

## GABION RETAINING WALL ANLYSIS \& DESIGN

In accordance with EN 1997-1:2004 - Code of Practice for Geotechnical design and the UK National Annex
Tedds calculation version 2.0.03
Design summary
Combination 1

| Action | Resistance | Force | FoS | Allowable FoS | Status |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Overturning, sliding and bearing at base level |  |  |  |  |  |
| Overturning (kNm/m) | 8869.5 | 1949.0 | 4.551 | 1.000 | PASS |
| Sliding (kN/m) | 1188.5 | 555.6 | 2.139 | 1.000 | PASS |
| Bearing (kN/m²) | 300.0 | 263.7 | 1.138 | 1.000 | PASS |
| Eccentricity (mm) | Reaction acts within the middle third of base |  |  |  | PASS |
| Overturning and sliding between courses 1 and 2 |  |  |  |  |  |
| Overturning (kNm/m) | 6468.2 | 1446.1 | 4.473 | 1.000 | PASS |
| Sliding (kN/m) | 998.7 | 455.8 | 2.191 | 1.000 | PASS |
| Overturning and sliding between courses 2 and 3 |  |  |  |  |  |
| Overturning (kNm/m) | 4544.9 | 1037.7 | 4.380 | 1.000 | PASS |
| Sliding (kN/m) | 788.5 | 365.8 | 2.155 | 1.000 | PASS |
| Overturning and sliding between courses 3 and 4 |  |  |  |  |  |
| Overturning (kNm/m) | 3046.6 | 714.1 | 4.266 | 1.000 | PASS |
| Sliding (kN/m) | 603.1 | 285.6 | 2.112 | 1.000 | PASS |
| Overturning and sliding between courses 4 and 5 |  |  |  |  |  |
| Overturning (kNm/m) | 1920.0 | 465.4 | 4.126 | 1.000 | PASS |
| Sliding (kN/m) | 442.6 | 215.1 | 2.057 | 1.000 | PASS |
| Overturning and sliding between courses 5 and 6 |  |  |  |  |  |
| Overturning (kNm/m) | 1112.4 | 281.8 | 3.947 | 1.000 | PASS |
| Sliding (kN/m) | 307.0 | 154.5 | 1.987 | 1.000 | PASS |
| Overturning and sliding between courses 6 and 7 |  |  |  |  |  |
| Overturning (kNm/m) | 570.6 | 153.6 | 3.714 | 1.000 | PASS |
| Sliding (kN/m) | 196.2 | 103.5 | 1.896 | 1.000 | PASS |
| Overturning and sliding between courses 7 and 8 |  |  |  |  |  |
| Overturning (kNm/m) | 241.6 | 71.0 | 3.404 | 1.000 | PASS |
| Sliding (kN/m) | 110.3 | 62.2 | 1.772 | 1.000 | PASS |
| Overturning and sliding between courses 8 and 9 |  |  |  |  |  |
| Overturning (kNm/m) | 72.4 | 24.1 | 3.007 | 1.000 | PASS |
| Sliding (kN/m) | 49.3 | 30.5 | 1.618 | 1.000 | PASS |
| Overturning and sliding between courses 9 and 10 |  |  |  |  |  |
| Overturning (kNm/m) | 10.1 | 3.2 | 3.126 | 1.000 | PASS |
| Sliding (kN/m) | 13.4 | 7.6 | 1.754 | 1.000 | PASS |



## Combination 2

| Action | Resistance | Force | FoS | Allowable FoS | Status |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Overturning, sliding and bearing at base level |  |  |  |  |  |
| Overturning (kNm/m) | 8903.7 | 1779.0 | 5.005 | 1.000 | PASS |
| Sliding (kN/m) | 953.5 | 503.4 | 1.894 | 1.000 | PASS |
| Bearing (kN/m²) | 300.0 | 263.7 | 1.138 | 1.000 | PASS |
| Eccentricity (mm) | Reaction acts within the middle third of base |  |  |  | PASS |
| Overturning and sliding between courses 1 and 2 |  |  |  |  |  |
| Overturning (kNm/m) | 6495.6 | 1321.9 | 4.914 | 1.000 | PASS |
| Sliding (kN/m) | 801.4 | 413.3 | 1.939 | 1.000 | PASS |


| Overturning and sliding between courses 2 and 3 |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Overturning (kNm/m) | 4566.2 | 950.2 | 4.805 | 1.000 | PASS |
| Sliding (kN/m) | 632.9 | 332.1 | 1.906 | 1.000 | PASS |

Overturning and sliding between courses 3 and 4

| Overturning (kNm/m) | 3062.5 | 655.3 | 4.673 | 1.000 | PASS |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Sliding (kN/m) | 484.3 | 259.6 | 1.865 | 1.000 | PASS |

Overturning and sliding between courses 4 and 5

| Overturning (kNm/m) | 1931.4 | 428.3 | 4.510 | 1.000 | PASS |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Sliding (kN/m) | 355.5 | 195.9 | 1.815 | 1.000 | PASS |
| Overturning and sliding between courses 5 and 6 |  |  |  |  | 4.303 |
| Overturning (kNm/m) | 1120.0 | 260.3 | 1.750 | 1.000 | PASS |
| Sliding (kN/m) | 246.7 | 141.0 |  |  |  |


| Overturning and sliding between courses 6 and 7 |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Overturning (kNm/m) | 575.2 | 142.6 | 4.033 | 1.000 | PASS |
| Sliding (kN/m) | 157.8 | 94.9 | 1.663 | 1.000 | PASS |

Overturning and sliding between courses 7 and 8

| Overturning (kNm/m) | 243.9 | 66.4 | 3.672 | 1.000 | PASS |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Sliding (kN/m) | 88.8 | 57.4 | 1.546 | 1.000 | PASS |


| Overturning and sliding between courses $\mathbf{8}$ and $\mathbf{9}$ |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Overturning (kNm/m) | 73.2 | 22.9 | 3.193 | 1.000 | PASS |
| Sliding (kN/m) | 39.7 | 28.6 | 1.390 | 1.000 | PASS |

Overturning and sliding between courses 9 and 10

| Overturning (kNm/m) | 10.1 | 3.3 | 3.038 | 1.000 | PASS |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Sliding $(\mathrm{kN} / \mathrm{m})$ | 10.7 | 7.7 | 1.384 | 1.000 | PASS |




## Wall geometry

Width of gabion 1
$\mathrm{w}_{1}=10000 \mathrm{~mm}$
Height of gabion 1
$h_{1}=1000 \mathrm{~mm}$
Width of gabion 2
Height of gabion 2
Step to front face between courses 1 and 2
Width of gabion 3
Height of gabion 3
Step to front face between courses 2 and 3
Width of gabion 4
Height of gabion 4
Step to front face between courses 3 and 4
Width of gabion 5
Height of gabion 5
Step to front face between courses 4 and 5
Width of gabion 6
Height of gabion 6
Step to front face between courses 5 and 6
Width of gabion 7
Height of gabion 7
Step to front face between courses 6 and 7
Width of gabion 8
$\mathrm{w}_{2}=9000 \mathrm{~mm}$
$\mathrm{h}_{2}=1000 \mathrm{~mm}$
$\mathrm{s}_{2}=0 \mathrm{~mm}$
$\mathrm{W}_{3}=8000 \mathrm{~mm}$
$\mathrm{h}_{3}=1000 \mathrm{~mm}$
$\mathrm{s}_{3}=0 \mathrm{~mm}$
$\mathrm{W}_{4}=\mathbf{7 0 0 0} \mathrm{mm}$
$\mathrm{h}_{4}=1000 \mathrm{~mm}$
$\mathrm{S}_{4}=\mathbf{0} \mathrm{mm}$
$\mathrm{W}_{5}=\mathbf{6 0 0 0} \mathrm{mm}$
$\mathrm{h}_{5}=1000 \mathrm{~mm}$
$\mathrm{S}_{5}=\mathbf{0} \mathrm{mm}$
$\mathrm{W}_{6}=5000 \mathrm{~mm}$
$\mathrm{h}_{6}=\mathbf{1 0 0 0} \mathbf{~ m m}$
$\mathrm{S} 6=0 \mathrm{~mm}$
$\mathrm{w}_{7}=4000 \mathrm{~mm}$
$\mathrm{h}_{7}=1000 \mathrm{~mm}$
$\mathrm{S}_{7}=0 \mathrm{~mm}$
$\mathrm{W}_{8}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{h}_{8}=1000 \mathrm{~mm}$
$\mathrm{S}_{8}=0 \mathrm{~mm}$
$\mathrm{W}_{9}=\mathbf{2 0 0 0} \mathrm{mm}$


| Height of gabion 9 | $\mathrm{~h}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$ |
| :--- | :--- |
| Step to front face between courses 8 and 9 | $\mathrm{~s}_{9}=\mathbf{0} \mathbf{~ m m}$ |
| Width of gabion 10 | $\mathrm{w}_{10}=\mathbf{1 0 0 0} \mathrm{mm}$ |
| Height of gabion 10 | $\mathrm{~h}_{10}=\mathbf{1 0 0 0} \mathrm{mm}$ |
| Step to front face between courses 9 and 10 | $\mathrm{~s}_{10}=\mathbf{0} \mathbf{~ m m}$ |
| Wall inclination | $\varepsilon=\mathbf{0} \mathrm{deg}$ |

## Gabion properties

Unit weight of fill
Friction between gabions
$\gamma_{\mathrm{d}}=18.0 \mathrm{kN} / \mathrm{m}^{3}$
$\delta_{\mathrm{bg} . \mathrm{k}}=35.0 \mathrm{deg}$
Loading
Variable surcharge
$\mathrm{p}_{\mathrm{o}, \mathrm{Q}}=10 \mathrm{kN} / \mathrm{m}^{2}$

## Soil properties

Slope of retained soil
$\beta=\mathbf{0 . 0}$ deg
Characteristic effective shearing resistance angle
Characteristic saturated density of retained soil
Coefficient for wall friction
Wall friction angle
Characteristic base friction angle
Bearing capacity of founding soil
$\phi_{\text {r.k }}=30.0 \mathrm{deg}$
$\gamma_{\mathrm{sr}}=19.0 \mathrm{kN} / \mathrm{m}^{3}$
$\mathrm{k}_{\text {membrane }}=\mathbf{0 . 7 5}$
$\delta_{\mathrm{r} . \mathrm{k}}=\mathbf{2 2 . 5 \mathrm { deg }}$
$\delta$ bb.k $=34.0 \mathrm{deg}$
$\mathrm{q}=300 \mathrm{kN} / \mathrm{m}^{2}$

## Wall geometry

Horizontal distance to centre of gravity gabion 1
Vertical distance to centre of gravity gabion 1
Weight of gabion 1
Horizontal distance to centre of gravity gabion 2
Vertical distance to centre of gravity gabion 2
Weight of gabion 2
Horizontal distance to centre of gravity gabion 3
Vertical distance to centre of gravity gabion 3
Weight of gabion 3
Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
$\mathrm{X}_{\mathrm{g} 1}=\mathrm{w}_{1} / 2=5000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 1}=\mathrm{h}_{1} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 1}=\gamma_{\mathrm{d}} \times \mathrm{W}_{1} \times \mathrm{h}_{1}=180.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 2}=\mathrm{w}_{2} / 2+\mathrm{S}_{2}=4500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 2}=\mathrm{h}_{2} / 2+\mathrm{h}_{1}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 2}=\gamma_{\mathrm{d}} \times \mathrm{W}_{2} \times \mathrm{h}_{2}=162.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 3}=\mathrm{w}_{3} / 2+\mathrm{s}_{2}+\mathrm{s}_{3}=4000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 3}=\mathrm{h}_{3} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 3}=\gamma_{\mathrm{d}} \times \mathrm{W}_{3} \times \mathrm{h}_{3}=144.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 4}=\mathrm{W}_{4} / 2+\mathrm{s}_{2}+\mathrm{s}_{3}+\mathrm{S}_{4}=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 4}=\mathrm{h}_{4} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=\mathbf{1 2 6 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{5} 5=\mathrm{w}_{5} / 2+\mathrm{s}_{2}+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{s}_{5}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=\mathbf{1 0 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{W}_{6} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$y_{g 6}=h_{6} / 2+h_{1}+h_{2}+h_{3}+h_{4}+h_{5}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{w}_{7} / 2+\mathrm{s}_{2}+\mathrm{s}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=\mathbf{6 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$


| Horizontal distance to centre of gravity gabion 8 | $\mathrm{Xg}_{8}=\mathrm{W}_{8} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathrm{mm}$ |
| :---: | :---: |
| Vertical distance to centre of gravity gabion 8 | $\mathrm{yg}_{88}=\mathrm{h}_{8} / 2+h_{1}+h_{2}+h_{3}+h_{4}+h_{5}+h_{6}+h_{7}=7500 \mathrm{~mm}$ |
| Weight of gabion 8 | $\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 9 | $\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{2}+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$ |
| Vertical distance to centre of gravity gabion 9 | $\mathrm{y}_{99}=\mathrm{h}_{9} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+h_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=8500 \mathrm{~mm}$ |
| Weight of gabion 9 | $\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 10 | $\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$ |
| Vertical distance to centre of gravity gabion 10 | $\mathrm{y}_{\mathrm{g} 10}=h_{10} / 2+h_{1}+h_{2}+h_{3}+h_{4}+h_{5}+h_{6}+h_{7}+h_{8}+h_{9}=9500 \mathrm{~mm}$ |
| Weight of gabion 10 | $\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$ |
| Weight of entire gabion | $W_{g}=W_{g 1}+W_{g 2}+W_{g}+W_{g 4}+W_{g}+W_{g 6}+W_{g 7}+W_{g}+W_{g 9}+W_{g 10}=$ $990.0 \mathrm{kN} / \mathrm{m}$ |
| Horiz distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 1} \times \mathrm{x}_{\mathrm{g} 1}\right)+\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{x}_{\mathrm{g} 2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{X}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{x}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{x}_{\mathrm{g} 5}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{x}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{x}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{x}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{x}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{x}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}= \\ & 3500 \mathrm{~mm} \end{aligned}$ |
| Vert distance to centre of gravity entire gabion | $\begin{aligned} & y_{g}=\left(\left(W_{g 1} \times y_{g 1}\right)+\left(W_{g 2} \times y_{g 2}\right)+\left(W_{g} \times y_{g 3}\right)+\left(W_{g 4} \times y_{g 4}\right)+\left(W_{g 5} \times y_{g 5}\right)+\right. \\ & \left.\left(W_{g 6} \times y_{g 6}\right)+\left(W_{g 7} \times y_{g 7}\right)+\left(W_{g 8} \times y_{g 8}\right)+\left(W_{g 9} \times y_{g 9}\right)+\left(W_{g 10} \times y_{g 10}\right)\right) / W_{g}= \\ & 3500 \mathrm{~mm} \end{aligned}$ |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=3500 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $H_{f}=y_{g 10}+h_{10} / 2-\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{1}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=48.0 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{1} \times \sin (\varepsilon)\right)-H_{f}=10000 \mathrm{~mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\text {g10 }}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=10000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $\begin{aligned} & K_{a}=\sin \left(\alpha+\phi^{\prime} r . k\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{r . k}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime} \text { r.k }+\delta_{\text {r.k }}\right) \times \sin \left(\phi^{\prime} \text { r.k }-\right.\right.\right.\right. \\ & \left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{r . k}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.901 \end{aligned}$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{a} \text { soil }}=0.5 \times \mathrm{Ka} \times \gamma_{\mathrm{sr}} \times \mathrm{H}^{2}=855.5 \mathrm{kN} / \mathrm{m}$ |
| Pressure at base |  |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h,q }}=\mathrm{Pa}_{\text {a,soil }} \times \cos \left(90-\alpha+\delta_{\text {r.k }}\right)=368.5 \mathrm{kN} / \mathrm{m}$ |
| Height of soil thrust resolved vertically | dh,soil $=\mathrm{H} / 3-\mathrm{w}_{1} \times \sin (\varepsilon)=3333 \mathrm{~mm}$ |
| Surcharge | $F_{\text {surch_h,q }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.k }}\right)=38.8 \mathrm{kN} / \mathrm{m}$ |
| Height of surcharge thrust resolved vertically | $\mathrm{d}_{\mathrm{h}, \text { surch }}=\mathrm{H} / 2-\mathrm{w} 1 \times \sin (\varepsilon)=5000 \mathrm{~mm}$ |
| Vertical forces |  |
| Gabion weight | $F_{\text {gabion_v,q }}=\mathrm{W}_{\mathrm{g}}=990.0 \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $F_{\text {soil } \mathrm{l}, \mathrm{q}}=\mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r. }}\right)=772.1 \mathrm{kN} / \mathrm{m}$ |
| Horizontal dist to where soil thrust acts | $\mathrm{b}_{\mathrm{v}, \text { soil }}=\mathrm{w}_{1} \times \cos (\varepsilon)-(\mathrm{H} / 3) / \tan (\alpha)=7000 \mathrm{~mm}$ |
| Surcharge |  |
| Horizontal dist to where surcharge thrust acts | $\mathrm{b}_{\mathrm{v}, \text { surch }}=\mathrm{W}_{1} \times \cos (\varepsilon)-(\mathrm{H} / 2) / \tan (\alpha)=5500 \mathrm{~mm}$ |
| Total horizontal unfactored force | $\mathrm{T}_{\mathrm{q}}=\mathrm{F}_{\text {soil_h,q }}+\mathrm{F}_{\text {surch_ } \mathrm{h}, \mathrm{q}}=407.3 \mathrm{kN} / \mathrm{m}$ |
| Total vertical unfactored force | $N_{\text {q }}=F_{\text {gabion_v,q }}+F_{\text {soil_v,q }}+F_{\text {surch_v,q }}=1843.3 \mathrm{kN} / \mathrm{m}$ |

Horizontal distance to centre of gravity gabion 8 Vertical distance to centre of gravity gabion 8 Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion

Horiz distance to centre of gravity entire gabion

Correcting for wall inclination horiz dist

## Design dimensions

Effective angle of rear plane of wall
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory

Active thrust due to soil
Pressure at base

## Horizontal forces

Height of soil thrust resolved vertically
Surcharge
Height of surcharge thrust resolved vertically

## Vertical forces

Retained soil
Horizontal dist to where soil thrust acts
Surcharge
Horizontal dist to where surcharge thrust acts

Total vertical unfactored force
$\mathrm{X}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S} 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S} 6+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathbf{m m}$
$y_{g 8}=h_{8} / 2+h_{1}+h_{2}+h_{3}+h_{4}+h_{5}+h_{6}+h_{7}=7500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma \mathrm{d} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathbf{~ m m}$
$\mathrm{y}_{9}=\mathrm{h}_{9} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=8500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W} 9 \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S} 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S} 5+\mathrm{S} 6+\mathrm{S} 7+\mathrm{S} 8+\mathrm{S} 9+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=9500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 1}+\mathrm{W}_{\mathrm{g} 2}+\mathrm{W}_{\mathrm{g} 3}+\mathrm{W}_{\mathrm{g} 4}+\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=$ $990.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 1} \times \mathrm{Xg}_{1}\right)+\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{x}_{\mathrm{g} 2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{X}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{X}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\right.$ $\left.\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g}} 8\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=$ 3500 m
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 1} \times \mathrm{y}_{\mathrm{g} 1}\right)+\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{y}_{\mathrm{g} 2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{y}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{9} 5\right)+\right.$ $\left.\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=$
$X_{g}=x_{g} \times \cos (\varepsilon)+\mathrm{X}_{\mathrm{g}} \times \sin (\varepsilon)=3500 \mathrm{~mm}$
$H_{f}=y_{g 10}+h_{10} / 2-\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(X_{g 10}+W_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} m m$
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{1}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=48.0 \mathrm{deg}$
$\theta=90$ deg $-\varepsilon=90.0$ deg
$\mathrm{H}=\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)+\left(\mathrm{w}_{1} \times \sin (\varepsilon)\right)-\mathrm{H}_{\mathrm{f}}=10000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=10000 \mathrm{~mm}$
$\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \mathrm{r} . \mathrm{k}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.k }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r. }}\right.\right.\right.\right.$. $\left.+\delta_{\text {r. } . k}\right) \times \sin \left(\phi^{\prime}\right.$ r.k -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{r . k}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 9 0 1}$
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{sr}} \times \mathrm{H}^{2}=855.5 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\text {soil } \_\mathrm{h}, \mathrm{q}}=\mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.k }}\right)=368.5 \mathrm{kN} / \mathrm{m}$
dh, soil $=\mathrm{H} / 3-\mathrm{w}_{1} \times \sin (\varepsilon)=3333 \mathrm{~mm}$
Fsurch_h, $\mathrm{q}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.k }}\right)=38.8 \mathrm{kN} / \mathrm{m}$
$\mathrm{d}_{\mathrm{h}, \text { surch }}=\mathrm{H} / 2-\mathrm{w}_{1} \times \sin (\varepsilon)=5000 \mathrm{~mm}$
$F_{\text {gabion_v, }}=\mathrm{W}_{\mathrm{g}}=990.0 \mathrm{kN} / \mathrm{m}$
$F_{\text {soil } \mathrm{v}, \mathrm{q}}=\mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.k }}\right)=772.1 \mathrm{kN} / \mathrm{m}$
$\mathrm{b}_{\mathrm{v}, \text { soil }}=\mathrm{W}_{1} \times \cos (\varepsilon)-(\mathrm{H} / 3) / \tan (\alpha)=7000 \mathrm{~mm}$
$F_{\text {surch_v, } \mathrm{q}}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . k}\right)=81.3 \mathrm{kN} / \mathrm{m}$
$\mathrm{b}_{\mathrm{v}, \text { surch }}=\mathrm{W}_{1} \times \cos (\varepsilon)-(\mathrm{H} / 2) / \tan (\alpha)=5500 \mathrm{~mm}$
$\mathrm{T}_{\mathrm{q}}=\mathrm{F}_{\text {soil_h,q}}+\mathrm{F}_{\text {surch } \_\mathrm{h}, \mathrm{q}}=407.3 \mathrm{kN} / \mathrm{m}$
$N_{q}=F_{\text {gabion_v,q }}+F_{\text {soil_ } \mathrm{v}, \mathrm{q}}+F_{\text {surch_ } \mathrm{v}, \mathrm{q}}=1843.3 \mathrm{kN} / \mathrm{m}$


| Force normal to base | $\mathrm{N}_{\mathrm{s}}=\mathrm{N}_{\mathrm{q}} \times \cos (\varepsilon)+\mathrm{T}_{\mathrm{q}} \times \sin (\varepsilon)=1843.3 \mathrm{kN} / \mathrm{m}$ |
| :---: | :---: |
| Total unfactored overturning force | $\mathrm{M}_{\mathrm{og}}=\mathrm{F}_{\text {soil }} \mathrm{h}, \mathrm{q} \times \mathrm{dh}$, soil $+\mathrm{F}_{\text {surch_h } \mathrm{h}, \mathrm{q}} \times \mathrm{d}_{\mathrm{h}, \text { surch }}=1422.2 \mathrm{kNm} / \mathrm{m}$ |
| Total unfactored restoring force |  |
| Eccentricity | $\mathrm{e}=\mathrm{w}_{1} / 2-\left(\mathrm{M}_{\mathrm{R}, \mathrm{q}}-\mathrm{M}_{\mathrm{o}, \mathrm{q}}\right) / \mathrm{N}_{\mathrm{s}}=717 \mathrm{~mm}$ |
|  | Reaction acts within middle third of base |
| Pressure at toe | $\sigma_{\text {toe }}=\mathrm{N}_{\mathrm{s}} / \mathrm{w}_{1} \times\left(1+\left(6 \times \mathrm{e} / \mathrm{w}_{1}\right)\right.$ ) $=\mathbf{2 6 3 . 7} \mathrm{kN} / \mathrm{m}^{2}$ |
| Pressure at heel | $\sigma_{\text {heel }}=\mathrm{N}_{\mathrm{s}} / \mathrm{w}_{1} \times\left(1-\left(6 \times \mathrm{e} / \mathrm{w}_{1}\right)\right.$ ) $=105.0 \mathrm{kN} / \mathrm{m}^{2}$ |
| Factor of safety | $\mathrm{FoSQ}_{\mathrm{Q}}=\mathrm{q} / \max \left(\sigma_{\text {toe }}, \sigma_{\text {heel }}\right)=1.138$ |
| Allowable factor of safety | FoSQ_allow $=1.000$ |

PASS - Design FoS for allowable bearing pressure exceeds min allowable pressure to base

## Design approach 1

## Partial factors on actions - Section A.3.1-Combination 1

Permanent unfavourable action
$\gamma G=1.35$
Permanent favourable action
$\gamma \mathrm{G}, \mathrm{f}=1.00$
Variable unfavourable action
$\gamma Q=1.50$
Variable favourable action
$\gamma Q, f=0.00$

## Partial factors for soil parameters - Section A.3.2-Combination 1

Angle of shearing resistance
$\gamma_{\phi^{\prime}}=1.00$
Weight density
$\gamma_{\gamma}=1.00$

## Design soil properties

Design effective shearing resistance angle
$\phi^{\prime}$ r.d $=\operatorname{Atan}\left(\tan \left(\phi^{\prime} r . \mathrm{k}\right) / \gamma_{\phi^{\prime}}\right)=\mathbf{3 0 . 0}$ deg
Design saturated density of retained soil
Design wall friction angle
Design base friction angle
Design friction between gabions
Active pressure using Coulomb theory

Active thrust due to soil

## Horizontal forces

Retained soil
Surcharge
$\mathrm{F}_{\text {soil_h }}=\gamma_{\mathrm{G}} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=497.4 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q} \times \mathrm{Ka}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{r . d}\right)=58.2 \mathrm{kN} / \mathrm{m}$

## Vertical forces

Gabion weight
Retained soil
F $_{\text {gabion_ } \mathrm{v}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=990.0 \mathrm{kN} / \mathrm{m}$

Surcharge
$F_{\text {soil } \_, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=772.1 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=\mathbf{0 . 0} \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe
Overturning moment
$M_{0}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=1949.0 \mathrm{kNm} / \mathrm{m}$
Restoring moment
Factor of safety
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=8869.5 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{\mathrm{o}}=4.551$
Allowable factor of safety


PASS - Design FOS for overturning exceeds min allowable FOS for overturning
Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{T}=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch } \_\mathrm{h}}=555.6 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil } \_v, f}+F_{\text {surch } \_v, f}=\mathbf{1 7 6 2 . 1} \mathbf{k N} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=555.6 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bb. }}\right)=1188.5 \mathrm{kN} / \mathrm{m}$
FoSs $=F_{R} / F_{f}=2.139$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 1 and 2

## Wall geometry

Horizontal distance to centre of gravity gabion 2
Vertical distance to centre of gravity gabion 2
Weight of gabion 2
Horizontal distance to centre of gravity gabion 3
Vertical distance to centre of gravity gabion 3
Weight of gabion 3
Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion

Horiz distance to centre of gravity entire gabion
$\mathrm{X}_{\mathrm{g} 2}=\mathrm{W}_{2} / 2=4500 \mathrm{~mm}$
$\mathrm{yg}_{\mathrm{g} 2}=\mathrm{h}_{2} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 2}=\gamma_{\mathrm{d}} \times \mathrm{W}_{2} \times \mathrm{h}_{2}=162.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{xg}_{\mathrm{g}}=\mathrm{W}_{3} / 2+\mathrm{s}_{3}=4000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 3}=\mathrm{h}_{3} / 2+\mathrm{h}_{2}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 3}=\gamma_{\mathrm{d}} \times \mathrm{W}_{3} \times \mathrm{h}_{3}=144.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 4}=\mathrm{w}_{4} / 2+\mathrm{s}_{3}+\mathrm{s}_{4}=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 4}=\mathrm{h}_{4} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=\mathbf{1 2 6 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{S}_{5}=3000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=\mathbf{7 2 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}} 8=\mathrm{W}_{8} / 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=1500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}=\mathbf{6 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathbf{m m}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=7500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=8500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 2}+\mathrm{W}_{\mathrm{g} 3}+\mathrm{W}_{\mathrm{g} 4}+\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{8 1 0 . 0}$
$\mathrm{kN} / \mathrm{m}$
$\mathrm{xg}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{Xg}_{2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{Xg}_{\mathrm{g}}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{X}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=3167 \mathrm{~mm}$


| Vert distance to centre of gravity entire gabion | $\begin{aligned} & y_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{y}_{\mathrm{g} 2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{y}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7} 7\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{3 1 6 7} \mathrm{mm} \end{aligned}$ |
| :---: | :---: |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{yg}_{\mathrm{g}} \times \sin (\varepsilon)=3167 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{2}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right)^{\prime}\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=48.4 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $H=\left(y_{g 10}+h_{10} / 2\right)+\left(\mathrm{w}_{2} \times \sin (\varepsilon)\right)-\mathrm{H}_{\mathrm{f}}=9000 \mathrm{~mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{110}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{110}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=9000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d - <br> $\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{r . d}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.890$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{a} \text { soil }}=0.5 \times \mathrm{Ka} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=684.9 \mathrm{kN} / \mathrm{m}$ |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=403.4 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_h }}=\mathrm{p}_{0, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=52.4 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight | Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=810.0 \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $\mathrm{F}_{\text {soil_ } \mathrm{v}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=616.3 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_v }, f}=p_{0, Q} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=0.0 \mathrm{kN} / \mathrm{m}$ |
| Overturning stability - take moments about the toe |  |
| Overturning moment | $M_{0}=F_{\text {soil_ }} \mathrm{h} \times \mathrm{dh}$, soil $+\mathrm{F}_{\text {surch_h }} \mathrm{h} \times \mathrm{d}_{\mathrm{h}, \text { surch }}=1446.1 \mathrm{kNm} / \mathrm{m}$ |
| Restoring moment | $M_{R}=F_{\text {gabion_v, }} \times \mathrm{X}_{\mathrm{g}}+\mathrm{F}_{\text {soil_l } \mathrm{f}, \mathrm{f}} \times \mathrm{b}_{\mathrm{v}, \text { soil }}+\mathrm{F}_{\text {surch_v }} \mathrm{v}$ f $\times \mathrm{b}_{\mathrm{v}, \text { surch }}=6468.2 \mathrm{kNm} / \mathrm{m}$ |
| Factor of safety | $\mathrm{FoS}_{M}=\mathrm{MR}_{R} / \mathrm{M}_{0}=4.473$ |
| Allowable factor of safety | $\mathrm{FoS}_{\text {M_allow }}=1.000$ |
|  | Design FOS for overturning exceeds min allowable FOS for overturning |
| Sliding stability - ignore any passive pressure in front of the structure |  |
| Total horizontal force | T $=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch_h }}=455.8 \mathrm{kN} / \mathrm{m}$ |
| Total vertical force | $N=F_{\text {gabion_v,f }}+\mathrm{F}_{\text {soil_v,f }}+\mathrm{F}_{\text {surch_v,f }}=1426.3 \mathrm{kN} / \mathrm{m}$ |
| Sliding force | $\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=455.8 \mathrm{kN} / \mathrm{m}$ |
| Sliding resistance | $\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=998.7 \mathrm{kN} / \mathrm{m}$ |
| Factor of safety | FoSs $=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=2.191$ |
| Allowable factor of safety | FoSs_allow = 1.000 |
|  | PASS - Design FOS for sliding exceeds min allowable FOS for sliding |
| Check overturning and sliding between courses 2 and 3 |  |
| Wall geometry |  |
| Horizontal distance to centre of gravity gabion 3 | $\mathrm{x}_{\mathrm{g} 3}=\mathrm{w}_{3} / 2=4000 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 3 | $\mathrm{y}_{\mathrm{g} 3}=\mathrm{h}_{3} / 2=500 \mathrm{~mm}$ |
| Weight of gabion 3 | $\mathrm{W}_{\mathrm{g} 3}=\gamma_{\mathrm{d}} \times \mathrm{W}_{3} \times \mathrm{h}_{3}=144.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 4 | $\mathrm{x}_{\mathrm{g} 4}=\mathrm{w}_{4} / 2+\mathrm{s}_{4}=3500 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 4 | $\mathrm{y}_{\mathrm{g} 4}=\mathrm{h}_{4} / 2+\mathrm{h}_{3}=1500 \mathrm{~mm}$ |



## Weight of gabion 4

Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion

Vert distance to centre of gravity entire gabion

Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination

## Design dimensions

Effective angle of rear plane of wall
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory

Active thrust due to soil

## Horizontal forces

Retained soil
Surcharge

## Vertical forces

Gabion weight
Retained soil
Surcharge
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=126.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{yg}_{5}=\mathrm{h}_{5} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{s}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$y_{g 6}=h_{6} / 2+h_{3}+h_{4}+h_{5}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{w}_{9} / 2+\mathrm{s}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{s}_{7}+\mathrm{s}_{8}+\mathrm{s}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=6500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=7500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 3}+\mathrm{W}_{\mathrm{g} 4}+\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{6 4 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{X}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{X}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{Xg}_{\mathrm{g} 7}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=2833 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{y}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 8 3 3} \mathrm{mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=2833 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$
$\alpha=90$ deg $-\operatorname{Atan}\left(\left(\mathrm{w}_{3}-\left(\mathrm{X}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=48.8 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{3} \times \sin (\varepsilon)\right)-H_{f}=8000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=8000 \mathrm{~mm}$
$\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.877$
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=533.3 \mathrm{kN} / \mathrm{m}$
$F_{\text {soil } \_h}=\gamma G \times P_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=319.2 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=p_{0, Q} \times \gamma_{Q} \times K_{a} \times H \times \cos \left(90-\alpha+\delta_{r . d}\right)=46.7 \mathrm{kN} / \mathrm{m}$
$F_{\text {gabion_v,f }}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=648.0 \mathrm{kN} / \mathrm{m}$
$F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=478.0 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{Ka} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=0.0 \mathrm{kN} / \mathrm{m}$


## Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety

$$
\begin{aligned}
& M_{0}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch } \_h} \times d_{h, \text { surch }}=1037.7 \mathrm{kNm} / \mathrm{m} \\
& M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch } \_v, f} \times b_{v, \text { surch }}=4544.9 \mathrm{kNm} / \mathrm{m} \\
& \mathrm{FoS}_{M}=M_{R} / M_{0}=4.380 \\
& \text { FoS }_{M \_ \text {_allow }}=1.000
\end{aligned}
$$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{T}=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch } \_\mathrm{h}}=365.8 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion } \_v, f}+F_{\text {soil } \_v, f}+F_{\text {surch } \_v, f}=1126.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=365.8 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=788.5 \mathrm{kN} / \mathrm{m}$
FoSs $=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=2.155$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 3 and 4

## Wall geometry

Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion
$\mathrm{X}_{\mathrm{g} 4}=\mathrm{w}_{4} / 2=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 4}=\mathrm{h}_{4} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=126.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2+\mathrm{S}_{5}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2+\mathrm{h}_{4}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{5}+\mathrm{S} 6+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{Xg}_{\mathrm{g}}=\mathrm{W}_{8} / 2+\mathrm{S}_{5}+\mathrm{S} 6+\mathrm{S} 7+\mathrm{S} 8=\mathbf{1 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{w}_{10} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=\mathbf{6 5 0 0} \mathbf{m m}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 4}+\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{5 0 4 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{x}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{x}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{x}_{\mathrm{g} 8}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=2500 \mathrm{~mm}$


| Vert distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 5 0 0} \mathrm{mm} \end{aligned}$ |
| :---: | :---: |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=2500 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{4}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right)^{\prime}\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=49.4 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $H=\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)+\left(\mathrm{w}_{4} \times \sin (\varepsilon)\right)-\mathrm{Hf}_{\mathrm{f}}=\mathbf{7 0 0 0} \mathrm{mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=7000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \mathrm{r} . \mathrm{d}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin (\alpha-\delta \mathrm{r} . \mathrm{d}) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime} \text { r.d }+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime} \text { r.d }-\right.\right.\right.\right.$ <br> $\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r. } \mathrm{d}}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 8 6 1}$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{a} \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=400.7 \mathrm{kN} / \mathrm{m}$ |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=\mathbf{2 4 4 . 7} \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=40.9 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight | Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=504.0 \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $\mathrm{F}_{\text {soil } \mathrm{l}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=357.3 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_v }, \mathrm{f}}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=0.0 \mathrm{kN} / \mathrm{m}$ |
| Overturning stability - take moments about the toe |  |
| Overturning moment | $M_{0}=F_{\text {soil }} \mathrm{h} \times \mathrm{dh}$, soil $+\mathrm{F}_{\text {surch } \_\mathrm{h}} \times \mathrm{dh}$, surch $=714.1 \mathrm{kNm} / \mathrm{m}$ |
| Restoring moment |  |
| Factor of safety | $\mathrm{FoS}_{M}=\mathrm{MR} / \mathrm{M}_{0}=4.266$ |
| Allowable factor of safety | $\mathrm{FoS}_{\text {M_allow }}=1.000$ |
| PASS - | Design FOS for overturning exceeds min allowable FOS for overturning |
| Sliding stability - ignore any passive pressure in front of the structure |  |
| Total horizontal force | T $=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch_h }}=285.6 \mathrm{kN} / \mathrm{m}$ |
| Total vertical force | $N=F_{\text {gabion_v, }}+\mathrm{F}_{\text {soil_v,f }}+\mathrm{F}_{\text {surch_v,f }}=861.3 \mathrm{kN} / \mathrm{m}$ |
| Sliding force | $\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=285.6 \mathrm{kN} / \mathrm{m}$ |
| Sliding resistance | $\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=603.1 \mathrm{kN} / \mathrm{m}$ |
| Factor of safety | FoSs $=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=2.112$ |
| Allowable factor of safety | FoSs_allow = 1.000 |
|  | PASS - Design FOS for sliding exceeds min allowable FOS for sliding |
| Check overturning and sliding between courses 4 and 5 |  |
| Wall geometry |  |
| Horizontal distance to centre of gravity gabion 5 | $\mathrm{X}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2=3000 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 5 | $\mathrm{yg}_{5}=\mathrm{h}_{5} / 2=500 \mathrm{~mm}$ |
| Weight of gabion 5 | $\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 6 | $\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{S}_{6}=2500 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 6 | $\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{5}=1500 \mathrm{~mm}$ |



| Weight of gabion 6 | $\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$ |
| :---: | :---: |
| Horizontal distance to centre of gravity gabion 7 | $\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathrm{mm}$ |
| Vertical distance to centre of gravity gabion 7 | $\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}=2500 \mathrm{~mm}$ |
| Weight of gabion 7 | $\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 8 | $\mathrm{X}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=1500 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 8 | $\mathrm{y}_{98}=\mathrm{h}_{8} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}=3500 \mathrm{~mm}$ |
| Weight of gabion 8 | $\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 9 | $\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{6}+\mathrm{s}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=1000 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 9 | $\mathrm{y}_{99}=\mathrm{h}_{9} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=4500 \mathrm{~mm}$ |
| Weight of gabion 9 | $\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 10 | $\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{6}+\mathrm{s}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{s}_{10}=\mathbf{5 0 0} \mathbf{~ m m}$ |
| Vertical distance to centre of gravity gabion 10 | $\mathrm{y}_{910}=\mathrm{h}_{10} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=5500 \mathrm{~mm}$ |
| Weight of gabion 10 | $\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$ |
| Weight of entire gabion | $\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=378.0 \mathrm{kN} / \mathrm{m}$ |
| Horiz distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{x}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{x}_{\mathrm{g} 9}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{x}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 1 6 7} \mathrm{mm} \end{aligned}$ |
| Vert distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 1 6 7} \mathrm{mm} \end{aligned}$ |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{X}_{\mathrm{g}} \times \sin (\varepsilon)=2167 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{5}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right)^{\prime}\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=50.2 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $H=\left(\mathrm{y}_{10}+\mathrm{h}_{10} / 2\right)+\left(\mathrm{w}_{5} \times \sin (\varepsilon)\right)-\mathrm{H}_{\mathrm{f}}=\mathbf{6 0 0 0} \mathrm{mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=6000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $\begin{aligned} & \mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi_{\text {'r.d }}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime} \text { r.d }+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {r.d }}\right.\right.\right.\right. \\ & \left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.839 \end{aligned}$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{a} \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=\mathbf{2 8 7 . 0} \mathrm{kN} / \mathrm{m}$ |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=180.0 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_h }}=\mathrm{p}_{0, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{Ka}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=35.1 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight |  |
| Retained soil | $F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=254.1 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_ }} \mathrm{v}, \mathrm{f}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K} \times \mathrm{H} \times \sin (90-\alpha+\delta \mathrm{r} . \mathrm{d})=0.0 \mathrm{kN} / \mathrm{m}$ |
| Overturning stability - take moments about the toe |  |
| Overturning moment | $\mathrm{M}_{\mathrm{o}}=\mathrm{F}_{\text {soil }} \mathrm{h} \times \mathrm{d}_{\mathrm{h}, \text { soil }}+\mathrm{F}_{\text {surch_h }} \times \mathrm{d}_{\text {,surch }}=465.4 \mathrm{kNm} / \mathrm{m}$ |
| Restoring moment | $M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil }}$ v,f $\times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=1920.0 \mathrm{kNm} / \mathrm{m}$ |
| Factor of safety | $\mathrm{FoSS}_{M}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=4.126$ |
| Allowable factor of safety | FoSm_allow = 1.000 |

$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$
$\mathrm{y}_{99}=\mathrm{h}_{9} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{3 7 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{9} 7\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 1 6 7} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 1 6 7} \mathrm{mm}$
$X_{g}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{X}_{\mathrm{g}} \times \sin (\varepsilon)=2167 \mathrm{~mm}$
$H_{f}=y_{g 10}+h_{10} / 2-\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(X_{g 10}+W_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{5}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=50.2 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)+\left(\mathrm{w}_{5} \times \sin (\varepsilon)\right)-\mathrm{H}_{\mathrm{f}}=\mathbf{6 0 0 0} \mathrm{mm}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=6000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r.d }}^{\prime}+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {r.d }}-\right.\right.\right.\right.$
阝) $\left.\left.\left./\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 8 3 9}$
Active thrust due to soil
$\mathrm{F}_{\text {soil_h }}=\gamma_{\mathrm{G}} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=\mathbf{1 8 0 . 0} \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r. }}\right)=35.1 \mathrm{kN} / \mathrm{m}$
Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{3 7 8 . 0} \mathrm{kN} / \mathrm{m}$
$F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin (90-\alpha+\delta \mathrm{r} . \mathrm{d})=254.1 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=\mathbf{0 . 0} \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe

Overturning moment
Restoring moment

Allowable factor of safety
$M_{0}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=465.4 \mathrm{kNm} / \mathrm{m}$
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=1920.0 \mathrm{kNm} / \mathrm{m}$
$F_{0 S m}=M_{R} / M_{0}=4.126$
FoSm_allow = 1.000


## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{T}=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch } \_\mathrm{h}}=\mathbf{2 1 5 . 1} \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=632.1 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=215.1 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=442.6 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoSs}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=2.057$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 5 and 6

## Wall geometry

Horizontal distance to centre of gravity gabion 6
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2=2500 \mathrm{~mm}$
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion

Vert distance to centre of gravity entire gabion

Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination
$\mathrm{y}_{96}=\mathrm{h}_{6} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{7}=2000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{6}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 8}=\mathrm{w}_{8} / 2+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2+\mathrm{h}_{6}+\mathrm{h}_{7}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=1000 \mathrm{~mm}$
$y_{g 9}=h_{9} / 2+h_{6}+h_{7}+h_{8}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{2 7 0 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{x}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) /$
$\mathrm{W}_{\mathrm{g}}=1833 \mathrm{~mm}$
$y_{g}=\left(\left(W_{g 6} \times y_{g 6}\right)+\left(W_{g 7} \times y_{g 7}\right)+\left(W_{g 8} \times y_{g 8}\right)+\left(W_{g 9} \times y_{g 9}\right)+\left(W_{g 10} \times y_{g 10}\right)\right) /$
$\mathrm{W}_{\mathrm{g}}=1833 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{X}_{\mathrm{g}} \times \sin (\varepsilon)=1833 \mathrm{~mm}$
$H_{f}=y_{g 10}+h_{10} / 2-\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(X_{g 10}+W_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$

## Design dimensions

Effective angle of rear plane of wall
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{6}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=51.3 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{6} \times \sin (\varepsilon)\right)-H_{f}=\mathbf{5 0 0 0} \mathbf{m m}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=5000 \mathrm{~mm}$
$\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \mathrm{r} . \mathrm{d}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\mathrm{r} . \mathrm{d}}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 8 0 9}$
Active thrust due to soil


## Horizontal forces

| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=125.2 \mathrm{kN} / \mathrm{m}$ |
| :---: | :---: |
| Surcharge | $\mathrm{F}_{\text {surch_h }}=\mathrm{p}_{0, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{Ka}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=29.3 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight | $\mathrm{F}_{\text {gabion_v,f }}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{2 7 0 . 0} \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=168.4 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_ }} \mathrm{v}, \mathrm{f}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=0.0 \mathrm{kN} / \mathrm{m}$ |

Overturning stability - take moments about the toe

Overturning moment
$M_{0}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=\mathbf{2 8 1 . 8} \mathrm{kNm} / \mathrm{m}$
Restoring moment
Factor of safety
Allowable factor of safety
$M_{R}=F_{g a b i o n \_v, f} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=1112.4 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=3.947$
$\mathrm{FoS}_{\mathrm{m}}$ _allow $=\mathbf{1 . 0 0 0}$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil } \_h}+F_{\text {surch_h }}=154.5 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f } f}+F_{\text {surch_v,f }}=438.4 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=154.5 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bg. }}\right)=307.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoSs}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.987$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 6 and 7

## Wall geometry

Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion
Vert distance to centre of gravity entire gabion
Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination
$\mathrm{X}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2=2000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{xg}_{\mathrm{g}}=\mathrm{w}_{8} / 2+\mathrm{S}_{8}=1500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2+\mathrm{h}_{7}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W} 9 / 2+\mathrm{S} 8+\mathrm{S} 9=1000 \mathrm{~mm}$
$\mathrm{y}_{9} 9=\mathrm{h}_{9} / 2+\mathrm{h}_{7}+\mathrm{h}_{8}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{1 8 0 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1500 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=\mathbf{1 5 0 0} \mathrm{mm}$
$H_{f}=y_{g 10}+h_{10} / 2-\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(x_{g 10}+W_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$


## Design dimensions

Effective angle of rear plane of wall
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{7}-\left(\mathrm{X}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=53.1 \mathrm{deg}$
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{7} \times \sin (\varepsilon)\right)-H_{f}=4000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(x_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=4000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r.d }}^{\prime}+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {r.d }}-\right.\right.\right.\right.$
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.766$
Active thrust due to soil
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=\mathbf{1 1 6 . 4} \mathrm{kN} / \mathrm{m}$

## Horizontal forces

Retained soil
$\mathrm{F}_{\text {soil } \_\mathrm{h}}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=80.1 \mathrm{kN} / \mathrm{m}$
Surcharge
$F_{\text {surch_h }}=p_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=23.4 \mathrm{kN} / \mathrm{m}$
Vertical forces
Gabion weight
Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{1 8 0 . 0} \mathrm{kN} / \mathrm{m}$
Retained soil
$F_{\text {soil_v,f }}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=\mathbf{1 0 0 . 2} \mathrm{kN} / \mathrm{m}$
Surcharge
$F_{\text {surch_v,f }}=p_{o, Q} \times \gamma, \mathrm{f}, \mathrm{f} \times \mathrm{K} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=0.0 \mathrm{kN} / \mathrm{m}$
Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety
$M_{o}=F_{\text {soil } \_} \times d_{h, \text { soil }}+F_{\text {surch } \_h} \times d_{\text {h,surch }}=153.6 \mathrm{kNm} / \mathrm{m}$
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, s u r c h}=570.6 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{M}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=3.714$
$\mathrm{FoS}_{\mathrm{m}}$ allow $=1.000$
PASS - Design FOS for overturning exceeds min allowable FOS for overturning

## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil_h }}+F_{\text {surch_h }}=103.5 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=280.2 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=103.5 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=196.2 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoSs}_{\mathrm{s}}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.896$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 7 and 8

## Wall geometry

Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
$\mathrm{X}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2=\mathbf{1 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S} 9=1000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{8}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{w}_{10} / 2+\mathrm{S} 9+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{8}+\mathrm{h}_{9}=\mathbf{2 5 0 0} \mathbf{~ m m}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$


## Weight of entire gabion

Horiz distance to centre of gravity entire gabion
Vert distance to centre of gravity entire gabion
Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination

## Design dimensions

Effective angle of rear plane of wall
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory

Active thrust due to soil

## Horizontal forces

Retained soil
Surcharge
Vertical forces
Gabion weight
Retained soil
Surcharge
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g}} 8\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{Xg}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{Xg}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1167 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1167 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=1167 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{8}-\left(\mathrm{X}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=56.3 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{8} \times \sin (\varepsilon)\right)-H_{f}=\mathbf{3 0 0 0} \mathbf{m m}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=3000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 6 9 7}$
$\mathrm{Pa}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=59.6 \mathrm{kN} / \mathrm{m}$

Fsoil_h $=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=44.8 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{r . d}\right)=\mathbf{1 7 . 5} \mathrm{kN} / \mathrm{m}$

Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{1 0 8 . 0} \mathrm{kN} / \mathrm{m}$
$F_{\text {soil } \mathrm{v}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=49.5 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . \mathrm{d}}\right)=0.0 \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety
$M_{o}=F_{\text {soil } \_h} \times d_{h, \text { soil }}+F_{\text {surch } \_h} \times d_{h, \text { surch }}=71.0 \mathrm{kNm} / \mathrm{m}$
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil_ } v, f} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=241.6 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=3.404$
$\mathrm{FoS}_{\mathrm{M} \text { _allow }}=1.000$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil_h }}+F_{\text {surch } \_h}=62.2 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=157.5 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=62.2 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=\mathbf{1 1 0 . 3} \mathrm{kN} / \mathrm{m}$
FoSs $=F_{R} / F_{f}=1.772$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 8 and 9

## Wall geometry

Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2=\mathbf{1 0 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{s}_{10}=\mathbf{5 0 0} \mathrm{mm}$


| Vertical distance to centre of gravity gabion 10 | $\mathrm{y}_{910}=\mathrm{h}_{10} / 2+\mathrm{h}_{9}=1500 \mathrm{~mm}$ |
| :---: | :---: |
| Weight of gabion 10 | $\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$ |
| Weight of entire gabion | $\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=54.0 \mathrm{kN} / \mathrm{m}$ |
| Horiz distance to centre of gravity entire gabion | $\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{x}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{x}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=833 \mathrm{~mm}$ |
| Vert distance to centre of gravity entire gabion | $\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{99}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=833 \mathrm{~mm}$ |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=833 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{9}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right)^{\prime}\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=63.4 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{9} \times \sin (\varepsilon)\right)-H_{f}=2000 \mathrm{~mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=2000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $\begin{aligned} & K_{a}=\sin \left(\alpha+\phi_{\text {r.d }}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r.d }}+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {'r.d }}-\right.\right.\right.\right. \\ & \left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.572 \end{aligned}$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=21.7 \mathrm{kN} / \mathrm{m}$ |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=19.2 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=11.2 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight | Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=54.0 \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $F_{\text {soil } \_ \text {v, }}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin (90-\alpha+\delta \mathrm{r} . \mathrm{d})=16.4 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=0.0 \mathrm{kN} / \mathrm{m}$ |
| Overturning stability - take moments about the toe |  |
| Overturning moment | $\mathrm{M}_{0}=\mathrm{F}_{\text {soil_h }} \times \mathrm{d}_{\mathrm{h}, \text { soil }}+\mathrm{F}_{\text {surch_h }} \times \mathrm{d}_{\mathrm{h}, \text { surch }}=24.1 \mathrm{kNm} / \mathrm{m}$ |
| Restoring moment | $M_{R}=F_{\text {gabion_v, }} \times \mathrm{X}_{\mathrm{g}}+\mathrm{F}_{\text {soil_v,f }} \times \mathrm{b}_{\mathrm{v}, \text { soil }}+\mathrm{F}_{\text {surch_v }} \mathrm{v}$ f $\times \mathrm{b}_{\mathrm{v}, \text { surch }}=\mathbf{7 2 . 4} \mathrm{kNm} / \mathrm{m}$ |
| Factor of safety | $\mathrm{FoS}_{M}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=3.007$ |
| Allowable factor of safety | $\mathrm{FoS}_{\text {M_allow }}=1.000$ |
| PASS - | Design FOS for overturning exceeds min allowable FOS for overturning |
| Sliding stability - ignore any passive pressure in front of the structure |  |
| Total horizontal force | $\mathrm{T}=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch_h }}=30.5 \mathrm{kN} / \mathrm{m}$ |
| Total vertical force | $N=F_{\text {gabion_v,f }}+\mathrm{F}_{\text {soil_v,f }}+\mathrm{F}_{\text {surch_v,f }}=70.4 \mathrm{kN} / \mathrm{m}$ |
| Sliding force | $\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=30.5 \mathrm{kN} / \mathrm{m}$ |
| Sliding resistance | $\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bg. }} \mathrm{d}\right)=49.3 \mathrm{kN} / \mathrm{m}$ |
| Factor of safety | $\mathrm{FoS}_{s}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.618$ |
| Allowable factor of safety | FoSs_allow $=1.000$ |
|  | PASS - Design FOS for sliding exceeds min allowable FOS for sliding |

## Check overturning and sliding between courses 9 and 10

## Wall geometry

Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{w}_{10} / 2=500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2=\mathbf{5 0 0} \mathbf{~ m m}$


## Weight of gabion 10

Weight of entire gabion
Horiz distance to centre of gravity entire gabion
Vert distance to centre of gravity entire gabion
Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination
Design dimensions
Effective angle of rear plane of wall
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory

Active thrust due to soil

## Horizontal forces

Retained soil
Surcharge

## Vertical forces

Gabion weight
Retained soil
Surcharge
$\alpha=90 \mathrm{deg}+\varepsilon=90.0 \mathrm{deg}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{x}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{5 0 0} \mathrm{mm}$
$X_{g}=x_{g} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=500 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{10} \times \sin (\varepsilon)\right)-H_{f}=1000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=1000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r.d }}^{\prime}+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.296$
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=\mathbf{2 . 8} \mathrm{kN} / \mathrm{m}$

Fsoil_h $=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=3.5 \mathrm{kN} / \mathrm{m}$
Fsurch_h $=p_{o, Q} \times \gamma \mathrm{Q} \times \mathrm{Ka}_{\mathrm{a}} \times \mathrm{H} \times \cos (90-\alpha+\delta$ r.d) $=4.1 \mathrm{kN} / \mathrm{m}$

Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$F_{\text {soil } \_, f, t}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=1.1 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . \mathrm{d}}\right)=0.0 \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe
Overturning moment
$M_{o}=F_{\text {soil } \_} \times d_{h, \text { soil }}+F_{\text {surch } \_h} \times d_{\text {h,surch }}=3.2 \mathrm{kNm} / \mathrm{m}$
Restoring moment
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil } \_v, f} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=\mathbf{1 0 . 1} \mathrm{kNm} / \mathrm{m}$
Factor of safety
Allowable factor of safety
$\mathrm{FoS}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{\mathrm{o}}=3.126$
$\mathrm{FoS}_{\mathrm{M}}$ _allow $=1.000$
PASS - Design FOS for overturning exceeds min allowable FOS for overturning
Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil_h }}+F_{\text {surch_h }}=7.6 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=19.1 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=7.6 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=13.4 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoSs}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.754$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Design approach 1

## Partial factors on actions - Section A.3.1-Combination 2

Permanent unfavourable action
Permanent favourable action
Variable unfavourable action
$\gamma G=1.00$
$\gamma \mathrm{G}, \mathrm{f}=1.00$
$\gamma Q=1.30$


Variable favourable action

$$
\gamma Q, f=\mathbf{0 . 0 0}
$$

## Partial factors for soil parameters - Section A.3.2-Combination 2

Angle of shearing resistance
Weight density

## Design soil properties

Design effective shearing resistance angle
Design saturated density of retained soil
Design wall friction angle
Design base friction angle
Design friction between gabions

## Wall geometry

Horizontal distance to centre of gravity gabion 1
Vertical distance to centre of gravity gabion 1
Weight of gabion 1
Horizontal distance to centre of gravity gabion 2
Vertical distance to centre of gravity gabion 2
Weight of gabion 2
Horizontal distance to centre of gravity gabion 3
Vertical distance to centre of gravity gabion 3
Weight of gabion 3
Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
$\gamma_{\phi^{\prime}}=1.25$
$\gamma_{\gamma}=1.00$
$\phi^{\prime}$ r.d $=\operatorname{Atan}\left(\tan \left(\phi^{\prime}\right.\right.$ r.k) $\left./ \gamma_{\phi^{\prime}}\right)=24.8 \mathrm{deg}$
$\gamma_{\mathrm{s} . \mathrm{d}}=\gamma_{\mathrm{sr}} / \gamma_{\gamma}=19.0 \mathrm{kN} / \mathrm{m}^{3}$
$\delta_{\text {r.d }}=\min \left(\operatorname{atan}\left(\tan \left(\delta_{r . k}\right) / \gamma_{\phi^{\prime}}\right), \phi^{\prime}\right.$ r.d $\times$ Kmembrane $)=18.3 \mathrm{deg}$
$\delta_{b b . d}=\operatorname{Atan}\left(\tan \left(\delta_{\text {bb.k }}\right) / \gamma_{\phi^{\prime}}\right)=28.4 \mathrm{deg}$
$\delta_{\mathrm{bg} . \mathrm{d}}=\operatorname{Atan}\left(\tan \left(\delta_{\mathrm{bg} . \mathrm{k}}\right) / \gamma_{\phi^{\prime}}\right)=29.3 \mathrm{deg}$
$\mathrm{x}_{\mathrm{g} 1}=\mathrm{w}_{1} / 2=5000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 1}=\mathrm{h}_{1} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 1}=\gamma_{\mathrm{d}} \times \mathrm{W}_{1} \times \mathrm{h}_{1}=180.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{xg}_{\mathrm{g}}=\mathrm{w}_{2} / 2+\mathrm{s}_{2}=4500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 2}=\mathrm{h}_{2} / 2+\mathrm{h}_{1}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 2}=\gamma_{\mathrm{d}} \times \mathrm{W}_{2} \times \mathrm{h}_{2}=162.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 3}=\mathrm{W}_{3} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}=4000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 3}=\mathrm{h}_{3} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 3}=\gamma_{\mathrm{d}} \times \mathrm{W}_{3} \times \mathrm{h}_{3}=144.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 4}=\mathrm{w}_{4} / 2+\mathrm{s}_{2}+\mathrm{s}_{3}+\mathrm{S}_{4}=3500 \mathrm{~mm}$
$y_{g 4}=h_{4} / 2+h_{1}+h_{2}+h_{3}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=126.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2+\mathrm{S}_{2}+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{s}_{5}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{s}_{2}+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{s}_{5}+\mathrm{s}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=\mathbf{6 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathbf{m m}$
$y_{g 8}=h_{8} / 2+h_{1}+h_{2}+h_{3}+h_{4}+h_{5}+h_{6}+h_{7}=7500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{2}+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{s}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{1}+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=8500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{w}_{10} / 2+\mathrm{s}_{2}+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{s}_{5}+\mathrm{s}_{6}+\mathrm{s}_{7}+\mathrm{s}_{8}+\mathrm{s}_{9}+\mathrm{s}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$y_{g 10}=h_{10} / 2+h_{1}+h_{2}+h_{3}+h_{4}+h_{5}+h_{6}+h_{7}+h_{8}+h_{9}=9500 m m$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$


| Weight of entire gabion | $W_{g}=W_{g 1}+W_{g 2}+W_{g 3}+W_{g 4}+W_{g 5}+W_{g 6}+W_{g 7}+W_{g 8}+W_{g 9}+W_{g 10}=$ 990.0 kN/m |
| :---: | :---: |
| Horiz distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{X}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 1} \times \mathrm{X}_{\mathrm{g} 1}\right)+\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{X}_{\mathrm{g} 2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{Xg}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{X}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}= \end{aligned}$ $3500 \mathrm{~mm}$ |
| Vert distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 1} \times \mathrm{y}_{\mathrm{g} 1}\right)+\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{y}_{\mathrm{g} 2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{y}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{95}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{99}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}= \\ & 3500 \mathrm{~mm} \end{aligned}$ |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=3500 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{W}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{1}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right)^{\prime}\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=48.0 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $\mathrm{H}=\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)+\left(\mathrm{w}_{1} \times \sin (\varepsilon)\right)-\mathrm{H}_{\mathrm{f}}=10000 \mathrm{~mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=10000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $\begin{aligned} & \mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime} \text { r.d }+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {'r.d }}-\right.\right.\right.\right. \\ & \left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 9 4 1} \end{aligned}$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{a} \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=894.3 \mathrm{kN} / \mathrm{m}$ |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{Pa}$ asoil $\times \cos (90-\alpha+\delta$ r.d $)=442.8 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_h }}=\mathrm{p}_{0, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=60.6 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight | $\mathrm{F}_{\text {gabion_v } \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=990.0 \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=777.0 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_v }}$ v $f=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=0.0 \mathrm{kN} / \mathrm{m}$ |
| Overturning stability - take moments about the toe |  |
| Overturning moment | $\mathrm{M}_{0}=\mathrm{F}_{\text {soil_ }} \mathrm{h} \times \mathrm{d}_{\mathrm{h}, \text { soil }}+\mathrm{F}_{\text {surch_h }} \times \mathrm{d}_{\mathrm{h}, \text { surch }}=1779.0 \mathrm{kNm} / \mathrm{m}$ |
| Restoring moment |  |
| Factor of safety | $\mathrm{FoS}_{M}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=5.005$ |
| Allowable factor of safety | $\mathrm{FoS}_{\text {M_allow }}=1.000$ |
| PASS - | Design FOS for overturning exceeds min allowable FOS for overturning |
| Sliding stability - ignore any passive pressure in front of the structure |  |
| Total horizontal force | T $=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch_h }}=503.4 \mathrm{kN} / \mathrm{m}$ |
| Total vertical force | $N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=1767.0 \mathrm{kN} / \mathrm{m}$ |
| Sliding force | $\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=503.4 \mathrm{kN} / \mathrm{m}$ |
| Sliding resistance | $\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bb. }}\right)=953.5 \mathrm{kN} / \mathrm{m}$ |
| Factor of safety | $\mathrm{FoS}_{s}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.894$ |
| Allowable factor of safety | FoSs_allow $=1.000$ |
|  | PASS - Design FOS for sliding exceeds min allowable FOS for sliding |



## Check overturning and sliding between courses 1 and 2

## Wall geometry

Horizontal distance to centre of gravity gabion 2
Vertical distance to centre of gravity gabion 2
Weight of gabion 2
Horizontal distance to centre of gravity gabion 3
Vertical distance to centre of gravity gabion 3
Weight of gabion 3
Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion

Horiz distance to centre of gravity entire gabion

Vert distance to centre of gravity entire gabion

Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination

## Design dimensions

Effective angle of rear plane of wall
Effective face angle
Effective height of wall
$\mathrm{X}_{\mathrm{g} 2}=\mathrm{w}_{2} / 2=4500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 2}=\mathrm{h}_{2} / 2=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 2}=\gamma_{\mathrm{d}} \times \mathrm{W}_{2} \times \mathrm{h}_{2}=162.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 3}=\mathrm{w}_{3} / 2+\mathrm{s}_{3}=4000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 3}=\mathrm{h}_{3} / 2+\mathrm{h}_{2}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 3}=\gamma_{\mathrm{d}} \times \mathrm{W}_{3} \times \mathrm{h}_{3}=144.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 4}=\mathrm{W}_{4} / 2+\mathrm{s}_{3}+\mathrm{s}_{4}=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 4}=\mathrm{h}_{4} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=\mathbf{1 2 6 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2+\mathrm{S}_{3}+\mathrm{s}_{4}+\mathrm{s}_{5}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{s}_{5}+\mathrm{s}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{w}_{7} / 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}=2000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{Xg}_{\mathrm{g}}=\mathrm{W}_{8} / 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathbf{~ m m}$
$y_{g 8}=h_{8} / 2+h_{2}+h_{3}+h_{4}+h_{5}+h_{6}+h_{7}=6500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{w}_{9} / 2+\mathrm{s}_{3}+\mathrm{s}_{4}+\mathrm{s}_{5}+\mathrm{s}_{6}+\mathrm{s}_{7}+\mathrm{s}_{8}+\mathrm{s}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$
$\mathrm{y}_{99}=\mathrm{h}_{9} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=7500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{3}+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{s}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{2}+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=8500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 2}+\mathrm{W}_{\mathrm{g} 3}+\mathrm{W}_{\mathrm{g} 4}+\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{8 1 0 . 0}$
$\mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{xg}_{\mathrm{g}}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{X}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{X}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\right.$ $\left.\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{3 1 6 7} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 2} \times \mathrm{y}_{\mathrm{g} 2}\right)+\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{y}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{94}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=3167 \mathrm{~mm}$
$X_{g}=x_{g} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=3167 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{2}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=48.4 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{2} \times \sin (\varepsilon)\right)-H_{f}=9000 \mathrm{~mm}$


Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=9000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} r . d\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{r}^{\prime} . \mathrm{d}+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{r . d}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.932$
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=716.9 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\text {soil } \_\mathrm{h}}=\gamma_{\mathrm{G}} \times \mathrm{P}_{\mathrm{a}, \text { soiil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=358.8 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=p_{0, Q} \times \gamma \mathrm{Q} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=54.6 \mathrm{kN} / \mathrm{m}$

Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{8 1 0 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\text {soil } \_\mathrm{v}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=\mathbf{6 2 0 . 6} \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=p_{o, Q} \times \gamma, f, f \times K_{a} \times H \times \sin \left(90-\alpha+\delta_{r . d}\right)=0.0 \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety
$M_{o}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=1321.9 \mathrm{kNm} / \mathrm{m}$
$M_{R}=F_{\text {gabion } \_v, f} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=6495.6 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=4.914$
$\mathrm{FoS}_{\mathrm{M} \text { _allow }}=1.000$
PASS - Design FOS for overturning exceeds min allowable FOS for overturning
Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil }}$ h $+F_{\text {surch } \_h}=413.3 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=1430.6 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=413.3 \mathrm{kN} / \mathrm{m}$
$F_{R}=(T \times \sin (\varepsilon)+N \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bg.d }}\right)=801.4 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoS}_{s}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.939$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 2 and 3

## Wall geometry

Horizontal distance to centre of gravity gabion 3
$\mathrm{Xg}_{\mathrm{g} 3}=\mathrm{W}_{3} / 2=4000 \mathrm{~mm}$
Vertical distance to centre of gravity gabion 3
$\mathrm{y}_{\mathrm{g} 3}=\mathrm{h}_{3} / 2=500 \mathrm{~mm}$
Weight of gabion 3
$\mathrm{W}_{\mathrm{g} 3}=\gamma_{\mathrm{d}} \times \mathrm{W}_{3} \times \mathrm{h}_{3}=144.0 \mathrm{kN} / \mathrm{m}$
Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
$\mathrm{x}_{\mathrm{g} 4}=\mathrm{w}_{4} / 2+\mathrm{S}_{4}=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 4}=\mathrm{h}_{4} / 2+\mathrm{h}_{3}=1500 \mathrm{~mm}$
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=126.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}=\mathbf{3 5 0 0} \mathrm{mm}$
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}=\mathbf{2 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=4500 \mathrm{~mm}$


## Weight of gabion 7

Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion

Vert distance to centre of gravity entire gabion

Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination
Design dimensions
Effective angle of rear plane of wall
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory

Active thrust due to soil

## Horizontal forces

Retained soil
Surcharge

## Vertical forces

Gabion weight
Retained soil
Surcharge
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=\mathbf{1 5 0 0} \mathrm{mm}$
$y_{g 8}=h_{8} / 2+h_{3}+h_{4}+h_{5}+h_{6}+h_{7}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{s}_{8}+\mathrm{s}_{9}=\mathbf{1 0 0 0} \mathbf{m m}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=\mathbf{6 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{4}+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{3}+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=7500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 3}+\mathrm{W}_{\mathrm{g} 4}+\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=648.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{xg}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{xg}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{xg}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{Xg}_{\mathrm{g} 7}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g}} 8\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 8 3 3} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 3} \times \mathrm{y}_{\mathrm{g} 3}\right)+\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{97}\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=2833 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=2833 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{3}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=48.8 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{3} \times \sin (\varepsilon)\right)-H_{f}=8000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(x_{g 10}-\left(w_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=8000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 9 2 0}$
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=559.1 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\text {soil } \_\mathrm{h}}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=\mathbf{2 8 3 . 6} \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=p_{0, Q} \times \gamma \mathrm{Q} \times \mathrm{Ka}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=48.5 \mathrm{kN} / \mathrm{m}$

Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=648.0 \mathrm{kN} / \mathrm{m}$
$F_{\text {soil } \mathrm{v}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=481.8 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=\mathbf{0 . 0} \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe

| Overturning moment | $M_{0}=F_{\text {soil_h }} \times d_{\text {h,soil }}+F_{\text {surch_h }} \times \mathrm{d}_{\mathrm{h}, \text { surch }}=950.2 \mathrm{kNm} / \mathrm{m}$ |
| :---: | :---: |
| Restoring moment |  |
| Factor of safety | $\mathrm{FoS}_{M}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=4.805$ |
| Allowable factor of safety | $\mathrm{FoSm}_{\mathrm{m}}$ allow $=1.000$ |

PASS - Design FOS for overturning exceeds min allowable FOS for overturning
Sliding stability - ignore any passive pressure in front of the structure
Total horizontal force
$T=F_{\text {soil_h }}+F_{\text {surch_h }}=332.1 \mathrm{kN} / \mathrm{m}$
Total vertical force
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=1129.8 \mathrm{kN} / \mathrm{m}$


## Sliding force

Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=332.1 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=632.9 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoSs}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.906$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 3 and 4

## Wall geometry

Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion

Vert distance to centre of gravity entire gabion

Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination

## Design dimensions

Effective angle of rear plane of wall
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
$\mathrm{xg}_{\mathrm{g} 4}=\mathrm{w}_{4} / 2=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 4}=\mathrm{h}_{4} / 2=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{W}_{\mathrm{g} 4}=\gamma_{\mathrm{d}} \times \mathrm{W}_{4} \times \mathrm{h}_{4}=126.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 5}=\mathrm{w}_{5} / 2+\mathrm{s}_{5}=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2+\mathrm{h}_{4}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}=2000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=1500 \mathrm{~mm}$
$\mathrm{y}_{98}=\mathrm{h}_{8} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=5500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{5}+\mathrm{S}_{6}+\mathrm{S} 7+\mathrm{S} 8+\mathrm{S} 9+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{4}+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=6500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 4}+\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{5 0 4 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{Xg}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{X}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{X}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g}} 8\right)+\right.$
$\left.\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 4} \times \mathrm{y}_{\mathrm{g} 4}\right)+\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{95}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\right.$
$\left.\left(W_{g 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=2500 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=2500 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{4}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=49.4 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{4} \times \sin (\varepsilon)\right)-H_{f}=7000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=7000 \mathrm{~mm}$


Active pressure using Coulomb theory
$\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{r . d}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=0.904$
Active thrust due to soil
$\mathrm{Pa}_{\mathrm{a} \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=420.9 \mathrm{kN} / \mathrm{m}$

## Horizontal forces

Retained soil
Surcharge

## Vertical forces

Gabion weight
Retained soil
Surcharge
$\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=\mathbf{2 1 7 . 2} \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r. }}\right)=42.5 \mathrm{kN} / \mathrm{m}$

Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=504.0 \mathrm{kN} / \mathrm{m}$
$F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin (90-\alpha+\delta$ r.d $)=360.5 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch } \_v, f}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}, \mathrm{f}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=\mathbf{0 . 0} \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe

Overturning moment
$M_{0}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=\mathbf{6 5 5 . 3} \mathrm{kNm} / \mathrm{m}$
Restoring moment
Factor of safety
Allowable factor of safety
$M_{R}=F_{\text {gabion_v, }} \times X_{g}+F_{\text {soil }}$ v,f $\times$ b $_{\text {v,soil }}+F_{\text {surch_v, }} \times \mathrm{b}_{\mathrm{v}, \text { surch }}=3062.5 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{\mathrm{o}}=4.673$
$\mathrm{FoS}_{\mathrm{m}}$ _allow $=1.000$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning
Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
T $=F_{\text {soil_h }}+F_{\text {surch_h }}=259.6 \mathrm{kN} / \mathrm{m}$
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{N}=\mathrm{F}_{\text {gabion_v,f }}+\mathrm{F}_{\text {soil_v,f }}+\mathrm{F}_{\text {surch_v,f }}=864.5 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=\mathbf{2 5 9 . 6} \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=484.3 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{s}}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.865$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 4 and 5

## Wall geometry

Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
Horizontal distance to centre of gravity gabion 6
Vertical distance to centre of gravity gabion 6
Weight of gabion 6
Horizontal distance to centre of gravity gabion 7
Vertical distance to centre of gravity gabion 7
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
$\mathrm{X}_{\mathrm{g} 5}=\mathrm{W}_{5} / 2=\mathbf{3 0 0 0} \mathrm{mm}$
$\mathrm{Y}_{\mathrm{g} 5}=\mathrm{h}_{5} / 2=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 5}=\gamma_{\mathrm{d}} \times \mathrm{W}_{5} \times \mathrm{h}_{5}=108.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2+\mathrm{s}_{6}=\mathbf{2 5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2+\mathrm{h}_{5}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 7}=\mathrm{W}_{7} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}=2000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}=1500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 8}=\mathrm{h}_{8} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}=3500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{6}+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=1000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=4500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$


| Horizontal distance to centre of gravity gabion 10 | $\mathrm{X}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S} 6+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S} 9+\mathrm{S}_{10}=\mathbf{5 0 0} \mathrm{mm}$ |
| :---: | :---: |
| Vertical distance to centre of gravity gabion 10 | $\mathrm{y}_{910}=\mathrm{h}_{10} / 2+\mathrm{h}_{5}+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=5500 \mathrm{~mm}$ |
| Weight of gabion 10 | $\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$ |
| Weight of entire gabion | $\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 5}+\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=378.0 \mathrm{kN} / \mathrm{m}$ |
| Horiz distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{X}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{x}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{x}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{x}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{x}_{\mathrm{g} 9}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{x}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 1 6 7} \mathrm{mm} \end{aligned}$ |
| Vert distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 5} \times \mathrm{y}_{\mathrm{g} 5}\right)+\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\right. \\ & \left.\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{2 1 6 7} \mathrm{mm} \end{aligned}$ |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=2167 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{5}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right)^{\prime}\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=50.2 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $H=\left(\mathrm{y}_{10}+\mathrm{h}_{10} / 2\right)+\left(\mathrm{w}_{5} \times \sin (\varepsilon)\right)-\mathrm{H}_{\mathrm{f}}=\mathbf{6 0 0 0} \mathrm{mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=6000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi_{\text {r.d }}^{\prime}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r.d }}+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {r.d }}-\right.\right.\right.\right.$ <br> $\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{r . d}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 8 8 4}$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{asoil}}=0.5 \times \mathrm{Ka} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=302.3 \mathrm{kN} / \mathrm{m}$ |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{Pa}_{\mathrm{a} \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=159.5 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=36.4 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight | $\mathrm{F}_{\text {gabion_v, }}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=378.0 \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $F_{\text {soil } \mathrm{v}, \mathrm{f}}=\gamma_{\mathrm{G}, \mathrm{f}} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=256.7 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_v,f }}=\mathrm{p}_{0, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=0.0 \mathrm{kN} / \mathrm{m}$ |

Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety
$M_{0}=F_{\text {soil_ }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=428.3 \mathrm{kNm} / \mathrm{m}$
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil } \_, f} \times b_{v, \text { soil }}+F_{\text {surch } \_v, f} \times b_{v, \text { surch }}=1931.4 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoSm}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{\mathrm{o}}=4.510$
$\mathrm{FoS}_{\mathrm{m}}$ _allow $=1.000$
PASS - Design FOS for overturning exceeds min allowable FOS for overturning

## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil_h }}+$ Fsurch_h $=195.9 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=634.7 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=195.9 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=355.5 \mathrm{kN} / \mathrm{m}$
FoSs $=F_{R} / F_{f}=1.815$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding


| Wall geometry |  |
| :---: | :---: |
| Horizontal distance to centre of gravity gabion 6 | $\mathrm{x}_{\mathrm{g} 6}=\mathrm{w}_{6} / 2=2500 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 6 | $\mathrm{y}_{\mathrm{g} 6}=\mathrm{h}_{6} / 2=500 \mathrm{~mm}$ |
| Weight of gabion 6 | $\mathrm{W}_{\mathrm{g} 6}=\gamma_{\mathrm{d}} \times \mathrm{W}_{6} \times \mathrm{h}_{6}=90.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 7 | $\mathrm{x}_{\mathrm{g} 7}=\mathrm{w}_{7} / 2+\mathrm{S}_{7}=2000 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 7 | $\mathrm{y}_{97}=\mathrm{h}_{7} / 2+\mathrm{h}_{6}=1500 \mathrm{~mm}$ |
| Weight of gabion 7 | $\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 8 | $\mathrm{x}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S}_{7}+\mathrm{S}_{8}=1500 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 8 | $\mathrm{y}_{98}=\mathrm{h}_{8} / 2+\mathrm{h}_{6}+\mathrm{h}_{7}=2500 \mathrm{~mm}$ |
| Weight of gabion 8 | $\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 9 | $\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}=1000 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 9 | $\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}=3500 \mathrm{~mm}$ |
| Weight of gabion 9 | $\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$ |
| Horizontal distance to centre of gravity gabion 10 | $\mathrm{x}_{\mathrm{g} 10}=\mathrm{w}_{10} / 2+\mathrm{S}_{7}+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=500 \mathrm{~mm}$ |
| Vertical distance to centre of gravity gabion 10 | $\mathrm{y}_{910}=\mathrm{h}_{10} / 2+\mathrm{h}_{6}+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=4500 \mathrm{~mm}$ |
| Weight of gabion 10 | $\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$ |
| Weight of entire gabion | $\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 6}+\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{2 7 0 . 0} \mathrm{kN} / \mathrm{m}$ |
| Horiz distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{x}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{x}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{x}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \\ & \mathrm{W}_{\mathrm{g}}=1833 \mathrm{~mm} \end{aligned}$ |
| Vert distance to centre of gravity entire gabion | $\begin{aligned} & \mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 6} \times \mathrm{y}_{\mathrm{g} 6}\right)+\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \\ & \mathrm{W}_{\mathrm{g}}=1833 \mathrm{~mm} \end{aligned}$ |
| Correcting for wall inclination horiz dist | $\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=1833 \mathrm{~mm}$ |
| Vertical change in height due to wall inclination | $H_{f}=y_{g 10}+h_{10} / 2-\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(x_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$ |
| Design dimensions |  |
| Effective angle of rear plane of wall | $\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{6}-\left(\mathrm{x}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right)^{\prime}\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=51.3 \mathrm{deg}$ |
| Effective face angle | $\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$ |
| Effective height of wall | $H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{6} \times \sin (\varepsilon)\right)-H_{f}=\mathbf{5 0 0 0} \mathrm{mm}$ |
| Height of wall from toe to front edge of top gabion | $H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=5000 \mathrm{~mm}$ |
| Active pressure using Coulomb theory | $\begin{aligned} & \mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {'r.d }}+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {'r.d }}-\right.\right.\right.\right. \\ & \left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)^{2}\right)=0.856 \end{aligned}$ |
| Active thrust due to soil | $\mathrm{Pa}_{\mathrm{a} \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=203.3 \mathrm{kN} / \mathrm{m}$ |
| Horizontal forces |  |
| Retained soil | $\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{Pa}_{\text {a,soil }} \times \cos (90-\alpha+\delta \mathrm{d} . \mathrm{d})=110.7 \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $\mathrm{F}_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos (90-\alpha+\delta \mathrm{r} . \mathrm{d})=30.3 \mathrm{kN} / \mathrm{m}$ |
| Vertical forces |  |
| Gabion weight | $\mathrm{F}_{\text {gabion_v,f }}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{2 7 0 . 0} \mathrm{kN} / \mathrm{m}$ |
| Retained soil | $F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=\mathbf{1 7 0 . 5} \mathrm{kN} / \mathrm{m}$ |
| Surcharge | $F_{\text {surch_ }} \mathrm{v}, \mathrm{f}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}, \mathrm{f}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=0.0 \mathrm{kN} / \mathrm{m}$ |



## Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety

$$
\begin{aligned}
& M_{0}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=260.3 \mathrm{kNm} / \mathrm{m} \\
& M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil } \_, f} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=1120.0 \mathrm{kNm} / \mathrm{m} \\
& \mathrm{FoS}_{\mathrm{M}}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{\mathrm{o}}=4.303 \\
& \mathrm{FoS}_{\mathrm{m}} \text { allow }=1.000
\end{aligned}
$$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{T}=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch } \_\mathrm{h}}=141.0 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion } \_v, f}+F_{\text {soil } \_v, f}+F_{\text {surch } \_v, f}=440.5 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=141.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=246.7 \mathrm{kN} / \mathrm{m}$
FoSs $=F_{R} / F_{f}=1.750$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 6 and 7

## Wall geometry

Horizontal distance to centre of gravity gabion 7
$\mathrm{xg}_{7}=\mathrm{W}_{7} / 2=2000 \mathrm{~mm}$
Vertical distance to centre of gravity gabion 7
$\mathrm{y}_{\mathrm{g} 7}=\mathrm{h}_{7} / 2=500 \mathrm{~mm}$
Weight of gabion 7
Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion
Vert distance to centre of gravity entire gabion
Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination
$\mathrm{W}_{\mathrm{g} 7}=\gamma_{\mathrm{d}} \times \mathrm{W}_{7} \times \mathrm{h}_{7}=72.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 8}=\mathrm{W}_{8} / 2+\mathrm{S} 8=1500 \mathrm{~mm}$
$\mathrm{y}_{98}=\mathrm{h}_{8} / 2+\mathrm{h}_{7}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S}_{8}+\mathrm{S}_{9}=\mathbf{1 0 0 0} \mathrm{mm}$
$\mathrm{y}_{9} 9=\mathrm{h}_{9} / 2+\mathrm{h}_{7}+\mathrm{h}_{8}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{X}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{S}_{8}+\mathrm{S}_{9}+\mathrm{S}_{10}=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{7}+\mathrm{h}_{8}+\mathrm{h}_{9}=\mathbf{3 5 0 0} \mathrm{mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathbf{~ k N} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 7}+\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{1 8 0 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{X}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 7} \times \mathrm{y}_{\mathrm{g} 7}\right)+\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1500 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=1500 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$

## Design dimensions

Effective angle of rear plane of wall
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{7}-\left(\mathrm{X}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=53.1 \mathrm{deg}$
$\theta=90$ deg $-\varepsilon=90.0$ deg
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{7} \times \sin (\varepsilon)\right)-H_{f}=4000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=4000 \mathrm{~mm}$
$\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \mathrm{r} . \mathrm{d}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\mathrm{r} . \mathrm{d}}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 8 1 5}$
Active thrust due to soil
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=123.9 \mathrm{kN} / \mathrm{m}$


## Horizontal forces

## Retained soil

Surcharge

## Vertical forces

Gabion weight
Retained soil
Surcharge
$F_{\text {soil_h }}=\gamma G \times P_{\text {a,soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=70.7 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=\mathbf{2 4 . 2 \mathrm { kN } / \mathrm { m }}$

Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{1 8 0 . 0} \mathrm{kN} / \mathrm{m}$
$F_{\text {soil }} \mathrm{v}, \mathrm{f}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=101.7 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=\mathbf{0 . 0} \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe

Overturning moment
$M_{0}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=142.6 \mathrm{kNm} / \mathrm{m}$
Restoring moment
Factor of safety
Allowable factor of safety
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch_ }, \mathrm{f}, f} \times b_{v, \text { surch }}=575.2 \mathrm{kNm} / \mathrm{m}$
$F_{0 S} M_{M}=M_{R} / M_{0}=4.033$
$\mathrm{FoS}_{\mathrm{m}}$ allow $=1.000$
PASS - Design FOS for overturning exceeds min allowable FOS for overturning

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{T}=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch_h }}=94.9 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f } f}+F_{\text {surch_v,f }}=281.7 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=94.9 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\mathrm{bg} . \mathrm{d}}\right)=157.8 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoSs}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.663$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 7 and 8

## Wall geometry

Horizontal distance to centre of gravity gabion 8
Vertical distance to centre of gravity gabion 8
Weight of gabion 8
Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion
Vert distance to centre of gravity entire gabion
Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination

## Design dimensions

Effective angle of rear plane of wall
Effective face angle
$\mathrm{xg}_{\mathrm{g} 8}=\mathrm{w}_{8} / 2=1500 \mathrm{~mm}$
$\mathrm{yg}_{\mathrm{g}}=\mathrm{h}_{8} / 2=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{W}_{\mathrm{g} 8}=\gamma_{\mathrm{d}} \times \mathrm{W}_{8} \times \mathrm{h}_{8}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 9}=\mathrm{W}_{9} / 2+\mathrm{S} 9=1000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2+\mathrm{h}_{8}=1500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{W}_{10} / 2+\mathrm{s} 9+\mathrm{s}_{10}=\mathbf{5 0 0} \mathbf{~ m m}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{8}+\mathrm{h}_{9}=2500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 8}+\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=\mathbf{1 0 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{X}_{\mathrm{g}} 8\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{x}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{x}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1167 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 8} \times \mathrm{y}_{\mathrm{g} 8}\right)+\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=1167 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{X}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=\mathbf{1 1 6 7} \mathrm{mm}$
$H_{f}=y_{g 10}+h_{10} / 2-\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(x_{g 10}+W_{10} / 2\right) \times \sin (\varepsilon)\right)=0 \mathrm{~mm}$
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{8}-\left(\mathrm{X}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=56.3 \mathrm{deg}$
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$


Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory

Active thrust due to soil

## Horizontal forces

Retained soil
Surcharge

## Vertical forces

Gabion weight
Retained soil
Surcharge
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{8} \times \sin (\varepsilon)\right)-H_{f}=\mathbf{3 0 0 0} \mathbf{m m}$
$H_{\text {incl }}=\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(x_{g 10}-\left(w_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=3000 \mathrm{~mm}$
$\mathrm{K}_{\mathrm{a}}=\sin \left(\alpha+\phi^{\prime} \mathrm{r} . \mathrm{d}\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi^{\prime}\right.\right.\right.\right.$ r.d $\left.+\delta_{\text {r.d }}\right) \times \sin \left(\phi^{\prime}\right.$ r.d -
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 7 5 0}$
$\mathrm{P}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=\mathbf{6 4 . 1} \mathrm{kN} / \mathrm{m}$
$F_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=39.4 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_h }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q} \times \mathrm{Ka}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{r . d}\right)=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\text {gabion } \_\mathrm{v}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{1 0 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\text {soil } \mathrm{v}, \mathrm{f}}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{Pa}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=50.5 \mathrm{kN} / \mathrm{m}$
$F_{\text {surch_v,f }}=\mathrm{p}_{\mathrm{o}, \mathrm{Q}} \times \gamma \mathrm{Q}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=0.0 \mathrm{kN} / \mathrm{m}$

Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety
$M_{o}=F_{\text {soil_h }} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{h, \text { surch }}=\mathbf{6 6 . 4} \mathrm{kNm} / \mathrm{m}$
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil_v,f }} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=243.9 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{m}}=\mathrm{Mr}_{\mathrm{R}} / \mathrm{M}_{0}=3.672$
$\mathrm{FoS}_{\mathrm{m}}$ _allow $=1.000$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning
Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil_h }}+F_{\text {surch_h }}=57.4 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=158.5 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=57.4 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bg. }}\right)=88.8 \mathrm{kN} / \mathrm{m}$
FoSs $=F_{R} / F_{f}=1.546$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 8 and 9

## Wall geometry

Horizontal distance to centre of gravity gabion 9
Vertical distance to centre of gravity gabion 9
Weight of gabion 9
Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion
Vert distance to centre of gravity entire gabion
Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination
$\mathrm{X}_{\mathrm{g} 9}=\mathrm{W} 9 / 2=1000 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 9}=\mathrm{h}_{9} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 9}=\gamma_{\mathrm{d}} \times \mathrm{W}_{9} \times \mathrm{h}_{9}=36.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{w}_{10} / 2+\mathrm{s}_{10}=500 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2+\mathrm{h}_{9}=\mathbf{1 5 0 0} \mathbf{~ m m}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 9}+\mathrm{W}_{\mathrm{g} 10}=54.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{X}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=833 \mathrm{~mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 9} \times \mathrm{y}_{\mathrm{g} 9}\right)+\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=833 \mathrm{~mm}$
$\mathrm{X}_{\mathrm{g}}=\mathrm{Xg}_{\mathrm{g}} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=833 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$


## Design dimensions

Effective angle of rear plane of wall
$\alpha=90 \mathrm{deg}-\operatorname{Atan}\left(\left(\mathrm{w}_{9}-\left(\mathrm{X}_{\mathrm{g} 10}+\left(\mathrm{w}_{10} / 2\right)\right)\right) /\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right)\right)+\varepsilon=63.4 \mathrm{deg}$
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{9} \times \sin (\varepsilon)\right)-H_{f}=2000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{x}_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=2000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r.d }}^{\prime}+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {r.d }}-\right.\right.\right.\right.$
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 6 3 0}$
Active thrust due to soil
$\mathrm{Pa}_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=23.9 \mathrm{kN} / \mathrm{m}$

## Horizontal forces

Retained soil
$\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=17.0 \mathrm{kN} / \mathrm{m}$
Surcharge
$F_{\text {surch_h }}=p_{\mathrm{o}, \mathrm{Q}} \times \gamma_{\mathrm{Q}} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=11.6 \mathrm{kN} / \mathrm{m}$
Vertical forces
Gabion weight
Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=54.0 \mathrm{kN} / \mathrm{m}$
Retained soil
$F_{\text {soil_v,f }}=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\text {r.d }}\right)=16.9 \mathrm{kN} / \mathrm{m}$
Surcharge
$F_{\text {surch_v,f }}=p_{o, Q} \times \gamma, \mathrm{f}, \mathrm{f} \times \mathrm{K} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=0.0 \mathrm{kN} / \mathrm{m}$
Overturning stability - take moments about the toe

Overturning moment
Restoring moment
Factor of safety
Allowable factor of safety
$M_{o}=F_{\text {soil } \_\mathrm{h}} \times \mathrm{d}_{\mathrm{h}, \text { soil }}+\mathrm{F}_{\text {surch_h }} \times \mathrm{d}_{\mathrm{h}, \text { surch }}=\mathbf{2 2 . 9} \mathrm{kNm} / \mathrm{m}$
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil } \_v, f} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=73.2 \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{M}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=3.193$
$\mathrm{FoS}_{\mathrm{M} \text { _allow }}=1.000$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

## Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$T=F_{\text {soil_h }}+F_{\text {surch_h }}=28.6 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=70.9 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=\mathbf{2 8 . 6} \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bg. }}\right)=39.7 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoSs}_{\mathrm{s}}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.390$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

## Check overturning and sliding between courses 9 and 10

## Wall geometry

Horizontal distance to centre of gravity gabion 10
Vertical distance to centre of gravity gabion 10
Weight of gabion 10
Weight of entire gabion
Horiz distance to centre of gravity entire gabion
Vert distance to centre of gravity entire gabion
Correcting for wall inclination horiz dist
Vertical change in height due to wall inclination
$\mathrm{x}_{\mathrm{g} 10}=\mathrm{w}_{10} / 2=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g} 10}=\mathrm{h}_{10} / 2=500 \mathrm{~mm}$
$\mathrm{W}_{\mathrm{g} 10}=\gamma_{\mathrm{d}} \times \mathrm{W}_{10} \times \mathrm{h}_{10}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
$\mathrm{W}_{\mathrm{g}}=\mathrm{W}_{\mathrm{g} 10}=18.0 \mathrm{kN} / \mathrm{m}$
$\mathrm{x}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{X}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{5 0 0} \mathrm{mm}$
$\mathrm{y}_{\mathrm{g}}=\left(\left(\mathrm{W}_{\mathrm{g} 10} \times \mathrm{y}_{\mathrm{g} 10}\right)\right) / \mathrm{W}_{\mathrm{g}}=\mathbf{5 0 0} \mathrm{mm}$
$X_{g}=X_{g} \times \cos (\varepsilon)+\mathrm{y}_{\mathrm{g}} \times \sin (\varepsilon)=500 \mathrm{~mm}$
$\mathrm{H}_{\mathrm{f}}=\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2-\left(\left(\mathrm{y}_{\mathrm{g} 10}+\mathrm{h}_{10} / 2\right) \times \cos (\varepsilon)-\left(\mathrm{X}_{\mathrm{g} 10}+\mathrm{w}_{10} / 2\right) \times \sin (\varepsilon)\right)=\mathbf{0} \mathrm{mm}$


## Design dimensions

Effective angle of rear plane of wall
$\alpha=90 \mathrm{deg}+\varepsilon=90.0 \mathrm{deg}$
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory
$\theta=90 \mathrm{deg}-\varepsilon=90.0 \mathrm{deg}$
$H=\left(y_{g 10}+h_{10} / 2\right)+\left(w_{10} \times \sin (\varepsilon)\right)-H_{f}=1000 \mathrm{~mm}$
$H_{\text {incl }}=\left(\left(y_{g 10}+h_{10} / 2\right) \times \cos (\varepsilon)-\left(x_{\mathrm{g} 10}-\left(\mathrm{w}_{10} / 2\right)\right) \times \sin (\varepsilon)\right)=1000 \mathrm{~mm}$
$K_{a}=\sin \left(\alpha+\phi^{\prime} \text { r.d }\right)^{2} /\left(\sin (\alpha)^{2} \times \sin \left(\alpha-\delta_{\text {r.d }}\right) \times\left(1+\sqrt{ }\left(\sin \left(\phi_{\text {r.d }}^{\prime}+\delta_{\text {r.d }}\right) \times \sin \left(\phi_{\text {r.d }}-\right.\right.\right.\right.$
$\left.\left.\left.\beta) /\left(\sin \left(\alpha-\delta_{\text {r.d }}\right) \times \sin (\alpha+\beta)\right)\right)\right)^{2}\right)=\mathbf{0 . 3 6 2}$
Active thrust due to soil
$P_{\mathrm{a}, \text { soil }}=0.5 \times \mathrm{K}_{\mathrm{a}} \times \gamma_{\mathrm{s} . \mathrm{d}} \times \mathrm{H}^{2}=3.4 \mathrm{kN} / \mathrm{m}$

## Horizontal forces

Retained soi
$\mathrm{F}_{\text {soil_h }}=\gamma \mathrm{G} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \cos \left(90-\alpha+\delta_{\text {r.d }}\right)=3.3 \mathrm{kN} / \mathrm{m}$
Surcharge
$F_{\text {surch_h }}=p_{0, Q} \times \gamma \mathrm{Q} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \cos \left(90-\alpha+\delta_{\text {r. }}\right)=4.5 \mathrm{kN} / \mathrm{m}$

## Vertical forces

Gabion weight
Fgabion_v,f $=\gamma \mathrm{G}, \mathrm{f} \times \mathrm{W}_{\mathrm{g}}=\mathbf{1 8 . 0} \mathrm{kN} / \mathrm{m}$
Retained soil
$F_{\text {soil_v,f }}=\gamma_{\mathrm{G}, \mathrm{f}} \times \mathrm{P}_{\mathrm{a}, \text { soil }} \times \sin \left(90-\alpha+\delta_{\mathrm{r} . \mathrm{d}}\right)=1.1 \mathrm{kN} / \mathrm{m}$
Surcharge
$F_{\text {surch_v,f }}=p_{o, Q} \times \gamma, \mathrm{f}, \mathrm{f} \times \mathrm{K}_{\mathrm{a}} \times \mathrm{H} \times \sin \left(90-\alpha+\delta_{r . d}\right)=0.0 \mathrm{kN} / \mathrm{m}$
Overturning stability - take moments about the toe
Overturning moment
$M_{0}=F_{\text {soil } \_h} \times d_{h, \text { soil }}+F_{\text {surch_h }} \times d_{\text {h,surch }}=3.3 \mathrm{kNm} / \mathrm{m}$
Restoring moment
$M_{R}=F_{\text {gabion_v,f }} \times X_{g}+F_{\text {soil } \_v, f} \times b_{v, \text { soil }}+F_{\text {surch_v,f }} \times b_{v, \text { surch }}=\mathbf{1 0 . 1} \mathrm{kNm} / \mathrm{m}$
$\mathrm{FoS}_{M}=\mathrm{M}_{\mathrm{R}} / \mathrm{M}_{0}=3.038$
$\mathrm{FoS}_{\mathrm{m}}$ _allow $=1.000$
PASS - Design FOS for overturning exceeds min allowable FOS for overturning
Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force
Total vertical force
Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety
$\mathrm{T}=\mathrm{F}_{\text {soil_h }}+\mathrm{F}_{\text {surch } \_\mathrm{h}}=7.7 \mathrm{kN} / \mathrm{m}$
$N=F_{\text {gabion_v,f }}+F_{\text {soil_v,f }}+F_{\text {surch_v,f }}=19.1 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{f}}=\mathrm{T} \times \cos (\varepsilon)-\mathrm{N} \times \sin (\varepsilon)=7.7 \mathrm{kN} / \mathrm{m}$
$\mathrm{F}_{\mathrm{R}}=(\mathrm{T} \times \sin (\varepsilon)+\mathrm{N} \times \cos (\varepsilon)) \times \tan \left(\delta_{\text {bg. }}\right)=10.7 \mathrm{kN} / \mathrm{m}$
$\mathrm{FoS}_{\mathrm{s}}=\mathrm{F}_{\mathrm{R}} / \mathrm{F}_{\mathrm{f}}=1.384$
FoSs_allow = 1.000
PASS - Design FOS for sliding exceeds min allowable FOS for sliding

