Assessment of Rock Mass Strength and Slope Stability at Bandar Mahkota Cheras, Malaysia Using RMR and SMR

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Abstract: The rock mechanical parameters are essential for slope stability studies. In Malaysia, limited research has conducted on classifying and evaluating rock mass quality using the Rock Mass Rating (RMR) and Slope Mass Rating (SMR) systems. This study aimed to determine the strength of rock materials and rock masses and to assess rock mass quality using RMR and SMR. Two slopes, labeled BMC-1 and BMC-2, were studied and all rocks were classified as fresh to slightly weathered. Based on Schmidt hammer tests, the estimated Uniaxial Compressive Strength (UCS) ranged from 44 MPa to 125 MPa, while corrected UCS values were between 69.3 MPa and 103.9 MPa. The average bulk and dry densities were 2.517 g/cm^3 and 2.511 g/cm^3 respectively, with an average porosity of 1.2%. Tensile strength, determined using Brazilian tests, ranged from 2.0 MPa to 4.0 MPa and point load strength varied from 1.3 MPa to 6.0 MPa, corresponding to derived UCS values between 31.3 MPa and 155.5 MPa. P-wave velocities (Vp) ranged from 3,692 m/s to 5,085 m/s, confirming the rocks as fresh to slightly weathered in nature. The rocks were classified as strong to very strong. Stereographic analysis indicated wedge failure potential at slope BMC-1, while BMC-2 remained stable. The basic RMR values were 75 and 77 for BMC-1 and BMC-2, respectively, corresponding to Class II (good-quality rock mass). SMR values were 67 (BMC-1) and 77 (BMC-2), both Class II, with a low failure probability (0.2), indicating stable conditions. The estimated rock mass strength ranged from 15.5–34.5 MPa (BMC-1) and 13.3–31.7 MPa (BMC-2), while the total induced stress (~0.1 MPa) was much lower than rock mass strength. Therefore, the water tank is considered safe. This study contributes valuable data for future research on foundation bearing capacity and applications in engineering geology and rock mechanics.

Keywords: ***RMR, SMR, Slope stability, Rock mass strength.***

Introduction

Rock mechanics is the branch of mechanics that studies the mechanical behavior of rocks and their response to natural force fields in the physical environment (Stagg and Zienkiewicz, 1975).

Rock mass classification systems, developed for over a century since Ritter (1879), play a crucial role in understanding rock behavior and designing engineering structures, with notable systems including those by Bieniawski (1973, 1989), Barton et al. (1974), and Wickham et al. (1972). Intact rock, free from structural features such as joints or faults, is classified mainly based on its uniaxial compressive strength and modulus of elasticity. Discontinuities, such as joints, fissures, and bedding planes, significantly influence rock mass behavior and stability (Dearman, 1991). Joints, the most common discontinuities, often form due to contraction during crystallization or tectonic stresses (Billings, 1972; Thorpe and Brown, 1985).

In this research work the "Geomechanical Characterization of rock mass" in Bandar Mahkota Cheras area has determined and illustrated by in-situ test as well as laboratory test analysis. The study comprised two sites that were labeled as BMC-1 and BMC-2 (Figure 1). The objectives of this research are: (1) to determine the rock material and rock mass strength, and (2) to determine the rock mass quality using Rock Mass Rating (RMR) and Slope Mass Rating (SMR) systems.

Methodology

The methodology of this research includes both fieldwork and laboratory investigations to determine the strength and quality of rock materials. The laboratory work involved conducting rock mechanics tests and basic physical properties tests following the International Society of Rock Mechanics (ISRM) Suggested Methods (2007).

Field investigations included a discontinuity survey to collect discontinuity parameters using a clinometer (MC 2, SUUNTO Finland) and a profiler to measure the Joint Roughness Coefficient (JRC), along with rock sample collection for laboratory analysis. The Schmidt hammer rebound hardness test was performed in the field to assess the in-situ hardness and quality of the rock. Laboratory tests conducted included the Uniaxial Compressive Strength (UCS) test, Point Load Index Strength (PLS) test, Schmidt hammer rebound hardness test, Brazilian tensile strength test, and Ultrasonic Velocity test. The PLS test, Schmidt hammer test, Brazilian test and Ultrasonic Velocity test were used as indirect methods to estimate the UCS value of the rock samples. The UCS values obtained from these indirect tests were correlated using empirical relationships established by previous researchers.

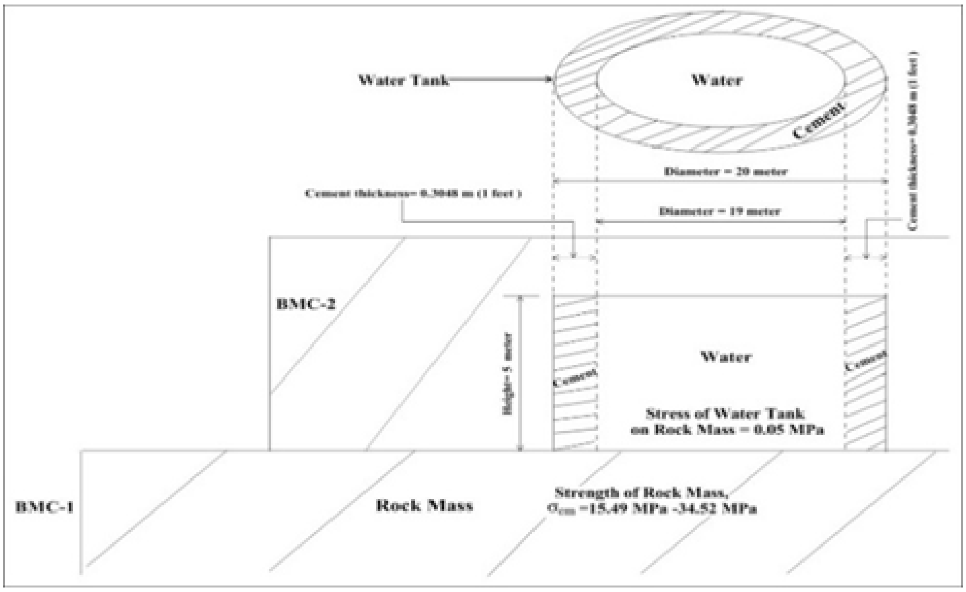

Figure 1, Sketch showing the water tank and studied slopes of the study area.

For determining rock physical properties, tests for porosity, density (bulk, dry and saturated), water content and specific gravity were performed. All tests were carried out systematically to ensure accuracy and reliability of results. The overall methodology of the study has been summarized through a flow chart presented in Figure 2.

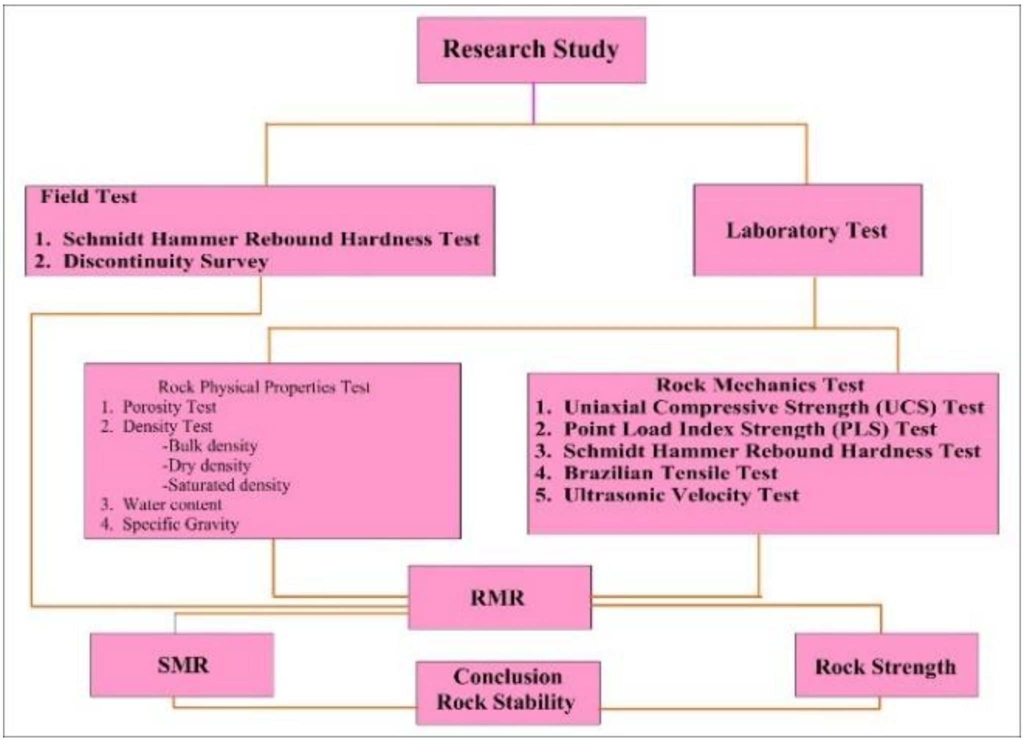

Figure 2, Flow chart of the materials and methods.

Results and Interpretations

Based on the results of average density and porosity, Schmidt hammer rebound hardness test, and Ultrasonic velocity test the rock materials were classified as fresh to slightly weathered. Based on the results strength tests such as uniaxial compressive strength (UCS) test, point load test, tensile strength test (Brazil test) the rock materials were classified as strong to very strong. The rock slope stability analysis for slope BMC-1 of the study area indicates that there are four sets of joint presence in the area with a wedge failure (264/58). BMC-2 consists of three sets of joints with no mode of failure and is stable in condition. The calculated RMR_{basic} of first and second site were 75 and 77 respectively (Table 1), which falls in rock class II and indicates the rock masses are of good quality. The calculated SMR value of first site was 67 which classified as class II, with the probability failure of 0.2 and stable in condition. The SMR of second slope is same as the RMR_{basic} and it was 77 and classified as class II, with the probability failure of 0.2 and stable in condition.

The estimated average rock mass strength (bearing capacity) for first slope is range from 25.47 MPa and for second slope is 23.94 MPa (Table 2). The calculated stress induced by water tank weight on the rock mass is approximately 0.05 MPa which is less than the rock mass strength. Therefore, the water tank is safe in condition.

Table 1, Results of RMR and SMR of the study area.

Site	Mode of failure	RMR_{basic}	SMR	Class
BMC-1	Material	75	67	II
	Mix	75	67	II
BMC-2	Material	77	77	II
	Mix	77	...	II

Table 2, Estimation of rock mass strength of slopes.

Slope	Est. rock mass Strength (MPa)		
	Min.	Max.	Average
BMC-1	15.49	34.52	25.47
BMC-2	13.29	31.75	23.94
Stress of Water Tank	0.05 MPa		

Conclusions

Based on the results of rock physical properties test and rock mechanics laboratory tests, the rock materials are classified as strong to very strong and classified as fresh to slightly weathered. Based on the stereographic discontinuity data, the first slope BMC-1 has a wedge failure condition, and the second one is no mode of failure. By determining the rock mass quality of the study area using RMR and SMR. Based on the basic RMR of first and second sites are falls in rock class II and indicate the rock masses are of good quality. Based on SMR value of first site is classified as class II, with the probability failure of 0.2 and stable in condition. The SMR of second slope is same as the RMR_{basic} and is classified as class II, with the probability failure of 0.2 and stable in condition. The estimated rock mass strength (bearing capacity) of the study area is greater than the calculated stress induces by water tank weight on the rock mass. Therefore, the water tank is safe in condition.

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