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# Characterizing the Strength of Different Deccan Traps by Evaluating the Mechanical Properties. In Some Indian River Valley Projects.

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***ABSTRACT***

***Assessing the strength of an intact rock is important in design of a range of civil structures associated with the river valley project. It could be successfully achieved from assessing the mechanical properties of the rock under consideration. Thus integrated studies of civil engineering, mechanical engineering and as well as geology and rock mechanics, included in this paper, describes an attempt made for different rock types encountered in the various river valley project sites situated in the Deccan trap basaltic region of Maharashtra state, India. Mechanical rock properties like p-wave velocity, density, young's modulus and uniaxial compressive strength are determined in the laboratory for Massive Basalt (MB), Amygdaloidal Basalt (AB), Volcanic Breccias (VBr) and Volcanic Tuff (VT). The findings indicate that there is an orderly change in the strengths of theses rocks which go behind as VT<VBr<AB<MB and this order is attributed to the variations in mineralogy, texture, structure etc, coupled with the rock formations.***

***Keywords***

***Mechanical properties of rocks, Strength of rocks, Deccan Trap basalts, River valley projects.***

## 1. INTRODUCTION

The achievement of good foundation for a civil structure lies on the strength of the rock at its bed. Various civil structures are foreseen in the development of a river valley project depending on the type of task like irrigation, hydro electric, thermal power generation, nuclear power generation projects and their intake tunnels/ out-falls etc. In Maharashtra state of India many civil structures of such projects found to lie on Deccan trap rocks having varying strengths owing to textural, structural and mineralogical differences raised from the volcanic activity. In simple, these variations are responsible for variations in the mechanical properties of the rocks rendering to the strength of a rock. Keeping this in view, some studies carried on different Basaltic rock types viz. (1) Volcanic Tuff (VT). (2) Volcanic Breccias (VBr), (3) Amygdaloidal Basalt (AB) and (4) Massive Basalt (MB) are evaluated in this research work such that charactering the strengths would become a tool for selecting the rock type for trouble-free foundations in the river valley projects under description. In this approach laboratory testing is carried out for determining the mechanical properties of the various rock types. These properties comprise determination of (1) p-wave (seismic) velocity (2) Static Modulus of elasticity (young's modulus), (3) Uni-axial compressive strength (UCS) and (4) Density by following respective guidelines of Bureau of Indian standards (BIS). The results indicate that VT and VBr rocks are relatively weaker than those of MB and AB rock types as arrived from the laboratory measurements of various physical properties and engineering strength parameters. Thus the succession of rock strengths inferred was found to be as VT < VBr < AB < MB. This class of charactering the rock strengths would be useful in selecting a good foundation site, appropriate to the load of the super structure, elsewhere in similar geological set ups besides en-lighting the knowledge of student civil engineers in implementing the technologies to shape future in India to stand on the same platform along with other developed counties in the world. .

## 2. GEOLOGY

Deccan trap basalts of upper cretaceous to Lower Miocene age are horizontally bedded and cover most of the parts of Maharashtra, wherein some river valley projects are envisaged for development .The eruption of basalt lava flow under open air has given rise to volcanic deposits like volcanic tuff (VT) and volcanic breccias (VBr) .Similarly, the lava deposits in the sub-aerial situations has given rise to different rock verities viz. Amygdaloidal basalt (AB) and the Massive Basalt (MB),also known as blocky basalt.

## 3. METHODOLOGY

### 3.1 P-wave (seismic) velocity

The velocity of propagation of elastic waves in rock cores in laboratory is carried out by high frequency ultrasonic pulse technique. Cores of length greater than the wavelength of the pulse used, are utilized .The transmitter is pressed to the centre of a plane perpendicular to the direction of wave propagation. The receiver is positioned on the plane opposite to the plane, to which transmitter is pressed .The velocities of either P- or S-waves are calculated from the measured travel time and the distances between the transmitter and receiver (ASTM D 5777-00-2011). Sine wave pulses of frequency between 100KHz to 2MHz were used.

### 3.2 Static modulus of elasticity (young's modulus)

Static modulus of elasticity of rock specimens for regular geometry in uniaxial compression is determined, in which two electrical strain gauges are mounted on the opposite sides of the specimen and is set in the measuring apparatus. The strain gauge terminals are connected to the measuring apparatus .Load on the specimens is applied continuously at a constant stress rate such that failure occurs within 10 to 15 minutes of loading (or at a stress rate within 0.5 to 10 MPa/ sec). Load and strains are recorded at evenly spaced load intervals. A few cycles of loading and unloading are performed. The compressive stress is calculated by dividing the compressive load on the specimen by the original cross sectional area of the specimen (BIS No. 9221:1979) and is determined in GPa by:

EL = Axial Stress / Axial Strain

### 3.3 Uniaxial Compressive Strength (UCS)

The uniaxial compressive strength (UCS) provides a way to determine rock strength at a specific location or depth .It is determined from samples (NX size ) of regular geometry .Straigth circular cylinders having height ti diameter ratio of 2.5 to 3 are prepared and load on the specimen is applied continuously on a constant rate such that failure occurs within 10 to 15 mins of loading ( or at a stress rate with in 0.5 to 10 MPa/sec). The maximum load on the specimen recorded and UCS is determined by dividing the maximum load carried by the specimen by the cross sectional area of the specimen (BIS No. : 1992 & BIS No.9143:1979).

### 3.4 Density

The density of the rock mass affects the strength of the rock Generally, as the dry density increases, the strength also increases. It is determined in the laboratory by selecting samples of mass greater than 50g.The sample is weighed in air and then in water .If Wa is the weight of the sample in air and Ww its weight when immersed in water, then its density is:

$$P = \frac{Wa}{Wa - Ww}$$

Assuming that water is pure H2O at 25o (Balco and Stone, 2003).

## 4. Results and Discussions:

Table -1 provides the results of the mechanical properties of the various rock types encountered in the Deccan trap basaltic province of Maharashtra state. These various rock types, comprising VT, VBr, AB and MB, have gradational contrast in their mechanical properties. The average p-wave velocity is maximum in MB samples .Of the three tested samples tested, it varies between 4.3 and 5.9 Km/s. The same for four AB samples is between 3.5 and 5.7 Km/s. However, this value for VBr and VT rock samples is 4.38 Km/s and 3.2 Km/s respectively. This indicates that the values of p-wave velocity follow the order as: MB>AB>VBr>VT. However, in porous and saturated rocks the increase in velocity does not always represent a higher strength. Therefore, velocity alone is not a suitable parameter for evaluating rock strength (Goel, 2002).There is not much variation in the densities of four rock types (For MB = 2.6-3.0 gm/cc, AB = 2.3-2.9 gm/cc, VBr = 2.3 gm/cc and for VT = 2.4 gm/cc). Similar to the attribution of P-wave velocity and strength of rock, the higher value in density may not always correlate with higher strength of rock.

The Static Modulus of Elasticity determined for these also follows the same order, In this test, the results show that the average value of MB and AB rock samples varies between 50 and 80 GPa. and 19.5 and 31.0 GPa, in order respectively. However, it is 16 and 31.8 GPa for VB and VT rock samples respectively.

The unconfined compressive strength (UCS) test results also lie in the same track, wherein the average value for MB rock samples ranges between 77 and 194 MPa whereas it is between 30 and 156 MPa for AB rock samples .But this value is relatively less in VBr and VT rock sample, consisting of 26.0 and 9.0 MPa respectively.

From the above results it can be inferred that there is a graduation in all the mechanical properties of four rock types tested as: MB>AB>VBr>VT. As the mechanical properties of rocks have direct bearing on their strength, it can be easily assessed that VBr and VT rocks have less strength. This could be attributed to their variations in the mineralogical and textural characteristics; the description of which is out of place in the present studies.

## 5. Conclusions:

- Characteristics of rock strengths are one of the important keys to assess sound rock, upon which the design any civil super structure in the development of river valley project could be better relies and hence the phenomena of characterization of rock strength to be considered before looking for good design to ensure stable structure.
- The laboratory testing of different Deccan Trap Basaltic rock types viz. VT, VBr, AB and MB for evaluating the mechanical properties and thereby correlating their strengths suggest that there is a gradation in all the mechanical properties of four rock types and accordingly their strengths follow an order as: MB>AB >VBr>VT. Such evaluation could be used to depict the subsurface conditions and interpreting the rock engineering properties and to incorporate in the design parameters for a stable and successful structure in the development of any river valley project in the similar geological environs elsewhere.

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acquainted with the research subject, much useful in their Bachelor and Master of Technology degree courses and thus enlightening their knowledge thereto.

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**Table.1: Mechanical Properties of Different Rock Types at Different River Valley Project Sites, Maharashtra State.**

Table.1: Mechanical Properties of Different Rock Types at Different River Valley Project Sites, Maharashtra State.

| Sl no | Location | Rock Type | No of samples tested | Average values of intact rock properties | | | |
|---|---|---|---|---|---|---|---|
| | | | | p-wave velocity (km/s) | Density (gm/c c) | Static Modulus of Elasticity(GPa) | Uniaxial Compressive strength (MPa) |
| 1 | Worli bandra outfall | VT | 4 | 3.2 | 2.4 | 3.18 | 9.0 |
| 2 | Koyna HE project,stage IV,Maharashtra | AB | 3 | 3.80 | 2.60 | 26.9 | 30.0 |
| 3 | Sewree tunnel,Mumbai | VBr | 5 | 4.38 | 2.30 | 16.0 | 26.0 |
| 4 | Malbarhili tunnel,Mumbai | AB | 7 | 3.90 | 2.30 | 23.0 | 33.0 |
| 5 | Bhandardara HE,Maharashtra | AB | 2 | 3.50 | 2.30 | 19.5 | 41.0 |
| 6 | Wan project,akola,maharashtra | MB | 4 | 5.90 | 3.00 | 80.0 | 79.0 |
| 7 | Ghatgar HE project,Maharashtra | MB | 3 | 4.30 | 2.60 | 50.0 | 77.0 |
| 8 | Mora(uran),Mumbai | AB | 5 | 4.10 | 2.60 | 31.0 | 51.0 |
| 9 | Tilari interstate irrigation project,sindhadurg,Maharashtra | AB | 4 | 5.70 | 2.90 | 23.5 | 156.0 |
| 10 | Ruparel college ,mumbai | MB | 6 | 5.80 | 2.90 | 73.0 | 194.0 |