



# Labour Exchange

## Retaining Wall Calculations

*For Hale*

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Date: 30 November 2018

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## DOCUMENT CONTROL SHEET

|              |                                                                                                                    |                                                                   |
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| Issued by    | Hydrock Consultants Limited<br>Castlebridge 5<br>5-19 Cowbridge Road East<br>Cardiff<br>CF11 9AB<br>United Kingdom | T +44 (0)2920 023 665<br>E cardiff@hydrock.com<br>www.hydrock.com |
| Client       | Hale                                                                                                               |                                                                   |
| Project name | Labour Exchange                                                                                                    |                                                                   |
| Title        | Retaining Wall Calculations                                                                                        |                                                                   |
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## Calculations

The following structural calculations are provided for the design of the slope retaining wall at the former Labour Exchange, Merthyr Tydfil.

The sections considered correspond with the gridlines shown on Hydrock Structural Drawings DR-S940 to DR-S943, with the relevant retained slope angles and backfill material properties allowed for, as outlined in Hydrock GDR Drawings G-1008.

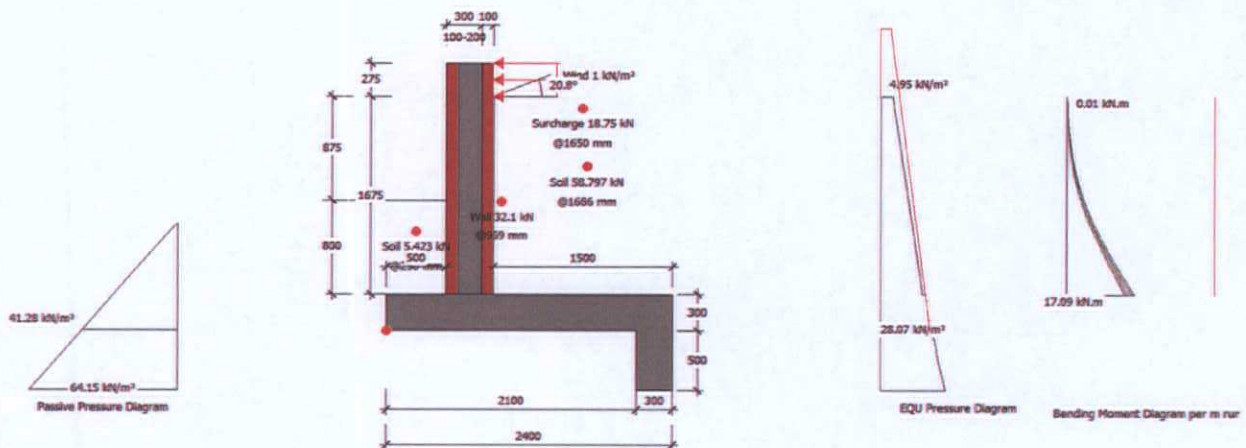
The calculations have been undertaken using Masterseries design software, conforming to Eurocodes EC 7, BS EN 1996-1-1, and EC 2.

Allowance of a structural nib has been made in the calculation of the retaining wall sections, to simulate the effect of mass fill concrete underpinning on the sliding forces and frictions of the retaining wall. Additionally checks have been made allowing for the reduction in sliding and overturning stability that would result from the presence of the water attenuation storage pipe that runs behind the retaining wall stem.

# MASTERKEY : RETAINING WALL DESIGN TO EC 7 : 2004, BS EN 1996-1-1:2005 AND EC 2 : 2004

## Basic Cavity Filled Masonry Retaining Wall Reinforced Masonry Cavity Filled Retaining Wall with Reinforced Concrete Base

GL2



### Summary of Design Data

|                                                                                                                       |                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Notes                                                                                                                 | All dimensions are in mm and all forces are per metre run                                           |
| Material Densities (kN/m <sup>3</sup> )                                                                               | Back soil 20.00, Front soil 18.00, Concrete 24.00, Masonry 19.00                                    |
| Angles                                                                                                                | Embankment 20.8°                                                                                    |
| Concrete grade                                                                                                        | C25/30 N/mm <sup>2</sup> , Permissible tensile stress 1.197 N/mm <sup>2</sup>                       |
| Concrete covers (mm)                                                                                                  | Cavity inner cover 30 mm, Cavity outer cover 160 mm, Base cover 75 mm                               |
| Reinforcement design                                                                                                  | f <sub>y</sub> 500 N/mm <sup>2</sup> , f <sub>yb</sub> 460 N/mm <sup>2</sup> designed to EC 2: 2004 |
| Surcharge and Water Table                                                                                             | Surcharge 12.50 kN/m <sup>2</sup> , Fully drained                                                   |
| Unplanned excavation depth                                                                                            | Front of wall 198 mm                                                                                |
| † The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice |                                                                                                     |

### Soil Properties

|                                  |                                                                                                                                                                                      |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil bearing pressure            | Allowable pressure M1 @ front 100.00 kN/m <sup>2</sup> , @ back 100.00 kN/m <sup>2</sup><br>Allowable pressure M2 @ front 100.00 kN/m <sup>2</sup> , @ back 100.00 kN/m <sup>2</sup> |
| EC7 EQU - Wall Stability         |                                                                                                                                                                                      |
| Back Soil Friction and Cohesion  | $\phi = \text{Atn}(\tan(35)/1.1) = 32.48^\circ$                                                                                                                                      |
| Base Friction and Cohesion       | $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.1))) = 27.69^\circ$                                                                                                         |
| Front Soil Friction and Cohesion | $\phi = \text{Atn}(\tan(28)/1.1) = 25.8^\circ$                                                                                                                                       |
| EC7 GEO/STR - M1                 |                                                                                                                                                                                      |
| Back Soil Friction and Cohesion  | $\phi = \text{Atn}(\tan(35)/1) = 35^\circ$                                                                                                                                           |
| Base Friction and Cohesion       | $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1))) = 30^\circ$                                                                                                              |
| Front Soil Friction and Cohesion | $\phi = \text{Atn}(\tan(28)/1) = 28^\circ$                                                                                                                                           |
| EC7 GEO/STR - M2                 |                                                                                                                                                                                      |
| Back Soil Friction and Cohesion  | $\phi = \text{Atn}(\tan(35)/1.25) = 29.26^\circ$                                                                                                                                     |
| Base Friction and Cohesion       | $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.25))) = 24.79^\circ$                                                                                                        |
| Front Soil Friction and Cohesion | $\phi = \text{Atn}(\tan(28)/1.25) = 23.04^\circ$                                                                                                                                     |

### Loading Cases EQU and GEO/STR - Design Approach 1

|                                                                                                                                   |                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| G <sub>Soil</sub> - Soil Self Weight, G <sub>Wall</sub> - Wall & Base Self Weight, F <sub>VHeel</sub> - Vertical Loads over Heel, |                                                                                                                           |
| P <sub>a</sub> - Active Earth Pressure, P <sub>surcharge</sub> - Earth pressure from surcharge,                                   |                                                                                                                           |
| P <sub>surch(fav)</sub> - Earth pressure from surcharge (no load over heel), P <sub>p</sub> - Passive Earth Pressure              |                                                                                                                           |
| Case 1: EQU Wall Stability                                                                                                        | 0.90 G <sub>Soil</sub> +0.90 G <sub>Wall</sub> +1.10 P <sub>a</sub> +1.50 P <sub>surcharge</sub> +0.90 P <sub>p</sub>     |
| Case 2: GEO/STR A1+M1 I                                                                                                           | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.50 F <sub>VHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |
| Case 3: GEO/STR A2+M2 I                                                                                                           | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.30 F <sub>VHeel</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surcharge</sub> |
| Case 4: GEO/STR A1+M1 II                                                                                                          | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surch(fav)</sub>                         |
| Case 5: GEO/STR A2+M2 II                                                                                                          | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surch(fav)</sub>                         |
| Case 6: GEO/STR A1+M1 III                                                                                                         | 1.35 G <sub>Soil</sub> +1.35 G <sub>Wall</sub> +1.50 F <sub>VHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |

### Geotechnical Design

#### Wall Stability - Virtual Back Pressure

EQU Case 1 Overturning/Stabilising 42.498/117.895

0.360

OK

**Wall Sliding - Virtual Back Pressure**

|                                                           |                         |       |    |
|-----------------------------------------------------------|-------------------------|-------|----|
| Case 2 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 42.999/(86.051+49.058)  | 0.318 | OK |
| Case 3 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 55.547/(67.108+40.495)  | 0.516 | OK |
| Case 4 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 42.999/(69.813+49.058)  | 0.362 | OK |
| Case 5 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 55.547/(55.850+40.495)  | 0.577 | OK |
| Case 6 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 42.999/(105.514+49.058) | 0.278 | OK |

**Soil Pressure**

|                       |                                                              |       |    |
|-----------------------|--------------------------------------------------------------|-------|----|
| Case 2 - Virtual Back | 55.357/100 kN/m <sup>2</sup> , Length under pressure 2.248 m | 0.554 | OK |
| Case 3 - Virtual Back | 56.115/100 kN/m <sup>2</sup> , Length under pressure 2.151 m | 0.561 | OK |
| Case 4 - Virtual Back | 49.628/100 kN/m <sup>2</sup> , Length under pressure 1.941 m | 0.496 | OK |
| Case 5 - Virtual Back | 51.784/100 kN/m <sup>2</sup> , Length under pressure 1.86 m  | 0.518 | OK |
| Case 6 - Virtual Back | 67.261/100 kN/m <sup>2</sup> , Length under pressure 2.351 m | 0.673 | OK |
| Case 2 - Wall Back    | 53.993/100 kN/m <sup>2</sup> , Length under pressure 2.305 m | 0.540 | OK |
| Case 3 - Wall Back    | 51.197/100 kN/m <sup>2</sup> , Length under pressure 2.357 m | 0.512 | OK |
| Case 4 - Wall Back    | 42.277/100 kN/m <sup>2</sup> , Length under pressure 2.278 m | 0.423 | OK |
| Case 5 - Wall Back    | 42.976/100 kN/m <sup>2</sup> , Length under pressure 2.241 m | 0.430 | OK |
| Case 6 - Wall Back    | 70.162/100 kN/m <sup>2</sup> , Length under pressure 2.254 m | 0.702 | OK |

**Structural Design****Outer Leaf Details**

|                                                     |                                                    |                        |            |
|-----------------------------------------------------|----------------------------------------------------|------------------------|------------|
| Partial Safety Factor ( $\gamma_{mf}/\gamma_{mf}$ ) | Units Category II, Execution Control Class 2       | 3/2.7                  | Table NA.1 |
| Material                                            | Clay bricks with water absorption less than 7%     |                        |            |
| Units and Mortar Strength                           | 15 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Compressive Strength ( $f_k$ )                      | Group 1, $\gamma = 19$ kN/m <sup>3</sup>           | 5.04 N/mm <sup>2</sup> | Table NA.4 |

**Inner Leaf Details**

|                                                     |                                                   |                        |            |
|-----------------------------------------------------|---------------------------------------------------|------------------------|------------|
| Partial Safety Factor ( $\gamma_{mf}/\gamma_{mf}$ ) | Units Category II, Execution Control Class 2      | 3/2.7                  | Table NA.1 |
| Material                                            | Concrete blocks, $\gamma = 19$ kN/m <sup>3</sup>  |                        |            |
| Units and Mortar Strength                           | 7 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Blocks Ratio                                        | Unit height=225, Least horizontal dimensions=100  | 2.25                   |            |
| Compressive Strength ( $f_k$ )                      | Group 1                                           | 4.44 N/mm <sup>2</sup> | Table NA.6 |

**Wall Design (Inner Steel)**

|                                                     |                                                                                     |                     |    |
|-----------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Critical Section                                    | Critical @ 62 mm from base, Case 3                                                  |                     |    |
| Steel Provided (Cover)                              | Dist. B10@200 (75 mm in cavity)                                                     |                     |    |
|                                                     | Main B10@200 (30 mm in cavity)                                                      | 393 mm <sup>2</sup> | OK |
| Leverarm $z = f_n(d, b, A_s, f_y, f_k)$             | 265 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 219 mm              |    |
| $M_r = f_n(\text{above}, \gamma_{mf}, \gamma_{ms})$ | 2.70, 1.15                                                                          | 37.4 kN.m           |    |
| Moment Capacity Check ( $M/M_r$ )                   | M 15.9 kN.m, $M_r$ 37.4 kN.m                                                        | 0.426               | OK |
| Shear Capacity Check                                | F 18.7 kN, $f_{vk}$ 0.298 N/mm <sup>2</sup> , $F_{vr}$ 31.6 kN                      | 0.59                | OK |

**Base Top Steel Design - Case 3**

|                                             |                                                                                     |                     |    |
|---------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                      | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)          | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm $z = f_n(d, b, A_s, f_y, F_{ck})$  | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| $M_r = f_n(\text{above}, A_s', d', x, x/d)$ | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check ( $M/M_r$ )           | M 15.2 kN.m, $M_r$ 35.7 kN.m                                                        | 0.426               | OK |
| Shear Capacity Check                        | F 17.2 kN, $v_c$ 0.478 N/mm <sup>2</sup> , $F_{vr}$ 105.1 kN                        | 0.16                | OK |

**Base Bottom Steel Design - Case 6**

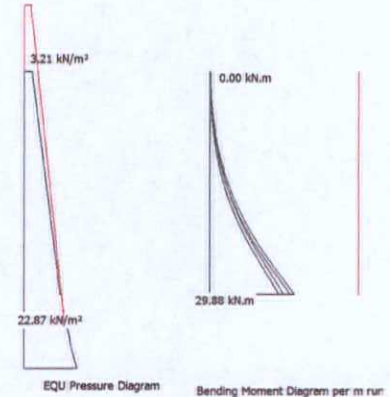
|                                             |                                                                                     |                     |    |
|---------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                      | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)          | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm $z = f_n(d, b, A_s, f_y, F_{ck})$  | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| $M_r = f_n(\text{above}, A_s', d', x, x/d)$ | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check ( $M/M_r$ )           | M 10.0 kN.m, $M_r$ 35.7 kN.m                                                        | 0.281               | OK |
| Shear Capacity Check                        | F 24.8 kN, $v_c$ 0.478 N/mm <sup>2</sup> , $F_{vr}$ 105.1 kN                        | 0.24                | OK |

**Nib Design - Case 2**

|                                             |                                                                                      |                      |    |
|---------------------------------------------|--------------------------------------------------------------------------------------|----------------------|----|
| Steel Provided (Cover)                      | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)          | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> |    |
| Leverarm $z = f_n(d, b, A_s, f_y, F_{ck})$  | 217 mm, 1000 mm, 2011 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 186 mm               |    |
| $M_r = f_n(\text{above}, A_s', d', x, x/d)$ | 2011 mm <sup>2</sup> , 83 mm, 77 mm, 0.36                                            | 162.7 kN.m           |    |
| Moment Capacity Check ( $M/M_r$ )           | M 3.2 kN.m, $M_r$ 162.7 kN.m                                                         | 0.019                | OK |
| Shear Capacity Check                        | F 10.9 kN, $v_c$ 0.670 N/mm <sup>2</sup> , $F_{vr}$ 145.5 kN                         | 0.07                 | OK |

## Reinforced Masonry Cavity Filled Retaining Wall with Reinforced Concrete Base

Diagram of a retaining wall cross-section showing dimensions and loads. The wall has a vertical stem 1550 mm high and a base 2500 mm wide. The stem is 300 mm wide at the top and 200 mm at the base. The base is 2200 mm wide. The wall is subjected to a wind load of 1 kN/m², a surcharge of 18.75 kN/m², and soil pressure. The soil pressure is shown as a triangular distribution with a maximum value of 41.28 kN/m² at the base and a minimum value of 64.15 kN/m² at the top. The wall is also subjected to a horizontal load of 301.100 kN and a vertical load of 100-200 kN.



|                                                                                                                       |                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Notes                                                                                                                 | All dimensions are in mm and all forces are per metre run                                           |
| Material Densities (kN/m <sup>3</sup> )                                                                               | Back soil 20.00, Front soil 18.00, Concrete 24.00, Masonry 19.00                                    |
| Angles                                                                                                                | Embankment 25.7°                                                                                    |
| Concrete grade                                                                                                        | C25/30 N/mm <sup>2</sup> , Permissible tensile stress 1.197 N/mm <sup>2</sup>                       |
| Concrete covers (mm)                                                                                                  | Cavity inner cover 30 mm, Cavity outer cover 160 mm, Base cover 75 mm                               |
| Reinforcement design                                                                                                  | f <sub>y</sub> 500 N/mm <sup>2</sup> , f <sub>yb</sub> 460 N/mm <sup>2</sup> designed to EC 2: 2004 |
| Surcharge and Water Table                                                                                             | Surcharge 12.50 kN/m <sup>2</sup> , Fully drained                                                   |
| Unplanned excavation depth                                                                                            | Front of wall 273 mm                                                                                |
| † The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice |                                                                                                     |

|                                  |                                                                                                                                                                                      |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil bearing pressure            | Allowable pressure M1 @ front 100.00 kN/m <sup>2</sup> , @ back 100.00 kN/m <sup>2</sup><br>Allowable pressure M2 @ front 100.00 kN/m <sup>2</sup> , @ back 100.00 kN/m <sup>2</sup> |
| EC7 EQU - Wall Stability         |                                                                                                                                                                                      |
| Back Soil Friction and Cohesion  | $\phi = \text{Atn}(\text{Tan}(45)/1.1) = 42.27^\circ$                                                                                                                                |
| Base Friction and Cohesion       | $\delta = \text{Atn}(1 \times \text{Tan}(\text{Atn}(\text{Tan}(30)/1.1))) = 27.69^\circ$                                                                                             |
| Front Soil Friction and Cohesion | $\phi = \text{Atn}(\text{Tan}(28)/1.1) = 25.8^\circ$                                                                                                                                 |
| EC7 GEO/STR - M1                 |                                                                                                                                                                                      |
| Back Soil Friction and Cohesion  | $\phi = \text{Atn}(\text{Tan}(45)/1) = 45^\circ$                                                                                                                                     |
| Base Friction and Cohesion       | $\delta = \text{Atn}(1 \times \text{Tan}(\text{Atn}(\text{Tan}(30)/1))) = 30^\circ$                                                                                                  |
| Front Soil Friction and Cohesion | $\phi = \text{Atn}(\text{Tan}(28)/1) = 28^\circ$                                                                                                                                     |
| EC7 GEO/STR - M2                 |                                                                                                                                                                                      |
| Back Soil Friction and Cohesion  | $\phi = \text{Atn}(\text{Tan}(45)/1.25) = 38.66^\circ$                                                                                                                               |
| Base Friction and Cohesion       | $\delta = \text{Atn}(1 \times \text{Tan}(\text{Atn}(\text{Tan}(30)/1.25))) = 24.79^\circ$                                                                                            |
| Front Soil Friction and Cohesion | $\phi = \text{Atn}(\text{Tan}(28)/1.25) = 23.04^\circ$                                                                                                                               |

$G_{Soil}$ - Soil Self Weight,  $G_{Wall}$ - Wall & Base Self Weight,  $F_{VHeel}$ - Vertical Loads over Heel,  
 $P_a$ - Active Earth Pressure,  $P_{surcharge}$ - Earth pressure from surcharge,  
 $P_{surch}(fav)$  - Earth pressure from surcharge (no load over heel),  $P_p$ - Passive Earth Pressure

|                            |                                                                                  |
|----------------------------|----------------------------------------------------------------------------------|
| Case 1: EQU Wall Stability | $0.90 G_{Soil} + 0.90 G_{Wall} + 1.10 P_a + 1.50 P_{surcharge} + 0.90 P_p$       |
| Case 2: GEO/STR A1+M1 I    | $1.00 G_{Soil} + 1.00 G_{Wall} + 1.50 F_{VHeel} + 1.35 P_a + 1.50 P_{surcharge}$ |
| Case 3: GEO/STR A2+M2 I    | $1.00 G_{Soil} + 1.00 G_{Wall} + 1.30 F_{VHeel} + 1.00 P_a + 1.30 P_{surcharge}$ |
| Case 4: GEO/STR A1+M1 II   | $1.00 G_{Soil} + 1.00 G_{Wall} + 1.35 P_a + 1.50 P_{surch}(fav)$                 |
| Case 5: GEO/STR A2+M2 II   | $1.00 G_{Soil} + 1.00 G_{Wall} + 1.00 P_a + 1.30 P_{surch}(fav)$                 |
| Case 6: GEO/STR A1+M1 III  | $1.35 G_{Soil} + 1.35 G_{Wall} + 1.50 F_{VHeel} + 1.35 P_a + 1.50 P_{surcharge}$ |

|                                    |                |
|------------------------------------|----------------|
| EQU Case 1 Overturning/Stabilising | 58.214/171.115 |
|------------------------------------|----------------|

0.340

OK

**Wall Sliding - Virtual Back Pressure**

|                                                             |                         |       |    |
|-------------------------------------------------------------|-------------------------|-------|----|
| Case 2 Fx/(Rx <sub>Friction</sub> + Rx <sub>Passive</sub> ) | 37.441/(105.927+49.058) | 0.242 | OK |
| Case 3 Fx/(Rx <sub>Friction</sub> + Rx <sub>Passive</sub> ) | 52.621/(83.009+40.495)  | 0.426 | OK |
| Case 4 Fx/(Rx <sub>Friction</sub> + Rx <sub>Passive</sub> ) | 37.441/(89.688+49.058)  | 0.270 | OK |
| Case 5 Fx/(Rx <sub>Friction</sub> + Rx <sub>Passive</sub> ) | 52.621/(71.751+40.495)  | 0.469 | OK |
| Case 6 Fx/(Rx <sub>Friction</sub> + Rx <sub>Passive</sub> ) | 37.441/(132.144+49.058) | 0.207 | OK |

**Soil Pressure**

|                       |                                                              |       |    |
|-----------------------|--------------------------------------------------------------|-------|----|
| Case 2 - Virtual Back | 66.929/100 kN/m <sup>2</sup> , Length under pressure 2.359 m | 0.669 | OK |
| Case 3 - Virtual Back | 69.192/100 kN/m <sup>2</sup> , Length under pressure 2.227 m | 0.692 | OK |
| Case 4 - Virtual Back | 61.451/100 kN/m <sup>2</sup> , Length under pressure 2.111 m | 0.615 | OK |
| Case 5 - Virtual Back | 65.253/100 kN/m <sup>2</sup> , Length under pressure 1.988 m | 0.653 | OK |
| Case 6 - Virtual Back | 81.682/100 kN/m <sup>2</sup> , Length under pressure 2.489 m | 0.817 | OK |
| Case 2 - Wall Back    | 65.635/100 kN/m <sup>2</sup> , Length under pressure 2.405 m | 0.656 | OK |
| Case 3 - Wall Back    | 62.089/100 kN/m <sup>2</sup> , Length under pressure 2.482 m | 0.621 | OK |
| Case 4 - Wall Back    | 53.451/100 kN/m <sup>2</sup> , Length under pressure 2.427 m | 0.535 | OK |
| Case 5 - Wall Back    | 55.018/100 kN/m <sup>2</sup> , Length under pressure 2.358 m | 0.550 | OK |
| Case 6 - Wall Back    | 87.318/100 kN/m <sup>2</sup> , Length under pressure 2.328 m | 0.873 | OK |

**Structural Design****Outer Leaf Details**

|                                                           |                                                    |                        |            |
|-----------------------------------------------------------|----------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2       | 3/2.7                  | Table NA.1 |
| Material                                                  | Clay bricks with water absorption less than 7%     |                        |            |
| Units and Mortar Strength                                 | 15 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1, γ=19 kN/m <sup>3</sup>                    | 5.04 N/mm <sup>2</sup> | Table NA.4 |

**Inner Leaf Details**

|                                                           |                                                   |                        |            |
|-----------------------------------------------------------|---------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2      | 3/2.7                  | Table NA.1 |
| Material                                                  | Concrete blocks, γ=19 kN/m <sup>3</sup>           |                        |            |
| Units and Mortar Strength                                 | 7 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Blocks Ratio                                              | Unit height=225, Least horizontal dimensions=100  | 2.25                   |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1                                           | 4.44 N/mm <sup>2</sup> | Table NA.6 |

**Wall Design (Inner Steel)**

|                                                |                                                                                     |                     |    |
|------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Critical Section                               | Critical @ 109 mm from base, Case 3                                                 |                     |    |
| Steel Provided (Cover)                         | Dist. B10@200 (75 mm in cavity)                                                     |                     |    |
|                                                | Main B10@100 (30 mm in cavity)                                                      | 785 mm <sup>2</sup> | OK |
| Leverarm z=fn(d,b,As,fy,f <sub>ck</sub> )      | 265 mm, 1000 mm, 785 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 174 mm              |    |
| Mr=fn(above,γ <sub>mf</sub> ,γ <sub>ms</sub> ) | 2.70, 1.15                                                                          | 52.5 kN.m           |    |
| Moment Capacity Check (M/Mr)                   | M 27.3 kN.m, Mr 52.5 kN.m                                                           | 0.519               | OK |
| Shear Capacity Check                           | F 24.2 kN, f <sub>vk</sub> 0.290 N/mm <sup>2</sup> , F <sub>vr</sub> 30.7 kN        | 0.79                | OK |

**Base Top Steel Design - Case 3**

|                                           |                                                                                     |                     |    |
|-------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                    | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)        | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                 | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)              | M 22.7 kN.m, Mr 35.7 kN.m                                                           | 0.636               | OK |
| Shear Capacity Check                      | F 25.6 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.24                | OK |

**Base Bottom Steel Design - Case 6**

|                                           |                                                                                     |                     |    |
|-------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                    | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)        | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                 | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)              | M 17.6 kN.m, Mr 35.7 kN.m                                                           | 0.494               | OK |
| Shear Capacity Check                      | F 38.5 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.37                | OK |

**Nib Design - Case 2**

|                                           |                                                                                      |                      |    |
|-------------------------------------------|--------------------------------------------------------------------------------------|----------------------|----|
| Steel Provided (Cover)                    | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)        | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,F <sub>ck</sub> ) | 217 mm, 1000 mm, 2011 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 186 mm               |    |
| Mr=fn(above,As',d',x,x/d)                 | 2011 mm <sup>2</sup> , 83 mm, 77 mm, 0.36                                            | 162.7 kN.m           |    |
| Moment Capacity Check (M/Mr)              | M 4.1 kN.m, Mr 162.7 kN.m                                                            | 0.025                | OK |
| Shear Capacity Check                      | F 14.6 kN, vc 0.670 N/mm <sup>2</sup> , F <sub>vr</sub> 145.5 kN                     | 0.10                 | OK |

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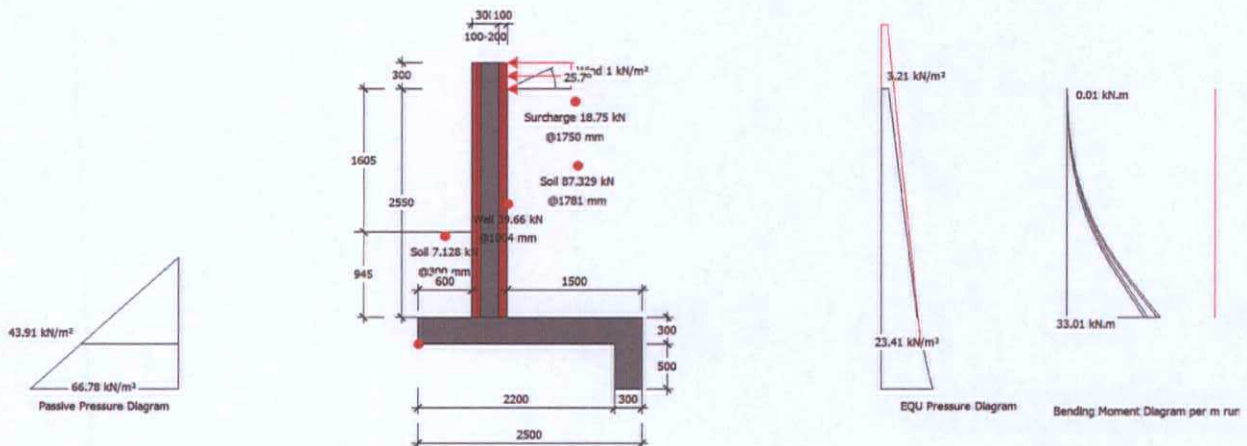
Job ref : Job Ref  
Sheet : Sheet Ref / 2 -  
Made By : STD  
Date : 29 Nov 2018  
Checked :  
Approved :

## MASTERKEY : RETAINING WALL DESIGN TO EC 7 : 2004, BS EN 1996-1-1:2005 AND EC 2 : 2004

### Basic Cavity Filled Masonry Retaining Wall

### Reinforced Masonry Cavity Filled Retaining Wall with Reinforced Concrete Base

GL 4



### Summary of Design Data

#### Notes

Material Densities (kN/m³)

Angles

Concrete grade

Concrete covers (mm)

Reinforcement design

Surcharge and Water Table

Unplanned excavation depth

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

All dimensions are in mm and all forces are per metre run

Back soil 20.00, Front soil 18.00, Concrete 24.00, Masonry 19.00

Embankment 25.7°

C25/30 N/mm², Permissible tensile stress 1.197 N/mm²

Cavity inner cover 30 mm, Cavity outer cover 160 mm, Base cover 75 mm

fy 500 N/mm², fyd 460 N/mm² designed to EC 2: 2004

Surcharge 12.50 kN/m², Fully drained

Front of wall 285 mm

### Soil Properties

Soil bearing pressure

Allowable pressure M1 @ front 100.00 kN/m², @ back 100.00 kN/m²

Allowable pressure M2 @ front 100.00 kN/m², @ back 100.00 kN/m²

EC7 EQU - Wall Stability

Back Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(45)/1.1) = 42.27^\circ$$

Base Friction and Cohesion

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.1))) = 27.69^\circ$$

Front Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(28)/1.1) = 25.8^\circ$$

EC7 GEO/STR - M1

Back Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(45)/1) = 45^\circ$$

Base Friction and Cohesion

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1))) = 30^\circ$$

Front Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(28)/1) = 28^\circ$$

EC7 GEO/STR - M2

Back Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(45)/1.25) = 38.66^\circ$$

Base Friction and Cohesion

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.25))) = 24.79^\circ$$

Front Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(28)/1.25) = 23.04^\circ$$

### Loading Cases EQU and GEO/STR - Design Approach 1

G<sub>Soil</sub>- Soil Self Weight, G<sub>Wall</sub>- Wall & Base Self Weight, F<sub>VHeel</sub>- Vertical Loads over Heel,P<sub>a</sub>- Active Earth Pressure, P<sub>surcharge</sub>- Earth pressure from surcharge,P<sub>surch(fav)</sub>- Earth pressure from surcharge (no load over heel), P<sub>p</sub>- Passive Earth Pressure

Case 1: EQU Wall Stability

$$0.90 G_{\text{Soil}} + 0.90 G_{\text{Wall}} + 1.10 P_a + 1.50 P_{\text{surcharge}} + 0.90 P_p$$



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|                           |                                                                                                                           |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Case 2: GEO/STR A1+M1 I   | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.50 F <sub>vHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |
| Case 3: GEO/STR A2+M2 I   | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.30 F <sub>vHeel</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surcharge</sub> |
| Case 4: GEO/STR A1+M1 II  | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surch(fav)</sub>                         |
| Case 5: GEO/STR A2+M2 II  | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surch(fav)</sub>                         |
| Case 6: GEO/STR A1+M1 III | 1.35 G <sub>soil</sub> +1.35 G <sub>wall</sub> +1.50 F <sub>vHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |

## Geotechnical Design

### Wall Stability - Virtual Back Pressure

|                                    |                |       |    |
|------------------------------------|----------------|-------|----|
| EQU Case 1 Overturning/Stabilising | 63.110/177.071 | 0.356 | OK |
|------------------------------------|----------------|-------|----|

### Wall Sliding - Virtual Back Pressure

|                                                                          |                         |       |    |
|--------------------------------------------------------------------------|-------------------------|-------|----|
| Case 2 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 38.937/(108.450+53.162) | 0.241 | OK |
| Case 3 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 54.828/(85.028+43.883)  | 0.425 | OK |
| Case 4 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 38.937/(92.212+53.162)  | 0.268 | OK |
| Case 5 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 54.828/(73.770+43.883)  | 0.466 | OK |
| Case 6 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 38.937/(135.551+53.162) | 0.206 | OK |

### Soil Pressure

|                       |                                                              |       |    |
|-----------------------|--------------------------------------------------------------|-------|----|
| Case 2 - Virtual Back | 69.588/100 kN/m <sup>2</sup> , Length under pressure 2.331 m | 0.696 | OK |
| Case 3 - Virtual Back | 72.337/100 kN/m <sup>2</sup> , Length under pressure 2.191 m | 0.723 | OK |
| Case 4 - Virtual Back | 64.281/100 kN/m <sup>2</sup> , Length under pressure 2.086 m | 0.643 | OK |
| Case 5 - Virtual Back | 68.668/100 kN/m <sup>2</sup> , Length under pressure 1.953 m | 0.687 | OK |
| Case 6 - Virtual Back | 84.717/100 kN/m <sup>2</sup> , Length under pressure 2.469 m | 0.847 | OK |
| Case 2 - Wall Back    | 66.854/100 kN/m <sup>2</sup> , Length under pressure 2.427 m | 0.669 | OK |
| Case 3 - Wall Back    | 63.684/100 kN/m <sup>2</sup> , Length under pressure 2.489 m | 0.637 | OK |
| Case 4 - Wall Back    | 55.906/100 kN/m <sup>2</sup> , Length under pressure 2.399 m | 0.559 | OK |
| Case 5 - Wall Back    | 57.749/100 kN/m <sup>2</sup> , Length under pressure 2.322 m | 0.577 | OK |
| Case 6 - Wall Back    | 89.267/100 kN/m <sup>2</sup> , Length under pressure 2.343 m | 0.893 | OK |

## Structural Design

### Outer Leaf Details

|                                                           |                                                    |                        |            |
|-----------------------------------------------------------|----------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2       | 3/2.7                  | Table NA.1 |
| Material                                                  | Clay bricks with water absorption less than 7%     |                        |            |
| Units and Mortar Strength                                 | 15 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Compressive Strength (f <sub>ck</sub> )                   | Group 1, γ=19 kN/m <sup>3</sup>                    | 5.04 N/mm <sup>2</sup> | Table NA.4 |

### Inner Leaf Details

|                                                           |                                                   |                        |            |
|-----------------------------------------------------------|---------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2      | 3/2.7                  | Table NA.1 |
| Material                                                  | Concrete blocks, γ=19 kN/m <sup>3</sup>           |                        |            |
| Units and Mortar Strength                                 | 7 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Blocks Ratio                                              | Unit height=225, Least horizontal dimensions=100  | 2.25                   |            |
| Compressive Strength (f <sub>ck</sub> )                   | Group 1                                           | 4.44 N/mm <sup>2</sup> | Table NA.6 |

### Wall Design (Inner Steel)

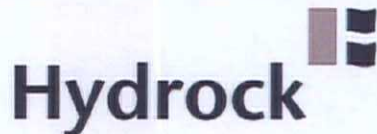
|                                                |                                                                                     |                     |    |
|------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Critical Section                               | Critical @ 175 mm from base, Case 3                                                 |                     |    |
| Steel Provided (Cover)                         | Dist. B10@200 (75 mm in cavity)                                                     |                     |    |
|                                                | Main B10@100 (30 mm in cavity)                                                      | 785 mm <sup>2</sup> | OK |
| Leverarm z=fn(d,b,As,fy,f <sub>ck</sub> )      | 265 mm, 1000 mm, 785 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 174 mm              |    |
| Mr=fn(above,γ <sub>mf</sub> ,γ <sub>ms</sub> ) | 2.70, 1.15                                                                          | 52.5 kN.m           |    |
| Moment Capacity Check (M/Mr)                   | M 28.6 kN.m, Mr 52.5 kN.m                                                           | 0.545               | OK |
| Shear Capacity Check                           | F 25.3 kN, f <sub>vk</sub> 0.290 N/mm <sup>2</sup> , F <sub>vr</sub> 30.7 kN        | 0.83                | OK |

### Base Top Steel Design - Case 3

|                                           |                                                                                     |                     |    |
|-------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                    | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)        | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                 | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)              | M 23.6 kN.m, Mr 35.7 kN.m                                                           | 0.662               | OK |
| Shear Capacity Check                      | F 27.0 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.26                | OK |

### Base Bottom Steel Design - Case 6

|                                           |                                                                                     |                     |    |
|-------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                    | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)        | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                 | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)              | M 17.8 kN.m, Mr 35.7 kN.m                                                           | 0.499               | OK |
| Shear Capacity Check                      | F 39.2 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.37                | OK |



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## Nib Design - Case 2

|                                                   |                                                                                      |                      |    |
|---------------------------------------------------|--------------------------------------------------------------------------------------|----------------------|----|
| Steel Provided (Cover)                            | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{ck})$  | 217 mm, 1000 mm, 2011 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 186 mm               |    |
| $M_r = \text{fn}(\text{above}, A_s', d', x, x/d)$ | 2011 mm <sup>2</sup> , 83 mm, 77 mm, 0.36                                            | 162.7 kN.m           |    |
| Moment Capacity Check (M/M <sub>r</sub> )         | M 4.4 kN.m, M <sub>r</sub> 162.7 kN.m                                                | 0.027                | OK |
| Shear Capacity Check                              | F 15.7 kN, v <sub>c</sub> 0.670 N/mm <sup>2</sup> , F <sub>vr</sub> 145.5 kN         | 0.11                 | OK |

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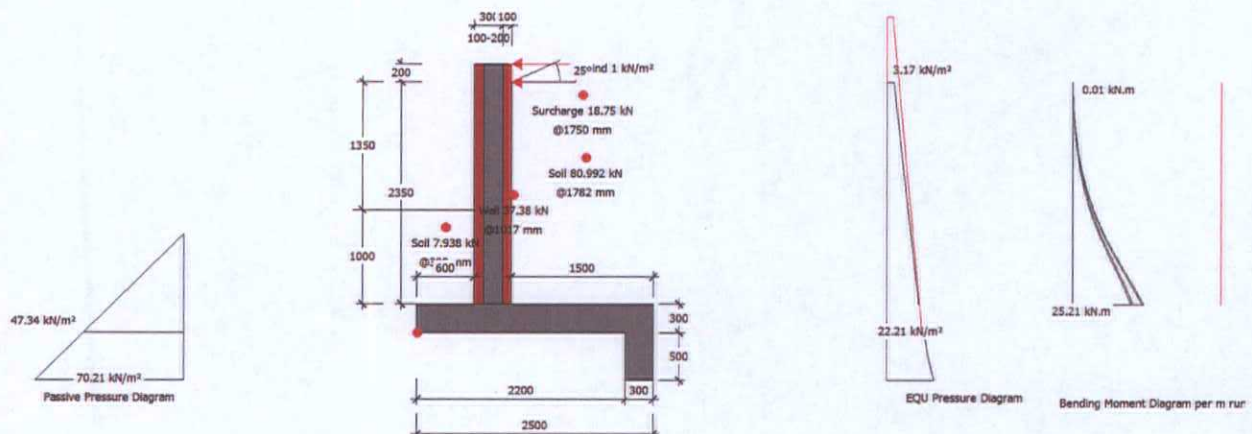
Job ref : Job Ref  
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Date : 29 Nov 2018  
Checked :  
Approved :

## MASTERKEY : RETAINING WALL DESIGN TO EC 7 : 2004, BS EN 1996-1-1:2005 AND EC 2 : 2004

### Basic Cavity Filled Masonry Retaining Wall

### Reinforced Masonry Cavity Filled Retaining Wall with Reinforced Concrete Base

GL 5



### Summary of Design Data

Notes  
Material Densities (kN/m³)  
Angles  
Concrete grade  
Concrete covers (mm)  
Reinforcement design  
Surcharge and Water Table  
Unplanned excavation depth  
† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

All dimensions are in mm and all forces are per metre run  
Back soil 20.00, Front soil 18.00, Concrete 24.00, Masonry 19.00  
Embankment 25°  
C25/30 N/mm², Permissible tensile stress 1.197 N/mm²  
Cavity inner cover 30 mm, Cavity outer cover 160 mm, Base cover 75 mm  
fy 500 N/mm², fyb 460 N/mm² designed to EC 2: 2004  
Surcharge 12.50 kN/m², Fully drained  
Front of wall 265 mm

### Soil Properties

Soil bearing pressure  
Allowable pressure M1 @ front 100.00 kN/m², @ back 100.00 kN/m²  
Allowable pressure M2 @ front 100.00 kN/m², @ back 100.00 kN/m²

EC7 EQU - Wall Stability  
Back Soil Friction and Cohesion  
Base Friction and Cohesion  
Front Soil Friction and Cohesion  
EC7 GEO/STR - M1  
Back Soil Friction and Cohesion  
Base Friction and Cohesion  
Front Soil Friction and Cohesion  
EC7 GEO/STR - M2  
Back Soil Friction and Cohesion  
Base Friction and Cohesion  
Front Soil Friction and Cohesion

$\phi = \text{Atn}(\tan(45)/1.1) = 42.27^\circ$   
 $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.1))) = 27.69^\circ$   
 $\phi = \text{Atn}(\tan(28)/1.1) = 25.8^\circ$

$\phi = \text{Atn}(\tan(45)/1) = 45^\circ$   
 $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1))) = 30^\circ$   
 $\phi = \text{Atn}(\tan(28)/1) = 28^\circ$

$\phi = \text{Atn}(\tan(45)/1.25) = 38.66^\circ$   
 $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.25))) = 24.79^\circ$   
 $\phi = \text{Atn}(\tan(28)/1.25) = 23.04^\circ$

### Loading Cases EQU and GEO/STR - Design Approach 1

G<sub>Soil</sub>- Soil Self Weight, G<sub>Wall</sub>- Wall & Base Self Weight, F<sub>VHeel</sub>- Vertical Loads over Heel,  
P<sub>a</sub>- Active Earth Pressure, P<sub>surcharge</sub>- Earth pressure from surcharge,  
P<sub>surch(fav)</sub>- Earth pressure from surcharge (no load over heel), P<sub>p</sub>- Passive Earth Pressure  
Case 1: EQU Wall Stability  
 $0.90 G_{\text{Soil}} + 0.90 G_{\text{Wall}} + 1.10 P_a + 1.50 P_{\text{surcharge}} + 0.90 P_p$



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Approved :

|                           |                                                                                                                           |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Case 2: GEO/STR A1+M1 I   | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.50 F <sub>VHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |
| Case 3: GEO/STR A2+M2 I   | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.30 F <sub>VHeel</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surcharge</sub> |
| Case 4: GEO/STR A1+M1 II  | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surch(fav)</sub>                         |
| Case 5: GEO/STR A2+M2 II  | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surch(fav)</sub>                         |
| Case 6: GEO/STR A1+M1 III | 1.35 G <sub>Soil</sub> +1.35 G <sub>Wall</sub> +1.50 F <sub>VHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |

## Geotechnical Design

### Wall Stability - Virtual Back Pressure

|                                    |                |       |    |
|------------------------------------|----------------|-------|----|
| EQU Case 1 Overturning/Stabilising | 52.490/165.425 | 0.317 | OK |
|------------------------------------|----------------|-------|----|

### Wall Sliding - Virtual Back Pressure

|                                                             |                         |       |    |
|-------------------------------------------------------------|-------------------------|-------|----|
| Case 2 Fx/(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 30.772/(103.944+58.764) | 0.189 | OK |
| Case 3 Fx/(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 45.813/(81.423+48.507)  | 0.353 | OK |
| Case 4 Fx/(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 30.772/(87.706+58.764)  | 0.210 | OK |
| Case 5 Fx/(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 45.813/(70.165+48.507)  | 0.386 | OK |
| Case 6 Fx/(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 30.772/(129.468+58.764) | 0.163 | OK |

### Soil Pressure

|                       |                                                              |       |    |
|-----------------------|--------------------------------------------------------------|-------|----|
| Case 2 - Virtual Back | 63.473/100 kN/m <sup>2</sup> , Length under pressure 2.433 m | 0.635 | OK |
| Case 3 - Virtual Back | 65.369/100 kN/m <sup>2</sup> , Length under pressure 2.305 m | 0.654 | OK |
| Case 4 - Virtual Back | 57.531/100 kN/m <sup>2</sup> , Length under pressure 2.196 m | 0.575 | OK |
| Case 5 - Virtual Back | 60.885/100 kN/m <sup>2</sup> , Length under pressure 2.075 m | 0.609 | OK |
| Case 6 - Virtual Back | 80.836/100 kN/m <sup>2</sup> , Length under pressure 2.457 m | 0.808 | OK |
| Case 2 - Wall Back    | 65.778/100 kN/m <sup>2</sup> , Length under pressure 2.348 m | 0.658 | OK |
| Case 3 - Wall Back    | 62.110/100 kN/m <sup>2</sup> , Length under pressure 2.426 m | 0.621 | OK |
| Case 4 - Wall Back    | 51.005/100 kN/m <sup>2</sup> , Length under pressure 2.476 m | 0.510 | OK |
| Case 5 - Wall Back    | 52.488/100 kN/m <sup>2</sup> , Length under pressure 2.406 m | 0.525 | OK |
| Case 6 - Wall Back    | 86.856/100 kN/m <sup>2</sup> , Length under pressure 2.287 m | 0.869 | OK |

## Structural Design

### Outer Leaf Details

|                                                           |                                                    |                        |            |
|-----------------------------------------------------------|----------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2       | 3/2.7                  | Table NA.1 |
| Material                                                  | Clay bricks with water absorption less than 7%     |                        |            |
| Units and Mortar Strength                                 | 15 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1, γ=19 kN/m <sup>3</sup>                    | 5.04 N/mm <sup>2</sup> | Table NA.4 |

### Inner Leaf Details

|                                                           |                                                   |                        |            |
|-----------------------------------------------------------|---------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2      | 3/2.7                  | Table NA.1 |
| Material                                                  | Concrete blocks, γ=19 kN/m <sup>3</sup>           |                        |            |
| Units and Mortar Strength                                 | 7 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Blocks Ratio                                              | Unit height=225, Least horizontal dimensions=100  | 2.25                   |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1                                           | 4.44 N/mm <sup>2</sup> | Table NA.6 |

### Wall Design (Inner Steel)

|                                                       |                                                                                     |                     |    |
|-------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Critical Section                                      | Critical @ 0 mm from base, Case 3                                                   |                     |    |
| Steel Provided (Cover)                                | Dist. B10@200 (75 mm in cavity)                                                     |                     |    |
|                                                       | Main B10@100 (30 mm in cavity)                                                      | 785 mm <sup>2</sup> | OK |
| Leverarm z=fn(d,b,As,f <sub>y</sub> ,f <sub>k</sub> ) | 265 mm, 1000 mm, 785 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 174 mm              |    |
| Mr=fn(above,γ <sub>mf</sub> ,γ <sub>ms</sub> )        | 2.70, 1.15                                                                          | 52.5 kN.m           |    |
| Moment Capacity Check (M/Mr)                          | M 25.2 kN.m, Mr 52.5 kN.m                                                           | 0.480               | OK |
| Shear Capacity Check                                  | F 18.0 kN, f <sub>wk</sub> 0.238 N/mm <sup>2</sup> , F <sub>vr</sub> 25.3 kN        | 0.71                | OK |

### Base Top Steel Design - Case 3

|                                                        |                                                                                     |                     |    |
|--------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                                 | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                     | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,f <sub>y</sub> ,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                              | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)                           | M 18.8 kN.m, Mr 35.7 kN.m                                                           | 0.527               | OK |
| Shear Capacity Check                                   | F 23.0 kN, v <sub>c</sub> 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN        | 0.22                | OK |

### Base Bottom Steel Design - Case 6

|                                                        |                                                                                     |                     |    |
|--------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                                 | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                     | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,f <sub>y</sub> ,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                              | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |



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|                                                  |                                                                                      |                      |    |
|--------------------------------------------------|--------------------------------------------------------------------------------------|----------------------|----|
| Moment Capacity Check (M/Mr)                     | M 16.7 kN.m, Mr 35.7 kN.m                                                            | 0.468                | OK |
| Shear Capacity Check                             | F 37.5 kN, vc 0.478 N/mm <sup>2</sup> , Fvr 105.1 kN                                 | 0.36                 | OK |
| <b>Nib Design - Case 2</b>                       |                                                                                      |                      |    |
| Steel Provided (Cover)                           | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)               | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{ck})$ | 217 mm, 1000 mm, 2011 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 186 mm               |    |
| $M_r = \text{fn}(\text{above}, A_s, d', x, x/d)$ | 2011 mm <sup>2</sup> , 83 mm, 77 mm, 0.36                                            | 162.7 kN.m           |    |
| Moment Capacity Check (M/Mr)                     | M 5.0 kN.m, Mr 162.7 kN.m                                                            | 0.031                | OK |
| Shear Capacity Check                             | F 18.3 kN, vc 0.670 N/mm <sup>2</sup> , Fvr 145.5 kN                                 | 0.13                 | OK |

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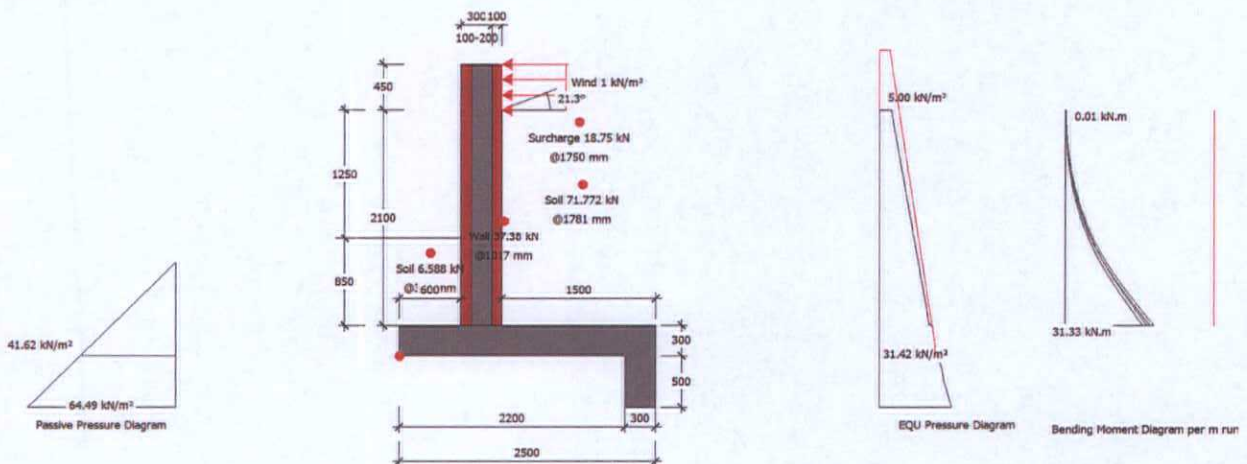
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## MASTERKEY : RETAINING WALL DESIGN TO EC 7 : 2004, BS EN 1996-1-1:2005 AND EC 2 : 2004

### Basic Cavity Filled Masonry Retaining Wall

### Reinforced Masonry Cavity Filled Retaining Wall with Reinforced Concrete Base

GL 6



### Summary of Design Data

#### Notes

Material Densities (kN/m³)

Angles

Concrete grade

Concrete covers (mm)

Reinforcement design

Surcharge and Water Table

Unplanned excavation depth

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

All dimensions are in mm and all forces are per metre run

Back soil 20.00, Front soil 18.00, Concrete 24.00, Masonry 19.00

Embankment 21.3°

C25/30 N/mm², Permissible tensile stress 1.197 N/mm²

Cavity inner cover 30 mm, Cavity outer cover 160 mm, Base cover 75 mm

fy 500 N/mm², fyd 460 N/mm² designed to EC 2: 2004

Surcharge 12.50 kN/m², Fully drained

Front of wall 240 mm

### Soil Properties

Soil bearing pressure

Allowable pressure M1 @ front 100.00 kN/m², @ back 100.00 kN/m²

Allowable pressure M2 @ front 100.00 kN/m², @ back 100.00 kN/m²

EC7 EQU - Wall Stability

Back Soil Friction and Cohesion

Base Friction and Cohesion

Front Soil Friction and Cohesion

EC7 GEO/STR - M1

Back Soil Friction and Cohesion

Base Friction and Cohesion

Front Soil Friction and Cohesion

EC7 GEO/STR - M2

Back Soil Friction and Cohesion

Base Friction and Cohesion

Front Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(35)/1.1) = 32.48^\circ$$

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.1))) = 27.69^\circ$$

$$\phi = \text{Atn}(\tan(28)/1.1) = 25.8^\circ$$

$$\phi = \text{Atn}(\tan(35)/1) = 35^\circ$$

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1))) = 30^\circ$$

$$\phi = \text{Atn}(\tan(28)/1) = 28^\circ$$

$$\phi = \text{Atn}(\tan(35)/1.25) = 29.26^\circ$$

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.25))) = 24.79^\circ$$

$$\phi = \text{Atn}(\tan(28)/1.25) = 23.04^\circ$$

### Loading Cases EQU and GEO/STR - Design Approach 1

G<sub>soil</sub>- Soil Self Weight, G<sub>wall</sub>- Wall & Base Self Weight, F<sub>vheel</sub>- Vertical Loads over Heel,P<sub>a</sub>- Active Earth Pressure, P<sub>surcharge</sub>- Earth pressure from surcharge,P<sub>surch(fav)</sub>- Earth pressure from surcharge (no load over heel), P<sub>p</sub>- Passive Earth Pressure

Case 1: EQU Wall Stability

$$0.90 G_{\text{soil}} + 0.90 G_{\text{wall}} + 1.10 P_a + 1.50 P_{\text{surcharge}} + 0.90 P_p$$



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|                           |                                                                                                                           |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Case 2: GEO/STR A1+M1 I   | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.50 F <sub>vHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |
| Case 3: GEO/STR A2+M2 I   | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.30 F <sub>vHeel</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surcharge</sub> |
| Case 4: GEO/STR A1+M1 II  | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surch(fav)</sub>                         |
| Case 5: GEO/STR A2+M2 II  | 1.00 G <sub>soil</sub> +1.00 G <sub>wall</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surch(fav)</sub>                         |
| Case 6: GEO/STR A1+M1 III | 1.35 G <sub>soil</sub> +1.35 G <sub>wall</sub> +1.50 F <sub>vHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |

## Geotechnical Design

### Wall Stability - Virtual Back Pressure

|                                    |                |       |    |
|------------------------------------|----------------|-------|----|
| EQU Case 1 Overturning/Stabilising | 64.729/150.421 | 0.430 | OK |
|------------------------------------|----------------|-------|----|

### Wall Sliding - Virtual Back Pressure

|                                                                          |                         |       |    |
|--------------------------------------------------------------------------|-------------------------|-------|----|
| Case 2 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 59.273/(97.841+49.584)  | 0.402 | OK |
| Case 3 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 73.619/(76.540+40.929)  | 0.627 | OK |
| Case 4 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 59.273/(81.603+49.584)  | 0.452 | OK |
| Case 5 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 73.619/(65.282+40.929)  | 0.693 | OK |
| Case 6 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 59.273/(121.229+49.584) | 0.347 | OK |

### Soil Pressure

|                       |                                                              |       |    |
|-----------------------|--------------------------------------------------------------|-------|----|
| Case 2 - Virtual Back | 65.709/100 kN/m <sup>2</sup> , Length under pressure 2.189 m | 0.657 | OK |
| Case 3 - Virtual Back | 67.650/100 kN/m <sup>2</sup> , Length under pressure 2.071 m | 0.676 | OK |
| Case 4 - Virtual Back | 61.861/100 kN/m <sup>2</sup> , Length under pressure 1.871 m | 0.619 | OK |
| Case 5 - Virtual Back | 65.380/100 kN/m <sup>2</sup> , Length under pressure 1.77 m  | 0.654 | OK |
| Case 6 - Virtual Back | 78.612/100 kN/m <sup>2</sup> , Length under pressure 2.345 m | 0.786 | OK |
| Case 2 - Wall Back    | 58.173/100 kN/m <sup>2</sup> , Length under pressure 2.473 m | 0.582 | OK |
| Case 3 - Wall Back    | 58.182/100 kN/m <sup>2</sup> , Length under pressure 2.408 m | 0.582 | OK |
| Case 4 - Wall Back    | 51.346/100 kN/m <sup>2</sup> , Length under pressure 2.254 m | 0.513 | OK |
| Case 5 - Wall Back    | 52.494/100 kN/m <sup>2</sup> , Length under pressure 2.205 m | 0.525 | OK |
| Case 6 - Wall Back    | 75.771/100 kN/m <sup>2</sup> , Length under pressure 2.433 m | 0.758 | OK |

## Structural Design

### Outer Leaf Details

|                                                           |                                                    |                        |            |
|-----------------------------------------------------------|----------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2       | 3/2.7                  | Table NA.1 |
| Material                                                  | Clay bricks with water absorption less than 7%     |                        |            |
| Units and Mortar Strength                                 | 15 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1, γ=19 kN/m <sup>3</sup>                    | 5.04 N/mm <sup>2</sup> | Table NA.4 |

### Inner Leaf Details

|                                                           |                                                   |                        |            |
|-----------------------------------------------------------|---------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2      | 3/2.7                  | Table NA.1 |
| Material                                                  | Concrete blocks, γ=19 kN/m <sup>3</sup>           |                        |            |
| Units and Mortar Strength                                 | 7 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Blocks Ratio                                              | Unit height=225, Least horizontal dimensions=100  | 2.25                   |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1                                           | 4.44 N/mm <sup>2</sup> | Table NA.6 |

### Wall Design (Inner Steel)

|                                                |                                                                                     |                     |    |
|------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Critical Section                               | Critical @ 1 mm from base, Case 3                                                   |                     |    |
| Steel Provided (Cover)                         | Dist. B10@200 (75 mm in cavity)                                                     |                     |    |
|                                                | Main B10@100 (30 mm in cavity)                                                      | 785 mm <sup>2</sup> | OK |
| Leverarm z=fn(d,b,As,fy,f <sub>k</sub> )       | 265 mm, 1000 mm, 785 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 174 mm              |    |
| Mr=fn(above,γ <sub>mf</sub> ,γ <sub>ms</sub> ) | 2.70, 1.15                                                                          | 52.5 kN.m           |    |
| Moment Capacity Check (M/Mr)                   | M 31.3 kN.m, Mr 52.5 kN.m                                                           | 0.596               | OK |
| Shear Capacity Check                           | F 29.9 kN, f <sub>vk</sub> 0.305 N/mm <sup>2</sup> , F <sub>vr</sub> 32.3 kN        | 0.92                | OK |

### Base Top Steel Design - Case 6

|                                           |                                                                                     |                     |    |
|-------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                    | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)        | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                 | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)              | M 23.3 kN.m, Mr 35.7 kN.m                                                           | 0.652               | OK |
| Shear Capacity Check                      | F 25.9 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.25                | OK |

### Base Bottom Steel Design - Case 6

|                                           |                                                                                     |                     |    |
|-------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                    | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)        | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,F <sub>ck</sub> ) | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)                 | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)              | M 14.3 kN.m, Mr 35.7 kN.m                                                           | 0.401               | OK |
| Shear Capacity Check                      | F 30.8 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.29                | OK |



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## Nib Design - Case 2

|                                                   |                                                                                      |                      |    |
|---------------------------------------------------|--------------------------------------------------------------------------------------|----------------------|----|
| Steel Provided (Cover)                            | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{ck})$  | 217 mm, 1000 mm, 2011 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 186 mm               |    |
| $M_r = \text{fn}(\text{above}, A_s', d', x, x/d)$ | 2011 mm <sup>2</sup> , 83 mm, 77 mm, 0.36                                            | 162.7 kN.m           |    |
| Moment Capacity Check ( $M/M_r$ )                 | M 2.7 kN.m, $M_r$ 162.7 kN.m                                                         | 0.017                | OK |
| Shear Capacity Check                              | F 9.1 kN, $v_c$ 0.670 N/mm <sup>2</sup> , $F_{vr}$ 145.5 kN                          | 0.06                 | OK |

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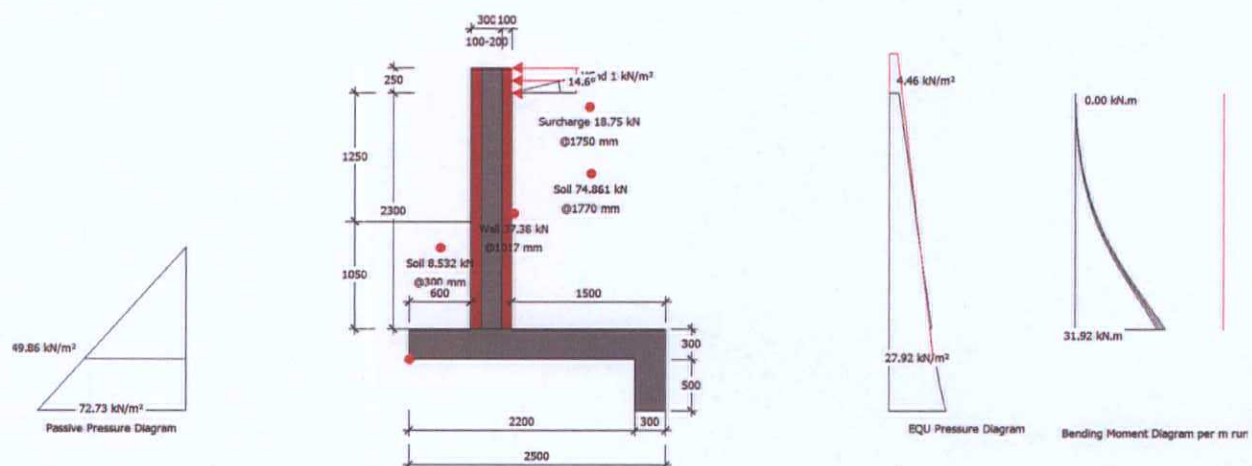
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## MASTERKEY : RETAINING WALL DESIGN TO EC 7 : 2004, BS EN 1996-1-1:2005 AND EC 2 : 2004

### Basic Cavity Filled Masonry Retaining Wall

### Reinforced Masonry Cavity Filled Retaining Wall with Reinforced Concrete Base

GL 7



### Summary of Design Data

#### Notes

Material Densities (kN/m³)

Angles

Concrete grade

Concrete covers (mm)

Reinforcement design

Surcharge and Water Table

Unplanned excavation depth

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

All dimensions are in mm and all forces are per metre run

Back soil 20.00, Front soil 18.00, Concrete 24.00, Masonry 19.00

Embankment 14.6°

C25/30 N/mm², Permissible tensile stress 1.197 N/mm²

Cavity inner cover 30 mm, Cavity outer cover 160 mm, Base cover 75 mm

fy 500 N/mm², fyt 460 N/mm² designed to EC 2: 2004

Surcharge 12.50 kN/m², Fully drained

Front of wall 260 mm

### Soil Properties

Soil bearing pressure

Allowable pressure M1 @ front 100.00 kN/m², @ back 100.00 kN/m²

Allowable pressure M2 @ front 100.00 kN/m², @ back 100.00 kN/m²

EC7 EQU - Wall Stability

Back Soil Friction and Cohesion

Base Friction and Cohesion

Front Soil Friction and Cohesion

EC7 GEO/STR - M1

Back Soil Friction and Cohesion

Base Friction and Cohesion

Front Soil Friction and Cohesion

EC7 GEO/STR - M2

Back Soil Friction and Cohesion

Base Friction and Cohesion

Front Soil Friction and Cohesion

$$\phi = \text{Atn}(\tan(35)/1.1) = 32.48^\circ$$

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.1))) = 27.69^\circ$$

$$\phi = \text{Atn}(\tan(28)/1.1) = 25.8^\circ$$

$$\phi = \text{Atn}(\tan(35)/1) = 35^\circ$$

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1))) = 30^\circ$$

$$\phi = \text{Atn}(\tan(28)/1) = 28^\circ$$

$$\phi = \text{Atn}(\tan(35)/1.25) = 29.26^\circ$$

$$\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.25))) = 24.79^\circ$$

$$\phi = \text{Atn}(\tan(28)/1.25) = 23.04^\circ$$

### Loading Cases EQU and GEO/STR - Design Approach 1

G<sub>Soil</sub> - Soil Self Weight, G<sub>Wall</sub> - Wall & Base Self Weight, F<sub>VHeel</sub> - Vertical Loads over Heel,P<sub>a</sub> - Active Earth Pressure, P<sub>surcharge</sub> - Earth pressure from surcharge,P<sub>surch(fav)</sub> - Earth pressure from surcharge (no load over heel), P<sub>p</sub> - Passive Earth Pressure

Case 1: EQU Wall Stability

$$0.90 G_{\text{Soil}} + 0.90 G_{\text{Wall}} + 1.10 P_a + 1.50 P_{\text{surcharge}} + 0.90 P_p$$



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|                           |                                                                                                                           |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Case 2: GEO/STR A1+M1 I   | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.50 F <sub>VHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |
| Case 3: GEO/STR A2+M2 I   | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.30 F <sub>VHeel</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surcharge</sub> |
| Case 4: GEO/STR A1+M1 II  | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surch</sub> (fav)                        |
| Case 5: GEO/STR A2+M2 II  | 1.00 G <sub>Soil</sub> +1.00 G <sub>Wall</sub> +1.00 P <sub>a</sub> +1.30 P <sub>surch</sub> (fav)                        |
| Case 6: GEO/STR A1+M1 III | 1.35 G <sub>Soil</sub> +1.35 G <sub>Wall</sub> +1.50 F <sub>VHeel</sub> +1.35 P <sub>a</sub> +1.50 P <sub>surcharge</sub> |

## Geotechnical Design

### Wall Stability - Virtual Back Pressure

|                                    |                |       |    |
|------------------------------------|----------------|-------|----|
| EQU Case 1 Overturning/Stabilising | 56.223/154.743 | 0.363 | OK |
|------------------------------------|----------------|-------|----|

### Wall Sliding - Virtual Back Pressure

|                                                                          |                         |       |    |
|--------------------------------------------------------------------------|-------------------------|-------|----|
| Case 2 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 45.163/(100.747+63.050) | 0.276 | OK |
| Case 3 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 55.996/(78.865+52.045)  | 0.428 | OK |
| Case 4 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 45.163/(84.508+63.050)  | 0.306 | OK |
| Case 5 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 55.996/(67.607+52.045)  | 0.468 | OK |
| Case 6 F <sub>x</sub> /(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 45.163/(125.151+63.050) | 0.240 | OK |

### Soil Pressure

|                       |                                                              |       |    |
|-----------------------|--------------------------------------------------------------|-------|----|
| Case 2 - Virtual Back | 64.016/100 kN/m <sup>2</sup> , Length under pressure 2.326 m | 0.640 | OK |
| Case 3 - Virtual Back | 64.651/100 kN/m <sup>2</sup> , Length under pressure 2.245 m | 0.647 | OK |
| Case 4 - Virtual Back | 58.840/100 kN/m <sup>2</sup> , Length under pressure 2.053 m | 0.588 | OK |
| Case 5 - Virtual Back | 60.635/100 kN/m <sup>2</sup> , Length under pressure 1.992 m | 0.606 | OK |
| Case 6 - Virtual Back | 78.179/100 kN/m <sup>2</sup> , Length under pressure 2.445 m | 0.782 | OK |
| Case 2 - Wall Back    | 60.728/100 kN/m <sup>2</sup> , Length under pressure 2.452 m | 0.607 | OK |
| Case 3 - Wall Back    | 60.588/100 kN/m <sup>2</sup> , Length under pressure 2.396 m | 0.606 | OK |
| Case 4 - Wall Back    | 54.286/100 kN/m <sup>2</sup> , Length under pressure 2.225 m | 0.543 | OK |
| Case 5 - Wall Back    | 55.212/100 kN/m <sup>2</sup> , Length under pressure 2.187 m | 0.552 | OK |
| Case 6 - Wall Back    | 77.817/100 kN/m <sup>2</sup> , Length under pressure 2.457 m | 0.778 | OK |

## Structural Design

### Outer Leaf Details

|                                                           |                                                    |                        |            |
|-----------------------------------------------------------|----------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2       | 3/2.7                  | Table NA.1 |
| Material                                                  | Clay bricks with water absorption less than 7%     |                        |            |
| Units and Mortar Strength                                 | 15 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1, γ=19 kN/m <sup>3</sup>                    | 5.04 N/mm <sup>2</sup> | Table NA.4 |

### Inner Leaf Details

|                                                           |                                                   |                        |            |
|-----------------------------------------------------------|---------------------------------------------------|------------------------|------------|
| Partial Safety Factor (γ <sub>mc</sub> /γ <sub>mf</sub> ) | Units Category II, Execution Control Class 2      | 3/2.7                  | Table NA.1 |
| Material                                                  | Concrete blocks, γ=19 kN/m <sup>3</sup>           |                        |            |
| Units and Mortar Strength                                 | 7 N/mm <sup>2</sup> , Mortar designation M4/(iii) |                        |            |
| Blocks Ratio                                              | Unit height=225, Least horizontal dimensions=100  | 2.25                   |            |
| Compressive Strength (f <sub>k</sub> )                    | Group 1                                           | 4.44 N/mm <sup>2</sup> | Table NA.6 |

### Wall Design (Inner Steel)

|                                                |                                                                                     |                     |    |
|------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Critical Section                               | Critical @ 220 mm from base, Case 3                                                 |                     |    |
| Steel Provided (Cover)                         | Dist. B10@200 (75 mm in cavity)                                                     |                     |    |
|                                                | Main B10@100 (30 mm in cavity)                                                      | 785 mm <sup>2</sup> | OK |
| Leverarm z=fn(d,b,As,fy,f <sub>k</sub> )       | 265 mm, 1000 mm, 785 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 174 mm              |    |
| Mr=fn(above,γ <sub>mf</sub> ,γ <sub>ms</sub> ) | 2.70, 1.15                                                                          | 52.5 kN.m           |    |
| Moment Capacity Check (M/Mr)                   | M 26.4 kN.m, Mr 52.5 kN.m                                                           | 0.502               | OK |
| Shear Capacity Check                           | F 25.5 kN, f <sub>vk</sub> 0.308 N/mm <sup>2</sup> , F <sub>vr</sub> 32.6 kN        | 0.78                | OK |

### Base Top Steel Design - Case 6

|                                    |                                                                                     |                     |    |
|------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)             | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover) | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,Fck)       | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)          | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)       | M 20.7 kN.m, Mr 35.7 kN.m                                                           | 0.580               | OK |
| Shear Capacity Check               | F 27.0 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.26                | OK |

### Base Bottom Steel Design - Case 6

|                                    |                                                                                     |                     |    |
|------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)             | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover) | Main B10@200 (75 mm) Dist. B10@200 (85 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm z=fn(d,b,As,fy,Fck)       | 220 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 209 mm              |    |
| Mr=fn(above,As',d',x,x/d)          | 393 mm <sup>2</sup> , 80 mm, 15 mm, 0.07                                            | 35.7 kN.m           |    |
| Moment Capacity Check (M/Mr)       | M 13.7 kN.m, Mr 35.7 kN.m                                                           | 0.383               | OK |
| Shear Capacity Check               | F 29.8 kN, vc 0.478 N/mm <sup>2</sup> , F <sub>vr</sub> 105.1 kN                    | 0.28                | OK |



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Made By : STD  
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Approved :

## Nib Design - Case 2

|                                    |                                                                                      |                      |    |
|------------------------------------|--------------------------------------------------------------------------------------|----------------------|----|
| Steel Provided (Cover)             | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover) | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> |    |
| Leverarm $z=fn(d,b,As,fy,Fck)$     | 217 mm, 1000 mm, 2011 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 186 mm               |    |
| $Mr=fn(above,As',d',x,x/d)$        | 2011 mm <sup>2</sup> , 83 mm, 77 mm, 0.36                                            | 162.7 kN.m           |    |
| Moment Capacity Check (M/Mr)       | M 4.3 kN.m, Mr 162.7 kN.m                                                            | 0.027                | OK |
| Shear Capacity Check               | F 15.6 kN, vc 0.670 N/mm <sup>2</sup> , Fvr 145.5 kN                                 | 0.11                 | OK |

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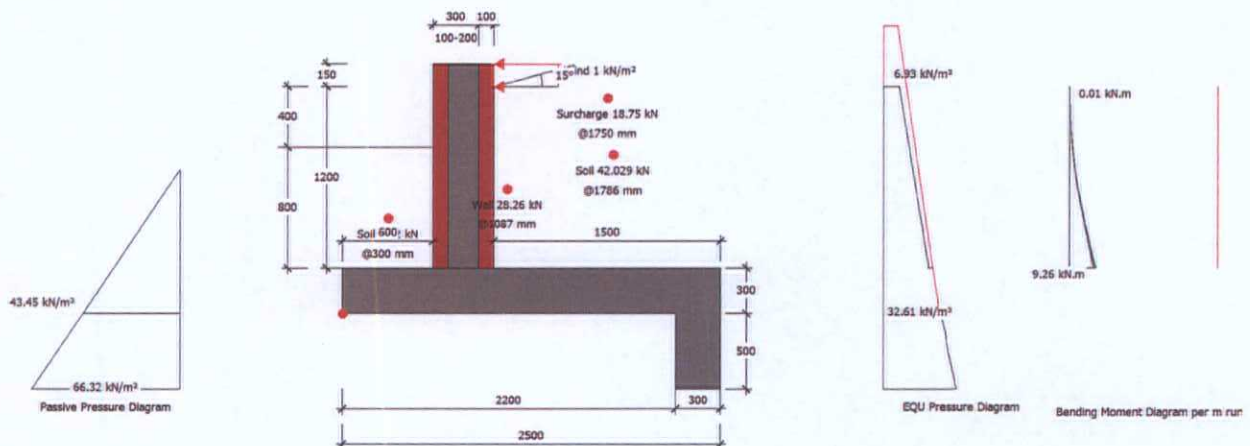
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## MASTERKEY : RETAINING WALL DESIGN TO EC 7 : 2004, BS EN 1996-1-1:2005 AND EC 2 : 2004

### Basic Cavity Filled Masonry Retaining Wall Reinforced Masonry Cavity Filled Retaining Wall with Reinforced Concrete Base

GL 8



### Summary of Design Data

#### Notes

Material Densities (kN/m³)

Angles

Concrete grade

Concrete covers (mm)

Reinforcement design

Surcharge and Water Table

Unplanned excavation depth

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

All dimensions are in mm and all forces are per metre run

Back soil 20.00, Front soil 18.00, Concrete 24.00, Masonry 19.00

Embankment 15°

C25/30 N/mm², Permissible tensile stress 1.197 N/mm²

Cavity inner cover 30 mm, Cavity outer cover 160 mm, Base cover 75 mm

fy 500 N/mm², fyd 460 N/mm² designed to EC 2: 2004

Surcharge 12.50 kN/m², Fully drained

Front of wall 150 mm

### Soil Properties

Soil bearing pressure

Allowable pressure M1 @ front 100.00 kN/m², @ back 100.00 kN/m²

Allowable pressure M2 @ front 100.00 kN/m², @ back 100.00 kN/m²

EC7 EQU - Wall Stability

Back Soil Friction and Cohesion

 $\phi = \text{Atn}(\tan(25)/1.1) = 22.97^\circ$ 

Base Friction and Cohesion

 $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.1))) = 27.69^\circ$ 

Front Soil Friction and Cohesion

 $\phi = \text{Atn}(\tan(28)/1.1) = 25.8^\circ$ 

EC7 GEO/STR - M1

Back Soil Friction and Cohesion

 $\phi = \text{Atn}(\tan(25)/1) = 25^\circ$ 

Base Friction and Cohesion

 $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1))) = 30^\circ$ 

Front Soil Friction and Cohesion

 $\phi = \text{Atn}(\tan(28)/1) = 28^\circ$ 

EC7 GEO/STR - M2

Back Soil Friction and Cohesion

 $\phi = \text{Atn}(\tan(25)/1.25) = 20.46^\circ$ 

Base Friction and Cohesion

 $\delta = \text{Atn}(1 \times \tan(\text{Atn}(\tan(30)/1.25))) = 24.79^\circ$ 

Front Soil Friction and Cohesion

 $\phi = \text{Atn}(\tan(28)/1.25) = 23.04^\circ$ 

### Loading Cases EQU and GEO/STR - Design Approach 1

G<sub>Soil</sub> - Soil Self Weight, G<sub>Wall</sub> - Wall & Base Self Weight, F<sub>VHeel</sub> - Vertical Loads over Heel,P<sub>a</sub> - Active Earth Pressure, P<sub>surcharge</sub> - Earth pressure from surcharge,P<sub>surch(fav)</sub> - Earth pressure from surcharge (no load over heel), P<sub>p</sub> - Passive Earth PressureCase 1: EQU Wall Stability 0.90 G<sub>Soil</sub> + 0.90 G<sub>Wall</sub> + 1.10 P<sub>a</sub> + 1.50 P<sub>surcharge</sub> + 0.90 P<sub>p</sub>Case 2: GEO/STR A1+M1 I 1.00 G<sub>Soil</sub> + 1.00 G<sub>Wall</sub> + 1.50 F<sub>VHeel</sub> + 1.35 P<sub>a</sub> + 1.50 P<sub>surcharge</sub>



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Case 3: GEO/STR A2+M2 I 1.00 G<sub>Soil</sub>+1.00 G<sub>Wall</sub>+1.30 F<sub>Vheel</sub>+1.00 P<sub>a</sub>+1.30 P<sub>surcharge</sub>  
Case 4: GEO/STR A1+M1 II 1.00 G<sub>Soil</sub>+1.00 G<sub>Wall</sub>+1.35 P<sub>a</sub>+1.50 P<sub>surch(fav)</sub>  
Case 5: GEO/STR A2+M2 II 1.00 G<sub>Soil</sub>+1.00 G<sub>Wall</sub>+1.00 P<sub>a</sub>+1.30 P<sub>surch(fav)</sub>  
Case 6: GEO/STR A1+M1 III 1.35 G<sub>Soil</sub>+1.35 G<sub>Wall</sub>+1.50 F<sub>Vheel</sub>+1.35 P<sub>a</sub>+1.50 P<sub>surcharge</sub>

## Geotechnical Design

### Wall Stability - Virtual Back Pressure

EQU Case 1 Overturning/Stabilising 29.794/96.427 0.309 OK

### Wall Sliding - Virtual Back Pressure

Case 2 F<sub>x</sub>/(R<sub>xFriction</sub>+ R<sub>xPassive</sub>) 45.552/(75.652+52.437) 0.356 OK  
Case 3 F<sub>x</sub>/(R<sub>xFriction</sub>+ R<sub>xPassive</sub>) 53.493/(58.790+43.284) 0.524 OK  
Case 4 F<sub>x</sub>/(R<sub>xFriction</sub>+ R<sub>xPassive</sub>) 45.552/(59.414+52.437) 0.407 OK  
Case 5 F<sub>x</sub>/(R<sub>xFriction</sub>+ R<sub>xPassive</sub>) 53.493/(47.531+43.284) 0.589 OK  
Case 6 F<sub>x</sub>/(R<sub>xFriction</sub>+ R<sub>xPassive</sub>) 45.552/(91.274+52.437) 0.317 OK

### Soil Pressure

Case 2 - Virtual Back 42.361/100 kN/m<sup>2</sup>, Length under pressure 2.489 m 0.424 OK  
Case 3 - Virtual Back 41.470/100 kN/m<sup>2</sup>, Length under pressure 2.452 m 0.415 OK  
Case 4 - Virtual Back 35.936/100 kN/m<sup>2</sup>, Length under pressure 2.151 m 0.359 OK  
Case 5 - Virtual Back 36.439/100 kN/m<sup>2</sup>, Length under pressure 2.122 m 0.364 OK  
Case 6 - Virtual Back 54.482/100 kN/m<sup>2</sup>, Length under pressure 2.432 m 0.545 OK  
Case 2 - Wall Back 46.102/100 kN/m<sup>2</sup>, Length under pressure 2.287 m 0.461 OK  
Case 3 - Wall Back 43.755/100 kN/m<sup>2</sup>, Length under pressure 2.324 m 0.438 OK  
Case 4 - Wall Back 31.737/100 kN/m<sup>2</sup>, Length under pressure 2.436 m 0.317 OK  
Case 5 - Wall Back 31.889/100 kN/m<sup>2</sup>, Length under pressure 2.424 m 0.319 OK  
Case 6 - Wall Back 58.337/100 kN/m<sup>2</sup>, Length under pressure 2.271 m 0.583 OK

## Structural Design

### Outer Leaf Details

Partial Safety Factor (γ<sub>mc</sub>/γ<sub>mf</sub>) Units Category II, Execution Control Class 2 3/2.7 Table NA.1  
Material Clay bricks with water absorption less than 7%  
Units and Mortar Strength 15 N/mm<sup>2</sup>, Mortar designation M4/(iii)  
Compressive Strength (f<sub>k</sub>) Group 1, γ=19 kN/m<sup>3</sup> 5.04 N/mm<sup>2</sup> Table NA.4

### Inner Leaf Details

Partial Safety Factor (γ<sub>mc</sub>/γ<sub>mf</sub>) Units Category II, Execution Control Class 2 3/2.7 Table NA.1  
Material Concrete blocks, γ=19 kN/m<sup>3</sup>  
Units and Mortar Strength 7 N/mm<sup>2</sup>, Mortar designation M4/(iii)  
Blocks Ratio Unit height=225, Least horizontal dimensions=100 2.25  
Compressive Strength (f<sub>k</sub>) Group 1 4.44 N/mm<sup>2</sup> Table NA.6

### Wall Design (Inner Steel)

Critical Section Critical @ 0 mm from base, Case 3  
Steel Provided (Cover) Dist. B10@200 (75 mm in cavity) 785 mm<sup>2</sup> OK  
Main B10@100 (30 mm in cavity)  
Leverarm z=fn(d,b,As,f<sub>y</sub>,f<sub>k</sub>) 265 mm, 1000 mm, 785 mm<sup>2</sup>, 500 N/mm<sup>2</sup>, 25 N/mm<sup>2</sup> 174 mm  
Mr=fn(above,γ<sub>mf</sub>,γ<sub>ms</sub>) 2.70, 1.15 52.5 kN.m  
Moment Capacity Check (M/Mr) M 9.3 kN.m, Mr 52.5 kN.m 0.176 OK  
Shear Capacity Check F 12.6 kN, f<sub>wd</sub>0.365 N/mm<sup>2</sup>, F<sub>vr</sub> 38.7 kN 0.33 OK

### Base Top Steel Design - Case 3

Steel Provided (Cover) Main B10@200 (75 mm) Dist. B10@200 (85 mm) 393 mm<sup>2</sup> OK  
Compression Steel Provided (Cover) Main B10@200 (75 mm) Dist. B10@200 (85 mm) 393 mm<sup>2</sup>  
Leverarm z=fn(d,b,As,f<sub>y</sub>,F<sub>ck</sub>) 220 mm, 1000 mm, 393 mm<sup>2</sup>, 500 N/mm<sup>2</sup>, 25 N/mm<sup>2</sup> 209 mm  
Mr=fn(above,As',d',x,x/d) 393 mm<sup>2</sup>, 80 mm, 15 mm, 0.07 35.7 kN.m  
Moment Capacity Check (M/Mr) M 9.9 kN.m, Mr 35.7 kN.m 0.279 OK  
Shear Capacity Check F 11.9 kN, vc 0.478 N/mm<sup>2</sup>, F<sub>vr</sub> 105.1 kN 0.11 OK

### Base Bottom Steel Design - Case 6

Steel Provided (Cover) Main B10@200 (75 mm) Dist. B10@200 (85 mm) 393 mm<sup>2</sup> OK  
Compression Steel Provided (Cover) Main B10@200 (75 mm) Dist. B10@200 (85 mm) 393 mm<sup>2</sup>  
Leverarm z=fn(d,b,As,f<sub>y</sub>,F<sub>ck</sub>) 220 mm, 1000 mm, 393 mm<sup>2</sup>, 500 N/mm<sup>2</sup>, 25 N/mm<sup>2</sup> 209 mm  
Mr=fn(above,As',d',x,x/d) 393 mm<sup>2</sup>, 80 mm, 15 mm, 0.07 35.7 kN.m  
Moment Capacity Check (M/Mr) M 9.3 kN.m, Mr 35.7 kN.m 0.262 OK  
Shear Capacity Check F 22.0 kN, vc 0.478 N/mm<sup>2</sup>, F<sub>vr</sub> 105.1 kN 0.21 OK



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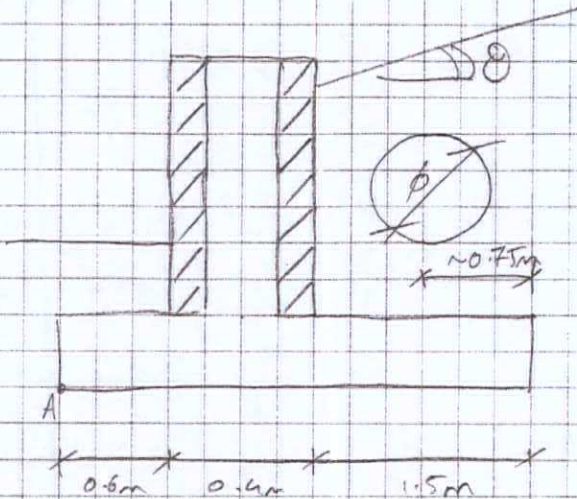
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## Nib Design - Case 2

|                                                   |                                                                                      |                      |    |
|---------------------------------------------------|--------------------------------------------------------------------------------------|----------------------|----|
| Steel Provided (Cover)                            | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                | Main B16@100 (75 mm) Dist. B16@100 (91 mm)                                           | 2011 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{ck})$  | 217 mm, 1000 mm, 2011 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 25 N/mm <sup>2</sup> | 186 mm               |    |
| $M_r = \text{fn}(\text{above}, A_s', d', x, x/d)$ | 2011 mm <sup>2</sup> , 83 mm, 77 mm, 0.36                                            | 162.7 kN.m           |    |
| Moment Capacity Check (M/M <sub>r</sub> )         | M 2.5 kN.m, M <sub>r</sub> 162.7 kN.m                                                | 0.015                | OK |
| Shear Capacity Check                              | F 8.3 kN, $v_c$ 0.670 N/mm <sup>2</sup> , F <sub>vr</sub> 145.5 kN                   | 0.06                 | OK |

|             |                      |       |         |
|-------------|----------------------|-------|---------|
| Project:    | LABOUR EXCHANGE      | Job:  | C161041 |
| Calcs for:  | SLOPE RETAINING WALL | Page: |         |
| Created by: | STD                  | Date: |         |
| Checked by: |                      | Date: |         |

## RETAINING WALL CHECK



PIPE DIAMETER,  $\phi = 0.9m$

$$\text{AREA ATTENUATION PIPE} = \pi r^2 = \pi \times 0.45^2 = 0.63m^2$$

$$\text{VOLUME PIPE} = 0.63m^3/m$$

$$\text{BULK DENSITY SOL} = 18 \text{ kN/m}^3$$

$$\begin{aligned} \text{MASS SOIL /m (REMOVED)} &= 18 \times 0.63 \\ &= 11.45 \text{ kN/m} \end{aligned}$$

$$\begin{aligned} \text{REDUCTION IN OVERTURNING} &= Fx \\ \text{MOMENT ABOUT PIVOT, A} &= 11.45 \times 1.75m \\ &= 20.1 \text{ kNm /m} \end{aligned}$$

$$\begin{aligned} \text{REDUCTION IN SLIDING FRICTION} &= N \times \mu \\ &= 11.45 \text{ kN/m} \times 0.5 \\ &= 5.725 \text{ kN/m} \end{aligned}$$

|             |                      |       |         |
|-------------|----------------------|-------|---------|
| Project:    | LABOUR EXCHANGE      | Job:  | C161041 |
| Calcs for:  | SLOPE RETAINING WALL | Page: |         |
| Created by: | STD                  | Date: |         |
| Checked by: |                      | Date: |         |

MAXIMUM ALLOWABLE 'TOLERANCE' OF RETAINING WALLS  
TO WALL OVERTURNING AND SLIDING.

— THE 'WORST CASE' SECTION HAS BEEN CONSIDERED  
FOR OVERTURNING AND SLIDING, WHICH IS SECTION 6.

OVERTURNING — SECTION 6

$$\frac{\text{OVERTURNING MMT}}{\text{STABILISING MMT}} = \frac{64.729}{150.421} = 0.430$$

→ ALLOWING REDUCTION:

$$\frac{\text{OVERTURNING MMT}}{\text{STABILISING MMT}} = \frac{64.729}{150.421 - 20.1} = 0.497 \leq 1 \quad \underline{\text{OK}}$$

SLIDING — SECTION 6

$$\frac{\text{SLIDING FORCE}}{\text{FRICTION FORCE}} = \frac{73.619}{76.540 + 40.929} = 0.627$$

→ ALLOWING REDUCTION

$$\frac{\text{SLIDING FORCE}}{\text{FRICTION FORCE}} = \frac{73.619}{(76.540 - 5.725) + 40.929} = 0.659 \leq 1 \quad \underline{\text{OK}}$$

AS REDUCTION IN STABILISING MOMENT AND SLIDING  
FRICTIONAL FORCE DOES NOT EXCEED 1, THE  
WALLS ARE SHOWN TO BE UNAFFECTED BY THE  
PRESENCE OF THE ATTENUATION TANKS.