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Structural Calculations for Kitchen Remodelling

St Catherine's New North Road Exeter

Marco Christoforou & Lisa Wood

Project ST CATHERINES
NEW NORTH ROAD EXETER

Project No. 20.07.051 Page 01

Date FEB'20. By PS. Chk

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DESIGN PHILOSOPHY

The proposals for the renovation of St Catherines include the removal of a load bearing wall in the kitchen.

The kitchen and dining room are bounded by walls giving a floor area less than 70m², hence adequate by inspection to Part A of the Building Regulations.

Beam 1 will support a first floor wall floor and conservatively some roof loading is included.

Existing block strengths are assumed to be at least 5N/mm². as the wall to Bed 4 arches between walls and there is no apparent distress.

Beam 2 has been added as a precautionary measure as currently there is no beam provided.

KEY

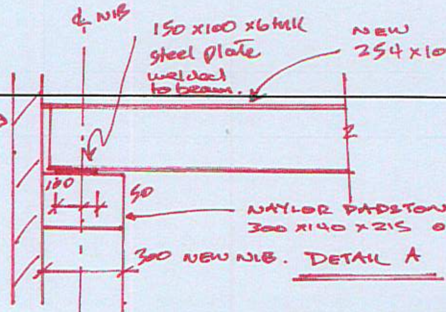
Existing Walls Retained

Existing Demolished

Thermalite Block-work

Sound insulated Stud-work with plywood board for rigidity

Indicative Lintels/Steels/Beams to be in accordance with Structural Engineers Design & Specification



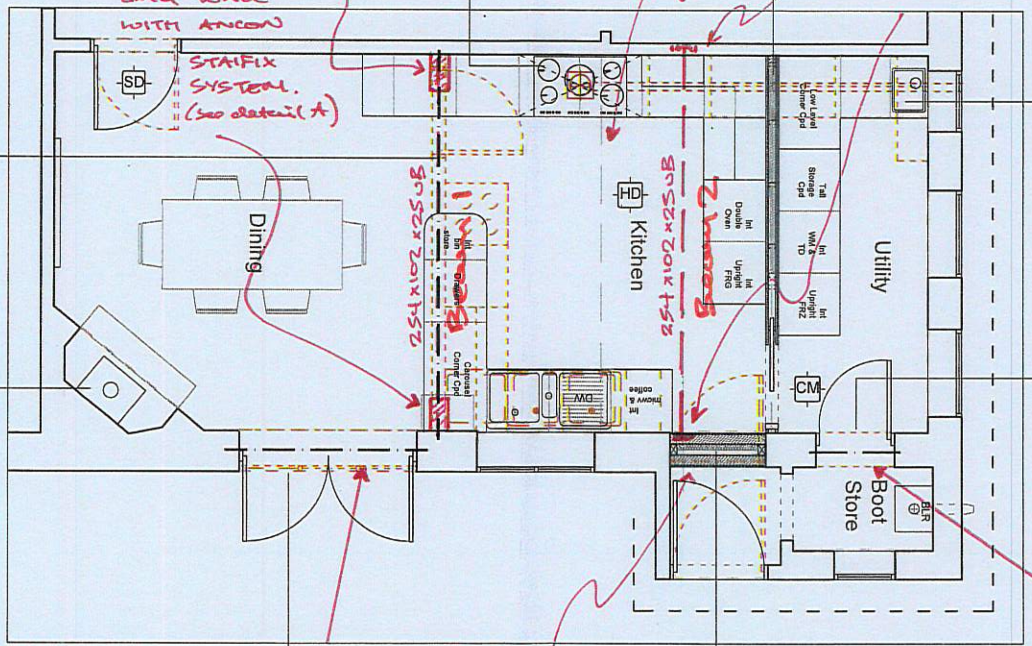
Cooker hood mechanical extract fan 60l/sec with 15min overrun ducted above ceiling (bewteen joists) via100mm duct and condensation trap to external air through proprietary grille on side elevation.

133mm overall thickness comprising 70mm Gyproc metal studs at 600mm centres max with 1 layer 19mm plywood board each side for rigidity, 1 layers 12.5 mm soundbloc board each side plus 2 x 25mm Isowool 1200 in cavity. Finish 5mm smooth plaster skim finish decorated to a professional standard to clients specification.

REMOVE EXTG TIMBER JOIST PRIOR TO REMOVAL REPORT JOIST SIZE AND SPACING TO ENGINEER. DETERMINE THAT JOISTS SPAN BETWEEN NEW BEAMS

NEW 300 x 140 BLOCKWORK NIB 10 N/mm² DENSE BLOCKS TIED TO EXTG WALL WITH ANCON STAIFIX SYSTEM. (see detail A)

NAYLOR PADSTONE 450 x 215 x 100 O.S.A.



Existing internal wall to be demolished; new steel to be provided within ceiling depth in accordance with structural engineers, design, specification and calculations.

Multi-fuel wood-burning stove to comply with Approved Document L, incorporating rear flue to external wall. Specific details to be provided once specified by client be installed by someone deemed competent to do so under the terms of Approved Document J. A commissioning certificate will be provided for the burner. Appropriate ventilation to be provided as necessary.

New sink in utility room to be connected, through external wall, to existing combined drain in accordance with structural engineers drainage design and specification.

New opening in external wall to incorporate an external rear door, Uvalue not to exceed 1.6 W/m2K. Lintel over to structural engineers design, specification and calculations.

2NO. NAYLOR P100 PC LINTEL O.S.A.

CHECK EXTG LINTEL CONDITION

NEW 7N/mm² BLOCKWORK BONDED TO EXISTING

New double glazed external patio doors, in existing window opening, Uvalue not to exceed 1.6 W/m2K. Lintel over to structural engineers design, specification and calculations.

Existing door opening in external wall to be infilled with:- partial fill insulation block-work cavity wall to comprise 100mm block-work 50mm clear cavity. 50mm partial fill Kingspan Kooltherm K8 Cavity Board,100mm thermal block-work inner leaf. To incorporate cavity closures. Finish both sides with 2 coats smooth Gypsum plaster, & decorated to a professional finish, to clients specification. Wall construction to incorporate stainless steel (non-corrosive), insulated, twist wall ties, to be at least 250mm long and in accordance with BS EN 1996-1-1 and BS EN 1996-2.

SD	Mains operated interlinked Smoke Detectors
HD	Mains operated interlinked Heat Detectors
CM	Carbon Monoxide Detectors

NOTES:

TO BE READ IN CONJUNCTION WITH STRUCTURAL ENGINEERS DETAILS AND SPECIFICATION. WHERE A CONFLICT OF INFORMATION OCCURS, ENGINEERS DETAILS TO TAKE PRECEDENT.

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Existing Building at:
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Marco Christoforou & Lisa Wood

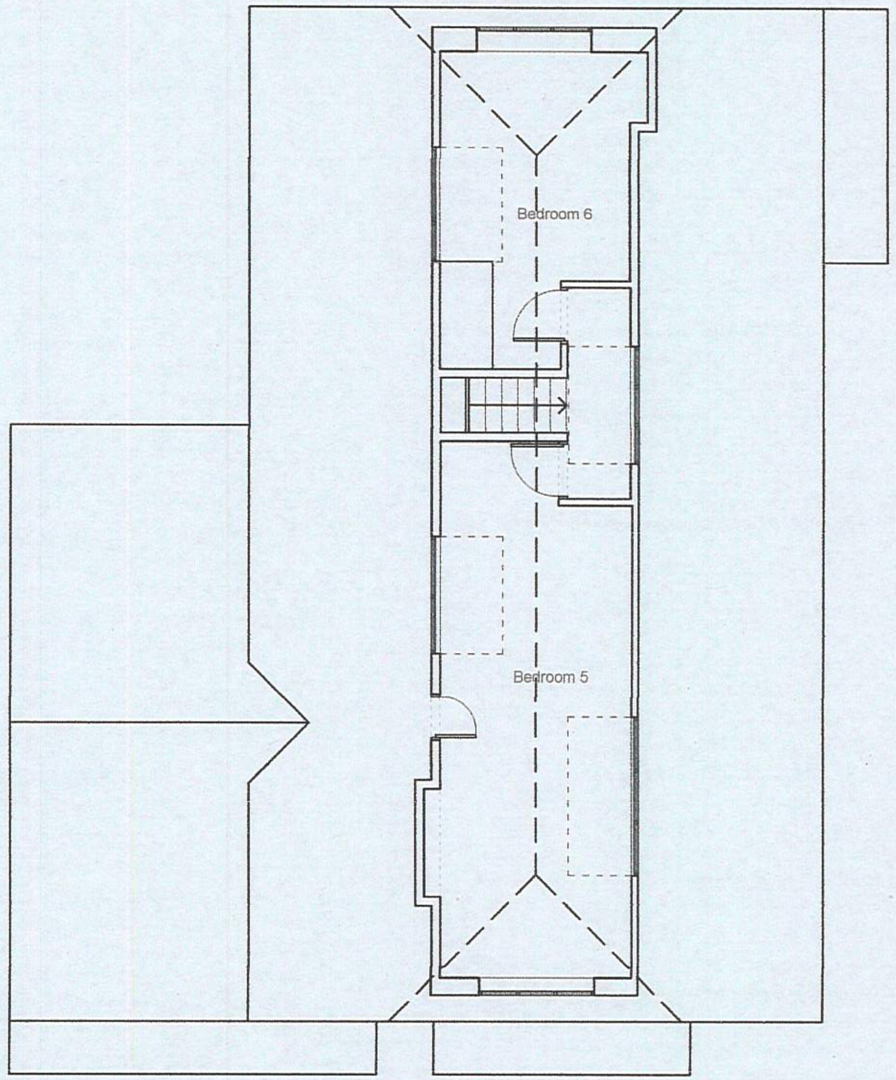
Proposed Building Regulation Kitchen Plan

No	Revision	Date

02

Job No: 19 - 005

Scale: 1 : 50 @ A3	Drawn by: RH
Date: February 2020	Drwg No: K_10.01



By email 13/2/20
From
Mr Christoforou

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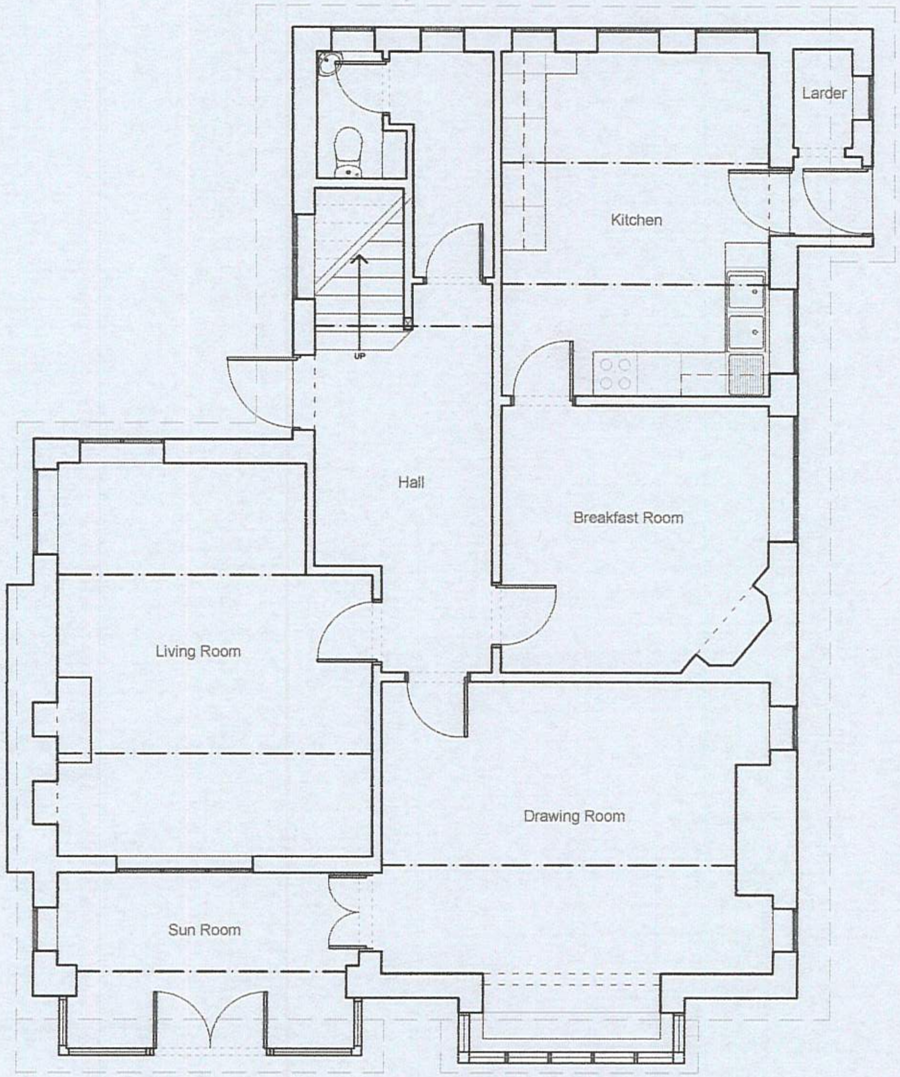
Existing
Second Floor Plan

No	Revision	Date

Job No: 19 - 005

Scale: 1 : 50 @ A2 | Drawn by: RH
Date: December 2019 | Drwg No: MS_10:02



By hand 13/2/20
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03

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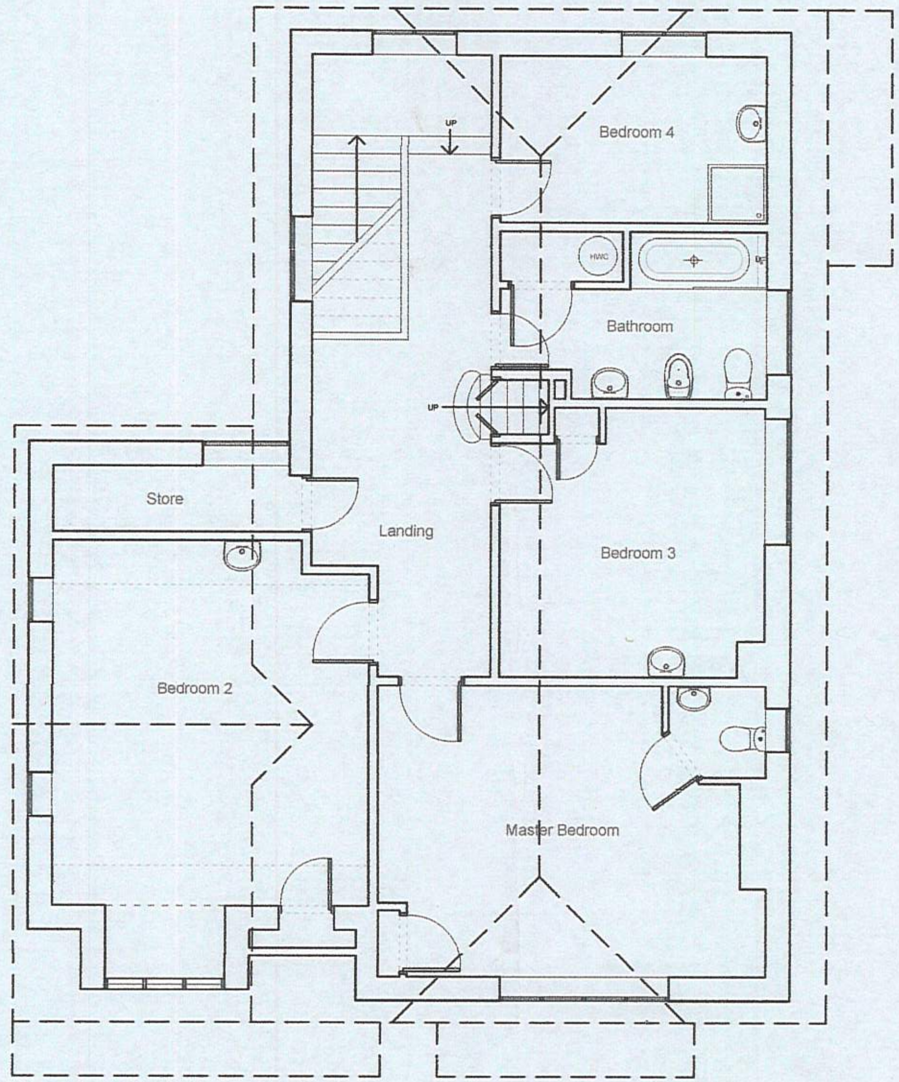
Existing Ground Floor Plan

No	Revision	Date

Job No: 19 - 005

Scale: 1 : 50 @ A2	Drawn by: RH
Date: December 2019	Dwg No: MS_10.00



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Existing First Floor Plan

No	Revision	Date

Job No: 19 - 005

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FIRST FLOOR LOADINGS

Timber boards on joists with ceiling and services

Timber boarding	=	0.07
Joists (150 x 50 @ 450 c/c)	=	0.13
Services	=	0.10
Ceiling (plasterboard)	=	0.13
		0.42 kN/m²

FIRST FLOOR BATHROOM / BED 3 MASONRY WALL

Brick	=	110 x 0.021	=	2.31
Plaster	=	2 x 0.22	=	0.44
				2.75 kN/m²

Assume 2.8m high wall.

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ROOF LOADINGS

Concrete tiles	0.55	
Battens	0.05	
Felt	0.11	
Sheeting	0.05	
Rafters	0.07	(125 x 50 @ 600 c/c)
	0.83 kN/m²	

Roof pitch 45°.

Imposed snow load = 0.60 kN/m².

CEILING LOADINGS.

Plasterboard	0.13	
Joists	0.06	(100 x 50 @ 600 c/c)
Services	0.10	
Insulation	0.06	
	0.35 kN/m²	

Imposed 1.5 kN/m² bedrooms
0.25 kN/m² general.

TIMBER STUD WALLS - 2.5 kN/m²

Project St Catherines
New North Road Exeter

Project No. 20.02.051 Page 08

Date FEB'20 By PS. Chk

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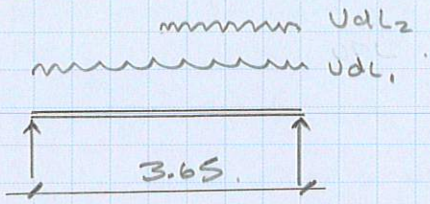
BEAM LOADINGS.



Udl1 – Floor & wall.

Udl2 – Roof load.

Udl1

				KN/M.
FLOOR, permanent dead	=	$0.42\,KN/m^2 \times 3.5$	=	1.47
WALL, permanent dead	=	$2.75\,KN/m^2 \times 2.8$	=	7.70
CEILING, dead	=	$0.35\,KN/m^2 \times 3.5$	=	1.23
				10.40
FLOOR, imposed	=	$1.5\,KN/m^2 \times 3.5$	=	5.25
CEILING, imposed	=	$0.25\,KN/m^2 \times 3.5$	=	0.88
				6.13

Udl2

ROOF, dead	=	$0.83/\cos 45 \times 3.5$	=	4.11
ROOF, imposed	=	$0.60/\cos 45 \times 3.5$	=	2.97

See TEDDS output for Beam design.

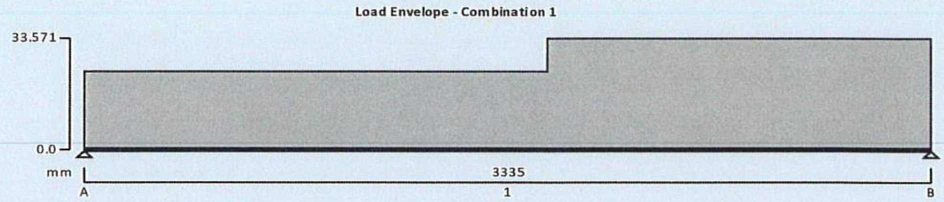
Use **254 x 102 x 25 UB** for Beam 1 and 2.

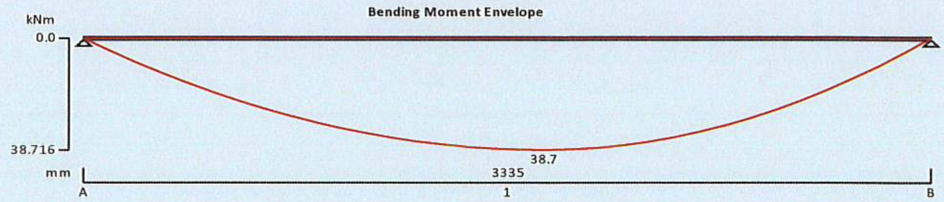
Sands Consultants	Project			Job no.	
	St Catherines, New North Road, Exeter			20.02.051	
	Calcs for			Start page no./Revision	
	Beams over Kitchen			~~8~~ 09	
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	PS	05/03/2020	JCL	05/03/2020		

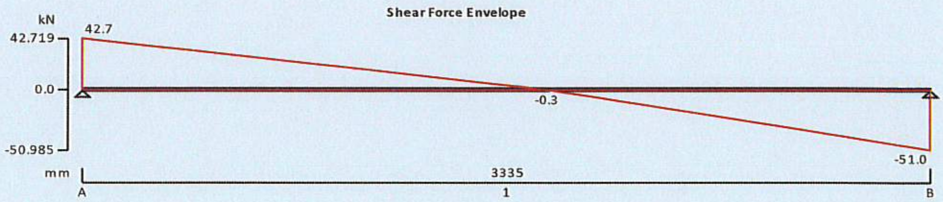
STEEL BEAM ANALYSIS & DESIGN (EN1993-1-1:2005)

In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex

TEDDS calculation version 3.0.14







Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads	Permanent self weight of beam × 1
	Permanent full UDL 10.4 kN/m
	Permanent partial UDL 4.11 kN/m from 1825 mm to 3650 mm
	Variable full UDL 6.13 kN/m
	Variable partial UDL 2.97 kN/m from 1825 mm to 3650 mm

Load combinations

Load combination 1 - Dead plus Imposed	Support A	Permanent × 1.35
		Variable × 1.50
		Permanent × 1.35
		Variable × 1.50

Sands Consultants	Project St Catherines, New North Road, Exeter			Job no. 20.02.051	
	Calcs for Beams over Kitchen			Start page no./Revision 10	
	Calcs by PS	Calcs date 05/03/2020	Checked by JCL	Checked date 05/03/2020	Approved by	Approved date

Support B — Permanent × 1.35, Variable × 1.50

Analysis results

Maximum moment	M_{max} = **38.7** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **42.7** kN	V_{min} = **-51** kN
Deflection	δ_{max} = **4.4** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **42.7** kN	R_{A_min} = **42.7** kN
Unfactored permanent load reaction at support A	$R_{A\_Permanent}$ = **19.2** kN	
Unfactored variable load reaction at support A	$R_{A\_Variable}$ = **11.2** kN	
Maximum reaction at support B	R_{B_max} = **51** kN	R_{B_min} = **51** kN
Unfactored permanent load reaction at support B	$R_{B\_Permanent}$ = **22.6** kN	
Unfactored variable load reaction at support B	$R_{B\_Variable}$ = **13.7** kN	

Section details

Section type — **UB 254x102x25 (BS4-1)**

Steel grade — **S355**

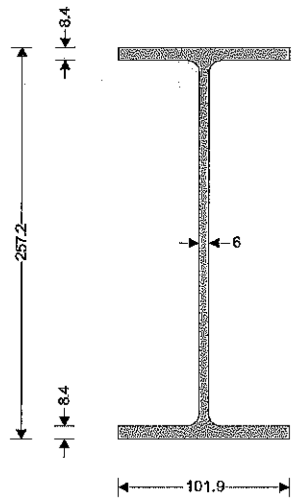
EN 10025-2:2004 - Hot rolled products of structural steels

Nominal thickness of element — $t = \max(t_f, t_w)$ = **8.4** mm

Nominal yield strength — f_y = **355** N/mm^2

Nominal ultimate tensile strength — f_u = **470** N/mm^2

Modulus of elasticity — E = **210000** N/mm^2



Partial factors - Section 6.1

Resistance of cross-sections — γ_{M0} = **1.00**

Resistance of members to instability — γ_{M1} = **1.00**

Resistance of tensile members to fracture — γ_{M2} = **1.10**

Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis — K_y = **1.000**

Effective length factor in minor axis — K_z = **1.000**

Effective length factor for torsion — $K_{LT.A}$ = **1.200** + 2 × h

$K_{LT,B}$ = **1.000**

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]}$ = **0.81**

Internal compression parts subject to bending - Table 5.2 (sheet 1 of 3)

Width of section — $c = d$ = **225.2** mm

$c / t_w = 46.1 \times \varepsilon <= 72 \times \varepsilon$ — Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section — $c = (b - t_w - 2 \times r) / 2$ = **40.3** mm

$c / t_f = 5.9 \times \varepsilon <= 9 \times \varepsilon$ — Class 1

Section is class 1

Check shear - Section 6.2.6

Height of web — $h_w = h - 2 \times t_f$ = **240.4** mm

Shear area factor — η = **1.000**

$h_w / t_w < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force — $V_{Ed} = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **51** kN

Shear area - cl 6.2.6(3) — $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w)$ = **1670** mm^2

Design shear resistance - cl 6.2.6(2) — $V_{c,Rd} = V_{pl,Rd} = A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0}$ = **342.3** kN

PASS - Design shear resistance exceeds design shear force

Check bending moment major (y-y) axis - Section 6.2.5

Design bending moment — $M_{Ed} = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min}))$ = **38.7** kNm

Design bending resistance moment - eq 6.13 — $M_{c,Rd} = M_{pl,Rd} = W_{pl,y} \times f_y / \gamma_{M0}$ = **108.5** kNm

Slenderness ratio for lateral torsional buckling

Correction factor - Table 6.6 — k_c = **0.94**

$C_1 = 1 / k_c^2$ = **1.132**

Curvature factor — $g = \sqrt{[1 - (I_z / I_y)]}$ = **0.978**

Poissons ratio — ν = **0.3**

Shear modulus — $G = E / [2 \times (1 + \nu)]$ = **80769** N/mm^2

Unrestrained length — $L = (1.2 \times L_{s1} + 2 \times h + 1.0 \times L_{s1}) / 2$ = **3926** mm

Elastic critical buckling moment — $M_{cr} = C_1 \times \pi^2 \times E \times I_z / (L^2 \times g) \times \sqrt{[I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z)]}$ = **47.1** kNm

Slenderness ratio for lateral torsional buckling — $\bar{\lambda}_{LT} = \sqrt{(W_{pl,y} \times f_y / M_{cr})}$ = **1.518**

Limiting slenderness ratio — $\bar{\lambda}_{LT,0}$ = **0.4**

$\bar{\lambda}_{LT} > \bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Design resistance for buckling - Section 6.3.2.1

Buckling curve - Table 6.5 — c

Imperfection factor - Table 6.3 — α_{LT} = **0.49**

Correction factor for rolled sections — β = **0.75**

LTB reduction determination factor — $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2]$ = **1.638**

LTB reduction factor - eq 6.57 — $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2)$ = **0.382**

Modification factor — $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1)$ = **1.000**

Modified LTB reduction factor - eq 6.58 — $\chi_{LT,mod} = \min(\chi_{LT} / f, 1)$ = **0.382**

Design buckling resistance moment - eq 6.55 — $M_{b,Rd} = \chi_{LT,mod} \times W_{pl,y} \times f_y / \gamma_{M1}$ = **41.5** kNm

PASS - Design buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 7.2.1

Consider deflection due to permanent and variable loads

Limiting deflection $\delta_{lim} = L_{s1} / 500 =$ **6.7** mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **4.445** mm

PASS - Maximum deflection does not exceed deflection limit

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BEARING DESIGN

1) INTERNAL WALL.

			kN
Reaction, Udl₁ dead =	$10.40 \times 3.65/2$	=	18.98
imposed =	$6.13 \times 3.65/2$	=	11.19
beam =	$0.25 \times 3.65/2$	=	0.46
Udl₂ dead =	$4.11 \times 1.825 \times \frac{0.91}{3.65}$	=	1.87
imp =	$\frac{2.97}{4.11} \times 1.87$	=	1.35

Σ dead reaction $= 18.98 + 0.46 + 1.87 = 21.31$ kN

Σ imposed reaction $= 11.19 + 1.35 = 12.54$ kN

2) EXTERNAL CAVITY WALL.

Beam reactions

$$dead = [10.40 + 0.25] \times 3.65/2 + 1.825 \times 4.11 \times \frac{2.74}{3.65} = \underline{\underline{25.10\ kN}}$$

$$Imposed = 6.13 \times 3.65/2 + 1.825 \times 2.97 \times \frac{2.74}{3.65} = \underline{\underline{15.26\ kN}}$$

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BLOCKWORK NIBS.

$h_{ef} / t_{ef} = 2700/140 = 19.30 < 27.0$.

Assuming 140 wide 10 N/mm² blocks.

$f_k = 6.85$ N/mm².

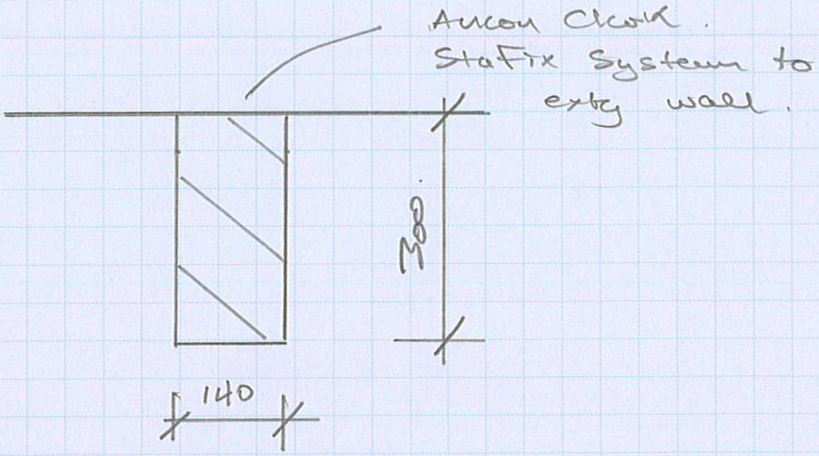
$\beta = 0.72$.

$$DULR = \frac{0.72 \times 300 \times 140 \times 6.85 \times 10^{-3}}{3.1}$$

$= 66.82$ kN.

Max applied $= 1.4 \times 25.10 + 1.6 \times 15.26$

$= 59.60$ kN $<$ DULR.



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PADSTONE

Assume min depth 150mm.

$$\sigma_{app} = \frac{59.60 \times 10^3}{140 \times 300} = 1.42 \ N/mm^2$$

$f_k / 3.1 = 6.85 / 3.10 = 2.21 \ N/mm^2 > \sigma_{APP}$ — o.k.

Assume 150 x 100 bearing plate

$$\sigma_{app} \text{ on padstone} = \frac{59.60 \times 10^3 \times 2}{100 \times 150}$$

$$= 7.95 \ N/mm^2$$

C30 padstone $= 0.4 \times 30 = 12 \ N/mm^2 > \sigma_{APP}$.

$$t_{reqd} = \sqrt{\frac{(7.95 \times 50^2/2) \times 6}{275 \times 100}} = 1.5 \ mm. \quad \text{Say } 6 \text{ thk.}$$

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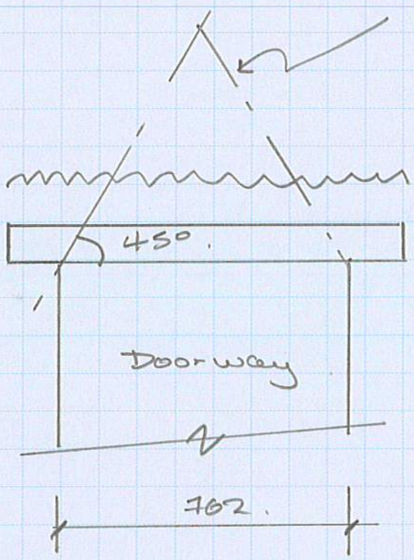
Sands
Est. 1991

BOOT STORE LINTEL

Clear opening 762mm



Roof, dead $= \dfrac{0.83 \times}{\cos 45°} 1.1/2 = 0.65$ kN/m

imposed $= \dfrac{0.60}{\cos 45°} \times 1.1/2 = 0.47$ kN/m

External wall + render

dead $= [24 \times 0.115] \times 1/2 \times 0.762 \;(\times 0.381)$

$= 0.40$ kN

Σ load $= (0.65 + 0.47) \times 0.762 + 0.4 = \underline{1.41 \text{ kN}}$

Use NAYLOR PC LINTEL P100 / leaf

12.97 kN/m Allowance

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Beam 2 Bearing Check.

			kN/m.
Floor, dead	= 0.42 kN/m² × 2.34	=	0.98
imposed	= 1.50 kN/m² × 2.34	=	3.51
Wall above	= 2.75 kN/m² × 2.80	=	7.70.

Dead reaction = $(0.25 + 0.98 + 7.7) \times \frac{3.65}{2}$ = **16.30 kN**

Imposed = 3.51 × 3.65 /2 = **6.41 kN**.

1) Internal Wall.

Assume blockwork loadbearing partition.

Existing 1st Floor partition supported on wall.
but no beam evident.

Take block strength as 5 N/mm².

See TEDDS output

Nib not required.

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MASONRY BEARING DESIGN

In accordance with EN1996-1-1:2005 + A1:2012, incorporating Corrigenda February 2006 and July 2009 and the UK National Annex.

Tedds calculation version 1.0.11

Summary table

Load	Local concentration		Spreader		Utilisation	
	Design force	Resistance	Design stress	Resistance		
1	31.6 kN	33.9 kN	1.43 N/mm^2	2.26 N/mm^2	0.634	Pass

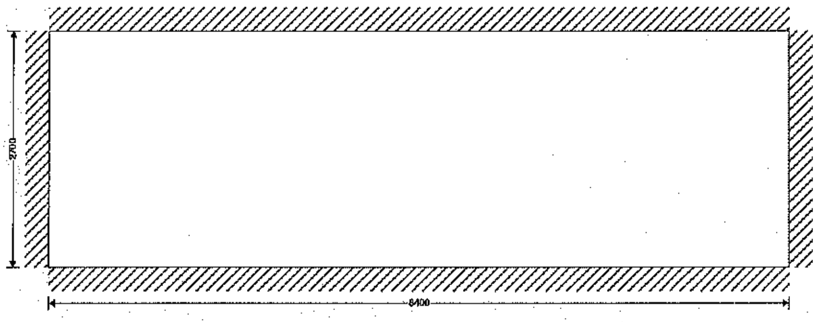
Masonry panel details

Panel length — L = **8400** mm

Panel height — h = **2700** mm

Panel support conditions

All edges supported



Effective height of masonry wall - Section 5.5.1.2

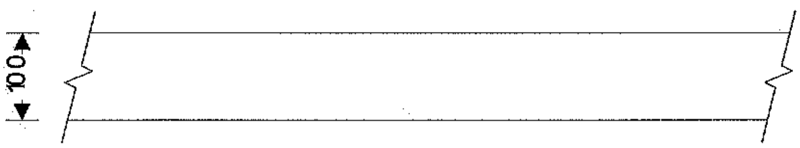
Vertical restraints — L >= 30 × t_{ef} (Wall restrained at top and bottom only)

Horizontal restraints — **Simply supported**

Reduction factor - eq. 5.5 — ρ_2 = **1.00**

Effective height of wall - eq. 5.2 — $h_{ef} = \rho_2 \times h$ = **2700** mm

Wall construction details



Wall type — **Single leaf panel**

Overall wall thickness — t = **100.0** mm

Effective thickness of masonry wall - Section 5.5.1.3

Effective thickness — t_{ef} = t = **100.0** mm

Masonry material details

Unit type — **Aggregate concrete - Group 1**

Compressive strength of masonry unit — f_b = **5.2** N/mm^2

Height of unit — h_u = **215** mm

Width of unit — w_u = **100** mm

Conditioning factor — k = **1.0**

- Conditioning to the air dry condition in accordance with cl.7.3.2

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Shape factor - Table A.1	d_{sf} = **1.38**
Mean compressive strength of masonry unit	$f_b = f_c \times k \times d_{sf}$ = **7.18** N/mm^2
Specific weight of units	γ = **18** kN/m^3
Mortar type	**M4 - General Purpose**
Compressive strength of mortar	f_m = **4.0** N/mm^2
Compressive strength factor - Tbl. NA 4	K = **0.75**
Characteristic compressive strength - eq. 3.1	$f_k = K \times f_b^{0.7} \times f_m^{0.3}$ = **4.52** N/mm^2
Short term secant modulus of elasticity factor	K_E = **1000**
Modulus of elasticity - cl.3.7.2	$E_w = K_E \times f_k$ = **4516** N/mm^2

Design compressive strength of masonry

Category of manufacturing control	**Category II**
Class of execution control	**Class 2**
Partial factor for compressive strength	γ_M = **3.00**
Cross-sectional area of wall	$A = L \times t$ = **0.84** m^2
Design compressive strength of masonry	$f_d = f_k / \gamma_M$ = **1.51** N/mm^2

Partial safety factors for design loads

Partial safety factor for permanent load	γ_{fG} = **1.35**
Partial safety factor for variable load	γ_{fQ} = **1.50**

Superimposed vertical loading details

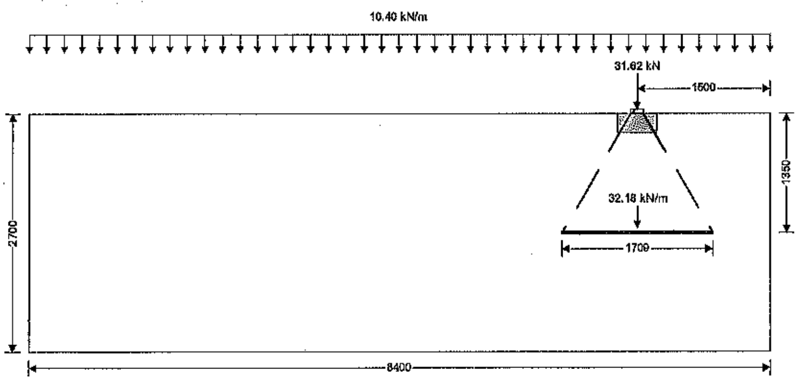
Permanent UDL at top of wall	g_k = **7.70** kN/m
Variable UDL at top of wall	q_k = **0.00** kN/m
Eccentricity of permanent UDL load	e_{gu} = **0** mm
Eccentricity of variable UDL load	e_{qu} = **0** mm

Slenderness ratio of masonry wall - Section 5.5.1.4

Slenderness ratio limit	λ_{lim} = **27**
Slenderness ratio	$\lambda = h_{ef} / t_{ef}$ = **27.0**

PASS - Slenderness ratio is less than slenderness limit

Concentrated Load 1 details - Kitchen Beam 2



Permanent concentrated load	G_{kc1} = **16.30** kN
Variable concentrated load	Q_{kc1} = **6.41** kN
Eccentricity of concentrated load	e_{c1} = **17** mm
Length of concentrated load	L_{c1} = **150** mm
Width of concentrated load	w_{c1} = **100** mm
Height of concentrated load	h_{c1} = **2700** mm

Distance of load to right vertical edge	r_{11} = **1425** mm
Distance of load to nearest vertical edge	a_{11} = **1425** mm

Walls subjected to concentrated loads - Section 6.1.3

Eccentricity check	$e_{c1} \le t / 4$
	PASS - Eccentricity of load is less than t/4
Area of bearing	$A_{b1} = L_{c1} \times w_{c1}$ = **15000** mm^2
Effective length of bearing at mid-height	$l_{efm1} = L_{c1} + h_{c1} \times \tan(30)$ = **1709** mm
Effective bearing area	$A_{ef1} = l_{efm1} \times t$ = **170885** mm^2
Bearing area ratio check	$A_{ratio1} = \mathrm{Min}(A_{b1} / A_{ef1}, 0.45)$ = **0.09**
Initial enhancement factor	$\beta_{init1} = \mathrm{Max}((1 + 0.3 \times a_{11} / h_{c1}) \times (1.5 - 1.1 \times A_{ratio1}), 1.0)$ = **1.63**
Maximum enhancement factor	$\beta_{max1} = \mathrm{Min}(1.25 + a_{11} / (2 \times h_{c1}), 1.5)$ = **1.50**
Enhancement factor for concentrated loads	$\beta_1 = \mathrm{Min}(\beta_{init1}, \beta_{max1})$ = **1.50**
Design value of the concentrated load	$N_{Edc1} = G_{kc1} \times \gamma_{fG} + Q_{kc1} \times \gamma_{fQ}$ = **31.62** kN
Design value concentrated load resistance	$N_{Rdc1} = \beta_1 \times A_{b1} \times f_d$ = **33.87** kN
	PASS - Design resistance exceeds applied concentrated load

Design of spreader beam

Type of spreader	**Concrete padstone**
Type of bearing onto spreader	**Point load**
Location of load from RHS of spreader	P_{11} = **225** mm
Length of spreader	L_{sp1} = **450** mm
Height of spreader	h_{sp1} = **215** mm
Width of spreader	w_{sp1} = **100** mm
Eccentricity of load on spreader	e_{sp1} = **17** mm
Modulus of elasticity	E_{sp1} = **29962** N/mm^2
Second moment of area	$I_{sp1} = 1/12 \times w_{sp1} \times h_{sp1}^3$ = **82819792** mm^4
Modulus of the wall	$k_0 = E_w / h$ = **1.67** N/mm^2/mm
Winkler's constant	$K_{c1} = k_0 \times w_{sp1}$ = **167.28** N/mm/mm
Characteristic of the system	$\alpha_1 = (K_{c1} / (4 \times E_{sp1} \times I_{sp1}))^{1/4}$ = **0.00203** mm^{-1}
Classification of spreader	$\alpha L_1 = \alpha_1 \times L_{sp1}$ = **0.91 Medium**
Krilov's functions for the spreader length	$B_{\alpha l1} = 1/2 \times (\cosh(\alpha L_1) \times \sin(180 \times \alpha L_1 / \pi) + \sinh(\alpha L_1) \times \cos(180 \times \alpha L_1 / \pi))$ = **0.89**
	$C_{\alpha l1} = 1/2 \times \sinh(\alpha L_1) \times \sin(180 \times \alpha L_1 / \pi)$ = **0.41**
	$D_{\alpha l1} = 1/4 \times (\cosh(\alpha L_1) \times \sin(180 \times \alpha L_1 / \pi) - \sinh(\alpha L_1) \times \cos(180 \times \alpha L_1 / \pi))$ = **0.13**
Krilov's functions at the point load	$A_{\alpha P11} = \cosh(\alpha_1 \times P_{11}) \times \cos(180 \times \alpha_1 \times P_{11} / \pi)$ = **0.99**
	$B_{\alpha P11} = 1/2 \times (\cosh(\alpha_1 \times P_{11}) \times \sin(180 \times \alpha_1 \times P_{11} / \pi) + \sinh(\alpha_1 \times P_{11}) \times \cos(180 \times \alpha_1 \times P_{11} / \pi))$ = **0.46**
Using method of initial conditions	
Initial moment of LH edge	M_{01} = **0** kNm
Initial shear of LH edge	V_{01} = **0** kN
Which gives	$(4 \times \alpha_1^2 \times C_{\alpha l1} \times \delta_{01} + 4 \times \alpha_1 \times D_{\alpha l1} \times \Phi_{01}) \times E_{sp1} \times I_{sp1} - B_{\alpha P11} / \alpha_1 \times N_{Edc1}$ = **0.00** kNm
and	$(4 \times \alpha_1^3 \times B_{\alpha l1} \times \delta_{01} + 4 \times \alpha_1^2 \times C_{\alpha l1} \times \Phi_{01}) \times E_{sp1} \times I_{sp1} - A_{\alpha P11} \times N_{Edc1}$ = **0.00** kN
Therefore,	
Initial deflection of LH edge	δ_{01} = **0.41465** mm

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Initial rotationof LH edge — Φ_{01} = **0.000053**

Location of maximum deflection — x_{def1} = **225** mm

Krilov's functions at the spreader length — $A_{\alpha xdef1} = \cosh(\alpha_1 \times x_{def1}) \times \cos(180 \times \alpha_1 \times x_{def1} / \pi)$ = **0.99**

$B_{\alpha xdef1} = 1/2 \times (\cosh(\alpha_1 \times x_{def1}) \times \sin(180 \times \alpha_1 \times x_{def1} / \pi) + \sinh(\alpha_1 \times x_{def1}) \times \cos(180 \times \alpha_1 \times x_{def1} / \pi))$ = **0.46**

Distance of point load right of loaction — p_{1def1} = **0** mm

Krilov's functions at the spreader length — $D_{\alpha p1def1} = 1/4 \times (\cosh(\alpha_1 \times p_{1def1}) \times \sin(180 \times \alpha_1 \times p_{1def1} / \pi) - \sinh(\alpha_1 \times p_{1def1}) \times \cos(180 \times \alpha_1 \times p_{1def1} / \pi))$ = **0.00**

Particular integral due to load — $\delta'_1 = D_{\alpha p1def1} / \alpha_1^3 \times N_{Edc1} / (I_{sp1} \times E_{sp1})$ = **0.000** mm

Maximum deflection — $\delta_{max1} = A_{\alpha xdef1} \times \delta_{01} + B_{\alpha xdef1} \times \Phi_{01} / \alpha_1 + \delta'_1$ = **0.424** mm

Location of maximum moment — x_{M1} = **225** mm

Krilov's functions at the spreader length — $C_{\alpha xM1} = 1/2 \times \sinh(\alpha_1 \times x_{M1}) \times \sin(180 \times \alpha_1 \times x_{M1} / \pi)$ = **0.10**

$D_{\alpha xM1} = 1/4 \times (\cosh(\alpha_1 \times x_{M1}) \times \sin(180 \times \alpha_1 \times x_{M1} / \pi) - \sinh(\alpha_1 \times x_{M1}) \times \cos(180 \times \alpha_1 \times x_{M1} / \pi))$ = **0.02**

Distance of point load right of loaction — p_{1M1} = **0** mm

Krilov's functions at the spreader length — $B_{\alpha p1M1} = 1/2 \times (\cosh(\alpha_1 \times p_{1M1}) \times \sin(180 \times \alpha_1 \times p_{1M1} / \pi) + \sinh(\alpha_1 \times p_{1M1}) \times \cos(180 \times \alpha_1 \times p_{1M1} / \pi))$ = **0.00**

Particular integral due to load — $M'_1 = -B_{\alpha p1M1} / \alpha_1 \times N_{Edc1}$ = **0.00** kNm

Maximum moment — $M_{Edsp1} = (4 \times \alpha_1^2 \times C_{\alpha xM1} \times \delta_{01} + 4 \times \alpha_1 \times D_{\alpha xM1} \times \Phi_{01}) \times (I_{sp1} \times E_{sp1}) + M'_1$ = **1.77** kNm

Location of maximum shear — x_{V1} = **225** mm

Krilov's functions at the spreader length — $B_{\alpha xV1} = 1/2 \times (\cosh(\alpha_1 \times x_{V1}) \times \sin(180 \times \alpha_1 \times x_{V1} / \pi) + \sinh(\alpha_1 \times x_{V1}) \times \cos(180 \times \alpha_1 \times x_{V1} / \pi))$ = **0.46**

$C_{\alpha xV1} = 1/2 \times \sinh(\alpha_1 \times x_{V1}) \times \sin(180 \times \alpha_1 \times x_{V1} / \pi)$ = **0.10**

Distance of point load right of loaction — p_{1V1} = **0** mm

Krilov's functions at the spreader length — $A_{\alpha p1V1} = \cosh(\alpha_1 \times p_{1V1}) \times \cos(180 \times \alpha_1 \times p_{1V1} / \pi)$ = **1.00**

Particular integral due to load — $V'_1 = -A_{\alpha p1V1} \times N_{Edc1}$ = **-31.62** kN

Shear at concentrated point load — $V_1 = (4 \times \alpha_1^3 \times B_{\alpha xV1} \times \delta_{01} + 4 \times \alpha_1^2 \times C_{\alpha xV1} \times \Phi_{01}) \times (I_{sp1} \times E_{sp1}) + V'_1$ = **-15.81** kN

Maximum shear — $V_{Edsp1} = Max(Abs(V_1), N_{Edc1} - Abs(V_1))$ = **15.81** kN

Maximum allowable stress under spreader — $\sigma_{Rdsp1} = 1.5 \times f_d$ = **2.26** N/mm^2

Maximum reaction — $N_{Edsp1} = K_{c1} \times \delta_{max1}$ = **70.87** kN/m

Design stress — $\sigma_{Edsp1} = 2 \times N_{Edsp1} / (3 \times (w_{sp1} / 2 - e_{sp1}))$ = **1.43** N/mm^2

PASS - Design stress under spreader is less than the allowable bearing stress

Walls subjected to mainly vertical loading - Section6.1.2

Eccentricity of permanent UDL at mid-height below concentrated load

$e_{gmu1} = e_{gu} \times h_{c1} / (2 \times h)$ = **0.0** mm

Eccentricity of variable UDL at mid-height below concentrated load

$e_{qmu1} = e_{qu} \times h_{c1} / (2 \times h)$ = **0.0** mm

Eccentricity of concentrated load at mid-height — $e_{mc1} = e_{c1} / 2$ = **8.5** mm

Initial eccentricity - cl.5.5.1.1(4) — $e_{init} = h / 450$ = **6.0** mm

Concentrated load at mid-height as UDL — $N_{mc1} = N_{Edc1} / l_{efm1}$ = **18.50** kN/m

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Vertical load at mid-height	$N_{Ed1} = (g_k + \gamma \times t \times (h - h_{c1} / 2)) \times \gamma_{fG} + q_k \times \gamma_{fQ} + N_{mc1}$ = **32.18** kN/m
Design moment at mid-height	$M_{Ed1} = g_k \times \gamma_{fG} \times e_{gmu1} + q_k \times \gamma_{fQ} \times e_{qmu1} + N_{mc1} \times e_{mc1}$ = **0.16** kNm/m
Eccentricities due to loads - eq. 6.7	$e_{m1} = Abs(M_{Ed1}) / N_{Ed1} + e_{init}$ = **10.9** mm
Slenderness ratio limit for creep eccentricity	λ_c = **27**
Eccentricity due to creep	e_{k1} = **0.0** mm
Eccentricity at mid-height - eq. 6.6	$e_{mk1} = Max(e_{m1} + e_{k1}, 0.05 \times t)$ = **10.9** mm
From eq. G2	$A_{11} = 1 - 2 \times e_{mk1} / t$ = **0.78**
From eq. G3	$u_1 = (h_{ef} / t_{ef} \times (1 / K_E)^{1/2} - 0.063) / (0.73 - 1.17 \times e_{mk1} / t)$ = **1.31**
Capacity reduction factor - eq. G1	$\Phi_{m1} = A_{11} \times exp(-(u_1^2) / 2)$ = **0.33**
Design vertical resistance of panel - eq.6.2	$N_{Rd1} = \Phi_{m1} \times t \times f_d$ = **49.78** kN/m

PASS - Design value of vertical resistance exceeds applied vertical load