Proceedings of the 9th International Conference on Physical Modelling in Coastal Engineering (Coastlab24)

Delft, Netherlands, May 13-16, 2024

Extended Abstract, DOI: 10.59490/coastlab.2024.748

LARGE SCALE EXPERIMENTAL MODEL OF NATURED BASED SOLUTIONS TO STABILIZE A LIVING DYKE

MITCHEL PROVAN[1], ENDA MURPHY[2], AMANJ RAHMAN[3], ERIC MORRIS[4], ALLISON MATFIN[5]

1 National Research Council Canada, Canada, Mitchel.Provan@nrc-cnrc.gc.ca

2 National Research Council Canada, Canada, Enda.Murphy@nrc-cnrc.gc.ca

3 National Research Council Canada, Canada, Amanj.Rahman@nrc-cnrc.gc.ca

4 Kerr Wood Leidal Consulting Engineers, Canada, EMorris@kwl.ca

5 Kerr Wood Leidal Consulting Engineers, Canada, AMatfin@kwl.ca

KEYWORDS: natured based solutions, living dyke, physical model, sediment transport

1 INTRODUCTION

Large stretches of Canada's coastlines are lined with legacy dykes (or levees) to provide protection against coastal flooding and erosion. However, future sea-level rise presents a risk to these structures, which may result in the dykes being under designed when exposed to future water levels and wave conditions. Under certain conditions, these dykes can be augmented with a coastal saltmarsh to create a living dyke, which allows for the existing dyke to be more resilient against sea level rise without the need to retrofit the dyke with a higher crest elevation or larger armour stone. The coastal saltmarsh is able to attenuate storm waves, resulting in lower wave energy at the dyke, while also attracting and retaining sediment to combat coastal erosion.

The Living Dyke project in Boundary Bay, Canada is a pilot project being used to test the living dyke concept by placing sediment and planting salt marsh vegetation in the foreshore combined with upgrades to the existing dyke. Kerr Wood Leidal Associates Ltd. prepared a preliminary design which incorporated four different edge treatment features that are to be installed at the offshore edge of a newly constructed salt marsh platform in order to attenuate wave energy and retain the placed sediment before the planted vegetation can be established. The proposed edge treatment features included a natural sand edge, a rounded gravel berm, an oyster-shell filled bag berm, and a brushwood dam. Large scale (full scale for all edge treatment feature tests except for the brushwood dam which was conducted at half-scale) physical model experiments were carried out by the National Research Council of Canada's Ocean, Coastal and River Engineering Research Centre in their Large Wave-Current Flume to investigate the performance, including stability of the edge treatment features, wave attenuation ability, and stability of the salt marsh platform, of these edge treatment features under varying water level and wave conditions that are present at Boundary Bay.

2 MODEL SETUP

The experimental setup in the flume consisted of a gently sloping, concrete bathymetry with a 1:100 slope, which is characteristic of the foreshore at Boundary Bay. The concrete bathymetry incorporated a sand pit that was filled with a fine sand representative of the gradation of the existing foreshore sediment at the location of the pilot project. Each of the edge treatment features were installed in the flume such that the toe of the feature was positioned in the middle of the sand pit in order to investigate potential toe scour of the various edge features. A flat platform of fine sand, representing the salt marsh platform, was installed on the leeward side of the edge treatment features as shown in Figure 1. No representation of vegetation was included on the model salt marsh platform, representing a conservative approach to platform stability before vegetation roots can become established. Wave conditions were measured with a series of wave probes both up-wave and down-wave of the edge treatment features to document their wave attenuation performance. Changes to the sand profile in the sediment pit and model salt marsh platform was measured using a 3D laser scanner between select tests and cross-section profiles of the platform were extracted and compared.

Each edge treatment feature was exposed to two water levels (0.3 m and 0.7 m water depth at the toe of the features) and two wave conditions at each water level. The wave conditions at each water level are representative of the monthly and yearly expected wave conditions at the project site and include offshore significant wave heights between 0.25 m to 0.44 m with wave periods ranging from 2.4 s to 3.3 s. Each test was conducted for a 3-hour duration, which resulted in exposing the edge treatment features and salt marsh platform to approximately 4000 to 5500 waves depending on the wave period during each test.

Figure 1. Constructed model edge treatment features from left to right: natural sand edge, rounded gravel berm, oyster-shell filled bag berm, and brushwood dam.

3 RESULTS

All of the tested edge treatment features were able to attenuate the wave height across the model salt marsh platform during testing at the lower water depth (see Figure 2). The rounded gravel berm and brushwood dam were most effective at attenuating the wave energy, with measured significant wave heights reducing across the features by 84% and 77%, respectively. The ability to attenuate waves was reduced at the higher tested water depth (0.7 m at the edge feature toe) for all edge treatment features owing to the greater water depths above each feature. The oyster-shell filled bag berm was most effective at attenuating the waves at the higher water level, reducing the measured significant wave height by up to 15%.

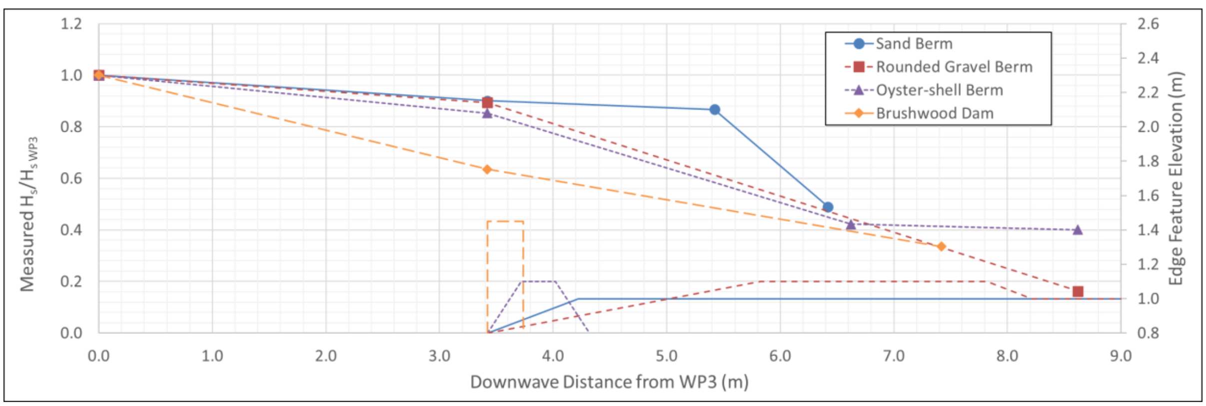

Figure 2. Normalized measured significant wave heights for a H_s = 0.27 m, T_p = 3.1 s offshore wave condition at a 0.3 m water depth at the edge feature toe. Approximate outlines of edge treatment features plotted on secondary axis.

The rounded gravel berm and the oyster-shell filled bags were found to be the most effective at limiting wave-induced scour/erosion of the model marsh platform sediment during the lower water level tests. Only minor reshaping of the platform was measured and observed. The brushwood dam was not as effective, with scour depths up to approximately 0.15 m forming immediately leeward of the dam. The natural sand edge resulted in the most reshaping and encroachment onto the salt marsh platform with erosion of the fine sand occurring up to approximately 4 m onto the salt marsh platform. A similar pattern of results was observed following the higher water level tests, with the rounded gravel berm and oyster-shell filled bags being the most effective at limiting marsh platform reshaping. The scour leeward of the brushwood dam propagated approximately 3 m onto the salt marsh platform, while the reshaping of the natural sand edge increased an additional 2 m onto the platform. Depending on the design criteria and the extent at which reshaping of the marsh platform is acceptable, all four tested edge treatments appear to have an acceptable performance in terms of salt marsh platform reshaping.