Moveable bridge inspection in Ancam Port North Kalimantan, Indonesia

S Sumargo1, * and A Rusmanto2

1 Department of Civil Engineering Universitas Jenderal Ahmad Yani, Jl. Terusan Jend. Sudirman, Cibeber, Kec. Cimahi Selatan, Cimahi, Jawa Barat 40525, Indonesia
2 Department of Civil Engineering Politeknik Negeri Bandung, Jl. Gegerkalong Hilir, Ciwaruga, Kec. Parongpong, Kabupaten Bandung Barat, Jawa Barat 40559, Indonesia

*smg.7ph1@gmail.com

Abstract. The Ancam Port is equipped with a moveable bridge to anticipate tides. The Moveable Bridge structure is a steel frame bridge with a length of 35,740 meters. This vertical free movement is accommodated by the pontoon but cannot deform in a horizontal plane in the direction of the bridge extending, causing damage to the connection between the pier and the moveable bridge. Under the pontoon there are indications of piles emerging from the riverbed and recurring collisions occur due to tides. This causes leakage so that water enters and causes an imbalance from the pontoon and a collapse of the Moveable Bridge occurs. The movable bridge analysis method is carried out using SAP 2000 software. Based on the analysis of the collapse the moveable bridge is able to withstand the planned load on the condition that the pontoon has to function properly. The solution to re-enable the moveable bridge is to use a geofoam-type styrofoam pontoon wrapped in steel plates. This research is expected to be a solution to the problem of movable bridges in Indonesia.

1. Introduction

Port is one part of the transportation system needed to meet the needs of loading and unloading of goods and passengers. With the port, it is expected to meet the needs of loading and unloading of goods and passengers that support the development / development of the region [1]. Thus, port development is not a stand-alone activity, but is closely related to social [2], and economic aspects [3], within the reach of the port transportation service. Ancam Port located in Bulungan Regency is a port that connects Tanjung Selor Subdistrict from Tarakan. The Threat Port which was built using the state budget in 2014 is planned to be a Ro-Ro port, a ship that can load vehicles that enter the ship with its own propulsion and can exit by itself as well, so it is called a roll on - roll off ship or abbreviated as Ro-Ro That is why the Ancam port is equipped with a moveable bridge to anticipate tides. Although it is not yet fully completed [4], from the previous study the current condition of the moveable bridge is collapsing [5]. As a result of the collapse of the moveable bridge is the cessation of construction of the pier itself and the estimated repair costs of billions of rupiahs. In inspection this condition focuses on the collapse of the movable bridge and aims to get the right action or treatment.
2. Research methods
The research method that will be carried out is a visual observation of the location survey. Here are some data on the harbor threat.

2.1. Dimensions of movable bridge
Following in Table 1, are the dimensions of the movable bridge on the Ancam Port.

Table 1. Moveable bridge cross section property.

| Section                  | Dimension            |
|--------------------------|----------------------|
| Right and Left Side      | U.300.100.10.16      |
|                          | 2U.300.100.10.16     |
|                          | H.300.300.10.15      |
| Bottom                   | IWF.350.175.7.11     |
|                          | H.300.300.10.15      |
| Top                      | 2L.100.100.7         |
|                          | L.100.100.7          |
|                          | H.300.300.10.15      |

2.2. Visual observation of moveable bridge
The Moveable Bridge that connects the trestle with the dolphin berthing is already partially collapsed in the river. The visual observation can be seen on Figure 1, Figure 2, and Figure 3.

Figure 1. Moveable Bridge Collapsing

Figure 2. One Collapsible Pile of Collapse

Figure 3. Joints of Moveable Bridge

2.3. Modeling
Structural analysis is done through 3D modeling with the help of the SAP2000 software program. The 3D model is used to get the structural behavior of the working loads.

3. Results and discussion
This chapter will explain the results analysis and discussion.
3.1. Results of structural analysis
Based on the results of structural analysis by checking the stress ratio and also the deviation can be concluded that the moveable bridge structure can function properly and properly, but with a note if the pontoon pedestal does not experience a collapse.

3.2. Collapse analysis on moveable bridge
Moveable Bridge (MB) structure is a steel frame bridge with a length of 35,740 meters with a pedestal joint and another pedestal that can move vertically. This vertical free movement is accommodated by the pontoon but it cannot deform in a horizontal plane in the direction of the bridge [6,7]. Based on tidal river data, the difference is greater than 2.0 meters, but in this analysis a pontoon value decrease of 2.0 meters will be used. To be able to move the pontoon as well as the MB in the vertical direction it is necessary to have a rail mechanism between the pontoon and the holder. If not enough space is given between the rails and the rails, there will be a drag by the bridge and this pull will cause the shear forces on the rails. If the rail is not given a minimum gap of 56mm there will be a tensile force. Structural analysis shows that with a 2.0 meter pontoon drop condition there will be a tensile force of \( T = 495.88 \) kN at one footing point. This force (Figure 4) occurs because the holder is not given space to move, while the bridge is very rigid.

The force which is big enough must then be able to be held by a kind of rail which is located on a concrete block pedestal. As a result of the tensile force \( T \) there will be several kinds of collapse, namely:

- **Collapse 1:** rail stand. If the rail is not given enough space, there will be a collapse in the rail holder. This collapse occurs due to shear forces that cannot be held by rail anchors to the concrete mass (Figure 5).
- **Collapse 2:** welding joint connecting the anchor to the rail. The force is large enough to cause a slide in the welded joint so that the mass of the concrete will remain intact but the rail is separated from the anchor connection (Figure 6).
- **Collapse 3:** rail on the pontoon. Rail and pontoon are connected by welding connections. If the welded joint is strong enough and the steel thickness is insufficient, a shear block can occur from the pontoon plate (Figure 7).
- **Collapse 4:** weld rail connection with pontoon. If the plate thickness is sufficient and the welded joint is not strong enough there will be a collapse in the welded joint (Figure 8).
Collapse 5: masses of concrete pontoons. This happens if the rail connection is strong enough so that the entire T force will be transferred to the concrete mass. If the concrete mass cannot withstand the T force, a concrete crack will occur, followed by a partial collapse of the concrete mass (Figure 9).

Collapse 6: collapse of the connection between the concrete mass and the pile foundation (Figure 10).

Collapse 7: foundation collapse occurs if the pole is pulled / pulled out beyond its frictional force or there is a compressive force that exceeds its carrying capacity (Figure 11).
**Figure 10.** The collapse mechanism of the foundation connection to the concrete mass

**Figure 11.** Foundation collapse mechanism.

Based on the results of the analysis it was found that the tidal conditions of the river cause the pontoon to move vertically. Under the pontoon there are indications of piles emerging from the riverbed and recurring collisions occur due to tides. This causes leakage so that water enters and causes an imbalance from the pontoon and the collapse occurs from the Moveable Bridge. As for the other assumption, the pontoon experiences rust so that the pontoon which was originally an empty steel with air in it easily enters water into the pontoon through the rust that occurs. The solution of the collapse analysis that can be proposed to re-function the moveable bridge is to use a geofoam styrofoam pontoon wrapped in steel or concrete plates as a blanket. The use of Styrofoam will not cause pontoon leakage because it is not hollow.

Styrofoam used is Geofoam with various advantages, such as:

- **Durable:** nonporous, no rot, chemically and dimensionally stable [8].
- **Special safety factor:** does not leak or sink.
- **High buoyancy capacity:** maximum load of 5 tons/m².
- **Environmentally friendly production:** recycled blend, without CFC, the module has been cut at the factory [9,10].

Based on some of these characteristics, styrofoam used is very suitable to be used as a substitute material for an empty pontoon into a pontoon containing styrofoam so that if it does leak then the pontoon does not immediately sink and collapse. The Styrofoam that will be used has a technical specification that is using a type of b-foam construction-grade expanded polystyrene (EPS) with a marine-grade polymer casing.

### 4. Conclusion

Based on the results of the study it can be concluded that:

- The pier that uses a movable bridge is a very practical type because it can adjust to the tides.
The moveable bridge footing (in this case the pontoon) must really be considered because if the pontoon has leaked, there will be no more structures that support the load of the moveable bridge, which in turn can cause the structure to collapse.

In building a pier that is equipped with a moveable bridge, it is best to pay attention to the mechanism of collapse that might occur.

The solution to the moveable bridge collapse due to a collapsed pontoon is to use a pontoon containing geofoam type styrofoam compared to a pontoon containing only air cavities so that in the event of a leak, the pontoon does not immediately collapse.

Acknowledgement
Thank you to PT. Beton Elemenindo Putra, which has supported the supply of geofoam type Styrofoam as a moveable bridge pontoon filler material.

References
[1] Dwarakish G and Akhil M 2015 Review on the Role of Ports in the Development of a Nation Aquatic Procedia 4 295-301
[2] Papaefthimiou S, Sitzimis I and Andriosopoulos 2017 A Methodological Approach for Environmental Characterization of Ports Maritime Policy & Management 44
[3] Zengqi X and Jasmine S 2017 A Systems Framework for the Sustainable Development of a Port City: A Case Study of Singapore's Policies Research in Transportation Business & Management 22 255-262
[4] PT. Ditori Geokarya Teknik 2018 Laporan Pendahuluan Revitalisasi Pelabuhan Penyerangan Ancam Provinsi Kalimantan Utara
[5] PT. Ditori Geokarya Teknik 2018 Laporan Antara Revitalisasi Pelabuhan Penyerangan Ancam Provinsi Kalimantan Utara
[6] Streeter R and Gross D 1999 Method and Apparatus for Connecting a Passenger Boarding Bridge to a Movable Body US Patent 5,950,266,
[7] Arminio F 1927 Bridge Construction US Patent 1 624,325
[8] Horvath J 2004 Geofoam Compressible Inclusions: The New Frontier in Earth Retaining Structures Geotechnical Engineering for Transportation Projects
[9] Stark T, Arellano D and Horvath J 2004 Geofoam Applications in the Design and Construction of Highway Embankments
[10] Gaebe M 2019 Case Study: Using Geofoam on a School Project in Encinitas, CA