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SHORT NOTES

FIELD ASSESSMENT OF ROCK STRENGTH BY IMPACT LOAD TEST

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Abstract: This paper introduces a new testing method for field determination of Index strength of rock mass. The method was developed as an alternative test in cases when difficulties were encountered by conventional Schmidt Hammer to determine the index strength of weak or weathered rock. This note explains the basic concept and the procedure of impact load test as an alternative way to determine the index strength of weak or highly weathered rock. A standard chart was developed for interpretation of impact load test through verification study on weathered granite.

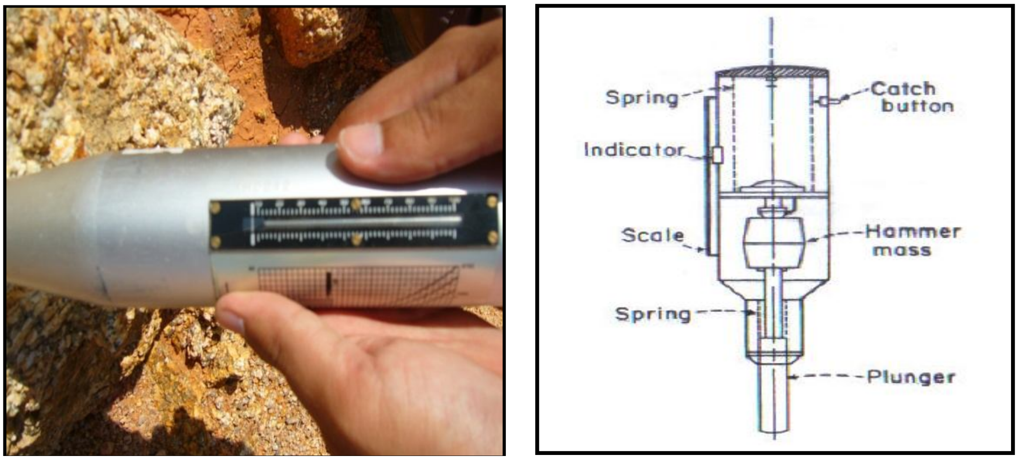
Keywords: *Surface hardness, Weathered rock, Schmidt Hammer Test, Impact Load Test*

1.0 Introduction

The strength of rock is usually assessed in-situ through surface hardness. The common method of measuring the surface hardness is by using Schmidt Rebound Hammer test. The Schmidt hammer (Figure 1) is a portable and relatively inexpensive instrument. The test can be performed quickly and efficiently in both laboratory and the field setting. The hammer measures the rebound of a spring loaded mass impacting against the surface of the sample indicated by rebound value which range from 0 to 100. There are three types of hammer i.e: (i) Type L-0.735 Nm impact energy, (ii) Type N-2.207 Nm impact energy; and (iii) Type M-29.43 Nm impact energy. The standard procedure for testing of rock is outlined in International Society of Rock Mechanics (ISRM) 1981 Part 2 and American Society for Testing Materials (ASTM) D-5873. Previous studies indicated that the rebound, in combination with dry unit weight, gives a good prediction of uniaxial compressive strength of the rock (Hucka 1965; Deere and Miller 1966; and Dearman 1974).

The test has been used successfully on strong or lowly weathered rocks (Anon, 1977). However, difficulties are often encountered on weak or highly weathered rock. Impact load test was introduced as an alternative method to assess the strength of weathered rock. The impact load test was developed based on the same concept as Schmidt hammer test i.e. by applying impact energy on rock surface. However, rather than measuring the rebound caused by the impact energy, impact load test measure the penetration made by the falling weight into the rock surface.

This paper is aimed at introducing the newly developed impact load test to predict the strength of weathered rocks. The application of the method is illustrated by test results on weathered granite at a location in Johor, Malaysia. The results of the pilot study was used to develop a standard chart for the interpretaion of the impact load test.

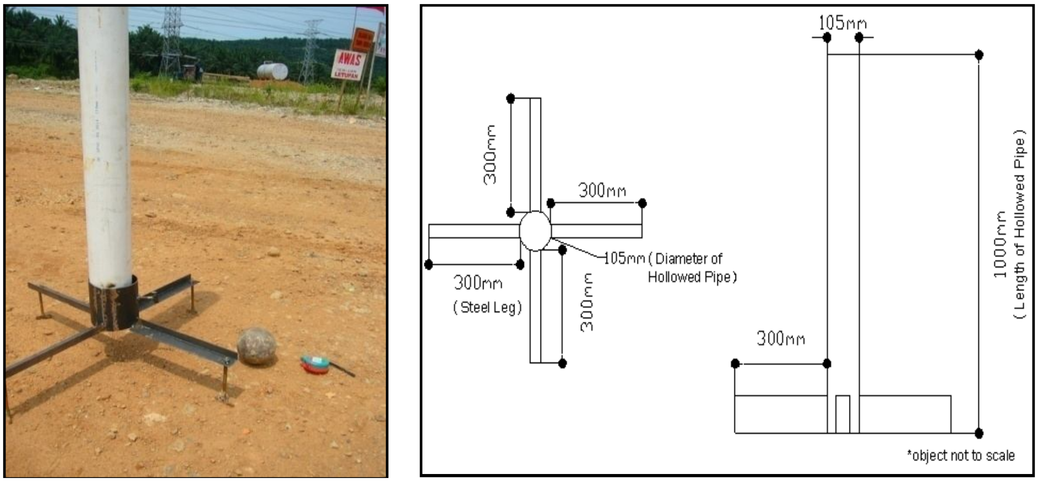


(a) (b)

Figure 1: Schmidt hammer (a) apparatus (b) schematic view

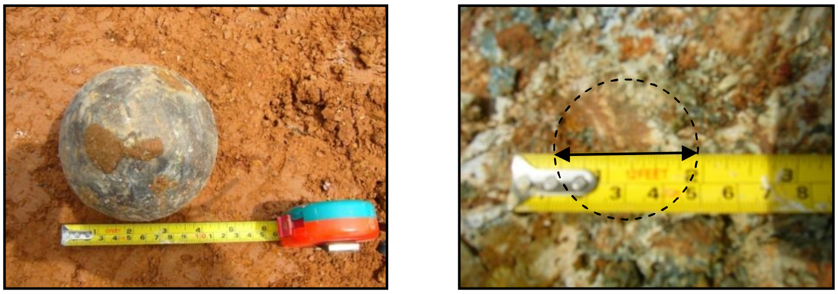
2.0 Apparatus and Procedure of Impact Load Test

The impact load test (Figure 2a & 2b) was developed based on a concept of impact energy. The apparatus comprises a hollowed pipe of diameter 110 mm and height of 1000 mm and a steel ball weighted 4.0 kg and diameter 105 mm (Figure 3a). It is important to ensure that the surface of the tested area is flat and the pipe stands vertical, hence; four steel legs 300 mm long each are connected to the hollowed pipe. The ball is dropped free inside the hollowed pipe from the height of 1000 mm to produce an impact energy of 40 N-m. The energy caused by the falling ball will cause deformation on rock surface (Figure 3b). The diameter of the dented surface is measured and recorded as Impact value.The test procedure was repeated at least three times for each area and the average value was recorded. Figure 4a & 4b show photographs of the studied site.



(a) (b)

Figure 2. Impact Load Test (a) Apparatus (b) Schematic diagram



(a) (b)

Figure 3. (a) Standard ball for impact load test (b) diameter of dented surface

(a) (b)

Figure 4 The study site (a) Location (b) Exposed rock surface

3.0 Verification Study

An extensive study has been performed to verify the method and to develop a standard guideline. A site at Bandar Seri Alam, Masai, Johor was selected because current excavation activities in this area exposing the surface of rock with different weathering grades have facilitated the identification of weathering zones. The site was divided into seven panels of 10 – 15 m length. Careful observations were made at every panel to identify the zone with different weathering grade. The identification of weathering grade was made through field observation on each panel following the chart provided by Hencher and Martin (1982) and Ibrahim Komoo (1995) through physical features by identifying the color, friability, rock-soil ratio, and joint aperture as well as performing index test Schmidt Hammer test.

Fifteen tests were performed on each weathering grade at various panels. The results were then compared with the rebound values obtained from Schidt Hammer test on Grade III and IV because the Schimdt hammer test cannot give a rebound value on Grade V material. N-Type Schmidt hammer was used in this study. All tests were performed with the hammer held vertically on dry samples of grade II to IV. Besides, the results of Impact load test were also evaluated by laboratory tests. Samples were collected at locations of impact load test and taken to laboratory for Point load test. Table 1 shows the results of Impact load test in terms of the dimater (*d*, mm) of the indented surface corresponding to the resuls of Scmidt N-hammer test (rebound value and strength index, *SHV*) as well as Point load test (I_{s50}).

Table 1: Results of Impact Load *(d)*, Point load (Is_{50}) and Schmidt hammer test

No of test/samples	Weathering Grade	*d* (mm)	Is_{50} (MPa)	Rebound value	Strength index (SHV)
15	II	0	5 – 9	>45	Very high
15	III	30-40	3 – 5	25 – 45	High
15	IV	60-70	0.15 – 3	0 – 25	Medium
15	V	80-90	< 0.15	0	No rebound
15	Residual Soil	100	-		-

Figure 5 shows the diameter of the deformed surface and the corresponding degree of weathering. Rock of weathering grade II will yield in a diameter of 30 – 40 mm, while Grade 4 produce a diameter of 60 – 70 mm. Deformation of diameter 80 – 90 mm will be obtained on the surface of Grade V material while almost half of the ball will penetrate into residual soil.

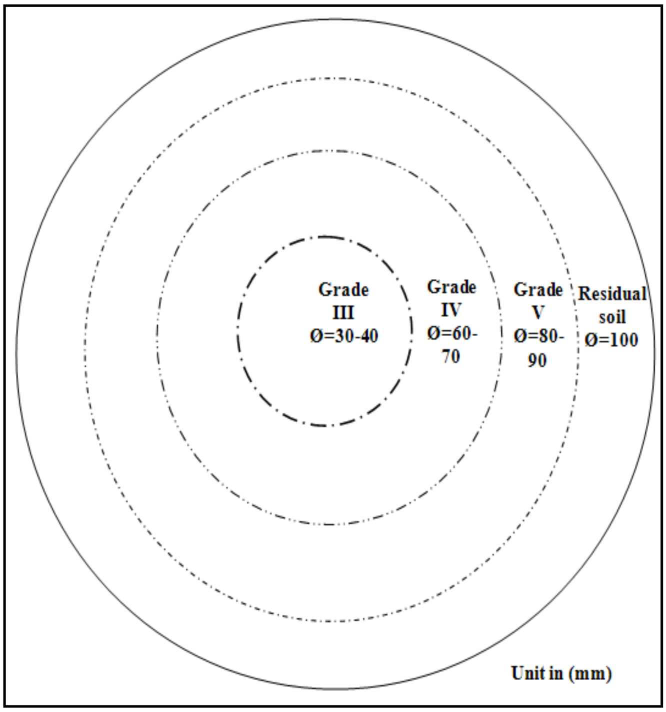


Figure 5 Standard ball diameter for analysis of the results of impact load test

4.0 Conclusions

An alternative method has been developed based on a concept of impact energy to evaluate the index strength of rock mass in-situ. While Schmidt hammer test performs well on Grade II to IV, this method is applicable on weak or highly weathered rock (weathering Grade III to V). The method was not designed to replace Schmidt Hammer test but very useful when difficulties were encountered with the conventional Schmidt hammer test.

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References

American Society for Testing Materials (2005) ASTM D5873 - 05 Standard Test Method for Determination of Rock Hardness by Rebound Hammer Method ASTM International, West Conshohocken, PA.

Anon (1977). The *Description of Rock Masses for Engineering Purposes.* Engineering Group Working Party Report. Quarterly Journal of Engineering Geology, 10, 355-388.

Dearman, W. R. (1974). *Weathering Classification in the Characterization of Rock for Engineering Purposes in British Practice.* Bulletin of International Association of Engineering Geology. 9:33-42.

Deere, D.U., and Miller, R.P. (1966). *Engineering Classification and Index Properties for Intact Rock*. Tech. Rept No. AFWL-TR-65-116, Air Force Weapons Ltd. Kirtland Air Force Base, New Mexico.

Hencher, S.R., & Martin, R.P. (1982). *The Description and Classification of Weathered Rocks in Hong Kong for Engineering Purposes*. Proceedings of 7th South-east Asian Geotechnical Conference. Hong Kong, 1:125-142.

Hucka, V. (1965). *A Rapid Method of Determining the Strength of Rock In-situ.* Intenational Journal Rock Mechanics and Mining Science 2:127-34.

Ibrahim Komoo (1995). *Weathering as an Important Factor in Assessing Engineering Properties of Rock Materials*. Proc. GSM Forum on Soil and Rock Properties. Kuala Lumpur. 31-35.

International Society of Rock Mechanics (1981). *Rock Characterization Testing and Monitoring*-International Society of Rock Mechanics Suggested Methods, E.T. Brown ed. Pergamon Press, Oxford.

Little, A.L. (1969). *Engineering Classification of Residual Tropical Soils.* Proceedings of the 7th International Conference on Soil Mechanics and Foundation Engineering Mexico, 1, 1-10.

Look, B. (2007). *Handbook of Geotechnical Investigation and Design Tables*. AK Leiden, Netherlands. Taylor and Francis Group.