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Port Structure Design of 1000 DWT Capacity in Masni District, West Papua Province

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ABSTRACT: Connectivity between regions in West Papua Province in particular and the eastern region of Indonesia is highly dependent on sea transportation, considering that land transportation is very limited, and the population is concentrated in coastal areas. Port development is one of the programs of the Masni Regency government to address the challenges of connectivity and regional development. Planning the design of a pier and wharf structure for a ship with a capacity of 1000 DWT was carried out because the majority of ships served in West Papua Province are ships with a capacity of 1000 DWT. This research was conducted by conducting hydro-oceanographic analysis, topographic and bathymetric analysis, and a detailed design of the pier structure. This research is expected to provide a detailed technical description for the local government in determining the construction of a technically and economically reliable pier. The findings will also serve as a valuable resource for ensuring safe navigation and efficient cargo handling in the region. Ultimately, the successful implementation of this project could enhance trade opportunities and foster economic growth for the communities in West Papua Province.

KEYWORDS: Marine Transportation, Ports, Pier and Wharf design, Hydro-oceanographic Analysis, Topographic and Bathymetric Analysis.

I. INTRODUCTION

Masni Port in the National Port Master Plan is stated as a Local Feeder Port (Decree of the Minister of Transportation of the Republic of Indonesia Number KP 432 of 2017 concerning the National Port Master Plan). This port is planned to support the government's program to connect and develop isolated areas. The planned port is a multipurpose port that serves various interests, including pioneer ship voyages, cargo ships, and other passenger ships. Therefore, the construction of this port is expected to increase the level of port services in Manokwari Regency, West Papua Province.

This study was conducted to examine the design of a deck on pile type pier structure which includes modeling the structure and foundation of the pier to serve 1000 DWT ships. The 1000 DWT capacity was chosen because the cargo ships and passenger ships that operate in West Papua are ships with a capacity of up to 1000 DWT. This study will also focus on obtaining a description related to the behavior of structures and piles with numerical modeling of structures with a structural modeling system and analysis of soil-bearing capacity with analytical methods.

The determination of the wharf layout and the initial design of the structure relies on secondary data, such as ship characteristics and environmental data. Data on operational equipment used on the designed dock is also included. The processed secondary data will produce the parameters needed to determine the dock layout and dock structure design. The reliability of the structural design is measured against the loads acting on the structure by structural modeling. Modeling is carried out until the optimum structural design is obtained by obtaining a UCR (unity check ratio), which is in the range of 0.7 to 1.0 and accompanied by deflection conditions that meet the permit. The force in the structural elements from the output of structural modeling is used to design the reinforcement of structural elements. Then, soil-bearing capacity analysis is also carried out to obtain the depth and height of the piles needed based on the structural reaction and geotechnical data.

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II. LITERATUR REVIEW

Comparable studies on the design of a wharf and pier for a port capacity of > 5000 DWT were carried out by **Farrosi** M. A. A., et al. (2019) by planning a multipurpose pier at Bagendang Port, Sampit, Central Kalimantan. Researchers determined that a 200 x 25 m pier with a 30 m trestle would allow for efficient container loading and unloading. Hafudiansyah E. (2020) conducted a study entitled Analysis of Cargo Pier Structure with a Capacity of 50,000 GT (Case Study of Kolaka Port, Central Sulawesi). Additionally, **Wijaya R. M**., et al, investigated the Tanjung Bonang Rembang Port Pier's design, which was intended to accommodate ships up to 10,000 DWT (2014). In 2016, Etmon M. T. B. studied the Depapre Container Pier, and in 2018, Abidin Z. et al. studied the Kapet Batulicin Container Pier in South Kalimantan for a Ship with a Capacity of 50,000 DWT. The planning for the development of Serui Seaport, Serui City, Papua was studied by Kherel J.G. et al. (2013).

Research for the design of a small capacity dock (<5000 DWT) conducted by Devina C. et al. (2015) entitled Planning of the Samber Papua People's Port Dock, research entitled Technical Planning of the Tanjung Awar-awar Tuban Port Dock, East Java by Anwar M. R., et al. (2018), and research by Da Costa T. G. S. (2020) entitled Evaluation of Dock Planning (Jetty) at Dili Port, Timor Leste has a similar discussion to the research on large capacity docks, these researches also uses structural modeling to model the structure and produce detailed design of dock structures such as beams, pile caps and dock floors.

Based on a literature review of previous studies, this research conducted a more comprehensive and detailed study and discussed the detailed design of the structure and foundations in the piles and the correlation between the results of structural modeling and analytical calculations of soil-bearing capacity.

III. PORT LOCATION

The location of the Masni Port Plan as stated in the Masni Port Master Plan Document is located in Masni District, Manokwari Regency, West Papua Province; with coordinates 0°43'36.24"S -133°44'19.80"E. The port location is presented in the figure below.

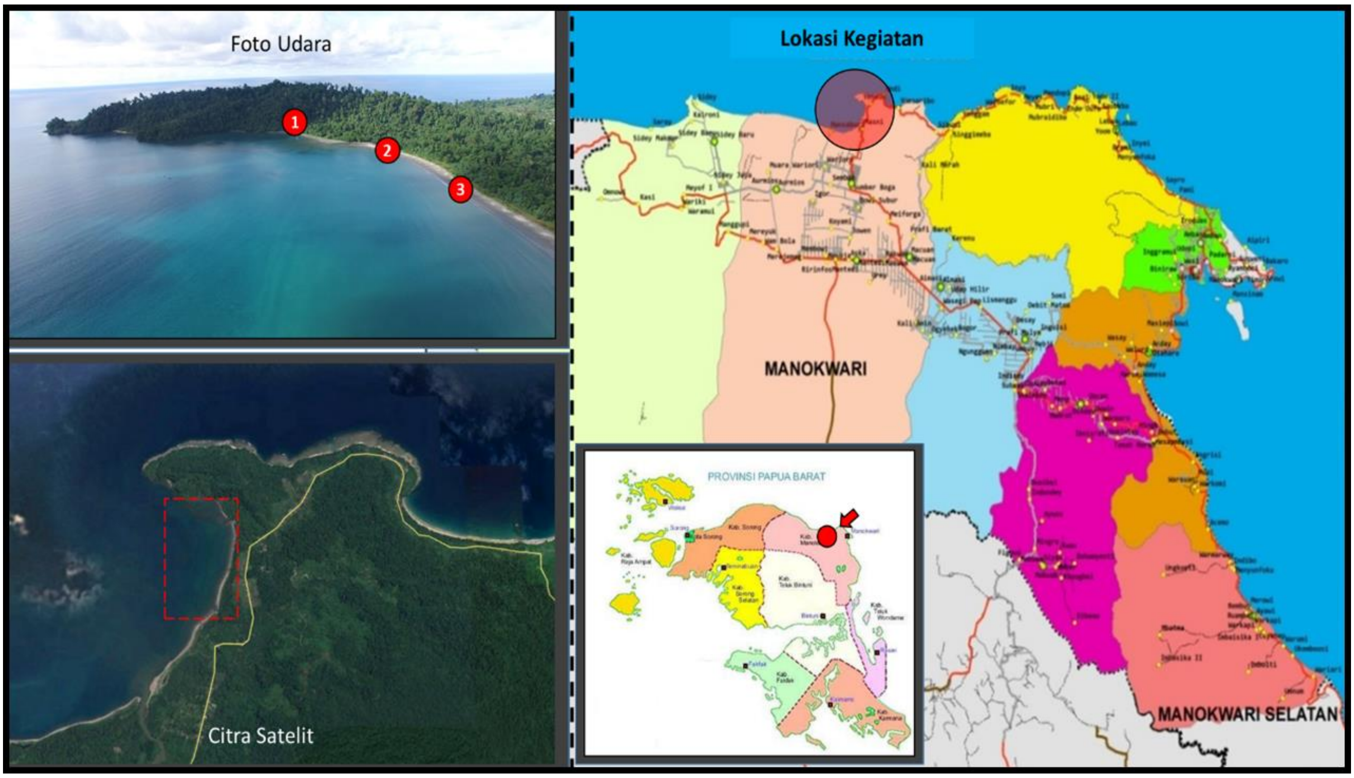


Figure 1. Port Location

IV. METHODS

The research method is presented in the flowchart in Figure 2, where the research begins with a literature review, then data collection. The data is then analyzed and the results of the data analysis are used for structural modeling and calculation of the bearing capacity of the piles.

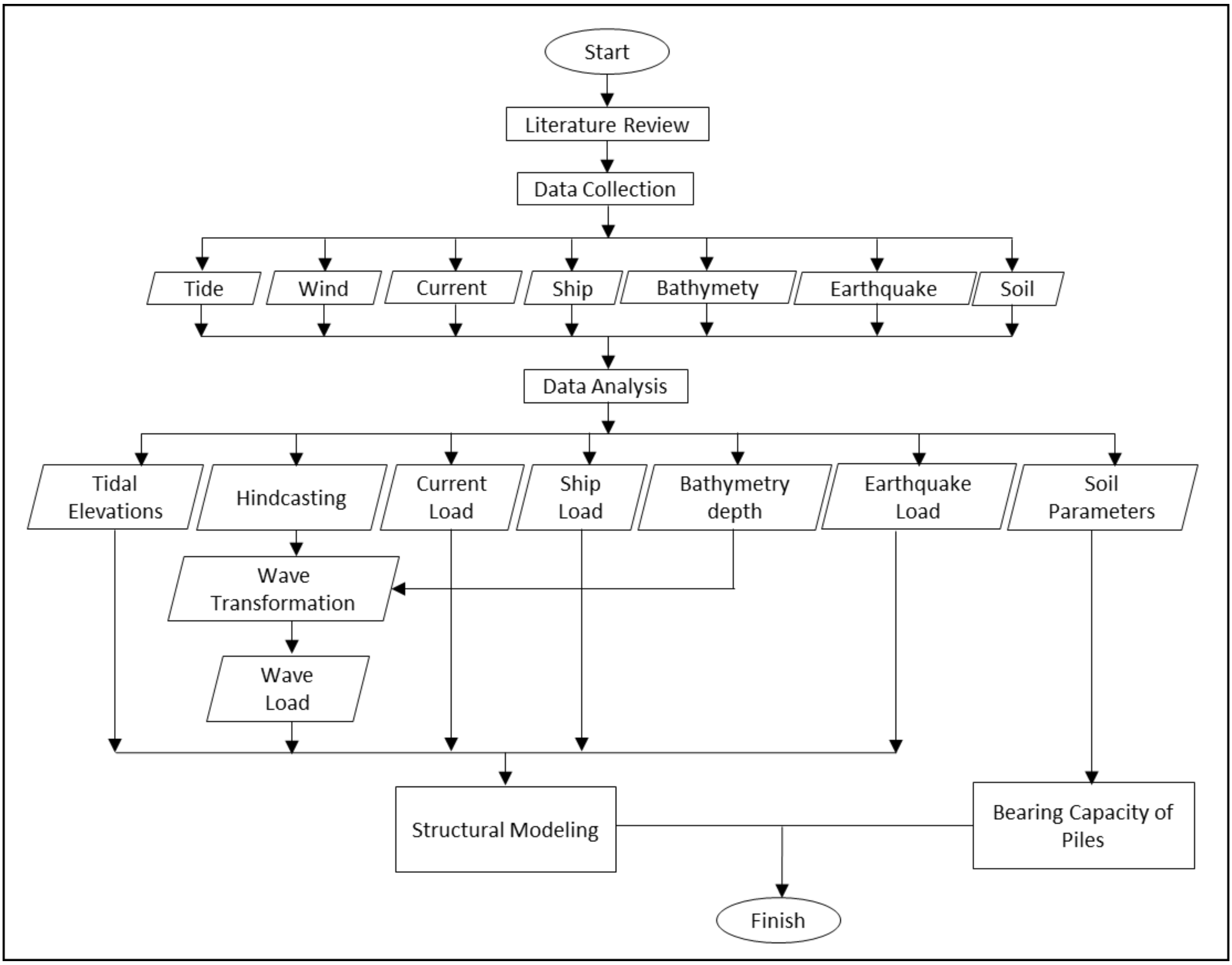


Figure 2. Research Method

V. DATA ANALYSIS

Analisa data dilakukan untuk mendapatkan parameter-parameter yang akan digunakan dalam pemodelan struktur dan perhitungan daya dukung tiang pancang.

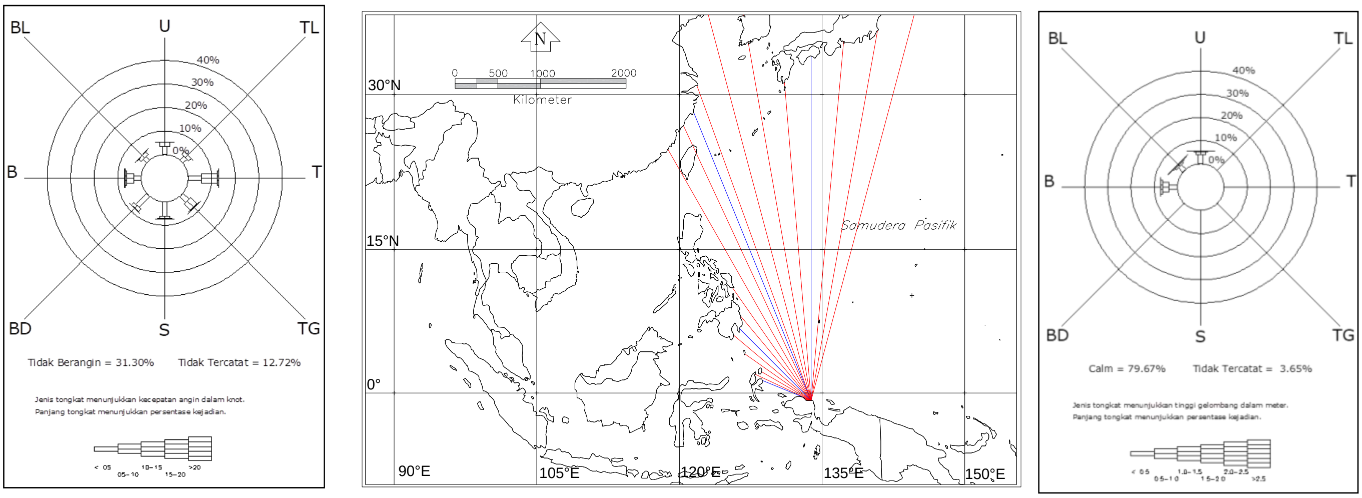
A. Hydro-oceanographic Analysis

Hydro-oceanographic involves the analysis of tidal data, wind data, and wave data. The results of the tidal analysis are sea level elevations, which are then used as a reference for structural design elevations. The tidal elevations are shown in Table 1.

Table 1. Tidal Elevations

Tidal Elevations		MSL (cm)	LWS (cm)
Highest Water Spring	(HWS)	95.76	219.52
Mean High Water Spring	(MHWS)	78.57	202.33
Mean High Water Level	(MHWL)	49.67	173.43
Mean Sea Level	(MSL)	0	123.76
Mean Low Water Level	(MLWL)	-48.5	75.26
Mean Low Water Spring	(MLWS)	-96.99	26.77
Lowest Water Spring	(LWS)	-123.76	0

Wind data is statistically analyzed and displayed in the form of monthly windrose and total windrose. Then the hindcasting process is carried out from the wind data and effective fetch distance which then obtains wave data. The wave data is then analyzed to obtain the H and T parameters of waves in the deep sea. From this analysis, waves with a return period of 25 years with H = 4.19 m and T = 10.06 s are selected.



a. Windrose b. Effective Fetch c. Waverose

Figure 3. Hydro-oceanographic Analysis

B. Bathymetric Condition

Water bathymetry is generated from water depth measurement data, this water depth data is used for wave transformation analysis and determining the layout of the dock structure. The water bathymetry conditions at the planned port location are presented in Figure 4.

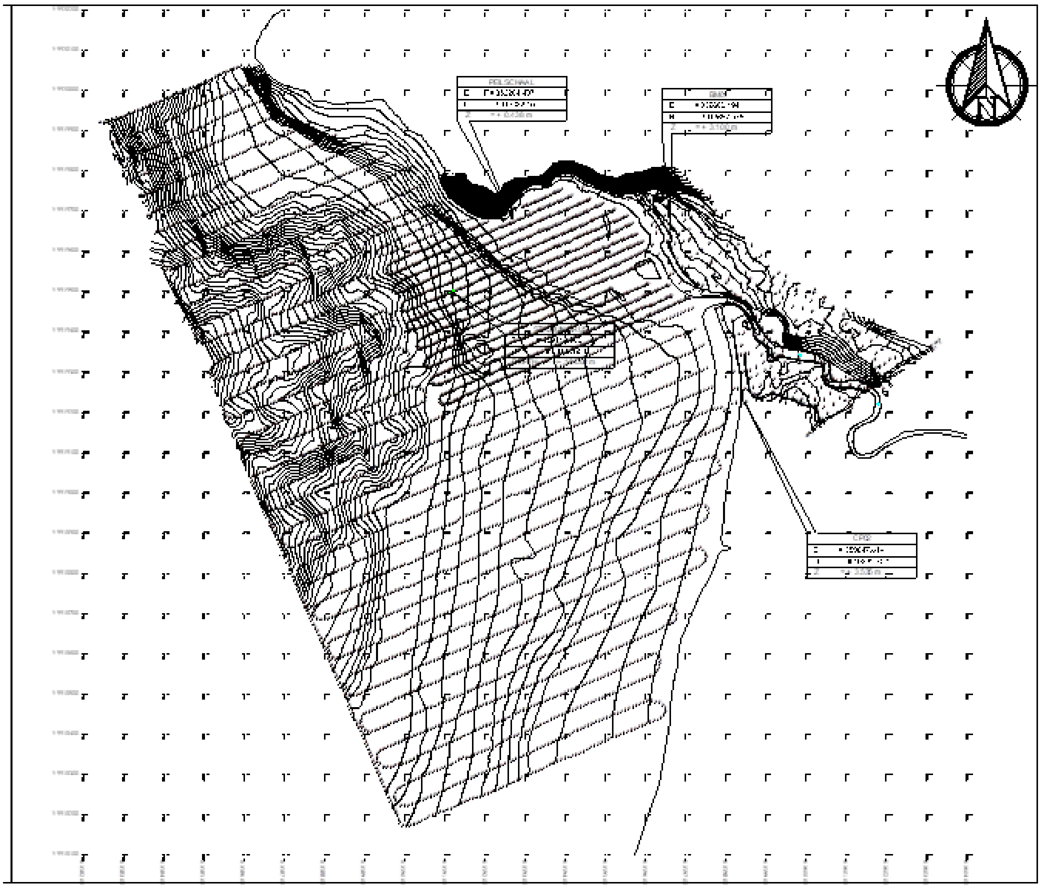
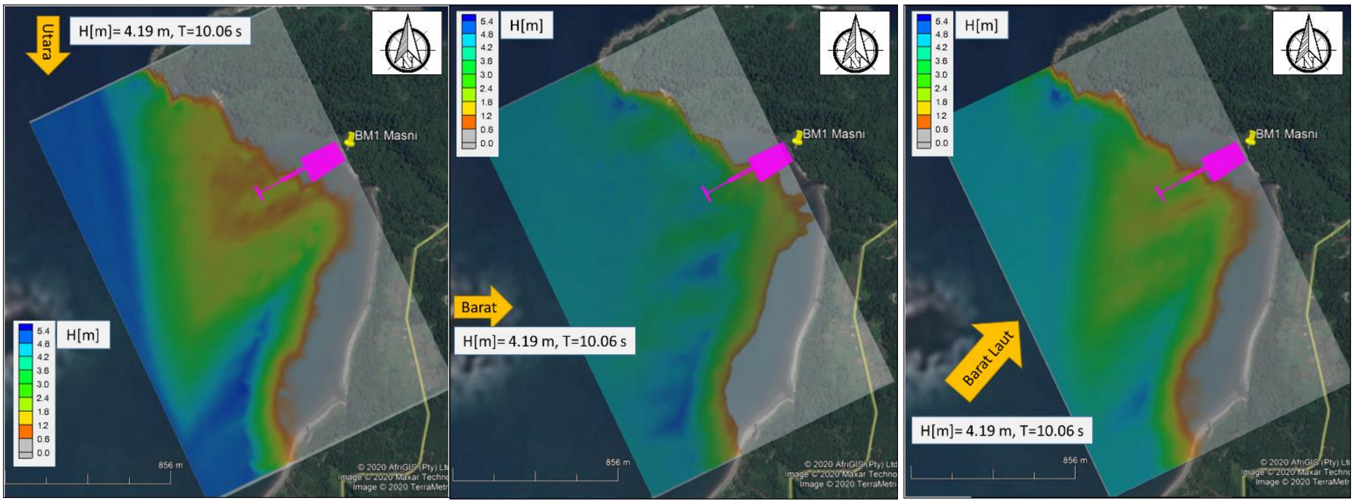


Figure 4. Bathymetric Conditions of Port Location

C. Wave Transformation Analysis

As waves move from deep to shallow water, they experience refraction, diffraction, and shoaling, which transform wave parameters such as wave height (H), wave period (T), and direction (θ). Wave transformationmodeling has been carried out to assess wave characteristics around the planned port, as illustrated in the following Figure 5. Wave transformation modeling obtain wave heights (H) of less than 1.0 m at the planned port location.



a. Wave From North b. Wave From West c. Wave From Northwest

Figure 5. Wave Transformation Analysis

D. Soil Analysis

Soil analysis is conducted by examining the results of soil drilling and laboratory investigations. The soil investigation data is organized in the form of soil stratigraphy based on depth and N-SPT values. This N-SPT value is then used for designing deep foundations. From the soil stratigraphy data, it was found that an N-SPT value of 60 occurs at a depth of 21 m, indicating a stiff to hard soil category (sandy silt).

E. Structural Analysis

1. Structural Modelling

The dimensions of the wharf structure are 35 x 8 m2 supported by steel piles with a diameter of 50.8 cm and a thickness of 1.20 cm. The beams use dimensions of 70 x 40 cm, while the floor slabs have a thickness of 30 cm. The concrete used is concrete with a compressive strength of *fc'* = 25 Mpa while the reinforcing steel uses steel with *fy* = 400 Mpa, and the piles use A252 Grade 2 Steel with *fy* = 240 Mpa and *fu* = 240 Mpa. The modeling of the wharf structure is presented in Figure 6. Load input in the structural model uses the self-load of the structure, operational loads of vehicles and loading and unloading equipment, wave loads, current loads, ship loads and earthquake loads.

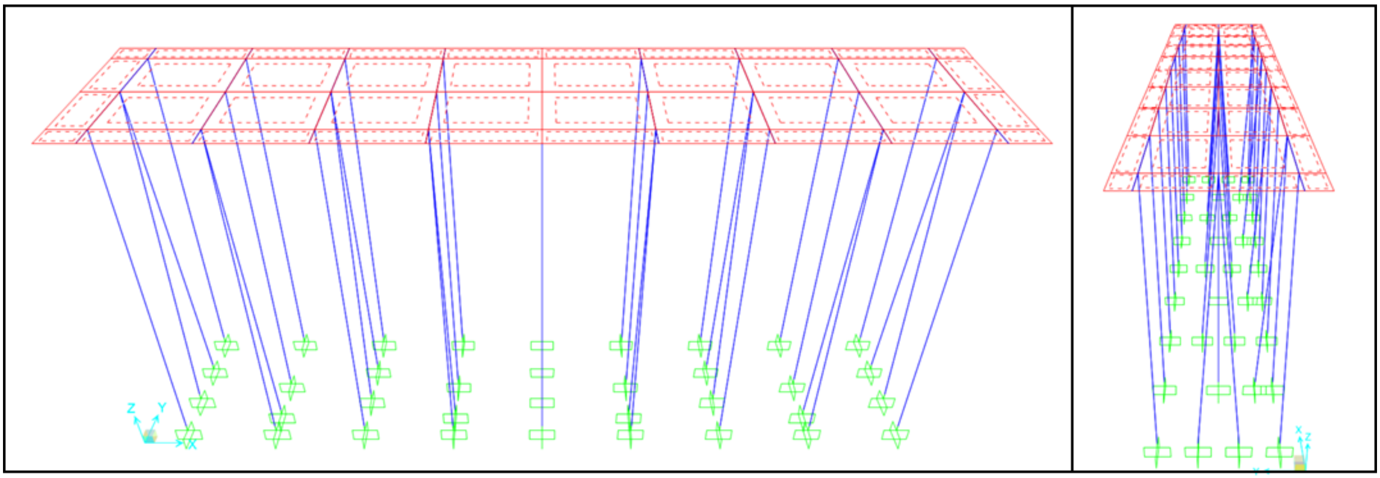


Figure 6. Structural Modelling of Wharf

2. Deep Foundation Design

The wharf foundation uses a deep foundation of A252 Grade 2 steel piles, with a diameter of 50.80 cm and a thickness of 1.20 cm. The design of the deep foundation is carried out by calculating the axial compressive bearing capacity, axial tensile bearing capacity and lateral bearing capacity by checking the maximum deflection that occurs based on the maximum force and moment values calculated in the structural modeling.

V. RESULTS AND DISCUSSIONS

1. Results on Structural Modelling

The structural modeling results shown in Table 2, the largest negative moment (M3) of -365.32 KN-m, the largest positive moment (M3) of 155.96 kN-m, and the maximum shear force value (V2) = -355.01 kN. The moment and shear force values are used to design the dimensions and reinforcement of the beam as follows:

a. Flexural Reinforcement:
Tensile reinforcement: 4D-22
Compression reinforcement: 6D-22
Additional reinforcement 2D-16
b. Field reinforcement
Tensile reinforcement: 6D22
Compression reinforcement: 4D-22
Additional reinforcement 2D-16
c. Shear reinforcement: D13-100 and D13-150

The floor slab uses double reinforcement in the x and y directions with reinforcement size D13-150.

Table 2. Structural Modelling Results

Sta (m)	*Output Case*	*P(kN)*	*V2(kN)*	*V3(kN)*	*T(kN-m)*	*M2(kN-m)*	*M3(kN-m)*
0	1.2D+1.6L+1.2Wa+1.2C+1.2M	-5.513	-355.011	-2.332	0.0639	-4.3499	-365.315
2.2	1.2D+1.6L	-6.247	-13.288	-7.297	6.6088	1.5193	155.955

Unity Check Range (UCR) is performed to compare the stress caused by external forces with the stress capacity of the steel pile material. From the UCR results, the range value is 0.0-0.5 so the pile structure is still within safe limits.

2. Results on Bearing Capacity of the Pile

The axial compressive bearing capacity of the pile at a depth of hard soil (21 m) is 221.95 tons, while the axial tensile bearing capacity is 69.94 tons. This bearing capacity can withstand the maximum forces that occur in the wharf structure well. The deflection that occurs in the pile is 0.33 cm, much smaller than the allowable deflection of 4.79 cm. The magnitude of the moment that occurs in the pile is 16.88 t-m, while the design moment capacity of the pile is 30.7 t-m.

2. Results on Bollard and Fender

The bollard and fender design is based on the design of a 1000 DWT ship, based on calculations, the bollard type SBA2-10 is used with a capacity of 15 tons, while the fender used is the SV type (V-shaped Fender) size 250H.

3. Discussions

Based on bathymetry and hydrooceanography analysis, the planned port location is technically suitable to be used as a port location because it has a small wave height so that it can support ship loading and unloading operations optimally. The design of the structure and steel piles is quite reliable and can withstand the combination of loads that occur. After the entire design process is carried out, it can be concluded that the construction of the Masni port is feasible to continue to the next stage. It is recommended that the study be continued with the calculation of the budget plan and costs so that it can be used as input for related parties in the construction process.

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