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CONSTRUCTION PROCEDURE FOR BEACH PROTECTION IN SÁNCHEZ MAGALLANES, TABASCO, MEXICO

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Summary – Fishing in Mexico is one of the economic activities of the populations living in coastal areas, as well as being a source of food from the sea as well as generating employment at certain times of the year due to tourism, the latter being a major activity, it is necessary to take into consideration the problems faced by the town of Sánchez Magallanes, Tabasco, where the sea has exceeded the beach line, causing loss of beach land and the destruction of previously inhabited areas. The objective is to improve this living environment and provide greater security for the inhabitants of this community. This entails the need to construct a civil engineering project that has the qualities to improve the above. It was therefore advisable to carry out a project to construct beach protection to prevent beach erosion, which had caused economic losses and loss of land. This protection is made from geotextile fabric.

Keywords: erosion, geotube, beach protection, geotextile fabric.

Abstract -- As fishing activities in Mexico are amongst the economic activities of the population living in the coastal areas, in addition to being a source of food supply from the sea; as well as a source of job creation at certain times of the year due to tourism; the latter being a major activity, it is imperative to take into account the problems that the town of Sánchez Magallanes, Tabasco deals with; where the sea has exceeded the beach line, causing loss of beach land and thus the obliteration of previously inhabited areas. To improve this living environment and promote greater security for the inhabitants of this community, it is necessary to set up some civil works that have the qualities to meet the goal. Therefore, it is advisable to carry out construction works based on geotextile tubes geotextile cloth for beach protection to avoid erosion that has caused economic and land losses. This protection is made from geotextile fabric.

Key words – erosion, geotube, beach protection, geotextile cloth.

INTRODUCTION

Never before has humanity faced such uncertainty in terms of survival. We are learning that the planet and its vital systems have limits and that once these are exceeded, there is no turning back. The climate has been affected in such a way that it is changing, and with it, the face of the Earth. Ecosystems and life itself are modulated by a series of elements such as rainfall and temperature, which, by altering their normal patterns, modify their expression in each region of the planet [1]. One of the areas most vulnerable to a changing climate and its effects is the coastal zone, as there has been an increase in the frequency and intensity of storms and associated natural phenomena, and the relentless advance of erosion is resulting in the loss of land facing the sea, as well as infrastructure [1]. This has significant consequences in terms of increased flooding due to rising sea levels, displaced populations, and the loss of vital communication lines such as streets, roads, homes, power lines, and telephone lines, etc. [1].

Coastal and/or beach protection is a human activity that emerged when humans acquired, through simple tools and works, the ability to protect the space around them for their own benefit. In their eagerness to settle on the coast in places that were convenient due to their climate and the availability of the resources necessary for their survival and well-being. However

However, they also suffered the onslaught of nature, so humans found it necessary to build structures or adapt the environment to protect themselves [2].

Today, with multiple and numerous coastal settlements and given the dynamism and vulnerability of the coastal balance, which is constantly changing on time scales ranging from hours to years or more depending on the type of coastline and the destabilizing and change-inducing forces, coastal protection is a common aspect of everyday life in coastal communities [2], [3].

As a result, coastal populations around the world face difficult problems in controlling shoreline erosion. This is due to the high cost of land in coastal areas, as well as erosion caused by waves from cyclones and/or storms, which can be seen as a major problem in attempts to reduce erosion as a coastal defense measure. For this reason, this study aims to describe the construction process of a coastal protection project for the community of Sánchez Magallanes, Tabasco, where coastal erosion has left buildings (homes, schools, restaurants, tourist palapas, streets, etc.) destroyed by waves and rising sea levels, which has also caused the beach itself to disappear due to rising sea levels. This coastal protection is based on geotextile fabric, which acts as a barrier to prevent erosion while allowing particles suspended in the sea to be retained on it, thus preventing the loss of beach material. It should be noted that there are no stone banks near this community that could be used in the work, so geotextile fabric is a solution to this severe problem in the community. Therefore, this paper will discuss the construction of this project to minimize waves, the loss of beach material, and infrastructure losses in the community.

DEVELOPMENT

Most common coastal protection works.

For coastal protection, there are works to reduce the loss of beach material. However, the decision has a lot to do with the costs of carrying out such protection works, among which the following can be highlighted: materials close to the site, analysis of waves, tides, currents, winds, and sedimentation; as well as the magnitude of the project under consideration (materials, labor, personnel, etc.).

In this regard, and within port and coastal engineering, a widely used definition of protective works can be as follows: structures designed to protect a specific area of the coast against the destructive action of various oceanographic phenomena, mainly waves [4], [5].

Coastal protection works can be classified according to the function they perform. Among the works to prevent erosion or reduction of the beach, we can mention the following:

- Breakwaters
- Breakwaters
- Breakwaters parallel to the beach

Breakwaters are structures that are generally built perpendicular to the coastline in order to prevent erosion caused by coastal transport, or to protect an area designated for a port that only needs protection at one point because it is located in a semi-sheltered natural area. [6], [7].

Figure 1. *Breakwaters in the Algarve, Portugal (Portugal Travel Guide, 2013)* [8].

Breakwaters, on the other hand, are structures built and designed on the coast to channel or maintain contact between a body of water (river, lagoon, or estuary) and the sea, and to control coastal transport (siltation) and protect against waves. [5], [9].

Figure 2. *Example of breakwaters in the port of Coatzacoalcos, Veracruz. (Ramírez, 2009).*

Breakwaters parallel to the coast are structures built for the purpose of reclaiming land from the sea and preventing its loss; they are built parallel to the

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beach line, as shown in the following figure. [6], [9].

Figure 3. *Example of a breakwater parallel to the coast, (Desonie, 2025) [10].*

Problems in the community of Sánchez Magallanes, Tabasco.

The problem in this area is the loss of beach land due to oceanographic conditions, resulting in a reduction in the area of the beach, as well as the loss of infrastructure close to it, as can be seen in Figure 4.

Figure 4. *Image showing the damage caused by waves on the beach, which has damaged restaurants, homes, businesses, palapas, and streets in the community of Sánchez Magallanes, Tabasco*.
Source: *author's image*.

This led to multiple community and municipal meetings (Figure 5), which were followed by the corresponding and necessary requests and efforts to obtain support from the authorities to carry out work that would prevent this serious problem from continuing, which has caused fear and uncertainty among the population.

Figure 5. *Figure showing one of the meetings with municipal and community authorities to mark the start of construction work*.
Source: *author's image*.

Considerations for beach protection.

Among the considerations for the construction of beach protection, it should be noted that the most commonly used material is rock. For example, in Figures 1, 2, and 3, it can be seen that for these constructions, which functionally serve as port and coastal protection, rock is the main material used. However, in the states of Tabasco and Campeche, it is difficult to find stone banks near the coast, so the use of this material increases the economic cost of the project. For this reason, it is necessary to seek alternatives in terms of materials that promote proper functioning and adequate economic savings, as well as correct construction processes.

Protecting the coastline from erosion is a task that very few materials can achieve. Rock is often used, and in other cases, concrete is used to create barriers that control the force of nature. Unfortunately, in most cases, none of these are optimal solutions [11]. The solution with geotubes, also known as geotextile tubes, is an economical and easy-to-implement solution compared to traditional solutions. After conducting the relevant studies, this material does not cause erosion. On the contrary, it can promote beach growth and dissipate the force of the waves, as the geotextile from which it is made is water-permeable, thus absorbing and dissipating the force of the waves [11].

For this beach protection, and in the absence of rock material, the alternative and decision was made to use geotextile fabric tubes as protective elements.

These tubes are made of geotextile material and will be filled with sand from the beach (area), which is a more economical alternative and will provide reliable protection for the beach.

It is worth mentioning that some of the benefits of working with this type of material include the following: [12].

Containment and filtration: They are filled directly with water and sand from the seabed; the water is filtered and the sand is contained or encapsulated in large quantities.

Easy installation: Can be easily installed above or below the water surface, even in adverse weather conditions

Cost reduction: Replaces more expensive rock or stone aggregates that are not available on site and require costly additional transportation.

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Stability and resistance: Resistant to currents and waves due to their high weight and great structural stability.

Flexible and versatile: Designed according to the needs of each project, they are a flexible solution due to their dimensions and the variety of geosynthetics available for their manufacture

These prefabricated elements, with special geotextiles, ready to be used in the construction of hydraulic and maritime structures, are determined based on the project requirements and are filled by directly coupling a hydraulic sand pumping system [13].

For Aquantica, 2021, the following advantages and properties are noted [13]:

- Minimal impact on the environment.
- Low-cost alternative to traditional construction methods.
- High resistance. Manufactured from special high-strength woven geotextiles.
- Easy to install above or below the water surface, even in adverse conditions.
- Prevents migration of sediments and fill materials.
- Excellent filtration and soil stabilization capacity.
- Generates a benefit by using site or dredged material in coastal applications.
- Resistant to storm surge due to its high weight and great structural stability.
- Flexible in manufacturing dimensions, customized project design [13].

Construction of coastal protection.

For the consideration of the works for the "Construction of beach protection in Sánchez Magallanes, Tabasco," a topographic survey was first carried out, as shown in Figure 6.

Figure 6. *Figure showing the start of work with a topographic survey of the site where the work will be carried out in the community of Sánchez Magallanes*.
Source: *author's image*.

Subsequently, the bathymetric survey was carried out (Figure 7). These two surveys are essential for obtaining the heights, distances, areas, volumes, and levels of the work, and for specifying in detail the length and location where the geotextile fabric tubes will be placed.

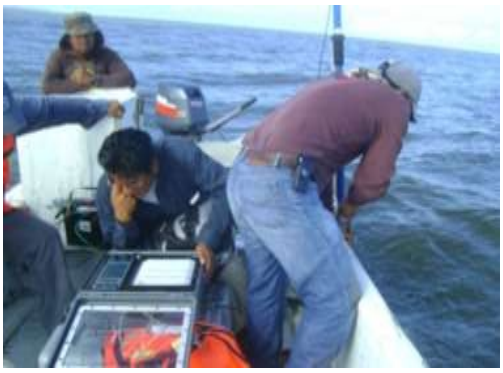

Figure 7. *Figure showing the bathymetric survey (measurement of sea depths to determine the topography of the seabed) with the appropriate specialized equipment*.
Source: *author's image.*

Once the respective surveys have been carried out, and the geotextile material and anti-scour mat are available for subsequent placement, the land is cleaned and leveled with the help of construction equipment such as a backhoe. After this, the line where the tubes will be placed is marked out (Figure 8).

Figure 8. *Figure showing the cleaning of the beach protection site, as well as the leveled ground and a person marking the line where the anti-scour mat and geotextile pipe will be placed*.
Source: *author's image*.

Once the above has been done (cleaning, leveling, and marking), the anti-scour mat must be laid, which will serve to prevent beach erosion in the area of the geotextile pipe, which will be placed later, once the anti-scour mat is in place (Figure 9).

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Figure 9. *Placement of the anti-scour mat in the area and length where the geotextile tube will subsequently be placed*.
Source: *author's image.*

After placing the anti-scour mat, the geotextile tubes are placed and filled with water and sea sand (Figure 10).

Figure 10. *Figure showing the anti-scour mat already in place and the start of the installation of the geotextile tube to be filled with water and sand*.
Source: *author's image*.

The above activity is carried out using a pump.
7.5 HP, which sucks up seawater and suspended sand, allowing the sand to remain inside the tube and the water, being liquid, to flow out (Figure 11). This process is carried out with each of the geotextile fabric tubes, which are joined together to form the protection.

Figure 11. *The laying and placement of the anti-scour mat and the filling of the geotextile fabric tube on top of the mat can be seen. The geotextile fabric tube is filled with water and sand using the 7.5 HP pump. The sand remains inside the tube, while the water flows out*.
Source: *author's image.*

Once the above has been carried out as part of the construction process, progress is made and the beach protection is formed. Figure 12 shows the placement of geotextile fabric tubes on top of the anti-scour mat along the length of the project, as well as the progress of the project on the beach in the town of Sánchez Magallanes, Tabasco, Mexico.

Figure 12. *Geotextile fabric tubes on top of the anti-scour mat. Visualization of the project, its progress, and length at the construction site*.
Source: *author's image*.

Similarly, during the construction of the beach protection, site visits were made to verify that the work was being carried out correctly.

Figure 13. *Meeting at the construction site between personnel from the Ministry of Communications and Transportation (SCT), the construction contractor, and supervisors to verify the beach construction work*.
Source: *author's image*.

In addition to holding work meetings and inspections to verify the work and activities during the execution of the project, meetings were held with municipal and local authorities to discuss the current situation, the schedule, and the progress of construction (Figure 14).

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Figure 14. *Meeting at the construction site with personnel from the Ministry of Communications and Transportation (SCT) and local authorities*.
Source: *author's image*.

DISCUSSION AND ANALYSIS OF RESULTS

Civil engineering works are extremely important, as they help to improve infrastructure so that people can live better and more comfortably and safely, thereby providing peace of mind to residents and functional improvements for their economic and recreational activities.

For example, according to López, 2023 [14], a beach recovery and stabilization project was carried out in 2008 at the Grand Velas Riviera Maya development. Although several hurricanes have hit the area since then, this project has continued to function properly, using the same construction procedure as the one mentioned in this paper.

Similarly, in Mayakoba (a tourist resort located on the Riviera Maya, Mexico), a beach recovery and stabilization project was launched in 2014 in conjunction with the UNAM Engineering Institute. The project includes the construction of several breakwaters, the search for sandbanks, the extraction of sand from the banks, and the filling of the beach with sand and a dune built with geotextile fabric tubes with anti-undercutting mats [14].

Also in Kanai (Riviera Maya), a beach recovery and stabilization project was built in 2018, which includes the construction of breakwaters with geotextile fabric tubes, filled with sand, over a length of approximately 1.8 km. Similarly, in Playa Mujeres, Mexico, a beach recovery and stabilization project was carried out with two breakwaters and a dune built with geotextile fabric tubes [14].

According to Peach, 2020, this type of beach erosion control project in other ports in the Mexican Caribbean has shown excellent results similar to those in the port of Chicxulub, where large areas of beach have been gained in a short time thanks to this type of geotube system (geotextile fabric tubes).

He also mentions his first applied geotube project against coastal erosion, which was carried out at the Playa Bonita beach resort in Lerma, Campeche, Mexico, with a 200-meter-long breakwater, whose primary function is to protect the beach resort, with very good results [15].

Citing the above, it should be noted that the present project, "Construction of beach protection in Sánchez Magallanes, Tabasco," was carried out over a period of approximately 150 days (five months). During this period, there were some unforeseen events such as strong waves, tides, and several days of rain, which on some occasions prevented the scheduled progress of the work. However, the work and activities for this project were completed within the established period.

As mentioned above, it was not possible to use rock due to the great distances between the stone banks, so geotextile fabric tubes were a very important alternative for the completion of this work.

It is worth mentioning that an agreement was also made to the contract because the community requested an extension to the length of the geotextile fabric tubes, resulting in a total length of around 3,000 meters for the entire project.

As an example of the completion of the work, Figure 15 shows the completed work, presenting the best alternative to the problem presented in this community, in addition to mentioning that at the end of the work, sand was filled behind the geotextile fabric pipes (reloading of beach material).

Figure 15. *Figure showing the completion of beach protection works using geotextile fabric tubes, as well as sand filling on the beach in front of the geotextile fabric tubes*.
Source: *author's image*.

CONCLUSIONS

Port and coastal works, activities, and projects are highly complex due to oceanographic variables such as tides, waves, currents, and wind.

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Some works of this nature have been mentioned above. In these, the construction procedure and purpose are similar, with very good results, and giving priority to the restoration of beaches in the face of oceanographic phenomena that occur in the region or coastal area. It is clear that this is an alternative and solution when there is no rock material close to the work site.

For this particular project, the activities were carried out with these oceanographic variables, taking care, skill, and dexterity at all times to ensure their successful completion.

This project allows the community of Sánchez Magallanes, Tabasco, to enjoy an improved quality of life with regard to its beach. It is worth mentioning that in certain parts of the year, fishing and tourism are extremely important, hence the relevance of this project.

The following figure shows the condition of the beach in the community of Sánchez Magallanes, Tabasco, Mexico.

Figure 16. *Initial state of the beach in 2009 with beach loss in the community of Sánchez Magallanes, Tabasco, Mexico*.
Source: *image extracted from Google Earth software, May 2022* [16].

Similarly, it can be concluded that beach protection is currently maintained in favorable conditions despite oceanographic events and phenomena that occur on the coast, such as waves, currents, winds, tides, and storms and cyclones. For example, from 2012 to 2021, the condition of the beach and its protection using geotextile fabric tubes has remained good (Figure 17).

Figure 17. *Figure showing the good physical condition of the beach protection and the material recovered from it in 2021, in the community of Sánchez Magallanes, Tabasco, Mexico*.
Source: *image extracted from Google Earth software, May 2022* [16].

In view of the above, it is important to mention that another conclusion of the work carried out is that this type of project is an alternative for beach protection, offering a great advantage when there is no stone quarry close to the work site.

It can also be concluded that periodic checks of the current state of the work should be carried out, due to the increasingly severe changes in climatic, meteorological, and oceanographic conditions on coastlines worldwide.

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