

Doc Ref: **2479**

Date: **24th March 2020**

Client

Cubic Surveying Solutions

63 Wilmslow Road

Handforth

SK9 3EN

Site Address

2 Inchfield Close

Rochdale

OL11 5SB

Document Title

**Structural Calculations for
Foundation Design**



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Project Title 2 Inchfield Close, Rochdale, OL11 5SB

Project No 2479

Date 24th March 2020

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Revision History

Issue	Date	Status	Prepared By	Signature
1	24.03.20	First Issue	Chris Askin MEng(Hons), CEng MStructE	

1.0 Design Philosophy

1.1 Background

- 1.1.1 The new house is to be built on the site of an older, fire-damaged property. The site is in a residential estate off the A680 (Edenfield Road) (Photo 1). Mine workings have been discovered in the area.
- 1.1.2 Brennan Consult have been appointed by the Client to design new foundations suitable for areas over mine workings.



Photo 1. Ariel view of site

1.2 Background

- 1.2.1 Following the fire at the previous house on the site, the site was cleared of all structure except the floor slabs and foundations to allow for the house to be rebuilt in entirety. A site survey uncovered mine workings in the area which had subsequently been filled with grout. A portion of the house foundations are within the zone of influence (ZOI) of these mine workings and as such need to be designed to take them into account.
- 1.2.2 Refer to Appendix A for the Zone of Influence Plan of the mine workings.

1.3 Substructure

- 1.3.1 Existing foundations outside the ZOI are to be reused.
- 1.3.2 Foundations within the ZOI shall consist of ground beams designed to span a 3m soft spot in-line with guidance for foundation design over mine workings. In addition to being designed as a beam spanning 3m, the new foundations are designed so the ends can cantilever 1.5m.
- 1.3.3 Existing foundations are 480mm x 200mm deep concrete strips, founded at circa 750mm below ground level.

- 1.3.4 The new foundations are to extend 2.5m beyond the ends of the wall within the ZOI. This ensures that under a scenario where the centre of the soft spot is at the extreme end of the wall within the ZOI that there is a minimum of 1.0m length of foundation to bear onto the ground (Photo 2).

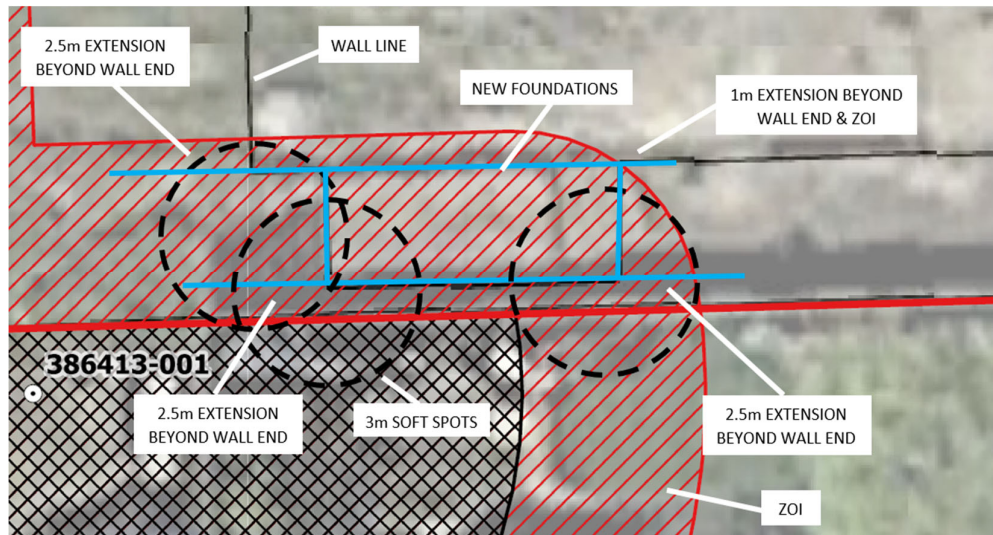


Photo 2. Sketch of required length of foundations within the ZOI

1.4 Analysis and Design

- 1.4.1 The analysis of the foundations has been done with a combination of hand calculations and TEDDs software. All analysis and designs in accordance with British Standards.

2.0 Design Loadings

2.1 Calculations are provided here to demonstrate the loadings and analysis used in the design of the new foundations.

2.2 The following British Standard codes of practice have been adhered to for the design calculations: -

BS 648: 1964 Schedule of weights of building materials

BS 8110-1: 1997 Structural use of Concrete – Part 1

2.3 Wall Heights

T.O.F – GF = say 0.50 m

GF – Eaves = 3.80 m

2.4 Ground Floor – say 150mm thick concrete slab

DL UDL

Finishes = 0.10 kN/m²

Screed, 75mm, 22 kN/m³ = 1.65 kN/m²

Insulation = 0.05 kN/m²

Concrete slab, 150mm, 24 kN/m³ = 3.60 kN/m²

Total = 5.4 kN/m²

LL UDL

Residential = 1.50 kN/m²

Partitions = 1.00 kN/m²

Total = 2.50 kN/m²

2.5 1st Floor – Dormer

DL UDL

Finishes = 0.10 kN/m²

Decking = 0.15 kN/m²

Joists = 0.20 kN/m²

Ceilings & services = 0.25 kN/m²

Total = 0.70 kN/m²

LL UDL

Residential = 1.50 kN/m²

Partitions = 1.00 kN/m²

Total = 2.50 kN/m²

2.6 Perimeter Masonry Wall

DL UDL

Facing brickwork, 100mm, 22.5 kN/m³ = 2.25 kN/m²

Blockwork, 100mm, 18 kN/m³ = 1.80 kN/m²

Plaster, etc. = 0.30 kN/m²

Total = 4.35 kN/m²

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2.7 Roof

DL UDL

Tiles = 0.50 kN/m²

Battens, etc. = 0.10 kN/m²

Trusses = 0.30 kN/m²

Insulation = 0.15 kN/m²

Ceilings & services = 0.25 kN/m²

Total (30° pitch) = 1.30 kN/m²

Total (on plan) = 1.50 kN/m²

LL UDL

Inaccessible roof = 0.75 kN/m²

Total = 0.75 kN/m²

2.8 Ground Beam

DL

Ground beam, 600mm x 400mm, 24 kN/m³ = 5.80 kN/m

Total = 5.80 kN/m

3.0 Foundation Designs

3.1 Foundation Reinforcement

3.1.1 There are 4No. lengths of new foundations, the 2No. intermediate foundations and 2No. main foundations. The intermediate foundations are supported by the main foundations. The critical main foundation supports the main building wall, the other only the annex.

3.1.2 The critical foundation is the one supporting the main building wall. By inspection, the reinforcement design for the critical foundation will be suitable for the remaining foundations.

3.1.3 Critical foundation supports the main building wall as a UDL and the intermediate foundation as a mid-span point load. Conservatism exists in that an internal foundation would halve the ground and first floor spans.

Span = 3.0 m (pinned – continuous)

DL UDL

Ground floor	$5.40 \times 8.5 / 2$	= 23.0 kN/m
First floor	$0.70 \times 6.8 / 2$	= 2.4 kN/m
Roof	$1.50 \times 8.5 / 2$	= 6.4 kN/m
Wall	$4.35 \times (0.5 + 3.8)$	= 18.7 kN/m
Total		= 50.5 kN/m

LL UDL

Ground floor	$2.5 \times 8.5 / 2$	= 10.6 kN/m
First floor	$2.5 \times 6.8 / 2$	= 8.5 kN/m
Roof	$0.75 \times 8.5 / 2$	= 3.2 kN/m
Total		= 22.3 kN/m

DL PL @ 1.5m

Ground beam	$5.80 \times 1.7 / 2$	= 4.9 kN
Wall	$4.35 \times (0.5 + 3.8) \times 1.7 / 2$	= 15.9 kN
Total		= 20.8 kN

Refer to TEDDs proforma 4No. H20s & H10 links @ 225mm c/c **U/R = 89 %**

3.2 Bearing Pressure

3.2.1 Under normal conditions where the new foundation does not need to span over a soft spot, the bearing pressure will not exceed that of the existing foundation as the new foundation is wider (600mm > 480mm).

3.2.2 Under conditions where the new foundation does need to span a soft spot, the bearing pressure should be assessed. Consider the internal foundation as reducing the ground and first floor spans.

Span = 3.0 m

DL UDL	$[50.5 - (23.0 + 6.4) / 2] \times 3.0 / 2$	= 53.6 kN
LL UDL	$[22.3 - (10.6 + 8.5) / 2] \times 3.0 / 2$	= 19.1 kN
DL PL	$20.8 / 2$	= 10.4 kN
Total		= 83.1 kN

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Area, say over 1m length

1×0.6

$= 0.6 \text{ m}^2$

Bearing Pressure

$83.1 / 0.6$

$= 139 \text{ kN/m}^2$

3.2.3 Presumed allowable bearing pressure would be over 100 kN/m². By inspection the bearing pressure which occurs in a soft spot scenario will be ok due to the following conservatisms in the calculation:

- Loads used are conservative
- A 1m length of foundation for the bearing pressure to be applied is conservative as the reinforcement will encourage further load dispersion
- Bearing capacity will have improved due to compaction from the existing building foundations
- Bearing capacity will have improved from ground improvement works undertaken when the mine workings were discovered

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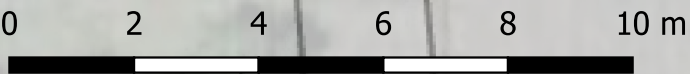
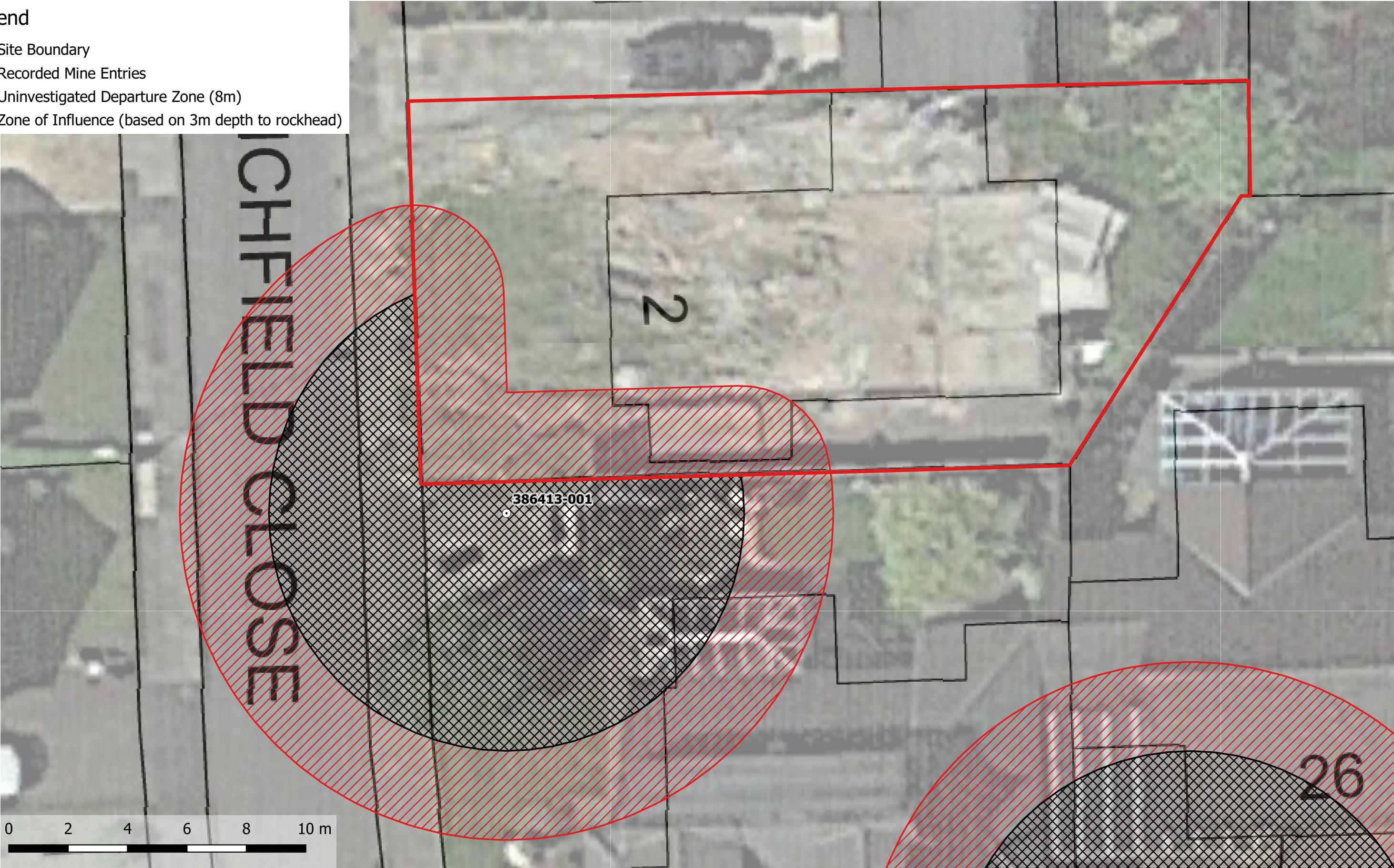
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Appendix A – Zone of Influence Plan

Legend

-  Site Boundary
-  Recorded Mine Entries
-  Uninvestigated Departure Zone (8m)
-  Zone of Influence (based on 3m depth to rockhead)



NOTES:

NOTES

CLIENT:

Cubic Surveying

PROJECT:

2 Inchfield Close, Rochdale

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Zone of Influence Plan for Recorded Mine Entries

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Appendix B – Foundation Design TEDDs Proforma



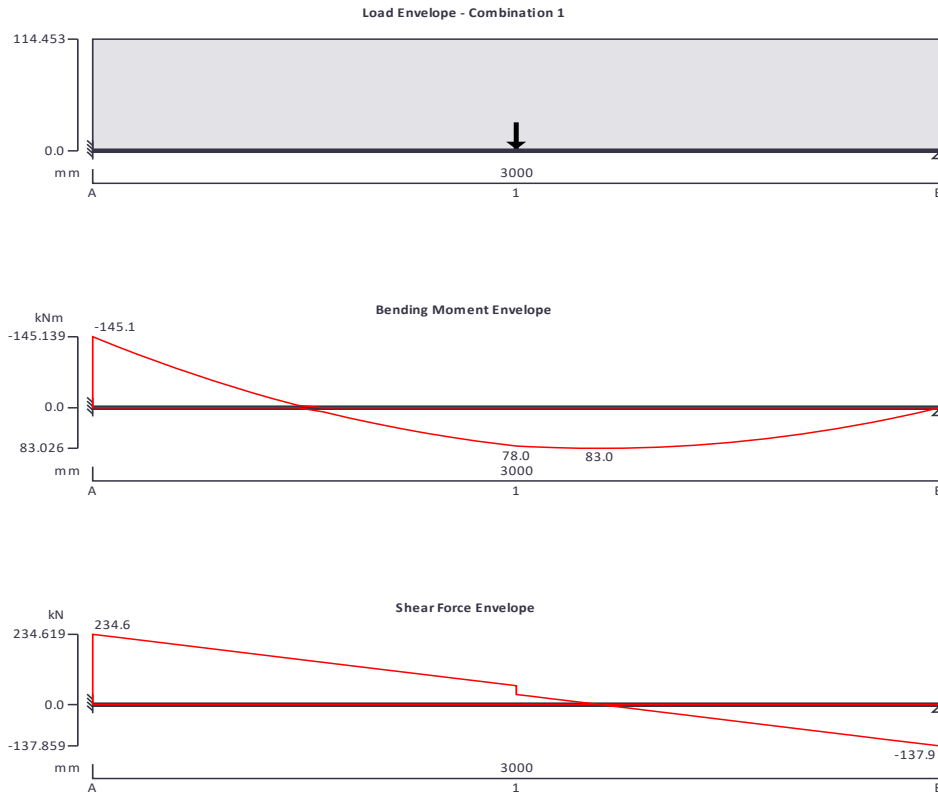


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CA	24/03/2020				

RC BEAM ANALYSIS & DESIGN BS8110

TEDDS calculation version 2.1.12



Support conditions

Support A

Vertically restrained
Rotationally restrained

Support B

Vertically restrained
Rotationally free

Applied loading

Dead self weight of beam $\times 1$
Dead full UDL 50.5 kN/m
Imposed full UDL 22.3 kN/m
Dead point load 20.8 kN at 1500 mm

Load combinations

Load combination 1

Support A	Dead $\times 1.40$ Imposed $\times 1.60$
Span 1	Dead $\times 1.40$ Imposed $\times 1.60$
Support B	Dead $\times 1.40$ Imposed $\times 1.60$



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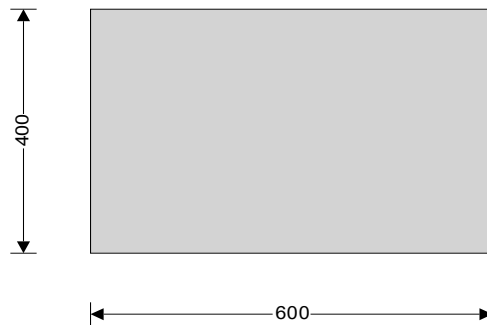
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Analysis results

Maximum moment support A	$M_{A_max} = -145 \text{ kNm}$	$M_{A_red} = -145 \text{ kNm}$
Maximum moment span 1 at 1796 mm	$M_{s1_max} = 83 \text{ kNm}$	$M_{s1_red} = 83 \text{ kNm}$
Maximum moment support B	$M_{B_max} = 0 \text{ kNm}$	$M_{B_red} = 0 \text{ kNm}$
Maximum shear support A	$V_{A_max} = 235 \text{ kN}$	$V_{A_red} = 235 \text{ kN}$
Maximum shear support A span 1 at 330 mm	$V_{A_s1_max} = 197 \text{ kN}$	$V_{A_s1_red} = 197 \text{ kN}$
Maximum shear support B	$V_{B_max} = -138 \text{ kN}$	$V_{B_red} = -138 \text{ kN}$
Maximum shear support B span 1 at 2668 mm	$V_{B_s1_max} = -100 \text{ kN}$	$V_{B_s1_red} = -100 \text{ kN}$
Maximum reaction at support A	$R_A = 235 \text{ kN}$	
Maximum reaction at support B	$R_B = 138 \text{ kN}$	

Rectangular section details

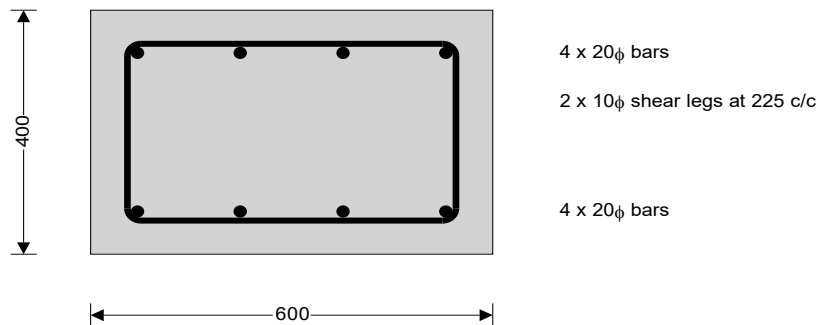
Section width $b = 600 \text{ mm}$ Section depth $h = 400 \text{ mm}$



Material details

Concrete strength class	C25/30	Char comp cube strength	$f_{cu} = 30 \text{ N/mm}^2$
Modulus of elasticity of conc	$E_c = 26000 \text{ N/mm}^2$	Maximum aggregate size	$h_{agg} = 20 \text{ mm}$
Char yield strength of reinf	$f_y = 500 \text{ N/mm}^2$	Char yield str of shear reinf	$f_{yv} = 500 \text{ N/mm}^2$
Nominal cover to top reinf	$c_{nom_t} = 50 \text{ mm}$	Nominal cover to bottom reinf	$c_{nom_b} = 50 \text{ mm}$
Nominal cover to side reinf	$c_{nom_s} = 50 \text{ mm}$		

Support A



Design moment resistance of rectangular section (cl. 3.4.4)

Design bending moment	$M = 145 \text{ kNm}$	Depth to tension reinf.	$d = 330 \text{ mm}$
	$K = 0.074$		$K' = 0.156$
		$K' > K$ - No compression reinforcement is required	
Lever arm	$z = 300 \text{ mm}$	Depth of neutral axis	$x = 66 \text{ mm}$
Area of tension reinf req'd	$A_{s,req} = 1112 \text{ mm}^2$	Tension reinf provided	$4 \times 20\phi \text{ bars}$



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Area of tension reinf prov $A_{s,prov} = 1257 \text{ mm}^2$ Minimum area of reinf $A_{s,min} = 312 \text{ mm}^2$
Maximum area of reinf $A_{s,max} = 9600 \text{ mm}^2$
PASS - Area of reinforcement provided is greater than area of reinforcement required

Rectangular section in shear

Shear - span 1 at 330 mm $V = 197 \text{ kN}$ Shear stress $v = 0.993 \text{ N/mm}^2$
Allowable design shear stress $v_{max} = 4.382 \text{ N/mm}^2$
PASS - Design shear stress is less than maximum allowable

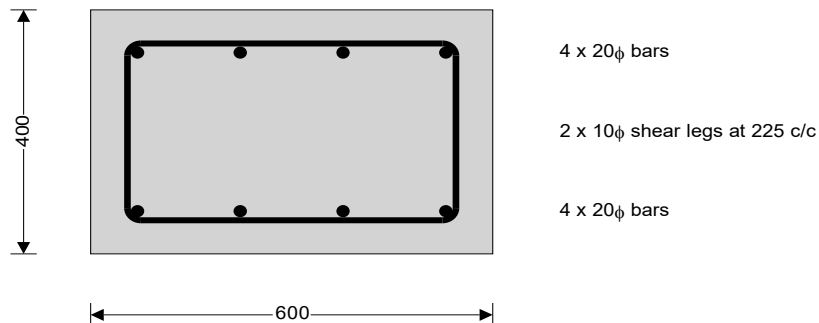
Value of v from Table 3.7 $0.5 \times v_c < v < (v_c + 0.4 \text{ N/mm}^2)$
Design shear resistance req'd $v_s = 0.400 \text{ N/mm}^2$ Area of shear reinf req'd $A_{sv,req} = 552 \text{ mm}^2/\text{m}$
Shear reinforcement provided $2 \times 10\phi$ legs at 225 c/c Area of shear reinf. prov $A_{sv,prov} = 698 \text{ mm}^2/\text{m}$
PASS - Area of shear reinforcement provided exceeds minimum required

Max longitudinal spacing $s_{vl,max} = 248 \text{ mm}$
PASS - Longitudinal spacing of shear reinforcement provided is less than maximum

Spacing of reinforcement (cl 3.12.11)

Actual dist between bars $s = 133 \text{ mm}$ Min dist between bars $s_{min} = 25 \text{ mm}$
PASS - Satisfies the minimum spacing criteria
Design service stress $f_s = 294.9 \text{ N/mm}^2$ Max distance between bars $s_{max} = 159 \text{ mm}$
PASS - Satisfies the maximum spacing criteria

Mid span 1



Design moment resistance of rectangular section (cl. 3.4.4)

Design bending moment $M = 83 \text{ kNm}$ Depth to tension reinf. $d = 330 \text{ mm}$
 $K = 0.042$ $K' = 0.156$
 $K' > K$ - No compression reinforcement is required

Lever arm $z = 314 \text{ mm}$ Depth of neutral axis $x = 37 \text{ mm}$
Area of tension reinf req'd $A_{s,req} = 609 \text{ mm}^2$ Tension reinf provided $4 \times 20\phi$ bars
Area of tension reinf prov $A_{s,prov} = 1257 \text{ mm}^2$ Minimum area of reinf $A_{s,min} = 312 \text{ mm}^2$
Maximum area of reinf $A_{s,max} = 9600 \text{ mm}^2$
PASS - Area of reinforcement provided is greater than area of reinforcement required

Rectangular section in shear

Shear reinforcement provided $2 \times 10\phi$ legs at 225 c/c
Area of shear reinf provided $A_{sv,prov} = 698 \text{ mm}^2/\text{m}$ Minimum area of shear reinf $A_{sv,min} = 552 \text{ mm}^2/\text{m}$
PASS - Area of shear reinforcement provided exceeds minimum required
Max longitudinal spacing $s_{vl,max} = 248 \text{ mm}$
PASS - Longitudinal spacing of shear reinforcement provided is less than maximum



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Spacing of reinforcement (cl 3.12.11)

Actual dist between bars $s = 133 \text{ mm}$

Min dist between bars $s_{\min} = 25 \text{ mm}$

PASS - Satisfies the minimum spacing criteria

Design service stress $f_s = 161.5 \text{ N/mm}^2$

Max distance between bars $s_{\max} = 291 \text{ mm}$

PASS - Satisfies the maximum spacing criteria

Span to depth ratio (cl. 3.4.6)

Span to depth ratio (T.3.9) $\text{span_to_depth}_{\text{basic}} = 20.0$

Service stress in tension rein $f_s = 161.5 \text{ N/mm}^2$

Modification for tension reinf $f_{\text{tens}} = 1.761$

Modification for comp reinf $f_{\text{comp}} = 1.175$

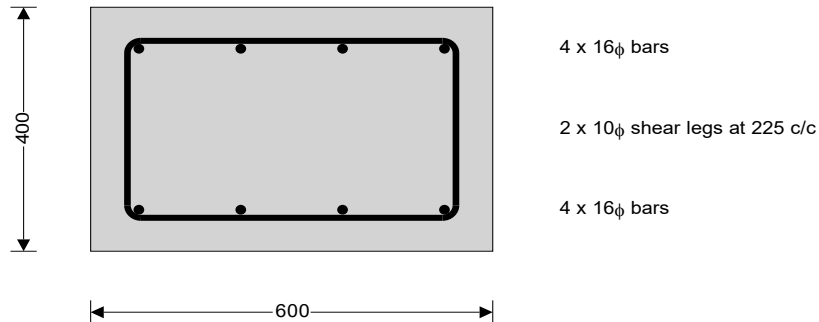
Modification for span > 10m $f_{\text{long}} = 1.000$

Allowable span to depth ratio $\text{span_to_depth}_{\text{allow}} = 41.4$

Actual span to depth ratio $\text{span_to_depth}_{\text{actual}} = 9.1$

PASS - Actual span to depth ratio is within the allowable limit

Support B



Rectangular section in shear

Shear - span 1 at 2668 mm $V = 100 \text{ kN}$

Shear stress $v = 0.501 \text{ N/mm}^2$

Allowable design shear stress $v_{\max} = 4.382 \text{ N/mm}^2$

PASS - Design shear stress is less than maximum allowable

Value of v from Table 3.7 $0.5 \times v_c < v < (v_c + 0.4 \text{ N/mm}^2)$

Design shear resistance req'd $v_s = 0.400 \text{ N/mm}^2$

Area of shear reinf req'd $A_{sv, \text{req}} = 552 \text{ mm}^2/\text{m}$

Shear reinforcement provided $2 \times 10\phi$ legs at 225 c/c

Area of shear reinf. prov $A_{sv, \text{prov}} = 698 \text{ mm}^2/\text{m}$

PASS - Area of shear reinforcement provided exceeds minimum required

Max longitudinal spacing $s_{vl, \max} = 249 \text{ mm}$

PASS - Longitudinal spacing of shear reinforcement provided is less than maximum