# PRESENT-DAY CLIMATE SCENARIO

**ENTER DATA ………**

| | | |
|---|---|---|
| $H_s$ = | 2.06 | metres |
| $T_p$ = | 8 | seconds |
| porosity coefficient **P** = | 0.4 | CIRIA Fig 5.39 on page 568 |
| structure 1 vert : | 1.5 | horiz |
| seabed 1 vert : | 150 | horiz |
| duration of storm waves = | 6 | hours |
| depth at toe **h** = | 3.29 | metres |
| damage coeff $S_d$ = | 2 | CIRIA Table 5.23 on page 569 (SEE TO RIGHT) |
| density rock $\rho_{rock}$ = | 2.65 | |
| density sea $\rho_{water}$ = | 1.025 | |
| $c_{pl}$ = | 8.4 | read CIRIA Table 5.27 on page 577 (SEE TO RIGHT) |
| $c_s$ = | 1.3 | read CIRIA Table 5.27 on page 577 (SEE TO RIGHT) |

**Table 5.23** *Design values of the damage parameter, $S_d$, for armourstone in a double layer*

| Slope (cotα) | Damage level | | |
|---|---|---|---|
| | Start of damage | Intermediate damage | Failure |
| 1.5 | 2 | 3–5 | 8 |
| 2 | 2 | 4–6 | 8 |
| 3 | 2 | 6–9 | 12 |
| 4 | 3 | 8–12 | 17 |
| 6 | 3 | 8–12 | 17 |

**Table 5.27** *Coefficients for "best fit" and "5 per cent exceedance limit" for Van der Meer formulae for shallow water (Equations 5.139 and 5.140)*

| Coefficient | Average value, $\mu$ | Standard deviation, $\sigma$, of the coefficient | Value to assess 5 per cent limit ($\mu - 1.64{\cdot}\sigma$) |
|---|---|---|---|
| $c_{pl}$ | 8.4 | 0.7 | 7.25 |
| $c_s$ | 1.3 | 0.15 | 1.05 |

## CHECK APPLICATION

**check for shallow water / deep water conditions using CIRIA Table 5.29 on page 579**

$h/H_s$ = 1.60019 *is this less than 3?*

yes, therefore use shallow water equations

no. of storm waves **N** = 2700
mean period $T_m$ = 7.48 seconds
fictitious wave steepness $s_o$ = 0.02058
$\varepsilon_m$ = 4.647632
$\varepsilon_{cr}$ = 4.628887
$\varepsilon_s$ = 4.647632
Δ = 1.57923

waves are surging
therefore use CIRIA eq. 5.140 (from page 575) in calculations below

**Table 4.10** *Values of $H_{1/10}/H_{rms}$ and $H_{2\%}/H_{rms}$ for some values of $H_{tr}/H_{rms}$*

| Characteristic height | Non-dimensional transitional wave $H_{tr}/H_{rms}$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.05 | 0.50 | 1.00 | 1.20 | 1.35 | 1.50 | 1.75 | 2.00 | 2.50 | 3.00 |
| $H_{1/10}/H_{rms}$ | 1.466 | 1.467 | 1.518 | 1.573 | 1.626 | 1.683 | 1.759 | 1.786 | 1.799 | 1.800 |
| $H_{2\%}/H_{rms}$ | 1.548 | 1.549 | 1.603 | 1.662 | 1.717 | 1.778 | 1.884 | 1.985 | 1.978 | 1.978 |

…need $H_{2\%}$
$H_{tr}$ = 1.27871 eq. 4.58 page 359
$H_s/H_{mo}$ = 1.25414 eq. 4.77 page 367
$H_{mo}$ = 1.63937
$H_{rms}$ = 1.2679 eq. 4.59 page 359
$H_{tr}/H_{rms}$ = 1.00853
$H_{2\%}/H_{rms}$ = 1.60552 read / interpolate from CIRIA Table 4.10 page 359
…$H_{2\%}$ = 2.03563

paste special = values & formats

| $H_{tr}/H_{rms}$ | insert | $H_{2\%}/H_{rms}$ | interpolated |
|---|---|---|---|
| 0.05 | | 1.548 | |
| 0.50 | | 1.549 | |
| 1.00 | | 1.603 | |
| | 1.009 | | 1.605516425 |
| 1.20 | | 1.662 | |
| 1.35 | | 1.717 | |
| 1.50 | | 1.778 | |
| 1.75 | | 1.884 | |
| 2.00 | | 1.985 | |
| 2.50 | | 1.978 | |
| 3.00 | | 1.8 | |

**if using eqn 5.140** **THIS IS THE FORMULA TO USE FOR SURGING WAVES**

$c_s$ = 1.3
$P^{-0.13}$ = 1.1265
(Sd/SQRTN)^0.2 = 0.52128
$H_s/H_{2\%}$ = 1.01001
SQRT cot = 1.22474
$\varepsilon_s$^P = 1.84881
RHS eq. 5.140 = 1.74585
**$D_{n50}$ = 0.7 metres**
**$M_{50}$ = 1.097 tonnes**

$$\frac{H_s}{\Delta D_{n50}} = c_s\, P^{-0.13}\left(\frac{S_d}{\sqrt{N}}\right)^{0.2}\left(\frac{H_s}{H_{2\%}}\right)\sqrt{\cot\alpha}\,\left(\xi_{s-1,0}\right)^P \qquad (5.140)$$

where:

$c_{pl}$ = 8.4 (-), with a standard deviation of $\sigma = 0.7$ (see also Table 5.27)
$c_s$ = 1.3 (-), with a standard deviation of $\sigma = 0.15$
$H_{2\%}$ = wave height exceeded by 2 per cent of the incident waves at the toe (m)
$\xi_{s-1,0}$ = surf similarity parameter (-), using the energy wave period $T_{m-1,0}$ (-);
$\xi_{s-1,0} = \tan\alpha / \sqrt{(2\pi H_s / (g T_{m-1,0}^2))}$, where $H_s = H_{1/3}$ from time domain analysis (m)
$T_{m-1,0}$ = the (spectral) mean energy wave period (s), equal to $m_{-1}/m_0$ (see Section 4.2.4.5).

# FUTURE CLIMATE SCENARIO

**ENTER DATA ........**

| | | |
|---|---|---|
| $H_s$ = | 2.51 | metres |
| $T_p$ = | 8 | seconds |
| porosity coefficient **P** = | 0.6 | CIRIA Fig 5.39 on page 568 |
| structure 1 vert : | 1.5 | horiz |
| seabed 1 vert : | 150 | horiz |
| duration of storm waves = | 6 | hours |
| depth at toe **h** = | 4.09 | metres |
| damage coeff $S_d$ = | 2.5 | CIRIA Table 5.23 on page 569 (SEE TO RIGHT) |
| density rock $\rho_{rock}$ = | 2.65 | |
| density sea $\rho_{water}$ = | 1.025 | |
| $c_{pl}$ = | 8.4 | read CIRIA Table 5.27 on page 577 (SEE TO RIGHT) |
| $c_s$ = | 1.3 | read CIRIA Table 5.27 on page 577 (SEE TO RIGHT) |

**Table 5.23** *Design values of the damage parameter, $S_d$, for armourstone in a double layer*

| Slope (cotα) | Damage level | | |
|---|---|---|---|
| | Start of damage | Intermediate damage | Failure |
| 1.5 | 2 | 3–5 | 8 |
| 2 | 2 | 4–6 | 8 |
| 3 | 2 | 6–9 | 12 |
| 4 | 3 | 8–12 | 17 |
| 6 | 3 | 8–12 | 17 |

**Table 5.27** *Coefficients for "best fit" and "5 per cent exceedance limit" for Van der Meer formulae for shallow water (Equations 5.139 and 5.140)*

| Coefficient | Average value, μ | Standard deviation, σ, of the coefficient | Value to assess 5 per cent limit (μ – 1.64·σ) |
|---|---|---|---|
| $c_{pl}$ | 8.4 | 0.7 | 7.25 |
| $c_s$ | 1.3 | 0.15 | 1.05 |

## CHECK APPLICATION

**check for shallow water / deep water conditions using CIRIA Table 5.29 on page 579**

$h/H_s$ = 1.63273 *is this less than 3?*

yes, therefore use shallow water equations

no. of storm waves **N** = 2700

mean period $T_m$ = 7.48 seconds

fictitious wave steepness $s_o$ = 0.02507

$\varepsilon_m$ = 4.210556

$\varepsilon_{cr}$ = 3.927413

$\varepsilon_s$ = 4.210556

Δ = 1.57923

waves are surging

therefore use CIRIA eq. 5.140 (from page 575) in calculations below

...need $H_{2\%}$

$H_{tr}$ = 1.58965 eq. 4.58 page 359

$H_s/H_{mo}$ = 1.22866 eq. 4.77 page 367

$H_{mo}$ = 2.0388

$H_{rms}$ = 1.5769 eq. 4.59 page 359

$H_{tr}/H_{rms}$ = 1.00809

$H_{2\%}/H_{rms}$ = 1.60539 read / interpolate from CIRIA Table 4.10 page 359

...$H_{2\%}$ = 2.53152

**Table 4.10** *Values of $H_{1/10}/H_{rms}$ and $H_{2\%}/H_{rms}$ for some values of $H_{tr}/H_{rms}$*

| Characteristic height | Non-dimensional transitional wave $H_{tr}/H_{rms}$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.05 | 0.50 | 1.00 | 1.20 | 1.35 | 1.50 | 1.75 | 2.00 | 2.50 | 3.00 |
| $H_{1/10}/H_{rms}$ | 1.466 | 1.467 | 1.518 | 1.573 | 1.626 | 1.683 | 1.759 | 1.786 | 1.799 | 1.800 |
| $H_{2\%}/H_{rms}$ | 1.548 | 1.549 | 1.603 | 1.662 | 1.717 | 1.778 | 1.884 | 1.985 | 1.978 | 1.978 |

paste special = values & formats

| $H_{tr}/H_{rms}$ | insert | $H_{2\%}/H_{rms}$ | interpolated |
|---|---|---|---|
| 0.05 | | 1.548 | |
| 0.50 | | 1.549 | |
| 1.00 | | 1.603 | |
| | 1.008 | | 1.605385535 |
| 1.20 | | 1.662 | |
| 1.35 | | 1.717 | |
| 1.50 | | 1.778 | |
| 1.75 | | 1.884 | |
| 2.00 | | 1.985 | |
| 2.50 | | 1.978 | |
| 3.00 | | 1.8 | |

**if using eqn 5.140** **THIS IS THE FORMULA TO USE FOR SURGING WAVES**

$c_s$ = 1.3

$P^{-0.13}$ = 1.06866

(Sd/SQRTN)^0.2 = 0.54507

$H_s/H_{2\%}$ = 0.98952

SQRT cot = 1.22474

$\varepsilon_s$^P = 2.36921

RHS eq. 5.140 = 2.17425

**$D_{n50}$ = 0.7 metres**

**$M_{50}$ = 1.027 tonnes**

$$\frac{H_s}{\Delta D_{n50}} = c_s\, P^{-0.13} \left(\frac{S_d}{\sqrt{N}}\right)^{0.2} \left(\frac{H_s}{H_{2\%}}\right) \sqrt{\cot\alpha}\, \left(\xi_{s-1,0}\right)^P \quad (5.140)$$

where:

$c_{pl}$ = 8.4 (-), with a standard deviation of $\sigma = 0.7$ (see also Table 5.27)

$c_s$ = 1.3 (-), with a standard deviation of $\sigma = 0.15$

$H_{2\%}$ = wave height exceeded by 2 per cent of the incident waves at the toe (m)

$\xi_{s-1,0}$ = surf similarity parameter (-), using the energy wave period $T_{m-1,0}$ (-): $\xi_{s-1,0} = \tan\alpha / \sqrt{(2\pi H_s / (g T_{m-1,0}^2))}$, where $H_s = H_{1/3}$ from time domain analysis (m)

$T_{m-1,0}$ = the (spectral) mean energy wave period (s), equal to $m_{-1}/m_0$ (see Section 4.2.4.5).