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RMR AND RHRS OF NGAIZEL ROAD CUTTING SECTION, AIZAWL, MIZORAM

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ABSTRACT

Due to unfavourable topographical features roads in hilly areas are usually small as compared to plain areas, therefore several problems may arise whenever rockfall occurs. One of the busiest domestic road in Aizawl i.e. Ngaizel road often encountered rockfall along its cutting slope. This road act as an important gateway which connects the southern parts of Mizoram. This road is packed with human activities which adds on the hazard level to rise high. The main factors that contribute to rockfalls include slope degree, geomechanical properties of rock mass and anthropogenic activities. Taking into consideration of all the adverse effect of rockfalls, RMR (Rock Mass Rating) become indispensable to identify the actual condition of rock mass on the slope of the study area. RMR classification is carried out to determine the geomechanical condition of slope rock mass and Rockfall Hazard Rating System (RHRS) is applied for identifying the hazard-prone area of rockfall along the cut slope of Ngaizel road. RHRS depends on various parameter which include slope height, annual precipitation, block size, block volume, decision sight distance, average vehicle risk, road width and rockfall history which mainly concern about the safety of pedestrians along the road. The RMR and RHRS study along Ngaizel cut slope provides a detailed and useful information about the geological condition and delineating the hazard level. The study also gave awareness and alertness about the actual condition of the area.

Keywords: *Aizawl, Ngaizel, hazard, rockfall, RMR, RHRS.*

Introduction

The rock mass quality depends on its geomechanical properties. The physical properties of rock mass can be determined in the laboratory as well as in-field observation. In areas where physical rock sample test is inaccessible, rock mass classification RMR method can be carried out. Rock Mass classification after Benwaski (1989) is widely used to analyzed slope stability in mining and other excavation, and is based on field investigations (Naithani, 2007).

RHRS was first developed by the Oregon Department of Transport (ODOT) in collaboration with the Federal Highway Administration (FHWA) to evaluate rockfall hazard for the existing slope. The Indian System for Rockfall Hazard Rating System (ISRHRS), a modified version of both after Pierson *et al.*, (1990) and Santi *et al.*, (2009) is used for the present study with the addition of crucial parameter for Indian rock mass. Slope instabilities along highways not only increase maintenance costs, but also may pose hazards that lead to detours, traffic delays, and safety issues for the travelling public (NIATT, 2003). The purpose of RHRS is to provide information in dealing with hazard zoning, land-use planning, investment decisions regarding risk mitigation measures and the assessment of the necessity of further evaluations in case of detected threads (Eliasen & Springstom, 2007).

Location and Geology of the study area

Ngaizel road is located at the southern part of Aizawl anticlinal ridge between N23°42.371′ and E92°43.204′ under 84A/10 survey of India toposheet (**Fig. 1 & 2**). The geology of the study area composed of intercalation of sandstone and shale (Sardana *et al.*, 2019). They exhibit moderate weathering conditions. Differential erosion took place as a result of soft shale overriding sandstone. Slopes along the cut slope may fails due to uneven oriented discontinuities in the rock mass distribution of different kind of joint such as longitudinal joints, normal or cross joint, diagonal or oblique joint, curvilinear joints and tensional joint formed as a result of tensional force are common in the study area (Sardana *et al.*, 2019).

Materials and Methodology

Rock Mass Rating (RMR)

It involves certain kinds of parameters such as Uniaxial compressive strength (UCS) of intact rock, rock quality designation (RQD), spacing of discontinuity, condition of discontinuities, orientation of discontinuities and groundwater condition (Hoek *et al.*, 1995).

The geophysical property of rock mass is analyzed by using rock schmidt, slake durability test and RMR. Rock schmidt is used to compute the mechanical properties of rock such as UCS, Tensile Strength and Young's Modulus (Selcuk & Yabalak, 2014). In case where the borehole is unavailable the RQD is estimate from the number of joints per unit volume of rock mass, the number of joint per meter for each joint set are considered for RQD. Therefore, the RQD is calculated by using the formula (**Equation 1**; Palmstrom, 2005).

$$\mathbf{RQD = 115- 3.3\ J_v} \text{ ----- (Equation 1)}$$

Where, J_V is a number of joints per cu.m

Discontinuities refer to all the weakness plane that occur within the strata. The joints spacing is the distance between individual joint within the joint set. The block size and shape can be identified from the discontinuity spacing which in turn, the strength of the jointed block can be analyzed from this spacing. The joint aperture controls the interlocking of the rock walls.

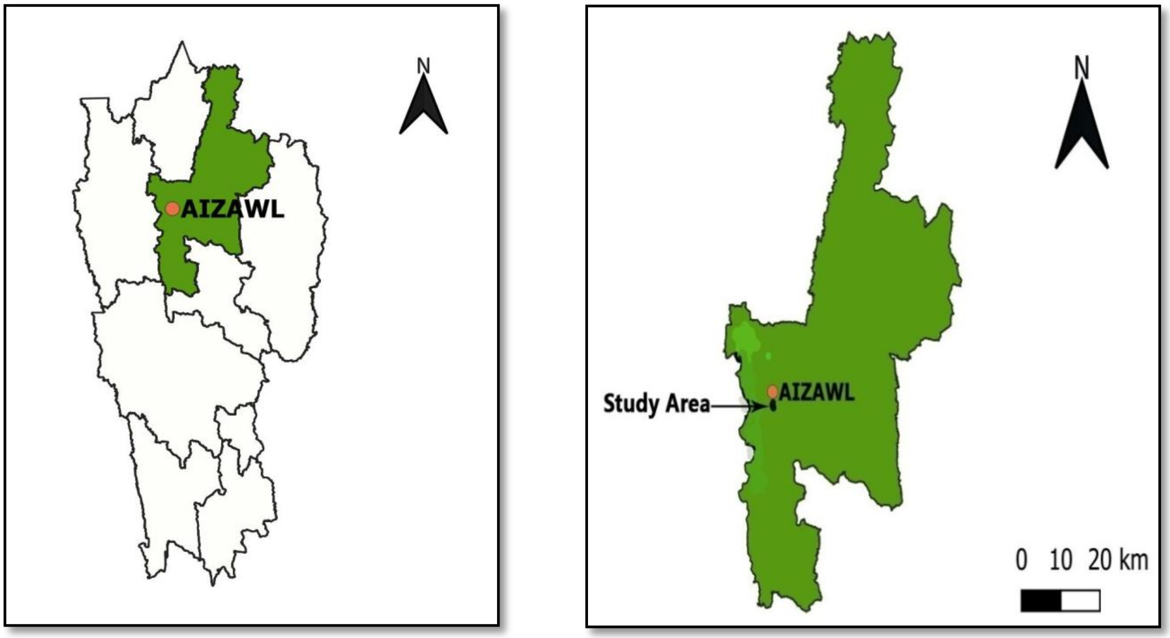

Fig. 1: Location map of study area

Fig. 2: Aerial view of study area (Drone image)

Smaller the aperture, higher the chance of interlocking. Where there is no interlocking, the filling material contribute to the shear strength. Therefore, it is obvious that both the fillings and the block materials contribute to the shear strength (Palmstrom, 1995).

When the trend of the structural plane is the same as that of the slope, and the dip angle is smaller than the slope, the rockfall is easy to occur. The failure mode usually shows a pull-splitting rockfall. When the strike of the structural plane is consistent with the slope and nearly erect, the possibility of rockfall is slightly reduced (Wang *et al.*, 2018). The characteristics of the joints, particularly where the walls are in direct rock to rock contact as in the case of unfilled joints, has a direct bearing on the strength of the rock mass (ISRM, 1978).The joint condition factor is meant to represent the friction properties of the block faces (Joints) and the relative scale effect imposed by the joints (Palmstrom, 1995)

Groundwater plays an important role for the stability of slope, seepage of water entered into the rock mass through discontinuities, as a result the effective normal stress across the joint decrease, which in turn reduce the shear strength of the rock mass. The effect of groundwater soften the infilling materials which distorted the interlocking property of the rock wall. It also reduces the cohesive strength and frictional strength. Water within the pores decrease the compressive strength of rock, and the rock is more prone to weathering. When a shale is soak with water, it begins to disintegrate and can be easily converted into slurries (Naithani, 2007). The cleft water applies hydraulic force on the rock wall which minimizes the frictional force that acts on the wall of the rock (Karaca & Goodman, 1993).

Rock mass classification focuses on determination of rock strength and also estimate the deformation properties of rock. It acquired different parameter so as to understand the rock mass quality. Table of rock mass classification used in this study after Bieniawski, 1989 is given below (**Table 1**).

As given in **Table 1**, rock mass classification is carried out using various geological and geotechnical parameters such as UCS of rock material, RQD, discontinuities spacing, discontinuities condition, groundwater conditions and discontinuities orientation. All these factors account for rock mass rating calculation. Each and every parameters are placed in separate column as shown in **Table 1** which coincide with different value based on the field investigation. The collected data which corresponds to the most efficient value in the rating table are considered for rating.

Rockfall Hazard Rating System (RHRS)

Various modifications of the RHRS has made with respect to its compatibilities with different region. In this study RHRS for Indian rock mass modified after Pierson *et al.* (1990), and Santi *et al.* (2009) is used for the present study.

There are five classes with their two sub-classes to consider to access Rockfall hazard Rating system for India, such as slope condition, climatic condition, geological condition, traffic condition and rockfall history (Ansari *et al.*, 2013).

Table 1: Rock Mass Classification (Bieniawski, 1989)

• CLASSIFICATION PARAMETERS AND THEIR RATINGS									
Parameters			**Range of values**						
1	Strength of intact rock material	PLI	>10 MPA	4-10 MPa	2-4 MPa	1-2 MPa	For this low range, UCS test is preferred		
		UCS	>250 MPa	100-250 MPa	50-100 MPa	25-50 MPa	5-25 MPa	1-5 MPa	<1 MPa
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**
2	Drill core quality RQD		90%-100%	75%-90%	50%-75%	25%-50%	<25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		> 2 m	0.6-2 m	200-600 mm	60-200 mm	< 60 mm		
	Rating		**20**	**15**	**10**	**8**	**5**		
4	Condition of discontinuities		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickenside surfaces Or Gouge < 5 mm thick Or Separation 1-5 mm Continuous	Soft gouge > 5 mm thick Or Separation > 5 mm Continuous		
	Rating		**30**	**25**	**20**	**10**	**0**		
5	Ground water	Inflow per 10 m tunnel length (l/m)	None	< 10	10-25	25-125	>125		
		(Joint water press)/ (Major principal σ)	0	< 0.1	0.1-0.2	0.2-0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		**15**	**10**	**7**	**4**	**0**		

A. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATION						
Strike and dip orientations		Very favorable	Favorable	Fair	Unfavorable	Very Unfavorable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS DETERMINED FROM TOTAL RATINGS					
Rating	100←81	80←61	60←41	40←21	< 21
Class Number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D.MEANING OF ROCK CLASSES					
Class Number	I	II	III	IV	V
Average Stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 minutes for 1 m span
Cohesion of rock mass (kPa)	>400	300-400	200-300	100-200	<100
Friction angle of rock mass(deg)	>45	35-45	25-35	15-25	<15

E.GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY					
Discontinuity length (persistence)	>1 m	1-3 m	3-10 m	10-20 m	>20 m
Rating	**6**	**4**	**2**	**1**	**0**
Separation (aperture)	None	<0.1 mm	0.1-1.0 mm	1-5 mm	>5 mm
Rating	**6**	**5**	**4**	**1**	**0**
Roughness	Very Rough	Rough	Slightly Rough	Smooth	Slickenside
Rating	**6**	**5**	**3**	**1**	**0**
Infilling(gouge)	None	Hard filing >5 mm	Hard filling <5 mm	Soft filling < 5 mm	Soft filling > 5 mm
Rating	**6**	**4**	**2**	**2**	**0**
Weathering	Unweathered	Slightly weathered	Moderately weathered	Highly weathered	Decomposed
Rating	**6**	**5**	**3**	**1**	**0**

F.EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING			
Strike perpendicular to the tunnel axis		Strike parallel to the tunnel axis	
Drive with dip- Dip 45-90°	Drive with dip – Dip 20-45°	Dip 45-90°	Dip 20-45°
Very favorable	Favorable	Very favorable	Fair
Drive against dip- Dip 45-90°	Drive against dip- Dip 20-45°	Dip 0-20° Irrespective of strike	
Fair	Unfavorable	Fair	

Table 2: RHRSI, modified after Pierson *et al.* (1990) and Santi *et al.* (2009)

Category			3 points	9 points	27 points	81 points
Slope		**Slope height**	7.5 m	15 m	23 m	30 m
		Average Slope Angle Score	A	B	C	D
		Vegetation	Fully Vegetated	Patchy Vegetated	Isolated Plants	None
		Lunching Features	None Smooth Slope	Minor(<0.6m) Surface Variation	Many(0.6-1.8 m) Surface Variation	Major(>1-8m) Surface Variation
		Ditch Catchment	Good Catchment	Moderate catchment	Limited catchment	No catchment
Climate		**Annual Precipitation**	254 mm	508 mm	762 mm	1016 mm
		Annual Freeze/Thaw Cycle	1 to 5	6 to 10	11 to 15	>16
		Seepage/water	Dry	Damp/Wet	Dripping	Running Water
		Slope Aspect	W	N,S,NW,SW	SE,NE,	E
Geology	**Sedimentary Rock**	**Degree of undercutting**	0 to 0.3 m	0.3 to 0.6 m	0.6 to 1.2 m	> 1.2 m
		SDI	95to 100%	60 to 95%	30 to 60%	<30%
		Degree of interbedding	1 to 2 weak interbed, <15 cm	1 to 2 weak interbed, >15 cm	>2 weak interbed, <15cm	> 2 weak interbed, >15 cm
	Crystalline Rock	**Rock Character**	Homogeneous/ Massive	Small Fault/ Strong Veins	Schist Shear Zones < 15 cm	Weak pematite's/ micas/shear zones > 15 cm
		Degree of overhang	0 to 0.3 m	0.3 to 0.6 m	0.6 to 1.2 m	> 1.2 m
		Weathering Grade	Fresh	Surface Staining	Slightly Altered/Softened	Core Stone
	Discontinuities	Block Size/Volume	0.3m/2.3 m^3	0.6m/ 4.6 m^3	0.9m / 6.9m^3	1.2m / 9.2 m^3
		Block Shape	Tabular	Blocky	Blocky to angular	Rounded and Smooth
		Number of sets	1	1 plus Random	2	>2

		Persistence / Orientation	<3m and Dip into slope	>3m and dips into slope	<3 meter and daylight out of the slope	>3m and Daylight out of the slope
		Apertures	Closed	0.1 to 1 mm	1 to 5 mm	>5mm
		Weathering Condition	Grade I & II	Grade III	Grade IV	Grade V & IV
		Friction	Rough	Undulating	Planner	Slickensided
		Infilling material	Heal infilling	Course Grain Fault Gouge	Fine Grain Fault Gouge	Clay Infilling
Traffic	Percentage Decision Sight Distance (DSD)		100%	80%	60%	40%
	Average Vehicle Risk (AVR)		25%	50%	75%	100%
	Road width including Pave Shoulder (m)		13,2m	10.8m	8.4 m	6m
	No of accident		0 to 2	3 to 5	6 to 8	9 and Over
Rock History/ Frequency			0 to 3 per year	4 to 7 per year	8 to 12 per year	>12per year

Class 1, 2, 3, and 5 falls under the hazard category whereas class 4 falls under vulnerability category. Table of Rockfall Hazard System for India (RHRSI) shown in **Table 2**.

Detailed rating has been evaluated by giving scores depending upon the nature of the parameter involve in RHRS. The slope height is measured by total station. The exact score for Average Vehicle Risk (AVR) is calculated by using the formula given by **Equation 2**.

$$\mathbf{AVR=\{(ADT/24)L_s \div S\}x100\%}\text{-(Equation 2)}$$

Where, ADT is the Average Daily Traffic, L_s is the slope length in kilometre, 24 is the number of hours per day and S is the speed limit. The Percentage Decision Sight Distance (PDSD) is calculated by **Equation 3**.

$$\mathbf{PDSD=(ASD/DSD)X100\%}\text{-(Equation 3)}$$

Where, ASD is the Actual Sight Distance. DSD is Decision Sight Distance. ASD is the distance at which a 15cm object disappears from the driver's sight (Ansari *et al.*, 2013). DSD is calculated on the basis of the Post speed limit and the corresponding value describe by AASHTO is taken for calculation as shown in the **Table 3**.

Table 3: Decision Sight Distance Based On Posted Speed Limits to Avoid Obstacles (AASHTO)

Posted Speed Limit	***Decision Site Distance (m)***
40	114
48	137
56	160
64	183
72	206
80	229
89	267
97	305
113	335

Average slope angle determines the average run out distance of the rock blocks. Slope angle between 35^o to 85^o act as an ideal condition for maximum damage. The modification made between slope angle and corresponding Average Angle Score after Maerz *et al.*, 2005 is used for rating.

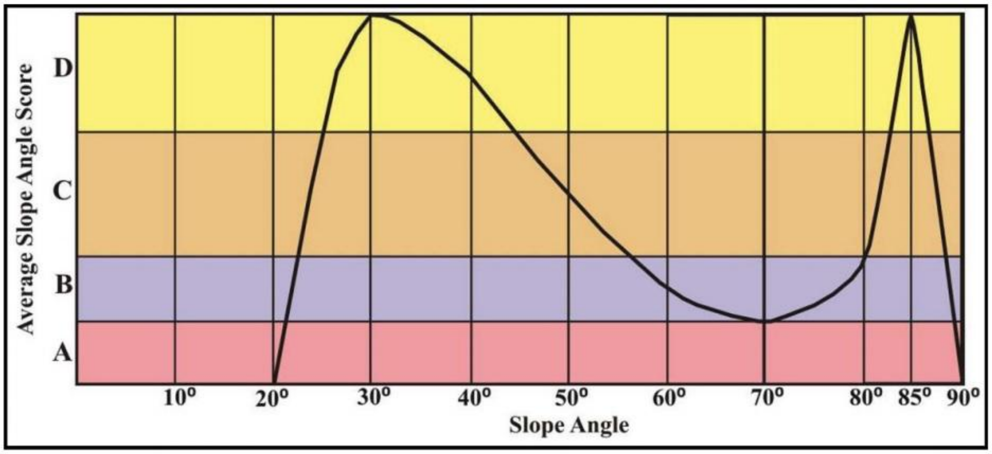

Fig. 3: Slope angle and corresponding Average Angle Score modified after Maerz *et al*., (2005)

Table 4: Exponent equation modified after Pierson *et al.*, (1990)

Parameter	***Exponent (k)***
Slope Height	Slope height (m) ÷ 25
Annual Precipitation	Annual Precipitation ÷ 254
Block Size	Block Size (m) ÷ 0.3
Block Volume	Block Volume (m^3) ÷ 2.3
Decision Sight Distance (DSD)	{120 – (% DSD)} ÷ 20
Average Vehicle risk (AVR)	(%AVR) ÷ 25
Road width	{15.6 – Road width (m)} ÷ 2.4
Rockfall History	1 + (0.25 * f)

Rating Results

The result obtained from the above studies based on Rock Mass Rating and Rockfall Hazard Rating are shown in **Table 5** to **12**.

Rock Mass Rating

Table 5: Table of GPS location of study area

Spot No.	***Location***	***Elevation***
1.	N23°42.371' & E92°43204'	1043m
2.	N23°42.252' & E92°43.249'	1020m
3.	N23°42.168' & E92°43.275'	1061m
4.	N23°42.125' & E92°43.267'	1035m
5.	N23°42.068' & E92°43.315'	1034m

Table 6: Classification parameters and rating

A. CLASSIFICATION PARAMETERS AND RATINGS									
Spot No.	***UCS***	***QRD***	***S.D***	***D.L***	***Aperture***	***Roughness***	***Infilling***	***Weathering***	***G.W***
1.	48Mpa	55%	0.69m	4.8m	4mm	Rough	None	Slightly	Dry
Rating	4	13	15	2	1	5	6	5	15
2.	66Mpa	75%	1m	2.9m	5mm	Rough	None	Slightly	Wet
Rating	7	17	15	4	1	5	6	5	7
3.	38Mpa	82.5%	453mm	6m	1mm	Rough	None	Slightly	Dry
Rating	4	17	10	2	1	5	6	5	15
4.	66Mpa	67.5%	220mm	5m	2mm	Rough	None	Slightly	Damp
Rating	7	13	10	2	1	5	6	5	10
5.	64Mpa	87.5%	386mm	7m	1mm	Rough	None	Slightly	Damp
Rating	7	17	10	2	1	5	6	5	10

Table 7: Rating of discontinuity orientation & rock mass determined

B. DISCONTINUITY ORIENTATIONS & ROCK MASS DETERMINED							
Spot No	***Strike &Dip orientation***	***RMR value***	***Class No***	***Description***	***ASUT***	***Cohesion***	***Friction angle***
1.	Unfavourable	16	V	Very poor rock	30 min for 1 m span	<100	<15
Rating	-50						
2.	Fair	42	V	Poor rock	10 hours for 2.5m span	100-200	15-25
Rating	-25						
3.	Unfavourable	15	V	Very poor rock	30 min for 1 m span	<100	<15
Rating	-50						
4.	Uufavourable	9	V	Very poor rock	30 min for 1 m span	<100	<15
Rating	-50						
5.	Unfavourable	13	V	Very poor rock	30 min for 1 m span	<100	<15
Rating	-50						

Whereas,

UCS = Uniaxial compressive strength
QRD =Quality Rock Designation
S.D =Spacing of discontinuity
D.L =Discontinuity length
G.W =Groundwater
ASUT =Average stand uptime

Rockfall Hazard Rating

Table 8: Table of GPS location of study area

Spot No.	*Location*	*Elevation*
1.	N23°42.371’ & E92°43204’	1043m
2.	N23°42.252’ & E92°43.249’	1020m
3.	N23°42.168’ & E92°43.275’	1061m
4.	N23°42.125’ & E92°43.267’	1035m
5.	N23°42.068’ & E92°43.315’	1034m

Table 9: Rockfall Hazard Rating for Slope and Climate

	Slope					Climate	
Spot	***Slope Height***	***Average Slope Angle Score***	***Vegetation***	***Lunching Features***	***Ditch Catchment***	***Annual Precipitation***	***Seepage/ Water***
Spot 1	9.01 m	D	Isolated plants	Minor <.6 surf. Variation	None	183.24mm	Dry
Score	3.7	81	27	9	81	2.2	3
Spot 2	23.36 m	D	Isolated plants	Minor <.6 surf. Variation	limited catchment	183.24mm	Damp
Score	30.63	81	27	9	27	2.2	9
Spot 3	25	D	Isolated plants	Minor <.6 surf. Variation	Moderate catchment	183.24mm	Dry
Score	38.94	81	27	9	27	2.2	3
Spot 4	24 m	D	Isolated plants	Many (.6-1-8)	limited catchment	183.24mm	Damp
Score	33.63	81	27	27	27	2.2	9
Spot5	17.12 m	D	Isolated plants	Many (.6-1-8)	Moderate Catchment	183.24mm	Damp
Score	**12.24**	**81**	**27**	**27**	**9**	**2.2**	**9**

Table 10: Rockfall hazard rating for Geology and discontinuities

	Geology			Discontinuities							
	Degree of Undercutting	Slake Dura-bility Index	Degree of inter-beded	Block Size / Vol.	Block Shape	Number of sets	Persistence /orient^{n}	Apertures	Weathering condition	Friction	Infilling Materials
Spot 1	0.9m	95%-100%	>2 weak interbeded, >15cm	0.3-2.3 m^3	Blocky to Angular	>2	>3meters and dip into the slope	4mm	Slightly altered	Rough	None
Score	27	3	81	3	27	81	9	27	27	3	0
Spot 2	1.8m	95%-100%	>2 weak interbeded, >15cm	0.3-2.3 m^3	Blocky to Angular	2	>3meters and dip into the slope	5mm	Slightly altered	Rough	None
Score	81	3	81	3	27	27	9	27	27	3	0
Spot 3	1.2 m	94.83 %	>2 weak interbeded, >15cm	0.3-2.3 m^3	Blocky to Angular	>2	>3meters and dip into the slope	2mm	Slightly altered	Rough	None
Scor	27	3	81	3	27	81	9	27	27	3	0

e											
Spot 4	1.5	98.08 %	>2 weak interbedded, >15cm	0.6-4.6 m^3	Blocky to Angular	>2	>3meters and dip into the slope	2mm	Slightly altered	Rough	None
Score	81	3	81	9	27	81	9	27	27	3	0
Spot 5	1.2m	97.43 %	>2 weak interbedded, >15cm		Blocky to Angular	>2	>3meters and dip into the slope	0.1 - 1mm	Slightly altered	Rough	None
Score	**27**	**3**	**81**		**27**	**81**	**9**	**9**	**27**	**3**	**0**

Table 11: Rockfall hazard rating for traffic and rockfall frequency

	Traffic				
	Percentage Decision Sight Distance (DSD)	***Average Vehicle Risk (AVR)***	***Road Width including Pave Shoulder***	***No of accident***	***Rockfall History/ Frequency***
Spot 1	80%	100%	5 m	0-2	0-3
Score	**9**	**81**	**1.6**	**3**	**3**
Spot 2	60%	100%	8.32 m	0-2	0-3
Score	**27**	**81**	**1.39**	**3**	**3**
Spot 3	100%	100%	11.5 m	0-2	0-3
Score	**3**	**81**	**1.20**	**3**	**3**
Spot 4	100%	100%	7.14 m	0-2	0-3
Score	**3**	**81**	**1.46**	**3**	**3**
Spot 5	100%	100%	5.6m	0-2	0-3
Score	**3**	**81**	**1.57**	**3**	**3**

Table 12: Cumulative score for overall rating

	Cumulative Score						
	Slope	***Climate***	***Geology***	***Traffic***	***Discontinuity***	***Rock History***	***Total Score***
Spot 1	201.7	5	111	177	94.6	3	**592.3**
Spot 2	174.63	11.2	165	123	112.39	3	**589.22**
Spot 3	182.94	5.2	111	177	88.2	3	**564.11**
Spot 4	195.63	11.2	165	183	88.46	3	**646.29**
Spot 5	156.24	11.2	111	165	88.57	3	**535.01**

Conclusions

The mean RMR value is 15 out of 100 and under category V. This indicates the study area is comprises of very poor rock mass. The average period for the rock mass able to withstand without breaking is 30 minutes for 1(one) metre span. It means that detachment of rock from the slope can occur easily if the rock is exposed, and even small external force applied on the rock mass may trigger rockfall. The average cohesive force lies below 100kPa and the rock mass possess a very low shear strength. The mean value of the angle of friction is 15°, which is a well below the average. Rocks with high angle friction lies between 34° to 40° (Wylllie & Norish, 1996).Therefore, the RMR described in cut slope of Ngaizel road possess a bad quality of rock mass.

RFHR result shows that due to differential erosion, undercutting erosion is found between 0-3m in the study area which implies that an increase in length of undercutting increases the percentage of overhanging rock mass making a greater chance of rock fall. The ditch length is found to be quite narrow in various spots of the study area making a very little chance to arrest the rock/blocks after falling. The slope angle in the study area lies between 80° to 90° indicating that a possibility of rockfall along Ngaizel road is very high. Water condition plays an important role for stability of rock mass, most of the spot is dry other than rainy season which give overall status of low rating in precipitation. A set of 2 to 3 joints are encountered in which the majority of the joint are not day lighted out to slope and actually dip into the slope which supplement to the stability of rock mass. The PDSD in spot 1 and 2 are 80 % and 60% respectively. In these two spots, the vehicle driver has less time to react while encountering rockfall. While the other remaining spot 3, 4 and 5 acquired 100% PDSD, they have sufficient time to react while encountering rockfall. The average daily traffic is taken as 6000, so that the AVR (Average Vehicle Risk) in the study area stand high. The length of slope for spot 1, 2, 3, 4, 5 is 5m, 5m, 5m, 20m, 10m respectively and huge rockfall does not frequent in the study area, so the rating is put low in this study. Even though, a consistent rockfall of pebbles size occurs throughout the year, a disturbing type of rockfall is not very frequent in the area. The mean value of the Slake Durability Index is 96.78% which shows that its durability due to weathering is high and the rock can withstand more weathering conditions. According to Hoek *et al.*, (1999), the slope with rating less than 300 is categorized as 'Low Urgency' while the rating between 300-500 is categorized as 'Moderate Urgency' and those with rating more than 500 is categorized as 'High Urgency' (Verma *et al.*, 2019).Calculating scores from the rating parameter all the spot falls under High Urgency and are prone to rockfall failure.

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