Effects of weathering on geotechnical properties of basalt rocks from the Vidarbha region in Maharashtra, India

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ABSTRACT: It is well known that the degree of weathering largely affects the geotechnical properties of rocks. Study of rock properties vis-à-vis degree of weathering and the site-specific parameters obtained through recovered rock core pieces during drilling is supposed to be useful for various engineering purpose. A similar effort has been made in the present study. Bore logs data were collected for different sites from Vidarbha region in Maharashtra, India, where basalt rocks are encountered. Based upon field identification, extent of weathering in various rock core pieces collected from different depths in boreholes at different locations was identified along with the determination of RQD value. Further, variation of some rock properties (viz., density, water absorption value, and unconfined compressive strength) with depth was studied. Results obtained from the analysis are presented and discussed in this paper.

Keywords: Basalt rock, Weathering, Depth, Unconfined compressive strength, Rock quality designation.

1 INTRODUCTION

Weathering is one among the major factors which influences the geotechnical properties of rocks. Some of the issues related to weathering of rocks includes surface erosion, formation of subsurface voids and cavities, landslides, loss of bearing capacity, slope failure etc. Weathering brings changes in texture, mineralogical composition and lithological characteristics which in turn affects the engineering properties of rocks. According to researchers (Ollier 1984, Dearman 1995, Undul & Tugrul 2012), weathering is defined as a phenomenon of disintegration and decomposition of rocks caused by physical, chemical and biological interactions together, with the surrounding environment. Several researchers (Irfan & Powell 1985; Zhao et al. 1994; Haskins & Bell 1995; Karpuz and Pasamehmetoglu 1997; Moon & Jayawardane 2004; Orhan et al. 2006; Undul and Tugrul 2016) have emphasized on the weathering effects of rocks on its index and engineering properties. Further, researchers have tried to correlate the engineering properties of rocks w.r.t. extent of weathering. For example, Rigopoulos et al. (2011) have correlated the initiation of microcracks and its propagation to the uniaxial compressive strength (UCS) results in fresh and

weathered ultrabasic rocks. Similarly, Kilic et al. (1999) have studied the relationship between weathering and geo-mechanical properties of ophiolitic rocks. Again, it is worth mentioning that the weathering effects on engineering properties of rocks are mostly region or site- specific (Gurocak & Kilic 2005).

Keeping this in view, the variation in the grade of weathering with depth for the basalt rocks from Vidarbha region in the state of Maharashtra, India, was studied. Rock core pieces from different depths and from different locations were collected through borehole drilling and the RQD value (Rock Quality Designation) along with UCS (Unconfined Compressive Strength), Rock density, water absorption value was determined. Based on this database from borehole drilling and laboratory tests, the weathering pattern with depth and its relation to RQD, UCS, density and water absorption value are studied and presented in this paper.

2 GEOLOGY OF THE AREA

The Vidarbha region is a part of Maharashtra state in India. Vidarbha lies between 19^0 to 21^0 North latitude and 76^0 to $80^030'$ east longitude in the eastern part of Maharashtra as shown in Figure 1. From the existing literature, it is found that Bhandara and Gondia which are among the districts of Vidarbha region are partly occupied by metamorphic rocks and alluvium deposits which make their geology unique in the state (Ali et al. 2016). Otherwise, most parts of the Vidarbha region are occupied with basaltic rocks which are part of 66-million-year-old volcanic Deccan Traps.

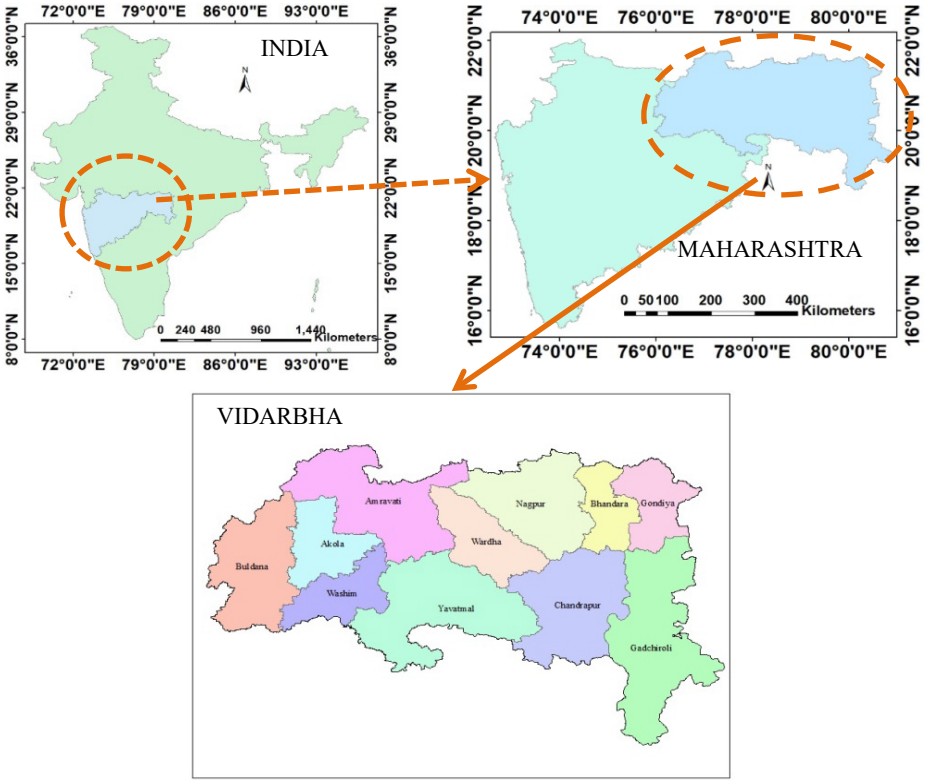

Figure 1. Location of the study area.

3 GEOTECHNICAL STUDIES

Borehole drilling was carried out up to a depth of about 25-30 metres at 40 different locations in the region as mentioned above. Based upon field identification, grade of weathering in all the rock core pieces was identified and further the RQD value was determined (per meter run). Laboratory

tests were conducted to determine the dry density, UCS and water absorption value of the rock core pieces as per ISRM 1981.

4 RESULTS AND DISCUSSIONS

In order to see the variation in the UCS value with depth, the rock core pieces were divided into five groups as per Table 1 (viz., I, II, III, IV and V).

Table 1. Rock classification as per UCS value (Geology National Engineering Handbook 2012).

UCS Group	UCS (MPa)	Description of rock hardness
I	0.6 to 5	Very weak to weak
II	5 to 50	Weak to moderately weak
III	50 to 100	Moderately weak to strong
IV	100 to 250	Strong to very strong
V	>250	Extremely strong

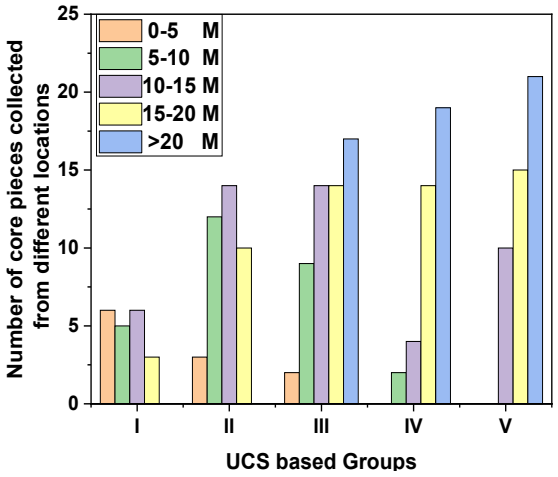

Figure 2. Availability of rock samples with different UCS value for different depths.

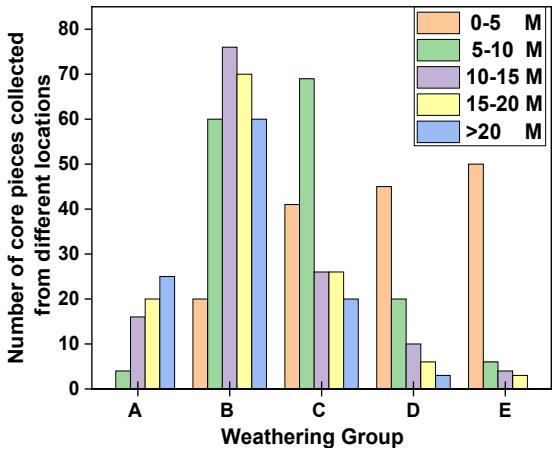

Figure 3. Rock samples with different grade of weathering found at different depths.

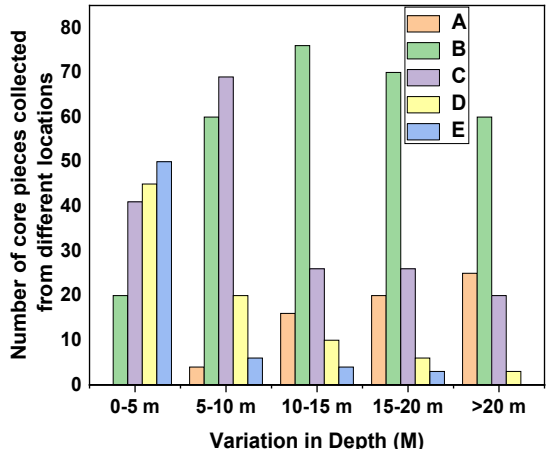

Figure 4. Variation in weathering of rock samples with depth.

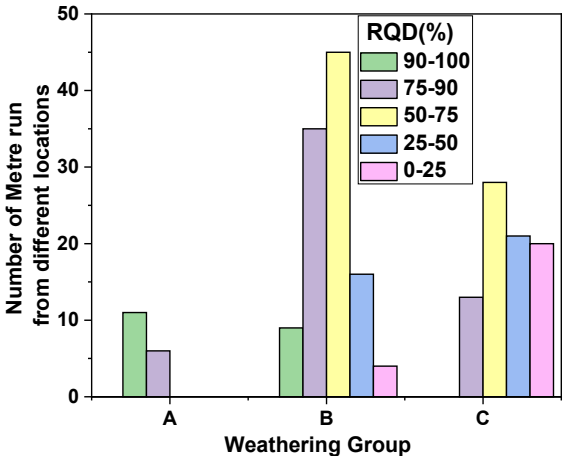

Figure 5. Variation in RQD w.r.t. weathering.

The UCS results obtained from the core pieces with depth are plotted in Figure 2. It was found that the core pieces found below a depth greater than 20m are moderately to extremely strong with UCS value varying from 50MPa to more than 250MPa. On the other hand, rocks found within a depth of 5m are very weak to moderately weak with UCS value less than 50MPa.

Further, all the rock core pieces were classified and divided into five groups (viz., A, B, C, D and E) based upon the grade of weathering as per Table 2.

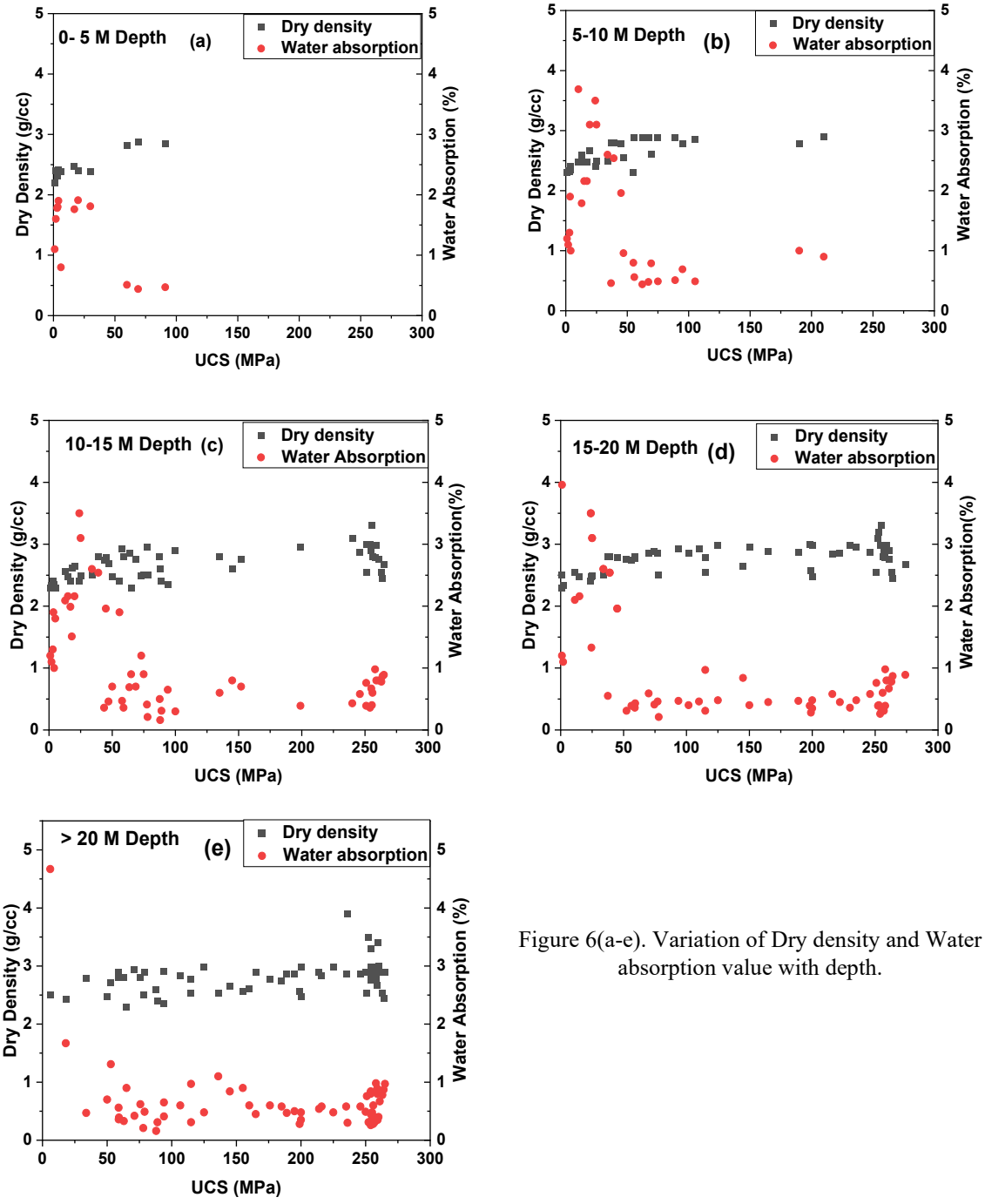

Figure 6(a-e). Variation of Dry density and Water absorption value with depth.

Table 2. Rock classification as per the extent of weathering (Engineered group of geological society working party 1995).

Weathering Group	Degree of weathering
A	Fresh to Slightly weathered
B	Slightly to Moderately weathered
C	Moderately to highly weathered
D	Highly to completely weathered
E	Completely weathered to Residual soil

In order to understand the weathering pattern w.r.t. depth or in other words to know the possible grade of weathering in any rock sample collected from a particular depth, the frequency (i.e., nos. of time) of rock core pieces recovered is plotted against the corresponding weathering group and depth as shown in Figure 3 and Figure 4, respectively. Based upon the results obtained, fresh to slightly weathered rock is hardly found within a depth of 5m. Beyond a depth of 10m, the core pieces obtained are mostly slightly to moderately weathered with the remaining identified as fresh to slightly weathered and moderately to highly weathered rock.

RQD value was determined for every one-meter run of core drilling in different boreholes and the results are plotted in Figure 5. Based on the findings, it can be said that the RQD of fresh to slightly weathered rock is more than 75%; RQD of Slightly to moderately weathered rock is mostly in between 50 to 90% and RQD of Moderately to highly weathered rock may vary from 0 to 90%.

Figure 6(a-e) shows the correlations between UCS value and the dry density as well as the water absorption value of the rock core pieces for different range of depths. The rock density is found to increase very marginally with increase in the UCS value. On the other hand, the water absorption value decreases with increase in the UCS value for very weak to moderately weathered rocks (i.e., up to 50MPa) and remains almost constant thereafter.

5 CONCLUSIONS

The present study is site and location specific and hence the need of detailed geotechnical investigations should not be ignored for any specific project. However, the results presented in this paper are supposed to be very helpful during the initial planning stage of any infrastructure development projects in the Vidarbha region of Maharashtra, India. It will be very interesting to conduct similar studies on other parts of the globe where basalt rock is found and to compare the results. The authors opine that different patterns will be found even for the same basalt rock due to varying weathering and climatic conditions.

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