CALCULATIONS RELATING TO STRUCTURAL WORKS
NOVEMBER 2017

Please note the numbered gaps between calculations have been left intentionally to allow for additional calculations to be inserted if required at a later date.

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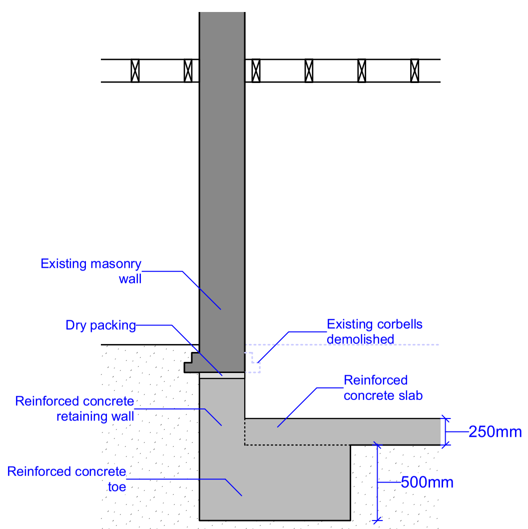
Preliminary

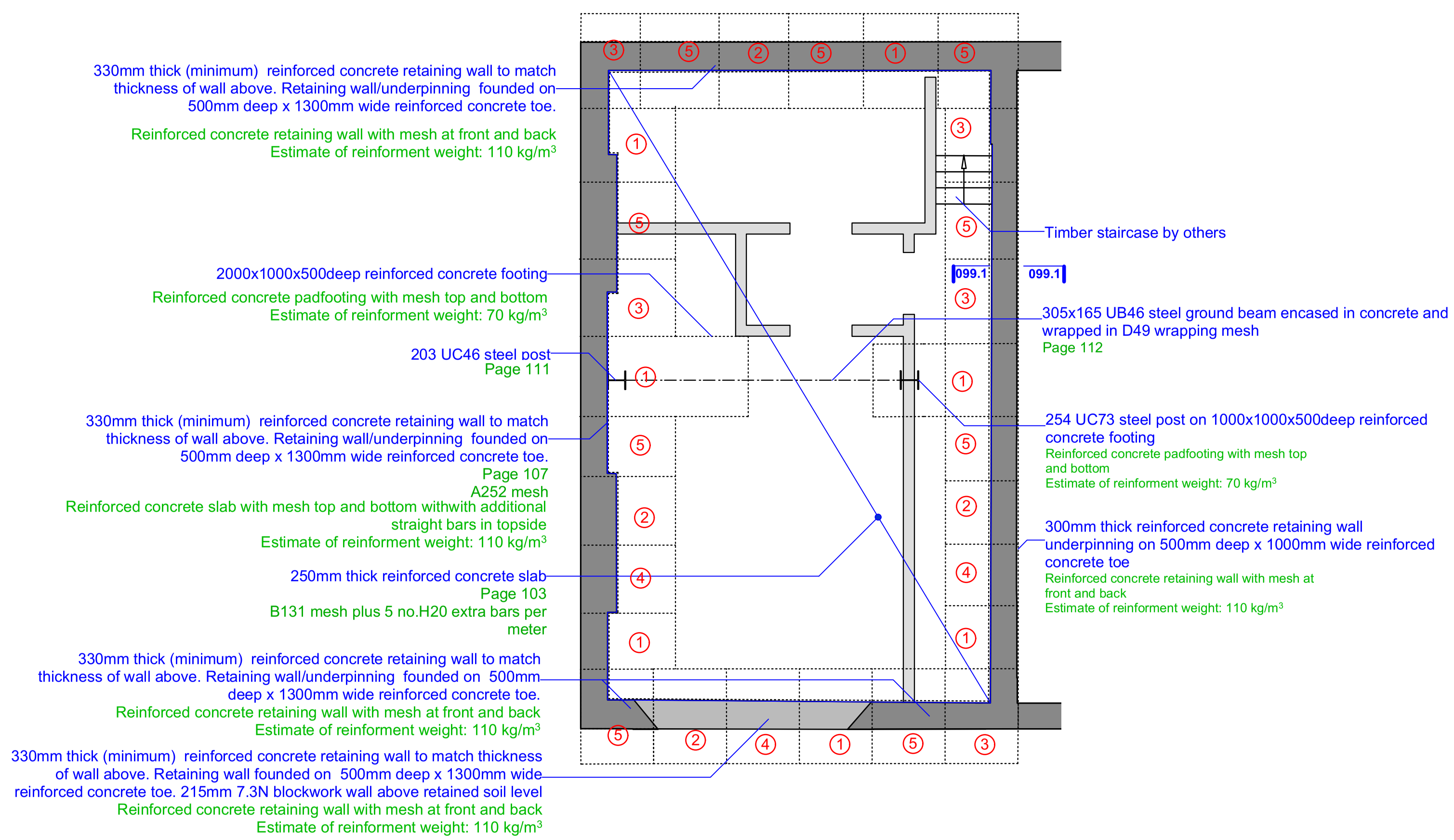
General Notes:
1. Do not scale from this drawing.
2. This drawing is to be read in conjunction with all relevant Engineers and Architects drawings and specifications.
3. Report any discrepancies between this drawing and on site to the engineer prior to commencement of works.
4. Concrete to be RC35 where decribed to be reinforced concrete and FND2 where described as mass concrete with 40mm cover to steelwork unless noted otherwise.
5. All steel beams to be painted with zinc phosphate primer prior to installation of frame.
6. All necessary temporary propping to existing structure is the sole responsiblity of the contractor
7. All foundation depths to be approved by building control and founded on virgin sub-soil.
8.New sections of new masonry to be joined to existing masonry with stainless steel wall starters unless notified otherwise.
9. Where elements of structure are specified by third parties, all responsibility and liability for said elements of structure belongs to the third parties that specified them.
10. Brick ties in cavity wall construction to architects specification and in accordance with the relevant building regulations.

NOTE:
Allow for anchoring using 'U' bars and 'L' bars. Precise reinforcement specification to be provided once excavation has been carried out and the scheme has been discussed and agreed with the contractor.

Note : (#) denotes suggested underpinning sequence. Allow 48hrs after concrete poured before excavating adjacent hit



099.1 STRUCTURAL SECTION THROUGH FOUNDATIONS AS PROPOSED (Scale 1:25)



099.1 STRUCTURAL LOWER GROUND FLOOR PLAN AS PROPOSED

KEY
existing building fabric
new load bearing structure. refer to annotations
demolition
new non loadbearing partitions. refer to architect's drawings

Project	91 Savernake Road
Drawing No.	A075 099
Revision	P4
Drawing Title	structural lower ground floor plan
Date	31/10/2017
Scale	1:50 @ A1
Status	Stage D
Project No.	A075
CAD Ref.	A075 proposed
Drawn	NM

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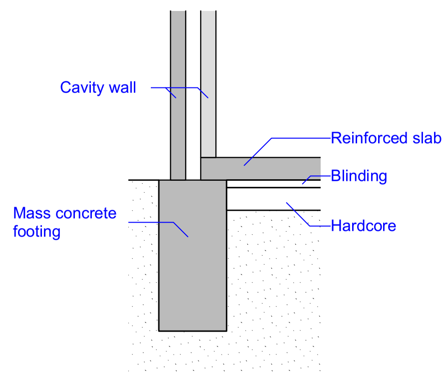
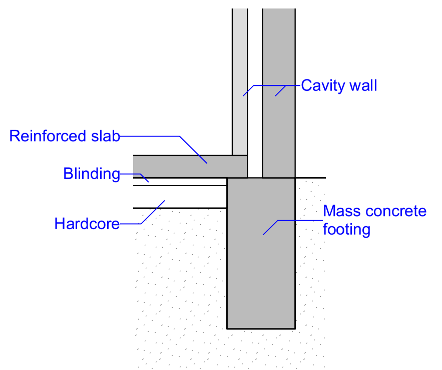
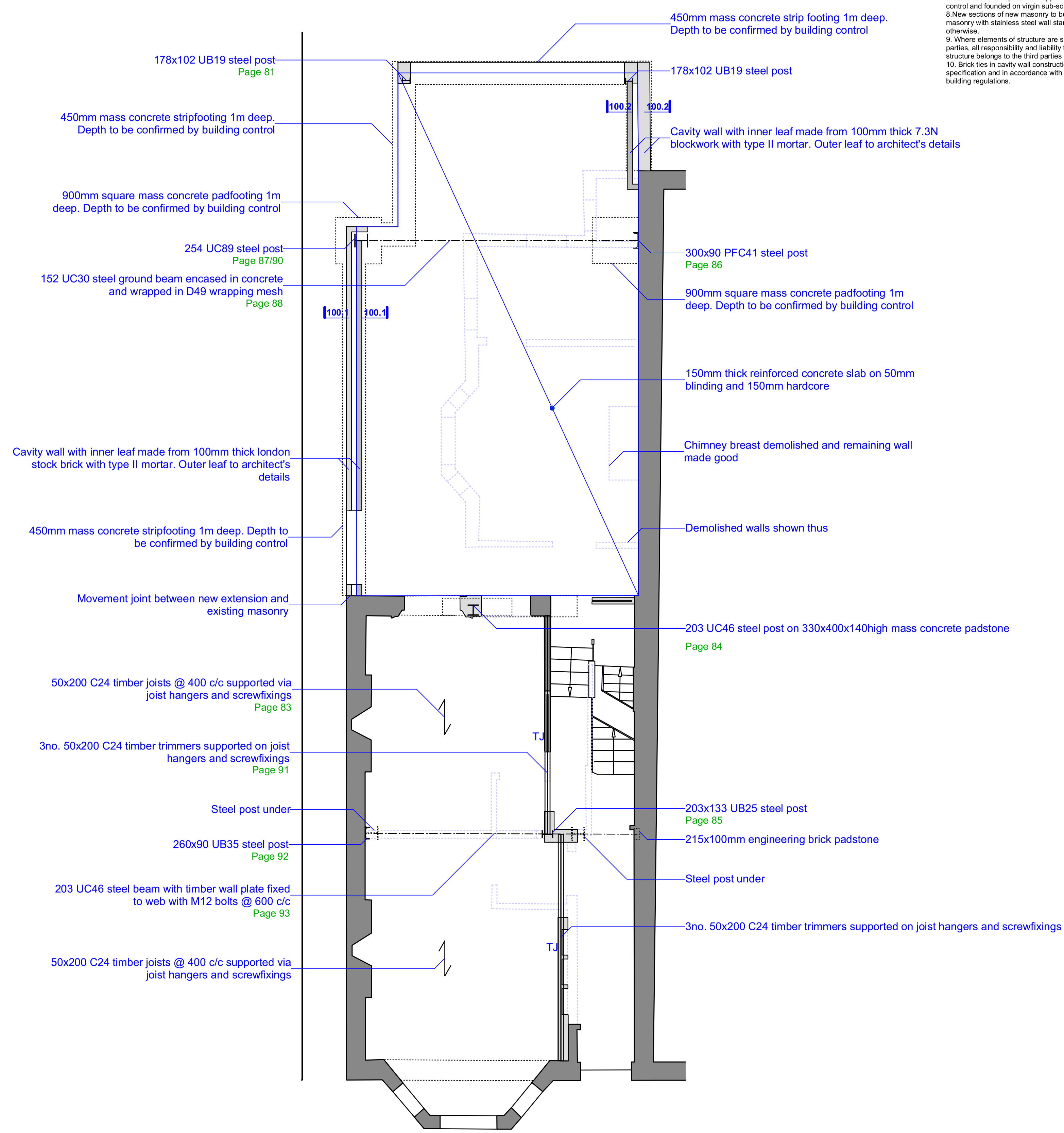


100.1 STRUCTURAL SECTION THROUGH FOUNDATIONS AS PROPOSED (Scale 1:25)



100.2 STRUCTURAL SECTION THROUGH FOUNDATIONS AS PROPOSED (Scale 1:25)



100.3 STRUCTURAL UPPER GROUND FLOOR PLAN AS PROPOSED

KEY
- existing building fabric
- new load bearing structure. refer to annotations
- demolition
- new non loadbearing partitions. refer to architect's drawings

Project	91 Savernake Road
Drawing No.	A075 100
Revision	P6
Drawing Title	structural upper ground floor plan
Date	31/10/2017
Scale	1:50
Status	Stage D
Project No.	A075
CAD Ref.	A075 proposed
Drawn	NM

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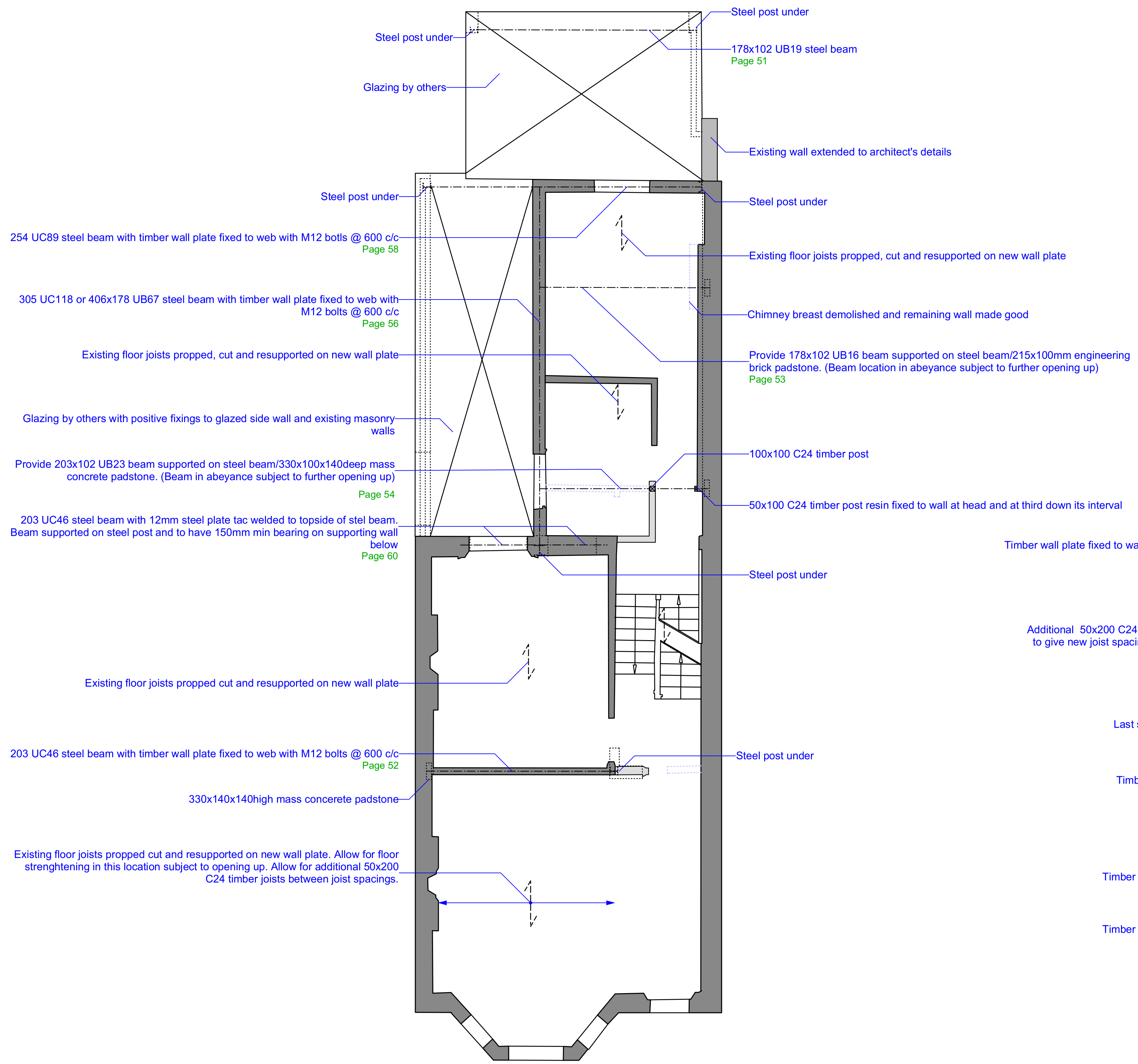
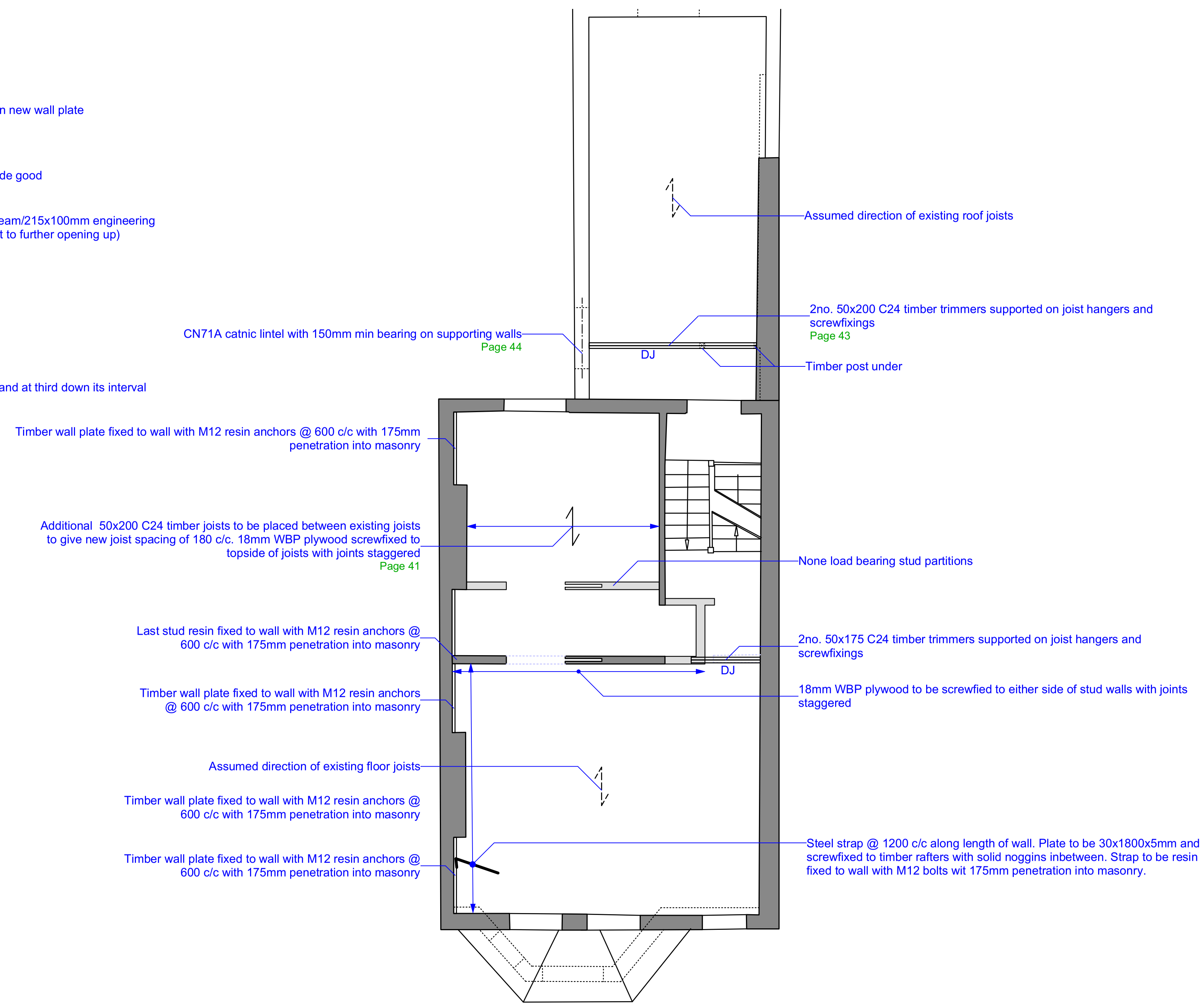


101.1 STRUCTURAL FIRST FLOOR PLAN AS PROPOSED



101.2 STRUCTURAL SECOND FLOOR PLAN AS PROPOSED

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3. Where elements of structure are specified by third parties, all responsibility and liability for said elements of structure belongs to the third parties that specified them.
4. All doubled up ('DJ') / tripled up ('TJ') beams to be fixed together with 10mm diameter threaded bars @ 600mm centres with square end plates and nuts.
5. All steel beams to be painted with zinc phosphate primer prior to installation of frame.
6. All necessary temporary propping to existing structure is the sole responsiblity of the contractor
7. Report any discrepancies between this drawing and on site to the engineer prior to commencement of works
8. Where WBP plywood is specified the plywood is to compy with EN636, Class 3
9.Where resin anchors are listed, resin should be HIT HY by HILTI or equivalent approved
10. Where a joist hanger is specified for a flitch beam, refer to the manufacturer's literature for number of fixings required

KEY
- existing building fabric
- new load bearing structure. refer to annotations
- demolition
- new non loadbearing partitions. refer to architect's drawings

Project	91 Savernake Road
Drawing No.	A075 101
Revision	P3
Drawing Title	structural 1st and 2nd floor plan
Date	31/10/2017
Scale	1:50
Status	Stage D
Project No.	A075
CAD Ref	A075 proposed
Drawn	NM

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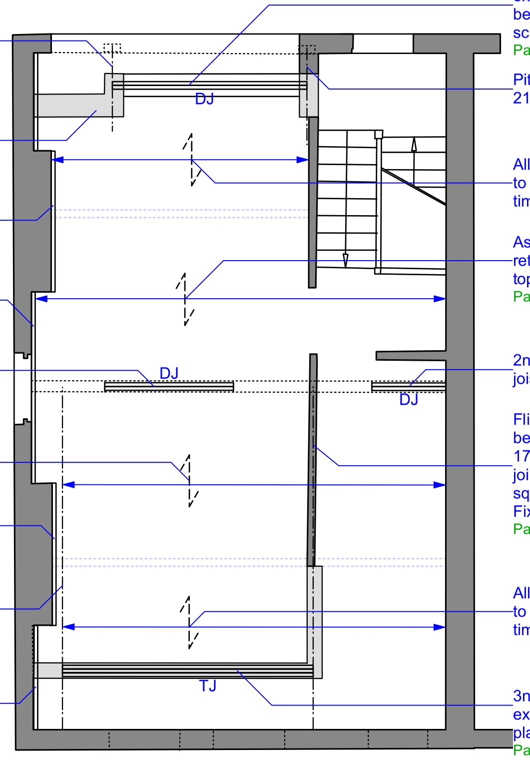
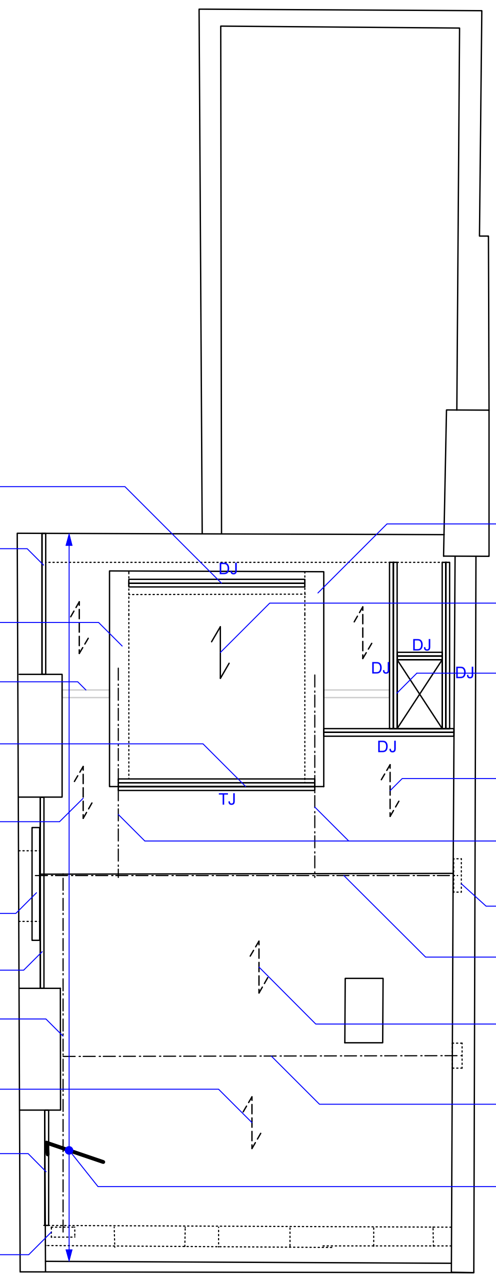


101.2 STRUCTURAL THIRD FLOOR PLAN AS PROPOSED



101.3 STRUCTURAL ROOF PLAN AS PROPOSED

KEY
- existing building fabric
- new load bearing structure. refer to annotations
- demolition
- new non loadbearing partitions. refer to architect's drawings

Project	91 Savernake Road
Drawing No.	A075 102
Revision	P1
Drawing Title	structural 3rd and roof plan
Date	31/10/2017
Scale	1:50
Status	Stage D
Project No.	A075
CAD Ref.	A075 proposed
Drawn	NM

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Pitched Roof, main

	thickness	kN/m²
Slate		0.3
Battens		0.05
Rafters	100	0.08
Plasterboard	30	0.30
		0.73 kN/m²

roof pitch (degrees): 30

hypotenuse length: $\frac{1}{\cos 30} = 1.15$

Pitched roof loading on plan = 0.73 x 1.15 = 0.84 kN/m²

Live load (snow) = 0.6 kN/m²

Flat roof (extension)

	thickness	kN/m²
Felt		0.11
Plywood (2x18)	36	0.22
Joists	150	0.14
Insulation	50	0.03
Plasterbd (2x12.5)	25	0.25
		0.74 kN/m²

Live load (snow) 0.6 kN/m²

Terrace

	thickness	Kn/m²
Decking	18	0.11
Asphalt	25	0.58
Boarding	18	0.11
Joists	150	0.11
Insulation	150	0.08
Plasterbd (2x12.5)	30	0.30
		1.28 kN/m²

Live load (domestic) 1.5 kN/m²

External timber framed tile clad walls

	thickness	kN/m²
Brick slips		0.3
Timber battens	35	0.03
Boarding	18	0.11
Insulation	100	0.05
Timber studs	100	0.08
Plasterwork	30	0.30
		0.86 kN/m²

Internal concrete slab: basement

	thickness	Kn/m²
Timber boards	15	0.09
Screed	75	1.80
Insulation	100	0.03
Concrete slab	250	6.00
Plasterboad(2x12.5)	30	0.30
		8.22 Kn/m²

Live load 1.5 Kn/m²

Timber stud walls

	thickness	kN/m²
Plasterboard (2no.)	30	0.30
Timber studs	100	0.08
Plasterboard (2no.)	30	0.30
		0.68 kN/m²

Window assembly: double glazed

	thickness	kN/m²
Timber framing		0.20
Double glazing	12	0.30
		0.50 kN/m²

Existing external masonry wall (230)

	thickness	kN/m²	
Plastered face	30	0.27	
Brickwork	230	4.14	
		4.41	kN/m²

Existing external masonry wall (440)

	thickness	kN/m²	
Plastered face	30	0.27	
Brickwork	440	7.92	
		8.19	kN/m²

Internal masonry wall (102 thick)

	thickness	kN/m²	
Plastered face	30	0.27	
Brickwork	102	1.84	
Plastered face	30	0.27	
		2.38	kN/m²

Timber floor (timber finish)

	thickness	kN/m²	
Timber floor boards	15	0.09	
Ply boards	18	0.11	
Joists	175	0.12	
Plasterboard	30	0.30	
		0.61	kN/m²
Live load (domestic)		1.5	kN/m²

Loft floor storage

	thickness	kN/m²	
Ply boards	18	0.11	
Joists	50	0.03	
Plasterwork	30	0.30	
		0.44	kN/m²
Live load (access)		0.6	kN/m²

External masonry cavity wall: inner leaf

	thickness	kN/m²	
Insulation	100	0.05	
Blockwork	100	1.80	
Plasterwork	25	0.25	
		2.10	kN/m²

External masonry cavity wall: outer leaf

	thickness	kN/m²	
Brickwork	102.5	1.85	kN/m²
		1.85	kN/m²
Inner + Outer wall		3.95	kN/m²

Timber trimmer supporting dormer roof (Roof)

Span 2.8 m

Modulus of Elasticity, E = 7200 N/mm² (C24)
Stiffness factor K9: 1.14 (2 members)
8.21 kN/mm²

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading-service kN/m²	kN	Loading-ultimate kN/m²	kN
Flat roof	Live	2.80	1.40	3.92	0.60	2.35	1.60	3.76
	Dead				0.74	2.89	1.40	4.05
						5.24		7.81

Beam is simply supported:

Maximum moment = $\frac{WL}{8} = \frac{5.24 \times 2.8}{8} =$ **1.83 kNm**

Max allowable deflection = 0.003 x 2800 mm = 8 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 5.24 \times 2800^3}{384 \times 8.21 \times 8}$

= **2173 cm⁴**

Max allowable stress = 7.5 N/mm² x 1.1 (Form factor K7)

= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 222 cm³ I.min = 2173 cm⁴

Assuming the timbers have a width of: 100 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 116 mm or D.min = 138 mm

Use 2no. 50x150 (C24) timbers

Loading at supports = 2.62 kN

Timber joists making up flat roof
(Roof)

Span : 2.8 m   Modulus of Elasticity, E: 10800 N/mm² (C24)

Spacing : 400 mm c/c

Loading

Live 0.60 kN/m
Dead 0.74 kN/m

Other 0 kN/m

w = 1.34 kN/m

Maximum moment

$$M.max = \frac{w.L^2}{8} = 1.31 \text{ kNm}$$

Max allowable stress = 7.5 N/mm² x 1.1 Load sharing factor, K8

= 8.25 N/mm²

Max allowable deflection = 0.003 x 2800 mm = 8 mm

Using the equations:

Using Stress = $\frac{\text{moment}}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

$$Z.min = \frac{M}{\text{max stress}} \quad \text{and} \quad I.min = \frac{5.w.L^4}{384.E.Dmax}$$

Z.min = 64 cm³   I.min = 472 cm^4

Assuming the timbers have a width of: 50 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 87 mm or D.min = 104 mm

Use 50x125 (C24) timbers at 400c/c minimum

Timber trimmer supporting flat and pitched roof
(Roof)

Span 2.6 m

Modulus of Elasticity, E = 7200 N/mm² (C24)
Stiffness factor K9: 1.21 (3 members)
8.71 kN/mm²

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading-service kN/m²	kN	Loading-ultimate kN/m²	kN
Pitched roof	Live	2.60	0.55	1.43	0.60	0.86	1.60	1.37
	Dead				0.84	1.20	1.40	1.68
Flat roof	Live	2.60	1.40	3.64	0.60	2.18	1.60	3.49
	Dead				0.74	2.68	1.40	3.76
						6.92		10.30

Beam is simply supported:

Maximum moment = $\frac{WL}{8} = \frac{6.92 \times 2.6}{8} =$ **2.25 kNm**

Max allowable deflection = 0.003 x 2600 mm = 8 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 6.92 \times 2600^3}{384 \times 8.71 \times 8}$

= **2332 cm^4**

Max allowable stress = 7.5 N/mm² x 1.1 (Form factor K7)

= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 273 cm³ I.min = 2332 cm^4

Assuming the timbers have a width of: 150 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 104 mm or D.min = 123 mm

Use 3no. 50x150 (C24) timbers

Loading at supports = 3.46 kN

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Steel beam supporting pitched roof
(Roof)

Span 5.20 m   Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	5.20	1.00	5.20	0.30	1.56	1.4	2.18
Pitched roof	Live	5.20	2.30	11.96	0.60	7.18	1.6	11.48
	Dead				0.84	10.01	1.4	14.02

Length of load, a1= 5.2 m Centroid, x1 = 2.6 m   18.75   27.68

Beam is simply supported

$$M.max = \frac{W.L}{8} = \frac{27.68 \times 5.20}{8} = 18.0 \text{ kNm, ultimate}$$

$$\text{Reactions (Ra \& Rb)} = \frac{W}{2} = \frac{27.68}{2} = 13.84 \text{ kNm}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{5200}{360} = 14.4 \text{ mm}$$

Deflection is limited to = 14 mm

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 18.75 \times 5200^3}{384 \times 205 \times 14}$$

$$= 1196 \text{ cm}^4$$

A 152 UC30 steel beam has : **Ixx = 1750 cm^4**

Mb =	42.6 kNm	for a Le =	5.00 m
Mb =	37.7 kNm	for a Le =	6.00 m
Mb =	**41.6 kNm**	**for a Le =**	**5.20 m**

Loading on support Ra and Rb = 13.84 kN, ultimate
9.37 kN, service

Checking bearing stress on masonry

Allowable stress in masonry = 2.2 N/mm² (Assumed low strength masonry)
x concentrated load factor 1.5
/ material safety factor 3.5
0.94 N/mm²

$$\text{Minimum bearing area required} = \frac{P}{\text{allow. Stress}} = \frac{13841}{0.94} = 14680 \text{ mm}^2$$

215 x 100 bearing on brick has a area of: 21500 mm²

Steel beam supporting pitched roof steel beam
(Roof)

Span 4.70 m   Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions		Area	Loading- service		Loading- ultimate	
		a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
Self weight	Dead	4.70	1.00	4.70	0.46	2.16	1.4	3.03

Length of load, a1= 4.7 m   Centroid, x1 = 2.35 m   2.16   3.03

Element P2	Dimensions		Area	Loading- service		Loading- ultimate	
	a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
Loading from steel beam supporting pitched roof (page 14)					9.37		13.84

Centroid, x2 = 2.40 m   9.37   13.84

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(P2xX2) = 0

$$Rb = \frac{(W1xX1) \quad +(P2xX2)}{L}$$

$$Rb = \frac{7.11 \quad + \quad 33.22}{4.70}$$

Rb = 8.58 kN, ultimate

Ra = W1+P2-Rb

Ra = 8.29 kN, ultimate

Ratio of ultimate to service loadings: $\frac{16.87}{11.54}$ = 1.46

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{3.03}{4.70} = 0.64 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

X = 2.40 m from A (at point of action of point load P2)

Max moment = X x Ra - 0.5X² x w1
= 19.89 - 1.85
= **18.03 kNm, ultimate**

Max moment = 12.33 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\ M}{L} = \frac{8 \quad x \quad 12.33}{4.70} = 20.99 \text{ kN}$$

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Limiting deflection: $\frac{L}{360} = \frac{4700}{360} =$ 13.1 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 20.99 \times 4700^3}{384 \times 205 \times 13}$

= 1060 cm^4

A 152 UC23 beam has : Ixx = **1250** $\mathbf{cm^4}$

and	Mb =	32.3	kNm	for a Le =	4.00	m
	Mb =	27.5	kNm	for a Le =	5.00	m
	Mb =	**28.9**	**kNm**	**for a Le =**	**4.70**	**m**

Loading on support Ra = 8.29 kN, ultimate
5.67 kN, service

Loading on support Rb = 8.58 kN, ultimate
5.87 kN, service

Steel beam supporting dormer wall (Roof)

Span 4.20 m

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	4.20	1.00	4.20	0.10	0.42	1.4	0.59

Length of load, a1= 4.2 m Centroid, x1 = 2.1 m — 0.42 — 0.59

Element P2		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Pitched roof	Dead	0.85	2.05	1.74	0.60	1.05	1.6	1.67
	Live				0.84	1.46	1.4	2.04

Centroid, x2 = 1.80 m — 2.50 — 3.72

Element P3		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from trimmer supporting flat roof (page11)						2.62		3.90
Glazing	Dead	1.40	2.40	3.36	0.50	1.68	1.4	2.35

Centroid, x3 = 0.40 m — 4.30 — 6.26

Element W4		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Dormer wall *(triangular loading)*	Dead	3.00	2.40	3.60	0.86	3.09	1.4	4.33

Length of load, a4= 3.0 m Centroid, x4 = 1.50 m — 3.09 — 4.33

Element P5		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from trimmer supporting flat and pitched roof (page 13)						3.46		5.15

Centroid, x5 = 3.00 m — 3.46 — 5.15

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(P2xX2) -(P3xX3) -(W4xX4) -(P5xX5) = 0

$$Rb = \frac{(W1xX1) + (P2xX2) + (P3xX3) + (W4xX4) + (P5xX5)}{L}$$

$$Rb = \frac{1.23 + 6.69 + 2.50 + 6.50 + 15.45}{4.20}$$

Rb = 7.71 kN, ultimate

Ra = W1+P2+P3+W4+P5-Rb

Ra = 12.33 kN, ultimate

Ratio of ultimate to service loadings: $\frac{20.04}{13.78}$ = 1.45

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{0.59}{4.20} = 0.14 \text{ kN/m}$$

$$w4 = \frac{W4}{a4} = \frac{4.33}{3.00} = 1.44 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

X = 1.80 m from A (At point of action of point load P2)

Max moment = X x Ra - 0.5X² x w1 - 0.5X² x w4 - (X-x3) x P3
= 22.20 - 0.23 - 2.34 - 8.76
= **10.88 kNm, ultimate**

Max moment = 7.48 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\,M}{L} = \frac{8 \times 7.48}{4.20} = 14.24 \text{ kN}$$

Limiting deflection: $\frac{L}{360} = \frac{4200}{360} = 11.7$ mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 14.24 \times 4200^3}{384 \times 205 \times 12}$

= 575 cm^4

A 152x89 UB16 beam has : Ixx = **834 cm^4**

and	Mb =	13.5 kNm	for a Le =	4.00 m
	Mb =	11.1 kNm	for a Le =	5.00 m
	Mb =	**13.0 kNm**	**for a Le =**	**4.20 m**

Loading on support Rb = 7.71 kN, ultimate
5.30 kN, service

Checking bearing stress on masonry

Allowable stress in masonry = 2.2 N/mm² (Assumed low strength masonry)
x concentrated load factor 1.5
/ material safety factor 3.5
0.94 N/mm²

Loading on support Ra = 12.33 kN, ultimate
8.48 kN, service

Support Ra
Minimum bearing area required = $\frac{P}{\text{allow. Stress}} = \frac{12333}{0.94} = 13081$ mm²

440 x 100 bearing on brick has a area of: 44000 mm²

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Steel ridge beam
(Roof)

Span 5.60 m

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	5.60	1.00	5.60	0.46	2.58	1.4	3.61
Pitched roof	Live	5.60	2.30	12.88	0.60	7.73	1.6	12.36
	Dead				0.84	10.78	1.4	15.10

Length of load, a1= 5.6 m Centroid, x1 = 2.8 m 21.09 31.07

Element P2	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from steel beam spanning next to chimney breast (page 15)					5.67		8.29

Centroid, x2 = 0.40 m 5.67 8.29

Element P3	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from flitch beam supporting dormer wall (page 17)					5.30		7.71

Centroid, x3 = 1.10 m 5.30 7.71

Element P3	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from flitch beam supporting dormer wall (page 17)					5.30		7.71

Centroid, x3 = 3.70 m 5.30 7.71

Take moments from the support A, counter clockwise positive:

$$Rb \times L \quad -(W1xX1) \quad -(P2xX2) \quad -(P3xX3) \quad -(P4xX4) \quad = \quad 0$$

$$Rb = \frac{(W1xX1) \quad +(P2xX2) \quad +(P3xX3) \quad +(P4xX4)}{L}$$

$$Rb = \frac{86.99 \quad + \quad 3.31 \quad + \quad 8.48 \quad + \quad 28.52}{5.60}$$

Rb = 22.73 kN, ultimate

Ra = W1+P2+P3+P4-Rb

Ra = 32.04 kN, ultimate

Ratio of ultimate to service loadings: $\frac{54.77}{37.35}$ = 1.47

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{31.07}{5.60} = 5.55 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

$$X = \frac{Ra - P2 - P3}{w1} = \frac{16.04}{5.55} = 2.89 \text{ m from A}$$

Max moment = X x Ra - 0.5X² x w1 - P2 x (X-x2) - P3 x (X-x3)
= 92.64 - 23.20 - 20.65 - 13.81
= **34.99 kNm, ultimate**

Max moment = 23.86 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\,M}{L} = \frac{8 \times 23.86}{5.60} = 34.09 \text{ kN}$$

Limiting deflection: $\frac{L}{360} = \frac{5600}{360} = 15.6$ mm

Deflection is limited to = 14 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 34.09 \times 5600^3}{384 \times 205 \times 14}$

= 2716 cm^4

A 203 UC46 beam has :	Ixx =	**4570 cm^4**		
and	Mb =	99.2 kNm	for a Le =	5.00 m
	Mb =	88.7 kNm	for a Le =	6.00 m
	Mb =	**92.9 kNm**	**for a Le =**	**5.60 m**

Loading on support Ra = 32.04 kN, ultimate
21.85 kN, service

Loading on support Rb = 22.73 kN, ultimate
15.50 kN, service

Checking bearing stress on masonry

Allowable stress in masonry = 2.2 N/mm² (Assumed low strength masonry)
x concentrated load factor 1.5
/ material safety factor 3.5
0.94 N/mm²

Support Ra

Minimum bearing area required = $\frac{P}{\text{allow. Stress}} = \frac{32037}{0.94} = 33979$ mm²

440 x 100 bearing on brick has a area of: 44000 mm²

Support Rb

Minimum bearing area required = $\frac{P}{\text{allow. Stress}} = \frac{22732}{0.94} = 24110$ mm²

330 x 100 bearing on brick has a area of: 33000 mm²

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Timber trimmer supporting loft floor
(3rd floor)

Span 1.7 m   Modulus of Elasticity, E = 7200 N/mm² (C24)
Stiffness factor K9: 1.14 (2 members)
8.21 kN/mm²

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading-service kN/m²	kN	Loading-ultimate kN/m²	kN
Loft floor	Live	1.70	4.05	6.89	0.60	4.13	1.60	6.61
	Dead				0.44	3.04	1.40	4.25
						7.17		10.86

Beam is simply supported:

Maximum moment = $\frac{WL}{8} = \frac{7.17 \times 1.7}{8}$ = **1.52 kNm**

Max allowable deflection = 0.003 x 1700 mm = 5 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 7.17 \times 1700^3}{384 \times 8.21 \times 5}$

= **1095 cm^4**

Max allowable stress = 7.5 N/mm² x 1.1 (Form factor K7)

= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 185 cm³   I.min = 1095 cm^4

Assuming the timbers have a width of: 100 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 105 mm or D.min = 110 mm

Use 2no. 50x150 (C24) timbers

Loading at supports = 3.58 kN

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Timber trimmer supporting loft floor at front (3rd floor)

Span 3.3 m

Modulus of Elasticity, E = 7200 N/mm² (C24)
Stiffness factor K9: 1.21 (3 members)
8.71 kN/mm²

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading-service kN/m²	kN	Loading-ultimate kN/m²	kN
Loft floor	Live	3.30	2.20	7.26	1.50	10.89	1.60	17.42
	Dead				0.61	4.45	1.40	6.24
Stud wall	Dead	3.30	0.40	1.32	0.68	0.90	1.60	1.43
						16.24		25.09

Beam is simply supported:

Maximum moment = $\frac{WL}{8} = \frac{16.24 \times 3.3}{8}$ = **6.70 kNm**

Max allowable deflection = 0.003 x 3300 mm = 10 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 16.24 \times 3300^3}{384 \times 8.71 \times 10}$

= **8811 cm^4**

Max allowable stress = 7.5 N/mm² x 1.1 (Form factor K7)
= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 812 cm³ I.min = 8811 cm^4

Assuming the timbers have a width of: 150 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 180 mm or D.min = 192 mm

Use 3no. 50x200 (C24) timbers

Loading at supports = 8.12 kN

Flitch beam supporting front elevation floor trimmer (3rd floor)

Span 4.50 m

Element W1		Dimensions		Area	Loading- service		Loading- ultimate	
		a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
Self weight	Dead	4.50	1.00	4.50	0.10	0.45	1.4	0.63
Stud wall	Dead	4.50	1.20	5.40	0.68	3.67	2.4	8.80

Length of load, a1= 4.5 m Centroid, x1 = 2.25 m 4.12 9.43

Element P2	Dimensions		Area	Loading- service		Loading- ultimate	
	a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
Loading from trimmer supporting floor loading (page 32)					8.12		12.55

Centroid, x2 = 3.70 m 8.12 12.55

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(P2xX2) = 0

$$Rb = \frac{(W1xX1) \quad +(P2xX2)}{L}$$

$$Rb = \frac{21.22 \quad + \quad 46.42}{4.50}$$

Rb = 15.03 kN, ultimate

Ra = W1+P2-Rb

Ra = 6.95 kN, ultimate

Ratio of ultimate to service loadings: $\frac{21.98}{12.24}$ = 1.80

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{9.43}{4.50} = 2.10 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

X = 3.70 m from A (At point of action of point load P2)

Max moment = X x Ra - 0.5X² x w1

= 25.70 - 14.34

= **11.35 kNm, ultimate**

Max moment = 6.32 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\,M}{L} = \frac{8 \quad x \quad 6.32}{4.50} = 11.24 \text{ kN}$$

Span: 4.5 m

Modulus of Elasticity (timber) = 7200 N/mm²

Modulus of Elasticity (steel) = 205000 N/mm²

Assume: 200 mm x 100 mm timber and 175 mm x 8 mm steel

Ixx (timber) = 66666667 mm^4

Ixx (steel) = 3572917 mm^4

Load sharing ratio:

$$K(timber) = \frac{Et \,.\, It}{Et \,.\, It + Es \,.\, Is} = 0.40$$

$$K(steel) = \frac{Es \,.\, Is}{Et \,.\, It + Es \,.\, Is} = 0.60$$

Bending moment from previous page of calculations: BM = 11.35 kNm, ultimate

6.32 kNm, service

Moments into steel plate = 6.86 kNm

$$\text{Stress in plate} = \frac{BM}{Z} = 167.98 \text{ N/mm}^2 < 275 \text{ N/mm}^2$$

Moments into timber beam = 2.50 kNm

$$\text{Stress in beam} = \frac{BM}{Z} = 3.75 \text{ N/mm}^2 < 7.5 \text{ N/mm}^2$$

Loading from previous page of calculations: 11.24 kN (service load)

$$\text{Deflection in steel plate} = \frac{5W.Ks.L^3}{384 \,.\, E \,.\, I} = \frac{5 \times 6.79 \times 4500^3}{384 \times 205 \times 3572.9}$$

$$= 11.0 \text{ mm}$$

Check deflection should be the same in the timber section:

$$\text{Deflection in timber beam} = \frac{5W.Kt.L^3}{384 \,.\, E \,.\, I} = \frac{5 \times 4.45 \times 4500^3}{384 \times 7.20 \times 66666.7}$$

$$= 11.0 \text{ mm}$$

Allowable deflection = 0.003 x span = 0.003 x 4500 = 13.5 mm

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Timber joists calculation: joists at rear of building (3rd floor)

Span 4.3 m   Modulus of Elasticity, E = 10800 N/mm² (C24)

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN
Floor	Live	4.30	0.36	1.55	1.50	2.32
	Dead				0.61	0.95

Length of load, a1 = 4.30 m   Centroid, x1 = 2.15 m   3.27

Element P2		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN
Stud wall	Dead	0.20	0.36	0.07	0.68	0.05

Centroid, x2 = 0.40   0.05

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(P2xX2) = 0

$$Rb = \frac{(W1xX1) + (P2xX2)}{L}$$

$$Rb = \frac{7.03 + 0.02}{4.3}$$

Rb = 1.64 kN, service

Ra = W1+P2-Rb

Ra = 1.68 kN, service

Loading per meter run close to B is equal to:

$$w = \frac{W1}{a1} = \frac{3.27}{4.30} = 0.76 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at:

$$X = \frac{Rb}{w1} = \frac{1.64}{0.76} = 2.16 \text{ m from B}$$

Max moment = X x Rb - 0.5X² x w
= 3.54 - 1.77
= **1.8 kNm, service**

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\ M}{L} = \frac{8 \times 1.8}{4.3} = 3.29 \text{ kN}$$

Max allowable deflection = 0.003 x 4300 mm = 12.9 mm

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Max allowable stress = 7.5 N/mm² x 1.1 K8 load sharing factor
= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{\text{moment}}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived, as follows:

Z.min = $\frac{M}{\text{max stress}}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 3.29 \times 4300^3}{384 \times 8.25 \times 13}$

= **3200 cm^4**

Z.min = 214 cm³ I.min = 3200 cm^4

Assuming the timbers have a width of: 50 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 160 mm or D.min = 197 mm

Existing 50x 200 C24 timbers @ 360c/c are sufficient

Timber trimmer supporting glazing at rear (3rd floor)

Span 2.8 m

Modulus of Elasticity, E = 7200 N/mm² (C24)
Stiffness factor K9: 1.14 (2 members)
8.21 kN/mm²

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading-service kN/m²	kN	Loading-ultimate kN/m²	kN
Glazing	Dead	2.80	2.60	7.28	0.50	3.64	1.60	5.82
						3.64		5.82

Beam is simply supported:

Maximum moment = $\frac{WL}{8} = \frac{3.64 \times 2.8}{8} =$ **1.27 kNm**

Max allowable deflection = 0.003 x 2800 mm = 8 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 3.64 \times 2800^3}{384 \times 8.21 \times 8}$

= **1509 cm^4**

Max allowable stress = 7.5 N/mm² x 1.1 (Form factor K7)

= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 154 cm³ I.min = 1509 cm^4

Assuming the timbers have a width of: 100 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 96 mm or D.min = 122 mm

Use 2no. 50x150 (C24) timbers

Loading at supports = 1.82 kN

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Timber joists calculation: joists at rear of building (2nd floor)

Span 4.3 m Modulus of Elasticity, E = 10800 N/mm² (C24)

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN
Floor	Live	4.30	0.18	0.77	1.50	1.16
	Dead				0.61	0.47

Length of load, a1 = 4.30 m Centroid, x1 = 2.15 m 1.64

Element P2		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN
Stud wall	Dead	2.60	0.18	0.47	0.68	0.32

Centroid, x2 = 1.20 0.32

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(P2xX2) = 0

$$Rb = \frac{(W1xX1) + (P2xX2)}{L}$$

$$Rb = \frac{3.52 + 0.38}{4.3}$$

Rb = 0.91 kN, service

Ra = W1+P2-Rb

Ra = 1.05 kN, service

Loading per meter run close to B is equal to:

$$w = \frac{W1}{a1} = \frac{1.64}{4.30} = 0.38 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at:

$$X = \frac{Rb}{w1} = \frac{0.91}{0.38} = 2.38 \text{ m from B}$$

Max moment = X x Rb - 0.5X² x w
= 2.16 - 1.08
= **1.1 kNm, service**

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\,M}{L} = \frac{8 \quad x \quad 1.1}{4.3} = 2.01 \text{ kN}$$

Max allowable deflection = 0.003 x 4300 mm = 12.9 mm

Max allowable stress = 7.5 N/mm² x 1.1 K8 load sharing factor
= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{\text{moment}}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived, as follows:

Z.min = $\frac{M}{\text{max stress}}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 2.01 \times 4300^3}{384 \times 8.25 \times 13}$

= **1955 cm^4**

Z.min = 131 cm³ I.min = 1955 cm^4

Assuming the timbers have a width of: 50 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 125 mm or D.min = 167 mm

Use 50x200 C24 timber joists @ 180 c/c

Timber trimmer supporting dormer roof
(2nd floor)

Span 2 m

Modulus of Elasticity, E = 7200 N/mm² (C24)
Stiffness factor K9: 1.14 (2 members)
8.21 kN/mm²

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading-service kN/m²	kN	Loading-ultimate kN/m²	kN
Terrace roof	Live	2.00	3.35	6.70	1.50	10.05	1.60	16.08
	Dead				1.28	8.57	1.40	11.99
						18.62		28.07

Beam is simply supported:

Maximum moment = $\frac{WL}{8} = \frac{18.62 \times 2}{8} =$ **4.65 kNm**

Max allowable deflection = 0.003 x 2000 mm = 6 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 18.62 \times 2000^3}{384 \times 8.21 \times 6}$

= **3938 cm^4**

Max allowable stress = 7.5 N/mm² x 1.1 (Form factor K7)
= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 564 cm³ I.min = 3938 cm^4

Assuming the timbers have a width of: 100 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 184 mm or D.min = 168 mm

Use 2no. 50x200 (C24) timbers

Loading at supports = 9.31 kN

Lintel supporting stud wall in middle of house (2nd floor)

Span 1.50 m

Element W1		Dimensions a (m)	b (m)	Area A (m^2)	Loading- service kN/m^2	kN
Self weight	Dead	1.50	1.00	1.50	0.46	0.69
Masonry	Dead	1.50	1.00	1.50	4.41	6.62
Loading from flitch beam supporting terrace floor (page 43)						9.31

Length of load, a1= 1.5 m Centroid, x1 = 0.75 m 16.61

Use CN71A catnic with max service capacity of 27kN for a max clear span of 2.1m

Steel beam supporting glazed roof at rear (1st floor)

Span 4.30 m Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	4.30	1.00	4.30	0.16	0.69	1.4	0.96
Flat roof light	Live	4.30	1.05	4.52	0.60	2.71	1.6	4.33
	Dead				0.50	2.26	1.4	3.16
						5.65		8.46

Length of load, a1= 4.3 m Centroid, x1 = 2.15 m

Beam is simply supported

$$M.max = \frac{W.L}{8} = \frac{8.46 \times 4.30}{8} = 4.5 \text{ kNm, ultimate}$$

$$\text{Reactions (Ra \& Rb)} = \frac{W}{2} = \frac{8.46}{2} = 4.23 \text{ kNm}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{4300}{360} = 11.9 \text{ mm}$$

Deflection is limited to = 14 mm

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 5.65 \times 4300^3}{384 \times 205 \times 14}$$

$$= 204 \text{ cm}^4$$

A 152x89 UB16 steel beam has : **Ixx = 834 cm^4**

Mb = 11.1 kNm for a Le = 5.00 m

Mb = 9.4 kNm for a Le = 6.00 m

Mb = 12.3 kNm for a Le = 4.30 m

Loading on support Ra and Rb = 4.23 kN, ultimate

2.83 kN, service

Steel beam supporting stud wall in middle of house (1st floor)

Span 3.70 m Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	3.70	1.00	3.70	0.46	1.70	1.4	2.38
Stud wall	Dead	3.70	9.60	35.52	0.68	24.12	1.4	33.76
1st floor	Live	3.70	4.30	15.91	1.50	23.87	1.6	38.18
	Dead				0.61	9.76	1.4	13.67
2nd floor	Dead	3.70	4.30	15.91	1.50	23.87	1.6	38.18
	Dead				0.61	9.76	1.4	13.67
3rd floor	Dead	3.70	4.30	15.91	1.50	23.87	1.6	38.18
	Dead				0.61	9.76	1.4	13.67

Length of load, a1= 3.7 m Centroid, x1 = 1.85 m 126.70 191.69

Beam is simply supported

$$M.max = \frac{W.L}{8} = \frac{191.69 \times 3.70}{8} = 88.7 \text{ kNm, ultimate}$$

$$\text{Reactions (Ra \& Rb)} = \frac{W}{2} = \frac{191.69}{2} = 95.85 \text{ kNm}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{3700}{360} = 10.3 \text{ mm}$$

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 126.70 \times 3700^3}{384 \times 205 \times 10}$$

$$= 3966 \text{ cm}^4$$

A 203 UC46 steel beam has : **Ixx = 4570 cm⁴**

Mb = 111.0 kNm for a Le = 3.00 m
Mb = 99.2 kNm for a Le = 4.00 m
Mb = 102.7 kNm for a Le = 3.70 m

Loading on support Ra and Rb = 95.85 kN, ultimate
63.35 kN, service

Steel beam supporting existing rear extension floor (1st floor)

Span 3.30 m — Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	3.30	1.00	3.30	0.23	0.76	1.4	1.06
1st floor	Live	3.30	2.90	9.57	1.50	14.36	1.6	22.97
	Dead				0.61	5.87	1.4	8.22
Stud wall	Live	1.50	2.60	3.90	0.68	2.65	1.4	3.71
						23.63		35.96

Length of load, a1= 3.3 m Centroid, x1 = 1.65 m

Beam is simply supported

$$M.max = \frac{W.L}{8} = \frac{35.96 \times 3.30}{8} = 14.8 \text{ kNm, ultimate}$$

$$\text{Reactions (Ra \& Rb)} = \frac{W}{2} = \frac{35.96}{2} = 17.98 \text{ kNm}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{3300}{360} = 9.2 \text{ mm}$$

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 23.63 \times 3300^3}{384 \times 205 \times 9}$$

$$= 588 \text{ cm}^4$$

A 178x102 UB19 steel beam has : **Ixx = 1340 cm⁴**

Mb =	25.0 kNm	for a Le =	3.00 m
Mb =	19.3 kNm	for a Le =	4.00 m
Mb =	**23.3 kNm**	**for a Le =**	**3.30 m**

Loading on support Ra and Rb = 17.98 kN, ultimate
11.82 kN, service

Checking bearing stress on masonry

Allowable stress in masonry = 2.2 N/mm² (Assumed low strength masonry)
x concentrated load factor 1.5
/ material safety factor 3.5
0.94 N/mm²

$$\text{Minimum bearing area required} = \frac{P}{\text{allow. Stress}} = \frac{17979}{0.94} = 19068 \text{ mm}^2$$

215 x 100 bearing on brick has a area of: 21500 mm²

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Steel beam supporting existing rear extension floor (1st floor)

Span 3.30 m

Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	3.30	1.00	3.30	0.23	0.76	1.4	1.06
1st floor	Live	3.30	2.45	8.09	1.50	12.13	1.6	19.40
	Dead				0.61	4.96	1.4	6.94
Partition allowance	Dead	1.50	2.6	3.9	0.68	2.65	1.4	3.71

Length of load, a1= 3.3 m Centroid, x1 = 1.65 m 20.49 31.12

Element P2	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from timber trimmer supporting terrace (page 43)					9.31		14.04

Centroid, x2 = 2.20 m 9.31 14.04

Element P3		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Terrace floor	Live	2.90	0.5	1.305	1.50	1.96	1.6	3.13
	Dead				1.28	1.67	1.4	2.34

Centroid, x3 = 3.10 m 3.63 5.47

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(P2xX2) -(P3xX3) = 0

$$Rb = \frac{(W1xX1) + (P2xX2) + (P3xX3)}{L}$$

$$Rb = \frac{51.34 + 30.88 + 16.95}{3.30}$$

Rb = 30.05 kN, ultimate

Ra = W1+P2+P3-Rb

Ra = 20.57 kN, ultimate

Ratio of ultimate to service loadings: $\frac{50.62}{33.43}$ = 1.51

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{31.12}{3.30} = 9.43 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

X = 2.20 m from A

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Max moment = X x Ra - $0.5X^2$ x w1
= 45.25 - 22.82
= **22.43 kNm, ultimate**

Max moment = 14.81 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8M}{L} = \frac{8 \times 14.81}{3.30} = 35.91 \text{ kN}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{3300}{360} = 9.2 \text{ mm}$$

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 35.91 \times 3300^3}{384 \times 205 \times 9}$$

$$= 894 \text{ cm}^4$$

A 203x102 UB23 beam has :	Ixx =	**2100**	**cm^4**			
and	Mb =	34.1	kNm	for a Le =	3.00	m
	Mb =	26.4	kNm	for a Le =	4.00	m
	Mb =	**31.8**	**kNm**	**for a Le =**	**3.30**	**m**

Loading on support Ra = 20.57 kN, ultimate
13.58 kN, service

Loading on support Rb = 30.05 kN, ultimate
19.85 kN, service

Checking bearing stress on masonry

Allowable stress in masonry =	2.2	N/mm^2	(Assumed low strength masonry)
x concentrated load factor	1.5		
/ material safety factor	3.5		
	0.94	N/mm^2	

$$\text{Minimum bearing area required} = \frac{P}{\text{allow. Stress}} = \frac{30053}{0.94} = 31874 \text{ mm}^2$$

330 x 100 bearing on brick has a area of: 33000 mm^2

Steel beam supporting existing rear side extension (1st floor)

Span 7.20 m — Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions		Area	Loading- service		Loading- ultimate	
		a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
Self weight	Dead	7.20	1.00	7.20	1.18	8.50	1.4	11.89
Masonry	Dead	7.20	3.10	22.32	4.41	98.43	1.4	137.80
voids in masony	Dead	1.10	1.30	1.43	-4.41	-6.31	1.4	-8.83
Glazing	Dead	1.10	1.30	1.43	0.50	0.72	1.4	1.00
Flat roof	Live	7.20	1.00	7.20	0.50	3.60	1.6	5.76
	Dead				0.60	4.32	1.4	6.05

Length of load, a1= 7.2 m — Centroid, x1 = 3.6 m — 109.26 — 153.68

Element P2	Dimensions		Area	Loading- service		Loading- ultimate	
	a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
Loading from steel beam supporting loft floor (page 53)					11.82		17.98

Centroid, x2 = 1.20 m — 11.82 — 17.98

Element P3	Dimensions		Area	Loading- service		Loading- ultimate	
	a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
Loading from steel beam supporting loft floor (page 54)					13.58		20.57

Centroid, x3 = 5.20 m — 13.58 — 20.57

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(P2xX2) -(P3xX3) = 0

$$Rb = \frac{(W1xX1) + (P2xX2) + (P3xX3)}{L}$$

$$Rb = \frac{553.24 + 21.57 + 106.96}{7.20}$$

Rb = 94.69 kN, ultimate

Ra = W1+P2+P3-Rb

Ra = 97.53 kN, ultimate

Ratio of ultimate to service loadings: $\frac{192.23}{134.66} = 1.43$

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{153.68}{7.20} = 21.34 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

$$X = \frac{Ra - P2}{w1} = \frac{79.56}{21.34} = 3.73 \text{ m from A}$$

Max moment = X x Ra - $0.5X^2$ x w1 - P2 x (X-x2)
= 363.54 - 148.27 - 45.44
= **169.84 kNm, ultimate**

Max moment = 118.97 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\,M}{L} = \frac{8 \times 118.97}{7.20} = 132.19 \text{ kN}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{7200}{360} = 20.0 \text{ mm}$$

Deflection is limited to = 14 mm

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 132.19 \times 7200^3}{384 \times 205 \times 14}$$

$$= 22385 \text{ cm}^4$$

A 305 UC118 beam has :	Ixx =	**27700 cm^4**		
and	Mb =	403.0 kNm	for a Le =	7.00 m
	Mb =	376.0 kNm	for a Le =	8.00 m
	Mb =	**397.6 kNm**	**for a Le =**	**7.20 m**

Beam is restrained along its length therefore, Le = 4 m

A 406x178 UB67 beam has :	Ixx =	**24300 cm^4**		
and	Mb =	224.0 kNm	for a Le =	4.00 m
	Mb =	181.0 kNm	for a Le =	5.00 m
	Mb =	**224.0 kNm**	**for a Le =**	**4.00 m**

Loading on support Ra = 97.53 kN, ultimate (going into steel post)
68.32 kN, service

Loading on support Rb = 94.69 kN, ultimate (going into steel beam)
66.33 kN, service

Steel beam supporting extension rear elevation (1st floor)

Span 5.40 m — Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	5.40	1.00	5.40	0.89	4.81	1.4	6.73
Glazing	Live	5.40	1.05	5.67	0.50	2.84	1.6	4.54
	Dead				0.60	3.40	1.4	4.76

Length of load, a1= 5.4 m Centroid, x1 = 2.7 m — 11.04 — 16.03

Element W2		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Masonry	Dead	3.30	2.40	7.92	4.41	34.93	1.4	48.90
voids in masonry	Dead	1.10	1.60	1.76	-4.41	-7.76	1.4	-10.87
Glazing	Dead	1.10	1.60	1.76	0.50	0.88	1.4	1.23
Terrace	Live	2.10	2.95	6.20	1.50	9.29	1.6	14.87
	Dead				1.28	7.92	1.4	11.09
1st floor	Live	2.10	0.95	2.00	1.50	2.99	1.6	4.79
	Dead				0.61	1.22	1.4	1.71

Length of load, a2= 3.3 Centroid, x2 = 1.65 m — 49.47 — 71.72

Element P3	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from steel beam supporting side elevation (page 56)					66.33		94.69

Centroid, x3 = 3.2 m — 66.33 — 94.69

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(W2xX2) -(P3xX3) = 0

$$Rb = \frac{(W1xX1) + (W2xX2) + (P3xX3)}{L}$$

$$Rb = \frac{43.27 + 118.34 + 303.01}{5.40}$$

Rb = 86.04 kN, ultimate

Ra = W1+W2+P3-Rb

Ra = 96.40 kN, ultimate

Ratio of ultimate to service loadings: $\frac{182.44}{126.85}$ = 1.44

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{16.03}{5.40} = 2.97 \text{ kN/m}$$

$$w2 = \frac{W2}{a2} = \frac{71.72}{3.30} = 21.73 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

X = 3.20 m from A, (point of action of point load P3)

Max moment = X x Ra - 0.5X² x w1 - 0.5X² x w2
= 308.47 - 15.20 - 111.28
= **182.00 kNm, ultimate**

Max moment = 126.54 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8M}{L} = \frac{8 \times 126.54}{5.40} = 187.47 \text{ kN}$$

Limiting deflection: $\frac{L}{360} = \frac{5400}{360} = 15.0$ mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 187.47 \times 5400^3}{384 \times 205 \times 15}$

$= 12500 \text{ cm}^4$

A 254 UC89 beam has :	Ixx =	**14300 cm⁴**		
and	Mb =	276.0 kNm	for a Le =	5.00 m
	Mb =	256.0 kNm	for a Le =	6.00 m
	Mb =	**268.0 kNm**	**for a Le =**	**5.40 m**

Steel beam as lintel over opening (1st floor)

Span 1.40 m — Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	1.40	1.00	1.40	0.30	0.42	1.4	0.59
1st floor	Live	1.40	2.15	3.01	1.50	4.52	1.6	7.22
	Dead				0.61	1.85	1.4	2.59
Glazing	Dead	1.40	1.00	1.40	0.50	0.70	1.4	0.98
Masonry	Dead	1.40	2.40	3.36	4.41	14.82	1.4	20.74

Length of load, a1= 1.4 m Centroid, x1 = 0.7 m — 22.30 — 32.12

Beam is simply supported

$$M.max = \frac{W.L}{8} = \frac{32.12 \times 1.40}{8} = 5.6 \text{ kNm, ultimate}$$

$$\text{Reactions (Ra \& Rb)} = \frac{W}{2} = \frac{32.12}{2} = 16.06 \text{ kNm}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{1400}{360} = 3.9 \text{ mm}$$

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 22.30 \times 1400^3}{384 \times 205 \times 4}$$

$$= 100 \text{ cm}^4$$

A 203 UC46 steel beam has : **Ixx = 2450 cm⁴**

Mb = 137.0 kNm for a Le = 1.00 m
Mb = 137.0 kNm for a Le = 2.00 m
Mb = 137.0 kNm for a Le = 1.40 m

Loading on support Ra and Rb = 16.06 kN, ultimate
11.15 kN, service

Checking bearing stress on masonry

Allowable stress in masonry = 2.2 N/mm² (Assumed low strength masonry)
x concentrated load factor 1.5
/ material safety factor 3.5
0.94 N/mm²

$$\text{Minimum bearing area required} = \frac{P}{\text{allow. Stress}} = \frac{16061}{0.94} = 17034 \text{ mm}^2$$

203 x 100 bearing on brick has a area of: 20300 mm²

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Steel post at rear
(Ground floor)

Height 2.6 m Modulus of elasticity, E = 205 kN/mm²

F	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
F1: Loading from beam supporting glazed roof (page 51)					2.83		4.23
					2.83		4.23

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 2 L as beam is subject to sway
Le: 5.20 m

Distance from centroid of beam, dx = 202 mm

Moment in post: Mx = F x dx
Moment in post: Mx = 4.2 x 0.202 = 0.9 kNm

For a 152x89 UB16 thick section:

Pcy = 26.5 kN $\frac{F1}{Pcy}$ = 0.16

Mb = 7.35 kNm $\frac{My}{Mb}$ = 0.12

$$\frac{F1}{Pcy} + \frac{Mx}{Mb} < 1$$

0.16 + 0.12 = **0.28 < 1**

Loading at the base = Post loading + self weight

Self weight (service) = 1.2 kN Self weight (ultimate) = 1.7 kN
Loading at base (service) = 4.0 kN Loading at base (ultimate) = 5.9 kN

Size mass concrete pad footing

Allowable bearing pressure, clay (Pmax): 100 kN/m²

Minimum area of footing req'd (85% capacity) = $\frac{loading}{Pmax} = \frac{4.02}{85}$ = 0.05 m²

If the footing is square, the required width/length is: 0.05 m^2

w = sqrt (A) = 218 mm

Mass concrete pad footing 450mm wide/long minimum

Check steel post under wind loading
(Ground floor)

Height 3.60 m   Modulus of Elasticity, E = 205 kN/mm²

Wind loading:

W1	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate kN/m²	kN
Wind on side of building	1.80	1.20	2.16	0.5	1.08	1.2	1.30
					1.08		1.30

Limiting deflection to $= \dfrac{L}{360} = \dfrac{3600}{360} =$ 10.0 mm

Ixx minimum required $= \dfrac{W1.L^3}{3Ed} = \dfrac{1.08 \times 3600^3}{3 \times 205 \times 10.0}$

$=$ **819 cm^4**

A 152x89 UB16 steel beam has Ixx = 873 cm^4

Two posts are going to be used therefore **Total Ixx** = **1746 cm^4**

Moment due to wind loading on post:

The safety factors being used for Dead, Live and Wind loads is 1.2

Max moment = WxLx2 = 1.08 x 3.6 x 1.2
= **3.89 kNm**

Element W	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
F1: Loading from beam supporting glazed roof (page 51)					2.83	1.2	3.39
Total vertical loading on post:					2.83		3.39

For an effective length equal to 2L: Le = 7.2 m

Two posts are going to be used therefore F = W/2 = 1.70 kN

For a **152x89 UB16** section:

Pcy = 592 kN $\dfrac{F}{Pcy} =$ 0.00

Mb = 88.7 kNm $\dfrac{My}{Mb} =$ 0.04

$\dfrac{F}{Pc} + \dfrac{Mx}{Mb} =$ 0.003 + 0.04 = **0.05**

Less than 1 therefore OK.

Timber joists making up ground floor
(Ground)

Span : 4.2 m Modulus of Elasticity, E: 10800 N/mm² (C24)

Spacing : 400 mm c/c

Loading

Live 1.50 kN/m
Dead 0.61 kN/m

Other 0 kN/m

w = 2.11 kN/m

Maximum moment

M.max = $\frac{w.L^2}{8}$ = 4.66 kNm

Max allowable stress = 7.5 N/mm² x 1.1 Load sharing factor, K8

= 8.25 N/mm²

Max allowable deflection = 0.003 x 4200 mm = 13 mm

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 226 cm³ I.min = 2517 cm^4

Assuming the timbers have a width of: 50 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 165 mm or D.min = 182 mm

Use 50x200 (C24) timbers at 400c/c minimum

Steel post supporting side elevation beam
(Ground floor)

Height 3.4 m   Modulus of elasticity, E = 205 kN/mm²

Loading from beams:

F	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
F2: Loading from steel beam acting as beam lintel (page 60)					11.15		16.06
F1: Loading from beam supportingside elevation (page 56)					68.32		97.53
					79.47		113.60

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 1 L as beam is not subject to sway

Le: 3.40 m

Distance from centroid of beam, dx = 202 mm

Moment in post: Mx = F x dx

Moment in post: Mx = 113.6 x 0.202 = 22.9 kNm

For a 203 UC46 thick section:

Pcy = 1080 kN $\frac{F1}{Pcy}$ = 0.11

Mb = 118 kNm $\frac{My}{Mb}$ = 0.19

$\frac{F1}{Pcy} + \frac{Mx}{Mb} < 1$

0.11 + 0.19 = **0.30** **< 1**

Loading at the base = Post loading + self weight

Self weight (service) = 1.6 kN   Self weight (ultimate) = 2.2 kN

Loading at base (service) = 81.0 kN   Loading at base (ultimate) = 115.8 kN

Post is supported on masonry wall therefore :

Checking bearing stress on masonry

Allowable stress in masonry = 2.2 N/mm² (Assumed low strength masonry)

x concentrated load factor 1.5

/ material safety factor 3.5

0.94 N/mm²

Minimum bearing area required = $\frac{P}{\text{allow. Stress}}$ = $\frac{115786}{0.94}$ = 122803 mm²

440 x 330 bearing on brick has a area of: 145200 mm²

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Steel post in middle of building
(Ground floor)

Height 2.6 m Modulus of elasticity, E = 205 kN/mm²
Loading from beams:

F	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
F1: Loading from beam supporting stud wall in middle of building (page 52)					63.35		95.85
					63.35		95.85

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 1 L as beam is subject to sway
Le: 2.60 m

Distance from centroid of beam, dx = 202 mm

Moment in post: Mx = F x dx
Moment in post: Mx = 95.8 x 0.202 = 19.3 kNm

For a 203x133 UB25 thick section:

Pcy = 470.0 kN $\frac{F1}{Pcy}$ = 0.20

Mb = 46 kNm $\frac{My}{Mb}$ = 0.42

$$\frac{F1}{Pcx} + \frac{Mx}{Mb} < 1$$

0.20 + 0.42 = **0.62** **< 1**

Loading at the base = Post loading + self weight

Self weight (service) = 0.7 kN Self weight (ultimate) = 0.9 kN
Loading at base (service) = 64.0 kN Loading at base (ultimate) = 96.8 kN

Steel post near party wall
(Ground floor)

Height 3.2 m   Modulus of elasticity, E = 205 kN/mm²

Loading from beams:

F	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
F1: Loading from beam supporting rear elevation (page 58)					67.03		96.40
					67.03		96.40

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 1 L as beam is not subject to sway

Le: 3.20 m

Distance from centroid of beam, dx = 105 mm

Moment in post: Mx = F x dx

Moment in post: Mx = 96.4 x 0.105 = 10.1 kNm

For a 300x90 PFC41 thick section:

Pcy = 473 kN $\frac{F1}{Pcy}$ = 0.20

Mcy = 20.8 kNm $\frac{My}{Mcy}$ = 0.49

$$\frac{F1}{Pcy} + \frac{Mx}{Mcy} < 1$$

0.20 + 0.49 = **0.69 < 1**

Loading at the base = Post loading + self weight

Self weight (service) = 1.5 kN   Self weight (ultimate) = 2.1 kN

Loading at base (service) = 68.5 kN   Loading at base (ultimate) = 98.5 kN

Size mass concrete pad footing

Allowable bearing pressure, clay (Pmax): 100 kN/m²

Minimum area of footing req'd (85% capacity) = $\frac{loading}{Pmax}$ = $\frac{68.50}{85}$ = 0.81 m²

If the footing is square, the required width/length is: 0.81 m^2

w = sqrt (A) = 898 mm

Mass concrete pad footing 900mm wide/long minimum

Steel post embeded in new cavity wall
(Ground floor)

Height 3.2 m   Modulus of elasticity, E = 205 kN/mm²

Loading from beams:

F	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
F1: Loading from beam supporting rear elevation (page 58)					59.82		86.04
					59.82		86.04

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 2 L as beam is subject to sway

Le: 6.40 m

Distance from centroid of beam, dx = 202 mm

Moment in post: Mx = F x dx

Moment in post: Mx = 86.0 x 0.202 = 17.3 kNm

For a 254 UC89 thick section:

Pcy = 1270 kN $\frac{F1}{Pcy}$ = 0.07

Mb = 238 kNm $\frac{My}{Mb}$ = 0.07

$$\frac{F1}{Pcy} + \frac{Mx}{Mb} < 1$$

0.07 + 0.07 = **0.14 < 1**

Loading at the base = Post loading + self weight

Self weight (service) = 1.5 kN   Self weight (ultimate) = 2.1 kN

Loading at base (service) = 61.3 kN   Loading at base (ultimate) = 88.1 kN

Size mass concrete pad footing

Allowable bearing pressure, clay (Pmax): 100 kN/m²

Minimum area of footing req'd (85% capacity) = $\frac{loading}{Pmax} = \frac{61.30}{85}$ = 0.72 m²

If the footing is square, the required width/length is: 0.72 m^2

w = sqrt (A) = 849 mm

Mass concrete pad footing 900mm wide/long minimum

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Web http://www.formlondon.co.uk

Steel ground beam transferring eccentric loading from beam to padfooting (Ground floor)

Beam transfers the load from the steel post to the centre line of the utilised foundation.
Span, L = 450 mm

Element, W1	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
Loading from column (pg 58)					61.30		88.10
Self weight	0.50	1.00	0.50	0.46	0.23	1.4	0.32
					61.53		88.42

Beam is cantilevered.
Maximum moment = P x L = 88.42 x 0.450 = 40 kNm

Limiting deflection to $\frac{L}{360} = \frac{450}{360} =$ 1.3 mm

Ixx minimum required = $\frac{PL^3}{3Ed} = \frac{61.53 \times 450^3}{3 \times 205 \times 1.3}$

= 729 cm^4

A 152 UC30 section has:

Ixx = 1750 cm^4
Mb = 45 kNm
Thickness of web, t = 6.5 mm
Depth of section, D = 157.6 mm
Flange = 9.4 mm
Depth of web, Dw = 138.8 mm

Shear capacity, Pv = 0.6Py Av

Where: Py = 275 N/mm^2
Av = t x D = 1024.4 mm^2

Pv = 0.6 x Pv x Av
= 0.6 x 275 x 1024.4
= 169.03 kN

$\frac{Fv}{Pv} < 1$

Plastic modulus S = 248 cm^3

Plastic modulus of shear area Sv = $\frac{tDw^2}{4}$ = 31.31 cm^3

Generally:

Mc = Py (S - ρSv) however the beam is in high shear at the point of maximum moment and therefore the area resisting shear is completely ignored when considering the moment capacity of the section.

ρ is therefore taken as 1 (100% of the shear area is ignored when considering bending):

Mc = 275 (248 - (1.00 x 31.31))

= 59.59 kNm

Max moment < Moment capacity

39.8 kNm < 59.59 kNm Therefore ok

Note:
The web and compression (lower) flange are encased in concrete to prevent buckling effectively restraining the section.

Check steel post under wind loading

Height 3.20 m Modulus of Elasticity, E = 205 kN/mm²

Wind loading:

W1	Dimensions		Area	Loading- service		Loading- ultimate	
	a (m)	b (m)	A (m²)	kN/m²	kN	kN/m²	kN
Wind on side of building	1.60	4.65	7.44	0.5	3.72	1.2	4.46
Wind on top of building	3.00	3.50	10.50	0.5	5.25	1.2	6.30
					8.97		10.76

Limiting deflection to $= \frac{L}{360} = \frac{3200}{360} =$ 8.9 mm

Ixx minimum required $= \frac{W1.L^3}{3Ed} = \frac{8.97 \times 3200^3}{3 \times 205 \times 8.9}$

= 5377 cm^4

A 254 UC89 steel beam has Ixx = 14300 cm^4

Moment due to wind loading on post:

The safety factors being used for Dead, Live and Wind loads is 1.2

Max moment = WxLx2 = 8.97 x 3.2 x 1.2

= **28.70 kNm**

Element W	Dimensions		Area	Loading- service		Loading-ultimate	
	a (m)	b (m)	A (m²)	kN/m²	kN	FoS	kN
F1: Loading from beam supporting existing floor (page 41)					67.03	1.2	80.43

Total vertical loading on post: 67.03 80.43

For an effective length equal to 2L: Le = 6.4 m

For a 254 UC89 thick section:

Pcy = 1270 kN $\frac{F}{Pcy} =$ 0.06

Mb = 238 kNm $\frac{My}{Mb} =$ 0.12

$\frac{F}{Pc} + \frac{Mx}{Mb} = 0.063 + 0.12 =$ **0.18**

Less than 1 therefore OK.

Timber trimmer supporting stud wall
(Ground floor)

Span 4.2 m   Modulus of Elasticity, E = 7200 N/mm² (C24)
Stiffness factor K9: 1.21 (3 members)
8.71 kN/mm²

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading-service kN/m²	kN	Loading-ultimate kN/m²	kN
Stud wall	Dead	4.20	3.00	12.60	0.68	8.55	1.40	11.98
						8.55		11.98

Beam is simply supported:

Maximum moment = $\frac{WL}{8} = \frac{8.55 \times 4.2}{8}$ = **4.49 kNm**

Max allowable deflection = 0.003 x 4200 mm = 13 mm

Ixx minimum required = $\frac{5WL^3}{384Ed} = \frac{5 \times 8.55 \times 4200^3}{384 \times 8.71 \times 13}$

= **7518 cm^4**

Max allowable stress = 7.5 N/mm² x 1.1 (Form factor K7)

= 8.25 N/mm²

Using the equations:

Using Stress = $\frac{moment}{Z}$ and Deflection = $\frac{5.w.L^4}{384.E.I}$

minimum values for Z and I can be derived.

Z.min = $\frac{M}{max\ stress}$ and I.min = $\frac{5.w.L^4}{384.E.Dmax}$

Z.min = 544 cm³   I.min = 7518 cm^4

Assuming the timbers have a width of: 150 mm

Minimum depth required is:

D.min = root $\frac{6.Z}{w}$ or D.min = 3root $\frac{12.I}{w}$, whichever is greater

D.min = 148 mm or D.min = 182 mm

Use 3no. 50x200 (C24) timbers

Loading at supports = 4.28 kN

Steel post in middle of building
(Ground floor)

Height 2.6 m Modulus of elasticity, E = 205 kN/mm²

Loading from beams:

F	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
F1: Loading from beam supporting stud wall in middle of building (page 52)					63.35		95.85
					63.35		95.85

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 1 L as beam is not subject to sway

Le: 2.60 m

Distance from centroid of beam, dx = 105 mm

Moment in post: Mx = F x dx

Moment in post: Mx = 95.8 x 0.105 = 10.1 kNm

For a 260x90 PFC35 thick section:

Pcy = 512.0 kN $\frac{F1}{Pcy}$ = 0.19

Mcy = 18.6 kNm $\frac{My}{Mcy}$ = 0.54

$$\frac{F1}{Pcy} + \frac{Mx}{Mcy} < 1$$

0.19 + 0.54 = **0.73** **<** **1**

Loading at the base = Post loading + self weight

Self weight (service) = 0.7 kN Self weight (ultimate) = 0.9 kN

Loading at base (service) = 64.0 kN Loading at base (ultimate) = 96.8 kN

Steel beam supporting steel post in middle of building (Ground floor)

Span 4.10 m Modulus of Elasticity, E = 205 kN/mm²

Element W1		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Self weight	Dead	4.10	1.00	4.10	0.46	1.89	1.4	2.64
Floor loading	Live	4.10	4.35	17.84	1.50	26.75	1.6	42.80
	Dead				0.61	10.94	1.4	15.32
Length of load, a1= 4.1 m	Centroid, x1 = 2.05 m					39.58		60.76

Element W2	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from trimmer supporting stud wall (page 91)					4.28		5.99
Loading from steel post in middle of building (page 85)					64.00		96.76
Centroid, x2 = 3.50 m					68.28		102.74

Element P3	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading- ultimate FoS	kN
Loading from trimmer supporting stud wall (page 91)					4.28		5.99
Centroid, x3 = 3.8 m					4.28		5.99

Take moments from the support A, counter clockwise positive:

$$Rb \times L \quad -(W1xX1) \quad -(P2xX2) \quad -(P3xX3) \quad = \quad 0$$

$$Rb = \frac{(W1xX1) \quad +(P2xX2) \quad +(P3xX3)}{L}$$

$$Rb = \frac{124.56 \quad + \quad 359.61 \quad + \quad 22.76}{4.10}$$

Rb = 123.64 kN, ultimate

Ra = W1+P2+P3-Rb

Ra = 45.86 kN, ultimate

Ratio of ultimate to service loadings: $\frac{169.50}{112.13}$ = 1.51

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{60.76}{4.10} = 14.82 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

$$X = \frac{Ra}{w1} = \frac{45.86}{14.82} = 3.09 \text{ m from A}$$

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Max moment = X x Ra - $0.5X^2$ x w1
= 141.88 - 70.94
= **70.94 kNm, ultimate**

Max moment = 46.93 kNm, service

If the max moment where a UDL, the equivalent service loading would be:

$$W = \frac{8\,M}{L} = \frac{8 \times 46.93}{4.10} = 91.57 \text{ kN}$$

$$\text{Limiting deflection: } \frac{L}{360} = \frac{4100}{360} = 11.4 \text{ mm}$$

$$\text{Ixx minimum required} = \frac{5WL^3}{384Ed} = \frac{5 \times 91.57 \times 4100^3}{384 \times 205 \times 11}$$

$$= 3520 \text{ cm}^4$$

A 203 UC46 beam has :	Ixx =	**4570 cm^4**		
and	Mb =	111.0 kNm	for a Le =	4.00 m
	Mb =	99.2 kNm	for a Le =	5.00 m
	Mb =	**109.8 kNm**	**for a Le =**	**4.10 m**

Bearing pressure area required (Party wall)

For a strip width of: 7.8 m

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading - service kN/m²	kN	Loading - Ultimate FoS	kN
Masonry (215mm)	Dead	7.8	11.0	85.80	4.41	378.4	1.40	529.7
Masonry (440mm)	Dead	7.8	5.4	42.12	8.19	345.0	1.40	482.9
Loading from steel beam supporting pitched roof (page 14)						9.4		13.8
Loading from steel ridge beam (page 20)						15.5		22.7

Length of load, a1 = 7.8 m Centroid, x1 = 3.9 m 748.2 1049.3

Allowable bearing pressure, clay (Pmax): 100 kN/m²

The loading is spread over a mass concrete strip footing:

Minimum area of footing req'd $= \frac{\text{loading}}{\text{Pmax}} = \frac{748.22}{100} =$ 7.48 m²

If the footing is L = 7800 mm long, the required width w is equal to:

$w = \frac{A}{L} =$ 959 mm

Bearing pressure area required (Opposite Party wall)

For a strip width of: 9.4 m

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading - service kN/m²	kN	Loading - Ultimate FoS	kN
Masonry (215mm)	Dead	9.4	11.0	103.40	4.41	456.0	1.40	638.4
Masonry (440mm)	Dead	9.4	5.4	50.76	8.19	415.7	1.40	582.0
Loading from steel beam supporting pitched roof (page 14)						9.4		13.8
Loading from steel ridge beam (page 20)						21.8		32.0

Length of load, a1 = 9.4 m Centroid, x1 = 4.7 m 902.9 1266.3

Allowable bearing pressure, clay (Pmax): 100 kN/m²

The loading is spread over a mass concrete strip footing:

Minimum area of footing req'd $= \frac{\text{loading}}{\text{Pmax}} = \frac{902.94}{100} =$ 9.03 m²

If the footing is L = 9400 mm long, the required width w is equal to:

$w = \frac{A}{L} =$ 961 mm

RC basement slab

Span 5.6 m **Width** 1 m

Uplift force due to the water pressure:

Water 10 kN/m^3 x 0.7 m = 7 kN/m^2

Uplift force due to the soil pressure:

Clay 20 kN/m^3 x 1.8 m = 36 kN/m^3

Element, W1		Dimensions a (m)	b (m)	Area A (m²)	Loading kN/m²	kN	Loading-ultimate FoS	kN
Bearing pressure from party wall causing bending in the slab						-79.6		-111.6
(loading from page 101 divided by length of wall i.e. 9.4m)								
Length of load, a1 = 1.00 m	Centroid, x1 = 0.50 m					-79.6		-111.6

Element, W2		Dimensions a (m)	b (m)	Area A (m²)	Loading kN/m²	kN	Loading-ultimate FoS	kN
Bearing pressure from wall opposite to party wall causing bending in the slat						-96.1		-134.7
(loading from page 102 divided by length of wall i.e. 9.4m)								
Length of load, a2 = 1.00 m	Centroid, x2 = 5.10 m					-96.1		-134.7

Element, W3		Dimensions a (m)	b (m)	Area A (m²)	Loading kN/m²	kN	Loading-ultimate FoS	kN
Sub-Basement	Live	5.6	1.0	5.60	1.5	8.4	0.0	0.0
	Dead				8.2	46.0	0.9	41.4
Water pressure	Dead	5.6	1.0	5.60	-7.0	-39.2	1.0	-39.2
Soil pressure	Dead	3.5	1.0	3.50	-36.0	-126.0	1.0	-126.0
Length of load, a3 = 5.60 m	Centroid, x3 = 2.80 m					-110.8		-123.8

Take moments from the support A, counter clockwise positive:

Rb x L -(W1xX1) -(W2xX2) -(W3xX3) = 0

$$Rb = \frac{(W1xX1) + (W2xX2) + (W3xX3)}{L}$$

$$Rb = \frac{-55.81 + -687.03 + -346.56}{5.6}$$

Rb = -194.54 kN, ultimate

Ra = W1+W2+W3-Rb

Ra = -175.57 kN, ultimate

Loading per meter run close to A is equal to:

$$w1 = \frac{W1}{a1} = \frac{-111.62}{1.00} = -111.62 \text{ kN/m}$$

$$w2 = \frac{W2}{a2} = \frac{-134.71}{1.00} = -134.71 \text{ kN/m}$$

$$w3 = \frac{W3}{a3} = \frac{-123.77}{5.60} = -22.10 \text{ kN/m}$$

Max moment occurs where shear equals 0. Shear equals 0 at

$$X = \frac{Ra - W1}{w3} = \frac{-63.95}{-22.10} = 2.89 \text{ m from A}$$

Max moment = X x Ra - 0.5X² x w3 - (X-0.5a1) x W1

= -507.97 - -92.51 - -267.14

= **-148.3 kNm, ultimate**

Area of steel required:

Slab width =	1000	mm
Slab depth =	250	mm
Link dia: =	8	mm
Bar dia: =	12	mm
Cover: =	65	mm
Fcu =	35	N/mm²
Fy =	500	N/mm²

Effective depth (d'): 171 mm

$$k = \frac{M}{b.d'^2.Fcu} = \frac{148.3 \times 10^3 \times 10^3}{1000 \times 29241 \times 35}$$

= 0.145

z/d = 0.80 (has to be lower than 0.95)

$$As\ req = \frac{M}{.87.n.Fy.d} = \frac{148.3 \times 10^3 \times 10^3}{0.87 \times 0.80 \times 500 \times 171}$$

= 2498 mm²

10	number	12	mm bars have an area of:	1131	mm²
5	number	20	mm bars have an area of:	1571	mm²
			TOTAL	2702	mm²

Steel post in middle of basement

Height 2.8 m Modulus of elasticity, E = 205 kN/mm²

Element F		Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
Loading from steel beam supporting terrace floor (page 11)						81.80		123.64
Ground floor	Live	0.55	4.40	2.42	1.50	3.63	1.6	5.81
	Dead				0.61	1.48	1.4	2.08
						86.91		131.53

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 1 L as post is not subject to sway
Le: 2.80 m

Distance from centroid of beam, dx = 202 mm

Moment in post: Mx = F x dx
Moment in post: Mx = 131.5 x 0.202 = 26.5 kNm

For a 203 UC46 section:

Pcy = 1200 kN $\frac{F1}{Pcy}$ = 0.11

Mb = 125 kNm $\frac{My}{Mb}$ = 0.21

$$\frac{F1}{Pcx} + \frac{Mx}{Mb} < 1$$

0.11 + 0.21 = **0.32** **<** **1**

Loading at the base = Post loading + self weight

Self weight (service) = 1.3 kN Self weight (ultimate) = 1.8 kN
Loading at base (service) = 88.2 kN Loading at base (ultimate) = 133.3 kN

Size mass concrete pad footing

Allowable bearing pressure, clay (Pmax): 100 kN/m²

Minimum area of footing req'd = $\frac{loading}{Pmax}$ = $\frac{88.20}{100}$ = 0.88 m²

If the footing is square, the required width/length is: 0.88 m^2

w = sqrt (A) = 939 mm

Mass concrete pad footing 950mm wide/long minimum

Designing the reinforcement in padfooting

Span = 0.475 m

Element, W1	Dimensions a (m)	b (m)	Area A (m²)	Loading kN/m²	kN	Loading-ultimate FoS	kN
Loading from steel post (page 105)					44.1		66.7
					44.1		66.7

Beam is canitlevered

Maximum moment = $\frac{W \times L}{2}$ = $\frac{66.67 \times 0.475}{2}$ = **15.8 kNm**

Loading at support = 0.5 x W = 0.5 x 66.7 = 33.3 kN

Area of steel required:

Beam width =	475 mm	Cover:	=	40 mm	
Beam depth =	500 mm	F_{ck}	=	40 N/mm²	
Link dia: =	8 mm	F_y	=	500 N/mm²	
Bar dia: =	6 mm	Partial material safety factor, γ_s		=	1.15
		F_{yd}	=	$F_y \times \gamma_s$	
Effective depth (d'):	449 mm		=	435 N/mm²	

$$k = \frac{M}{b.d'^2.F_{ck}}$$

$$= \frac{15.8 \times 10^3 \times 10^3}{475 \times 201601 \times 40}$$

$$= 0.0041$$

z/d = 0.95 (has to be lower than 0.95)

$$A_{s\,req} = \frac{M}{F_{yd}z} = \frac{15.8 \times 10^3 \times 10^3}{0.95 \times 435 \times 449}$$

$$= 85 \text{ mm}^2$$

5 number 6 mm bars have an area of: 141 mm²

Use A142 mesh at bottom of footing

Check retaining wall for wall opposite party wall
(Lower Ground floor)

Height of wall (H) =	2.2 m	Soil type	clay		
Factor of safety (Permanent) :	1.6	Weight of soil (Ws)	20	kN/m²	(undrained)
Factor of safety (Temporary) :	1.0	Angle of friction (θ)	20	°	
F. of safety (stabilising loads) :	0.9	Pad footing width	1.3	m	
		Pad footing depth	0.5	m	

Height of water from
base of retaining wall, Hw = 0.70 m

Surcharge (W) = 1.50 kN/m² (domestic)

(active pressure)
Ka = tan (45 - θ/2)² = 0.49

(passive pressure)
Kp = 1/Ka = 2.04

PERMANENT CONDITION

Failure by overturning : In final condition the reinforcement to be tied into slab therefore retaining wall will not overturn

Failure by sliding : In final condition the reinforcement to be tied into slab therefore retaining wall will not slide

TEMPORARY CONDITION

Surcharge Pressure (ultimate):

Ps =	ka	x	W	x	FoS	x	H
Ps =	0.49	x	1.50	x	1.0	x	2.2
Ps =	1.62 kN/m						

Soil Pressure (ultimate):

Pg = 0.5 x Ka x Ws x H
= 0.00 kN/m at 0.00 m
= 10.79 kN/m at 2.20 m

Pressure from water (ultimate)

Pw = 10(Hw) = 7.00 kN/m at 2.20 m

The retaining wall is cantilevered

Maximum moment

Maximum moment will be at the base of the retaining wall

Height:	2.2 m	Ps:	1.62 kN/m
Hw :	0.70 m	Pw:	7.0 kN/m max
		Pg:	10.79 kN/m

Mmax = (Ps x H x 0.5 H) + (Pg x 0.5H x (1/3)H) + (Pw x 0.5Hw x (1/3)Hw)
Mmax = 3.9 + 8.7 + 0.6
Mmax = 13.2 kNm (overturning moment)

Rb: reaction at the base

Take moments about its head to determine the horizontal force at its base. Clockwise positive

0	=	(Rb x H) - (Ps x H x 0.5 H) - (Pg x 0.5H x (2/3)H) - (Pw x 0.5Hw x (H - (1/3)Hw)
(Rb x H)	=	(Ps x H x 0.5 H) + (Pg x H x H/3) + (Pw x 0.5Hw x (H - 1/3Hw)
Rb x H	=	3.92 + 17.40 + 4.82
Rb x H	=	26.14

Rb = 11.88 kN (sliding force)

The proposed wall is = 300 mm = 0.300 m thick

Section modulus of a retaining wall:

$$Z = \frac{bd^2}{6} = \frac{1000 \times 300^2}{6} = 15000 \text{ cm}^3$$

Maximum stress in concrete, from bending = M/Z

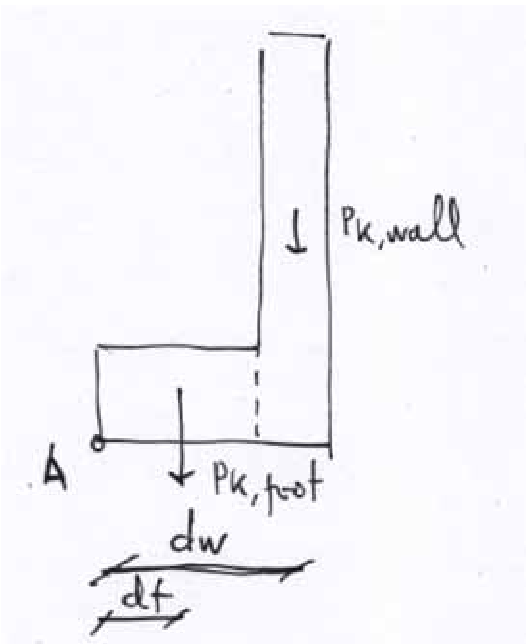
$$\text{Stress} = \frac{3915}{15000} = 0.26 \text{ N/mm}^2$$

Failure by overturning :

Overturning moment = Max moment at base of retaining wall
= 13.2 kNm (from above)

Stabilising moment

Loadings scheme



d_w distance from center of gravity of the wall to the point A (point of the rotation)

d_f distance from center of gravity of the footing to the point A (point of the rotation)

self-weight of wall	$P_{k,wall}$=	16	kN
self-weight of footing	$P_{k,foot}$=	16	kN

moment generated by existing masonry and retaining wall's self-weight:

$M_{stab,wall}$= fs x $P_{k,wall}$ x d_w

$M_{stab,wall}$= 0.9 x 15.84 x 1.150 = 16.39 kNm

moment generated by footing's self-weight:

$M_{stab,foot}$= fs x $P_{k,foot}$ x d_f

$M_{stab,foot}$= 0.9 x 15.60 x 0.65 = 9.13 kNm

M_{stab} = $M_{stab,wall}$ + $M_{stab,foot}$ = 25.5 kNm

M_{stab}= 25.5 kNm	>	M_{rcb}= 13.2 kNm

Factor of safety : = $\frac{M_{stab}}{M_{rcb}}$ = $\frac{25.52}{13.19}$ = 1.94

Therefore is OK

Failure by sliding :

Sliding force (from previous page) = F_{slide} = Rb = 11.88 kN/m

Resistance force

Soil Pressure (ultimate):

P_p = 0.5 x K_p x Ws x H

= 0.00 kN/m	at	0.00	m	where:	Kp =	2.04
= 10.20 kN/m	at	0.50	m		Ws =	20

Ground floor friction factor= tg (θ) = 0.3 (Concrete on clay)

$F_{stab, wall}$	=	0.9	x	15.84	x	0.30	=	4.28 kN/m
$F_{stab, foot}$	=	0.9	x	15.60	x	0.30	=	4.21 kN/m
$F_{stab, ground}$	=	1.0	x	10.20	x	0.30	=	3.06 kN/m
$F_{stab, soil}$	=	10.20 kN/m						

F_{resist} = $F_{stab, wall}$ + $F_{stab, foot}$ + $F_{stab, ground}$ + $F_{stab, soil in rest}$

F_{resist} = 4.28 + 4.21 + 3.06 + 10.20

F_{resist} = 21.75 kN/m

F_{resist} = 21.75 kN/m	>	F_{slide} = 11.88 kN/m

Factor of safety : = $\frac{F_{resist}}{F_{slide}}$ = $\frac{21.75}{11.88}$ = 1.83

Area of steel required:

Link dia: 8 mm
Bar dia: 8 mm
Fcu 35 N/mm²
Fy 500 N/mm²

Cover: 65 mm

Effective depth (d'): 223 mm

$$k = \frac{M}{b.d'^2.Fcu} = \frac{13.19 \times 10^3 \times 10^3}{1000 \times 49729 \times 35}$$

$$= 0.008$$

$$z/d = 0.95$$

$$As\ req = \frac{M}{.87.n.Fy.d} = \frac{13.19 \times 10^3 \times 10^3}{0.87 \times 0.95 \times 500 \times 223}$$

$$= 143\ \text{mm}^2$$

5 number 8 mm bars have an area of: 251 mm²

Use A252 mesh

Check span to effective depth ratio

$$\frac{span}{d'} = \frac{2200}{223} = 9.9$$

Service stress in tension reinforcement

$$fs = \frac{2fyAsreq}{3As\ prov} = \frac{2 \times 500 \times 143}{3 \times 251} = 190$$

$$\frac{M}{bd^2} = \frac{13.2}{49729} = 0.3$$

Modification factor, F2 = 2

$$\frac{100As}{bd} = \frac{100 \times 143}{1000 \times 223} = 0.06$$

Modification factor, F3 = 1

Allowable ratio: 7 (cantilevered) x 2 x 1 = 14.0

Steel post in next to wall opposite basement

Height 2.8 m Modulus of elasticity, E = 205 kN/mm²

Element F	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
Loading from steel beam supporting terrace floor (page 92)					64.02		96.79
Loading from steel beam supporting terrace floor (page 93)					30.34		45.86
					94.36		142.65

Post has main beam fixed into its side. Assume loading occurs 100mm from the outside edge to determine a notional applied moment. Le is equal to: 1 L as post is not subject to sway

Le: 2.80 m

Distance from centroid of beam, dx = 202 mm

Moment in post: Mx = F x dx
Moment in post: Mx = 142.6 x 0.202 = 28.7 kNm

For a 203 UC46 section:

Pcy = 1200 kN $\frac{F1}{Pcy}$ = 0.12

Mb = 125 kNm $\frac{My}{Mb}$ = 0.23

$$\frac{F1}{Pcx} + \frac{Mx}{Mb} < 1$$

0.12 + 0.23 = **0.35 < 1**

Loading at the base = Post loading + self weight

Self weight (service) = 1.3 kN Self weight (ultimate) = 1.8 kN
Loading at base (service) = 95.6 kN Loading at base (ultimate) = 144.5 kN

Size mass concrete pad footing

Allowable bearing pressure, clay (Pmax): 100 kN/m²

Minimum area of footing req'd = $\frac{loading}{Pmax}$ = $\frac{95.65}{100}$ = 0.96 m²

If the footing is square, the required width/length is: 0.96 m^2

w = sqrt (A) = 978 mm

Mass concrete pad footing 1000mm wide/long minimum

Form London Limited
Webheath Workshops, 235 Netherwood St, NW6 2JX, London
Tel 020 7284 2613
Email enquiries@formlondon.co.uk
Web http://www.formlondon.co.uk

Steel ground beam transferring eccentric loading from beam to padfooting (Ground floor)

Beam transfers the load from the steel post to the centre line of the utilised foundation.
Span, L = 1000 mm

Element, W1	Dimensions a (m)	b (m)	Area A (m²)	Loading- service kN/m²	kN	Loading-ultimate FoS	kN
Loading from column (pg 111)					95.65		144.45
Self weight	1.00	1.00	1.00	0.46	0.46	1.4	0.64
					96.11		145.10

Beam is cantilevered.
Maximum moment = P x L = 145.10 x 1.000 = 145 kNm

Limiting deflection to $\frac{L}{360} = \frac{1000}{360}$ = 2.8 mm

Ixx minimum required = $\frac{PL^3}{3Ed} = \frac{96.11 \times 1000^3}{3 \times 205 \times 2.8}$

= 5626 cm^4

A 305x165 UB46 section has:
Ixx = 9900 cm^4
Mb = 233 kNm
Thickness of web, t = 6.7 mm
Depth of section, D = 306.6 mm
Flange = 11.8 mm
Depth of web, Dw = 283 mm

Shear capacity, Pv = 0.6Py Av

Where: Py = 275 N/mm^2
Av = t x D = 2054.22 mm^2

Pv = 0.6 x Pv x Av
= 0.6 x 275 x 2054.22
= 338.95 kN

$\frac{Fv}{Pv} < 1$

Plastic modulus S = 720 cm^3

Plastic modulus of shear area Sv = $\frac{tDw^2}{4}$ = 134.15 cm^3

Generally:

Mc = Py (S - ρSv) however the beam is in high shear at the point of maximum moment and therefore the area resisting shear is completely ignored when considering the moment capacity of the section.

ρ is therefore taken as 1 (100% of the shear area is ignored when considering bending):

Mc = 275 (720 - (1.00 x 134.15))

= 161.11 kNm

Max moment < Moment capacity

145.1 kNm < 161.11 kNm Therefore ok

Note:
The web and compression (lower) flange are encased in concrete to prevent buckling effectively restraining the section.

Bearing pressure area required on rear wall

For a strip width of: 5.2 m

Element W		Dimensions a (m)	b (m)	Area A (m²)	Loading - service kN/m²	kN	Loading - Ultimate FoS	kN
Masonry (215mm)	Dead	5.2	8.0	41.60	4.41	183.5	1.4	256.8
Masonry (440mm)	Dead	5.2	5.4	28.08	8.19	230.0	1.4	322.0
Loading from pitched steel beam supporting dormer cheek (page 17)						5.3		7.7
Loading from pitched steel beam supporting dormer cheek (page 17)						5.3		7.7
Loading from steel post supporting side elevation beam (page 84)						81.0		115.8
Ground floor	Live	5.20	2.10	10.92	1.50	16.38	1.6	26.21
	Dead				0.61	6.70	1.4	9.38
1st floor	Live	5.20	2.10	10.92	1.50	16.38	1.6	26.21
	Dead				0.61	6.70	1.4	9.38
2nd floor	Live	5.20	2.10	10.92	1.50	16.38	1.6	26.21
	Dead				0.61	6.70	1.4	9.38
Loft floor	Live	5.20	2.10	10.92	1.50	16.38	1.6	26.21
	Dead				0.61	6.70	1.4	9.38
Pitched roof	Live	1.70	1.15	1.96	0.60	1.17	1.6	1.88
	Dead				0.84	1.64	1.4	2.29
Dormer wall	Dead	2.80	2.40	6.72	0.86	5.77	1.4	8.08
Partion allowance	Dead	8.60	2.40	20.64	0.68	14.01	1.4	19.62

Length of load, a1 = 5.2 m Centroid, x1 = 2.6 m — 620.0 — 884.2

Allowable bearing pressure, clay (Pmax): 100 kN/m²

The loading is spread over a mass concrete strip footing:

Minimum area of footing req'd $= \frac{\text{loading}}{\text{Pmax}} = \frac{619.98}{100} =$ 6.20 m²

If the footing is L = 5200 mm long, the required width w is equal to:

$w = \frac{A}{L} =$ 1192 mm