EFFECT OF GRAVEL PARTICLE SIZE ON THE RESHAPING OF DYNAMIC REVETMENTS

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INTRODUCTION

Gravel beaches are prevalent natural features on many coastlines and play a vital role in shore protection, often inspiring protection structures (Bayle *et al.*, 2020) and nature-based solutions. Dynamic revetments are constructed features, designed to mimic gravel beaches, dissipating wave energy and preventing or limiting erosion. Compared to sand beaches, gravel revetments dissipate incident wave energy and dampen backwash intensity by percolating through the relatively large pore volume space (Komar, 2007). During storm events, gravel particles move up the beach, accreting at the crest. This predominately onshore-directed transport of gravel material differs from the storm-driven morphodynamic behaviour of sandy beaches, which tend to exhibit higher rates of offshore-directed transport (Komar, 2007).

RESEARCH NEEDS

Dynamic revetments have been implemented in many regions by mimicking dynamically coarse-sediment beach local analogues. However, this approach involves subjectivity and expert judgment, and therefore lacks consistency, defensibility and design standardization. Ahrens (1990) established the *Critical Mass Theorem*, providing a gravel volume estimate determined by local conditions, as shown by the following equations:

$$h_c/H_{mo} = 0.27(H_{mo}/L_P)^{-0.645} \quad (1)$$
$$h_c/H_{mo} = 0.677(H_{mo}/L_P)^{-0.521} \quad (2)$$
$$l_e/h_t = \exp[0.27(H_{mo}/L_P)^{0.143}] \quad (3)$$
$$A_s = (h_t + h_c)(l_e + l_c) \quad (4)$$

The crest length l_c, crest height h_c and erosion length l_e (Fig. 1) are estimated using Eq.(1) - Eq.(3) from known values h_t, H_{mo} and L_P, water depth above the toe, incident zero-moment wave height and wave length, respectively. Using Eq.(4) for A_s, the rectangular gravel area, a unit volume A_t is selected following criteria shown in Table 1.

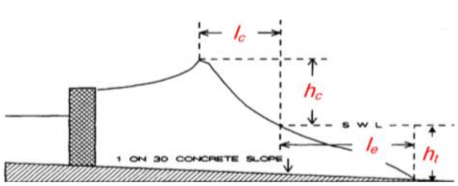

Figure 1 - Characteristic dimensions of a dynamic revetment (modified from Ahrens, 1990).

Table 1 - Revetment response categories (Ahrens, 1990)

$A_t > 0.67A_s$	**Safe**
$0.67A_s > A_t > 0.46A_s$	**Intermediate**
$0.46A_s > A_t$	**Failure**

OBJECTIVE AND NOVELTY

Ahrens' Theorem continues to be used as a design volume estimator for dynamic revetments (Bayle *et al.*, 2020). However, Eq.(1) - Eq.(3) do not consider fundamentally important and influential properties of the dynamic revetment, such as median sediment particle size (D_{50}) or porosity. This knowledge gap has motivated the primary **objective of this study**: *to investigate how dynamic revetments with different D_{50} reshape under various wave conditions.*

EXPERIMENTAL SETUP

An experimental program was performed in the Steel Wave Flume (60 x 1.2 x 1.2 meters) at the National Research Council Canada's Ocean, Coastal and Engineering Research Centre in Ottawa. The program employed beaches characterized by three different D_{50}'s (7.8, 9.3 and 10.5 mm) of dynamic revetments to study their wave-induced reshaping for a constant gravel volume of 0.50 m^3. This gravel volume was selected using Eq.(1) - Eq.(4). For a "baseline" test, D_{50} = 7.8 mm was selected for direct comparison to the work of Ahrens. The dynamic revetment response to storm waves was then investigated for two larger D_{50}'s, with their response categories compared to those in Table 1. Fig. 2 shows a reshaped dynamic revetment near the end of a test.

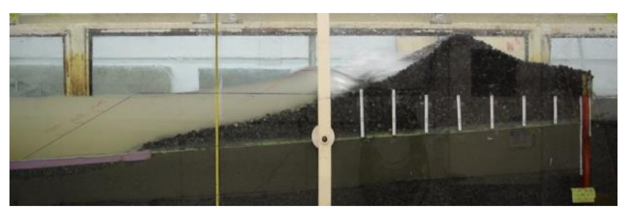

Figure 2 - Reshaped dynamic revetment structure due to incoming wave action causing gravel transport to the crest.

Reshaping of the revetment was monitored using two fixed Nikon D5300 cameras set to capture images at a frequency of 30 fps. Video analysis was used to determine wave runup and identify differences in beach reshaping.

RESULTS AND FUTURE RESEARCH

This study proves that the sediment D_{50} significantly influences revetment reshaping, differing from Table 1. Using these results, refinement of Ahrens model will be made to include the influence of sediment size, providing improved design guidance for dynamic revetments.

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