Calculations

Building Report
for
Wallcork Upland Ltd

at

34 Upland Road
Kelburn
Wellington 6012

As built
achieved 60%NBS

Job No 210263

Don Thomson
Consulting Engineers

81 Harbour View Road, Northland, Wellington
tel 0-4-475 7933 fax 0-4-475 8414
email don@donthomson.co.nz

DON THOMSON
consulting engineers

address	34 Upland Road	designed	RLM	date	08-10-15
project no	210263	checked	PAC	date	21-10-15
project	Seismic strengthening	approved	DWT	date	21-10-15

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DESIGN STANDARDS

NZBC Sections: ✓ B1 *Others:* None

✓ NZS 3101:2006 - Concrete Structures Standard
✓ NZS 3404:1997 Steel Structures Standard
NZS 3603:1993 Timber Structures Standard
NZS 3604:2011 Timber Framed Buildings

✓ NZS 1170:2002 - Structural Design Actions
NZS 4229:1999 - Concrete Masonry Buildings
NZS 4230:2004 Concrete Masonry Structures
✓ Assessment and Improvement of the Structural Performance of Buildings in Earthquakes

SCOPE

The scope of the project is to provide a seismic strengthening scheme for the five storey concrete walled building that sits on soil with significant soil inclination. Strengthening is achieved by sprayed concrete walls, steel reinforcement and Sika wrap FRPs. In order to restain global movement of the building at foundation level, new Ischebeck anchors are designed at selected locations. Due to unforeseen soil and site conditions the initial target of strengthening to 67%NBS could not be reached. However, the building is capable of achieving 60%NBS compliance.

DESIGN PHILOSOPHY

We determined the seismic loads on the building using New Zealand Standard 1170 (NZS1170.5:2004) Structural Design Actions. A time period of 0.4s (T<0.4s), ductility of μ=1.5 in both directions and subsoil class of C was used to calculate the seismic load. The available ductility was determined using the AISPBE chapter 7 publication by NZSEE. Seismic loads were distributed to the lateral restraining structural elements using the Equivalent Static method. A 10% accidental load eccentricity was included in the calculations. The building's capacity to resist lateral load was then compared to the demand, which gives its %NBS. It must be appreciated that %NBS is a performance indicator, but does not reflect the full complexity of the seismic behaviour of a building. The failure mode of the building is assumed to occur when the weakest lateral resisting system, such as a connected line of walls with openings, reaches its calculated strength.

A computer model was created for the analysis of the structure using ETABS computer software. Concrete walls, spandrels and floors were modelled using effective property modifiers (cracked section) as per NZS3101:2006. The shear capacity of the elements was assessed using AISPBE methods. Original drawings show the walls are reinforced with 12.7mm bars at 300mm centres. At level 4 only, the internal walls are breeze block and reinforced with 9.5mm bars at 300mm centres. Significant walls that meet less than 60%NBS are strengthened using a mixture of sprayed concrete and Sika Wrap. Sika Wrap is designed in accordance with ACI440 and new concrete walls are designed to NZS3101:2009. The structural stability is provided by a series of walls divided by openings into piers and spandrels. A number of piers and spandrel elements, namely P57, P62, P85, S13, S14, meet less than 60%NBS by a small margin. When failure intiriates at these elements, moment redistribution to the rest of the elements in their wall can occur and therefore not leading to the collapse of the structure, allowing the structure to achieve globally a 60%NBS compliance.

The existing concrete retaining walls provide sliding resistance to lateral load due to soil-concrete friction. It is conservatively assumed that the existing concrete piles do not provide lateral resistance as the depth to firm ground is variable. New soil nails are designed to resist the remainder of the lateral load up to 60%NBS. A pull out test of a 32mm Reidbar embedded 6m into the soil and grouted 1.5m showed the bond stress of the soil is 250kPa. The soil nails are designed to give a factor of safety of 2.0 on bond stress and 1.1 on bar tensile strength. The first 3m of embedment is debonded.

From the previous we conclude that the structure as strengthened can achieve 60%NBS compliance. The superstructure is likely to exceed this percentage, while the uncertainties in the foundation/soil interaction restrict the probable compliance. The likely range of compliance is between 60%-70%NBS and we conclude the lower figure is appropriate.

REFERENCE DOCUMENTS

These calculations are to be read in conjunction with the following documents:

Don Thomson Consulting Engineers *Others*

Structural drawings

DON THOMSON
consulting engineers

project	Seismic Strengthening	designed	RLM	date	24/04/2013
address	34 Upland Road	checked		date	
project no.	210263	approved		date	

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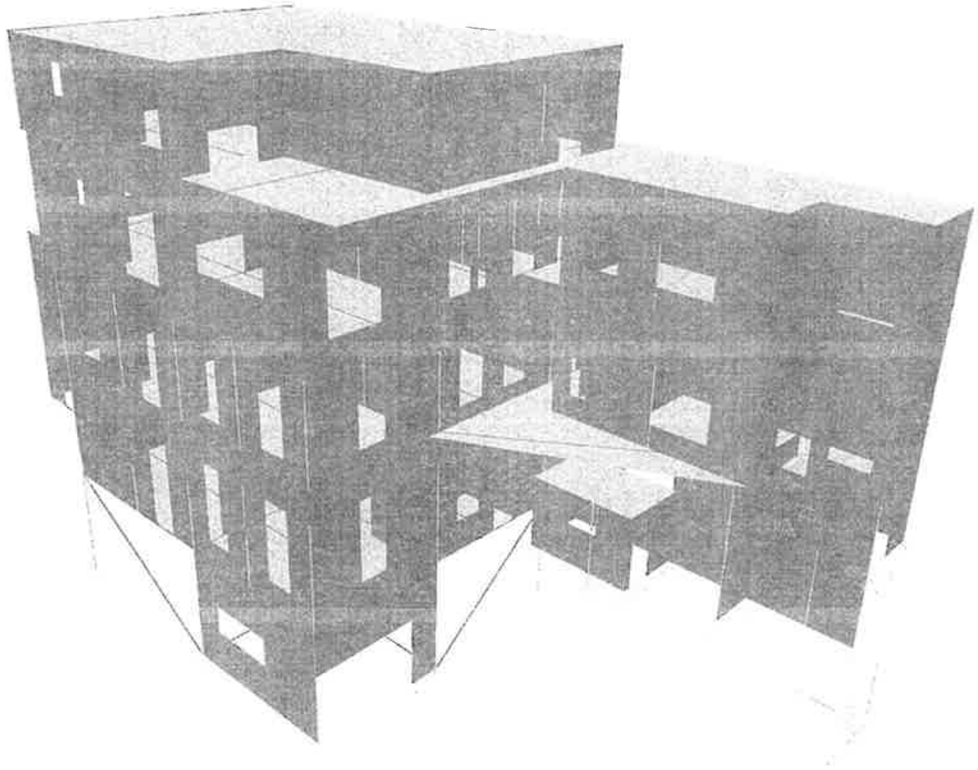

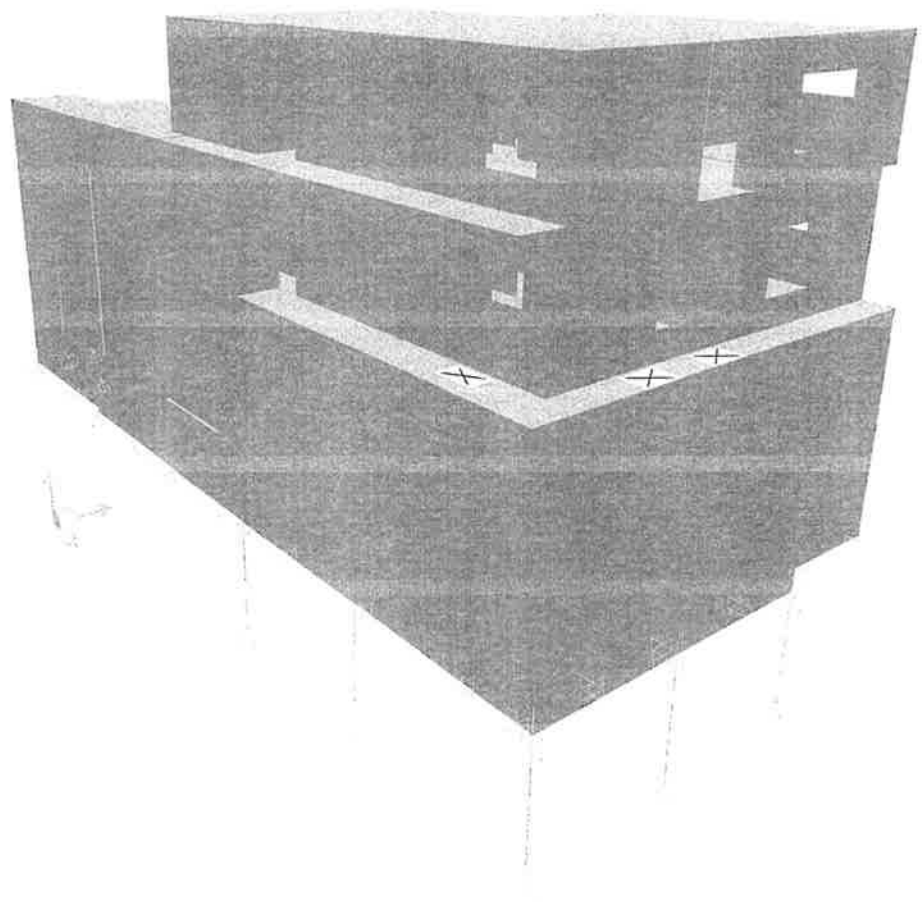

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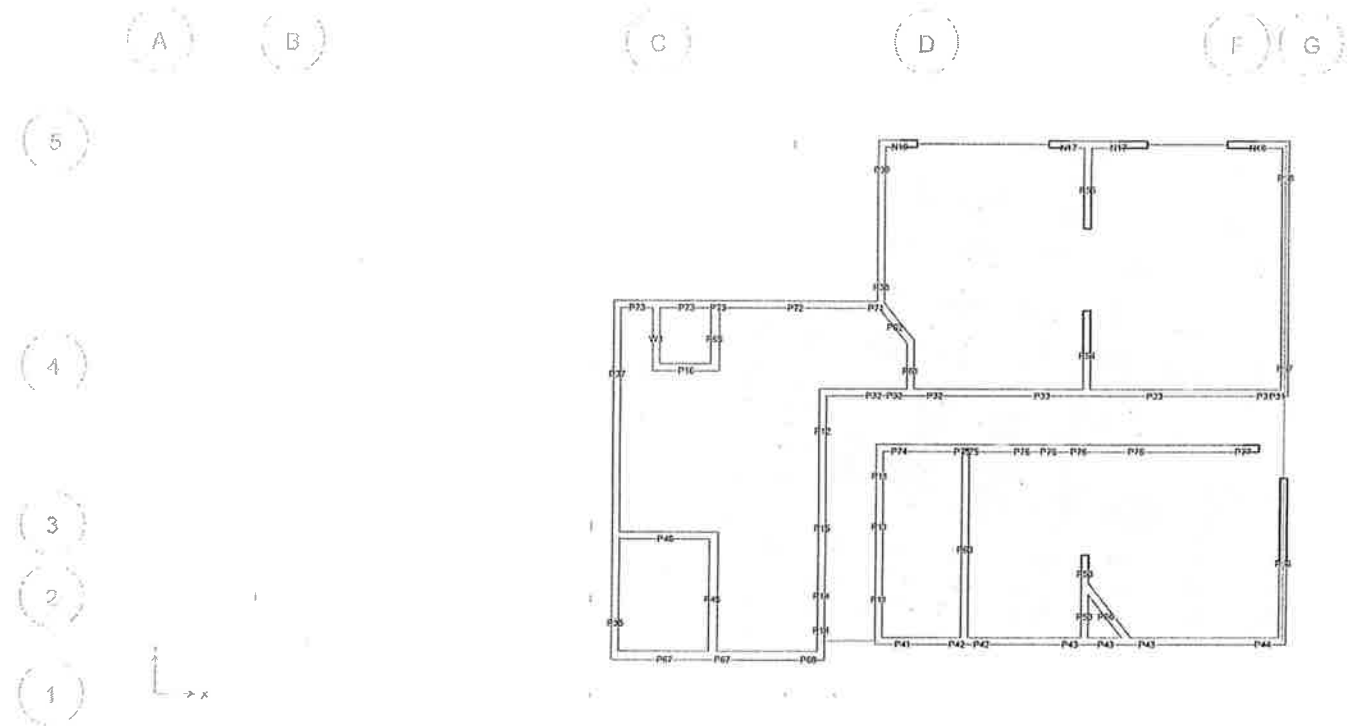
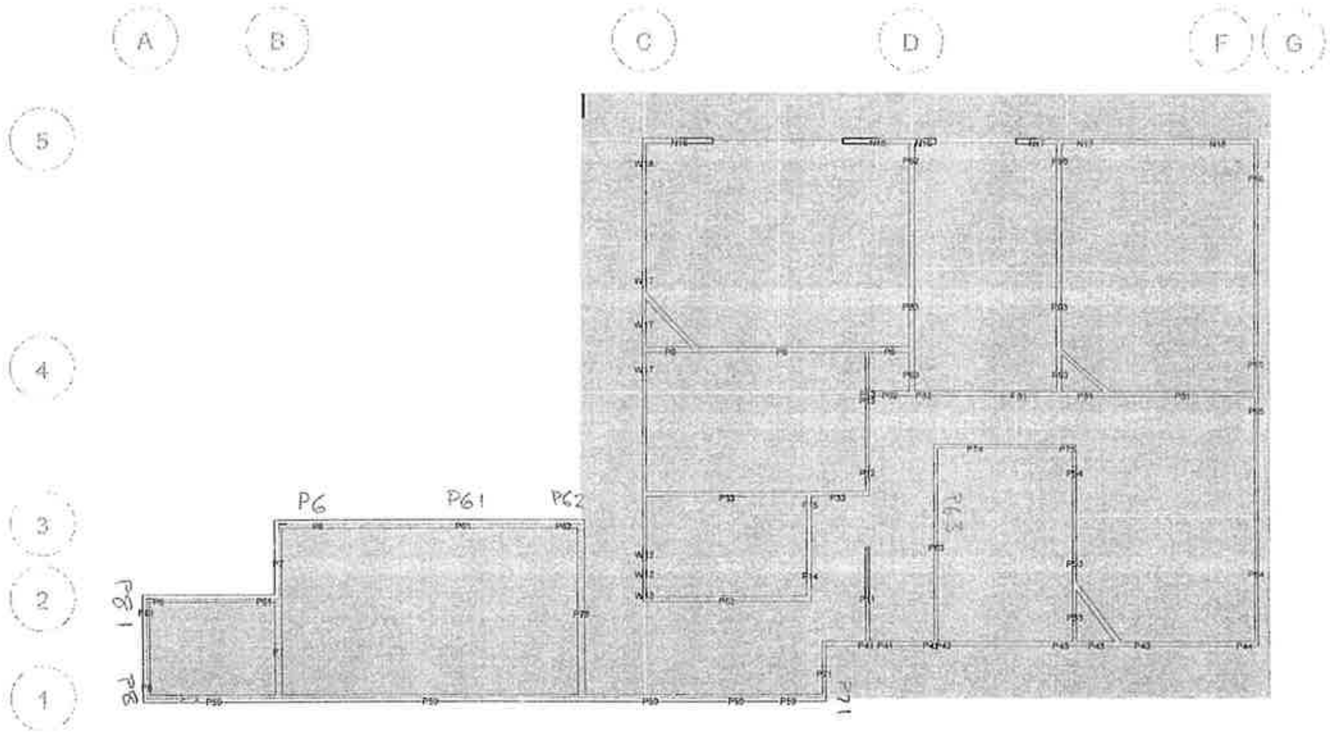


Plan View - STORY5 - Z = 17.8 (m)

Storey 5

Storey	Pier	V* (kN)				φVn (kN)	%NBS	M* (kNm)				φMn (kNm)	%NBS
		μ=1.0	μ=1.5	G+0.3Q	Total			μ=1.0	μ=1.5	G+0.3Q	Total		
STORY5	P11	183.4826	121.0	12.3	133.3	563		401.4673	264.8	36.7	301.5	802	
STORY5	P12	102.9567	67.9	4.5	72.4	197		95.2616	62.8	5.9	68.7	107	
STORY5	P14	71.9539	47.5	0.8	48.3	197		53.7045	35.4	2.8	38.2	107	
STORY5	P15	75.3519	49.7	5.9	55.6	141		74.2713	49.0	6.6	55.5	56	
STORY5	P16	20.1227	13.3	1.1	14.4	169		8.9377	5.9	0.9	6.8	80	
STORY5	P31	10.5945	7.0	1.5	8.5	70		8.2631	5.5	0.5	6.0	24	
STORY5	P32	157.632	104.0	6.6	110.6	267		156.7602	103.4	6.5	109.9	199	
STORY5	P33	343.9254	226.8	27.4	254.2	633		330.1866	217.8	59.1	276.9	1007	
STORY5	P35	14.1718	9.3	4.1	13.4	211		23.7869	15.7	7.0	22.7	122	
STORY5	P37	195.1945	128.7	15.1	143.9	380		104.0983	68.7	23.0	91.6	373	
STORY5	P38	39.9436	26.3	2.3	28.7	113		20.9466	13.8	1.4	15.2	39	
STORY5	P39	22.2096	14.6	9.9	24.6	127		26.5265	17.5	7.9	25.4	49	
STORY5	P41	82.4653	54.4	6.7	61.1	141		118.522	78.2	9.7	87.9	56	64%
STORY5	P42	82.2905	54.3	0.6	54.8	141		47.3537	31.2	1.4	32.7	56	
STORY5	P43	109.2636	72.1	6.0	78.1	310		76.5617	50.5	8.4	58.9	252	
STORY5	P44	46.177	30.5	3.1	33.5	113		27.2465	18.0	1.2	19.1	39	
STORY5	P45	114.312	75.4	9.9	85.3	352		59.896	39.5	7.8	47.3	322	
STORY5	P46	58.5458	38.6	6.0	44.7	281		46.6964	30.8	10.3	41.1	210	
STORY5	P53	28.9695	19.1	4.3	23.4	253		15.2187	10.0	8.2	18.2	172	
STORY5	P54	17.0943	11.3	10.5	21.8	239		13.2406	8.7	8.9	17.6	154	
STORY5	P55	75.585	49.9	27.3	77.1	239		97.3847	64.2	27.4	91.6	154	
STORY5	P56	201.1833	132.7	15.5	148.1	478		74.3113	49.0	13.0	62.0	597	
STORY5	P57	144.4897	95.3	12.3	107.6	169		210.9295	139.1	8.7	147.8	80	54%
STORY5	P58	112.4008	74.1	20.1	94.2	169		88.8767	58.6	22.3	80.9	80	99%
STORY5	P61	84.2734	55.6	8.0	63.6	141		42.3124	27.9	5.1	33.0	56	
STORY5	P62	49.0611	32.4	12.5	44.9	141		20.0415	13.2	8.5	21.7	56	
STORY5	P63	142.9647	94.3	14.7	109.0	563		62.1871	41.0	9.4	50.4	802	

STORY5	P65	21.5294	14.2	4.3	18.5	183		9.7871	6.5	4.9	11.4	92	
STORY5	P66	22.7679	15.0	3.3	18.3	211		13.6499	9.0	2.7	11.7	122	
STORY5	P67	119.1214	78.6	13.9	92.5	338		73.9524	48.8	9.4	58.2	298	
STORY5	P68	34.9897	23.1	2.0	25.1	70		14.1543	9.3	1.0	10.4	24	
STORY5	P71	13.4895	8.9	0.8	9.7	28		4.2835	2.8	0.3	3.1	5	
STORY5	P72	54.5022	35.9	7.8	43.8	70		19.3054	12.7	2.8	15.5	24	
STORY5	P73	73.0012	48.1	1.8	50.0	295		37.8037	24.9	2.9	27.9	230	
STORY5	P74	38.5843	25.4	3.0	28.4	113		55.875	36.9	2.4	39.2	39	99%
STORY5	P75	14.0122	9.2	2.1	11.4	56		8.684	5.7	1.3	7.1	11	
STORY5	P76	138.4062	91.3	16.9	108.2	478		157.2086	103.7	43.0	146.7	585	
STORY5	P77	20.265	13.4	7.5	20.9	98		21.2228	14.0	9.7	23.6	29	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P81
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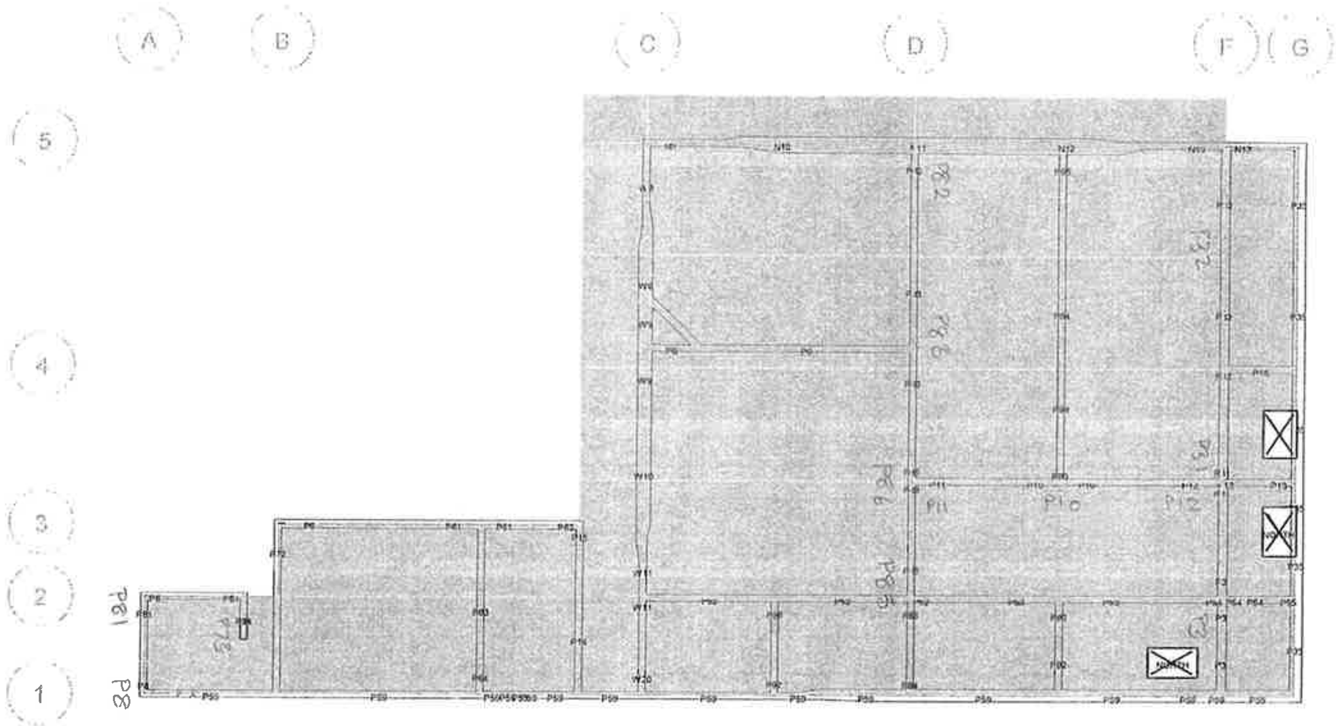
P71
P63

Storey 4

Storey	Pier	V* (kN)				φVn (kN)	%NBS	M* (kNm)					
		μ=1.0	μ=1.5	G+0.3Q	Total			μ=1.0	μ=1.5	G+0.3Q	Total	φMn (kNm)	%NBS
STORY4	P11	69	45.8	8.1	53.9	123		75	49.6	11.7	61.3	105	
STORY4	P12	71	46.8	1.3	48.1	65		59	38.9	2.9	41.7	31	74%
STORY4	P13	12	7.7	1.0	8.7	19		6	4.3	0.7	4.9	4	81%
STORY4	P14	50	33.0	12.3	45.3	65		56	36.7	11.9	48.6	31	64%
STORY4	P15	11	7.4	1.0	8.4	19		6	3.7	0.5	4.1	4.7	
STORY4	P31	484	319.4	138.0	457.4	364	80%	613	404.1	265.1	669.2	845	
STORY4	P32	48	31.5	5.7	37.2	91		53	35.2	1.9	37.1	58	
STORY4	P33	243	160.6	43.1	203.7	299		181	119.7	40.2	159.9	576	
STORY4	P41	36	24.0	0.5	24.5	52		22	14.5	2.1	16.6	21	
STORY4	P42	12	7.8	0.8	8.5	32		7	4.6	0.7	5.4	13	
STORY4	P43	80	53.1	18.9	72.0	156		43	28.4	6.9	35.3	162	
STORY4	P44	51	33.5	7.9	41.5	32	78%	18	12.0	3.3	15.3	13	85%
STORY4	P5	32	20.8	1.0	21.8	70		13	8.4	0.6	9.1	24	
STORY4	P51	68	44.6	4.8	49.3	84		33	21.8	4.8	26.6	27	
STORY4	P52	103	68.2	11.8	80.0	221		115	75.7	9.0	84.7	320	
STORY4	P53	134	88.4	25.1	113.6	136		118	78.1	32.4	110.4	136	
STORY4	P54	68	45.0	6.6	51.6	65		56	36.6	5.3	41.9	34	81%
STORY4	P59	1079	712.0	72.8	784.8	1955		2953	1947.8	202.7	2150.5	13573	
STORY4	P6	246	162.1	18.5	180.7	225		129	84.9	13.5	98.4	137	
STORY4	P61	205	135.4	16.4	151.8	169		93	61.4	7.8	69.2	80	
STORY4	P62	99	65.4	4.3	69.8	98		80	52.7	2.7	55.4	30	54%
STORY4	P63	447	294.9	52.3	347.1	261	75%	560	369.5	58.9	428.3	439	
STORY4	P7	288	190.0	16.8	206.8	492		259	170.6	1.8	172.4	616	
STORY4	P71	75	49.7	14.7	64.3	71		44	29.1	10.1	39.2	37	94%
STORY4	P74	67	43.9	20.0	63.9	104		56	37.0	11.7	48.8	76	
STORY4	P75	10	6.7	0.8	7.5	19		4	2.6	0.3	2.9	4	
STORY4	P76	354	233.4	25.2	258.6	492		271	178.5	31.3	209.8	616	

STORY4	P8	15	10.1	0.3	10.5	84		8	5.0	0.7	5.7	27	
STORY4	P81	20	13.0	0.8	13.8	56		7	4.6	0.4	5.0	11	
STORY4	P82	66	43.6	9.6	53.2	45	85%	42	27.8	6.4	34.2	21	61%
STORY4	P83	351	231.8	38.6	270.4	175	65%	351	231.4	30.5	261.8	203	78%
STORY4	P84	430	283.6	10.1	293.7	188	64%	280	184.5	38.4	222.9	233	
STORY4	P85	339	223.4	30.9	254.3	123	49%	305	201.4	19.0	220.4	105	48%
STORY4	P86	181	119.3	26.2	145.5	91	63%	109	71.6	18.5	90.1	58	64%
STORY4	P9	422	278.0	19.5	297.5	358		310	204.6	18.1	222.7	818	
STORY4	P93	313	206.4	21.2	227.7	175	77%	284	187.0	29.6	216.6	203	94%
STORY4	P95	54	35.8	15.4	51.2	45	89%	32	21.1	8.9	30.0	21	70%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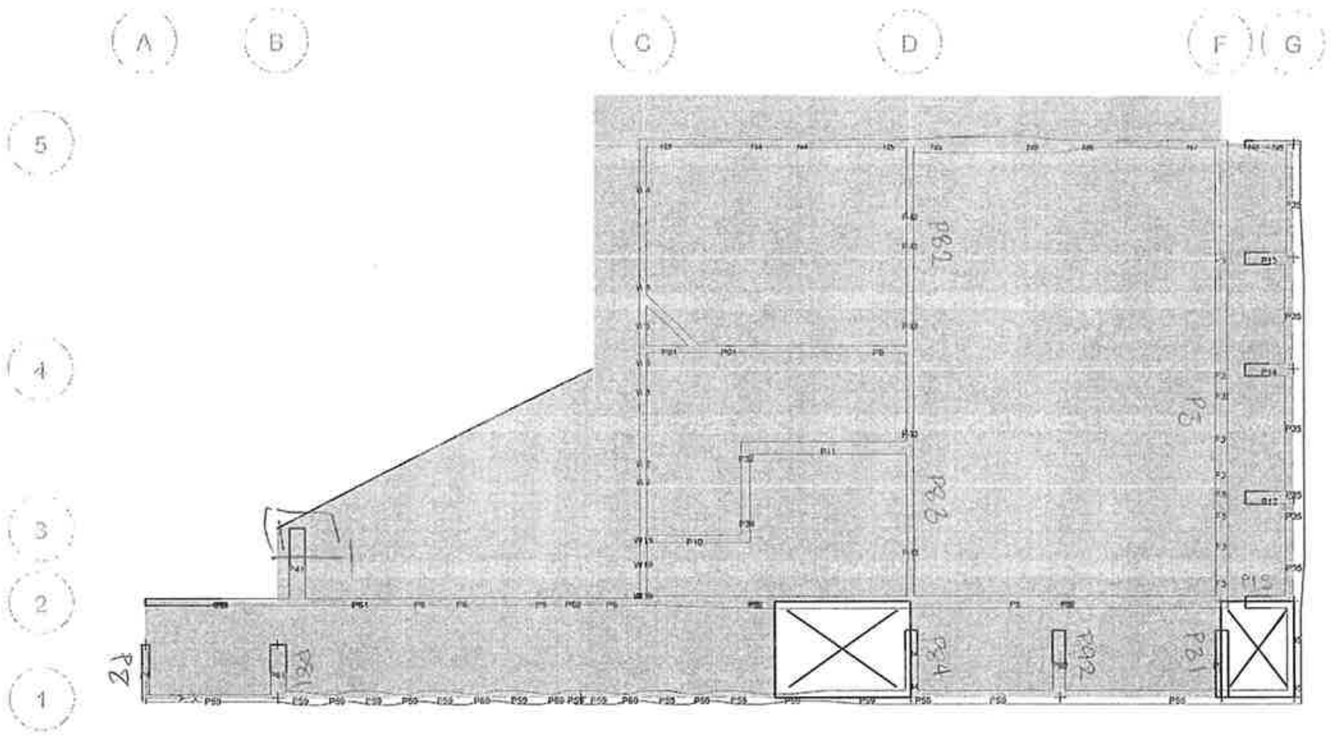
P3

Storey 3

Storey	Pier	V* (kN)				φVn (kN)	%NBS	M* (kNm)				φMn (kNm)	%NBS
		μ=1.0	μ=1.5	G+0.3Q	Total			μ=1.0	μ=1.5	G+0.3Q	Total		
STORY3	P10	101	66.3	10.2	76.6	296		165	108.5	19.1	127.7	230	
STORY3	P11	48	32.0	21.2	53.1	155		49	32.5	27.5	60.1	69	
STORY3	P12	60	39.6	45.2	84.8	197		66	43.7	54.6	98.3	107	
STORY3	P13	31	20.4	21.4	41.8	99		28	18.6	14.3	32.9	30	91%
STORY3	P14	160	105.4	47.2	152.6	324		197	130.2	34.8	164.9	274	
STORY3	P15	11	7.0	2.0	9.0	56		5	3.3	1.4	4.7	11	
STORY3	P16	194	127.9	56.8	184.7	211		111	73.2	40.9	114.1	144	
STORY3	P3	251	165.6	29.1	194.7	408		351	231.3	49.6	280.9	427	
STORY3	P31	32	21.2	3.8	25.0	113		32	21.3	2.3	23.5	39	
STORY3	P32	578	381.5	13.3	394.8	664		614	404.8	102.3	507.2	1287	
STORY3	P35	2374	1565.6	195.9	1761.5	2648		7124	4698.8	793.3	5492.0	8422	
STORY3	P5	23	15.1	0.8	15.9	56		12	8.1	0.6	8.7	11	
STORY3	P51	23	15.5	2.2	17.7	70		19	12.9	0.8	13.7	24	
STORY3	P52	620	409.0	25.1	434.1	837		930	613.4	100.5	713.9	1865	
STORY3	P53	290	191.0	14.7	205.8	535		498	328.7	37.2	366.0	882	
STORY3	P54	42	27.6	6.3	33.9	155		41	27.3	8.0	35.4	86	
STORY3	P55	6	4.0	3.2	7.2	42		3	2.1	1.7	3.8	8	
STORY3	P59	2891	1906.6	152.2	2058.8	3305		15298	10090.4	2335.5	12425.9	38773	
STORY3	P6	87	57.1	31.7	88.8	183		53	35.0	26.2	61.3	190	
STORY3	P61	143	94.3	39.1	133.4	295		128	84.3	39.7	124.0	311	
STORY3	P62	23	14.9	1.7	16.7	84		14	9.2	2.8	12.0	27	
STORY3	P63	42	27.9	13.4	41.4	71		19	12.6	6.1	18.6	24	
STORY3	P64	82	54.2	18.6	72.8	113		56	36.8	9.0	45.7	44	96%
STORY3	P71	0	0.0		0.0	29		0	0.0		0.0	4.3	
STORY3	P72	92	60.7	5.3	66.0	155		67	44.3	2.0	46.3	69	
STORY3	P73	21	14.0	3.6	17.6	127		29	19.4	5.8	25.2	56	
STORY3	P8	29	19.1	0.7	19.8	56		7	4.9	1.0	5.9	11	

STORY3	P81	41	27.1	0.7	27.8	84		25	16.6	0.4	17.0	27	
STORY3	P82	100	66.0	14.8	80.8	127		69	45.4	8.8	54.2	77	
STORY3	P83	576	380.0	11.5	391.5	523		826	545.1	57.0	602.1	762	
STORY4	P84	48	31.5	10.1	41.6	70		30	20.0	5.6	25.6	24	94%
STORY4	P85	232	153.2	65.5	218.7	253		208	137.0	67.2	204.2	1627	
STORY3	P86	47	30.8	1.5	32.3	98		39	25.6	3.0	28.6	30	
STORY3	P9	566	373.5	6.2	379.7	778		581	383.4	76.6	460.0	1520	
STORY3	P92	229	151.1	50.8	202.0	281		139	91.9	39.2	131.0	282	
STORY3	P93	10	6.8	4.3	11.1	56		5	3.4	2.3	5.7	13	
STORY3	P94	97	64.2	10.4	74.6	520		142	93.5	23.1	116.6	621	
STORY3	P95	21	14.0	20.0	34.0	127		34	22.4	17.4	39.8	33	83%
STORY3	P96	50	32.9	11.5	44.4	70		18	11.6	4.7	16.4	24	
STORY3	P97	43	28.7	9.9	38.6	70		15	10.0	3.9	13.8	24	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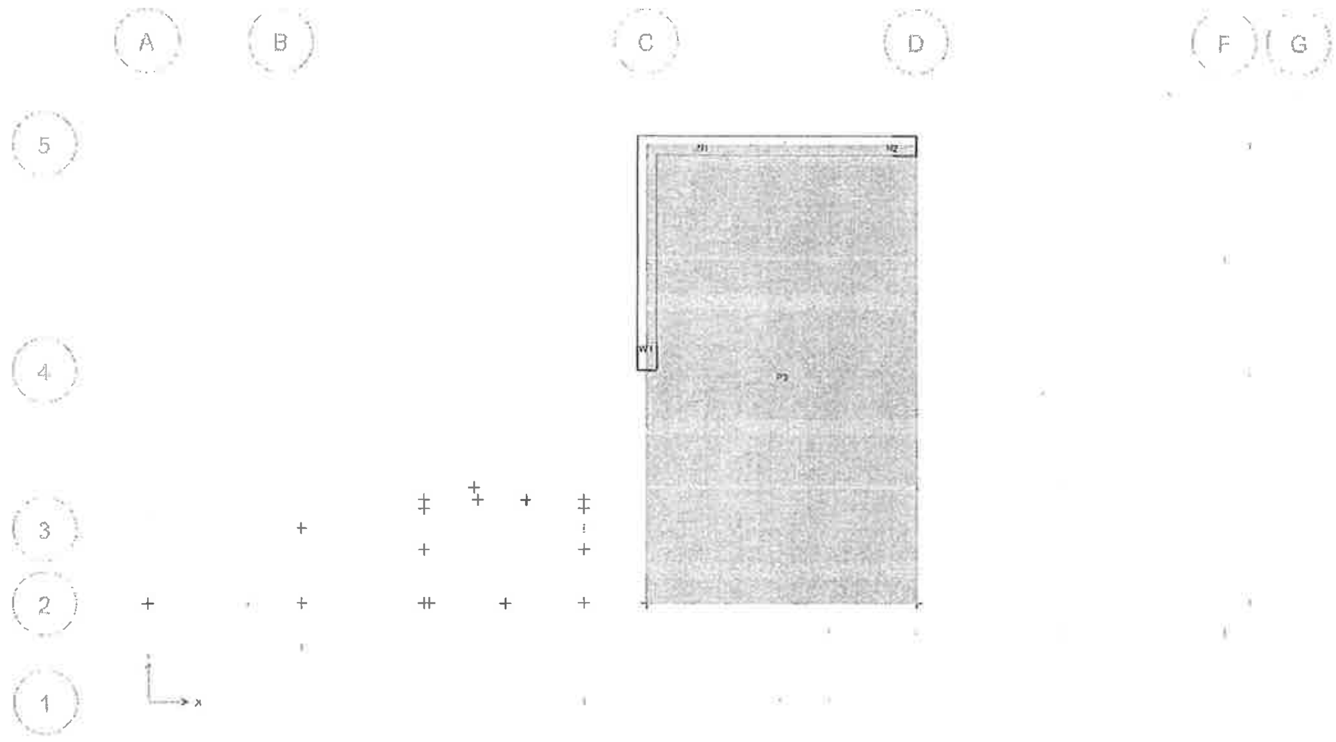
P8
P3
P13

Storey 2

Storey	Pier	V* (kN)				φVn (kN)	%NBS	M* (kNm)				φMn (kNm)	%NBS
		μ=1.0	μ=1.5	G+0.3Q	Total			μ=1.0	μ=1.5	G+0.3Q	Total		
STORY2	P10	54	35.6	41.6	77.2	295		32	20.8	2.4	23.2	230	
STORY2	P11	257	169.8	53.9	223.7	478		349	230.2	124.8	355.0	585	
STORY2	P12	93	61.6	11.6	73.2	234		72	47.6	12.9	60.5	112	
STORY2	P13	176	115.9	23.2	139.2	234		123	81.3	20.5	101.9	112	
STORY2	P14	154	101.8	15.2	117.1	234		107	70.4	13.3	83.7	112	
STORY2	P15	81	53.5	16.6	70.2	234		61	40.3	9.1	49.4	112	
STORY2	P3	1967	1297.6	39.6	1337.2	2192		1666	1099.0	1155.3	2254.4	5902	
STORY2	P31	137	90.3	11.4	101.7	328		130	85.7	7.8	93.5	212	
STORY2	P32	17	11.2	2.3	13.5	42		8	5.0	1.2	6.1	8	
STORY2	P34	25	16.2	8.7	25.0	98		17	11.1	6.5	17.6	30	
STORY2	P35	2984	1968.3	337.5	2305.8	3178		10338	6818.7	1439.5	8258.2	14813	
STORY2	P41	554	365.5	27.3	392.9	353	90%	219	144.6	7.4	152.1	268	
STORY2	P5	347	228.7	69.4	298.0	3324		3170	2091.1	1176.1	3267.2	25600	
STORY2	P51	462	304.7	15.6	320.3	802		594	391.5	93.4	484.9	2002	
STORY2	P52	2667	1758.8	18.9	1777.7	2783		3672	2422.0	918.7	3340.7	12245	
STORY2	P59	3636	2397.9	248.4	2646.4	4406		23320	15381.0	2549.7	17930.7	49800	
STORY2	P8	169	111.5	2.5	114.0	155		144	95.0	2.5	97.6	69	71%
STORY2	P81	302	199.2	8.4	207.6	350		261	172.1	6.0	178.1	344	
STORY2	P82	35	23.4	11.8	35.2	169		52	34.5	20.6	55.2	107	
STORY2	P83	611	403.1	303.9	707.0	877		265	175.0	211.4	386.4	1875	
STORY2	P84	276	181.7	38.8	220.5	328		236	155.6	23.1	178.8	212	
STORY2	P9	19	12.7	34.1	46.8	184		18	12.2	19.1	31.3	76	
STORY2	P91	82	54.0	87.7	141.6	338		69	45.7	80.6	126.4	347	
STORY2	P92	206	136.0	33.7	169.7	328		178	117.7	23.2	140.9	212	


A
B
C
D
F
G
5
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3
2
1
W1
P3

DON THOMSON consulting engineers	calculation sheet		page: 2-9	
	job name	34 Upland Road		
	job no:	210263	designed:	RLM
	date:	19/02/2013	checked:	

Description: **New Concrete Wall - Pier 81**

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	150 mm
Overall depth	H	1100 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	500 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.0025 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i} \times (H/2 - d_i)$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
100	16	1	500.0	201	0.0018	360	72.3	32.5
300.0	16	1	500.0	201	-0.0006	-121	-24.3	-6.1
500.0	16	1	500.0	201	-0.0030	-500	-100.5	-5.0
700.0	16	1	500.0	201	-0.0054	-500	-100.5	15.1
900.0	16	1	500.0	201	-0.0078	-500	-100.5	35.2
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
100.0	12.7	1	275.0	127	0.0018	275	34.8	15.7
405.0	12.7	1	275.0	127	-0.0019	-275	-34.8	-5.1
710.0	12.7	1	275.0	127	-0.0055	-275	-34.8	5.6
1015.0	12.7	1	275.0	127	-0.0092	-275	-34.8	16.2
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Axial load	P*	353.0 kN
Depth to neutral axis	c	249.6 mm
Concrete compressive force	C_c	676.3 kN
Sum of steel axial force	$C_s + T_s$	-323.3 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	300 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]\ (H/2 - d_i)]$	104 kNm
Section moment capacity	ϕM_n	**343.7** kNm
Moment Demand	M*	**624** kNm

Compression taken as positive NG

Steel stress-strain curve assumed bi-linear

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		10 mm
Bar spacing	s	200 mm
Max spacing	s_{max}	220 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	500 MPa
Area of shear steel	A_v	79 mm^2
Min area of shear steel	$A_{v,min}$	42 mm^2
Area of concrete shear	A_{cv}	132000 mm^2
Steel shear strength	V_s	173 kN
Concrete shar strength	V_c	160 kN
Total shear strength	ϕV_{total}	**249** kN +101kN
Shear demand	V*	**802** kN

NG

DON THOMSON consulting engineers

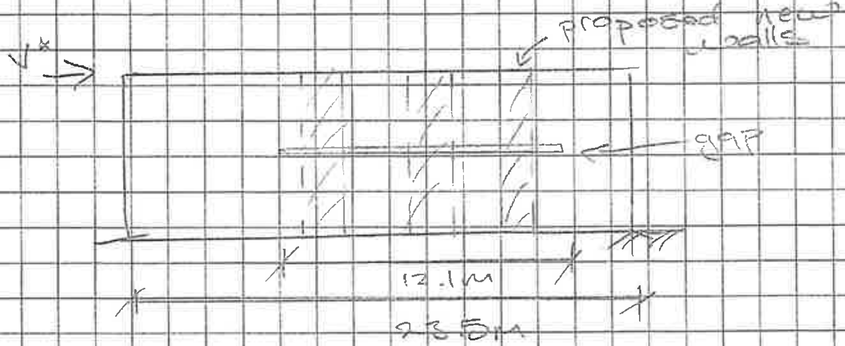
project: 34 Upland Rd | project no.: 210263 | section: 3 | page: 1

part: Storey 2 | date: 21/2/13

element: Pier 59 | designer: RLM

Pier 59 has ~30mm horizontal gap at mid height. New concrete walls designed to transfer load over gap.

$V^* = 4139kN$



Shear force to be transferred

$V^* = 4139kN \times 12.1m / 23.5m$

$= 2131kN$

Try 7 walls

$V^*_{wall} = 2131kN / 7$

$= 304kN$

Try 4HD16 vertical per wall

$\phi V = \phi f_y A_s n$

$= 0.9 \times 500MPa \times 16^2\pi/4$

$= 362kN$ > V^* ok

use 4HD16

81 Harbour View Rd Northland Wellington 6012 tel: +64 4 475 7933 fax: +64 4 475 8414 web: www.donthomson.co.nz

Don Thomson
Consulting Engineers
81 Harbour View Road
Northland Wellington
tel 04 475 7933 fax 04 475 8414

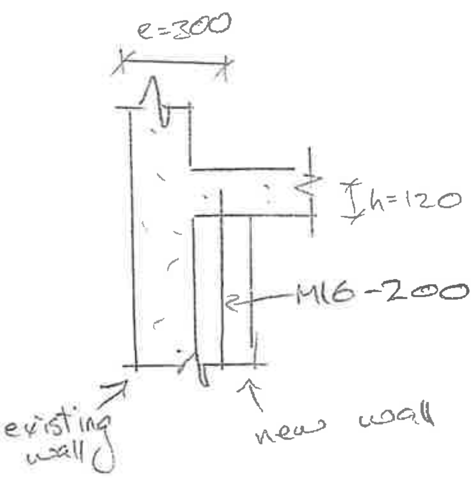
calculation sheet		page no: 3-2
job name:	34 Upland Road	
designed: RLM	job no:	210263
checked:	date:	21-02-13

Chemset Injection Anchor Design Sheet

Top connection of new wall to pier 59

Size	M16	N*	2 kN
Depth	120 mm	V*	304 kN
f'_c	25 MPa		
e	300 mm		
a	200 mm		
$\alpha°$	90 degrees		
n	4 bolts		
ΦN_{uc}	23.3 kN	ΦV_{uc}	91.3 kN
X_{nc}	0.93	X_{vc}	0.88
X_{ne}	1	X_{vd}	2
X_{na}	1	X_{va}	0.63
		X_{vn}	0.706667
ΦN_{urc}	86.68 kN		
		ΦV_{urc}	286.15 kN

Combined Action 1.264 Fails
NBS 94 % > 67% ok



use 4 M16 at 200 ctrs for each wall

DON THOMSON consulting engineers	calculation sheet		page: 3-3
	job name	34 Upland Road	
	job no:	210263	designed: RLM
	date:	22/02/2013	checked:

Description: **New wall to Pier 59**

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	150 mm
Overall depth	H	900 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	500 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.0025 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i} \times (H/2 - d_i)$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
50	16	1	500.0	201	0.0018	354	71.2	28.5
250.0	16	1	500.0	201	-0.0031	-500	-100.5	-20.1
450.0	16	1	500.0	201	-0.0081	-500	-100.5	0.0
650.0	16	1	500.0	201	-0.0130	-500	-100.5	20.1
850.0	16	1	500.0	201	-0.0179	-500	-100.5	40.2
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Axial load	P*	kN
Depth to neutral axis	c	122.1 mm
Concrete compressive force	C_c	330.9 kN
Sum of steel axial force	$C_s + T_s$	-330.9 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	132 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$ $(H/2 - d_i)]$	69 kNm
Section moment capacity	ϕM_n	**170.4** kNm
Moment Demand	M*	kNm

Compression taken as positive — ok

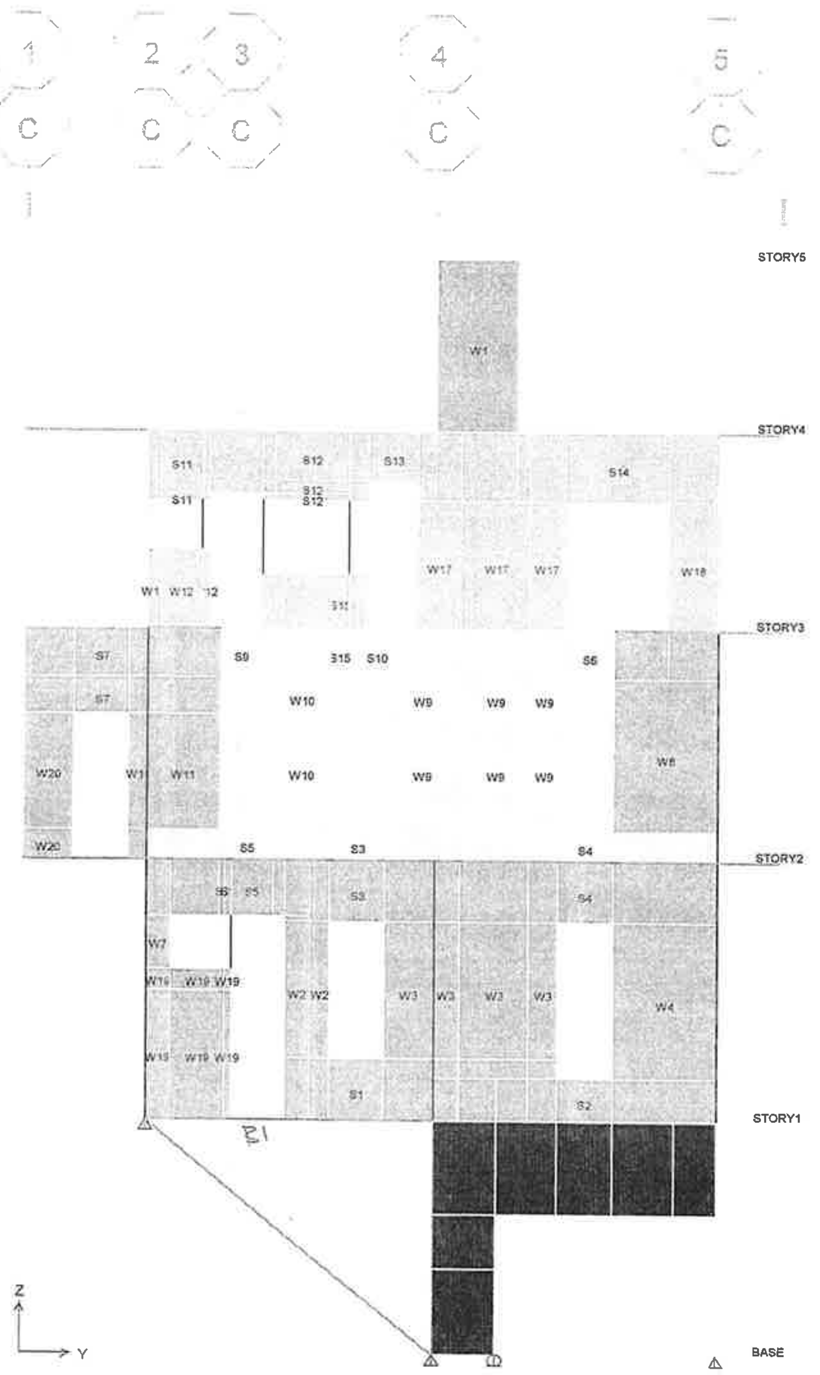
Steel stress-strain curve assumed bi-linear

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		12 mm
Bar spacing	s	200 mm
Max spacing	s_{max}	180 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	500 MPa
Area of shear steel	A_v	113 mm^2
Min area of shear steel	$A_{v,min}$	42 mm^2
Area of concrete shear	A_{cv}	108000 mm^2
Steel shear strength	V_s	204 kN
Concrete shar strength	V_c	73 kN
Total shear strength	ϕV_{total}	**207** kN
Shear demand	V*	**304** kN

NG 68%

shear ok


1
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STORY5
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S12
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S12
W17
W17
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W18
W1
W12
STORY3
S7
S7
S9
S15
S10
S6
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W9
W9
W20
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W11
W10
W9
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W9
W8
W20
S5
S3
S4
STORY2
S6
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S3
S4
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W19
W2
W2
W3
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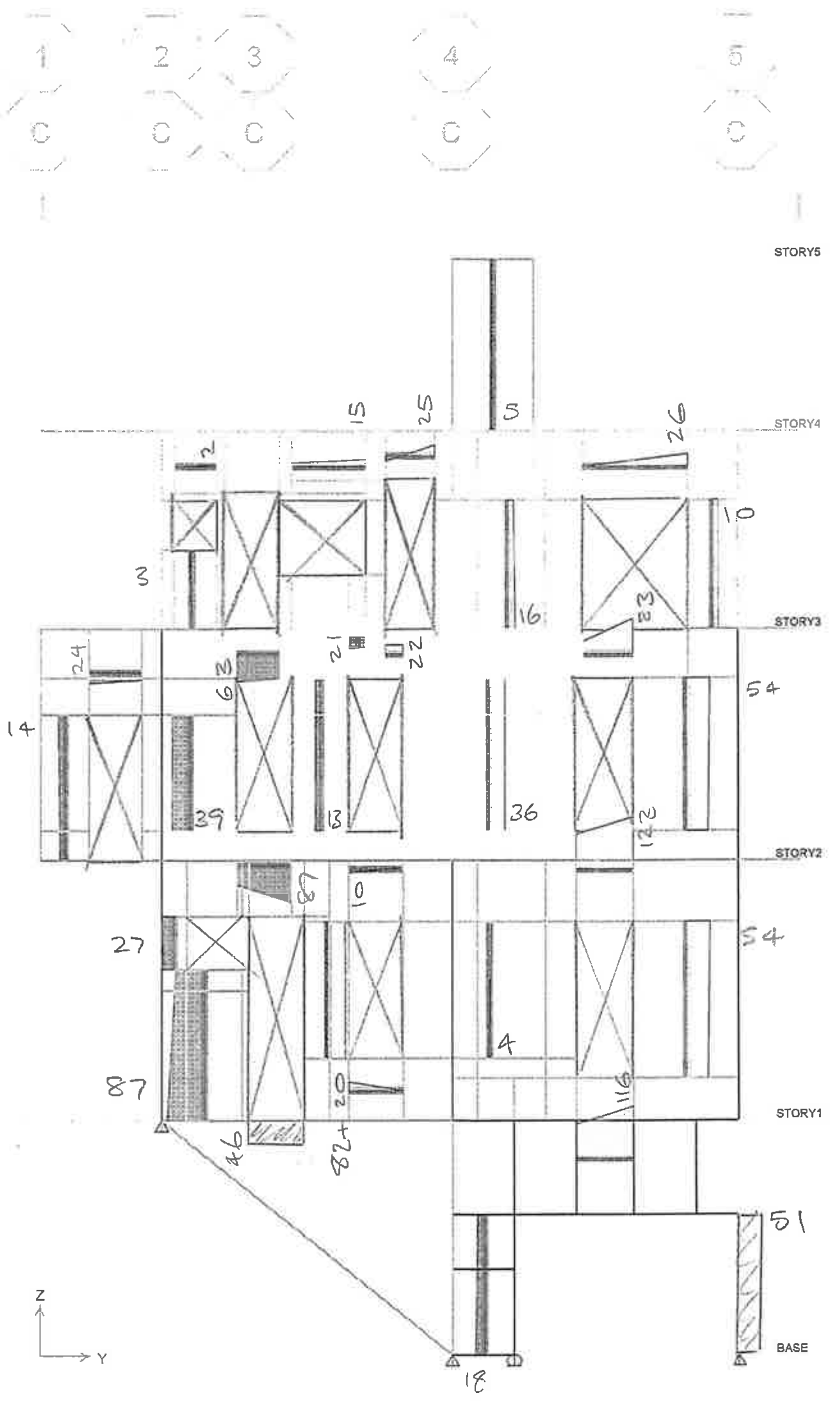
W19
W19
W19
S1
S2
STORY1
B1
Z
Y
BASE

West Wall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STORY4
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STORY2
STORY1
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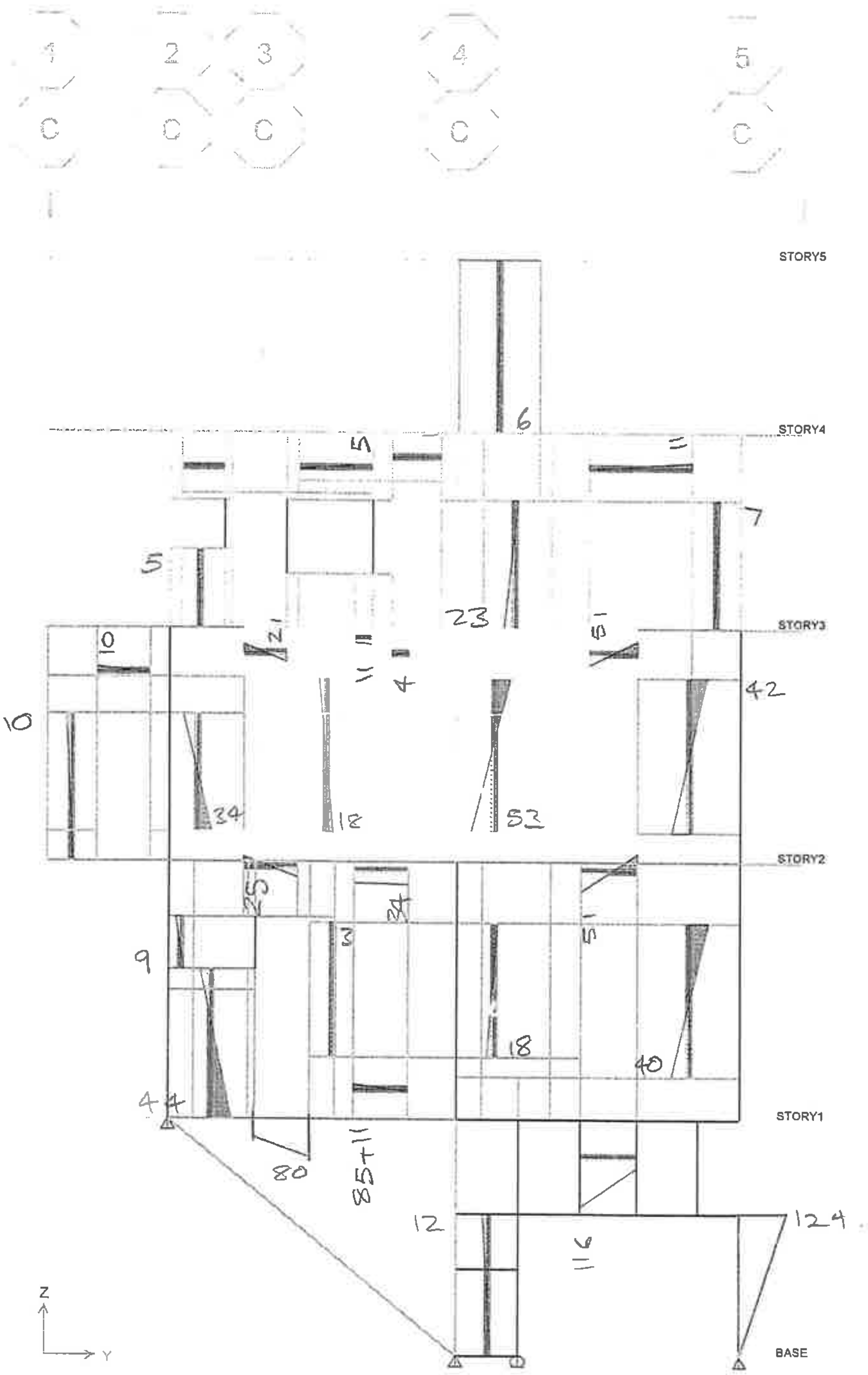
Y

West Wall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42
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44
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85+11
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124

West Wall

Storey	Pier	$V^*_{E(mu=1)}$ (k	$V^*_{E(mu=1.5)}$ (	$V^*_{G+0.3Q}$ (k	V^*_{total} (kN)	φVn (kN)	%NBS	$M^*_{E(mu=1)}$ (k	$M^*_{E(mu=1.5)}$ (	$M^*_{G+0.3Q}$ (k	M^*_{total} (kN	φMn (kNm)	%NBS	Strengthening Shear	Strengthening Flexural
West Wall															
STORY5	W1	41.2	27.2	4.6	31.8	183		14.8	9.7	5.7	15.4	122		0	0
STORY4	W12	34.7	22.9	3.4	26.3	67		19.8	13.0	4.9	17.9	36		0	0
STORY4	W17	203.6	134.3	14.8	149.0	161		256.7	169.3	19.8	189.2	169	89%	0	0
STORY4	W18	66.4	43.8	11.3	55.1	54	98%	53.1	35.0	7.9	42.9	25	58%	0	0
STORY4	S11	22.2	14.6	2.2	16.8	61		18.3	12.1	0.3	12.4	29		0	0
STORY4	S12	59.8	39.4	15.8	55.3	61		29.6	19.5	5.6	25.1	29		0	0
STORY4	S13	92.2	60.8	24.9	85.7	43	50%	39.1	25.8	1.4	27.2	16	59%	0	0
STORY4	S14	119.3	78.7	26.4	105.1	61	58%	83.7	55.2	12.3	67.5	29	43%	0	0
STORY3	W8	334.3	220.5	44.8	265.2	309		254.1	167.6	29.7	197.3	291		0	0
STORY3	W9	671.2	442.7	37.7	480.4	1009		951.4	627.5	69.3	696.9	1552		HD16-200	HD16-200
STORY3	W10	141.9	93.6	13.7	107.2	171		175.8	116.0	19.0	135.0	252		R10-200	HD16-150
STORY3	W11	233.6	154.1	33.9	187.9	211		202.7	133.7	26.6	160.3	241		0	0
STORY3	W20	77.8	51.3	14.0	65.4	113		51.4	33.9	10.2	44.1	118		0	0
STORY3	S6	441.6	291.3	59.6	350.9	226	64%	180.0	118.7	19.6	138.3	188		HR10-150	3 HD16
STORY3	S7	176.2	116.2	22.9	139.1	220		88.2	58.2	12.1	70.3	146		0	0
STORY3	S9	228.3	150.6	54.4	205.0	226		105.9	69.8	19.4	89.3	188		HR10-150	3 HD16
STORY3	S10	372.4	245.7	26.6	272.3	226	83%	123.3	81.4	4.5	85.8	188		HR10-150	3 HD16
STORY4	S15	344.1	227.0	17.4	244.4	341		87.9	58.0	8.1	66.1	269		HR10-150	0
STORY2	W2	17.8	11.7	1.9	13.6	110		19.7	13.0	4.0	16.9	91		0	2 -150mm 600C
STORY2	W3	141.9	93.6	9.3	102.9	484		195.4	128.9	21.3	150.2	808		0	0
STORY2	W4	120.2	79.3	56.6	135.9	325		92.7	61.1	47.7	108.9	370		0	0
STORY2	W5	0.0	0.0		0.0	0		0.0	0.0		0.0	0		0	0
STORY2	W7	112.1	73.9	26.4	100.4	131		35.7	23.6	9.5	33.0	108		0	0
STORY2	W19	187.2	123.5	87.2	210.7	256		18.2	12.0	47.9	59.9	246		0	0
STORY2	S3	317.7	209.5	6.6	216.2	247		286.6	189.0	18.0	207.0	334		R10-200	3 HD16
STORY2	S4	439.5	289.9	136.3	426.2	247	58%	214.1	141.2	56.6	197.8	334		R10-200	3 HD16
STORY2	S5	359.4	237.0	85.2	322.2	247	77%	186.9	123.2	28.8	152.1	334		R10-200	3 HD16
STORY1	W1	21.8	14.4	17.7	32.1	487		15.1	10.0	12.6	22.5	321		0	0
STORY1	S1	118.5	78.1	56.6	134.8	222		172.4	113.7	79.4	193.0	206		0	2 -200mm 600C
STORY1	S2	93.7	61.8	122.2	184.0	129	70%	76.3	50.3	119.4	169.7	265		R10-200	HD16-150
STORY1	C10	66.0	43.5	50.9	94.4	626		161.0	106.2	124.0	230.2	198	86%		
STORY1	B1	167.0	110.1	46.0	156.1	200		134.0	88.4	80.0	168.4	165	98%	0	HD16-150

Strength of FRP

	f_f (MPa)	C_l	$C_l f_f$ (MPa)	E (GPa)	ε_{fu}	t_f (mm)
SikaWrap-930G	1944	0.65	1263.6	67.1	0.029	0.365
SikaWrap-600C	2564	0.85	2179.4	211	0.012	0.331

f'_c 25 MPa

ϕ 0.75

k_1 0.95 $=(fc/27)^{0.67}$

ψ_f 0.85

	E (GPa)
SCH-41	82
SEH-51A	20.9

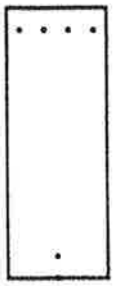
West Wall

		Member	$\phi V_{n,existing}$ (kN)	V* (kN)	ΔV* (kN)	L (m)	Type	No. Layers	Layer width (mm)	Spacing (mm)	$L_e = 23300/(nt_fE_f)^{0.58}$	$k_2 = (L-2L_e)/L$	$kv=k_1k_2L_e/11900\varepsilon_{fu}$	$\varepsilon_{fe} = k_v\varepsilon_{fu}$	$f_{fe} = E_f\varepsilon_{fe}$ (MPa)	$A_{fv} = w_ft_fn$ (mm)	$\Delta\phi V_n$ (kN)	$\phi V_{n,proposed}$ (kN)
14	Story 3	W8	309	265		1.9					0.0	1.00					0	309
15	Story 3	W9	1009	480		2.8					0.0	1.00					0	1009
16	Story 3	W10	171	107	99	0.9	SikaWrap-930G	1	1000	1000	66.3	0.87	0.15	0.0040	268	365	45	216
17	Story 3	W11	211	188		1.5					0.0	1.00					0	211
18	Story 3	S6	226	351	9	0.8	SikaWrap-600C	5	400	600	14.2	0.96	0.09	0.0016	338	662	152	378
21	Story 3	S9	220	139	127	0.8	SikaWrap-600C	2	1000	1000	24.2	0.92	0.15	0.0018	376	662	102	322
19	Story 3	S10	226	205	89	0.8	SikaWrap-600C	4	1000	1000	16.2	0.95	0.10	0.0012	259	1324	140	366
20	Story 3	S15	341	244	177	1.9	SikaWrap-600C	1	1000	1000	36.1	0.95	0.23	0.0027	580	331	186	527
8	Story 2	W2	110	14		0.75	SikaWrap-600C	1	1000	1000	36.1	0.88	0.21	0.0025	535	331	68	178
7	Story 2	W3	484	103		2.8	SikaWrap-600C	3	1000	1000	19.1	0.98	0.12	0.0015	316	993	448	932
6	Story 2	W4	325	136		1.55	SikaWrap-600C	4	1000	1000	16.2	0.97	0.10	0.0013	265	1324	278	603
	Story 2																	
9	Story 2	W7	131	100		0.6					0.0	1.00					0	131
10	Story 2	W19	256	211		1.5					0.0	1.00					0	256
12	Story 2	S3	247	216	102	1.6	SikaWrap-600C	2	1000	1000	24.2	0.96	0.15	0.0019	392	662	212	459
11	Story 2	S4	247	426	19	1.6	SikaWrap-600C	3	400	600	19.1	0.97	0.12	0.0015	312	397	169	584
11	Story 2				19	1.6	SikaWrap-600C	3	400	600	19.1	0.97	0.12	0.0015	312	397	169	
13	Story 2	S5	247	322	-31	1.6	SikaWrap-600C	2	1000	1000	24.2	0.96	0.15	0.0019	392	662	212	459
2	Story 1	W1	487	32		1.7	SikaWrap-600C	4	1000	1000	16.2	0.98	0.10	0.0013	266	1324	305	792
4	Story 1	S1	222	135		2					0.0	1.00					0	222
3	Story 1	S2	129	184	-6	1.7	SikaWrap-600C	4	1000	1000	16.2	0.98	0.10	0.0013	266	1324	305	434
1	Story 1	C10	626	94		1					0.0	1.00					0	626
5	Story 1	B1	200	156		1					0.0	1.00					0	200

DON THOMSON consulting engineers	calculation sheet	page:
	job name: 34 Upland Road	
	designed: RLM	job no: 210263
	checked:	date: 12/06/2013

Description: Member **B1** existing

Designed June 2009 in accordance with NZS3101:2006, Amendment 2



Section and material properties

Flexural strength reduction factor	ϕ	0.85 -	*[Clause 2.3.2.2]*
Section width	b	400 mm	
Overall section depth	H	1225 mm	
Overall flange width (if present)	b_{flange}	mm	
Flange thickness (if present)	t_{flange}	mm	
28 day concrete compressive stress	f'_c	25 MPa	
Equivalent stress block stress factor	α	0.85 -	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85 -	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200 GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ε_c	0.0030 mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\varepsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
100	31.8	4.0	275	3177	-0.0009	-172	-546.0	54.6
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
1125	8.5	1.0	275	57	-0.0404	-275	-15.6	17.6

Depth to centroid of tension steel	d	1125.0 mm		
Total area of tension steel	A_s	57 mm^2		
Min allowable reinforcement area	$A_{s,min}$	2290.9 mm2 > As	NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum rec check)	$c_{max} = 0.75c_b$	578.6 mm > c	OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0 kN
Depth to neutral axis at failure	c	77.7 mm
Section moment capacity	ϕM_n	**45.6** kNm
	M* 178	kNm **NG**

26%

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Minimum shear reinforcement provided:	-	No -	*[Clause 9.3.9.4.15]*
Member depth factor	k_d	0.77 -	*[Clause 9.3.9.3.4]*
Tension reinforcement ratio	ρ	0.0001 -	
Basic concrete shear	v_b	0.071 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Concrete shear stress	v_c	0.309 MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	104.2 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	13 mm	
Number of legs	n	1 -	
Stirrup yield stress	f_{yt}	275 MPa	
Stirrup spacing	s	305 mm	
Dependable reinforcing shear	ϕV_s	96.4 kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**200.6** kN	oK
	V* 165.	kN	

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DON THOMSON consulting engineers	calculation sheet		page:
	job name:	34 Upland Road	
	designed:	RLM	job no: 210263
	checked:		date: 12/06/2013

Description: **B1 strengthened**

Designed June 2009 in accordance with NZS3101:2006, Amendment 2

Section and material properties

Flexural strength reduction factor	ϕ	0.85 -	*[Clause 2.3.2.2]*
Section width	b	150 mm	
Overall section depth	H	1100 mm	
Overall flange width (if present)	b_{flange}	mm	
Flange thickness (if present)	t_{flange}	mm	
28 day concrete compressive stress	f'_c	25 MPa	
Equivalent stress block stress factor	α	0.85 -	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85 -	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200 GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ε_c	0.0030 mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\varepsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
100	12.0	1.0	500	113	0.0005	104	11.7	-1.2
250	12.0	1.0	500	113	-0.0032	-500	-56.5	14.1
400	12.0	1.0	500	113	-0.0069	-500	-56.5	22.6
550	12.0	1.0	500	113	-0.0106	-500	-56.5	31.1
700	12.0	1.0	500	113	-0.0144	-500	-56.5	39.6
850	12.0	1.0	500	113	-0.0181	-500	-56.5	48.1
1000	12.0	1.0	500	113	-0.0218	-500	-56.5	56.5

Depth to centroid of tension steel	d	1000.0 mm	
Total area of tension steel	A_s	113 mm^2	
Min allowable reinforcement area	$A_{s,min}$	420.0 mm2 > As NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	409.1 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0 kN	
Depth to neutral axis at failure	c	120.9 mm	
Section moment capacity	ϕM_n	**164.9** kNm	93%
	M*	5 kNm	**OK**
		178	

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Minimum shear reinforcement provided:	-	No -	*[Clause 9.3.9.4.15]*
Member depth factor	k_d	0.80 -	*[Clause 9.3.9.3.4]*
Tension reinforcement ratio	ρ	0.0008 -	
Basic concrete shear	v_b	0.078 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Concrete shear stress	v_c	0.318 MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	35.8 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	10 mm	
Number of legs	n	1 -	
Stirrup yield stress	f_{yt}	300 MPa	
Stirrup spacing	s	200 mm	
Dependable reinforcing shear	ϕV_s	88.4 kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**124.1** kN	existing + 200 = 224kN > V* ok
	V* 165	) kN	

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Don Thomson Consulting Engineers

Concrete flexural capacity (sagging)

Designed June 2009 in accordance with NZS3101:2006, Amendment 2

Job Name:	34 Upland Rd	Date:	21-Feb-13
Job Number:	210263	Designer	RLM
Description:	S1 - FRP strengthening	Checker:	

Section and material properties

				Clauses
Flexural strength reduction factor	ϕ	0.90	-	[Clause 2.3.2.2]
Web width	b	150	mm	
Overall section depth	H	1700	mm	
Overall flange width (if present)	b_{flange}	400	mm	
Flange thickness (if present)	t_{flange}	1100	mm	
Concrete cylinder compressive strength at 28 days	f'_c	25	MPa	
Concrete modulus of elasticity	E_c	23.5	GPa	
Reinforcement modulus of elasticity	E_s	200	GPa	[Clause 5.3.4]
Yield strain of reinforcement	ε_y	0.0014	mm / mm	
Ultimate concrete compressive strain	ε_c	-0.0004	mm / mm	[Clause 7.4.2.3]
Type of Fibrewrap		SikaWrap600C		
Maximum allowable strain	$\varepsilon_{f,max}$	0.004	mm / mm	
Thickness of fibrewrap	t_f	211	mm	
Fibrewrap modulus of elasticity	E_f	0.331	GPa	
Bond Stress	σ_{bs}	1.38	MPa	

Flexural reinforcement

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$-T_{s,i} \times d_i$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
1000.0	8.5	1.0	275.0	56	0.0024	275	15.5	-15.5
1304.8	8.5	1.0	275.0	56	0.0032	275	15.5	-20.2
1609.6	8.5	1.0	275.0	56	0.0040	275	15.5	-24.9
				-	-	-	-	-
100.0	31.8	4.0	275.0	3167	-0.0001	-21	-66.1	6.6
				-	-	-	-	-

FRP

Depth from comp. fibre	Width	Number of layers	Ulitmate strength	Area	Strain	Stress	Force	Moment contribution
d_i	w_f	-	f_u	$A_{f,i}$	$\varepsilon_{f,i}$	$f_{f,i}$	$T_{f,i}$	$-T_{f,i} \times d_i$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
				-	-	-	-	-
				-	-	-	-	-
1600.0	200.0	2.0	834.0	84400	0.0040	1	111.7	-178.8
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-

Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load	P*	0.0	kN
Depth to bottom fibrewrap	d_1	1600.0	mm
Depth to neutral axis at failure	c	138.2	mm
Concrete compressive force	C_c	-92.1	kN
Sum of steel axial force	$C_s + T_s$	92.1	kN
Check axial force	$C_c + C_s - T_s$	0	kN
Concrete moment contribution	$-C_c \times c/3$	4	kNm
Steel moment contribution	$\Sigma[-(C_{s,i} + T_{s,i}) \times d_i]$	-233	kNm
Section moment capacity	ϕM_n	**-205.7**	kNm
	M*	314	kNm

66%

OK

Yield Curvature		ϕ_y	0.0009	$\times 10^{3}$ mm^{-1}
Ultimate Curvature		ϕ_u	0.0027	$\times 10^{3}$ mm^{-1}
Curvature Ductility		μ_ϕ	**2.9**	
Development Length	$T_f/\sigma_{BS}w_f$	L_d	405	mm

Description: **S2 - sprayed beam**

Designed June 2009 in accordance with NZS3101:2006, Amendment 2

Section and material properties

Flexural strength reduction factor	ϕ	0.85 -	*[Clause 2.3.2.2]*
Section width	b	125 mm	
Overall section depth	H	1100 mm	
Overall flange width (if present)	b_{flange}	mm	
Flange thickness (if present)	t_{flange}	mm	
28 day concrete compressive stress	f'_c	25 MPa	
Equivalent stress block stress factor	α	0.85 -	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85 -	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200 GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ε_c	0.0030 mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\varepsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
100	16.0	1.0	500	201	0.0015	309	62.2	-6.2
250	16.0	1.0	500	201	-0.0006	-127	-25.5	6.4
400	16.0	1.0	500	201	-0.0028	-500	-100.5	40.2
550	16.0	1.0	500	201	-0.0050	-500	-100.5	55.3
700	16.0	1.0	500	201	-0.0072	-500	-100.5	70.4
850	16.0	1.0	500	201	-0.0094	-500	-100.5	85.5
1000	16.0	1.0	500	201	-0.0115	-500	-100.5	100.5
				-	-	-	-	-

Depth to centroid of tension steel	d	1000.0 mm	
Total area of tension steel	A_s	201 mm^2	
Min allowable reinforcement area	$A_{s,min}$	350.0 mm2 > As NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	409.1 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0 kN
Depth to neutral axis at failure	c	206.4 mm
Section moment capacity	ϕM_n	**264.5** kNm
	M*	) kNm

219

ok

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Minimum shear reinforcement provided:	-	Yes -	*[Clause 9.3.9.4.15]*
Member depth factor	k_d	1.00 -	*[Clause 9.3.9.3.4]*
Tension reinforcement ratio	ρ	0.0016 -	
Basic concrete shear	v_b	0.086 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Concrete shear stress	v_c	0.430 MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	40.4 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	10 mm	
Number of legs	n	1 -	
Stirrup yield stress	f_{yt}	300 MPa	
Stirrup spacing	s	200 mm	
Dependable reinforcing shear	ϕV_s	88.4 kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**128.7** kN	46%
	V* 279	kN	NG

see sika wrap strengthening

DON THOMSON consulting engineers	calculation sheet		page:	
	job name:	34 Upland Road		
	designed:	RLM	job no:	210263
	checked:		date:	15/06/2015

Description: **S3** (S4 & S5 similar) (A3, A5 & A6 similar)

Designed June 2009 in accordance with NZS3101:2006, Amendment 2

Section and material properties

Flexural strength reduction factor	ϕ	0.85 -	*[Clause 2.3.2.2]*
Section width	b	150 mm	
Overall section depth	H	1600 mm	
Overall flange width (if present)	b_{flange}	300 mm	
Flange thickness (if present)	t_{flange}	1000 mm	
28 day concrete compressive stress	f'_c	25 MPa	
Equivalent stress block stress factor	α	0.85 -	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85 -	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200 GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ϵ_c	0.0030 mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\epsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
900	22.2	3.0	275	1161	-0.0257	-275	-319.3	287.4
50	16.0	1.0	500	201	0.0014	282	56.6	-2.8
250	16.0	1.0	500	201	-0.0050	-500	-100.5	25.1
450	16.0	1.0	500	201	-0.0113	-500	-100.5	45.2
950	8.5	1.0	275	57	-0.0272	-275	-15.6	14.8
1250	8.5	1.0	275	57	-0.0368	-275	-15.6	19.5
1550	8.5	1.0	275	57	-0.0463	-275	-15.6	24.2

Depth to centroid of tension steel	d	1400.0 mm	
Total area of tension steel	A_s	113 mm^2	
Min allowable reinforcement area	$A_{s,min}$	1069.1 mm2 > As NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	634.1 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0 kN
Depth to neutral axis at failure	c	94.2 mm
Section moment capacity	ϕM_n	**334.1** kNm
	M*	712 kNm

NG 47%

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Is minimum shear reinforcement required?		**no**	*[Clause 9.3.9.4.13]*
Member depth factor	k_d	1.00 -	*[Clause 9.3.9.3.4]*
Basic concrete shear	v_b	0.075 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	63.0 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	13 mm	
Number of legs	n	1 -	
Stirrup yield stress	f_{yt}	275 MPa	
Stirrup spacing	s	300 mm	
Minimum stirrup spacing	s_{max}	600 mm > s OK	
Area of shear reinforcing	A_v	126.7 mm^2	
Minimum area of shear reinforcing	$A_{v,min}$	51.1 mm2 < Av OK	*[Clause 9.3.9.4.15]*
Dependable reinforcing shear	ϕV_s	121.9 kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**184.9** kN	
	V*	887 kN	

NG 21%

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DON THOMSON consulting engineers	calculation sheet		page:	
	job name:	34 Upland Road		
	designed:	RLM	job no:	210263
	checked:		date:	15/06/2015

Description: **125x500 Sprayed Concrete**

Designed June 2009 in accordance with NZS3101:2006, Amendment 2

Section and material properties

Flexural strength reduction factor	ϕ	0.85	-	*[Clause 2.3.2.2]*
Section width	b	125	mm	
Overall section depth	H	500	mm	
Overall flange width (if present)	b_{flange}		mm	
Flange thickness (if present)	t_{flange}		mm	
28 day concrete compressive stress	f'_c	25	MPa	
Equivalent stress block stress factor	α	0.85	-	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85	-	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200	GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ϵ_c	0.0030	mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\epsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
				-	-	-	-	-
50	16.0	1.0	500	201	0.0009	186	37.4	-1.9
250	16.0	1.0	500	201	-0.0073	-500	-100.5	25.1
450	16.0	1.0	500	201	-0.0156	-500	-100.5	45.2
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-

Depth to centroid of tension steel	d	450.0 mm	
Total area of tension steel	A_s	201 mm^2	
Min allowable reinforcement area	$A_{s,min}$	157.5 mm2 < As OK	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	184.1 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0	kN
Depth to neutral axis at failure	c	72.5	mm
Section moment capacity	ϕM_n	**53.9**	kNm
	M*		kNm

OK (0%)

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75	-	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00	-	*[Clause 9.3.9.3.4]*
Is minimum shear reinforcement required?		**no**		*[Clause 9.3.9.4.13]*
Member depth factor	k_d	1.00	-	*[Clause 9.3.9.3.4]*
Basic concrete shear	v_b	0.106	$\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	22.3	kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	10	mm	
Number of legs	n	1	-	
Stirrup yield stress	f_{yt}	300	MPa	
Stirrup spacing	s	200	mm	
Minimum stirrup spacing	s_{max}	225	mm > s OK	
Area of shear reinforcing	A_v	78.5	mm^2	
Minimum area of shear reinforcing	$A_{v,min}$	26.0	mm2 < Av OK	*[Clause 9.3.9.4.15]*
Dependable reinforcing shear	ϕV_s	39.8	kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0	MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**62.1**	kN	
	V*	887	kN	

see sika strengthening

$V_{total} = 62 + 185$
$= 247 kN$

DON THOMSON consulting engineers	calculation sheet	page: 4-10
	job name	34 Upland Road
	job no: 210263	designed: RLM
	date: 15/02/2013	checked:

Description: **S6 - Existing** Strength (S9 & S10 similar)

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	150 mm
Overall depth	H	900 mm
Concrete compressive strength	f'_c	30 MPa
Longitudinal bar yield stress	f_y	275 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.001375 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
450	8.5	1	275.0	57	-0.0095	-275	-15.6	0.0
755.0	8.5	1	275.0	57	-0.0180	-275	-15.6	4.8
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
350.0	22.2	3	275.0	1161	-0.0067	-275	-319.3	-31.9

Axial load	P*		kN
Depth to neutral axis	c	107.8	mm
Concrete compressive force	C_c	350.5	kN
Sum of steel axial force	$C_s + T_s$	-350.5	kN
Check axial force	$C_c + C_s - T_s$	0	kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	142	kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$ (H/2 - d_i)]	-27	kNm
Section moment capacity	ϕM_n	**97.3**	kNm
Moment Demand	M*	310	kNm

NG

Compression taken as positive
Steel stress-strain curve assumed bi-linear

Horizontal Steel

Wall type		limited ductile	
Strength Reduction Factor	ϕ	0.75	-
Bar size		12.7	mm
Bar spacing	s	305	mm
Max spacing	s_{max}	180	mm
Number of bars per row	n	1	mm
Bar yield stress	f_{yt}	275	MPa
Area of shear steel	A_v	127	mm^2
Min area of shear steel	$A_{v,min}$	116	mm^2
Area of concrete shear	A_{cv}	108000	mm^2
Steel shear strength	V_s	82	kN
Concrete shar strength	V_c	80	kN
Total shear strength	ϕV_{total}	**122**	kN
Shear demand	V*	768	kN

NG

DON THOMSON consulting engineers	calculation sheet		page: 4 - 11	
	job name	34 Upland Road		
	job no:	210263	designed:	RLM
	date:	15/02/2013	checked:	

Description: **S6 - Strengthened Beam** Combined

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	150 mm
Overall depth	H	900 mm
Concrete compressive strength	f'_c	30 MPa
Longitudinal bar yield stress	f_y	275 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.001375 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
50	8.5	1	275.0	57	0.0019	275	15.6	6.2
355.0	8.5	1	275.0	57	-0.0048	-275	-15.6	-1.5
50.0	16	1	500.0	201	0.0019	380	76.4	30.6
250.0	16	1	500.0	201	-0.0025	-499	-100.3	-20.1
450.0	16	1	500.0	201	-0.0069	-500	-100.5	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
				0	0.0030	0	0.0	0.0
550.0	22.2	3	275.0	1161	-0.0091	-275	-319.3	31.9
				0	0.0030	0	0.0	0.0

Axial load	P*	0.0 kN
Depth to neutral axis	c	136.5 mm
Concrete compressive force	C_c	443.8 kN
Sum of steel axial force	$C_s + T_s$	-443.8 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	C_c(H/2 - βc/2)	174 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i})$ x (H/2 - d_i)] (H/2 - d_i)]	47 kNm
Section moment capacity	ϕM_n	**188.0** kNm
Moment Demand	M*	310 kNm

Compression taken as positive

Steel stress-strain curve assumed bi-linear

NG

61%

DON THOMSON consulting engineers	calculation sheet		page: 4-12
	job name	34 Upland Road	
	job no:	210263	designed: RLM
	date:	24/04/2013	checked:

Description: **S6 - Sprayed Concrete Beam Only**

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	125 mm
Overall depth	H	500 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	500 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.0025 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
50	16	1	500.0	201	0.0009	186	37.4	7.5
225.0	16	1	500.0	201	-0.0063	-500	-100.5	-2.5
400.0	16	1	500.0	201	-0.0136	-500	-100.5	15.1
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Axial load							P*	0.0 kN
Depth to neutral axis							c	72.5 mm
Concrete compressive force							C_c	163.6 kN
Sum of steel axial force							$C_s + T_s$	-163.6 kN
Check axial force							$C_c + C_s - T_s$	0 kN
Concrete moment contribution							$C_c(H/2 - \beta c/2)$	36 kNm
Steel moment contribution							$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$	20 kNm
Section moment capacity							ϕM_n	**47.5** kNm
Moment Demand							M*	kNm

Compression taken as positive

ok

Steel stress-strain curve assumed bi-linear

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		10 mm
Bar spacing	s	150 mm
Max spacing	s_{max}	100 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	500 MPa
Area of shear steel	A_v	79 mm^2
Min area of shear steel	$A_{v,min}$	26 mm^2
Area of concrete shear	A_{cv}	50000 mm^2
Steel shear strength	V_s	105 kN
Concrete shar strength	V_c	34 kN
Total shear strength	ϕV_{total}	**104** kN
Shear demand	V*	768 kN

ok

ϕV_{total} = 104kN + 122kN
= 226kN

$< V^*$

see Sika strengthening

DON THOMSON consulting engineers	calculation sheet		page:
	job name:	34 Upland Road	
	designed:	RLM	job no: 210263
	checked:		date: 16/06/2015

Description: **S11 - Existing** (S12 & S14 similar)

Designed June 2009 in accordance with NZS3101:2006, Amendment 2

Section and material properties

Flexural strength reduction factor	ϕ	0.85 -	*[Clause 2.3.2.2]*
Section width	b	100 mm	
Overall section depth	H	1100 mm	
Overall flange width (if present)	b_{flange}	mm	
Flange thickness (if present)	t_{flange}	mm	
28 day concrete compressive stress	f'_c	12 MPa	
Equivalent stress block stress factor	α	0.85 -	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85 -	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200 GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ϵ_c	0.0030 mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\epsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
125	8.5	1.0	275	57	-0.0022	-275	-15.6	2.0
425	8.5	1.0	275	57	-0.0147	-275	-15.6	6.6
				-	-	-	-	-
725	8.5	1.0	275	57	-0.0272	-275	-15.6	11.3
				-	-	-	-	-
1025	8.5	1.0	275	57	-0.0397	-275	-15.6	16.0

Depth to centroid of tension steel	d	1025.0 mm	
Total area of tension steel	A_s	57 mm^2	
Min allowable reinforcement area	$A_{s,min}$	521.8 mm2 > As NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	527.1 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0 kN	
Depth to neutral axis at failure	c	72.0 mm	
Section moment capacity	ϕM_n	**28.9** kNm	
	M*	kNm	**OK (0%)**

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Is minimum shear reinforcement required?		**no**	*[Clause 9.3.9.4.13]*
Member depth factor	k_d	1.00 -	*[Clause 9.3.9.3.4]*
Basic concrete shear	v_b	0.076 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	21.3 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	9 mm	
Number of legs	n	1 -	
Stirrup yield stress	f_{yt}	275 MPa	
Stirrup spacing	s	300 mm	
Minimum stirrup spacing	s_{max}	513 mm > s OK	
Area of shear reinforcing	A_v	56.7 mm^2	
Minimum area of shear reinforcing	$A_{v,min}$	23.6 mm2 < Av OK	*[Clause 9.3.9.4.15]*
Dependable reinforcing shear	ϕV_s	40.0 kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	2.4 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**61.3** kN	
	V*	kN	**OK (0%)**

DON THOMSON consulting engineers			
calculation sheet		page:	
job name:	34 Upland Road		
designed:	RLM	job no:	210263
checked:		date:	15/06/2015

Description: **S15** (A9 similar)

Designed June 2009 in accordance with NZS3101:2006, Amendment 2

Section and material properties

Flexural strength reduction factor	ϕ	0.85	-	*[Clause 2.3.2.2]*
Section width	b	150	mm	
Overall section depth	H	1900	mm	
Overall flange width (if present)	b_{flange}	300	mm	
Flange thickness (if present)	t_{flange}	1000	mm	
28 day concrete compressive stress	f'_c	25	MPa	
Equivalent stress block stress factor	α	0.85	-	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85	-	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200	GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ϵ_c	0.0030	mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\epsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
50	16.0	1.0	500	201	0.0015	297	59.7	-3.0
250	16.0	1.0	500	201	-0.0046	-500	-100.5	25.1
450	16.0	1.0	500	201	-0.0106	-500	-100.5	45.2
900	8.5	1.0	500	57	-0.0243	-500	-28.4	25.5
1200	8.5	1.0	275	57	-0.0334	-275	-15.6	18.7
1500	8.5	1.0	275	57	-0.0425	-275	-15.6	23.4
1800	8.5	1.0	275	57	-0.0516	-275	-15.6	28.1
550	22.2	3.0	275	1161	-0.0137	-275	-319.3	175.6

Depth to centroid of tension steel	d	1800.0	mm	
Total area of tension steel	A_s	57	mm^2	
Min allowable reinforcement area	$A_{s,min}$	1374.5	mm2 > As NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	736.4	mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0	kN
Depth to neutral axis at failure	c	98.9	mm
Section moment capacity	ϕM_n	**268.8**	kNm
	M*	201	kNm

OK

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75	-	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00	-	*[Clause 9.3.9.3.4]*
Is minimum shear reinforcement required?		**no**		*[Clause 9.3.9.4.13]*
Member depth factor	k_d	1.00	-	*[Clause 9.3.9.3.4]*
Basic concrete shear	v_b	0.072	$\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	81.0	kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	13	mm	
Number of legs	n	1	-	
Stirrup yield stress	f_{yt}	275	MPa	
Stirrup spacing	s	300	mm	
Minimum stirrup spacing	s_{max}	600	mm > s OK	
Area of shear reinforcing	A_v	126.7	mm^2	
Minimum area of shear reinforcing	$A_{v,min}$	51.1	mm2 < Av OK	*[Clause 9.3.9.4.15]*
Dependable reinforcing shear	ϕV_s	156.8	kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0	MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**237.8**	kN	

$\phi V_{total} = 238 + 104$
$= 342 kN$
$< V^* = 698 kN$ NG
see sk9 strengthening

Concrete Flexural Capacity

Wall W2- FRP strengthening

Strength Reduction Factor	ϕ	0.85 -
Section width	b	150 mm
Overall depth	H	800 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	275 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.00145 mm / mm
Yield Strain	ε_y	0.001375 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
152.4	12.7	1	275.0	127	-0.0006	-125	-15.8	-3.9
457.2	12.7	1	275.0	127	-0.0048	-275	-34.8	2.0
762.0	12.7	1	275.0	127	-0.0089	-275	-34.8	12.6
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
				0	0.0015	0	0.0	0.0
				0	0.0015	0	0.0	0.0
400.0	250	2	834.0	166	-0.0040	-964	-159.5	0.0

2 layers Sikawrap 600C

Axial load	P*	27.4 kN
Depth to neutral axis	c	106.5 mm
Concrete compressive force	C_c	272.4 kN
Sum of steel axial force	$C_s + T_s$	-245.1 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	97 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$	11 kNm
Section moment capacity	ϕM_n	**91.2** kNm
	M*	54 kNm

Compression taken as positive
Steel stress-strain curve assumed bi-linear

OK

DON THOMSON consulting engineers	calculation sheet		page: 4-15	
	job name	34 Upland Road		
	job no:	210263	designed:	RLM
	date:	15/02/2013	checked:	

Description: W9 — sprayed concrete

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	125 mm
Overall depth	H	2800 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	500 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.0025 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
100	16	1	500.0	201	0.0024	475	95.4	124.1
300.0	16	1	500.0	201	0.0011	224	45.0	49.5
500.0	16	1	500.0	201	-0.0001	-27	-5.4	-4.8
700.0	16	1	500.0	201	-0.0014	-277	-55.8	-39.0
900.0	16	1	500.0	201	-0.0026	-500	-100.5	-50.3
1100.0	16	1	500.0	201	-0.0039	-500	-100.5	-30.2
1300.0	16	1	500.0	201	-0.0051	-500	-100.5	-10.1
1500.0	16	1	500.0	201	-0.0064	-500	-100.5	10.1
1700.0	16	1	500.0	201	-0.0077	-500	-100.5	30.2
1900.0	16	1	500.0	201	-0.0089	-500	-100.5	50.3
2100.0	16	1	500.0	201	-0.0102	-500	-100.5	70.4
2300.0	16	1	500.0	201	-0.0114	-500	-100.5	90.5
2500.0	16	1	500.0	201	-0.0127	-500	-100.5	110.6
2700.0	16	1	500.0	201	-0.0139	-500	-100.5	130.7
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Axial load	P*	155.0 kN
Depth to neutral axis	c	478.8 mm
Concrete compressive force	C_c	1080.9 kN
Sum of steel axial force	$C_s + T_s$	-925.9 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	1293 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$ (H/2 - d_i)]	532 kNm
Section moment capacity	ϕM_n	**1551.5** kNm
Moment Demand	M*	1713 kNm

Compression taken as positive
Steel stress-strain curve assumed bi-linear

ok 91%

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size	d_t	16 mm
Bar spacing	s	200 mm
Max spacing	s_{max}	375 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	500 MPa
Area of shear steel	A_v	201 mm^2
Min area of shear steel	$A_{v,min}$	35 mm^2
Area of concrete shear	A_{cv}	280000 mm^2
Steel shear strength	V_s	1126 kN
Concrete shar strength	V_c	220 kN
Total shear strength	ϕV_{total}	**1009** kN
Shear demand	V*	1270 --- kN

79% ok

DON THOMSON consulting engineers		
	calculation sheet	page: 4 - 16
	job name	34 Upland Road
	job no: 210263	designed: RLM
	date: 21/02/2013	checked:

Description: **W10** – sprayed concrete wall

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	275 mm
Overall depth	H	900 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	500 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.0025 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i} \times (H/2 - d_i)$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
75	16	1	500.0	201	0.0011	223	44.8	16.8
225.0	16	1	500.0	201	-0.0027	-500	-100.5	-22.6
375.0	16	1	500.0	201	-0.0064	-500	-100.5	-7.5
525.0	16	1	500.0	201	-0.0102	-500	-100.5	7.5
675.0	16	1	500.0	201	-0.0140	-500	-100.5	22.6
825.0	16	1	500.0	201	-0.0177	-500	-100.5	37.7
-	-	-	-	-	-	-	-	-
150.0	12.7	1	275.0	127	-0.0008	-154	-19.5	-5.8
455.0	12.7	1	275.0	127	-0.0084	-275	-34.8	0.2
760.0	12.7	1	275.0	127	-0.0161	-275	-34.8	10.8
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Axial load	P*	46.0 kN
Depth to neutral axis	c	119.4 mm
Concrete compressive force	C_c	593.0 kN
Sum of steel axial force	$C_s + T_s$	-547.0 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	237 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$ $(H/2 - d_i)]$	60 kNm
Section moment capacity	ϕM_n	**251.9** kNm
Moment Demand	M*	375 kNm

Compression taken as positive
Steel stress-strain curve assumed bi-linear

NG 67%

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		10 mm
Bar spacing	s	200 mm
Max spacing	s_{max}	180 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	300 MPa
Area of shear steel	A_v	79 mm^2
Min area of shear steel	$A_{v,min}$	128 mm^2
Area of concrete shear	A_{cv}	198000 mm^2
Steel shear strength	V_s	85 kN
Concrete shar strength	V_c	143 kN
Total shear strength	ϕV_{total}	**171** kN
Shear demand	V*	298 kN

NG 57% see sika strengthening

DON THOMSON consulting engineers	calculation sheet		page:	
	job name:	34 Upland Road		
	job no:	210263	designed:	RLM
	date:	15/06/2015	checked:	

Description: **Level 4 - W17**

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	1.00 -
Section width	b	100 mm
Overall depth	H	2400 mm
Concrete compressive strength	f'_c	12 MPa
Longitudinal bar yield stress	f_y	275 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ϵ_c	0.003 mm / mm
Yield Strain	ϵ_y	0.001375 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\epsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i} \times (H/2 - d_i)$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
100	9.5	1	275.0	71	0.0009	180	12.7	14.0
400.0	9.5	1	275.0	71	-0.0054	-275	-19.5	-15.6
700.0	9.5	1	275.0	71	-0.0117	-275	-19.5	-9.7
1000.0	9.5	1	275.0	71	-0.0180	-275	-19.5	-3.9
1300.0	9.5	1	275.0	71	-0.0243	-275	-19.5	1.9
1600.0	9.5	1	275.0	71	-0.0306	-275	-19.5	7.8
1900.0	9.5	1	275.0	71	-0.0369	-275	-19.5	13.6
2200.0	9.5	1	275.0	71	-0.0433	-275	-19.5	19.5
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Axial load	P*	0.0 kN
Depth to neutral axis	c	142.7 mm
Concrete compressive force	C_c	123.7 kN
Sum of steel axial force	$C_s + T_s$	-123.7 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	141 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$ (H/2 - d_i)]	28 kNm
Section moment capacity	ϕM_n	**168.6** kNm
Moment Demand	M*	kNm

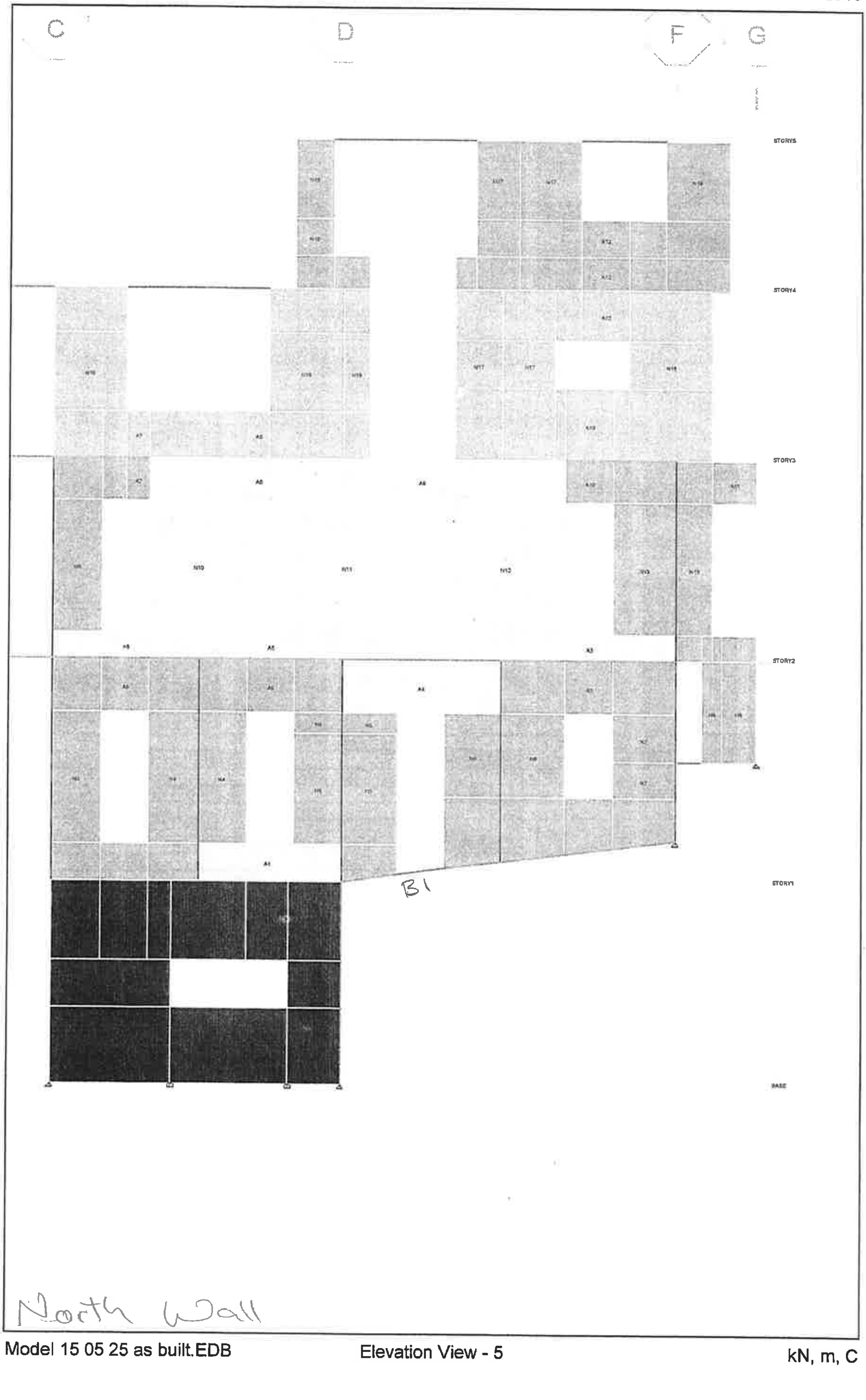
Compression taken as positive
Steel stress-strain curve assumed bi-linear

ok

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		9.5 mm
Bar spacing	s	300 mm
Max spacing	s_{max}	300 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	275 MPa
Area of shear steel	A_v	71 mm^2
Min area of shear steel	$A_{v,min}$	76 mm^2
Area of concrete shear	A_{cv}	192000 mm^2
Steel shear strength	V_s	125 kN
Concrete shar strength	V_c	90 kN
Total shear strength	ϕV_{total}	**161** kN
Shear demand	V*	kN

ok


C
D
F
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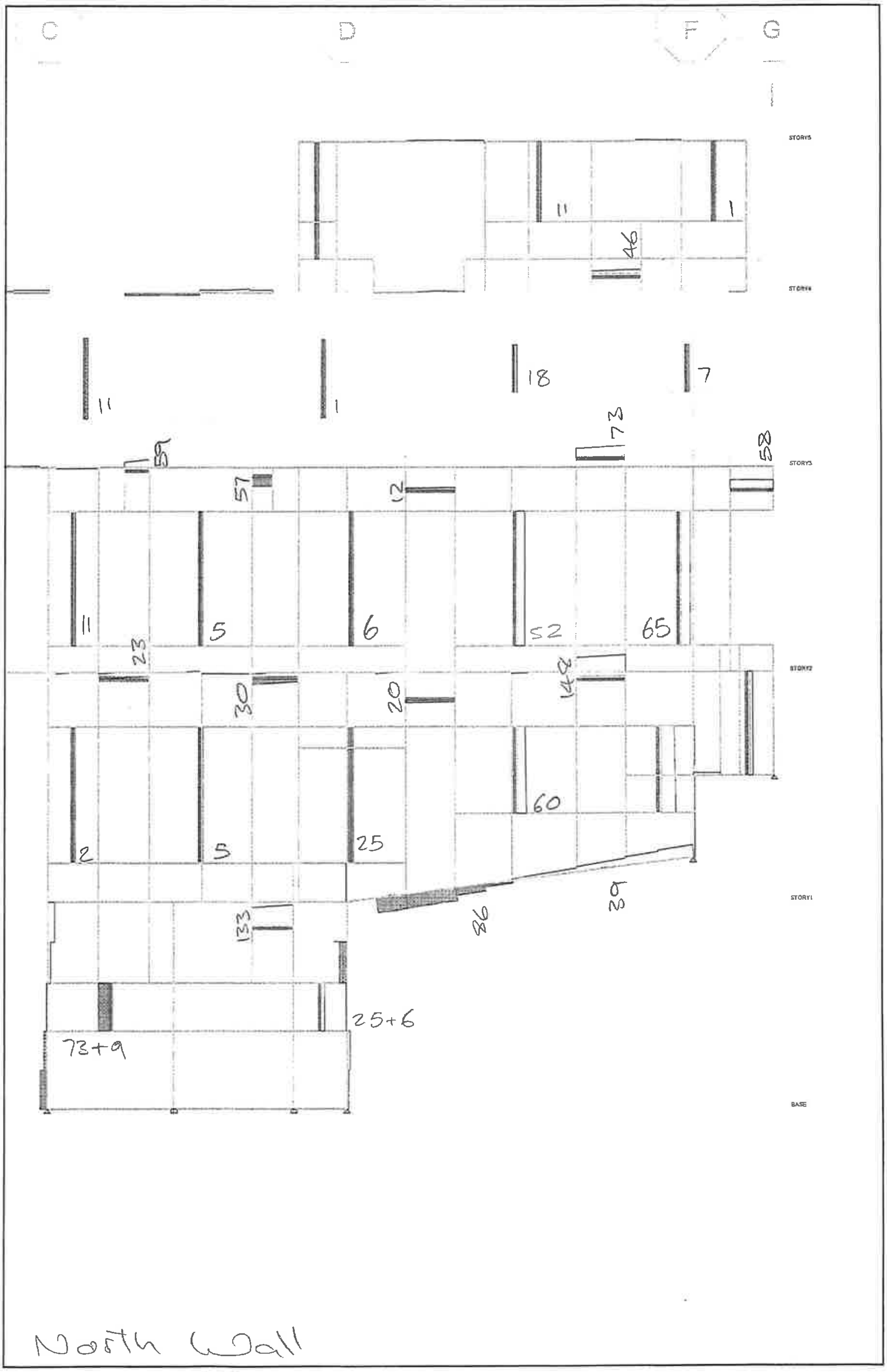
STORY5
STORY4
STORY3
STORY2
STORY1
BASE
B1
North Wall


C
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BASE
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46
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18
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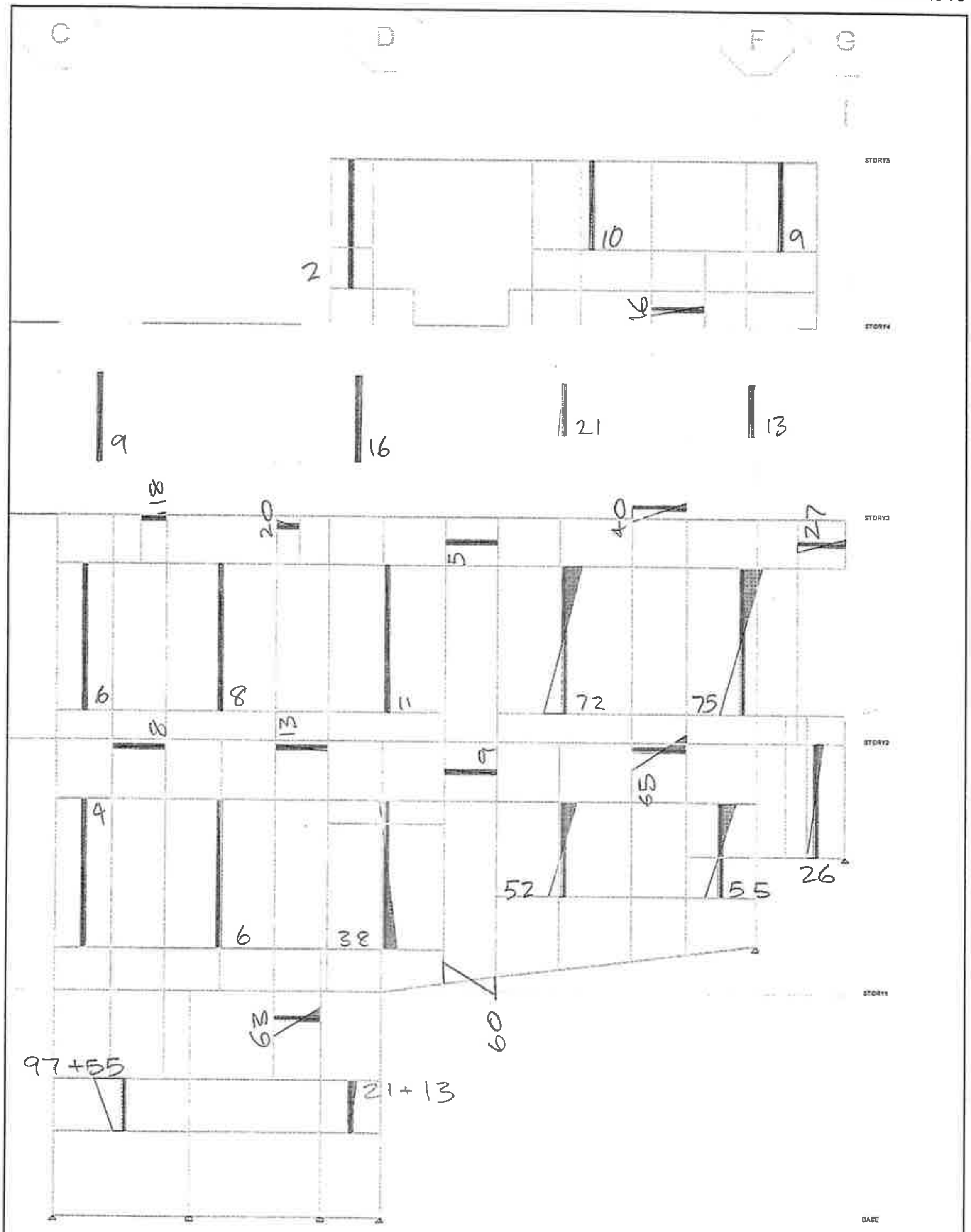
173
58
59
57
12
11
5
6
52
65
23
30
20
140
2
5
25
60
133
86
80
25+6
73+9
North Wall


C
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16
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6
8
11
72
75
5
4
6
38
52
55
26
97+55
21+13

North Wall

North Wall

Storey	Pier	$V^*_{E(mu=1)}$ (k	$V^*_{E(mu=1.5)}$ (	$V^*_{G+0.3Q}$ (k	V^*_{total} (kN)	φVn (kN)	%NBS	$M^*_{E(mu=1)}$ (k	$M^*_{E(mu=1.5)}$ (	$M^*_{G+0.3Q}$ (k	M^*_{total} (kN	φMn (kNm)	%NBS	Shear	Flexural
STORY5	N17	71.9	47.4	9.9	57.3	281		57.8	38.1	8.1	46.2	190		0	0
STORY5	N18	51.5	34.0	2.2	36.1	169		40.0	26.4	9.5	35.9	80		0	0
STORY5	N19	22.7	15.0	3.2	18.2	98		6.3	4.1	2.2	6.3	30		0	0
STORY4	N15	61.9	40.8	11.4	52.2	91		65.3	43.1	8.7	51.8	68		0	0
STORY4	N16	99.9	65.9	0.7	66.6	123		120.1	79.2	16.0	95.2	123		0	0
STORY4	N17	184.2	121.5	17.7	139.1	123	89%	89.2	58.8	20.3	79.2	123		0	0
STORY4	N18	188.7	124.4	7.2	131.6	104	79%	104.1	68.7	12.5	81.1	89		0	0
STORY4	A12	189.8	125.2	45.7	170.9	215		50.0	33.0	19.3	52.3	112		0	0
STORY3	N9	103.0	67.9	11.4	79.3	197		66.0	43.5	6.1	49.6	102		0	0
STORY3	N10	347.3	229.1	4.3	233.4	634		440.2	290.3	7.5	297.8	563		HD16-200	HD16-200
STORY3	N11	425.2	280.5	5.7	286.1	634		474.9	313.2	11.9	325.1	563		HD16-200	HD16-200
STORY3	N12	488.8	322.4	49.4	371.9	775		575.0	379.3	70.1	449.3	847		HD16-200	HD16-200
STORY3	N13	238.2	157.1	63.8	220.9	309		267.6	176.5	71.1	247.6	399		0	0
STORY3	A7	240.8	158.8	62.4	221.2	246		50.6	33.4	21.3	54.6	204		0	0
STORY3	A8	306.1	201.9	60.5	262.4	341		47.5	31.3	21.3	52.7	269		HR10-150	0
STORY3	A9	455.3	300.3	13.1	313.4	226	72%	198.7	131.0	5.2	136.2	188		HR10-150	0
STORY3	A10	354.8	234.0	71.1	305.1	243	80%	180.5	119.1	36.9	156.0	231		0	0
STORY3	A11	170.4	112.4	57.4	169.8	103	61%	74.3	49.0	27.2	76.2	28	37%	0	0
STORY2	N3	55.5	36.6	2.4	39.0	197		34.1	22.5	4.1	26.6	102		0	0
STORY2	N4	102.6	67.7	4.5	72.2	299		132.5	87.4	5.3	92.7	440		0	0
STORY2	N5	115.3	76.0	24.8	100.9	295		131.7	86.9	38.2	125.1	440		0	0
STORY2	N6	227.3	149.9	59.9	209.8	352		138.3	91.2	51.6	142.9	507		0	0
STORY2	N7	234.5	154.7	94.9	249.6	225	90%	28.6	18.8	54.7	73.6	217		0	2-200mm 600C
STORY2	N8	143.4	94.6	30.6	125.2	141		95.3	62.9	18.5	81.4	169		0	0
STORY2	A3	445.2	293.7	148.8	442.5	247	56%	152.2	100.4	64.9	165.2	334		R10-200	3 HD16
STORY2	A4	386.1	254.7	22.9	277.6	253	91%	136.9	90.3	9.8	100.1	222		HR10-150	3 HD16
STORY2	A5	311.2	205.2	25.9	231.2	247		132.8	87.6	11.2	98.8	334		R10-200	3 HD16
STORY2	A6	272.4	179.7	22.4	202.1	247		95.3	62.9	4.4	67.3	334		R10-200	3 HD16
STORY1	N1	18.5	12.2	73.1	85.3	942		80.2	52.9	96.8	149.7	884		0	0
STORY1	N2	43.3	28.6	25.5	54.1	492		12.7	8.4	20.8	29.2	321		0	0
STORY1	A1	157.3	103.8	133.7	237.5	269		98.8	65.2	63.4	128.6	505		R10-200	3 HD16
STORY1	A2	157.3	103.8	115.4	219.1	329		173.3	114.3	117.2	231.5	165	71%	0	0
STORY1	B1	213.0	140.5	86.0	226.5	188	83%	113.0	74.5	60.0	134.5	103	77%	0	2-150mm 600C

North Wall

Member	V* (kN)	$\varphi V_{n,existing}$ (kN)	ΔV^* (kN)	L (m)	Type	No. Layers	Layer width (mm)	Spacing (mm)	$L_e = 23300/(nt_fE_f)^{0.58}$	$k_2 = (L-2L_e)/L$	$kv=k_1k_2L_e/11900\varepsilon_{fu}$	$\varepsilon_{fe} = k_v\varepsilon_{fu}$	$f_{fe} = E_f\varepsilon_{fe}$ (MPa)	$A_{fv} = w_ft_fn$ (mm)	$\Delta\varphi V_n$ (kN)	$\varphi V_{n,proposed}$ (kN)	
N9	197	197		0.75					0.0	1.00					0	197	100%
N10	233	634		1.8					0.0	1.00					0	634	
N11	286	634		1.8					0.0	1.00					0	634	
N12	372	775		2.2					0.0	1.00					0	775	
N13	221	309		0.95					0.0	1.00					0	309	
A7	221	246	98	1.7	SikaWrap 600C	1	1000	1000	36.1	0.95	0.22	0.0027	576	331	165	411	
A8	262	341	165	1.7	SikaWrap-600C	1	1000	1000	36.1	0.95	0.22	0.0027	576	331	165	506	
A9	313	226	16	0.8	SikaWrap-600C	5	1000	1000	14.2	0.96	0.09	0.0011	229	1655	154	380	
A10	305	243		2.4					0.0	1.00					0	243	80%
N3	39	197		0.75					0.0	1.00					0	197	
N4	72	299		1.8	SikaWrap-930G	1	1000	1000	66.3	0.91	0.17	0.0040	268	365	90	389	
N5	101	295		1.8	SikaWrap-930G	1	1000	1000	66.3	0.91	0.17	0.0040	268	365	90	385	
N6	210	352		2.2					0.0	1.00					0	352	
N7	250	225		0.95	SikaWrap-600C	3	1000	1000	19.1	0.95	0.12	0.0014	306	993	147	372	
A3	443	247	49	1.6	SikaWrap-600C	2	1000	1000	24.2	0.96	0.15	0.0019	392	662	212	459	
A4	278	253	34	0.8	SikaWrap-600C	4	1000	1000	16.2	0.95	0.10	0.0012	259	1324	140	532	
			34	0.8	SikaWrap-600C	4	1000	1000	16.2	0.95	0.10	0.0012	259	1324	140		
A5	231	247	92	1.6	SikaWrap-600C	1	1000	1000	36.1	0.94	0.22	0.0027	574	331	155	402	
A6	202	247	112	1.6	SikaWrap-600C	1	1000	1000	36.1	0.94	0.22	0.0027	574	331	155	402	
N1	85	942		2.1					0.0	1.00					0	942	
N2	54	492		0.45					0.0	1.00					0	492	
A1	238	269	110	1.7	SikaWrap-600C	1	400	600	36.1	0.95	0.22	0.0027	576	132	110	379	
A2	219	329		2.6					0.0	1.00					0	329	
B1	226	188		1					0.0	1.00					0	188	83%
P3	1337	2192	1296	9.3	SikaWrap-600C	2	1000	1000	24.2	0.99	0.16	0.0019	404	662	1270	3462	

DON THOMSON consulting engineers	calculation sheet	page:	
	job name:	34 Upland Road	
	designed: RLM	job no:	210263
	checked:	date:	17/06/2015

Description: **Member B1 - FRP Strengthening**

Designed 2012 in accordance with NZS3101:2006, Amendment 2 and Tyfo Design Manual 2007

Section and material properties

				Clauses
Flexural strength reduction factor	ϕ	0.90	-	[Clause 2.3.2.2]
Web width	b	380	mm	
Overall section depth	H	1200	mm	
Overall flange width (if present)	b_{flange}		mm	
Flange thickness (if present)	t_{flange}		mm	
Concrete cylinder compressive strength at 28 days	f'_c	25	MPa	
Concrete modulus of elasticity	E_c	23.5	GPa	
Reinforcement modulus of elasticity	E_s	200	GPa	[Clause 5.3.4]
Yield strain of reinforcement	ϵ_y	0.0014	mm / mm	
Ultimate concrete compressive strain	ϵ_c	0.0004	mm / mm	[Clause 7.4.2.3]
Type of Fibrewrap		SikaWrap600C		
Maximum allowable strain	$\epsilon_{f,max}$	0.004	mm / mm	
Thickness of fibrewrap	t_f	211	mm	
Fibrewrap modulus of elasticity	E_f	0.331	GPa	
Bond Stress	σ_{bs}	1.38	MPa	

Flexural reinforcement

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\epsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$-T_{s,i} \times d_i$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
950.0	12.7	1.0	275.0	127	0.0039	275	34.8	-33.1
100.0	31.8	4.0	275.0	3167	0.0001	11	35.6	-3.6
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-

FRP

Depth from comp. fibre	Width	Number of layers	Ulitmate strength	Area	Strain	Stress	Force	Moment contribution
d_i	w_f	-	f_u	$A_{f,i}$	$\epsilon_{f,i}$	$f_{f,i}$	$T_{f,i}$	$-T_{f,i} \times d_i$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
				-	-	-	-	-
				-	-	-	-	-
975.0	150.0	2.0	834.0	63300	0.0040	1	83.8	-81.7
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-

Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load	P*	0.0	kN
Depth to bottom fibrewrap	d_1	975.0	mm
Depth to neutral axis at failure	c	87.5	mm
Concrete compressive force	C_c	154.2	kN
Sum of steel axial force	$C_s + T_s$	154.2	kN
Check axial force	$C_c + C_s - T_s$	0	kN
Concrete moment contribution	$-C_c \times c/3$	5	kNm
Steel moment contribution	$\Sigma[-(C_{s.i} + T_{s.i}) \times d_i]$	-118	kNm
Section moment capacity	ϕM_n	**102.5**	kNm
	M*		kNm **OK (0%)**

Yield Curvature		ϕ_y	0.0016	$x10^3$ mm^{-1}
Ultimate Curvature		ϕ_u	0.0045	$x10^3$ mm^{-1}
Curvature Ductility		μ_ϕ	**2.8**	
Development Length	$T_f/\sigma_{BS}w_f$	L_d	405	mm

DON THOMSON consulting engineers	calculation sheet		page:	
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	designed:	RLM	job no:	210263
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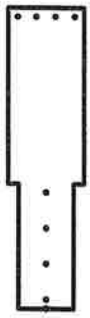
Description: **A1 strengthened**

Designed June 2009 in accordance with NZS3101:2006, Amendment 2



Section and material properties

Flexural strength reduction factor	ϕ	0.85	-	*[Clause 2.3.2.2]*
Section width	b	275	mm	
Overall section depth	H	1700	mm	
Overall flange width (if present)	b_{flange}	380	mm	
Flange thickness (if present)	t_{flange}	1000	mm	
28 day concrete compressive stress	f'_c	25	MPa	
Equivalent stress block stress factor	α	0.85	-	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85	-	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200	GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ϵ_c	0.0030	mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\epsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
1050	16.0	1.0	500	201	-0.0571	-500	-100.5	105.6
1250	16.0	1.0	500	201	-0.0685	-500	-100.5	125.7
1450	16.0	1.0	500	201	-0.0799	-500	-100.5	145.8
1650	16.0	1.0	500	201	-0.0914	-500	-100.5	165.9
1050	8.5	1.0	275	57	-0.0571	-275	-15.6	16.4
1350	8.5	1.0	275	57	-0.0742	-275	-15.6	21.1
1650	8.5	1.0	275	57	-0.0914	-275	-15.6	25.7
50	31.8	4.0	275	3167	0.0001	28	88.9	-4.4

Depth to centroid of tension steel	d	1584.0 mm	
Total area of tension steel	A_s	258 mm^2	
Min allowable reinforcement area	$A_{s,min}$	2217.6 mm2 > As NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	675.0 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0	kN
Depth to neutral axis at failure	c	52.5	mm
Section moment capacity	ϕM_n	**504.6**	kNm
	M*		kNm **OK (0%)**

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Is minimum shear reinforcement required?		**no**	*[Clause 9.3.9.4.13]*
Member depth factor	k_d	1.00 -	*[Clause 9.3.9.3.4]*
Basic concrete shear	v_b	0.076 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	130.7 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	13 mm	
Number of legs	n	1 -	
Stirrup yield stress	f_{yt}	275 MPa	
Stirrup spacing	s	300 mm	
Minimum stirrup spacing	s_{max}	600 mm > s OK	
Area of shear reinforcing	A_v	126.7 mm^2	
Minimum area of shear reinforcing	$A_{v,min}$	93.8 mm2 < Av OK	*[Clause 9.3.9.4.15]*
Dependable reinforcing shear	ϕV_s	137.9 kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**268.6** kN	

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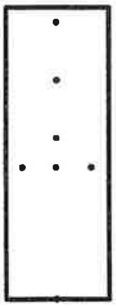
Description: **A4 strengthened**

Designed June 2009 in accordance with NZS3101:2006, Amendment 2



Section and material properties

Flexural strength reduction factor	ϕ	0.85	-	*[Clause 2.3.2.2]*
Section width	b	300	mm	
Overall section depth	H	1000	mm	
Overall flange width (if present)	b_{flange}		mm	
Flange thickness (if present)	t_{flange}		mm	
28 day concrete compressive stress	f'_c	25	MPa	
Equivalent stress block stress factor	α	0.85	-	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85	-	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200	GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ϵ_c	0.0030	mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\epsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
50	16.0	1.0	500	201	0.0014	275	55.3	-2.8
250	16.0	1.0	500	201	-0.0051	-500	-100.5	25.1
450	16.0	1.0	500	201	-0.0116	-500	-100.5	45.2
50	8.5	1.0	275	57	0.0014	275	15.6	-0.8
350	8.5	1.0	275	57	-0.0084	-275	-15.6	5.5
950	12.7	1.0	275	127	-0.0279	-275	-34.8	33.1
				-	-	-	-	-
550	22.2	3.0	275	1161	-0.0149	-275	-319.3	175.6

Depth to centroid of tension steel	d	950.0	mm	
Total area of tension steel	A_s	127	mm^2	
Min allowable reinforcement area	$A_{s,min}$	1450.9	mm2 > As NG	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	388.6	mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0	kN	
Depth to neutral axis at failure	c	92.3	mm	
Section moment capacity	ϕM_n	**222.2**	kNm	84%
	M*	264	kNm	**OK**

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75	-	*[Clause 2.3.2.2]*
Basic concrete shear	v_b	0.074	$\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	85.5	kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	13	mm	
Number of legs	n	1	-	
Stirrup yield stress	f_{yt}	275	MPa	
Stirrup spacing	s	300	mm	
Minimum stirrup spacing	s_{max}	475	mm > s OK	
Area of shear reinforcing	A_v	126.7	mm^2	
Minimum area of shear reinforcing	$A_{v,min}$	102.3	mm2 < Av OK	*[Clause 9.3.9.4.15]* see Sika strengthening
Dependable reinforcing shear	ϕV_s	82.7	kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0	MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**168.2**	kN	NG
	V*	714	kN	

$\phi V_{total} = 168 + 85 = 253kN$

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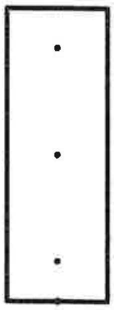
checked:		date:	16/06/2015

Description: **A4 - new concrete beam only**

Designed June 2009 in accordance with NZS3101:2006, Amendment 2



Section and material properties

Flexural strength reduction factor	ϕ	0.85 -	*[Clause 2.3.2.2]*
Section width	b	150 mm	
Overall section depth	H	500 mm	
Overall flange width (if present)	b_{flange}	mm	
Flange thickness (if present)	t_{flange}	mm	
28 day concrete compressive stress	f'_c	25 MPa	
Equivalent stress block stress factor	α	0.85 -	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85 -	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200 GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ϵ_c	0.0030 mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\epsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
68	16.0	1.0	500	201	0.0002	32	6.4	-0.4
				-	-	-	-	-
				-	-	-	-	-
250	16.0	1.0	500	201	-0.0074	-500	-100.5	25.1
				-	-	-	-	-
432	16.0	1.0	500	201	-0.0150	-500	-100.5	43.4

Depth to centroid of tension steel	d	432.0 mm	
Total area of tension steel	A_s	201 mm^2	
Min allowable reinforcement area	$A_{s,min}$	181.4 mm2 < As OK	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	176.7 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0 kN	
Depth to neutral axis at failure	c	71.8 mm	
Section moment capacity	ϕM_n	**52.9** kNm	
	M*	kNm	**OK (0%)**

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Is minimum shear reinforcement required?		**no**	*[Clause 9.3.9.4.13]*
Member depth factor	k_d	1.00 -	*[Clause 9.3.9.3.4]*
Basic concrete shear	v_b	0.101 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	24.5 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	10 mm	
Number of legs	n	1 -	
Stirrup yield stress	f_{yt}	500 MPa	
Stirrup spacing	s	150 mm	
Minimum stirrup spacing	s_{max}	216 mm > s OK	
Area of shear reinforcing	A_v	78.5 mm^2	
Minimum area of shear reinforcing	$A_{v,min}$	14.1 mm2 < Av OK	*[Clause 9.3.9.4.15]*
Dependable reinforcing shear	ϕV_s	84.8 kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**109.4** kN	
	V*	kN	**OK (0%)**

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Description: **N4 Existing Strength**

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	150 mm
Overall depth	H	1800 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	275 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ϵ_c	0.003 mm / mm
Yield Strain	ϵ_y	0.001375 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\epsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
50	12.7	1	275.0	127	0.0023	275	34.8	29.6
350.0	12.7	1	275.0	127	-0.0020	-275	-34.8	-19.2
650.0	12.7	1	275.0	127	-0.0063	-275	-34.8	-8.7
1150.0	12.7	1	275.0	127	-0.0135	-275	-34.8	8.7
1450.0	12.7	1	275.0	127	-0.0179	-275	-34.8	19.2
1750.0	12.7	1	275.0	127	-0.0222	-275	-34.8	29.6
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
800.0	22.2	2	275.0	774	-0.0085	-275	-212.9	-21.3
1000.0	22.2	2	275.0	774	-0.0114	-275	-212.9	21.3

Axial load	P*	0.0 kN
Depth to neutral axis	c	208.6 mm
Concrete compressive force	C_c	565.1 kN
Sum of steel axial force	$C_s + T_s$	-565.1 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	459 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$ (H/2 - d_i)]	59 kNm
Section moment capacity	ϕM_n	**440.1** kNm
Moment Demand	M*	kNm

Compression taken as positive ok
Steel stress-strain curve assumed bi-linear

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		8.5 mm
Bar spacing	s	300 mm
Max spacing	s_{max}	360 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	275 MPa
Area of shear steel	A_v	57 mm^2
Min area of shear steel	$A_{v,min}$	115 mm^2
Area of concrete shear	A_{cv}	216000 mm^2
Steel shear strength	V_s	75 kN
Concrete shar strength	V_c	146 kN
Total shear strength	ϕV_{total}	**166** kN
Shear demand	V*	kN

ok

Concrete Flexural Capacity

Member N7 - FRP strengthening

Strength Reduction Factor	ϕ	0.85 -
Section width	b	300 mm
Overall depth	H	1300 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	275 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.00055 mm / mm
Yield Strain	ε_y	0.001375 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
152.4	12.7	1	275.0	127	0.0000	-6	-0.8	-0.4
457.2	12.7	1	275.0	127	-0.0012	-237	-30.0	-5.8
762.0	12.7	1	275.0	127	-0.0023	-275	-34.8	3.9
1066.8	12.7	1	275.0	127	-0.0035	-275	-34.8	14.5
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
50.0	22.23	2	275.0	776	0.0004	72	55.6	33.4
250.0	22.23	2	275.0	776	-0.0004	-80	-62.1	-24.8
1200.0	200	2	834.0	132	-0.0040	-964	-127.6	70.2

2layers sikawrap

Axial load	P*	44.5 kN
Depth to neutral axis	c	144.5 mm
Concrete compressive force	C_c	279.0 kN
Sum of steel axial force	$C_s + T_s$	-234.5 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	164 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i})$ x (H/2 - d_i)]	91 kNm
Section moment capacity	ϕM_n	**216.9** kNm
	M*	**213.0** kNm

Compression taken as positive
Steel stress-strain curve assumed bi-linear

ok

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Description: **N9 Existing Strength**

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	150 mm
Overall depth	H	1100 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	275 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ϵ_c	0.003 mm / mm
Yield Strain	ϵ_y	0.001375 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\epsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i}$ x (H/2 - d_i)
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
450	12.7	1	275.0	127	-0.0165	-275	-34.8	-3.5
750.0	12.7	1	275.0	127	-0.0295	-275	-34.8	7.0
1050.0	12.7	1	275.0	127	-0.0424	-275	-34.8	17.4
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
50.0	22.2	2	275.0	774	0.0008	167	129.5	64.8
250.0	22.2	2	275.0	774	-0.0078	-275	-212.9	-63.9

Axial load	P*	0.0 kN
Depth to neutral axis	c	69.3 mm
Concrete compressive force	C_c	187.9 kN
Sum of steel axial force	$C_s + T_s$	-187.9 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	98 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i})$ x $(H/2 - d_i)]$ $(H/2 - d_i)]$	22 kNm
Section moment capacity	ϕM_n	**101.7** kNm
Moment Demand	M*	kNm

Compression taken as positive — ok

Steel stress-strain curve assumed bi-linear

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		8.5 mm
Bar spacing	s	300 mm
Max spacing	s_{max}	220 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	275 MPa
Area of shear steel	A_v	57 mm^2
Min area of shear steel	$A_{v,min}$	115 mm^2
Area of concrete shear	A_{cv}	132000 mm^2
Steel shear strength	V_s	46 kN
Concrete shar strength	V_c	89 kN
Total shear strength	ϕV_{total}	**101** kN
Shear demand	V*	kN

ok

DON THOMSON consulting engineers	calculation sheet		page: 5-11
	job name	34 Upland Road	
	job no:	210263	designed: RLM
	date:	18/02/2013	checked:

Description: **New sprayed concrete Wall** – N10 to N12

Concrete Flexural Capacity

Designed October 2012 in accordance with NZS3101:2006, Amendment 2

Strength Reduction Factor	ϕ	0.85 -
Section width	b	125 mm
Overall depth	H	1800 mm
Concrete compressive strength	f'_c	25 MPa
Longitudinal bar yield stress	f_y	500 MPa
Stress block ultimate concrete stress factor	α	0.85 -
Stress block neutral axis depth factor	β	0.85 -
Steel modulus	E	200 GPa
Ultimate concrete compressive strain	ε_c	0.003 mm / mm
Yield Strain	ε_y	0.0025 mm / mm

Depth from comp. fibre	Bar diameter	Number of bars	Bar grade	Area of steel	Steel strain	Steel stress	Steel force	Steel moment contribution
d_i	d_b	-	f_y	$A_{s,i}$	$\varepsilon_{s,i}$	$f_{s,i}$	$T_{s,i}$	$T_{s,i} \times (H/2 - d_i)$
mm	mm	No.	MPa	mm^2	mm / mm	MPa	kN	kNm
50	16	1	500.0	201	0.0024	485	97.5	82.9
250.0	16	1	500.0	201	0.0001	24	4.9	3.2
450.0	16	1	500.0	201	-0.0022	-436	-87.7	-39.4
650.0	16	1	500.0	201	-0.0045	-500	-100.5	-25.1
850.0	16	1	500.0	201	-0.0068	-500	-100.5	-5.0
1050.0	16	1	500.0	201	-0.0091	-500	-100.5	15.1
1250.0	16	1	500.0	201	-0.0114	-500	-100.5	35.2
1450.0	16	1	500.0	201	-0.0137	-500	-100.5	55.3
1650.0	16	1	500.0	201	-0.0160	-500	-100.5	75.4
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Axial load	P*	kN
Depth to neutral axis	c	260.6 mm
Concrete compressive force	C_c	588.4 kN
Sum of steel axial force	$C_s + T_s$	-588.4 kN
Check axial force	$C_c + C_s - T_s$	0 kN
Concrete moment contribution	$C_c(H/2 - \beta c/2)$	464 kNm
Steel moment contribution	$\Sigma[(C_{s,i} + T_{s,i}) \times (H/2 - d_i)]$	197 kNm
Section moment capacity	ϕM_n	**562.6** kNm
Moment Demand	M*	kNm

Compression taken as positive

Steel stress-strain curve assumed bi-linear

ok

Horizontal Steel

Wall type		limited ductile
Strength Reduction Factor	ϕ	0.75 -
Bar size		16 mm
Bar spacing	s	200 mm
Max spacing	s_{max}	360 mm
Number of bars per row	n	1 mm
Bar yield stress	f_{yt}	500 MPa
Area of shear steel	A_v	201 mm^2
Min area of shear steel	$A_{v,min}$	35 mm^2
Area of concrete shear	A_{cv}	180000 mm^2
Steel shear strength	V_s	724 kN
Concrete shar strength	V_c	122 kN
Total shear strength	ϕV_{total}	**634** kN
Shear demand	V*	kN

ok

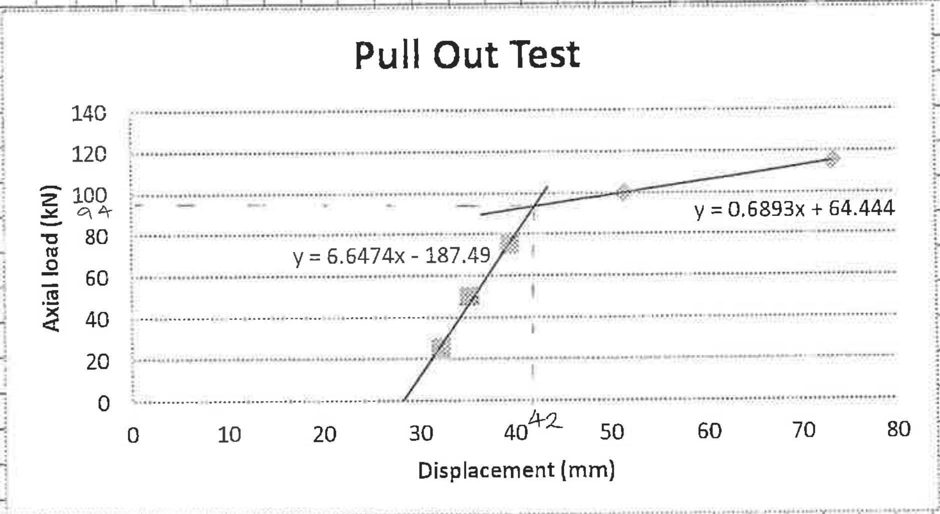
DON THOMSON
consulting engineers

section	page
6	1

project	34 Upland Road	project no.	210263
part	Soil Nail Pull Out Test	date	24/04/2013
element	Results	designer	RLM

Test anchor consisted of 32mm Ø Reidbar in 100mm Ø grout column, embedded 6m into slope with 1.5m bonded at end

P (kN)	Δ (mm)
25	32
50	35
75	40
100	52
115	73



Ultimate bond stress of soil - grout interface

$$\tau = \frac{P}{AL}$$

$$= \frac{115\,kN}{\pi \times 0.1m \times 1.5m}$$

$$= 244\,kPa \approx 250\,kPa$$

Strain of soil

$$\varepsilon = \frac{\Delta}{L}$$

$$= \frac{(73-42)}{1500}$$

$$= 0.0207$$

6-2

WEBSTER DRILLING

phone +64 4 237 5264
facsimile +64 4 237 6587
info@websterdrilling.com

Location : 34 Upland Road		**Anchor no.:** Test anchor 1	
Operator: Michael		**Date:** 4-Feb-13	
Durapac 60T		**Model: RDH-606**	
CEJN 10K gauge		**Serial: 090191788**	**Cert. Exp:** 14-Jun-13

Target load *kN*	**Target pressure** *psi*	**Initial reading** *mm*	**+2 mins** *mm*
25	434	32.25	32.38
50	868	35.25	35.34
75	1301	39.68	40.77
100	1735	51.58	54.28
125	2169	*73.34	
150	2603		
175	3036		
200	3470		
225	3904		
250	4338		
275	4771		
300	5205		
325	5639		
350	6073		
375	6506		
400	6940		
425	7374		

*Unable to load above 2000 psi / 115kN

Soil nails designed to resist sliding at foundations. First 3m of bar embedment considered to be unbonded.

Soil nail – 200mmØ hole, 13m long

Soil resistance

$\phi N_t = \phi \tau \pi D L$

$= 0.5 \times 250\,kPa \times 0.2m \times \pi \times (13m - 3m)$

$= 786\,kN$

Yield strength of bar needs to be equal to or greater than soil resistance

Use Titan 73/53

$\phi N_y = 0.9 \times 970\,kN = 873\,kN > \phi N_t$ ok

Elastic deflection of bar over 3m unbonded length

$\Delta = \frac{PL}{AE}$

$= \frac{970\,kN \times 3m}{1631\,mm^2 \times 80\,GPa}$

$= 22\,mm$

Soil deflection over 10m bonded.
Strain from pull out test conservatively used as strain for Titan anchor.

$\Delta = \varepsilon L$

$= 0.0207 \times 10\,m$

$= 207\,mm$

Total deflection of soil nail

$\Delta_T = 207\,mm + 22\,mm$

$= 229\,mm$

Plate at end of anchor bears on concrete
Try 250x250 plate

$\phi N_c = \phi 0.85 A_1 f'_c$

$= 0.85 \times 0.85 \times (250 \times 250 - 80^2 \pi/4) \times 25\,MPa$

$= 1038\,kN$

$> \phi N_y = 970\,kN$ ok

DON THOMSON consulting engineers

project	34 Upland Rd
part	Foundations
element	Soil nails
project no.	210263
date	24/4/13
designer	RLM
section	
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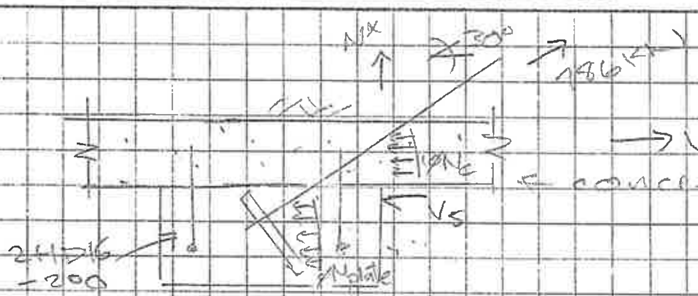

$\rightarrow V^* = 786kN \cos 30° = 680kN$

← concrete wall

Transfer of shear load into anchor

$V^* = 680kN$

Shear strength of Titan 73/53

$\phi V = \dfrac{\phi N_y A_c}{1.75\sqrt{3}}$

$= \dfrac{0.9 \times 970kN \times 1631mm^2}{1.75 \times \sqrt{3}}$

$= 470kN$

Anchor bears on concrete

$\phi N_c = \phi A_p 0.85 f'_c$

$= 0.85 \times 73mm \times 300mm \times 0.85 \times 20MPa$

$= 316kN$

Maximum load transferred by anchor is 316kN. Rest of load taken by HD16s dowelled into concrete wall.

$V^* = 680kN - 316kN$

$= 364kN$

try 8 HD16

$\phi N_s = \phi\, 0.6 A_s f_y$

$= 0.9 \times 0.6 \times 16^2 \pi / 4 \times 500MPa$

$= 434kN$ $> V^* = 364kN$ ok

Bars chemset into concrete wall 150mm at 300mm centres. from Ramset Manual 2010

$\phi V_{uc} = 140.5kN$ $(e = 500mm)$

$X_{vc} = 0.79$ $(f'_c = 20MPa)$

$X_{vd} = 1.0$ $(\alpha = 0°)$

$X_{va} = 0.62$ $(a = 300mm)$

$X_{vn} = 1.0$ $(n = 2$ in a row$)$

$\phi V_{urc} = \phi V_{uc} X_{vc} X_{vd} X_{va} X_{vn}\, n$

$= 140.5kN \times 0.79 \times 1 \times 0.62 \times 1 \times 8$

$= 551kN$ $> V^* = 364kN$ ok

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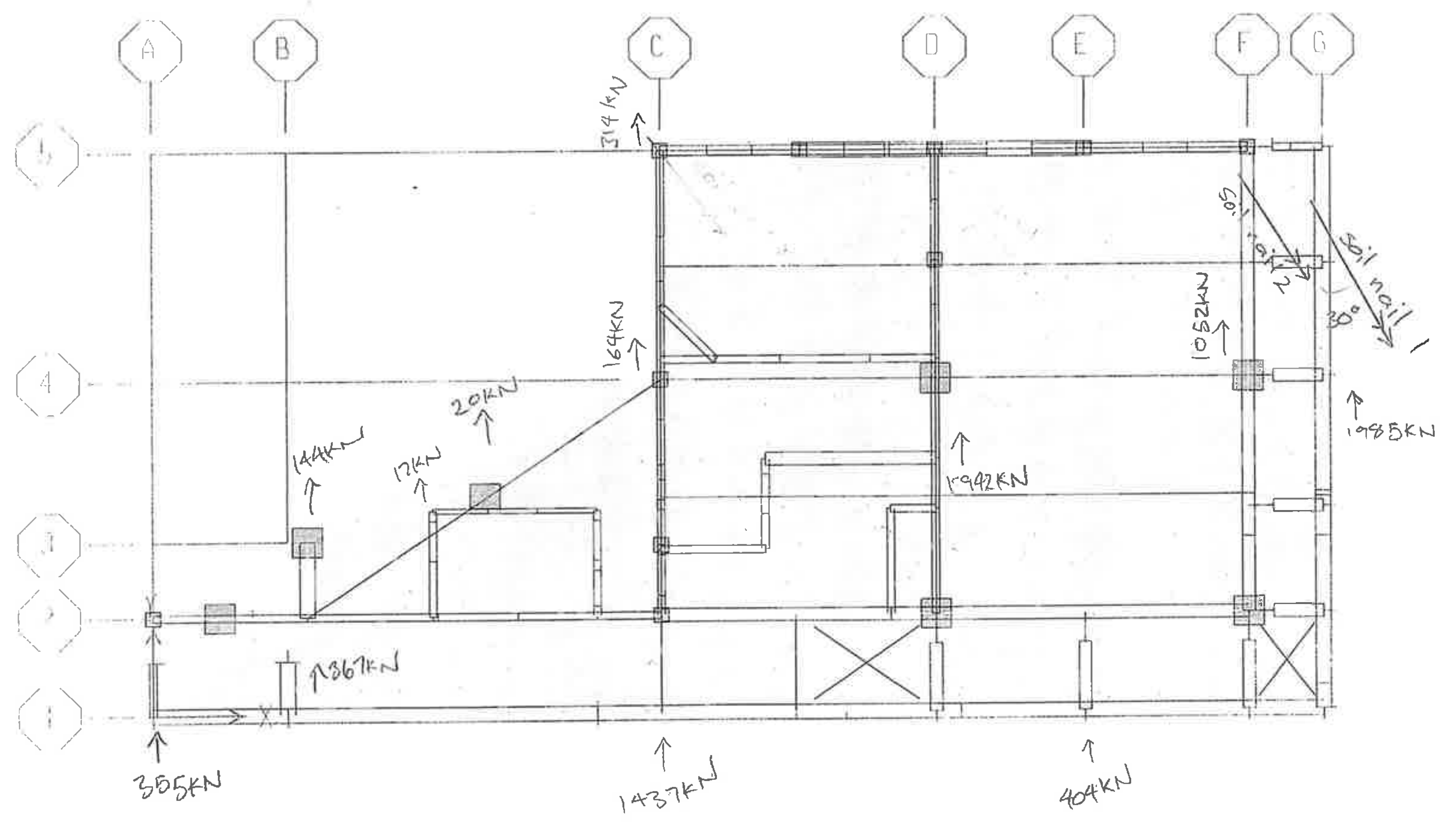
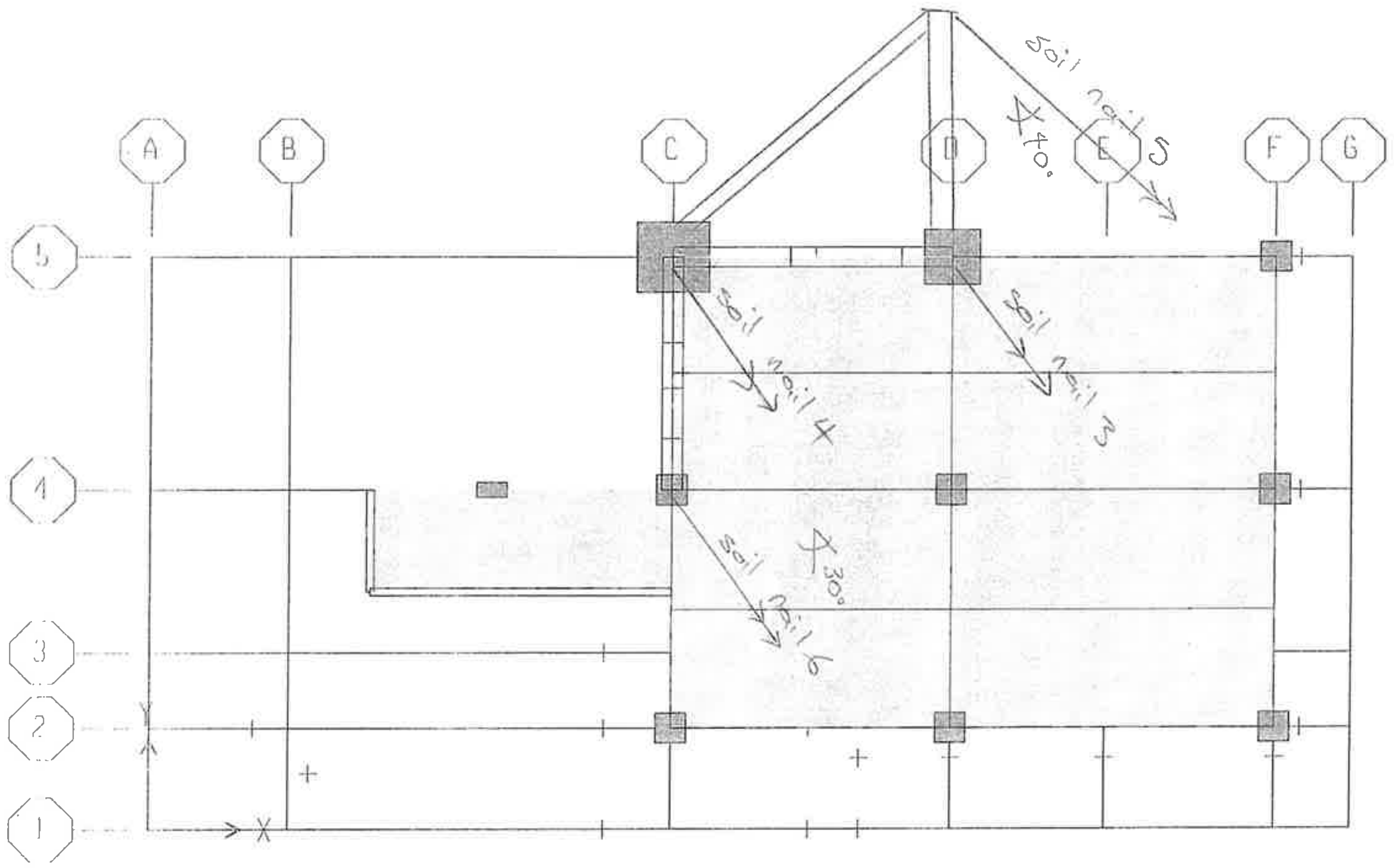
J - 1

2.6m high
3.1m base



Storey 2 - Base Reactions NS, μ=1


A
B
C
D
E
F
G
5
4
3
2
1
soil nail 5
∡40°
soil nail 3
soil nail 4
∡30°
soil nail 6

Storey 1

7-2

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project: 34 Upland Road
part: Foundations
element: North - South

project no.: 210263
date: 23/4/13
designer: RLM

section	page
7	3

Total shear force NS at foundations for $\mu = 1.50$

$C_d(T, \mu=1) = 0.94$
$C_d(T, \mu=1.50) = 0.62$

$V^*_{NS} = (1988kN + 1052kN + 404kN + 1947kN + 1437kN + 164kN + 314kN) \times 0.62 / 0.94$
$= 4814kN$

Building strengthened to 60% NBS so foundations designed to resist:
$V^*_{NS} = 4814 \times 60\%$
$= 2888kN$

Sliding resistance of wall at grid G resists
$\phi V_s = 522kN$ (see pg 7-4)

new soil nails embedded 13m at 30°
$\phi V_{nail\,1} = \phi z \pi D L \cos\alpha$
$= 0.5 \times 250kPa \times 200mm \times \pi \times (13m - 3m) \cos 30°$
$= 680kN$

Two new soil nails embedded 14m
$\phi V_{nail\,14m} = 0.5 \times 250kPa \times 200mm \times \pi \times (14m - 3m) \cos 30° \times \cos K$
$= 737kN$

Total resistance at foundations
$\phi V_{total} = 522kN + 680kN + 737kN \times 2 + 405kN$
$= 3081kN$
$> V^*_{NS}$ ok

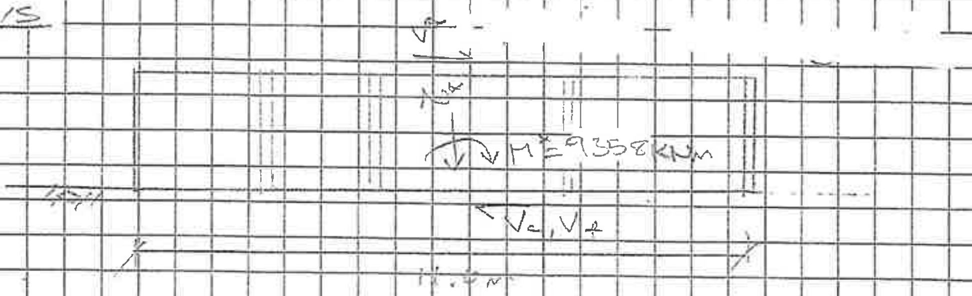
New soil nail embedded 13m at 55° angle
$\phi V_{nail\,2} = \phi z \pi D L \cos\alpha$
$= 0.5 \times 250kPa \times 200mm \times \pi (13m - 4m) \cos 55°$
$= 405kN$

DON THOMSON consulting engineers

project	34 Upland Rd	project no.	210263
part	Foundations	date	27/1/11
element	Pier 35, Grid G	designer	RLM

section: 7 page: 4

F N/S



Axial load on wall

$G = 24kN/m^3 \times (0.3m \times 11.6m \times 1.9m$ = 159 kN : ret. wall
+ $1.9m \times 0.25 \times (0.95 + 0.84 + 0.78 + 0.68)$ = 37 kN : return wall
+ $0.3m \times 11.6m \times 3.8m$ = 317 kN : level 3 wall
+ $0.15m \times 11.6m \times 3.1m$ = 129 kN : level 4 wall
+ $0.15m \times 11.6m \times 1.5m \times 3/2$ = 94 kN : floor
+ $0.15m \times 11.6 \times 2.8m)$ = 117 kN : level 5 wall
853 kN

$\psi_c Q = 1.5kPa \times 11.6m \times 1.5m \times 3/2 \times 0.4$ = 16 kN
869 kN

Sliding Resistance

$V_D = N^* \tan \phi$
$= 869kN \times \tan 35$
$= 608kN$

Cohesion

$V_c = c\, l_f\, b$
$= 5kPa \times 11.6m \times 0.3m$
$= 17kN$

Passive Pressure

$V_p = \gamma l^2 b/2$
$= 18kN/m^3 \times (1.0m)^2 \times 1.4m/2 \times 4$
$= 50kN$

Total

$\phi V = 0.8(608 + 17) + 0.45 \times 50$
$= 522kN$

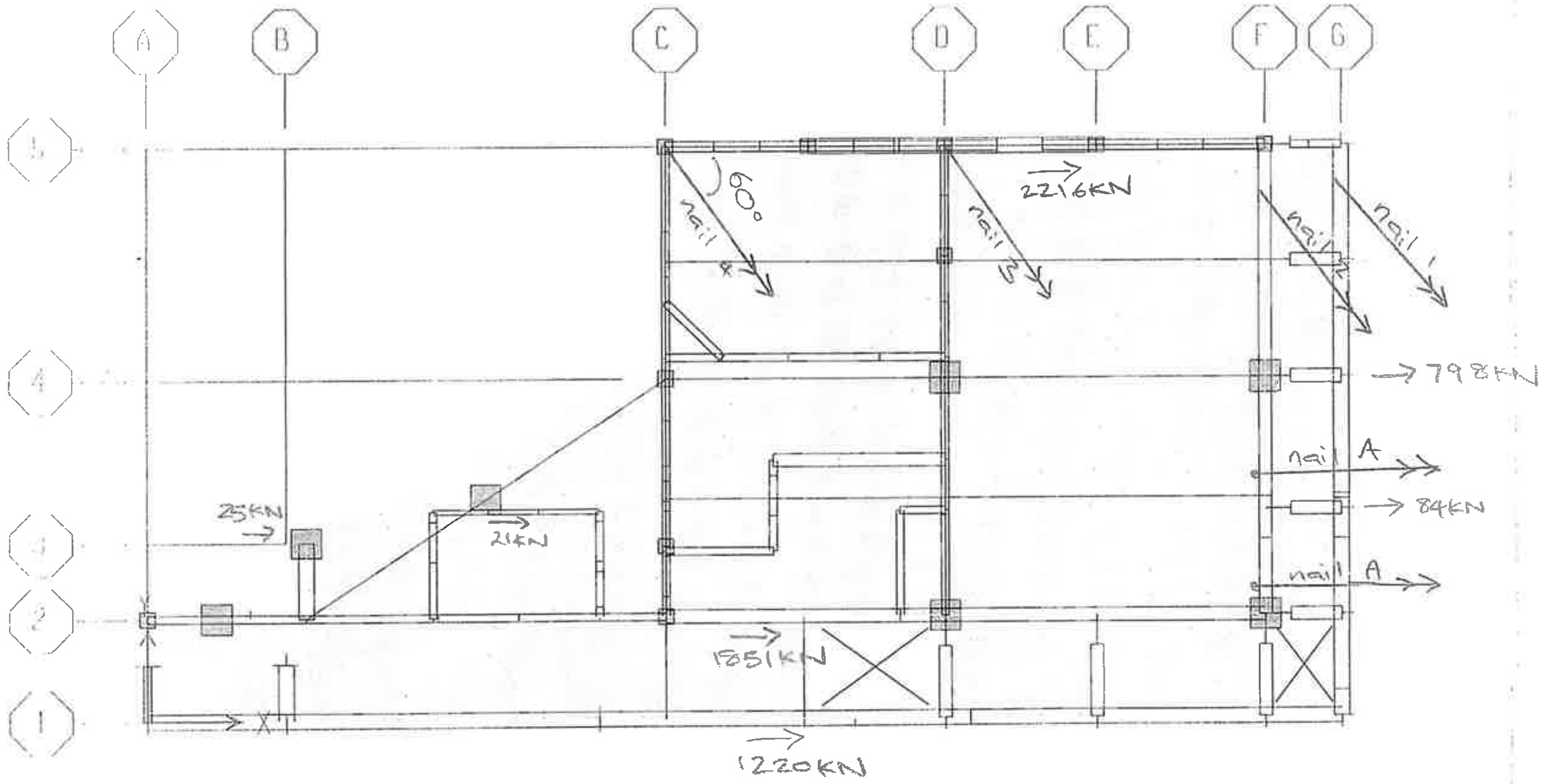
Overturning

$M_o = 9358kNm \times 0.62/0.94 = 6172kN$ ($\mu = 1.50$)

$M_r = 869kN \times 11.6m/2$
$= 5040kN.m$

%NBS = 5040 / 6172
= 82 %

OK



Storey 2- Base Reactions EW (μ=1)

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project: 34 Upland Road — project no.: 210263
part: Foundations — date: 10/4/13
element: E/W — designer: RLM

section: 8 — page: 2

Grid 1

$V^* = 1220\,kN \times 0.62/0.94 \times 60\% = 483\,kN$ ($\mu = 1.50$)

Sliding resistance from concrete wall
$\phi V_s = 883\,kN > V^*$ ok
(see pg 8-3)

Grid 2

$V^* = (185\,kN + 84\,kN + 798\,kN) \times 0.62/0.94 \times 60\%$
$= 1082\,kN$

3 new soil nails designed to resist load, see pg 8-4

$\phi V_{total} = 408\,kN \times 3 = 1224\,kN$

Grid 5

$V^* = (2216\,kN + 101\,kN) \times 0.62/0.94 \times 60\%$ ($\mu = 1.50$)
$= 917\,kN$

4 new soil nails angled at 60° from the direction of applied load provide resistance

Soil nail 1 & 2, 13m long, $\alpha = 60°$
$\therefore \phi V = \phi \tau \pi D L \cos\alpha$
$= 0.5 \times 250\,kPa \times \pi \times 0.2\,m \times (13\,m - 3\,m) \times \cos 60°$
$= 393\,kN$

Soil nail 3 & 4, 14m long, $\alpha = 60°$, $\beta = 10°$ (angle to horizontal)
$\phi V = 0.5 \times 250\,kPa \times \pi \times 0.2\,m \times (14\,m - 3\,m) \times \cos 60° \times \cos 10°$
$= 425\,kN$

$\phi V_{total} = 425\,kN \times 2 + 393\,kN \times 2$
$= 1636\,kN > V^*$ ok

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project	34 Upland Rd
part	Foundations
element	Pier 59, Grid 1
project no.	210263
date	14/1/11
designer	RLM
section	8
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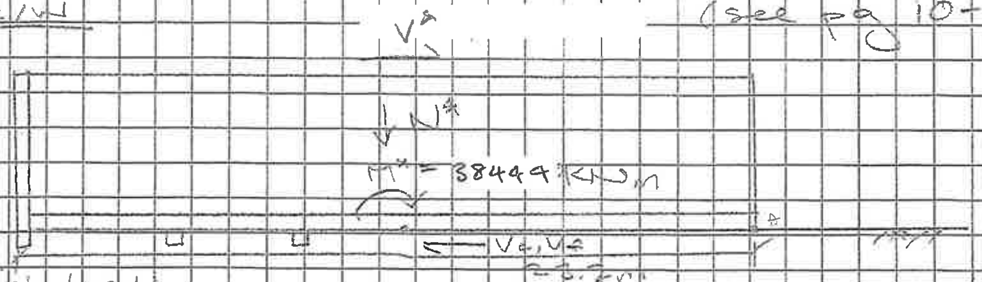
F E/W

(see pg 10+11)



Axial load

G = 24kN/m³ × (1.9m × 0.3m × 23.2m = 317 kN : level 2 ret. wall
+ 0.9m × 0.3m × 23.2m = 150 kN : footing
+ 1.9m × 0.25m × 1.3m × 3 = 44 kN : level 2 walls
+ 0.15m × 3.8m × 23.2m = 317 kN : level 3 wall
+ 0.15m × 1.0m × 21m × 3 = 227 kN : level 3 & 4 floor
+ 0.15m × 3.1m × 14m = 156 kN : level 4 wall
+ 0.15m × 9.0m × 2.8m) = 91 kN : level 5 wall

1302 kN

Q = 1.5kPa × 1.0m × 21m × 3 = 95kN

N* = G + ψQ = 1302 + 95 × 0.4 = 1340kN

- Sliding Resistance

$V_b = N^* \tan \phi$: resistance due to friction

= 1340 kN × tan 35

= 938 kN

resistance due to adhesion

$V_c = c' l_e b$

= 5kPa × 23.2m × 1.2m

= 139 kN

resistance from beams passive pressure

$V_p = \gamma l^2 b / 2$

= 19kN/m³ × (1.0m)² × 1.8m / 2 × 3

= 49 kN

total resistance

φV = 0.8 × (938 + 139) + 0.45 × 49kN

= 883 kN

- Overturning

A = 1.50

M_o = 38444 kNm × 0.62/0.94 = 25356 kNm

M_r = $N^* l$

= 1340 kN × 23.2m/2

= 15544 kNm

%NBS = 15544/25356 × 100

= 61%

OK

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Passive Anchor Design - E/W Nails A

Design for Passive (un-stressed) tension anchor in straight shaft gravity-grouted drill hole.

Anchor Details

Design Case

$n := 3$ Number of nails

$N_{t\_static} := 0kN$ $N_{t\_seismic} := 1105\dfrac{kN}{n}$ Horizontal force in anchor obtained from analysis, including safety & load factors

$D := 130mm$ Diameter of drilled hole

$\alpha := 10deg$ Inclination of anchor to horizontal

$N_{tstar\_seismic} := \dfrac{N_{t\_seismic}}{\cos(\alpha)}$

$N_{tstar\_seismic} = 374\,kN$ Total design force (tension) in anchor

Strength of Bars 40/16 Titan Anchors

$N_t := 525kN$ Tensile strength of steel

$\phi_{s\_seismic} := 0.9$ Strength reduction factor on steel capacity

$\phi N_{ts\_seismic} := \phi_{s\_seismic} \cdot N_t$

$\phi N_{ts\_seismic} = 472.5\,kN$

$FOS_{bar} := \dfrac{N_t}{N_{tstar\_seismic}}$ $FOS_{bar} = 1.415$

Embedment in soil

Ground Type: Sandy silt

$\tau := 250kPa$ Ultimate Bond stress of soil for ground/grout interface from pull out test

$L_1 := 4m$ Distance to failure plane obtained from analysis

$\phi_{g\_static} := \dfrac{1}{3}$ $\phi_{g\_seismic} := 0.5$ Strength reduction factor on country bond capacity

$L_2 := \dfrac{N_{tstar\_seismic}}{\phi_{g\_seismic} \cdot \tau \cdot \pi \cdot D}$

$L_2 = 7.3\,m$ Minimum anchor bond length

$L_{2abl} := \max(\mathrm{ceil}(L_2), 3m)$ $L_{2abl} = 8\,m$ Anchor bond length used

$\phi N_{ta} := \phi_{g\_seismic} \cdot \tau \cdot \pi \cdot D \cdot L_{2abl}$

$\phi N_{ta} = 408.407\,kN$

$FOS_{bond} := \dfrac{\tau \cdot \pi \cdot D \cdot L_{2abl}}{N_{tstar\_seismic}}$ $FOS_{bond} = 2.202$

Total Embedment

Use 40/16 Titan anchors with $L_T = 12\,m$ embedment

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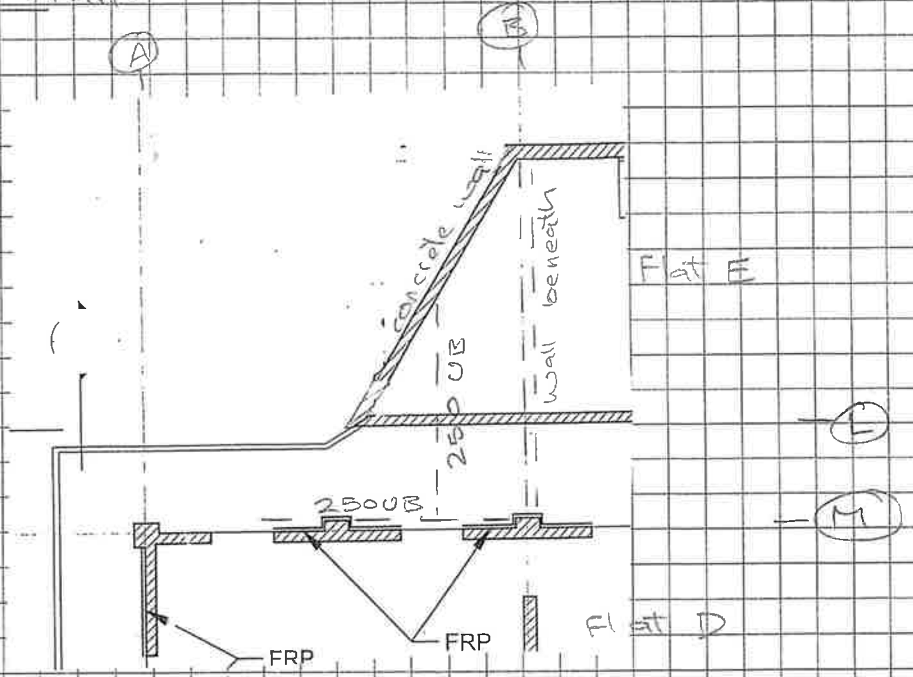
project	34 Upland Road	project no.	210263
part	Flat E	date	24/4/13
element	Gravity support	designer	RLM

section	page
9	1

Level 2 Plan:



Existing steel beam on grid M severely rusted. At grid L there is differential movement between Flat E and walkway. New steel beams designed to support walkway and floor of Flat E.

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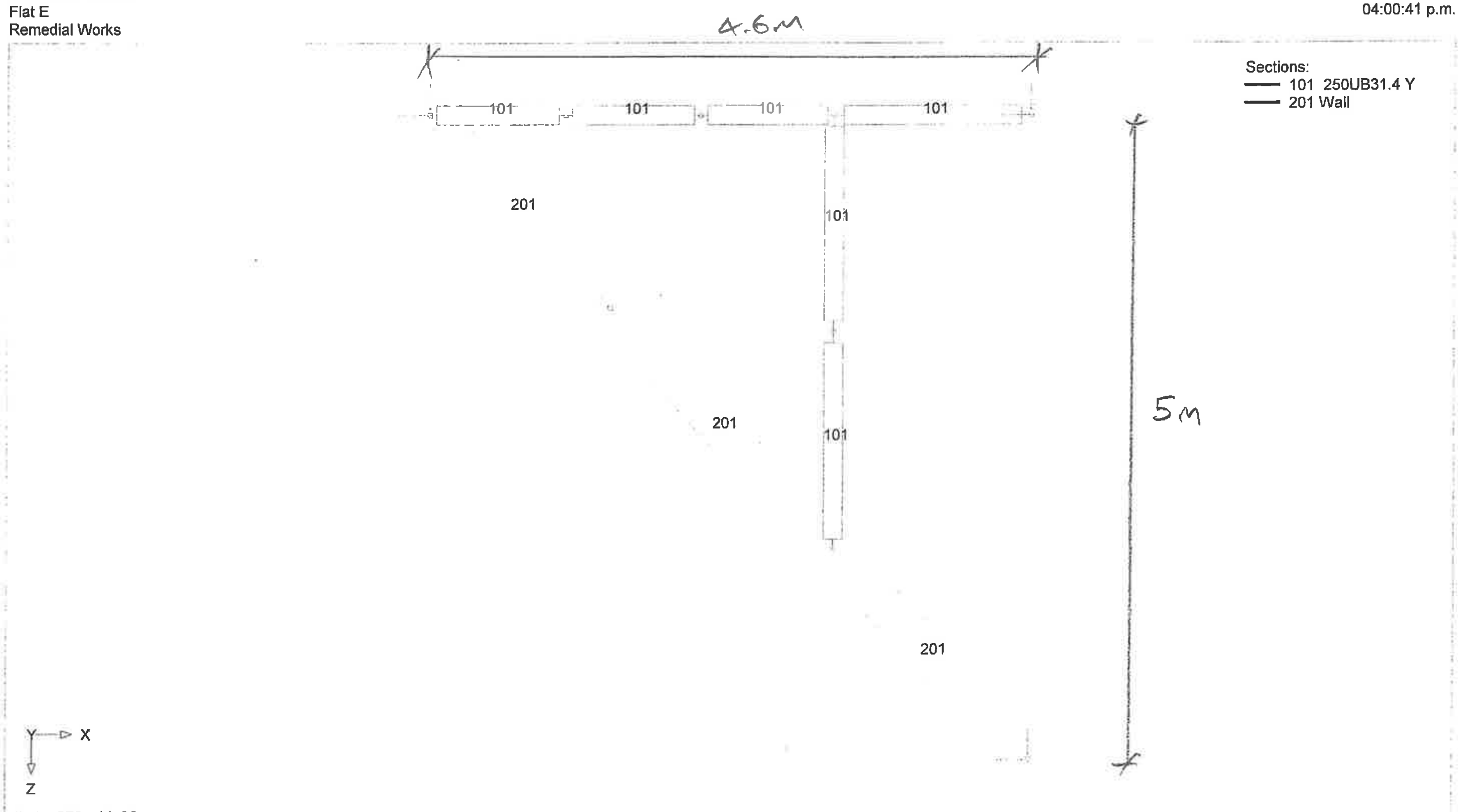
Microstran V9

Don Thomson Consulting Engineers
Job: Flat E beams
Flat E
Remedial Works

22/02/2013
04:00:41 p.m.



theta: 270 phi: 90

Model of Flat E Beams

Microstran V9.00.111108 {854422}

K:\210263\Calcs\Stregnthening\Construction\Flat E beams.msw

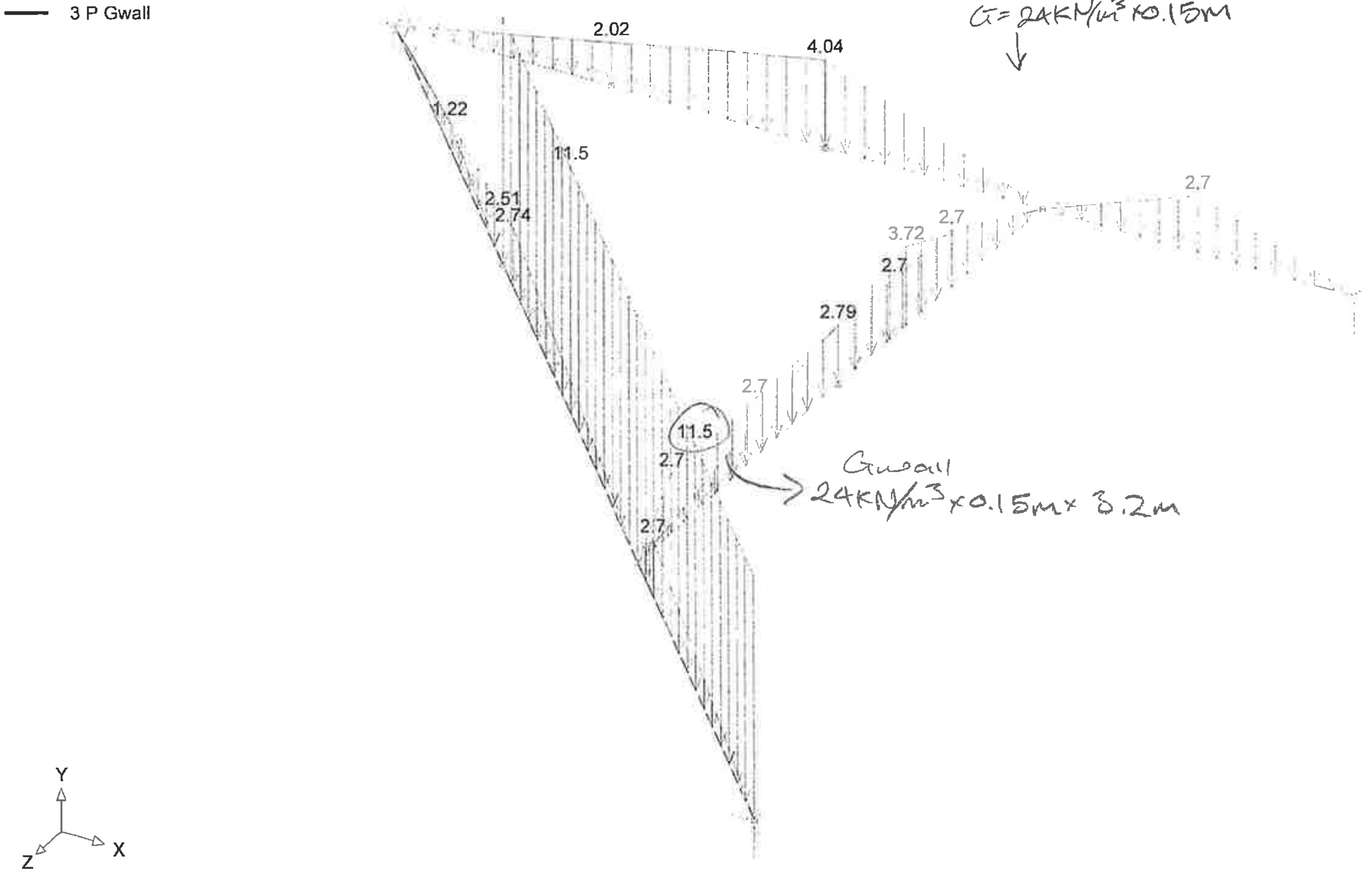
9-2

Microstran V9

Don Thomson Consulting Engineers
Job: Flat E beams
Flat E
Remedial Works

22/02/2013
03:59:50 p.m.

Load Cases:
1 P G
3 P Gwall



theta: 300 phi: 30

Dead Load

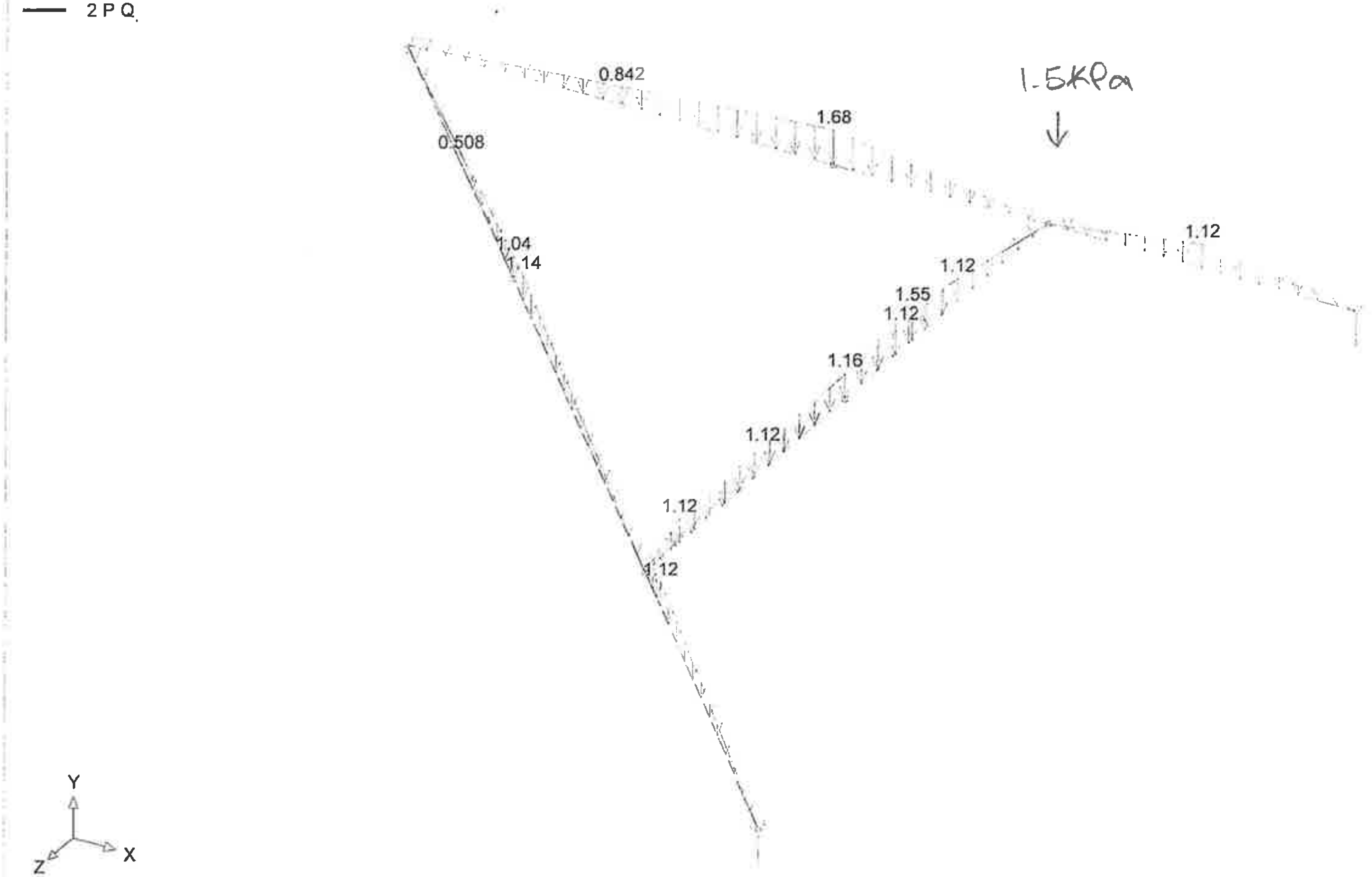
9-3

Microstran V9

Don Thomson Consulting Engineers
Job: Flat E beams
Flat E
Remedial Works

22/02/2013
03:59:59 p.m.

Load Cases:
2 P Q



theta: 300 phi: 30

Live Load

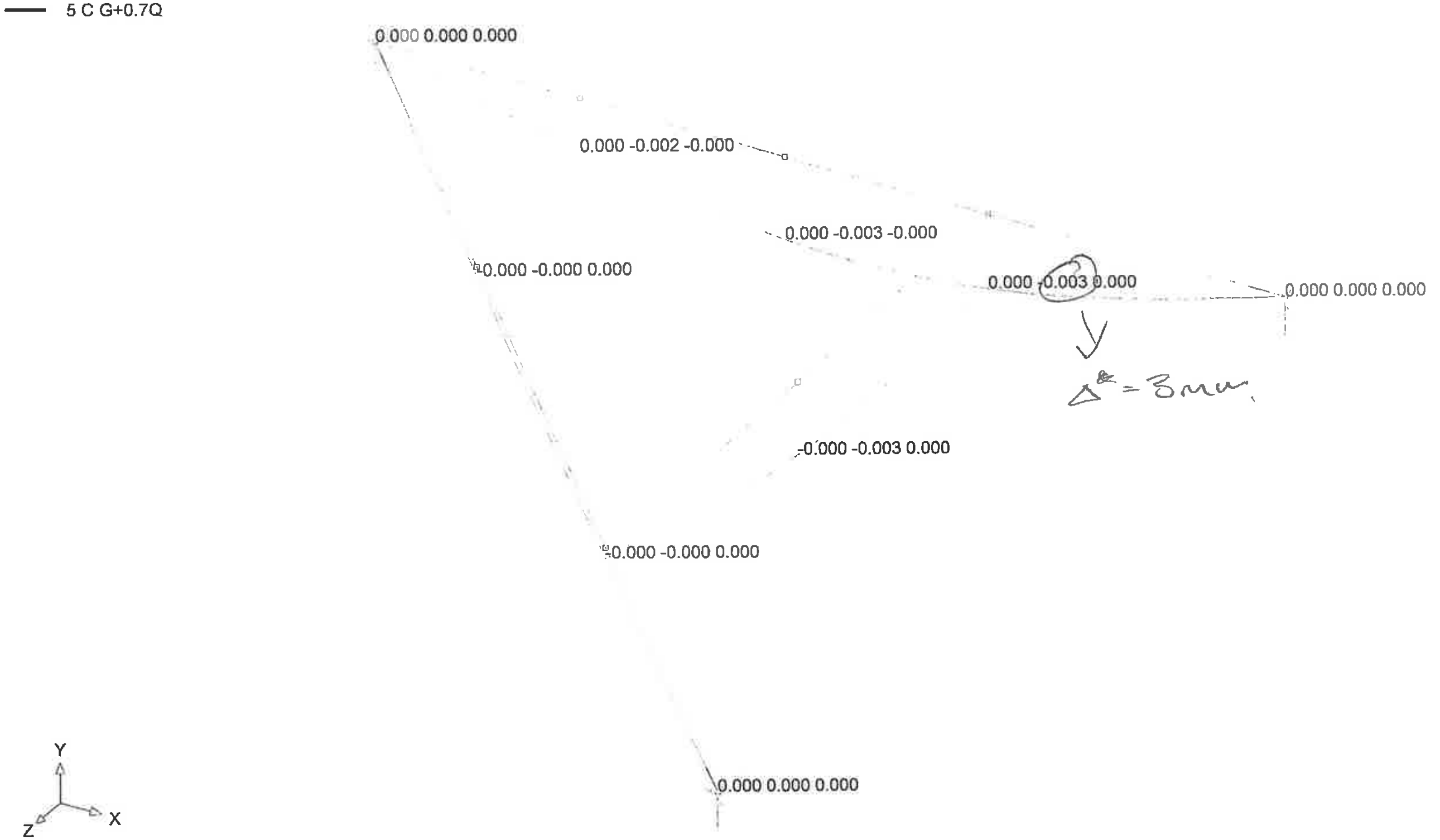
9-4

Microstran V9

Don Thomson Consulting Engineers
Job: Flat E beams
Flat E
Remedial Works

22/02/2013
03:58:49 p.m.

Load Cases:
5 C G+0.7Q



$\Delta^{*} = 3mm.$

theta: 300 phi: 30

SLS Deflection

Displaced Shape

Microstran V9.00.111108 {854422}

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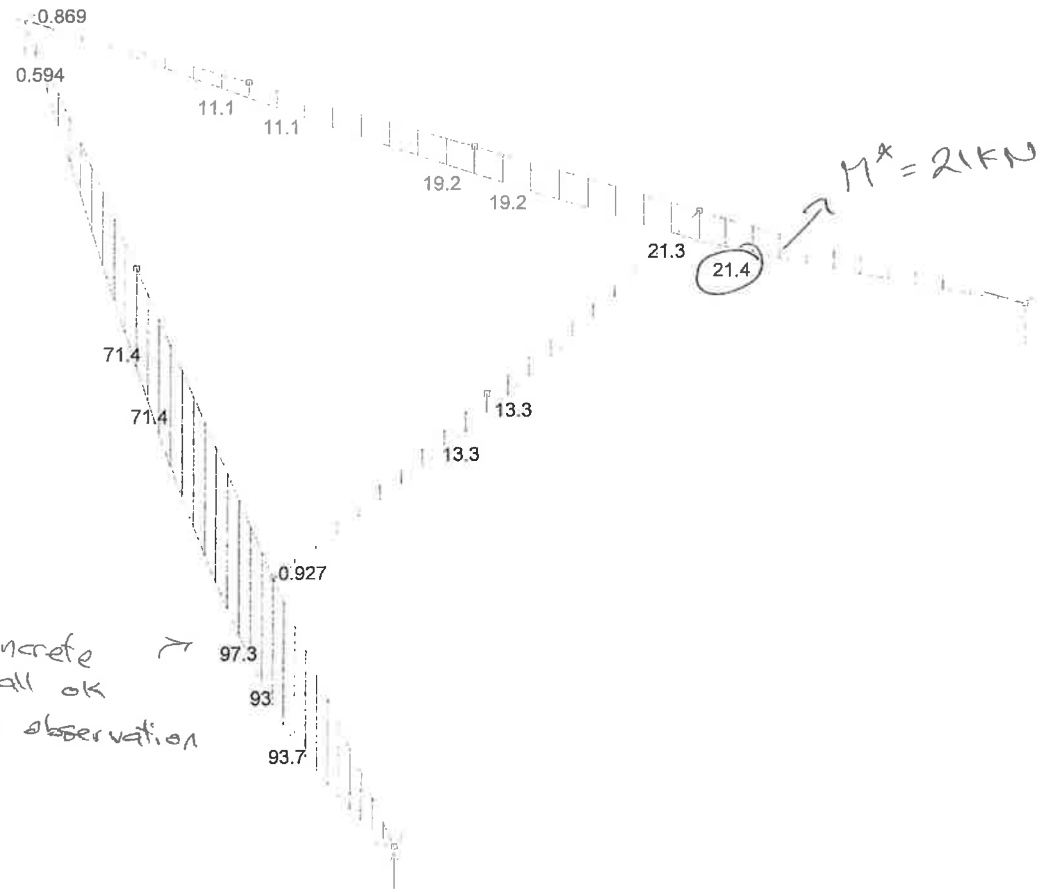
9-5

Microstran V9

Don Thomson Consulting Engineers
Job: Flat E beams
Flat E
Remedial Works

22/02/2013
03:59:03 p.m.

Load Cases:
4 C 1.2G+1.5Q



$M^* = 21kNm$

try 250UB31

$\phi M_b = \phi M_s \alpha_s \alpha_m$

$= 114kNm \times 0.45 \times 1.13$

$= 58kNm$

$> M^*$ ok

use 250UB31

concrete wall ok by observation

theta: 300 phi: 30

BMD

Bending Moment, Mz

Microstran V9.00.111108 {854422}

K:\210263\Calcs\Stregnthening\Construction\Flat E beams.msw

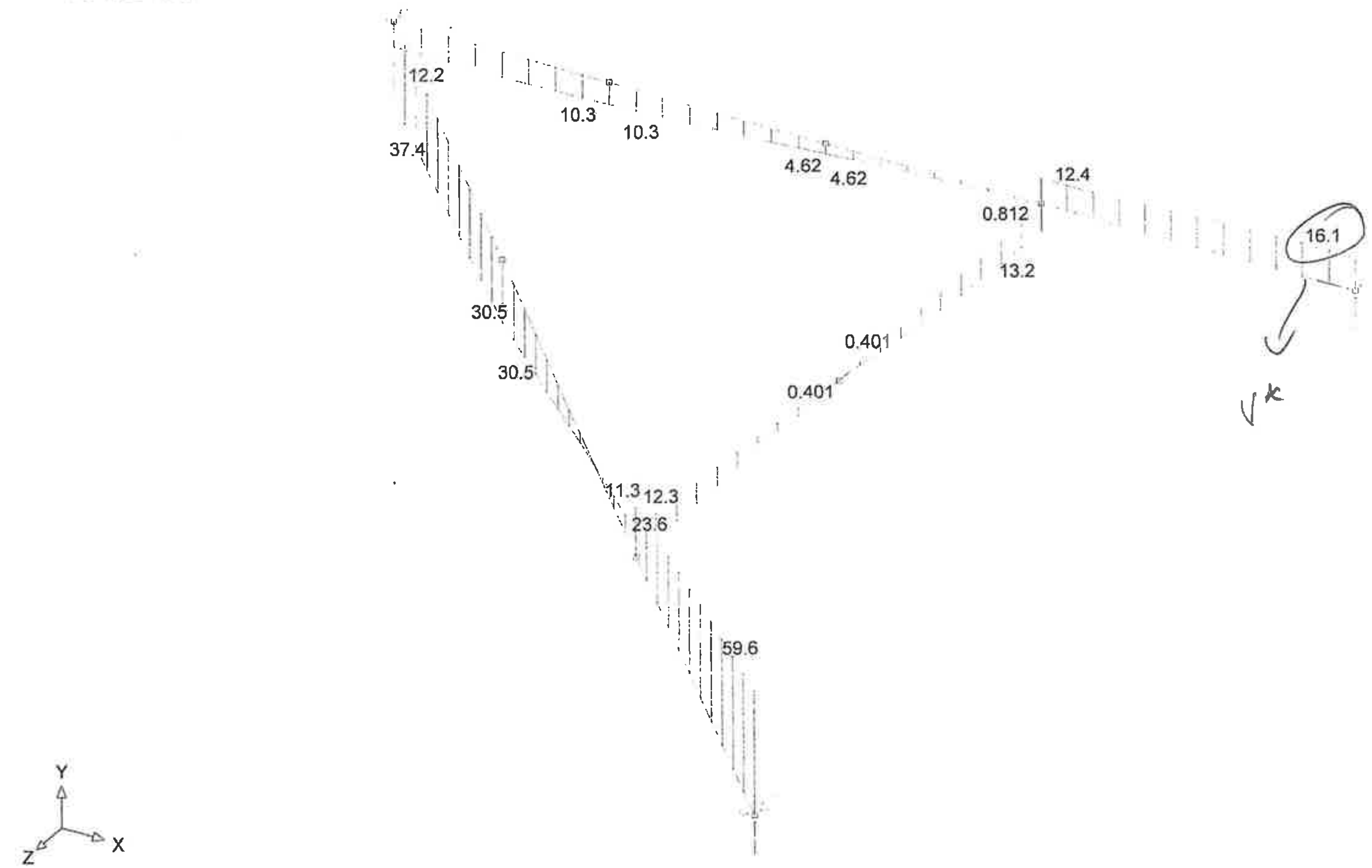
9-6

Microstran V9

Don Thomson Consulting Engineers
Job: Flat E beams
Flat E
Remedial Works

22/02/2013
03:59:14 p.m.

Load Cases:
4 C 1.2G+1.5Q



theta: 300 phi: 30

SFD

Shear Force, Fy

Microstran V9.00.111108 {854422}

K:\210263\Calcs\Stregnthening\Construction\Flat E beams.msw

9-7

Don Thomson
Consulting Engineers
81 Harbour View Road
Northland Wellington
tel 04 475 7933 fax 04 475 8414

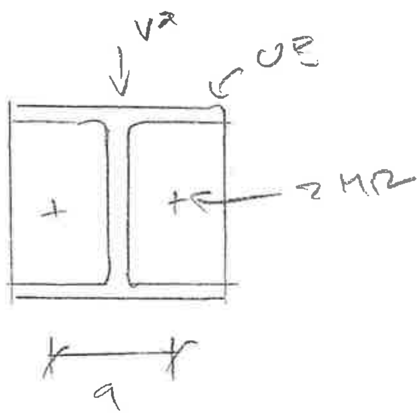
calculation sheet			page no: 9-8
job name:		34 Upland Road	
designed: RLM	job no:	210263	
checked:	date:	21-02-13	

Connection of UB to Concrete Wall for Remedial works to Flat E

Chemset Injection Anchor Design Sheet

Size	M12	N^*	5 kN
Depth	150 mm	V^*	19 kN
f'_c	25 MPa		
e	300 mm		
a	165 mm		
$\alpha°$	90 degrees		
n	2 bolts		
ΦN_{uc}	19.7 kN	ΦV_{uc}	80.5 kN
X_{nc}	0.93	X_{vc}	0.88
X_{ne}	1	X_{vd}	2
X_{na}	1	X_{va}	0.61
		X_{vn}	1
ΦN_{urc}	36.64 kN	ΦV_{urc}	172.57 kN

Combined Action 0.247 Okay



Existing concrete beam to level 3 walkway severely rusted. Concrete broken away and new reinforcing installed to create new beam

G = 24kN/m³ × 0.1m × 0.6M + 24kN/m³ × 0.2m × 0.1m
walkway / beam
= 1.92kN/m

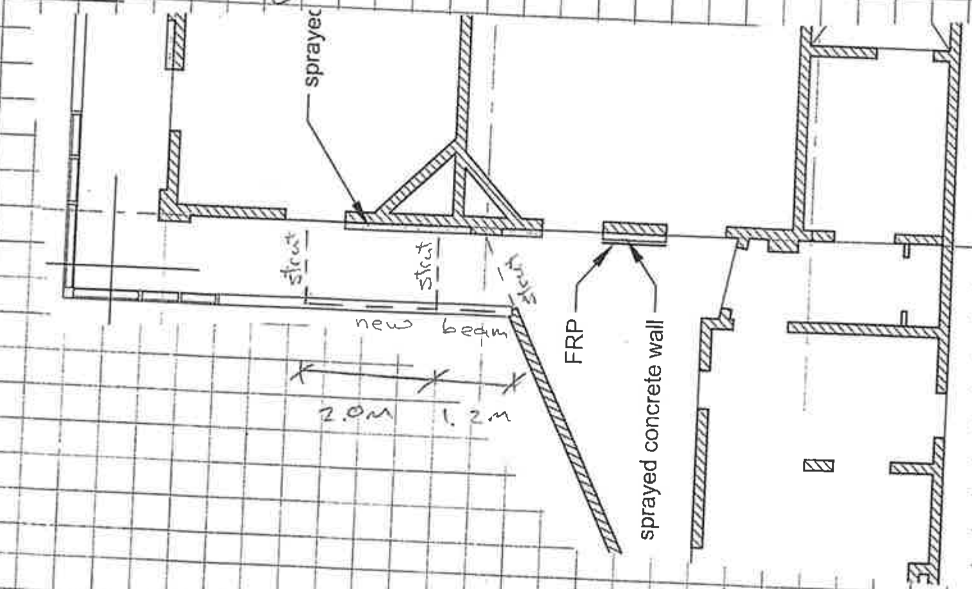
Q = 2.0kPa × 0.6M
= 1.2kN/m

1.2G + 1.5Q = 1.2×1.92 + 1.5×1.2
= 4.1kN/m

: BMD

: SFD

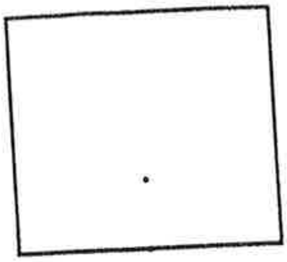
Plan level 3:



DON THOMSON consulting engineers	calculation sheet		page: 10 - 2
	job name:	34 Upland Road	
	designed:	RLM	job no: 210263
	checked:		date: 27/03/2013

Description: **Beam to Flat B Walkway**

Designed June 2009 in accordance with NZS3101:2006, Amendment 2



Section and material properties

Flexural strength reduction factor	ϕ	0.85 -	*[Clause 2.3.2.2]*
Section width	b	200 mm	
Overall section depth	H	200 mm	
Overall flange width (if present)	b_{flange}	mm	
Flange thickness (if present)	t_{flange}	mm	
28 day concrete compressive stress	f'_c	25 MPa	
Equivalent stress block stress factor	α	0.85 -	*[Clause 7.4.2.7(c)]*
Equivalent stress block depth factor	β	0.85 -	*[Clause 7.4.2.7(d)]*
Reinforcement modulus of elasticity	E	200 GPa	*[Clause 5.3.4]*
Ultimate concrete compressive strain	ε_c	0.0030 mm / mm	*[Clause 7.4.2.3]*

Flexural reinforcement

Depth from comp. fibre d_i mm	Bar diameter d_b mm	Number of bars - No.	Bar grade f_y MPa	Area of steel $A_{s,i}$ mm^2	Steel strain $\varepsilon_{s,i}$ mm / mm	Steel stress $f_{s,i}$ MPa	Steel force $T_{s,i}$ kN	Steel moment contribution $-T_{s,i} \times d_i$ kNm
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
				-	-		-	-
142	16.0	1.0	500	201	-0.0123	-500	-100.5	14.3

Depth to centroid of tension steel	d	142.0 mm	
Total area of tension steel	A_s	201 mm^2	
Min allowable reinforcement area	$A_{s,min}$	79.5 mm2 < As OK	*[Clause 9.3.8.2.1]*
Max allowable neutral axis depth (maximum reo check)	$c_{max} = 0.75c_b$	58.1 mm > c OK	*[Clause 9.3.8.1]*

Sagging Flexural Capacity *[Clause 7.4.2.1(a)]*

Axial load (compression positive)	P*	0.0 kN	
Depth to neutral axis at failure	c	27.8 mm	
Section moment capacity	ϕM_n	**11.1** kNm	
	M*	**1.6** kNm	**OK (14.4%)**

Shear capacity *[Clause 9.3.9]*

Shear strength reduction factor	ϕ	0.75 -	*[Clause 2.3.2.2]*
Aggregate size factor	k_a	1.00 -	*[Clause 9.3.9.3.4]*
Minimum shear reinforcement provided:	-	No -	*[Clause 9.3.9.4.15]*
Member depth factor	k_d	1.00 -	*[Clause 9.3.9.3.4]*
Tension reinforcement ratio	ρ	0.0071 -	
Basic concrete shear	v_b	0.141 $\sqrt{f'_c}$ MPa	*[Clause 9.3.9.3.4]*
Concrete shear stress	v_c	0.850 MPa	*[Clause 9.3.9.3.4]*
Dependable concrete shear contribution	ϕV_c	18.1 kN	*[Clause 9.3.9.3.4]*
Stirrup size	d_t	mm	
Number of legs	n	-	
Stirrup yield stress	f_{yt}	MPa	
Stirrup spacing	s	mm	
Dependable reinforcing shear	ϕV_s	- kN	*[Clause 9.3.9.4.2]*
Maximum permitted nominal shear stress	$v_{n,max}$	5.0 MPa	*[Clause 9.3.9.3.3]*
Maximum dependable shear capacity	ϕV	**18.1** kN	
	V*	**4.9** kN	**OK (27.1%)**

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