iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 **Issue:** XII **Month of publication:** December 2014

DOI:

Volume 2 Issue XII, December 2014
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Effect of Moisture and Confining Pressure on Mechanical Behavior of Shiwalik Sandstone

Sana Zafar[1], K. S. Rao[2]
[1] Assistant Professor (Adhoc), M.M.M.U.T. Gorakhpur-273010
[2] Professor,Civil Engg. Deptt., IIT Delhi-110016

Abstract: The study for the effect of moisture on Shiwalik Sandstone has been carried out considering the different hydroelectric projects running in the foothills of the Himalayas. The strength of the rock depends upon its mineralogical composition, arrangement and orientation of grains, its physical and mechanical properties. For the proper accomplishment of the objectives different tests were conducted on the Shiwalik Sandstone sample.

Results show that the rock is a soft rock. The porosity of the rock obtained by the testing is quite high which shows that the rock becomes weaker by the ingress of water. Voids are clearly visible through the scanning electron microscopy. And so the fatigue behavior of rock is affected by the varying confining pressure.
Key words: Porosity, Moisture, Shiwalik Sandstone, Diffractogram, Cyclic load test, confining pressure

I. INTRODUCTION

The rocks are subjected to adverse climatic conditions. In order to estimate the long-term stability of the structures the effect of moisture is to be studied. This paper deals with the study of effect of moisture on the mechanical properties of Shiwalik Sandstone. Shiwalik Sandstone is a soft rock with high porosity and so the mechanical properties are highly effected by the moisture content and confining pressure because it is known for example that the strength and deformation characteristics of soft rocks show strong non- linearity [1]. Rock masses in different engineering applications are in a stressed state and are subjected to confining pressure. So it is necessary to study the effect of varying confining pressure on the dynamic properties of rock [6] .In the present study the fatigue life of rock is predicted under varying confining pressure. Cyclic load test was conducted at 5 and 7 MPa confining pressure [1]-[4]. After the experimentation the effect of varying confining pressure on the rock was analyzed and finally was compared to Berea Sandstone [4]

II. DESCRIPTION OF THE ROCK SAMPLE

Shiwalik Sandstone samples have been collected from the powerhouse location of UJH Multipurpose Project, Jammu and Kashmir. Different test were conducted on the Shiwalik sandstone so as to categorize the rock because fatigue of rock depends on the rock type and its mineralogical composition. For the accomplishment of the experimental program, N_X size that is 54 mm diameter cylindrical cores of Shiwalik sandstone were obtained from the sample collected from the site. After coring the samples were properly cut and lapped so as to satisfy the tolerance limit suggested by ISRM**.** According to the requirement of the testing different length to diameter ratio (L/D) specimen were prepared. In order to get the mineralogical composition and the grain size of the sample X-Ray diffraction and scanning electron microscopy test were conducted [13].

Fig. 1: Location of samples collection (at Powerhouse, UJH Multipurpose Project, J&K)

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

The X-Ray diffractogram for Shiwalik Sandstone is shown (fig.2). The peaks obtained in the diffractogram were compared by the literature [9] and minerals were specified. The sample on reaction with dilute HCl gave effervescence which shows the presence of carbonate. The results obtained from X-Ray diffraction shows the presence of **Quartz, Felspar, Chlorite** and clayey minerals like **kaolinite; illite** etc. Especially the percentage of quartz is high in the rock sample.

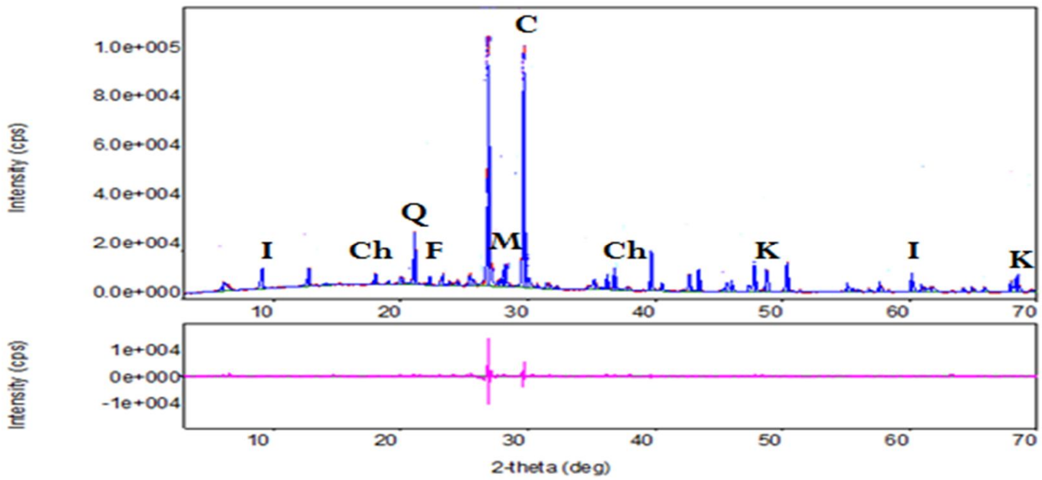


Fig. 2: X-Ray Diffractogram for Shiwalik Sandstone

SEM analysis has been carried out to study the morphology of the grains, grain size and the mutual contact between the grains. The samples used were fresh samples. As the rock is soft and highly porous so SEM analysis was highly required to get an idea of the voids or cracks present in the structure [8].

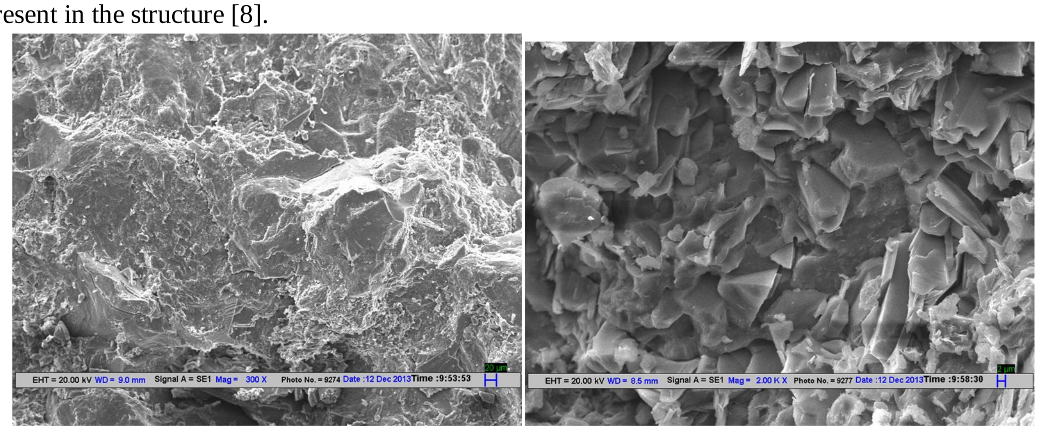


Fig.3: Shows the well sorted grains of quartz and flaky clay minerals

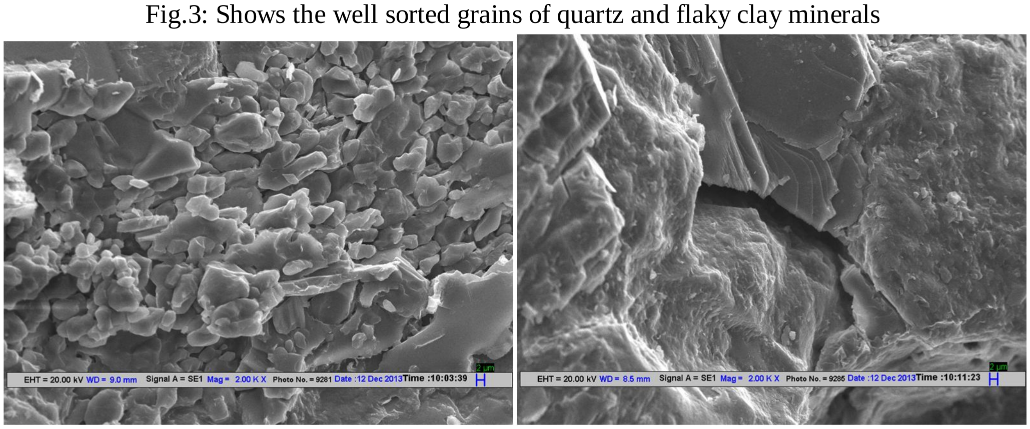


Fig.4: Hexagonal 2D grains of Kaolinite and voids present in the structure

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

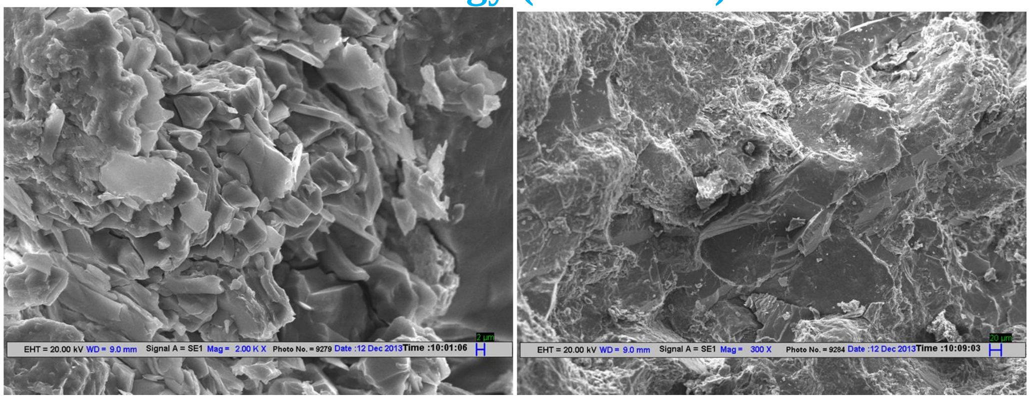


Fig.5: Rounded and subrounded grains of quartz

The size of the quartz grains are 0.18 mm.The flaky minerals present were of illite and kaolinite The size of the clay particles surrounding the grains are of 0.002 mm.Grains are well sorted and rounded in shape which shows long distance transport.The cementation is poor which makes the rock porous with high porosity.The subrounded shape of the coarser grains shows that the cement material will not have firm grip.

III. EXPERIMENTAL METHODOLOGY

A. Physical Properties

The physical properties like density, void ratio, porosity and specific gravity for the shiwalik sandstone [Results of all test has been presented in the Table I

Table 1 Results of physical property test on Shiwalik Sandstone

Physical Properties	Observed Value
Dry density (gm/cc)	2.289
Saturated density (gm/cc)	2.432
Porosity (%)	13.02
Void ratio (%)	4.100
Specific gravity	2.28

B. Static Strength Properties

Point load strength index test, Brazilian tensile strength test, Uniaxial and Triaxial Compression test were performed on the Shiwalik Sandstone sample and axial strains were measured [11]-[17].

Table 2 Average value of Strength Properties for Shiwalik Sandstone

Strength Properties	Observed value
Point load strength index $I_{s(50)}$(MPa)	3.87 (axial)
	1.79 (diametral)
Brazilian Tensile Strength σ_{tb} (MPa)	4.18
UCS σ_c (MPa)	45.57 (dry)
UCS σ_c (MPa)	24.94 (saturated)
Elastic Modulus (GPa)	6.5 (dry)
Elastic Modulus (GPa)	3.2 (saturated)
Cohesion (MPa)	3.89
Friction angle (φ)	62.25°

IV. EXPERIMENTAL APPARATUS

The testing facility was based on the principle of “Closed Loop Servo Control”. The system can be operated in load or displacement

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

control mode. It Consists of three parts i.e. Compression Loading Frame (1000 KN), Power Pack Unit, Control system and Control Software

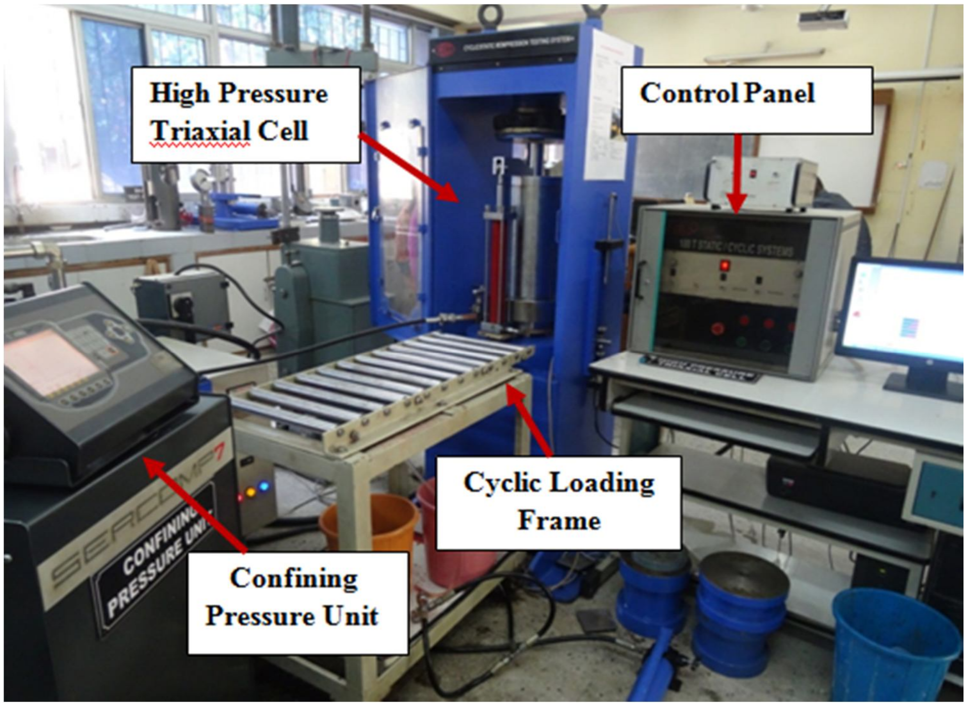


Fig 5: Cyclic Triaxial Testing Facility

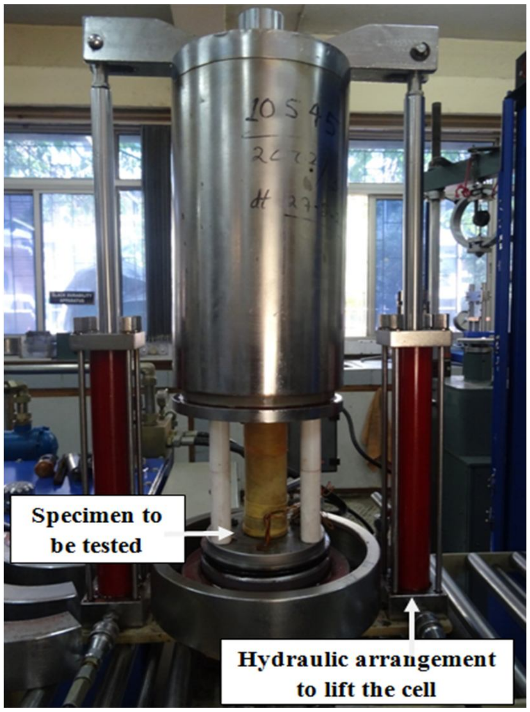


Fig.7: High Pressure Triaxial Cell

The HPT cell can withstand confining pressure upto 140MPa (fig 7).It is basically designed for N_X size sample. There is a hydraulic jack for the lifting of the cell so that samples can be easily placed and a valve which is released for the lowering of the cell.

V. CYCLIC LOAD TEST UNDER VARYING CONFINING PRESSURE

Cyclic triaxial test was performed on Shiwalik Sandstone samples under two confining pressure of 5 MPa and 7 MPa [1]-[4]. The parameters of cyclic loading are as follows [5]-[6].
Waveform –Sinusoidal [2]-[3]
Frequency – 1 Hz
Uniaxial Compressive Strength in Static condition = 46 MPa [1]
Valley stress= 50% of UCS
Peak stress= 90% to 60% of UCS

VI. EXPERIMENTAL RESULTS AND DISCUSSIONS

The trend of the curve shows that the fatigue life of the rock increases as the confinement increases.As the confinement increases the stiffness of the rock increases and so the strength also increases.

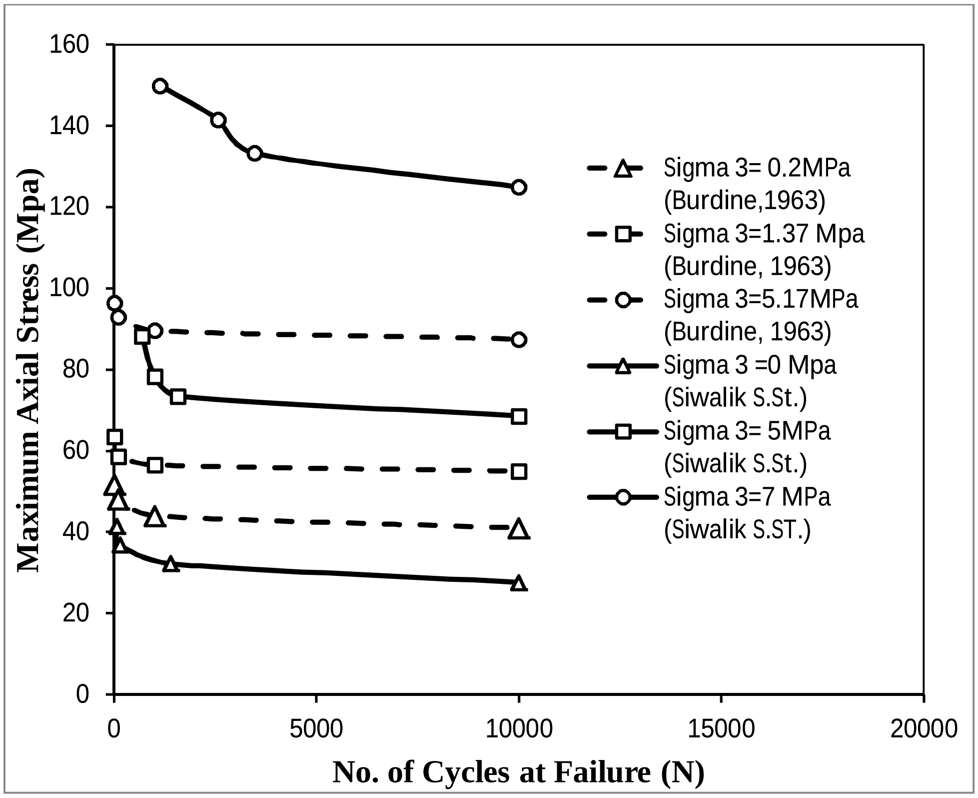


Fig.8: Comparison of S-N curve of Shiwalik Sandstone with Berea Sandstone (Burdine , 1963)

It is clearly visible from Fig.4 that the pattern of S-N curve for Shiwalik Sandstone follows the pattern of Berea Sandstone [4]. The porosity of Shiwalik Sandstone is high as that of Berea Sandstone and as the confinement increases the void ratio is reduced.This makes the material strong and stiff and so the fatigue stress increases.Thus as the confining pressure increases the number of cycles at failure increases.As the confining pressure increases from 5MPa to 7MPa the endurance limit increases from 70% to 75% of the maximum axial stress value at static triaxial test.

VII. CONCLUSIONS

The rock has been classified as low strength-low modulus ratio rock on the basis of Deere- Miller classification [10].The strength values obtained in saturated condition are much lesser than the those in dry condition this shows the presence of some clay mineral in the rock which becomes soluble in saturated conditions.Cyclic behaviour of Shiwalik Sandstone was studied and fatigue limit was obtained under varying confining pressure.S-N curve was plotted. By comparing the S-N curve at confining pressures of 0, 5 and 7 MPa it was observed that as the confinement increases the fatigue life increases.

VIII. ACKNOWLEDGEMENT

The authors would like to express their deep gratitude towards **Prof. K.G.Sharma**, Civil Engineering Department, Indian Institute of Technology Delhi for his valuable guidance.They would also like to thanks the technicians of the Rock Mechanics Laboratory,IIT Delhi for their co-operation.

REFERENCES

[1] Yoshinaka R., Tran T.V., Osada M.,1997 ."*Mechanical behavior of soft rocks under cyclic triaxial loading conditions*" Rock Mechanics & Rock Engineering 34, 3-4.

[2] Bagde M.N.and Petros V.,2005."*Waveform effect on fatigue properties of intact sandstone in uniaxial cyclical loading*."Rock Mechanics & Rock Engineering 38,169-196.

[3] Bagde, M.N., Petros, V., 2004. "*The Effect of Machine Behaviour and Mechanical Properties of Intact Sandstone Under Static and Dynamic Uniaxial Cyclic Loading*" Rock Mechanics & Rock Engineering 37,3-23

[4] Burdine NT , 1963. "*Rock failure under dynamic loading conditions*."SPE J 3:1–8

[5] Enlong Liu,Runqiu Huang, Siming He, 2012."*Effects of frequency on the dynamic properties of intact rock samples subjected to cyclic loading under confining pressure conditions.*" Rock Mechanics & Rock Engineering 45,89-102.

[6] EnLong Liu, Siming He, Xinhua Xue, Jin Xu,2011 "*Dynamic Properties of Intact Rock Samples Subjected to Cyclic Loading under Confining Pressure Conditions*" Rock Mechanics & Rock Engineering

[7] Nara Y, Morimoto K, Yoneda T, Hiroyoshi N, Kaneko K, 2011"*Effects of Humidity and Temperature on Subcritical Crack Growth in Sandstone.*"International Journal of Solids and Structures

[8] Vutukuri,V.S.,Lama,R.D. and Saluja,S.S. 1978 ,"*Handbook on mechanical properties of rocks (Series on rock and soil mechanics).*" Trans Technical Publication,pp.279-289

[9] Mitchell J.K. and Soga K., 2005 " *Fundamentals of soil behavior.*" Third Edition, John Wiley & Sons, INC.

[10] Goodman,R.E.,1980, "*Introduction to rock mechanics*"

[11] IS :10050-1981 "*Method for determination of slake durability index of rocks*"

[12] IS :10082-1996 "*Method of test for determination of tensile strength by indirect test on rock specimens*"

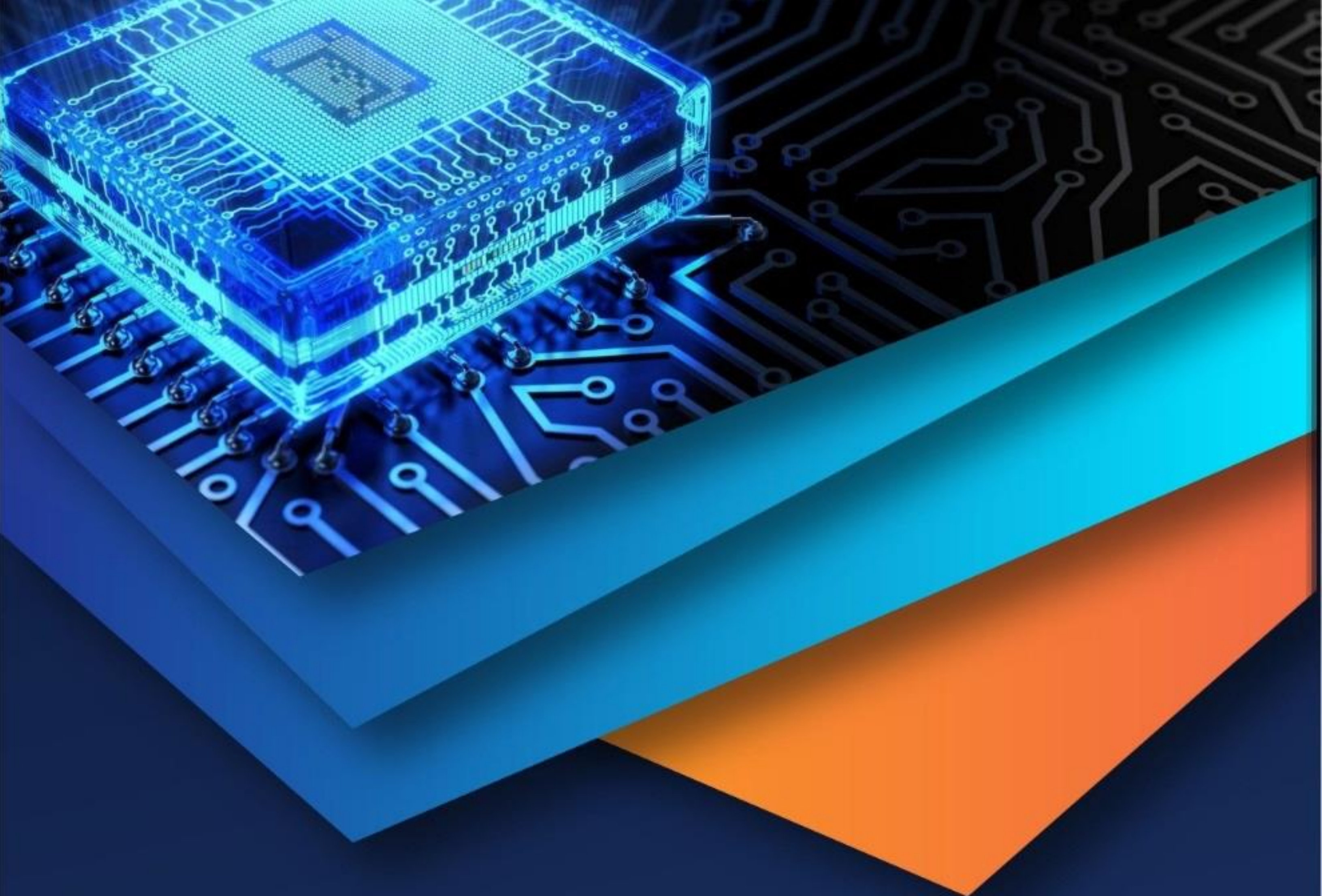
[13] IS :9179-1979 "*Method for preparation of rock specimen for laboratory testing*"

[14] IS :9231-1979 "*Method for determination of modulus of elasticity and poisson's ratio of rock materials in uniaxial compression*"

[15] IS :8764-1998 "*Method for determination of point load strength index of rocks*"

[16] IS :9143-1996 " "

[17] ISRM, 1982



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY