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Study of stability of slopes of tunnel portals using modified SMR approach: A Case Study of Lower Likhu Hydropoer Project

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ABSTRACT

The Slope Mass Rating (SMR) is widely used for stability assessment of rock slopes. The Modified SMR approach is used for the stability assessment of six rock slopes in tunnel portals and surge shaft area of Lower Likhu Hydropower Project (28.1Mw). The major rock types of the study area are Phyllite and Metasandstone. The study shows some probability of wedge and planar failures at some slopes, whereas some slopes were found to be stable.

Key words: Likhu Khola Hydropower Project, Likhu Khola, Slope Mass Rating, Planar failure

INTRODUCTION

The Lower Likhu Hydropower Project (28 Mw) is run-off-the river type hydropower project located at Ramechhap and Okhaldhunga district. The studied slopes are five headrace tunnel portals, namely Seti Outlet, Seti Inlet, Poku Outlet, Poku Inlet, Main Outlet, and one surge shaft slope. Modified SMR approach is used for the slope stability assessment of the area (Anbalagan et al., 1992). The general geology of the area comprises of mainly two units: phyllite dominated and metasandstone dominated rock units.

GEOLOGICAL SETTING

The general geology of the area comprises of two rock units. Thinly foliated, greenish grey, slightly to moderately weathered phyllite with intercalations of metasandstone and quartzite is present on the northern part of the study area (Fig. 1). Fine to coarse grained, greenish grey to grey, fresh to moderately weathered metasandstone with partings of phyllite, and few interbedding of coarse-grained meta-conglomerate is present on the southern part of the study area. The regional geological map published by DMG (1984) shows that the area lies in Seti Formation of Pokhara Sub-group, which comprises of grey to greenish grey phyllites, gritty and quartzites with minor conglomeratic layer with some basic intrusions.

METHODS

The field data were collected using standard geological instruments. Modified SMR approach (Anbalagan et al., 1992) was used for the slope analysis.

The stability of rock mass using SMR approach is obtained using the Bieniawski's Rock Mass Rating (RMR_{basic}) and substraction of adjustment factors of the joint-slope relationship and addition of a factor dependent to the method of excavation.

$SMR = RMR_{basic} - (F_1.F_2.F_3) + F_4$, in which

RMRbasic is calculated according to Bieniawski (1979, 1989) by adding the ratings of five parameters, which are:

i. Uniaxial Compressive Strength of intact rock material,

ii. Rock Quality Designation (RQD),

iii. Joint or discontinuity spacing,

iv. Joint condition, and

v. Ground water condition.

F_1 is dependent on parallelism between joints and slope face strike. The approximate relationship to obtain the value of F_1 is:

$$F_1 = (1- \sin A)^2$$

Where, A denotes the angle between the strikes of the slope face and that of the joints.

F_2 refers to the angle of dip of the joint considered, and value ranges from 0.15 to 1.

F_3 is the relationship between the slope face and joint dip angle.

F_4 is related to the method of excavation.

Romana (1985) used planar and toppling failures for the analysis using SMR. Anbalagan 1992 considered the plane and wedge failures as different cases and presented a modified SMR approach for slope stability analysis, which is used for the present study. In this approach, the plunge and direction of dip of the line of intersection of unstable wedge were used.

Five different slope faces of the tunnel portals, namely Seti Outlet portal, Seti Inlet portal, Poku Outlet portal, Poku Inlet portal and Main Outlet portal, and one in surge shaft area

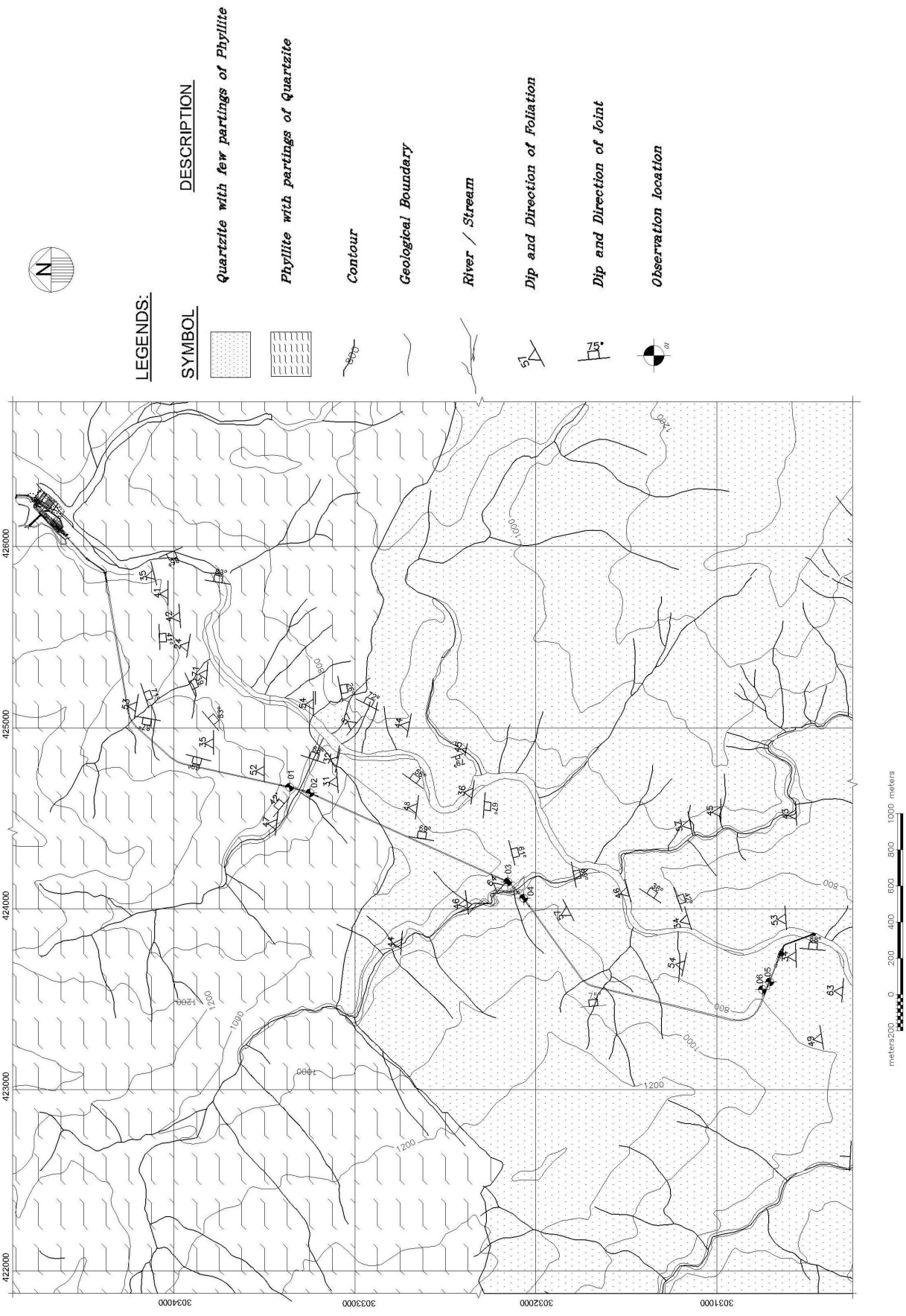

Fig. 1: Geological map of the area, showing observation locations for modified SMR

Table 1: RMR calculation at different locations

Observaition Locations	Location	Ratings					RMR_{basic}
		UCS	RQD	Spacing	Condition of discontinuities	Ground Water Condition	
01	Seti Outlet	4	3	5	20	10	42
02	Seti Inlet	4	3	5	20	15	47
03	Poku Outlet	7	8	9	22	15	61
04	Poku Inlet	12	13	10	25	15	75
05	Main Outlet	7	8	9	20	15	59
06	Surge Shaft	7	8	8	20	15	58

of the Lower Likhu Hydropower Project (28.1 Mw) were studied for the slope analysis and the support were suggested for the rock classes according to the obtained value of SMR.

RESULTS

Six rock slopes were chosen and RMRbasic for different slopes were calculated (Table 1). The graphical analysis is performed for the joints to deduce the mode of failure using Dips (Fig. 2).

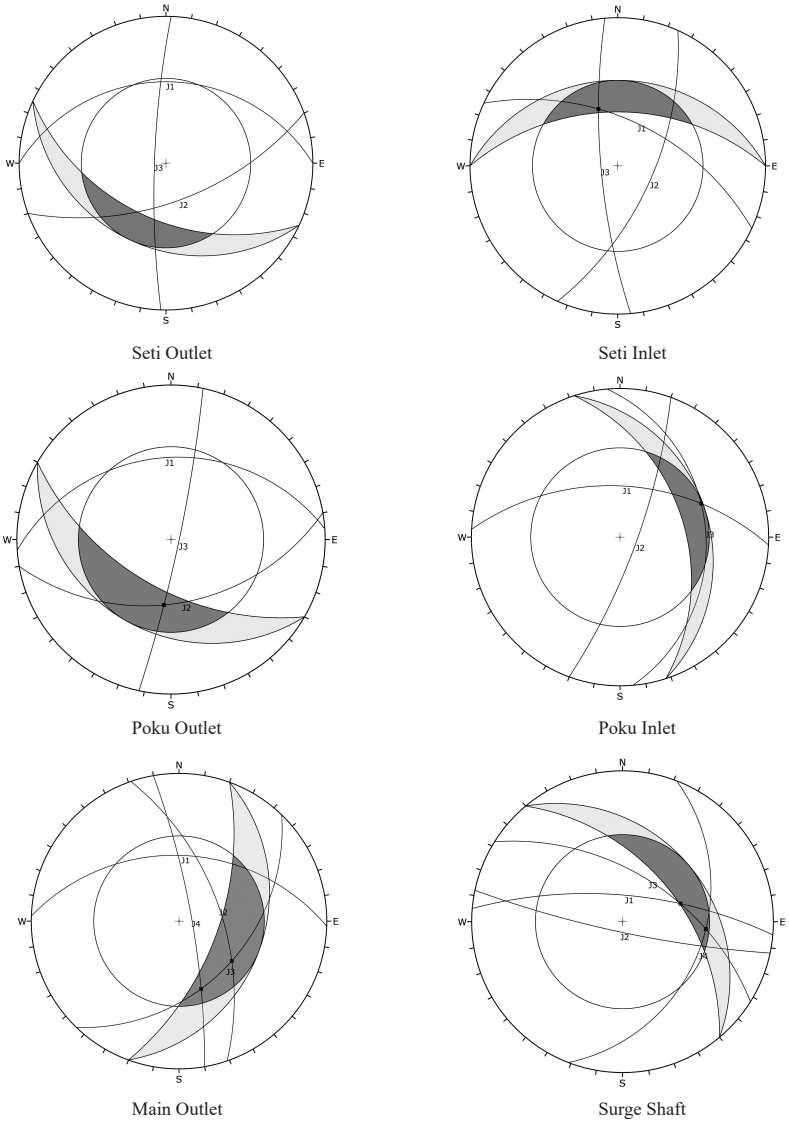

Fig. 2: Stereo-plot for identification of wedge

The orientatation of intersection of the joint planes for different locations were found as shown in Table 2.

The analysis of discontinuities using the software Dips produced eight different wedges probable to failure. The slope stability of wedges was analysed using the modified SMR approach, and the results are tabulated (Table 3).

Table 2: Attitude of slope face (Strike/Dip amount/Dip direction) and (Trend/Plunge) of wedge formed by intersection of joint planes

Location	Slope orientation	Wedge orientation
Seti Outlet	115/48/205	60/160
Seti Inlet	90/50/0	55/025
Poku Outlet	120/55/210	45/170
Poku Inlet	162/43/72	52/003
Main outlet	20/60/110	58/071 42/134
Surge Shaft	135/49/45	54/032 70/005

Table 3: Slope Mass Rating results

Location	Main Lithology	SMR Value	Stability	Failures
Seti Outlet	Phyllite	42	Partially Stable	Planar along some joint and many wedges
Seti Inlet	Phyllite and metasandstone	47.36	Partially Stable	Planar along some joint and many wedges
Poku Outlet	Phyllite and metasandstone	59.37	Partially Stable	Planar along some joint and many wedges
Poku Inlet	Metasandstone and Quartzite	67.9	Stable	Some block failure
Main Outlet	Metasandstone	76	Completely Stable	No Failure
	Metasandstone	74.65	Completely Stable	No Failure
Surge Shaft	Phyllite and Metasandstone	58.9	Partially Stable	Planar along some joint and many wedges
	Phyllite and Metasandstone	58	Partially Stable	Planar along some joint and many wedges

CONCLUSION

Modified SMR approach was applied on six different slopes containing different rock types. Among eight wedges with potential wedge failure formed, three wedges were found to be stable and partially stable and the remaining five wedges formed at different locations were found to be partially stable (Table 3). Spot bolting is recommended for the completely stable slopes, spot or systematic bolting is recommended for stable slopes, and systematic bolting with systematic shotcrete is recommended for the partially stable slope to contain the possible slope failure.

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