# Overtopping of Berm Breakwaters Evaluation of Overtopping Formula

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# OVERTOPPING OF BERM BREAKWATERS
# EVALUATION OF OVERTOPPING FORMULA

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## 1. INTRODUCTION

The berm breakwater concept is basicly rather old, but was not used very much until it was "reinvented" in the early 1980'ties, when a slope protection for an airfield runway extending into the sea in the Alutian Islands, Alaska was designed, Rauw (1987). Since then, many berm breakwaters have been built, especially in Iceland. Fig. 1 illustrates the berm breakwater concept.

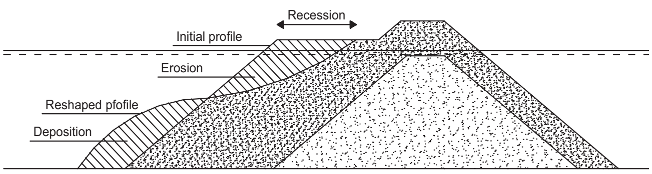


Figure 1: Typical initial and reshaped profile.

It is very difficult to destroy a berm breakwater by incoming head-on-waves, unless the structure is overtopped or the berm is too narrow. Overtopping waves can easily damage the rear side of a berm breakwater and an erosion process may start which quickly causes a breach in the breakwater.

Until recently the available information on overtopping of berm breakwaters was very limited and no systematic study existed. However, Lykke Andersen & Burcharth (2004) presented a dimensionless overtopping formula for berm breakwaters based on a large parametric model test study with berm breakwaters. More than 700 tests were performed to derive the formula. The formula was derived for statically and dynamically stable berm breakwaters as well as non-reshaping statically stable berm breakwaters, all with homogenous berms.

The formula presented by Lykke Andersen & Burcharth (2004) is based on tests with initial front slopes 1:1.25 only, and the formula does not include the influence of other slopes. The main purpose of the paper is to give guidelines on how to modify the formula to take into account the front slope and to compare the derived formula with the data of other authors. Also data from multi-layer berm breakwaters are used for the comparison which will lead to conclusions on the usage of the derived formula for multi-layer berm breakwaters.

Lissev (1993) and Lissev and Tørum (1996) measured irregular wave overtopping on berm breakwaters for two different core configurations using one cross-section only. Lissev and Tørum (1996) concluded that the core could be extended into the berm without significant influence on the reshaping and the overtopping. A non-dimensionless overtopping formula was presented by Lissev (1993). However, because only one cross section was tested it is not possible to establish a generic overtopping formula on basis of this formula.

Viggosson et. al. (1993) performed 3D model tests with a multi-layer berm breakwater proposed for the Keilisnes harbour. Overtopping was measured at the trunk section.

Kuhnen (2000) performed model tests measuring wave ovetopping on a multilayer berm breakwater for the Sirevåg breakwater.

Porarinsson (2004) performed physical model tests with a proposed multilayer berm breakwater cross section for the Porlakshöfn breakwater. The tests were carried out in the same flume as used by Lykke Andersen & Burcharth (2004) and overtopping was measured in 13 test series.

## 3. OVERTOPPING FORMULA

The model test study by Lykke Andersen & Burcharth (2004) was performed with an initial cross-section as shown in Fig. 2. $R_c$, B, $G_c$, $h_b$, h, $D_{n,50}$ and sea state are varied in the model tests.

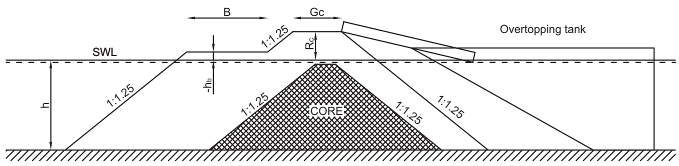


Figure 2: Initial geometry of breakwater.

The following overtopping formula was derived by Lykke Andersen & Burcharth (2004)

$$Q_* = 4.56 \cdot 10^{-3} \cdot H_0 T_0^{1.31} \cdot s_{0p}^{-2.95} \cdot$$
$$\exp\left[-13.9 \cdot R_*^{0.40} - 0.92 \cdot G_*^{1.24} - 0.76 \cdot h_{b*}^{1.32} \cdot B_*^{1.24}\right]$$

where

$$Q_* = \frac{Q}{\sqrt{g \cdot H_{m0}^3}}$$

$H_{m0}$ is the significant wave height at the toe of the structure (frequency domain parameter).

$$R_* = \frac{R_c}{H_{m0}} \; ; \; G_* = \frac{G_c}{H_{m0}} \; ; \; B_* = \frac{B}{H_{m0}}$$

$h_{b*} = \dfrac{3 \cdot H_{m0} - h_b}{3 \cdot H_{m0} + R_c}$ when $h_b > 3H_{m0}$ use $h_{b*} = 0$. Note $h_b$ is negative when the berm is above water level.

$H_0 T_0 = \dfrac{H_{m0}}{\Delta \cdot D_{n50}} \cdot \sqrt{\dfrac{g}{D_{n,50}}} \cdot T_m$ no reshaping takes place for $H_0 T_0 < 30$. For such cases use $H_0 T_0 = 30$.

In Fig. 3 the overtopping formula is evaluated against the data of Lykke Andersen & Burcharth (2004).

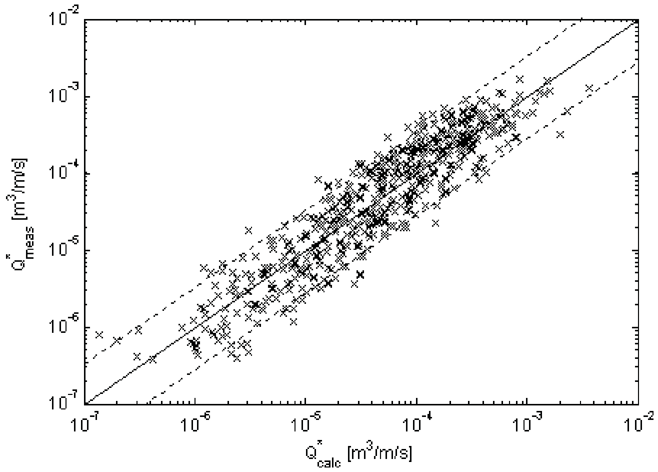


Figure 3: Evaluation of overtopping formula against data by Lykke Andersen & Burcharth (2004). Dashed lines show the 90% confidence band.

The performance of the formula seems good considering the amount of scatter normally related to overtopping formulae.

## 4. GUIDELINES FOR INITIAL SLOPES OTHER THAN 1:1.25

In case of dynamically stable structures one could still use the formula despite the initial front slopes are different from 1:1.25. This is because for dynamical stable situations the reshaped profiles are identical for the same volume of stones independent on the lower slope, leading to $B$ has to be enlarged by $0.5 \cdot (h\text{-}h_b) \cdot (\cot(\alpha_d)\text{-}1.25)$ in the formula for a slope different than 1.25.

For front slope above berm different from 1:1.25 it is proposed to enlarge/reduce $B$ and $G_C$ so the distance to the back of the crest is the same as for a slope 1:1.25. That means increasing both B and $G_C$ with the distance $0.5 \cdot (R_C + h_b) \cdot (\cot(\alpha_u)\text{-}1.25)$.

For multilayer berm breakwaters it is proposed to use the largest stones when calculating $H_0T_0$, as very little reshaping is allowed and $H_0T_0$ will typically will be around 30 for the largest stones.

## 4. COMPARISON WITH OTHER DATA

Fig. 4-7 shows a comparison between present formula and data by Lissev (1993), Kuhnen (2000), Viggosson et. al. (1993) and Porarinsson (2004).

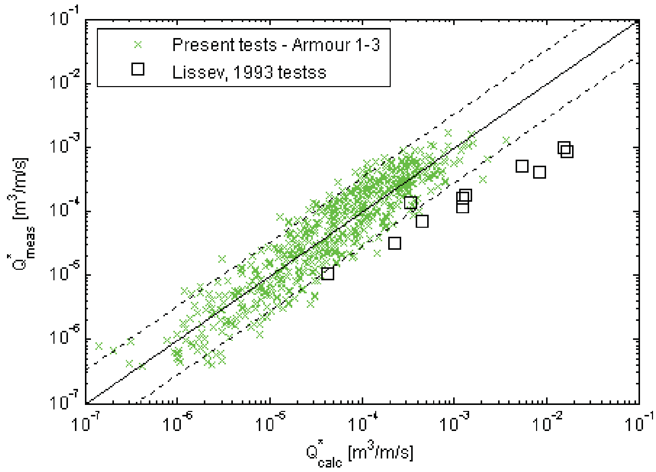


Figure 4: Evaluation of overtopping formula against data by Lissev (1993).

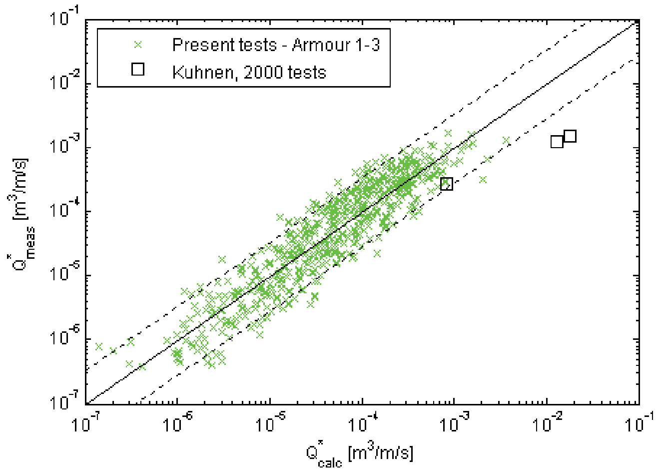


Figure 5: Evaluation of overtopping formula against data by Kuhnen (2000).

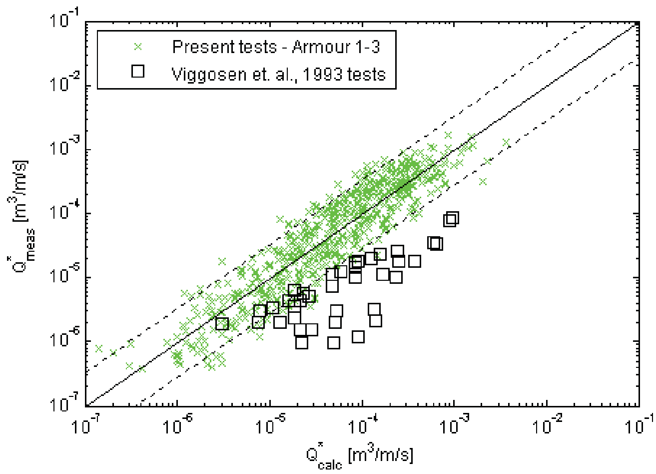


Figure 6: Evaluation of overtopping formula against data by Viggosson et. al. (1993).

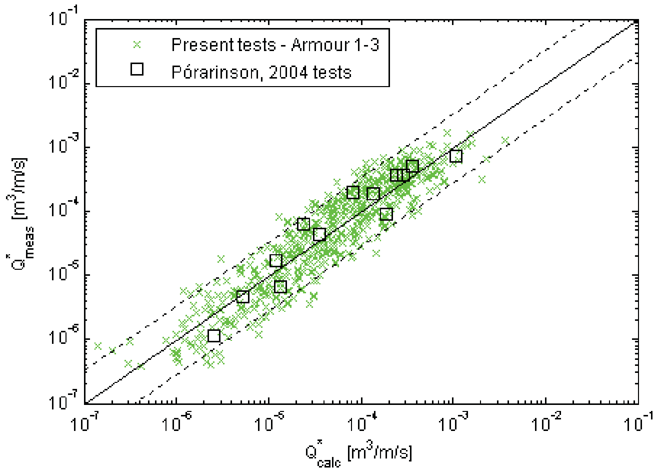


Figure 7: Evaluation of overtopping formula against data by Porarinsson (2004).

The agreement between the present formula and the data of Porarinsson (2004) are very good with all data with 90% confidence bands. This demonstrates that the formula could be used for multi-layer berm breakwaters as well. The tests of Porarinsson (2004) are performed in the same flume as the present tests with the same location of measuring incident waves and same software package for data analysis. The two test series are however considered independent as the model was completely different and was constructed and tested by other persons. When comparing to data from other laboratories the agreement is fair when the different ways of measuring waves and overtopping is taken into account.

After publishing the ICCE2004 formula it was found that the $H_0T_0$ parameter is not good to describe reshaping on more stable structures as it overpredicts the influence of the wave period. The deviations for the Viggosson et. al. (1993) can be explained by this and by only measuring total waves.

## 5. ACKNOWLEDGEMENT

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