RELATION BETWEEN INDEX PROPERTIES AND UNIAXIAL COMPRESSIVE STRENGTH (UCS) OF GNEISSIC ROCKS

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Abstract **:** This paper presents the results of 20 samples from laboratory experiments carried out to determine UNIAXIAL COMPRESSIVE STRENGTH (UCS) and INDEX PROPERTIES (specific gravity, dry density, saturated density) of gneissic rock samples.The cylindrical core of 100cm of Gneissic rocks have been drilled out by Rotary driiling with Diamond Bit of NX (54mm) casing size from 50 meter depth at the construction site in Byrnihat, Meghalaya. All tests were carried out according to IS Code 2720 and IS Code 9221-1979 for the gneissic rocks of Meghalaya.. An estimation of the relation between stress and strain is determined by using Hook's Law Table1.shows good corelationship between UCS and index properties-specific gravity,saturated density and dry density which were proved to be suitable for an immediate requirement during the construction.

IndexTerms-Uniaxial Compressive Strength, Index Properties, Hook's La

I.INTRODUCTION

Rock strength is a very important criterion in order to optimize construction usage and surface or subsurface structure designs**(Yilmaz,2009).**Some authors believe that the textural and compositional characteristics of rock affect the strength of rocks**(Kahraman et.al, 2005).** The term 'Rock Strength' refers to its ability to resist the force that causes shear failure or deformation. It is a very important property or characteristics of rocks in terms of Geotechnical and Engineering purposes. The rock strength varies from rock to rock depending on some specific properties called 'Index Properties'such as specific gravity,density, water absorption capacity, void ratio that plays an important role as rock strength parameter. The use of such parameters are often useful to determine the strength of rocks .

Several works have been conducted to represent the relation between index properties and strength of different rock types,**Tungal and Zarif (2000)**.**Turgul** and **Gurpinar(1997)** investigated the Weathering Classification and Engineering Properties of Basalts from the Niksar Region of Eastern Turkey.They found that Uniaxial Compressive Strength decreased to almost zero as the dry density of the rock material decreased to 2g/cm³. With the increase in weathering grade,the UCS decreased with increased porosity.**Marques and Pereira(2015)** in their investigation on correlation between UCS and Point load strength for some Brazilian high-grade metamorphic rocks found 37.93MPa(UCS) for porosity 2.35% and water absorption capacity 0.85%.

II.Laboratory test for Rock strength and Index properties

The strength of rocks has been obtained by carrying out the UCS tests of rocks in the laboratory. The cores of Gneissic rocks were cut into test specimens of 11cm length(L) and 5cm diameter(D) and the ends of the specimens were polished to acquire smooth and even surface free from abrupt irregularities and straight to within 0.3mm over the full length of the specimen in laboratory. The diameter of the test specimens were measured to the nearest 0.1mm by averaging two diameters measured at right angles to each other at about the upper height, the mid height and the lower height of the specimen not varying by more than 0.3mm over the length of the specimen. The value of rock strength has been obtained by using the following calculation-

$$Q_U = F*127.388/\pi r^2$$

Q_U = Compressive strength.

F = Force = Failure load*Proving ring constant.

(Indian Sandard Code: 9221-1979; Re-affirmed 1996 and 2001)

Fig:1 Failure of test sample

Fig:2 Uniaxial Compressive Strength Apparatus

III.The specific gravity is obtained by using Archimedi's Principle

Apparatus required: Analytical balance and weight Specific gravity bottle-500 ml with capillary tube stopper, Thermometer, Drying oven,Weighing bottle and dessicator. For the determination of specific gravity of gneissic rock samples,the rock samples are crushed to small pieces so that the density bottles can be filled easily.

The specific gravity is calculated from the following formula by using Archimedis Principle-

$$G_0 = \frac{W2-W1}{(W4-W2)-(W4-W2)}$$

W_2= Weight of bottle with stopper and sample
W_1= Weight of empty bottle with stopper
W_4= Weight of bottle with stopper filled fully with water
W_3= Weight of bottle with stopper +sample filled fully with water

(Indian Standard Code:1122-1974; Reaffirmed 2003)

Fig:3 Specific Gravity Samples

Fig:4 Measuring weight of crushed test sample

Fig:5 Measuring dimensions of cylindrical test specimen

IV.Methodology: The following methodologies has been used for determining different index properties-

Density:

$\gamma = \frac{m}{v} = \frac{w}{v}$, where

w = mg (weight)

v = volume

Porosity(n_o) :

$$n_o\ (\%) = \frac{Volume\ of\ voids(Vv)}{Total\ volume\ of\ rock} * 100$$

Water absorbtion (W_A):

$$W_A = (M_W/M_S)*100, \text{ where}$$

M_W = Mass of water

M_S = Mass of solid

V.Study area

Location:

The Byrnihat area in Ri bhoi district of Meghalaya near Nongpoh has an area of 2448 square kilometer and lies between E91°20' and E92°17' longitude and N25°40' to N26°20' latitude. It is bounded in the north by the Kamrup district of Assam, east by the Karbi Anglong district of Assam, south by the East Khasi Hills and west by the West Khasi Hills district. Byrnihat is well connected with Guwahati and Shillong by National Highway 40.

Geology and geomorphology of the study area:

The rocks of gneissic complex,comprising quartzo-feldspathic gneiss with enclaves of granites, amphibolites, schists etc occupy major part of the Byrnihat area. Shillong group of rocks consisting of quartzite and phyllite are laid down as sedimentary deposits during the Pre- cambrian times and have been metamorphosed over time, are exposed in the south-eastern part of the district. The quartzites are moderate to steeply dipping rocks having a trend in NE-SW direction. These rocks were intruded by epidiorite rocks known as Khasi Greenstone. These metabasic rocks occur mostly as sills being concordant with the formation they intruded. Granite plutons occur as porphyritic coarse.The hills comprise Archean gneissic complex rocks, which are highly deformed, fractured and fissured in nature.

Geomorphologically, Byrnihat is a hilly region with intermontane valleys. They are intruded by basic and ultramafic rocks, which occur as linear or curvilinear ridges. The drainage system is controlled by topography. The drainage pattern shows annular, trellis, sub- dendritic type, which also indicate the structural control.

General Geological Succession

Geological Age	Group	Formation	Rock type
Quaternary			Undifferentiated fluvial sediments

---unconformity---

Neo- Proterozoic	Nongpoh granite	Granite plutons	Porphyritic coarse

Lower Proterozoic			granite, pegmatite, aplite/quartz vein etc

Intrusive contact

Proterozoic (undifferentiated)	Khasi basic – ultrabasic intrusives	Epidiorite, dolerite,amphibolite and pyroxene dykes and sills
Palaeo-Mesoproterozoic	Shillong group	Upper division - mainly quartzites intercalated with phyllites. Lower division - mainly schists with calc silicate rocks, carbonaceous phyllite and thin quartzite layers.

------------------------------------unconformity(sheared conglomerate)--------------------------------

Gneissic Basement

(Government of India, Ministry of Water Resources, CENTRAL GROUND WATER BOARD RI BHOI DISTRICT, MEGHALAYA) Technical Report Series: D, No: 48/2011-12, September, 2013.

Test Results:

Table: Average values of various Index Parameters.

Sl.no	UCS(apparatus lab test) σ,ϵ R^2=0.9993	UCS G_0 R^2=0.1672	UCS Y R^2=0.1922	UCS Ys R^2=0.1465	UCS η_o R^2=0.0819
1	91.739	2.632	2.632	2.688	0.056
2	333.270	2.649	2.628	2.636	0.008
3	542.356	2.667	2.634	2.646	0.012
4	837.586	2.667	2.647	2.654	0.023
5	491.709	2.667	2.605	2.628	0.022
6	592.252	2.667	2.667	2.689	0.017
7	216.151	2.685	2.64	2.657	0.022
8	1151.544	2.685	2.667	2.689	0.018
9	972.239	2.632	2.685	2.719	0.009
10	883.853	2.759	2.666	2.700	0.066
11	789.299	2.721	2.671	2.689	0.029
12	780.992	2.685	2.662	2.671	0.009

13	780.992	2.703	2.688	2.694	0.003
14	748.451	2.685	2.606	2.635	0.009
15	721.333	2.685	2.676	2.679	0.027
16	775.569	2.653	2.653	2.662	0.023
17	956.469	2.685	2.624	2.647	0.015
18	559.321	2.685	2.645	2.660	0.002
19	1161.813	2.667	2.661	2.663	0.002
20	1161.813	2.703	2.664	2.689	0.012

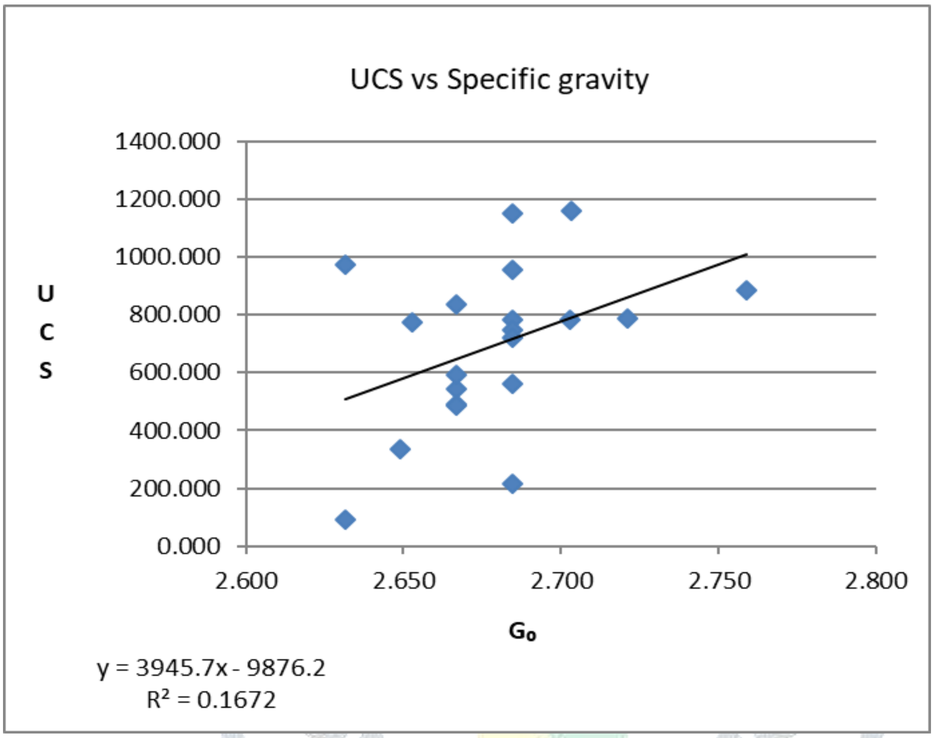

Fig:1 Correlation between UCS and Specific gravity

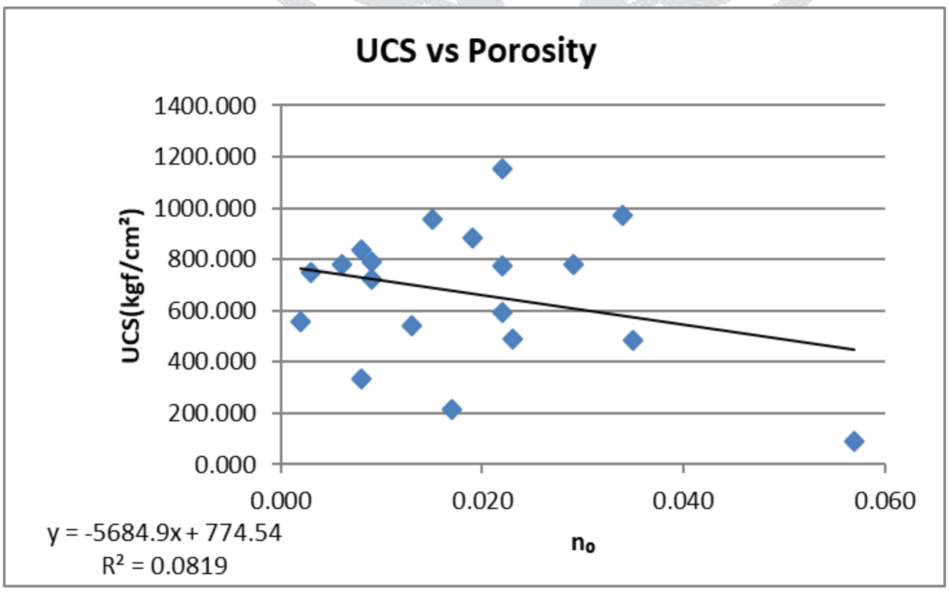

Fig:2 Correlation between UCS and Porosity

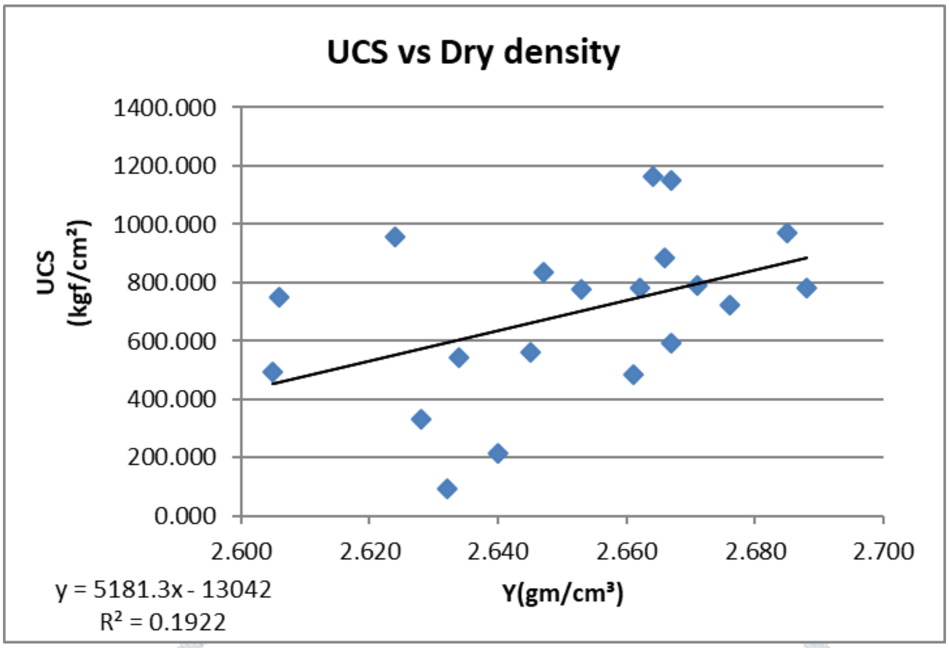

Fig:3 Correlation between UCS and Dry density

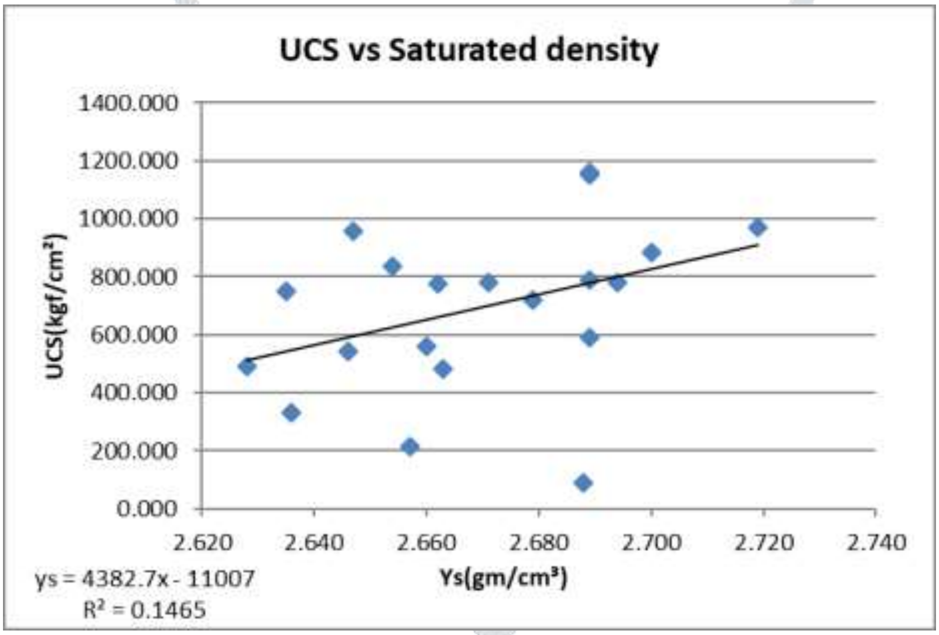

Fig:4 Correlation between UCS and Saturated density

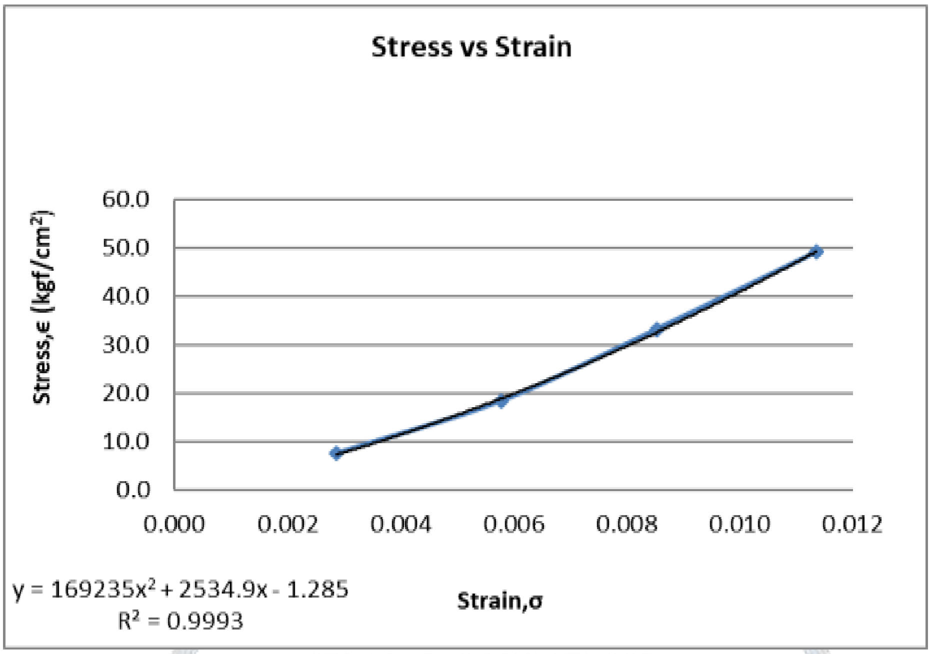

Fig:5 Correlation between Stress and Strain

V. DISCUSSION AND CONCLUSION

The values of Index Properties and UCS of gneissic rock samples are tabulated in table1.

The values are obtained by using Regression Analysis for determining the relationship between Index properties and UCS . The index properties; specific gravity, dry density, porosity and saturated density are plotted against UCS in scatter diagram shows a Coefficient Regression value,R^2as 0.1672,0.1922,0.0819 and 0.1465 respectively. All these values show a low accuracy as the accuracy range of R^2 value is 0-1. In figure5, the R^2 value of stress and strain for UCS is 0.999 which is near to 1 and hence show a high accuracy.

From the following experiments, it can be concluded that-20 laboratory tests of Gneissic rocks samples were conducted for finding correlation between index properties and UCS.The relations between UCS and index properties from the experiments show a considerable reliability,whereas, stress and strain gives a correlation value that has high reliability and degree of accuracy(R^2). Therefore, it can also be concluded that the index properties has effect on the strength (UCS) of rocks and the values obtained by laboratory experiments has been proved to be useful in this project.

Referrences:

[1] Turgul and Gurpinar, 1997; Weathering Classification and Engineering properties of Basalts from the Niksar Region of Eastern Turkey

[2] Marques and Pereira,2005;Correlation between UCS and Point Load Strength for some Brazilian high-grade metamorphic rocks

[3]Tungal and Zarif, 2000;Engineering Properties of Weathered Limestone found in Istanbul;

[4] Indian Standard Code;9221-1979, Re-affirmed 1996 and 1979

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[6] Kabilan.N,Muttharam,M ;Correlation between UCS and indirect tensile strength for jointed rocks

[7] Government of India, Ministry of Water Resources (CENTRAL GROUND WATER BOARD RI BHOI DISTRICT, MEGHALAYA) Technical Report Series: D, No: 48/2011-12, September, 2013.