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Proceedings of the 4th International Conference of The Euro-Asia Civil Engineering Forum (EACEF 2013)

EACEF2013
SINGAPORE

Proceedings of the 4th International Conference of The Euro-Asia Civil Engineering Forum

Singapore, 26 – 28 June 2013

Innovations in Civil Engineering for Society and the Environment

Editors:
Djwantoro Hardjito & Antoni

Organized by:

NUS National University of Singapore

UPH Universitas Pelita Harapan

Universitas Kristen Petra

Universitas Atma Jaya Yogyakarta

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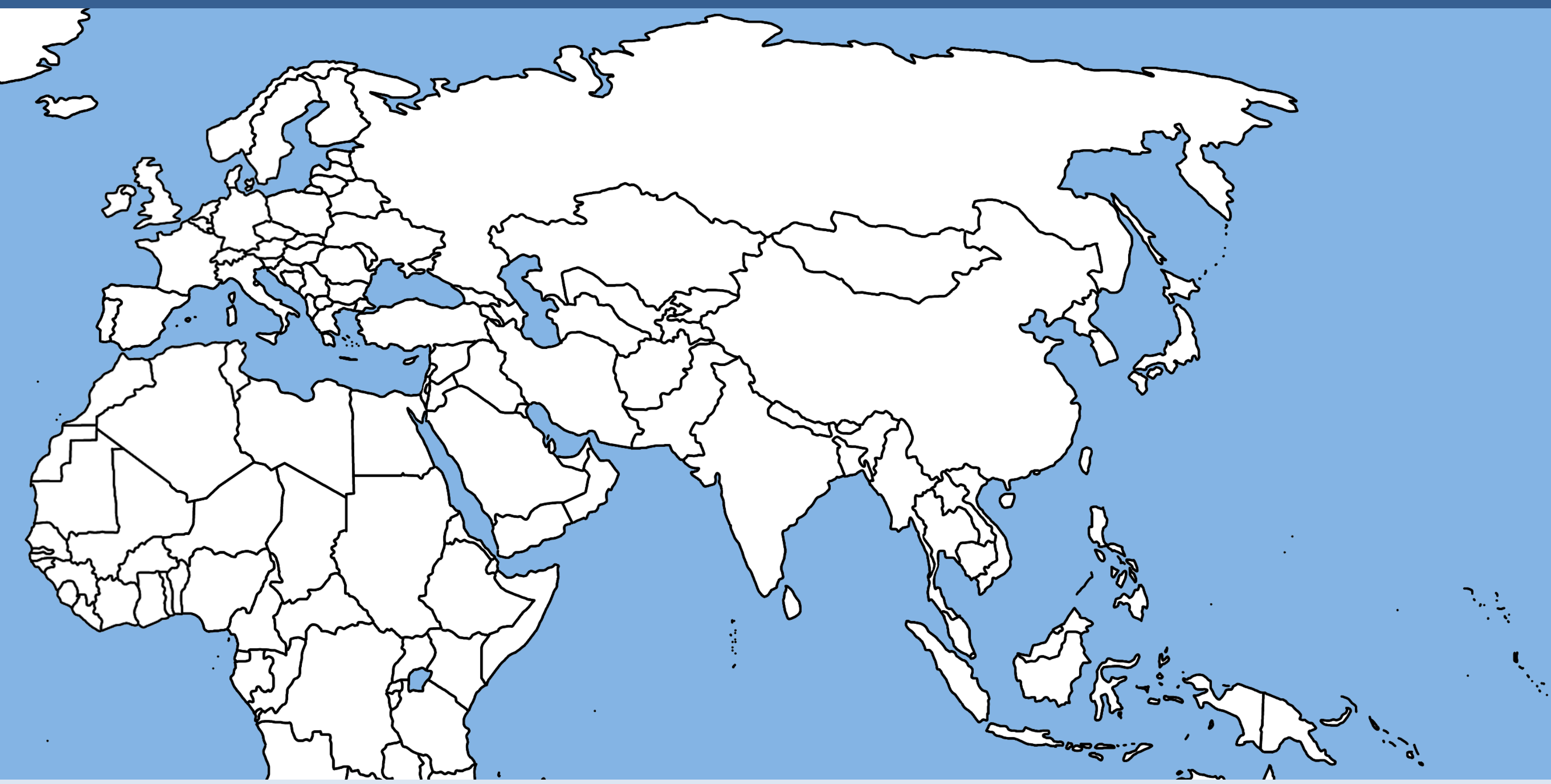

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SINGAPORE

The 4th International Conference of Euro Asia Civil Engineering Forum 2013

Innovations in Civil Engineering for Society and the Environment

Conference date

26-27 June 2013 (Wed, Thu - 2 full days)
28 June 2013 (Fri - technical visit)

Venue

Engineering Auditorium,
Faculty of Engineering,
National University of Singapore

Organizers

National University of Singapore, SINGAPORE
Universitas Pelita Harapan, INDONESIA
Universitas Atma Jaya Yogyakarta, INDONESIA
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PREFACE

This book is the proceedings of 'The 4th International Conference of Euro Asia Civil Engineering Forum 2013 (EACEF 2013)'**,** held at the National University of Singapore, from 26 to 28 June 2013. The conference is hosted by The National University of Singapore (NUS), in collaboration with three universities from Indonesia, i.e. Universitas Pelita Harapan, Jakarta; Universitas Atmajaya, Yogyakarta; and Petra Christian University, Surabaya

*The theme of EACEF 2013 is '**Innovations in Civil Engineering for Society and the Environment'**. The conference brings together academicians, researchers and practitioners, especially in Civil Engineering field, from many different countries in Asia and Europe to exchange ideas and experiences, and to strengthen network among them.*

As this publication represents a wealth of knowledge of eminent researchers and engineers involved in many different areas in Civil Engineering, it is hoped that this conference proceedings will become a useful resource.

Djwantoro Hardjito & Antoni

Editors

Petra Christian University, Surabaya, Indonesia

June 2013

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Climate and Water Issues

STABILITY ANALYSIS OF GABION CRUSHED ROCK AS A COASTAL PROTECTION STRUCTURE DUE TO SEA LEVEL RISE USING TWO-DIMENSIONAL PHYSICAL MODEL

(OC-011)

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ABSTRACT

Indonesia as a country in the tropics made up of thousands of island experiences climate pattern changes. The major threat as result of climate change impact in relation to Indonesia's geographical condition is sea level rise. The threat of sea level rise and islands subsidence into the sea in the future will be made worse by the incident of high sea waves along the coastal areas. The subsidence of several small islands in the outermost borderline of Indonesia's territory has also become a serious threat due to sea level rise. Coastal protection structures are commonly constructed to reduce the effects of wave action due to sea level rise. In this study, the coastal protection structure is built using material that is readily available in Indonesia, namely gabion crushed rock. Two dimensional physical modeling of gabion crushed rock as a coastal protection structure are conducted in a flume with dimensions length 8 m, width 0.4 m, water depths 0.6 m. A scaled-down model of the structure and the beach profile are put into the flume and subjected to appropriately scaled unidirectional wave conditions. Two models of Gabion crushed rock are applied, and each model is run using two slopes of sea bed. Analysis is conducted to evaluate the geotechnical stability (overturning, sliding, and bearing capacity) of the coastal protection structure. Combined between experimental and numerical results provide a safety factor of the gabion crushed rock is stable and secure. Based on the analysis of the stability of coastal protection structures, is expected to reduce the level of damage to coastal structures and other buildings in the vicinity.

Keywords: Coastal protection structures, gabion crushed rock, geotechnical stability analysis, sea-level rise.

1. INTRODUCTION

Indonesia is often referred to as the world's largest archipelago, a name which aptly represents its 17,000 or so islands which span more than 5000 km. Its vast population spread across thousands of islands remains highly vulnerable to natural disasters. Rising sea levels due to climate change threaten the extensive coastal and island communities throughout the Indonesian archipelago. The threat of sea level rise and islands subsidence into the sea in the future will be made worse by the incident of high sea waves along the coastal areas, especially during the transitional season. Inter-Governmental Panel on Climate Change (IPCC, 2007) report states that with the sea rise of about 1 meter, it is estimated that 405.000 hectares of coastal areas including small archipelago will be flooded.

As the sea level rises, the water depth increases and the wave base becomes deeper; waves reaching the coast have more energy and therefore can erode and transport greater quantities of sediment. Thus, sea level rise has had significant impact on coastal erosion. Coastal erosion has become anomalous and widespread in the coastal zone of Indonesia. Coastal protection structure is usually built to stop or reduce the rate of coastal erosion and to protect shore property from damage by wave attack (Shore Protection Manual, 1984).

Structural stability is a primary concern for evaluation of the existing coastal protection structure. Structural stability criteria are usually associated with extreme environmental conditions, which may cause severe damage to, or failure of a coastal protection structure. The cost of stability testing for the existing coastal protection structure is very expensive. This can be avoided by using a physical model tests in the laboratory (Hughes, 1995). In addition to physical modelling, which predominates, numerical modelling is applied methodology. In this paper, the analysis of geotechnical stability for coastal protection structure due to sea level rise is focused and determined by safety factors against overturning, sliding, and bearing capacity.

1. METHODOLOGY

The physical modeling and numerical modeling are applied methodologies. Physical modeling is a model to be tested must be adjusted to its prototype, so the behavior of the model will be similar to its prototype behavior (Hughes, 1995). Although the application is not exactly the same in the laboratory to field conditions, but endeavored to observe the effects of scaling and minimize the effects of the laboratory. Similarity between the prototypes with the physical model can be obtained if all the factors that influence the reaction are the appropriate portion between the actual conditions of the model.

As numerical model, the analysis of geotechnical stability for coastal protection structure is determined by the horizontal and vertical forces of soil and water that covers the stability against the overturning, sliding, bearing capacity, and uplifting (Das, 2006).

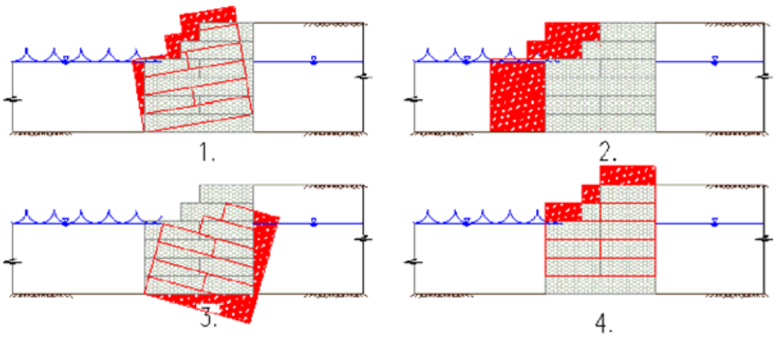


Figure 1. Failure mechanism due to overturning (1), sliding (2), bearing capacity (3), and uplifting (4) on coastal protection structure

The failure mechanism on coastal protection structure in Figure 1 can be avoided, if the stability of structure is reached against the following factors:

1. Overturning

   Stability against overturning is reached, if the safety factor reaches

$$2 \le FS_{overturning} \le 3 \quad (1)$$

   where, $FS_{overturning}$ depends on the sum of moments at the toe of the coastal protection structure that contribute to its stability and the sum of moments at the toe of the coastal protection structure that tend to cause overturning.

2. Sliding

   Stability against sliding is achieved, if the safety factor is reached the following conditions:

$$FS_{sliding} \ge 1.5 \quad (2)$$

   where $FS_{sliding}$ is influenced by the force resisting sliding along the wall base and the force driving sliding along the wall base.

3. Bearing Capacity

   The safety factor for bearing capacity is

$$FS_{bearing\ capacity} \ge 3 \quad (3)$$

   where $FS_{bearing\ capacity}$ depends on the ultimate stress and is the vertical stress at the base.

4. Uplifting

   The factor of safety against uplifting expressed as follows

$$FS_{uplifting} \ge 1.5 \quad (4)$$

   where the safety factor is influenced by the normal forces (structure dead loads, earth loads, and hydrostatic loads), and the hydrostatic uplift forces acting against the base of the structure. In this paper, the uplifting stability of coastal protection structure is not evaluated.

2. RESULTS AND DISCUSIONS

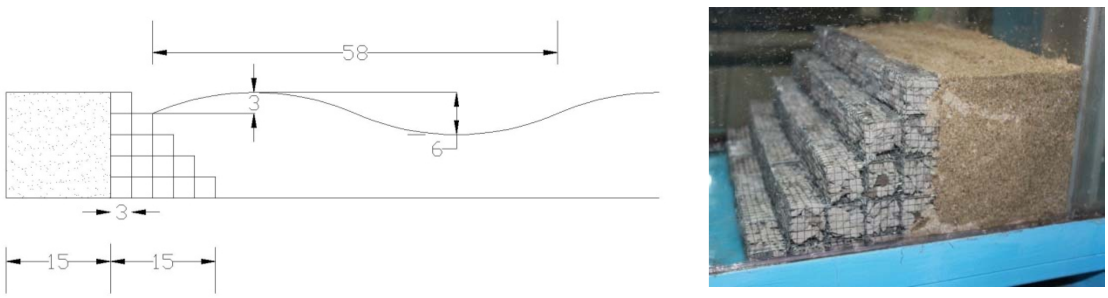
The coastal protection structure used in this study is constructed using gabion. Gabions are wire mesh baskets filled with crushed rock. Gabions are an efficient method of gravity retaining wall construction offering with locally available material and therefore have a relatively low capital cost, easy installation, and generally requiring a minimum of foundation preparation and drainage. As coastal protection structure, gabion retaining wall is designed as mass gravity structure, where the weight of the gabion wall retains the backfill material in a stable manner. Because gabions are flexible and porous, gabions can absorb some wave and wind energy, thereby reducing the scour problems associated with impermeable sea defences such as concrete seawalls.

For the best approach to the problem of obtaining the optimum balance between the functional, stability, and economical aspects of design is the use of scale models. To model the coastal protection structure with gabion crushed rock, a fixed-bed model created following the geometric similarity. Length scale of the model is formulated as follows:

$$\frac{\ell_m}{\ell_p} = \frac{b_m}{b_p} = \frac{d_m}{d_p} = \frac{h_m}{h_p} = \frac{1}{30} \tag{5}$$

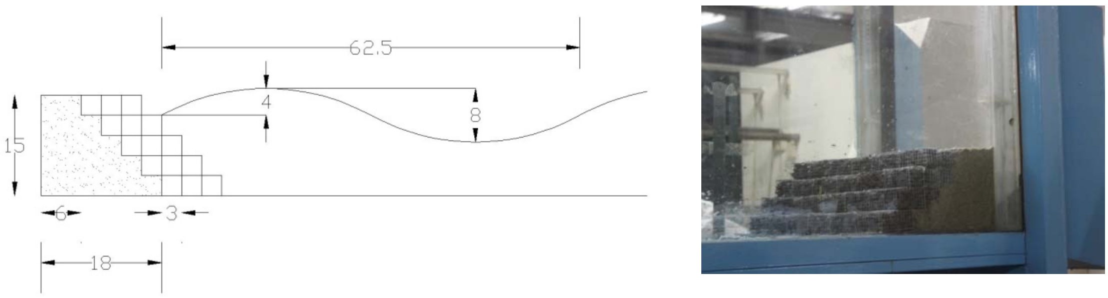
where ℓ_m is the length of the model, ℓ_p is the prototype length, b_m is the width of the model, b_p is a prototype width, h_m is the model height, h_p is the prototype height, d_m is the depth of water in the model and d_p is the depth of water in the prototype.

A fixed-bed model studies in two-dimensional facility include wave tank tests to examine wave propagation, coastal protection structure stability tests, and measurement of hydrodynamic forces on structure. The two dimensional physical modeling of coastal protection structure is conducted at Maranatha Christian University's Hydraulics Laboratory in Bandung, Indonesia. The flume is 0.4 m wide, 0.6 m deep and 8 m long and can be tilted to a slope of 0.25% percent. At one end waves are generated. At the other end a coastal protection structure using gabion crushed rock is built. To visualize the wave induced loads, the waves are recorded using two digital video cameras which are put at the middle of the flume and at near a coastal protection structure.



(a) (b)

Figure 2. Model 1 for bed slope 0:800



(a) (b)

Figure 3. Model 2 for bed slope 1:400

The physical model testing for coastal protection structure using gabion crushed rock consists of Model 1 (Figure 2) and Model 2 as shown in Figure 3. Model 1 and 2 represent the vertical coastal protection structure and the sloping coastal protection structure, respectively. Figure 2 (a) and Figure 3 (a) show the unit of measurement of the structure and wave force in centimeter (cm). Model 1 and Model 2 are carried on bed slope of 0:800 and 1:400.

The input data for a numerical model are obtained as follows:

Weight of gabion crushed rock : 7.688 kg
Mass density of gabion crushed rock : $\gamma_{gabion} = 1424$ kg/m^3
Soil data:
Mass density of sand : $\gamma_{sand} = 1840$ kg/m^3
shear angle : $\Phi = 38^o$
cohesion : $c = 0$ kg/m^2
Structures height (Ht) : 0.150 m

In this fixed-bed model examines response of the physical system to short-duration. Short-term physical models are more practical to conduct. The effect of climate change, specifically a rising sea level, has the potential to increase water levels and wave heights. The input data for the numerical model from the physical model testing that include the rising sea level factor are:

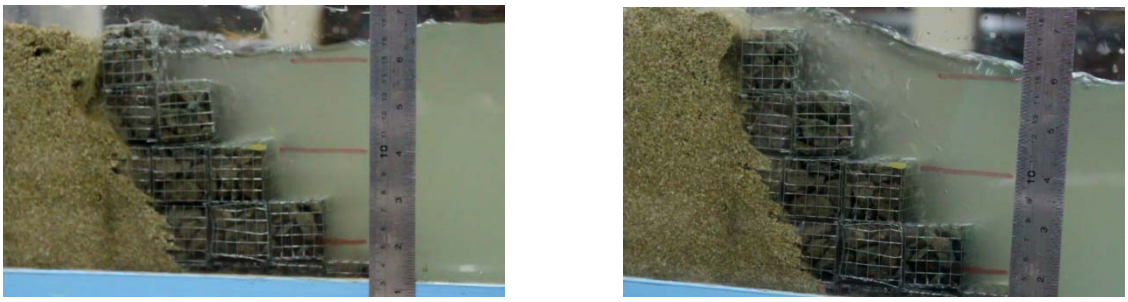
Wave data:
Slope 0:800
Wave height (H) : 0.030 m
Wave length (L) : 0.580 m
Wave period (T) : 1 second
Slope 1:400
Wave height (H) : 0.040 m
Wave length (L) : 0.625 m
Wave period (T) : 1 second
Water depth (d) : 0.120 m

The weight of the gabion retaining wall as a coastal protection structure provides the stability to the structure. For stability of gabion gravity retaining wall, there are three limit states – overturning, sliding, and bearing capacity. To determine the stability against overturning, moments are summed around the front toe of the gabion retaining wall to arrive at a suitable level of safety, which depend on restoring moment due to weight of the wall, hydrostatic force, and dynamic force due to wave and overturning moment due to active earth pressure acting on the wall and hydrostatic force. The stability against sliding can be reached if the component of the resultant force normal to the base of the wall has to counteract the component of the resultant force parallel to the base of the wall. In this case, the stability against sliding is accomplished if the resulting pressure on the rear of the wall from active soil pressure and groundwater has to be less than the sum of the frictional resistance over the base of the wall and the passive resistance at the toe. Bearing capacity stability is fulfilled, if the resultant force at the base of the wall acts eccentrically resulting in a trapezoidal pressure distribution across the base of the wall. The maximum bearing stress acting on the foundation has to be less than or equal to the ultimate bearing capacity of the foundation divided by a suitable factor of safety.

Table 1 Geotechnical stability results

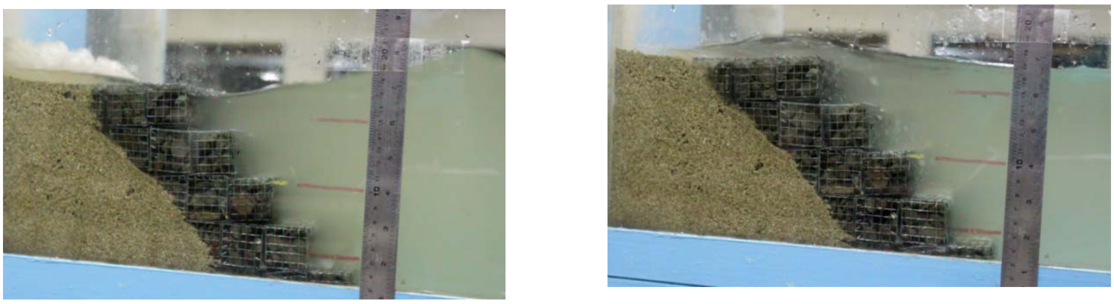
Safety Factor	Model 1		Model 2	
	Slope 0:800	Slope 1:400	Slope 0:800	Slope 1:400
Overturning	6.33	6.33	8.51	8.51
Sliding	1.53	1.53	1.64	1.64
Bearing Capacity	25.70	25.70	5.37	5.37

Geotechnical stability results for two-dimensional physical models of coastal protection structures with gabion crushed rock can be seen in Table 1. The results of the geotechnical stability for the bed slope of 0:800 and 1:400 showed the same results, because the slope of 1:400 produces a very small angle. Geotechnical stability results for Model 2 show that stability of coastal protection structure is better than Model 1. Quantitatively, the sloping coastal protection structure is more stable than the near vertical coastal protection structure.



(a) (b)

Figure 4. The maximum wave force for model 1 with slope of 0:800 (a) and 1:400 (b)



(a) (b)

Figure 5. The maximum water depth for model 2 with slope of 0:800 (a) and 1:400 (b)

Figures 4 and 5 show the model of the coastal protection structures at the maximum wave force condition. Based on the qualitative observation, the physical test model two-dimensional on coastal protection structures with gabion crushed rock in Figures 4 and 5 also show that the sloping coastal protection structure is more stable than the near vertical coastal protection structure. Near vertical gabion walls are more prone to structural failure and outflanking, more intrusive on the landscape and are much less likely to become buried by new foredunes relative to the sloping gabion revetments.

3. CONCLUSION

Indonesia is particularly vulnerable to the impact of climate change as global warming threatens to raise sea levels. The most important direct physical effects of a significant rise in mean sea level is coastal erosion. Controlling coastal erosion can be solved by built a hard structural stabilization structure. In this paper, a coastal protection structure with gabion crushed rock is used because this material is locally available, has a relatively low capital cost, and can absorb wave.

The stability of the gabion crushed rock as a coastal protection structure is evaluated using two applied methodologies, i.e., two dimensional physical model and numerical calculation and is determined by safety factor of overturning, sliding, and bearing capacity. Two physical models of gabion crushed rock structures are conducted: sloping gabion and near vertical gabion walls. The results show that sloping gabion is almost always preferable to near vertical structure. The sloping gabion can provide good erosion protection. Near vertical gabion walls are more likely to suffer toe scour and structural collapse as they are less able to dissipate wave energy during storm wave attack.

4. ACKNOWLEDGEMENT

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5. REFERENCES

[1] Coastal Engineering Research Center (1984). Shore Protection Manual. Dept. of the Army, Waterways Experiment Station, Corps of Engineers. Vicksburg, Mississippi.

[2] Das, B.M. (2006). Principles of Geotechnical Engineering. 5th Edition. Canada. Thomson Canada Ltd.

[3] Hughes, S. A. (1995). Physical Models and Laboratory Techniques in Coastal Engineering. Advanced Series on Ocean Engineering, Volume 7. New Jersey. World Scientific Publishing Co. Pte. Ltd.

[4] Intergovernmental Panel on Climate Change. Retrieved on 23 September 2011 from http://www.ipcc.ch

[5] Kamphuis, J.W. (2002). Introduction to Coastal Engineering and Management. Advance Series in Ocean Engineering**.** New Jersey. World Scientific Publishing Co. Pte. Ltd.