# PERFORMANCE OF GABION REVETMENTS FOR STABILIZING BEACH PROFILE

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## ABSTRACT

Gabion revetments are often installed in front of beach scarps for short-term protection of the eroded beaches. Although the effect of a gabion revetment on direct sand protection is weaker than other impermeable costal structures, gabions induce natural recovery of a stable beach profile because of their permeability. This allows cross-shore sand transport while protecting the eroded beach if the gabions are installed at proper locations. The final goal of this research is to find out the optimum arrangement of beach-erosion countermeasures towards sustainable management of a beach profile. In this study, we will discuss the performance of round-shaped gabions as a material to form beach stabilization structures through laboratory experiments.

*Keywords: Gabion revetment, round shaped gabions, coastal erosion, hydraulic stability, beach profile*

## 1. INTRODUCTION

Coastal erosion is a serious problem in many parts of the world yet to be solved despite intensive research for last decades. In addition to decline in sediment supply due to the construction of artificial structures, a major cause of coastal erosion, recent change in the atmospheric and ocean climates is also becoming one of the factors to accelerate morphological change in a coast. Coasts of the Sea of Okhotsk, for instance, are often considered as one of the areas of most concern. Beach erosion is anticipated to accelerate in the future because of the decline in sea-ice extent as well as the increase in frequency of high waves due to extreme cyclones in winter. Beach scarps on those coasts tend to be further eroded by repeated high waves before recovering their beach profiles. Enhancement of recovery of the beach profile is needed on such coasts regarding disaster-risk reduction as well as environmental conservation.

Gabion revetments have been often installed in front of a beach scarp to protect the backshore from further erosion until the beach attains the equilibrium profile. The porosity of the gabions effectively dissipates the wave energy and may enhance vegetation growth by trapping sand in the structure. Although gabions allow rapid and low-cost installation of beach protection measures, they tend to have a relatively short lifetime because of the deformation and destruction of the basket and resulting displacement and spilling of the rock fill.

Rectangular shaped gabions have been long used for construction of coastal revetments. The main target of this study, however, is the round shaped gabions so-called ‘Daruma-Kago’. Round gabions may exhibit a longer lifetime because higher resistivity against wave forces is expected with the rock fills more efficiently packed into the edges of the basket than rectangular gabions. The final goal of this research is to find out the optimum arrangement of beach-erosion countermeasures towards sustainable management of a beach profile. This study aims to characterize stability of the round-gabion revetment against wave action as well as fundamental features of the beach profile change around the round gabions through laboratory experiments.

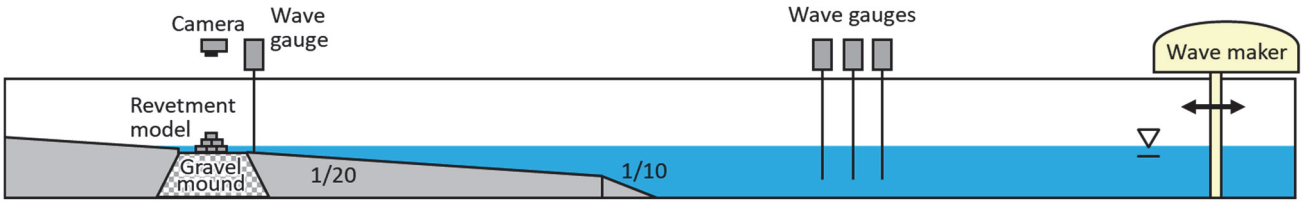


Figure 1. Experimental setup for the stability experiment.

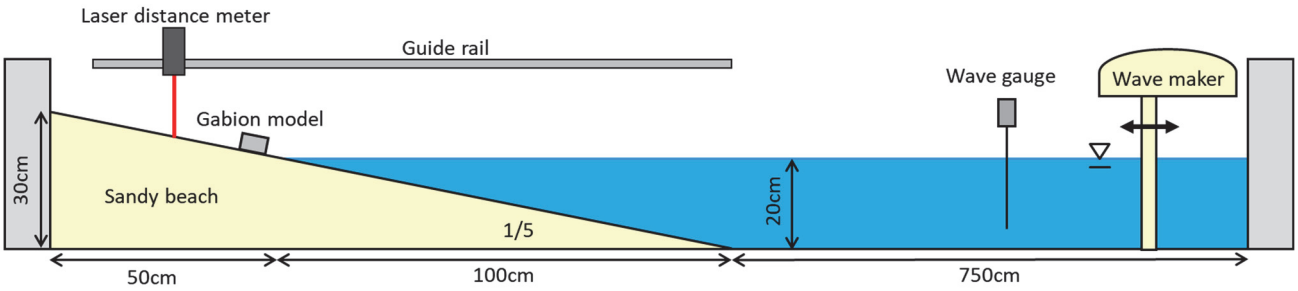


Figure 2. Experimental setup for the sand-erosion experiment.

## 2. EXPERIMENTAL SETUP

### 2.1 Stability against wave forces

A laboratory experiment at a scale of 1:50 to estimate stability factors of a round-gabion revetment was performed in a two-dimensional wave flume with 23 m long and 0.60 m width. The scaled model of the round gabion has 5.0 cm diameter, 2.7 cm height and 85 g weight. The revetment model that is composed of three layers of gabions was installed on a gravel mound at the onshore side of a 1/20 slope as shown in Figure 1. The experiment was conducted with various initial water levels from the bottom of the first layer to the middle of the third layer of the revetment in order to investigate the response of the stability to the sea-level change due to tide or storm surge. 800–2000 irregular waves with the offshore significant wave height $H_s$ = 2.8–11.2 cm and significant wave period $T_s$ = 1.5–4.8 sec were generated based on the modified Bretschneider-Mitsuyasu spectrum and exerted on the revetment. Three capacitance-type wave gauges were installed at 30 cm intervals to measure the offshore wave spectrum and one gauge was installed 1-m in front of the revetment model to measure incident wave height to the revetment. The wave gauges recoded instantaneous surface elevation at a measuring frequency of 100 Hz. Simultaneously, the damage rate of the revetment was measured using interval images recorded every 1 sec by a digital camera installed above the model.

### 2.2 Beach profile change

An experiment to investigate features on beach profile change around the round gabion was conducted on a sandy beach with 1/5 slope that is formed in a three-dimensional wave tank with 9 m long and 5 m width (see Figure 2). Median grain size of the sand in this experiment is 0.1 mm, silica sand no. 8, which was determined based on the Dean number corresponding to the typical grain size of the Japanese beaches. Water depth at the wave paddle is 20 cm. Regular waves (up to 1000) with an offshore wave height of 4 cm and wave periods of 1.0, 1.5 sec were generated. Three kinds of the structure models, the round gabions, rectangular gabions and rectangular concrete blocks, were installed at the initial coastline. As this experiment was to simply compare the sand erosion processes between different kinds of gabion structures, only one layer of the gabions was installed on the beach and the wave dissipation effect by the structure was almost negligible. After 100–200 waves, tank was drained, and then longshore and cross-shore beach level distribution were measured at 1 cm intervals using a laser distance meter from the top of each structure model to measure the beach erosion. In addition to the basic experiments, another experiment was performed under the same conditions. This time, the round gabion sand protection was enhanced by being wrapped with geotextile.

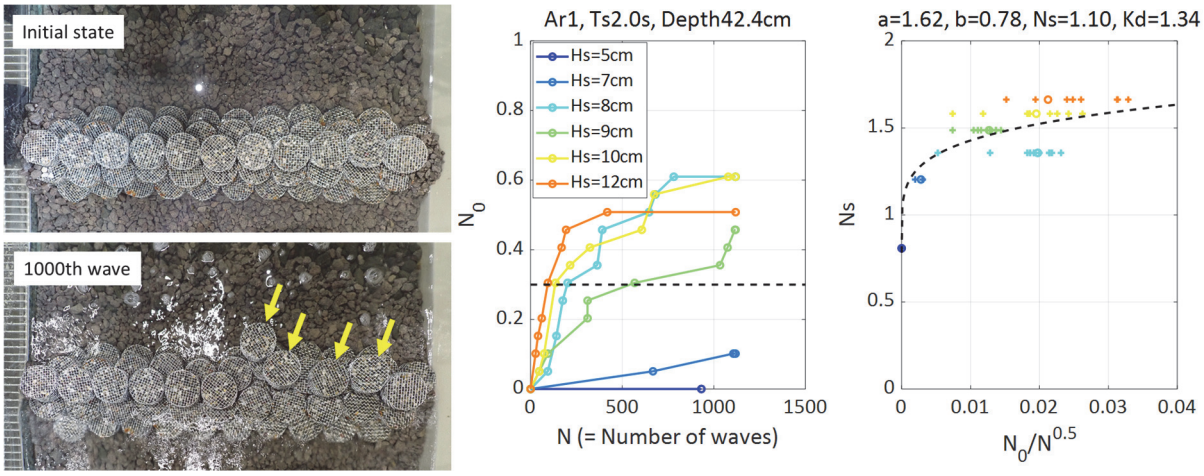


Figure 3. The round gabion revetment damaged after 1000 waves generated (left). Relations between stability number and number of waves generated (right).

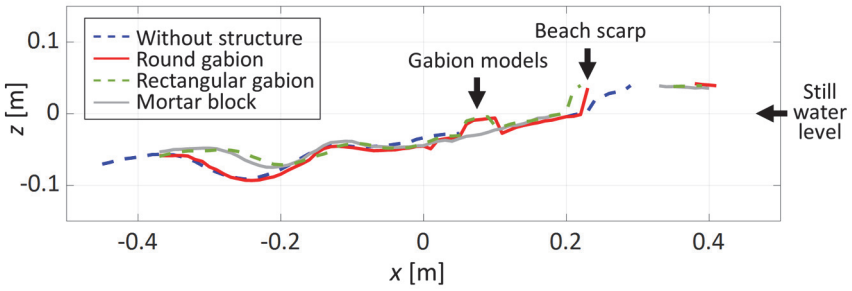


Figure 4. Longshore beach profile after 300 waves were generated.

## 3. RESULTS

### 3.1 Stability of the gabion revetment

The round gabion revetment showed sufficiently high stability against high waves when the static water level is lower than the bottom of the revetment (see Figure 3). The stability factor of the revetment, however, declined with the increase in the initial water level. An additional experiment with a different gabion arrangement confirmed that the revetment stability may be significantly reinforced by increasing the number of gabion lines in each gabion layer. It was found that the round gabion revetment may exhibit sufficient stability to dissipate the wave energy, resulting in protection of the beach scarp from high waves. This is achieved by optimizing arrangement of the round gabions depending on the possible tide level and wave height expected at each construction site of the gabion revetment.

### 3.2 Beach stabilization

Porosity of the gabion and the gap between the round gabions allow sand to move through the gabion structure. Development processes of the beach scarp and the trough near the round gabions were similar to those without any structures under the present experimental conditions (Figure 4). Meanwhile, as we enhance the sand protection function of the round gabion by wrapping it with geotextile, the round gabions were found to work as a similar or even better beach protection measure than the regular rectangular gabions.