



Cwm Planning & Design Ltd.
(Civil, Structural & Architectural)

STRUCTURAL CALCULATIONS

**Masonry Retaining wall
(Proposed Garage)**

at:

**35 Clare Road
Ystalyfera**

Date: 2nd September 2022

BRIEF:

- 1) Produce design calculations for new masonry retaining wall to strengthen the existing retaining wall present at 35 Clare Road. Retaining wall to support new garage construction above.

REFERENCES:

Architectural Drawings
TEDDS structural computer package.

DESIGN LOADINGS:

Refer to structural calculations attached.

Surcharge = **3kN (1 No. Car)**
Loads from New Construction = **19.62kN/m (Dead)**
3.0 kN/m (Live)

**RETAINING WALL
DESIGN CALCULATIONS**



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Project:

Section:

Calc By:

Date:

Sheet:

Job No.

VERTICAL LOAD ON WALL

<u>ELEMENT</u>	<u>D (K_N/m²)</u>	<u>L (K_N/m²)</u>
MASONRY WALL (325mm cavity)	4.2	-
RC SUSPENDED SLAB (150mm thick)	3.0	2.0

$$\text{WALL} - D = 3.6\text{m} \times 4.2 \text{ K_N/m}^2 = \underline{15.12 \text{ K_N/m}}$$

$$\text{SLAB} - D = \frac{3.0\text{m}}{2} \times 3.0 \text{ K_N/m}^2 = \underline{4.5 \text{ K_N/m}}$$

$$L = \frac{3.0\text{m}}{2} \times 2.0 \text{ K_N/m}^2 = \underline{3.0 \text{ K_N/m}}$$

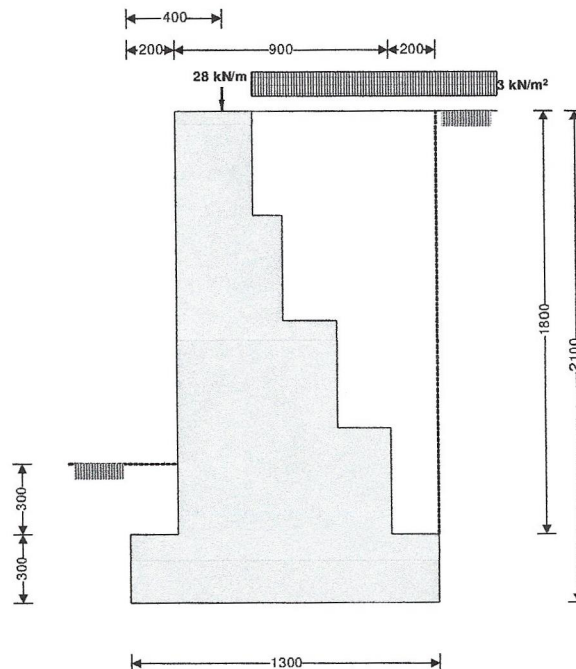
$$\underline{\Sigma \text{ DEAD} = 19.62 \text{ K_N/m}}$$

$$\underline{\Sigma \text{ LIVE} = 3.0 \text{ K_N/m}}$$

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RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.08



Wall details

Retaining wall type
Number of steps
Height of retaining wall stem
Length of toe
Length of heel
Overall length of base
Thickness of base
Depth of downstand
Position of downstand
Thickness of downstand
Height of retaining wall
Depth of cover in front of wall
Depth of unplanned excavation
Height of ground water behind wall
Height of saturated fill above base
Density of wall construction
Density of base construction
Angle of rear face of wall
Angle of soil surface behind wall
Effective height at virtual back of wall

Unpropped cantilever with stepped rear face

4
 $h_{\text{stem}} = 1800 \text{ mm}$
 $l_{\text{toe}} = 200 \text{ mm}$
 $l_{\text{heel}} = 200 \text{ mm}$
 $l_{\text{base}} = l_{\text{toe}} + l_{\text{heel}} + t_{s1} = 1300 \text{ mm}$
 $t_{\text{base}} = 300 \text{ mm}$
 $d_{\text{ds}} = 0 \text{ mm}$
 $l_{\text{ds}} = 250 \text{ mm}$
 $t_{\text{ds}} = 300 \text{ mm}$
 $h_{\text{wall}} = h_{\text{stem}} + t_{\text{base}} + d_{\text{ds}} = 2100 \text{ mm}$
 $d_{\text{cover}} = 300 \text{ mm}$
 $d_{\text{exc}} = 0 \text{ mm}$
 $h_{\text{water}} = 0 \text{ mm}$
 $h_{\text{sat}} = \max(h_{\text{water}} - t_{\text{base}} - d_{\text{ds}}, 0 \text{ mm}) = 0 \text{ mm}$
 $\gamma_{\text{wall}} = 23.6 \text{ kN/m}^3$
 $\gamma_{\text{base}} = 23.6 \text{ kN/m}^3$
 $\alpha = 90.0 \text{ deg}$
 $\beta = 0.0 \text{ deg}$
 $h_{\text{eff}} = h_{\text{wall}} + (l_{\text{heel}} + t_{s1} - t_{s4}) \times \tan(\beta) = 2100 \text{ mm}$

Retained material details

Mobilisation factor
 $M = 1.5$

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Moist density of retained material

$$\gamma_m = 18.0 \text{ kN/m}^3$$

Saturated density of retained material

$$\gamma_s = 21.0 \text{ kN/m}^3$$

Design shear strength

$\phi' = 24.2 \text{ deg}$

Angle of wall friction

$$\delta = 18.6 \text{ deg}$$

Base material details

Stiff or hard glacial clay

Moist density

$$\gamma_{mb} = 18.0 \text{ kN/m}^3$$

Design shear strength

$\phi'_b = 24.2 \text{ deg}$

Design base friction

$$\delta_b = 18.6 \text{ deg}$$

Allowable bearing pressure

$$P_{\text{bearing}} = 150 \text{ kN/m}^2$$

Using Coulomb theory

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^2) = \mathbf{0.369}$$

Passive pressure coefficient for base material

$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = 4.187$$

At-rest pressure

At-rest pressure for retained material

$$K_0 = 1 - \sin(\phi') = 0.590$$

Loading details

Surcharge load on plan

Surcharge = **3.0 kN/m²**

Applied vertical dead load on wall

$$W_{\text{dead}} = 25.0 \text{ kN/m}$$

Applied vertical live load on wall

$$W_{\text{live}} = 3.0 \text{ kN/m}$$

Position of applied vertical load on wall

$$l_{\text{load}} = 400 \text{ mm}$$

Applied horizontal dead load on wall

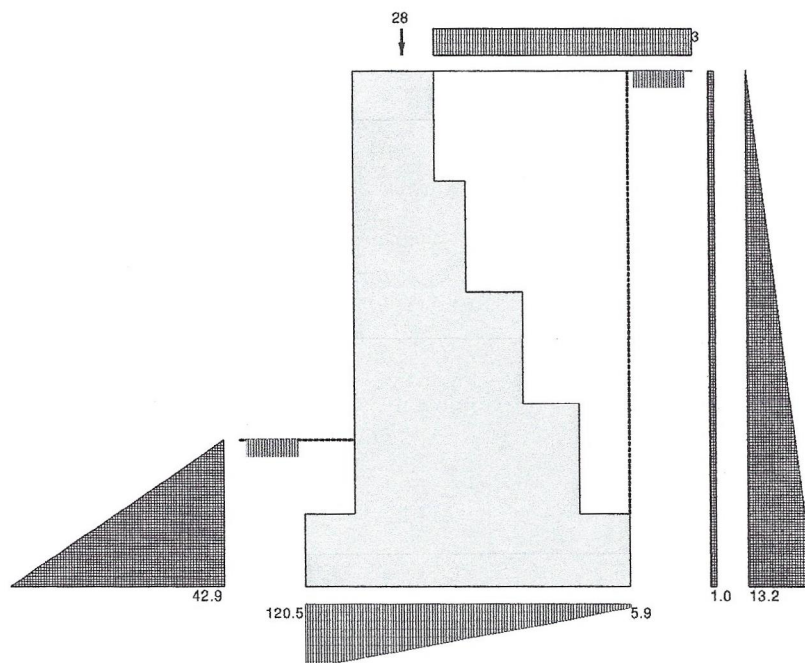
$$F_{\text{dead}} = 0.0 \text{ kN/m}$$

Applied horizontal live load on wall

$$F_{live} = 0.0 \text{ kN/m}$$

Height of applied horizontal load on

$$h_{\text{load}} = 0 \text{ mm}$$



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Loads shown in kN/m, pressures shown in kN/m²

Vertical forces on wall

Wall step no. 4

$$W_{step4} = h_{s4} \times t_{s4} \times \gamma_{wall} = 3.5 \text{ kN/m}$$

Wall step no. 3

$$W_{step3} = h_{s3} \times t_{s3} \times \gamma_{wall} = 4.8 \text{ kN/m}$$

Wall step no. 2

$$W_{step2} = h_{s2} \times t_{s2} \times \gamma_{wall} = 7.2 \text{ kN/m}$$

Wall step no. 1

$$W_{step1} = h_{s1} \times t_{s1} \times \gamma_{wall} = 9.6 \text{ kN/m}$$

Wall base

$$W_{base} = l_{base} \times t_{base} \times \gamma_{base} = 9.2 \text{ kN/m}$$

Surcharge

$$W_{sur} = \text{Surcharge} \times [l_{heel} + (t_{s1} - t_{s4})] = 2.3 \text{ kN/m}$$

Moist backfill to step no. 4

$$W_{m_w4} = (l_{heel} + t_{s1} - t_{s4}) \times h_{s4} \times \gamma_m = 6.3 \text{ kN/m}$$

Moist backfill to step no. 3

$$W_{m_w3} = (l_{heel} + t_{s1} - t_{s3}) \times h_{s3} \times \gamma_m = 5.3 \text{ kN/m}$$

Moist backfill to step no. 2

$$W_{m_w2} = (l_{heel} + t_{s1} - t_{s2}) \times h_{s2} \times \gamma_m = 3.4 \text{ kN/m}$$

Moist backfill to step no. 1

$$W_{m_w1} = (l_{heel} + t_{s1} - t_{s1}) \times h_{s1} \times \gamma_m = 1.6 \text{ kN/m}$$

Soil in front of wall

$$W_p = l_{toe} \times d_{cover} \times \gamma_m = 1.1 \text{ kN/m}$$

Applied vertical load

$$W_v = W_{dead} + W_{live} = 28 \text{ kN/m}$$

Total vertical load

$$W_{total} = W_{step4} + W_{step3} + W_{step2} + W_{step1} + W_{base} + W_{sur} + W_{m_w4} + W_{m_w3} +$$

$$W_{m_w2} + W_{m_w1} + W_p + W_v = 82.2 \text{ kN/m}$$

Horizontal forces on wall

Surcharge

$$F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times \text{Surcharge} \times h_{eff} = 2.2 \text{ kN/m}$$

Moist backfill above water table

$$F_{m_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = 13.9 \text{ kN/m}$$

Total horizontal load

$$F_{total} = F_{sur} + F_{m_a} = 16.1 \text{ kN/m}$$

Calculate stability against sliding

Passive resistance of soil in front of wall

$$F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 12.9 \text{ kN/m}$$

Resistance to sliding

$$F_{res} = F_p + (W_{total} - W_{sur} - W_p - W_{live}) \times \tan(\delta_b) = 38.4 \text{ kN/m}$$

PASS - Resistance force is greater than sliding force

Overturning moments

Surcharge

$$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 2.3 \text{ kNm/m}$$

Moist backfill above water table

$$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 9.7 \text{ kNm/m}$$

Total overturning moment

$$M_{ot} = M_{sur} + M_{m_a} = 12 \text{ kNm/m}$$

Restoring moments

Wall step no. 4

$$M_{step4} = W_{step4} \times (l_{toe} + t_{s4} / 2) = 1.3 \text{ kNm/m}$$

Wall step no. 3

$$M_{step3} = W_{step3} \times (l_{toe} + t_{s3} / 2) = 2 \text{ kNm/m}$$

Wall step no. 2

$$M_{step2} = W_{step2} \times (l_{toe} + t_{s2} / 2) = 3.9 \text{ kNm/m}$$

Wall step no. 1

$$M_{step1} = W_{step1} \times (l_{toe} + t_{s1} / 2) = 6.2 \text{ kNm/m}$$

Wall base

$$M_{base} = W_{base} \times l_{base} / 2 = 6 \text{ kNm/m}$$

Moist backfill to step no. 4

$$M_{m_w4} = W_{m_w4} \times (l_{base} - (l_{heel} + t_{s1} - t_{s4}) / 2) = 5.7 \text{ kNm/m}$$

Moist backfill to step no. 3

$$M_{m_w3} = W_{m_w3} \times (l_{base} - (l_{heel} + t_{s1} - t_{s3}) / 2) = 5.1 \text{ kNm/m}$$

Moist backfill to step no. 2

$$M_{m_w2} = W_{m_w2} \times (l_{base} - (l_{heel} + t_{s1} - t_{s2}) / 2) = 3.7 \text{ kNm/m}$$

Moist backfill to step no. 1

$$M_{m_w1} = W_{m_w1} \times (l_{base} - (l_{heel} + t_{s1} - t_{s1}) / 2) = 1.9 \text{ kNm/m}$$

Design vertical dead load

$$M_{dead} = W_{dead} \times l_{load} = 10 \text{ kNm/m}$$

Total restoring moment

$$M_{rest} = M_{step4} + M_{step3} + M_{step2} + M_{step1} + M_{base} + M_{m_w4} + M_{m_w3} + M_{m_w2} +$$

$$M_{m_w1} + M_{dead} = 45.9 \text{ kNm/m}$$

Check stability against overturning

Total overturning moment

$$M_{ot} = 12.0 \text{ kNm/m}$$

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Total restoring moment

$$M_{rest} = 45.9 \text{ kNm/m}$$

PASS - Restoring moment is greater than overturning moment

Check bearing pressure

Surcharge

$$M_{sur_r} = w_{sur} \times (l_{base} - (l_{heel} + t_{s1} - t_{s4}) / 2) = 2.1 \text{ kNm/m}$$

Soil in front of wall

$$M_{p_r} = w_p \times l_{toe} / 2 = 0.1 \text{ kNm/m}$$

Design vertical live load

$$M_{live} = W_{live} \times l_{load} = 1.2 \text{ kNm/m}$$

Total moment for bearing

$$M_{total} = M_{rest} - M_{ot} + M_{sur_r} + M_{p_r} + M_{live} = 37.3 \text{ kNm/m}$$

Total vertical reaction

$$R = W_{total} = 82.2 \text{ kN/m}$$

Distance to reaction

$$x_{bar} = M_{total} / R = 454 \text{ mm}$$

Eccentricity of reaction

$$e = \text{abs}((l_{base} / 2) - x_{bar}) = 196 \text{ mm}$$

Reaction acts within middle third of base

Bearing pressure at toe

$$p_{toe} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) = 120.5 \text{ kN/m}^2$$

Bearing pressure at heel

$$p_{heel} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 5.9 \text{ kN/m}^2$$

PASS - Maximum bearing pressure is less than allowable bearing pressure