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COMPARATION BETWEEN SUSPENDED OR SEABED PIPELINE INSTALATION FOR INTER ISLAND FRESH WATER SYSTEM

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ABSTRACT

Provision of drinking water in small islands that do not have the potential for fresh water needs to be done with several alternative technology applications. One of the technologies being carried out is by installing underwater drinking water pipes. Taking into account the operational technical factors, at sea depths above 30 m, several considerations need to be taken into account, given that installing pipes at these depths is difficult to control pipes manually, so additional equipment is needed for the safety of workers who will control the installed pipes, so this problem the best solution must be found. One problem that must be considered is the selection of pipe specifications that must meet technical requirements. Pipeline selection was carried out by conducting a study through the pipeline model and needs to be studied carefully and thoroughly so that the installed pipe is completely safe in the sea and does not suffer damage due to forces acting on the pipe caused by ocean currents, waves and underwater conditions others. The installation model that will be examined is the installation model suspended in the sea and installation on the sea floor. From the results of the analysis conducted on the pipe suspended in the sea with a depth of over 30 m and the installation of pipes on the seabed shows that the pipe installed in the sea is more stable both from the effects of waves and ocean currents with a smaller deformation value compared to the pipe that is installed suspended in in the sea. Pipe installed suspended in the sea with a span of 2,500 m and given a weight of 65 kg with a distance of 12 m can experience vertical deflection down to 2,775,326 mm. Pipes placed at the bottom of the sea are more stable because the flow of waves and waves is already small so that the pipes are more stable and do not oscillate. The recommended pipe installation is seabed with pipe specifications in accordance with the conditions of the Hiri Strait, namely HDPE pipes with a nominal pressure of at least 25 bar.

Keywords: pipeline, suspended, seabed.

INTRODUCTION

Underwater pipeline installation requires detailed analysis and must meet technical aspects. This sea pipe installation model will determine the stability of installed pipes, so it must be ensured that the installed pipes are completely safe from the influence of waves, ocean currents and also other factors such as ship and fishing activities [1]. In this study, it will be studied the comparison of underwater pipeline installation models with two alternatives, namely the Suspended system in the sea and the seabed. The study was conducted in the Hiri Strait precisely between Ternate Island and Hiri Island, North Maluku Province of Indonesia. The analysis to be carried out is a Hydrostatic analysis to find out the planned level of pipe stability.

Hiri Island, which is located on the north side of Ternate Island, is an island that does not have enough fresh water potential to meet the needs of the local community, so an alternative supply of drinking water is needed. The distance between the island of Hiri and Ternate Island is around 1.2 nautical miles or about 2.2 km with 185 m into the sea with uneven conditions on the seabed and is a rock and sea trench. The waves in this strait are also quite high and can even reach 5 m with strong currents between 0.5 - 2.8 m/s.

INSTALLATION ANALYSIS

In this study an analysis of two underwater pipeline installation models, namely the suspended pipe in the sea and the pipeline at the bottom of the sea [2], [3]. In the Suspended pipe will be examined several factors that affect the stability of the pipe [4]. Analyze were carried out on the effects of waves, ocean currents, ballast concrete, pipe contents and pipe weights. Analysis of pipelines designed at sea level includes hydrostatic, span analysis, longitudinal stress, hoop stress, pipeline protection and selection of pipe specifications [5], [6], [7], [8].

Analysis of pipe suspended

The effect of waves, ocean currents, ballast concrete, pipe contents and pipe weight is very large in the pipe installation system suspended in the sea. This needs to be studied to determine the stability of the pipe from the influence of buoyancy which results in deformation of the installed pipe. In Figure 1 and Figure 2 we can see the forces acting on the suspended pipe.

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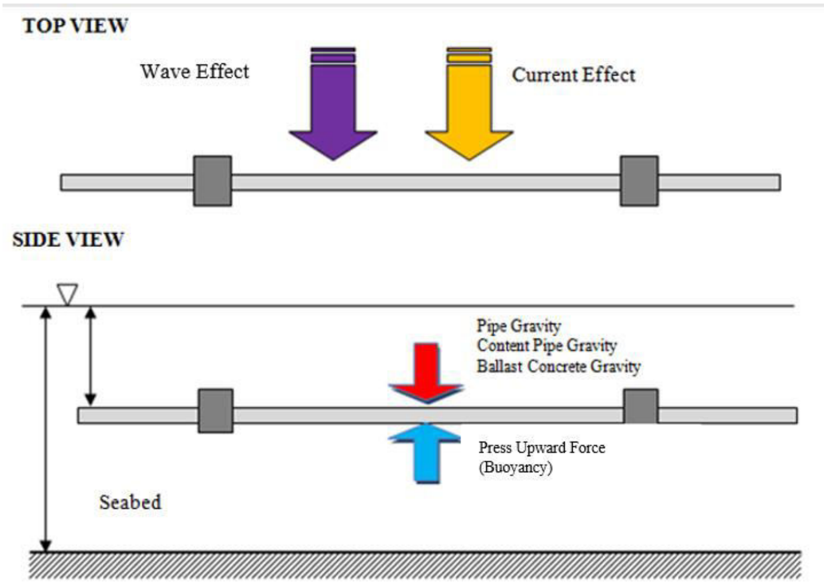

Figure-1. Forces on suspended pipe [1].

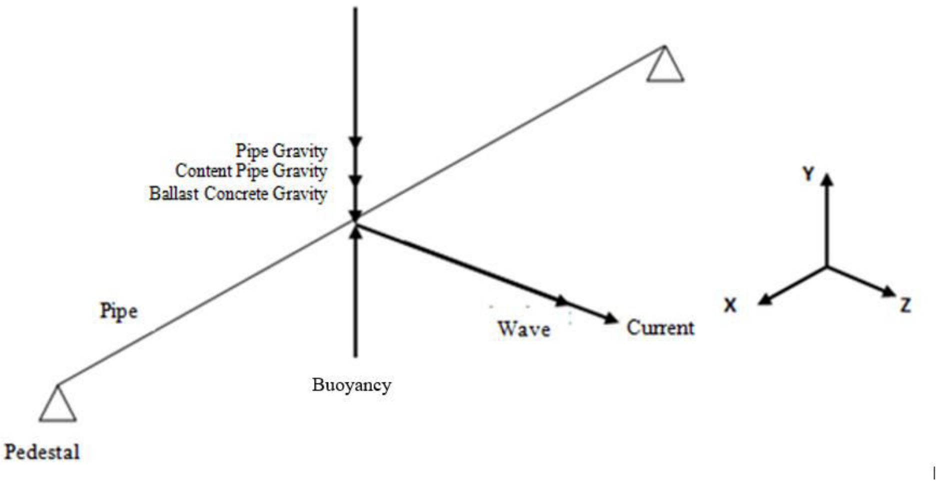

Figure-2. Isometric view of the forces on the underwater pipeline [1].

Analysis of pipe installed on sea

Pipes installed at the base will catch up with a number of conditions so that they need to be studied properly so that the installed construction will be strong and not prone to construction failure.

a. Hoop stress

The ability of the pipe to accept pressure at the depth of the deep sea. This analysis is needed to ensure that the pipe used is able to withstand pressure.

b. Longitudinal stress

An analysis to get the longitudinal stress that occurs in pipes due to bending, hoop stress, thermal stress and end cap stress.

c. Analysis of span

The shape of the seabed surface is not always evenly distributed, so there must be a part of the pipe that is not resting on the surface.

d. Hydrodynamic analysis

Is a pipe stress analysis due to the influence of the current speed? At sufficient depth, the wave effect is gone. One of the things that needs to be taken into account in the installation of pipes on the seabed is the ability of the pipe to withstand pressure. The deeper the sea, the greater the pressure. With the pressure of drinking water in the pipe, external pressure can be balanced. However, the pipe pressure must be taken into account when the pipe is empty.

e. Ability of pipe to accept hydrostatic pressure

Hydrostatic pressure is formulated by:

$$Ph = r\ g\ h \quad (1)$$

Where,

Ph = hydrostatic pressure
r = sea density (1,030 kg/m^3)
h = depth of sea.

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Installation model

The analysis was carried out on two models of pipe installation, namely Suspended in the sea and on the seabed. In the Suspended model the pipeline is planned to be installed at a depth of 30 m, with the consideration that the pipe will be safe from the influence of normal boat traffic passing through the waters [9], [10]. Installation under the sea is carried out following the underwater contours with the deepest sea conditions 185 m. The pipe weights are made of reinforced concrete K 300 with a special mixture of cement in the building with a minimum weight of 65 kg with an installation distance of 12 m.

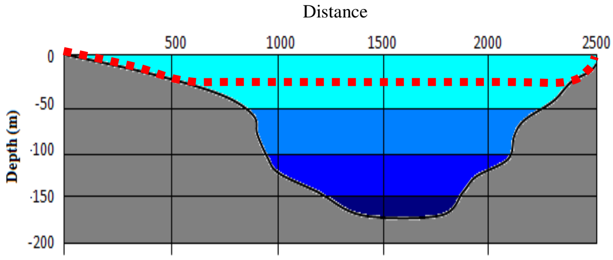

Figure-3. Suspended system pipeline installation plan.

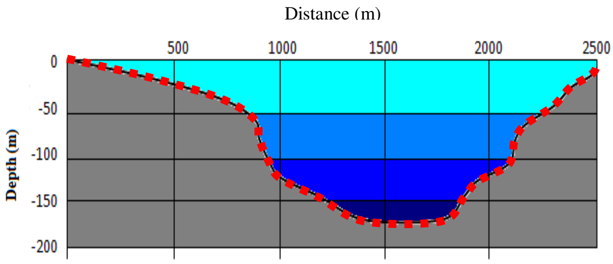

Figure-4. Seabed system pipeline installation plan.

RESULTS AND DISCUSSIONS

Analysis of pipe suspended in pipe

The ideal ballast will make the pipe always sink in an empty condition or filled with water. But this ballast must not be of great value [11]. Giving too much ballast will cause a very large pipe deflection [12]. From the analysis above it can be seen that the minimum weight of a concrete ballast installed every 12 m is 65 kg per piece. If the weight of the concrete used is less than that, the pipe will float when it is empty [13]. This floating pipe condition will be very dangerous because it will disrupt ship traffic in the Straits of Hiri. In addition, with a position close to sea level, the influence of waves and ocean currents will be very large and can cause the pipe to break. Adding an additional load of 65 kg every 12 m will cause the pipe to sink in an empty or filled condition. The results of the auto pipe analysis show the deflection of the pipe in the water due to the buoyancy force and the additional weight.

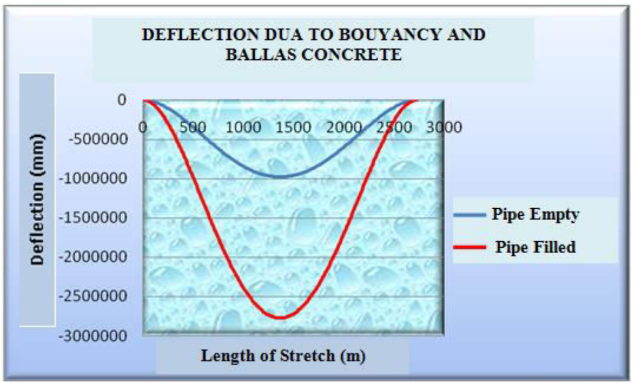

Figure-5. Seabed system pipeline installation plan.

The maximum deflection value right in the middle of the pipe is 971,719 mm in an empty condition and 2,775,326 mm in a condition filled with water in a vertical direction downward. Taking the assumption that the pipe will be hung at a depth of 30 m, the pipe deflection that occurs due to currents and waves as shown in Figure 6. It seems that the defect is very large. If the failure limits are included in the analysis, the pipe has failed. Because the voltage received exceeds the allowable limit.

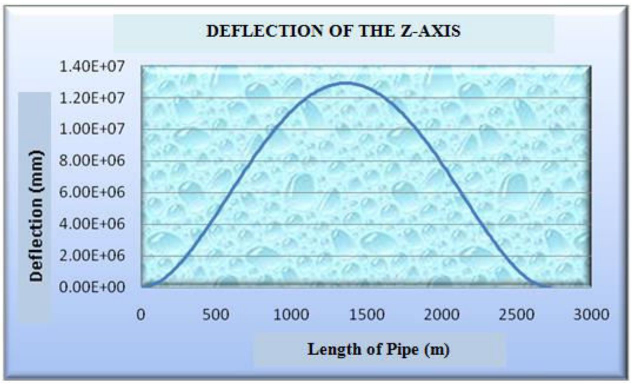

Figure-6. Horizontal deflection of the Z-Axis.

Analysis of pipe installed on sea

In general, the installation of underwater pipelines is to put pipes on the seabed. In a seabed environment with sufficient depth, the effect of waves and ocean currents is already so small that it does not affect the stability of the pipeline [14]. However, in-depth knowledge is needed about the underwater conditions themselves [15]. Sufficient studies are needed on underwater conditions, seabed species, soil, and also the marine environment. The stability of the pipeline at the sea level is designed by giving the weight of the pipe distance per 4 m with a weight of 85 kg, so that the pipe will be stable at the bottom of the sea, and basically the underwater pipeline should not be shifted or even oscillate after it is installed, because if this happens it will cause damage on the pipe. In the analysis of pipes placed at the bottom, the emphasis is on the analysis of the ability of pipes to accept hydrostatic pressure, so that the selected pipe specifications are correct [16].

Equation (1) was used for calculate hydrostatic pressure. Then maximum depth of sea of pipe is 247.6719 m, as shown in Figure-7. Assuming that the pipe is always full of water, the depth of pipe installation with the above specifications must not exceed 247.6719 m. Based on this analysis, the pipe used for the installation of subsea pipelines in the Strait of Hiri is a minimum of 25 bar HDPE Nominal Pressure pipe which is able to accept a pressure of 25 bar or 2.5 MPa.

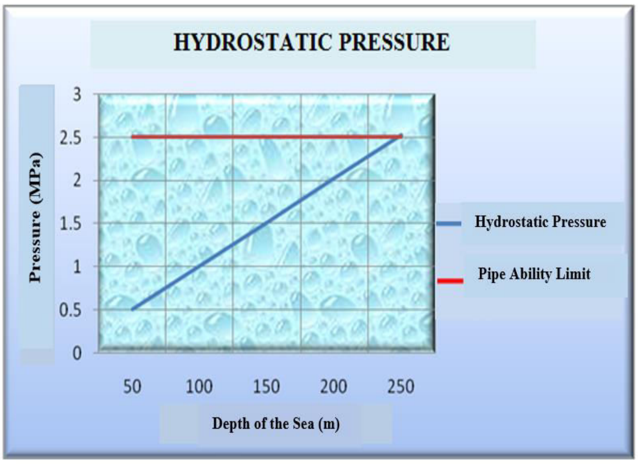

Figure-7. Pressure hydrostatic.

CONCLUSIONS

Installation of pipes in a suspended condition of 30 m has several advantages, namely the length of the pipe will be reduced and detection of failure is easier, but the installation of a pipe with the system suspended in the sea will cause a very large deflection. Deflection due to pipe weight, weight, concrete weight, waves and currents will cause a failure in construction (broken pipe). The closer to the surface, the greater the influence of currents and waves. By using DHPE material and analyse the current and wave conditions in the left strait, suspended pipe installation is not recommended.

Piping on the seabed is more advantageous because of the effects of waves and low currents, higher construction stability, small pipe deformation due to sealing of the seabed and this method is used the most in the installation of subsea pipelines, so it is more tested so that installation of pipelines at the bottom of the sea is recommended. But this installation model also has weaknesses, so all these weaknesses must be anticipated. Weaknesses of this method the total length of the larger pipe requires an in-depth study of conditions on the seabed because of the possibility of failure that could occur due to interactions between the pipe and the seabed.

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