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Influence of Weathering on Rebound Hardness Values of Biotite Gneiss

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Abstract - *The rebound hardness value (R) from a Schmidt hammer test, is a widely used index in rock engineering for estimation of strength parameters both in laboratory and in situ conditions. Micro structural changes induced by weathering in rocks, results in different rebound values. The main objective of this paper was to understand the effect of weathering on R values of Biotite Gneiss collected from Eastern Ghat belt of southern peninsular India. For this purpose, the rock was divided broadly into three variants, namely - fresh rock (FR), slightly weathered rock (SWR), moderately weathered rock (MWR). Also, tests were performed by L-type (0.735N/m) and N-type (2.207N/m) Schmidt hammers, to delineate the sensitivity of impact energy on selected variants of rock. The results showed a good linear correlation between rebound values of L-type and N-type hammers. Except for FR, the rebound values of L-type hammer were higher than N-type hammer for different grades of weathering. And, for the same weathering grade, scatter in the data is significant for L-type hammers. It is inferred that L-type hammer was shown greater sensitivity to the changes in microstructures of weathering grades with low impact energy than N-type hammer. An attempt was made to compare R values with uniaxial compressive strength (UCS) and density of selected variants. It was also observed an exponential relation with UCS, and with the density for selected weathering grades.*

Key Words: Schmidt rebound hammer, Impact energy, weathering, hardness.

1. INTRODUCTION

Weathering of rocks is a result of the destructive processes from atmospheric agents at or near the Earth's surface. It largely affects the physical and mechanical properties [7,8,11,12]of rock material. It is the process that involves disintegration and decomposition of rocks in nature. Majorly, engineering classification of weathering [10] varies in to five categories namely unweathered (Fresh Rock) –slightly weathered- moderately weathered-highly weathered-residual soil.

In this study, the rock core specimens were grouped qualitatively in to three weathering grades[6] based on colour, surface texture and friability (rock to soil ratio) namely - Fresh Rock (FR), Slightly Weathered Rock (SWR), and Moderately Weathered Rock (MWR).The main objective of this paper was to understand the effect of weathering on Schmidt rebound hardness values of Biotite Gneiss collected from Eastern Ghat belt of southern peninsular India. However, determination of the rebound hardness values in laboratory conditions is sometimes very difficult for weak friable rocks and for foliated/fissured rocks, due to the fact that the samples can be broken during the test. Accordingly, recent publication of Aydin [3], on revised version of Schmidt hammer test, 20 rebound values averaging the upper 10 readings should be recorded from single impacts separated by at least a plunger diameter. In addition, based on the revised version, the test may be stopped when any ten following readings differ only by four. Aydin also stated that the UCS values of a material are strongly affected by the density, distribution and connectivity of its weak micro structural elements; thus, low and high rebound readings are equally necessary to reflect the nature of heterogeneity. Accordingly, in the present investigation, no reading is discarded; the mean (arithmetic average) values were presented to fully explain the variations of surface hardness for three weathering grades.

The instrument measures the distance of rebound of hammer in controlled impact on rock surface. For this purpose, tests were also performed by L-type (0.735N/m) and N-type (2.207N/m) Schmidt hammers, to delineate the sensitivity of impact energy on selected variants of rock. ISRM [10] suggested minimum 54.7mm and 84mm diameter specimens for use of L-type and N-type hammers, however, in the present case both hammers were used on same size of specimens to understand correlation among them. From the past studies[1,2,4], it was revealed that the large variation in results could possible when using N-type Schmidt hammers due to high impact energy. Whereas, L-type hammers with low impact energy of 0.735 Nm, is marginally influence by microstructures. Additionally, Li [5, 9] showed that the Schmidt impact hammer is not appropriate for very soft plastic rocks and extremely hard rocks. Aydin [3] proposed that L-type hammers give better results when testing in weak, porous and weathered rocks, thus caution should be exercised with hard rocks, which could lead to deviations. In the present study, an attempt was also made to compare rebound values with uniaxial compressive strength (UCS) and density of the selected variants. All these investigations have been carried out on dried rock core specimens as per procedures of ISRM [10] suggested methods.

2. METHODOLOGY

1. Mineralogical Composition of Rock Variants

The average composition of minerals through XRD (X-ray diffractions) analysis on powered samples of three grades of weathering is determined as shown in Table-1.Here, Cukα radiation (λ = 1.5404A°) is used for generating diffraction patterns. It is observed that Labradorite(La), Biotite(B), Quartz(Q), Feldspar(F), Plagioclase (Pl) minerals are majorly exposed in three grades of rock variants. The X-ray diffraction patterns of three grades of weathering (counts v/s 2-THETA) are as shown in Figure-1-3.

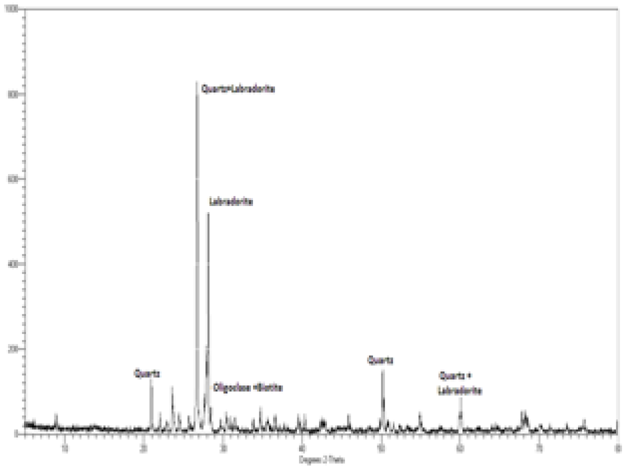

Figure-1 : Diffraction Pattern for Fresh Rock

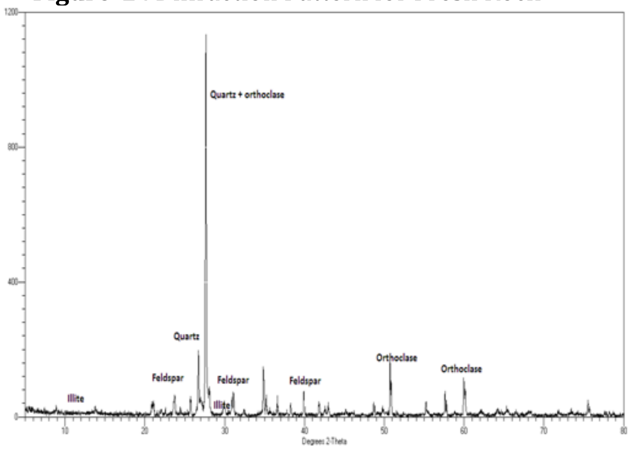

Figure-2 : Diffraction Pattern for SWR

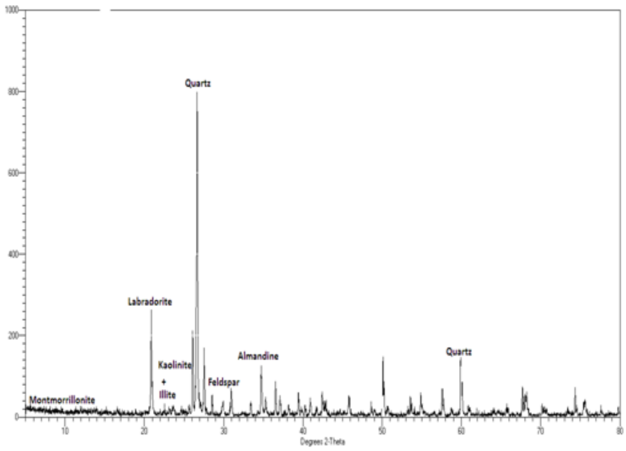

Figure-3 : Diffraction Pattern for MWR

2. Determination of UCS and dry density

The uniaxial compressive strength (UCS) was evaluated for NX size (54.7 mm) cylindrical cores with length to diameter ratio of 2.5 under dry conditions by applying loading axially until the specimen fails. And, the dry density is calculated by measuring dry weight and volume of regular shaped cylindrical cores. These investigations are carried out as per ISRM [10] suggested methods.

Table-1 Mineralogical Composition

Mineral	FR	SWR	MWR
La (%)	48.4	8.2	8.9
B (%)	3.0	9.3	15.8
Q (%)	27.1	48.2	7.3
F (%)	1.5	14.1	47.6
Pl (%)	20	14.9	10.0
Clay (%)	-	5.3	10.4

3. Determination of Schmidt Rebound Hardness

For the present study, L-type and N-type hammers were used to obtain rebound values of rock cores. For this, at 20 distinct points single impact readings were recorded and average of these recorded values is obtained without discarding any value. The test surface of specimens was fairly smooth without any noticeable cracks and at least two plunger diameters were maintained to separate each impact point. No reading was discarded unless the impact produced visible cracks and /or chips on the test surface. Ten samples were tested for each weathering grade. The procedure followed as per ISRM [10] suggested method.

3. RESULTS AND DISCUSSION

1. Correlation between RL and RN values

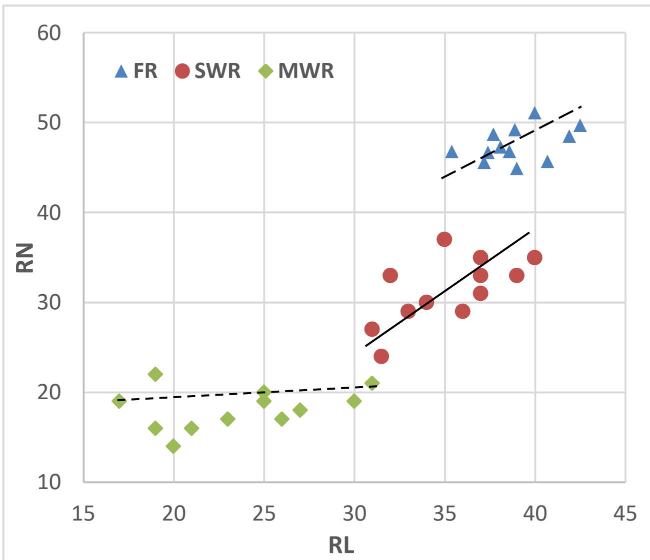

Chart-1: Relationship of RL and RN values

Chart-1 shows the correlation between Rebound values of L-type (RL) and N-type (RN) for different weathering grades. It reveals a good linear correlation for FR and SWR grades in comparison with MWR.

It is inferred that for MWR grade, N-type hammer becomes non significant for rocks which are highly weathered, soft & weak in nature with rebound values under high impact energy. Hence, L-type hammers could give better results when tested for soft and weak rocks due to its lower impact energy.

Moreover, it is also observed that the rebound values are decreased with the increase of weathering. This is a consequence of micro structural changes that occurred in the rock during course of weathering.

2. Effect of Weathering on R and UCS

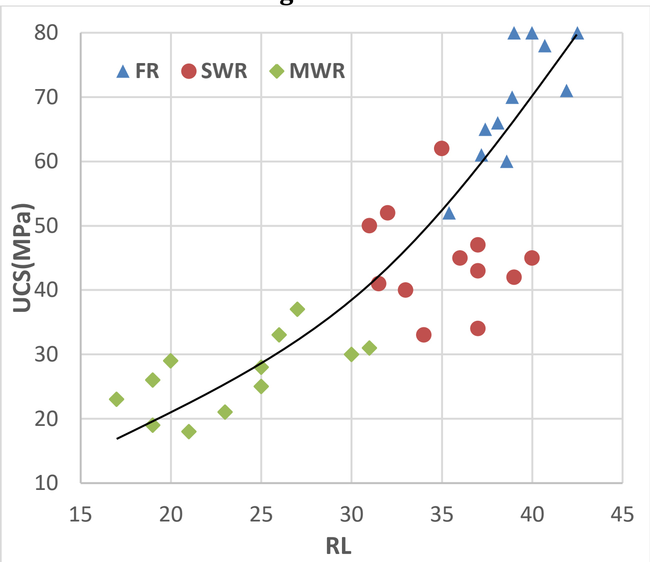

Chart-2: Variation of RL values with UCS at different weathering grades

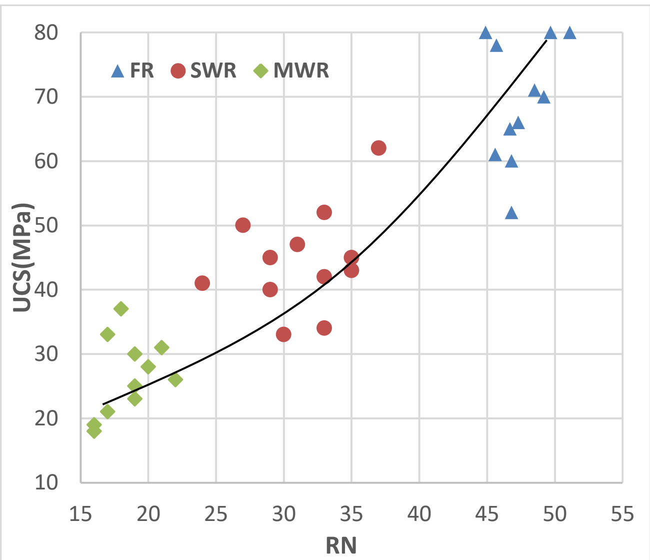

Chart-3: Variation of RN values with UCS at different weathering grades

From the above Chart-2 and Chart-3 it is observed that UCS values are decreased as the weathering increases. Also, the R values (both RL and RN) varied exponentially with the UCS test data.

It is also observed that the scatter in the data is higher for SWR and MWR grades when L-type hammer is used. It is inferred from this that L-type hammer reflected high sensitivity to rock intrinsic properties and micro-structural changes due to lower impact energy.

3. Effect of Weathering on R and Density

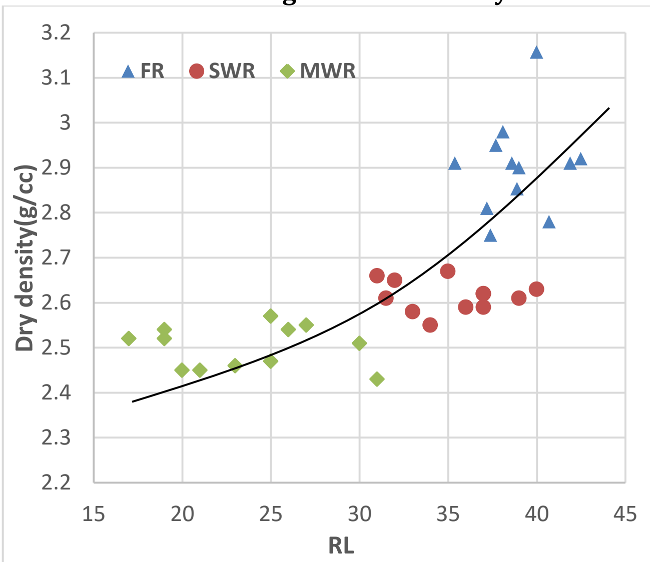

Chart-4: Variation of RL values with Density at different weathering grades

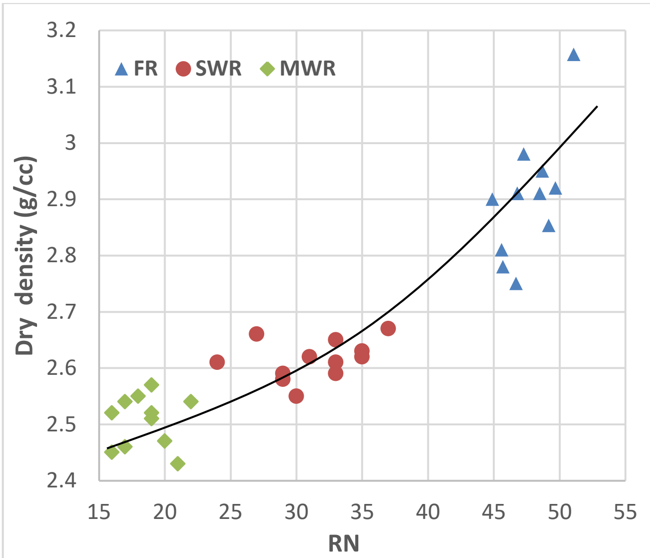

Chart-5: Variation of RN values with Density at different weathering grades

Generally, density is strongly correlated with UCS for most of the rocks. In the present case, similar to UCS, density is also varied exponentially with the R values both in L-type and N-type hammers.

However, L-type hammer resulted in high scatter in comparison with N-type hammer for all selected weathering grades due to increasing sensitivity to rock heterogeneity under lower impact energies.

5. CONCLUSION

The results showed a good linear correlation between rebound values of L-type and N-type hammers. Except for FR, the rebound values of L-type hammer were higher than N-type hammer for SWR and MWR grades of weathering. Both types of hammers are equally suitable for obtaining rebound results of rocks. However, for the same weathering grade, scatter in the data is significant for L-type hammers. It is inferred that L-type hammer was reflected greater sensitivity to rock heterogeneity and to the changes in microstructures of weathering grades with lower impact energy than N-type hammer. As noticed from the past studies, in the present case also the rebound values are decreased with the increase of weathering. It was also observed that rebound values are exponentially varied with UCS, and with the density for selected weathering grades.

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