCE LEVEL 2				IMPORTANCE LEVEL 3			
	TERRAIN CATEGORY							
z (m)	1	2	2.5	3	1	2	2.5	3
10	1.417	1.215	1.028	0.837	1.481	1.270	1.075	0.875
20	1.579	1.417	1.239	1.074	1.650	1.481	1.295	1.122
30	1.692	1.524	1.365	1.215	1.768	1.593	1.427	1.270
40	1.779	1.635	1.470	1.314	1.859	1.708	1.536	1.373
50	1.838	1.692	1.551	1.391	1.921	1.768	1.621	1.454
60	1.886	1.738	1.596	1.444	1.971	1.816	1.667	1.508
70	1.935	1.785	1.641	1.497	2.022	1.865	1.714	1.564
80	1.984	1.820	1.680	1.546	2.074	1.902	1.756	1.615
90	2.034	1.844	1.715	1.590	2.126	1.927	1.792	1.662
100	2.085	1.868	1.750	1.635	2.179	1.952	1.828	1.708
110	2.117	1.886	1.773	1.663	2.212	1.971	1.853	1.738
120	2.149	1.905	1.797	1.692	2.246	1.990	1.877	1.768
130	2.182	1.923	1.820	1.721	2.280	2.009	1.902	1.798
140	2.214	1.941	1.844	1.750	2.314	2.028	1.927	1.828
150	2.247	1.960	1.868	1.779	2.348	2.048	1.952	1.859
160	2.267	1.972	1.886	1.797	2.369	2.061	1.971	1.877
170	2.287	1.984	1.905	1.814	2.390	2.074	1.990	1.896
180	2.307	1.997	1.923	1.832	2.411	2.087	2.009	1.915
190	2.327	2.009	1.941	1.850	2.432	2.100	2.028	1.933
200	2.348	2.022	1.960	1.868	2.453	2.113	2.048	1.952

TABLE A3.4.2(B): REGION NZ3 - BASIC WIND PRESSURES

REGION NZ3 - BASIC WIND PRESSURES (kPa)								
FLOOR HEIGHT	IMPORTANCE LEVEL 2				IMPORTANCE LEVEL 3			
	TERRAIN CATEGORY							
z (m)	1	2	2.5	3	1	2	2.5	3
10	1.966	1.685	1.427	1.161	2.041	1.750	1.481	1.205
20	2.190	1.966	1.719	1.489	2.274	2.041	1.785	1.546
30	2.347	2.114	1.894	1.685	2.436	2.195	1.966	1.750
40	2.468	2.268	2.039	1.823	2.562	2.354	2.117	1.892
50	2.550	2.347	2.152	1.930	2.647	2.436	2.234	2.003
60	2.617	2.411	2.213	2.002	2.716	2.503	2.298	2.079
70	2.684	2.476	2.276	2.077	2.786	2.570	2.362	2.156
80	2.753	2.525	2.331	2.144	2.858	2.621	2.420	2.226
90	2.822	2.558	2.379	2.206	2.930	2.656	2.469	2.290
100	2.892	2.591	2.427	2.268	3.002	2.690	2.519	2.354
110	2.937	2.617	2.459	2.307	3.049	2.716	2.553	2.395
120	2.981	2.642	2.492	2.347	3.095	2.743	2.587	2.436
130	3.026	2.667	2.525	2.387	3.142	2.769	2.621	2.478
140	3.072	2.693	2.558	2.427	3.189	2.795	2.656	2.519
150	3.117	2.718	2.591	2.468	3.236	2.822	2.690	2.562
160	3.145	2.736	2.617	2.492	3.265	2.840	2.716	2.587
170	3.173	2.753	2.642	2.517	3.293	2.858	2.743	2.613
180	3.200	2.770	2.667	2.542	3.322	2.876	2.769	2.638
190	3.228	2.787	2.693	2.566	3.351	2.893	2.795	2.664
200	3.256	2.805	2.718	2.591	3.380	2.912	2.822	2.690

TABLE A3.4.2(C): REGION NZ4 - BASIC WIND PRESSURES

REGION NZ4 - BASIC WIND PRESSURES (kPa)								
FLOOR HEIGHT	IMPORTANCE LEVEL 2				IMPORTANCE LEVEL 3			
	TERRAIN CATEGORY							
z (m)	1	2	2.5	3	1	2	2.5	3
10	1.750	1.500	1.270	1.033	1.750	1.500	1.270	1.033
20	1.949	1.750	1.530	1.325	1.949	1.750	1.530	1.325
30	2.089	1.882	1.685	1.500	2.089	1.882	1.685	1.500
40	2.196	2.018	1.815	1.622	2.196	2.018	1.815	1.622
50	2.269	2.089	1.915	1.717	2.269	2.089	1.915	1.717
60	2.329	2.146	1.970	1.782	2.329	2.146	1.970	1.782
70	2.389	2.203	2.025	1.848	2.389	2.203	2.025	1.848
80	2.450	2.247	2.074	1.909	2.450	2.247	2.074	1.909
90	2.512	2.277	2.117	1.963	2.512	2.277	2.117	1.963
100	2.574	2.306	2.160	2.018	2.574	2.306	2.160	2.018
110	2.614	2.329	2.189	2.053	2.614	2.329	2.189	2.053
120	2.653	2.351	2.218	2.089	2.653	2.351	2.218	2.089
130	2.693	2.374	2.247	2.124	2.693	2.374	2.247	2.124
140	2.734	2.397	2.277	2.160	2.734	2.397	2.277	2.160
150	2.774	2.419	2.306	2.196	2.774	2.419	2.306	2.196
160	2.799	2.435	2.329	2.218	2.799	2.435	2.329	2.218
170	2.824	2.450	2.351	2.240	2.824	2.450	2.351	2.240
180	2.848	2.465	2.374	2.262	2.848	2.465	2.374	2.262
190	2.873	2.481	2.397	2.284	2.873	2.481	2.397	2.284
200	2.898	2.496	2.419	2.306	2.898	2.496	2.419	2.306

NOTES TO TABLES:
1. For intermediate values of floor height and/or terrain category use linear interpolation.
2. Wind speed and Annual Probability of Exceedance in accordance with Tables A3.4.2.1(A) and A2.2(B) respectively.

Section 3.4.2.1 provides a commentary on the variables used to develop the basic wind pressure design tables.

3.4.2.1 DESIGN WIND SPEED ($V_{DES,\theta}$)

The building orthogonal design wind speed ($V_{des,\theta}$) is taken as the maximum site wind speed determined below.

SITE WIND SPEED ($V_{SIT,\beta}$)

The site wind speed is determined for the eight cardinal directions (N, NE, E, SE, S, SW, W, NW) as follows:

$(V_{sit,\beta}) = V_R\, M_c\, M_d\, (M_{z,cat}\, M_s\, M_t)$

Taking into consideration wind approaching from within a ±45^0 sector for each of the building orthogonal directions.

LOCALITY OF THE BUILDING (REGION)

New Zealand, also recently, has been split into four (4) primary wind classifications NZ1 to NZ4.

Regions NZ1 to NZ4 are all non-cyclonic.

REGIONAL WIND SPEED (V_R)

With reference to Table A3.4.2.1(A) below, the Regional Wind Speed (V_R) for regions NZ1 to NZ4 can be determined using the design wind event for safety based on the building importance level previously established.

TABLE A3.4.2.1(A): REGIONAL WIND SPEEDS

RETURN PERIOD V_R	REGIONAL WIND SPEED (m/s)		
	NZ (1 TO 2)	NZ3	NZ4
V_5	35	42	42
V_{10}	37	44	43
V_{25}	39	46	45
V_{500}	45	53	50
V_{1000}	46	54	50
V_{2500}	47	55	52

Refer to AS/NZS1170.2 Table 3.1(B) for alternative Average Recurrence Intervals and corresponding wind speeds.

GEOMETRY OF THE STRUCTURE
CLIMATE CHANGE FACTOR (M_C)

The climate change factor considers the affects in extreme wind events during the life of the structure. For Regions NZ1, NZ2, NZ3 and NZ4 the factor is 1.0.

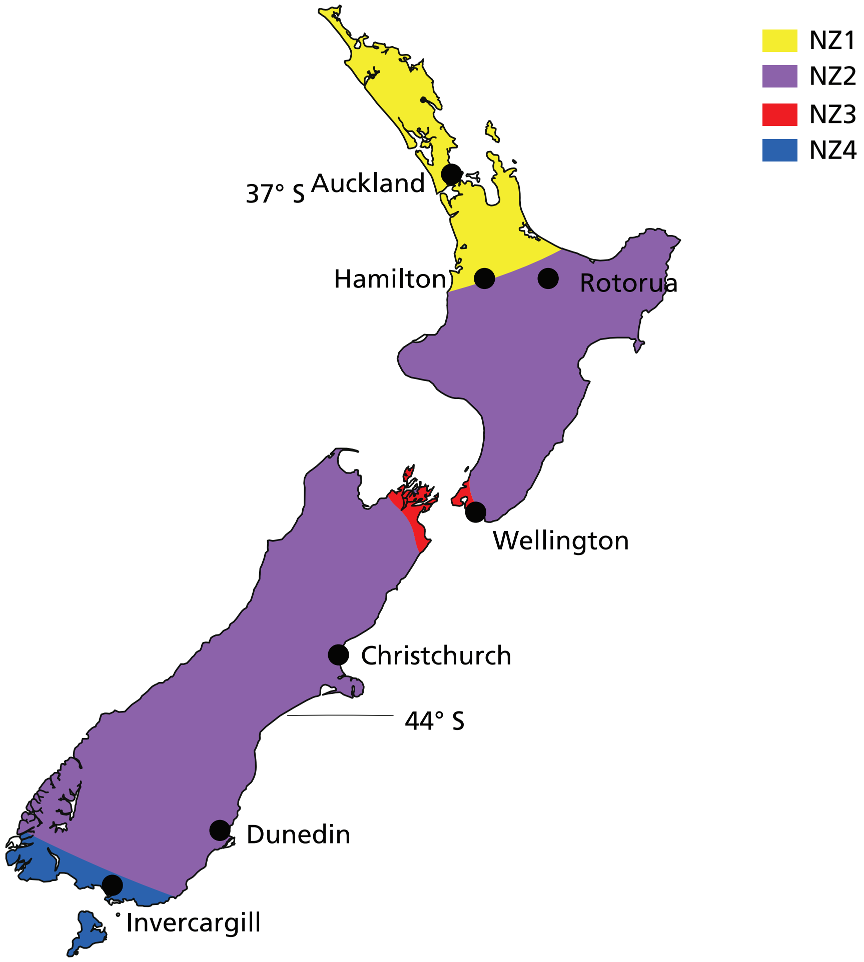


FIGURE A3.4.2.1(A): WIND REGIONS ACROSS NEW ZEALAND

DIRECTIONALITY (M_D)

In some instances, the regional wind speed may be reduced depending on the direction of the prevailing winds.

Rondo has used 1.0 for all of NZ Regions. Contact your Rondo representative if you wish to consider alternative wind directional factors.

TERRAIN / HEIGHT ($M_{Z,CAT}$)

The regional wind speed is adjusted up or down according to the Terrain Category (TC), over which the approach wind flows, and the reference height on the structure above the average local ground level (z), using the $M_{z,cat}$ multiplier.

TERRAIN CATEGORIES (TC)

The wind code considers four (4) primary terrain categories, and further allows for intermediate terrains to be linearly interpolated from the primaries.

The terrain categories range from 1 through to 4, with 1 being the most exposed and 4 presenting the roughest approach for the wind.

Refer to diagrams below for additional detail.

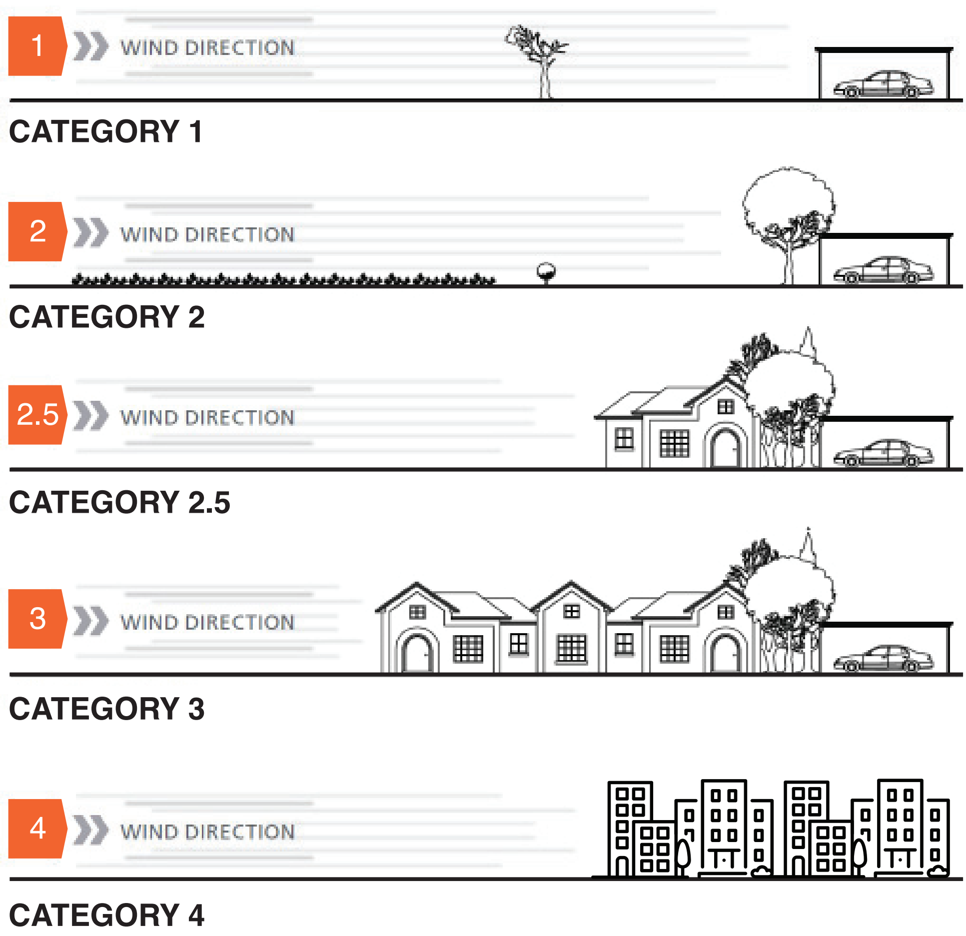


FIGURE A3.4.2.1(B): TERRAIN CATEGORIES

All design tables herein have been prepared assuming a fully developed upwind terrain category across the required averaging distance. Where the terrain category varies across the upwind averaging distance, reference shall be made to AS/NZS1170.2 Clause 4.2.3.

Refer to Figure A3.4.2.1(B) above for representations of the four primary and one intermediate terrain category.

This Professional Series considers Terrain Categories 1, 2, 2.5 and 3. For consideration of alternative Terrain Categories please contact your Rondo representative for a specific design.

SHIELDING (M_S)

The regional wind speed may be reduced depending on the disturbance of the approaching wind due to the surrounding buildings, using the shielding multiplier M_s as applicable.

Rondo uses 1.0 for this factor unless noted otherwise.

TOPOGRAPHY (M_T)

The regional wind speed may be increased depending on the elevation and/or topography of the surrounding area, using the multiplier (M_t) as appropriate.

It should be noted that using 1.0 for this can be unconservative in locations where the site is elevated, the terrain is undulating, steeped or escarpments and the like are present. For buildings over 500m above sea level please contact your Rondo for assistance. Notwithstanding the above, Rondo uses 1.0 for this factor unless noted otherwise.

REFERENCE HEIGHT (Z) AND AVERAGE ROOF HEIGHT (H)

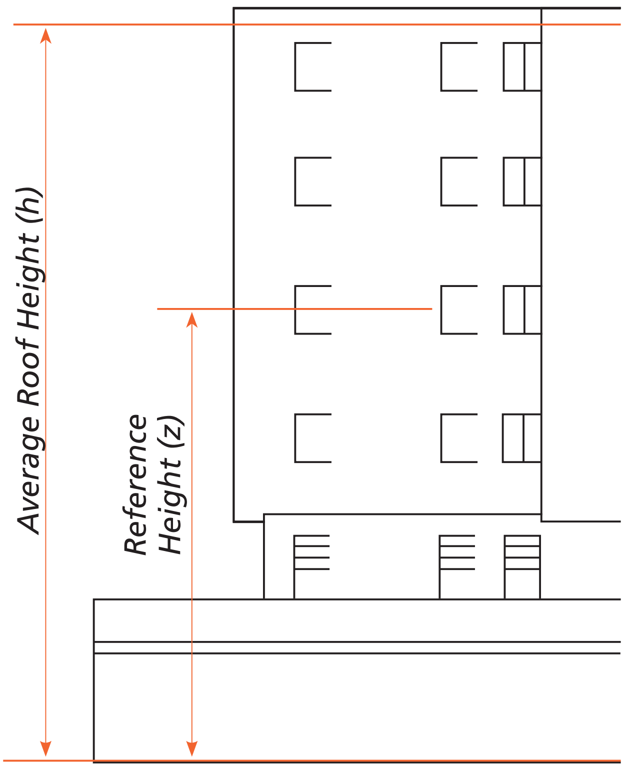


FIGURE A3.4.2.1(C): REFERENCE HEIGHT (z) AND AVERAGE ROOF HEIGHT (h)

The reference height, used in the determination of the design wind pressure, may vary according to the wind design scenario being considered.

Figure A3.4.2(A) provides a flow chart to allow the assessment of the building height to be used appropriate for the design scenario being considered.

where;

z - reference height on the structure above the average local ground level.

h - average roof height of the structure above ground level.

as depicted in Figure A3.4.2.1(C) on the left.

3.4.3 AERODYNAMIC SHAPE FACTOR (C_{SHP})

The aerodynamic shape factor (C_{shp}) shall be determined for the different Rondo systems and design scenarios as follows:

For internal Rondo systems, including walls, ceilings and bulkheads etc;

$C_{shp} = C_{p,i}\ K_{c,i}\ K_v$

$C_{p,i}$ = Internal pressure coefficient

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

K_v = Open area / volume factor for internal pressures

For external Rondo systems, including walls and soffit systems etc;

$C_{shp} = C_{p,e}\ K_a\ K_{c,e}\ K_l\ K_p$

$C_{p,e}$ = External pressure coefficient

K_a = Area reduction factor

$K_{c,e}$ = Combination factor for external pressures

K_l = Local pressure factor

K_p = Porous cladding reduction factor

The net design wind pressure for external walls will be the summation of the external wind pressure (p_e) and the internal wind pressure (p_i), calculated using the appropriate aerodynamic shape factor.

A3.4.3.1 INTERNAL PRESSURES

The net design internal wind pressure ($p_{i,u}$) can now be determined using the basic wind pressure (p_u) as follows:

$p_{i,u} = p_u C_{shp}$

$= p_u C_{p,i} K_{c,i} K_v$

INTERNAL PRESSURE COEFFICIENT ($C_{P,I}$)

The following flowchart provides an overview of the determination of the internal pressure coefficient ($C_{p,i}$) for some building types:

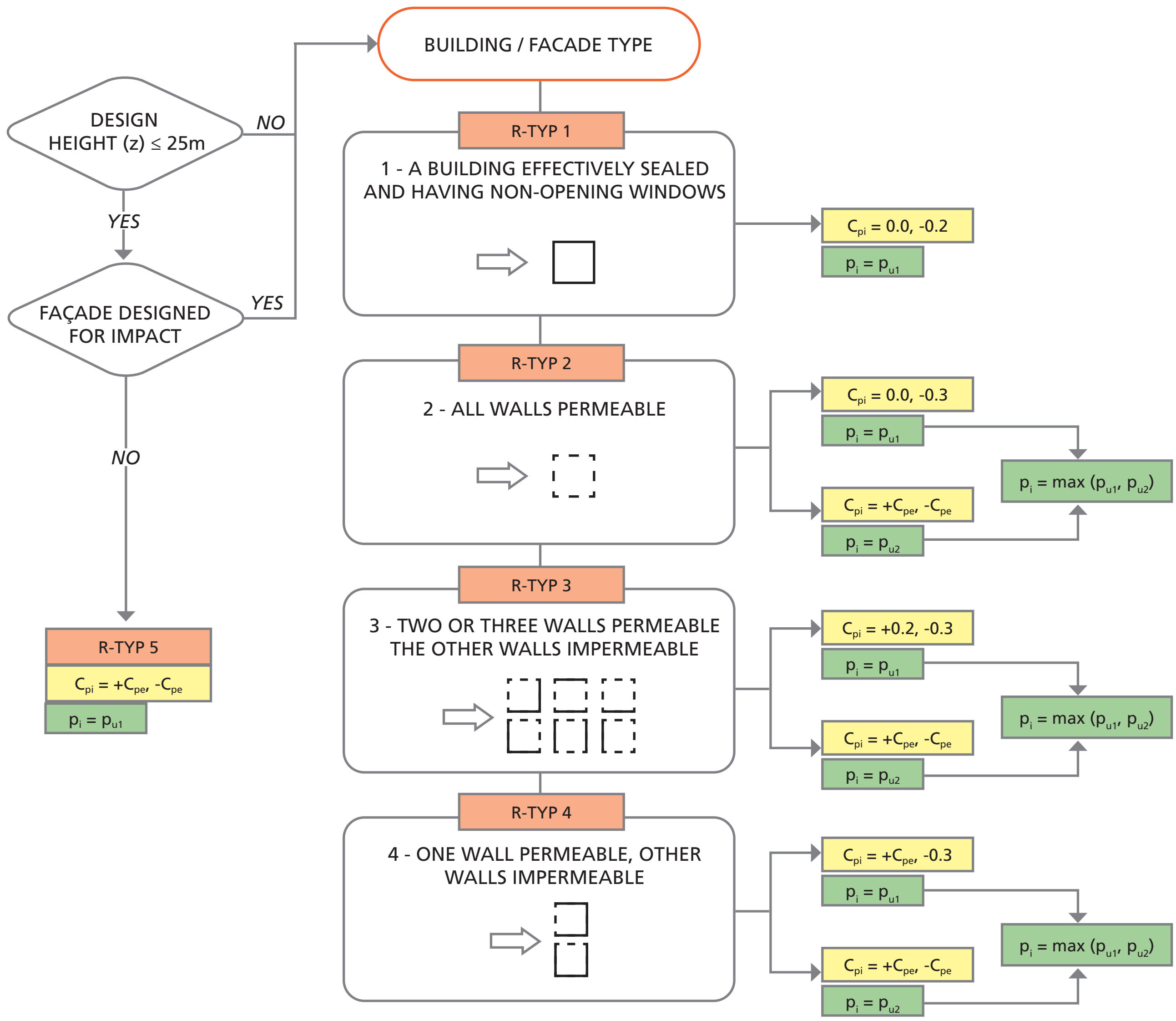


FIGURE A3.4.3.1(A): INTERNAL PRESSURE COEFFICIENT FLOWCHART

NOTES:

1. *C_{pi} values given in the yellow box are typically what Rondo would use in their design for this facade type.*
2. *The internal pressure shall be the larger, determined for either the facade leakage or opening case.*
3. *Internal pressure p_{u1} is calculated for a V_{500} or V_{1000} wind event (V_{500} for IL2 or V_{1000} for IL3 buildings) assuming the façade to be effectively sealed. This scenario correlates to the most severe wind event, for which the primary building structures have been designed to resist. For this case, it is assumed that operable windows and doors are closed.*
4. *Internal pressure p_{u2} is calculated for a V_1 wind event assuming a dominant opening has formed in the façade. This scenario correlates to a storm event where an operable window is left open. For this case the bounding sealed space walls are designed to contain the resulting internal pressurisation; such that adjacent spaces will not be adversely affected.*

The internal pressure coefficient ($C_{p,i}$) takes into consideration the façade permeability and or openings within the façade.

When considering façade permeability the C_{pi} value shall be determined in accordance with AS/NZS1170.2 Table 5.1(A). Some typical examples are shown below:

TABLE A3.4.3.1(A): FAÇADE LEAKAGE - INTERNAL PRESSURE COEFFICIENT $C_{p,i}$

CONDITION	$C_{p,i}$	EXAMPLE
ONE WALL PERMEABLE, OTHER WALLS IMPERMEABLE		
(a) Windward wall permeable	$C_{p,e}$	
(b) Windward wall impermeable	-0.3	
TWO OR THREE WALLS PERMEABLE		
(a) Windward wall permeable	-0.1 , 0.2	
(b) Windward wall impermeable	-0.3	
ALL WALLS PERMEABLE	-0.3 , 0.0	
A BUILDING EFFECTIVELY SEALED AND HAVING NON-OPENING WINDOWS	-0.2 , 0.0	

In the above table:

Impermeable means a surface having a ratio of total open area to total surface area less than 0.10%.

Permeable means a surface having a ratio of total open area to total surface area between 0.10-0.50%.

When considering openings within the façade the $C_{p,i}$ value shall be determined in accordance with AS/NZS1170.2 Table 5.1(B). Some typical examples are shown below:

TABLE A3.4.3.1(B): FAÇADE OPENINGS - INTERNAL PRESSURE COEFFICIENT $C_{p,i}$

RATIO OF AREA OF OPENINGS ON ONE SURFACE TO THE SUM OF THE TOTAL OPEN AREA (INCLUDING PERMEABILITY) OF OTHER WALL AND ROOF SURFACES	LARGEST OPENING ON WINDWARD WALL	LARGEST OPENING ON LEEWARD WALL	LARGEST OPENING ON SIDE WALL	LARGEST OPENING ON ROOF
0.5 or less	-0.3 , 0.0	-0.3, 0.0	-0.3, 0.0	-0.3, 0.0
1	-0.1 , 0.2	-0.3, 0.0	-0.3, 0.0	-0.3, 0.0
2	0.7 K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$
3	0.85 K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$
6 or more	K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$	K_a K_l $C_{p,e}$

Internal pressures and internal pressure coefficients on walls and ceilings are further discussed in the relevant Rondo systems.

AREA REDUCTION FACTOR (K_A)

In the determination of the internal pressures, the area reduction factor (K_a) refers to the total area of the opening(s) on the surface being considered and substituted as the tributary area (A) when using Table 5.4 in AS/NZS1170.2.

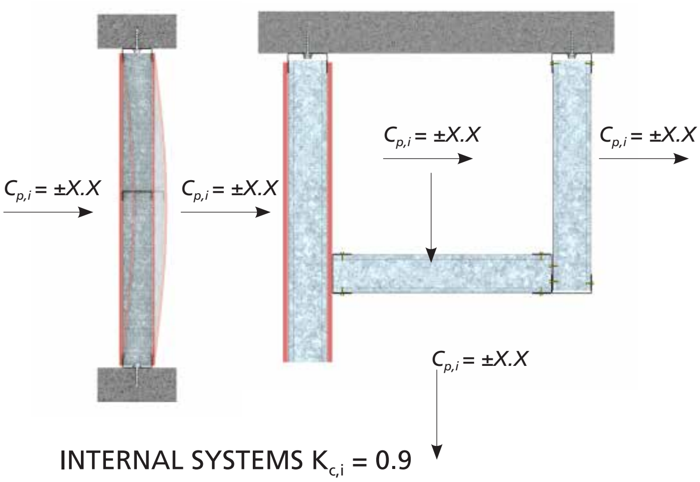
For the Rondo systems herein, the minimum tributary area would rarely be exceeded, and the Ka factor is always taken as 1.0 unless noted otherwise.

LOCAL PRESSURE FACTOR (K_l)

The local pressure factor (K_l) shall be based on the area and location of the opening on the surface being considered.

COMBINATION FACTOR $K_{C,I}$

Where the wind pressure acts on both faces of an internal wall, ceiling or bulkhead such that they contribute simultaneously to a structural action on the system, AS/NZS1170.2 allows the application of a reduction factor $K_{c,i}$ = 0.9, where the absolute value of C_{pi} is equal to or greater than 0.4.



INTERNAL SYSTEMS $K_{c,i}$ = 0.9

FIGURE A3.4.3.1(B): $K_{c,i}$ FOR INTERNAL SYSTEMS

For all other cases $K_{c,i}$ = 1.0

VOLUME FACTOR K_V

Where the ratio of the open area on one surface to the total open area on the other surfaces is six or more, then the open area / volume factor K_v can be considered in accordance with AS/NZS1170.2 Clause 5.3.4.

For the Rondo systems herein, the K_v factor is always taken as 1.0 unless noted otherwise.

A3.4.3.2 EXTERNAL PRESSURES

The net design external wind pressure ($p_{e,u}$) is determined using the basic wind pressure (p_u) as follows:

$p_{e,u} = p_u \, C_{p,e} \, K_a \, K_{c,e} \, K_l \, K_p$

EXTERNAL PRESSURE COEFFICIENTS $C_{P,E}$

The external pressure coefficient will vary depending on which part of the structure is being considered. The following provides an overview of some of the scenarios to be considered.

WINDWARD WALL

The external pressure coefficient on the windward walls varies according to the building height, and elevation. The table below provides a summary for rectangular enclosed buildings.

TABLE A3.4.3.2(A) EXTERNAL PRESSURE COEFFICIENT $C_{p,e}$

HEIGHT (h)	EXTERNAL PRESSURE COEFFICIENT ($C_{p,e}$)
> 25.0m	**0.8** when wind speed varies with height
≤ 25.0m	For building on ground – **0.8** when wind speed varies with height **0.7** when wind speed taken at z = h
	For elevated buildings – **0.8** wind speed taken at h

SIDE WALLS

The external pressure coefficient varies along the side wall according to the distance from the windward edge of the building and the overall building height. The table below provides a summary for rectangular enclosed buildings.

TABLE A3.4.3.2(B): SIDE WALL PRESSURE COEFFICIENTS

HORIZONTAL DISTANCE FROM WINDWARD EDGE	EXTERNAL PRESSURE COEFFICIENT ($C_{p,e}$)
0 to 1h	-0.65
1h to 2h	-0.50
2h to 3h	-0.30
> 3h	-0.20

It should be noted that when assessing the net design external wind pressure on side walls the basic pressure at the top of the building (z= h) shall be used.

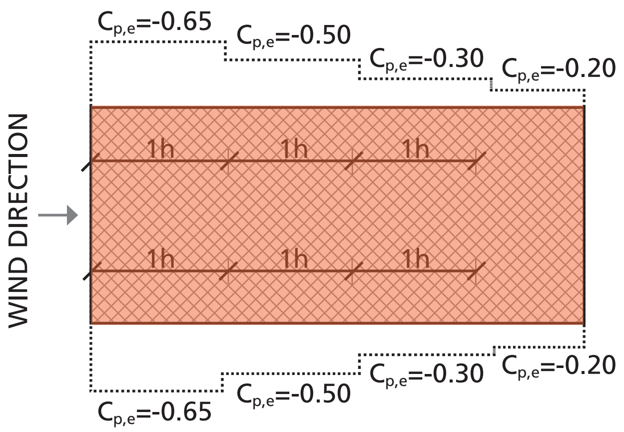


FIGURE A3.4.3.2(A): $C_{p,e}$ FOR SIDE WALLS

LEEWARD WALL

The leeward wall external pressure coefficient varies according to the roof pitch, roof profile and the building depth to breadth ratio. The table below provides a summary for rectangular enclosed buildings.

TABLE A3.4.3.2(C): LEEWARD WALL PRESSURE COEFFICIENTS

ROOF PITCH	d/b	EXTERNAL PRESSURE COEFFICIENT ($C_{p,e}$)
< 10°	≤ 1	-0.50
	2	-0.30
	≥ 4	-0.20

In the above table, wind direction is taken as 0 degrees and the roof shape may be either hip or gable ends.

d = building depth (m)

b = building breadth (m)

Typically, leeward wall pressures do not control the design of the Rondo stud framing, but still need to be checked.

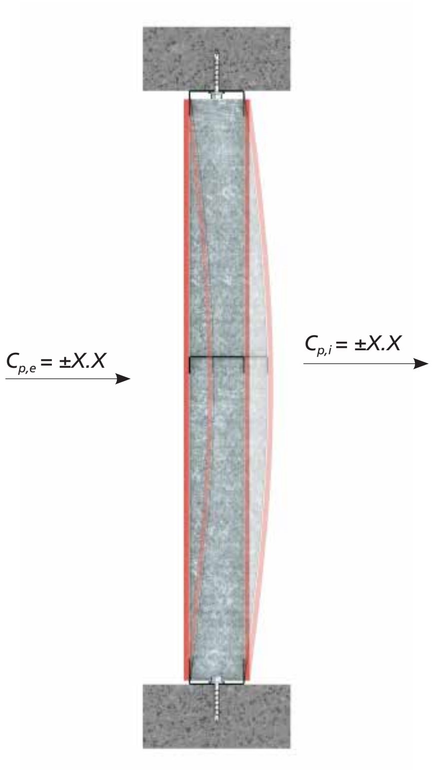
AREA REDUCTION FACTOR K_A

For roofs and sidewalls an area reduction factor may be applied when the wall tributary area supported by a single member exceeds 10m².

For the Rondo wall framing, this would rarely be exceeded, and the Ka factor is always taken as 1.0 unless noted otherwise.

COMBINATION FACTOR $K_{C,E}$

Where the wind pressure acts on both faces of the external wall, such that they contribute simultaneously to a structural action on the wall, AS/NZS1170.2 allows the application of a reduction factor $K_{c,e}$.



EXTERNAL WALL $K_{c,e}$ = 0.9

FIGURE A3.4.3.2(B): $K_{c,e}$ FOR EXTERNAL WALLS

For all other cases $K_{c,e}$ = 1.0

LOCAL PRESSURE FACTOR K_L

The local pressure factor applies to claddings, their fixings and the members and their fixings that directly support the cladding.

The local pressure zones (a) are dependent upon the building aspect ratio (r), both of which will vary depending on the geometrical properties breadth (b), depth (d) and height (h) of the building as follows:

Local pressure zone

a = minimum of [0.2b, 0.2d, h]

Building aspect ratio

r = h / minimum of [b, d]

Where;

h = average roof height of the building
b = breadth of the building
d = depth of the building

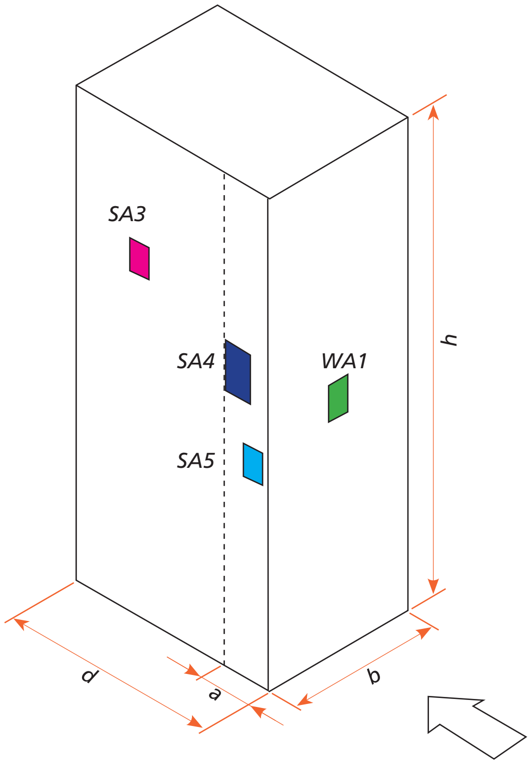


FIGURE A3.4.3.2(D): LOCAL PRESSURE ZONES - r > 1.0

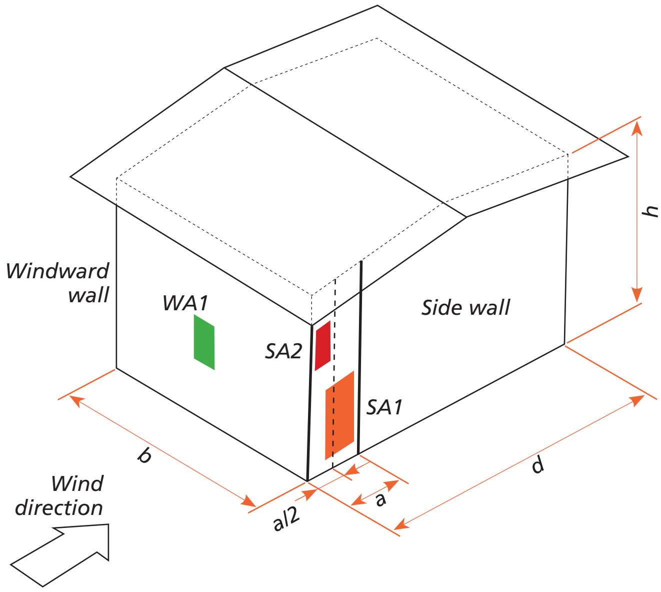


FIGURE A3.4.3.2(C): LOCAL PRESSURE ZONES - r ≤ 1.0

TABLE A3.4.3.2(D): WINDWARD WALL LOCAL PRESSURE ZONES

ZONE	BUILDING ASPECT RATIO (r)	AREA (A) m^2	PROXIMITY TO EDGE	K_l
WA1	All	$A \leq 0.25a^2$	Anywhere	1.5

TABLE A3.4.3.2(E): SIDE WALL LOCAL PRESSURE ZONES

ZONE	BUILDING ASPECT RATIO (r)	AREA (A) M^2	PROXIMITY TO EDGE	K_l
SA1	≤ 1	$A \leq a^2$	< a	1.5
SA2		$A \leq 0.25a^2$	< 0.5a	2.0
SA3	> 1	$A \leq 0.25a^2$	> a	1.5
SA4		$A \leq a^2$	< a	2.0
SA5		$A \leq 0.25a^2$	< 0.5a	3.0

For all other areas K_l has been taken as 1.

For rectangular buildings, the the negative limit of K_l $C_{p,e}$ shall be -3.0.

CLADDING PERMEABILITY FACTOR K_P

The cladding permeability reduction factor can be applied when porous or open claddings are utilised in the façade, for all other cases K_p shall be taken as 1.

Refer to AS/NZS1170.2 for the relevant permeability factor if applicable.

Rondo always utilises K_p = 1.0 unless noted otherwise.

External pressures and external pressure coefficients are further discussed in the relevant Rondo systems as applicable.

A3.4.4 DYNAMIC RESPONSE FACTOR (C_{DYN})

The dynamic response factor (C_{dyn}) considers the buildings response to the wind loading, which in some building forms, can magnify the wind effects.

In all design scenarios herein, the dynamic response factor has been taken as 1.0. Should your project need to consider a dynamic response factor other than 1.0 this should be discussed with your Rondo representative.

A3.4.5 SERVICEABILITY PRESSURES

In the previous sections the design pressures were calculated for the Ultimate Limit State (ULS), however these pressures need to be reduced when considering the Serviceability Limit State.

Unless noted otherwise, Rondo uses a V_{25} wind speed for serviceability checks.

The simple method is to pro-rata the ULS design pressures using the applicable Regional Wind Speeds as follows:

$$p_s = p_u \times (V_s / V_u)^2$$

Where;

p_S = serviceability limit state design pressure
p_U = ultimate limit state design pressure
V_S = serviceability limit state wind speed
V_U = ultimate limit state wind speed

Eg; for Region NZ1 IL2 buildings the service pressures correction factor will be as follows:

p_U = 1.00 kPa (as an example)
V_S = 39 m/s
V_U = 45 m/s

$$p_s = 1.0 \times (39 / 45)^2 = 0.751 \text{ kPa}$$

A3.4.6 ADJUSTED RETURN PERIOD

In the event that the basic design pressure needs to be adjusted for a different Return Period, such as large openings within the façade, the simple method is to pro-rata the original design pressures using the applicable Wind Speeds as follows:

$$p_r = p_u \times (V_2 / V_1)^2$$

Where;

p_r = pressure at revised return period R
p_U = original design pressure
V_2 = wind speed at revised return period R
V_1 = original wind speed

Eg; if you want to consider the wind pressure for an IL2 building in NZ1 (V_{500}), Terrain Cat 3 at a height of 150m, for a 10 year return period (V_{10}) then the calculation will be as follows:

p_U = 1.779 kPa (Table A3.4.2(A))
V_{500} = 45 m/s (Table A3.4.2.1(A))
V_{10} = 37 m/s (Table A3.4.2.1(A))

$$p_{10} = 1.779 \times (37 / 45)^2 = 1.203 \text{ kPa}$$

The basic wind pressure, for a 10 year return period is approximately 67% of the corresponding basic pressure for a 500 year return period.

A3.5 EARTHQUAKE ACTIONS

A3.5.1 INTRODUCTION

The objective of seismic design is to safeguard people from hazard or injury and to minimize damage by preventing failure of engineering systems when subjected to earthquake actions.

Earthquake actions for ceiling and wall systems shall be determined in accordance with the code NZS1170.5 for New Zealand. These actions are generated in the installed Rondo systems due to the inertial response of the building to the earthquake event.

Design actions on the installed Rondo systems are determined in accordance with Section 8 of the code. Earthquake actions will vary based on the following factors.

- Building Importance Level
- Location of the building
- Overall height of the building
- Soil type and conditions
- Height above ground level at which the ceiling or wall is attached to the structure
- Seismic mass (including weights of linings, insulation, service loads attached to and supported by ceiling/wall, lighting, ceiling restraint, etc.)
- Ductility of the parts and systems

According to section 8.1.1 of NZS 1170.5, every component of a structure, including permanent and non-structural elements, their connections, and any permanent services or equipment that the structure supports, must be built to withstand earthquakes.

A3.5.2 DESIGN PROCEDURE

Rondo wall and ceiling systems, including bulkheads and soffits, are considered non-structural parts or components and shall be designed in accordance with NZS 1170.5: Section 8.

The code allows for the earthquake actions on the parts to be determined using horizontal design actions (clause 8.5.1).

$$F_{ph} = [C_p(T_p)C_{ph}R_p]W_p \leq 3.60W_p$$

Where: $C_p(T_p) = C(0)C_{Hi}C_i(T_p)$

$C(0) = N(T,D)(R_s,R_u)zC_h(0)$

Where

$C_h(0)$ - Spectral Shape Factor
z - Hazard Factor
R_s, R_u - Return Period Factor
$N(T,D)$ - Near Fault Factor
$C(0)$ - Elastic Site Hazard Spectrum
C_{Hi} - Floor Height Coeffcient
$C_i(T_p)$ - Part Spectral Shape Factor
$C_p(T_p)$ - Design Response Coefficient for Parts
C_{ph} - Part Horizontal Design Coefficient
R_p - Part Risk Factor
W_p - Seismic Weight of the Parts in kN

Rondo recommends all connectors be independently assessed and designed as necessary in accordance with the relevant code provisions.

ANNUAL PROBABILITY OF EXCEEDANCE (APE)

In New Zealand, unless otherwise nominated, the annual probability of exceedance (APE) for the earthquake limit states shall be not less than that given in Table A2.1(B).

In accordance with the Earthquake Code NZS1170.5, there are two levels of Serviceability Limit State. The Serviceability Limit States (SLS1) are deemed to be satisfied for IL1, 2 and 3 structures designed in accordance with NZS1170.5 and the relevant material standards.

Serviceability Limit States SLS2 level is required for structures of Importance level 4. A special study is required to ensure the building remains serviceable for immediate use following an IL2 design event. These buildings require a more detailed design review, are not considered herein and should be discussed with your Rondo representative to arrange a specific design to be carried out.

RETURN PERIOD FACTOR (R_s OR R_u)

The limit state return period factor (R_s or R_u) shall be obtained from Table A3.5.2(A) by using the appropriate APE determined from Table A2.2(B).

TABLE A3.5.2(A): LIMIT STATE PROBABILITY FACTOR

ANNUAL PROBABILITY OF EXCEEDANCE (P)	RETURN PERIOD FACTOR (R_s OR R_u)
1:2500	1.80
1:2000	1.70
1:1000	1.30
1:500	1.00
1:250	0.75
1:100	0.50
1:50	0.35
1:25	0.25
1:20	0.20

HAZARD DESIGN FACTOR (Z)

The hazard design factor (Z) shall be taken from Table A3.5.2.(B) based on the location of the building.

TABLE A3.5.2(B): HAZARD DESIGN FACTOR

LOCATION	HAZARD DESIGN FACTOR (Z)
CAPITAL CITIES	
Wellington CBD	0.400
OTHER LOCALITIES	
Auckland	0.130
Cambridge	0.180
Christchurch	0.300
Dunedin	0.130
Hamilton	0.160
Hastings	0.390
Invercargill	0.170
Manukau City	0.130
Napier	0.380
Nelson	0.270
Palmerston	0.130
Palmerston North	0.380
Queenstown	0.320
Rotorua	0.240
Taupo	0.280
Tauranga	0.200
Wellington	0.400
Whangarei	0.100
Upper Hutt	0.420

If the location is not listed then it should be determined directly from NZS1170.5.

SITE SUB-SOIL CLASS

The site shall be assessed and assigned to the site sub-soil class it most closely resembles.

The site sub-soil is classified into one of five (5) types ranging from A (strong rock) through to E (very soft soil). The site sub-soil class should be nominated on the project structural notes or Geotechnical report.

The site sub-soil class, amongst other variables, will affect the earthquake design action.

In situations where the site sub-soil is not identified Rondo uses a C classification which results in a worst-case scenario.

SPECTRAL SHAPE FACTOR - $C_h(0)$

The spectral shape factor for parts and components is assessed using a period (T) of 0 seconds.

The spectral shape factor shall be determined using Table A3.5.2(C) for the appropriate site sub-soil class.

TABLE A3.5.2(C): SPECTRAL SHAPE FACTOR

SITE SUB-SOIL CLASS	SPECTRAL SHAPE FACTOR ($C_h(0)$)
A - Strong Rock	1.00
B - Rock	1.00
C - Shallow Soil	1.33
D - Deep or Soft Soil	1.12
E - Very Soft Soil	1.12

FLOOR HEIGHT COEFFICIENT (C_{Hi})

The floor height coefficient is used to vary the earthquake action up the height of the building and will vary from 1.0, when the part is attached to the structural base of the building, up to 3.0 when the part is attached between h_i>=0.2hn and the top of the building.

In this Series, C_{Hi} has conservatively been taken as 3.0 when h_i > 12m, unless noted otherwise.

The earthquake action can be reduced for a more detailed assessment at heights lower than 0.2hn using the following formula to calculate the actual floor height coefficient:

Where,

$C_{Hi} = \left(1 + \frac{h_i}{6}\right)$ for all $h_i < 12$ m

$C_{Hi} = \left(1 + 10\frac{h_i}{h_n}\right)$ for $h_i < 0.2h_n$

$C_{Hi} = 3.0$ for $h_i \geq 0.2h_n$

h_i = height at which the part is attached above the structural base of the structure, in metres

h_n = total height of the structure above the structural base, in metres

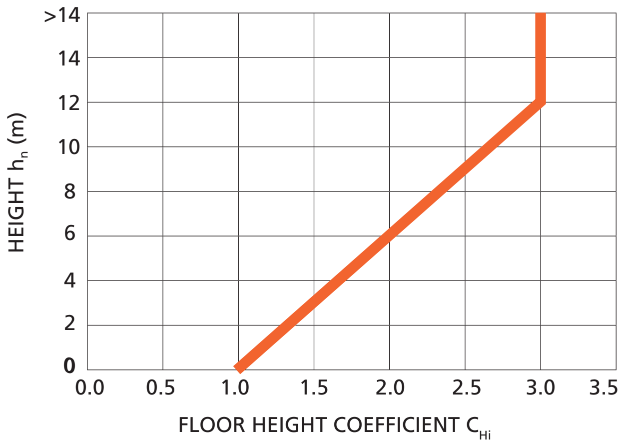


FIGURE A3.5.2(A) – FLOOR HEIGHT COEFFICIENT C_{Hi}

NEAR FAULT FACTOR N(T,D)

When a site is located within 20 kilometers of a major fault, the near fault factor is applicable.

Clauses 3.1.6.1 for annual probability of exceedance => 1/250 will require near fault factor, N(T,D) = 1.0.

Clause 3.1.6.2 for annual probability of exceedance < 1/250 shall use the equation.

$N(T,D) = N_{max}(T)$ — D < 2 km

$= 1 + (N_{max}(T) - 1)$ 20-D/18 — 2km < D < 20 km

$= 1$ — D > 20 km

TABLE A3.5.2(D): MAXIMUM NEAR-FAULT FACTORS

MAXIMUM NEAR-FAULT FACTORS	
PERIOD T UNIT - (S)	Nmax(T)
1.5	1.00
2.0	1.12
3.0	1.36
4.0	1.60
5.0	1.72

STRUCTURAL PERIOD OF VIBRATIONS $T(_S)$

The structural period of vibration is the translation period in seconds the building completes one cycle in the direction being considered. Clause C4.1 of NZS 1170.5 Supp. uses the following equations to calculate this.

$T = 1.0k_t h_{n0.75}$ for serviceability limit state

$T = 1.25k_t h_{n0.75}$ for ultimate limit state

Where $k_t = 0.085$

PART RISK FACTOR (R_P)

All parts of structures shall be classified into categories as per Table 8.1 of NZS 1170.5. Rondo wall and ceiling systems, including bulkheads and soffits, are considered category P.4 for ULS,P.7 for SLS1 and P.5 for SLS2.

R_P = 1.0 for ULS, SLS1 and SLS2

PART SPECTRAL SHAPE COEFFICIENT $C_i(T_P)$

The Spectral Shape Coefficient is a component in assessing the horizontal motion of the part with the period of that part, T_p. Section 8.4 of NZS1170.5 requires $C_i(T_p)$ as follows:

$C_i(T_p) = 2.0$ for $T_p \leq 0.75$ s

$= 0.5$ for $T_p \geq 1.5$ s

$= 2(1.75 - T_p)$ for $0.75 < T_p < 1.5$ s

PART RESPONSE FACTOR (C_{ph})

The part horizontal factor C_{ph} takes into consideration the amount of deformation the part can sustain before breaking, or as stated, the ductility.

The code requires C_{ph} be taken as follows.

= 1.0 for parts and connection

ELASTIC SITE HAZARD SPECTRUM C(0)

The elastic demand is expressed in C(0)
= $C_h(0)\ Z\ (R_s, R_u)\ N(T,D)$

DESIGN RESPONSE COEFFICIENT $C_p(T_p)$

The design response coefficient of a part supported at level i of a structure is determine as per clause 8.2 of NZS 1170.5, using the given
equation: $C_p(T_p) = C(0)\ C_{Hi}\ C_i(T_p)$

SEISMIC WEIGHT OF THE PART/COMPONENT (W_P)

The weight of the part (W_p) under earthquake actions shall include, but not necessarily limited to, the following:

(1) Self-weight of all applied linings and finishes plus the framing system itself.

(2) All light fixtures, speakers, smoke detectors, signage or similar directly supported by the component.

(3) Other services that are attached to, supported or restrained by the component.

(4) Insulation and the like.

(5) Additional imposed actions required to be considered in combination with an earthquake action.

The flowchart below can be used to calculate the horizontal earthquake action:

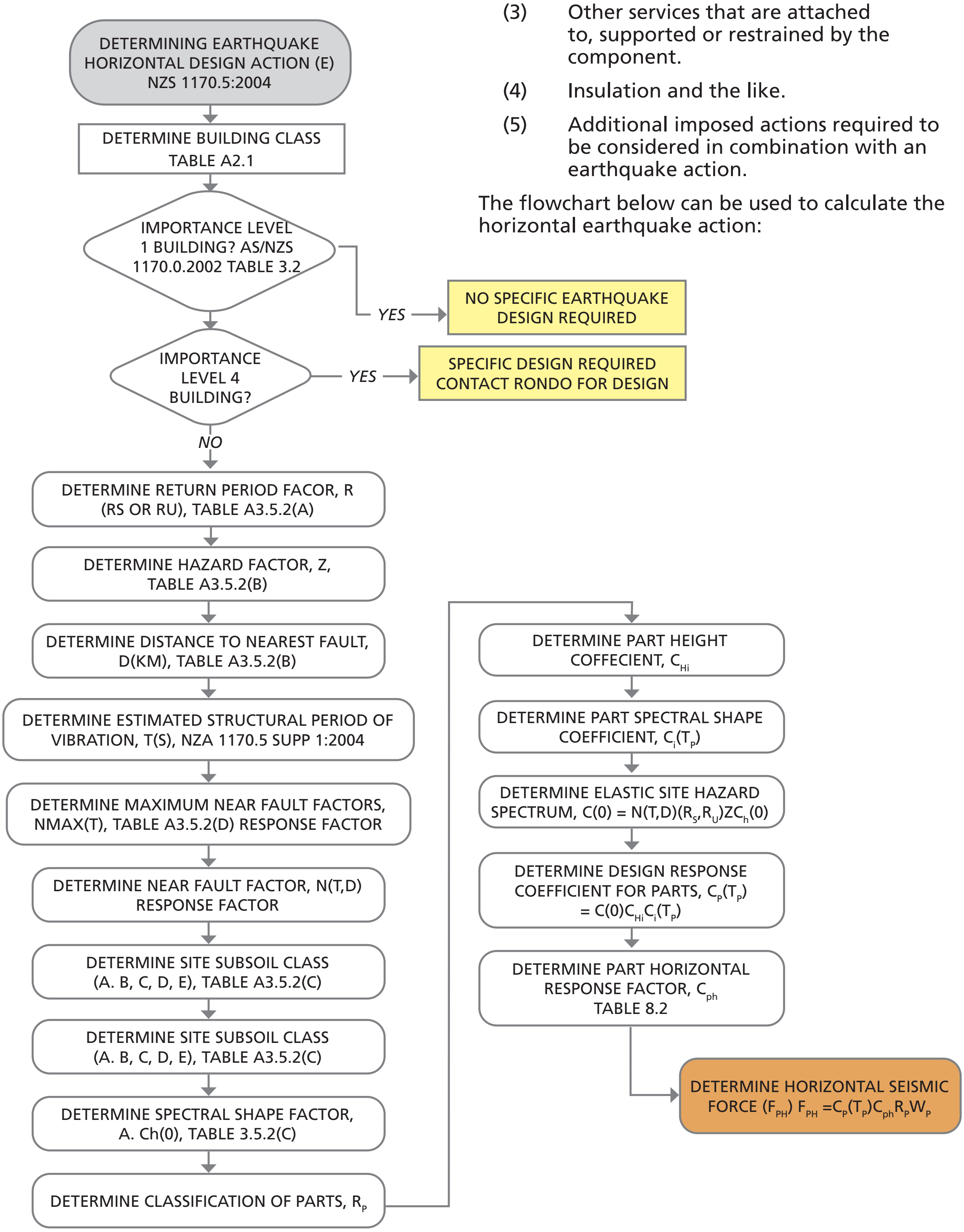


FIGURE A3.5.2(B): EARTHQUAKE ACTION (F_C)

Horizontal seismic action;

$$F_{ph} = C_P(T_P)C_{ph}R_PW_P$$

$$F_{ph}/W_P = C_P(T_P)C_{ph}R_P$$

Figure A3.5.2(C) provides a graphical representation of the Earthquake action F_{ph}/W_P vs Z for IL2 and 3 buildings, for hazard factors up to and including 0.60.

The earthquake action ranges from $0.80W_p$ up to $3.60W_p$.

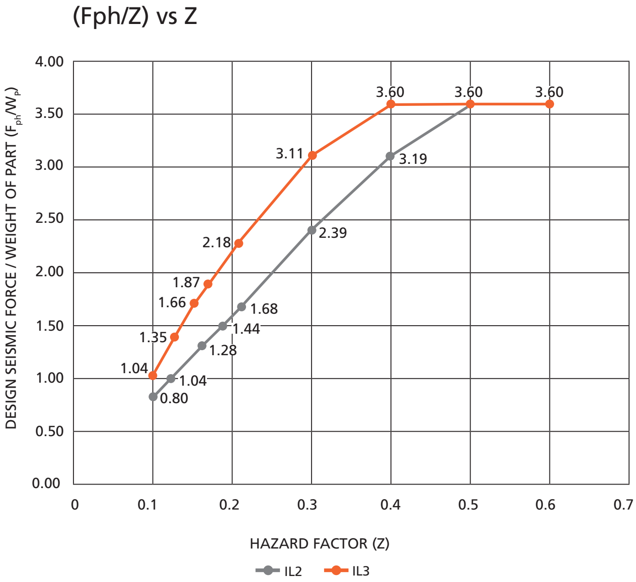


FIGURE A3.5.2(C): EARTHQUAKE ACTION - F_{ph}/W_P VS Z

NOTES:

1. *The graph has been prepared using Ch(0) = 1.33, assuming a site sub-soil class of C. For other site sub-soil classes the resulting seismic action (F_{ph}) may be proportioned accordingly using the spectral shape factor Ch(0) determined from Table A3.5.2(D) for the actual site conditions.*
2. *The graph has been prepared using C_{Hi} = 3.0, which is a worst case scenario where the component is installed at the top of the building. For components installed below the top of the building the resulting seismic action (F_{ph}) may be proportioned accordingly using actual height amplification factor determined from Figure A3.5.2(A) for the actual site conditions.*
3. *Figure A3.5.2(C) is not applicable for IL4 Buildings. Contact Rondo for a specific design for these buildings.*

A3.5.3 ATTACHMENTS OR MODIFICATIONS TO COMPONENTS

The earthquake action is applied through the centre of mass of the component. Accordingly, care should be taken that any design assumptions or simplifications made in interpreting the Series does not adversely affect the result.

The following are a few key points to consider:

- Adding or removing mass can shift the centre of mass and affect earthquake actions and effects, for example:
  - Overhead cupboards attached to a wall or floor mounted cupboards restrained by the wall
  - Adding decorative ceilings below an existing ceiling
  - Creating voids within a ceiling
- Partially lined walls will have a centre of mass in the lined wall section
- Irregular shaped ceilings should be seismically jointed to minimise torsional effects

A4 LOAD COMBINATIONS

In New Zealand, AS/NZS1170.0 provides the load combinations for the Ultimate and Serviceability Limit States and can be used as a means of demonstrating compliance with verification method B1/VM1 which in-turn achieves compliance to the performance requirements of clause B1 of the New Zealand Building Code.

Wall and ceiling systems must be designed to sustain the most critical load combinations for the Ultimate and Serviceability Limit States, as applicable.

A4.1 ULTIMATE LIMIT STATE

The following load combinations are used to determine the critical design action effect for the ultimate limit state condition:

Case 1: 1.35G

Case 2: [1.2G, 1.5Q]

Case 3: [1.2G, Wu, Ψ_cQ]

Case 4: [0.9G, Wu]

Case 5: [G, Eu, Ψ_EQ]

In addition to the consideration of the above Ultimate Limit State load combinations, Rondo follows the design procedure given in AS/NZS1170.0 Clause 2.2 as applicable.

A4.2 SERVICEABILITY LIMIT STATE

The following load combinations are used to determine the critical design action effect for the serviceability limit state condition:

Case 1: G

Case 2: Q

Case 3: Ws

Case 4: Es

The above does not preclude the possibility that other combinations may be required, in which case reference should be made to AS/NZS1170.0 as applicable.

Serviceability limit states are subjective and can vary depending on many different factors. The deflection limits are typically discussed in each of the Rondo systems as applicable.

Rondo generally designs in accordance with the guidelines provided in AS/NZS1170.0 Appendix C.

A4.3 WORKED EXAMPLE

Consider the building below, having a couple of storeys of commercial with 14 storeys of residential apartments over. In the following example we will establish the basic wind pressures and seismic actions applicable for Level 17. 13mm plasterboard will be assumed for all wall and ceiling linings.

Project Location:	Auckland
Importance Level:	2
Terrain Category:	3
Breadth:	51.3m
Depth:	25.0m
Height:	70.0m

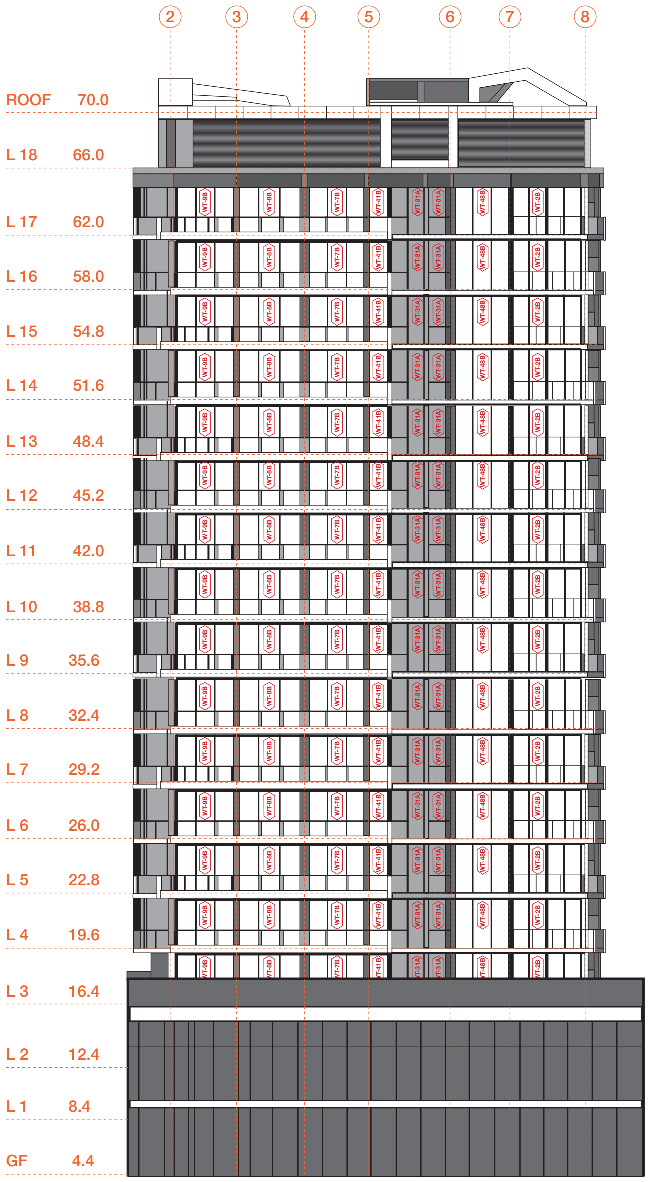


FIGURE A4.3(A): BUILDING ELEVATION

STEP 1: DETERMINE THE DESIGN EVENTS FOR SAFETY

Refer to Table A2.1(B):

Building is IL2, Auckland is non-cyclonic and snow load is not applicable, then:

IL	DESIGN EVENTS FOR SAFETY	
	WIND	EARTHQUAKE
2	1:500	1:500

STEP 2: BASIC WIND PRESSURES (P_U)

Figure A3.4.2.1(A) – Auckland is Region NZ1

Refer to Table A3.4.2(A)

Importance Level 2

Terrain Category 3

REGION NZ1 Basic wind pressures (kPa)				
FLOOR HEIGHT	IMPORTANCE LEVEL 2			
	TERRAIN CATEGORY			
z (m)	1	2	2.5	3
10	1.417	1.215	1.028	0.837
20	1.579	1.417	1.239	1.074
30	1.692	1.524	1.365	1.215
40	1.779	1.635	1.47	1.314
50	1.838	1.692	1.551	1.391
60	1.886	1.738	1.596	1.444
70	1.935	1.785	1.641	1.497
80	1.984	1.82	1.68	1.546

Level 17 is about 62m above ground level. Approximate basic pressure:

60m = 1.45kPa

62m: p_u = 1.46kPa

70m = 1.50kPa

Using linear interpolation, between the 60 and 70m heights, the basic pressure (p_u) for Level 17 can be found to be approximately 1.46kPa.

Similarly, the basic pressure can be determined for other levels of the building as necessary.

This basic pressure can now be used to determine the internal and external design pressures to be used in the design of the various Rondo wall and ceiling systems, with reference to the applicable sections in this Professorial Series.

STEP 3: SERVICABILITY PRESSURES (P_S)

The serviceability limit state basic pressures can be determined by proportioning the ultimate limit state pressures above.

Refer to Table A3.4.2.1(A)

V_{25} = 39 m/s

V_{500} = 45 m/s

Reduction factor = $(39 / 45)^2$

= 0.751

p_s = 1.46 x 0.751

= 1.096 kPa

The seismic design parameters can now be determined.

STEP 4: DETERMINE THE HAZARD DESIGN FACTOR (Z)

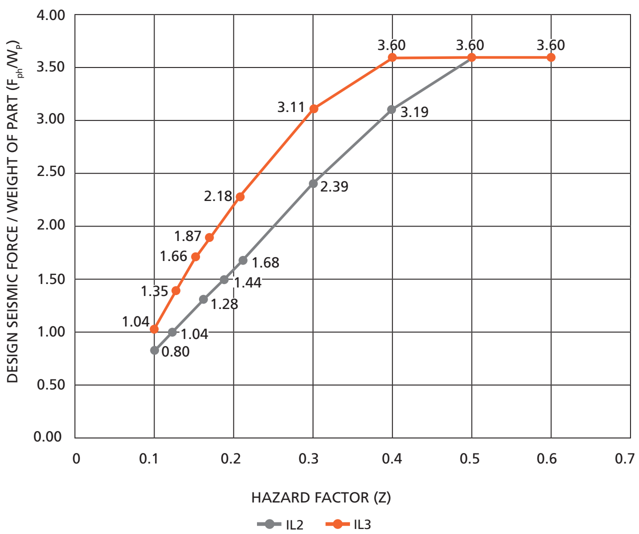
Refer to Table A3.5.2(B), for Auckland, the hazard factor can be read as Z = 0.13.

STEP 5: DETERMINE THE DESIGN SEISMIC ACTION (F_{ph})

Refer to Figure A3.5.2(C)

Using the horizontal axis and Z = 0.13, strike a vertical line until it crosses the IL2 graph (grey). Where the two lines meet, strike a horizontal line across the left axis and the design earthquake action can be read:

(Fph/Z) vs Z



$F_{ph}/W_p = 1.04$

Or, the horizontal earthquake action (F_{ph}) can be written as :

$F_{ph} = 1.04W_p$ (Part)

In addition, the other variables used to develop the design graph should be assessed for the specific site as follows:

Site sub-soil class = C

Refer to Table A3.5.2(C)

Floor Height Coefficient $C_{Hi} = 3.0$

Refer to Figure A3.5.2(A)

Part Return Period Factor $R_s/R_u = 1.0$ Increase design actions by 1.8 for life safety critical components and all components in IL4 Buildings.

Assuming a component weight (ie; wall system) of $W_c = 20kg/m^2$ then the wall framing would be designed for a seismic action of:

$F_{ph} = 1.04 \times 20 = 20.8kg/m^2$

A5 INSTALLATION

A5.1 CONNECTIONS

Connections for seismic actions shall be designed using ductility factor of up = 1.0 for non-ductile connections in accordance with NZS 1170.5 clause 8.7.1.

Where a connection to the primary structure is shown, or indicated by design actions, the connection has been checked based on the following assumptions:

A5.1.1 TO CONCRETE:

All concrete shall comply with the requirements of NZS 3101, as applicable.

Grade: f'c = 32MPa minimum

Min edge distance to fasteners:

In Wall Tracks: 45mm for single 6 or 8mm anchor
40mm for double 6 or 8mm anchor

Wall Brackets: for 8mm anchors
60mm for #201 and #203
110mm for #205 and #207

Top hats and cleats: 45mm for single 6 or 8mm anchor

Ceiling suspension: 60mm

Min spacing between fasteners:

6mm anchor	100mm
8mm anchor	100mm

A5.1.2 TO STRUCTURAL STEEL

All structural steel shall comply with NZS3404 as applicable.

C350 Hollow sections   min 3mm thick
Grade 250 hot rolled   min 3.5mm thick

Self-drilling (SD) screws shall comply with the following:
AS3566.1 Self-drilling screws for the building and construction industries.

Coating shall be:
- Class 3 minimum for interiors
- Class 4 for wall cavities or protected exteriors

Do not use Stainless Steel screws in direct contact with Rondo zinc coated products.

All SD screws which are stripped or damaged during installation shall be replaced.

Minimum distances for fasteners:

Edge distance: greater than 1.5d_f from the centre of the screw to the edge of any part

End distance: per Table A5.1.2(B) below from the centre of the screw to the open end of any part, measured in the line of action

Spacing: 3d_f or greater

Where;
d_f is the nominal screw diameter per Table A5.1.2(A) below

TABLE A5.1.2(A): NOMINAL FASTENER DIAMETER

SCREW GAUGE	NOMINAL FASTENER DIAMETER d_f (mm)
#8	4.20
#10	4.80
#12	5.40

No screw fastener diameter (d_f) shall be less than 3.0mm, nor greater than 7.0mm.

The end distance of the connected part, in the line of the applied action, is not to be less than the following:

TABLE A5.1.2(B): END DISTANCE

SCREW GAUGE	PART THICKNESS (mm)	END DISTANCE (mm)
#8 - #12	≤ 0.55bmt	15
#8 - #12	> 0.55bmt	10

NOTES:
1. *When using two different thickness parts, use the greater end distance of the two thicknesses.*
2. *The above table is not applicable for other than G2 grade steel.*

Drill point fasteners are not to be used where the steel base metal thickness is less than 0.75mm.

Screw length shall be sufficient to ensure minimum 3 full threads penetration.

Screw quality can vary significantly, which can also impact design requirements. Accordingly, Rondo recommends the use of reputable brands with consistent quality.

The design shear capacity, in Newtons, shall not exceed the values given in Table A5.1.2(C) unless specifically designed otherwise:

TABLE A5.1.2(C): SCREW SHEAR CAPACITY ØV_v (N)

SCREW GAUGE	d_f	Base Metal Thickness t_1 & t_2			
		0.5	0.55	0.75	1.15
#8	4.2	502	579	922	1751
#10	4.8	537	619	986	1872
#12	5.4	569	657	1046	1986

The design tensile capacity in a joint, in Newtons and considering both pullout and pullover, shall not exceed the values given in Table A5.1.2(D) unless specifically designed otherwise:

TABLE A5.1.2(D): SCREW PULLOUT/PULLOVER ØN$_t$ (N)

SCREW GAUGE	d_f	Base Metal Thickness tmin			
		0.5	0.55	0.75	1.15
#8	4.2	295	324	442	677
#10	4.8	337	370	505	774
#12	5.4	379	417	568	871

Where;

d_w the screw head diameter or washer, shall not be less than 8mm.

Combined shear and tension actions on screwed connections shall be independently checked in accordance with AS/NZS4600.

A5.1.3 TO STRUCTURAL TIMBER

All timber grades shall comply to AS/NZS 1748, including timber species, strength groups and joint groups.

Type 17 self-drilling (SD) screws shall comply with AS3566.1 Self-drilling screws for the building and construction industries.

Coating shall be:

- Class 3 minimum for interiors
- Class 4 for wall cavities or protected exteriors

Do not use Stainless Steel screws in direct contact with Rondo zinc coated products.

All SD screws which are stripped or damaged during installation shall be replaced.

Minimum distances for fasteners into timber:

Edge distance: greater than 5d_f from the centre of the screw to the edge of the timber

End distance: 10d_f from the centre of the screw to the cut end of the timber

Spacing: 3d_f across the timber grain
10d_f along the timber grain

Where;

d_f is the nominal screw diameter per Table A5.1.2(A) above

Where a minimum embedment depth is specified, tapered ends are not to be included in the embedment depth.

Refer to Section A6.5.2 Materials for additional considerations when fixing to Structural Timbers.

A5.1.4 WELDING OF COATED STEEL

Light gauge cold formed coated steel can be welded using an arc or resistance welding process.

Arc welding shall be in accordance with AS/NZS1554.7 for parts less than 3mm thick or 2.5mm if fillet welding is employed.

Resistance welding shall be in accordance with AWS C1.1 or AWS C1.3 as appropriate.

APPLICATIONS

Welding is an ideal connection method for prefabricated wall framing and connections, particularly where they need to be transported long distances.

The suitability of the application should be assessed prior to fabrication.

WELDING PROCESS

Selecting the correct welding method will depend on many factors, not the least of which is available resources. The two most popular methods, MIG (Metal Inert Gas) and TIG (Tungsten Inert Gas) are suitable for thin gauge steel, and can produce high quality welds with minimal risk of defects and melt through of the base metal.

The selection of the filler rod should be based on, but not limited to, the weld strength and the application in which it is to be used.

When welding sections of two different gauges, care is required to ensure the weld is evenly distributed, and melt through of the thinner section is prevented.

WELD QUALITY

The galvanised coating applied to the steel does not affect the weld properties, although it can cause greater weld spatter than would occur with plain mild steel. The weld spatter can be controlled, somewhat, by use of different gases, and adhesion of weld spatter to the gun nozzle can be controlled by use of spatter release compounds.

Weld porosity can occur in galvanised steel, and complete elimination is not possible. Consideration of the weld strength, fatigue and cracking should therefore be considered.

COATING REPAIRS

Rondo recommends all welded areas, including heat affected zones, be repaired after welding.

In the first instance, the affected area should be wire brushed to remove any loose or flaking coating. Thereafter, the affected area may be painted with zinc rich paint. Rondo recommends all work be completed in accordance with AS/NZS4680.

ENVIRONMENTAL CONSIDERATIONS

The galvanised coating has a relatively low melting point when compared to the base steel. During the welding process, as the galvanising is burnt off, it gives off a visible white zinc oxide fume.

Although the welding fume is not toxic, provision for adequate ventilation, air circulation and respiratory and other protection of personnel should be undertaken in accordance with the relevant statutory and WH&S requirements.

WELD DESIGN

AS/NZS4600 provides design methods for various weld types and load conditions. Where the provisions of the above code are insufficient for design purposes, testing of prototypes is available in accordance with the same standard.

A5.2 LININGS

The Rondo systems throughout this Professional Series are typically designed with plasterboard linings, assuming a homogeneous and continuous membrane. Rondo partners with GIB in the design, testing and development of integrated wall and ceiling systems using Rondo steel framing with their linings.

Although the Rondo systems can be designed to support any lining, care should be taken when using the design tables herein with other than plasterboard linings and Rondo recommends discussing these situations with your Rondo technical representative.

Refer to the specific Rondo System section for further consideration of the linings to those systems.

A5.2.1 ACOUSTIC AND FIRE-RATED CONSTRUCTION

Acoustic and fire performance of the wall and ceilings is a specialist function and relies on the individual elements of the system to achieve the overall system performance.

Accordingly, the lining manufacturer, such as our partner GIB, shall confirm the acoustic and / or fire-rating performance of the systems herein.

A5.2.2 JOINTS

CONTROL JOINTS

Control joints are installed in the framing and linings to relieve stresses resulting from changes in ambient temperature, humidity or differential building movements. Generally, control joints should be placed in the following scenarios:

1. In large continuous internal plasterboard lined areas, control joints should be installed at not more than 12m centers in any direction.
2. In external applications as per plasterboard manufacturers recommendations, or internal areas which are not conditioned, control joint spacing shall be independently assessed for the actual site conditions.
3. At changes in wall heights, where the change in height is greater than 30% of

the lower wall height.

4 At corridor junctions with large open area ceilings, when there is no bulkhead or other means of disconnecting the two ceiling areas.

5 At all locations where the framing configuration changes (ie; across a column where the wall framing changes from studs to direct fix furring channels) or the lining changes etc.

6 At all locations coinciding with control joints in the supporting structure.

As control joints are an aesthetic consideration, the designer should specify the location of such joints based on the project requirements.

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 system as standard control joints or seismic joints are unable to accommodate the required movements.

Refer to Rondo for design clarification.

A5.3 CEILING AND PARTITION INTERACTIONS

A5.3.1 GENERAL

Ductwork, cable trays, mechanical plant, pipework, electrical conduits and the like shall be independently supported from the primary structure.

Wall and ceiling bracing should be coordinated with the services for an effective solution, and to maintain minimum clearances as specified herein.

No service that has rotating or moving parts shall be attached to the wall or ceiling systems, including ceiling fans.

Clear distances between the wall and ceiling systems shall be maintained in accordance with AS/NZS 2785:2020 (Suspended Ceilings-Design and Installation) as applicable. Where this is not applicable reference can be taken from NZS4219 and the table below:

TABLE A5.3.1(A): CLEARANCES TO CEILINGS AND WALLS

CONDITION BEING CONSIDERED	MINIMUM CLEARANCE (mm)	
	HORIZONTAL	VERTICAL
Unrestrained ceiling to wall	250	50
Restrained wall to unrestrained service, or vice versa	150	50
Restrained wall to restrained service	50	50
Penetrations through structure (such walls and floors)	50	50

NOTES:
1. *Ceiling hangers and bracing shall be assessed as restrained components, with respect to the table above.*
2. *Penetration clearances may be lowered with flexible connections within the service.*

A5.3.2 PARTITIONS

Partitions shall not be connected to the underside of any ceiling unless specifically designed.

Where low height partitions are required to restrain the ceiling, the partition shall be suitably braced to the primary structure and shall consider the ceiling seismic action in addition to the partition seismic action.

The partitions maximum height tables in series C2 have been designed to provide lateral restraint to the ceilings and have been checked for a horizontal

seismic action that can be calculated using the maximum ceiling length and F_{ph}/W_p as per table C2.4.2.1(C2).

This action is in addition to the seismic action resulting from the self-weight of the partition and equates to:

a. Total ceiling weight (≤10.50 kg/m²), including linings, framing + insulation

b. $F_{ph}/W_p \leq 0.8, 1.0, 1.3, 2.0$ & 3.6

c. Maximum length of ceiling restrained by the wall with reference to Table C2.4.2.1(C2)

d. Ceiling height is within the limits nominated below.

Where ceilings are restrained by the partitions:

- Refer to Maximum Wall Height Table Notes in series C2 for adopted ceiling height
- Where the ceilings are fixed to both sides of the same partition, in addition to the above limits, the sum of the ceiling lengths either side of the wall shall not exceed the maximum ceiling length as provided in Table C2.4.2.1(C2)
- Where the ceiling configuration is outside the above limits refer to Rondo for clarification

Where the actual ceiling lengths or weight differ to that nominated above, proportionality may be used provided the ceiling installation is consistent with the above.

Walls unlined at the head track may not achieve the above seismic action limits. This design scenario has not been considered in this Series and should be referred to Rondo for a specific design.

A5.3.3 CEILINGS

Ceilings shall be installed strictly in accordance with their design details.

Reorientating the ceiling grid can render the ceiling design null and void, and therefore should not be done unless approved by the ceiling designer.

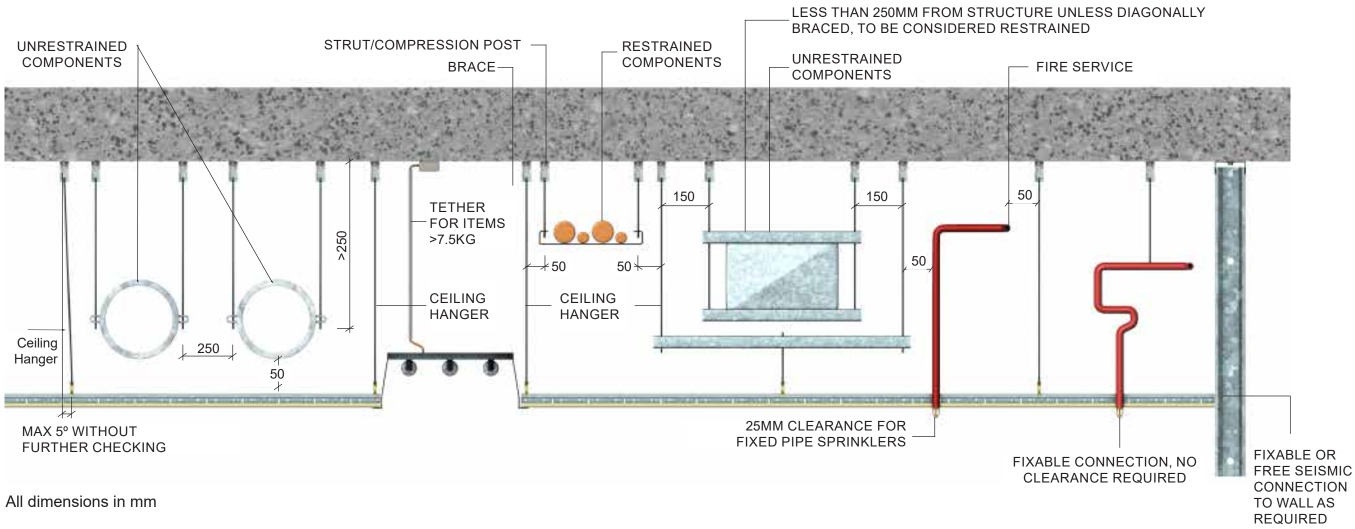


FIGURE A5.3.1(A) CLEARANCES TO CEILING AND WALLS

A6 OTHER CONSIDERATIONS

A6.1 BUILDING MOVEMENT ALLOWANCE

A6.1.1 INTER-STOREY DRIFT

Inter-storey drift is the differential horizontal deflections between two consecutive floors in a building. Refer to Figure A6.1.1(A) for inter-storey drift details.

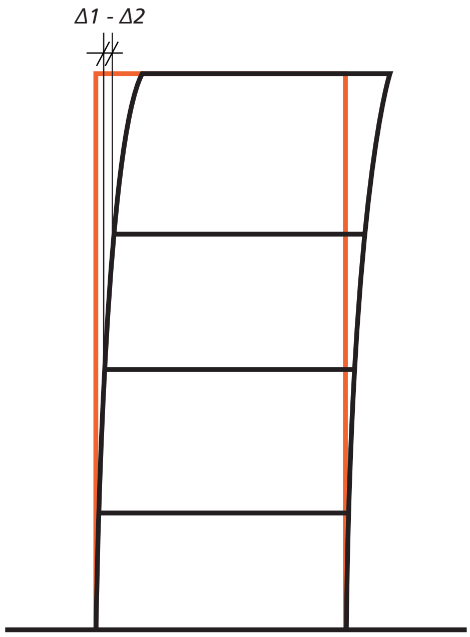


FIGURE A6.1.1(A): INTER-STOREY DRIFT

For the ULS condition, in New Zealand, the earthquake code NZS1170.5 allows 2.5% of the storey height for inter-storey drift deflection. This equates to 25mm for every 1m of storey height.

Damage to the partitions and ceiling systems, at this ULS condition is expected, however, collapse or loss of stability shall not occur.

SLS 1 and SLS 2

Importance Level 4 buildings require a special study to be undertaken to demonstrate that the non-structural parts and components required to remain operational following the SLS event do so, whilst also satisfying the ULS requirements. IL4 buildings are not considered in this Professional Series and require a specific design.

Notwithstanding this, Rondo recommends the serviceability requirements of their wall and ceiling systems be considered at a serviceability drift limit of H/500. This drift limit aligns with the serviceability drift limits given in NZ3101 Concrete Structures Code.

At the SLS condition, some damage can be expected and this should be nominated in the contract documents. Rondo typically limits the damage to patch and paint limits depending on the building element being considered.

Building movement reports are a great source of relevant information and allows the partition abutments to be assessed for the expected building movements, as required.

A6.1.2 VERTICAL DEFLECTION LIMITS

Unless noted otherwise, the following vertical building movement allowances have been assumed:

TABLE A6.1.2(A) – VERTICAL MOVEMENT ALLOWANCES

COMPONENT	PHENOMENON CONSIDERED	LIMIT
Floor beams and slabs	Incremental slab deflection	The lesser of: L/500 or 15mm
Column shortening	Long term	0.5mm / m height
Metal deck roof	Roof uplift	15mm maximum
	Roof downward deflection	5mm maximum

Where the vertical building movement is expected to exceed the above limits refer to Rondo for further clarification and consideration.

A6.1.3 HORIZONTAL DEFLECTION LIMITS

Unless noted otherwise, the following horizontal building movement allowances have been assumed:

TABLE A6.1.3(A) – HORIZONTAL MOVEMENT ALLOWANCES

COMPONENT	PHENOMENON CONSIDERED	LIMIT
Sway due to seismic or wind	Serviceability inter-storey drift	The lesser of: H/500 or 8mm
Slab shrinkage	Long term	0.6mm per m length
Window mullions	Lateral deflection	The lesser of: H/250 or 12mm
Permanent movement joints in the structure	Joint movement	To be specifically designed

Where the horizontal building movement is expected to exceed the above limits refer to Rondo for further clarification and consideration.

A6.2 MATERIAL SPECIFICATIONS

Rondo sections are typically manufactured from hot-dipped zinc-coated cold roll-formed steel manufactured in accordance with AS1397.

Steel Grade: G2 or G250

Yield Strength: F_y = 270 MPa for G2
F_y = 250 MPa for G250

Coating Grade: Z275 -275g/m^2 zinc

Base Metal Thickness: As specified

The steel is generally supplied by New Zealand Steel Pty Ltd.

The nominated coating mass is the sum of the coatings on both sides of the strip.

A6.3 PROPERTIES OF STEEL:

The properties of steel used for design of the Rondo Steel Stud and Tracks are listed below:

TABLE A6.3(A): PROPERTIES OF STEEL

PROPERTY	SYMBOL	VALUE
Elastic Modulus	E	200 x 10^3 MPa
Shear Modulus	G	80 x 10^3 MPa
Density	ρ	7850 kg/m^3
Poisson's ratio	ν	0.30
Coefficient of Thermal Expansion	α_T	11.7 x 10^{-6} / ^{0}C

A6.4 EARLY FIRE HAZARD PROPERTIES

Rondo steel stud and track sections are manufactured using steel having the following properties:

TABLE A6.4(A): EARLY FIRE HAZARD PROPERTIES OF STEEL

PROPERTY	STANDARD	RESULT
Ignitability Index	AS/NZS 1530.3	0
Spread of Flame Index		0
Heat evolved Index		0
Smoke Developed Index		2

A6.5 DURABILITY

The New Zealand Building Code (NZBC) Clause B2 Durability sets out the performance requirements for durability relevant to various building elements and applications. These requirements are defined in terms of years that the element must remain serviceable with only normal maintenance. The required performance periods are defined as:

1. The life of the building being not less than 50 years, if:
   a. Those building elements provide structural stability to the building, or
   b. Those building elements are difficult to access or replace, or
   c. Failure of those building elements to comply with the building code would go undetected during both normal use and maintenance of the building.
2. 15 years if:
   a. Those building elements are moderately difficult to access or replace, or
   b. Failure of those building elements to comply with the building code would go undetected during normal use of the building, but would be easily detected during normal maintenance.
3. 5 years if:
   a. The building elements are easy to access and replace, and
   b. Failure of those building elements to comply with the building code would be easily detected during normal use of the building.

Rondo products and systems have been interpreted to generally require compliance to category 2 above and perform to a period of at least **15 years** with respect to durability.

This performance is achieved in accordance with the following design standards and technical specification which are referenced within B2/AS1 as acceptable solutions for meeting the durability requirements (Clause B2) of the NZBC:

- SNZ TS3404:2018 - Durability requirements for steel structures and components
- ISO9223:2012 - Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation (as equivalent to AS 4312:2019)
- ISO11844:2006 - Corrosion of metals and alloys – Classification of low corrosivity of indoor atmospheres – Determination and estimation of indoor corrosivity

There are five (5) main factors to consider when assessing durability requirements:

(a) In-service conditions

(b) Materials

(c) Design and detailing

(d) Workmanship; and

(e) Maintenance

The durability of the system will ultimately depend on the complex interaction of all these factors.

A6.5.1 IN-SERVICE CONDITIONS

The in-service conditions that relate to the durability of the system or component can be separated into (1) environmental and (2) imposed conditions.

Understanding and assessment of these conditions will assist in achieving better design outcomes and more durable buildings.

A6.5.1.1 ENVIRONMENTAL CONDITIONS

Whilst there are many in-service conditions that need to be considered, the following are generally considered the key factors and the most likely to be encountered in-service:

Time of wetness – the impact due to rainfall can vary depending on locality, and it is not unreasonable to assume the components could get wet at some point during construction. The time of wetness is a major contributor to corrosion, particularly when coupled with contaminants, for example, airborne salt.

Rondo recommends their products be protected against long term wetting and drying cycles, however short periods of exposure (intermittent wetting) to uncontaminated rainfall should not adversely affect the coating performance.

Where the components are wet, with the possibility of contamination such as flooding,burst pipes, wind-driven salt-laden rain etc., Rondo recommends the components be washed down with clean potable water, then dried. Care should be taken with bottom tracks to ensure they are suitably cleaned and dried both inside and under the tracks.

Where moisture accumulation could potentially be a problem, Rondo recommends a vapour-permeable wrap or waterproof membrane be employed to eliminate the possibility of the framing being exposed to the moisture.

Rondo recommends their products not be directly exposed to salt in any form. Similarly, vapour permeable wraps or waterproof membranes should be employed to eliminate possible exposure.

Temperature – higher temperature naturally increases the chemical reaction process of corrosion but also reduces the time of wetness. In isolation, higher temperatures will not adversely affect the coating performance.

Wind – can cause abrasion of the coating and, or, can carry salt particles when building in close proximity to saltwater. In isolation, short term exposure to winds will not adversely affect the coating performance however, winds effects should be considered when building near saltwater. Rondo recommends their products not be directly exposed to wind-driven salt particles.

Pollutants – chemicals can be very aggressive to zinc coatings and these include, but are not limited to sulfur dioxide (SO2), chlorides, oxides of nitrogen (NOx) and other like compounds. Where the pH level is outside the range of 8 – 11, and there is direct contact to the coating / product, Rondo recommends appropriate measures be taken to eliminate the interaction.

Wet concrete – wet concrete can have a pH approaching 11 or more in its early stages of curing. During its life the pH will reduce due to carbonation and can get as low as 8. Zinc is less prone to corroding in alkaline substances, and on typical large-scale construction, Rondo framing won't be installed until the concrete is older than 28 days or more. For this reason, there is no requirement to separate the Rondo products from direct contact with the cured concrete.

The environmental conditions during construction are likely to be very different to the final finished environment. For this reason, it is important to assess these conditions separately, to ensure the protective coating on the component or the component itself is not damaged during this time.

Proper storage - keep the product off the ground, dry, shielded from salt spray and ventilated during storage.

If the product will be stored in a basement area, ensure the basement is kept dry, and there is adequate ventilation throughout. Opening bulk packs and separating the product can assist.

Façade - the coating of the Rondo products have not been assessed for direct external exposure and it is important that the site is ready for framing to progress when products are delivered.

Ensure the façade is installed, and or, the building is weatherproofed before commencing installation of the Rondo products and systems. Refer to Table A6.5.2(A) for coating of Rondo products in different corrosion zones.

Even small gaps or temporary openings in the façade can create micro-environmental conditions that could cause localized corrosion of products. A visual check of these areas is recommended, particularly after wet days to assess any potential problems.

Service risers, lift shafts and the like - quite likely these areas will be open for some time during construction. Framing in the vicinity of these areas should be visually checked, particularly after wet days to assess any potential problems such as ponding water or inundation.

A6.5.1.2 IMPOSED CONDITIONS

Where there are known conditions that form part of the project requirements, they should be explicitly identified and quantified in terms of intensity, concentrations, cycle times or other appropriate means as necessary, so they may be considered as part of the design process.

Inclusion or mention of imposed conditions does not constitute acceptance, and the conditions listed below need separate and specific deliberation, and do not form part of a Rondo design unless specifically nominated otherwise.

Condensation – condensation is the process where water vapour suspended in the air is deposited on colder surfaces.

Condensation can form on a surface or within the building fabric. These are known as surface and interstitial condensation, respectively. The latter is the most dangerous as it is not typically visible, and unless the design allows the moisture to be drained can seriously compromise the building fabric and durability.

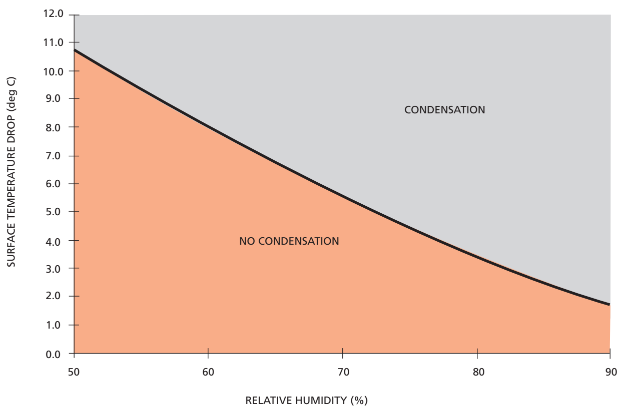


FIGURE A6.5.1.2(A): CONDENSATION POTENTIAL

The condensation potential graph which has been reproduced from the ABCB Condensation in Buildings Handbook 2011, shows the approximate surface temperature differential for condensation to form.

As an example, at 70% Relative Humidity (RH) the surface temperature differential is less than 6^0C for condensation to form and this reduces to less than 2^0C at 90% RH.

It should be remembered that warmer air can hold more water vapour than colder air. Accordingly, condensation will be more prevalent in the warmer regions. This does not preclude condensation in colder climates, rather reminds us to consider direction of potential flow.

This is a complex phenomenon, and Rondo recommends specialist professional advice be sought for those projects that require assessment.

Swimming Pools – quite often we are asked to consider Rondo systems and components for use in indoor swimming pool facilities and the like. These environments present significant challenges on many fronts, such as:

Ventilation - Whilst many facilities are designed with adequate ventilation, the performance of such systems rely on maintenance and operating cycles. When the system is inadequately maintained or is not used to control operating costs, it will have a significant negative influence on the environmental conditions, potentially leading to increased corrosivity.

Temperature / Relative Humidity - The temperature and relative humidity will influence the amount of condensation present within the facility. The presence of condensation on zinc coated steel allows a galvanic cell to form – which ultimately can lead to corrosion.

Ceiling Construction - Perforated ceiling linings can allow the free passage of contaminated or moisture laden air into the ceiling plenum space where it can potentially condense on the ceiling grid members. This is more likely where no or inadequate barriers are installed.

This can be further compounded if the insulation collects the condensation and allows it to pond against the ceiling grid members.

Following Trades / Maintenance - It is unlikely that following trades will have the same understandings of the complexities involved in the ceiling design, and this leads to considerable risk of disruption, perforation, penetration or compromise of the ceiling system.

Chemical Treatments - The corrosion rate of zinc in fresh water at normal atmospheric conditions is very low. As the pH of the water changes so does the corrosion rate of zinc, and outside a pH of approximately 8 – 11 the corrosion rate escalates significantly. Whilst it is unlikely that the ceiling grid would come in direct contact with the chemicals used to treat the pool, it is not unreasonable to expect these chemicals to exist in water vapour that forms part of the atmosphere above the pool.

Figure A6.5.1.2(B) provides a simple diagram of Rondos' recommended setup of the ventilation system for these facilities.

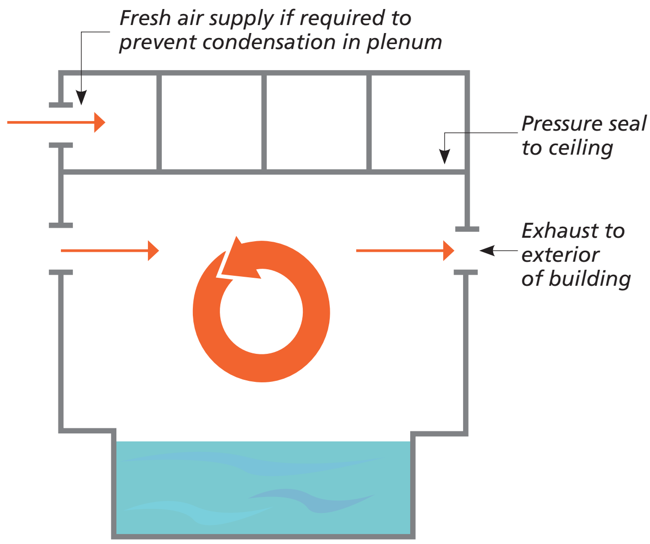


FIGURE A6.5.1.2(B): ENCLOSED POOL RECOMMENDED VENTILATION SETUP

These facilities present a complex phenomenon, and Rondo recommends specialist professional advice be sought for these projects and direct consultation with the Rondo design team.

Building use or function - Careful consideration of the installed Rondo system and components is required when a building form or function is being changed, modified or altered in some way.

A6 OTHER CONSIDERATIONS (CONTINUED)

A6.5 DURABILITY (CONTINUED)

A6.5.2 MATERIALS

Steel is a very stable material in that it is not susceptible to varied reactions under normal construction practice and will behave in a predictable manner.

Coating performance - the durability of the Rondo components and systems will likely be determined by the performance of the coating. Accordingly, it is critical that the "standard" Rondo coating be assessed for suitability to the application.

It should be noted that the coating life is directly proportional to the coating mass, when exposed to the same environmental conditions. Doubling the coating thickness will double the life expectancy of the coating.

The following table provides guidance on the recommended coating against the different corrosion zones for the various building applications.

TABLE A6.5.2(A): COATING PERFORMANCE AND RECOMMENDATIONS FOR A DESIGN LIFE[6] OF AT LEAST 15 YEARS

EXTERNAL FRAMING INCLUDING TOP HATS				
RONDO ELEMENT, LOCATION AND CONSTRUCTION TYPE	External Corrosivity Zones from SNZ TS3404:2018 and ISO 9223:2012			
	C1	C2	C3	C4
	Semi-sheltered locations remote from marine or industrial influence	Areas >50km from the coast but can extend to 1km for calm coastal Areas	Coastal areas with low salinity and urban and industrial areas with low pollution. This zone can vary significantly and should be checked closely	Coastal areas with rough seas, extent varies from 300m to 1km inland.
External wall located behind a pressure sealed barrier	Z275	Z275	Z275	Z275 Fully wrapped[1]
External wall located within a rain screen façade, or ventilated[2]	NA	Z275	Z450	Z450 Exterior to fully wrapped wall. Alternatively Z275 2pack epoxy primer (75μm) + 2pack epoxy topcoat (175μm)[3] Exterior to fully wrapped wall
External soffit unventilated	Z275	Z275	Z275	Z275 Fully wrapped[1]
External soffit ventilated	NA	Z275	Z275	Z450 Exterior to fully wrapped wall. Alternatively Z275 2pack epoxy primer (75μm) + 2pack epoxy topcoat (175μm)[3] Exterior to fully wrapped wall

The NZBC requirements take precedence over the recommendations given in Table A6.5.2(A), and Rondo recommends all construction comply with the NZBC requirements.

The corrosivity zones can vary significantly depending on many factors and detailed descriptions should be considered with SNZ TS3404, or a suitably qualified consultant.

Refer to next page for notes for table.

TABLE A6.5.2(A): COATING PERFORMANCE AND RECOMMENDATIONS FOR A DESIGN LIFE(6) OF AT LEAST 15 YEARS

INTERNAL WALL AND CEILING FRAMING SYSTEMS AND OTHER					
RONDO ELEMENT, LOCATION AND CONSTRUCTION TYPE	**Corrosivity Zones from SNZ TS3404:2018 and ISO 9223:2012**				
	C1	**C2**	**C3**	**C4**	**COMMENTS**
	Heated spaces with low relative humidity and insignificant pollution (offices, schools, galleries or museums)	Unheated or non-air-conditioned spaces with varying temperature and relative humidity. Low condensation and low pollution (clean storage facilities, sports halls)	Spaces with moderate frequency of condensation and moderate pollution from production process (food processing plants, laundries, breweries, dairies	Spaces with high frequency of condensation and high pollution from production process (Industrial processing plants, swimming pools).	
Dry, air-conditioned and unventilated space	Z200	NA (4)	NA (4)	NA (4)	Offices, schools, hospitals and museums
Dry, unheated and ventilated space (5)	Z200	Z200	Z275	Z275 (7)	Storage facilities, sports halls
Ceiling Battens unventilated	Z200	Z200	Z275	Z275	Condensation in the roof space should be assessed.
Ceiling Battens ventilated	Z200	Z275	Z275	Z450 Alternatively Z275 2pack epoxy primer (75um) + 2pack epoxy topcoat (175um). (3)	External patios and alfresco areas.
Exposed Ceiling Grids (5)	Z100	NA (4)	NA (4)	NA (4)	Condensation in the roof space should be assessed.
Bulkhead unventilated	Z200	Z200	Z275	Z275	Condensation in the roof space should be assessed.
Plaster and Render products Interior	Z100	NA (4)	NA (4)	NA (4)	

NOTES TO TABLE:

1. *Fully wrapped refers to the installation of a vapour permeable membrane, installed in accordance with AS/NZS4200.2 Pliable Building Membranes and Underlays to the external side of the framing. The internal side of the framing is to be directly lined and sealed full height. Proper cavity drainage is required when the wall is wrapped.*
2. *Framing members are assumed to be on the exterior side of the membrane. For framing inboard of the membrane refer to the framing details for the external wall behind the pressure sealed barrier.*
3. *See NASH Standard Part 2 Table B3 for specific paint details. The coating is specified as the Dry Film Thickness (DFT).*
4. *NA – these corrosivity zones don't exist if the space is not ventilated.*
5. *Temperature can vary, but framing should not be directly subjected to external atmosphere. Condensation needs to be prevented.*
6. *The term Design Life is defined in the introductory section A6.5 Durability. An indicated Design Life does not imply a warranty.*
7. *Specific design required for enclosed swimming pool areas.*

General notes – The achieved life, relative to the design life, is very much dependent on the quality of the building detailing at the time of construction.

An ongoing, comprehensive maintenance regime is essential to achieving the building design life.

For specific projects that require a design life in excess of 15 years, the Rondo design team should be consulted for material selection and construction detailing advice.

Dissimilar materials - Care should be taken when selecting materials of construction to ensure compatibility within the different components that combine to make up the system.

In some instances, galvanic or electrolytic corrosion can occur when two dissimilar materials are connected in the presence of an electrolyte that allows a galvanic current to flow. The electrolyte could simply be high humidity.

The following materials should not be placed in direct contact with any of the Rondo framing systems:

LINING MATERIAL TO AVOID
Green, unseasoned or treated timber(1)
Stainless Steel
Copper, brass or Lead
Limestone

TABLE A6.5.2(B) MATERIALS TO AVOID

NOTE:
1. Treated timber includes CCA and LOSP treated timbers. Refer below for more details.

Attachment of, or contact with green or unseasoned timber, can promote accelerated deterioration of the galvanized coating applied to the Rondo products. This is due to the substances which can naturally occur in some timbers, or are impregnated in the timber during the treatment process.

This is particularly more significant in locations of high humidity, where the equilibrium moisture content (EMC) of the timber can be higher than 17%.

Rondo recommends only kiln dried or appropriately dried timber be used in direct contact with their zinc coated products and this should be limited to areas and applications where the EMC of the timber can be maintained below 17%.

The zinc coating applied to Rondo products is a sacrificial coating and in benign applications will not deteriorate significantly. However, when placed in direct contact with other metals, and in the presence of an electrolyte, can form a galvanic cell. Depending on the metal in contact will determine which one corrodes, that is, the more active metal will corrode. Hence, when a galvanic cell is formed, zinc being more active than steel will corrode more quickly and protect the base steel.

A6.5.3 DESIGN AND DETAILING

Design and detailing can provide significant benefits to the durability of a structure when done properly.

Certainly, dissimilar metals, interstitial condensation, adequate ventilation and membrane selection are classical examples where good design can be used to mitigate potential problems

A6.5.4 WORKMANSHIP

Ultimately, the durability of the installed system will be significantly affected by the competency of the installer. Accordingly, having good quality professional tradespeople who are familiar with the Rondo systems and components can provide dividends to the longevity of the building.

A6.5.5 MAINTENANCE AND INSPECTION

The specific durability requirements of a project can be achieved when a defined and documented inspection system is implemented. This should be considered at the initial design stage. Designs that preclude this solution should be discussed with the Rondo design team.

The Rondo systems specified herein require maintenance and inspection to achieve the nominated durability levels.

LIMITATION OF LIABILITY:

The information contained in this Professional Series is not intended to be a complete statement of all possible design considerations or relevant data applicable to the Rondo Systems and Products. This Professional Series, and the information it contains, has been prepared as a guide to the range of Rondo's Systems and Products and some of the primary design considerations.

To the extent permitted by law, all conditions, obligations and liabilities of any kind which are, or may be implied or imposed to the contrary by any statute, rule or regulation or under the general law and whether arising from negligence of Rondo, its employees or agents, are excluded.

All information and specifications contained in this Professional Series may be altered, varied or modified by Rondo at its discretion and without notice.

Rondo is not liable for any loss or damage (including consequential loss or damage) arising from or in connection with:

- The provision of the Professional Series to any party;
- The accuracy, completeness or currency of any information in this Professional Series
- The absence or omission of any information from this Professional Series and;
- The reliance by any party on information contained in this Professional Series

we're behind the best buildings

rondo.co.nz