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Evaluating Rock Slope Stability Using Geomechanical Classification System: An Experimental study from the Western Ghats, India

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Abstract
Rock slopes within the Deccan basaltic terrain of Sahyadri Group in the Western Ghat region of Maharashtra were evaluated using geomechanical classification systems including Basic Rock Mass Rating (RMRb), Geological Strength Index (GSI) and Kinematic analysis to provide a preliminary assessment of slope stability conditions of eight different zones. Kinematic analysis of joints data was performed to determine the potential failure (Plane, Wedge and Toppling) for one natural slope and three artificial slopes. Modified Slope Mass Rating (M-SMR) has been done exclusively for the natural slope. Geological-geotechnical mapping was carried out to determine key geomechanical parameters, including Rock Quality Designation (RQD), Uniaxial Compressive Strength (UCS), degree of rock weathering, joint conditions, joints infilling, orientations of discontinuities (joints) of rock and slope geometry (slope dip and slope aspect) for each selected zone. Basalt rock mass is characterized by 3-4 sets of joints, slightly to moderately weathered, medium to high persistence, close spacing and no infillings. The basic RMR$_b$ values range from 73-89.75, indicating good to very good rock mass quality, while GSI values range from 46-67.46 corresponding to fair to good conditions. Kinematic analysis indicates that wedge sliding may be more prominent than other modes of failure. The results of the M-SMR have been obtained from class I (Very Low Risk/Very Good), indicating overall stable conditions. Nevertheless, despite favorable geomechanical classification, the slopes within the study area are interpreted considered to have a comparatively lower probability of structural failures governed primarily by orientations of discontinuities (joints) of rock and slope geometry.

Keywords
Rock discontinuities, Failure mechanism, Rock mass classification, Geological strength index, Stereographic projection

List of Symbols and Abbreviations

RMR : Rock Mass Rating
RMR_b : Basic rock mass rating
RQD : Rock quality designation
UCS : Uniaxial compressive strength
GSI : Geological strength index
M-SMR : Modified slope mass rating
R1 : UCS
R2 : RQD
R3 : Discontinuity spacing
R4 : Discontinuity condition
R5 : Water flow.
R6 : Discontinuity orientation
F1 : Parallelism between discontinuity and slope direction
F2 : Discontinuity dip angle.
F3 : Relationship between discontinuity and slope dips

F4 : Method of excavation.
MPa : Megapascal
RN : Rebound Number
J_v :Joint volume
$JCond_{89}$: Bieniawski (1989) Joint conditions
Jr : Joint roughness
Ja : Joint alteration
ϕ : Internal friction
DMR : Design model review
SS : Slope stabilization
PM : Protection measures
DS : Discontinuity spacing
P : Persistence
A : Alteration
S : Separation (aperture)
R : Roughness
I : Infilling
W : Weathering
GW : Ground water condition,
T.RMR : Total rock mass rating
CN : Class number
RQ : Rock quality
FJ : Flow joint,
J1, J2 and J3: Joint sets
R/J : Random joint.
m : Meter.
cm : Centimeter.
amsl : above mean sea level.

1. Introduction

Instability mechanism in mountainous and engineered slopes are combining effects of natural (lithology, fault/thrust, shear strength, water condition, adverse discontinuity, joint condition, slope aspect and the slope angles) and anthropogenic (the asymmetric excavation, lack of suitable support measures) factors that have caused human, economic and geo-environmental losses around the world (Hassan and Abood, 2024; Khanduri and Rautela, 2021; Khanduri, 2019; Li et al., 2024; Lasantha and Athapaththu, 2024; Ogila et al., 2021; Siddique et al., 2015; Zhou et al., 2025).

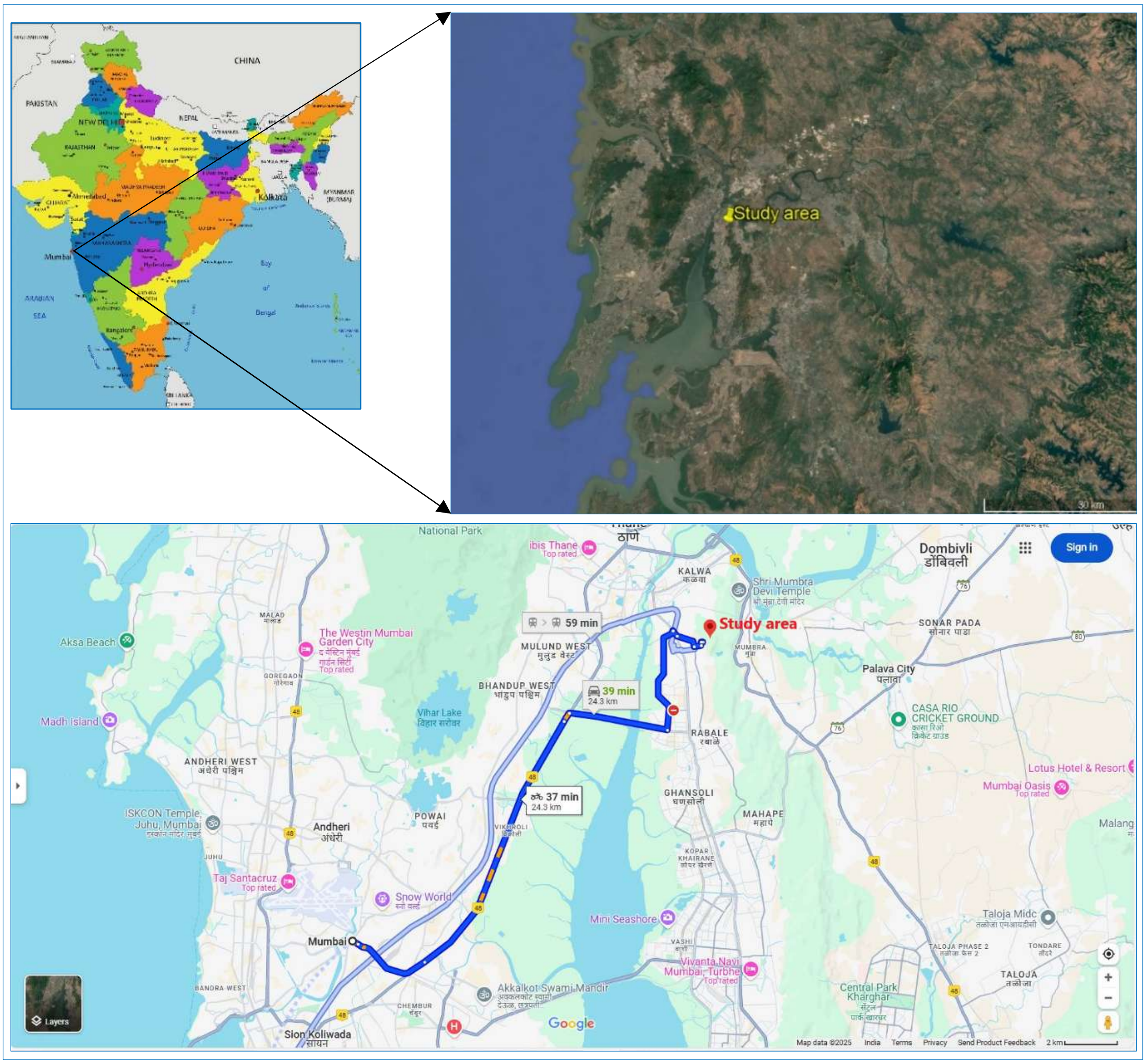


Fig. 1. The map depicts location of the study area

Fig. 2. Field photographs of the investigation each selected zones A, B, C, D, E, F, G and H as figures (a-h)

The stability of slope is of utmost importance for the safety and success of any developmental initiatives in mountains area. This is a key concern for administrator, planner, designer, environmentalist, engineering geologist and geotechnical engineer. Therefore, the stability condition of any hilly terrain is essential for the feasibility of the lands before any developmental initiatives over and in front of that area. This may help the planner/engineer to understand the actual ground conditions and to help with the design of the structures with proper remedial/treatment measures in such areas. After the identification of the key hazard-prone areas, we can also regulate developmental initiatives in the highly unstable zones (Khanduri, 2017). In order to understand the importance of rock materials and their properties for slope stability, many researchers across the world widely used different rock mass classification systems. Some popular classification systems like rock quality designation, rock mass rating, rock quality, slope rock mass rating and geological strength Index are extensively used methods for rock mass classification (Deere and Miller, 1966; Bieniawski et al., 1979; Barton et al., 1974; Romana, 1985; Hoek et al., 2013; Winn et al., 2019).

Fig. 3. Assessing geomechanical parameters of in situ rock mass: (a) measuring orientations of discontinuities (joints) of rock and slope geometry using Bruntorn Compass and (b) achieving rebound nos. of each joint using Schmidth hammer for strength of rock mass

Table 1. Lithostratigraphy of the studied region (Godbole et al., 1996)

Group	Sub-group	Formation
Sahyadri	Mahabaleshwar	Mahabaleshwar Purandargarh
	Diveghat	Diveghat Elephanta
	Lonavala	Karla Indrayani
	Kalsubai	Upper Ratangarh Lower Ratangarh Salher

The failure modes are assessed through kinematic analysis by considering the orientation, spacing, persistence, and intersection of discontinuities within the rock mass, as well as the geometry and structural characteristics of the slope (Deere et al., 1967; Deere and Deere, 1989, Hock and Bray, 1981; Goodman, 1989; Priest, 1993).

The trend and plunge of the intersection of two joints planes are valued from the stereoplot (Wyllie and Mah, 2004) while examining mode of failure with respect to slope aspect and internal friction angle of discontinuity (Park et al., 2016). Researchers across the worldwide have done stability assessment of rock slopes using various rock mass classification systems, kinematic analysis and numerical modelling techniques in the potential rockfall area (Cai et al., 2004; Kumar et al., 2023; Kumar and Pandey, 2021; Kumar et al., 2019; Martireni et al., 2023; Moses et al., 2020; Ogila et al., 2021; Somodi et al., 2021; Sukplum and Wongsamakkan, 2021; Sharma et al., 2020; Sardana et. al., 2019).

The study area has focused to investigate the stability of basaltic terrain. In order to geological investigations have been conducted for the selected 8 different slopes using different classification systems. Rock slope stability study along the different stretches of highway in the state of Maharashtra were carried out in recent past by researchers using different techniques (Aher et al., 2024; Niyongi et al., 2020; Sharma et al., 2020) while soil slopes stability assessment has done along road (SH- 72) in Maharashtra, India by researchers (Ahmad et al., 2013).

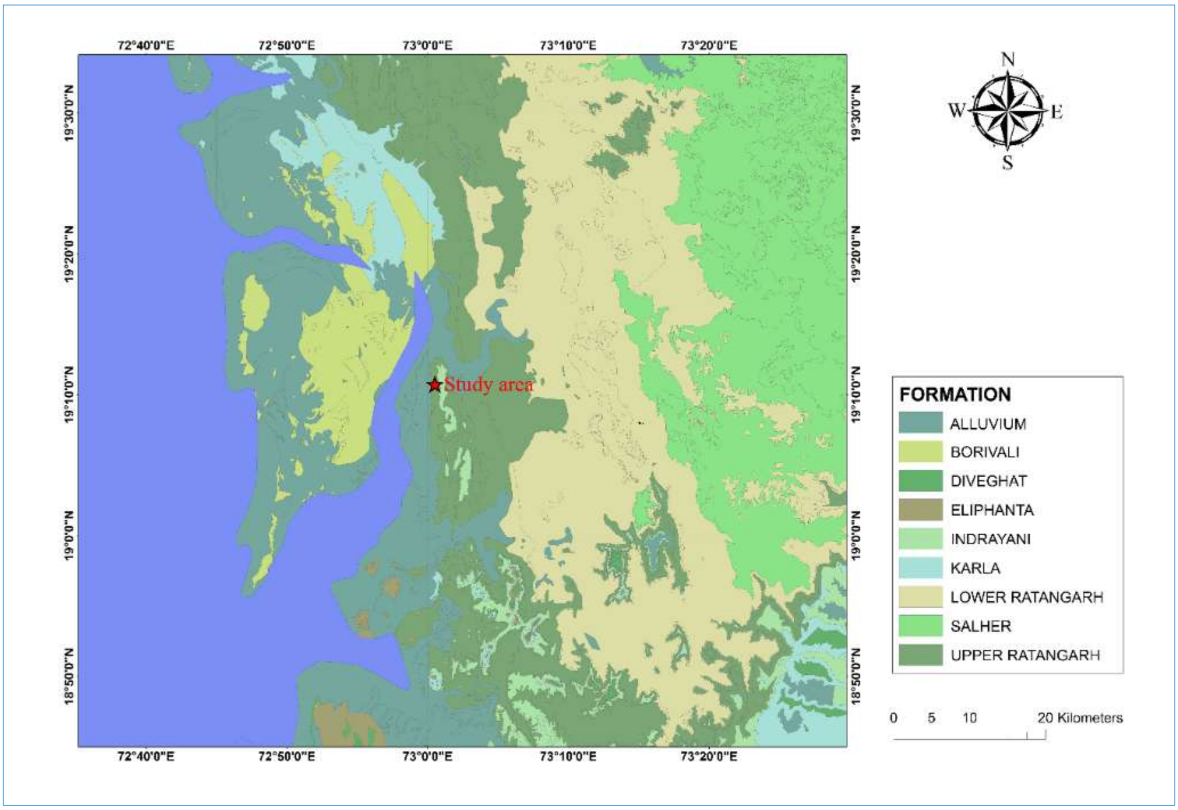


Fig. 4. The map illustrates general geology

2. Materials and Methods

2.1. Study Area

The area under the present investigations lies to the northern proximity of Trans Thane Creek where the north-south trending hill is located to the east surrounded by various manufacturing industries and residential settlements. This area is connected by Thane-Belapur Road in Navi Mumbai which is easily accessible from Mumbai by road and rail networks. The rocky hill slopes have been investigated under the present study (Fig. 1) that were divided into eight zones (A, B, C, D, E, F, G and H), having with at an around 2 m–3 0m high natural slopes (B, E, F, G and H) and around 7 m–15 m high excavated rock slopes (A, C and D) across the hill shown in Fig. 2a–h.

2.2. Data and Procedure

Different classification systems of rock as rock mass rating and geological strength Index which are analyzed based on different geomechanical parameters taken during the field works to observe the quality of rock under the present study area. Orientations of rock discontinuities (joints) and slope geometry (slope dip and slope aspect) for the selected each zone were measured through Brunton Compass (Fig. 3a) while achieving rebound numbers of each joint using Schmidt hammer for UCS of rock mass (Fig. 3b) (Bieniawski, 1989).

The data gathered from the field were plotted in Google earth pro and moved to *GIS* software to finalize the geomorphological map. The value and rating of the *RQD* are found through the J_v count method (Deere, 1963). Kinematic analysis of discontinuities data of rock with respect to slope has been done in DIP software for the potential failure and the *M-SMR* has been estimated for the most critical slope.

3. Geological Setting

Geologically, the occurrence of two lava flows with a thick sequence of intertrappenans of “aa” and “pahoehoe” types of the Deccan Traps (Upper Cretaceous to Lower Eocene age), are exposed in the Mumbai region (Buist, 1857; Carter, 1857; Wynne, 1866; Sukheswala, 1953; Sukheswala and Poldervaarat, 1958; Subbarao and Hooper, 1988). Lithostratigraphy of the Western Deccan Volcanic Province is as Table 1.

The rocks exposed in the area under the present study is basalt of Upper Ratangarh Formation of Sahyadri Group. The general geological map of the study area is shown in Fig. 4.

The area under study is underlain by exposed locally 4 volcanic flows that are composed of massive and amygdular basalts with gently inclined layers but at some places it is moderate. Three flow unit's joint sets have been recognized of which sub-horizontal to low dipping flow joints are most prominent. These dip mostly in west to southwest directions and occasionally towards northwest. They show long continuity and often small openings. The joints are usually tight in depth and cavities some joints are also filled with secondary minerals due to circulating waters. Joints are either very steep to sub-vertical contraction joints or sub-horizontal flow joints and intermediate dip inclination are also significant. The sub-horizontal joints have high continuity while the sub-vertical joints have medium to low continuity.

Fig. 5. Photographs depict different grades of weathering in basalt

Table 2. Measuring the *RQD*%, J_v and average spacing of all discontinuities

Zone	Average frequency of all joints	J_v (joints/m^3)	Average spacing of all discontinuities (m)	*RQD* (%)
A	0.887	2.661	1.127	100
B	4.736	18.945	0.211	57
C	1.647	4.942	0.809	97
D	1.489	5.958	0.671	95
E	3.283	13.134	0.304	77
F	3.499	13.999	0.285	75
G	1.136	4.545	0.88	98
H	0.619	1.857	1.615	100

Table 3. Estimating *UCS* from Rebound numbers of discontinuities

Zone	Rebound nos. of discontinuities	Average Rebound nos. of discontinuities	Estimated *UCS* from graph (*MPa*)	
			Average	Maximum
A	60, 64, 65, 68, 70	65	219.91	236.56
B	48, 50, 52, 64, 66	56	189.94	223.24
C	50, 64, 66, 70	62.5	211.58	236.56
D	54, 58, 62, 66, 68, 70	63	213.25	236.56
E	40, 48, 54, 62	51	173.29	209.92
F	50, 54, 56, 60	55	186.61	203.26
G	36, 50, 54, 55, 56, 60	52	176.62	203.26
H	58, 65, 68	63.67	215.48	229.90

Joints are mostly tight, undulating and rather rough. Their spacing varies generally from 10 cm - 300 cm. Master joints of large continuity with strikes are found to be on the NW-SE and NNE - SSW trending top ridge, these have vertical or near vertical dips. The random joints of similar attitudes though found scattered in the area.

4. Geomorphology and Physiography

Geomorphology plays a vital role in identifying complex geomorphological features affecting slope stability (Byizigiro et al., 2015; Giuseppe et al., 2016; Lupiano et al., 2019; Oldroyd and Grapes, 2008; Roman and Reyes, 2023). It provides valuable outcome on the landform processes including weathering, erosion, deposition and change in landform etc. The area consists of lofty hill ranges and extensive plateaus, and the landforms of Deccan Traps are covered out by erosional and depositional processes. Ground elevations in this hill vary between 10 m and 220 m amsl., wherein the flow ranges from 10m to 30 m in thickness.

Both residual as well as transported soils are observed in the area. The residual soil cover in the area is maximum of the order 0.2 m to 0.5 m, the weathered zone of the rock underlying the soil including scree material varies from a few centimeters to nearly 3.0 m but generally it is thin and irregular in planar dimensions. Nine depressions are noticed in the area which are small and parallel and flowing in westerly directions. Natural slopes on the hill are gentle to very steep. These slopes in weaker materials, including highly and completely weathered basalt and soils are widespread, while those in stronger materials, including slightly to moderately weathered basalt cover major areas in the lower and upper parts of the hill (Fig. 5). Mostly the top ridge and middle slopes are covered with natural vegetation.

Table 4. Rating values of field data obtained for estimation of RMR_b

Zone	*UCS*	*RQD*	*DS*	Joint Condition						*GW*	*T. RMR*	*CN.*	*RQ*
				P	*A*	*S*	*R*	*I*	*W*				
A	12	20	15	2	0.75	4	5	6	5	15	84.75	I	Very good
B	12	13	15	4	1	4	5	2	2	15	73	II	Good
C	12	20	20	2	0.75	4	5	6	5	15	89.75	I	Very good
D	12	20	10	2	0.75	4	5	6	5	15	79.75	II	Good
E	12	17	10	3	2	3	5	4	2	15	73	II	Good
F	12	13	15	3	1	4	5	6	2	15	76	II	Good
G	12	20	15	3	1	4	5	2	2	15	79	II	Good
H	12	20	20	2	1	4	5	2	4	15	85	I	Very good

Legend: see List of Symbols

Table 5. Estimated *GSI* values of each zone in the study area

Zone	$JCond_{89}$	$1.5JCond_{89}$	*RQD/3*	Quantified *GSI*	*RQ*
	(a)	(b)	(c)	(b + c)	
A	22.75	34.13	33.33	67.46	Good
B	18	27	19	46	Fair
C	22.75	34.13	32.33	66.46	Good
D	22.75	34.13	31.66	65.79	Good
E	19	28.5	25.66	54.16	Fair
F	21	31.5	25	56.50	Good
G	17	25.5	32.66	58.16	Fair
H	18	27	33.33	60.33	Good

Legend: see List of Symbols

Table 6. Details of rock discontinuity and slope of each zone

Zone	Slope height (m)	Slope angle/aspect	Rock discontinuity (dip angle/dip direction)				
			FJ	*J1*	*J2*	*J3*	*R/J*
A	12	85°/280°	15°/245°	75°/270°	90°/90°	-	80°/135°
C	10	80°/280°	15°/300°	90°/300°	55°/290°	85°/190°	80°/250°
D	8	85°/270°	15°/285°	50°/245°	75°/020°	90°/190°	45°/180°
H	20	80°/255°	05°/255°	80°/315°	90°/190°	-	-

Table 7. Potential failure mechanism in the selected rock slopes

Zone	Planar sliding	Wedge sliding	Direct toppling	Potential mass failure
A	Yes (25%)	Yes (16.67%)	No	Planner or many wedges
C	Yes (20%)	Yes (40.00%)	No	Planner or many wedges
D	No	Yes (30.00%)	Yes (30.00%)	Many wedges or toppling
H	No	Yes (33.33%)	No	Wedges or some blocks

5. Analysis and Results

Rock mass characteristics are a serious concern in the stability and behavior of both natural and engineered rock slopes. Orientation of rock discontinuities control rock mass behaviors and contribute to either the stabilization or destabilization of rock slopes (Stead and Wolter, 2015). Therefore, different rock mass classification systems were conducted to all zones while kinematic analysis of a critical natural slopes (Zone H) and three artificial slopes (Zones A, C and D) have been conducted in the study area.

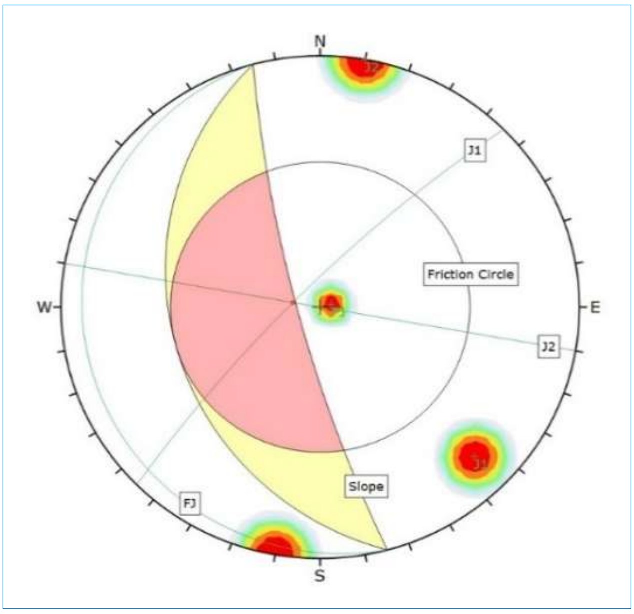


Fig. 6. Kinematic analysis for natural slopes; wedge sliding on Zone H

5.1. Rock Mass Rating (RMR)

RMR is a systematic approach to assess the quality and stability of rock masses (Bieniawski, 1989; Bieniawski, 1993). It considers six primary parameters (1) *RQD*; (2) *UCS*; (3) *DS*; (4) *DC*; (5) *GW* and, (6) Orientation of discontinuities. The sixth parameter of *RMR* cannot be applied for the slope (Aksoy, 2008). Hence, basic *RMR* (RMR_b) only considers the first 5 parameters, is utilized for the present study (IS 13365, 1997). In this study, the RMR_b is obtained by use of the *Equation 1*.

$$RMR_b = UCS + RQD + DS + DC + GW \tag{1}$$

5.1.1. Rock Quality Designation (RQD)

The term *RQD* is most common method for characterizing the degree of joints in borehole cores (Deere 1963; Bieniawski, 1984). In surface, it is estimated from joint spacing or volumetric joints (J_v) count of the rockmass (Palmstorm, 1974). The *RQD* and J_v is calculated by using *Equation 2* suggested by Palmstorm (2005).

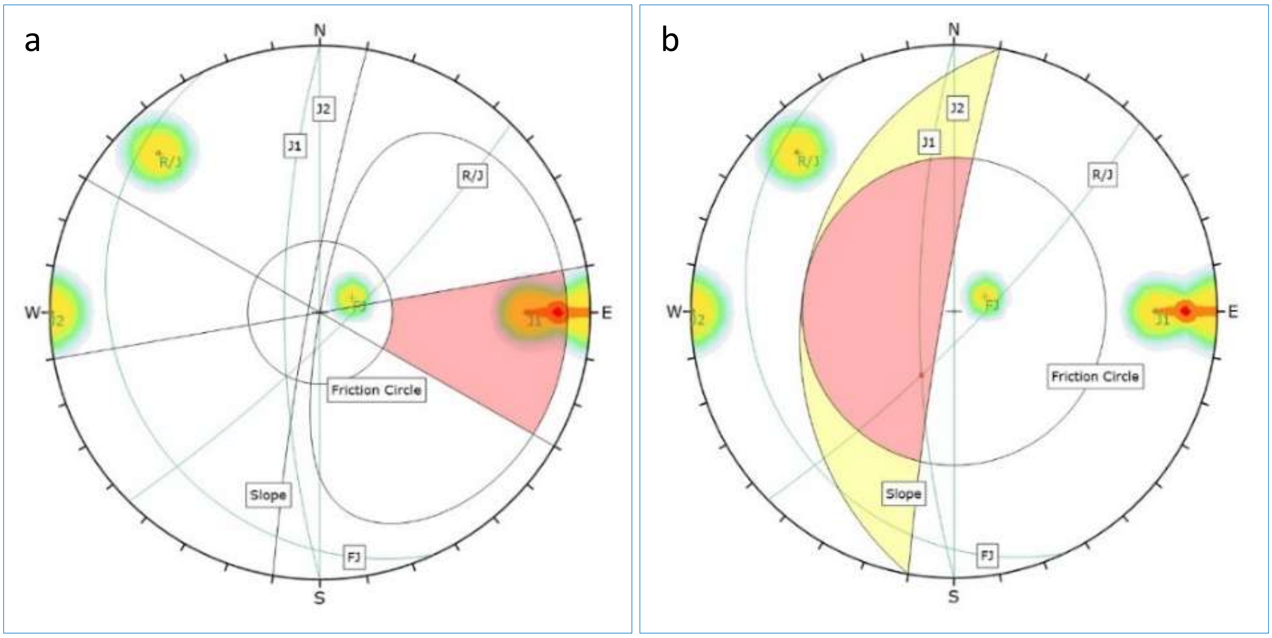
$$RQD = 110 + 2.5\,J_v \; (RQD{=}100 \text{ for } J_v \leq 4) \tag{2}$$

where J_v is defined as numbers of joints count in the per cubic meter.

The average spacing and frequency of all discontinuities were observed from joint sets for each zone as suggested by Bieniawski (2011) and Palmstrom (2005). The *RQD* %, J_v and average spacing and frequency of all discontinuities were measured from joints for each zone in the study area is given in Table 2.

5.1.2. Uniaxial Compressive Strength (UCS)

Climate variables and lithological properties are among the key factors affecting rock weathering (Xie et al., 2022). Due to gradational behavior, separation of individual weathering grades is not always possible. Hence, Schmidt Hammer has been used to measure *UCS* of rock mass under the study. It was originally developed by Schmidt (1951) to estimate hardness of concrete. Later, estimating *UCS* of rocks using Schmidt hammer by researchers (Barton and Choubey, 1977). Different researchers have suggested an empirical equation, making use of Schmidt hammer rebound number (*RN*) values, for calculating the *UCS* of jointed rock mass of different rock types (Ghose and Chakrabarti, 1986; Haramy and DeMarco, 1985; Sachpazis, 1990; Xu et al., 1990).



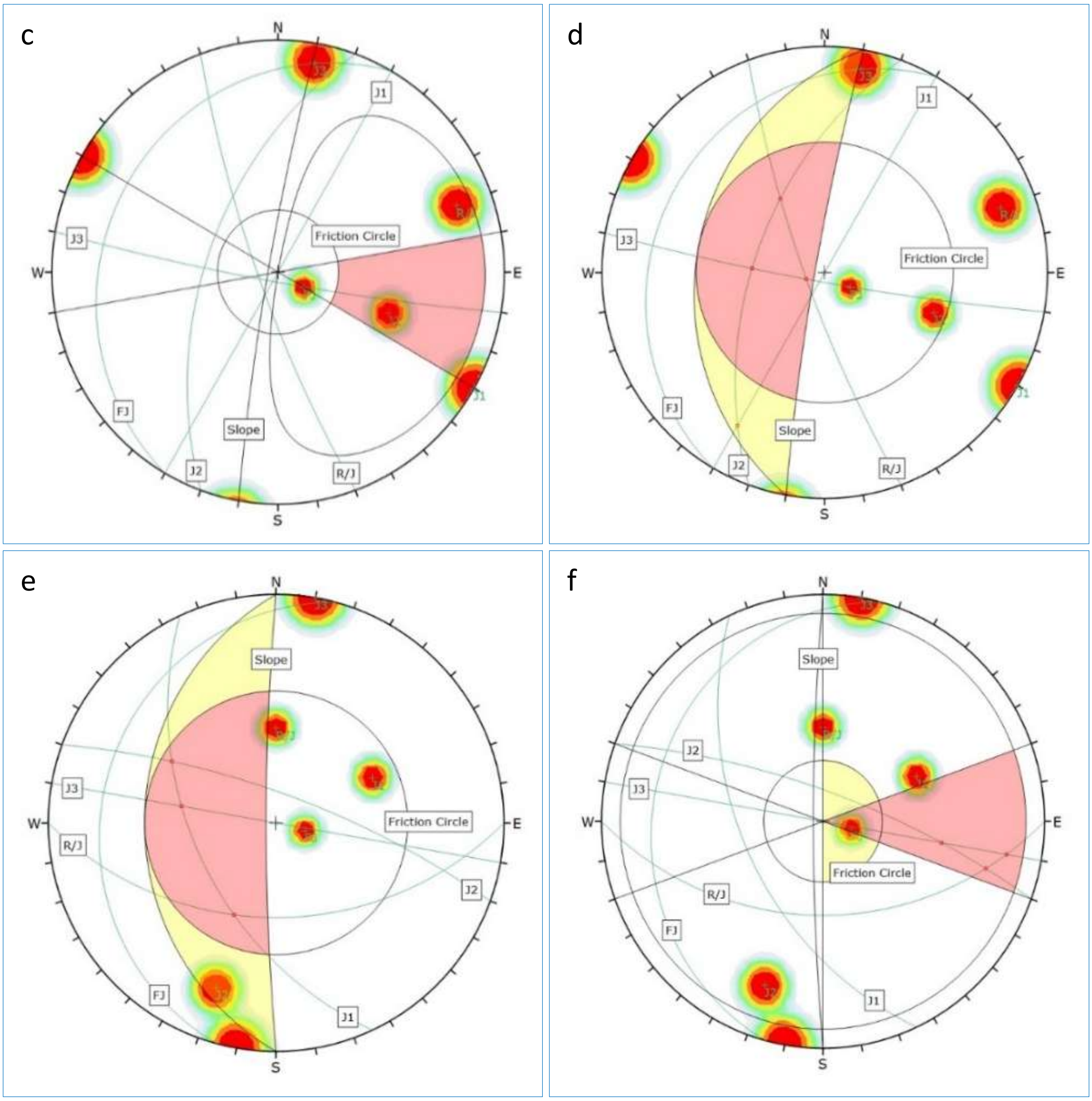


Fig. 7. Kinematic analysis for artificial cut slopes: (a) Planar and (b) wedge sliding on Zone A, (c) Planar and (d) wedge sliding on Zone C and (e) wedge sliding and (f) direct toppling on Zone D

Some researchers have estimated the strength of volcanic rocks using Schmidt hammer rebound (Aggistalis et al., 1996; Dincer et al., 2004; Kurtulus et al., 2018). The *UCS* of rock mass acquired from the rebound hammer tests, average and maximum ranges from 176.62–219.91 and 203.26–236.56 *MPa*, respectively. Calculating *UCS* from *RN* is used by *Equation 3* suggested by Dincer et al. (2004) and given in Table 3.

$$UCS = 3.33(RN) + 3.46 \tag{3}$$

The strength of jointed rock mass controlled by block size and intersecting discontinuities (Hoek et al., 1992; Milne et al., 1992). By assigning numerical values to each parameter and summing them, RMR_b provides an overall rating that aids in decision-making. Estimating RMR_b values displays that most of the zones (B, D, E, F and G) have good rock quality whereas zones (A, C and H) have very good rock quality. Rating of each parameter was assigned and calculating RMR_b value to each zone in the study area are given in Table 4.

5.2. Geological Strength Index (GSI)

GSI is a quantitative method for estimating the strength of rock masses based on geological characteristics which is first proposed by Hoek and Brown (1997) and modified by researchers (Hoek and Marinos, 2000; Sonmez and Ulusay, 2002; Cai et al., 2004; Hoek et al., 2013; Winn et al., 2019). It considers parameters such as intact rock strength, joint conditions, rock fabric, and weathering. GSI values range from 10 to 100, with higher values indicating stronger and more stable rock masses. Hoek et al. (2013) put forward valuable improvement on the quantification of the *GSI* based on the joint conditions ($JCond_{89}$) rating defined by Bieniawski (1989) and the *RQD* defined by Deere (1963). Estimating $JCond_{89}$ rating defined by Bieniawski (1989) considering J_r and J_a for rock wall contact defined by Barton et al. (1974). However, Winn et al. (2019) modified in the calculation GSI_{2013} relationship by substituting *RQD/2* with *RQD/3* by suggested *Equation 4* included:

$$GSI = 1.5\,JCond_{89} + \frac{RQD}{3} \tag{4}$$

The outcome of quantifying *GSI* for each studied zone depicts that mostly comes under fair to good rock quality conditions. The quantified *GSI* values of two zones (B and E) range from 46 to 54.16 that comes under fair rock quality conditions whereas six zones (A, C, D, F, G and H) range from 56.50 to 67.46 which comes under good rock quality conditions. The assigned rating of x-axis and y-axis respectively $1.5JCond_{89}$ and *RQD/3* are given to each zone and quantifying *GSI* values in the different zones of the study using *Equation 4* are given in Table 5.

5.3. Kinematic Analysis

In kinematic analysis for rock slopes, several failure modes include plane sliding, wedge sliding and direct toppling are assessed to understand and evaluate the stability of the slope under different conditions (Hoek and Bray, 2018). The discontinuities data has been analysed in the DIPS software for the potential failure (Goodman, 1989). In the kinematic analysis, the important geotechnical parameter is the angle of internal friction (ϕ). The friction angle of joints present in basalt has been assumed as 30° for preliminary assessment. Only, five potential rocky slope zones were selected for stability assessment. Kinematic analyses were performed for about 20-30 m high natural rocky slopes such as Zones H and about 8-12 m high artificial cut slopes as Zones A, C and D. Details of rock discontinuity and slope have been taken for each zone during the field investigations are given in Table 6.

The stereographic projection of discontinuity and slope for planar sliding, wedge sliding and direct toppling for natural and artificial cut slopes are illustrated in Figs. 6-7, respectively. The kinematic analysis results of selected slopes are given in Table 7.

5.4. Slope Mass Rating (SMR)

The *SMR* geomechanical classification is used to assess the rock slopes stability developed by Romana (1985) and modified by researchers (Anbalagan et al., 1992; Rahim et al., 2009; Rahim et al., 2012; Tomas et al., 2012). The modified rock mass rating (*M-SMR*) is computed from *RMRb* of Bieniawski (1989) and uses discontinuity orientation factor (*R6*). *M-SMR* value is obtained using *Equations 5-7*.

$$M - SMR = RMR_b + R6 \tag{5}$$

$$RMR_b = R1 + R2 + R3 + R4 + R5 \tag{6}$$

$$R6 = (F1\ x\ F2\ x\ F3\ ) + R4 \tag{7}$$

where, R1: UCS, R2: RQD, R3: discontinuity spacing, R4: discontinuity condition, R5: water flow, R6: discontinuity orientation, F1: parallelism between discontinuity and slope direction, F2: discontinuity dip angle, F3: relationship between discontinuity and slope dips and F4: method of excavation.

Table 8. *M-SMR* analysis results on Zone I slope

***M-SMR* Parameter**	**Result**
F1	0.40
F2	1.00
F3	-25
F4	15
RMR_b	85
Total *M-SMR*	85 + 0.40 x 1.00 x (-25) + 15= 90

Table 9. *SS* & *PM* and *DMR* slope remapping, adopted from Rahim (2015) and Rahim and Musta (2023)

***M-SMR* Class**	***M-SMR* Value**	***DMR* and slope remapping**	***SS* and *PM***
I (Very Low Risk/Very Good)	90	Recommended for DMR and slope remapping by engineering geologist/ geotechnical engineer	None, local trimming or scaling if required

Legend: see List of Symbols.

M-SMR is used to quantify the effect of discontinuities on the stability of rocks slope design such as protection measures and recommendation for design model review and slope remapping (Rahim, 2015; Rahim and Musta, 2023).

In order to assess the stability of rock slopes, the *M-SMR* assessment of rock mass has been estimated on zone H slope. Kinematic analysis data indicates that the unfavourable condition for slope stability is due to wedge sliding (intersection of *J1* and *J2* joints) (Fig. 6), hence *M-SMR* value has been calculated with reference to trend and plunge (279°/77°) of intersection of above-mentioned joints. A tabular summary of *M-SMR* is given in Table 8.

A description of class, value, design model review, slope stabilization and protection measures for estimated *M-SMR* as suggested by Rahim (2015) and Rahim and Musta (2023) is given in Table 9.

6. Conclusion

Rock slopes belonging to the Sahyadri Group in the Western Ghat region of Maharashtra, India were analyzed using geomechanical classification schemes to characterize rock mass quality and assess slope stability conditions. In this study, total of 8 zones has been investigated using different classification methods (*RQD, RMR_b* and *GSI*) of rock mass classification systems. *RQD* % can be applied to determine the strength of rock mass. *RMR_b* can only be applied to determine the quality of rock and not for slope stability whereas the *GSI* used to determine the slope stability conditions of rock. Estimated *RQD* % range from 75% to 100% showing good to excellent rock conditions. Basic *RMR* values range from 73 to 89.75 which comes under good to very good conditions. Quantifying *GSI* values range from 46 to 67.46 which comes under fair to good conditions.

Kinematic analysis of a most critical natural slope (Zone H) and three artificial cut slopes (Zones A, C and D) have been performed to identify the structural risk for different modes of failure like planar sliding, wedge sliding and direct toppling. The results of kinematic analysis show that each zone has comparatively less potential for failures. *M-SMR* analysis of high natural slope (Zone H) has been performed to assess the stability of rock slope. The results of *M-SMR* on Zone H slope have completely stable condition considered in very low risk/very good class (Class I).

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Declaration of Interest

The author has no conflict of interest with this publication.

Author's Contribution

SK has performed investigations, conceptualization, data curation, methodology, validation and writing - original draft.

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