Three-Dimensional Model Test Study of the New Breakwaters at Playa Blanca, Lanzarote

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Three-dimensional Model Test Study of the New Breakwaters at Playa Blanca, Lanzarote

October 2012

Thomas Lykke Andersen
Karsten Garborg
Esben Rubeck Stagsted

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Three-dimensional Model Test Study of the New Breakwaters at Playa Blanca, Lanzarote

by

Thomas Lykke Andersen
Karsten Garborg
Esben Rubeck Stagsted

October 2012

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This report presents the results of 3-D physical model tests (length scale 1:42.5) carried out in a wave basin at Department of Civil Engineering, Aalborg University (AAU) on behalf of SENER Ingeniería y Sistemas S.A.

Associate Prof. Thomas Lykke Andersen was in charge of the model tests, assisted by B.Sc. Karsten Garborg and B.Sc. Esben Rubeck Stagsted. Engineer assistant Niels Drstrup and Leif Mortensen assisted in the laboratory with the construction and instrumentation of the model. The model construction, testing and reporting were performed during August and September 2012. The present version of the report is a revised version with corrections to the figures in Appendix A.

For further information please contact Associate Prof. Thomas Lykke Andersen (tla@civil.aau.dk)
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<td>CXIX</td>
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This report deals with a three-dimensional model study test of the new rubble mound and caisson breakwater at Port of Playa Blanca, Lanzarote. The objective of the work is to verify the structural and hydraulic responses of the new breakwaters for waves approaching from SW and SSW. Focus is on the trunk sections close to the corner connecting the two breakwaters.

The model tests include:

- Tests at increasing wave height for two water levels and two peaks periods.
- Recording of pressures on the base slab and front of the crown wall of the rubble mound breakwater, and on the front of the caisson. The horizontal wave force and tilting moment around the heel are documented for the pressure distribution giving minimum stability against sliding and overturning respectively.
- Measurement of the average overtopping discharge behind the crown wall of the rubble mound and caisson breakwater, where the measurements on the rubble mound includes the spatial distribution of the discharge. Characteristic situations have been video recorded.
- Investigation of toe and berm stability on the caisson and armour on the rubble mound, using photo overlay technique.

3-D model tests of the caisson breakwater in the port were performed for design and overload conditions in scale 1:42.5. Unless otherwise specified, all values given in this report are prototype values assuming Froude scaling. Table 1.1 lists the scales, assuming a factor 1.025 due to salt water in prototype and fresh water in the model.
<table>
<thead>
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<th>Unit</th>
<th>Scale</th>
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</tr>
<tr>
<td>Volume</td>
<td>[m$^3$]</td>
<td>$1 : 42.5^3 = 1 : 76.8 \cdot 10^3$</td>
</tr>
<tr>
<td>Time</td>
<td>[m$^{0.5}$]</td>
<td>$1 : 42.5^{0.5} = 1 : 6.52$</td>
</tr>
<tr>
<td>Discharge</td>
<td>[m$^3$ / (s \cdot m)]</td>
<td>$1 : 42.5^{1.5} = 1 : 277$</td>
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<tr>
<td>Velocity</td>
<td>[m/s]</td>
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<tr>
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<td>[N/m]</td>
<td>$1 : 42.5^2 \cdot 1.025 = 1 : 1.85 \cdot 10^3$</td>
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<td>Pressure</td>
<td>[N/m$^2$]</td>
<td>$1 : 42.5 \cdot 1.025 = 1 : 43.6$</td>
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<tr>
<td>Moment</td>
<td>[Nm]</td>
<td>$1 : 42.5^4 \cdot 1.025 = 1 : 3.34 \cdot 10^6$</td>
</tr>
</tbody>
</table>

*Table 1.1.* Scale relations between model and prototype.
Chapter 2. Model Set-up and Instrumentation

Model Set-up and Instrumentation

2.1 Model set-up in basin

Figure 2.1. Set-up in the basin (model values in millimetres). The red arrows show the angle of view in Figure 2.3 to 2.7.
Figure 2.2. Set-up of the instrumentation in the basin (model values in millimetres).
Chapter 2. Model Set-up and Instrumentation

*Figure 2.3.* Picture taken from direction 1.  
*Figure 2.4.* Picture taken from direction 2.  
*Figure 2.5.* Picture taken from direction 3.  
*Figure 2.6.* Picture taken from direction 4.  
*Figure 2.7.* Picture taken from direction 5.  
*Figure 2.8.* Picture of the model with water and waves.
2.2 Prototype bathymetry and cross-sections

*Figure 2.9.* Overview of prototype with bathymetry (prototype values in metres).
Figure 2.10. Prototype cross-section of cut B-B’ (prototype values in metres). Model with impermeable membrane on rear slope.

Figure 2.11. Prototype cross-section of cut C-C’ (prototype values in metres).
2.3 Materials

The foundation for the caisson breakwater was constructed of two types of rock/gravel and parallelepipeds foot protection blocks. The rubble-mound breakwater was constructed with a core of gravel, a rock armour layer and cubes. The specifications for these materials are given in Table 2.1 and Table 2.2 for rubble mound and caisson foundation. A histogram of the mass of the stones are shown in Figure 2.13.

Placing density of cubes was 0.449 units/m$^2$.

The nominal diameter was calculated as:

$$D_{n50} = \left( \frac{W_{50}}{\rho_s} \right)^{\frac{1}{3}}$$

$D_{n50}$ | nominal diameter  
---|---
$W_{50}$ | median weight of the stones  
$\rho_s$ | stone density

<table>
<thead>
<tr>
<th>Type</th>
<th>$W_{50}$</th>
<th>Size</th>
<th>Density</th>
<th>$\Delta D_{n50}$</th>
</tr>
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<tr>
<td>Core/filter material</td>
<td>0.30</td>
<td>4.7</td>
<td>2.87</td>
<td>8.8</td>
</tr>
<tr>
<td>Inner armour rock layer</td>
<td>10.4</td>
<td>15.7</td>
<td>2.71</td>
<td>26.7</td>
</tr>
<tr>
<td>Armour cubes, 2 layers</td>
<td>148</td>
<td>40x40x40</td>
<td>2.31</td>
<td>52.6</td>
</tr>
</tbody>
</table>

Table 2.1. Material specifications for rubble mound breakwater (model scale).
Because of a difference in density for the foot protection blocks at the toe of the caisson (concrete in prototype, $\rho_c = 2.40 \text{ t/m}^3$, aluminium in model, $\rho_{alu} = 2.66 \text{ t/m}^3$), the target $\Delta D_{n50} = 48.2 \text{ mm}$ was not achieved and all wave heights relating to stability of protection blocks should be lowered by a factor of $\frac{55.5 \text{ mm}}{48.2 \text{ mm}} = 1.15$. The wave heights that has been corrected with this factor will be denoted $H_{m0}$.

Due to lack of number of cube armour units, the cubes were substituted with parallelepipeds, with the same weight and density, on a stretch of the inner armour layer shown on Figure 2.14. The overtopping discharge and pressure were measured on the part of the rubble mound with the correct cube armour layer.
Figure 2.14. Inner armour layer. Note the cubes were substituted with parallelepiped armour block in the inner layer on a stretch of the rubble mound.

### 2.4 Pressure gauges

Druck PMP Unik 5000 pressure gauges were used to measure the wave loads on the crown wall and the caisson breakwater. 10 and 6 pressure gauges were located at the front and bottom of the crown wall on the rubble-mound breakwater and 9 pressure gauges were located at the front face of the caisson breakwater.
Figure 2.15. Pressure gauge locations at the crown wall on the rubble mound breakwater (annotations in millimetres in model scale).
Chapter 2. Model Set-up and Instrumentation

Calibration

The pressure gauges were initially verified to be linear. Hereafter the pressure gauges were calibrated after installation with two water depths (in both cases all pressure gauges were fully submerged), as shown on Figure 2.17. The calibration was checked after completion of the test programme. The offset was found by measuring the signal for 20 seconds at the beginning of each test, before inducing waves, thereby excluding hydrostatic pressure from the measurements.

2.5 Wave gauges

Two wave gauge arrays, consisting of five and seven wave gauges, were located in the basin, as shown on Figure 2.18. The five gauge array was used to identify the wave height of the generated waves ($H_{m0}^{Gen}$), and the seven gauge array was placed in front of the breakwater
to identify the waves besides the model and on horizontal bed, and thereby the influence
of shoaling and refraction due to the bathymetry in front of the rubble mound ($H_{m0}^{\text{Break}}$).

\textbf{Figure 2.18.} The wave gauge arrays as positioned in the basin.
2.6 Overtopping chambers

Figure 2.20 and 2.21 shows the overtopping chambers installed on the rubble-mound and the caisson.
Figure 2.20. Overtopping chambers for rubble-mound. Annotations are in model scale.
2.7 Stability

Stability of the rock and cube armour layers on the rubble-mound breakwater and the toe protection of the caisson breakwater were detected by visual observations, using photos taken before and after each test. For each test photos were taken from specific locations of interest.
Figure 2.22. Set-up of the rubble mound and caisson breakwater, with indications of where the stability picture are taken from.
3.1 Sea States

Low and high water conditions were tested corresponding to +0.09 and +3.50 respectively.

Peak wave periods of 8 s and 16 s were used. The wave height were increased stepwise, with the following significant wave heights as target: 2.0 m, 2.5 m, 3.0 m, 3.5 m, 4.0 m, and 4.5 m. A significant wave height of 3.7 m was estimated by SENER to have a return period of 500 years.

A JONSWAP spectrum with peak enhancement parameter $\gamma = 3.3$ were used.

A directional spreading of $s = 10$ (corresponding to a standard deviation of $25^\circ$) was used.

3.2 Wave Generation

3-D irregular waves were generated by the AWASYS system with the Filtered White Noise generation method. Because of a high amount of passive absorption in the basin, active absorption of the reflected waves were not used.

3.3 Wave Analysis

The data acquisition was done using a NI USB-6225 acquisition box and the WaveLab software package. The Wavelab software package was also used to analyse the measured surface elevations, splitting incident and reflected spectra on the basis of the BDM method (Hashimoto et al. 1987).

In a few tests wave gauge 8 and 9 were not working (mainly tests with 8 s waves) and were in these cases left out of the wave analysis.
Figure 3.1. 3D variance spectrum of measured waves.
Analysis Method for Wave Induced Loads on Crown Wall and Caisson

Wave forces are calculated by numerical pressure integration.

Impact loads were not expected because $H_s/h_s < 0.35$ for the caisson and for the crown wall the entire height is protected by cubes. A sample frequency of 500 Hz (model scale) was used with a moving average of 5 samples to smoothen the signal.

Figure 4.1 and 4.2 shows the location of pressure gauges used for the wave force integration for the crown wall and the caisson breakwater. The numerical integration procedure is explained in the following.

4.1 Crown wall loads

On the crown wall two rows of pressure cells are available and the average of the two are used to calculate the overall forces.
Assumptions regarding crown wall loads:
The horizontal pressure was assumed uniform from gauge $H_2$ and to the top of the model ($H_1$). The pressure at the front foot corner of the model ($H_7, V_1$), was found by linear extrapolation of $H_5$ and $H_6$. The pressure was assumed to be equal around the corner.

$$H_1 = H_2$$
$$V_1 = H_7 = H_6 - \frac{H_5 - H_6}{h_5} h_6$$

Pressure at the heal ($V_5$) is found by linear extrapolation of $V_3$ and $V_4$.

$$V_5 = V_4 - \frac{V_3 - V_4}{v_4} v_5$$

### 4.1.1 Horizontal wave induced force and related moment

Contribution to $F_{H}$ from pressure on $h_n$:

$$\Delta F_{H,hn} = \frac{1}{2} h_n \left( H_n + H_{n+1} \right)$$

$$\Delta M_{F_{H,hn}} = \frac{1}{2} h_n \left[ \sum_{i=n+1}^{6} h_i \left( H_n + H_{n+1} \right) + h_n \left( \frac{2}{3} H_n + \frac{1}{3} H_{n+1} \right) \right]$$

$$F_{H} = \sum_{n=1}^{6} \Delta F_{H,hn}$$

$$M_{F_{H}} = \sum_{n=1}^{6} \Delta M_{F_{H,hn}}$$
4.1.2 Vertical wave induced force and related moment

\[ F_V = \sum_{n=1}^{4} \frac{1}{2} v_n (V_n + V_{n+1}) \]

\[ M_{FO} = \sum_{n=1}^{4} \left( \frac{1}{2} v_n \left[ \left( \sum_{i=1}^{n} v_i \right) \cdot (V_n + V_{n+1}) + v_n \left( \frac{1}{3} V_n + \frac{2}{3} V_{n+1} \right) \right] \right) \]

Moment around the rear corner of the base plate:

\[ M_{PV} = \left( \sum_{i=1}^{4} v_i - \frac{M_{FO}}{F_V} \right) F_V \]

4.2 Caisson loads

![Diagram of pressure gauges on caisson](image)

**Figure 4.2.** Location of pressure gauges on caisson (model scale).

**Assumptions regarding caisson loads:**

The horizontal pressure was assumed uniform from gauge \( H_2 \) and to the top of the model (\( H_1 \)). The pressure at the front foot corner of the model (\( H_{11} \)), was found by linear extrapolation of \( H_9 \) and \( H_{10} \). The pressure was assumed to be equal around the toe of the caisson, and the toe is therefore neglected.

\[ H_1 = H_2 \]

\[ H_{11} = H_{10} - \frac{H_9 - H_{10}}{h_9} h_{10} \]

![Diagram of caisson dimensions](image)
Chapter 4. Analysis Method for Wave Induced Loads on Crown Wall and Caisson

The uplift force is estimated by assuming a triangular distribution of the pressure underneath the caisson. The pressure $V_1$ is assumed equal to $H_{11}$ and the pressure at the heel of the caisson is assumed to be zero.

$$V_1 = H_{11}$$

### 4.2.1 Horizontal wave induced force and related moment

Contribution to $F_H$ from pressure on $h_n$:

$$\Delta F_{H, hn} = \frac{1}{2} h_n (H_n + H_{n+1})$$

$$\Delta M_{F_H, hn} = \frac{1}{2} h_n \left[ \left( \sum_{i=n+1}^{10} h_i \right) (H_n + H_{n+1}) + h_n \left( \frac{2}{3} H_n + \frac{1}{3} H_{n+1} \right) \right]$$

$$F_H = \sum_{n=1}^{11} \Delta F_{H, hn}$$

$$M_{F_H}^P = \sum_{n=1}^{11} \Delta M_{F_H, hn}$$

### 4.2.2 Vertical wave induced force and related moment

$$F_V = \frac{1}{2} V_1 v_1$$

$$M_{F_V}^P = \frac{1}{3} V_1 v_1^2$$
The test programme is shown in Table 5.1. The number of waves in each test was at least 1,500.

Test no. 2.2.6 was re-done for 2 hours (≈ 2.930 waves) to see the prolonged effect on armour stability. In the following the 2 hour-test is denoted (2.2.6).

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<thead>
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<th>Prototype data</th>
<th>Model data</th>
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<td>( T_p )</td>
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<td>0.09</td>
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<td>1.1.4</td>
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<td>1.1.6</td>
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<td>1.1.7</td>
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<td>1.2.1</td>
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<tr>
<td>(2.2.6)</td>
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</table>

*Table 5.1.* Conditions used in each test as measured by the two arrays using BDM method. \( H_{m0} \) is the incident spectral wave height.
Chapter 6. Caisson Stability Results

Caisson Stability Results

The results of the wave induced forces and caisson displacement are given in Table 6.1. The safety factor SF\(_{slide}\) was calculated using a friction factor of \(\mu = 0.6\).

Even for the overload conditions, high safety factors was observed for the very oblique SSW waves. It should though be taken into account that the uplift is not measured and is based on a triangular distribution. The tests though indicate that head-on waves (SE) results in loads that are slightly larger than the ones obtained for SSW waves (see Lykke Andersen et al. [2012]).

Stability of the caissons at the heads has not been investigated and these might have lower safety factors than for the trunk section.

<table>
<thead>
<tr>
<th>Test no.</th>
<th>SWL [m]</th>
<th>(T_p) [s]</th>
<th>(H_{max}) [m]</th>
<th>(\min g) [kN/m]</th>
<th>(F_{H,max}) [kN/m]</th>
<th>(F_{V,max}) [kN/m]</th>
<th>(M_{max}^P) [kNm/m]</th>
<th>SF(_{slide}) [-]</th>
<th>SF(_{tilt}) [-]</th>
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Table 6.1. Extreme forces and moments calculated from the pressure readings along with safety factors against sliding and overturning.
Chapter 7. Crownwall Stability Results

Crownwall Stability Results

The results of the wave induced forces and crownwall displacement are given in Table 7.1. The safety factor SF\text{slide} was calculated using a friction factor of \( \mu = 0.6 \).

Passive and active soil pressures from the armour in front and pavement behind the crown wall has not been included in the load calculation and in the safety factors.

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*Table 7.1.* Extreme forces and moments calculated from the pressure readings along with safety factors against sliding and overturning (note soil pressures not included).
Chapter 8. Armour Layer and Toe Stability Results

8.1 Cube armour layer

Photos of the armour layer taken before and after each test, are shown in appendix B.

Cube armour unit displacements are given in Table 8.1 and cumulative damage is plotted in Figure 8.2. The rubble-mound was divided into three sections, as shown on Figure 8.1. The sections were divided this way because some movement was observed due to turbulence behind the corner of the caisson (section 1) and because an increase in wave energy was also observed along the rubble-mound from section 2 towards section 3, thereby expecting more damage to the armour layer in section 3 than section 2. Section 1, 2 and 3 contains 160, 1600 and 1050 units respectively.

In all sections the cumulative damage has not resulted in visible filter layer.

Figure 8.1. Sections used for rubble-mound armour cube stability.
## Chapter 8. Armour Layer and Toe Stability Results

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**Table 8.1.** Number of displaced units in each test and cumulative damage of cube armour layer (given in percentage of total number of cubes in section).

![Figure 8.2. Cumulative damage of cube armour layer.](image-url)
8.2 Caisson toe

Movement of foot protection blocks was observed near front corner of caisson at a wave height of $H_{m0}^{Break*} = 2.33$ m, with SWL +0.09 and $T_p = 16$ s. See Figure 8.3 for example (note $H_{m0}^{Break*} = 4.03$ m).

Filter material was exposed beneath the blocks, but no further exposure of the filter material was observed.

Similar movement for caisson foundation at the head compared to the front corner, see Figure 8.4, with a wave height of $H_{m0}^{Break*} = 3.83$ m, SWL +0.09 and $T_p = 16$ s. Significant movement of foot protection blocks at $H_{m0}^{Break*} = 4.03$ m.
Figure 8.3. Front corner, before and after test no. 1.2.7 - SWL: +0.09, Tp: 16 s, \(H_{\text{break}} = 4.64\) m, \(H_{m0} = 4.03\) m
Figure 8.4. Caisson head, before and after test no. 1.2.7 - SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Break} = 4.64$ m, $H_{m0}^{Break*} = 4.03$ m
The measured overtopping discharges are given in Table 9.1. For test no. 2.2.1 and down, a second overtopping chamber was added to the caisson (chamber 2). This was done because run-up on the caisson from the oblique waves were observed, thereby producing more overtopping further along the caisson. This is verified by the average discharges being slightly larger for almost all tests.

For some tests the second overtopping chamber were filled (test no. 2.1.6, 2.1.7, 2.2.6 and (2.2.6)), which means that the measured overtopping might be larger. For some tests, the overtopping chamber 2 was filled over a short amount of time.

The measured average discharges are in Figure 9.1 to 9.7 compared with estimates from...
CLASH Neural Network.

Comparison with Neural Network for the caisson

Figure 9.1. Average measured overtopping discharge for the caisson, and estimates from CLASH Neural Network.
Figure 9.2. Average measured overtopping discharge for the caisson, and estimates from CLASH Neural Network.

Figure 9.3. Average measured overtopping discharge for the caisson, and estimates from CLASH Neural Network.
Figure 9.4. Average measured overtopping discharge for the caisson, and estimates from CLASH Neural Network.

Comparison with Neural Network for the crownwall

Tests with SWL at +0.09 m and waves with a period of 8 seconds did not experience overtopping, and CLASH Neural Network did not estimate any overtopping.
Chapter 9. Overtopping Results

**Figure 9.5.** Average measured overtopping discharge on the rubble mound, and estimates from CLASH Neural Network.

**Figure 9.6.** Average measured overtopping discharge on the rubble mound, and estimates from CLASH Neural Network.
Figure 9.7. Average measured overtopping discharge on the rubble mound, and estimates from CLASH Neural Network.
Conclusions

10.1 Stability of armour material

The foundation at the front corner of the caisson turning towards the rubble mound breakwater seems to be unstable for the tests run with a wave period of 16 s period at low water level, as the foot protection block were unstable at $H_{m0}^{Gen} = 2.18$ m. Regarding the rest of the armour material, the displacements were insignificant for wave heights below $H_{m0}^{Gen} = 3.73$ m.

10.2 Overtopping discharge

The measured overtopping rates at the rubble mound are very small and significantly smaller than for the caisson. No overtopping occurred for wave heights $H_{m0}^{Gen} \leq 3.74$ m for low water level and $H_{m0}^{Gen} \leq 3.14$ m for high water level. The highest average overtopping discharge measured were $q_{avg} = 3.35$ l/s m for test no. 2.1.7 (SWL: +3.50, $T_p = 8$ s, $H_{m0}^{Gen} = 4.87$ m).

10.3 Stability of caisson and crown wall

Regarding the pressure readings, the caisson and crown wall is stable in the tested conditions, except for test no. 2.2.6 (SWL: +3.50, $T_p = 16$ s, $H_{m0}^{Break} = 4.72$ m), which showed expected sliding of the crown wall. It should be noted that the same test running for 2 hours, test no. (2.2.6), showed no sliding instabilities. In these analyses the soil pressured (active and passive) have been neglected which might change the stability conclusion for the crown wall.

In the following pages, certain characteristic pressure readings are shown. The pressure distribution at the maximum horizontal force, maximum uplift force, maximum overturning moment and minimum value of sliding failure function. Furthermore the maximum reading in each pressure gauge is shown.
A.1 Caisson loads

Test no. 1.1.1, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen}$ = 2.21 m

- Max. horizontal force
  - SWL: +0.09
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 2.21 m
  - $F_H$ = 416 kN/m
  - $F_V$ = 220 kN/m
  - $M_{tilting}$ = 6799 kNm/m

- Pressure in [kPa]

- Max. uplift force
  - SWL: +0.09
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 2.21 m
  - $F_H$ = 416 kN/m
  - $F_V$ = 220 kN/m
  - $M_{tilting}$ = 6799 kNm/m

- Pressure in [kPa]

- Max. sliding failure
  - SWL: +0.09
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 2.21 m
  - $F_H$ = 416 kN/m
  - $F_V$ = 220 kN/m
  - $M_{tilting}$ = 6799 kNm/m

- Pressure in [kPa]

- Max. pressure-reading
  - SWL: +0.09
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 2.21 m

- Pressure in [kPa]

- Goda pressure distribution
  - SWL: +0.09
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 2.21 m
  - $F_H$ = 416 kN/m
  - $F_V$ = 220 kN/m
  - $M_{tilting}$ = 4904 kNm/m

- Pressure in [kPa]
Test no. 1.1.2, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 2.72$ m
Test no. 1.1.3, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen}$ = 3.03 m

Test 1.1.3
Max. horizontal force
SWL: +0.09
$T_p$ = 8 s
$H_{m0}^{Gen}$ = 3.03 m
$F_H$ = 536 kN/m
$F_V$ = 277 kN/m
$M_{tilting}$ = 8723 kNm/m

Test 1.1.3
Max. uplift force
SWL: +0.09
$T_p$ = 8 s
$H_{m0}^{Gen}$ = 3.03 m
$F_H$ = 536 kN/m
$F_V$ = 277 kN/m
$M_{tilting}$ = 8723 kNm/m

Test 1.1.3
Max. sliding failure
SWL: +0.09
$T_p$ = 8 s
$H_{m0}^{Gen}$ = 3.03 m
$F_H$ = 536 kN/m
$F_V$ = 277 kN/m
$M_{tilting}$ = 8723 kNm/m
$S_{F_{sliding}}$ = 5.29

Test 1.1.3
Max. pressure-reading
SWL: +0.09
$T_p$ = 8 s
$H_{m0}^{Gen}$ = 3.03 m

Goda pressure distribution
SWL: +0.09
$T_p$ = 8 s
$H_{m0}^{Gen}$ = 3.03 m
$F_H$ = 419 kN/m
$F_V$ = 140 kN/m
$M_{tilting}$ = 5641 kNm/m

Pressure in [kPa]
Test no. 1.1.4, SWL: +0.09, $T_p$: 8 s, $H^{Gen}_{m0} = 3.57$ m

**Max. horizontal force**

Test 1.1.4

- SWL: +0.09
- $T_p$: 8 s
- $H^{Gen}_{m0} = 3.57$ m
- $F_H = 723$ kN/m
- $F_V = 291$ kN/m
- $M_{tilting} = 11622$ kNm/m

**Max. uplift force**

Test 1.1.4

- SWL: +0.09
- $T_p$: 8 s
- $H^{Gen}_{m0} = 3.57$ m
- $F_H = 720$ kN/m
- $F_V = 307$ kN/m
- $M_{tilting} = 11738$ kNm/m

**Max. tilting moment**

Test 1.1.4

- SWL: +0.09
- $T_p$: 8 s
- $H^{Gen}_{m0} = 3.57$ m
- $F_H = 720$ kN/m
- $F_V = 307$ kN/m
- $M_{tilting} = 11738$ kNm/m
- $SF_{tilting} = 4.69$

**Min. sliding failure**

Test 1.1.4

- SWL: +0.09
- $T_p$: 8 s
- $H^{Gen}_{m0} = 3.57$ m
- $F_H = 720$ kN/m
- $F_V = 307$ kN/m
- $M_{tilting} = 11738$ kNm/m
- $SF_{sliding} = 3.91$

**Max. pressure-reading**

Test 1.1.4

- SWL: +0.09
- $T_p$: 8 s
- $H^{Gen}_{m0} = 3.57$ m

**Goda pressure distribution**

- SWL: +0.09
- $T_p$: 8 s
- $H^{Gen}_{m0} = 3.57$ m
- $F_H = 496$ kN/m
- $F_V = 164$ kN/m
- $M_{tilting} = 6673$ kNm/m
Test no. 1.1.5, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{\text{Gen}} = 3.74$ m
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Test no. 1.1.6, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.06$ m
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Test no. 1.1.7, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.52$ m

Test 1.1.7
Max. horizontal force
SWL: +0.09
$T_p$: 8 s
$H_{m0}^{Gen} = 4.52$ m
$F_H = 911$ kN/m
$F_V = 360$ kN/m
$M_{tilting} = 14870$ kNm/m

Goda pressure distribution
SWL: +0.09
$T_p$: 8 s
$H_{m0}^{Gen} = 4.52$ m
$F_H = 649$ kN/m
$F_V = 208$ kN/m
$M_{tilting} = 8746$ kNm/m

Max. uplift force
SWL: +0.09
$T_p$: 8 s
$H_{m0}^{Gen} = 4.52$ m
$F_H = 821$ kN/m
$F_V = 370$ kN/m
$M_{tilting} = 13471$ kNm/m

Max. tilting moment
SWL: +0.09
$T_p$: 8 s
$H_{m0}^{Gen} = 4.52$ m
$F_H = 911$ kN/m
$F_V = 360$ kN/m
$M_{tilting} = 14870$ kNm/m
$SF_{tilting} = 3.70$

Min. sliding failure
SWL: +0.09
$T_p$: 8 s
$H_{m0}^{Gen} = 4.52$ m
$F_H = 911$ kN/m
$F_V = 360$ kN/m
$M_{tilting} = 14870$ kNm/m
$SF_{sliding} = 3.06$

Max. pressure-reading
SWL: +0.09
$T_p$: 8 s
$H_{m0}^{Gen} = 4.52$ m

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Test no. 1.1.8, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.68$ m

Goda pressure distribution
SWL: +0.09
$T_p$: 8 s
$H_{m0}^{Gen} = 4.68$ m
$F_H = 680$ kN/m
$F_V = 216$ kN/m
$M_{tilting} = 9185$ kNm/m

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Chapter A. Characteristic Pressure Readings

Test no. 1.2.1, SWL: +0.09, $T_p$: 16 s, $H_{\text{m0}}^{\text{Gen}} = 2.22$ m

Analysis of pressure readings for Test 1.2.1 under specific conditions:

- **Max. horizontal force**:
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{m0}}^{\text{Gen}} = 2.22$ m
  - $F_H = 558$ kN/m
  - $F_V = 347$ kN/m
  - $M_{\text{tilting}} = 9530$ kNm/m

- **Max. uplift force**:
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{m0}}^{\text{Gen}} = 2.22$ m
  - $F_H = 551$ kN/m
  - $F_V = 353$ kN/m
  - $M_{\text{tilting}} = 9555$ kNm/m

- **Max. tilting moment**:
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{m0}}^{\text{Gen}} = 2.22$ m
  - $F_H = 551$ kN/m
  - $F_V = 353$ kN/m
  - $M_{\text{tilting}} = 9555$ kNm/m
  - $SF_{\text{tilting}} = 5.76$

- **Min. sliding failure**:
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{m0}}^{\text{Gen}} = 2.22$ m
  - $F_H = 558$ kN/m
  - $F_V = 347$ kN/m
  - $M_{\text{tilting}} = 9530$ kNm/m
  - $SF_{\text{sliding}} = 5.01$

- **Goda pressure distribution**:
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{m0}}^{\text{Gen}} = 2.22$ m
  - $F_H = 479$ kN/m
  - $F_V = 219$ kNm/m
  - $M_{\text{tilting}} = 6933$ kNm/m
Test no. 1.2.2, SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 2.51$ m

Test 1.2.2
Max. horizontal force
SWL: +0.09
$T_p = 16$ s
$H_{m0}^{Gen} = 2.51$ m
$F_H = 694$ kN/m
$F_V = 375$ kN/m
$M_{tilting} = 11504$ kNm/m

Test 1.2.2
Max. uplift force
SWL: +0.09
$T_p = 16$ s
$H_{m0}^{Gen} = 2.51$ m
$F_H = 664$ kN/m
$F_V = 422$ kN/m
$M_{tilting} = 11465$ kNm/m

Test 1.2.2
Max. tilting moment
SWL: +0.09
$T_p = 16$ s
$H_{m0}^{Gen} = 2.51$ m
$F_H = 690$ kN/m
$F_V = 385$ kN/m
$M_{tilting} = 11605$ kNm/m
$SF_{tilting} = 4.74$

Test 1.2.2
Min. sliding failure
SWL: +0.09
$T_p = 16$ s
$H_{m0}^{Gen} = 2.51$ m
$F_H = 691$ kN/m
$F_V = 387$ kN/m
$M_{tilting} = 11604$ kNm/m
$SF_{sliding} = 4.01$

Goda pressure distribution
SWL: +0.09
$T_p = 16$ s
$H_{m0}^{Gen} = 2.51$ m
$F_H = 543$ kN/m
$F_V = 247$ kN/m
$M_{tilting} = 7847$ kNm/m

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Test no. 1.2.3, SWL: +0.09, $T_p$: 16 s, $H_{\text{Gen}} = 2.70$ m

- **Max. horizontal force**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{Gen}} = 2.70$ m
  - $F_H = 670$ kN/m
  - $F_V = 425$ kN/m
  - $M_{\text{tilting}} = 11496$ kNm/m

- **Max. uplift force**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{Gen}} = 2.70$ m
  - $F_H = 669$ kN/m
  - $F_V = 442$ kN/m
  - $M_{\text{tilting}} = 11766$ kNm/m

- **Max. tilting moment**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{Gen}} = 2.70$ m
  - $F_H = 669$ kN/m
  - $F_V = 442$ kN/m
  - $M_{\text{tilting}} = 11766$ kNm/m
  - $SF_{\text{tilting}} = 4.68$

- **Min. sliding failure**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{Gen}} = 2.70$ m
  - $F_H = 669$ kN/m
  - $F_V = 442$ kN/m
  - $M_{\text{tilting}} = 11766$ kNm/m
  - $SF_{\text{sliding}} = 4.09$

- **Max. pressure-reading**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{Gen}} = 2.70$ m

- **Goda pressure distribution**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H_{\text{Gen}} = 2.70$ m
  - $F_H = 585$ kN/m
  - $F_V = 266$ kN/m
  - $M_{\text{tilting}} = 8447$ kNm/m

Pressure in [kPa]
Test no. 1.2.4, SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 3.35$ m
Chapter A. Characteristic Pressure Readings

Test no. 1.2.5, SWL: +0.09, $T_p$: 16 s, $H_{\text{Gen}} = 3.66$ m

---

Max. horizontal force
SWL: +0.09
$T_p$: 16 s
$H_{\text{Gen}} = 3.66$ m
$F_H = 1130$ kN/m
$F_V = 581$ kN/m
$M_{\text{tilting}} = 19309$ kNm/m

Max. uplift force
SWL: +0.09
$T_p$: 16 s
$H_{\text{Gen}} = 3.66$ m
$F_H = 1130$ kN/m
$F_V = 581$ kN/m
$M_{\text{tilting}} = 19309$ kNm/m

Max. tilting moment
SWL: +0.09
$T_p$: 16 s
$H_{\text{Gen}} = 3.66$ m
$F_H = 1130$ kN/m
$F_V = 581$ kN/m
$M_{\text{tilting}} = 19309$ kNm/m
$S_{\text{tilting}} = 2.84$

Min. sliding failure
SWL: +0.09
$T_p$: 16 s
$H_{\text{Gen}} = 3.66$ m
$F_H = 1130$ kN/m
$F_V = 581$ kN/m
$M_{\text{tilting}} = 19309$ kNm/m
$S_{\text{sliding}} = 2.35$

Max. pressure-reading
SWL: +0.09
$T_p$: 16 s
$H_{\text{Gen}} = 3.66$ m

Goda pressure distribution
SWL: +0.09
$T_p$: 16 s
$H_{\text{Gen}} = 3.66$ m
$F_H = 798$ kN/m
$F_V = 360$ kN/m
$M_{\text{tilting}} = 11501$ kNm/m
Test no. 1.2.6, SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 4.19$ m
Test no. 1.2.7, SWL: +0.09, $T_p$: 16 s, $H_{\text{Gen}} = 4.28$ m

Max. horizontal force
SWL: +0.09
$T_p = 16$ s
$H_{m0} = 4.28$ m
$F_H = 1440$ kN/m
$F_V = 723$ kN/m
$M_{\text{tilting}} = 24730$ kNm/m

Max. uplift force
SWL: +0.09
$T_p = 16$ s
$H_{m0} = 4.28$ m
$F_H = 1290$ kN/m
$F_V = 840$ kN/m
$M_{\text{tilting}} = 24247$ kNm/m

Max. tilting moment
SWL: +0.09
$T_p = 16$ s
$H_{m0} = 4.28$ m
$F_H = 1440$ kN/m
$F_V = 723$ kN/m
$M_{\text{tilting}} = 24730$ kNm/m
$S_F_{\text{tilting}} = 2.23$

Min. sliding failure
SWL: +0.09
$T_p = 16$ s
$H_{m0} = 4.28$ m
$F_H = 1440$ kN/m
$F_V = 723$ kN/m
$M_{\text{tilting}} = 24730$ kNm/m
$S_F_{\text{sliding}} = 1.78$

Max. pressure-reading
SWL: +0.09
$T_p = 16$ s
$H_{m0} = 4.28$ m

Goda pressure distribution
SWL: +0.09
$T_p = 16$ s
$H_{m0} = 4.28$ m
$F_H = 942$ kN/m
$F_V = 422$ kN/m
$M_{\text{tilting}} = 13551$ kNm/m
Test no. 2.1.1, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 2.70$ m
Test no. 2.1.2, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 3.14$ m

Max. horizontal force

Test 2.1.2

Max. uplift force

Min. sliding failure

Max. pressure-reading

Goda pressure distribution
Test no. 2.1.3, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen}$ = 3.31 m

**Max. horizontal force**

- **SWL:** +3.50
- **$T_p$:** 8 s
- **$H_{m0}^{Gen}$:** 3.31 m
- **$F_H$:** 604 kN/m
- **$F_V$:** 236 kN/m
- **$M_{tilting}$:** 10201 kNm/m

**Max. uplift force**

- **SWL:** +3.50
- **$T_p$:** 8 s
- **$H_{m0}^{Gen}$:** 3.31 m
- **$F_H$:** 444 kN/m
- **$F_V$:** 335 kN/m
- **$M_{tilting}$:** 9250 kNm/m

**Max. tilting moment**

- **SWL:** +3.50
- **$T_p$:** 8 s
- **$H_{m0}^{Gen}$:** 3.31 m
- **$F_H$:** 587 kN/m
- **$F_V$:** 266 kN/m
- **$M_{tilting}$:** 10645 kNm/m
- **$SF_{tilting}$:** 4.41

**Min. sliding failure**

- **SWL:** +3.50
- **$T_p$:** 8 s
- **$H_{m0}^{Gen}$:** 3.31 m
- **$F_H$:** 587 kN/m
- **$F_V$:** 266 kN/m
- **$M_{tilting}$:** 10645 kNm/m
- **$SF_{sliding}$:** 4.09

**Goda pressure distribution**

- **SWL:** +3.50
- **$T_p$:** 8 s
- **$H_{m0}^{Gen}$:** 3.31 m
- **$F_H$:** 456 kN/m
- **$F_V$:** 123 kN/m
- **$M_{tilting}$:** 6333 kNm/m
Chapter A. Characteristic Pressure Readings

Test no. 2.1.4, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 3.92$ m

- **Max. horizontal force**
  - SWL: +3.50
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 3.92 m
  - $F_H$ = 711 kN/m
  - $F_V$ = 268 kN/m
  - $M_{tilting}$ = 12136 kNm/m

- **Max. uplift force**
  - SWL: +3.50
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 3.92 m
  - $F_H$ = 642 kN/m
  - $F_V$ = 402 kN/m
  - $M_{tilting}$ = 12724 kNm/m

- **Max. tilting moment**
  - SWL: +3.50
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 3.92 m
  - $F_H$ = 641 kN/m
  - $F_V$ = 392 kN/m
  - $M_{tilting}$ = 12820 kNm/m
  - $SF_{tilting}$ = 3.66

- **Min. sliding failure**
  - SWL: +3.50
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 3.92 m
  - $F_H$ = 642 kN/m
  - $F_V$ = 402 kN/m
  - $M_{tilting}$ = 12724 kNm/m
  - $SF_{sliding}$ = 3.61

- **Max. pressure-reading**
  - SWL: +3.50
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 3.92 m

- **Goda pressure distribution**
  - SWL: +3.50
  - $T_p$: 8 s
  - $H_{m0}^{Gen}$ = 3.92 m
  - $F_H$ = 555 kN/m
  - $F_V$ = 146 kN/m
  - $M_{tilting}$ = 7756 kNm/m
Test no. 2.1.5, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen}$ = 4.15 m

![Graph showing test results for Test 2.1.5, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen}$ = 4.15 m]
Chapter A. Characteristic Pressure Readings

Test no. 2.1.6, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 4.74$ m

---

Max. horizontal force
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.74$ m
$F_H = 832$ kN/m
$F_V = 383$ kN/m
$M_{tilting} = 14891$ kNm/m

Max. uplift force
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.74$ m
$F_H = 509$ kN/m
$F_V = 438$ kN/m
$M_{tilting} = 10976$ kNm/m

Max. tilting moment
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.74$ m
$F_H = 830$ kN/m
$F_V = 385$ kN/m
$M_{tilting} = 14909$ kNm/m
$S_{F_{tilting}} = 3.15$

Min. sliding failure
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.74$ m
$F_H = 830$ kN/m
$F_V = 385$ kN/m
$M_{tilting} = 14909$ kNm/m
$S_{F_{sliding}} = 2.80$

Max. pressure-reading
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.74$ m

Goda pressure distribution
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.74$ m
$F_H = 689$ kN/m
$F_V = 176$ kN/m
$M_{tilting} = 9689$ kNm/m
Test no. 2.1.7, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 4.87$ m

- **Max. horizontal force**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{Gen} = 4.87$ m
  - $F_H = 863$ kN/m
  - $F_V = 301$ kN/m
  - $M_{tilting} = 15503$ kNm/m

- **Max. uplift force**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{Gen} = 4.87$ m
  - $F_H = 669$ kN/m
  - $F_V = 429$ kN/m
  - $M_{tilting} = 13344$ kNm/m

- **Min. sliding failure**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{Gen} = 4.87$ m
  - $F_H = 857$ kN/m
  - $F_V = 319$ kN/m
  - $M_{tilting} = 15383$ kNm/m
  - $SF_{sliding} = 2.76$

- **Max. pressure-reading**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{Gen} = 4.87$ m

Goda pressure distribution
- SWL: +3.50
- $T_p = 8$ s
- $H_{m0}^{Gen} = 4.87$ m
- $F_H = 711$ kN/m
- $F_V = 181$ kN/m
- $M_{tilting} = 9998$ kNm/m
- $SF_{sliding} = 2.75$
Chapter A. Characteristic Pressure Readings

Test no. 2.2.1, SWL: +3.50, $T_p$: 16 s, $H_{\text{Gen}} = 2.50$ m

---

Test 2.2.1
Max. horizontal force
SWL: +3.50
$T_p$: 16 s
$H_{\text{Gen}} = 2.50$ m
$F_H = 738$ kN/m
$F_V = 389$ kN/m
$M_{\text{tilting}} = 13023$ kNm/m

Test 2.2.1
Max. uplift force
SWL: +3.50
$T_p$: 16 s
$H_{\text{Gen}} = 2.50$ m
$F_H = 724$ kN/m
$F_V = 397$ kN/m
$M_{\text{tilting}} = 12995$ kNm/m

Test 2.2.1
Max. tilting moment
SWL: +3.50
$T_p$: 16 s
$H_{\text{Gen}} = 2.50$ m
$F_H = 736$ kN/m
$F_V = 389$ kN/m
$M_{\text{tilting}} = 13040$ kNm/m

Test 2.2.1
Max. pressure-reading
SWL: +3.50
$T_p$: 16 s
$H_{\text{Gen}} = 2.50$ m

Goda pressure distribution
SWL: +3.50
$T_p$: 16 s
$H_{\text{Gen}} = 2.50$ m
$F_H = 559$ kN/m
$F_V = 230$ kN/m
$M_{\text{tilting}} = 8166$ kNm/m

---
Chapter A. Characteristic Pressure Readings

Test no. 2.2.2, SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 3.04$ m

![Diagram: Max. horizontal force](image_1)

- Max. horizontal force
  - SWL: +3.50
  - $T_p$: 16 s
  - $H_{m0}^{Gen} = 3.04$ m
  - $F_H = 892$ kN/m
  - $F_V = 387$ kN/m
  - $M_{tilting} = 14916$ kNm/m

- Max. uplift force
  - SWL: +3.50
  - $T_p$: 16 s
  - $H_{m0}^{Gen} = 3.04$ m
  - $F_H = 799$ kN/m
  - $F_V = 434$ kN/m
  - $M_{tilting} = 14222$ kNm/m

- Max. tilting moment
  - SWL: +3.50
  - $T_p$: 16 s
  - $H_{m0}^{Gen} = 3.04$ m
  - $F_H = 884$ kN/m
  - $F_V = 428$ kN/m
  - $M_{tilting} = 15342$ kNm/m
  - $SF_{tilting} = 3.06$

- Min. sliding failure
  - SWL: +3.50
  - $T_p$: 16 s
  - $H_{m0}^{Gen} = 3.04$ m
  - $F_H = 884$ kN/m
  - $F_V = 428$ kN/m
  - $M_{tilting} = 15342$ kNm/m
  - $SF_{sliding} = 2.60$

Goda pressure distribution

- SWL: +3.50
- $T_p$: 16 s
- $H_{m0} = 3.04$ m
- $F_H = 694$ kN/m
- $F_V = 280$ kN/m
- $M_{tilting} = 10181$ kNm/m

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Test no. 2.2.3, SWL: +3.50, $T_p$: 16 s, $H_{Gen}^{mid} = 3.66$ m

---

**Test 2.2.3**
Max. horizontal force
SWL: +3.50
$T_p$: 16 s
$H_{Gen}^{mid} = 3.66$ m
$F_H = 1160$ kN/m
$F_V = 520$ kN/m
$M_{tilting} = 19975$ kNm/m

---

**Test 2.2.3**
Max. uplift force
SWL: +3.50
$T_p$: 16 s
$H_{Gen}^{mid} = 3.66$ m
$F_H = 1160$ kN/m
$F_V = 538$ kN/m
$M_{tilting} = 20258$ kNm/m

---

**Test 2.2.3**
Max. tilting moment
SWL: +3.50
$T_p$: 16 s
$H_{Gen}^{mid} = 3.66$ m
$F_H = 1160$ kN/m
$F_V = 538$ kN/m
$M_{tilting} = 20258$ kNm/m
$S_F_{tilting} = 2.32$

---

**Test 2.2.3**
Min. sliding failure
SWL: +3.50
$T_p$: 16 s
$H_{Gen}^{mid} = 3.66$ m
$F_H = 1160$ kN/m
$F_V = 538$ kN/m
$M_{tilting} = 20258$ kNm/m
$S_F_{sliding} = 1.93$

---

**Goda pressure distribution**
SWL: +3.50
$T_p$: 16 s
$H_{Gen}^{mid} = 3.66$ m
$F_H = 857$ kN/m
$F_V = 337$ kN/m
$M_{tilting} = 12641$ kNm/m
Test no. 2.2.4, SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 3.77$ m

**Max. horizontal force**
- SWL: +3.50
- $T_p = 16$ s
- $H_{m0}^{Gen} = 3.77$ m
- $F_H = 952$ kN/m
- $F_V = 449$ kN/m
- $M_{tilting} = 16457$ kNm/m

**Max. uplift force**
- SWL: +3.50
- $T_p = 16$ s
- $H_{m0}^{Gen} = 3.77$ m
- $F_H = 919$ kN/m
- $F_V = 468$ kN/m
- $M_{tilting} = 16003$ kNm/m

**Max. tilting moment**
- SWL: +3.50
- $T_p = 16$ s
- $H_{m0}^{Gen} = 3.77$ m
- $F_H = 950$ kN/m
- $F_V = 460$ kN/m
- $M_{tilting} = 16574$ kNm/m
- $SF_{tilting} = 2.83$

**Min. sliding failure**
- SWL: +3.50
- $T_p = 16$ s
- $H_{m0}^{Gen} = 3.77$ m
- $F_H = 950$ kN/m
- $F_V = 460$ kN/m
- $M_{tilting} = 16574$ kNm/m
- $SF_{sliding} = 2.40$

**Max. pressure-reading**
- SWL: +3.50
- $T_p = 16$ s
- $H_{m0}^{Gen} = 3.77$ m

**Goda pressure distribution**
- SWL: +3.50
- $T_p = 16$ s
- $H_{m0}^{Gen} = 3.77$ m
- $F_H = 886$ kN/m
- $F_V = 347$ kN/m
- $M_{tilting} = 13079$ kNm/m
Chapter A. Characteristic Pressure Readings

Test no. 2.2.5, SWL: +3.50, \( T_p: 16 \) s, \( H_{\text{Incl}}^{\text{Gen}} = 4.36 \) m
Chapter A. Characteristic Pressure Readings

Test no. 2.2.6, SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 4.84$ m
A.2 Crown wall loads

Test no. 1.1.1, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 2.21$ m

Max. horizontal force
SWL: +0.09
$T_p = 8$ s
$H_{m0}^{Gen} = 2.21$ m
$F_H = 4$ kN/m
$F_V = 2$ kN/m
$M_{tilting} = 14$ kNm/m

Max. uplift force
SWL: +0.09
$T_p = 8$ s
$H_{m0}^{Gen} = 2.21$ m
$F_H = 2$ kN/m
$F_V = 3$ kN/m
$M_{tilting} = 13$ kNm/m

Max. tilting moment
SWL: +0.09
$T_p = 8$ s
$H_{m0}^{Gen} = 2.21$ m
$F_H = 3$ kN/m
$F_V = 1$ kN/m
$M_{tilting} = 16$ kNm/m

Max. pressure-reading
SWL: +0.09
$T_p = 8$ s
$H_{m0}^{Gen} = 2.21$ m
$F_H = 2$ kN/m
$F_V = 2$ kN/m
$M_{tilting} = 15$ kNm/m
Test no. 1.1.2, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 2.72$ m

**Max. horizontal force**

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$: 2.72 m
- $F_H$: 4 kN/m
- $F_V$: 1 kN/m
- $M_{tilting}$: 13 kNm/m

**Max. uplift force**

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$: 2.72 m
- $F_H$: 0 kN/m
- $F_V$: 3 kN/m
- $M_{tilting}$: 7 kNm/m

**Max. tilting moment**

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$: 2.72 m
- $F_H$: 3 kN/m
- $F_V$: 2 kN/m
- $M_{tilting}$: 16 kNm/m

**Min. sliding failure**

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$: 2.72 m
- $F_H$: 3 kN/m
- $F_V$: 3 kN/m
- $M_{tilting}$: 12 kNm/m

**Max. pressure-reading**

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$: 2.72 m
Test no. 1.1.3, SWL: +0.09, \(T_p: 8\) s, \(H^{Gen}_{m0} = 3.03\) m
Chapter A. Characteristic Pressure Readings

Test no. 1.1.4, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 3.57$ m

---

Max. horizontal force

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$ = 3.57 m
- $F_H = 4$ kN/m
- $F_V = −0$ kN/m
- $M_{tilting} = 12$ kNm/m

---

Max. uplift force

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$ = 3.57 m
- $F_H = 1$ kN/m
- $F_V = 3$ kN/m
- $M_{tilting} = 6$ kNm/m

---

Max. tilting moment

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$ = 3.57 m
- $F_H = 3$ kN/m
- $F_V = 1$ kN/m
- $M_{tilting} = 16$ kNm/m

---

Min. sliding failure

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$ = 3.57 m
- $F_H = 4$ kN/m
- $F_V = 3$ kN/m
- $M_{tilting} = 14$ kNm/m

---

Max. pressure-reading

- SWL: +0.09
- $T_p$: 8 s
- $H_{m0}^{Gen}$ = 3.57 m
Test no. 1.1.5, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 3.74$ m
Chapter A. Characteristic Pressure Readings

Test no. 1.1.6, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.06$ m
Test no. 1.1.7, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.52$ m
Chapter A. Characteristic Pressure Readings

Test no. 1.1.8, SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.68$ m

Test 1.1.8 Max. horizontal force

Max. uplift force

Max. tilting moment

Min. sliding failure

Max. pressure-reading

Pressure in [kPa]
Test no. 1.2.1, SWL: +0.09, \( T_p: 16 \) s, \( H_{m0}^{Gen} = 2.22 \) m
Test no. 1.2.2, SWL: +0.09, $T_p$: 16 s, $H_{Gen}^{m0} = 2.51$ m
Test no. 1.2.3, SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen}$ = 2.70 m
Test no. 1.2.4, SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 3.35$ m

**Max. horizontal force**

- SWL: +0.09
- $T_p$: 16 s
- $H_{m0}^{Gen} = 3.35$ m
- $F_H = 4$ kN/m
- $F_V = 1$ kN/m
- $M_{tilting} = 12$ kNm/m

**Max. uplift force**

- SWL: +0.09
- $T_p$: 16 s
- $H_{m0}^{Gen} = 3.35$ m
- $F_H = -1$ kN/m
- $F_V = 4$ kN/m
- $M_{tilting} = 12$ kNm/m

**Max. tilting moment**

- SWL: +0.09
- $T_p$: 16 s
- $H_{m0}^{Gen} = 3.35$ m
- $F_H = 3$ kN/m
- $F_V = 2$ kN/m
- $M_{tilting} = 15$ kNm/m

**Min. sliding failure**

- SWL: +0.09
- $T_p$: 16 s
- $H_{m0}^{Gen} = 3.35$ m
- $F_H = 3$ kN/m
- $F_V = 2$ kN/m
- $M_{tilting} = 15$ kNm/m

**Max. pressure-reading**

- SWL: +0.09
- $T_p$: 16 s
- $H_{m0}^{Gen} = 3.35$ m
Test no. 1.2.5, SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 3.66$ m
Chapter A. Characteristic Pressure Readings

Test no. 1.2.6, SWL: +0.09, $T_p$: 16 s, $H^{Gen} = 4.19$ m

- **Max. horizontal force**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H^{Gen} = 4.19$ m
  - $F_H = 4$ kN/m
  - $F_V = 0$ kN/m
  - $M_{tilting} = 15$ kNm/m

- **Max. uplift force**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H^{Gen} = 4.19$ m
  - $F_H = 1$ kN/m
  - $F_V = 4$ kN/m
  - $M_{tilting} = 8$ kNm/m

- **Max. tilting moment**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H^{Gen} = 4.19$ m
  - $F_H = 4$ kN/m
  - $F_V = 1$ kN/m
  - $M_{tilting} = 22$ kNm/m

- **Min. sliding failure**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H^{Gen} = 4.19$ m
  - $F_H = 4$ kN/m
  - $F_V = 2$ kN/m
  - $M_{tilting} = 15$ kNm/m

- **Max. pressure-reading**
  - SWL: +0.09
  - $T_p$: 16 s
  - $H^{Gen} = 4.19$ m
Test no. 1.2.7, SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 4.28$ m
Test no. 2.1.1, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 2.70$ m
Test no. 2.1.2, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 3.14$ m

Test 2.1.2 Max. horizontal force
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen}$ = 3.14 m
$F_H$ = 14 kN/m
$F_V$ = 7 kN/m
$M_{tilting}$ = 14 kNm/m

Test 2.1.2 Max. uplift force
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen}$ = 3.14 m
$F_H$ = 0 kN/m
$F_V$ = 24 kN/m
$M_{tilting}$ = 30 kNm/m

Test 2.1.2 Max. tilting moment
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen}$ = 3.14 m
$F_H$ = 12 kN/m
$F_V$ = 18 kN/m
$M_{tilting}$ = 51 kNm/m

Test 2.1.2 Min. sliding failure
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen}$ = 3.14 m
$F_H$ = 12 kN/m
$F_V$ = 18 kN/m
$M_{tilting}$ = 51 kNm/m

Test 2.1.2 Max. pressure-reading
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen}$ = 3.14 m
Test no. 2.1.3, SWL: +3.50, \( T_p \): 8 s, \( H_{m0}^{Gen} = 3.31 \) m

- **Max. horizontal force**
  - SWL: +3.50
  - \( T_p = 8 \) s
  - \( H_{m0}^{Gen} = 3.31 \) m
  - \( F_H = 12 \) kN/m
  - \( F_V = 14 \) kN/m
  - \( M_{tilting} = 52 \) kNm/m

- **Max. uplift force**
  - SWL: +3.50
  - \( T_p = 8 \) s
  - \( H_{m0}^{Gen} = 3.31 \) m
  - \( F_H = -4 \) kN/m
  - \( F_V = 28 \) kN/m
  - \( M_{tilting} = 32 \) kNm/m

- **Max. tilting moment**
  - SWL: +3.50
  - \( T_p = 8 \) s
  - \( H_{m0}^{Gen} = 3.31 \) m
  - \( F_H = 12 \) kN/m
  - \( F_V = 14 \) kN/m
  - \( M_{tilting} = 52 \) kNm/m

- **Min. sliding failure**
  - SWL: +3.50
  - \( T_p = 8 \) s
  - \( H_{m0}^{Gen} = 3.31 \) m
  - \( F_H = 8 \) kN/m
  - \( F_V = 24 \) kN/m
  - \( M_{tilting} = 50 \) kNm/m

- **Max. pressure-reading**
  - SWL: +3.50
  - \( T_p = 8 \) s
  - \( H_{m0}^{Gen} = 3.31 \) m
Chapter A. Characteristic Pressure Readings

Test no. 2.1.4, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 3.92$ m
Chapter A. Characteristic Pressure Readings

Test no. 2.1.5, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 4.15$ m

Max. horizontal force
- SWL: +3.50
- $T_p$: 8 s
- $H_{m0}^{Gen} = 4.15$ m
- $F_H = 12$ kN/m
- $F_V = 11$ kN/m
- $M_{tilting} = 42$ kNm/m

Max. uplift force
- SWL: +3.50
- $T_p$: 8 s
- $H_{m0}^{Gen} = 4.15$ m
- $F_H = -1$ kN/m
- $F_V = 30$ kN/m
- $M_{tilting} = 42$ kNm/m

Max. tilting moment
- SWL: +3.50
- $T_p$: 8 s
- $H_{m0}^{Gen} = 4.15$ m
- $F_H = 6$ kN/m
- $F_V = 11$ kN/m
- $M_{tilting} = 53$ kNm/m

Min. sliding failure
- SWL: +3.50
- $T_p$: 8 s
- $H_{m0}^{Gen} = 4.15$ m
- $F_H = 9$ kN/m
- $F_V = 20$ kN/m
- $M_{tilting} = 49$ kNm/m

Max. pressure-reading
- SWL: +3.50
- $T_p$: 8 s
- $H_{m0}^{Gen} = 4.15$ m

Pressure in [kPa]

Test 2.1.5
Max. horizontal force
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.15$ m
$F_H = 12$ kN/m
$F_V = 11$ kN/m
$M_{tilting} = 42$ kNm/m

Pressure in [kPa]

Test 2.1.5
Max. uplift force
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.15$ m
$F_H = -1$ kN/m
$F_V = 30$ kN/m
$M_{tilting} = 42$ kNm/m

Pressure in [kPa]

Test 2.1.5
Max. tilting moment
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.15$ m
$F_H = 6$ kN/m
$F_V = 11$ kN/m
$M_{tilting} = 53$ kNm/m

Pressure in [kPa]

Test 2.1.5
Min. sliding failure
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.15$ m
$F_H = 9$ kN/m
$F_V = 20$ kN/m
$M_{tilting} = 49$ kNm/m

Pressure in [kPa]

Test 2.1.5
Max. pressure-reading
SWL: +3.50
$T_p$: 8 s
$H_{m0}^{Gen} = 4.15$ m

Pressure in [kPa]
Test no. 2.1.6, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 4.74$ m

Max. horizontal force
- SWL: +3.50
- $T_p = 8$ s
- $H_{m0}^{Gen} = 4.74$ m
- $F_H = 15$ kN/m
- $F_V = 13$ kN/m
- $M_{tilting} = 53$ kNm/m

Max. uplift force
- SWL: +3.50
- $T_p = 8$ s
- $H_{m0}^{Gen} = 4.74$ m
- $F_H = 2$ kN/m
- $F_V = 38$ kN/m
- $M_{tilting} = 76$ kNm/m

Max. tilting moment
- SWL: +3.50
- $T_p = 8$ s
- $H_{m0}^{Gen} = 4.74$ m
- $F_H = 2$ kN/m
- $F_V = 38$ kN/m
- $M_{tilting} = 76$ kNm/m

Min. sliding failure
- SWL: +3.50
- $T_p = 8$ s
- $H_{m0}^{Gen} = 4.74$ m
- $F_H = 14$ kN/m
- $F_V = 22$ kN/m
- $M_{tilting} = 65$ kNm/m

Max. pressure-reading
- SWL: +3.50
- $T_p = 8$ s
- $H_{m0}^{Gen} = 4.74$ m
Test no. 2.1.7, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{\text{Gen}} = 4.87$ m

- **Max. horizontal force**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{\text{Gen}} = 4.87$ m
  - $F_H = 15$ kN/m
  - $F_V = 14$ kN/m
  - $M_{\text{tilting}} = 54$ kNm/m

- **Max. uplift force**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{\text{Gen}} = 4.87$ m
  - $F_H = 3$ kN/m
  - $F_V = 43$ kN/m
  - $M_{\text{tilting}} = 86$ kNm/m

- **Max. tilting moment**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{\text{Gen}} = 4.87$ m
  - $F_H = 3$ kN/m
  - $F_V = 43$ kN/m
  - $M_{\text{tilting}} = 86$ kNm/m

- **Max. pressure-reading**
  - SWL: +3.50
  - $T_p = 8$ s
  - $H_{m0}^{\text{Gen}} = 4.87$ m
Test no. 2.2.1, SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 2.50$ m

Chapter A. Characteristic Pressure Readings

Page LIV
Test no. 2.2.2, SWL: +3.50, $T_p$: 16 s, $H_{mid}^{Gen} = 3.04$ m
Chapter A. Characteristic Pressure Readings

Test no. 2.2.3, SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 3.66$ m

- Max. horizontal force
  - SWL: +3.50
  - $T_p = 16$ s
  - $H_{m0}^{Gen} = 3.66$ m
  - $F_H = 28$ kN/m
  - $F_V = 59$ kN/m
  - $M_{tilting} = 156$ kNm/m

- Max. uplift force
  - SWL: +3.50
  - $T_p = 16$ s
  - $H_{m0}^{Gen} = 3.66$ m
  - $F_H = 26$ kN/m
  - $F_V = 68$ kN/m
  - $M_{tilting} = 160$ kNm/m

- Max. tilting moment
  - SWL: +3.50
  - $T_p = 16$ s
  - $H_{m0}^{Gen} = 3.66$ m
  - $F_H = 28$ kN/m
  - $F_V = 64$ kN/m
  - $M_{tilting} = 163$ kNm/m

- Min. sliding failure
  - SWL: +3.50
  - $T_p = 16$ s
  - $H_{m0}^{Gen} = 3.66$ m
  - $F_H = 28$ kN/m
  - $F_V = 65$ kN/m
  - $M_{tilting} = 162$ kNm/m

- Max. pressure-reading
  - SWL: +3.50
  - $T_p = 16$ s
  - $H_{m0}^{Gen} = 3.66$ m
Chapter A. Characteristic Pressure Readings

Test no. 2.2.4, SWL: +3.50, $T_p$: 16 s, $H^{Gen}_{mid} = 3.77$ m

![Graph of max. horizontal force](image1)

- SWL: +3.50
- $T_p$: 16 s
- $H^{Gen}_{mid} = 3.77$ m
- $F_H = 29$ kN/m
- $F_V = 65$ kN/m
- $M_{tilting} = 158$ kNm/m

![Graph of max. uplift force](image2)

- SWL: +3.50
- $T_p$: 16 s
- $H^{Gen}_{mid} = 3.77$ m
- $F_H = 20$ kN/m
- $F_V = 70$ kN/m
- $M_{tilting} = 152$ kNm/m

![Graph of max. tilting moment](image3)

- SWL: +3.50
- $T_p$: 16 s
- $H^{Gen}_{mid} = 3.77$ m
- $F_H = 28$ kN/m
- $F_V = 68$ kN/m
- $M_{tilting} = 164$ kNm/m

![Graph of min. sliding failure](image4)

- SWL: +3.50
- $T_p$: 16 s
- $H^{Gen}_{mid} = 3.77$ m
- $F_H = 28$ kN/m
- $F_V = 68$ kN/m
- $M_{tilting} = 161$ kNm/m

![Graph of max. pressure-reading](image5)

- SWL: +3.50
- $T_p$: 16 s
- $H^{Gen}_{mid} = 3.77$ m
- $F_H = 28$ kN/m
- $F_V = 68$ kN/m
- $M_{tilting} = 161$ kNm/m

Page LVII
Test no. 2.2.5, SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 4.36$ m
Test no. 2.2.6, SWL: +3.50, $T_p$: 16 s, $H_{Gen}^{m0} = 4.84$ m
Test no. 1.1.1 - SWL: +0.09, Tp: 8 s, $H_{m0}^{Gen} = 2.21$ m, $H_{m0}^{Gen*} = 1.92$ m

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Chapter B. Armour Stability Photos

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Test no. 1.1.2 - SWL: +0.09, T_p: 8 s, H_{m0}^{Gen} = 2.72 m, H_{m0}^{Gen\ast} = 2.36 m

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Test no. 1.1.3 - SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 3.03$ m, $H_{m0}^{Gen\ast} = 2.63$ m

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Chapter B. Armour Stability Photos

Test no. 1.1.4 - SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 3.57$ m, $H_{m0}^{Gen\ast} = 3.10$ m

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Chapter B. Armour Stability Photos

Test no. 1.1.5 - SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 3.74$ m, $H_{m0}^{Gen*} = 3.25$ m

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Chapter B. Armour Stability Photos

Test no. 1.1.6 - SWL: +0.09, T_p: 8 s, H_{m0}^{Gen} = 4.06 m, H_{m0}^{Gen*} = 3.53 m

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Test no. 1.1.7 - SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.52$ m, $H_{m0}^{Gen*} = 3.93$ m

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Test no. 1.1.7 - SWL: +0.09, $T_p$: 8 s, $H_{m0}^{Gen} = 4.68$ m, $H_{m0}^{Gen*} = 4.07$ m

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Chapter B. Armour Stability Photos

Test no. 1.2.1 - SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 2.22$ m, $H_{m0}^{Gen*} = 1.93$ m

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Test no. 1.2.2 - SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 2.51$ m, $H_{m0}^{Gen^*} = 2.18$ m

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Test no. 1.2.3 - SWL: +0.09, $T_p$: 16 s, $H^{Gen}_{m0} = 2.70$ m, $H^{Gen*}_{m0} = 2.35$ m

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Test no. 1.2.4 - SWL: $+0.09$, $T_p$: 16 s, $H_{m0}^{Gen} = 3.35$ m, $H_{m0}^{Gen*} = 2.91$ m

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Test no. 1.2.5 - SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 3.66$ m, $H_{m0}^{Gen*} = 3.18$ m

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Test no. 1.2.6 - SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 4.19$ m, $H_{m0}^{Gen*} = 3.64$ m

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Test no. 1.2.7 - SWL: +0.09, $T_p$: 16 s, $H_{m0}^{Gen} = 4.28$ m, $H_{m0}^{Gen*} = 3.73$ m

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Chapter B. Armour Stability Photos

Test no. 2.1.1 - SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 2.70$ m, $H_{m0}^{Gen*} = 2.34$ m

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Test no. 2.1.2 - SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 3.14$ m, $H_{m0}^{Gen*} = 2.73$ m

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### Chapter B. Armour Stability Photos

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Test no. 2.1.3 - SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 3.31$ m, $H_{m0}^{Gen*} = 2.88$ m
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Test no. 2.1.4 - SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 3.92$ m, $H_{m0}^{Gen*} = 3.41$ m

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</table>
Chapter B. Armour Stability Photos

Test no. 2.1.5 - SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 4.15$ m, $H_{m0}^{Gen\ast} = 3.61$ m

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Chapter B. Armour Stability Photos

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Test no. 2.1.6 - SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 4.74$ m, $H_{m0}^{Gen*} = 4.12$ m

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Test no. 2.1.7 - SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen} = 4.87$ m, $H_{m0}^{Gen*} = 4.24$ m

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## Chapter B. Armour Stability Photos

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Test no. 2.2.1 - SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 2.50$ m, $H_{m0}^{Gen*} = 2.17$ m
## Chapter B. Armour Stability Photos

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Test no. 2.2.2 - SWL: +3.50, $T_p$: 16 s, $H_{m0}^{\text{Gen}} = 3.04$ m, $H_{m0}^{\text{Gen}} = 2.64$ m

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Test no. 2.2.3 - SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 3.66$ m, $H_{m0}^{Gen\ast} = 3.18$ m
Chapter B. Armour Stability Photos

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Test no. 2.2.4 - SWL: +3.50, $T_p$: 16 s, $H_{m0}^{gen} = 3.77$ m, $H_{m0}^{gen*} = 3.27$ m

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Test no. 2.2.5 - SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 4.36$ m, $H_{m0}^{Gen*} = 3.80$ m

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Test no. 2.2.6 - SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 4.84$ m, $H_{m0}^{Gen*} = 4.21$ m

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Test no. (2.2.6) - SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen} = 4.70$ m, $H_{m0}^{Gen*} = 4.09$ m

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</table>
Two interesting sequences have been identified for the rubble mound breakwater, with SWL = +3.5, \( T_p = 8 \) and 16 s and \( H_{m0} \approx 4.8 \) m. Regarding the overtopping for the other tests, very insignificant discharge was observed, as shown in Table 9.1.
Test no. 2.1.6, SWL: +3.50, $T_p$: 8 s, $H_{m0}^{Gen}$: 4.74 m
Test no. 2.2.6, SWL: +3.50, $T_p$: 16 s, $H_{m0}^{Gen}$: 4.84 m