Ecos Maclean Ecos Maclean Ltd Engineering - materials, energy, structure	Job no.		Revision
	17054		-
	Project description: Lower Ground Floor Extension		
Job Title: 9 St George's Terrace	Done By: MG	Date:	Checked by:

1. INTRODUCTION

This document provides a summary of the structural design philosophy adopted for the works associated with the construction described in the Detailed Basement Construction Plan. It outlines structural design principles and should be read in conjunction with all relevant drawings and specifications.

2. DESIGN STANDARDS, SOURCES OF REFERENCES & IT-TOOLS

The structure is to be designed to the requirements of the following British Standards and documents:

- BS EN 1990: Eurocode 0: Basis of structural design
- BS EN 1991-1-1: Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight and imposed loads
- BS EN 1993-1-1: Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings
- BS EN 1995-1-1: Eurocode 5: Design of timber structures – Part 1-1: General. Common rules and rules for buildings
  masonry structures

The structure has been designed using the next IT-Tools:

- Microsoft Office
- AutoCad Lt 2015
- GSA Oasys 8.6
- Tata Steel sections interactive Blue Book

3. INVESTIGATIONS

Investigations of the existing construction of the building have been carried out during the works and the design is based on these.

4. ASSUMPTIONS AND MATERIALS

It has been assumed that all the existing timber elements will have at least the same strength capacity as a new timber grade C16 after having visually inspected them on site.

The existing brick work is assumed to have a minimum compression strength capacity of 63N/mm^2.

5. CALCULATIONS

These calculations cover the structural design for the alterations on the lower ground, ground, first and roof level.

5.1. LOADING ASSUMPTIONS

New Floor in LGF level	UDL (kN/m^2)	Point load (KN)
Dead Loads		
Beam & Block	2.06	
100mm screed	2.40	
Underfloor heating	0.15	
Waterproof layer	0.01	
Insulation	0.04	
Total:	**4.66**	
Imposed Loads		
Domestic A1	**1.50**	**2.00**

New Roof - Upper Garden	UDL (kN/m^2)	Point load (KN)
Dead Loads		
Beam & Block	2.06	
100mm screed	2.40	
Waterproof layer	0.01	
Insulation	0.04	
Plaster	0.11	
Total:	**4.61**	
Handrail (kN/m)	**0.70**	
Imposed Loads		
Green roof	**1.50**	**0.90**

We assumed imposed load of 1.50 kN/m^2 that covers all the possible loading cases for the roof.

Proposed Timber Flat Roof	UDL (kN/m^2)	Point load (kN)
Dead Loads		
Bituminous felt	0.04	
Waterproof layer	0.05	
Insulation	0.04	
Vapour membrane	0.01	
22mm thk plywood	0.11	
Timber @ 600 c/c	0.07	
Plaster	0.11	
Sednm roof	0.50	
Total:	**0.92**	

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Imposed Loads

Maintenance - flat roof	**0.60**	**0.90**

Walls	**UDL (kN/m^2)**	**Point load (KN)**
Dead Loads		
brick wall (215mm)	4.73	
brick wall (105mm)	2.48	

Windows/Rooflights	**UDL (kN/m^2)**	**Point load (KN)**
Dead Loads		
Glazing	**0.75**	

5.2. GROUND FLOOR-UPER GARDEN DESIGN

5.2.1. Beam & Block Roof

Span = 6.00 m

Loading from the roof:
DL= 4.61 KN/m^2
IL = 1.50 KN/m^2

From Milbank Concrete:
T155 @ 285 c/c
DL = Self-weight + 75 screed + 1.0 kN/m² parition allowance
IL = 1.5 KN/m^2
Max. span = 6.25 m OK

5.2.2. Timber Roof - Sednm roof and canopy above patio doors

Loading:
DL = 0.85 kN/m^2
IL_{UDL}= 0.60 kN/m^2
IL_{PL}= 0.90 kN

From Trada Tables T36:
Timber: C16
Service class: 1 or 2
DL not more than 1.0 kN/m^2

195 x 47 @ 600 c/c C16

				Check	
Permissible clear span	=	3.72	m		
Length of joists - roof	=	2	m	0.54	OK
Length of joists	=	0.42	m	0.11	OK

5.3. RETAINING WALLS DESIGN

5.3.1. Stepoc Retaining Wall (Section A-A)

ground level: 8.61 m
structural bottom level: 6.4 m
Loading:

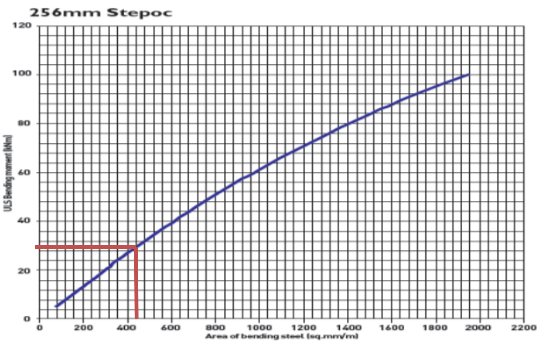
RW Vertical Forces:
- Load from brick wall:
DL = 4.73 kN/m^2 x 1.1 = 5.20 kN/m

RW Horizontal Forces:
Surcharge = 1.5 kN/m^2 - traffic load
ka (Su)= 0.4
ka= 0.6
Soil ɣc= 18 kN/m^3
h= 2.21 m

										Arm		M_{over}	
Surcharge P_{su}=	0.4	x	1.5	x	2.2	=	1.3	kN/m	x	1.105 m	=	1.4652	kNm/m
Soil P_s=	0.6	x	18	x	2.4	=	26.37	kN/m	x	0.7367 m	=	19.4	kNm/m
										Total SLS	=	20.9	kNm/m
										Total ULS	=	28.4	kNm/m

Reinforcement Design:
M_{ULS}= **28.4 kNm**

325 Stepoc wall
From Supreme Stepoc brochure
Area of required reinforcement ≈ 440 mm^2/m
Hence 10mm bar @ 133 c/c , 591mm^2/m



Area of reinforcement (mm/m²) for various bar diameters and centres.

BAR DIAMETER (mm)		10	12	16	20
BAR CENTRES	133	591	851	1512	2363
	266	295	425	756	1181

ALSO SEE ATTACHED TEDDS DOCUMENT FOR DETAILED CALCULATIONS

5.3.2. Beam & Block Wall (Section B-B)

ground level: 9.7 m -> case in the middle of length
structural propping level from roof: 9.15 m
structural bottom level: 6.5 m

Loading:

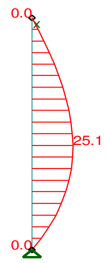
Vertical Forces:

- Load from brick wall:							
DL =	4.73 kN/m²	x	1.3	=	6.15	kN/m	*Assuming 1.3m high brick wall*
- Load from B&B wall:							
DL =	2.06 kN/m²	x	2.6	=	5.36	kN/m	
- Load from roof:							
DL =	4.61 kN/m²	x	2.8	=	12.91	kN/m	
IL =	1.50 kN/m²	x	2.8	=	4.20	kN/m	
- Load from floor:							
DL =	4.66 kN/m²	x	2.8	=	13.04	kN/m	
IL =	1.50 kN/m²	x	2.8	=	4.20	kN/m	
			Total SLS	=	45.86	kN/m	

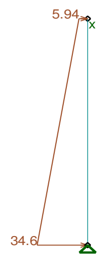
RW Horizontal Forces:

Surcharge = 1.5 kN/m²
ka = 0.6
ka (Su)= 0.4
ɣc = 18 kN/m³
wall height = 2.65 m
total height from ToW: 3.2 m

Horizontal loading:



Bending Moment (ULS):



Propped at roof level:

			Load
Soil, at ground level, Ps =	0.6 x 18 x 3.2	=	34.6 kN/m²
Soil, at roof-propping level, Ps =	0.6 x 18 x (3.2 - 2.65)	=	5.9 kN/m²
Surcharge, Psu =	0.4 x 1.5	=	0.6 kN/m²

ULS bottom: 1.35 Ps + 1.5 Psu = 47.6 kN/m²
ULS top: 1.35 Ps + 1.5 Psu = 8.9 kN/m²
ULS: 1.5 Psu = 0.9 kN/m²

Design moment (per m): **Med = 25.1 kN**

	top	bottom	
R_{DL} =	20.5	33.2	kN
R_{IL} =	0.80	0.80	kN

From Milbank Concrete:

T155 @ 395 c/c

DL = Self-weight + 75 screed + 1.0 KN/m² partition allowance = 2.50 + 1.80 + 1.00 = 5.30 kN/m²
IL = 1.50 kN/m²
Max. span = 5.35 m
Moment of Resistance: [(1.35x5.30)+(1.5x1.50)] x 5.35^2 / 8 = **33.65 kN** Check **0.75 OK**

Foamglas® Block

Loading:

load from wall above (1100mm, assume height 1300mm) 1.3 x 4.73 = 6.15 kN/m

Foamglas® ready block 600x450 100thk cut in 4 pieces of 300x225

Stress applied: $\frac{6.15 \times 1000}{150 * 225}$ = **0.18 N/mm²**

Check **0.36 OK**

Capacity of a random Foamglas ready block: > 0.5 **N/mm²**

Strip Footing

Loading:

From Vertical Forces calculation
Total SLS load= 45.86 kN/m

Assuming a strip footing of 400mm - 114.64 kN/m²
Allowable bearing pressure of the soil - 120 kN/m² *The same value was used to justify the design for planning.*
Minimum height of foundation 250mm

Check	
0.96	OK

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5.3.3. Stepoc Retaining Wall (Section C-C)

ground level: 10.18 m -> worst case

structural level: 6.4 m

Loading:

Vertical Forces:

											Arm		M_{res}
		Taking moment about corner of the base											
Brick wall=	4.73	kN/m^2	x	1.30			=	6.15	kN/m	x	0.905		5.6 kNm/m
Wall W_w=	19	kN/m^3	x	0.37	x	3.8	=	26.43	kN/m	x	(1.2-(0.256/2))	=	28.3 kNm/m
Base W_b=	19	kN/m^3	x	1.2	x	0.2	=	4.56	kN/m	x	1.2/2	=	2.74 kNm/m
											Total SLS	=	36.6 kNm/m

RW Horizontal Forces:

Surcharge = 1.5 kN/m^2

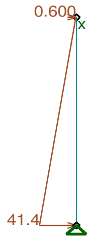
ka = 0.6

ka (Su)= 0.4

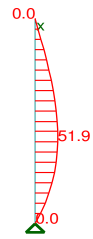
ɣc = 18 kN/m^3

wall height = 3.78 m

Loads:



Bending Moment (ULS):



Propped at ground level by RC beam

			Base	
Soil, cantilever level Ps =	0.6 x 18 x 3.78	=	40.824	kN/m^2
Surcharge, Psu =	0.4 x 1.5	=	0.6	kN/m^2

ULS bottom: 1.35 Ps + 1.5 Psu = 55.1 kN/m^2

ULS: 1.5 Psu = 0.9 kN/m^2

Design moment (per m): **Med (ULS) = 51.9 kNm/m**

Med (SLS) = 38.4 kNm/m

	top	bottom	
R_{DL} =	25.7	51.4	kN/m
R_{IL} =	1.13	1.13	kN/m

Temporary Stability

$$\frac{M_{res}}{M_{over}} \geq 2$$

$$\frac{36.6}{38.4} = 1.0$$ Temporary props will be necessary to avoid overturning effects

$$F_{prop} = \frac{2 \times M_{over} - M_{res}}{h} = \frac{(2 \times 38.4) - 36.6}{3.78} = 10.6 \text{ kN}$$

Reinforcement Design:

M_{ULS}= 51.9 kNm

325 Stepoc wall

From Supreme Stepoc brochure

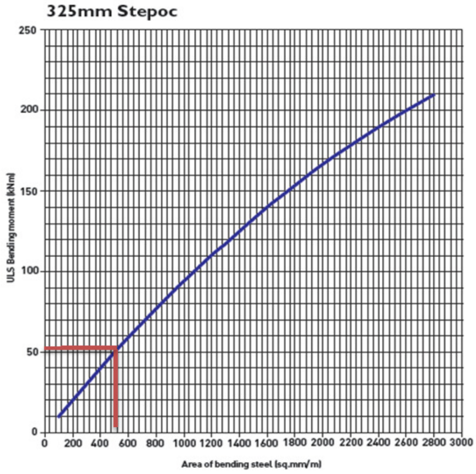
Area of required reinforcement ≈ 500 mm^2/m

Hence 12mm bar @ 162 c/c , 699 mm^2/m

Area of reinforcement (mm/m²) for various bar diameters and centres.

BAR DIAMETER (mm)		10	12	16	20	25
BAR CENTRES	162	485	699	1242	1940	3031
	325	242	348	619	969	1511

325mm Stepoc



ALSO SEE ATTACHED TEDDS DOCUMENT FOR DETAILED CALCULATIONS

RC capping beam across Stepoc wall

width: 325

depth: 500

		top		Reactions	A	B	
Loading:	DL:	25.7	kN/m	R_{DL} =	64.3	64.3	KN
	IL:	1.13	kN/m	R_{IL} =	2.83	2.83	KN

SEE ATTACHED TEDDS DOCUMENT FOR DETAILED CALCULATIONS

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5.3.4. Mass Concrete Underpin (Section D-D)

Vertical Forces:

									SLS	
mass concrete =	24	kN/m^3	x	0.39	x	1.16	=	10.86	kN/m	
mass concrete (base) =	24	kN/m^3	x	0.69	x	0.8	=	13.25	kN/m	
Brick Wall (225mm) =	4.95	kN/m^2	x	5.46			=	27.03	kN/m	*Assuming ToW level +13.00*
Inner skin (brick facing) =	2.48	kN/m^2	x	3.72			=	9.22	kN/m	
						TOTAL	=	60.4	kN/m	

Horizontal forces:

Surcharge = 1.5 kN/m^2
ka (Su) = 0.4
ka = 0.6
ɣc= 18 kN/m^3
h= 3.35 m

Horizontal Loads:

								Base			Height		Area	
Soil	0.6	x	18	kN/m^3	x	3.35	=	36.18	kN/m^2	x	3.35	=	60.6	kN/m
Surcharge	0.4	x	1.5	kN/m^2			=	0.6	kN/m^2	x	3.35	=	2.01	kN/m
												$\sum P_b$=	62.6	kN/m

There is a two-storey high mews on top of the wall so there are no overturning issues.

Checking Ground Bearing Pressure:

This panel of wall is propped at each end and is also continuous and there is, we know, a bonded party-crosswall in the middle of the mews so that the vertical loads on the foundation will be effectively uniform and the earth pressure will not give rise to an increase at the edge.

Allowable Bearing Pressure = 120 kN/m^2 *The same value was used to justify the design for planning.*

Maximum Bearing Pressure = $\frac{P}{t}$ = 87 kN/m^2 OK

5.3.5. Stepoc Retaining Wall (Section E-E)

ground level: 8.45 m
structural level: 6.3 m
Loading:

RW Vertical Forces: Taking moment about corner of the base

											Arm		M_{res}	
Brick Wall=	4.73	kN/m^2	x	2.07			=	9.79	kN/m	x	(1.2-(0.215/2))	=	10.7	kNm/m
Wall W_w=	19	kN/m^3	x	0.256	x	2.15	=	10.46	kN/m	x	(1.2-(0.256/2))	=	11.2	kNm/m
Base W_b=	19	kN/m^3	x	1.2	x	0.2	=	4.56	kN/m	x	1.2/2	=	2.74	kNm/m
											Total SLS	=	24.6	kNm/m

RW Horizontal Forces:

Surcharge = 1.5 kN/m^2 - traffic load
ka (Su)= 0.4
ka= 0.6
Soil ɣc= 18 kN/m^3
h= 2.15 m

											Arm			M_{over}	
Surcharge P_{su}=	0.4	x	1.5	x	2.15	=	1.3	kN/m	x	1.075	m	=	1.3868	kNm/m
Soil P_s=	0.6	x	18	x	2.3	=	24.96	kN/m	x	0.7167	m	=	17.9	kNm/m
										Total SLS		=	19.3	kNm/m
										Total ULS		=	26.23	kNm/m

Temporary Stability

$$\frac{M_{res}}{M_{over}} \geq 2$$

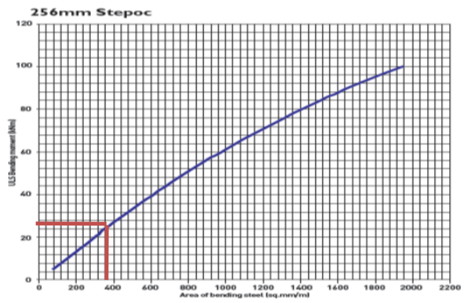
$$\frac{24.6}{19.3} = 1.3$$ Temporary props will be necessary to avoid overturning effects

Fprop = $\frac{2 \times Mover - Mres}{h}$ = $\frac{(2 \times 19.3) - 24.6}{2.15}$ = 6.5 kN

Reinforcement Design:

M_{ULS}= 26.2 kNm

From Supreme Stepoc brochure
Area of required reinforcement ≈ 360 mm^2/m
Hence 10mm bar @ 133 c/c , 591mm^2/m



Area of reinforcement (mm/m²) for various bar diameters and centres.

BAR DIAMETER (mm)		10	12	16	20
BAR CENTRES	133	591	851	1512	2363
	266	295	425	756	1181

ALSO SEE ATTACHED TEDDS DOCUMENT FOR DETAILED CALCULATIONS

5.3.6. Vertical Steel Beams in Existing Brickwall (Section F-F)

Loading:

Horizontal Pressures from wall section BB:

Proping reaction ULS = 1.35 x 20.50 + 1.50 x 0.80 = 28.9 kN

wall height = 2.5 m (up to roof floor level - we do not consider the cantilever part to check the deflections because there is no earth on the other side)

Design moment (per m): **Med = 31.8 kN**

Insert T sections or I sections in the wall to provide stiffness

$M/f_y = S$ S (required) = 31.8/0.18 = 176.67 cm^3

From Tata Steel tables:

Try with 203x102 UB:

Section modulus (plastic): 234 cm^3 OK

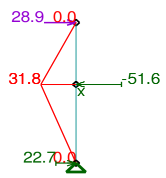
Deflection at propping point:

w_{IL} = 0.20 mm

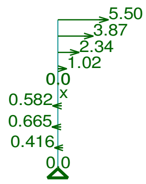
w_{DL} = 5.30 mm

Diagrams:

Load, bending moment and reaction (ULS):



Deflection:



Concrete lintels 140x100 continuous over 2 spans, 2100mm long each

Reaction in propping position 2 (ULS): **51.6 kN/m**

UDL per lintel 0.14 x 51.6 / 1.12 = 6.45 kN/m udl for gsa

1.12 is 8 lintels x 0.14

Bending moment (ULS):

M_{ED} = 0.88 kNm

From Supreme Brochure:

Service moment of 140x100 pc lintel: 3.37 kNm

Check **0.26 OK**

Strip Footing

Loading:

- Load from brick wall:

DL =	4.73	kN/m²	x	2.07	=	9.79	kN/m				

- Load from pc lintels:

DL =	8	x	24	kN/m³	x	0.14	x	0.1	=	2.69	kN/m
DL =	1	x	24	kN/m³	x	0.1	x	0.1	=	0.24	kN/m

- Load from blockwork:

DL =	1	x	24	kN/m³	x	0.215	x	0.225	=	1.16	kN/m
DL =	3	x	24	kN/m³	x	0.125	x	0.14	=	1.26	kN/m

- Load from steel beams (one beam per meter):

DL =	0.23	kN/m/m	x	2.61	=	0.60	kN/m

- Load from roof:

DL =	4.61	kN/m²	x	2.8	=	12.91	kN/m
IL =	1.50	kN/m²	x	2.8	=	4.20	kN/m

- Load from floor:

DL =	4.66	kN/m²	x	2.8	=	13.04	kN/m
IL =	1.50	kN/m²	x	2.8	=	4.20	kN/m

Total SLS load= 50.1 kN/m

Assuming a strip footing of 500mm - 100.18 kN/m^2

Allowable bearing pressure of the soil - 120 kN/m^2

Minimum height of foundation 250mm

Check	
0.83	OK

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5.3.7. Steel Frame (Section H-H)

Steel frame in outer leaf of cavity wall

Horizontal propping force from beam	DL =	64.3	kN	ULS: 1.35x64.3 + 1.50x2.83 =	**91.1** kN
on top of the frame:	IL =	2.83	kN		

Vertical forces on B2:

- Load from canopy - roof:

DL =	0.42	kN/m^2	x	0.42	=	0.18	kN/m	ULS: 1.35x(0.39+0.70+0.25) + 1.50x0.25 = **1.90** kN/m
IL =	0.60	kN/m^2	x	0.42	=	0.25	kN/m	

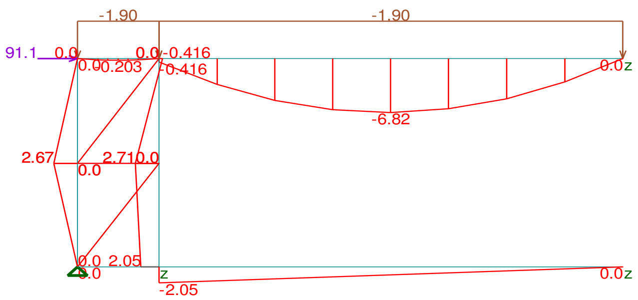
- Load from glass balustrade:

DL = 0.70 kN/m

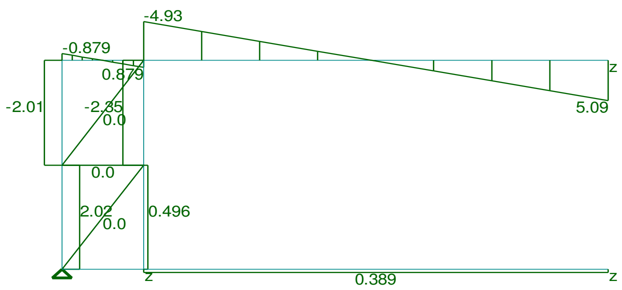
- Self weight = 0.25 kN/m

Diagrams:

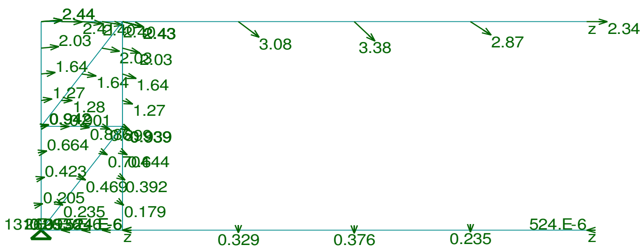
Bending Moment and Loading (ULS)



Shear (ULS)



Deflection (SLS)



Vertical frame members

Geometry			**Calculations**				A	B	
L =	2.65	m	$M_{y\ max,\ ED}$ =	2.71	kNm				
$l_{bearing}$ =	-	mm	$V_{max,\ ED}$ =	2.35	kN	R_{DL} =	-181.30	184.90	kN
$L_{effective}$ =	-	m	w_{IL} =	0.12	mm	R_{IL} =	-8.37	9.33	kN
L/360 =	7.36	mm	w_{DL} =	2.33	mm				
L/250 =	10.6	mm							

From TATA Steel Book — Steel beam fully restrained

					Check	
Section:	203 x 102 UB 23					
$M_{c,Rd}$ =	64.4	kNm		Bending	0.04	OK
$V_{c,Rd}$ =	197	kN		Shear	0.01	OK
				Deflection (IL)	0.02	OK
				Deflection (DL + IL)	0.23	OK

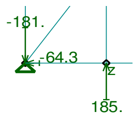
Pad Footing Under Frame

Loading:

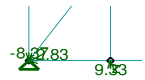
- Column C3:

DL = 184.9 kN
IL = 9.33 kN

R_{DL}



R_{IL}



Total SLS load= 194.23 kN

Allowable bearing pressure of the soil - 120 kN/m^2
Area of pad footing required = 1.619 m^2

Check	
0.83	OK

USE 1400 x 1400 square footing: A = 1.96 m^2

Uplift bearing in wall.

5.3.8. Beam B2

From frame analysis:

Geometry			**Calculations**				C1	
L (for checking)=	5.17	m	$M_{y\ max,\ ED}$ =	6.82	kNm			
$l_{bearing}$ =	100	mm	$V_{max,\ ED}$ =	5.09	kN	R_{DL} =	3.29	kN
$L_{effective}$ =	5.37	m	w_{IL} =	0.30	mm	R_{IL} =	0.5785	kN
L/360 =	14.4	mm	w_{DL} =	3.10	mm			
L/250 =	21.5	mm						

From TATA Steel Book
Section: **254 x 102 UB 25**
$M_{b,Rd}$ = 84.2 kNm
$V_{c,Rd}$ = 265 kN

	Check	
Bending	0.08	OK
Shear	0.02	OK
Toral Deflection	0.16	OK
IL Deflection	0.02	OK

<u>Torsion check</u>

cantilever length: 0.42 m

Torsional moments (per meter):

- From canopy - roof:

DL = 0.42 kN/m^2 x 0.42 x 0.42/2 = 0.04 kNm/m
IL = 1.50 kN/m^2 x 0.42 x 0.42/2 = 0.13 kNm/m

- From balustrade:

DL = 0.70 kN/m^2 x 0.42 = 0.29 kNm/m

Total SLS: 0.46 kNm/m

SEE ATTACHED TEDDS DOCUMENT FOR DETAILED CALCULATIONS

5.3.9. Beam B3

Loading:

*ULS: 1.35 * DL + 1.5 * IL =* 2.48 kN/m

- Load from floor:

DL = 0.92 kN/m^2 x 1 = 0.92 kN/m
IL = 0.60 kN/m^2 x 1 = 0.6 kN/m

- Self weight = 0.25 kN/m

Geometry			**Calculations**				A	B	
L =	5.20	m	$M_{y\ max,\ ED}$ =	7.35	kNm				
$l_{bearing}$ =	100	mm	$V_{max,\ ED}$ =	6.04	kN	R_{DL} =	1.7	2.9	kN
$L_{effective}$ =	5.40	m	w_{IL} =	0.70	mm	R_{IL} =	0.88	1.46	kN
L/360 =	14.4	mm	w_{DL} =	1.36	mm				
L/250 =	21.6	mm							

From TATA Steel Book
Section: **254 x 102 UB 25** - Beam restrained by wall above
$M_{b,Rd}$ = 84.2 kNm
$V_{c,Rd}$ = 265 kN

	Check	
Bending	0.09	OK
Shear	0.02	OK
Toral Deflection	0.10	OK
IL Deflection	0.05	OK

5.3.10. Beam B4

Loading:

*ULS: 1.35 * DL + 1.5 * IL =* 3.53 kN/m

- Load from timber roof:

DL = 0.92 kN/m^2 x 1 = 0.92 kN/m

IL = 0.60 kN/m^2 x 1 = 0.60 kN/m

- Load from glazing:

DL = 0.75 kN/m^2 x 0.53 = 0.40 kN/m

- Self weight = 0.63 kN/m

Try with: **200** **x** **75** C24

Geometry

L =	3480	mm
$L_{effective}$ =	3132	mm
h =	200	mm
b =	75	mm
$L_{bearing}$ =	100	mm
h_{notch} =	50	mm
b_{notch} =	100	mm

Strength properties

$f_{m,k}$ =	24	N/mm^2
$f_{c,90,k}$ =	5.3	N/mm^2
$f_{v,k}$ =	2.5	N/mm^2
$E_{0,mean}$ =	11000	N/mm^2
$E_{0.05}$ =	7400	N/mm^2
ρ_{mean} =	350	N/mm^2

Assumptions:

SC = Internal hot   LD = Medium-term

NOTCH = None

Modification Factors

$k_{h,y}$ =	1.00	*- depth factor*	k_v =	1.00	*- notch factor*
k_{sys} =	1.1	*- load sharing*	k_{mod} =	0.8	*- load duration*
$\lambda_{rel,m}$ =	0.657	*- slenderness*	k_{def} =	0.6	*- material factor*
k_{crit} =	1.00	*-lateral buckling*	γ_m =	1.3	*- safety factor*
$k_{c,90}$ =	1.5	*- load config.*	k_{cr} =	0.67	*- influence of cracks*

Laterally Restrained = Yes

A_y = 10050 mm^2

W_y = 500000.0 mm^3

I_y = 5.00E+07 mm^4

Calculations & checks

- IL UDL

							A	B	
$M_{y\ max}$ =	4.44	kNm	w_{DL} =	5.91	mm	R_{DL} =	3.67	3.08	kN
V_{max} =	5.67	kN	w_{IL} =	1.83	mm	R_{IL} =	1.14	0.9527	kN

Bending

$$\sigma_{m,90,d} \leq f_{m,y,d}$$

$\sigma_{m,y,d}$ = 8.9 N/mm^2

$f_{m,y,d}$ = 16.2 N/mm^2

Check: 0.55 OK

Bearing

$$\sigma_{c,90,d} \leq k_{c,90}\, f_{c,90,d}$$

$\sigma_{c,90,d}$ = 0.64 N/mm^2

$f_{c,90,d}$ = 6.1 N/mm^2

Check: 0.10 OK

Shear

$$\tau_d \leq k_v f_{v,d}$$

t_d = 0.8 N/mm^2

$f_{v,d}$ = 1.7 N/mm^2

Check: 0.50 OK

Deflection

$$w_{net,fin} \leq w_{lim}$$

ψ_2 = 0.3

$w_{G,fin}$ = 9.5 mm

$w_{Q,fin}$ = 2.2 mm

$w_{net,fin}$ = 11.6 mm

w_{lim} = 12.5 mm

Check: 0.93 OK

5.3.11. Column C2

Loading:

DL = 3.67 kN

IL = 1.14 kN

Column length = 2.5 m

Total load

DL	IL	ULS	SLS	
3.67	1.14	6.66	4.81	kN/m

Moment due eccentricity: e = 0.1

0.3671	0.114	0.666	0.4806	kNm

From TATA Steel Book

L = 2.5 m

Section: **88.9 CHS 4 thk**

$N_{ED} / N_{pl,Rd}$ = 0.01752

$N_{pl,Rd}$ = 380 kN $M_{b,Rd}$ = 10.3 kNm

$M_{c,Rd}$ = 10.3 kNm $N_{b,Rd}$ = 229 kN

Check: 0.03 OK; 0.06 OK

Assuming simple construction:

$$\frac{N_{ED}}{N_{b,z,Rd}} + \frac{M_{y,ED}}{M_{b,Rd}} + 1.5\,\frac{M_{z,ED}}{M_{c,z,Rd}} \leq 1$$

$$\frac{6.66}{229} + \frac{0.67}{10.3} + 1.5\,\frac{0}{10.3} = 0.0937$$

Check: 0.09 OK

5.3.12. Column C1

Loading:

From beam analysis:
DL = 3.29 kN
IL = 0.58 kN
worst case from beam analysis

From frame analysis:
DL = 3.59 kN
IL = 0.58 kN

Total load

DL	IL	ULS	SLS	
3.29	0.58	5.31	3.87	kN/m

Moment due eccentricity: e = 0.1

0.329	0.058	0.531	0.3869	kNm

Column length = 2.5 m

From TATA Steel Book
L = 2.5 m
Section: **80x40 RHS 5 thk**
$N_{ED} / N_{pl,Rd}$= 0.01397
$N_{pl,Rd}$= 380 kN $M_{b,Rd}$= 9.27 kNm
$M_{c,y,Rd}$= 9.27 kNm $N_{b,y,Rd}$= 203 kN

Check	
0.03	OK
0.06	OK

Assuming simple construction:

$$\frac{N_{ED}}{N_{b,y,Rd}} + \frac{M_{y,ED}}{M_{b,Rd}} + 1.5\frac{M_{z,ED}}{M_{c,y,Rd}} \leq 1$$

$$\frac{5.31}{203} + \frac{0.53}{9.27} + 1.5\frac{0}{9.27} = 0.0834$$

Check	
0.08	OK

5.4. LOWER GROUND FLOOR DESIGN

5.4.1. Beam & Block Floor

Span = 6.00 m

Loading of the floor:
DL= 4.66 KN/m^2
IL = 1.50 KN/m^2

From Litecast Homefloor:
T155 @ 285 c/c
DL = Self-weight + 75 screed
IL = 1.5 KN/m^2
Max. span = 6.25 m OK

5.4.2. Beam B1

Loading:
*ULS: 1.35 * DL + 1.5 * IL =* 10.10 kN/m
- Load from patio doors:

DL = 0.75 kN/m^2 x 2.24 = 1.68 kN/m
- Load from brick wall:

DL = 2.48 kN/m^2 x 2.24 = 5.55 kN/m
- Self weight = 0.25 kN/m

Geometry

L =	6.22	m
$l_{bearing}$ =	100	mm
$L_{effective}$ =	6.42	m
L/360 =	17.3	mm
L/250 =	25.7	mm

Calculations

$M_{y\ max,\ ED}$ =	16.6	kNm
$V_{max,\ ED}$ =	15.7	kN
w_{IL} =	0.00	mm
w_{DL} =	7.22	mm

	A	B	
R_{DL} =	6.9	11.7	kN
R_{IL} =	-	-	kN

From TATA Steel Book
Section: **254 x 102 UB 25**
$M_{b,Rd}$ = 84.2 kNm
$V_{c,Rd}$ = 265 kN

	Check	
Bending	0.20	OK
Shear	0.06	OK
Total Deflection	0.28	OK
IL Deflection	-	-