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A new type of artificial submerged reef is compared with standard low- and medium-porous rubble mound designs to determine the key advantages of the reef. Properties such as wave reflection from the structure, wave transmission over the structure, and wave setup onshore from the structure are examined. Wave setup is especially a significant factor for the consideration of coastal defense design due to the influence of currents, sediment transport, and wave-overtopping.

Keywords: *CADMAS-SURF, artificial reef, wave setup, porous barrier*

1. INTRODUCTION

Submerged artificial reefs are a commonly used measure to protect shorelines from beach erosion and wave-overtopping phenomena. These structures offer coastal protection with many advantages: no visual impact (preserves natural landscape), acts as a partial barrier for sediment transport, and reduces the amount of wave-overtopping when combined with seawall. However, if not designed properly, these structures can enhance wave breaking and circulation over the structure, leading to erosive processes and degradation of the coast. It is necessary to study new types of artificial reefs that can not only reduce wave transmittance in the coastal zone, but also minimize the amount of sediment transport and beach erosion that can occur as a result. The wave setup behind structures influences the longshore currents and occurrence of rip currents that may cause intense localized erosions, as well as a serious risk to people[1)]. The goal of this research was to study the properties of a new reef design compared with standard rubble mound designs to determine efficacy, using both experiments and numerical simulations.

2. DESIGNED ARTIFICIAL REEF

A wave flume with a piston-type wave generator was used in large-scale experiments and numerical simulations, 25 m length, 5 m width, and 2 m height. Thirteen wave gauges and two electromagnetic current meters were used to measure the water surface profile and velocity, respectively, and analyze data.

The base unit design of the reef is a new type of concrete block with a solid base (36 cm x 48 cm x 4 cm) on which solid cylinders (diameter 8 cm, height 8 cm) sit spaced evenly in a 3x4 grid. The blocks were used to construct a 3-tier reef structure, **Fig. 1a**, with 2 tiers laid out 5 units in length (2.4 m) and 13 units in width (4.68 m) and a crest offset by a half unit that is 4 units in length (1.92 m) and 13 units in width (4.6 m). The reef was positioned 11.6 meters from the wave generator.

The CADMAS-SURF numerical simulation is two-dimensional; the parameters for the reef in the simulation were determined by comparing the experiment results with several numerical simulations of solid bases with porous layers to replicate the effect of the cylinders, **Fig. 1b**. The best fit porosity was 85% and drag/inertia coefficients were 1.0. The mesh size was $\Delta x = 0.01$ m and $\Delta z = 0.01$ m. CADMAS-SURF was used to extend the hydraulic experiment results to evaluate the performance and effectiveness of the new reef.

The trapezoidal rubble mound is shown in **Fig. 2**. The rubble mounds tested in the numerical simulation are low-porosity (5%-20%) and medium-porosity (50%). Further cases were calculated to examine the effect of mound height; the crest length and slope angle are key properties in the breaking of waves and energy dissipation, so they were kept the same while height and base varied proportionally.

3. CONCLUSIONS

Key non-dimensional properties were calculated. The reflection coefficient trend of the rubble mound cases is somewhat higher than the new model, **Fig. 3**; however, the low-porous rubble mound also shows a decreasing trend with an increase in freeboard whereas for the new type of reef it remains nearly constant and eventually approaches the same value

The new model cases show a trend in the transmission coefficient only slightly higher than that of the rubble mound cases, **Fig.4**. However, the new model is still well within acceptable transmission values predicted by previous research collected by Van der Meer *et. Al*[2), 3)]. Overall, the newly designed reef shows adequate results with regards to reflection and transmission coefficient values as compared with the rubble mound structures.

Wave setup is the amount of sea-level change behind the reef (calculated from difference of still and mean water levels). The primary advantage of the new reef model is the reduced wave setup compared with the rubble mounds, **Fig. 5**. The wave setup in the newly designed reef is significantly reduced. A low wave setup is advantageous because it influences longshore currents and dangerous rip currents that cause erosion through sediment transport and serious risks to human life; a more porous reef allows for low setup due to the backflow of nearshore currents and a more natural circulation flow while still protecting the shoreline from wave action[4)]. A low wave setup is also a benefit when the reef is coupled with a seawall. A reduced wave transmission via wave breaking over the designed reef results in lower wave energy and less overtopping during high wave events, combined with less erosion-causing currents that will help to counteract the beach erosion typically occurring near a seawall.

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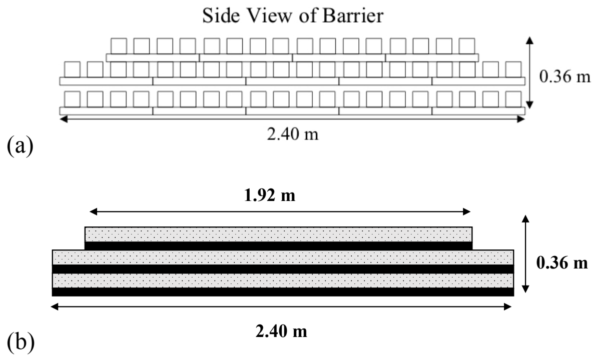

Fig. 1 (a) Experiment model, (b) CADMAS-SURF model.

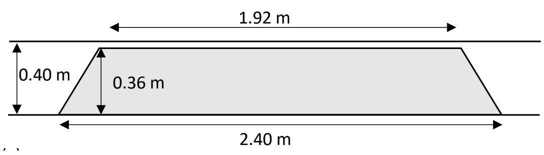

Fig. 2 Basic rubble mound reef schematic.

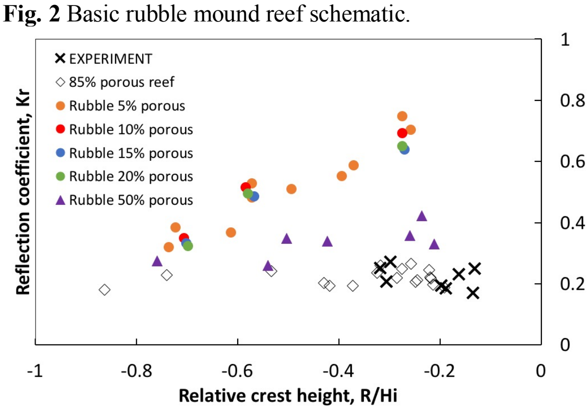

Fig. 3 Reflection coefficient.

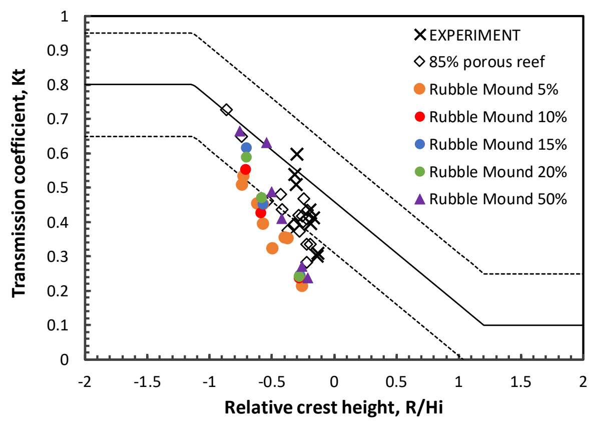

Fig. 4 Transmission coefficient with confidence lines.

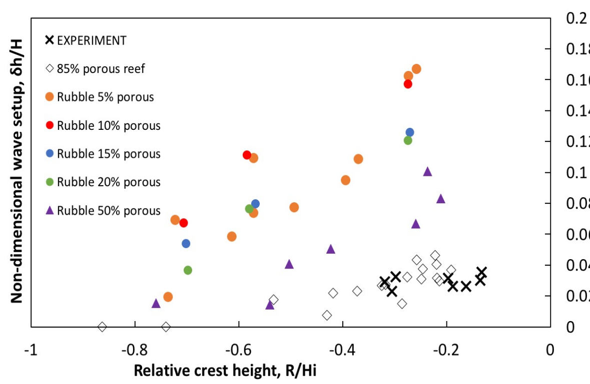

Fig. 5 Non-dimensional wave setup.