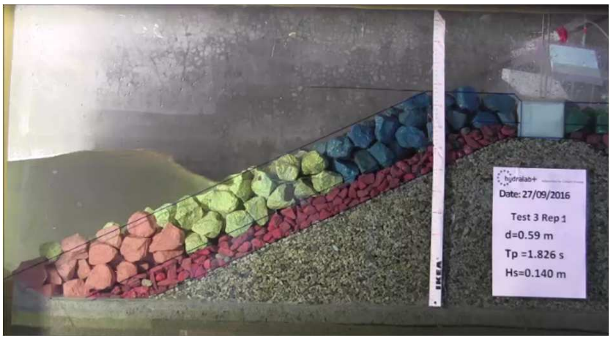
Data Storage Report

RECIPE Task 8.2: Overtopping events in breakwaters under climate change scenarios



Project Information

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Document History

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	Draft			
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Document objective

This data storage report describes the project and how data were collected. The data are described so that others can use them.

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Contents

The draft Data Storage Report should be completed BEFORE the tests have started. After the tests, the the final Data Storage Report should be completed, but this may be an iterative process. The report describes the data and how it is stored in order to make it available for those interested. Note that for HYDRALAB ACCESS user groups, they have the first right of publication during a period of two years, but after that any European researcher should be able to use the data.
The data storage report should contain a list of instruments, tests conducted, a full explanation of parameters, and all other relevant information. It also contains a list of files, and a description of what is in the files (identify what is in each column in the table that is stored in the file, such as 'time (s)', 'pressure at location 1 (Pa)', etc., including type of column separator). It should be made clear which test corresponds with which file. Give also the data type: binary / ascii.
The report should be updated as often as necessary, particularly during the tests.
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1 Introduction

1.1 Scientific background

Reliable prediction of wave run-up/overtopping and structure damage is a key task in the design and safety assessment of coastal and harbor structures. Run-up/overtopping and damage must be below acceptable limits, both in extreme and in normal operating conditions, to guarantee the stability of the structure and the safety of people and assets on and behind the structure. The mean-sea-level rise caused by climate change and its effects on wave climate may increase the number and intensity of run-up/overtopping events and make the existing coastal/harbor structures more vulnerable to damage. Accurate estimates, through physical modelling, of the statistics of overtopping waves for a set of climate change conditions, are needed. The research project HYDRALAB+ (H2020-INFRAIA-2014-2015) gathers an advanced network of environmental hydraulic institutes in Europe, which provides access to a suite of environmental hydraulic facilities. They play a vital role in the development of climate change adaptation strategies, by allowing the direct testing of adaptation measures and by providing data for numerical model calibration and validation. The use of physical (scale) models allows the simulation of extreme events as they are now, and as they are projected to be under different climate change scenarios.

1.2 Aims and Objectives

The experimental work developed at LNEC within HYDRALAB+, task 8.2 of RECIPE, entitled “Damage characterization under variable and unsteady test conditions”, aims at characterising damage, run-up and overtopping of a rubble mound breakwater section under variable and unsteady test conditions, which include extreme events and climate change scenarios.

These experiments are intended to ensure that physical hydraulic modelling plays its full role in solving problems of climate change mitigation and adaptation. One of the objectives is to develop protocols for experiments in physical models representative of extreme events (storms, floods, etc.) or sequence of such events, since these events and their frequency are strongly impacted by climate change.

The data collection is used:

- For comparison of measured (physical model tests) and predicted (empirical formulae, EurOtop(2016)) run-up, mean overtopping discharges and individual overtopping volumes at a cross-section of a rubble mound breakwater subject to climate change scenarios (Mendonça et al., 2017);
- To evaluate damage evolution under future climate change scenarios (Lemos et al., 2018).

2 Experimental setup

2.1 General description of experimental setup

Model setup

LNEC´s experiments were performed at the Ports and Maritime Structures Unit (NPE) of the Hydraulics and Environment Department of LNEC, in a wave flume (COI 1) approximately 50 m long, with an operating width and an operating water depth of 80 cm.

The flume is equipped with a piston-type wave-maker that combines both irregular wave generation and dynamic absorption of reflected waves through the use of two wave gauges located in front of the paddle, AWA0 and AWA1 (Figure 2-1). Fourteen additional resistive-type wave gauges were deployed along the flume (Figure 2-1) and gauge Sr5 was placed on the model armor layer slope to measure run-up levels. A computer was used to collect and store the measured data, in digital format, at a frequency of 25Hz.

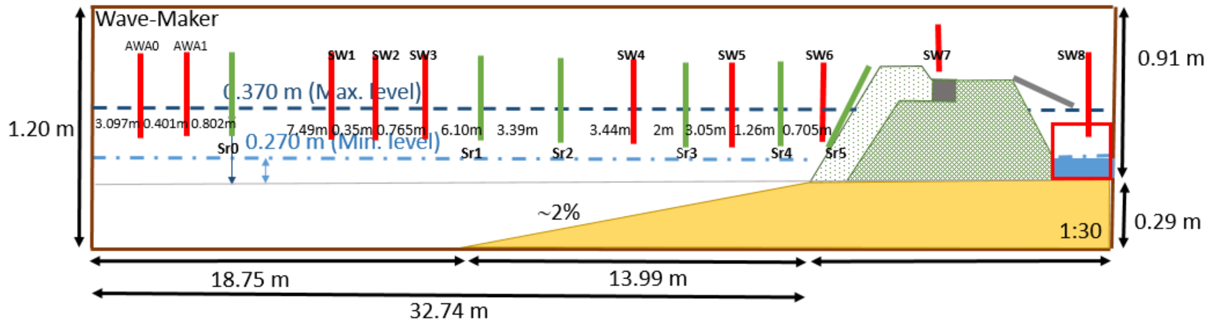

Figure 2-1. Sketch of the experimental setup in the wave flume (dimensions for a 1:30 scale and for the minimum and maximum water levels).

The equipment used to collect the overtopping water consisted on a tank, located at the back of the structure. The water was directed to the tank by means of a chute, 40 cm wide. The overtopping tank was placed over a weighing scale (KERN KXS-TM), which also allowed the measurement of the overtopping variation in time. The measured data were collected and stored, in digital format, at a frequency of 1Hz (Figure 2-2).

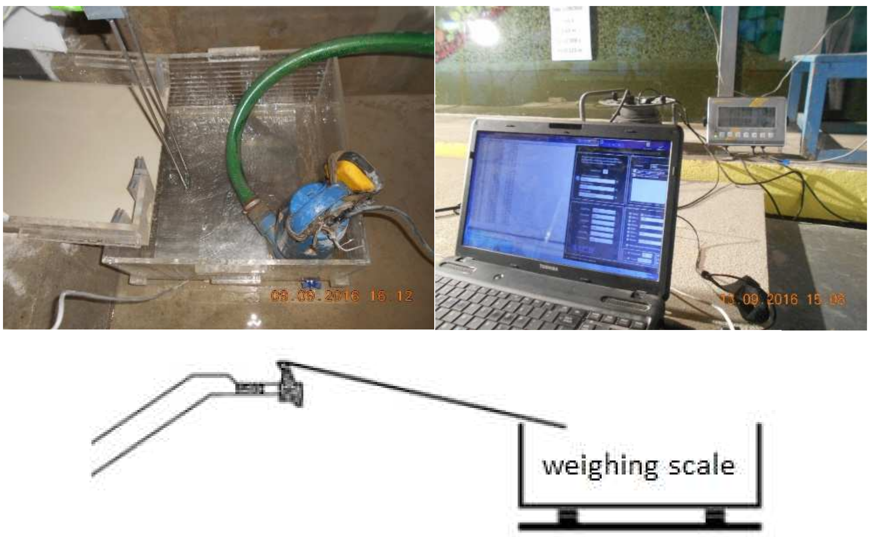

Figure 2-2. Setup for overtopping measurement.

The breakwater model was built and operated according to Froude's similarity law, with a geometrical scale of 1:30, to ensure reduced scale effects (wave heights should lead to values of the Reynolds number Re>3x10^4). The breakwater cross-section at prototype scale is presented in Figure 2-3.

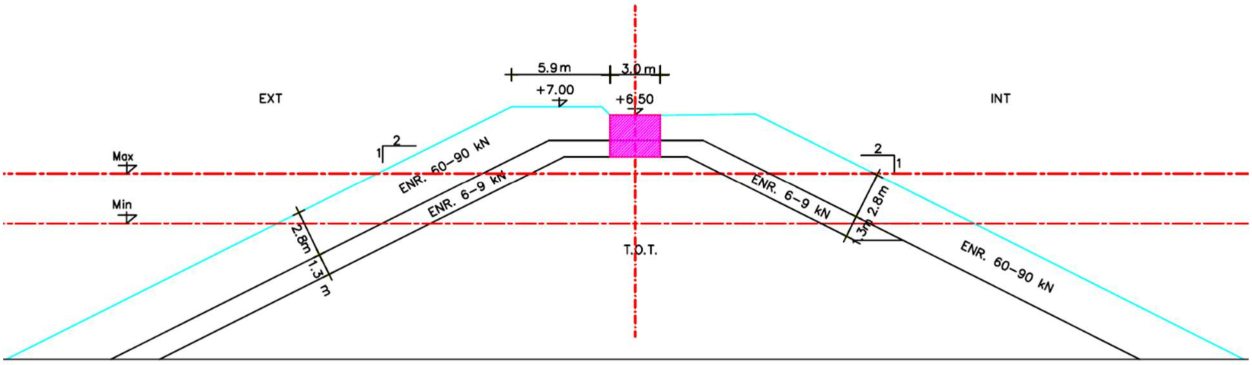

Figure 2-3. Breakwater cross-section at prototype scale (natural seabed at -8.1 m (CD)).

2.2 General data storage principles and organization of data files

The data uploaded is level L0 and L1, saved as ".TXT", ".ASC", ".mat" and ".JPG".
Files ".TXT" and ".ASC" can be open/edit in, for e.g., Notepad++.
Files ".mat" can be open in MatLab.
Files ".JPG" are image files.
Data is organized in 4 main folders "**Storm_SequenceA**", "**Storm_SequenceB**", "**Storm_SequenceC**" and "**Storm_SequenceE**" corresponding to each storm sequence tested.

Each "Storm_Sequence *n*" folder has 4 subfolders described as:

- "**Damage**": with subfolders "*day_month_year*"
  - Each folder "*day_month_year*" has:
    - Files "Test*x*_..._.JPG" to analyse damage
    - Subfolder "Camera_calibration" with ".JPG" and ".mat" files

- "**Spider**": with subfolders called "series*y*". Each "series*y*" is a repetition of the storm sequence
  - Each folder "series*y*: has:
    - Files "Teste*x*_..._*date*.ASC" with information on time series of surface elevation (in Volts) in 6 wave gauges, Sr0 to Sr5 (Figure 2-1). The first column of each file refers to time (dt=0.04s)
    - Files "Calib_coefs_*date*.txt" with information on the gauges calibration values to be multiplied by the surface elevation (in Volts) from files "Teste*x*_..._*date*.ASC"

- "**Wallingford**": with subfolders called "series*y*". Each "series*y*" is a repetition of the storm sequence:
  - Each folder "series*y*: has:
    - Files "Teste*x*_..._*date*.txt" with information on time series of surface elevation (in Volts) in 8 wave gauges, SW1 to SW8 (Figure 2-1). Data is acquired every 0.04s.
    - Files "Calib_coefs_*date*.txt" with information on the gauges calibration values to be multiplied by the surface elevation (in Volts) from files "Teste*x*_..._*date*.txt"
- "**Weighing scale**": with subfolders called "series*y*". Each "series*y*" is a repetition of the storm sequence:
  - Each folder "series*y*: has:
    - Files "Teste*x*_..._*date*.txt" with information on the overtopped water (kg) to the weighing scale.

2.3 Definition and application of spatial and temporal reference systems

No spatial or temporal reference systems were used. All spatial data is given relative to the flume. All temporal data is given in 'Model Time'.

2.4 Relevant fixed parameters

No relevant fixed parameters

2.5 Test Programme

Test approaches and conditions

Two-dimensional damage and overtopping tests for a rock armor slope were performed to represent five approaches: A) a standard cumulative storm build-up (with increasing wave heights and increasing peak period) with increasing water level; B) simulates a constant wave period, alternating water levels and increasing significant wave height; C) simulates, for two water levels, a standard storm build-up, with a constant peak period; and D) simulates a standard cumulative storm build-up with a constant water level. Also, 2D run-up and overtopping tests with an impermeable/smooth slope were performed (Approach E), to be compared with scaled HR Wallingford conditions (Silva et al.,2017).

Irregular wave tests conformed to a JONSWAP spectrum, with a peak enhancement factor of 3.3. Test durations were 1980 s, 2160 s and 2400 s for peak periods of 10 s, 11 s and 12 s, respectively (approximately 1000 waves). All tests were repeated at least three times.

The nominal test conditions are presented in Table 2-1, in which H_s represents the significant wave height at the toe of the structure and T_p the peak wave period. Tests 1-7 represent approach A; tests 10-17 represent approach B; tests 11, 13, 15, 17, 10, 12, 14 and 16 represent approach C; tests 1-3 and 4-7 represent approach D; and tests 22 and 23, represent approach E.

Table 2-1. Nominal test conditions at structure toe.

Storm sequence		Test number	Prototype			Model		
			Water depth (m)	**T_p (s)**	**H_s (m)**	**Water depth (m)**	**T_p (s)**	**H_s (m)**
A	D	1	9.1	10	3.2	0.30	1.826	0.107
		2	9.1	10	3.7	0.30	1.826	0.123
		3	9.1	10	4.2	0.30	1.826	0.140
	D	4	10.1	11	3.7	0.34	2.008	0.123
		5	10.1	11	4.2	0.34	2.008	0.140
		6	10.1	11	4.7	0.34	2.008	0.157
		7	10.1	11	5.2	0.34	2.008	0.173
Reconstruction								
B		10	11.1	12	3.7	0.37	2.191	0.123
		11	8.1	12	3.7	0.27	2.191	0.123
		12	11.1	12	4.2	0.37	2.191	0.140
		13	8.1	12	4.2	0.27	2.191	0.140
		14	11.1	12	4.7	0.37	2.191	0.157
		15	8.1	12	4.7	0.27	2.191	0.157
		16	11.1	12	5.2	0.37	2.191	0.173
		17	8.1	12	5.2	0.27	2.191	0.173
Reconstruction								
C		11	8.1	12	3.7	0.37	2.191	0.123
		13	8.1	12	4.2	0.27	2.191	0.140
		15	8.1	12	4.7	0.27	2.191	0.157
		17	8.1	12	5.2	0.27	2.191	0.173
		10	11.1	12	3.7	0.37	2.191	0.123
		12	11.1	12	4.2	0.37	2.191	0.140
		14	11.1	12	4.7	0.37	2.191	0.157
		16	11.1	12	5.2	0.37	2.191	0.173
Reconstruction								
E		22	9.3	7.2	3.0	0.31	1.311	0.100
		23	9.3	7.2	1.74	0.31	1.311	0.058

These tests were repeated at least three times, resulting in a dataset of about 100 experiments.

3 Instrumentation – Wage gauges Spider

3.1 Instruments

Six resistive-type wave gauges (Sr0 to Sr5)
Positions identified in Figure 2-1.

3.2 Measured parameters

- Coefficients for the wave gauge calibration (m/Volts)
- Water surface elevation (Volts)

3.3 Experimental procedure

Measurements of water surface elevation (Volts) were taken for Tests 1 to 17, for 1000 waves.
Time series of water surface elevation (m) for each wave gauge are obtained multiplying each time series of surface elevation by the calibration coefficient (m/Volts) of that wave gauge.
More details given in the Report "Protocols for representing variability and unsteadiness in flume facilities" (see References section).

3.4 Data post-processing

Details given in Mendonça et al. (2017) and in the Report "Protocols for representing variability and unsteadiness in flume facilities" (see References section).

3.5 Organization of data files

- Format: ASCII
- File name: *Teste"x"_depth_waveperiod_waveheight_date.ASC*
- column separator: space
- type of data: numeric
- units of data: Volts
- structure of file content: the first column of the file refers to time (dt=0.04s). The next 6 columns correspond to 6 wave gauges, Sr0 to Sr5 (Figure 2-1).
- organization of files in directories: Storm_Sequence"n"/spider/serie"y"

3.6 Remarks

Coefficients for the wave gauge calibration are in the file named: **Calib_coefs_*"date"*.txt**
Coefficients for the wave gauge calibration are in the directory: Storm_Sequence"n"/spider/serie"y"
Folders named **serie"y"** correspond to repetitions of a storm sequence.

4 Instrumentation – Wave gauges Wallingford

4.1 Instruments

Eight resistive-type wave gauges (SW1 to SW8)
Positions identified in Figure 2-1.

4.2 Measured parameters

- Coefficients for the wave gauge calibration (m/Volts)
- Water surface elevation (Volts)

4.3 Experimental procedure

Measurements of water surface elevation (Volts) were taken for Tests 1 to 23, for 1000 waves.
Time series of water surface elevation (m) for each wave gauge are obtained multiplying each time series of surface elevation by the calibration coefficient (m/Volts) of that wave gauge.
More details given in the Report "Protocols for representing variability and unsteadiness in flume facilities" (Moulin, 2018).

4.4 Data post-processing

Details given in Mendonça et al. (2017) and in the Report "Protocols for representing variability and unsteadiness in flume facilities" (Moulin, 2018).

4.5 Organization of data files

- Format: ASCII
- File name: *Teste"x"_depth_waveperiod_waveheight_date.txt*
- column separator: space
- type of data: numeric
- units of data: Volts
- structure of file content: Header with information on: channel names, start times and acquisition interval (dt=0.04s). Each file has 8 columns that correspond to 8 wave gauges, SW1 to SW8 (Figure 2-1).
- organization of files in directories: Storm_Sequence"n"/wallingford/serie"y"

4.6 Remarks

Coefficients for the wave gauge calibration are in the file named: **Calib_coefs_*"date"*.txt**
Coefficients for the wave gauge calibration are in the directory:
Storm_Sequence"n"/wallingford/serie"y"
Folders named **serie"y"** correspond to repetitions of a storm sequence.

5 Instrumentation – Weighing Scale]

5.1 Instruments

One weighing scale KERN KXS-TM.
Tank positioned over the weighing scale.
Chute, 40 cm wide, to direct water to the tank.
Positions identified in Figure 2-1.

5.2 Measured parameters

- Water overtopping the structure (kg)

5.3 Experimental procedure

Measurements of wave overtopping by weighing the water that is directed to the tank.
Time series of wave overtopping (kg) are measured for Tests 1 to 17, for 1000 waves.
More details given in the Report "Protocols for representing variability and unsteadiness in flume facilities" (see References section).

5.4 Data post-processing

Details given in Mendonça et al. (2017) and in the Report "Protocols for representing variability and unsteadiness in flume facilities" (Moulin, 2018).

5.5 Organization of data files

- Format: ASCII
- File name: *Teste"x"_depth_waveperiod_waveheight_date.txt*
- column separator: space
- type of data: numeric
- units of data: kg
- structure of file content: Each file has 4 columns: overtopping water, units, date, time
- organization of files in directories: Storm_Sequence"n"/weighing scale/serie"y"

5.6 Remarks

Folders named **serie"y"** correspond to repetitions of a storm sequence.

6 Instrumentation – Photographic cameras

6.1 Instruments

Two digital SLR cameras (Canon EOS 600D) fitted with 2 mini USB cable
Fixed focal length lenses (Canon EF 35mm ƒ/2) manual focused lenses,
Support structure, approximately 2 m above the flume
A Laptop computer
Checkered target for camera calibration
Position identified in Figure 2-1.

6.2 Measured parameters

- Three-dimensional coordinates of point clouds resulting from photogrammetric survey (m)

6.3 Experimental procedure

Two digital SLR cameras (Canon EOS 600D) fitted with fixed focal length lenses (Canon EF 35mm ƒ/2) manual focused lenses were mounted side by side in a support structure, approximately 2 m above the flume; they were triggered from a desktop computer. Photogrammetric surveys were conducted for Tests 1 to 17.

More details given in the Report "Protocols for representing variability and unsteadiness in flume facilities" (Moulin, 2018).

6.4 Data post-processing

The resulting clouds of points were manipulated with an in-house MATLAB algorithm to extract surfaces and profiles.
Details given in Lemos et al. (2018) and in the Report "Protocols for representing variability and unsteadiness in flume facilities" (Moulin, 2018).

6.5 Organization of data files

- Format: ".JPG" and ".mat"
- File name: Test"x"_IMG_..JPG and Test"x"_IMG_..mat
- type of data: image and matlab files
- units of data: n/a
- structure of file content: each file has 1980 x 1280 pixel
- organization of files in directories: Storm_Sequence"n"/damage/"date" and Storm_Sequence"n"/damage/"date"/Camera_calibration

6.6 Remarks

Files for the camera calibration are in the directory:
Storm_Sequence"n"/damage/"date"/Camera_calibration
".mat" files contain camera parameters resulting from camera calibration
".JPG" pairs of files are used for camera calibration
In the directory Storm_Sequence"n"/damage/"date" are the files ".JPG" to analyse damage
Test"x"_IMG_"z"_**l**.JPG: this is referred to the **left** side
Test"x"_IMG_"z"_**r**.JPG: this is referred to the **right** side

7 References

EurOtop (2016). Manual on Wave Overtopping of Sea Defences and Related Structures, An Overtopping Manual Largely Based on European Research. EurOtop Overtopping Manual.

Lemos, R., Neves, M.G., Fortes, C.J.E.M., Mendonça, A., Capitão, R. and Reis, M.T. (2018). "Damage progression in rubble-mound breakwaters scale model tests under different storm sequences". Proceedings of the 7th International Conference on the Application of Physical Modelling in Coastal and Port Engineering and Science (Coastlab18), Santander, Spain, May 22-26, 2018

Mendonça, A., Lemos, R., Fortes, J., Reis, M.T., Neves, M.G., Ramos, A. and Capitão, R. (2017). "Overtopping events in breakwaters: comparison of 2D physical experiments and empirical formulae". Proc. 37th IAHR World Congress, 13-18 August, Kuala Lumpur, Malásia

Moulin, F. (2018). "Protocols for representing variability and unsteadiness in flume facilities". EC contract no 654110, HYDRALAB+ Deliverable 8.2, Full Report, September 2018

Silva, E. and Allsop, W. and Riva, R. and Rosa Santos, P. and Taveira Pinto, F. and Mendonça, A. and Teresa Reis, M. The Conundrum of Specifying very low Wave Overtopping Discharges. ICE Coasts, Marine Structures and Breakwaters 2017, 5-7 September 2017, Liverpool, UK (2017).