Design and Selection of Alternative Embankments To Overcome Tidal Flood (A Case Study of The Construction Plan Of a Tidal Embankment at Sayung, Demak)

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ABSTRACT

Abstract: Tidal embankment project in Sayung is one of the construction planning projects of the government. There are three alternatives of embankment designs that may be applied in the construction project; (1) Parapet Wall and Corrugated Concrete Sheet Pile (CCSP) reinforcement, (2) Concrete Wall Embankment with mini pile reinforcement, and (3) Multipurpose Panel System Embankment (SPS). The research was needed to examine the designs to find the fittest. This study aimed to redesign the construction plan of the tidal embankment using Plaxis software. This software was to analyze and determine the safety factors of the three alternative embankment designs. It was stated to be safe because it exceeded the standard of 1.5. One of the three alternative embankments was implemented using the Analytical Hierarchy Process (AHP) method based on predetermined criteria: (1) Aspects of function and benefits, and (2) Aspects of site conditions which include cost and construction process. From the alternative selection using the expert choice program analysis method, the concrete wall embankment with mini-pile reinforcement was the main priority, with a weight value of 45.9%. Meanwhile, the second priority was the Parapet Wall and CCSP Reinforcement with a weight value of 37.2%, and the third choice was the Multipurpose Panel System Embankment (SPS) with a weight of 17%.

Keywords: Embankment, selection of embankment design, embankment alternatives, method of Analytical Hierarchy Process (AHP)

1. INTRODUCTION

A number of coastal areas in Indonesia experience tidal flooding due to high tides. Construction of dam and embankment infrastructure is one of the main aspects of overcoming floods and tides.

Tidal floods cause losses and disrupt community activities. The events took place in several cities and regencies on the north coast of Java Island (Syafitri & Rochani, 2022; Puspitotanti & Karmilah, 2022). Demak Regency was one of the affected districts, especially the area of Sayung located between the River Babon and the River Sayung. BMKG Maritime of Tanjung Mas Harbor reported a peak of tidal flooding at Sayung at the end of May 2019. It was about +1.66 meters high. As a result, there was a severe traffic jam about 4 km long on the north coast road of Semarang-Demak (BMKG, 2019).

Embankment design planning in the construction of flood control infrastructure plays a very important role in determining the form of construction and its function. For this reason, it is necessary to have several structural design options that are used as a reference in selecting the right design, both in determining the variations in form, technician, function, and durability of the embankment structure (Fahlevi, 2018).

Indonesia currently has several types of embankment structures with their plan and

structural designs, such as (1) embankments with parapet walls and Corrugated Concrete Sheet Pile (CCSP) reinforcement, (2) embankments with parapet walls and mini pile reinforcement, and (3) embankments. With the reinforcement of the multipurpose panel system (SPS).

Based on these problems, a scientific approach is needed to determine the accuracy level in determining the embankment's design. In this case, the Analytical Hierarchy Process (AHP) is selected as it is possible to apply in the present study. This method has been widely used in the decision-making and management of an appropriate choice. Using a reliable multi-criteria method contributes to the logical decision-making process. The Analytical Hierarchy Process (AHP) was chosen because of its simplicity and transparency in selecting multi-criteria. In addition, many real-world applications have proven that AHP is a valuable tool for dealing with complex issues, given its functionality that allows decision makers to describe problems related to decisions and their constituent parts hierarchically (Anagnostopoulus et al, 2006).

Therefore, research is needed to examine the tidal embankment's design, the embankment's stability, and the safety factors, in addition to selecting from the three alternative designs of embankments using the Analytical Hierarchy Process (AHP) method based on predetermined criteria.

Objectives of the research

This research aimed to:

a. Design the tidal embankment using Plaxis software.
b. Analyze the stability and safety factors of the three alternatives of the tidal embankment using Plaxis software.
c. Review the comparison of the selection criteria for embankment designs concerning the available embankment design alternatives.
d. Obtain a suitable embankment design for the project of Demak tidal embankment using the AHP method.

2. RESEARCH METHOD

This study was a combination of qualitative and quantitative research. A qualitative

method was to determine the criteria influencing the selection of an alternative design for the tidal embankment in Sayung. At the same time, the quantitative method was to determine the hierarchical level and calculate each element's weight.

3. RESULTS AND DISCUSSIONS

Below is the summary of the results and discussion:

3.1 Embankment Design

There are three alternative designs of embankments:

1. Concrete wall embankment with mini pile reinforcement
2. Multipurpose Panel System (SPS) Embankment
3. Parapet Wall and Corrugated Concrete Sheet Pile Reinforcement (CCSP)

The following is an explanation of the three alternatives above:

A. Alternative 1: Embankment with retaining wall structure in the form of concrete with mini pile reinforcement

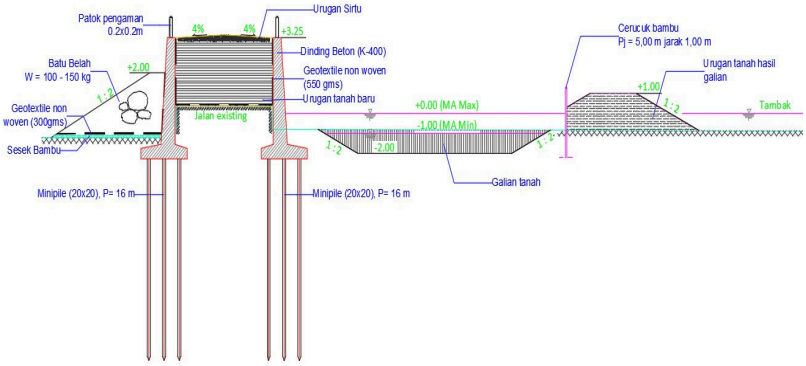
The main material of this embankment is a K400 concrete wall with reinforced concrete cylindrical mini pile poles reinforced with soil piles on the land side. Structurally, this type of embankment functions as a barrier to water (sea) pressure and a retaining wall with high cliffs. This construction is a K400 precast concrete wall with 20x20cm mini pile reinforcement with a depth of 16m.

The embankment construction consists of several materials:

1. The main material is K400 concrete wall, Mini pile 20x20, P 16m
2. Landfill
3. Geotextile non-woven
4. Landfill, Sandstone backfills
5. Split stone for breakwater

The construction plan costs Rp. 45,787,399.21.

Figure 1. Show the alternative design 1
Figure 1. Embankment Design of alternative 1



B. Alternative 2: Multipurpose Panel System Embankment (SPS)

This type of embankment construction is very suitable to be applied to areas of cliffs, rivers, road structures, and beaches that have stable soil conditions and are directly adjacent to water.

Multipurpose Panel System is a System consisting of Precast Panels that are connected and filled with earth fill between the two Precast Panels.

An embankment with Precast Panel components is a construction in the form of a large panel container filled with sand or soil material. The material filling is done by backfilling.

Construction of this embankment is relatively easy and requires a faster execution time so that it can save costs.

The construction of an embankment consists of several materials:

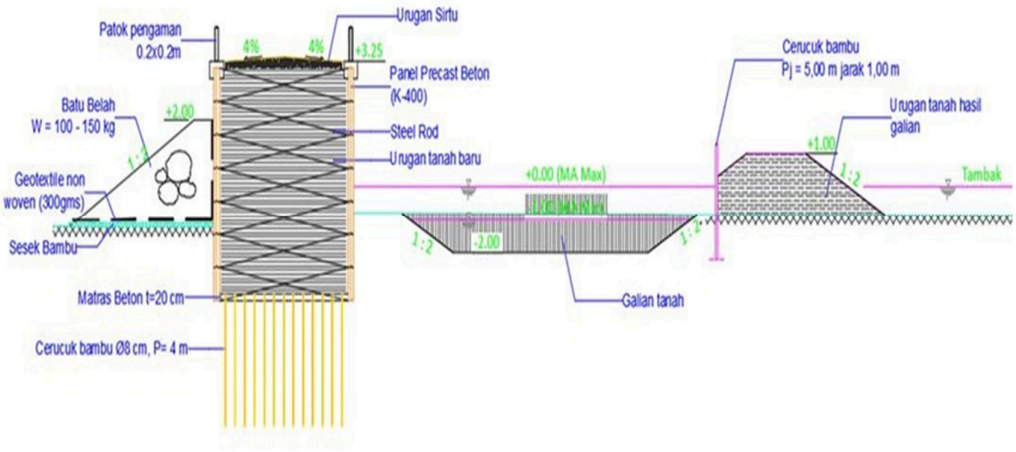
1. Heap of soil/sand (selected material) for the main material (core),
2. K400. Precast Concrete Panels
3. Non-woven Geotextile
4. Split stone for protection layer (protection)
5. Steel pull rod of concrete (safety stake),
6. Paving blocks at the top of the embankment (if needed for roads)
7. 4 meters long bamboo cone

The construction costs required for the design plan are Rp. 39,955,936.25.

Figure 3.2 below shows the alternative design 2

Figure 2. Multipurpose Panel System Embankment (SPS)

C. Alternative 3: Parapet Wall and Corrugated Concrete Sheet Pile Reinforcement



(CCSP)

The main materials for this embankment consist of:

1. *Corrugated Concrete Sheet* Pile (CCSP) with a concrete block breakwater.
2. *Corrugated Concrete Sheet Pile* (CCSP) 16 m length.
3. Landfill with geotextile layers for each layer.

With the construction cost of From the design plan, the budget required is Rp. 64,377,000/mFigure 3.3 below is an example image of the foundation CCSP :

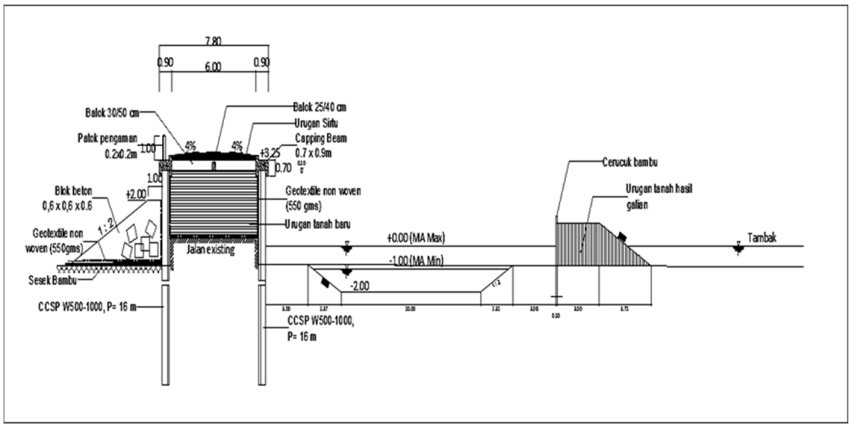


Figure 3. Parapet Wall and Corrugated Concrete Sheet Pile Reinforcement (CCSP)

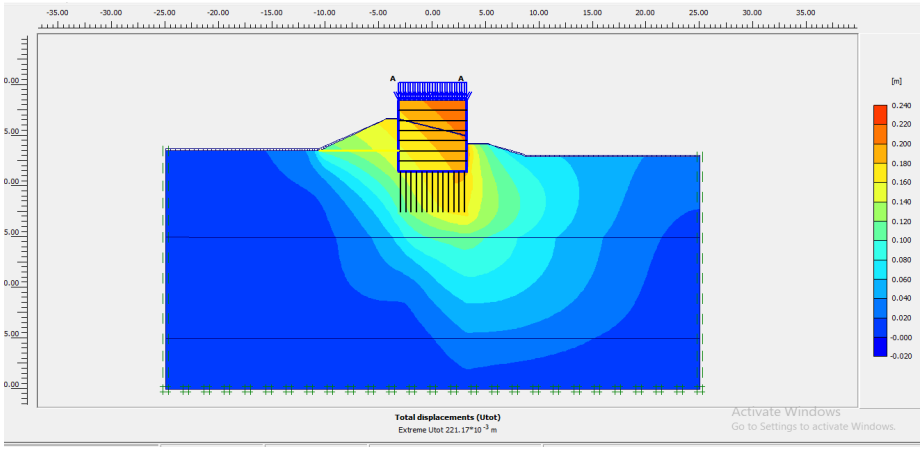
3.2 Testing using the Plaxis Program

A. Alternative 1 Concrete wall with mini pile reinforcement

Figure 3.4 below shows the embankment testing using the Plaxis application

Figure 4. Alternative 1 testing using the Plaxis application

In general, alternative 1 of tidal embankment design experienced a displacement of 2.15



m with an inward movement direction with a safety number of

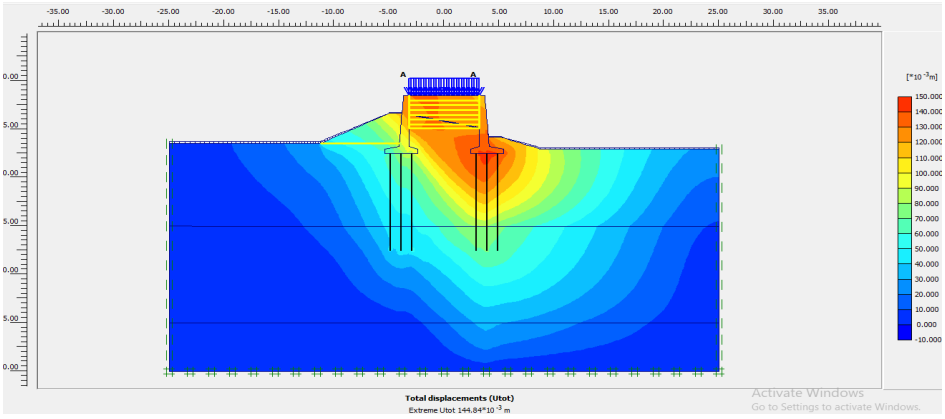
(SF) = 1.8 > 1.5 (meet)

B. Multipurpose Panel System Embankment (SPS)

Figure 3.5 below shows the embankment testing using the Plaxis application:

Figure 5. Testing alternative 2 with the Plaxis application

The tidal embankment design experienced a displacement of 0.221 m with the

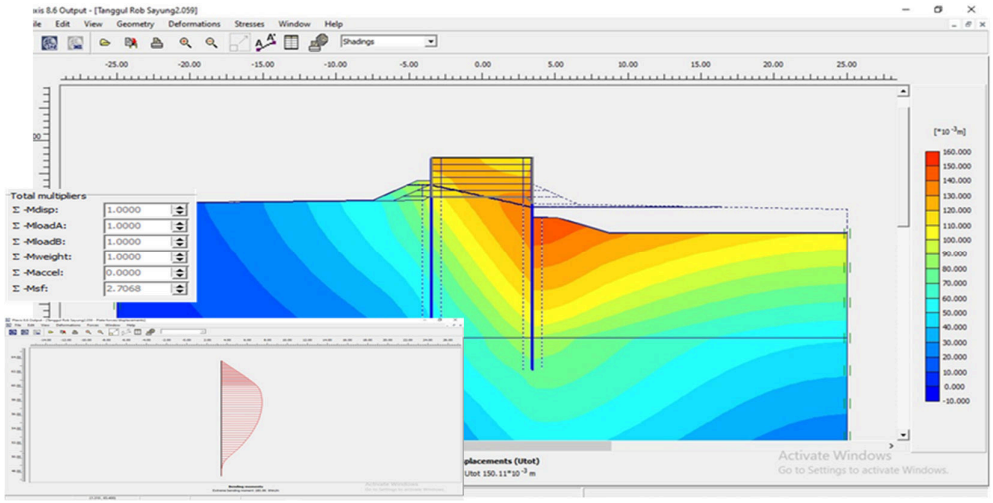


direction of movement towards the channel with a safety number (SF) = 2.69 > 1.5 (meet).

C. Parapet Wall Embankment and Corrugated Concrete Sheet Pile Reinforcement (CCSP)

Figure 3.6 below shows the embankment testing using the Plaxis application:

Figure 6. Testing of alternative 3 with the Plaxis application



The embankment design has a displacement of 0.221 m with the direction of movement towards the channel with a safety number (SF) = 2.70 > 1.5 (meet).

3.3 Weighting criteria using expert choice

Respondents are required to apply the AHP method. This study involved as many as 5 (five) people as respondents with different education levels, positions/positions, and agencies

Gambar di bawah menunjukkan table parameter pemilihan tanggul

The figure below shows a parameter table of embankment selection

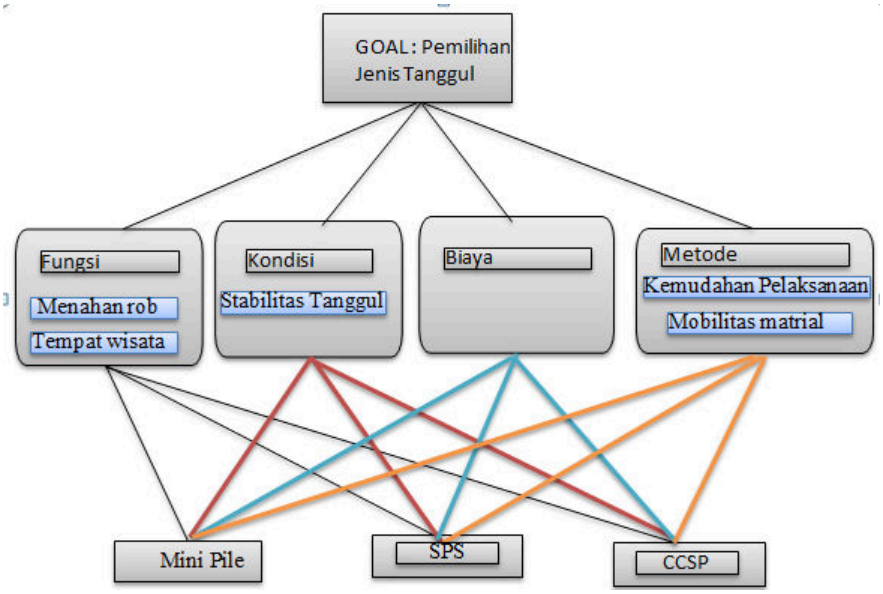


Figure 7. Parameter of embankment selection

By looking at the results of the alternative sensitivity test using the Analytical Hierarchy Process (AHP), each weight obtained from the 5 respondents can be seen with the help of Software Expert Choice.

The following is the order of alternative weights for the embankment construction which can be seen in the following figure.

Alternative Ranking: by looking at the results of the alternative sensitivity test using the Analytical Hierarchy Process (AHP), each weight obtained from the 5 respondents can be seen with the help of Software Expert Choice. The following is an image of the alternative weight order of the Embankment construction:

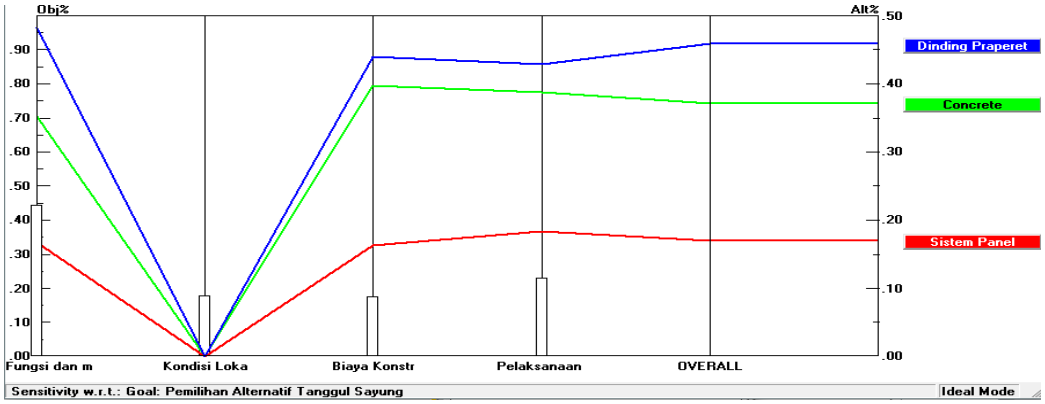


Figure 8. Overall Ranking Results of Alternatives and Criteria using Expert Choice

The analysis results using Expert Choice show that the Parapet Wall alternative with mini pile reinforcement has the highest weight of 45.9%. The second highest weight is found in the alternative CCSP reinforced concrete wall, which weighs 37.2%. In comparison, the third highest weight is on the Multipurpose Panel System (SPS), with a weight of 17%.

4. CONCLUSION

The following is a conclusion of the research entitled Analysis of Design and Alternative Selection of Embankments to Overcoming Tidal Floods:

a. The design of the tidal embankment at Sayung has three alternatives:
   1. Concrete wall embankment with mini pile reinforcement
   2. Multipurpose Panel System Embankment (SPS)
   3. Parapet Wall and Corrugated Concrete Sheet Pile Reinforcement (CCSP).

b. The three designs above have been tested using the Plaxsis program to determine the stability and safety factor of the embankment, with the results: Concrete wall embankment with mini pile reinforcement of 1.8. The Multipurpose Panel System Embankment (SPS) of 2.69 and the Parapet Wall and CCSP Reinforcement of 2.70. This condition is regarded as safe as it exceeds the safety standard of 1.5.

c. The criteria as considerations in mentioning the fittest option in deciding the construction design of the tidal Embankment at Sayung are:
   - Functional aspects and benefits include fisherman's transportation routes, tidal and wave barriers, and a place of recreation.
   - Aspects of site conditions include stability of the embankment.

- Cost aspects include construction costs.
- Aspects of construction implementation include ease of implementation and mobilization of materials.

d. From the analysis of the design selection of Sayung embankment using the expert choice program, it is revealed: that the concrete wall embankment with mini pile reinforcement is the top priority, with a weight value of 45.9%. The second priority is Parapet Wall and CCSP Reinforcement, with a weight value of 37.2%, and option number three is the Multipurpose Panel System Embankments (SPS), with a weight of 17%.

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