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CLUSTERING SLOPE STABILITY USING DEM LINEAMENT EXTRACTION AND ROCK MASS RATING IN PANGKALAN KOTO BARU, WEST SUMATRA, INDONESIA

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ABSTRACT: Clustering slope stability in the Pangkalan Koto Baru, West Sumatra has become one of priority in disaster management. The method used for this study is using a combination of structural lineament analysis, scanline with window sampling and Rock mass rating (RMR) calculations. The analysis results of the fourteen observed slope sites showed significant outcome, which seen in the structural lineament show dominant trend from northwest-southeast, which also correlate from the measurement of discontinuity by using scanline with window sampling. From RMR calculation, value showed range between 17 - 42 which belonged to class V (Very Poor Rock) - class III (Medium Rock). Integration data of structural lineament, scanline method and RMR analysis suggested that 1 slope included in the very poor rock category, 12 slopes are poor rock category, and 1 slope in the medium rock category. So, it can be ascertained that most of the slopes will potentially be prone to landslides.

Keywords: Slope Stability, RMR, Cluster, Pangkalan, West Sumatra

1. INTRODUCTION

Unstable hillside is become dangerous when it happens, causing financial loss, traffic jam, fatalities, etc. The rock slide that closing the road could have caused an economic problem, especially Riau and West Sumatera province that connecting by this road.

The research area located on the Riau-West Sumatera road, Pangkalan Koto Baru, Lima Puluh Kota, West Sumatra Province. Fourteen different types of slope become the object in this research activity. This area has the occurrence of slope failure along the road that caused a potential hazard. Slopes in the research area had natural discontinuity meanwhile the other was disturbed by human activity such as excavation and rock mining.

Unsuitable treatment would be worsening the slope condition. Because of that, a Rock Mass Rating method (RMR) and Kinematic analysis become the appropriate method that had been used to determine to prevent slope failure. Hopefully, This research can give consideration for not to build construction near the slopes that have poor quality mass rock and also another way to prevent landslide hazard in the future.

2. GEOLOGY REGIONAL

Geologically, research area located in Central Sumatra Basin which is a back-arc basin that develops along the west and south coasts of the Sunda Shelf in the Southeast Asian Southwest.

Rocks from the Tertiary era were lifted to the surface graben structure and then deposited with tertiary-aged sedimentary rocks in the basin and produced tertiary intrusive rocks. The results of erosion from intrusive rocks are carried and settle around the river flow and then produce alluvial deposits [1].

Based on the Pekanbaru Sheet Geological Map, the study area consisted of four formations[2][3][4]. Geology area consists of three formations which passed by road which are Sihapas Formation, Bahorok Formation, and Tanjung Pauh Formation. On the northern part, Sihapas formation consists of conglomeratic sandstone and sandstone, which some area are having moderate dip bedding. In the middle area filled by Pematang Formation that consists of Red and Mottled mudstone, Breccio-conglomerates, and Conglomeratic sandstones. At Southern part was Tanjungpauh Member that consist of muscovite, chlorite, carbonate schist that strongly lineated. Structure geology is affected by a normal fault in the southern and only several locations with moderate dipping of bedding [5][6].

3. METHODOLOGY

3.1 Step by Step Method

The methodology begins with defining lineaments from DEM data [7] [6], [8], [9]to see the structural trends on the area that cut by roads, by using rose diagram we will see the trend of the structural lineament. Secondly, finding the selection of road cuts from the region which based on anticipated failure mechanism. The third step is the field investigation and data collection. In the current study, all data and measurements related to rock mass and discontinuities characteristics were gathered. This includes the state of weathering, RQD, joint spacing, joint surface conditions, effect of water, and attitudes of different joint sets, as well as the slope geometrical properties such as slope height, face dip and dip direction [10][11], [12].

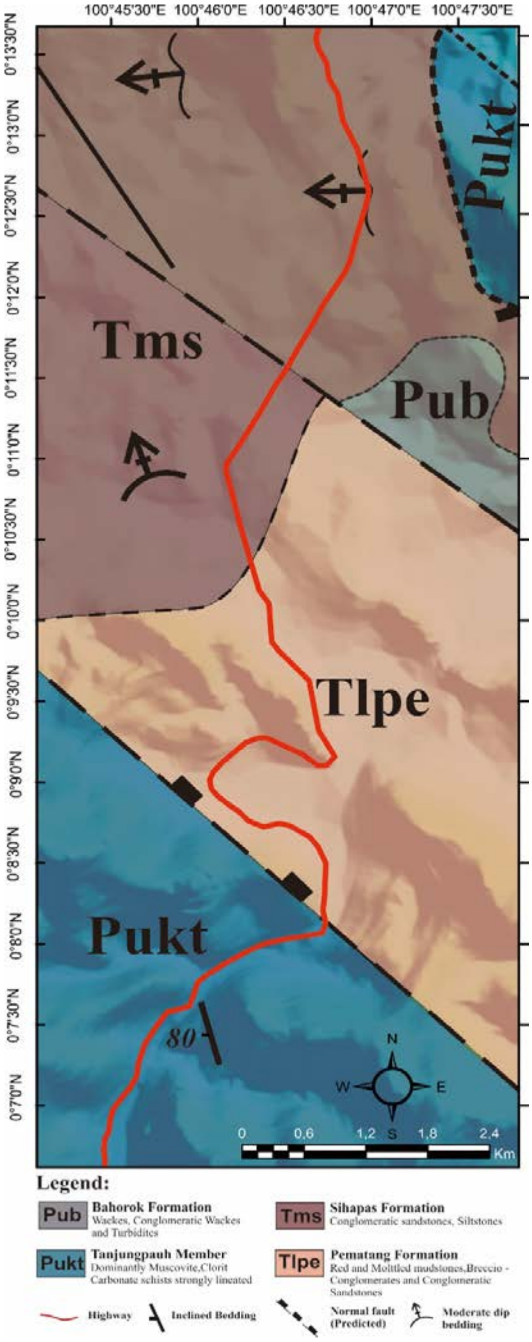


Fig.2 Geology regional of the research area

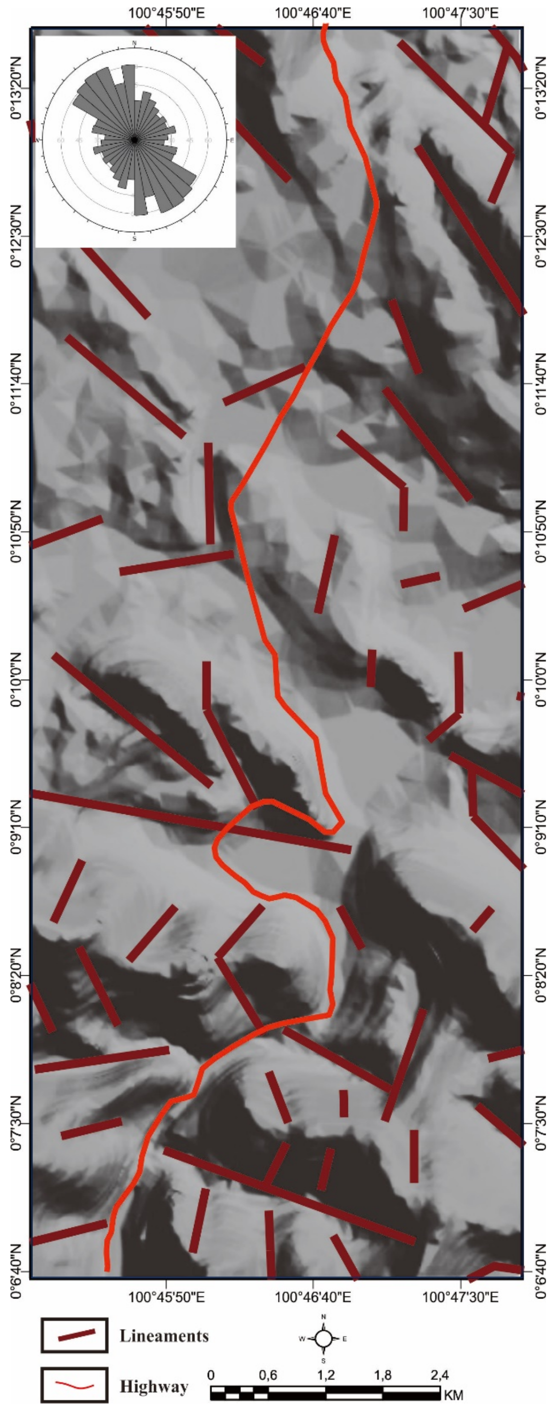


Fig.1 lineament extraction of the research area

3.2 Classification System For Rock Slope

3.2.1 Rock Mass Rating

Rock Mass Rating (RMR) method analyzed some parameters of slope such as uniaxial compressive strength of rock material (UCS) in megapascal (Mpa) unit, rock quality designation (RQD) in percentage (%) unit, spacing of discontinuities in meters (m) unit, condition of discontinuities, groundwater condition, and orientation of discontinuities with degrees unit. Whereas kinematic analyzed by using azimuth and dip data[12] [13]–[16][17], [18].

3.3 Governing Equation

Rock mass rating (RMR) is a method in slope mechanics analysis to define or classified rock mass quality.

Another purpose of Rock mass rating (RMR) analysis is to calculate the potential risk that would happen at the slope along the construction activity. This method is appropriate for controlling and preventing risks.

Rock quality designation (RQD) value can be calculated by field survey as core sample were not available – [19]. The following equation was used to calculate the rock quality designation (RQD) of rock mass using [20]:

$$RQD = 115\text{-}3{,}3\ .\ J\,v \qquad (1)$$

Where Jv is the sum of the number of joints per unit length for all joint sets known as the volumetric joint count.

Each RMR parameter would have its own rating to be summarized to get the RMR classification by using the formula:

$$RMR = R1+R2+R3+R4+R5+R6 \qquad (2)$$

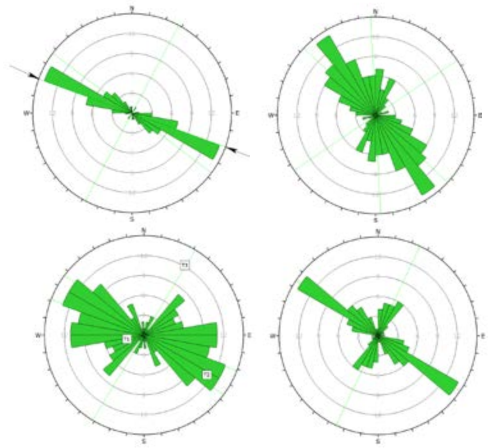
R1 is a rating of uniaxial compressive strength (UCS), R2 is a rating of rock quality designation (RQD), R3 is a rating of discontinuity, R4 is a rating of the condition of discontinuity, R5 is a rating of groundwater condition, and R6 is a rating of the orientation of discontinuity. These headings should be in 10 pt, italics, and sentence case. Insert one blank line before and after the headings. The further lower level headings should be avoided.

4. RESULTS AND DISCUSSION

4.1 Lineament Extraction

From 729 data lineament extraction using GIS software, the result showing the trends of structure dominantly trending Northwest – Southeast (N 315 E to N 135 E), this indicates that structural phases that happen in the area, are affected by tectonics that governed by subduction of movement Indo-Australian plates into Eurasian Plates. Which can suggest that structurally will be dominated by this trend of azimuth and dip?

Scanline with window sampling measurement on sites shows eight locations have the same dominant stress with Northwest – Southeast trend. And four location are opposing the direction, which indicates the athletic of structure on the study are.



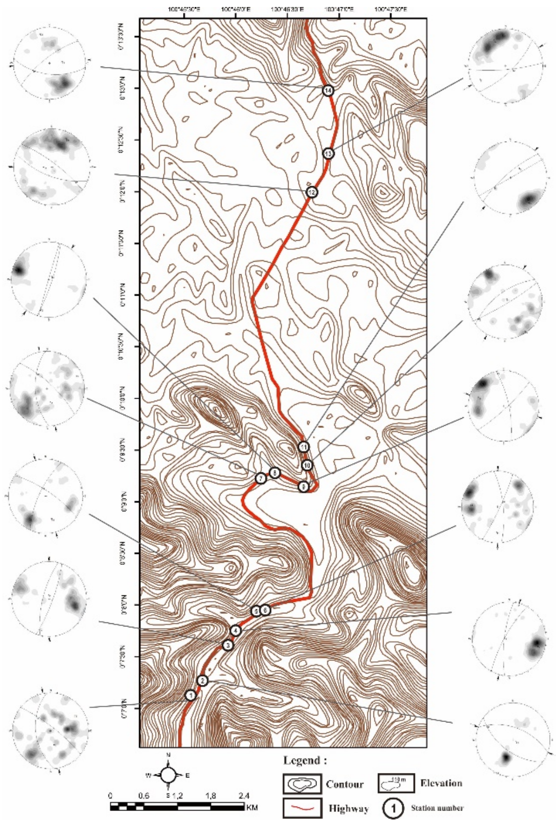


Fig 3. Measurement of discontinuity data on research location

4.2 Rock Mass Rating

In this study, 14 road cuts have been chosen in the study area to examine their stability conditions using the kinematic and discrete RMR methods. The stability of rock cuts for the selected rock slopes has been assessed through application of the rock mass classification systems, especially the ones developed for rock slopes. To do this, RMR should be determined, and the type of failure mechanism for jointed rock mass (structurally controlled failure) needs to be identified.

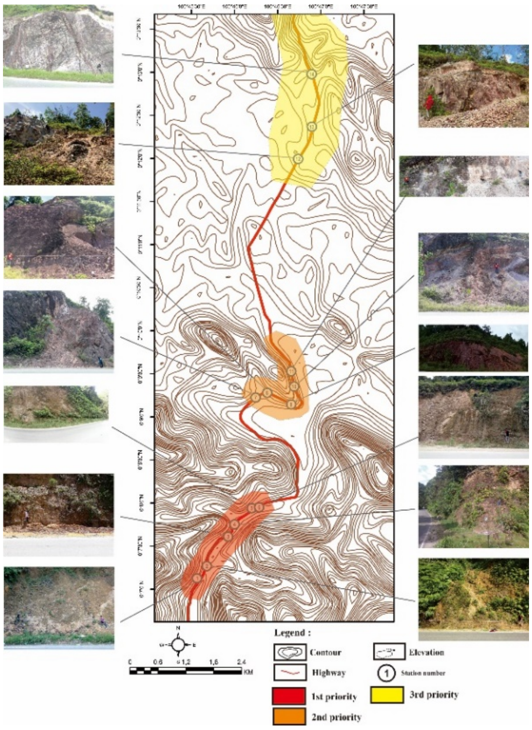


Fig 4. Picture of 14 spots of unstable slopes in Pangkalan Koto Baru.

The results of the RMR system (Fig. 1) indicate that One sites locations (2) have RMR values of 42 and are classified as "fair". The 12 rock cuts sites (1, 3, 4, 5, 6 - 14) have RMR values of 26 – 40 and are classified as "poor rock". Site 2 gives very poor rock quality with an RMR value of 17, the result is given in table 1 and table 2.

4.3 Clustering

From 14 road cuts, we can identify and clustering in each section that categorist to become first priority, second priority, and third priority to be evaluated more and having a treatment, in order to minimalize the potential hazard. From site 1 – 6 categorize into a first priority to be done, based on RMR data very poor rock to poor rock. On middle area, Site 7 – 11 categorize into 2nd priority, and third priority will be on site 12 – 14.

5. CONCLUSIONS

Based on this lineament extraction, scanline with window sampling, and RMR method we suggested that :

1. Overall trending structure having northwest-southeast direction, which this correlate with scanline measurement.
2. RMR calculation shows that the value of 14 sites location ranged between 17 to 42 which belonged to class V (Very Poor Rock) - class III (Medium Rock). Integration data of structural lineament extraction, scanline method and RMR analysis suggested that site 2 included in the very poor rock category. Sites 1,3,4, 5, 6 – 14 are poor rock category, and Site 2 in the medium rock category.
3. By clustering the zone we identified that there are three types of priority that need to be done by engineering treatment. Which are site 1 – 6 categorize into a first priority that prone to landslide. On middle area, Site 7 – 11 categorize into 2nd priority, and third priority will be on site 12 – 14.

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Table 1. The result of the RMR Method in 14 locations

Parameter		SITE- 1	SITE- 2	SITE- 3	SITE- 4	SITE- 5	SITE- 6	SITE- 7
UCS (MPa)		5-25	25-50	1-5	25-50	25-50	5-25	50-100
RQD (%)		31,35	9,4	35,5	44,05	55,6	20,3	41,8
Discontinuity Spacing (m)		0,4	0,3	0,4	0,24	0,5	0,6	0,3
Discontinuity Classification	Pesistence (m)	0,6	0,8	0,09	1,5	0,6	1,3	0,6
	Apperture (mm)	-	-	-	-	-	-	<0,1mm
	Roughness	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Rough
	Weathering	mod	Mod	Mod	Mod	Mod	Mod	Mod
Water		Dry	Flowing	Wet	Dry	Dry	Dry	Dry
Discontinuity orientation		Fair	Fair	Fair	Fair	Fair	Fair	Fair
UCS		2	4	1	4	4	2	7
RQD		8	3	8	8	13	3	8
Spacing		10	10	10	10	10	10	10
Discontinuity Classification		25	25	25	25	25	25	25
Water		15	0	7	15	15	15	15
Value of discontinuity orientation		-25	-25	-25	-25	-25	-25	-25
RMR		35	17	26	37	42	30	40
Class of RMR		IV	V	IV	IV	III	IV	IV
Category of RMR		Poor Rock	Very Poor Rock	Poor Rock	Poor Rock	Fair	Poor Rock	Poor Rock

Table 2. (cont).

Parameter		SITE- 8	SITE- 9	SITE- 10	SITE- 11	SITE- 12	SITE- 13	SITE- 14
UCS (MPa)		25-50	25-50	5-25	25-50	50-100	50-100	50-100
RQD (%)		34	21	28,4	34,6	37	39,95	21,4
Discontinuity Spacing (m)		0,14	0,3	0,4	0,2	0,2	0,3	0,2
Discontinuity Classification	Pesistence (m)	0,3	1,2	0,4	0,5	0,3	1,1	1
	Apperture (mm)	0.1-1.0 mm	-	-	-	-	-	-
	Roughness	Smooth	Smooth	Rough	Smooth	Smooth	Rough	Rough
	Weathering	Mod	mod	Mod	Mod	Mod	Mod	Mod
Water		Dry	Dry	Dry	Dry	Dry	Dry	Dry
Discontinuity orientation		Fair	Fair	Fair	Fair	Fair	Fair	Fair
UCS		4	4	2	4	7	7	7
RQD		8	8	8	8	8	8	8
Spacing		10	10	10	10	10	10	10
Discontinuity Classification		25	25	25	25	25	25	25
Water		15	15	15	15	15	15	15
Value of discontinuity orientation		-25	-25	-25	-25	-25	-25	-25
RMR		37	37	35	37	40	40	40
Class of RMR		IV	IV	IV	IV	IV	IV	IV
Category of RMR		Poor Rock	Poor Rock	Poor Rock	Poor Rock	Poor Rock	Poor Rock	Poor Rock

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