JHARKHAND Rai University RANCHI

MINING ENGINEERING LAB MANUAL

APPLIED ROCK MECHANICS LAB (B.TECH)

SEMESTER VI

LIST OF EXPERIMENTS

EXPERIMENT: 01

AIM: Study of Load-yield characteristics of friction prop and hydraulic prop/leg.
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Materials & Equipment:

1. Friction prop.
2. Hydraulic prop.

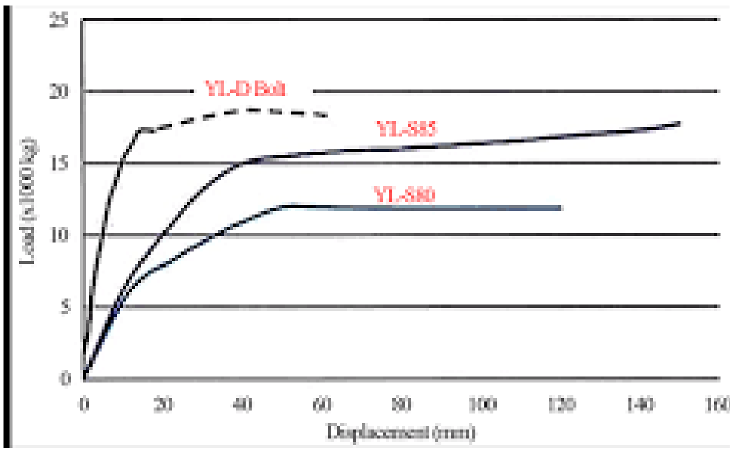
THEORY:

A mining yielding support is used for securing roadways against the static and dynamic impact of the rock mass. Hydraulic props and friction props are used to produce the support. Their essential part decisive for load-bearing capacity and yield capacity are friction joints and hydraulic support. The characteristic feature of a yielding support and its crucial advantage is that it is capable of changing its dimensions by itself during work. The interworking shaped sections in a friction joint may displace (yield) due to a rock mass deformation load and after such operation a yielding support transits into a new state of equilibrium and may further ensure that the heading is protected.

PROCEDURE:

The stand tests of friction joints work under a dynamic load were carried out at a special test stand. A friction joint in such tests is subjected to an axial load with m mass falling from a specific h height. The size of the m mass during the tests was constant. The tests were carried out for four different heights from which the impact mass was dropped. The heights were so selected so that the characteristics of the determined parameters included the broadest possible range of variations in the impact energy. The impact of the falling mass on the joint was exerted through a cross-beam with constant m mass that rested upon the friction joint.

Load yield characteristics of Hydraulic prop:



YL-D Bolt
YL-S85
YL-S80
Load (x1000 kg)
Displacement (mm)
0
5
10
15
20
25
0
20
40
60
80
100
120
140
160

EXPERIMENT: 02

AIM: Study of Drillability of rock.

Materials & Equipment:

1. Rock samples.
2. Drill bit.
3. Brittleness value test setup.
4. Swedish stamp test setup.

THEORY:

Drillability may be defined as an ease of drilling or rate of penetration (ROP). Drillability indicates whether penetration is easy or hard. Rock drilling is performed with a number of techniques ranging from rotary/percussive drilling in very hard rock, via rotary/crushing drilling in medium hard rock, down to cutting in soft rock types. Penetration of rocks is influenced by rock properties as well as machine parameters.

PROCEDURE:

Penetration rate test:-

A laboratory scaled core retrieval machine was used to determine rocks' penetration rates. Penetration rate tests were carried out on five samples for each natural stone type. Thus, penetration rate test were carried on a total of 50 samples. A new drill bit was used in penetration rate tests and all tests were carried out with this bit. Rotational speed of the drill bit was determined to be 1479 rpm in all penetration tests. It was decided that while penetration rates of rocks are determined, water debit and drilling force parameters are constant at all tests.

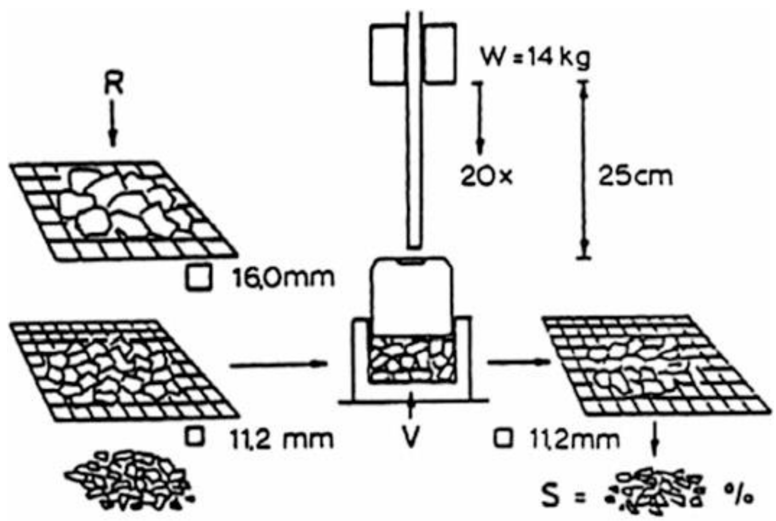
Drilling Rate Index (DRI):-

The DRI is assessed on the basis of two laboratory tests: the brittleness value (S_{20}) test and The Sievers' J value (Sj) miniature drill test.

The brittleness value S_{20} is an indirect measure of rock resistance to crack growth and crush. S_{20} is determined by the Swedish Stamp Test.

The crushed and sieved aggregate, sizes ranging 16.0–11.2 mm, is placed in a mortar and then struck 20 times with a 14-kg hammer. The mortar aggregate volume corresponds to that of a 0.5-kg aggregate with a density of 2.65tons/m^3.

S_{20} equals the percentage of undersized material that passes through 11.2-mm mesh after drop test. S_{20} is presented as a mean value of three or four parallel tests.



R = Rock sample aggregate
W = Weight (14 kg)
S_{20} = Brittleness value after 20 impacts

EXPERIMENT: 03

AIM: Study of Anchorage strength of rock bolt.

Materials & Equipment:

1. Rock bolt
2. Anchorage test setup.

THEORY:

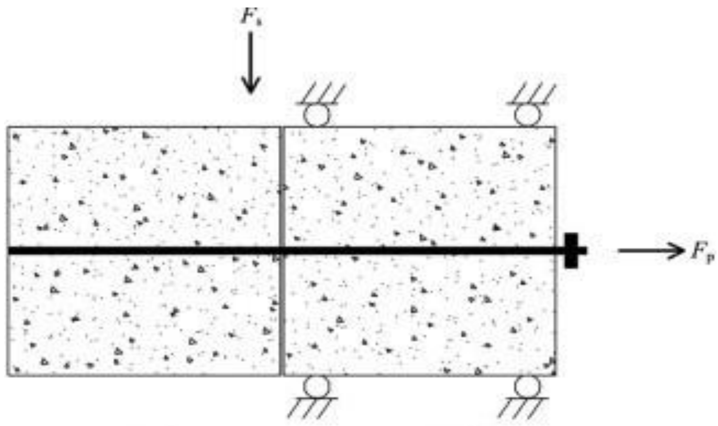
Rock bolts have been widely used as the primary support element to stabilize the rock masses around tunnels, mines, slopes, and other structures in association with rock masses. For better understanding of rock bolt performance, several studies have been carried out by laboratory and field tests, analytical methods, and numerical analysis. According to practical engineering experiences, rock bolts may be subjected to pull-and-shear loadings in field.

PROCEDURE:

ANCHORAGE TEST:

This method was developed to apply pull-and-shear loads to the bolt specimen in order to evaluate the anchorage performance of the rock bolt. In the tests, five displacing angles (0°, 20°, 40°, 60°, and 90°), two joint gaps (0 mm and 30 mm), and three kinds of host rock materials (weak concrete, strong concrete, and concrete-granite) were considered, and stress–strain measurements were conducted. Results show that the ultimate loads of rock bolt remained constant with any displacing angles. The compressive stress exists at 50 mm from the bolt head, and the maximum bending moment value rises with the increasing displacing angle. The displacement capacity of the bolts increased with the joint gap. The bolt subjected to joint gap effect yields more quickly with greater bending moment and smaller applied load. In pure shear condition, the ultimate load of the bolts slightly decreases in the hard rock. The yielding speed in the hard rock is higher than that in the weak rock.

Typical arrangement of Anchorage test:



EXPERIMENT: 04

AIM: Study of Dynamic modulus of elasticity.

Materials & Equipment:

1. Impact hammer
2. Piezoelectric accelerometer
3. Connecting cables for impact hammer and accelerometer

THEORY:

Dynamic modulus is the ratio of stress to strain under vibratory conditions (calculated from data obtained from either free or forced vibration tests, in shear, compression, or elongation). It is a property of viscoelastic materials.

Experimental determination of dynamic modulus of elasticity of fiber-reinforced concrete (FRC) by using impact hammer is based on measuring resonant frequencies of flexural vibrations in prismatic specimens. The natural frequencies are determined as resonant peaks from frequency response function (FRF), which is obtained by measuring the excitation and response function. The determination of the natural frequencies in this way represents an improvement over standardized test methods. The dynamic modulus of elasticity is determined using fundamental resonant frequency according to relations given in standards. The results are compared to the modulus of elasticity obtained by correlation with compression strength.

PROCEDURE:

For the experimental research cube specimens with dimensions of 150 mm and prismatic concrete specimens of dimensions 100 × 100 × 400 mm are casted.

The striking end of the hammer can be supplied with different impact tips (steel, aluminum, and rubber, plastic) to create different frequency response. Therefore, effect of different impact tips is investigated first. Plastic impact tip is found to be the most appropriate for present test specimens, i.e. it produces impulse with the acceptable frequency range.

Once the fundamental resonant frequency is determined and knowing specimen dimensions and density, dynamic modulus of elasticity can be easily calculated.
Dynamic modulus of elasticity according standard ASTM is given by following expression:

$$E_d = C \times M \times n^2$$

Where;

Ed – dynamic modulus of elasticity [Pa]

C = 0.9464 [N·s2(kg·m2)] for the prismatic specimen,

M – Mass of the specimen [kg],

n – Fundamental resonant frequency of the specimen in flexure [Hz] and

EXPERIMENT: 05

AIM: Study of Shear properties of discontinuity.

Materials & Equipment:

1. Rock sample.
2. Shear box.

THEORY:

The shear strength of a discontinuity in a soil or rock mass may have a strong impact on the mechanical behavior of a soil or rock mass

All rock masses contain discontinuities such as bedding planes, joints, shear zones and faults. At shallow depth, where stresses are low, failure of the intact rock material is minimal and the behavior of the rock mass is controlled by sliding on the discontinuities.
In order to analyze the stability of this system of individual rock blocks, it is necessary to understand the factors that control the shear strength of the discontinuities which separate the blocks.

PROCEDURE:

A **direct shear test** is a laboratory or field test used by geotechnical engineers to measure the shear strength properties of soil or rock material, or of discontinuities in soil or rock masses. The test is performed on three or four specimens from a relatively undisturbed soil sample. A specimen is placed in a *shear box* which has two stacked rings to hold the sample; the contact between the two rings is at approximately the mid-height of the sample. A *confining stress* is applied vertically to the specimen, and the upper ring is pulled laterally until the sample fails, or through a specified strain. The load applied and the strain induced is recorded at frequent intervals to determine a stress–strain curve for each confining stress. Several specimens are tested at varying confining stresses to determine the shear strength parameters, the soil cohesion (c) and the angle of internal friction, commonly known as *friction angle*.

EXPERIMENT: 06

AIM: Study of Blast induced ground vibration.

THEORY:

Ground vibration generated due to blasting is an undesirable phenomenon which is harmful for the nearby habitants and dwellings and should be prevented.

A blast generates ground shock and vibration which may cause damage to the surrounding structures. In the recent decades, blast-induced ground shocks and their propagation in rock mass have been drawing more and more attention. The blast effects include change in rock behavior having implications on the stability and integrity of structures. Structures are designed and constructed to bear static and dynamic loads in addition to taking care of settlement of foundations within permissible limits. Dynamic loads include earthquake load, vibratory machine load, blast load, etc. The blast load on structures is caused by quarrying, mining activities, accidental explosion of underground explosives, terrorist attacks, excavation activities, etc. There are complexities in the wave and ground motion characteristics, blasting parameters and site factors. Various experimental site-specific studies have been performed to predict and control blasting effects. The parameters associated with the vibration are displacement, velocity and acceleration with their respective frequencies. It has been inferred from literature that peak particle velocity (PPV) is generally a good index of damage to structure:

$$v = n + k(R/Q^{1/2})^{-1}$$

The vibration level at a distance depends on charge per delay, vibration frequency, rock characteristics (type, unit weight, layering, slope of layers), blast hole conditions, presence of water, propagation of surface and body waves in the ground, and to a lesser extent on method of initiation. Fractures are developed in rocks due to tensile and shear stresses. Hence, studies of blast-induced ground vibrations in rocks have become important.

The relationship between PPV and scaled distance (*D*) can be written as

$$v=kD-b$$

where v is the PPV (m/s); D is the scaled distance (m/kg$^{1/2}$), which is defined as the ratio of distance from charge point, R (m), to the square root of charge mass, Q (kg), expressed in TNT net equivalent charge weight, i.e. $D = R/Q^{1/2}$; k and b are site constants.

EXPERIMENT: 07

AIM: Use of rock mass monitoring system in assessing blasting performance.

Materials & Equipment:

1. JKMRC fragmentation Modelling.

THEORY:

In the mining industry blasts are usually designed to fracture the in-situ rock mass and prepare it for excavation and subsequent transport. The run of mine (ROM) fragmentation is considered good when it is fine enough and loose enough to ensure efficient digging and loading operations. Mining optimization strategy is hence usually focused on minimizing total mining costs and maintaining these ROM fragmentation characteristics. Although this approach ensures an efficient mining operation it ignores the potential impact on crushing and grinding. Investigations by several researchers have shown that designing blasts to produce ROM fragmentation to optimize crushing and grinding performance, enhances the overall efficiency and profitability.

Field experimentation in this area is often found to be difficult because of high implementation costs and insufficient understanding about the effect of fragmentation at different stages in a comminution circuit. Modelling and simulation of blasting and comminution processes provide a more economic alternative to explore the impact of blast design changes on the downstream operations.

PROCEDURE:

<u>JKMRC Fragmentation Modelling Approaches-</u>

Fragmentation due to blasting is produced by two mechanisms. One is related to the compressive-shear failure of the rock (mainly of the rock matrix) close to the blast holes, while the second mechanism is the tensile failure of the rock mass. Fines in a blast are generated predominantly by the crushing of rock around the blast hole due to compressive-shear failure.

The coarse fragments are generated predominantly by tensile failure beyond the crushing zone.