Assessment of Schmidt rebound Hammer for Determination of Uniaxial Compressive Strength

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Abstract

The paper discusses the application of the L-type Schmidt rebound hammer for determination of the uniaxial compressive strength of discontinuity surfaces of rock masses. The result revealed that there is no correlation between L-type rebound hammer values and uniaxial compressive strength, if it is applied on natural rough joint surfaces under saturated conditions.

Keywords:Rebound hammer, Uniaxial compressive strength, Discontinuity surface.

Introduction

The stability of rock masses is influenced in part by their strength. However, the presence of a network of defective planes and fractures in rock masses influence their behaviour. The strength of a rock mass decreases whenever these defective surfaces are found and is affected by their attitude, geometry, spatial distribution and the number and

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continuity of such surfaces. Therefore, the shearing strength of a rock mass, in a way, is found to be largely governed by the presence of discontinuities which mean that the rock mass is anisotropic in its strength and deformational properties. It is, therefore, not surprising to observe that the surfaces of failure in hard rock follow pre-existing surface of weakness in the rock mass.

The strength along a discontinuity surface is governed by its roughness, if other factors are kept nearly constant [1]. Thus joint wall compressive strength (JCS) needs to be determined in the field under natural conditions. Various workers have recommended the use of L-type Schmidt rebound hammer for measurement of JCS.

Determination of JCS using L-type Schmidt hammer

The Schmidt rebound hammer was designated specially to test the strength of concrete is also widely in use for determination of uniaxial compressive strength of joint surfaces of the rock mass. This is a simple device for recording the rebound of a spring- loaded plunger after its impact on a surface. The L-type rebound hammer, used in the present study had an impact energy of 0.075 mkg.

Miller [2] found a correlation between rebound number (ranging 10 to 60) and the uniaxial compressive strength (q_c) of rock as follows:

$\mathrm{Log}_{10}\, q_c = 0.00088\, \gamma R + 1.01$

where:

q_c= uniaxial compressive strength, UCS (Mn- 1)

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γ= Dry density of rock (kN- 1)

R= Rebound hammer value

Aufmuth[3], Irfan and Dearman[4], Jesch etal.[5], poole and farmer [6], Karnataka Engineering Research Station[7], Cargil and shakoor [8], Okatz etal.[9] have found different relationships between hammer value and uniaxial compressive strength of the rock mass discontinuity surfaces. The published relationship, however, differed widely and significantly. Keeping in view the problem of estimating compressive strength by Schmidt rebound hammer, and also considering the fact that their test had been conducted on very smooth surface of cubes and cores, which are rarely encountered in practice, natural fresh unweathered samples of quartzite and siltstone were collected from field. The samples were large enough with average dimensions of 30 cm × 20 cm × 15 cm, to take hammer readings, at different parts on the same joint surface. Each sample was inspected for macroscopic defects to avoid testing near fractures or material inhomogennities.

Experimental set up and test procedure

The samples were kept for a period of two weeks in a container (3 m length, 2 m width and 1.25 m depth) filled with water.

In order to determine JCS with the help of rebound hammer, a small pit was constructed (80 cm length, 50 cm width and 40 cm depth) in the laboratory and filled with very fine slightly moist sand up to 30 cm. The samples were placed firmly in the fine sand to avoid sample movement during experiment (Fig.1).

Fig. 1: Measurement of uniaxial compressive strength (JCS) by L-type Schmidt rebound hammer under saturated condition.

A spirit level was also used to ensure the horizontal position of sample in space. The joint faces of the samples were thoroughly checked and made free from sand particles. The surfaces of nearly 160 joint faces were tested in natural saturated conditions, taking 30 readings on each joint surface with an L-type hammer held vertically downward following standard [10]. Tests that caused cracking or other visible damage were rejected. Thirty specimens were randomly selected. They were cut into 25 mm cubes to represent the strength along discontinuity surfaces. Two cubes were prepared from each joint surface. All the cubes and their faces were properly marked

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before testing (Fig.2). Care was taken to have final smooth finishes towards the ends of specimens to 0.05 mm by using different meshes. Samples were kept in water under low pressure vacuum conditions for a period of two weeks.

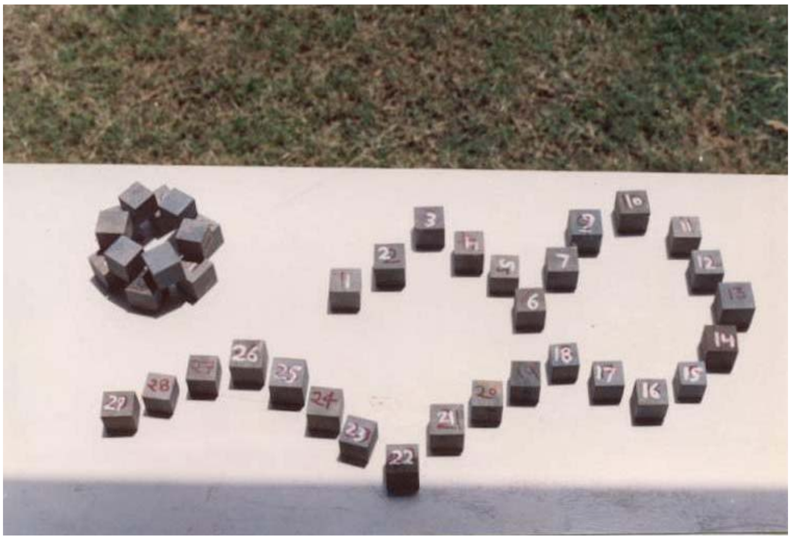

Fig. 2: Rock cubes preparation for measurement of uniaxial compressive strength (JCS)

The cubes were tested as per standard [11] under a ten tone capacity universal testing machine. The loading platen was brought down slowly so as to be in contact with the top of specimen. Load on the specimen was applied continuously at a constant stress rate till failure occurred. The maximum load on each specimen was recorded. The average unconfined compressive strength of each joint surface were determined (Table.1).

Table 1: Showing the Density of Rock and Rebound Number Under saturated Condition

Sample NUmber	Density (wet) KN m^{3}- 1	Rebound Number (average of 30 reading)	Rebound Number (average of 10 highest reading)	Uniaxial compressive strength observed in the lab (MN m^{2}- 1)
1	25.91	31.4	36.3	153.09
2	25.74	29.4	34.2	166.07
3	24.69	35.6	39.6	100.64
4	24.53	34.0	38.2	116.69
5	25.71	41.9	45.3	161.20
6	26.43	41.0	43.6	142.50
7	26.70	30.3	34.6	152.41
8	26.15	23.0	25.6	122.15
9	26.57	37.7	41.9	148.80
10	26.35	40.9	44.7	148.40
11	26.10	38.0	41.6	155.18
12	24.93	32.0	38.0	157.41
13	26.24	37.4	41.3	110.76
14	26.43	33.7	38.8	131.36
15	26.42	35.8	39.8	155.36
16	26.48	40.6	43.4	114.56
17	26.11	42.6	45.9	110.62
18	26.93	35.7	41.5	133.38
19	27.01	35.5	39.9	116.66
20	25.97	29.2	32.7	86.34
21	26.42	39.6	43.3	92.02
22	25.98	39.2	46.0	149.87
23	26.18	43.8	46.3	109.61
24	25.77	43.7	46.6	109.91
25	26.30	36.0	40.1	104.57
26	25.48	34.6	38.2	141.62
27	26.85	29.0	32.9	126.95
28	26.35	25.0	35.5	127.42
29	26.19	38.1	42.4	113.31
30	25.79	41.5	44.4	113.30

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Analysis and Discussion

The saturated density (γ_{sat}) and average of the 10 highest rebound numbers for each of the discontinuity surfaces were calculated under saturated condition. Then the average uniaxial compressive strength of two specimen for each joint surface, as observed in the laboratory under saturated conditions, was plotted against the product of L-type rebound hammer and saturated density values (γR). The plot indicated that no correlation exists between observed uniaxial compressive strength and γR values (Fig.3). However, on examining the surface roughness of discontinuity surfaces under study, it was noted, that it may estimate the observed uniaxial compressive strength, if it is applied on smooth planar natural surfaces of joint walls (Fig.4). Hence, the use of the hammer should be restricted to smooth natural surfaces with JRC profile value less than five.

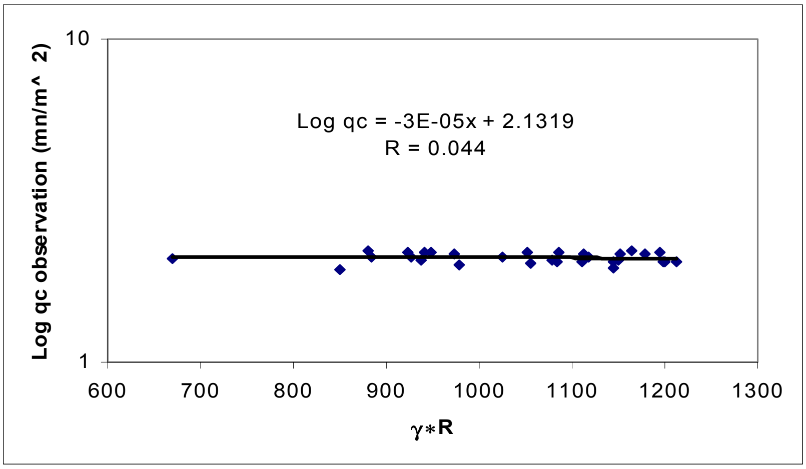

Fig. 3: Observed joint walls compressive strength Vs γR values measured on joint surfaces with different roughness under saturated condition

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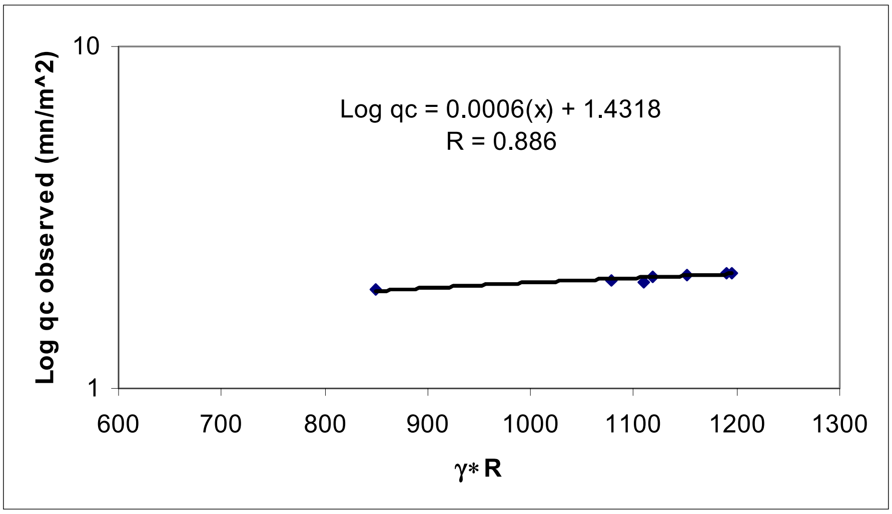

Fig. 4: Observed joint walls compressive strength Vs γR values measured on smooth planar of joint wall surface with roughness profile less than five under saturated condition.

Conclusions

On the basis of this study the following conclusions have been drawn:

I. The L-type rebound hammer, which is frequently used for estimating uniaxial compressive strength, was applied on natural joint surface with different roughness did not yield any correlation with observed uniaxial compressive strength estimated in the laboratory under saturated condition.

II. The use of hammer should be restricted on smooth planar natural joint surfaces of rock mass with JRC profile value less than five under saturated condition.

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