

Vale Consultancy

CONSULTING CIVIL & STRUCTURAL ENGINEERS

STRUCTURAL CALCULATIONS

4 Dyffryn Road
Pontardawe
SA8 3BX

Prepared for: Tom Ware
Project Ref: 25302



DOCUMENT CONTROL

Project:	4 Dyffryn Road, Pontardawe, SA8 3BX
Client:	Tom Ware
Vale Consultancy Ref:	25302

Issue	Prepared by	Approved by	Date	Status
01	Callum Margetson <i>BEng (Hons)</i> Structural Engineer	Chris Danielsen BEng (Hons) CEng MStructE Director	07.08.26	First issue



DESIGN STATEMENT

The design has been completed in accordance with Eurocodes: Foundation Design BS EN 1997-1 + UK NA (2004). Information for this has been collated from survey/site visit and information provided by the client.

Ground bearing pressure assumed to be 100kPa, to be confirmed on site by contractor or building control officer prior to works.

Refer to our sketches 25302 – V1 for references.

The design is conditional upon the foundation arrangement of the existing higher retaining tier within the garden being exposed and confirmed before construction of the new wall. The opening-up works are required to establish the depth, width and position of the existing tier foundation and to confirm that it will not impose an additional surcharge or foundation load onto the proposed reinforced concrete wall.

No allowance has presently been made for loading from the existing higher tier acting directly within the retained ground behind the proposed wall. Should the exposed foundation be found to lie within the zone of influence of the new wall, the design, wall geometry and/or proposed position will require review before works proceed.

The final position of the new reinforced concrete retaining wall is therefore to be confirmed following the opening-up works. The intention is to position the wall as far away from the house as reasonably practicable, subject to maintaining adequate separation from the higher retaining tier and its foundation.

If there are any discrepancies, the Engineer MUST be informed immediately, and prior to proceeding with construction works on site.

CDM Comments:

- All temporary propping/support is to correspond to contractor's specification and details.

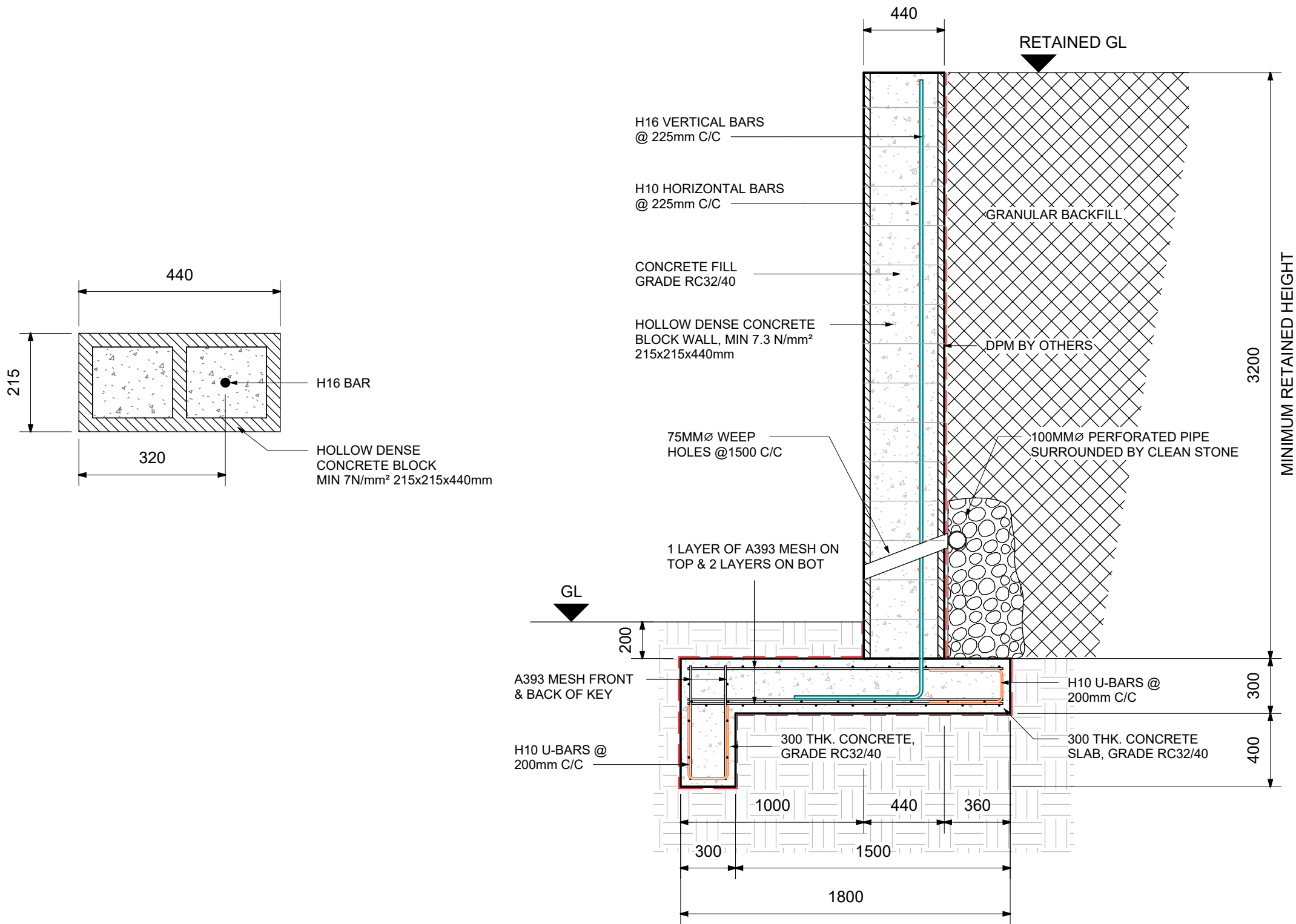
DESIGN SUMMARY

The proposed structure comprises a reinforced hollow concrete block retaining wall designed for a maximum retained height of approximately 3.2m. The wall comprises a 440mm thick hollow concrete block stem, with a minimum block strength of 7.3N/mm², fully infilled with C32/40 concrete.

Free-draining granular backfill is to be provided behind the wall, incorporating a 100mm diameter perforated land drain surrounded by clean stone and wrapped in Terram geotextile, together with weep holes at maximum 1500mm centres.

The retaining wall geometry and reinforcement arrangement are shown on drawing 25302-V1.

The retaining wall has been designed for a maximum imposed surcharge of 1.5kN/m².



REINFORCED HOLLOW CONCRETE BLOCK
Scale 1 : 25

1:25

0 5 10 15 25 m

GENERAL NOTES:

1. All dimensions are in millimetres unless noted otherwise.
2. All levels are shown in metres unless noted otherwise.
3. Do not scale from the drawing. use figured dimensions only.
4. Any discrepancies to be reported immediately to the engineer.
5. This drawing to be read in conjunction with all relevant architects, engineers, subcontractors and specialists drawings and specifications.

REINFORCEMENT NOTES:

1. Unless shown otherwise, the concrete cover to the outermost layer of steel is:
 - Top - 40mm
 - Bottom - 40mm
 - Sides - 40mm
2. All reinforcement to be Grade B500A for Mesh & B500B for Loose bars conforming to BS4449:2005+A3:2016
3. Bar bending schedule complies with BS 8666:2020.
4. The lap lengths provided between bars are appropriate to the smaller of the 2No. bars being lapped, according to the following, u.n.o.
 - H8 320mm
 - H10 400mm
 - H12 480mm
 - H16 640mm
 - H20 800mm
 - H25 1000mm
5. Reinforcement layers denoted as:
 - B1 - Bottom reinforcement outer layer.
 - B2 - Bottom reinforcement inner layer.
 - T1 - Top reinforcement outer layer.
 - T2 - Top reinforcement inner layer.
 - E - External
 - NF - Internal
 - EF - Each face
 - ABR - Alter bar reversed
 - STG - Staggered
6. Kickers are to be 150mm u.n.o.

rev.	drawn	chkd.	apprvd.	date	description

Client
TOM WARE

Project
4 DYFFRYN ROAD, PONTARDAWE,
SA8 3BX

Title
REINTEINING WALL DETAIL



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date	drawn	checked	approved
Issue Date	AK	CM	CD
scale @ A3	As indicated		
status	drg no.	V1	
Const	25302	rev.	



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Calcs for Reinforced Hollow Block Retaining Wall 3000mm				Start page no./Revision 1	
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RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.9.24

Retaining wall details

Stem type	Cantilever
Stem height	$h_{\text{stem}} = 3200 \text{ mm}$
Stem thickness	$t_{\text{stem}} = 440 \text{ mm}$
Angle to rear face of stem	$\alpha = 90 \text{ deg}$
Stem density	$\gamma_{\text{stem}} = 25 \text{ kN/m}^3$
Toe length	$l_{\text{toe}} = 1000 \text{ mm}$
Heel length	$l_{\text{heel}} = 360 \text{ mm}$
Base thickness	$t_{\text{base}} = 300 \text{ mm}$
Key position	$p_{\text{key}} = 0 \text{ mm}$
Key depth	$d_{\text{key}} = 400 \text{ mm}$
Key thickness	$t_{\text{key}} = 300 \text{ mm}$
Base density	$\gamma_{\text{base}} = 25 \text{ kN/m}^3$
Height of retained soil	$h_{\text{ret}} = 3000 \text{ mm}$
Angle of soil surface	$\beta = 0 \text{ deg}$
Depth of cover	$d_{\text{cover}} = 200 \text{ mm}$
Depth of excavation	$d_{\text{exc}} = 200 \text{ mm}$

Retained soil properties

Soil type	Dense gravel
Moist density	$\gamma_{\text{mr}} = 18 \text{ kN/m}^3$
Saturated density	$\gamma_{\text{sr}} = 21 \text{ kN/m}^3$

Base soil properties

Soil type	Medium dense well graded sand
Soil density	$\gamma_{\text{b}} = 20 \text{ kN/m}^3$

Loading details

Variable surcharge load	Surcharge _Q = 1.5 kN/m²
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Calcs date

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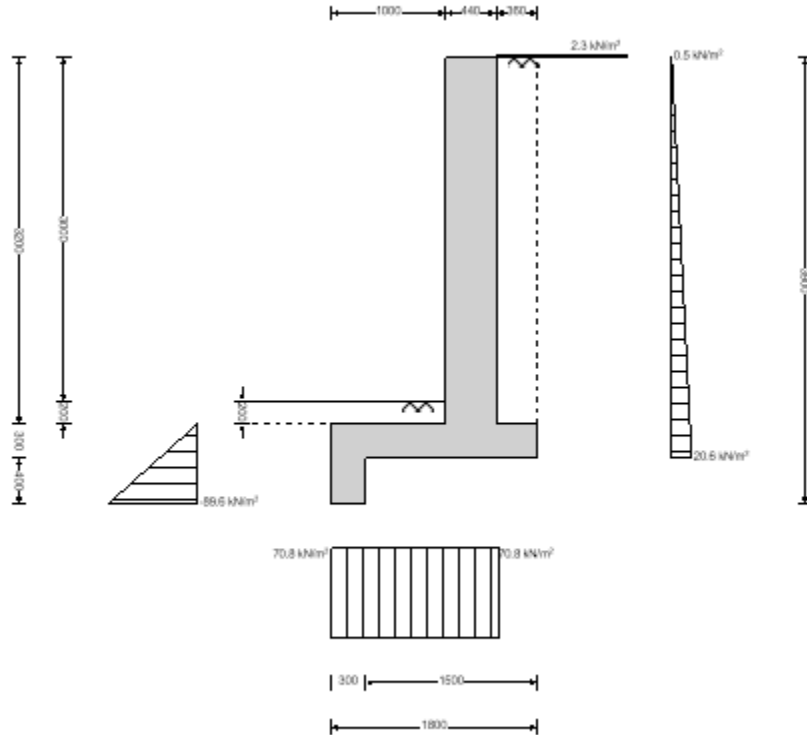
07/08/2026

Approved by

CD

Approved date

07/08/2026



General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length

$$l_{base} = l_{toe} + t_{stem} + l_{heel} = \mathbf{1800 \text{ mm}}$$

Base height

$$h_{base} = t_{base} + d_{key} = \mathbf{700 \text{ mm}}$$

Moist soil height

$$h_{moist} = h_{soil} = \mathbf{3200 \text{ mm}}$$

Length of surcharge load

$$l_{sur} = l_{heel} = \mathbf{360 \text{ mm}}$$

- Distance to vertical component

$$x_{sur_v} = l_{base} - l_{heel} / 2 = \mathbf{1620 \text{ mm}}$$

Effective height of wall

$$h_{eff} = h_{base} + d_{cover} + h_{ret} = \mathbf{3900 \text{ mm}}$$

- Distance to horizontal component

$$x_{sur_h} = h_{eff} / 2 - d_{key} = \mathbf{1550 \text{ mm}}$$

- Distance to horizontal component above key

$$x_{sur_h_a} = (h_{eff} - d_{key}) / 2 = \mathbf{1750 \text{ mm}}$$

Area of wall stem

$$A_{stem} = h_{stem} \times t_{stem} = \mathbf{1.408 \text{ m}^2}$$

- Distance to vertical component

$$x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{1220 \text{ mm}}$$

Area of wall base

$$A_{base} = l_{base} \times t_{base} + d_{key} \times t_{key} = \mathbf{0.66 \text{ m}^2}$$

- Distance to vertical component

$$x_{base} = (l_{base}^2 \times t_{base} / 2 + d_{key} \times t_{key} \times (p_{key} + t_{key} / 2)) / A_{base} = \mathbf{764 \text{ mm}}$$

Area of moist soil

$$A_{moist} = h_{moist} \times l_{heel} = \mathbf{1.152 \text{ m}^2}$$

- Distance to vertical component

$$x_{moist_v} = l_{base} - (h_{moist} \times l_{heel}^2 / 2) / A_{moist} = \mathbf{1620 \text{ mm}}$$

- Distance to horizontal component

$$x_{moist_h} = h_{eff} / 3 - d_{key} = \mathbf{900 \text{ mm}}$$

- Distance to horizontal component above key

$$x_{moist_h_a} = (h_{eff} - d_{key}) / 3 = \mathbf{1167 \text{ mm}}$$

Area of base soil

$$A_{pass} = d_{cover} \times l_{toe} = \mathbf{0.2 \text{ m}^2}$$

- Distance to vertical component

$$x_{pass_v} = l_{base} - (d_{cover} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{pass} = \mathbf{500 \text{ mm}}$$

- Distance to horizontal component

$$x_{pass_h} = (d_{cover} + h_{base}) / 3 - d_{key} = \mathbf{-100 \text{ mm}}$$



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Design approach 1

Partial factors on actions - Table A.3 - Combination 1

Partial factor set	A1
Permanent unfavourable action	$\gamma_G = 1.350$
Permanent favourable action	$\gamma_{Gf} = 1.000$
Variable unfavourable action	$\gamma_Q = 1.500$
Variable favourable action	$\gamma_{Qf} = 0.000$

Partial factors for soil parameters – Table A.4 - Combination 1

Soil parameter set	M1
Angle of shearing resistance	$\gamma_{\phi'} = 1.00$
Effective cohesion	$\gamma_{c'} = 1.00$
Weight density	$\gamma_r = 1.00$

Retained soil properties

Design moist density	$\gamma_{mr}' = \gamma_{mr} / \gamma_r = 18 \text{ kN/m}^3$
Design saturated density	$\gamma_{sr}' = \gamma_{sr} / \gamma_r = 21 \text{ kN/m}^3$

Base soil properties

Design soil density	$\gamma_b' = \gamma_b / \gamma_r = 20 \text{ kN/m}^3$
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Soil coefficients

Coefficient of friction to back of wall	$K_{fr} = 0.350$
Coefficient of friction to front of wall	$K_{fb} = 0.350$
Coefficient of friction beneath base	$K_{fbb} = 0.350$
Active pressure coefficient	$K_A = 0.236$
Passive pressure coefficient	$K_P = 4.977$

Sliding check

Vertical forces on wall

Wall stem	$F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem} = 35.2 \text{ kN/m}$
Wall base	$F_{base} = \gamma_{Gf} \times A_{base} \times \gamma_{base} = 16.5 \text{ kN/m}$
Moist retained soil	$F_{moist_v} = \gamma_{Gf} \times A_{moist} \times \gamma_{mr}' = 20.7 \text{ kN/m}$
Total	$F_{total_v} = F_{stem} + F_{base} + F_{moist_v} = 72.4 \text{ kN/m}$

Horizontal forces on wall

Surcharge load	$F_{sur_h} = K_A \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} = 2.1 \text{ kN/m}$
Moist retained soil	$F_{moist_h} = \gamma_G \times K_A \times \gamma_{mr}' \times h_{eff}^2 / 2 = 43.6 \text{ kN/m}$
Total	$F_{total_h} = F_{sur_h} + F_{moist_h} = 45.7 \text{ kN/m}$

Check stability against sliding

Base soil resistance	$F_{exc_h} = \gamma_{Gf} \times K_P \times \gamma_b' \times (h_{pass} + h_{base})^2 / 2 = 24.4 \text{ kN/m}$
Base friction	$F_{friction} = F_{total_v} \times K_{fbb} = 25.4 \text{ kN/m}$
Resistance to sliding	$F_{rest} = F_{exc_h} + F_{friction} = 49.7 \text{ kN/m}$
Factor of safety	$FoS_{sl} = F_{rest} / F_{total_h} = 1.088$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Wall stem	$F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem} = 35.2 \text{ kN/m}$
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Wall base

$$F_{base} = \gamma_{Gf} \times A_{base} \times \gamma_{base} = \mathbf{16.5 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_v} = \gamma_{Gf} \times A_{moist} \times \gamma_{mr}' = \mathbf{20.7 \text{ kN/m}}$$

Total

$$F_{total_v} = F_{stem} + F_{base} + F_{moist_v} = \mathbf{72.4 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge load

$$F_{sur_h} = K_A \times \gamma_Q \times \text{Surcharge}_Q \times (h_{eff} - d_{key}) = \mathbf{1.9 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_h} = \gamma_G \times K_A \times \gamma_{mr}' \times (h_{eff} - d_{key})^2 / 2 = \mathbf{35.1 \text{ kN/m}}$$

Base soil

$$F_{exc_h} = -\gamma_{Gf} \times K_P \times \gamma_b' \times (h_{pass} + h_{base})^2 / 2 = \mathbf{-24.4 \text{ kN/m}}$$

Total

$$F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = \mathbf{12.6 \text{ kN/m}}$$

Overturning moments on wall

Surcharge load

$$M_{sur_OT} = F_{sur_h} \times X_{sur_h_a} = \mathbf{3.3 \text{ kNm/m}}$$

Moist retained soil

$$M_{moist_OT} = F_{moist_h} \times X_{moist_h_a} = \mathbf{41 \text{ kNm/m}}$$

Base soil

$$M_{exc_OT} = F_{exc_h} \times X_{exc_h} = \mathbf{4.1 \text{ kNm/m}}$$

Total

$$M_{total_OT} = M_{sur_OT} + M_{moist_OT} + M_{exc_OT} = \mathbf{48.3 \text{ kNm/m}}$$

Restoring moments on wall

Wall stem

$$M_{stem_R} = F_{stem} \times X_{stem} = \mathbf{42.9 \text{ kNm/m}}$$

Wall base

$$M_{base_R} = F_{base} \times X_{base} = \mathbf{12.6 \text{ kNm/m}}$$

Moist retained soil

$$M_{moist_R} = F_{moist_v} \times X_{moist_v} = \mathbf{33.6 \text{ kNm/m}}$$

Total

$$M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} = \mathbf{89.1 \text{ kNm/m}}$$

Check stability against overturning

Factor of safety

$$FoS_{ot} = M_{total_R} / M_{total_OT} = \mathbf{1.845}$$

PASS - Maximum restoring moment is greater than overturning moment

Bearing pressure check

Vertical forces on wall

Wall stem

$$F_{stem} = \gamma_G \times A_{stem} \times \gamma_{stem} = \mathbf{47.5 \text{ kN/m}}$$

Wall base

$$F_{base} = \gamma_G \times A_{base} \times \gamma_{base} = \mathbf{22.3 \text{ kN/m}}$$

Surcharge load

$$F_{sur_v} = \gamma_Q \times \text{Surcharge}_Q \times l_{heel} = \mathbf{0.8 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_v} = \gamma_G \times A_{moist} \times \gamma_{mr}' = \mathbf{28 \text{ kN/m}}$$

Base soil

$$F_{pass_v} = \gamma_G \times A_{pass} \times \gamma_b' = \mathbf{5.4 \text{ kN/m}}$$

Total

$$F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{pass_v} = \mathbf{104 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge load

$$F_{sur_h} = K_A \times \gamma_Q \times \text{Surcharge}_Q \times (h_{eff} - d_{key}) = \mathbf{1.9 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_h} = \gamma_G \times K_A \times \gamma_{mr}' \times (h_{eff} - d_{key})^2 / 2 = \mathbf{35.1 \text{ kN/m}}$$

Base soil

$$F_{pass_h} = \max(-\gamma_{Gf} \times K_P \times \gamma_b' \times (d_{cover} + h_{base})^2 / 2, -(F_{moist_h} + F_{sur_h})) = \mathbf{-37 \text{ kN/m}}$$

Total

$$F_{total_h} = \max(F_{sur_h} + F_{moist_h} + F_{pass_h} - F_{total_v} \times K_{fbb}, 0 \text{ kN/m}) = \mathbf{0 \text{ kN/m}}$$

Moments on wall

Wall stem

$$M_{stem} = F_{stem} \times X_{stem} = \mathbf{58 \text{ kNm/m}}$$

Wall base

$$M_{base} = F_{base} \times X_{base} = \mathbf{17 \text{ kNm/m}}$$

Surcharge load

$$M_{sur} = F_{sur_v} \times X_{sur_v} - F_{sur_h} \times X_{sur_h_a} = \mathbf{-1.9 \text{ kNm/m}}$$

Moist retained soil

$$M_{moist} = F_{moist_v} \times X_{moist_v} - F_{moist_h} \times X_{moist_h_a} = \mathbf{4.3 \text{ kNm/m}}$$

Base soil

$$M_{pass} = F_{pass_v} \times X_{pass_v} - F_{pass_h} \times X_{pass_h} = \mathbf{-1 \text{ kNm/m}}$$

Total

$$M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} = \mathbf{76.4 \text{ kNm/m}}$$



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Check bearing pressure

Distance to reaction $\bar{x} = M_{total} / F_{total_v} = 734 \text{ mm}$

Eccentricity of reaction $e = \bar{x} - l_{base} / 2 = -166 \text{ mm}$

Loaded length of base $l_{load} = 2 \times \bar{x} = 1469 \text{ mm}$

Bearing pressure at toe $q_{toe} = F_{total_v} / l_{load} = 70.8 \text{ kN/m}^2$

Bearing pressure at heel $q_{heel} = 0 \text{ kN/m}^2$

Factor of safety $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = 1.412$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

Design approach 1

Partial factors on actions - Table A.3 - Combination 2

Partial factor set	A2
Permanent unfavourable action	$\gamma_G = 1.000$
Permanent favourable action	$\gamma_{Gf} = 1.000$
Variable unfavourable action	$\gamma_Q = 1.300$
Variable favourable action	$\gamma_{Qf} = 0.000$

Partial factors for soil parameters – Table A.4 - Combination 2

Soil parameter set	M2
Angle of shearing resistance	$\gamma_{\phi} = 1.25$
Effective cohesion	$\gamma_{c'} = 1.25$
Weight density	$\gamma_{\gamma} = 1.00$

Retained soil properties

Design moist density	$\gamma_{mr}' = \gamma_{mr} / \gamma_{\gamma} = 18 \text{ kN/m}^3$
Design saturated density	$\gamma_{sr}' = \gamma_{sr} / \gamma_{\gamma} = 21 \text{ kN/m}^3$

Base soil properties

Design soil density	$\gamma_b' = \gamma_b / \gamma_{\gamma} = 20 \text{ kN/m}^3$
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Soil coefficients

Coefficient of friction to back of wall	$K_{fr} = 0.350$
Coefficient of friction to front of wall	$K_{fb} = 0.350$
Coefficient of friction beneath base	$K_{fbb} = 0.350$
Active pressure coefficient	$K_A = 0.236$
Passive pressure coefficient	$K_P = 4.977$

Sliding check

Vertical forces on wall

Wall stem	$F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem} = 35.2 \text{ kN/m}$
Wall base	$F_{base} = \gamma_{Gf} \times A_{base} \times \gamma_{base} = 16.5 \text{ kN/m}$
Moist retained soil	$F_{moist_v} = \gamma_{Gf} \times A_{moist} \times \gamma_{mr}' = 20.7 \text{ kN/m}$
Total	$F_{total_v} = F_{stem} + F_{base} + F_{moist_v} = 72.4 \text{ kN/m}$

Horizontal forces on wall

Surcharge load	$F_{sur_h} = K_A \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} = 1.8 \text{ kN/m}$
Moist retained soil	$F_{moist_h} = \gamma_G \times K_A \times \gamma_{mr}' \times h_{eff}^2 / 2 = 32.3 \text{ kN/m}$
Total	$F_{total_h} = F_{sur_h} + F_{moist_h} = 34.1 \text{ kN/m}$

Check stability against sliding

Base soil resistance	$F_{exc_h} = \gamma_{Gf} \times K_P \times \gamma_b' \times (h_{pass} + h_{base})^2 / 2 = 24.4 \text{ kN/m}$
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Base friction
Resistance to sliding
Factor of safety

$$F_{\text{friction}} = F_{\text{total}_v} \times K_{\text{fbb}} = \mathbf{25.4 \text{ kN/m}}$$

$$F_{\text{rest}} = F_{\text{exc}_h} + F_{\text{friction}} = \mathbf{49.7 \text{ kN/m}}$$

$$F_{\text{oSsl}} = F_{\text{rest}} / F_{\text{total}_h} = \mathbf{1.458}$$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Wall stem

$$F_{\text{stem}} = \gamma G \times A_{\text{stem}} \times \gamma_{\text{stem}} = \mathbf{35.2 \text{ kN/m}}$$

Wall base

$$F_{\text{base}} = \gamma G \times A_{\text{base}} \times \gamma_{\text{base}} = \mathbf{16.5 \text{ kN/m}}$$

Moist retained soil

$$F_{\text{moist}_v} = \gamma G \times A_{\text{moist}} \times \gamma_{\text{mr}}' = \mathbf{20.7 \text{ kN/m}}$$

Total

$$F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} + F_{\text{moist}_v} = \mathbf{72.4 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge load

$$F_{\text{sur}_h} = K_A \times \gamma Q \times \text{Surcharge}_Q \times (h_{\text{eff}} - d_{\text{key}}) = \mathbf{1.6 \text{ kN/m}}$$

Moist retained soil

$$F_{\text{moist}_h} = \gamma G \times K_A \times \gamma_{\text{mr}}' \times (h_{\text{eff}} - d_{\text{key}})^2 / 2 = \mathbf{26 \text{ kN/m}}$$

Base soil

$$F_{\text{exc}_h} = -\gamma G \times K_P \times \gamma_b' \times (h_{\text{pass}} + h_{\text{base}})^2 / 2 = \mathbf{-24.4 \text{ kN/m}}$$

Total

$$F_{\text{total}_h} = F_{\text{sur}_h} + F_{\text{moist}_h} + F_{\text{exc}_h} = \mathbf{3.3 \text{ kN/m}}$$

Overturning moments on wall

Surcharge load

$$M_{\text{sur}_{\text{OT}}} = F_{\text{sur}_h} \times X_{\text{sur}_h_a} = \mathbf{2.8 \text{ kNm/m}}$$

Moist retained soil

$$M_{\text{moist}_{\text{OT}}} = F_{\text{moist}_h} \times X_{\text{moist}_h_a} = \mathbf{30.4 \text{ kNm/m}}$$

Base soil

$$M_{\text{exc}_{\text{OT}}} = F_{\text{exc}_h} \times X_{\text{exc}_h} = \mathbf{4.1 \text{ kNm/m}}$$

Total

$$M_{\text{total}_{\text{OT}}} = M_{\text{sur}_{\text{OT}}} + M_{\text{moist}_{\text{OT}}} + M_{\text{exc}_{\text{OT}}} = \mathbf{37.3 \text{ kNm/m}}$$

Restoring moments on wall

Wall stem

$$M_{\text{stem}_R} = F_{\text{stem}} \times X_{\text{stem}} = \mathbf{42.9 \text{ kNm/m}}$$

Wall base

$$M_{\text{base}_R} = F_{\text{base}} \times X_{\text{base}} = \mathbf{12.6 \text{ kNm/m}}$$

Moist retained soil

$$M_{\text{moist}_R} = F_{\text{moist}_v} \times X_{\text{moist}_v} = \mathbf{33.6 \text{ kNm/m}}$$

Total

$$M_{\text{total}_R} = M_{\text{stem}_R} + M_{\text{base}_R} + M_{\text{moist}_R} = \mathbf{89.1 \text{ kNm/m}}$$

Check stability against overturning

Factor of safety

$$F_{\text{oSot}} = M_{\text{total}_R} / M_{\text{total}_{\text{OT}}} = \mathbf{2.392}$$

PASS - Maximum restoring moment is greater than overturning moment

Bearing pressure check

Vertical forces on wall

Wall stem

$$F_{\text{stem}} = \gamma G \times A_{\text{stem}} \times \gamma_{\text{stem}} = \mathbf{35.2 \text{ kN/m}}$$

Wall base

$$F_{\text{base}} = \gamma G \times A_{\text{base}} \times \gamma_{\text{base}} = \mathbf{16.5 \text{ kN/m}}$$

Surcharge load

$$F_{\text{sur}_v} = \gamma Q \times \text{Surcharge}_Q \times l_{\text{heel}} = \mathbf{0.7 \text{ kN/m}}$$

Moist retained soil

$$F_{\text{moist}_v} = \gamma G \times A_{\text{moist}} \times \gamma_{\text{mr}}' = \mathbf{20.7 \text{ kN/m}}$$

Base soil

$$F_{\text{pass}_v} = \gamma G \times A_{\text{pass}} \times \gamma_b' = \mathbf{4 \text{ kN/m}}$$

Total

$$F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} + F_{\text{sur}_v} + F_{\text{moist}_v} + F_{\text{pass}_v} = \mathbf{77.1 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge load

$$F_{\text{sur}_h} = K_A \times \gamma Q \times \text{Surcharge}_Q \times (h_{\text{eff}} - d_{\text{key}}) = \mathbf{1.6 \text{ kN/m}}$$

Moist retained soil

$$F_{\text{moist}_h} = \gamma G \times K_A \times \gamma_{\text{mr}}' \times (h_{\text{eff}} - d_{\text{key}})^2 / 2 = \mathbf{26 \text{ kN/m}}$$

Base soil

$$F_{\text{pass}_h} = \max(-\gamma G \times K_P \times \gamma_b' \times (d_{\text{cover}} + h_{\text{base}})^2 / 2, -(F_{\text{moist}_h} + F_{\text{sur}_h})) = \mathbf{-27.6 \text{ kN/m}}$$

Total

$$F_{\text{total}_h} = \max(F_{\text{sur}_h} + F_{\text{moist}_h} + F_{\text{pass}_h} - F_{\text{total}_v} \times K_{\text{fbb}}, 0 \text{ kN/m}) = \mathbf{0 \text{ kN/m}}$$



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Moments on wall

Wall stem	$M_{stem} = F_{stem} \times X_{stem} = 42.9 \text{ kNm/m}$
Wall base	$M_{base} = F_{base} \times X_{base} = 12.6 \text{ kNm/m}$
Surcharge load	$M_{sur} = F_{sur_v} \times X_{sur_v} - F_{sur_h} \times X_{sur_h_a} = -1.7 \text{ kNm/m}$
Moist retained soil	$M_{moist} = F_{moist_v} \times X_{moist_v} - F_{moist_h} \times X_{moist_h_a} = 3.2 \text{ kNm/m}$
Base soil	$M_{pass} = F_{pass_v} \times X_{pass_v} - F_{pass_h} \times X_{pass_h} = -0.8 \text{ kNm/m}$
Total	$M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} = 56.3 \text{ kNm/m}$

Check bearing pressure

Distance to reaction	$\bar{x} = M_{total} / F_{total_v} = 730 \text{ mm}$
Eccentricity of reaction	$e = \bar{x} - l_{base} / 2 = -170 \text{ mm}$
Loaded length of base	$l_{load} = 2 \times \bar{x} = 1460 \text{ mm}$
Bearing pressure at toe	$q_{toe} = F_{total_v} / l_{load} = 52.8 \text{ kN/m}^2$
Bearing pressure at heel	$q_{heel} = 0 \text{ kN/m}^2$
Factor of safety	$FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = 1.893$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

RETAINING WALL DESIGN

In accordance with EN1992-1-1:2004 + A1:2014 incorporating Corrigenda January 2008, November 2010 and January 2014 and the UK National Annex incorporating National Amendment No.1 and EN1996-1-1:2005 incorporating Corrigenda dated February 2006 and July 2009 and the UK National Annex

Tedds calculation version 2.9.24

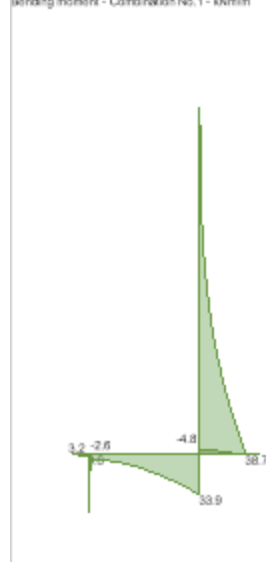
Concrete details - Table 3.1 - Strength and deformation characteristics for concrete

Concrete strength class	C32/40
Characteristic compressive cylinder strength	$f_{ck} = 32 \text{ N/mm}^2$
Characteristic compressive cube strength	$f_{ck,cube} = 40 \text{ N/mm}^2$
Mean value of compressive cylinder strength	$f_{cm} = f_{ck} + 8 \text{ N/mm}^2 = 40 \text{ N/mm}^2$
Mean value of axial tensile strength	$f_{ctm} = 0.3 \text{ N/mm}^2 \times (f_{ck} / 1 \text{ N/mm}^2)^{2/3} = 3.0 \text{ N/mm}^2$
5% fractile of axial tensile strength	$f_{ctk,0.05} = 0.7 \times f_{ctm} = 2.1 \text{ N/mm}^2$
Secant modulus of elasticity of concrete	$E_{cm} = 22 \text{ kN/mm}^2 \times (f_{cm} / 10 \text{ N/mm}^2)^{0.3} = 33346 \text{ N/mm}^2$
Partial factor for concrete - Table 2.1N	$\gamma_C = 1.50$
Compressive strength coefficient - cl.3.1.6(1)	$\alpha_{cc} = 0.85$
Design compressive concrete strength - exp.3.15	$f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C = 18.1 \text{ N/mm}^2$
Maximum aggregate size	$h_{agg} = 20 \text{ mm}$
Ultimate strain - Table 3.1	$\epsilon_{cu2} = 0.0035$
Shortening strain - Table 3.1	$\epsilon_{cu3} = 0.0035$
Effective compression zone height factor	$\lambda = 0.80$
Effective strength factor	$\eta = 1.00$
Bending coefficient k_1	$K_1 = 0.40$
Bending coefficient k_2	$K_2 = 1.00 \times (0.6 + 0.0014/\epsilon_{cu2}) = 1.00$
Bending coefficient k_3	$K_3 = 0.40$
Bending coefficient k_4	$K_4 = 1.00 \times (0.6 + 0.0014/\epsilon_{cu2}) = 1.00$

Reinforcement details

Characteristic yield strength of reinforcement	$f_{yk} = 500 \text{ N/mm}^2$
Modulus of elasticity of reinforcement	$E_s = 200000 \text{ N/mm}^2$
Partial factor for reinforcing steel - Table 2.1N	$\gamma_S = 1.15$

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Moment of resistance - exp.6.22 and exp.6.24a

$$M_{Rd} = \min(A_{sr,prov} \times f_{yd} \times z, 0.4 \times f_d \times d^2) = \mathbf{95.1 \text{ kNm/m}}$$

$$M / M_{Rd} = \mathbf{0.358}$$

PASS - Moment of resistance exceeds applied design moment

Reinforced masonry members subjected to shear loading - Section 6.7

Design shear force

$$V = \mathbf{31.081 \text{ kN/m}}$$

Design shear resistance - exp.6.40

$$V_{Rd} = \min(f_{vd}, f_{cvd,infill}) \times d = \mathbf{29.12 \text{ kN/m}}$$

$$V / V_{Rd} = \mathbf{1.067}$$

Design shear resistance is less than applied design shear force - try concrete shear alone

Determine shear resistance due to concrete infill alone - Clause 6.7.1(3)

Effective depth taking in to account concrete only

$$d = d_{stem} - t_{shell} = \mathbf{285 \text{ mm}}$$

$$C_{Rd,c} = 0.18 / \gamma_c = \mathbf{0.120}$$

$$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) = \mathbf{1.838}$$

Longitudinal reinforcement ratio

$$\rho_l = \min(A_{sr,prov} / d, 0.02) = \mathbf{0.003}$$

$$V_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck,infill}^{0.5} = \mathbf{0.436 \text{ N/mm}^2}$$

Design shear resistance - exp.6.2a & 6.2b

$$V_{Rd,c} = \max(C_{Rd,c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck,infill})^{1/3}, V_{min}) \times d$$

$$V_{Rd,c} = \mathbf{124.8 \text{ kN/m}}$$

$$V / V_{Rd,c} = \mathbf{0.249}$$

PASS - Design shear resistance exceeds design shear force

Check stem design at 1200 mm

Depth of section

$$t = \mathbf{440 \text{ mm}}$$

Hollow wall details

Face shell thickness

$$t_{shell} = \mathbf{35 \text{ mm}}$$

Web shell thickness

$$t_{web} = \mathbf{35 \text{ mm}}$$

Masonry characteristics

Compressive strength constants - Table NA.4

$$K = \mathbf{0.750}$$

Characteristic compressive strength - cl.3.6.1.2(1)

$$f_k = K \times f_b^{0.7} \times f_m^{0.3} = \mathbf{5.162 \text{ N/mm}^2}$$

Design compressive strength

$$f_d = \min(f_k, f_{ck,infill}) / \gamma_{Mc} = \mathbf{2.581 \text{ N/mm}^2}$$

Design flexural strength

$$f_{xd} = f_{xk} / \gamma_{Mt} = \mathbf{0 \text{ N/mm}^2}$$

Height of masonry

$$h_{wt} = h_{stem} - 1200 \text{ mm} = \mathbf{2000 \text{ mm}}$$

Compressive axial force combination 0

$$F_x = \gamma_{Gf} \times \gamma_{stem} \times h_{wt} \times t = \mathbf{22 \text{ kN/m}}$$

Moment combination 0

$$M_x = \gamma_{Gf} \times \gamma_{stem} \times h_{wt} \times t^2 / 2 = \mathbf{4.8 \text{ kNm/m}}$$

Eccentricity of axial load

$$e = \max(\text{abs}(t / 2 - M_x / F_x), 0.05 \times t) = \mathbf{22 \text{ mm}}$$

Capacity reduction factor - exp.6.4

$$\Phi = 1 - 2 \times e / t = \mathbf{0.9}$$

Design vertical resistance - exp.6.2

$$N_{Rd} = \Phi \times t \times f_d = \mathbf{1022.1 \text{ kN/m}}$$

Design vertical compressive stress

$$\sigma_d = \min(F_x / t, 0.15 \times N_{Rd} / t) = \mathbf{0.05 \text{ N/mm}^2}$$

Apparent design flexural strength - exp.6.16

$$f_{xd,app} = f_{xd} + \sigma_d = \mathbf{0.05 \text{ N/mm}^2}$$

Limit of charact. shear strength - exp. 3.1

$$f_{vk,lim} = 0.065 \times f_b = \mathbf{0.475 \text{ N/mm}^2}$$

Characteristic shear strength - exp.3.5

$$f_{vk} = \min(f_{vko} + 0.4 \times \sigma_d, f_{vk,lim}) = \mathbf{0.17 \text{ N/mm}^2}$$

Design shear strength

$$f_{vd} = f_{vk} / \gamma_{Mv} = \mathbf{0.085 \text{ N/mm}^2}$$

Library item: Masonry characteristics output

Reinforced masonry members subjected to bending, bending and axial loading, or axial loading - Section 6.6

Design bending moment combination 1

$$M = \mathbf{8.7 \text{ kNm/m}}$$

Tension reinforcement provided

$$\mathbf{16 \text{ dia. bars @ 225 c/c}}$$

Area of tension reinforcement provided

$$A_{sr1,prov} = \pi \times \phi_{sr1}^2 / (4 \times S_{sr1}) = \mathbf{894 \text{ mm}^2/\text{m}}$$

Depth to tension reinforcement

$$d = \mathbf{320 \text{ mm}}$$



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Minimum area of reinforcement - cl.8.2.3(1)

$$A_{sr,min} = 0.0005 \times d = \mathbf{160 \text{ mm}^2/m}$$

Lever arm - exp.6.23

$$z = d \times \min(1 - 0.5 \times A_{sr1,prov} \times f_{yd} / (d \times f_d), 0.95) = \mathbf{245 \text{ mm}}$$

Moment of resistance - exp.6.22 and exp.6.24a

$$M_{Rd} = \min(A_{sr1,prov} \times f_{yd} \times z, 0.4 \times f_d \times d^2) = \mathbf{95.1 \text{ kNm/m}}$$

$$M / M_{Rd} = \mathbf{0.092}$$

PASS - Moment of resistance exceeds applied design moment

Reinforced masonry members subjected to shear loading - Section 6.7

Design shear force

$$V = \mathbf{12.54 \text{ kN/m}}$$

Design shear resistance - exp.6.40

$$V_{Rd} = \min(f_{vd}, f_{cvd,infill}) \times d = \mathbf{27.2 \text{ kN/m}}$$

$$V / V_{Rd} = \mathbf{0.461}$$

PASS - Design shear resistance exceeds applied design shear force

Check stem design at 3000 mm

Depth of section

$$t = \mathbf{440 \text{ mm}}$$

Hollow wall details

Face shell thickness

$$t_{shell} = \mathbf{35 \text{ mm}}$$

Web shell thickness

$$t_{web} = \mathbf{35 \text{ mm}}$$

Masonry characteristics

Compressive strength constants - Table NA.4

$$K = 0.750$$

Characteristic compressive strength - cl.3.6.1.2(1)

$$f_k = K \times f_b^{0.7} \times f_m^{0.3} = \mathbf{5.162 \text{ N/mm}^2}$$

Design compressive strength

$$f_d = \min(f_k, f_{ck,infill}) / \gamma_{Mc} = \mathbf{2.581 \text{ N/mm}^2}$$

Design flexural strength

$$f_{xd} = f_{xk} / \gamma_{Mt} = \mathbf{0 \text{ N/mm}^2}$$

Height of masonry

$$h_{wt} = h_{stem} - 3000 \text{ mm} = \mathbf{200 \text{ mm}}$$

Compressive axial force combination 0

$$F_x = \gamma_{Gf} \times \gamma_{stem} \times h_{wt} \times t = \mathbf{2.2 \text{ kN/m}}$$

Moment combination 0

$$M_x = \gamma_{Gf} \times \gamma_{stem} \times h_{wt} \times t^2 / 2 = \mathbf{0.5 \text{ kNm/m}}$$

Eccentricity of axial load

$$e = \max(\text{abs}(t / 2 - M_x / F_x), 0.05 \times t) = \mathbf{22 \text{ mm}}$$

Capacity reduction factor - exp.6.4

$$\Phi = 1 - 2 \times e / t = \mathbf{0.9}$$

Design vertical resistance - exp.6.2

$$N_{Rd} = \Phi \times t \times f_d = \mathbf{1022.1 \text{ kN/m}}$$

Design vertical compressive stress

$$\sigma_d = \min(F_x / t, 0.15 \times N_{Rd} / t) = \mathbf{0.005 \text{ N/mm}^2}$$

Apparent design flexural strength - exp.6.16

$$f_{xd,app} = f_{xd} + \sigma_d = \mathbf{0.005 \text{ N/mm}^2}$$

Limit of charact. shear strength - exp. 3.1

$$f_{vk,lim} = 0.065 \times f_b = \mathbf{0.475 \text{ N/mm}^2}$$

Characteristic shear strength - exp.3.5

$$f_{vk} = \min(f_{vko} + 0.4 \times \sigma_d, f_{vk,lim}) = \mathbf{0.152 \text{ N/mm}^2}$$

Design shear strength

$$f_{vd} = f_{vk} / \gamma_{Mv} = \mathbf{0.076 \text{ N/mm}^2}$$

Library item: Masonry characteristics output

Reinforced masonry members subjected to bending, bending and axial loading, or axial loading - Section 6.6

Design bending moment combination 1

$$M = \mathbf{0 \text{ kNm/m}}$$

Tension reinforcement provided

$$\mathbf{16 \text{ dia.bars @ 225 c/c}}$$

Area of tension reinforcement provided

$$A_{sr2,prov} = \pi \times \phi_{sr2}^2 / (4 \times s_{sr2}) = \mathbf{894 \text{ mm}^2/m}$$

Depth to tension reinforcement

$$d = \mathbf{320 \text{ mm}}$$

Minimum area of reinforcement - cl.8.2.3(1)

$$A_{sr,min} = 0.0005 \times d = \mathbf{160 \text{ mm}^2/m}$$

Lever arm - exp.6.23

$$z = d \times \min(1 - 0.5 \times A_{sr2,prov} \times f_{yd} / (d \times f_d), 0.95) = \mathbf{245 \text{ mm}}$$

Moment of resistance - exp.6.22 and exp.6.24a

$$M_{Rd} = \min(A_{sr2,prov} \times f_{yd} \times z, 0.4 \times f_d \times d^2) = \mathbf{95.1 \text{ kNm/m}}$$

$$M / M_{Rd} = \mathbf{0.000}$$

PASS - Moment of resistance exceeds applied design moment

Reinforced masonry members subjected to shear loading - Section 6.7

Design shear force

$$V = \mathbf{0.221 \text{ kN/m}}$$

Design shear resistance - exp.6.40

$$V_{Rd} = \min(f_{vd}, f_{cvd,infill}) \times d = \mathbf{24.32 \text{ kN/m}}$$



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$$V / V_{Rd} = 0.009$$

PASS - Design shear resistance exceeds applied design shear force

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.8.2.3(4) $A_{sx.req} = 0.0005 \times d = 160 \text{ mm}^2/\text{m}$
 Transverse reinforcement provided 10 dia.bars @ 225 c/c
 Area of transverse reinforcement provided $A_{sx.prov} = \pi \times \phi_{sx}^2 / (4 \times S_{sx}) = 349 \text{ mm}^2/\text{m}$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Check base design at toe

Depth of section $h = 300 \text{ mm}$

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 $M = 23.4 \text{ kNm/m}$
 Depth to tension reinforcement $d = h - C_{bb} - \phi_{bb} / 2 = 220 \text{ mm}$
 $K = M / (d^2 \times f_{ck}) = 0.015$
 $K' = (2 \times \eta \times \alpha_{cc} / \gamma_c) \times (1 - \lambda \times (\delta - K_1) / (2 \times K_2)) \times (\lambda \times (\delta - K_1) / (2 \times K_2))$
 $K' = 0.207$

$K' > K$ - No compression reinforcement is required

Lever arm $z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_c))^{0.5}, 0.95) \times d = 209 \text{ mm}$
 Depth of neutral axis $x = 2.5 \times (d - z) = 28 \text{ mm}$
 Area of tension reinforcement required $A_{bb.req} = M / (f_{yd} \times z) = 258 \text{ mm}^2/\text{m}$
 Tension reinforcement provided 10 dia.bars @ 100 c/c
 Area of tension reinforcement provided $A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times S_{bb}) = 785 \text{ mm}^2/\text{m}$
 Minimum area of reinforcement - exp.9.1N $A_{bb.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = 346 \text{ mm}^2/\text{m}$
 Maximum area of reinforcement - cl.9.2.1.1(3) $A_{bb.max} = 0.04 \times h = 12000 \text{ mm}^2/\text{m}$
 $\max(A_{bb.req}, A_{bb.min}) / A_{bb.prov} = 0.44$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Crack control - Section 7.3

Limiting crack width $w_{max} = 0.3 \text{ mm}$
 Variable load factor - EN1990 – Table A1.1 $\psi_2 = 0.6$
 Serviceability bending moment $M_{Sls} = 16.8 \text{ kNm/m}$
 Tensile stress in reinforcement $\sigma_s = M_{Sls} / (A_{bb.prov} \times z) = 102.3 \text{ N/mm}^2$
 Load duration Long term
 Load duration factor $k_t = 0.4$
 Effective area of concrete in tension $A_{c.eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2)$
 $A_{c.eff} = 90833 \text{ mm}^2/\text{m}$
 Mean value of concrete tensile strength $f_{ct.eff} = f_{ctm} = 3.0 \text{ N/mm}^2$
 Reinforcement ratio $\rho_{p.eff} = A_{bb.prov} / A_{c.eff} = 0.009$
 Modular ratio $\alpha_e = E_s / E_{cm} = 5.998$
 Bond property coefficient $k_1 = 0.8$
 Strain distribution coefficient $k_2 = 0.5$
 $k_3 = 3.4$
 $k_4 = 0.425$
 Maximum crack spacing - exp.7.11 $S_{r.max} = k_3 \times C_{bb} + k_1 \times k_2 \times k_4 \times \phi_{bb} / \rho_{p.eff} = 452 \text{ mm}$
 Maximum crack width - exp.7.8 $w_k = S_{r.max} \times \max(\sigma_s - k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
 $w_k = 0.139 \text{ mm}$
 $w_k / w_{max} = 0.462$



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PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force

$$V = 42.6 \text{ kN/m}$$

$$C_{Rd,c} = 0.18 / \gamma_c = 0.120$$

$$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) = 1.953$$

Longitudinal reinforcement ratio

$$\rho_l = \min(A_{bb,prov} / d, 0.02) = 0.004$$

$$v_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5} = 0.541 \text{ N/mm}^2$$

Design shear resistance - exp.6.2a & 6.2b

$$V_{Rd,c} = \max(C_{Rd,c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$$

$$V_{Rd,c} = 118.9 \text{ kN/m}$$

$$V / V_{Rd,c} = 0.358$$

PASS - Design shear resistance exceeds design shear force

Check base design at heel

Depth of section

$$h = 300 \text{ mm}$$

Rectangular section in flexure - Section 6.1

Design bending moment combination 1

$$M = 2.7 \text{ kNm/m}$$

Depth to tension reinforcement

$$d = h - c_{bt} - \phi_{bt} / 2 = 245 \text{ mm}$$

$$K = M / (d^2 \times f_{ck}) = 0.001$$

$$K' = (2 \times \eta \times \alpha_{cc} / \gamma_c) \times (1 - \lambda \times (\delta - K_1) / (2 \times K_2)) \times (\lambda \times (\delta - K_1) / (2 \times K_2))$$

$$K' = 0.207$$

K' > K - No compression reinforcement is required

Lever arm

$$z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_c))^{0.5}, 0.95) \times d = 233 \text{ mm}$$

Depth of neutral axis

$$x = 2.5 \times (d - z) = 31 \text{ mm}$$

Area of tension reinforcement required

$$A_{bt,req} = M / (f_{yd} \times z) = 26 \text{ mm}^2/\text{m}$$

Tension reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of tension reinforcement provided

$$A_{bt,prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt}) = 393 \text{ mm}^2/\text{m}$$

Minimum area of reinforcement - exp.9.1N

$$A_{bt,min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = 385 \text{ mm}^2/\text{m}$$

Maximum area of reinforcement - cl.9.2.1.1(3)

$$A_{bt,max} = 0.04 \times h = 12000 \text{ mm}^2/\text{m}$$

$$\max(A_{bt,req}, A_{bt,min}) / A_{bt,prov} = 0.981$$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Crack control - Section 7.3

Limiting crack width

$$w_{max} = 0.3 \text{ mm}$$

Variable load factor - EN1990 – Table A1.1

$$\psi_2 = 0.6$$

Serviceability bending moment

$$M_{sls} = 1.8 \text{ kNm/m}$$

Tensile stress in reinforcement

$$\sigma_s = M_{sls} / (A_{bt,prov} \times z) = 20.2 \text{ N/mm}^2$$

Load duration

Long term

Load duration factor

$$k_t = 0.4$$

Effective area of concrete in tension

$$A_{c,eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2)$$

$$A_{c,eff} = 89792 \text{ mm}^2/\text{m}$$

Mean value of concrete tensile strength

$$f_{ct,eff} = f_{ctm} = 3.0 \text{ N/mm}^2$$

Reinforcement ratio

$$\rho_{p,eff} = A_{bt,prov} / A_{c,eff} = 0.004$$

Modular ratio

$$\alpha_e = E_s / E_{cm} = 5.998$$

Bond property coefficient

$$k_1 = 0.8$$

Strain distribution coefficient

$$k_2 = 0.5$$

$$k_3 = 3.4$$

$$k_4 = 0.425$$



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Maximum crack spacing - exp.7.11

$$S_{r,max} = k_3 \times C_{bt} + k_1 \times k_2 \times k_4 \times \phi_{bt} / \rho_{p,eff} = \mathbf{559 \text{ mm}}$$

Maximum crack width - exp.7.8

$$W_k = S_{r,max} \times \max(\sigma_s - k_t \times (f_{ct,eff} / \rho_{p,eff}) \times (1 + \alpha_e \times \rho_{p,eff}), 0.6 \times \sigma_s) / E_s$$

$$W_k = \mathbf{0.034 \text{ mm}}$$

$$W_k / W_{max} = \mathbf{0.113}$$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force

$$V = \mathbf{14.5 \text{ kN/m}}$$

$$C_{Rd,c} = 0.18 / \gamma_c = \mathbf{0.120}$$

$$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) = \mathbf{1.904}$$

Longitudinal reinforcement ratio

$$\rho_l = \min(A_{bt,prov} / d, 0.02) = \mathbf{0.002}$$

$$V_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5} = \mathbf{0.520 \text{ N/mm}^2}$$

Design shear resistance - exp.6.2a & 6.2b

$$V_{Rd,c} = \max(C_{Rd,c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, V_{min}) \times d$$

$$V_{Rd,c} = \mathbf{127.4 \text{ kN/m}}$$

$$V / V_{Rd,c} = \mathbf{0.114}$$

PASS - Design shear resistance exceeds design shear force

Check key design

Depth of section

$$h = \mathbf{300 \text{ mm}}$$

Rectangular section in flexure - Section 6.1

Design bending moment combination 1

$$M = \mathbf{1.5 \text{ kNm/m}}$$

Depth to tension reinforcement

$$d = h - c_{bb} - \phi_k / 2 = \mathbf{220 \text{ mm}}$$

$$K = M / (d^2 \times f_{ck}) = \mathbf{0.001}$$

$$K' = (2 \times \eta \times \alpha_{cc} / \gamma_c) \times (1 - \lambda \times (\delta - K_1) / (2 \times K_2)) \times (\lambda \times (\delta - K_1) / (2 \times K_2))$$

$$K' = \mathbf{0.207}$$

K' > K - No compression reinforcement is required

Lever arm

$$z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_c))^{0.5}, 0.95) \times d = \mathbf{209 \text{ mm}}$$

Depth of neutral axis

$$x = 2.5 \times (d - z) = \mathbf{28 \text{ mm}}$$

Area of tension reinforcement required

$$A_{k,req} = M / (f_{yd} \times z) = \mathbf{17 \text{ mm}^2/\text{m}}$$

Tension reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of tension reinforcement provided

$$A_{k,prov} = \pi \times \phi_k^2 / (4 \times s_k) = \mathbf{393 \text{ mm}^2/\text{m}}$$

Minimum area of reinforcement - exp.9.1N

$$A_{k,min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = \mathbf{346 \text{ mm}^2/\text{m}}$$

Maximum area of reinforcement - cl.9.2.1.1(3)

$$A_{k,max} = 0.04 \times h = \mathbf{12000 \text{ mm}^2/\text{m}}$$

$$\max(A_{k,req}, A_{k,min}) / A_{k,prov} = \mathbf{0.881}$$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Crack control - Section 7.3

Limiting crack width

$$W_{max} = \mathbf{0.3 \text{ mm}}$$

Variable load factor - EN1990 – Table A1.1

$$\psi_2 = \mathbf{0.6}$$

Serviceability bending moment

$$M_{sls} = \mathbf{1.1 \text{ kNm/m}}$$

Tensile stress in reinforcement

$$\sigma_s = M_{sls} / (A_{k,prov} \times z) = \mathbf{13.5 \text{ N/mm}^2}$$

Load duration

$$\text{Long term}$$

Load duration factor

$$k_t = \mathbf{0.4}$$

Effective area of concrete in tension

$$A_{c,eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2)$$

$$A_{c,eff} = \mathbf{90833 \text{ mm}^2/\text{m}}$$

Mean value of concrete tensile strength

$$f_{ct,eff} = f_{ctm} = \mathbf{3.0 \text{ N/mm}^2}$$

Reinforcement ratio

$$\rho_{p,eff} = A_{k,prov} / A_{c,eff} = \mathbf{0.004}$$



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Modular ratio

$$\alpha_e = E_s / E_{cm} = \mathbf{5.998}$$

Bond property coefficient

$$k_1 = \mathbf{0.8}$$

Strain distribution coefficient

$$k_2 = \mathbf{0.5}$$

$$k_3 = \mathbf{3.4}$$

$$k_4 = \mathbf{0.425}$$

Maximum crack spacing - exp.7.11

$$s_{r,max} = k_3 \times c_{bb} + k_1 \times k_2 \times k_4 \times \phi_k / \rho_{p,eff} = \mathbf{648 \text{ mm}}$$

Maximum crack width - exp.7.8

$$w_k = s_{r,max} \times \max(\sigma_s - k_t \times (f_{ct,eff} / \rho_{p,eff}) \times (1 + \alpha_e \times \rho_{p,eff}), 0.6 \times \sigma_s) / E_s$$

$$w_k = \mathbf{0.026 \text{ mm}}$$

$$w_k / w_{max} = \mathbf{0.087}$$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force

$$V = \mathbf{7.6 \text{ kN/m}}$$

$$C_{Rd,c} = 0.18 / \gamma_c = \mathbf{0.120}$$

$$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) = \mathbf{1.953}$$

Longitudinal reinforcement ratio

$$\rho_l = \min(A_{k,prov} / d, 0.02) = \mathbf{0.002}$$

$$v_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5} = \mathbf{0.541 \text{ N/mm}^2}$$

Design shear resistance - exp.6.2a & 6.2b

$$V_{Rd,c} = \max(C_{Rd,c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$$

$$V_{Rd,c} = \mathbf{118.9 \text{ kN/m}}$$

$$V / V_{Rd,c} = \mathbf{0.064}$$

PASS - Design shear resistance exceeds design shear force

Secondary transverse reinforcement to base - Section 9.3

Minimum area of reinforcement – cl.9.3.1.1(2)

$$A_{bx,req} = 0.2 \times A_{bb,prov} = \mathbf{157 \text{ mm}^2/\text{m}}$$

Maximum spacing of reinforcement – cl.9.3.1.1(3)

$$s_{bx,max} = \mathbf{450 \text{ mm}}$$

Transverse reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of transverse reinforcement provided

$$A_{bx,prov} = \pi \times \phi_{bx}^2 / (4 \times s_{bx}) = \mathbf{393 \text{ mm}^2/\text{m}}$$

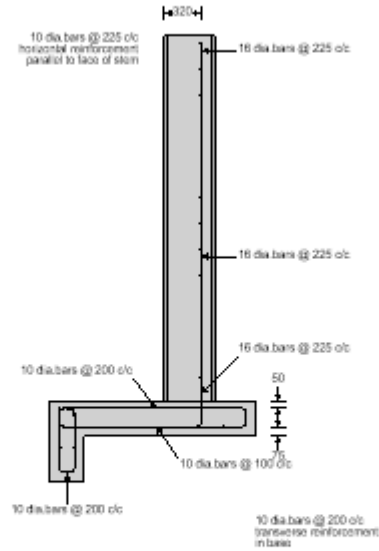
PASS - Area of reinforcement provided is greater than area of reinforcement required



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Reinforcement details