



PHILIP WRIGHT  
ASSOCIATES

**STRUCTURAL CALCULATIONS**  
**FOR**  
**RETAINING WALL**  
**99 BURY NEW ROAD**  
**RAMSBOTTOM**

**SHEET NOS 1-5**

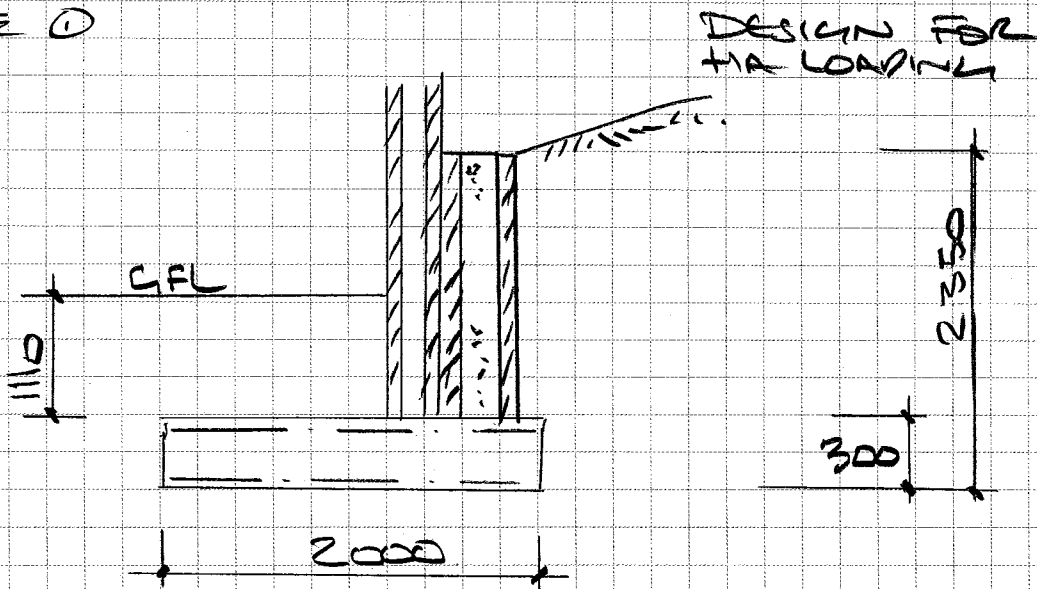
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|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CONTRACT NO. 3083</b> | <b>PHILIP WRIGHT ASSOCIATES LTD</b><br><b>21 UNION STREET</b><br><b>RAMSBOTTOM</b><br><b>BURY BLO 9AN</b>                                                  |
| <b>DECEMBER 2023</b>     | <b>TEL. 01706 828781</b><br><b>07939 547865</b><br><b>E-MAIL: <a href="mailto:info@philipwrightassociates.co.uk">info@philipwrightassociates.co.uk</a></b> |

Consulting Structural Engineers

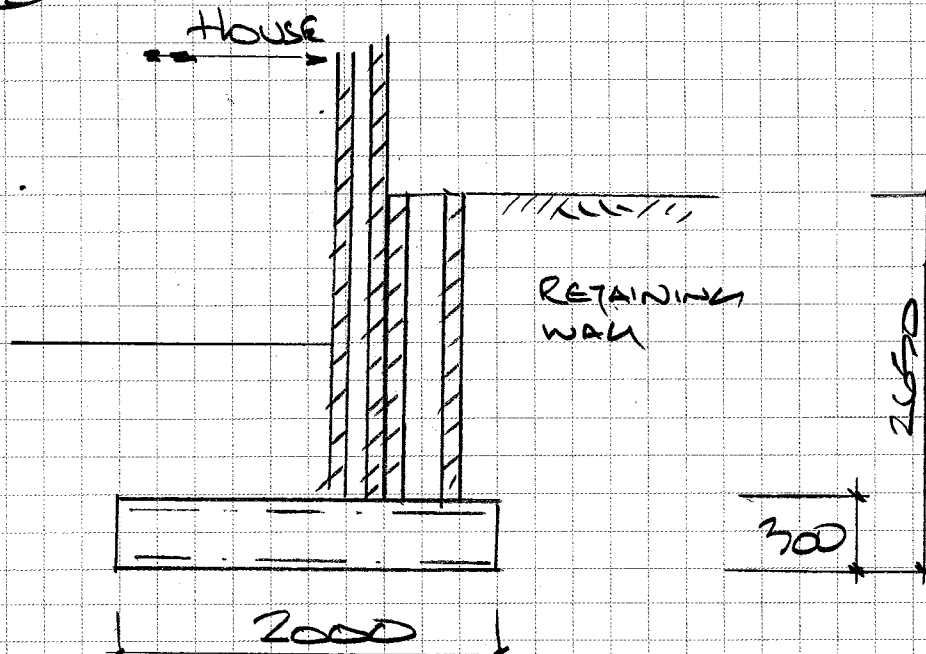
Part of Structure RETAINING WALL

## RETAINING WALL TO HIGHWAY

CASE ①



CASE ②



STEM 200 TK H110 - 200

BASE 300 TK 2 LAYERS 130g MESH  
T + B.

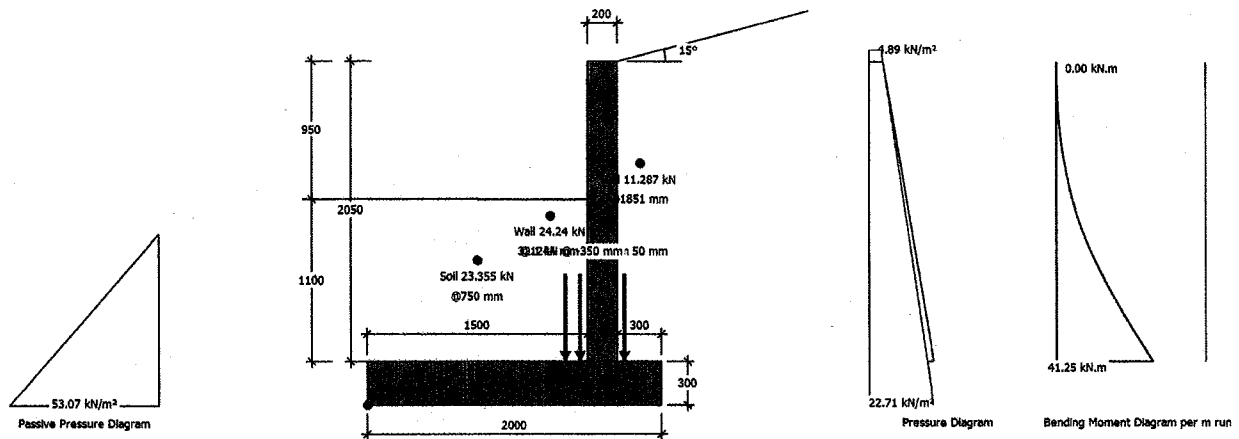
**PHILIP WRIGHT ASSOCIATES**

25554

Wellington St  
Westhoughton,  
Bolton, Lancs, BL5 3YW  
Tel: 01942 811532

Job Ref : 3083  
Sheet : /  
Made by : PW  
Date : 13 December 2023 / Ver. 2022.07.14  
Checked :  
Approved :

**MasterKey : Retaining Wall Design to BS 8002 : 1994 and Highways design to BD30/87 & BD37/01**  
**RETAINING WALL CASE 1**  
**Reinforced Concrete Retaining Wall with Reinforced Base**

**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

Soil 18.00, Concrete 24.00

Embankment 15°

fcu 30 N/mm², Permissible tensile stress 0.250 N/mm²

Wall inner cover 30 mm, Wall outer cover 30 mm, Base cover 50 mm

fy 500 N/mm² designed to BS 8110: 1997

Minimum HA Surcharge 10.00 kN/m², Fully drained

Front of wall 235 mm

**Additional Loads**

Vertical Line Loads

4 kN/m @ X 50 mm and Y 2050 mm - Load type HA

4 kN/m @ X -250 mm and Y 2050 mm - Load type HA

32.1 kN/m @ X -350 mm and Y 2050 mm - Load type HA

† Dimensions

Ties, line loads and partial loads are measured from the inner top edge of the wall

**Soil Properties**

Bearing pressure

Back Soil Friction and Cohesion

Base Friction and Cohesion

Front Soil Friction and Cohesion

Premissable service pressure @ front 100.00 kN/m², @ back 100.00 kN/m²

 $\alpha = \text{Atn}(\tan(30)/1.2) = 25.69^\circ$  $\delta = \text{Atn}(0.75 \times \tan(\text{Atn}(\tan(30)/1.2))) = 19.84^\circ$  $\phi = \text{Atn}(\tan(30)/1.2) = 25.69^\circ$ **Loading Cases to Highways BD 37/01** $G_{\text{Soil}}$ - Earth Pressure Vertical 5.8,  $G_{\text{Wall}}$ - Wall & Base Self Weight 5.1,  $S_{\text{HA}}$ - HA Surcharge, $P_a$ - Earth Pressure Non-vertical 5.8,  $P_p$ - Passive Pressure 5.8,  $P_{\text{MinSurch}}$ - Minimum SurchargeCase 1 Construction  $1.20 G_{\text{Soil}} + 1.15 G_{\text{Wall}} + 1.50 P_a + 1.00 P_p + 1.50 P_{\text{MinSurch}}$ Case 2 Comb 1  $1.20 G_{\text{Soil}} + 1.15 G_{\text{Wall}} + 1.50 S_{\text{HA}} + 1.50 P_a + 1.00 P_p + 1.50 P_{\text{MinSurch}}$ Case 3 Comb 2  $1.20 G_{\text{Soil}} + 1.15 G_{\text{Wall}} + 1.25 S_{\text{HA}} + 1.50 P_a + 1.00 P_p + 1.50 P_{\text{MinSurch}}$ 

Note: Equivalent unity cases are used for geotechnical design

**Geotechnical Design - Active Earth Pressures****Wall Stability - Virtual Back Pressure**

|                                |                |       |    |
|--------------------------------|----------------|-------|----|
| Case 1 Overturning/Stabilising | 30.881/68.502  | 0.451 | OK |
| Case 2 Overturning/Stabilising | 30.881/124.637 | 0.248 | OK |
| Case 3 Overturning/Stabilising | 30.881/124.637 | 0.248 | OK |

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**Wall Sliding - Virtual Back Pressure**

|                                                           |                        |       |    |
|-----------------------------------------------------------|------------------------|-------|----|
| Case 1 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 32.946/(21.247+30.941) | 0.631 | OK |
| Case 2 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 32.946/(35.717+30.941) | 0.494 | OK |
| Case 3 $F_x/(R_{x\text{Friction}} + R_{x\text{Passive}})$ | 32.946/(35.717+30.941) | 0.494 | OK |

**Soil Pressure**

|                                 |                                                              |       |    |
|---------------------------------|--------------------------------------------------------------|-------|----|
| Case 1 Virtual Back (No uplift) | Max(43.295/100, 15.587/100) kN/m <sup>2</sup>                | 0.433 | OK |
| Case 2 Virtual Back (No uplift) | Max(39.292/100, 59.690/100) kN/m <sup>2</sup>                | 0.597 | OK |
| Case 3 Virtual Back (No uplift) | Max(39.292/100, 59.690/100) kN/m <sup>2</sup>                | 0.597 | OK |
| Case 1 Wall Back                | 72.894/100 kN/m <sup>2</sup> , Length under pressure 1.905 m | 0.729 | OK |
| Case 2 Wall Back (No uplift)    | Max(66.727/100, 62.869/100) kN/m <sup>2</sup>                | 0.667 | OK |
| Case 3 Wall Back (No uplift)    | Max(67.728/100, 51.844/100) kN/m <sup>2</sup>                | 0.677 | OK |

**Structural Design****Highways Design**

|                                                                                                        |                                                                              |     |
|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----|
| At rest earth pressures magnification                                                                  | $(1 + \sin(\phi)) \times \sqrt{\text{OCR}} = (1 + \sin(30)) \times \sqrt{1}$ | 1.5 |
| Reinforced concrete design to BS5400 Pt4. All design forces are multiplied by global factor $\gamma_b$ |                                                                              | 1.1 |

**Wall Design (Inner Steel)**

|                                                   |                                                                                        |                      |    |
|---------------------------------------------------|----------------------------------------------------------------------------------------|----------------------|----|
| Critical Section                                  | Critical @ 0 mm from base, Case 1                                                      |                      |    |
| Steel Provided (Cover)                            | Main H16@200 (30 mm) Dist. H10@200 (46 mm)                                             | 1005 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                | Main H10@200 (30 mm) Dist. H10@200 (40 mm)                                             | 393 mm <sup>2</sup>  |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{cu})$  | 162 mm, 1000 mm, 1005 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 30.0 N/mm <sup>2</sup> | 146 mm               |    |
| $M_r = \text{fn}(\text{above}, A_s', d', x, x/d)$ | 393 mm <sup>2</sup> , 35 mm, 36 mm, 0.22                                               | 63.7 kN.m            |    |
| Moment Capacity Check (M/M <sub>r</sub> )         | M 41.2 kN.m, M <sub>r</sub> 63.7 kN.m                                                  | 0.647                | OK |
| Shear Capacity Check                              | F 39.2 kN, v <sub>c</sub> 0.759 N/mm <sup>2</sup> , F <sub>v</sub> 122.9 kN            | 0.32                 | OK |

**Base Top Steel Design - Case 1**

|                                                   |                                                                                     |                     |    |
|---------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                            | Main H10@200 (50 mm) Dist. H10@200 (60 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                | Main H10@100 (50 mm) Dist. H10@200 (60 mm)                                          | 785 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{cu})$  | 245 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 30 N/mm <sup>2</sup> | 239 mm              |    |
| $M_r = \text{fn}(\text{above}, A_s', d', x, x/d)$ | 785 mm <sup>2</sup> , 55 mm, 14 mm, 0.06                                            | 40.8 kN.m           |    |
| Moment Capacity Check (M/M <sub>r</sub> )         | M 2.7 kN.m, M <sub>r</sub> 40.8 kN.m                                                | 0.065               | OK |
| Shear Capacity Check                              | F 17.6 kN, v <sub>c</sub> 0.436 N/mm <sup>2</sup> , F <sub>v</sub> 106.8 kN         | 0.17                | OK |

**Base Bottom Steel Design - Case 2**

|                                                   |                                                                                     |                     |    |
|---------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                            | Main H10@100 (50 mm) Dist. H10@200 (60 mm)                                          | 785 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)                | Main H10@200 (50 mm) Dist. H10@200 (60 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{cu})$  | 245 mm, 1000 mm, 785 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 30 N/mm <sup>2</sup> | 232 mm              |    |
| $M_r = \text{fn}(\text{above}, A_s', d', x, x/d)$ | 393 mm <sup>2</sup> , 55 mm, 28 mm, 0.12                                            | 79.4 kN.m           |    |
| Moment Capacity Check (M/M <sub>r</sub> )         | M 50.1 kN.m, M <sub>r</sub> 79.4 kN.m                                               | 0.632               | OK |
| Shear Capacity Check                              | F 65.2 kN, v <sub>c</sub> 0.549 N/mm <sup>2</sup> , F <sub>v</sub> 134.5 kN         | 0.48                | OK |

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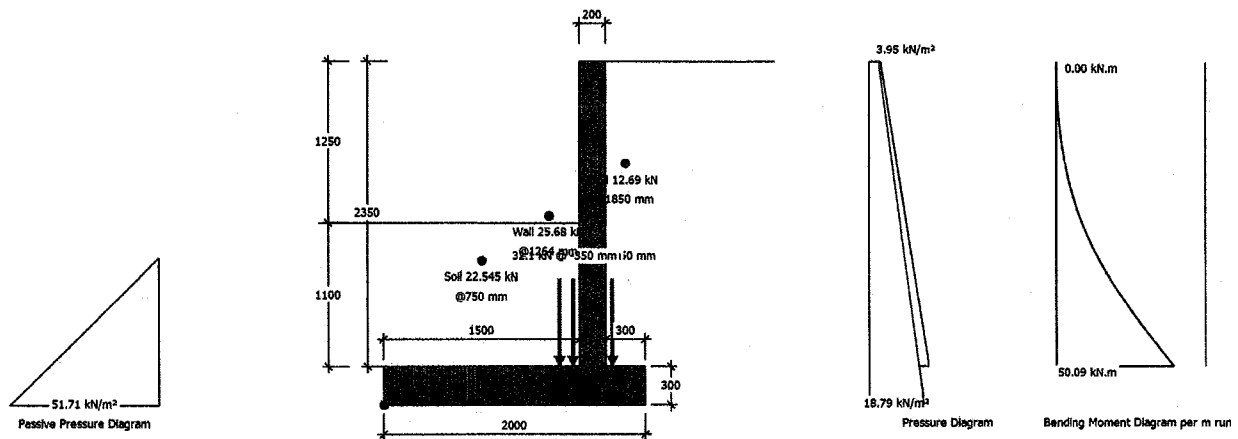
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**RETAINING WALL CASE 2**

**Reinforced Concrete Retaining Wall with Reinforced Base**



**Summary of Design Data**

**Notes**  
Material Densities (kN/m³) Soil 18.00, Concrete 24.00  
Concrete grade fcu 30 N/mm², Permissible tensile stress 0.250 N/mm²  
Concrete covers (mm) Wall inner cover 30 mm, Wall outer cover 30 mm, Base cover 50 mm  
Reinforcement design fy 500 N/mm² designed to BS 8110: 1997  
Surcharge and Water Table Minimum HA Surcharge 10.00 kN/m², Fully drained  
Unplanned excavation depth Front of wall 265 mm  
† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

**Additional Loads**

Vertical Line Loads 4 kN/m @ X 50 mm and Y 2350 mm - Load type HA  
4 kN/m @ X -250 mm and Y 2350 mm - Load type HA  
32.1 kN/m @ X -350 mm and Y 2350 mm - Load type HA  
† Dimensions Ties, line loads and partial loads are measured from the inner top edge of the wall

**Soil Properties**

Bearing pressure Premissable service pressure @ front 100.00 kN/m², @ back 100.00 kN/m²  
Back Soil Friction and Cohesion  $\phi = \text{Atn}(\text{Tan}(30)/1.2) = 25.69^\circ$   
Base Friction and Cohesion  $\delta = \text{Atn}(0.75 \times \text{Tan}(\text{Atn}(\text{Tan}(30)/1.2))) = 19.84^\circ$   
Front Soil Friction and Cohesion  $\phi = \text{Atn}(\text{Tan}(30)/1.2) = 25.69^\circ$

**Loading Cases to Highways BD 37/01**

G<sub>Soil</sub>- Earth Pressure Vertical 5.8, G<sub>Wall</sub>- Wall & Base Self Weight 5.1, S<sub>HA</sub>- HA Surcharge,  
P<sub>a</sub>- Earth Pressure Non-vertical 5.8, P<sub>p</sub>- Passive Pressure 5.8, P<sub>MinSurch</sub>- Minimum Surcharge  
Case 1 Construction 1.20 G<sub>Soil</sub>+1.15 G<sub>Wall</sub>+1.50 P<sub>a</sub>+1.00 P<sub>p</sub>+1.50 P<sub>MinSurch</sub>  
Case 2 Comb 1 1.20 G<sub>Soil</sub>+1.15 G<sub>Wall</sub>+1.50 S<sub>HA</sub>+1.50 P<sub>a</sub>+1.00 P<sub>p</sub>+1.50 P<sub>MinSurch</sub>  
Case 3 Comb 2 1.20 G<sub>Soil</sub>+1.15 G<sub>Wall</sub>+1.25 S<sub>HA</sub>+1.50 P<sub>a</sub>+1.00 P<sub>p</sub>+1.50 P<sub>MinSurch</sub>  
Note: Equivalent unity cases are used for geotechnical design

**Geotechnical Design - Active Earth Pressures**

**Wall Stability - Virtual Back Pressure**

| Case   | Overturning/Stabilising | Value          | Status   |
|--------|-------------------------|----------------|----------|
| Case 1 | Overturning/Stabilising | 29.829/72.783  | 0.410 OK |
| Case 2 | Overturning/Stabilising | 29.829/128.918 | 0.231 OK |
| Case 3 | Overturning/Stabilising | 29.829/128.918 | 0.231 OK |

**Wall Sliding - Virtual Back Pressure**

| Case                                                        | Value                  | Status   |
|-------------------------------------------------------------|------------------------|----------|
| Case 1 Fx/(R <sub>xFriction</sub> + R <sub>xPassive</sub> ) | 29.415/(21.981+29.368) | 0.573 OK |

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|-------------------------------------------------------------|------------------------|-------|----|
| Case 2 Fx/(Rx <sub>Friction</sub> + Rx <sub>Passive</sub> ) | 29.415/(36.451+29.368) | 0.447 | OK |
| Case 3 Fx/(Rx <sub>Friction</sub> + Rx <sub>Passive</sub> ) | 29.415/(36.451+29.368) | 0.447 | OK |

**Soil Pressure**

|                                 |                                                              |       |    |
|---------------------------------|--------------------------------------------------------------|-------|----|
| Case 1 Virtual Back (No uplift) | Max(40.717/100, 20.198/100) kN/m <sup>2</sup>                | 0.407 | OK |
| Case 2 Virtual Back (No uplift) | Max(36.714/100, 64.301/100) kN/m <sup>2</sup>                | 0.643 | OK |
| Case 3 Virtual Back (No uplift) | Max(36.714/100, 64.301/100) kN/m <sup>2</sup>                | 0.643 | OK |
| Case 1 Wall Back                | 79.549/100 kN/m <sup>2</sup> , Length under pressure 1.806 m | 0.795 | OK |
| Case 2 Wall Back (No uplift)    | Max(72.793/100, 59.171/100) kN/m <sup>2</sup>                | 0.728 | OK |
| Case 3 Wall Back (No uplift)    | Max(73.793/100, 48.146/100) kN/m <sup>2</sup>                | 0.738 | OK |

**Structural Design****Highways Design**

|                                                                                                        |                                                                              |     |
|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----|
| At rest earth pressures magnification                                                                  | $(1 + \sin(\phi)) \times \sqrt{\text{OCR}} = (1 + \sin(30)) \times \sqrt{1}$ | 1.5 |
| Reinforced concrete design to BS5400 Pt4. All design forces are multiplied by global factor $\gamma_B$ |                                                                              | 1.1 |

**Wall Design (Inner Steel)**

|                                                  |                                                                                        |                      |    |
|--------------------------------------------------|----------------------------------------------------------------------------------------|----------------------|----|
| Critical Section                                 | Critical @ 0 mm from base, Case 1                                                      |                      |    |
| Steel Provided (Cover)                           | Main H16@200 (30 mm) Dist. H10@200 (46 mm)                                             | 1005 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)               | Main H10@200 (30 mm) Dist. H10@200 (40 mm)                                             | 393 mm <sup>2</sup>  |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{cu})$ | 162 mm, 1000 mm, 1005 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 30.0 N/mm <sup>2</sup> | 146 mm               |    |
| $M_r = \text{fn}(\text{above}, A_s, d', x, x/d)$ | 393 mm <sup>2</sup> , 35 mm, 36 mm, 0.22                                               | 63.7 kN.m            |    |
| Moment Capacity Check (M/M <sub>r</sub> )        | M 50.1 kN.m, M <sub>r</sub> 63.7 kN.m                                                  | 0.786                | OK |
| Shear Capacity Check                             | F 42.8 kN, v <sub>c</sub> 0.759 N/mm <sup>2</sup> , F <sub>v</sub> 122.9 kN            | 0.35                 | OK |

**Base Top Steel Design - Case 1**

|                                                  |                                                                                     |                     |    |
|--------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                           | Main H10@200 (50 mm) Dist. H10@200 (60 mm)                                          | 393 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)               | Main H10@100 (50 mm) Dist. H10@200 (60 mm)                                          | 785 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{cu})$ | 245 mm, 1000 mm, 393 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 30 N/mm <sup>2</sup> | 239 mm              |    |
| $M_r = \text{fn}(\text{above}, A_s, d', x, x/d)$ | 785 mm <sup>2</sup> , 55 mm, 14 mm, 0.06                                            | 40.8 kN.m           |    |
| Moment Capacity Check (M/M <sub>r</sub> )        | M 2.9 kN.m, M <sub>r</sub> 40.8 kN.m                                                | 0.072               | OK |
| Shear Capacity Check                             | F 19.5 kN, v <sub>c</sub> 0.436 N/mm <sup>2</sup> , F <sub>v</sub> 106.8 kN         | 0.18                | OK |

**Base Bottom Steel Design - Case 2**

|                                                  |                                                                                     |                     |    |
|--------------------------------------------------|-------------------------------------------------------------------------------------|---------------------|----|
| Steel Provided (Cover)                           | Main H10@100 (50 mm) Dist. H10@200 (60 mm)                                          | 785 mm <sup>2</sup> | OK |
| Compression Steel Provided (Cover)               | Main H10@200 (50 mm) Dist. H10@200 (60 mm)                                          | 393 mm <sup>2</sup> |    |
| Leverarm $z = \text{fn}(d, b, A_s, f_y, F_{cu})$ | 245 mm, 1000 mm, 785 mm <sup>2</sup> , 500 N/mm <sup>2</sup> , 30 N/mm <sup>2</sup> | 232 mm              |    |
| $M_r = \text{fn}(\text{above}, A_s, d', x, x/d)$ | 393 mm <sup>2</sup> , 55 mm, 28 mm, 0.12                                            | 79.4 kN.m           |    |
| Moment Capacity Check (M/M <sub>r</sub> )        | M 58.2 kN.m, M <sub>r</sub> 79.4 kN.m                                               | 0.733               | OK |
| Shear Capacity Check                             | F 72.4 kN, v <sub>c</sub> 0.549 N/mm <sup>2</sup> , F <sub>v</sub> 134.5 kN         | 0.54                | OK |