A Study of Saw-Cut Shear Strength

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY
IN
MINING ENGINEERING

By

Pradeep Kumar Yadav
Roll No. 110MN0406

DEPARTMENT OF MINING ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA – 769008

2013-2014

A Study of Saw-Cut Shear Strength

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY
IN
MINING ENGINEERING

By

Pradeep Kumar Yadav
Roll No. 110MN0406

Under the Guidance of

Prof. M.K. Mishra

DEPARTMENT OF MINING ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA – 769008
2013-2014

National Institute Of Technology, Rourkela

CERTIFICATE

This is to certify that the thesis entitled **"A Study of Saw-Cut Shear Strength"** submitted by **Pradeep Kumar Yadav (110MN0406)** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date:

Prof. M.K. Mishra
Dept. of Mining Engineering
National Institute of Technology
Rourkela – 769008

ACKNOWLEDGEMENT

I wish to convey my heartfelt gratitude and obligation to **Prof. M. K. Mishra**, Department of Mining Engineering, and NIT Rourkela for introducing the present topic and for his inspiring guidance, constructive criticism and valuable suggestion throughout the project work.

I am also thankful to **Mr. S. Mallik**, **Mr. S. Oram, Mr. B. Jena** and other staffs in Department of Mining Engineering for providing all joyful environments in the laboratory and helping us out in different ways.

Last but not the least my sincere thanks to all my friends who have patiently extended all sorts of help for accomplishing this undertaking.

Date:

Pradeep Kumar Yadav

Roll No. 110MN0406

Department of Mining Engineering

National Institute of Technology

Rourkela – 769008

ABSTRACT

It is necessary to determine the shear strength of intact rock to analyze the stability of excavations. The strength of rock and rock mass are important parameters for design of mine excavation and its stability. Shear strength of the rock is one of those. It is carried out to determine the cohesion and angle of friction of the rock material. Determination of direct shear strength value of rock in the field is very difficult due to direct shear testing machine is bulky which is difficult to carry to the site and experiment is only possible at laboratory as it requires a constant power for application of consistent horizontal force. A conventional shear-box testing machine is unsuitable due to high strength of rock and it minimizes the bending stresses of rock specimens. However the procedure of direct shear strength is complex and often require varying machine characteristics. Saw cut shear is a process which incorporates punching action so that the ends of the sample experience shear.

This investigation reports the experiments carried out to correlate the conventional shear and saw cut shear data. Thin dolomite plates of were cut from core with rock cutting machine and tested in double shear by a linear punching action. Saw-cut shear strength of dolomite is determined for the different thickness of plates and optimum value is found to be 14.7 MPa and a relation between saw-cut shear strength and thickness is established.

Keywords: Saw Cut Shear, Triaxial Strength, Rock Cores

CONTENTS

CHAPTER 4. CONCLUSION

4.1 Conclusion

4.2 Future Scope

CHAPTER 5. REFERENCES

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

Aim

Objectives

Methodology

1. INTRODUCTION

Shear strength is the strength of rock material to resist the deformation due to shear stress. Rock resists the shear stress by the two internal mechanisms, first one is cohesion and another one is internal friction. Cohesion is the measure of bonding of rock materials whereas internal friction is due to contact between the particles and defined by internal friction angle, Φ. Different rocks are having different cohesion and different internal friction angle. Shear and tensile strengths of rock are important as the rock fails mostly in shearing and tension, even the loading may appears to be compressive. Failure in pure compressive loading is very uncommon because compressive strength of rock is very high.

1.1 AIM

Determination of saw-cut shear strength of dolomite by double shear testing device.

1.2 OBJECTIVES

I. Conventional Method: Determination of shear strength of dolomite by tri-axial compression strength test.
II. Inexpensive Method: Determination of saw-cut shear strength of dolomite.

1.3 METHODOLOGY

1. First of all the dolomite lumps were collected from the “Bisra Stone Lime Company Limited(BSL)” (Duarsini Dolomite Quarry), Birmitrapur, Sundargarh(Odisha).
2. After that core cutting of dolomite lumps was carried out in laboratory using core cutting machine of 54mm diameter and 10cm length.

3. For the saw-cut shear strength, 15 thin disc of thickness between 10.7mm to 5.2mm were cut from the core using rock cutting machine.
4. And for tri-axial compression test three specimens of length 10.5cm and diameter of 54mm were cored. Then the facing of thin plates as well as of NX size specimens were done using corundum powder.
5. For the saw cut shear strength determination, specimens of different thickness were placed on the device which is having three strips of which two acts as base and one forms the punch.
6. And punch passes between the base strips with a clearance of 0.3mm.
7. Then the whole device along with specimen was placed in conventional compression testing machine which induced the double shear failure in rock disc.
8. The force registered by compression machine is the required force to shear the sample. Saw-cut shear strength of the dolomite is calculated by the dividing this force by the area through which shearing takes place, τ_{saw}.
9. Also the shear strength of dolomite was calculated through tri-axial compression strength test.
10. Using the Mohr-coulomb criteria the shear strength of dolomite was calculated, τ_{tri}.

Chapter 2

LITERATURE REVIEW

Shear strength

Factors affecting shear strength

Failure criteria of rock

Saw-Cut Shear Strength

Tri-Axial Test

2.1 SHEAR STRENGTH

Shear strength is the strength of a material against the type of yield or structure failure where the material fails in shear. Shear load is the force that tends to produce a sliding action failure on a material along a plane which is parallel to the direction of force. Shear stress is increase rapidly until the peak strength is reached.

Shear modulus or modulus of rigidity, denoted by G, is defined as ratio of shear stress to the shear strain.

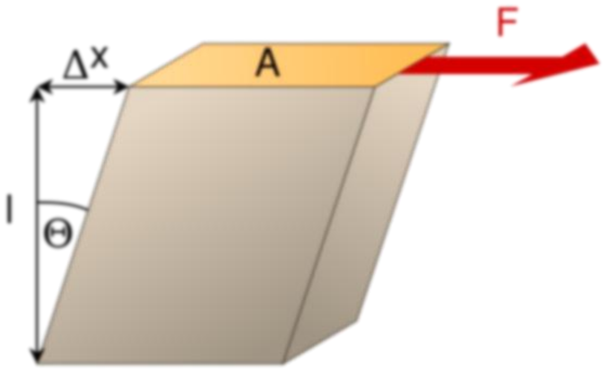


Fig 2.1_Shear Strain (http://en.wikipedia.org/wiki/Shear_modulus)

$$G \stackrel{\text{def}}{=} \frac{\tau_{xy}}{\gamma_{xy}} = \frac{F/A}{\Delta x/l} = \frac{Fl}{A\Delta x}$$ ……………. Eq. (1)

Where,

$\tau_{xy} = F/A$ = shear stress

F = force which acts,

A = area on which force acts,

$\gamma_{xy} = \Delta x/l = \tan\theta$ = shear strain,

Δx = the transverse displacement,

l = the initial length'

Shear modulus' derived SI unit is the Pascal (Pa), dimensional form is $M^1L^{-1}T^{-2}$.

Shear stress increases rapidly till the peak strength is reached. After that, shear stress will fall to residual value and residual value remains constant but the shear displacement continues even for larger value.

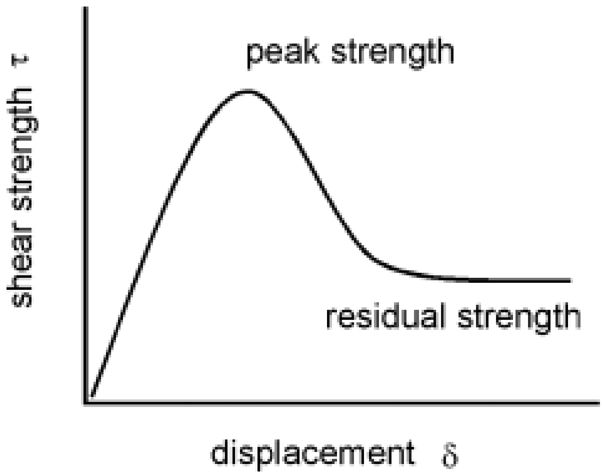


Fig. 2.2_Generalized shear strength vs shear displacement curve(https://www.rocscience.com/hoek/corner/4_Shear_strength_of_discontinuities.pdf)

By plotting the peak and residual shear strength for different normal stresses, shows the linear illustration where peak strength line has a slope of Φ and an intercept of C on the shear strength axis and the residual strength line having a slope of Φ_r and zero intercept. Relation between peak shear strength and normal stress σ_n can be represented by Mohr - Coulomb equation:

$$\tau = c + \sigma_n \tan\phi \quad \text{……………………….. Eq.(2)}$$

Where, C = cohesive strength of material

Φ = angle of friction

But in the case of residual shear strength, cohesion becomes zero and relationship between Φ_r and σ_n is as:

$$\tau = \sigma_n \tan(\Phi_r) \text{……………………Eq. (3)}$$

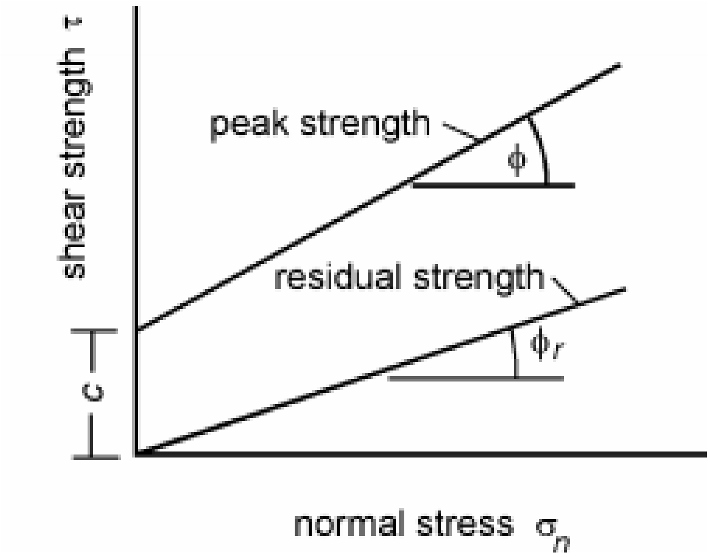


Fig. 2.3_Residual and peak shear strength for different normal stresses(https://www.rocscience.com/hoek/corner/4_Shear_strength_of_discontinuities.pdf)

PEAK SHEAR STRENGTH

Peak shear strength is the maximum shear strength at the yield point obtained by shear strength vs shear displacement curve at constant normal stress (fig. 2).

PEAK FRICTION ANGLE

Peak friction angle is the angle given by the slope of a straight line representing the relationship between normal stress and peak shear strength (fig.3).

RESIDUAL SHEAR STRENGTH

Residual Shear Strength is a shear stress that found out at a constant value with increasing shear displacement and at constant normal stress in shear test (fig. 2).

RESIDUAL FRICTION ANGLE

Residual friction angle is the slope of straight line representing the relationship between normal stress and residual shear strength (fig. 3).

2.2 FACTORS AFFECTING SHEAR STRENGTH

2.2.1 INSTANTANEOUS COHESION AND FRICTION

Instantaneous cohesion C_i and instantaneous friction angle Φ_i are the main factors which affects the shear strength of the material. From the Eq.(2) we can see that as the cohesion and friction is increases it also enhances the shear strength of that material because they are directly proportional to shear strength.

2.2.2 WATER PRESSURE

As the water present in the rock mass, the surfaces of discontinuities are forced apart and normal stress is reduced, which reduces the shear strength of the rock.

$$(\sigma_n)' = (\sigma_n - u)$$

Where,

u = water pressure

and $(\sigma_n)'$is "the effective normal stress"

2.2.3 CONFINING PRESSURE

Confining pressure increases the strength of the rock and the degree of post yield axial strain hardening, these effects diminishes with increasing pressures. At low confining pressure there is increasing dilation which reduces at higher confining pressure.

2.3 FAILURE CRITERIA OF ROCK

2.3.1 MOHR-COULOMB CRITERIA

In Mohr-Coulomb criteria it is assumed that the shear failure plane is developed in the rock material. When failure occurs, the stresses developed on the failure plane are on the Mohr-Coulomb strength envelope.

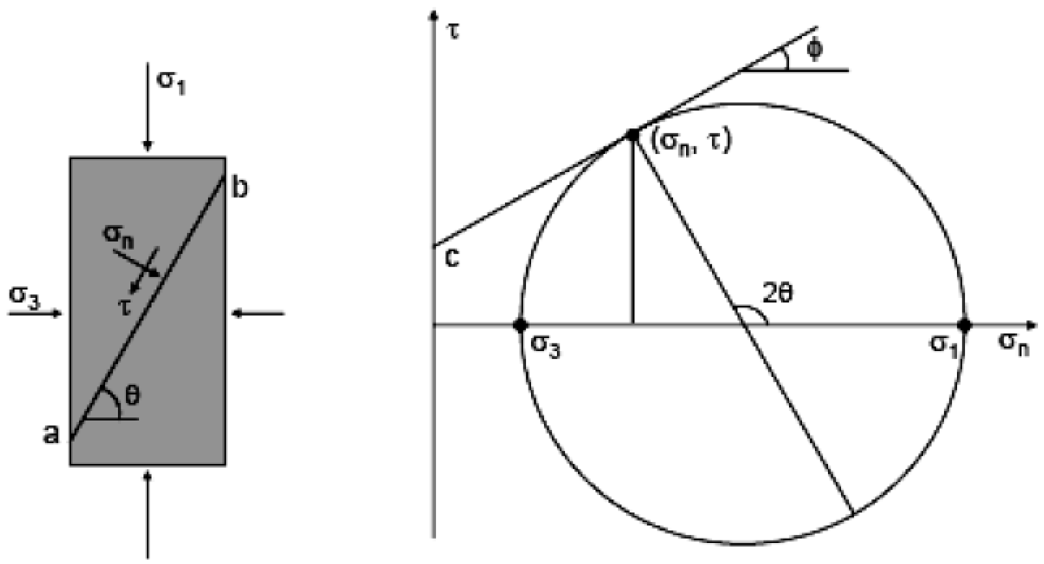


Fig. 2.4_stresses on failure plane a-b and Mohr's circle (Dr. K.M.U. Rao, Rock mechanics and ground control)

From the above Mohr circle,

$$\sigma_n = \tfrac{1}{2}(\sigma_1 + \sigma_3) + \tfrac{1}{2}(\sigma_1 - \sigma_3)\cos 2\theta$$

$$\tau = \tfrac{1}{2}(\sigma_1 - \sigma_3)\sin 2\theta \qquad \text{……………………Eq. (4)}$$

But from the basic equation (1) of Mohr-Coulomb criteria,

$$\sigma_1 = \frac{2c + \sigma_3\,[\sin 2\theta + \tan\phi\,(1 - \cos 2\theta)]}{\sin 2\theta - \tan\phi\,(1 + \cos 2\theta)} \qquad \text{………………………Eq.(5)}$$

As seen from the Mohr's circle failure plane is defined by θ, and

$$\theta = \tfrac{1}{4}\pi + \tfrac{1}{2}\varphi$$

$$\sigma_1 = \frac{2c\cos\phi + \sigma_3\,(1 + \sin\phi)]}{1 - \sin\phi} \qquad \text{………………………Eq.(6)}$$

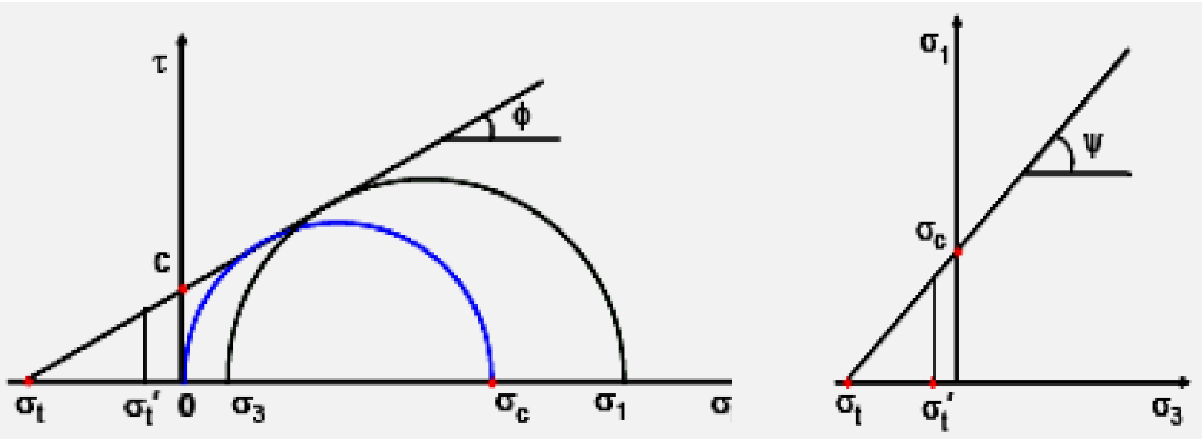


Fig. 2.5_Mohr- Coulomb strength envelope in terms of normal and shear stresses and principle stresses with, tensile cut-off(Dr. K.M.U. Rao, Rock mechanics and ground control)

By extrapolating the Mohr-Coulomb strength envelope, uniaxial compressive strength can be found,

$$\sigma_c = \frac{2\,c\,\cos\phi}{1-\sin\phi}$$ …………Eq.(7)

And also the apparent value of uniaxial tensile strength of the material is given by,

$$\sigma_t = \frac{2\,c\,\cos\phi}{1+\sin\phi}$$ ………………….Eq.(8)

2.3.2 HOEK- BROWN CRITERIA

Due to classical strength theory used for other materials have not been apply to rock over wide range of compressive strength conditions, empirical strength criteria have been used. Hoek - Brown criteria is the one of the widely used for isotropic rock. **Hoek-Brown**(1980) shows that the tri-axial peak compressive strength of isotropic rock is could be describe by the following equation:

$$\frac{\sigma_1}{\sigma_c} = \frac{\sigma_3}{\sigma_c} + \left(m\frac{\sigma_3}{\sigma_c} + 1.0\right)^{1/2}$$ ……………………Eq.(9)

Where "m" is the parameter changes with rock type. Hoek – Brown envelope is a curve but not a straight and at high stresses, the envelope curves down and gives the low strength estimated than Mohr-Coulomb envelope.

2.4 SAW CUT SHEAR STRENGTH

Saw cut shear strength of the rock is the strength of material at which it fails when subjected to double shear test where only shear stresses are applied but not any normal stress is applied to the shearing faces. Here two shearing faces are developed so it is also called the double shear.

G. Everling has shown theoretically that the stress distribution across the shear surfaces is non-uniform and the load at failure must consequently be lower than in a uniform shear-stress distribution, and that the shear strength will depend on the size of the test piece.

W. C. Maurer from the numbers of practical experiment shows that the shear strength is independent of specimen thickness and apparently plastic deformation and localized failure tends to equalize shear stress along the failure plane.

DESCRIPTION OF DEVICE

The device operates on the linear punch principle as describe by **W. C Maurer.** It is a very simple device in which only shear stresses are applied and no any normal stress is applied to the shearing surfaces. It consists of three strips of hardened steel. Two strips forms a base on which specimen is held. The third strip act as a punch that passes between two base supports with a clearance of approximately 0.3 mm.

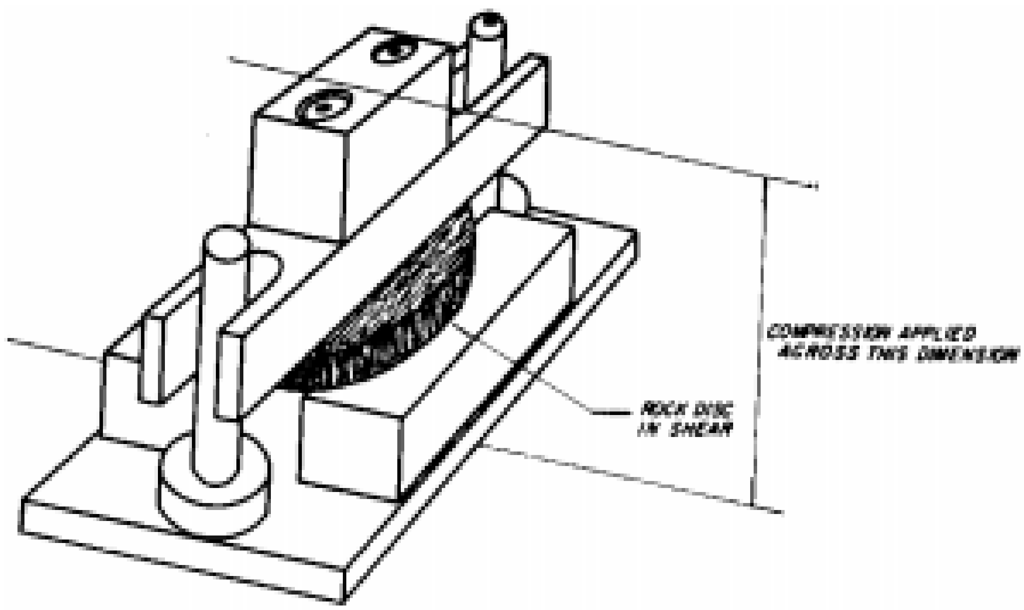


Fig. 2.6_ Saw cut shear testing device (Stacey T.R., “A simple device for the direct shear-strength testing of intact rock”)

PREPARATION OF ROCK SPECIMENS

Thin rock plates, cuts from the core using rock cutting machine of thickness between 10.7mm to 5.2 mm(15 specimens). By varying the thickness in a number of specimens, change in shear strength can be measured. After cutting the thin disc from core facing of the specimens is done using corundum powder.

PROCEDURE:

1. In the first step rock specimens (disc) are placed in shear device on the two base strips as shown in figure_2.6, so that the required planes of shearing is parallel to the long axis of the device.
2. Then third strip is placed at the top of the specimen as it can form the punch.
3. Then the whole assembly is placed in the conventional compression testing machine.
4. Compressive loading of device induces the double shear failure in the rock specimens.
5. Force registered by the compressive machine is the force required to shear the specimen and forms the two shearing faces.
6. Shear strength of the disc is calculated by dividing the force by total shearing area.

2.5 TRI-AXIAL TEST:

Specimens of right circular cylinder with height to diameter ratio of 2 or more are prepared with cutting and facing with corundum powder. The specimen is placed in the tri-axial cell (**Hoek-Franklin cell**) and desired confining pressure is maintained using hydraulic pump. The specimen is then further compressed with compression machine using a spherical seating.

INDIAN STANDARD 13047:1991

Test provides individual points on failure envelope from several tests. From this the value of the internal friction angle Φ and the apparent cohesion C may be obtained.

Following Indian standards are necessary additions to this standard:

IS 1586:1986----Methods for Rockwell hardness test(Band C scales)

IS 9179:1979----Method for preparation of rock specimen for laboratory testing.

APPARATUS:

Apparatus consists mainly of three parts: a tri-axial cell, a loading device for axial loading and a device for generating confining pressure.

A TRIAXIAL CELL:

1. It comprises of (a) a tri-axial cell to apply confining pressure to the specimen. The body of cell have an air bleeder valve, entry port for filling the cylinder with hydraulic fluid, outlet for pore pressure measurement and drainage.
2. Platens which is having a Rockwell Hardness of more than or equal to HRC 30 for placing at the both ends of specimens, diameter of the platens should be between D and 1.02D, where d is the diameter of the specimen. Thickness of platens shall be at least 15 mm or D/3. Surface of the platens shall be ground and shall not depart from plane surfaces by more than +0.005 mm.
3. The top platens shall incorporate a spherical seat and centre of curvature of seat must coincide with the centre of the top surface of specimen. The specimen, platens and spherical seat must be accurately centred with one another.

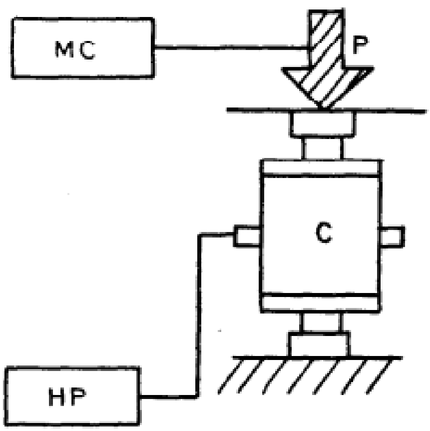
4. Flexible membrane of suitable materials (neoprene/butyl rubber) wrapped around the specimen to prevent the entering of hydraulic fluid into the specimen and shall be long enough to extend well on the platens.

LOADING DEVICE FOR AXIAL LOAD: A suitable loading machine shall be used for applying, controlling, and measuring the axial load on specimen and having sufficient capacity and capable of applying load at a rate as per requirements. The two loading faces shall be parallel to each other.

DEVICE FOR CONFINING PRESSURE: It includes the following:

(a) a hydraulic pump/pressure intensifier of sufficient capacity and capable of maintaining constant confining pressure within 2 % of desired value.

(b) pressure indicator device which must be accurate to -+2%



P=Testing machine

MC=Control unit for applying and controlling axial load, C= Tri-axial cell

HP=Equipment for generating and controlling confining pressure

Fig2.7_Block diagram of test arrangement for determination of tri-axial compressive strength

(IS**13047:1991**)

SPECIMEN PREPARATION:

Specimen was prepared according to IS 9179: 1979

Moisture content of the specimen shall be as close as to field condition.

Shape and Dimension of the Specimen: (1). Specimen should be right circular cylinder; and length to diameter ratio of specimen shall be between 2 to 3.

(2). Diameter of the specimen shall not be less than ten times the largest grain in the rock, preferably not less than NX size(54 mm).

(3). Ends of specimen shall be flat to 0.02 mm and shall not depart from perpendicularity to the longitudinal axis of the specimen by more than 0.001 radians

(4). Cylindrical surface shall be smooth and free from rapid irregularities and straight within 0.3 mm over the full length of specimen.

(5). Diameter of specimen shall be measured to the nearest 0.1 mm by averaging two diameter measured at right angle to each other at upper, mid and lower height of specimen.

(6). Core shall be marked with in-situ orientation and number.

PROCEDURE:

(1). Test cell assembled with the specimen aligned between steel platens and surrounded by flexible membrane. The specimen, platens and spherical seat must be accurately aligned coaxially with one another.

(2). Cell shall be filled with hydraulic oil by allowing the air to escape via an air bleeder valve, and then the valve shall be closed.

(3). Cell shall be placed in the axial loading device. The axial load and confining pressure should be increased simultaneously and in such a way that axial stress and confining pressure be approximately equal, until the predetermined test level for the confining pressure is reached.

(4). Then the axial load on the test specimen shall be increased continuously without shock for constant rate of load. Otherwise stress rate shall be within the limit of 0.5 to 1.0 MPa/s.

(5). Maximum axial load and corresponding confining pressure shall be recorded.

(6). Axial displacement is measured up to the accuracy of 0.5 %.

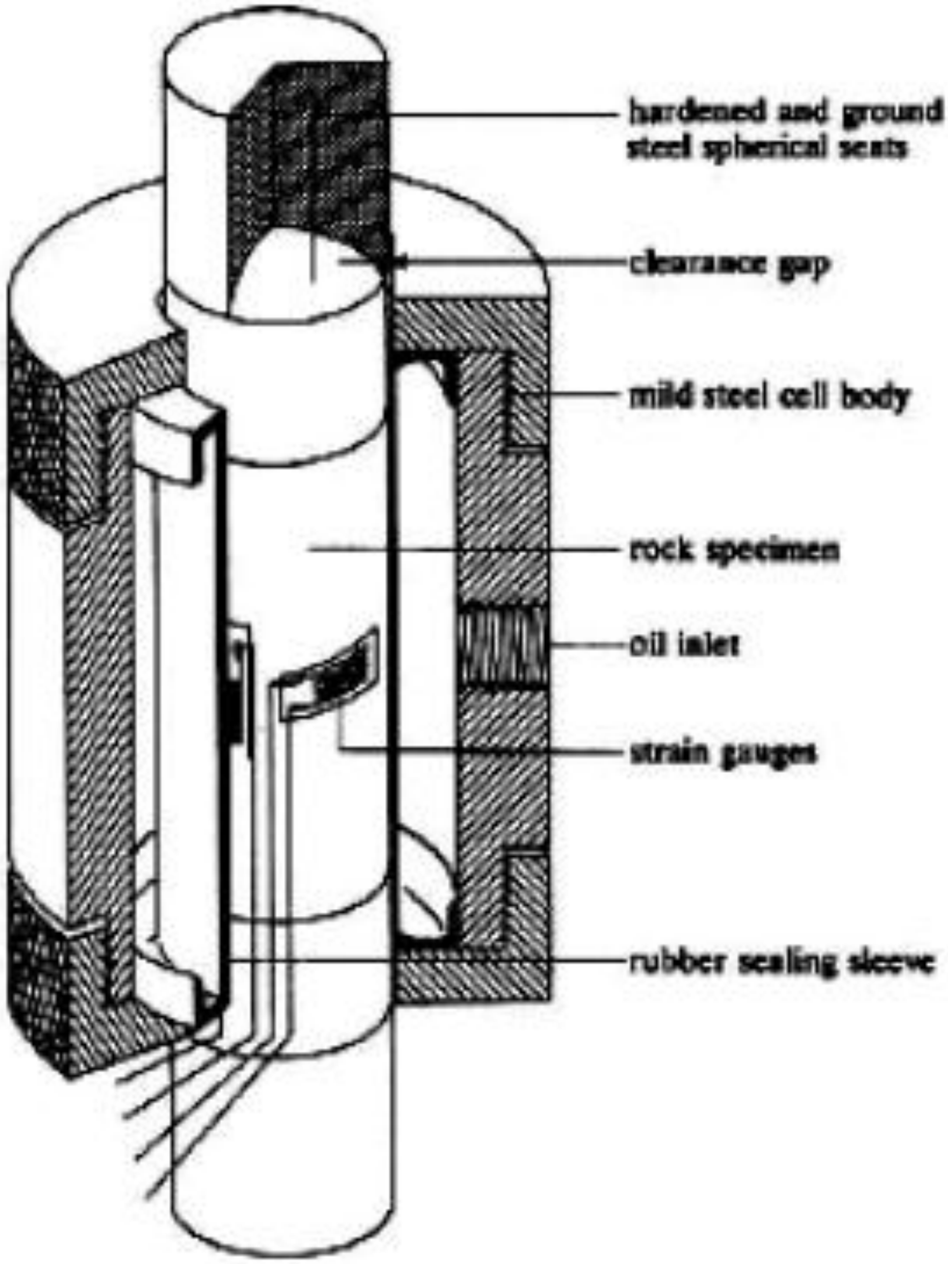


Fig. 2.8_Triaxial compression test using **Hoek-Franklin** cell

(Brady B.H.G., Brown E.T., “Rock Mechanics for Underground Mining”)

Chapter 3

RESULTS AND ANALYSIS

Area

Geology

Sample Collection

Sample preparation

Saw-Cut Shear Strength Test

Tri-axial test

3.1 AREA

Dolomite lumps were collected from the **Bisra Stone Lime Company Limited (BSL)**, Biramitrapur (Duarsini Dolomite Quarry), which is situated in the Sundargarh district of Odisha, beside NH-23 and is at a distance of 35 Km. north of Rourkela Steel City. Duarsini Dolomite Quarry is situated adjacent to the Biramitrapur Municipality area. Mine is having the co-ordinate of N 22^0 15' E 84^0 30'. Average dip of the limestone and dolomite is 65^0 towards North. The strike is East-West and having length of 7.5 Km

3.2 GEOLOGY

The deposit is complex type sedimentary deposit and belongs to **Biramitrapur stage** of **Gangpur series** of **Indian Dharwar**. The deposit occurs in the form of overlapping layers of limestone and dolomite and the hangwall consists of quartzite and the footwall of schists.

COMPOSITION OF DOLOMITE ($CaCO_3.MgCO_3$):

Parameters	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	Total Alkali	Loss on Ignition
Dolomite ($CaCO_3.MgCO_3$)	28-30%	19-20%	6-7%	1.4%	0.9%	0.4%	45%

3.3 SAMPLE COLLECTION

(1). Dolomite lumps from the Duarsini mine were collected from the freshly blasted face.

(2). Then the lumps were wrapped in the plastic sheet for the preservation of moisture content of the dolomite and for accurate readings as the in-situ condition may be maintained.

(3). Then after plastic wrapping, lumps were put in a container which is having a good damping capacity for the insurance of any further cracks development or breaking of lumps due to the jerk during transportation from mine to laboratory.

3.4 SAMPLE PREPARATION

(1). First of all the coring of the lumps were done using core cutting machine.

(2). For the **saw-cut shear strength**, cutting of the core with the help of rock cutting machine was carried out. And disc or thin plates of thickness between 10.7 mm to 5.2 mm were made.

(3). When the disc of the above thickness range were made then facing of each(12 specimens) is carried out using corundum powder.

(4). For the **tri-axial test**, three specimens of 54mm diameter and 10.5cm, were cut and facing of that sample is done using corundum powder.

3.5 SAW-CUT SHEAR STRENGTH TEST

Shear length of each specimen = 80.50 mm, Shearing area = (thickness of specimen)(shear length of each specimen) mm^2

τ (saw-cut shear strength) = (load/area) in MPa

From the graph 3.1 the optimum saw-cut shear strength of the dolomite is found to be **14.7 MPa** at the thickness **of 9.3 mm.** Therefore,

$\tau_{saw\text{-}cut}$ = 14.7 MPa………………………………………………………..(a)

Table 3.1 Saw cut shear test data

Specimens	Thickness(mm)	Shearing length(mm)	Shearing area(mm^2)	Load(KN)	Saw-cut shear strength(MPa)
S1	10.7	861.35	80.5	13	15.09
S2	10.6	853.3	80.5	13	15.23
S6	8.6	692.3	80.5	10	14.45
S7	8.3	668.15	80.5	10	14.96
S8	7.6	611.8	80.5	9.5	15.52
S9	7.3	587.65	80.5	9	15.31
S10	6.3	507.15	80.5	8	15.77
S11	6.8	547.4	80.5	8.5	15.52
S12	6.3	507.15	80.5	8	15.77
S13	5.4	434.7	80.5	7	16.1
S14	5.3	426.65	80.5	7	16.41
S15	5.2	418.6	80.5	7	16.72

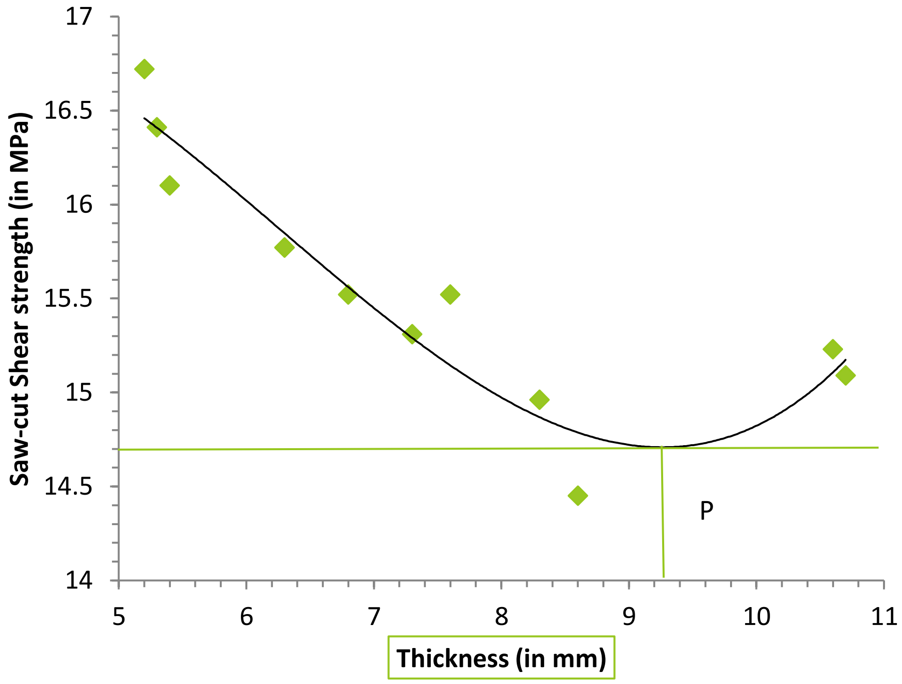


Figure 3.1: Shear Strength vrs thickness of sample

RESULT:

Optimum Saw-cut shear strength of dolomite is found to be 14.7 MPa for the thickness of 9.3 mm.

Fig. 3.2 The specimen before, during and after testing

3.6 TRIAXIAL COMPRESSION TEST

Specimen size s1 (diameter 54.3mm and length= 105.30 mm)

Specimen size s2 (diameter 54.3mm and length= 105.30 mm)

Specimen size s3 (diameter 54.2mm and length= 87.90 mm)

Table 3.2 Tri-axial compression test data

	Minor principal stress σ_3 (MPa)	Major principal stress σ_1 (MPa)
S1.	3.928(40 kg/cm^2)	51.81(120KN)
S2.	5.89(60 kg/cm^2)	53.55(124 KN)
S3.	7.86(80 kg/cm^2)	70.21(162 KN)

Fig 3.3: Triaxial Failure of sample

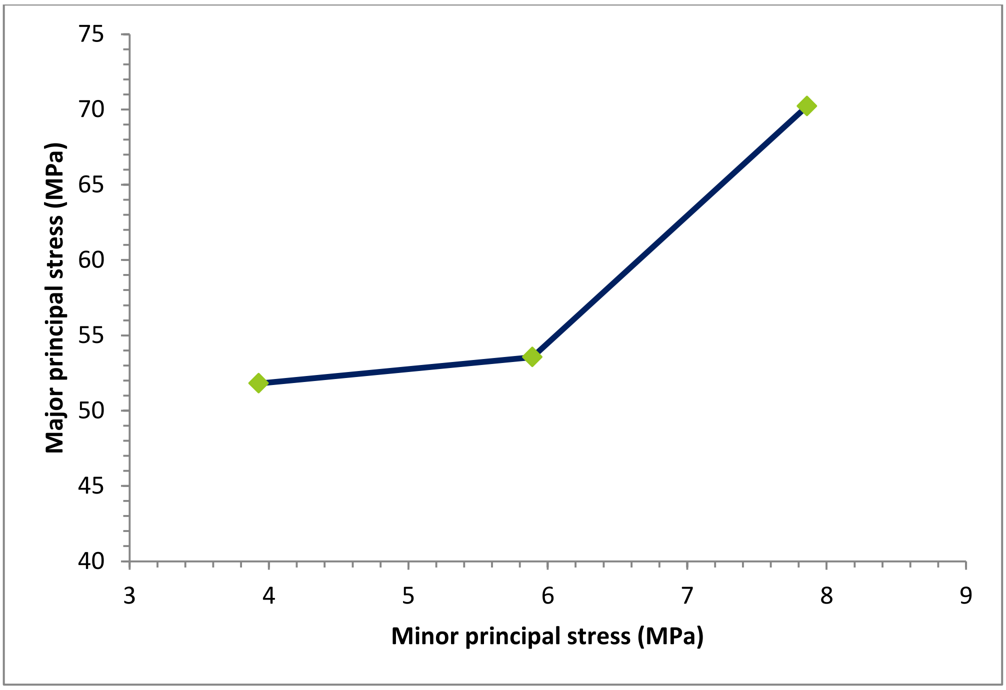


Fig. 3.4 Relation between measure principal stress and minor principal stress

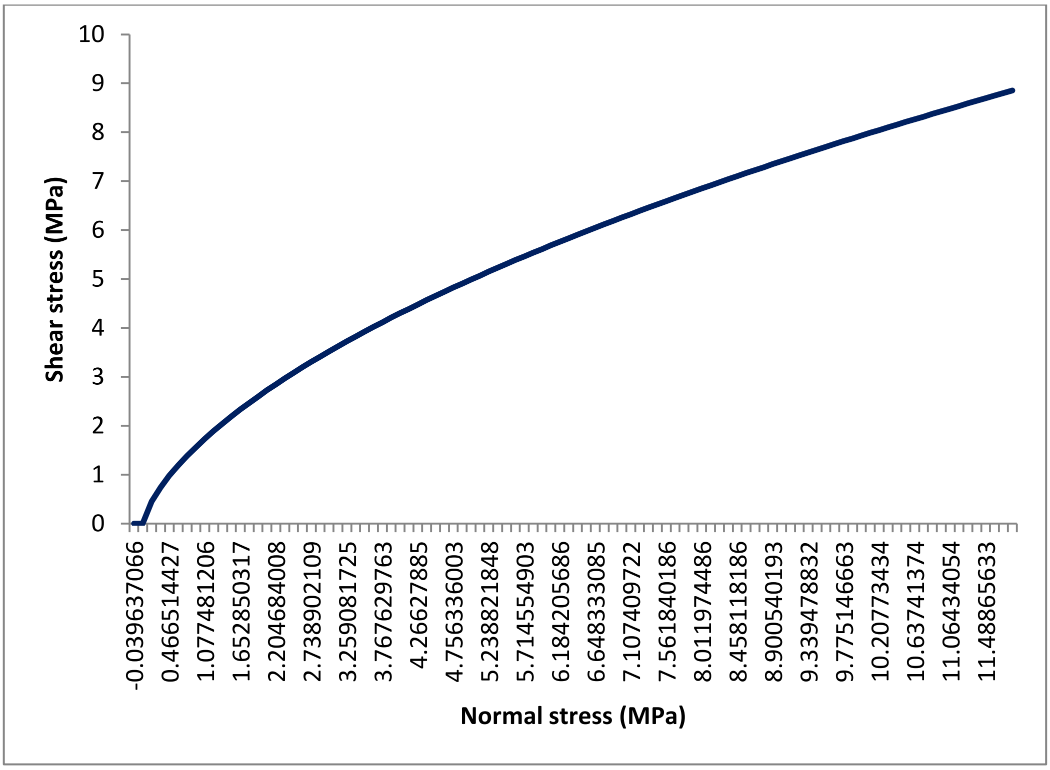


Fig. 3.5 Relation between between shear stress vs normal stress in Triaxial test

From the Roclab, software**,** rock mass parameters and the value of cohesion and angle of friction were found.

Mohr-Coulomb Fit			
C	=	1.40615	MPa
Phi, Φ	=	33.7828	degrees

Rock Mass Parameters		
σ_t	-0.03964	MPa
σ_c	1.51544	MPa

From the equation (4), tri-axial shear strength value was found to be

τ_1 = 19.90 MPa
τ_2 =19.81 MPa
τ_3 =25.91 MPa

RESULT:

The mean of the three tri-axial shear strength is, $\tau_{mean\ triaxial}$ = 21.87 MPa and standard deviation is coming out to be 3.49.

3.7 RELATION BETWEEN SAW-CUT SHEAR STRENGTH AND TRI-AXIAL SHEAR STRENGTH OF DOLOMITE

From the saw-cut shear strength and tri-axial shear strength experiments the shear strength value is found to be 14.7 MPa and 21.87 MPa respectively.

τ saw-cut =14.7 MPa

τ tri-axial = 21.87 MPa

Therefore, the relation between saw-cut shear strength and tri-axial shear strength is found to be:

$\tau_{tri\text{-}axial} = \alpha\, \tau_{saw\text{-}cut}$……………………………………………Eq.(10)

Where, α = 1.487

Chapter 4

CONCLUSION

Future Scope

4.1 CONCLUSION

1. From the saw-cut shear strength test the optimum saw-cut shear strength was found to be 14.7 MPa.
2. Saw-cut shear test is a rapid and inexpensive method for the determination of the shear strength of rock mass, and strength can be easily determined in the field.
3. Tri-axial shear strength of the dolomite was found to be 21.87 MPa.
4. From the above research the relation between saw-cut shear strength and tri-axial shear strength was found out. It was concluded that tri-axial shear strength is 1.487 times saw-cut shear strength of dolomite.

4.2 FUTURE SCOPE

This investigation was limited by time and availability of rock samples. More investigations in terms of large number of samples and more variables are necessary for a better understanding of its efficiency.

REFERENCES:

1. EVERLING, G. “Comments upon the definition of shear strength”. Int. J. Rock Mech. Min. Sci, vol. 1. 1964. pp.145-154
2. MAURER, W. C. Shear failure of rock under axial and hydrostatic pressure. Proc. 1st Congo Int. Soc. Rock Mech., Lisbon 1966, vol. I, pp. 337-341.
3. http://home.agh.edu.pl/~cala/hoek/Chapter4.pdf
4. http://192.168.1.115/bispdf/Index/bis/pdf/S03/S03V48/13047.pdf
5. Stacey T.R. “A simple device for the direct shear-strength testing of intact rock”, Journal of the Southern African Institute of Mining and Metallurgy, 2008.
6. http://www.geotechdata.info/geotest/triaxial-test.html
7. Brady B.H.G., Brown E.T., “Rock Mechanics for Underground Mining”, 3rd Edition, Kluwer academic publishers, 2004.