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WEST SUMATRA COASTLINE CHANGE DUE TO ABRASION PROTECTION STRUCTURES: PADANG BEACH

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ABSTRACT: The abrasion disaster that has resulted in remarkable coastline changes is one of the national disasters that concern the Indonesian government. The West Sumatra Government which has a significant long beach has made many abrasion prevention structures to stop loosing of hundreds of meters of land due to abrasion. In fact, the abrasion prevention structures not only protect the beach but on the other hand they also change the shape of the beach. A field study has been conducted and found that beaches that have been protected with abrasion prevention structures are susceptible to changes in shape. On the one side, the change provides benefits but on the other hand, it causes a new problem. This paper explains the relationship between the dimensions of the coastal abrasion prevention structure and the properties of adjacent beach sediment related to the shoreline changes occurring in West Sumatra. This study is very important to provide a prediction of shoreline changes due to the prevention of abrasion related to the beach soil properties. The result can be used to determine the precise abrasion prevention structures in accordance with the conditions of sediment on the beach for a future expected change.

Keywords: West Sumatra Coastline, Abrasion protection structure, Field Survey

1. INTRODUCTION

West Sumatra has been experiencing beach abrasion since hundred years ago. The history of abrasion especially has been recorded since 1890 in Padang. The abrasion is generally due to the Indian Ocean waves and currents. In Padang, the abrasion has been causing damage to public facilities and the beautiful environment such as sandy beach (Fig.1).

Abrasion is known as part of the natural phenomenon in terms of erosion and sedimentation cycles along the coastline. But for the developed area, the abrasion may result in many disadvantages such as cutting the accesses, destruction of houses and even the loss of a beautiful public playground. With so many losses due to abrasion, the Indonesian government has included this natural phenomenon into one disaster that needs to be managed [1].

In order to minimize the negative effects of abrasion to the coastline, engineered beach protections such as groin construction can be used [2]. Even though building such wave protector to prevent abrasion could not restore back the loss of beautiful sandy beaches. In Padang beach, the breakwater construction has been built since the last century. (Fig.2).

Damage of beaches due to erosion or abrasion becomes a matter of concern to researchers since decades. Researches on coastal abrasion become excessive by linking up to the issue of global warming. A number of reports from the 19th to the 20th centuries on the relationship between sea levels and coastal damage have summarized by Zhang et al in 2004 [3]. They found that the damage to the beaches has been twice over with the rate of actually sea level rise. This study also notified that with the global warming scenario, the coastal abrasion problems that already look severe in the last century will be worse in this century. The other studies concerned about the changes in the coastal environment due to land use and global warming [4].

Fig.1 Padang Beach in 1890 [5]

Even the abrasion protection using hard structures can eliminate the natural and may not beautiful [6], but the natural protections as an alternative may need several times before the work. The hard structure can be designed and built in months. Then the West Sumatra Government has made many abrasion prevention structures to stop loosing of hundreds of meters of land due to abrasion.

Fig.2 Groins in Padang Beach

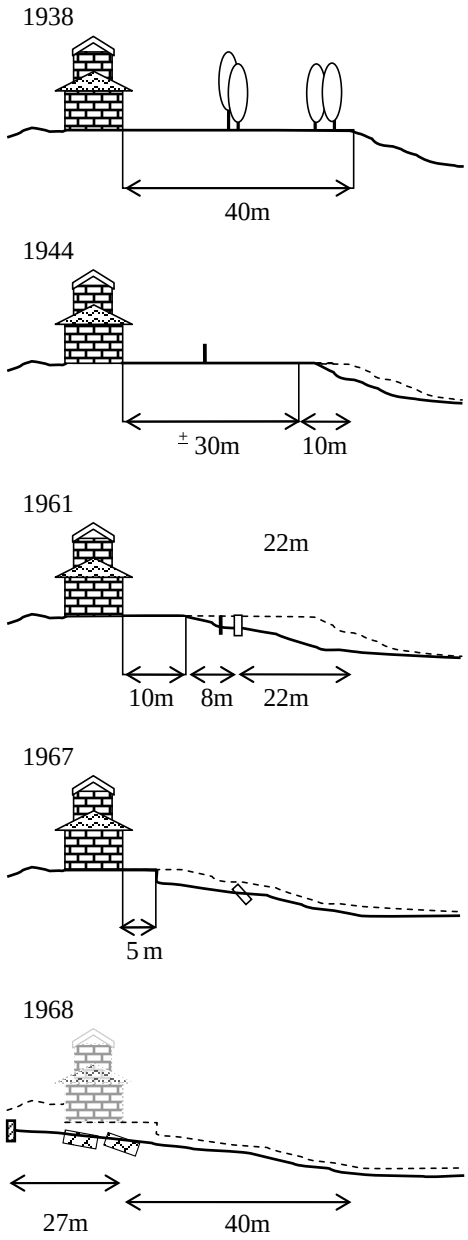

Fig.3 Abrasion on Padang Beach.

The Abrasion on Padang Beach has been the object of research from the Marine Geology Research and Development Center of Indonesia. That Research Center has recorded the history of Padang Beach abrasion since almost a century ago as well as the estimated lost of the Padang coastline. It was predicted that the abrasion rate on Padang Beach up to 6m per year inland. The setback is expected to take away and reduce the stability of coastal geometry more than 40 meters towards the center of the City as illustrates in Fig.3 [7]. Unfortunately, at that distance there has been densely populated by houses, shops, offices and various other city facilities.

The Priority areas in the construction of a coastal structure in West Sumatra are the areas that have a historical record of abrasion. One of them is in the Padang city, where the historical record of abrasion has been begun since more than 100 years ago and the abrasion has resulted in lost of Padang land more than 50m.

This paper will discuss the influence of abrasion prevention structures located in Padang beach, especially those located in downstream of Banjir Kanal River (Flood Control Canal) as shown in Fig.4. This area is quite interesting because besides it was influenced by the sea, abrasion and accretion in this area are influenced also by the existence of Bajir Kanal River.

2. GROINS IN PADANG

Padang is a Capital City of West Sumatra which originally developed by Dutch colonists in the early of 1800s when its abrasion record was begun. The cause of abrasion in Padang Beach is expected due to the Littoral Barrier in the form of Padang Mountain which stops the sediment transport from the south- part to the north-part of it.

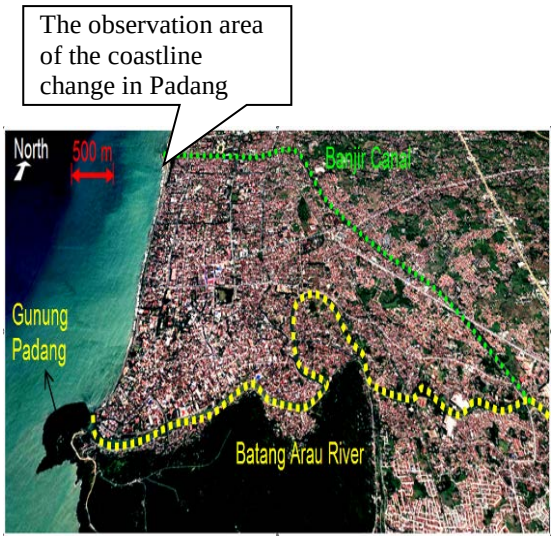

Fig.4 Birdseye of Padang Beach

In addition, the development of Banjir Kanal River since 1926 which divided the volume of water Batang Arau River causing disruption of coastal equilibrium around Padang Mountain to Banjir Kanal River. Banjir Kanal River reduces the sediment supply from Batang Arau River, resulting in abrasion in Padang Beach (Fig.4). Meanwhile, the causes of abrasion in the form of waves and currents from the Indian Ocean are ignored and have not been observed yet.

The development aimed for dealing with abrasion using groins in Padang Beach was carried out since 1969 [8]. At that time in Padang Beach, there was a special building called Wisma Pancasila where the adjacent beach has been eroded so. It was predicted that if it just let it goes, the foundation of the building would be eroded. For that reason, the first 40m groins were constructed in the perpendicular direction to the coastline. Later in the year of 1970 to 1980, the Government made additional groins along the coast of Padang from Gunung Padang to the Banjit Kanal River (Fig.5).

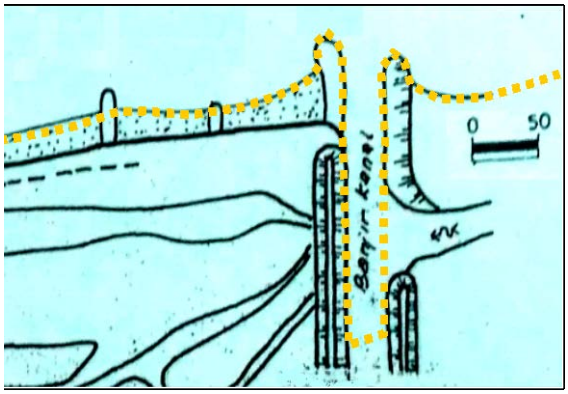

Fig.5 Padang Beach's Groins in the 1980s

In this study a review of the effects of offshore construction around the area. These two points will be discussed, the coastline change and physical of sediment around the Banjir Kanal. The existing abrasion prevention constructions in this Padang Beach area are groins with the main shape towards the sea. These groin constructions were built in 1980 and they were enlarged in 2008. The main material used for this constructions is cobbles and boulders. The design plan of the main jetty and groin structures are shown in Fig.6. The jetty is designed to trap sediment behind it, meanwhile, the groin is to protect the right-beach from Banjir Kanal current.

3. COASTLINE CHANGE

The field observation, as well as literature review, have been done to focus on the shoreline changes due to the existence of abrasion prevention construction located in the Bajir Kanal. The map showed the Padang Beach before the construction (before 2008) as shown in Fig.7.

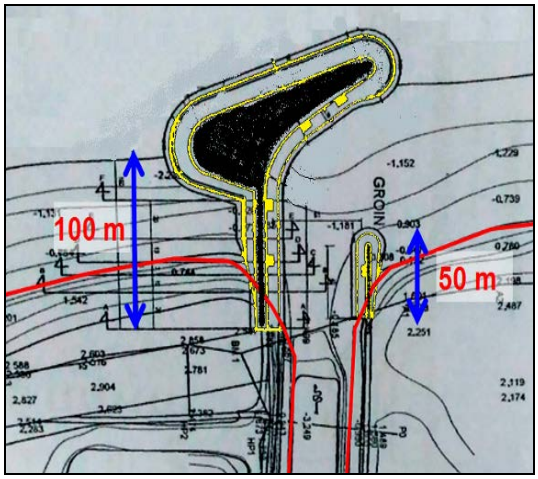

Fig.6 Jetty and Groin design in Padang Beach 2008 [9]

It shows that there is a road near the beach does not have a bridge yet to cross the river the north. It is also seen that jetty and groin structure on the mouth of Banjir Kanal has not been constructed. The color of the sea also indicates the origin of the sea water. It can be seen that the water from Banjir Kanal river goes through to the sea straightly. The water of the river meets and bumps directly with currents and waves from the ocean. At that point, the sea waves were breaking. Then theoretically it could be understood that as a result of the silting sidemen causing the wave breaks in the sea. This sediment then will be pushed to the land side and trapped behind the jetty. This theoretical statement is adopted by Padang Government to build the new dry ground behind the planned Jetty and will be used as new land instead of a reclamation work.

Fig.7 Padang Beach before 2008

Furthermore, Fig.8 shows the current situation, which is 10 years after the jetty and groin structures are constructed in Banjir Kanal. In the picture also can be seen a new bridge connecting the coastal road from the north and south of the parts of Banjir Kanal river. The color of the sea water indicates the water from the Banjir Kanal river has been turned by the jetty to the north direction. This condition contributes to the change of the coastline surrounding area since the water Banjir Kanal river brings sediment particles. The coastline of the north side of the Banjir Kanal river have been gone to the seaward due to the sedimentation.

Fig.8 Padang Beach in 2018

The shoreline changes can be seen by making up the change of average boundary lines to form the monitored coastline in several years. The available digital documentations of Padang Beach are started in 2008. The shoreline in 2018 then is plotted along with the shoreline in 2008 (Fig.9).

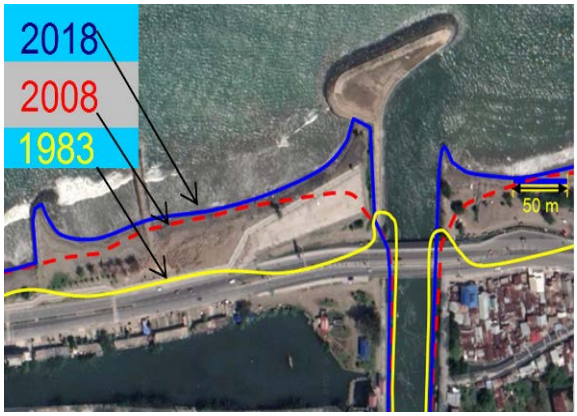

Fig.9 Coastline change at Padang Beach

To complete the picture of the shoreline changes, there is also plotted the shoreline in coastal estimates in 1983 (35 years ago). The 1983 shoreline is plotted based on the results of the sedimentation study of Padang Beach [9].

There are noticeable shoreline changes in 1983 (yellow line), 2008 (red line) and 2018 (blue line). Although in general, the change was possible, because in 1983 the picture of Padang beach is still manually drafted so that the change is quite dubious.

While the shoreline changes in the last 10 years, may occur due to the additional length of the groin and jetty constructions at the mouth of Banjir Kanal River. This form of change is still appropriate with the theoretical prediction, even the sediments in the eastern part of the jetty exceed the predicted amount.

Estimated sediments trapped by this jetty have been predicted in the design phase. The trapped sediments behind the jetty are used by the Padang Government as a public playground. However, the amount of sediments trapped is not calculated properly due to the lack of marine data. The condition of trapped sediment is actually consistent with one of the conclusions of the past study on coastline changes due to the grain effect. That study also concluded the amount of accretion and erosion did not show in a balanced amount [11].

4. SEDIMENT GRAIN SIZE

This study also attempts to investigate the changes that occur in the nature of the sediment on the coastline (Fig.10).

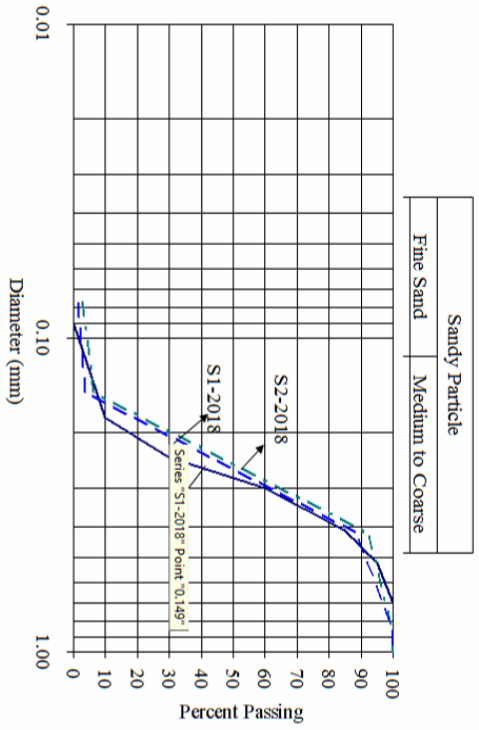

Fig.10 Grain distribution of Padang Beach sands

For that reason, the sediment samples have been taken from Padang Beach at the location adjacent to the mouth of Banjir Kanal. Furthermore, a sieve analysis of sediment sand is conducted. The laboratory test results are plotted on the graph in Fig.10.

In the Figure also plotted the results of the sieve analysis of the sand beach sample in the same location 35 years ago. From the picture, it is seen that there is no significant change in sand gradation at that point. It is possible that the newly beach sand is originally come from the same area as in the previous year. The source of new sand sediments is likely to originally come from the mouth of the Banjir Kanal where in front of the jetty before it is built. Meanwhile, after the construction of the jetty and groin structures in the mouth of the Banjir Kanal, this sediment was pushed by the sea water and moved to the beach side. This phenomenon is also marked by the loss of breaking wave in the mouth of Banjir Kanal that existed before the construction. Breaking waves can occur when the seabed undergoes shallower, in this case, is due to sand sedimentation, and it is moved after the jetty construction. It cam is seen by comparing Fig. 6 and Fig. 7 and 8.

This result differs from previous studies in which there was a change in the physical properties of sediment in the same place [12]. The past study reported that surface sediment on the eastern part of the dock became coarser while on the west part became finer during the 4-year period. The increase and alteration of physical properties in the sediment may be caused by the wind as well as the presence of the offshore structure.

5. CONCLUSIONS

Abrasion is one of the Indonesian national disasters that has resulted in a disadvantage as well as advantage coastline changes. The impact of abrasion that has wiped out the mainland can be reduced by constructing proper hard structures such as jetties or groins. Even those unnatural structures have less beautiful, but for Padang city, the structures have a significant way to draw back the beach sediment that has been wiped away in the past.

This study has been conducted by comparing the present condition of Padang shoreline to the one in the past. This study found that there is a change in the coastline of Padang due to the existence of abrasion protection structures. The coastline change in Padang Beach as observed in this study is found almost agree with the expected one.

The possible change in the sediment in the Padang Beach is observed by comparing the laboratory test at the recent condition to secondary data from the past. This study has found that the sediment in the area of study is just moving close by. It was shown by the similar grain distributions of the sand sediment event it has 35 years of time differences.

6. ACKNOWLEDGMENTS

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