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Strengthening Railway Stability In Indonesia

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Abstract
The selection of tunnel construction is considered possible if you see the background of Indonesia with diverse mountainous topography. Buffer construction is one of the things that must be considered in tunnel construction because the buffer serves to hold the tunnel load so that it does not collapse. The method used in the construction of the Ijo Tunnel is the New Austrian Tunneling Method (NATM) method with the strengthening of tunnel stability one of which uses using Wiremesh. This research is intended to provide safety factor information (safety factor) to strengthen tunnel stability using wire mesh by giving earthquake load or not. Analysis of calculations using the finite element method (finite element method) using Plaxis software. Based on the calculation results obtained the safety factor or safety factor of 2428> 1.25 (Bowles, 1984). Furthermore, the use of Wiremesh adds a safe number value of 0.076 to the tunnel stability.

Keywords*:* Tunnel, Train, Stability

1. Introduction

The use of tunnel construction is now more suitable crossing construction option than the use of bridges. This is due to Indonesia's topography which has many mountainous contours. A tunnel is an underground construction with a comparison of the length and width of a large cross-section and has an elongated gradient.

Ijo Tunnel is a railroad tunnel that is located in Bumiagung Village, Rowokele District, Kebumen Regency, Central Java Province. This tunnel was built in 1885-1886 by Staatsspoorwegen (SS), a Dutch East Indies railroad company, with a length of 579 m through the limestone hills of Mount Malang. As a result of the construction of the double-track on the Cirebon-Kroya line, the green tunnel was rebuilt. It is planned that the drilling will be divided into two parts, namely drilling at the inlet portal and the portal outlet with the aim of minimizing the work time available on the project.

Based on BH-D log drill test results, the type of soil at the Ijo Tunnel location is a type of soft soil. The parameters of the log drill test results will be used to model the soil structure at the time of analysis. The following parameters are the results of the log drill test.

Table 1.1: Parameters of BH-D Log Log Test Results

Layer	γsat (kN/m^3)	γunsat (kN/m^3)	C (kN/m^2)	k_x (o)	k_y (o)	Ψ (o)
1	20.160	16.180	388.400	0.001	0.001	0
2	20.400	16.570	214.800	0.001	0.001	0
3	19.970	15.930	229.900	0.001	0.001	0
4	19.530	15.300	199.200	0.001	0.001	0

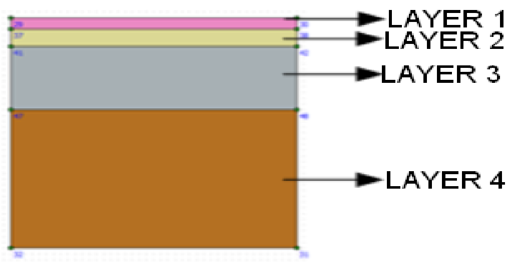

Figure 1.1: Modeling of Soil Section

The buffer system is one of the things that needs to be considered in the process of tunnel construction. Some cases of collapse are caused by the buffer system being unable to withstand the load given. So a good analysis is needed on the stability or construction of tunnel support.
One of the buffer systems used in the construction of the green tunnel is a wiremesh system. Wiremesh (often used in tunnel construction) includes weld mesh and chain link mesh. Weld mesh consists of rectangular or square-patterned steel reinforcement joined by being brazed at the intersection points, serves to strengthen shotcrete, while chain link mesh is used on surfaces because it is strong and flexible.

Figure 1.2: Wiremesh

In this case, used wiremesh is a type of weld mesh with a reinforcement diameter of 5 mm. It serves to strengthen the shotcrete to be more rigid and also serves to bind small rock material and hold it in order to not collapse.

Table 1.2: Wiremesh Specifications

Parameter	**Unit**	
EI	KNm	3230,3466
EA	KN	2492551,404
W	KN	45,3039

The complexity of the form of construction and the demands for speed in workmanship require the development of better and easier calculation methods. Generally, the numerical method used as an exact approach solution takes a long time to work on. One of the numerical methods developed is the Finite Element Method (Finite Element Method). With the finite element base, plaid is a program developed for deformation analysis. The initial aim of this program was to use river embankment analysis on soft soils from the Dutch low lands, further plaids were widely used for geotechnical engineering.

The tunnel structure design is analyzed using static earthquake load where equivalent static forces are used to replace horizontal forces acting on the structure due to ground movement, this method is commonly called the equivalent lateral force method.

Research to review the strength of the tunnel support system with the finite element method and an analysis of the use of appropriate methods for tunnel strengthening was carried out by Apriyono (2012). From this study it was concluded that the method or Q actor supporting the actor reduced the value of displacement significantly, reinforcement with the supporting actor reduced displacement around the tunnel by 12.5 mm.

Further research to analyze tunnel geotechnics using the finite element method was also carried out by Fadhilah (2016), research carried out in the Garutee Aceh rock tunnel. The focus of this research is to design tunnels for highways in the rocky area and mapping soil and rock data. From this study, it was found that the insignificant difference in deformation between tunnels without reinforcement and tunnels with reinforcement, this occurs due to the composition of rocks in the area has a steady mass. Safety factors in the two models have values above the safe limit to a length of 19.5m. But the tunnel model without the tunnel has a track decrease in a safety factor to <2 in subsequent excavations. So it is recommended to use tunnel strength actors because actor blasting can cause collapse during excavation.

Based on this background, tunnel stability analysis was carried out using the finite element method using the Plaxis v.8.2 program. Stability analysis was carried out with wiremesh strengthening involving earthquake loads.

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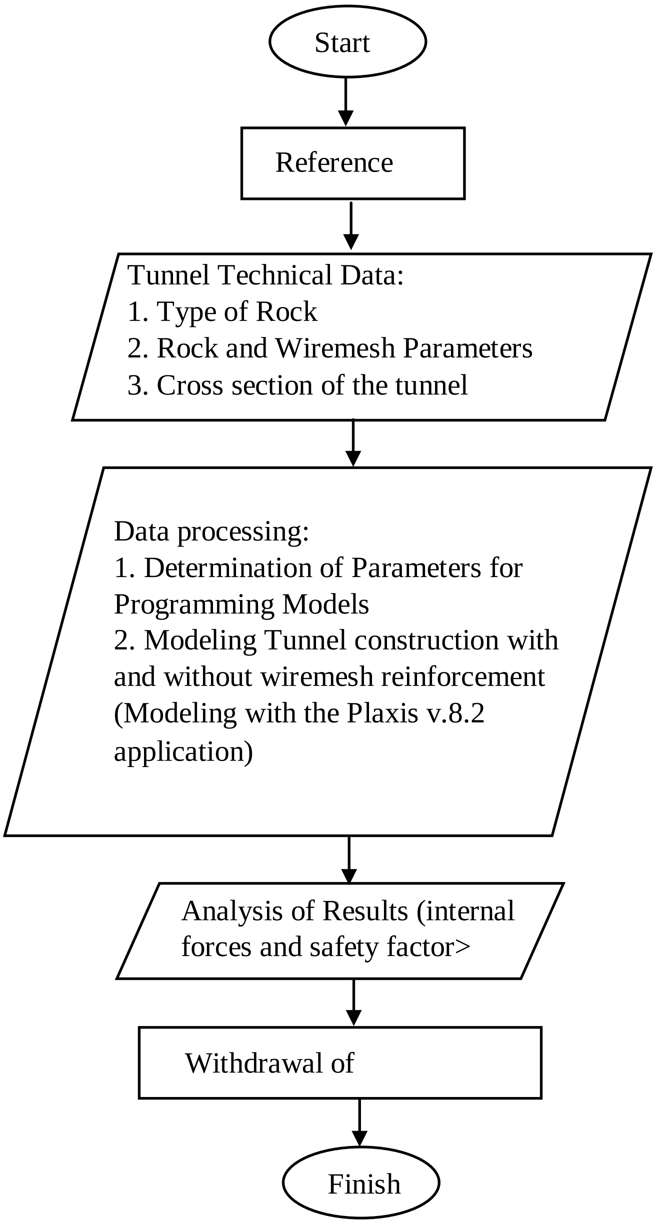


Figure 2.1: Flow chart

2. Method

Broadly speaking, the stages of the study are divided into three stages, namely the stages of data collection, data processing and conclusions. A description of the research method used is contained in the following flowchart.

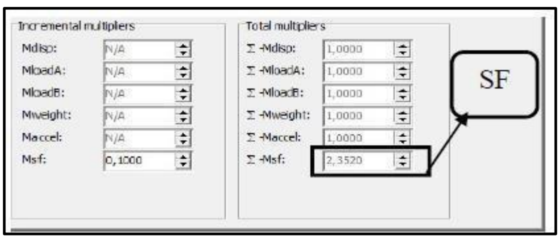


Figure 2.2: Research Method

3. Results And Discussion

The purpose of this study is to obtain the value of the safety factor, by reviewing the drill point 3 in the tunnel. Strengthening analysis is done by modeling tunnel construction using Plaxis v.8.2 program, analysis includes tunnel construction using Wiremesh and without Wiremesh.

Earthquake load is taken from the zoning map of the earthquake published in 2010 where the peak earthquake acceleration (PPG) for the area around the green tunnel is 0.4 g.

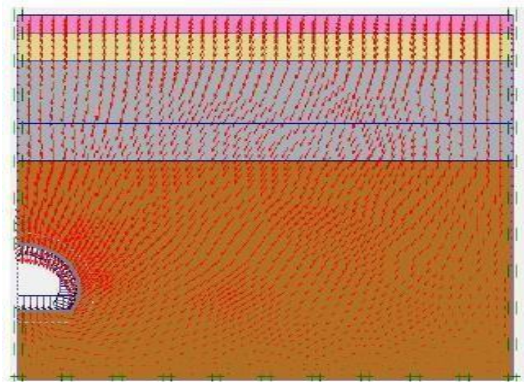
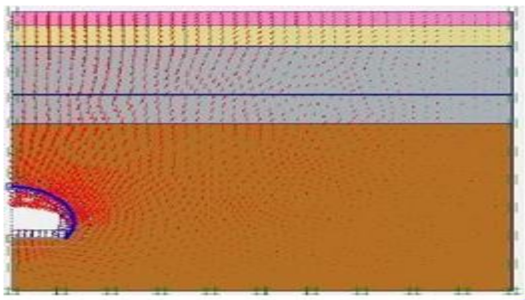


Figure 3.1: Nilai *Safety Factor* during Drilling without Earthquake Loads

a. Tunnel Stability Analysis Without Using WireMesh

Following the results of calculations and analysis using plaids v.8.2., Analysis of tunnel stability without reinforcement is divided into two, involving earthquake loads and no earthquake loads.

Based on Figure 3.1. known safety factor values in tunnel construction without reinforcement with earthquake loads are not too significant compared to those using earthquake loads, where the values are 3.2991 and 2.3520. As for the movement of land and the potential for collapse in the tunnel can be seen in the following figure.



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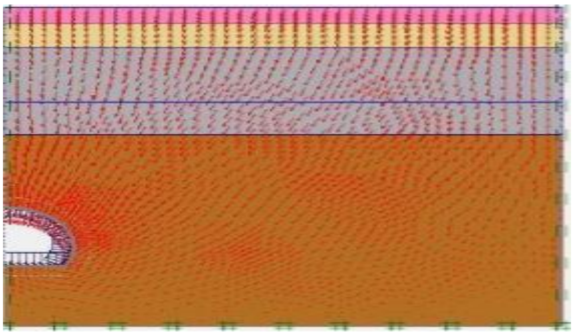
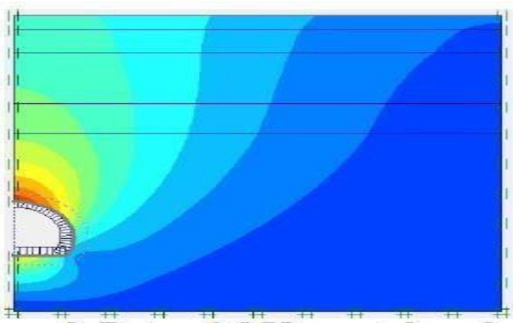


(b)

Figure 3.2: (a) Direction of Soil Movement when Drilling without Earthquake Load; (b) with Earthquake Loads after Drilling

Based on the picture above in all models of ground movement construction that occurs is approaching tunnel construction or leading to the tunnel.



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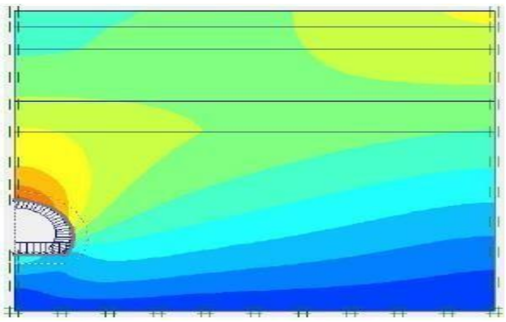


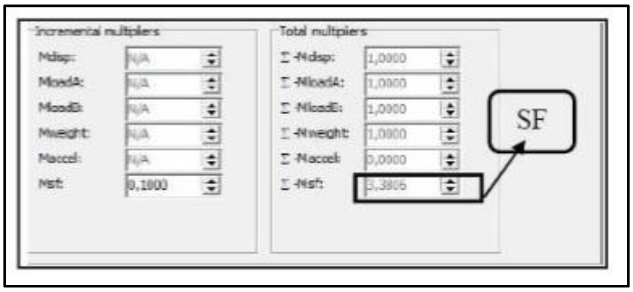
(b)

Figure 3.3: (a) Potential Areas Collapse when Drilling without Earthquake Loads; (b) with Earthquake Loads after Drilling

Seen from the picture above the largest potential collapse area in the two construction models is located in the upper tunnel area.

b. Tunnel Stability Analysis Using Wiremesh

Tunnel construction analysis using wiremesh reinforcement is divided into dual construction models, namely construction with earthquake free view and earthquake load. The following are the results of calculations and analysis using Plaxis v.8.2. The following results are obtained.



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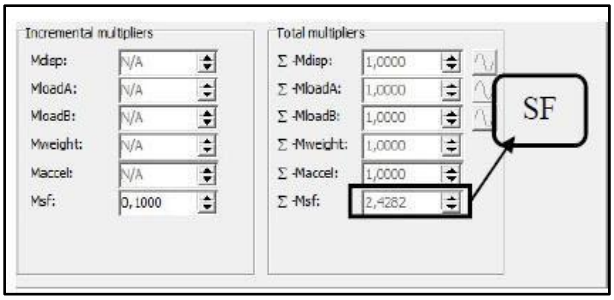
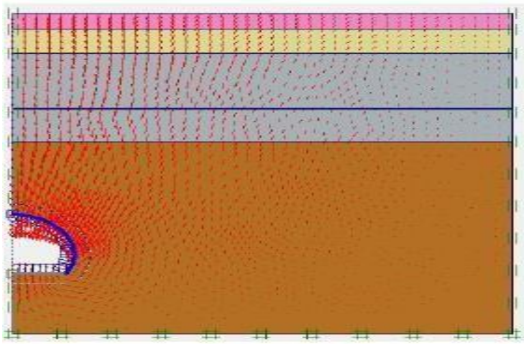


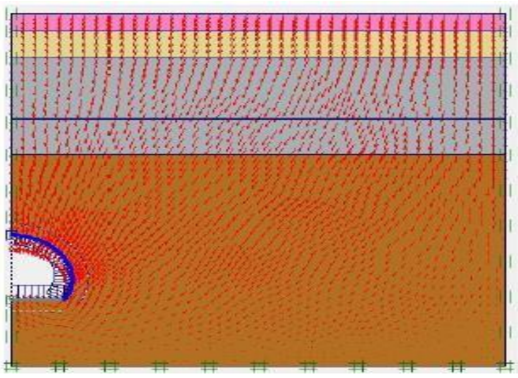
(b)

Figure 3.4: (a) Nilai *Safety Factor* during Drilling without Earthquake Loads; (b) with Earthquake Loads after Drilling

According to Figure 3.4. construction using wiremesh reinforcement has a greater safety factor value than in construction without reinforcement, the value of the safety factor on both models is 3.3806 and 2.4282.



(a)



(b)

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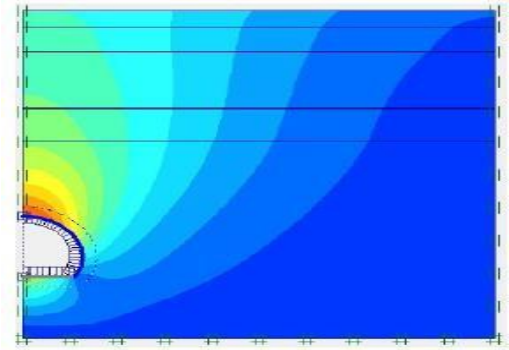
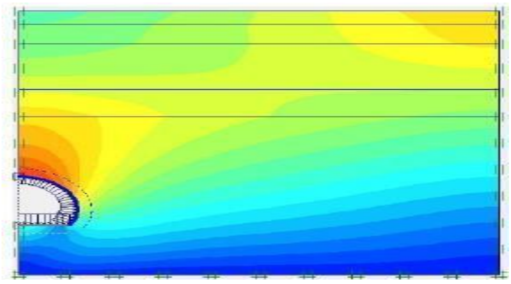
Figure 3.5: (a) Direction of Soil Movement when Drilling without Earthquake Load; (b) with Earthquake Loads after Drilling

When viewed from the ground motion picture in all tunnel construction models using Wiremesh, the ground movement leads to tunnel construction.



(a)



(b)

Figure 3.6: (a) Potential Areas Collapse when Drilling without Earthquake Loads; (b) with Earthquake Loads after Drilling

Similar to tunnel construction without reinforcement, the potential area collapses in tunnel construction with wiremesh reinforcement, the area that has a high probability of collapse is in the area above the tunnel.

4. Conclusion

Based on the discussion in the previous chapters, conclusions can be drawn for this study, including:

a. All tunnel construction modeling (without and with wiremesh reinforcement) on tunnel stability has a safety factor above the required safety factor of 1.25 (Bowles, 1984). It can be interpreted that the addition of existing reinforcement in tunnel construction can reduce the value of the existing deformation.

b. The direction of soil movement in tunnel construction modeling (without and with wiremesh reinforcement) by modeling the plaque program can be known that the movement of the ground approaches tunnel construction. This indicates that the movement of the soil is towards the weakening point (hole/tunnel) of construction.

The location of the largest potential collapse area is located in the upper construction area, this can be interpreted that the area of the tunnel holds the biggest load compared to other tunnel areas.

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