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Empirical and numerical method approaches in determining the value of rock slope safety factors at JJLS Gunung Kidul, Yogyakarta

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ABSTRACT

Limestone is one of the most numerous sedimentary rock groups, limestone consists of non-clastic limestone and clastic limestone. The research slope is on the Southern Cross Road (JJLS) in Gunung Kidul LOT 4 (Legundi-Plajan) which has length of 4.7 KM, where the rock slopes are in a location that is busy with traffic and close to where residents live. The purpose of this study is to determine the slope safety value with empirical and numerical approaches using RMR and RS 2. In this study, there are several types of data used, namely field data including megascopic rock descriptions at the research location, and laboratory data, namely UCS data. From this study, it was found that the formation of slopes 1 and 2 was included in the category of rock mass quality, while slope 3 was good. RMR values that are not much different do not make the slopes have the same weighting, because the slope geometry and the discontinuity geometry plane. Based on the value of slope stability using phase 2 software to get stable FK, there is a significant difference between slope 1,2 and slope 3, where the difference in safety factors can be influenced by discontinuity conditions, discontinuity orientation and activities around the slope.

INTRODUCTION

Limestone is one of the most numerous sedimentary rock groups, limestone consists of non-clastic limestone and clastic limestone. Clastic limestone is the result of the breakdown of non-clastic types of limestone through the process of erosion by water, transportation, sorting and sedimentation. Therefore, during the process other types of minerals also follow which are impurities and give color to the limestone. Meanwhile, non-clastic limestones are colonies of starfish, namely Coelenterata, Mollusca, Protozoa and Foraminifera (Sukandarrumidi, 2009). In this study, the limestone slopes are composed of crystalline limestone with brownish yellow color, non-clastic texture, massive structure with mineral conditions of calcite, carbonate, and reef limestone with bright white color, weathered yellowish brown color. According

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to Sustriani (2012) the geological structure can affect the stability of the slope, where the geological structure will find a weak field that has the potential as a slip plane if it is in the direction of the slope. Unstable slopes are very dangerous to the surrounding environment, therefore slope stability analysis is very necessary. Instability on slopes can also be caused by geological structural conditions, the direction of discontinuities in rocks such as joints, fractures, planes, faults and other types of cracks in rock, physical properties mechanics of slope-forming rock, groundwater pressure, and slope geometry. Thus it can be said that the fundamental behavior of rock mass is strongly influenced by its discontinuities (Endaryanto 2007).

The research slope is on the Southern Cross Road (JJLS) in Gunung Kidul LOT 4 (Legundi-Plajan) see Figure 1 which has a length of 4.7 KM, where the rock slopes are in a location that is busy with traffic and close to residents' residences, there are three research slopes. namely the first slope at STA 3+000, the second slope at STA 1+250 and the last slope at STA 3+300. Therefore, this research is focused on empirical and numerical approach to slope stability, using RMR (Rock Mass Rating) and kinematic analysis using RS2 to determine the FK (Safety Factor) value of the slope.

RESEARCH METHODS

The research begins with calculating the stiffness in the field, then the next stage is the data collection and processing stage. In this study, there are several types of data used, namely field data and laboratory data and the next stage is data analysis. Field data includes megascopic rock descriptions at the research location, such as discontinuity areas, discontinuity length, discontinuity position, discontinuity position (strike, dip and dip direction), discontinuity openings, fill material, and water conditions. Laboratory data, namely data from the test results of rock strength values based on the UCS (uniaxial compressive strength) test. Rock samples used are rock samples taken directly in the field, then preparation is carried out before testing.

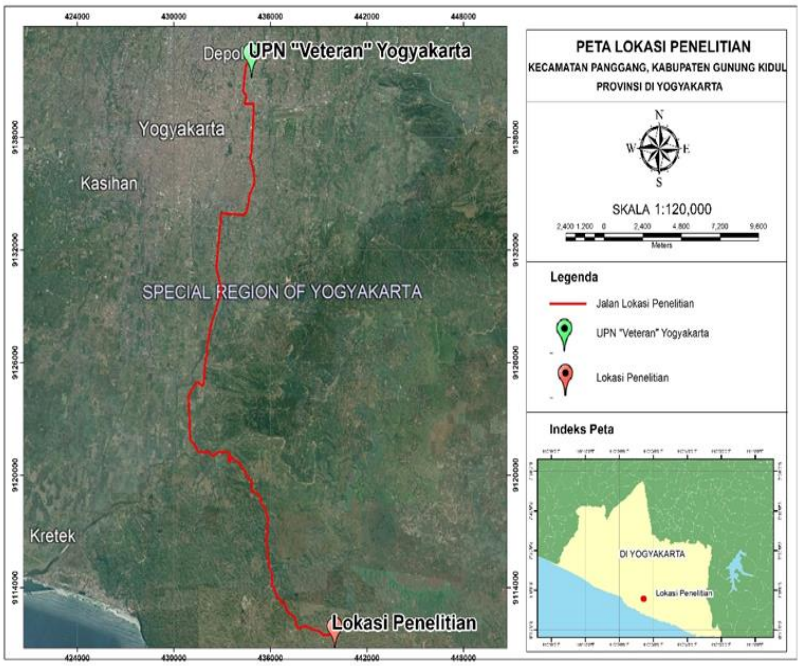

Figure 1. Research site map

Analysis stage

After all the data is complete, the next stage is kinematic analysis, rock mass classification and calculation of the safety factor value.

Kinematic analysis

This analysis was carried out based on field data, namely joint distance, joint conditions and groundwater conditions. Where data retrieval is done based on the scanline method. The analysis was carried out by entering slope geometry data, discontinuity data on the observation slope with the help of Phase 2 software.

Rock mass analysis

Rock mass classification is carried out based on the parameters in the RMR taken from three research slopes and UCS tests in the laboratory, aiming to determine the condition of the rock mass. In this study, using the RMR table developed by Bieniawski (1987), so that the weights of the three slopes are obtained and determine the rock mass class.

Calculation of safety factor value

Calculation of the value of the factor of safety (FK) is carried out to determine the comparison of the value of the resisting force with the driving force on a slope, which aims to determine the condition of the slope in a stable or unstable condition. Determining the FK value using Phase 2 software, which uses the Mohr-Coloumb criteria by entering the shear strength test data, namely the value of cohesion, internal shear angle and the proton ratio. From these data, the results of the safety factor of the three slopes and also the rock mass class at the study site were obtained.

RESULTS AND DISCUSSION

Based on the calculation of RMR in the three research sites, it was found that all research sites were composed of rocks with RMR values ranging from 51-62 which were included in class II (good) and III (moderate). The RMR value on the 1st research slope at STA 3+000 is 54 in class 3 which is moderate, the 2nd slope at STA 1+250 with an RMR value of 51 which is class 3 moderate and the 3rd slope STA 3+300 with an RMR value his 62 are in class 2 which is good. The difference in RMR values at each study site is relatively small, due to the similarity of lithology. The RMR value is determined based on the parameters in the RMR including rock strength data (UCS), RQD (Rock Quality Designation) data, distance data between discontinuity planes, discontinuity plane conditions and general groundwater conditions. The following is the weighting of the three slopes.

Table 1. RMR value on slope 1

No.	Parameter	Weight
1.	Compressive strength	4
2.	RQD	20
3.	Sturdy distance	10
4.	Strong condition	10
5.	Groundwater	10
Total		**54**

Table 2. RMR value on slope 2

No.	Parameter	Weight
1.	Compressive strength	4
2.	RQD	20
3.	Sturdy distance	10
4.	Strong condition	10
5.	Groundwater	7
Total		**51**

Table 3. RMR value on slope 3

No.	Parameter	Weight
1.	Compressive strength	7
2.	RQD	20
3.	Sturdy distance	8
4.	Strong condition	20
5.	Groundwater	7
Total		**62**

The following graph shows the relationship between classification parameters and RMR weighting.

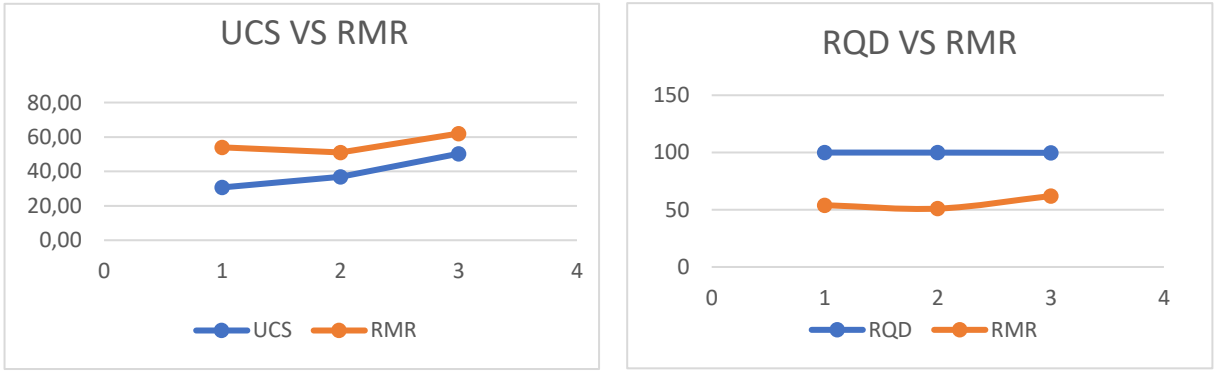

Figure 2. (a) Relationship between UCS VS RMR (b) Relationship between RQD vs RMR

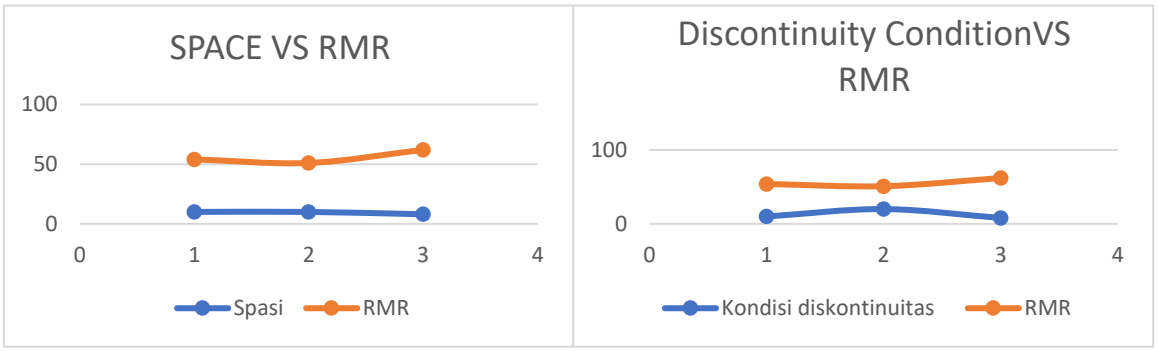

Figure 3. (a) Relationship between discontinuity spaces VS RMR (b) The relationship between discontinuity conditions VS RMR

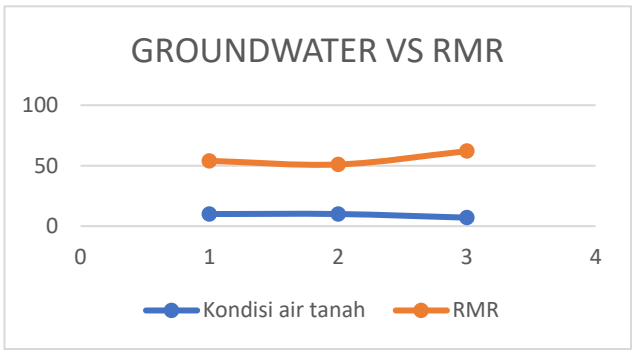

Figure 4. Relationship between groundwater VS RMR

SAFETY FACTOR

Slope conditions can be reviewed through the value of the safety factor. The factor of safety is the ratio between the resisting force and the driving force. Based on the calculation results of the FK (Safety Factor) it is found that the relationship between the RMR value of the constituent rocks and the FK is directly proportional, so the higher the RMR value, the higher the FK value. To determine the relationship between slope stability parameters, it is necessary to analyze the actual conditions of the slopes to be analyzed. The model was obtained after analyzing the slope conditions. Calculation of the safety factor is done by entering the data from the shear strength test. For FK on each slope, the 1st slope of STA 3+300 is 8.48, the 2nd slope of STA 1+250 is 7.79 and the 3rd slope of STA 3+300 is 5.26.

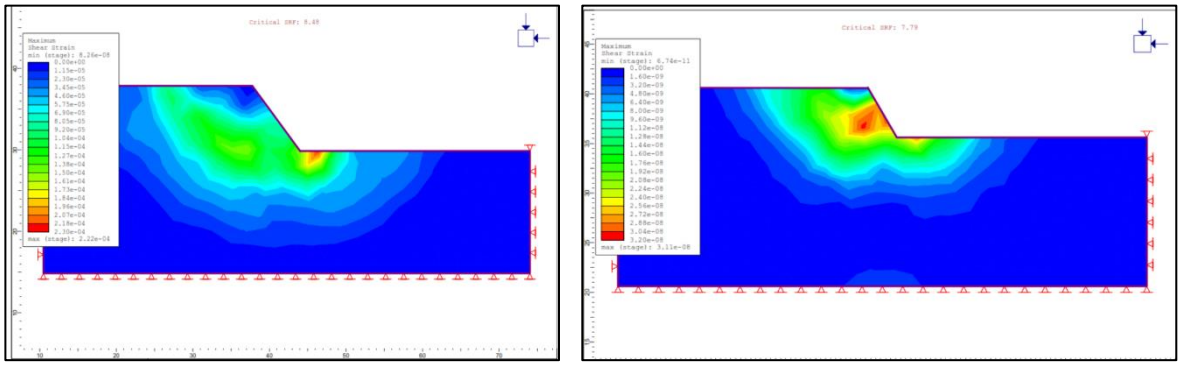

Figure 5. (a) Slope condition with FK 8.48 (b)Slope condition with FK 7.79

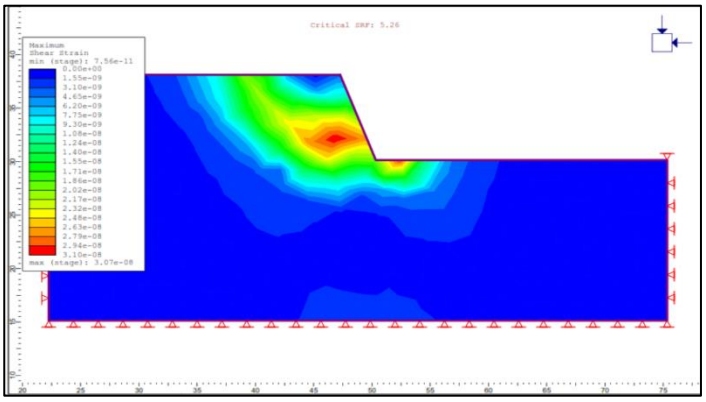

Figure 6. Slope conditions with FK 5.26

Table 4. Safety factor of each slope

No	Slope	Safety factor
1	I	8,48
2	II	7,79
3	III	5,26

CONCLUSION

Based on empirical and numerical calculations at the research site, it can be concluded that the rock mass classification (RMR) shows that the formation of slopes 1 and 2 is in the category of moderate rock mass quality and the third slope is in the good category. In weighting the RMR values, the three slopes have weights that are not much different, but do not make the three slopes have the same rock mass class due to slope geometry and discontinuity geometry. Calculation of the value of slope stability using software phase 2 obtained stable FK and there is a significant difference between slope 1,2 and slope 3, where the difference in FK can be influenced by discontinuity conditions, discontinuity orientation and activities around the slope.

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