DISPOSAL LIQUEFACTION POTENTIAL ANALYSIS BASED ON WASTE DUMP STABILITY RATING HAZARD CLASSIFICATION SYSTEM (WSRHC) METHOD AT DISPOSAL TAMBANG AIR LAYA, SOUTH SUMATRA

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ABSTRACT

South Tambang Air Laya Disposal is in-pit disposal located in an active tectonic area adjacent to Sumatran Fault Zone. Area's support this with a peak acceleration value of 0.2 – 0.25. One of the causes of liquefaction is the presence of shocks or earthquakes. For this reason, it is necessary to analyse the liquefaction potential to determine the liquefaction potential, especially in the disposal material and the disposal foundation of the research area. The method used in this research is the Waste Dump Stability Rating Hazard Classification System; this method is used to assess the liquefaction potential at the disposal, divided into two parts, namely the liquefaction potential at the foundation and the liquefaction potential at the disposal material. The data used in this research include secondary data from seismic factor data, South Sumatra earthquake zone data, South Sumatra liquefaction zone data, and laboratory test results of disposal foundations. In addition, data on the results of physical and mechanical properties of the disposal material were used in the form of grain size gradation data and data from plasticity test results. All the data used shows that the liquefaction potential of the disposal foundation is included in a negligible category with a rating value of 0. Meanwhile, the potential for liquefaction of disposal material is included in the low category with a rating value of -2.5, which must still be considered to avoid unexpected things that can occur.

Keyword: *Tambang Air Laya, Liquefaction, Ratings, WSRHC, Disposal*

INTRODUCTION

Tambang Air Laya is one of the coal mining sites managed by PT. Bukit Asam Tbk., the principles used in mining at PT. Bukit Asam is open-pit mining. The principle used in the open-pit mining method is carried out by stripping the overburden. The overburden is removed from the mining area then the mining commodities are excavated and transported out (Subowo, 2011). The removed overburden is then buried in the disposal area (Hawley, 2017). One of the problems or potentials that can occur in the disposal area of the research area is the potential for liquefaction at the foundation and disposal material.

Liquefaction is a phenomenon of loss of soil strength due to increased pore-water tension and a decrease in the adequate pressure of the soil layer caused by dynamic cyclical loads. (Hakam & Darjanto, 2013). One of the causes of liquefaction is the presence of shocks or earthquakes. Disposal Tambang Air Laya is located in an active tectonic area adjacent to the active Sumatran Fault Zone. Area's support this by the research area based on the Earthquake Resource Map, which has a peak acceleration value of 0.2 – 0.25. The peak acceleration value has passed the lower threshold for liquefaction at the peak acceleration of 0.1 g (Santucci de Magistris et al., 2013 Buana et al., 2019). Therefore, the liquefaction potential is a severe problem to be considered because it can occur at any time. After all, the disposal area has a reasonably high seismicity value and is close to the Sumatran fault zone.

To see the potential for liquefaction in the disposal area, one of the methods used is the Waste Dump Stability Rating Hazard Classification System (WSRHC) method. With this method, liquefaction potential can be determined based on an analysis of the foundation state of disposal and state of the material quality of the disposal. So, how much liquefaction potential can occur can be seen from the analysis of the two conditions.

This research aims to help determine the liquefaction potential, especially in the

E-ISSN : 2579 – 3136

research area's disposal material and the disposal foundation. This research has been carried out in the disposal area of the Tambang Air Laya, especially the backfill of the south Tambang Air Laya, Tanjung Enim, Muara Enim Regency, South Sumatra, which is the location of the overburden buried managed by PT. Bukit Asam Tbk. at the Disposal backfill site at the Air Laya Selatan Mine. Geographically, this location is located at coordinates Northing 9586617 to 9584725, Easting 363685 to 365770.

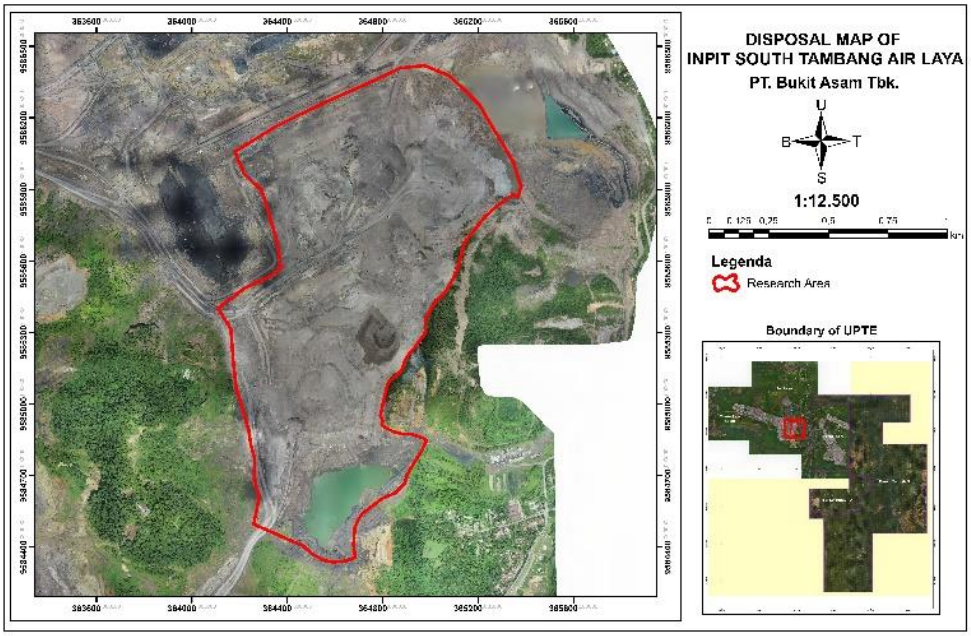

Figure 1. Disposal Conditions of backfill south Tambang Air Laya.

RESEARCH METHOD

The object of this research is disposal located in the Disposal area of South Tambang Air Laya, Tanjung Enim, South Sumatra. The method used in this research is the Waste Dump Stability Rating Hazard Classification System (WSRHC) method. This method is a system popularised by Mark Hawley in 2017 that assesses a disposal's stability and risk conditions.

Waste Dump and Stockpile Stability Rating and Hazard Classification System is a rating which is divided into seven groups with two major index groups, namely the Engineering Geology Index (EGI), which consists of regional disposal conditions, disposal foundation conditions, and the quality of the disposal material. In contrast, the Design Performance Index (DPI) consists of the mass and geometry of disposal, analysis of disposal slope stability, disposal construction, and disposal performance. However, in this study, the index used is the Engineering Geology Index (EGI), especially in the group of foundation conditions of disposal and the quality of disposal materials.

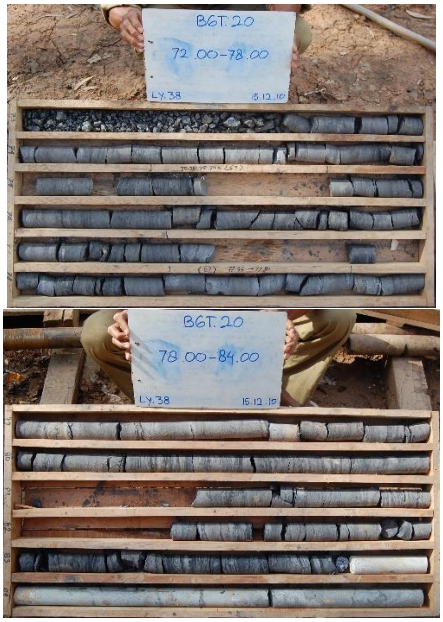

Figure 2. Sample cores drilled for the inter burden layer B2 – C.

The data used to analyse the liquefaction potential in this research were divided into two groups. In the foundation condition group, the analysis requires data requiring data on the

E-ISSN : 2579 – 3136

in-situ condition of the disposal foundation, in the form of data on the Provincial Liquefaction Vulnerability Zone Map, which was obtained from Badan Geologi, and data on the South Sumatra Earthquake Hazard Map from the Centre of Volcanology and Geological Hazard Mitigation.

In addition to these data, material disposal data is also required in this analysis. Material disposal data was obtained from drilling results in the rock layer between seam B2 and seam C in coal mining exploration activities (Figure 2). The core samples were analysed in the laboratory to produce data on the gradation of the grain size of the foundation, the results of the Atterberg Limit test, and the void ratio number. All these data are secondary data from previous research, which supports the potential for liquefaction of the research area.

The data used in the quality of the disposal material is the same as the condition of the foundation. However, on the quality of the disposal material, the samples used are samples taken directly to determine the physical and mechanical properties of the disposal soil. The samples are analysed in the laboratory, and several test data are produced, including data the results of the grain size gradation test and the results of the Atterberg Limit test, which are the primary data used in the analysis of determining the liquefaction potential.

All data used in this research were tested statistically to test the normal distribution. After analysing the data, it will be continued with the rating based on the WSRHC method. The rating considers the condition of the foundation and the quality of the disposal material to produce a final value that can be seen in how the liquefaction potential occurs at disposal. Liquefaction in the WSRHC weighting is essential because if the liquefaction potential is very high, the disposal of the research area is in a very high hazard condition and is included in the Waste Dump Hazard Classification Level V.

Seismicity of the Research Area

The research area's seismic conditions or seismicity can be seen from the Peak Ground Acceleration (PGA) basis. The research area is in Muara Enim Regency, South Sumatra Province. The 2017 Indonesia Earthquake Source and Hazard Map (Figure 3) was issued by the Ministry of Public Works and Public Housing. The research area is an area that is close to the earthquake source in the form of the Sumatra Fault and the Subduction Plate Boundary, which makes the PGA value important for analysis.

The research location has a Peak Ground Acceleration (PGA) value of 0.2 – 0.25 g. The seismic factor used is a 500-year return period or a probability of exceeding 10% in 50 years is used as the basis for seismic factor analysis (Tim Pusat Studi Gempa Nasional, 2017).

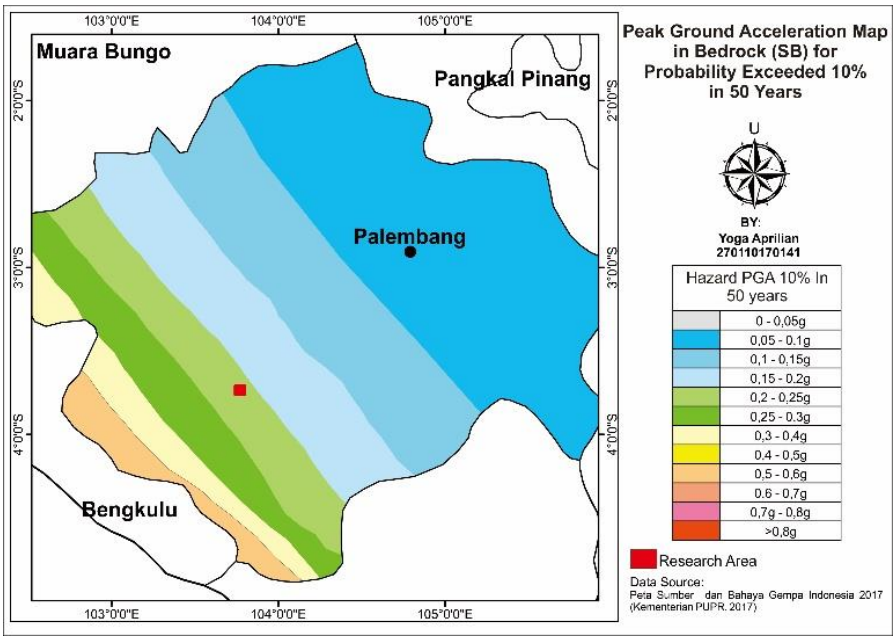

Figure 3. Indonesia Earthquake Source and Hazard Map (Modification from Tim Pusat Studi Gempa Nasional, 2017).

E-ISSN : 2579 – 3136

Liquefaction

According to Hakam and Darjanto (Hakam & Darjanto, 2013), liquefaction is a loss of soil strength due to increased pore water stress and a decrease in the soil layer's adequate pressure caused by dynamic cyclical loads. Cyclic loads that occur for only a few moments can result in such short cyclic loads that the soil mass in a short time undergoes a transition from a solid-state to a search state or has a paramount consistency like liquid.

Based on several research results on liquefaction events in the world, liquefaction can occur at several Peak Ground Acceleration values. In some cases, the lower threshold for liquefaction is 0.1 g (Santucci de Magistris et al., 2013 (Buana et al., 2019)).

According to Hawley (2017), disposal material that has the potential for liquefaction occurs is material in a state of uniform grain size gradation; coarse grain size has a high port number and the influence of loads due to earthquakes.

RESULT AND DISCUSSION

ANALYSIS OF FOUNDATION LIQUEFACTION POTENTIAL

According to Hakam and Darjanto (2013), materials with liquefaction potential are very loose materials, saturated with water, have a rounded grain shape, are well separated with poor grain size diversity, and have a small content of fine material.

Determination of liquefaction potential using Liquefaction Vulnerability Zone Map of South Sumatra, issued by the Badan Geologi in 2019, shown in Figure 4. In addition to paying attention to some of the parameters above, this study also pays attention to the map of the disposal area's potential liquefaction zone and earthquake vulnerability zone. The research area is included in the site not vulnerable to liquefaction based on the map.

Furthermore, based on the South Sumatra Earthquake Hazard Zone Map (Figure 5), the research area is included in the category of the moderate earthquake hazard area, this can indicate that the foundation can experience earthquake shaking with an intensity ranging from VII – VIII MMI (Pusat Vulkanologi dan Mitigasi Bencana Geologi, 2013).

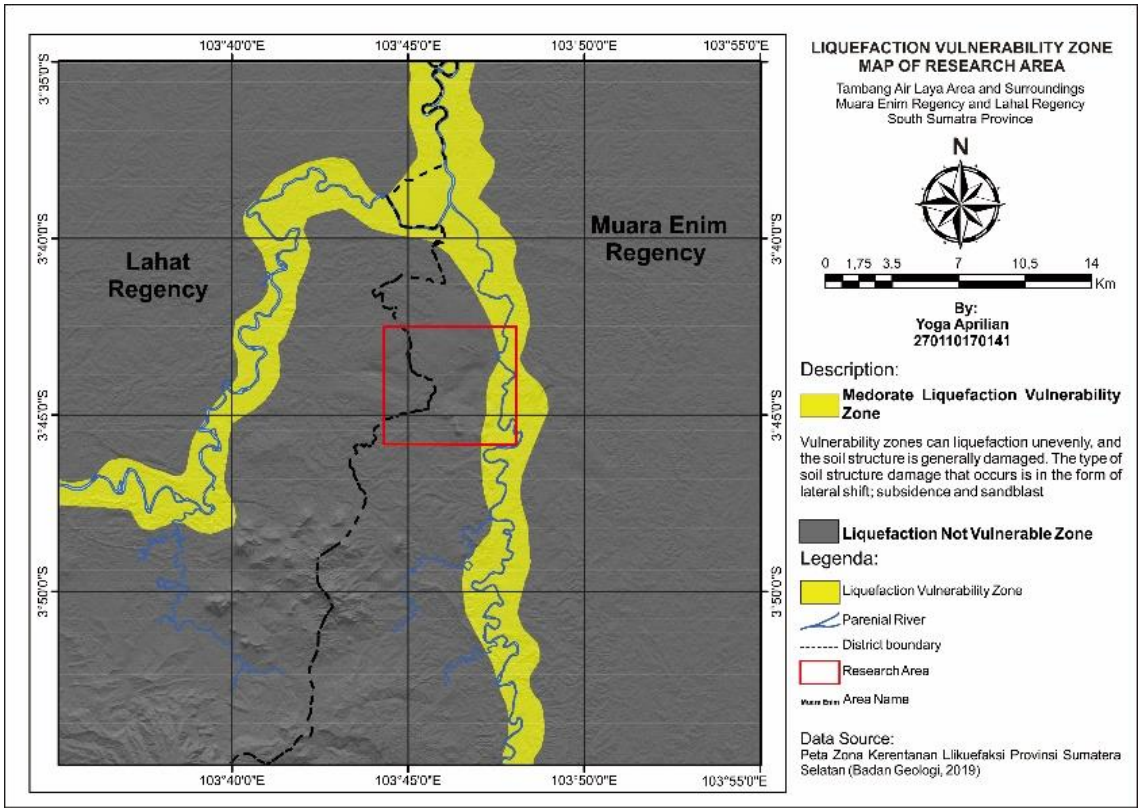

Figure 4. Liquefaction Vulnerability Zone Map of Research Area (Modification from Buana et al., 2019)

E-ISSN : 2579 – 3136

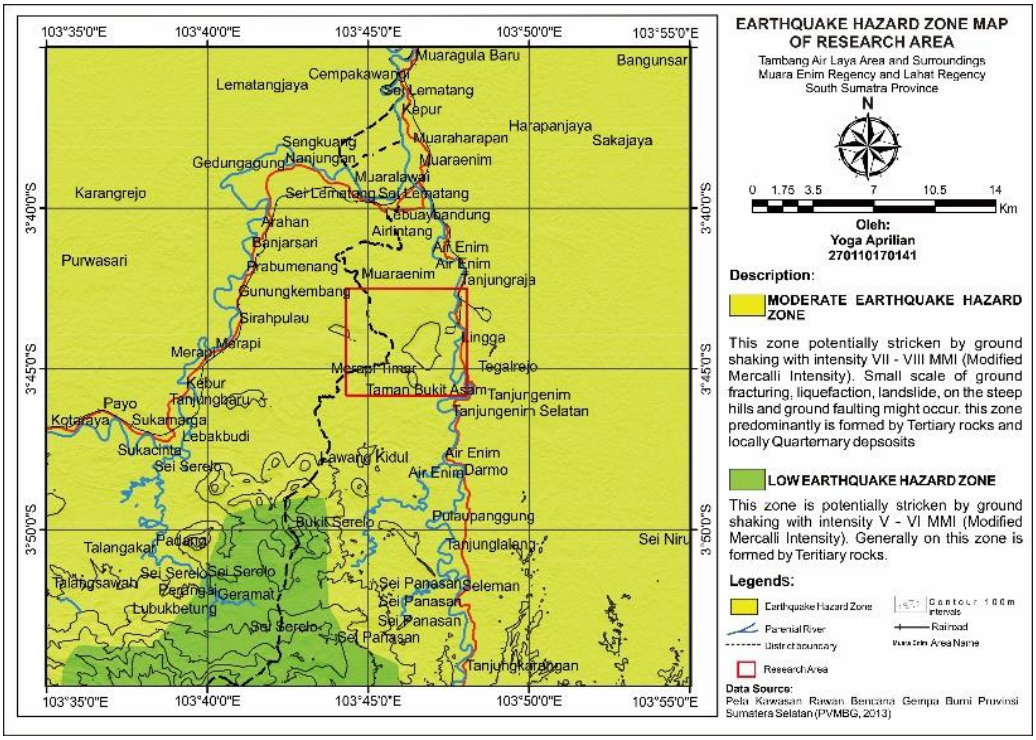

Figure 5. Earthquake Hazard Zone Map of Research Area (Modification Pusat Vulkanologi dan Mitigasi Bencana Geologi, 2013).

Based on the test results of the grain size distribution of the foundation rock layers shown in Figure 6, shows a gradation of sand grain size with 35.24%, besides that the value of clay grain size is 28.50% and silt with a value of 31.46% with a total fine grain size of 59.96%. It shows that the foundation has a coarse to fine grain size, classifying it as good gradation.

The level of plasticity can affect the liquefaction potential of the disposal foundation. According to Boulanger and Idriss (2006), sand-like materials with a plasticity index value of ≤ 7 are more susceptible to liquefaction than clay-like materials with a plasticity index value of ≥ 7. The results of the Atterberg limit test shown in Figure 7, the plasticity index value of the disposal foundation rock is included in the clay-like material with a plasticity index of 18.17%. A plasticity index indicates that the research area has a low potential for liquefaction. Additionally, the void ratio at the foundation of a low value of 0.29 is obtained from the average value. According to Hawley (2017), a small void ratio causes the potential for liquefaction to be small.

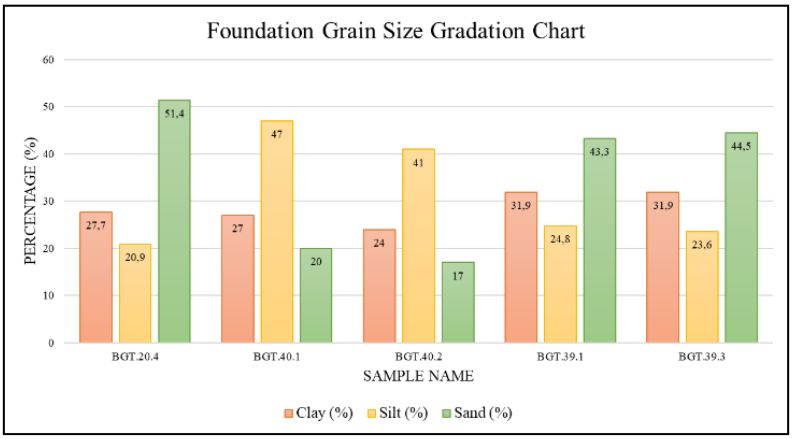

Figure 6. Grain size distribution in the foundation rock layer IB B2-C Disposal foundation

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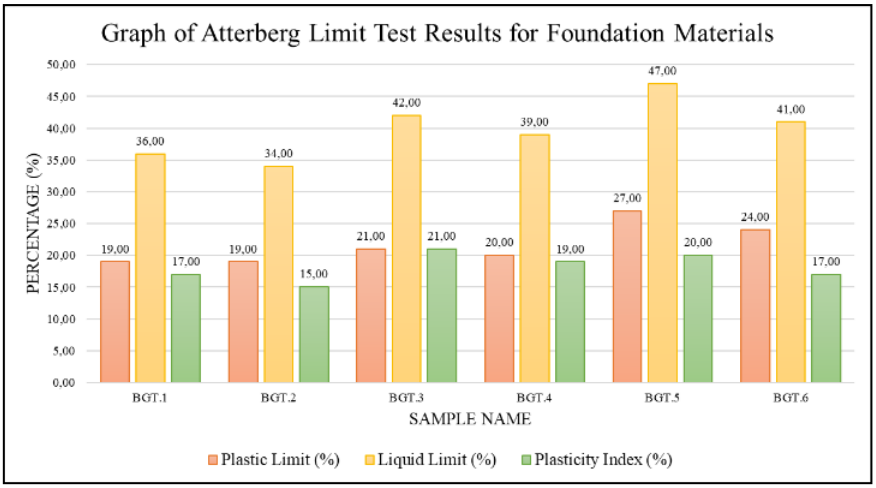

Figure 7. Atterberg limits test results on the disposal foundation

ANALYSIS OF THE POTENTIAL LIQUEFACTION OF DISPOSAL MATERIALS

The analysis of the potential liquefaction potential of disposal material is the same as the condition of the possibility on the foundation, but what is different is that the study of the disposal material does not consider the seismicity factor or the potential for regional liquefaction because the disposal material is ex-situ material or material originating from other areas outside the disposal area of the study area.

The results of the grain size distribution test carried out on 11 samples (Figure 8) spread over the disposal area showed that the southern TAL backfill disposal was dominated by clay-silt grain size with a percentage value of 98% and a sand grain size of 1.036%. So, it can be concluded that the disposal material is included in the fine grain size consisting of clay and silt.

According to Hawley (2007), materials with a low level of plasticity will be more likely to occur than disposal materials that have a high plasticity value, which will lead to the potential for liquefaction to occur According to Boulanger and Idriss (2006), sand-like materials with a plasticity index value of ≤7 are more susceptible to liquefaction than clay-like materials with a plasticity index value of ≥ 7. Based on the data shown in Figure 9, the plasticity index value of the disposal material is 17% - 24%, which has a PI value ≥7 and is classified as clay-like. Otherwise, the value of the void ratio in the research area is included in the low weight with an average of 0.84.

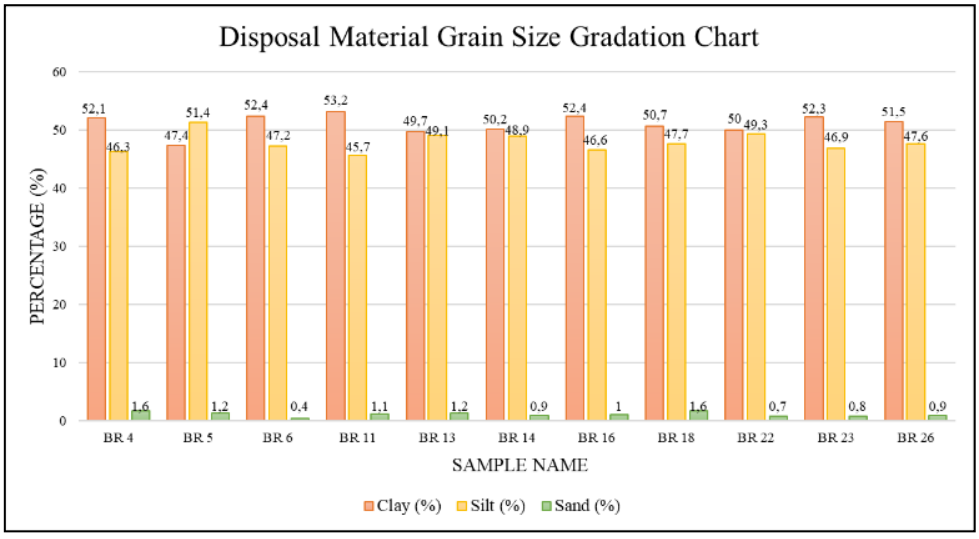

Figure 8. Grain size distribution on material disposal

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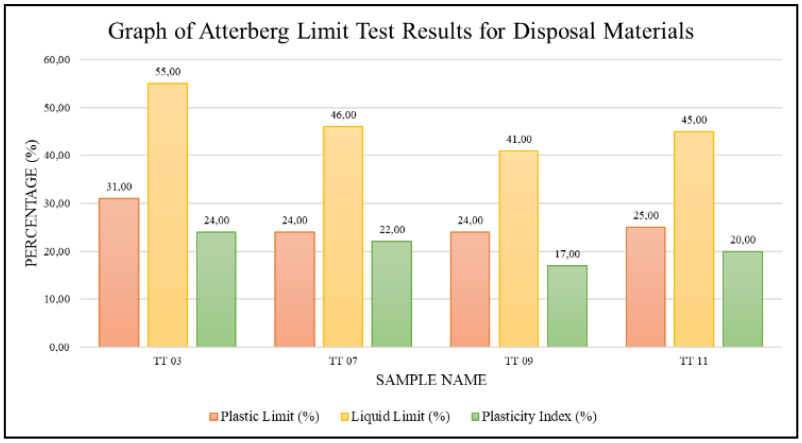

Figure 9. Grain size distribution on material disposal

DISCUSSION

Based on the analysis that has been described, on the liquefaction potential of the foundation, based on data from the Earthquake Hazard Zone Map, Liquefaction Vulnerability Zone Map, grain size gradation results, plasticity index, and void ratio, the research area is included in the potential liquefaction zone which is meaningless with a rating value of 0 based on the classification WSRHC ratings (Table 1). The rating explains that the condition of the disposal foundation of the study area does not have significant conditions to cause liquefaction to occur. The foundation's condition that supports the absence of potential liquefaction is based on a good gradation of the foundation material; the state of the foundation material also has a high plasticity content. Besides, the number of fine grains in the foundation dominates, and the foundation is dry or not saturated with water.

Meanwhile, for the liquefaction potential of the disposal material in the study area, based on the grain size distribution data and the results of the Atterberg limit material disposal test in the form of plasticity index data, the disposal of the research area is included in the low liquefaction potential with a weight value of -2.5 based on the WSRHC classification. The selection of low conditions is based on the consideration of seismic factors and the seismic zone of the study area, as well as the element of disposal material, which is generally loose, and the research is only carried out on the surface of the disposal, not thoroughly until it is in the disposal causing different results. So even though the potential for liquefaction of the foundation is low, care must be taken to keep the risk of liquefaction from occurring.

Table 1. Ratings of Foundation Liquefaction Potential and Material Liquefaction

Factor	**Ratings**				
Foundation Liquefaction Potential	Very High	High	Moderate	Low	Negligible
Description	Very uniform; very loose; minimal plastic fine; open, clast supported structure; high void ratio, rounded clasts, saturated	Extra-sensitive clays and extremely weak soils	moderate (or unknown) liquefaction potential	low liquefaction potential but cannot be fully discounted	well graded; dense; high content of plastic fines; matrix supported structure; low void ratio; angular clasts; dry
Rating	-20	-10	-5	-2,5	0
Material Liquefaction Potential	Very High	High	Moderate or unknown	Low	Negligible
Description	Very uniform; very loose; minimal plastic fine; open, clast supported structure; high void ratio, rounded clasts, saturated		Moderate (or unknown) liquefaction potential	low liquefaction potential but cannot be fully discounted	well graded; dense; high content of plastic fines; matrix supported structure; low void ratio; angular clasts; dry
Rating	-20	-10	-5	-2,5	0

E-ISSN : 2579 – 3136

CONCLUSION

Based on the results of the analysis obtained, it can be concluded that:

1. Liquefaction potential the foundation of the study area is insignificant with a weight value of 0; this is due to the condition of the foundation material with a good gradation of the foundation material, the shape of the foundation material also having a high plasticity content, the number of fine grains contained in the foundation is more dominant, and in a state of dry or unsaturated.
2. Liquefaction Potential Disposal material is included in the low category with a weight value of -2.5, but monitoring must be carried out and considered because disposal materials are generally loose.

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