# Use of sea wave containment techniques

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**ABSTRACT**
This work makes a comparison between different wave control methods applied in coastal cities, using a small-scale experimental model. The coastal zone of Brazil extends over a considerable area and covers a significant portion of the national territory. It is common to find a variety of constructions on the seashore, from large buildings to small kiosks, many of which are irregular, as they do not follow the proper authorizations from the competent authorities, resulting in environmental, social and economic problems. The coastal environment is dynamic, subject to constant changes in its configuration, since the waves transport and deposit sand, even in small quantities. However, human activity has accelerated this process, although it is natural. Therefore, some methods have been developed to mitigate it.

**Keywords:** Coast, Model, Sea, Tide.

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## INTRODUCTION

A breakwater is a coastal protection structure built in places where sea and coastal processes directly impact properties near the coast. The purpose of breakwaters is to protect inhabited and preserved areas from the influence of tides, waves, or tsunamis. Like a fixed structure, a seawall is out of harmony with the dynamic nature of the coast, disrupting the exchange of sediments between land and sea.

The purpose of this study is to examine the effects of tides on the coast and to explore some techniques for tidal control through a small-scale experimental model that simulates a beach during a sequence of large waves, in order to identify the most suitable for coastal environments. The wave tank prototype was developed by engineering students at the University of Vassouras in 2023, with the aim of improving the training of qualified professionals for the job market, offering the opportunity to solve, in practice, real everyday problems.

## LITERATURE REVIEW

In this work we will compare four types of artificially built barriers for the containment of waves and tides, they are these:

### THE VERTICAL AND RECURVED WALLS

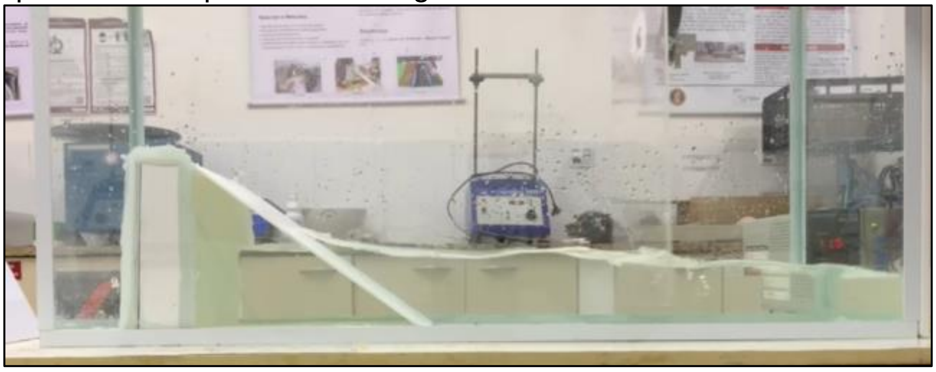
They are man-made structures with the aim of protecting the coast from erosion and the advance of the sea. These structures can be built with different materials, such as concrete, stone, rocks, among others.

Artificial walls can have different shapes, such as vertical, inclined or curved, depending on the purpose for which they were built. They can be built in places where coastal erosion is advancing rapidly, such as in urban areas, ports, or industrial zones.

Although they are intended to protect the coast, the construction of artificial walls can have negative impacts on the coastal ecosystem, such as the destruction of marine species habitats and the alteration of the natural dynamics of the beach. In addition, the maintenance of these structures can be quite costly and complex.

Therefore, before building an artificial seawall, it is important to carefully assess the need for the work and its possible impacts, seeking more sustainable and less impactful alternatives for the protection of the coast.

Photo: Experiment/Maquete Láb. - Eng. civil – UniVassouras/RJ, inclined flat talude



## STAGGERED AND SLOPING COATINGS

These are coastal protection techniques used to minimize the effects of marine erosion in coastal areas. These techniques involve creating a layer of stones or other tough material that is arranged in a staggered or inclined manner on the shoreline.

In the case of stepped coatings, the stones are arranged in horizontal layers that overlap at different heights, creating a stone staircase along the coast. This helps dissipate the energy of the waves, reducing their strength before they reach the shore.

In the case of sloping coatings, the stones are arranged on a gentle slope along the coast. This helps to reduce the speed of the waves, dissipating their energy and reducing the impact of coastal erosion.

These techniques can be used in different situations, such as in the protection of beaches, ports, and other coastal structures. However, it is important that these techniques are implemented carefully and that prior studies are carried out to assess their environmental impacts, such as interference with sediment circulation and local marine life.

Photos: Experiment/Model Láb. Civil Engineer – UniVassouras/RJ, Slope Staggered and inclined coating with elongated wave in formation and with wave to energy stacking

## ROCHA'S ARMOR

It is a coastal protection technique that consists of placing large blocks of rock on the coast to minimize the effects of marine erosion. This technique is especially effective in areas with a high wave energy index, where other coastal protection techniques may be less effective.

The layer of stones formed by the rock armor serves as a natural barrier that dissipates wave energy, reducing its impact on the shoreline and protecting coastal structures from erosion. In addition, the rock armor also helps to maintain the stability of the coast, preventing landslides and cave-ins.

This technique is widely used around the world and can be applied in different situations, from the protection of small beaches to large ports and coastal structures. However, it is important that the implementation of rock reinforcement is carried out carefully and that the environmental impacts of the technique are considered, such as interference with sediment circulation and local marine life.

Photo: Experiment/Model Láb. Civil Engineer – UniVassouras/RJ, Rock Armor Slope with and without stacked power

## SUBMERGED BREAKWATER

It is a coastal protection technique that consists of placing a barrier of stones or other resistant material along the coast, submerged in water. This barrier is designed to break down wave energy before they reach shore, reducing the impact of coastal erosion.

The submerged breakwater is usually built near the coast, in areas where coastal erosion is most intense. This technique is especially useful in areas where the construction of a conventional breakwater is not possible or desirable, such as in environmental preservation areas or in areas with high ship traffic.

The construction of submerged breakwaters involves placing large blocks of rock or other tough materials on the seabed, forming a barrier that stretches along the coast. This barrier can be designed to integrate into the marine environment, creating habitats for local marine life.

Photo: Experiment/Model Láb. Civil Engineer – UniVassouras/RJ, Elongated Submerged Breakwater Slope without power

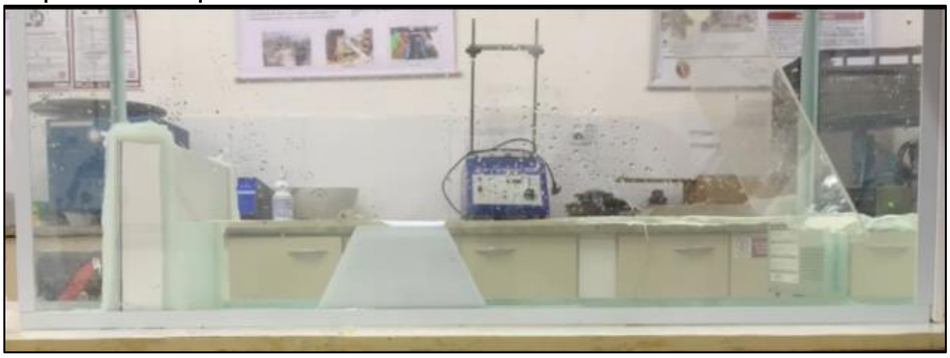
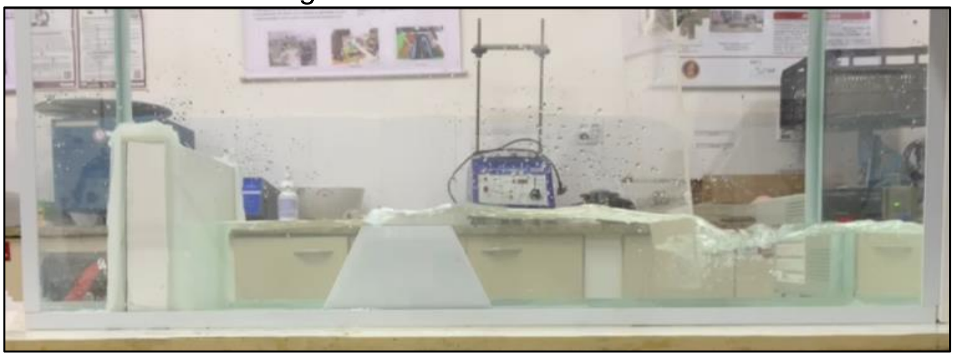


Photo: Experiment/Model Láb. Civil Engineer – UniVassouras/RJ, Submerged Breakwater Slope with energy stacking

Photo: Experiment/Model Láb. Civil Engineer – UniVassouras/RJ, Submerged Breakwater Slope with Broken Power Stacking



The use of submerged breakwaters is an effective technique to protect the coast from coastal erosion. However, it is important that the implementation of the technique is carried out carefully and that the environmental impacts of the technique are considered, such as interference with sediment circulation and local marine life.

## MATERIALS AND METHODS

The initial purpose would be to automate the experiment/model of the wave simulator, standardizing the method to obtain the real evaluation of each of the barriers.

The following is a wave generator for the tank mentioned above[1], with the dimensions of 100 X 50 X 30 (scale in centimeters – cm).

With the measurements in hand, the first step was to define the movement necessary for the wave generation and control it. To do so, it was necessary to take into account the following calculations:

- Tank volume;
- Liquid used;
- Specific weight of the liquid;
- Type of mechanical movement that best served;
- Type of electric motor;
- Engine control type.

## MECHANICAL DESIGN AND INSTALLATION – PRACTICAL EXPERIMENT

With the dimensions of the tank we extract the volume in $cm^3$, which is 150000$cm^3$, converting to $m^3$ we have 0.15$m^3$; The specific mass of water by the international system is:

| Fluido | $kg.m^{-3}$ | $N.m^{-3}$ |
|---|---|---|
| Água 4ºC | 1000 | 9810 |
| Água 25ºC | 997 | 9780 |

Source: Specific Mass: Formula, Table, Exercises - Brasil Escola (uol.com.br)

Therefore, the mechanics would have to withstand an effort above 15 $Kg.m^3$.

Some mechanical models of variation and transformation of movement were studied and studies in dynamics and kinematics were also taken into account.

One of the criteria for classifying mechanical mechanisms is that they are based on the transformation of movement between the motor and moved organs. Its characteristics are to transform movement from rotation to rotation, rotation into translation and translation into translation,

Of the movements studied, it was necessary to join two of them to dye our goal, rotate on its own axis generating the eccentric movement and order this movement forward and backward, transforming ROTATION into EXPANSION and RETRACTION. The result chosen was the BIELA MACRANK.

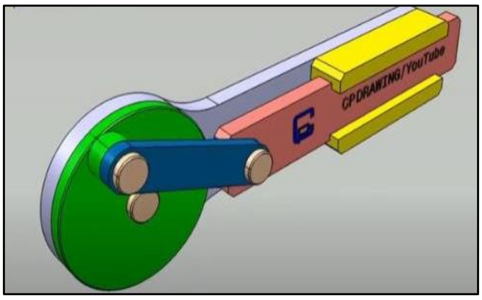



Image Source: +60 IMPRESSIVE MECHANICAL PRINCIPLES (youtube.com)

The formulas used to calculate the perfect motion in the wave generations and the amount of work required for it were:

- Displacement: $\Delta S = S - S0$
- Moment of force: $M = F \cdot b$
- Work: $w = F \cdot d \cdot \cos \theta$
- Amount of movement: $Q = m \cdot v$
- Density: $\mu = m/V$
- Pressure: $p = Fn/A$
- Pressure in a Liquid Column: $p = \mu \cdot g \cdot h$

The prototype went up to the MARK 3, with its predecessors having flaws in the plywood, wood and acrylic structure. All resulted in failures due to unbalance, little elastic resistance and little ductile. The finished prototype was therefore made of 2 and 3mm thick aluminum for the connecting rod and articulated support, and the Crank rod in ACM of 2mm.

## ELECTRICAL DESIGN AND INSTALLATION – PRACTICAL EXPERIMENT

With the mechanics developed, we needed to size the engine. This in turn was the one that took the most work, going up to the MARK 5, its predecessors were tested with a remote control car DC motor, old DVD tray, sewing machine motor, blender and small fan. When finished, the best test was with the windshield wiper motor with gearbox attached to its axle.

The formulas used to calculate the force required for the required movement were:

Average scalar velocity: $vm = \Delta S/\Delta t$ – If it varied velocity, it would cause instability in the mechanics and could break the prototype;

Average scalar acceleration: $am = \Delta v/\Delta t$ – If it started too fast, it would spread the waves and the model would not fulfill its purpose;

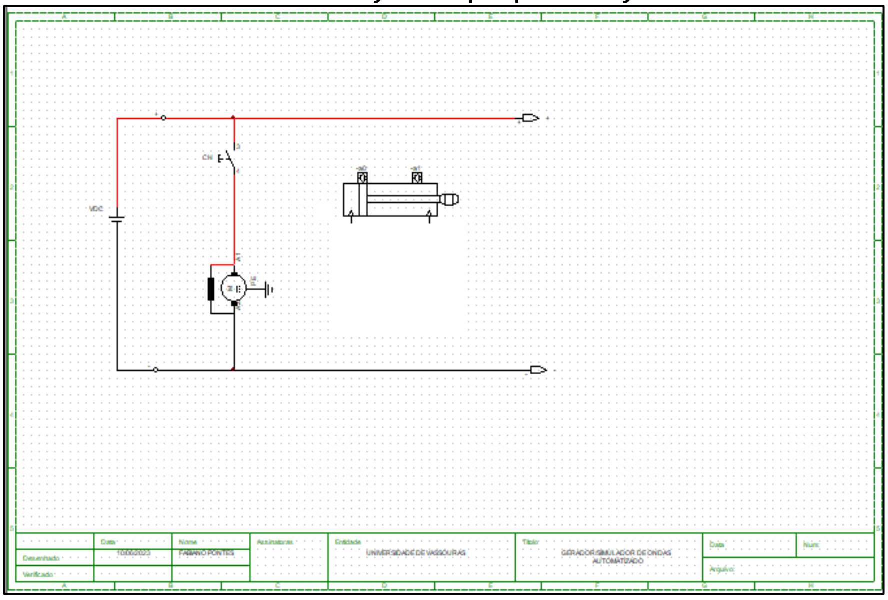
Newton's 2nd law: $F = m \cdot a$ – If weak, it would not perform the necessary movement and if too strong, it could crack the acrylic blade that is in contact with water;

Moment of force: M = F . d – If the mechanical rod was fixed in the wrong place, the blade would break in the first test. The exact moment where the force of mechanics was applied was undoubtedly the most tense to test;

Average power: Potm = E/Δt – Thanks to the dimensioned motor, our average power is constant, being it Energy for Working Time. The power will only lose its performance if the power source runs out, so the power will be limited to the system's battery (the best option is the 12Vdc 60Ah automotive battery or a 12Vdc 10A Buck DC/DC stabilized source).

## OPERATING CIRCUIT

Figure 1: Sketch of the electrical system prepared by the authors of this article




## CONCLUSION

The choice of the best protection technique depends on the specific characteristics of the site, the protection objectives and the environmental impacts considered. Each has advantages and disadvantages, the ideal choice should take into account factors such as the intensity of the waves, the depth of the water, the type of soil, the local environmental conditions and the potential environmental impacts. There is no single technique that is the best in all scenarios. Each approach has its advantages and advantages. Here are some general considerations:

## SUBMERGED BREAKWATERS

Advantages: It can efficiently dissipate wave energy, reducing continental erosion. It may be less visible on the horizon line. In our experiment, it was the one that best dictated the waves.

Disadvantages: It can interfere with marine ecosystems and sedimentary dynamics. Construction can be complex and expensive.

## ROCHA'S ARMOR

Advantages: Offers a robust barrier against erosion. It can be relatively simple to implement.

Disadvantages: It can affect the aesthetics of the beach and impact the qualities of marine life. Maintenance may be required.

## STAGGERED AND INCLINED COATINGS

Advantages: They reduce the force of waves and help prevent coastal erosion. They can be integrated into the landscape in a more natural way.

Disadvantages: They may require periodic maintenance and adjustments. Effectiveness may depend on the specific configuration.

The decision on which technique to use should be based on detailed engineering studies, taking into account local factors, costs, environmental impacts, and other specific aspects of the project. In addition, the advice of experts in marine and environmental engineering and other relevant fields in the decision-making process to ensure that the chosen solution is effective and sustainable in the short and long term.

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