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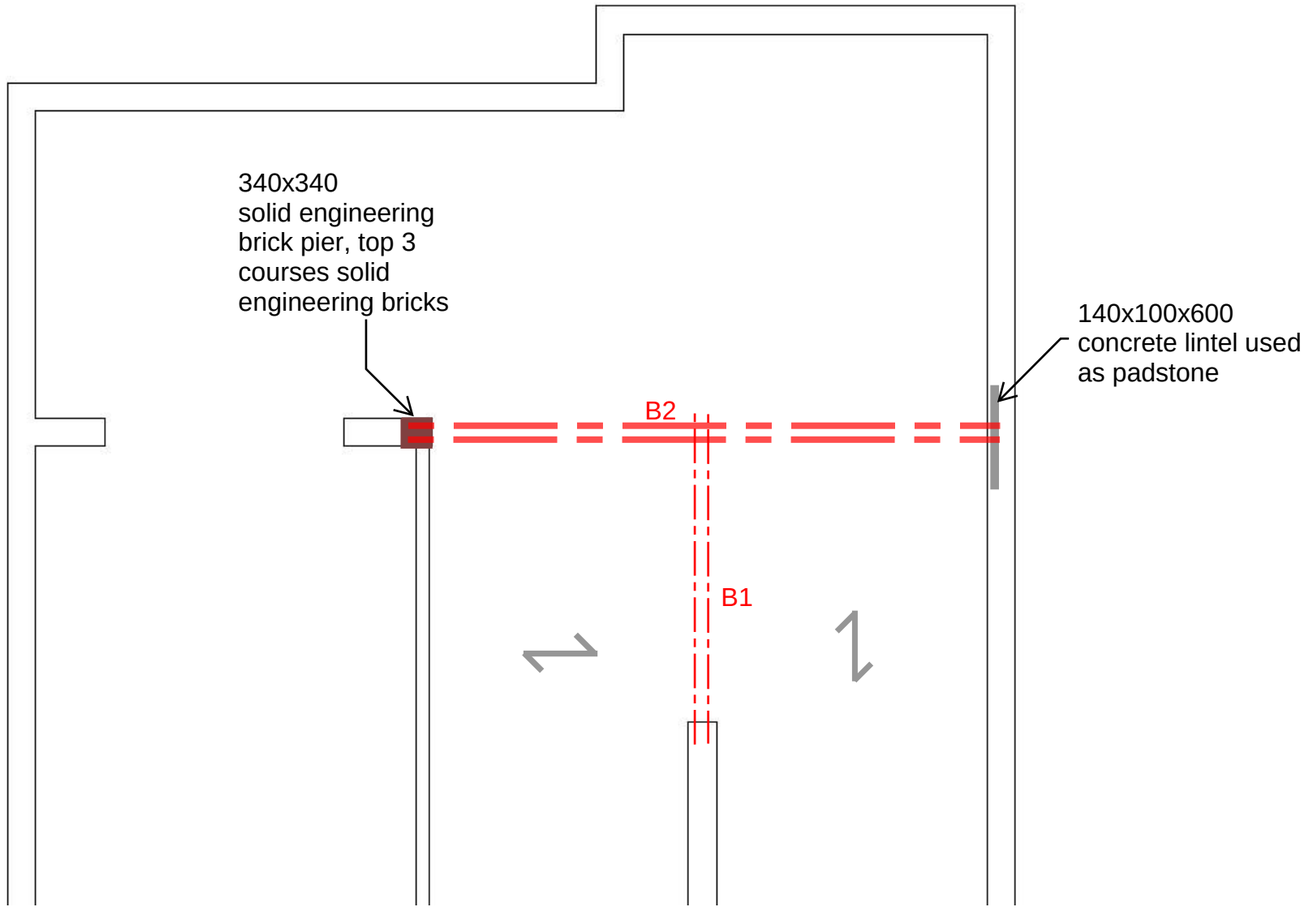
Supporting Calculations

GENERAL NOTES

1. All dimensions are to be obtained or confirmed by the Contractor on site prior to construction. DO NOT SCALE FROM THESE DRAWINGS.
2. Construction work not to be started until calculations have been approved by Building Control.
3. All foundations, as per Building Control Officer requirements.
4. All temporary works, eg. propping before/ during installing new beams, to be responsibility of the Contractor.
5. To minimise deflections of existing structure, new beams must be pinned up tight to existing construction with dry-pack mortar (1:3 cement: sharp sand, low water content), and all mortar allowed to cure prior to de-propping.
6. Due to significant structural works, minor post-construction deflection and cracking of brittle finishes may be expected in the existingbuilding.
7. All works to be undertaken in accordance with the current Building Regulations Part A, British Standards and good building practice. 8. Beams and lintels to have a minimum bearing length of 100mm when perpendicular to the wall, and 150mm when parallel to the wall unless noted otherwise.
9. In vicinity of all new steel beams, masonry to be minimum - bricks solid 50N, block 7.3N. Mortar to be M4(iii) unless noted otherwise.Masonry repairs to match existing brick.
10. Any masonry/ brickwork/ foundations in vicinity of new structural members to be checked by the Contractor and replaced/ repaired, ifdefective.
11. All new steel columns/windposts to be fixed to existing/new masonry with M6x125mm resin-fixed threaded bars @ 300mm vertical c/c.
12. Where floor joists, flat roof joists & rafters span parallel to external cavity wall provide 30 x 5 thick galvanised MS straps at 1.5m centres.Straps to be turned over blockwork into cavity minimum 100mm and fixed to 3 No. joists ensuring solid noggins provided between joists and last joist is packed tight to inner leaf.
13. Wall plates to be strapped to wall using 30 x 5 thick galvanised MS straps at 1.5m centres.
14. Simplify Structural Engineering LLP have been instructed to produce structural design for the specific elements identified withincalculations. We have not assessed any other elements of the structure.
15. CDM Regulations - Under the Construction (Design & Management) Regulations 2015 for commercial clients, the client duties apply infull. For Domestic clients, the client duties pass on to the Principal Contractor or Sole Contractor. For more information visit www.hse.gov.uk.



Padstones:

Unless stated otherwise use 3 courses of engineering brick 450mm long

S355 Steel
B2: 2No. 203x133x30 UB
B1: 2No. 178x102x19 UB

Exiting Trench Fill Foundation to be min 600 wide, 800mm deep, otherwise 800x800mm Pad Foundation will be required

Depth of excavation to be confirmed by BCO on site.
If Pad Foundation footprint encompasses existing trench fill foundation, 400mm long M20 dowel bars are to be used at 300 C/C

EuroBeam 3.05b 150010

Beam: **B1** **Span: 2.5 m.**

	Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U G	o.w.	0.4	0		L	0.50	0.50
U G	Cavity wall	4.0x2.5	0		L	12.50	12.50
U G	Roof dead	1x3/2	0		L	1.88	1.88
U QA	Roof live	0.75x3/2	0		L	1.41	1.41
U G	Floor dead	0.5x3/2	0		L	0.94	0.94
U QA	Floor live	1.5x3/2	0		L	2.81	2.81
			Total load (unfactored): 40.06 kN			**20.03**	**20.03**
			Dead/Permanent (unfactored): 31.63 kN			15.81	15.81
			Live/Variable (unfactored): 8.44 kN			4.22	4.22
					(6.10): 55.35 kN	27.67	27.67

Load types: U:UDL; Load positions are measured in m. from R1 Load durations: G: Dead; Qx: Imposed: QA: Residential

Maximum B.M. = 17.3 kNm (6.10) at 1.25 m. from R1

Maximum S.F. = 27.7 kN (6.10) at R1

Mid-span deflections: Dead: 6.43 x 10^8/EI *(E in N/mm², I in cm⁴)*
Live: 1.72 x 10^8/EI
Total: 8.15 x 10^8/EI

Beam calculation to BS EN1993.1.1 using S355 steel

SECTION SIZE : **2No 178 x 102 x 19 UKB S355** (Class 1, plastic)

D=177.8 mm B=101.2 mm t=4.8 mm T=7.9 mm I_y=1,360 cm⁴ i_z=2.37 cm $W_{pl,y}$=171 cm³ $W_{el,y}$=153 cm³

Classification: Flange: c/t = 40.6/7.9 = 5.14 <= 9e (7.32): Class 1, plastic

EC3 Table 5.2 Web: c/t = 146.8/4.8 = 30.6 <= 72e (58.6): Class 1, plastic

Shear

Design shear force, V_{Ed} = 27.7 kN

Shear area, $A_v = A - 2bt_f + (t_w + 2r)t_f$ = 24.3 x 100 - 2 x 101 x 7.90 + (4.80 + 2 x 7.60) x 7.90 = 989 mm² [EC3 6.2.6 (3)]

Shear resistance, $V_{pl,Rd} = A_v.(f_y/\sqrt{3})/\gamma_{M0}$ = 2 x 989 x (355/√3)/(1.0 x 1000) = 405 kN (>=27.7) OK [EC3 6.2.6] Shear buckling: h_w/t_w = 162.0/4.8 = 33.75 <= 72e (58.58): check not required [EC3 6.2.6(6)]

Bending

Moment resistance

Design moment, M_{Ed} = 17.3 kNm

Moment resistance, $M_{c,y,Rd} = f_y.W_{pl,y}$ = 355 x 171 x 2/1000 = 121.4 kNm OK

Lateral-torsional buckling check

Beam is laterally restrained at supports only

Support conditions R1/R2: Compression flange laterally restrained. Nominal torsional restraint. Both flanges free to rotate on plan (1.0L)

Design buckling resistance moment, $M_{b,Rd} = \chi_{LT,mod}.M_{c,Rd}$ $\chi_{LT,mod}$ =

χ_{LT}/f (but <=1/λ_{LT}^2 and <=1.0) [Eq.6.58]

$f = 1 - 0.5(1-k_c)[1 - 2(\lambda_{LT} - 0.8)^2]$ 6.3.2.3(2) $k_c = 1/C_1$ [NA2.18] Use

buckling curve b: a = 0.340 [EC3 Tables 6.3/6.4 NA 2.17] $\chi_{LT} = 1/[f$ λ_{LT}

+ (F_{LT}^2-bl_{LT}^2)] [EC3 (6.57)] F_{LT} = 0.5[1 + a $_{LT}$(l_{LT} - $l_{LT,0}$) + bl_{LT}^2] l

$_{LT,0}$ = 0.4 b = 0.75 [EC3 UK NA 2.17] l_{LT} = (f_y.$W_{pl,y}$/M_{cr})

M_{cr} = C_1($p^2$$EI_z$/$L_e^2$)($I_w$/$I_z$ + $L_e^2$$GI_T$/$p^2$$EI_z$) [SN003: k and k_w taken as 1.0, conservative]

W_y = 171.0 cm^3 I_w = 0.010 dm^6 I_T = 4.41 cm^4 I_z = 137 cm^4 G = 81,000N/mm^2

Segment	L_e	M_{Max}	C_1	k_c	M_{cr}	l_z	l_{LT}	f_{LT}	c_{LT}	$c_{LT,mod}$	$M_{c,Rd}$	$M_{b,Rd}$	#
0.00-2.50	2.50	8.6	1.13*	0.94	63.1	1.381	0.981	0.960	0.711	0.732	60.7	44.4	OK
		–	–										

* C1 = 4$M_{\#\,max}$/(M_{max}^2+4M_a^2+7M_b^2+4M_c^2) <= 2.5 [$M_{a,b,c}$ quarter pt moments] [Wong & Driver, AISC Eng. Journal, Q1 2010]

Figures in this table apply to one section of two-member beam i.e. M_{Max} = $M_{seg,max}$/2

Combined bending and shear

V_{Ed} <= 0.5 $V_{c,Rd}$: Check for bending/shear interaction not required [EC3 6.2.8(2)]

Web capacity at bearings

Resistance of web to transverse forces, F_{Rd} = f_{yw}.L_{eff}.t_w/g_{M1}

f_{yw} = 355 N/mm^2 L_{eff} = $c_F$$l_y$

c_F = 0.5/l_F <= 1.0 l_F = (l_y.t_w.f_{yw}/F_{cr}) F_{cr} = 0.9k_f.E.(t_w^3/h_w) k_F = 2 + 6((S_s + c)/h_w)^2 <= 6

Type (c) load application assumed:

Effective loaded length, l_y = min S_s + 2t_f(1 + (√(m_1 + m_2)) [EC3-1-5 Eq.6.10], l_e + t_f (m_1/2 + (l_e/t_f)^2 + m_2) [Eq.6.11] or l_e + t_f (m_1 + m_2) [Eq.6.12]

l_e = k_F.E.t_w^2/(2.f_{yw}.h_w) <= s_s + c [Eq.6.13] m_1 = f_{yf}.b_f/(f_{yw}.t_w)

m_2 = 0.02(h_w/t_f)^2 if l_F > 0.5 else 0.0

Reactions R1 & 2: 13.84 kN

Required minimum stiff bearing length, S_s = 0 mm

c (end of beam to stiff bearing) taken as 0.0

m_1 = 21.1 m_2 = 0.00 F_{cr} = 258 kN k_F = 2.00 l_e = 0.00 l_y = 25.65 l_F = 0.412 c_f = 1.00 L_{eff} = 25.65

Resistance of web to transverse forces, $F_{R,d}$ = 355 x 25.65 x 4.8/(1000 x 1.0) = 43.7 kN x 2 = 87.4 kN OK

Deflection

LL deflection = 1.72 x 1e8/(2 x 210,000 x 1,360) = 0.3 mm (L/8319) OK

TL deflection = 8.15 x 1e8/(2 x 210,000 x 1,360) = 1.4 mm (L/1752)

Sections to be bolted together with tube spacers or suitable alternative connection at max 1.5m c/s

Beam: B1

2.5 m. span

Section : **2No 178 x 102 x 19 UKB S355**

Analysis

From	*B.M*	*S.F*	*Deflection mm.*		
R1 m.	*kNm*	*kN*	*Dead*	*Live*	*Total*
0.000	0.00	27.67	0.00	0.00	0.00
0.125	3.29	24.91	0.18	0.05	0.23
0.250	6.23	22.14	0.35	0.09	0.45
0.375	8.82	19.37	0.52	0.14	0.66
0.500	11.07	16.60	0.67	0.18	0.85

0.625	12.97	13.84	0.80	0.21	1.02
0.750	14.53	11.07	0.92	0.24	1.16
0.875	15.74	8.30	1.01	0.27	1.28
1.000	16.60	5.54	1.07	0.29	1.36
1.125	17.12	2.77	1.11	0.30	1.41
1.250	17.30	0.00	1.13	0.30	1.43
1.375	17.12	-2.77	1.11	0.30	1.41
1.500	16.60	-5.54	1.07	0.29	1.36
1.625	15.74	-8.30	1.01	0.27	1.28
1.750	14.53	-11.07	0.92	0.24	1.16
1.875	12.97	-13.84	0.80	0.21	1.02
2.000	11.07	-16.60	0.67	0.18	0.85
2.125	8.82	-19.37	0.52	0.14	0.66
2.250	6.23	-22.14	0.35	0.09	0.45
2.375	3.29	-24.91	0.18	0.05	0.23
2.500	0.00	-27.67	0.00	0.00	0.00

Above figures are calculated ignoring imposed load(s) on cantilevers.

Bending moment and shear force figures are factored using equation 6.10

Beam: **B2** **Span: 5.1 m.**

	Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U G	o.w.	0.6	0		L	1.53	1.53
U G	Cavity wall	4.0x2.5	0		L	25.50	25.50
U G	Roof dead	1x6/2	0		L	7.65	7.65
U QA	Roof live	0.75x6/2	0		L	5.74	5.74
U G	Floor dead	0.5x3/2	0		L	1.91	1.91
U QA	Floor live	1.5x3/2	0		L	5.74	5.74
P G	Bm: B1 [2.5 m.] 2No : R1	15.81	2.5			8.06	7.75
P QA	Bm: B1 [2.5 m.] 2No : R1	4.22	2.5			2.15	2.07
					Total load (unfactored): 116.16 kN	**58.28**	**57.89**
					Dead/Permanent (unfactored): 88.99 kN	44.65	44.34
					Live/Variable (unfactored): 27.17 kN	13.63	13.54
					(6.10): 160.90 kN	80.72	80.18

Load types: U:UDL; P:Point load; Load positions are measured in m. from R1

Load durations: G: Dead; Qx: Imposed: QA: Residential

Maximum B.M. = 120.2 kNm (6.10) at 2.50 m. from R1

Maximum S.F. = 80.7 kN (6.10) at R1

Mid-span deflections: Dead: 170.1 x 10^8/EI *(E in N/mm², I in cm⁴)*

Live: 51.3 x 10^8/EI

Total: 221.4 x 10^8/EI

Beam calculation to BS EN1993.1.1 using S355 steel

SECTION SIZE : **2No 203 x 133 x 30 UKB S355** (Class 1, plastic)

D=206.8 mm B=133.9 mm t=6.4 mm T=9.6 mm I_y=2,900 cm⁴ i_z=3.17 cm $W_{pl,y}$=314 cm³ $W_{el,y}$=280 cm³

Classification: Flange: c/t = 56.1/9.6 = 5.85 <= 9e (7.32): Class 1, plastic

EC3 Table 5.2 Web: c/t = 172.4/6.4 = 26.9 <= 72e (58.6): Class 1, plastic

Shear

Design shear force, V_{Ed} = 80.7 kN

Shear area, $A_v = A - 2bt_f + (t_w + 2r)t_f$ = 38.2 x 100 - 2 x 134 x 9.60 + (6.40 + 2 x 7.60) x 9.60 = 1,456 mm² [EC3 6.2.6 (3)]

Shear resistance, $V_{pl,Rd} = A_v.(f_y/\sqrt{3})/\gamma_{M0}$ = 2 x 1,456 x (355/√3)/(1.0 x 1000) = 597 kN (>=80.7) OK [EC3 6.2.6] Shear buckling: h_w/t_w = 187.6/6.4 = 29.31 <= 72e (58.58): check not required [EC3 6.2.6(6)]

Bending

Moment resistance

Design moment, M_{Ed} = 120.2 kNm

Moment resistance, $M_{c,y,Rd} = f_y.W_{pl,y}$ = 355 x 314 x 2/1000 = 222.9 kNm OK

Lateral-torsional buckling check

Beam is laterally restrained at supports only

Support conditions R1/R2: Compression flange laterally restrained. Nominal torsional restraint. Both flanges free to rotate on plan (1.0L)

Design buckling resistance moment, $M_{b,Rd} = \chi_{LT,mod}.M_{c,Rd}$ $\chi_{LT,mod}$ = χ_{LT}/f (but <=1/$\bar{\lambda}_{LT}^2$ and <=1.0) [Eq.6.58]

$f = 1 - 0.5(1-k_c)[1 - 2(\bar{\lambda}_{LT} - 0.8)^2]$ 6.3.2.3(2) $k_c = 1/\sqrt{C_1}$ [NA2.18] Use buckling curve b: a = 0.340 [EC3 Tables 6.3/6.4 NA 2.17] $\chi_{LT} = 1/[f + (F_{LT}^2 - b\bar{\lambda}_{LT}^2)]$ [EC3 (6.57)] $F_{LT} = 0.5[1 + a_{LT}(\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + b\bar{\lambda}_{LT}^2]$

$\bar{\lambda}_{LT,0}$ = 0.4 b = 0.75 [EC3 UK NA 2.17] $\bar{\lambda}_{LT} = (f_y.W_{pl,y}/M_{cr})$

$M_{cr} = C_1\sqrt{(p^2EI_z/L_e^2)(I_w/I_z + L_e^2GI_T/p^2EI_z)}$ [SN003: k and k_w taken as 1.0, conservative]

W_y = 314.0 cm³ I_w = 0.037 dm⁶ I_T = 10.3 cm⁴ I_z = 385 cm⁴ G = 81,000N/mm²

Segment	L_e	$M_{Max\#}$	C_1	k_c	M_{cr}	$\bar{\lambda}_z$	$\bar{\lambda}_{LT}$	f_{LT}	χ_{LT}	$\chi_{LT,mod}$	$M_{c,Rd}$	$M_{b,Rd}$
0.00-5.10	5.10	59.8	1.17*	0.92	68.8	2.106	1.273	1.256	0.538	0.550	111.5	61.3 OK

* $C1 = 4M_{\#\,max}/\sqrt{(M_{max}^2+4M_a^2+7M_b^2+4M_c^2)}$ <= 2.5 [$M_{a,b,c}$ quarter pt moments] [Wong & Driver, AISC Eng. Journal, Q1 2010]

Figures in this table apply to one section of two-member beam i.e. $M_{Max} = M_{seg,max}/2$

Combined bending and shear

V_{Ed} <= 0.5 $V_{c,Rd}$: Check for bending/shear interaction not required [EC3 6.2.8(2)]

Web capacity at bearings

Resistance of web to transverse forces, $F_{Rd} = f_{yw}.L_{eff}.t_w/\gamma_{M1}$

f_{yw} = 355 N/mm² $L_{eff} = \chi_F\bar{\lambda}_y$

$\chi_F = 0.5/\bar{\lambda}_F$ <= 1.0 $\bar{\lambda}_F = (\bar{\lambda}_y.t_w.f_{yw}/F_{cr})$ $F_{cr} = 0.9k_f.E.(t_w^3/h_w)\sqrt{k_F}$ $k_F = 2 + 6((S_s + c)/h_w)^2$ <= 6

Type (c) load application assumed:

Effective loaded length, $l_y = \min S_s + 2t_f(1 + \sqrt{(m_1 + m_2)})$ [EC3-1-5 Eq.6.10], $l_e + t_f\sqrt{(m_1/2 + (l_e/t_f)^2 + m_2)}$ [Eq.6.11] or $l_e + t_f(m_1 + m_2)$ [Eq.6.12]

$l_e = k_F.E.t_w^2/(2.f_{yw}.h_w)$ <= $s_s + c$ [Eq.6.13] $m_1 = f_{yf}.b_f/(f_{yw}.t_w)$

$m_2 = 0.02(h_w/t_f)^2$ if $\bar{\lambda}_F > 0.5$ else 0.0

Reaction R1: 40.36 kN

Required minimum stiff bearing length, S_s = 0 mm

c (end of beam to stiff bearing) taken as 0.0

EuroBeam 3.05b 150010

m_1 = 20.9 m_2 = 0.00 F_{cr} = 528 kN k_F = 2.00 l_e = 0.00 l_y = 31.05 $\bar{l}_F$ = 0.365 c_f = 1.00 L_{eff} = 31.05 Resistance of web to transverse forces, $F_{R,d}$ = 355 x 31.05 x 6.4/(1000 x 1.0) = 70.5 kN x 2 = 141 kN OK

Reaction R2: 40.09 kN

Required minimum stiff bearing length, S_s = 0 mm

c (end of beam to stiff bearing) taken as 0.0

m_1 = 20.9 m_2 = 0.00 F_{cr} = 528 kN k_F = 2.00 l_e = 0.00 l_y = 31.05 $\bar{l}_F$ = 0.365 c_f = 1.00 L_{eff} = 31.05 Resistance of web to transverse forces, $F_{R,d}$ = 355 x 31.05 x 6.4/(1000 x 1.0) = 70.5 kN x 2 = 141 kN OK

Deflection

LL deflection = 51.3 x 1e8/(2 x 210,000 x 2,900) = 4.2 mm (L/1211) OK

TL deflection = 221.4 x 1e8/(2 x 210,000 x 2,900) = 18.2 mm (L/281)

Sections to be bolted together with tube spacers or suitable alternative connection at max 1.5m c/s

Beam: B2

5.1 m. span

Section : **2No 203 x 133 x 30 UKB S355**

Analysis

From	*B.M*	*S.F*	*Deflection mm.*		
R1 m.	*kNm*	*kN*	*Dead*	*Live*	*Total*
0.000	0.0	80.72	0.00	0.00	0.00
0.255	19.7	74.06	2.19	0.66	2.85
0.510	37.8	67.40	4.33	1.31	5.63
0.765	54.1	60.74	6.35	1.92	8.27
1.020	68.7	54.08	8.21	2.48	10.69
1.275	81.7	47.41	9.87	2.98	12.85
1.530	92.9	40.75	11.29	3.41	14.70
1.785	102.5	34.09	12.44	3.75	16.19
2.040	110.3	27.43	13.28	4.01	17.28
2.295	116.5	20.77	13.79	4.16	17.95
2.550	119.5	-13.57	13.96	4.21	18.17
2.805	115.2	-20.23	13.78	4.16	17.94
3.060	109.2	-26.89	13.26	4.00	17.26
3.315	101.5	-33.55	12.41	3.75	16.16
3.570	92.1	-40.21	11.27	3.40	14.67
3.825	81.0	-46.87	9.85	2.97	12.82
4.080	68.2	-53.53	8.19	2.47	10.66
4.335	53.7	-60.19	6.33	1.91	8.24
4.590	37.5	-66.86	4.31	1.30	5.62
4.845	19.6	-73.52	2.18	0.66	2.85
5.100	0.0	-80.18	0.00	0.00	0.00

Above figures are calculated ignoring imposed load(s) on cantilevers.

Bending moment and shear force figures are factored using equation 6.10