

Application of Used Tyres and Waste Building Materials in The Design Concept of Breakwater Structures

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Abstract: Coastal erosion occurs in almost many national coastlines in the world. This incident may be due to climate change being experienced around the world. Global warming and rising sea levels are also likely to contribute to this phenomenon. In this study, a comparison between several types of breakwater structure designs that have been identified is used for the purpose of producing a conceptual design of breakwater structures. This design is done using used tires and discarded building materials. An analysis of the effectiveness of the design concept of the breakwater structure can be produced through a comparison of the features that have been identified from the literature review. As a result of this study, the researchers found that the design concept called MyBREAKER which works like the construction concept of breakwater structures compared to existing breakwater structures and can contribute to a more economical construction. A comparison of breakwater structure design concept found, there are advantages on MyBREAKER as a breakwater structure and it not only contributes to reducing its construction cost but also more environmentally friendly and reduces pollution to the environment by reusing used and waste materials. The advantage of MYBREAKER is that it can shorten construction time while reducing labor and equipment costs because the time taken is shorter at the same time it can reduce the effects of corrosion on the breakwater structure itself and absorb waves more effectively than existing breakwater structures. However, an in-laboratory test on a small model needs to be performed to confirm the results of this study as suggested at the end of this report.

Keywords: Breakwater, Design, Waste Materials

1. Introduction

A breakwater or known as a wave breaker is an infrastructure developed to break waves on the coast that serves to absorb part of the wave frequency. With this breakwater abrasion (wave abrasion process) can be reduced and ships can anchor more easily and quickly. The problem of erosion due to waves can

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be seen along the coast of Peninsular Malaysia. The most significantly affected area is the east coast because it is exposed to vast oceans and monsoon winds that cause relatively large waves and there is unfriendly development built around the coast. The construction of this breakwater structure is relatively slow because the cost required to build a breakwater structure costs tens of billions of ringgits.

Due to the very high cost of materials and construction of breakwater structures, most of the beach locations are not built with such structures. Therefore, this study will use a lot of used or discarded materials for the fabrication of the relevant structures and some effectiveness tests will be done based on simulations in the laboratory or a suitable location to be determined. Parameters such as water velocity, short-term erosion effects on the materials used and other parameters will be studied to ensure that the materials used are environmentally friendly and provide a positive impact.

However, this study will not look in depth at the cost of construction of structures with actual size due to time constraints and research funding constraints. It is expected that this study will be able to produce a structure capable of being a breakwater that will protect the eroded coastline and the responsible authorities will use this research.

2. Causes of Coastal Erosion

There are several causes of erosion that occur along the coast. This is because the coastal areas in Peninsular Malaysia are mostly exposed to vast oceans and monsoon winds that cause relatively large waves and there is construction built around the coast and construction built not according to specifications set by the authorities. The construction of this breakwater structure has also become relatively slow as the costs required are relatively large and the allocated costs are insufficient. Due to the very high cost of construction materials of breakwater structures several initiatives need to be taken to reduce the construction cost of breakwater structures. Therefore, this study will use used or discarded materials and the concept design of breakwater structure is done for the construction of breakwater structure and the study will be done to get a positive impact and in time I this study will succeed in attracting the relevant parties to use research this. Whereas according to Willard, (1959) states that erosion is a process or carving of the physical shape of the earth's surface that involves the removal of a material from its original place followed by the process of transporting the material to another place.

Among the factor that causes coastal erosion are as follows:

2.1. Waves

Coastal areas exposed to wave and wind movements will cause erosion rates to be more intense compared to sheltered coastal areas (Yanalagaran & Ramli, 2018). The phenomenon of big waves that cause coastal areas to erode to the point of destroying homes and buildings on the coastal areas around Peninsular Malaysia.

2.2. Sea Tides

Formed as a result of the gravitational pull of the moon and sun on the surface of sea water. Tides and tides are capable of eroding, transporting and depositing material in coastal areas. This phenomenon occurs as a result of unavoidable natural processes between natural forces that interact with each other in coastal areas such as waves, sediments, wind, currents and tides (JPS, 2014).

3. Effects of Breakwater Structures Constructions

The construction of this breakwater structure is necessary to protect the coastline to prevent erosion around the coastline as found on the coast in Peninsular Malaysia. With the existence of various breakwater structures, there are several effects from the construction of breakwater structures:

3.1. Wave Weakening

The effect is often seen by oblique incident wave angles, diffraction around the tip of the breakwater, wave reflection from a nearby shoreline or wind bias starting from the base of the breakwater. The waves that hit the coast often do not break and they will disappear just like that. In a heavy wave, the first row

of modules moves rapidly. The second row is less than the first row, while the third and fourth rows are barely moving. According to Charles A. Gifford, Jeffrey A. Fisher, Todd L. Walton, (1977), tire breakers show their effectiveness in reducing the largest waves of 3' high and 10'20' long, a duration of 1-2 seconds that usually occurs in Santa Rosa Sound.

3.2. Coastline Effect

Before discussing the observed effects for breakwaters on the coast, it is important to look at the history of the coast in its area and the natural features of the area studied. Physical ocean factors that necessarily involve coastal waters fund genes acting on the physical environment of coastal zones such as waves, currents, tides and angina coupling elements of natural subsystems that explain conditions in coastal zones (McCartney, B., 1985).

3.3. Biological Effects

Breakwaters can affect biological processes in several ways. It obtains a stable and strong effect with various combinations of protection and movement of water, in the presence of existing plants and animals. In the shadow of the waves, the bottom becomes stable, protected and supplied with an abundant supply of organic matter. The coast behind it is protected from wave reactions. The possibility of the cultivation of emerging plants and the possibility of an increase in the population of organisms living on the coast.

4. Research Methods

4.1. Study Flow Chart

This study is conducted by desktop research and the production of the design concept is to compare the design of existing breakwater structures used by the authorities around the world. The workflow of this study is as in Figure 1 (Study Flow Chart). An explanation of the implementation of the phase is as in sections 4.1 to 4.3.

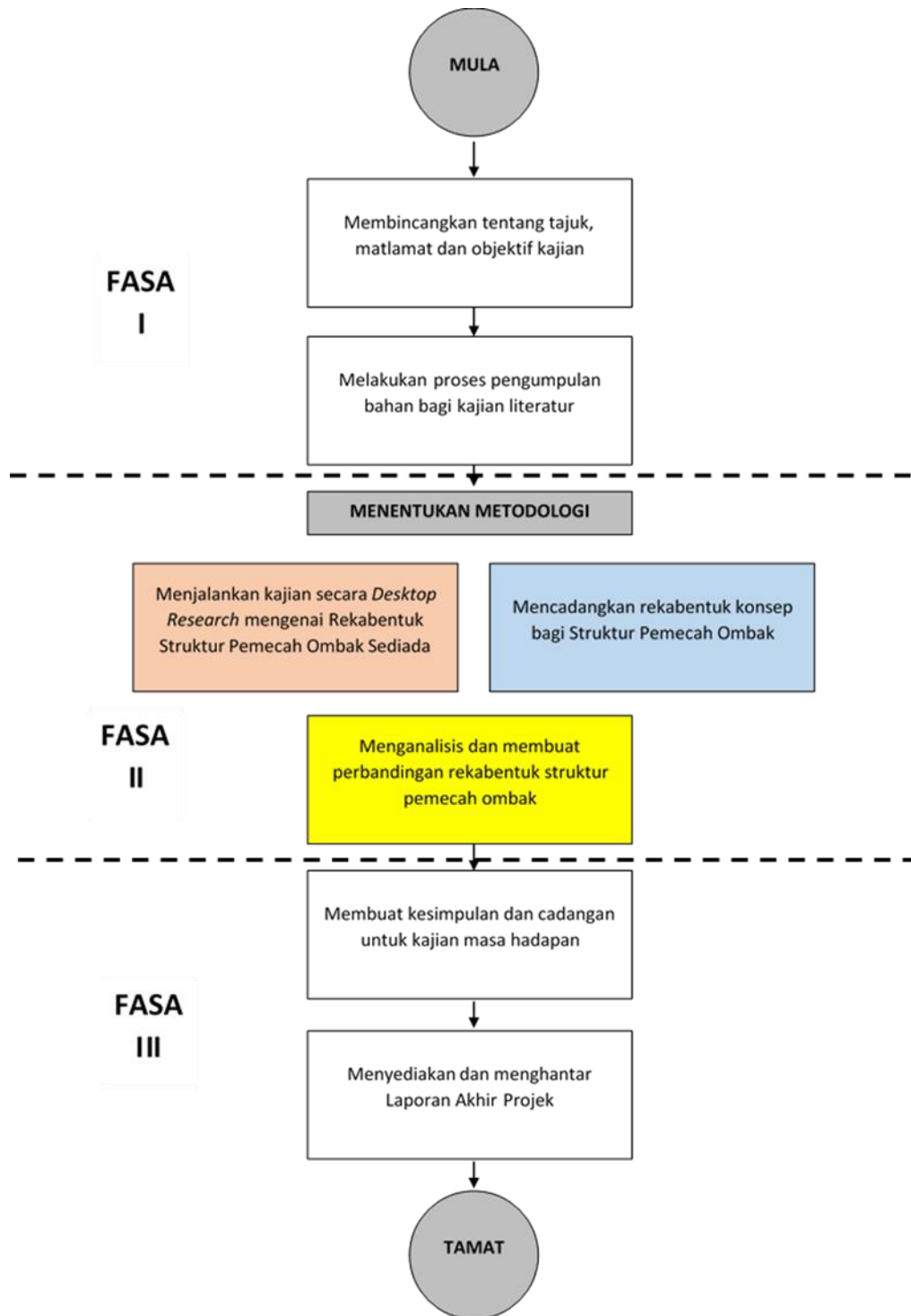


Figure 1: Study Flow Chart

4.1.1 Phase I (Preliminary Study)

Phase I shows the initial stage of the study such as the selection of the title, goals and objectives of this study. At the same time the literature review will be collected at an early stage to gather information about this study.

4.1.2 Phase II (Concept Design Stage Study)

Phase II shows the conceptual design stage study, which is like conducting a desktop research study on the design of existing breakwater structures. Next, propose a conceptual design of the most suitable breakwater structure. Perform analysis and make some comparisons with existing breakwater structure designs.

4.1.3 Phase III (Discussion and Preparation of Final Report)

Phase III shows the discussion and preparation of the final report by drawing conclusions and recommendations for future studies. Finally, prepare and submit the completed final report.

4.2. The Process of Determining the Design of the Concept of a Breakwater Structure

Determining the conceptual design of the breakwater structure for this study will facilitate a study to be conducted and the study will be more organized and neater. There are several processes to determine the design concept of the breakwater structure that will be done as follows:

4.2.1 Selection of 3 Breakwater Structure Design as the Basis of Concept Design

After reviewing the literature on several existing breakwater structure designs around the world. The selection of the breakwater structure design will be carried out by selecting the 3 best and suitable designs to be used as the basis of the design concept of the breakwater structure. The selection of breakwater structure design as the basis of conceptual design must be in accordance with the specified characteristics.

4.2.2 Features to Be Considered in Concept Design

Various features need to be emphasized in the design of the breakwater structure concept because it will determine the outcome of a design. There are several features that will be taken into account:

(a) Design

The choice of design is like aesthetic value so that this design has its own design and is not the same as the design of the existing breakwater structure. This is very much in line with the opinion given by Harper, (2018), who said that aesthetics is a branch of philosophy that contains a relationship with the nature of beauty, art, taste, creation and perception of its own beauty.

(b) Function of breakwater structures design

The design produced plays a role that must meet the desired purpose and requirements. Therefore, a good design should have a main function and a side function. For example, a breakwater structure with its primary function of breaking or stopping waves at the same time it will be able to stop coastal erosion.

(c) Materials for breakwater structure

Material selection is one of the features that must be taken into account in the construction of the concept design because the right material will make the result of the construction of a building structure. Materials will affect a construction cost and at the same time the cost of construction will be low.

4.3. Materials Proposed to Be Used in Breakwater Structure

Material selection is an important aspect of determining the strength and use of readily available materials. At the same time cost reduction is also important and the materials proposed for use in the structure are as follows:

(a) Used Tyres

For material selection, used tyres will be used for one of the materials to build the breakwater structure because used tyres are easily available which are usually discarded just like that. There are many uses of used tyres that led to the idea to study the construction of breakwater structures using used tyres. Usually used tyres will be used as flower pots and as attractive decorations in the yard. As such, each of the tyre production results from limited natural resources while at the same time the construction of breakwater structures not only saves costs for materials but also preserves the environment for the future. Recycling is a very important step and needs to be done to reduce waste and protect the environment from contaminants.

(b) Waste Concrete

Waste concrete material from the construction of other building structures can be reused to build breakwater structures and does not leave side effects even if it is used from the fragments of other construction containers is very useful. When concrete structures, roads, sidewalks or parking lots are destroyed, the concrete is often stored in landfills. Unfortunately, concrete will not decompose and instead it just takes up space and causes environmental problems that will affect humans themselves. At the same time, new concrete is being made to start the process again.

There is a solution to this wasteful and expensive cycle which is recycling. Recycling crushed concrete for reuse can help reduce landfill congestion and save more resources from being used to make new concrete. Old concrete can be crushed to a certain size, cleaned so that unwanted debris is removed from the mix and reused as a solution to a number of problems of lack of allocation for the construction of breakwater structures.

5. Data and Analysis

In this chapter, it explains and discusses the findings from the results of this study. It discusses the data obtained from desktop research which is entirely from a literature review conducted. This comparison is done to find out whether the MyBREAKER concept is able to work when it is tested by simulation in the laboratory or at a real location site. As explained in the early stages of this study, the scope of this study is only as far as designing concepts and making concept comparisons only. The next stage could not be done due to access constraints to equipment and time throughout this COVID19 pandemic.

5.1. Data from Desktop Research

5.1.1 Types of designs that have been identified & their characteristics

There are several design concepts done by some engineers in several countries around the world. Among the design concepts that have been done are:

- The concept of permanent construction
- The concept of semi -permanent construction
- Pre-fabricated concept
- The concept of coastal construction

The concept of permanent construction is the most widely done and usually it will be placed at a distance of 100meters to 500meters from the beach. The purpose of this construction is to ensure that strong waves do not continue to reach the beach and erode the coastline. The same goes for semi -permanent constructions. It works the same but, part of this beach breaker construction can be altered or altered to suit the conditions of the waves that hit the beach. If during the small wave season, then the breaker

height does not need to be high while for strong and high or large wave season, the breaker height needs to be raised and strengthened.

As for the Pre-fabricated concept, it is not built in the field but a structure that has been completed in the factory with a predetermined design. This concept is widely used in developed countries such as Korea and Japan because they have the technology and expertise in the field of manufacturing high quality materials and structures. However, in Malaysia, we are also able to do so with existing factories and current structural design technology. However, perhaps due to the low demand in Malaysia, the production cost of breakwater structures with this pre-fabricated concept may be more expensive. And last but not least, the concept of coastal construction. It is a concept that is also widely used in many countries to protect the coast but, the concept of breakwaters, is not widely available in the construction of coastal protection structures. In Malaysia, Sine Slab which is a product of lecturers and researchers from Universiti Teknologi Malaysia (1997) is one of the efforts to adapt the concept of breakwaters in coastal protection structures. However, it received less response and was only built in Pantai Klebang, Melaka in 1998 as a pilot project. Thus, from the results of this desktop research, it can be concluded that the above four concepts are alternatives in designing breakwaters and reduce the effects of coastal erosion caused by waves.

5.1.2 Comparison of Selected Breakwater Structure Designs with MyBREAKER Breakwater Structure Design Proposed

Table 1: Types of Breakwater Advantages and Disadvantages (Triatmojo, 2003)

Type	Advantages	Disadvantages
Vertical Breakwater	Faster execution of work	High construction costs
	The possibility of damage during the work is low	High construction peak height
	Larger area of port waters	Large wave pressure
	The interior can be used as an additional place or jetty	Need a large kaison making place
	Low maintenance costs	If damaged it is difficult to repair Requires heavy equipment Erosion on the base foot
Rubble Mound	Low construction peak height	Large amount of material consumption
Breakwater	Small reflection waves	Execution of long jobs
	Gradual damage	Possible damage during construction
	Easy repairs	
	Low construction costs	

5.2. MyBREAKER proposed design and its features

There is a proposal for the construction of a new breakwater design, MyBreaker, which is based on the concept of permanent construction with several types of breakwater structures:

5.2.1 Floating Tire Breakwater

The history of the use of many types of floating breakwaters has been widely used around the world. Principal use has become semi-protection where the wave height is 3-4 feet or less, and where depth, cost or other factors prohibit the use of conventional structures such as mounds of breakwater. An added advantage to breakers is that they can reorient or discard them causing more damage that they heal. The comparative advantage is the lack of durability compared to large boulders or concrete structures

requiring periodic inspection and maintenance, and the possibility of fundamental failure allowing the adjoining breakwater to run aground or become a navigational hazard. This type of floating tire breaker is recommended to use used tyres because it will be able to help in reducing construction costs compared to building using new tyres or the use of concrete stone.

5.2.2 Mixed Breakwater

According to Bambang Triatmodjo in his book Pelabuhan-(1999) and Cempaka, (2012), mixed breakwater is a breakwater that consists of a vertical side breakwater that stands on a sloping side breakwater. This building is used if the depth of the plan is large enough but the ground conditions cannot withstand the load of the upright side breakwater building. At low tide, the building serves as a sloping side breakwater, while if the water is high, then the building serves as a vertical side wave breaker. With this, this construction proposal is very suitable for construction in most locations and it works regardless of when the tide or low tide can absorb the existing waves.

The following are Figures 2 and 3 which show an overview of the proposed construction of a breakwater structure that combination several types of breakers such as floating tire breakwater, vertical breakwater, and rubble mound.

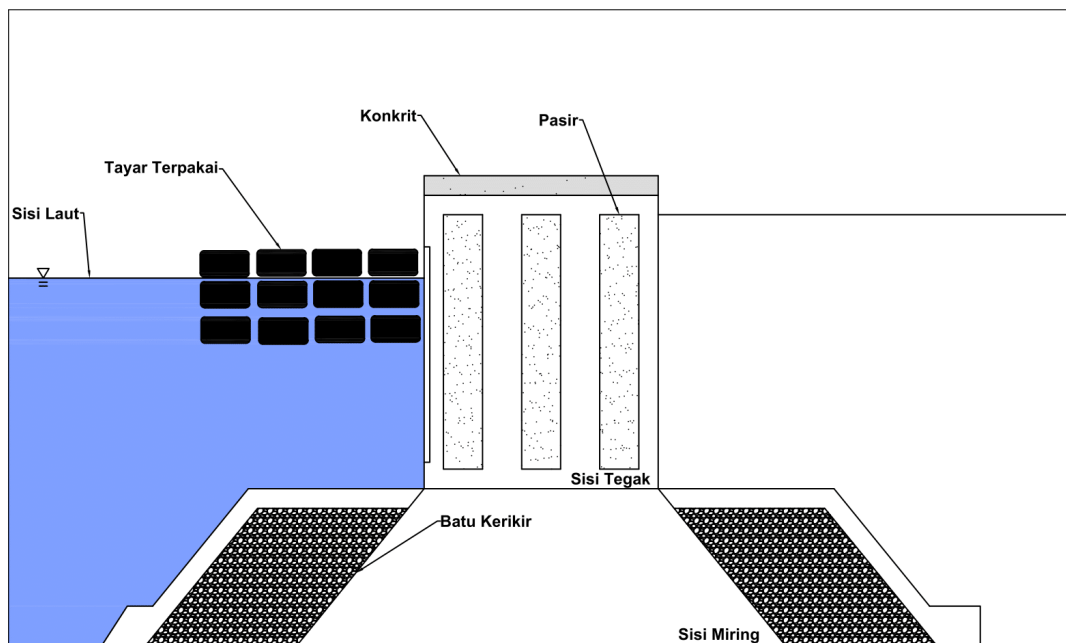


Figure 2: Proposed breakwater structure when the water level is at its highest level

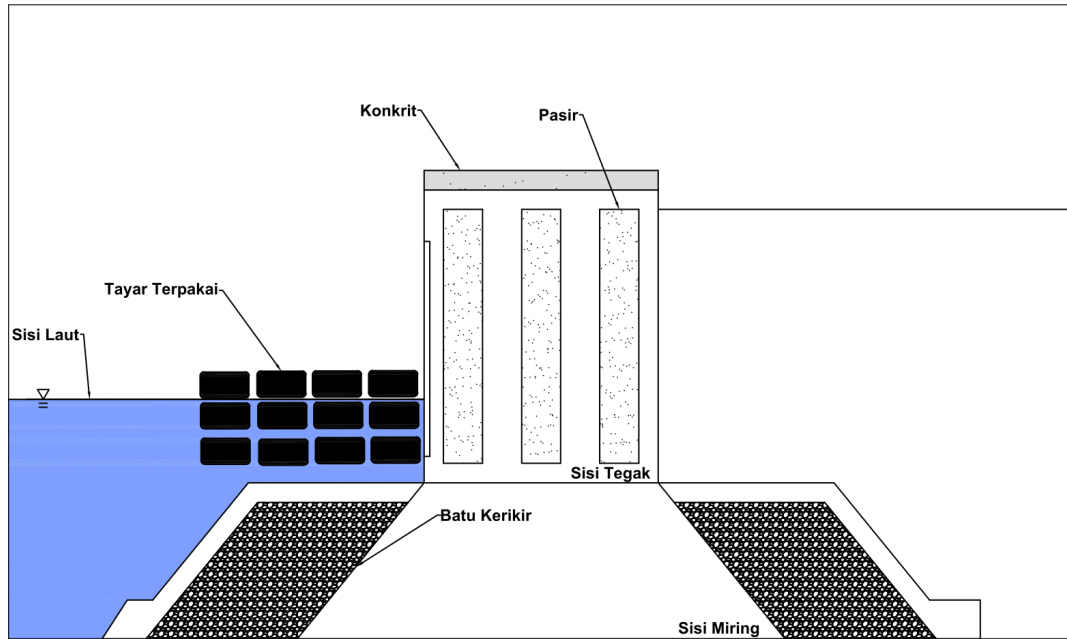


Figure 1 Proposed breakwater structure when the water level is at its lowest level

5.3. Comparison of three (3) selected designs with MyBREAKER

There are several comparisons of selected designs with MyBREAKER designs as in Table 2.

Table 2: Comparison of Selected Design Concepts with MyBREAKER

Selected Design Concepts		MYBREAKER Design Concepts	
CONCEPT #1: Vertical Breakwater	Faster execution of work The possibility of damage during the work is low Larger area of port waters The interior can be used as an additional place or jetty Low maintenance costs	CONCEPT #1: Floating Tire Breakwater	Only use tyres as the main material Low maintenance costs More flexible and changeable According to sea level
CONCEPT #2: Rubble Mound Breakwater	Low construction peak height Small reflection waves Gradual damage Easy repairs Low construction costs	CONCEPT #2: Mixed Breakwater	Fast execution of work The possibility of damage during construction is low Spacious for large port area

5.4. Advantages of MyBREAKER design with other Breakwater structures

There are many advantages to this proposed breakwater (MyBREAKER) structure. Here are some of the advantages of MyBREAKER over other breakwater structures:

5.4.1 Floating Tire Breakwater

- It can reduce the risk of damage in the event of a collision with the boat compared to the boat directly colliding with the concrete stone part.
- The floating tire breaker is the main breaker protector because the vertical side breaker has a large wave pressure so the wave can be reduced first when passing through the tire.
- This floating tire breaker can follow the sea level because of its floating nature so at every sea level it will be able to withstand or receive waves.
- The construction of floating tire breakwaters as a protective layer is also cheaper than the construction of concrete such as tetrapods as a protective layer because the construction of this construction uses used tyres.
- According to the study, the construction cost of a tetrapod is more than 10 times compared to the use of used tyres and its function is the same to absorb waves and provide protection to the main breakwater structure.

5.4.2 Mixed Breakwater

- The construction of this breakwater structure is better because it can shorten the construction time as well as reduce the cost of labor and equipment because the time taken is shorter,
- According to the study, the construction of this mixed breakwater structure takes less time than building a fully upright side breakwater structure. (Triatmojo, 2003)
- According to (Goda, 1985) upright side breakwater structures at the base will be more prone to erosion than sloping side breakwater structures. Thus, the construction of this mixed breakwater structure sloping side breakwater construction is basically to reduce the effects of erosion and can avoid high maintenance costs to repair the effects of erosion that occur.

6. Conclusion

Based on the proposed data and design analysis, the researchers found that the use of used tyres and waste materials such as concrete from building materials will be able to save the construction cost of breakwater structures without affecting the design function requirements of a breakwater structure. However, the next phase to ensure the function and durability of the designed breakwater structure is small -scale simulation testing in the laboratory or real or large scale at the coastal site to be studied. From the comparative study conducted as described in Chapter 4, the researchers also found that there are advantages to the proposed design of the MyBREAKER breakwater structure compared to the existing breakwater structure. In essence, the use of used and discarded materials will not only reduce the cost of structural building materials but will also be able to reduce the materials from polluting the environment and resulting in pollution to community life.

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