Safety Manual

Rock Excavation Laboratory

Department of Mining Engineering

IIT(ISM) Dhanbad

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Practical Courses

- **B.Tech.(Mining Engineering)**

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**MNC 204**	**Rock Excavation Lab.**	**0**	**0**	**2**	**2**

- **M.Tech.(Opencast Mining)**
- **M.Tech.(Tunnelling and Underground Space Technology)**

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MNC516	Rock Excavation Practical	0	0	3	3

Course Objective
The objective of the above practical is to enable the learner to understand the determination of different dynamic properties and specific energy for rock excavation as per the suggested methods (ISRM, ASTM, BIS, NTNU etc.) and also to provide an over view of their application in geo-engineering design.
Learning Outcomes
Upon successful completion of this course, students will: • know determination of various mechanical properties of rock (dynamic) • correlate their application in rock excavation system design

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Do's and Don'ts

The following instructions may be followed while conducting practicals in the above-mentioned laboratory:

1. Read the experimental manuals/standard operating procedures in advance, carefully and completely, and make your own observations on the type, procedure and care that needs to be exercised in each practical.

2. Listen to the instructions of the instructor, technical personnel and associated scholar and follow meticulously. Any doubts with regards to usage please do not hesitate to contact any one of the above.

3. Unless you are asked do not touch any equipment, samples or any part of the equipment.

4. Carryout the measurements and experiments under the supervision of the designated instructor. Do not operate or insist to operate equipment without proper permissions.

5. Any uncommon noise, smoke, vibration and leakage while operating the machine or any other nearby equipment if noticed please bring it to the notice of the concerned laboratory technical person and teacher concerned. Never venture into solve it unless asked for.

6. Any impeding danger foreseen please evacuate the place and inform the concerned.

7. Wear cotton clothes with loose fit and shoes before you enter the lab. Goggles as per the need shall be provided to you to wear. Wear them before you start your work.

8. Do not leave any of your belongings in the laboratory and check before you leave.

9. Take a good care of yourself, the equipment and samples and leave them in good shape.

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1.0 General Hazards in the Rock Excavation Laboratory

The purpose of this document is to implement the risk/hazard-based safety management system in the Rock Excavation Laboratory of the Department of Mining Engineering. The first step is to identify the potential hazards associated with the available infrastructure and conducting experiments/testing in the laboratory. Once the potential hazards are identified, the existing controls and protection measures are reviewed. In the process of review of the existing controls, if the existing controls are found to be inadequate, additional controls are suggested. This enables the users and visitors in the laboratory to take due care of safety and avert any untoward incident that may lead to serious accident.

Accordingly, this manual first deliberates on the general hazards associated with the laboratory, and then further sections of the document explains the safety management in the use of equipment available in the laboratory. The standard operating procedures (SOPs) have been developed for use of major equipment in the laboratory based on the risk-based safety management system.

1.1 Hazards related to electrical installations

S. No.	Existing / Potential hazards (General Electrical)	Existing controls / protection	Additional Controls	Remarks
1	Fire from electrical apparatus / switches	1. Individual machine power control. 2. Individual Circuit Breaker 3. Main Circuit Breakers are available	1. Suitable Fire extinguishers are provided near main switch boards and distribution boards 2. All technical staffs are trained in use of firefighting apparatus (FFA) 3. Procedure to be prepared for checking of FFA 4. FFA to be periodically checked 5. Expiry of FFA to be checked 6. Windows can open easily when lab is conducted, to avert asphyxiation of persons inside the room in case of fire.	

1.2 General / common Hazards

S. No.	Existing / Potential hazards (General Injury)	Existing controls / protection	Additional Controls	Remarks
1	Slip, trip and fall hazard Injury of the feet by hitting hard objects lying on floor	1. Non-slippery concrete floor provided in laboratory. 2. Arrangements for drainage of water in rock cutting lab provided. Proper housekeeping	1. Tile separator made on floor having elevation difference and also for demarcating safe distance from machine. 2. Temporary barricading to be installed 3. Friction rubber mats to be provided at conspicuous locations 4. Warning boards to be provided at conspicuous locations 5. Shoes to be worn while in the laboratory 6. Use of safety shoe to be made mandatory	
2	Fall of materials from height	1. Supervision 2. Training 3. Helmets to be worn	1. Prohibitary order for complete elimination of working under suspended load is to be issued and implemented. 2. Table tops to be provided with friction rubber mats 3. Presence of loose materials above ground to be examined regularly.	

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S. No.	Existing / Potential hazards (General Injury)	Existing controls / protection	Additional Controls	Remarks
3	Injury due to lack of illumination	1. Tube lights provided	1. Additional LED lights to be installed	
4	lack of communication while operating equipment	1. All operation under supervision of Technical staff	1. Procedure for communication to be developed. 2. Provision of portable audio system in noisy environment.	
5	Biological hazard (snake bite, rats, cats)	1. Periodic pest control measures	1. Doors and windows to be repaired to prevent entry of animals / snakes etc. 2. Snake entry points to be sealed. 3. Periodic cleaning of grass and bushes around the outside boundary of the lab.	
6	Unauthorized entry	1. Supervision	1. Prohibitory notice boards to prevent unauthorised entry to be provided 2. fluorescent lines to be marked on floor	
7	Emergency exits	1. Grilled Gates available	1. Aluminium panelled glass doors to be provided.	
8	Injury on feet due to hitting rock samples, other materials lying on floor		1. Improving house keeping 2. Use of shoes 3. Adequate illumination	

1.3 Hazards related to lifting of heavy material using chain blocks

Chain blocks (Figure 1) are designed solely for hand vertical lifting and lowering of free loads in the workplace. The load mass must not exceed the specified nominal lifting capacity as provided by the manufacturer. Numerous accidents have taken place during the use of chain blocks and danger exists when loads are lifted, particularly when the chain block is not used properly or is poorly maintained. This can result in an accident or serious injury. Therefore, special safety precautions are applicable to the operation with the chain block during its assembly, maintenance and inspection. The golden rule for use of chain pulley blocks is "Proper rigging and lifting techniques are the responsibility of the operator".

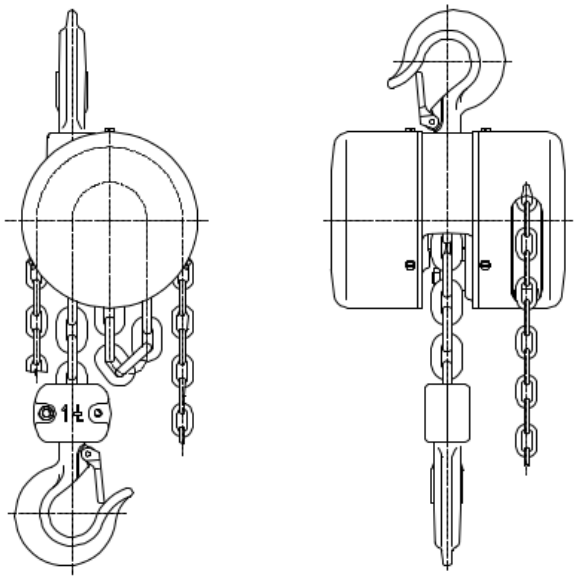

Figure 1 – Chain block and pulley arrangement

Hazards related to chain block with applicable controls are described below:

S. No.	Existing / Potential hazards (General Injury)	Existing controls / protection	Additional Controls	Remarks
1	Failure of chain pulley block causing injury Damage in the components of the chain	1. Visual inspection 2. Supervision	1. Checking of chain block at regular interval. 2. Maintaining records of examination 3. Testing of chain pulley block.	1. Lab manual in place 2. Dos and Don'ts list displayed 3. Operation procedure displayed on the equipment 4. Helmet 5. Eye glasses 6. Gloves 7. Fire extinguisher provided near main switch board 8. Main Circuit Breakers 9. Mains Control
2	Crushing the fingers / hands while operating chain block due to incorrect assembly.		1. Correct the entangled links of the chain. 2. Use of hand gloves	
4.	Cuts from sharp edges	1. There can be sharp edges or pressed metal chips on the chain. To avoid injury, protective gloves should be worn	1. Use of hand gloves is mandatory	
5	Fatigue cracks	1. Visual inspection	1. Testing of chain blocks at regular interval	
6	Fall of hanging load	1. Cautioning all personnel to move away from the hanging load.	1. Working under suspended load is to be completely banned. 2. Suitable caution boards to be provided 3. Marking danger zone before lifting heavy load 4. Barricading danger zone 5. Supervisors to ensure persons are not within danger zone	

Based on the hazards associated with the use of chain pulley blocks, the standard operating procedures are enumerated as under:

1.4 Standard Operating Procedure of using chain pulley block (Table 1)

i. Golden Rule: **No person should stand or work under suspended load**

ii. Suitable caution boards to be provided

iii. Marking danger zone before lifting heavy load

iv. Barricading danger zone must be ensured

v. Supervisors to ensure persons are not within danger zone

vi. NEVER lift more than lifting capacity shown on the chain block nameplate.

vii. ALWAYS make sure the load carrying structure will provide adequate support to handle fully loaded chain block and all the lifting operation.

viii. ALWAYS let people around to know when a lift is about to begin.

ix. Provide notice board for the golden rule "Proper rigging and lifting techniques are the responsibility of the operator".

x. Only authorised personnel are allowed to use the chain blocks.

Procedures to be followed prior to use of chain blocks

i. ALWAYS ensure physically fit, qualified and instructed persons over 18 years of age, and trained in safety conditions and way of work, operate the chain block.

ii. ALWAYS check the chain block daily before use

iii. ALWAYS make sure the length of chain is long enough for the intended job.

iv. ALWAYS check the brake function before use.
v. DO NOT use repaired chain only.
vi. ALWAYS ensure the load chain is not corroded, it is cleaned and oiled.
vii. ALWAYS make sure the last link of load chain is strongly fastened to the body.
viii. NEVER use damaged or worn out chain block.
ix. NEVER use chain block with jumped out, damaged or missing hook's safety latch.
x. NEVER use a chain block without a visible marking of the lifting capacity.
xi. NEVER use modified or deformed hooks.
xii. NEVER connect or lengthen the load chain.
xiii. NEVER use a chain block marked by the label „OUT OF SERVICE".
xiv. ALWAYS consult the manufacturer or his authorized representative, if you plan to use a chain block in non-standard or extreme environments.

Procedures to be followed when the chain block is in use

i. ALWAYS make sure the load is properly seated in the hook.
ii. ALWAYS make sure the safety latches of hooks work in the correct way
iii. ALWAYS pay attention to the limit positions.
iv. NEVER use a chain block for tensioning, pulling or anchoring loads.
v. NEVER allow swinging the load, causing impacts or vibrations.
vi. NEVER use a chain as a sling
vii. NEVER hitch a load on the tip of the hook.
viii. NEVER pull the chain over any edge.
ix. NEVER weld, cut or make any operation on a suspended load.
x. NEVER operate a chain block, if chain is jumping or atypical or excessive noise occurs.

Procedures to be followed after use of chain block

i. NEVER leave a load suspended.
ii. ALWAYS ensure the chain block against incompetent use.

Procedures to be followed for Maintenance of chain block

i. ALWAYS Ensure competent personnel inspect the chain block regularly.
ii. ALWAYS ensure the chain was clean and oiled.
iii. ALWAYS ensure the sliding parts were greased enough.
iv. NEVER add other parts for lengthening the load chain.

Table 1

Standard Operating Procedure for

Chain Block and Pulley (2 Tonne)

S.No.	Procedure	Operation
1	Connect chain block to the fixed load via grabbing hook	
2	Fix and lock grabbing hook	
3	Attach grabbing hook with chain pulley block	
4	Slack section with pulley, hand chain/load chain wheel	
5	Load hook fitted with safety latch for holding weight	
6	Load/hoist chain for lifting load	
7	Bind loads with webbing sling	
8	Manual hand pulled chain for tightening grip on the wheel and lift load through load chain	

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2.0 Hazard identification and SOP for operation of 50 T Punch Penetration and Fracture Toughness Testing Machine (CSTM)

2.1 Brief description of the 50 T Loading Frame and the associated hazards

The Punch penetration and fracture toughness strength-testing machine serves the purpose of determination of two major indices namely Punch Penetration Index (PPI) and Fracture Toughness Index(FTI) of rock/concrete specimen. It is an electro-mechanical machine. The foundation is firm and bolted with a base. The two major parts of the machine are (I) Testing Machine including two columns, cross head and the base portion (ii) Operating Levers and controls (Figure 2). Accessories for punch penetration test and fracture toughness test are also shown in Figure 2. Detailed operating instructions are provided in Table 2.

Figure 2 - 50 T Loading frame for Punch Penetration and Fracture Toughness Tests and Accessories

The hazards associated with the use of 50 T CSTM are given in the table below:

S. No	Existing / Potential hazards associated with demonstration / testing / maintenance	Existing controls / protection	Additional Controls	Remarks
1	1. Rotating gears & Gear wheels 2. Ejection of broken rock 3. Rotating gears & Gear wheels 4. Ejection of broken rock	1. Check appropriate gear knob. 2. Provided acrylic sheet around loading frame, face shield and eye glasses 3. Check appropriate gear knob. 4. Provided acrylic sheet around loading frame, face shield and eye glasses	1. Emergency Stop Switch	1. Lab manual in place 2. Dos and Don'ts list displayed 3. Standard Operating procedure displayed on the equipment 4. Helmet as needed 5. Eye glasses 6. Gloves 7. Fire extinguisher provided near main switch board 8. Main Circuit Breakers 9. Mains Control
2	1. Electrical hazards 2. Fire from electrical short circuit 3. Electric shock while operating machine due to earth leakage current	1. Maintaining proper earthing	1. Please refer Sl. 1 Section 1.1 2. Testing of leakage current 3. Providing suitable fire fighting apparatus	
3	1. Collision with obstructions while raising the cross head e.g. loose wires or other fixtures	1. No wire should run over the X-head. 2. Obstructions if any must be removed.	1. Operator and demonstrator must ensure proper clearance of obstruction above the crosshead. 2. Dedicated and experienced operators to operate the machine.	
4	1. While applying load, broken sample may hit the Instructor / Technician / Students / Visitors and cause serious injury	1. Providing a guard or screen while applying load 2. Skill & competency of technical staff 3. Supervision	1. Induction training / initial briefing 2. Maintaining a safe distance for the students / visitors 3. Providing face shields, Protective eye glass.	
5	1. Injury on feet due to hitting rock samples, other materials lying on floor	1. Pl. refer sl. 8 Section 1.3	1. Pl. refer sl. 8 Section 1.3	
6	1. Serious cut injury while using rock testing tools	1. Pl. refer Sl. 1 Section 1.3	1. Pl. refer Sl. 1 Section 1.3	

2.2 Standard operating procedure (SOP) for 50 T Loading Frame with PPI and FTI (Table 2 & Table 3)

Based on the hazards identified and existing as well as additional controls as discussed in Section 2.1, the SOP for operation of the 50 T loading frame and other parts is given as under.

Standard Operating Procedure and Controls:

1. Only dedicated/authorised and experienced operators must operate the machine.
2. Before demonstration, an initial briefing regarding the potential hazards shall be explained to the students or visitors
3. If the earth to neutral voltage exceeds the prescribed limit of (15 V), qualified electrical engineer must be contacted to rectify the problem. When the ELCB is provided, it should not be bye-passed.
4. Operator and demonstrator must ensure proper clearance of obstruction above the cross head.
5. Proper guard or screen should be placed around sample while applying load to prevent broken sample hitting the Instructor / Technician / Students / Visitors and causing serious injury
6. The operator and the instructor must ensure maintaining a safe distance for the students / visitors
7. Providing face shields/ Protective eyeglass should be worn by persons working in vicinity of the specimen being tested.

Table 2

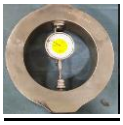
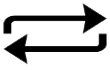
Standard Operating Procedure for
Punch Penetration Index (50 T Loading Frame)

S.No.	Procedure	Operation
1	Connect 2-phase plug and switch on the power	
2	Set the knob to fast/slow movement	
3	Set the Switch to '0ff' '1', '2' positions for halting, downward, upward movement of platen	
4	Set loading rate kN/min from the options (1,1) for highest rate; (2,5) for lowest rate	
7	Set the position of PP indenter	
8	Place punch penetration cell with set rock specimen	
9	Fix load cell for load measurement and connect to DAS	
10	Fix LVDT and connect to DAS	
10	Press the green switch to start the machine	
11	Press the red switch to stop the machine and repeat the procedure from step 2 for 4 test values.	 
12	Disconnect the power plug before leaving the place	

Table 3

Standard Operating Procedure for

Fracture Toughness Index (50 T Loading Frame)

S.No.	Procedure	Operation
1	Connect 2-phase plug and switch on power	
2	Set knob to fast/slow movement	
3	Set the Switch to '0ff' '1', '2' positions for halting, downward, upward movement of platen	
4	Set loading rate kN/min from the options (1,1) for highest rate; (2,5) for lowest rate	
5	Set the support roller	
6	Set the proving ring for load indication	
7	Set loading roller below the end position of proving ring	
8	Press the green switch to start the machine	
9	Press the red switch to stop the machine	
10	Repeat the procedure from step 2 for 4 test values	
11	Disconnect the power plug before leaving the place	

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3.0 Hazard identification and SOP for operation Linear Cutting Rig with High Pressure Hydraulic Hand Pumps / Power Packs

3.1 Brief Description of Linear Cutting Rig and the High-Pressure Hydraulic Hand Pumps / Power Packs and the associated hazards

High pressure hydraulic hand pumps / power packs are a convenient, portable source of hydraulic power. They are designed to be stable during operation. Hydraulic equipment and systems are designed to accomplish work using confined liquid pressure to produce a greater mechanical force. The operators/ maintenance crews are subjected to hazards from high pressure liquids and large mechanical forces. Hydraulic systems store fluid under high pressure. Three hydraulic systems attached to linear cutting rig (LCR), Triaxial Cell (Hoek Cell) and Bemek Rock Tester for fracture toughness test. Pressurised systems are shown in Figure 3.

Linear Cutting Rig Test

Bemek Rock Fracture Toughness Test

Figure 3 – Pressurised systems in different equipment

The following hazards and their control measures have been identified:

S. No.	Existing / Potential hazards associated with demonstration / testing / maintenance	Existing controls / protection	Additional Controls	Remarks
1	1. Lifted weight 2. Moving part 3. Cutting disc 4. Hydraulic system failure 5. Electrical failure 6. Leakage of Hydraulic oil 7. Flying particles	1. Check load position before starting and keep it in rest position grounded on the trolley. 2. Don't force the moving trolley and cutting disc with extra pressure and don't hold by hand 3. Keep hands away from the cutting disc and all moving parts. 4. Check Hydraulic controller/pressure knob/valve 5. Check all electrical switches and circuit breaker 6. Check any leakage before starting the machine 7. Providing face shield and eye glass	1. Emergency Stop Switch 2. Circuit breaker	1. Lab manual in place 2. Dos and Don'ts list displayed 3. Standard Operating procedure displayed on the equipment 4. Helmet as needed 5. Eye glasses 6. Gloves 7. Fire extinguisher provided near main switch board 8. Main Circuit Breakers 9. Mains Control
2	Oil leakage and electrical earth leakage while starting the machine	Please refer Section 2.1, Sl.1	Please refer Section 2.1, Sl.1	
3	Burns from hot, high-pressure fluid	Condition monitoring by way of visual checks	-	
4	Injection of fluid into the skin	Maintain safe distance from pressurised lines and parts.		
5	Fire Hazards	Please refer Section 1.1, Sl.1	Please refer Section 1.1, Sl.1	
6	bruises, cuts or abrasions from flailing hydraulic lines	Condition monitoring of critical hydraulic parts and hoses training and supervision		
6	Injury of people due to unexpected movement of equipment. □ During maintenance of equipment and their parts.	Supervision Training		
7	Injury due to sudden release of residual pressurized oil.	Supervision skill training		
8	Slippage due to oily floor area.□	Please refer Section 1.3, Sl.1	Please refer Section 1.3, Sl.1	

3.2 Standard operating procedure (SOP) for High Pressure Hydraulic Hand Pumps / Power Packs

In response to the hazards identified as above, the following SOP for High Pressure Hydraulic Hand Pumps / Power Packs is recommended.

For Hand Pumps

1. For best performance, operate the pump handle at moderate speed. When the handle gets hard to push at high pressure, take short strokes. The maximum leverage is obtained in the last 5 degrees of stroke. Adding an extension to the pump handle is dangerous and is not recommended.
2. Close the release valve finger tight only. Using tools on the release valve can damage it and cause the pump to malfunction.
3. In certain situations the pump handle can "kick back." Always keep your body to the side of the pump, away from the line of force of the handle.
4. Many hand pumps can be operated in the horizontal or vertical position. However, when using it in the vertical position, the hose end must be down or you will pump air instead of oil.
5. Check the pump instruction sheet to determine the correct operating position for your pump.
6. Clean all areas around the oil ports of the pump and the unit's quick disconnect coupling.

For hand pumps and Power Packs

1. Inspect all threads and fittings for signs of wear and damage. Replace as needed. Clean all hose ends, couplers, and union ends.
2. Connect the hose assembly to the hydraulic pump oil outlet and couple the hose to the power unit's quick disconnect.

   IMPORTANT: Seal all pipe connections with Teflon tape. Apply the tape in a clockwise direction relative to the top a total of 1-1/2 times. Apply the tape carefully to prevent it from being pinched by the coupler and broken off inside the pipe end. Any loose pieces of tape could travel through the system and obstruct the flow of oil or cause jamming of precision parts.
3. Attach one end of the hose to the high pressure port of the desired equipment and the other end of the hose to the high pressure port of the power unit.
4. Put off the motor power from MCC and lock out & Tag out. Obtain permit to work as per plant procedures.
5. Depressurize the system before start of work. Shut down/ Local Isolation may be taken, if required.
6. Never begin work on a hydraulic system until fully trained.
7. Never begin work on a hydraulic system without using a risk assessment.
8. Carefully review the manuals on equipments before beginning work. Ask questions about anything you do not fully understand.
9. Read the Material Safety Data Sheet (MSDS) for chemicals used.
10. Use all required safety Equipments.
11. Never try to repair a part without having full knowledge about it.
12. Each hydraulic system must have a documented procedure of de-energizing and load locking. This should be known to all maintenance personnel.
13. Document and practice de-pressurizing procedure in each of the circuit.
14. While testing the system after repair never stand close to the unit. Any component, pipe, hose, fitting may fail.
15. Before start of work, drain the pressure line up to the actuator.

16. If pressure gauge is showing zero, then also bleed the hose for confirmation.
17. During the tightening of pressurized lines hammering should not be done.
18. Tightening of Joints should be done in depressurized condition.
19. In any of the hydraulic maintenance jobs, all other agencies working in that area should be well communicated about the hydraulic work and its effects.
20. All hydraulic pipes and hydraulic cylinders should be tested at 1.5 times working pressure. All accumulators should be tested for its wall thickness and pressures as per Factories Act.
21. Do not use bare hand to check the hydraulic leakage; any fluid leakage through pinhole leakage can be injected into your skin. Use a card board or wooden piece to check leakages.
22. Hot work like gas cutting, welding should be avoided near hydraulic pipeline or near tank.
23. Any modification being carried out in Hydraulic System Circuit, should be approved by competent authority.
24. Do not weld on a hydraulic reservoir/sump without emptying the oil.
25. Ensure all vents (air breather & hatch plate) should be opened. For any maintenance/ cleaning job to release entrapped gases.

For Hoses & fittings

26. Before replacing hoses, depressurize the system
27. Check the hose or hoses to be replaced by twisting or squeezing them to see if the pressure has been relieved, or by another method suitable to the hose being used. If pressure is still in the hose or hoses, take appropriate measures to relieve the pressure before loosening the fittings. Care to
28. be taken that replacement of hose should be with hoses with same size and specifications.
29. Each and every hose in a hydraulic system must be able to handle the highest pressure produced by the system. Pressure surges or peaks exceeding the hose rated working pressure are destructive and must be considered when selecting a hose. Please ensure compatibility of hose with design pressure of system.
30. Improper Length/Routing - Forcing a hose into an improper geometry causes high stresses in the hose components that may also reduce pressure capacity (avoid multi-plane bending, small bend radii, tension in hose, etc.). Hose life can be reduced by 90% when subject to these type of stresses
31. Abrasion and Cuts - Wear against other hoses or objects will wear off the outer cover and lead to corrosion of the reinforcing mesh.
32. Extreme Pressure Fluctuations - Pressure surges above the hose working pressure will damage hose components.
33. Vibration - Cyclic loading of hoses can damage hose components even when motion seems relatively small.
34. Hoses having bulges or getting wet surface to be immediately replaced.

Table 4

Standard Operating Procedure for

Linear Cutting Rig

S.No.	Procedure	Operation
1	Place the rock sample on the sample tray	
2	Mark test line on rock surface with the desired spacing (25mm, 50mm and 75 mm)	
3	Close the acrylic fence for safety	
4	Connect tri-axial transducer, data acquisition device and start computer	
5	Connect 3 phase plug and neutral wire and switch on	
6	Press green switch for starting the machine	
7	Press F12 for moving disc cutter upwards vertically	
8	Press F14 button for moving disc cutter downwards	
9	Press F11 button for moving sample tray forward	
10	Press F13 button for moving sample tray backwards	
11	Press 0 button for Pause the Trolley	
12	Press 1 for normal and 2 for high speed of trolley	
13	Press red button to switch off the machine	
14	For emergency stop, press larger red button with arrows	
15	Detach the plug before leaving the machine.	

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4.0 Hazard identification and SOP for operation of Cerchar Hardness Index and Sj Value Apparatus

4.1 Brief Description of Cerchar Hardness Index and Sj Value Apparatus and the associated hazards

The CHI and Sj determination apparatus is used to conduct tests on rock specimen with a miniature drill bit under varied thrust for assessing the rate of penetration. There are three main parts in this apparatus. (i) The miniature drill setup (ii) Drill bit and (iii) Data Acquisition System for recording the penetration with time. The test setup is shown in Figure 4.

Figure 4 – Cerchar hardness and Siever'J Value Apparatus

All controls on the drilling setup are placed on the front and side panel. The lowering and raising is done manually with rotating mechanical levers and locks for conducting the test. All are within easy reach of the operator. Detailed operation and maintenance instructions are available in the user manual issued by the supplier.

The hazards associated with the use of CHI and Sj Machine are given in the table below.

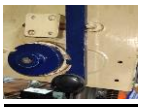
Sl. No.	Existing/Potential hazards associated with demonstration/testing/ maintenance	Existing controls/Protection	Additional Controls	Remarks
1	Loss of grip of sample Rotating part Fall of weight Rotating speed Spindle dropping	Vice to be checked before starting Knob control Checking the final position of the knob and tighten of the weight VFD control Checking the manual lock	Circuit breaker	1. Lab manual in place 2. Dos and Don'ts list displayed 3. Standard Operating procedure displayed on the equipment 4. Helmet as needed 5. Eye glasses 6. Gloves 7. Fire extinguisher provided near main switch board 8. Main Circuit Breakers 9. Mains Control
2	Injury due to movement of rotating arm	Open lock carefully to release the machine downwards. Then lock it after the drill bit touches the sample.	Rotating arm must be operated slowly after disengaging the lock till it carefully rests on the sample. Supervision Training	
3	Slippage of rock specimen from the sample holder	Proper tightening of the samples using wooden holders and vice	Supervision	

4.2 Standard operating procedure (SOP) for Cerchar Hardness Index and Sj Value Apparatus (Table 5)

1. Only authorised and experienced operators must operate the machine.
2. Before demonstration, an initial briefing regarding the potential hazards shall be explained to the students or visitors.
3. Engage levers in locked position.
4. If the earth to neutral voltage exceeds the prescribed limit of (15 V), qualified electrical engineer must be contacted to rectify the problem. When the ELCB is provided, it should not be bye-passed.
5. Proper locking should be placed around the sample while drilling to prevent sample slipping and hitting the Instructor / Technician / Students / Visitors and causing serious injury
6. The operator and the instructor must ensure maintaining a safe distance for the students / visitors
7. The spindle speed should not be changed while the machine is running.

Table 5

Standard Operating Procedure for
Cerchar Hardness Index/Siever's J Value

S.No.	Procedure	Operation
1	Connect 3-phase plug and switch on the power	
2	Check the switch on Generic/VFD mode	
3	Clamp the drilling bit and tighten the holder (Chunk)	
4	Disc for upward and downward movement of spindle	
5	Set the vice and wooden holder for tightening the sample	
6	Spindle gets unlocked when bit contacts rock	
7	Check final position of drill bit and tighten the knob	
8	Set load to 70N/200N/400N as required	
9	Set the control panel to 1 for pilot hole and 2 for drilling	
10	Switch on the vacuum cleaner for sucking drill cuttings	
11	To stop rotation, switch on to '0' position and repeat from step 3 for another 4 test values	 ⇄
12	Disconnect the power plug before leaving the place	

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5.0 Hazard identification and SOP for operation of Tool Wear Index

5.1 Brief Description of Tool wear index the associated hazards

The Tool Wear Index machine is used for determining bit wear index and abrasion value steel for cutting tools. This is to assess the abrasion capacity of rocks as well as abrasion resistance of cutting steel used in disc cutter. This machine consists of rotating table/turning plate powered by 1 HP motor (Figure 5). The broken powder (less than 1 mm size is fed through hopper and vibrating feeded. The detailed standard operating procedure is provided on Table 6. The thrust to the specimen is provided by the thrust cylinder weighing 10 kg.

Figure 5 – Tool wear index apparatus

The hazards associated with the use of Rock Grinding Machine are given in the table below:

S. No.	Existing / Potential hazards associated with demonstration / testing / maintenance	Existing controls / protection	Additional Controls	Remarks
1	1. Bit and tool holder 2. Rotating wheel	1. Secure and clamp the piece being worked. 2. Check the position and do not hold the work by hand	1. Emergency Stop Switch 2. Circuit breaker	1. Lab manual in place 2. Dos and Don'ts list displayed 3. Standard Operating procedure displayed on the equipment 4. Helmet as needed 5. Eye glasses 6. Gloves 7. Fire extinguisher provided near main switch board 8. Main Circuit Breakers 9. Mains Control
2	1. Electrical earth leakage while starting the machine	1. Please refer Section 2.1, Sl.1	1. Please refer Section 2.1, Sl.1	
3	1. Injury to hand while rock powder is fed.	1. Avoid touching the hopper and turning plate	1. Start the rotating plate only after the entire setup is ready for the test.	

5.2 Standard operating procedure (SOP) for Tool wear index

1. The machine should be used only under the supervision of dedicated/authorised and experienced operators.
2. Before using the machine, a demonstration and an initial briefing regarding the potential hazards shall be obtained by the students.
3. Those using this machine to compulsorily wear gloves and shoes.
4. The operator must be vigilant while running the machine and he must always be within the reach of the emergency switch.
5. If the earth to neutral voltage exceeds the prescribed limit of (15 V), qualified electrical engineer must be contacted to rectify the problem. When the ELCB is provided, it should not be bye-passed.
6. The operator/demonstrator/instructor must ensure maintaining a safe distance for the students / visitors

Table 6

Standard Operating Procedure for
Tool Wear Index

S.No.	Procedure	Operation
1	Pour crushed rock powder (less than 1mm) into hopper	
2	Weigh the tool and check tool shape (Curvature:15 mm)	
3	Connect 3-phase plug and switch on the power	
4	Switch on the vacuum cleaner for sucking powder	
5	Set the flow rate of vibrating feeder to 80 g/min	
6	Clamp the cutting tool below 10 kg weight on powder bed	
7	Set the steel disc rotation to 20rpm for 5 min on controller	
8	Press the green switch to start the machine (wheel rotation)	
9	Press red button to switch off the machine	
10	Weigh the tool for weight loss and repeat step 2 for 4 tests	 ⇄
11	For emergency stop, press larger red button with arrows	
12	Disconnect the power plug before leaving the place	

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6.0 Hazard identification and SOP for operation of Brittleness Index

6.1 Brief Description of Brittleness Index and the associated hazards

The CHI and Sj determination apparatus is used to conduct tests on rock specimen with a miniature drill bit under varied thrust for assessing the rate of penetration. There are three main parts in this apparatus. (i) The miniature drill setup (ii) Drill bit and (iii) Data Acquisition System for recording the penetration with time. The test setup is shown in Figure 6.

Figure 6 – Brittleness index apparatus

All controls on the drilling setup are placed on the front and side panel. The lowering and raising is done manually with rotating mechanical levers and locks for conducting the test. All are within easy reach of the operator. Detailed operation and maintenance instructions are available in the user manual issued by the supplier.

The hazards associated with the use of CHI and Sj Machine are given in the table below:

Sl. No.	Existing/Potential hazards associated with demonstration/testing/ maintenance	Existing controls/Protection	Additional Controls	Remarks
1	1. Rotating part 2. Fall of weight 3. Rotating speed	1. Keys and adjusting wrenches must be removed before starting 2. Avoid awkward operation and hand position 3. VFD Control	1. Emergency Stop Switch 2. Circuit breaker	1. Lab manual in place 2. Dos and Don'ts list displayed 3. Standard Operating procedure displayed on the equipment 4. Helmet as needed 5. Eye glasses 6. Gloves 7. Fire extinguisher provided near main switch board 8. Main Circuit Breakers 9. Mains Control

6.2 Standard operating procedure (SOP) for Cerchar Hardness Index and Sj Value Apparatus (Table 7)

1. Only authorised and experienced operators must operate the machine.
2. Before demonstration, an initial briefing regarding the potential hazards shall be explained to the students or visitors.
3. Engage levers in locked position.
4. If the earth to neutral voltage exceeds the prescribed limit of (15 V), qualified electrical engineer must be contacted to rectify the problem. When the ELCB is provided, it should not be bye-passed.
5. Proper locking should be placed around the sample while drilling to prevent sample slipping and hitting the Instructor / Technician / Students / Visitors and causing serious injury
6. The operator and the instructor must ensure maintaining a safe distance for the students / visitors
7. The spindle speed should not be changed while the machine is running.

Table 7

Standard Operating Procedure for

Brittleness Index

S.No.	Procedure	Operation
1	Weigh the rock sample (about 500gm) between -16 and +11.2 sieve size	
2	Place the rock sample into container	
3	Connect 3 phase plug to switch on the machine	
4	Press green switch to start machine	
5	Use Control panel for setting the number of drops (20 drops) from a height of 25cm.	
6	Fix the safety pin before removing sample container	
7	Perform the sieving operation with 11.2 mm sieve size	
8	Weigh the crushed sample -16 and + 11.2 mm size	
9	For emergency stop, press larger red button with arrows	
10	Disconnect the 3-phase plug to switch off the machine	

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7.0 Hazard identification and SOP for operation of Tool Grinding Machine

7.1 Brief Description of Tool Grinding Machine and associated hazards

The Tool grinding machine is used for preparing cutting tools (abrasivity pins, drilling bits, tools for BWI and AVS) required for evaluating the rock abrasivity and tool life. This machine consists of two stations (i) Station A for Pin grinding (ii) Station B: for bit grinding. An attachment for special steel tool grinding is also available. It has two rotating discs for sharpening the tools at desired angle, width and curvature. The rotating plates are powered by 0.5 HP motor (Figure 7).

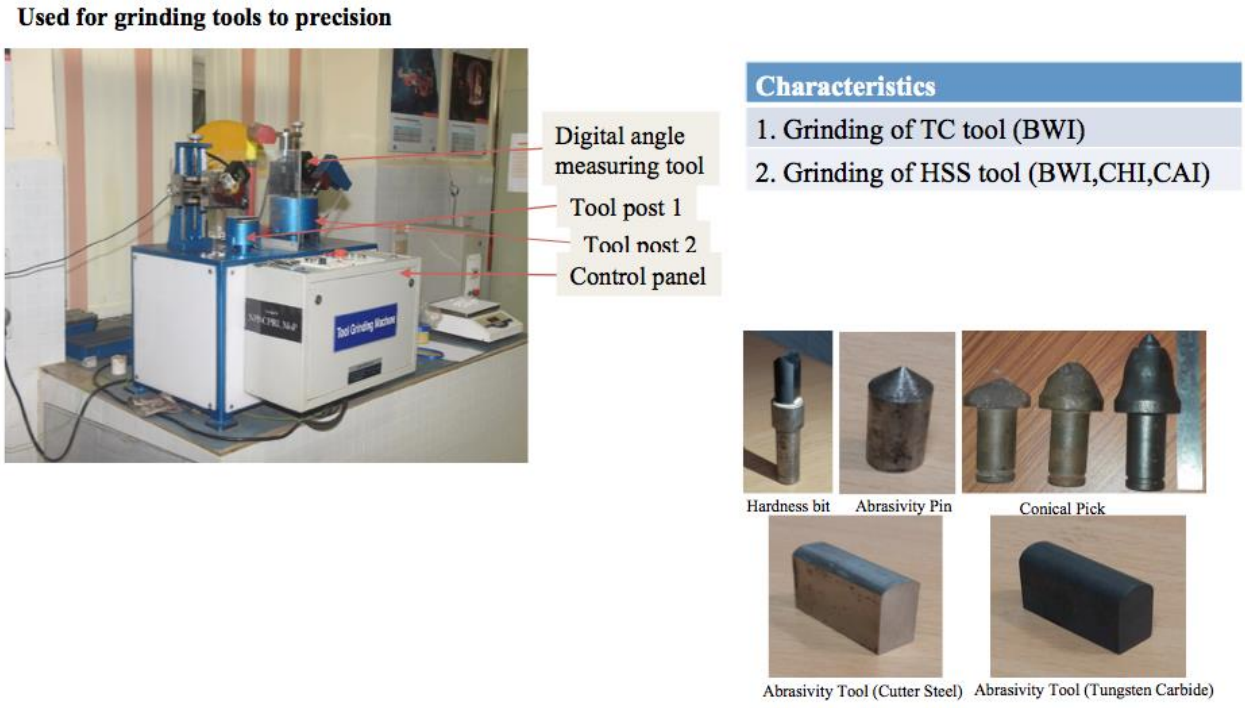

Figure 7 – Tool grinding machine and pins/bits/tools to be prepared

The detailed operating procedure is provided on Table 2. The thrust to the tool specimen is provided manually as per the need.

The hazards associated with the use of Rock Grinding Machine are given in the table below:

S. No.	Existing / Potential hazards associated with demonstration / testing / maintenance	Existing controls / protection	Additional Controls	Remarks
1	1. Grinding wheel 2. Checks for wear or damage 3. Material ejection during grinding	1. Check the mounting and speed 2. Inspect chuck for wear or damage 3. Cutting tools and blades must be clean 4. Provide face shield and eye glass	1. Emergency Stop Switch 2. Circuit breaker	10. Lab manual in place 11. Dos and Don'ts list displayed 12. Standard Operating procedure displayed on the equipment 13. Helmet as needed 14. Eye glasses 15. Gloves 16. Fire extinguisher provided near main switch board 17. Main Circuit Breakers 18. Mains Control
2	Electrical earth leakage while starting the machine	Please refer Section 2.1, Sl.1	Please refer Section 2.1, Sl.1	
3	Injury to hand while rock powder is fed.	Avoid touching the hopper and turning plate	Start the rotating plate only after the entire	

S. No.	Existing / Potential hazards associated with demonstration / testing / maintenance	Existing controls / protection	Additional Controls	Remarks
			setup is ready for the test.	

7.2 Standard operating procedure (SOP) for Tool Grinding Machine (Table 8)

1. The machine should be used only under the supervision of dedicated/authorised and experienced operators.
2. Before using the machine, a demonstration and an initial briefing regarding the potential hazards shall be obtained by the students.
3. Those using this machine to compulsorily wear gloves and shoes.
4. The operator must be vigilant while running the machine and he must always be within the reach of the emergency switch.
5. If the earth to neutral voltage exceeds the prescribed limit of (15 V), qualified electrical engineer must be contacted to rectify the problem. When the ELCB is provided, it should not be bye-passed.
6. The operator/demonstrator/instructor must ensure maintaining a safe distance for the students / visitors

Table 8

Standard Operating Procedure for

Tool Grinding Machine

S.No.	Procedure	Operation
1	Connect 3-phase plug and switch on the power	
2	Tighten the grinding tool with tool holder	
3	Set the bit/pin/tool rotation speed as per requirement	
4	Tighten the grinding tool and fix the bit/pin/tools with Knob	
6	Set the bit/pin/tool on grinding disc	
7	Set the switch for forward/backward movement of tools	
8	Press the green switch to start the machine (wheel rotation)	
9	Press red button to switch off the machine	
10	Loosen the knob, remove the bit/pin/tool after grinding and repeat the procedure from step 2 for 4 times	
11	For emergency stop, press larger red button with arrows	
12	Disconnect the power plug before leaving the place	

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