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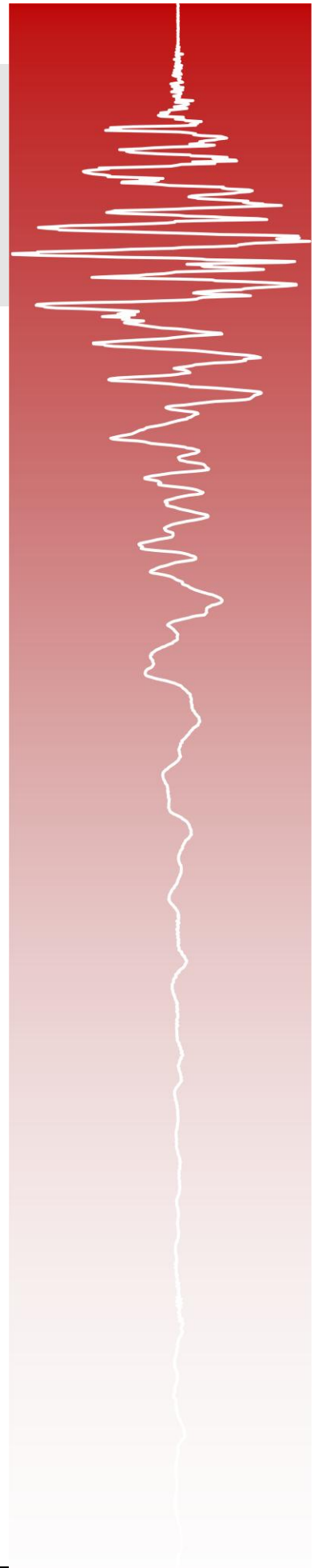
CTV Building

1986 Code Compliance ETABS Analysis Report

Ref: 12042-00

Revision 0

August 2012

Prepared for: Canterbury Earthquakes Royal Commission

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Document Control Record

Report Title	

Document ID	12042-00	**Project Number**	12042

File Path	Z:\01 Projects current\12042 - CTV ETABS Code Compliance\CEL_CTV 1986 ETABS Analysis Results.docx

Client	Canterbury Earthquakes Royal Commission	**Client Contact**	

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Rev	Date	Revision Details/Status	Author	Verifier	Approver
0	7 August 2012	Draft	DSB		

Current Revision	0

Approval

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1.   Introduction

Compusoft Engineering limited was engaged by the Canterbury Royal Commission to undertake linear elastic seismic analyses of the CTV building as it would have been undertaken when it was originally designed in 1986. Seismic analysis of the structure has been undertaken using the finite element package "ETABS Version 9.7" (CSI Berkeley 2010). Analyses have been undertaken in accordance with the provisions of the following New Zealand Standards

NZS4203:1984 - Code of practice for General Structural Design and Design Loadings for Buildings

NZS 3101:1982 - Concrete Structures Standard

2.   Structural Elements

2.1.   Foundation Stiffness

Analyses have been undertaken assuming three different stiffness states of the foundation - a rigid base (denoted *'Rigid Base'*), the most likely dynamic soil stiffness at the site (denoted *'Most Likely Soil Stiffness'*), and the same soil stiffness used in analyses undertaken by Alan Reay Consultants Ltd (ARCL) and documented in the report 'Seismic Analysis Report: Building: CTV Building, 249 Madras Street, Christchurch' (Revision v1) (denoted *'Soft Soil Stiffness'*)

2.1.1.   *'Rigid Base'.*

These analyses assume the base to be fully rigid, with no translation or rotation of the foundations permitted.

2.1.2.   *Most Likely Soil Stiffness.*

Soil stiffness was considered to behave in a linear manner, with applied soil stiffness based on values provided by Tonkin and Taylor for the probable soil conditions at the site (Sinclair 2011), as shown in Table 1 and Figure 1

Table 1: Expected soil stiffness

Foundation Element	Compressive Stiffness (MN/m^3)
1	122.7
1a	130.89
1b	65.98
2	85.4
2a	53.14
3	117.22
3a	78.59
4	159.69
4a	73.94
5	104.35
6	185.42
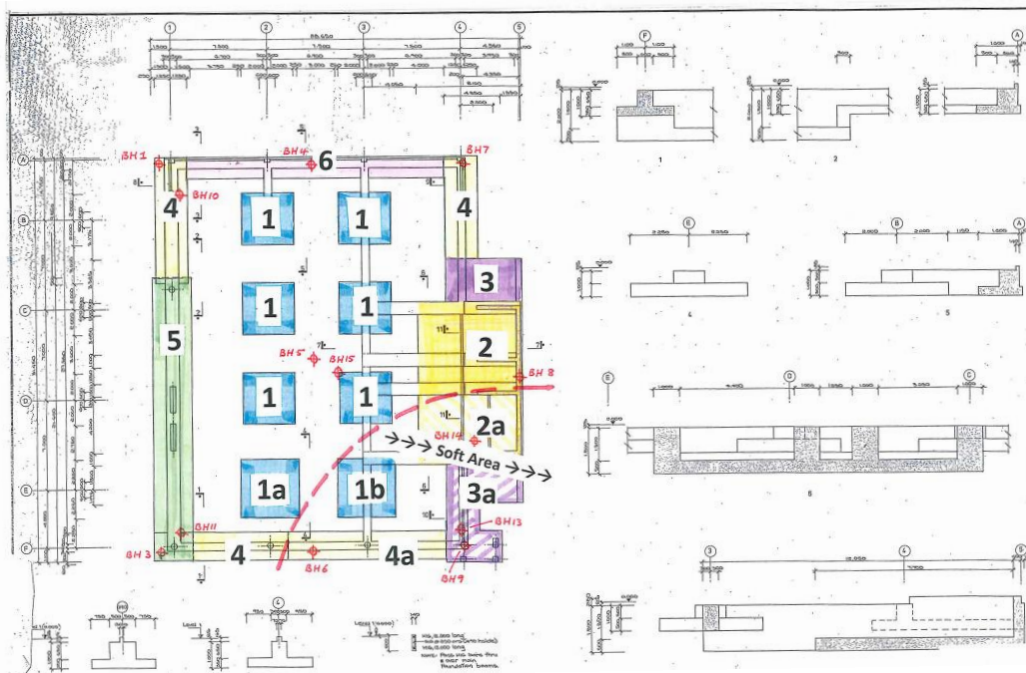
Figure 1: CTV foundation element location plan (Design Engineer 1986a)

2.1.3.   *Soft Soil Stiffness.*

Soil stiffness was considered to behave in a linear manner, with applied soil stiffness based on values used by Alan Reay Consultants Ltd and documented in the report 'Seismic Analysis Report: Building: CTV Building, 249 Madras Street, Christchurch' (Revision v1). It is understood that these values represent the soil stiffness determined by the original CTV site investigation undertaken by Soils & Foundations Ltd as being appropriate for determining foundation settlement under gravity actions. The values used in the ETABS analysis are presented in Figure 2 which is an extract from the ARCL 'Code of the Day Analysis' results summary.

Footing Stiffness		T&T		McCahon	
		Pads	Beams	Pads	Beams
Foundation line	Width (m)	K (kN/m3)	kN/m2)	K (kN/m3)	kN/m2)
Grid 1	3	142070	426210	5200	15600
Grid 1	2.5	217410	543525	5800	14500
Pad	4	167060		4600	
Pad	4.5	178200		4600	
Pad (soft)	4.5	118900		2600	
Grid A	1.7	252450	429165	7660	13022
Grid F	2.5	217410	543525	5800	14500
Grid F (soft)	2.5	133230	184850	3500	8750
Grid 4	2.5	217410	543525	5800	14500
Grid 4 (soft)	2.5	141620	354050	3500	8750
Core	5.9	159590		4600	
Core	8.2	116260		4600	
Core (soft)	8.2	95750		2600	
Core (soft)	5.9	141620		2600	

Figure 2: CTV Soft Soil Stiffness Values (ARCL 2012)

2.2.   Structural Parameters

2.2.1.   *Material Properties.*

Material properties used for the analysis are as per the specified material properties for the original design and listed in the CTV Building materials specification. Concrete strengths used are

Walls: fc' = 25 MPa

Foundation Beams: fc' = 20 MPa

2.2.2.   *Structural Element Stiffness.*

Only the primary lateral load resisting system assumed by the original designers has been modelled i.e. the coupled shear wall on the south face of the building, and the core walls at the north face of the building.

Effective stiffness for these walls has been determined from the recommendations contained within Volume 13, Issue No.2 of the Bulletin of the New Zealand National Society for Earthquake Engineering, and specifically the paper titled *'The analysis and design of and the evaluation of design actions for reinforced concrete ductile shear wall structures'* authored by T. Paulay and R.L Williams. Wall stiffness adopted are;

North core walls: 0.6Ig

Southern coupled shear wall: 0.65Ig (note that this is an average of the 0.8Ig recommended for the compression wall, and the 0.5Ig recommended for the tension wall)

Diagonally reinforced coupling beams: 0.4Ig

Where foundation beams contribute to the building response the effective stiffness has been assumed to be 0.5Ig.

3.   Analyses Undertaken

When the CTV Building was designed, analysis requirements were documented in NZS4203:1984.   In order to examine the effects that the various analysis methods documented in NZS4203 have on building displacements (and to investigate differing interpretations of these requirements), three different analysis techniques have been used. These analysis methods are described in Section 3.2.

It should be noted that the applicability of these analysis methods with regard to the requirements of NZS4203:1984 has not been explored or commented on in this document

3.1.   Model Mass Data

The total mass of the building has been determined as being 3371 tons. Table 2 presents the mass distribution used in the analysis models.

Table 2: Diaphragm Mass Data.

Level	N/S Mass (t)	E/W Mass (t)	MMI (tm^2)	N/S c.o.m (m)	E/W c.o.m (m)
Level 8	71.6	71.6	1366	25.08	12.08
Level 7	64.1	64.1	1014	25.46	13.71
Level 6	660.3	660.3	107891	12.44	13.94
Level 5	626.7	626.7	100383	12.86	13.85
Level 4	635.5	635.5	103196	12.84	14.08
Level 3	646.0	646.0	106503	12.82	14.35
Level 2	666.8	666.8	110999	12.88	14.32

3.2.   Analysis Techniques Undertaken

3.2.1.   *Equivalent Static (EQS) Analyses.*

An Equivalent Static (EQS) analysis has been undertaken in accordance with the requirements of Section 3.4 of NZS4203:1984. Torsional effects have been incorporated via application of static forces at a location equivalent to +/- 0.1 times the breath or width of the floor diaphragm.

Table 3 to Table 5 present the building period (the Rayleigh period) and design level base shears determined for each force eccentricity case, and for each of the foundation stiffness cases considered. Note that the base shears have been calculated using $M = 0.8$, $S = 1$, and $R = 1$.

Table 3: Rigid Base EQS Analysis Rayleigh Periods and Base Shears.

Load Direction	North/South			East/West		
Eccentricity case	Concentric	minus 0.1b	plus 0.1b	Concentric	minus 0.1b	plus 0.1b
Period, T_1 (sec)	0.79	0.8	0.8	0.76	0.85	0.67
Base shear (kN)	3079	3040	3034	3153	2918	3307

Table 4: Most Likely Soil Stiffness EQS Analysis Rayleigh Periods and Base Shears.

Load Direction	North/South			East/West		
Eccentricity case	Concentric	minus 0.1b	plus 0.1b	Concentric	minus 0.1b	plus 0.1b
Period, T_1 (sec)	1.29	1.3	1.3	0.92	1.03	0.81
Base shear (kN)	1984	1984	1984	2735	2439	3029

Table 5: Soft Soil Stiffness EQS Analysis Rayleigh Periods and Base Shears.

Load Direction	North/South			East/West		
Eccentricity case	Concentric	minus 0.1b	plus 0.1b	Concentric	minus 0.1b	plus 0.1b
Period, T_1 (sec)	2.13	2.13	2.15	1.26	1.37	1.18
Base shear (kN)	1984	1984	1984	1984	1984	2029

The force magnitude and distribution used in each of the equivalent static analyses is presented in Table 6 to Table 9. The magnitude of the static forces have been based upon the expected elastic base shear at the site (determined using S =5).

Table 6: Equivalent Static Diaphragm Forces - North/South -0.1B Eccentricity

Level	Eccentricity	Foundation Stiffness Condition		
		Rigid Base	Most Likely Soil Stiffness	Soft Soil Stiffness
		$V_{N/S}$ (kN)	$V_{N/S}$ (kN)	$V_{N/S}$ (kN)
Level 7	minus 0.1B N/S	592	386	386
Level 6	minus 0.1B N/S	472	308	308
Level 5	minus 0.1B N/S	5732	3738	3738
Level 4	minus 0.1B N/S	3225	2103	2103
Level 3	minus 0.1B N/S	2488	1623	1623
Level 2	minus 0.1B N/S	1734	1131	1131
Level 1	minus 0.1B N/S	969	632	632

Table 7: Equivalent Static Diaphragm Forces - North/South +0.1B Eccentricity

Level	Eccentricity	Foundation Stiffness Condition		
		Rigid Base	Most Likely Soil Stiffness	Soft Soil Stiffness
		$V_{N/S}$ (kN)	$V_{N/S}$ (kN)	$V_{N/S}$ (kN)
Level 7	plus 0.1B N/S	591	386	386
Level 6	plus 0.1B N/S	470	308	308
Level 5	plus 0.1B N/S	5719	3738	3738
Level 4	plus 0.1B N/S	3218	2103	2103
Level 3	plus 0.1B N/S	2483	1623	1623
Level 2	plus 0.1B N/S	1730	1131	1131
Level 1	plus 0.1B N/S	967	632	632

Table 8: Equivalent Static Diaphragm Forces - East/West -0.1B Eccentricity

Level	Eccentricity	Foundation Stiffness Condition		
		Rigid Base	Most Likely Soil Stiffness	Soft Soil Stiffness
		$V_{E/W}$ (kN)	$V_{E/W}$ (kN)	$V_{E/W}$ (kN)
Level 7	minus 0.1B E/W	501	383	378
Level 6	minus 0.1B E/W	399	305	301
Level 5	minus 0.1B E/W	4849	3702	3655
Level 4	minus 0.1B E/W	2728	2083	2057
Level 3	minus 0.1B E/W	2105	1607	1587
Level 2	minus 0.1B E/W	1467	1120	1106
Level 1	minus 0.1B E/W	820	626	618

Table 9: Equivalent Static Diaphragm Forces - East/West +0.1B Eccentricity

Level	Eccentricity	Foundation Stiffness Condition		
		Rigid Base	Most Likely Soil Stiffness	Soft Soil Stiffness
		$V_{E/W}$ (kN)	$V_{E/W}$ (kN)	$V_{E/W}$ (kN)
Level 7	plus 0.1B E/W	568	475	386
Level 6	plus 0.1B E/W	452	378	308
Level 5	plus 0.1B E/W	5495	4598	3738
Level 4	plus 0.1B E/W	3092	2587	2103
Level 3	plus 0.1B E/W	2385	1996	1623
Level 2	plus 0.1B E/W	1662	1391	1131
Level 1	plus 0.1B E/W	929	777	632

3.2.2. *Elastic Response Spectrum (ERS) Analyses.*

An Elastic response spectrum (ERS) analysis has been undertaken in accordance with the requirements of Section 3.5 of NZS4203:1984. Torsional effects have been incorporated via

application of the building mass detailed in Section 3.1 at locations equivalent to +/- 0.1 times the breath or width of the appropriate floor diaphragm and then undertaking the ERS analyses.

Table 10 to Table 12 present the building period (the Rayleigh period) and design level base shears determined for each mass eccentricity case, and for each of the foundation stiffness cases considered. Note that the base shears have been calculated using $M = 0.8$, $S = 1$, and $R = 1$. Results have been scaled so that at least 90% of the base shear determined by the ERS analyses is present.

Table 10: Rigid Base ERS Analysis Rayleigh Periods and Base Shears.

Load Direction	North/South			East/West		
Eccentricity case	Concentric	minus 0.1b	plus 0.1b	Concentric	minus 0.1b	plus 0.1b
Period, T_1 (sec)	0.79	0.80	0.80	0.76	0.85	0.67
Base shear (kN)	–	2736	2731	–	2626	–

Table 11: Most Likely Soil Stiffness ERS Analysis Rayleigh Periods and Base Shears.

Load Direction	North/South			East/West		
Eccentricity case	Concentric	minus 0.1b	plus 0.1b	Concentric	minus 0.1b	plus 0.1b
Period, T_1 (sec)	1.29	1.30	1.30	0.92	1.03	0.81
Base shear (kN)	–	1786	1786	–	2195	–

Table 12: Soft Soil Stiffness ERS Analysis Rayleigh Periods and Base Shears.

Load Direction	North/South			East/West		
Eccentricity case	Concentric	minus 0.1b	plus 0.1b	Concentric	minus 0.1b	plus 0.1b
Period, T_1 (sec)	2.13	2.13	2.15	1.26	1.37	1.18
Base shear (kN)	–	1786	1786	–	1786	–

3.2.3. _Modified Equivalent Static (MEQS) Analyses._

An equivalent static analysis has been undertaken by applying the storey forces determined by an ERS analysis as a static load to each level of the structure. This analysis has been termed a

modified equivalent static analysis as it considers a modified force magnitude and distribution from that detailed in Section 3.2.1. Static loads have been applied at the location of the centre of mass considered during the base ERS analyses. The force magnitude and distribution used in each of the modified equivalent static analyses undertaken are presented in Table 13 to Table 15. The magnitude of the static forces have been based upon the expected elastic base shear at the site (S =5) determined and scaled in accordance with the ERS analysis method.

Table 13: MEQS Analysis Diaphragm Forces - North/South -0.1B Eccentricity

Level	Eccentricity	Foundation Stiffness Condition		
		Rigid Base	Most Likely Soil Stiffness	Soft Soil Stiffness
		$V_{N/S}$ (kN)	$V_{N/S}$ (kN)	$V_{N/S}$ (kN)
Level 7	minus 0.1B N/S	900	523	499
Level 6	minus 0.1B N/S	598	356	349
Level 5	minus 0.1B N/S	4631	2875	2816
Level 4	minus 0.1B N/S	2979	1934	1927
Level 3	minus 0.1B N/S	2167	1444	1464
Level 2	minus 0.1B N/S	1555	1099	1132
Level 1	minus 0.1B N/S	846	694	739

Table 14: MEQS Analysis Diaphragm Forces - North/South +0.1B Eccentricity

Level	Eccentricity	Foundation Stiffness Condition		
		Rigid Base	Most Likely Soil Stiffness	Soft Soil Stiffness
		$V_{N/S}$ (kN)	$V_{N/S}$ (kN)	$V_{N/S}$ (kN)
Level 7	plus 0.1B N/S	959	545	519
Level 6	plus 0.1B N/S	611	362	352
Level 5	plus 0.1B N/S	4555	2856	2804
Level 4	plus 0.1B N/S	2883	1899	1900
Level 3	plus 0.1B N/S	2125	1431	1450
Level 2	plus 0.1B N/S	1607	1114	1143
Level 1	plus 0.1B N/S	914	722	760

Table 15: MEQS Analysis Diaphragm Forces - East/West -0.1B Eccentricity

Level	Eccentricity	Foundation Stiffness Condition		
		Rigid Base	Most Likely Soil Stiffness	Soft Soil Stiffness
		$V_{E/W}$ (kN)	$V_{E/W}$ (kN)	$V_{E/W}$ (kN)
Level 7	plus 0.1B E/W	806	735	521
Level 6	plus 0.1B E/W	567	547	383
Level 5	plus 0.1B E/W	4404	3407	2802
Level 4	plus 0.1B E/W	2841	2387	1934
Level 3	plus 0.1B E/W	1969	1702	1382
Level 2	plus 0.1B E/W	1587	1337	1130
Level 1	plus 0.1B E/W	959	862	774

4.   Analysis Results

4.1.   Equivalent Static (EQS) Analysis Results

Displacements and inter storey drifts for a selection of indicator columns have been presented in Table 16 and Table 17. All results presented have been scaled by K/SM in accordance with clause 3.8.1.1 of NZS 4203:1984 using K = 2.

Table 16: EQSA Column Displacements and Drifts - North/South Direction.

Column	Storey	Rigid Base			Most Likely Soil Stiffness			Soft Soil Stiffness		
		Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)
A1	STORY5	0.0684	0.0168	0.52	0.1113	0.0238	0.74	0.3007	0.0604	1.86
	STORY4	0.0516	0.0164	0.51	0.0874	0.0236	0.73	0.2403	0.0602	1.86
	STORY3	0.0352	0.0150	0.46	0.0638	0.0227	0.70	0.1802	0.0593	1.83
	STORY2	0.0202	0.0125	0.39	0.0411	0.0211	0.65	0.1209	0.0577	1.78
	STORY1	0.0077	0.0077	0.20	0.0200	0.0200	0.52	0.0631	0.0631	1.65
A2	STORY5	0.0684	0.0168	0.52	0.1113	0.0238	0.74	0.3007	0.0604	1.86
	STORY4	0.0516	0.0164	0.51	0.0874	0.0236	0.73	0.2403	0.0602	1.86
	STORY3	0.0352	0.0150	0.46	0.0638	0.0227	0.70	0.1802	0.0593	1.83
	STORY2	0.0202	0.0125	0.39	0.0411	0.0211	0.65	0.1209	0.0577	1.78
	STORY1	0.0077	0.0077	0.20	0.0200	0.0200	0.52	0.0631	0.0631	1.65
B2	STORY5	0.0661	0.0162	0.50	0.1087	0.0232	0.72	0.2935	0.0589	1.82
	STORY4	0.0499	0.0158	0.49	0.0855	0.0230	0.71	0.2347	0.0587	1.81
	STORY3	0.0340	0.0145	0.45	0.0625	0.0222	0.68	0.1760	0.0579	1.79
	STORY2	0.0195	0.0121	0.37	0.0403	0.0206	0.64	0.1181	0.0564	1.74
	STORY1	0.0074	0.0074	0.19	0.0197	0.0196	0.51	0.0617	0.0617	1.61
F1	STORY5	0.0683	0.0168	0.52	0.1087	0.0231	0.71	0.2825	0.0565	1.74
	STORY4	0.0515	0.0166	0.51	0.0856	0.0231	0.71	0.2260	0.0566	1.75
	STORY3	0.0349	0.0152	0.47	0.0624	0.0223	0.69	0.1694	0.0559	1.73
	STORY2	0.0197	0.0123	0.38	0.0401	0.0206	0.64	0.1135	0.0543	1.68
	STORY1	0.0074	0.0074	0.19	0.0195	0.0195	0.51	0.0592	0.0592	1.55
F2	STORY5	0.0683	0.0168	0.52	0.1087	0.0231	0.71	0.2825	0.0565	1.74
	STORY4	0.0515	0.0166	0.51	0.0856	0.0231	0.71	0.2260	0.0566	1.75
	STORY3	0.0349	0.0152	0.47	0.0624	0.0223	0.69	0.1694	0.0559	1.73
	STORY2	0.0197	0.0123	0.38	0.0401	0.0206	0.64	0.1135	0.0543	1.68
	STORY1	0.0074	0.0074	0.19	0.0195	0.0195	0.51	0.0592	0.0592	1.55

Table 17: EQSA Column Displacements and Drifts - East/West Direction.

Column	Storey	Rigid Base			Most Likely Soil Stiffness			Soft Soil Stiffness		
		Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)
A1	STORY5	0.0770	0.0200	0.62	0.0955	0.0228	0.70	0.1386	0.0303	0.94
	STORY4	0.0571	0.0194	0.60	0.0727	0.0223	0.69	0.1082	0.0299	0.92
	STORY3	0.0377	0.0173	0.53	0.0504	0.0205	0.63	0.0783	0.0285	0.88
	STORY2	0.0203	0.0133	0.41	0.0299	0.0171	0.53	0.0498	0.0257	0.79
	STORY1	0.0071	0.0070	0.18	0.0128	0.0128	0.33	0.0241	0.0241	0.63
A2	STORY5	0.0574	0.0149	0.46	0.0731	0.0173	0.54	0.1163	0.0251	0.78
	STORY4	0.0426	0.0144	0.45	0.0558	0.0170	0.52	0.0912	0.0248	0.77
	STORY3	0.0281	0.0129	0.40	0.0388	0.0157	0.48	0.0664	0.0237	0.73
	STORY2	0.0152	0.0099	0.31	0.0232	0.0132	0.41	0.0427	0.0217	0.67
	STORY1	0.0053	0.0053	0.14	0.0100	0.0100	0.26	0.0210	0.0209	0.55
B2	STORY5	0.0574	0.0149	0.46	0.0731	0.0173	0.54	0.1163	0.0251	0.78
	STORY4	0.0426	0.0144	0.45	0.0558	0.0170	0.52	0.0912	0.0248	0.77
	STORY3	0.0281	0.0129	0.40	0.0388	0.0157	0.48	0.0664	0.0237	0.73
	STORY2	0.0152	0.0099	0.31	0.0232	0.0132	0.41	0.0427	0.0217	0.67
	STORY1	0.0053	0.0053	0.14	0.0100	0.0100	0.26	0.0210	0.0209	0.55
F1	STORY5	0.0770	0.0200	0.62	0.0955	0.0228	0.70	0.1386	0.0303	0.94
	STORY4	0.0571	0.0194	0.60	0.0727	0.0223	0.69	0.1082	0.0299	0.92
	STORY3	0.0377	0.0173	0.53	0.0504	0.0205	0.63	0.0783	0.0285	0.88
	STORY2	0.0203	0.0133	0.41	0.0299	0.0171	0.53	0.0498	0.0257	0.79
	STORY1	0.0071	0.0070	0.18	0.0128	0.0128	0.33	0.0241	0.0241	0.63
F2	STORY5	0.0574	0.0149	0.46	0.0731	0.0173	0.54	0.1163	0.0251	0.78
	STORY4	0.0426	0.0144	0.45	0.0558	0.0170	0.52	0.0912	0.0248	0.77
	STORY3	0.0281	0.0129	0.40	0.0388	0.0157	0.48	0.0664	0.0237	0.73
	STORY2	0.0152	0.0099	0.31	0.0232	0.0132	0.41	0.0427	0.0217	0.67
	STORY1	0.0053	0.0053	0.14	0.0100	0.0100	0.26	0.0210	0.0209	0.55

4.2. Elastic Response Spectrum (ERS) Analysis Results

Displacements and inter storey drifts for a selection of indicator columns have been presented in Table 18 and Table 19. All results presented have been scaled by K/SM in accordance with clause 3.8.1.1 of NZS 4203:1984 using K = 2.2.

Table 18: ERSA Column Displacements and Drifts - North/South Direction.

Column	Storey	Rigid Base			Most Likely Soil Stiffness			Soft Soil Stiffness		
		Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)
A1	STORY5	0.0851	0.0213	0.66	0.1134	0.0245	0.76	0.2894	0.0581	1.79
	STORY4	0.0638	0.0208	0.64	0.0889	0.0242	0.75	0.2312	0.0579	1.79
	STORY3	0.0431	0.0189	0.58	0.0647	0.0233	0.72	0.1733	0.0571	1.76
	STORY2	0.0242	0.0153	0.47	0.0415	0.0214	0.66	0.1162	0.0556	1.71
	STORY1	0.0090	0.0089	0.23	0.0200	0.0200	0.52	0.0606	0.0606	1.58
A2	STORY5	0.0851	0.0213	0.66	0.1134	0.0245	0.76	0.2894	0.0581	1.79
	STORY4	0.0638	0.0208	0.64	0.0889	0.0242	0.75	0.2312	0.0579	1.79
	STORY3	0.0431	0.0189	0.58	0.0647	0.0233	0.72	0.1733	0.0571	1.76
	STORY2	0.0242	0.0153	0.47	0.0415	0.0214	0.66	0.1162	0.0556	1.71
	STORY1	0.0090	0.0089	0.23	0.0200	0.0200	0.52	0.0606	0.0606	1.58
B2	STORY5	0.0747	0.0186	0.57	0.1084	0.0233	0.72	0.2806	0.0563	1.74
	STORY4	0.0562	0.0181	0.56	0.0851	0.0231	0.71	0.2243	0.0561	1.73
	STORY3	0.0380	0.0165	0.51	0.0621	0.0222	0.69	0.1682	0.0554	1.71
	STORY2	0.0215	0.0135	0.42	0.0399	0.0206	0.63	0.1128	0.0539	1.66
	STORY1	0.0080	0.0080	0.21	0.0194	0.0193	0.51	0.0589	0.0589	1.54
F1	STORY5	0.0817	0.0204	0.63	0.1083	0.0231	0.71	0.2695	0.0539	1.66
	STORY4	0.0613	0.0202	0.62	0.0851	0.0231	0.71	0.2156	0.0540	1.67
	STORY3	0.0412	0.0183	0.57	0.0620	0.0223	0.69	0.1615	0.0534	1.65
	STORY2	0.0229	0.0145	0.45	0.0397	0.0205	0.63	0.1082	0.0518	1.60
	STORY1	0.0084	0.0083	0.22	0.0192	0.0192	0.50	0.0564	0.0564	1.47
F2	STORY5	0.0817	0.0204	0.63	0.1083	0.0231	0.71	0.2695	0.0539	1.66
	STORY4	0.0613	0.0202	0.62	0.0851	0.0231	0.71	0.2156	0.0540	1.67
	STORY3	0.0412	0.0183	0.57	0.0620	0.0223	0.69	0.1615	0.0534	1.65
	STORY2	0.0229	0.0145	0.45	0.0397	0.0205	0.63	0.1082	0.0518	1.60
	STORY1	0.0084	0.0083	0.22	0.0192	0.0192	0.50	0.0564	0.0564	1.47

Table 19: ERSA Column Displacements and Drifts - East/West Direction.

Column	Storey	Rigid Base			Most Likely Soil Stiffness			Soft Soil Stiffness		
		Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)
A1	STORY5	0.1005	0.0260	0.80	0.1124	0.0267	0.82	0.1617	0.0353	1.09
	STORY4	0.0746	0.0254	0.78	0.0857	0.0263	0.81	0.1264	0.0350	1.08
	STORY3	0.0493	0.0227	0.70	0.0595	0.0243	0.75	0.0915	0.0334	1.03
	STORY2	0.0267	0.0174	0.54	0.0353	0.0203	0.63	0.0582	0.0302	0.93
	STORY1	0.0093	0.0093	0.24	0.0150	0.0150	0.39	0.0280	0.0280	0.73
A2	STORY5	0.0738	0.0191	0.59	0.0834	0.0198	0.61	0.1251	0.0271	0.84
	STORY4	0.0548	0.0187	0.58	0.0637	0.0195	0.60	0.0980	0.0269	0.83
	STORY3	0.0362	0.0167	0.51	0.0442	0.0180	0.56	0.0711	0.0257	0.79
	STORY2	0.0196	0.0128	0.39	0.0263	0.0151	0.47	0.0454	0.0234	0.72
	STORY1	0.0068	0.0068	0.18	0.0112	0.0112	0.29	0.0221	0.0221	0.58
B2	STORY5	0.0738	0.0191	0.59	0.0834	0.0198	0.61	0.1251	0.0271	0.84
	STORY4	0.0548	0.0187	0.58	0.0637	0.0195	0.60	0.0980	0.0269	0.83
	STORY3	0.0362	0.0167	0.51	0.0442	0.0180	0.56	0.0711	0.0257	0.79
	STORY2	0.0196	0.0128	0.39	0.0263	0.0151	0.47	0.0454	0.0234	0.72
	STORY1	0.0068	0.0068	0.18	0.0112	0.0112	0.29	0.0221	0.0221	0.58
F1	STORY5	0.1005	0.0260	0.80	0.1124	0.0267	0.82	0.1617	0.0353	1.09
	STORY4	0.0746	0.0254	0.78	0.0857	0.0263	0.81	0.1264	0.0350	1.08
	STORY3	0.0493	0.0227	0.70	0.0595	0.0243	0.75	0.0915	0.0334	1.03
	STORY2	0.0267	0.0174	0.54	0.0353	0.0203	0.63	0.0582	0.0302	0.93
	STORY1	0.0093	0.0093	0.24	0.0150	0.0150	0.39	0.0280	0.0280	0.73
F2	STORY5	0.0738	0.0191	0.59	0.0834	0.0198	0.61	0.1251	0.0271	0.84
	STORY4	0.0548	0.0187	0.58	0.0637	0.0195	0.60	0.0980	0.0269	0.83
	STORY3	0.0362	0.0167	0.51	0.0442	0.0180	0.56	0.0711	0.0257	0.79
	STORY2	0.0196	0.0128	0.39	0.0263	0.0151	0.47	0.0454	0.0234	0.72
	STORY1	0.0068	0.0068	0.18	0.0112	0.0112	0.29	0.0221	0.0221	0.58

4.3. Modified Equivalent Static (MEQS) Analysis Results

Displacements and inter storey drifts for a selection of indicator columns have been presented in Table 20 and Table 21. All results presented have been scaled by K/SM in accordance with clause 3.8.1.1 of NZS 4203:1984 using K = 2.2.

Table 20: MEQS Column Displacements and Drifts - North/South Direction.

Column	Storey	Rigid Base			Most Likely Soil Stiffness			Soft Soil Stiffness		
		Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)
A1	STORY5	0.0680	0.0168	0.52	0.1080	0.0231	0.71	0.2899	0.0582	1.80
	STORY4	0.0513	0.0163	0.50	0.0849	0.0229	0.71	0.2317	0.0580	1.79
	STORY3	0.0349	0.0149	0.46	0.0620	0.0220	0.68	0.1737	0.0571	1.76
	STORY2	0.0200	0.0124	0.38	0.0400	0.0205	0.63	0.1166	0.0557	1.72
	STORY1	0.0076	0.0076	0.20	0.0195	0.0195	0.51	0.0609	0.0609	1.59
A2	STORY5	0.0680	0.0168	0.52	0.1080	0.0231	0.71	0.2899	0.0582	1.80
	STORY4	0.0513	0.0163	0.50	0.0849	0.0229	0.71	0.2317	0.0580	1.79
	STORY3	0.0349	0.0149	0.46	0.0620	0.0220	0.68	0.1737	0.0571	1.76
	STORY2	0.0200	0.0124	0.38	0.0400	0.0205	0.63	0.1166	0.0557	1.72
	STORY1	0.0076	0.0076	0.20	0.0195	0.0195	0.51	0.0609	0.0609	1.59
B2	STORY5	0.0659	0.0163	0.50	0.1057	0.0226	0.70	0.2832	0.0568	1.75
	STORY4	0.0497	0.0158	0.49	0.0831	0.0224	0.69	0.2264	0.0566	1.75
	STORY3	0.0338	0.0145	0.45	0.0607	0.0216	0.67	0.1698	0.0558	1.72
	STORY2	0.0194	0.0120	0.37	0.0392	0.0201	0.62	0.1140	0.0544	1.68
	STORY1	0.0074	0.0074	0.19	0.0191	0.0191	0.50	0.0596	0.0596	1.56
F1	STORY5	0.0688	0.0170	0.52	0.1060	0.0225	0.70	0.2732	0.0546	1.69
	STORY4	0.0518	0.0167	0.52	0.0834	0.0225	0.70	0.2186	0.0547	1.69
	STORY3	0.0350	0.0153	0.47	0.0609	0.0218	0.67	0.1638	0.0541	1.67
	STORY2	0.0197	0.0124	0.38	0.0392	0.0201	0.62	0.1098	0.0525	1.62
	STORY1	0.0074	0.0074	0.19	0.0190	0.0190	0.50	0.0573	0.0573	1.50
F2	STORY5	0.0688	0.0170	0.52	0.1060	0.0225	0.70	0.2732	0.0546	1.69
	STORY4	0.0518	0.0167	0.52	0.0834	0.0225	0.70	0.2186	0.0547	1.69
	STORY3	0.0350	0.0153	0.47	0.0609	0.0218	0.67	0.1638	0.0541	1.67
	STORY2	0.0197	0.0124	0.38	0.0392	0.0201	0.62	0.1098	0.0525	1.62
	STORY1	0.0074	0.0074	0.19	0.0190	0.0190	0.50	0.0573	0.0573	1.50

Table 21: MEQS Column Displacements and Drifts - East/West Direction.

Column	Storey	Rigid Base			Most Likely Soil Stiffness			Soft Soil Stiffness		
		Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)	Displ (m)	Drift (m)	Drift (%)
A1	STORY5	0.0723	0.0187	0.58	0.0874	0.0207	0.64	0.1282	0.0279	0.86
	STORY4	0.0536	0.0182	0.56	0.0667	0.0203	0.63	0.1002	0.0276	0.85
	STORY3	0.0354	0.0162	0.50	0.0463	0.0188	0.58	0.0726	0.0263	0.81
	STORY2	0.0191	0.0125	0.39	0.0276	0.0157	0.49	0.0463	0.0238	0.74
	STORY1	0.0067	0.0067	0.17	0.0118	0.0118	0.31	0.0224	0.0224	0.59
A2	STORY5	0.0540	0.0140	0.43	0.0674	0.0159	0.49	0.1090	0.0234	0.72
	STORY4	0.0400	0.0136	0.42	0.0515	0.0156	0.48	0.0855	0.0231	0.71
	STORY3	0.0265	0.0121	0.37	0.0359	0.0144	0.45	0.0624	0.0222	0.69
	STORY2	0.0144	0.0093	0.29	0.0215	0.0122	0.38	0.0402	0.0204	0.63
	STORY1	0.0050	0.0050	0.13	0.0094	0.0093	0.24	0.0198	0.0198	0.52
B2	STORY5	0.0540	0.0140	0.43	0.0674	0.0159	0.49	0.1090	0.0234	0.72
	STORY4	0.0400	0.0136	0.42	0.0515	0.0156	0.48	0.0855	0.0231	0.71
	STORY3	0.0265	0.0121	0.37	0.0359	0.0144	0.45	0.0624	0.0222	0.69
	STORY2	0.0144	0.0093	0.29	0.0215	0.0122	0.38	0.0402	0.0204	0.63
	STORY1	0.0050	0.0050	0.13	0.0094	0.0093	0.24	0.0198	0.0198	0.52
F1	STORY5	0.0723	0.0187	0.58	0.0874	0.0207	0.64	0.1282	0.0279	0.86
	STORY4	0.0536	0.0182	0.56	0.0667	0.0203	0.63	0.1002	0.0276	0.85
	STORY3	0.0354	0.0162	0.50	0.0463	0.0188	0.58	0.0726	0.0263	0.81
	STORY2	0.0191	0.0125	0.39	0.0276	0.0157	0.49	0.0463	0.0238	0.74
	STORY1	0.0067	0.0067	0.17	0.0118	0.0118	0.31	0.0224	0.0224	0.59
F2	STORY5	0.0540	0.0140	0.43	0.0674	0.0159	0.49	0.1090	0.0234	0.72
	STORY4	0.0400	0.0136	0.42	0.0515	0.0156	0.48	0.0855	0.0231	0.71
	STORY3	0.0265	0.0121	0.37	0.0359	0.0144	0.45	0.0624	0.0222	0.69
	STORY2	0.0144	0.0093	0.29	0.0215	0.0122	0.38	0.0402	0.0204	0.63
	STORY1	0.0050	0.0050	0.13	0.0094	0.0093	0.24	0.0198	0.0198	0.52