ASSESSMENT OF SAFETY ISSUES IN METRO TUNNEL CONSTRUCTION USING NATM

Final year project report

Submitted by

SANKAR VELISTTY

500030873

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Under the guidance of

BIKRAMA PRASAD YADAV

DEPARTMENT OF HEALTH, SAFETY, FIRE AND ENVIRONMENT
COLLEGE OF ENGINEERING STUDIES
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
DEHARADUN

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UNIVERSITY OF PETROLEUM AND ENERRGY STUDIES, DEHRADUN

BONAFIDE CERTIFICATE

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INTERNAL GUIDE NAME

BIKRAM PRASAD YADAV

Asst.Professor

Department of HSE

UPES, Dehradun

ABSTRACT

This study focuses on to identify the hazards present in the various operations carried out in the metro tunnel project and to give control measures. This project describes the various hazards involved in the operations carried out in the tunnel construction by using NATM and its harmful effects on workers, community and environment. This project study is carried out to determine the safety aspects in operations inside tunnel and additional control measures are given by studying the Aspect-Impact document of the company. Health and Safety of the employees are important aspects of an organization's smooth and effective functioning. Good Health and Safety performance ensures an accident free industrial environment. Awareness of safety still needs improvements in India considerably. Safety is a serious issue that has to pay special attention in this, particularly in the construction industries. Any accident can result in property damage, loss of productivity, severe bodily injuries, permanent or temporary disability of workers, financial loss at best, or may involve loss of life depending on severity of accident.

The main operations studied are NATM Operation, TBM Operation, and Tunnel Activities which include gas cutting, welding, reinforcement, concrete pump operation, chipping, grinding, de-watering, and vehicular movement, shotcreting, rock bolting.

Keywords: Safety, Tunnel project, Tunnel

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EHS	Environment, Health and Safety
OSHA	Occupational Safety & Health Administration
PPE	Personal protective equipment
FMA	Factory and machinery act
OSH	Occupational, safety and health
HCS	Hazardous chemical substances
VOCs	Volatile organic compounds
ACGIH	American Occupational Safety & Health Administration Industrial Hygienists
CIMAH	Control of industrial major accident hazards
COMAH	Control of major accident hazards
SCR	Safety case regulations
NIOSH	National institute for occupational safety and health
WHO	World health organization
ILO	International labor organization
ETP	Effluent treatment plant
SPM	Suspended particulate matter
MSDS	Material safety data sheet
CPCB	Central pollution control board
SOP	Safe operating procedure

Chapter 1

Introduction

1.1. General

Tunneling work is widely carried out in the construction Industry for railway, metro, road and hydel projects. Underground caverns are used for strategic storage purposes.

The work involved in both the areas is of specialized and hazardous nature due to cramped working space in the headings, wet & slippery floorings, artificial lighting – often inadequate, difficult ventilation, presence of obnoxious gases, unseen weakness in the rock, handling of explosives, leading and handling muck, etc. Such hazardous working environment might contribute to accidents. In order to avoid hazards it is necessary to lay down the safety precautions for the use of machinery, electrical installations and labour and arrange for their compliance in such works. In many areas the safety plans may have to be tailor made to suit the site condition.

1.2. Tunneling

The choice of tunnelling method may be dictated by:

- geological and hydrological conditions,
- cross-section and length of continuous tunnel,
- Local experience and time/cost considerations (what is the value of time in the project), limits of surface disturbance, and many others factors.

Following are the construction methods of tunneling.

Conventional Method

a. Drilling and Blasting Method
b. New Austrian Tunneling Methodology(NATM)
c. Drainage, Reinforcement, Excavation, Support Solution
d. Cut-and-cover

Mechanized Method

a) Road Headers

b) Tunnel Boring Machines (TBM)

c) Mechanical drilling/cutting

1.2.1 Conventional Tunnelling System

In this approach used from earlier times the excavated rock mass is supported with/without use of steel ribs made up generally of ISMB/ISHB with the different spacing depending upon the rock mass type along with lagging generally made of cement concrete M15 these days. The space between the steel support/lagging and excavated section is filled with lower grade of cement concrete generally M10 backfill. Sometimes shotcrete with use of rock bolts is also resorted. However the final lining where required is also given of plain cement concrete generally M20 grade.

1.2.2 New Austrian Tunnelling Method (NATM)

This method has been developed basically in Austria so its name make use of providing flexible primary lining in shape of shotcrete , wire mesh, rock bolts ,lattice girder. In case of weaker rock mass the use of pipe fore pole/pipe roofing is also resorted for crown support which in turn leads to less over break as well as ensure safety during the execution. The main aspect of the approach is dynamic design based on rock mass classification as well as the in situ deformation observed.

NATM broadly based on the following principles:

• Mobilization of the strength of rock mass: The method relies on the inherent strength of the rock mass being conserved as the main component of tunnel support. Primary support is directed to enable the rock to support itself.

• Shotcrete protection - Loosening and excessive rock mass deformation should be minimised by applying a layer 25-50mm of sealing shotcrete immediately after opening of the face.

Figure 1.1: new Australian tunnelling method

1.2.3 Cut and Cover Method

The “Cover and Cut” method for tunnel construction was originally developed for urban subway structures where the least possible disruption of traffic is required. In motorway construction projects, road designers prescribe the method for underground structures to efficiently face major issues of instability. At a first stage, a shallow excavation and grading is performed, followed by the construction of a sub-soil concrete “vault”. This vault acting as a retaining structure provides full protection to the main excavation activities below carried out by conventional drilling and hauling equipment. The tunnel bore construction constitutes the final stage of the technique. In this paper, an overview of both methods is presented illustrating main features, advantages and field of application. Relevant environmental and geotechnical issues are displayed and fundamental elements of the design process are addressed. Representative sketches of the construction stage are given as well as an outline of a number of case studies in major motorway construction projects.

Figure 1.2: cut and cover method

1.2.4 Tunnel Boring Machine (TBM)

A tunnel boring machine (TBM) also known as a "mole", is a machine used to excavate tunnels with a circular cross section through a variety of soil and rock strata. They can bore through anything from hard rock to sand. This method is totally mechanized but capital intensive. It is very much suitable where there is reasonably kind of rock mass to be encountered during construction and not suitable for highly varying geology. Here lining can be done with precast member just behind the tunnelling Tunnel diameters can range from a meter (done with micro-TBMs) to 19.25 metres to date. Tunnels of less than a metre or so in diameter are typically done using trenchless construction methods or horizontal directional drilling rather than TBMs.

Tunnel boring machines are used as an alternative to drilling and blasting (D&B) methods in rock and conventional "hand mining" in soil. TBMs have the advantages of limiting the disturbance to the surrounding ground and producing a smooth tunnel wall. This significantly reduces the cost of lining the tunnel, and makes them suitable to use in heavily urbanized areas. The major disadvantage is the upfront cost. TBMs are expensive to construct, and can be difficult to transport. However, as modern tunnels become longer, the cost of tunnel boring machines versus drill and blast is actually less. This is because tunneling with TBMs is much more efficient and results in shortened completion times.

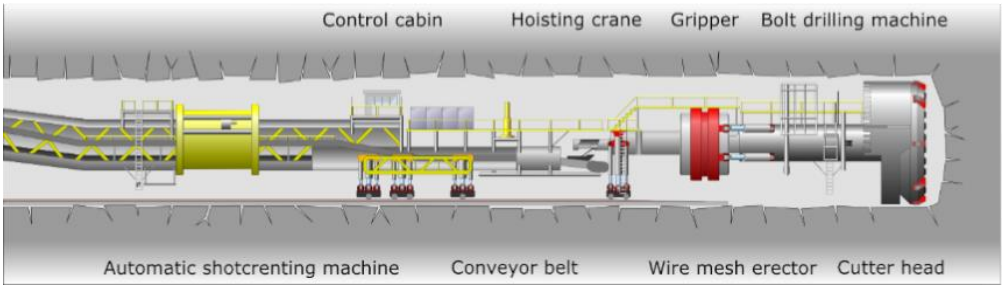


Figure 1.3: Tunnel Boring Machine

The process for bored tunnelling involves all or some of the following operations:

- Probe drilling (when needed)
- Grouting (when needed)
- Excavation (or blasting)
- Supporting
- Transportation of muck
- Lining or coating/sealing
- Draining
- Ventilation

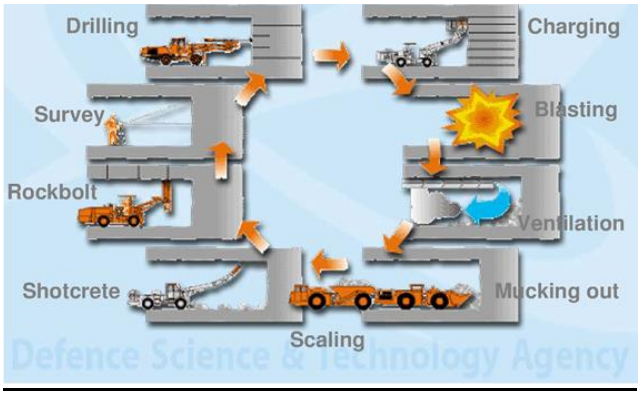


Figure 1.4: Tunneling life cycle

1.3 Project Aim

To provide understandable visualization of the relationships between the causes of business upsets, the escalation of such events, the controls preventing the event from occurring and the preparedness measures in place to limit the consequences to reduce the risks of personnel injury and ill health in underground metro rail construction in Delhi.

1.4 Project Objective.

- To understand the processes involved during metro construction by using NATM/TBM involves drilling, mucking, shot Crete, rock bolting.
- To identify the Health, Safety and Environment issues found during tunneling activities.
- To find out the hazards and to provide realistic suggestions to control these hazards.

1.5 Scope of the Project

This document serves to provide an outline on the various elements governing the use of Health, Safety & Environment Management System. It will be a controlled document & shall be distributed to all concerned & confirmation of receipt of the same maintained.

This procedure shall be applicable to the following activities performed at Head office, Regional offices, workshops and all projects of Pratibha Construction ltd.All routine and non-routine activities carried out at project sites, offices, workshops. (E.g. routine – excavation, Non Routine like – breakdown maintenance, shut-down, emergency situation)

Activities of all personnel having access to the work place (including suppliers, contractors and visitors).Activities originating outside the workplace leading to hazards capable of adversely affecting the health and safety of the persons under the control of the organization within the workplace. (E.g. Dust, noise generating outside)

Work related activities under the control of the organization, leading to hazards in the vicinity of the workplace. The OEPP is applicable to all the construction activities carried out at project site for both day & night time operations, also operation during weekend, off days. These also apply to all employees, all contractors, sub-contractors & their employees and visitor at site. This Emergency Preparedness Plan (EPP) is designed to link all the emergency scenarios that are identified as possibly occurring in our project during construction.

1.6 COMPANY PROFILE

PRATIBHA INDUSTRIES LIMITED (PIL), the flagship company of the Pratibha Group is dedicated and committed to providing the society at large with quality infrastructure in its field of expertise which currently include design, engineering and execution/construction of complex & integrated water transmission & distribution projects, water treatment plants, elevated and underground reservoirs, mass housing projects, commercial complexes, pre-cast design & construction and real-estate. The company which started with pre-cast products in just over two decades has created a technical niche for itself graduating into a multifunctional construction and infrastructure development company of repute with annual turnover of INR 8060 million. Our rapid and consistent growth over the years bear testimony to our focus on dedication, quality of production and services through continuously evolving technologies along with timely execution of projects which has won us accolades and repeated business from our clientele.

In 2009 the company has set up its PPP Division (Public Private Partnership). "The Public-Private Partnership (PPP) Project would be a project based on contract or concession agreement between a Government or statutory entity on the one side and a private sector company on the other side, for delivering an infrastructure service on payment of user charges. "The company over the next few years on standalone basis or through Joint Ventures, strategic alliances & acquisitions [if a suitable opportunity arises] proposes to have strong presence in road, retail, urban, oil and gas transmission and power segments of the infrastructure sector, apart from water supply segment. It also proposes to be global player in pipe segment and market spill over capacities

after accounting for in-house consumption. The said projects will be executed on both, EPC & PPP basis.

Vision of the Company

"To become a globally reputed and recognized corporation in its field of expertise through synergetic investment, innovation and ethical practices".

Health and Safety at Pratibha

At Pratibha, extensive health and safety guidelines defined standards for every project. Regular safety training programs are undertaken at the sites. Pratibha maintains a high standard of safety through meticulous risk assessment. Pratibha has a stellar record accident-free work. This is a consistent track record, which is no mean achievement, since most of their initiatives take place under hazardous geographical conditions. These are challenges that their staff can face because of their training. They also have the assurance of a health & safety code that is considerate and transparent.

Chapter 2

Literature Review

M.K Gupta (2004)

The tunneling work is of a specialized and hazardous nature done in a cramped, wet and slippery working space under artificial lighting where one has to deal with unseen and often unexplored weak strata, explosives, leading and hauling excavated materials. Any one of these, if not handled properly, might contribute to accidents. Safety of men involved in tunneling work is the foremost important requirements, which has to be ensured**.**

Human beings have used underground excavation for making caves for habitation since the beginning of civilization. Ajanta and ellora are not only the finest surviving examples of sculpture & art but also of the expertise in tunnel excavation. However, the tunnel for transportation widely came into existence from 19th centuries onwards. In the context of Indian Railways, after independence, with the exception of Konkan Railway and now J&K Rail project, very few construction projects involved large scale construction of tunnels.

In this paper an attempt has been made to summarize the basic safety requirement in tunneling work, which if adopted will improve safety at tunnel work site.

Safety Standards of the U.S. Bureau of Mines

The Bureau of Mines/NIOSH electrical safety research program has focused on a wide variety of topics over its 100-year history. Research has been conducted to address safety issues associated with advancing technology as well as to develop new solutions prompted by regulatory mandates. Future priorities will be driven by surveillance, customer/stakeholder input, and risk analyses and should include overhead power line, electrical maintenance, and lightning hazards. The technical feasibility of an improved power line proximity warning system that does not depend on electric field detection should be studied. There will be a continuing need to provide effective training for both experienced and younger, inexperienced maintenance personnel to increase awareness of electrical shock and burn hazards and the need for, and type of, protections available. The procedures for electrical

maintenance can be systematized by developing job hazard methodologies for critical tasks. Finally, further investigation is needed in the future to achieve a better understanding of lightning and develop practical guidelines and recommendations that can help mine operators reduce the chance of ignitions and protect workers from the resulting hazards.

U.S. Bureau of Reclamation Construction Safety Standards

Federal law and departmental regulations provide the authority to expend funds and manpower to develop and implement programs that protect the safety and health of Federal and contractor employees and prevent accidental damage of Government property. (See 5 United States Code [U.S.C.] 7902; Sections 6 and 19 of Public Law 91-596, Occupational Safety and Health Act of 1970; 29 U.S.C. 651 et. seq., 43 U.S.C. 1457, Executive Order 12196, 29 Code of Federal Regulations [CFR] 1960; Contract Work Hours and Safety Standards Act and Departmental Manual, 485 DM.) These standards are incorporated into the Reclamation Manual by reference through SAF 01-01, Safety and Occupational Health – General, Para. 3.E. under a waiver authorized by the Commissioner dated December 22, 2009.

The standards prescribe the safety and health requirements for all Bureau of Reclamation (Reclamation) activities and operations. All contracts or agreements for performance of work on Reclamation facilities must incorporate provisions for compliance with these standards. These standards are consistent with the health and safety standards prevalent in industry, the Occupational Safety and Health Act of 1970, Public Law 91-596, and Department of the Interior regulations. This section sets forth the authority, purpose, and scope of Reclamation Safety and Health Standards. In addition to the requirements set forth in these standards, all operations on Reclamation facilities and operations utilizing Reclamation equipment must comply with applicable provisions of Federal, State, and municipal safety, health, and sanitary statutes and codes. If there is a difference between the provisions of these standards and the safety and health regulations promulgated by the U.S. Department of Labor in Title 29 CFR, Parts 1910 and 1926, Occupational Safety and Health Act of 1970, or approved State plans, the more stringent provision will prevail.

Stephen W. Weldon (1983)

This chapter explores fire protection systems and fire prevention techniques in an attempt to discuss fire prevention and emergency planning. To assist in preserving and caring for collection pieces, one uses everything from the basic wax to more sophisticated fabric and material preservers. Modern science and technology have developed compounds and liquids that can repair and extend the life of objects of art. However, many of these compounds possess highly flammable and explosive ingredients. Mechanical and physical plant operations are another threat to art treasures. Constant and correct temperatures and humidity-controlled environments are critical. In addition, most art facilities have a conservation staff that is able to repair artifacts damaged by a temporary change in environment. Electricity can become a fire hazard through arcing or overheating of electrical components. Both these hazards can be triggered by lighting systems. To minimize these hazards, only tested and approved material recognized by testing U.L. laboratories should be used. Equipment should be sized according to the safe electrical circuits that will feed the components and vice versa.

Stevan P. Layne (2014)

Fire remains the greatest threat to people, assets, and valuable collections. Fires occur daily in cultural institutions, some more devastating than others, but almost all, according the fire protection specialists, are avoidable. This chapter discusses the common causes to fires in a variety of institutions, including arson. Some prevention methods include enforcement of policies and procedures. Fire prevention practices must be institution wide, by staff at every level. Further discussion regarding the priorities of detection versus suppression is presented. A detailed list of recommendations for better fire protection includes training concerns, system considerations, and evacuation methods. Since valuable collections are involved, guidelines for protection of collections are included**.**

Chapter 3

Material and Methodology

3.1 Work Methodology:

1. Identification of various activities on the site through site visit.
2. Studying the safety practices during work processes.
3. Assessing and evaluating the hazards and risk.
4. Evaluation of risk and conclusion.

3.2 Identifying the Various Activities on the Site through Site Visit.

Identify all potentially hazardous things or situations that may cause harm. In general, hazards are likely to be found in the following;

- Physical work environment,
- Equipment, materials or substances used,
- Work tasks and how they are performed,
- Work design and management

The process for bored tunnelling involves all or some of the following operations

1. Drilling
2. Charging
3. Blasting
4. Mucking
5. Scaling
6. Shot Crete
7. rock bolting

3.3 Studying the Safety Practices during Tunneling Work

3.3.1 HSE Policies and Objectives

- To ensure optimum standards of safety, environment and health including statutory requirements promulgated vide various acts / rules from time to time.
- To maintain safe as well as environment friendly work places, work practices and efficient and safe plant and equipment.
- To devise ways and means to protect persons from foreseeable work hazards.
- Encourage, support and implement suggestions methods aimed at continuous improvement of safety at work and control of health hazards.
- Employ safety professionals at site and head office to assume an assisting, monitoring and training role in all respects of Industrial Safety, health & environment with an emphasis on "PARTICIPATIVE" safety management approach to achieve the results.
- Assign the responsibilities for ensuring a safe & healthy working environment at sites with an overall objective of "Accident Prevention"

3.3.2 HSE Organization

The site safety Engineer shall be responsible for the maintenance of HSE safeguards in this project. However the site management Team comprising of Project Manager, Engineers, supervisors and Foremen equally hold functional responsibilities for their respective areas and are individually responsible for execution of the HSE Management Plan.This section of the safety plan describes the company's organizational chart for Health, Safety & Environment on the Project, which is given bellow and clearly defines the responsibilities and accountability of number of key personnel who have significant contributions to make in the successful implementation of this plan. Safety and loss prevention are line management responsibilities and a condition of employment for all persons assigned to the project.

3.3.3 Monthly Safety Committee Meeting

In order to review / achieve HSE Plan objective, safety committee meeting will be held every month. The main aim of which are Confirm if the management safety and health is being properly carried out all the parties concerned. The safety Committee shall comprise of representative of every department and sub-contractors. The Safety Committee will be presided over by the Project manager or his Deputy as the Chairman and Safety Engineer shall be the Secretary. The Employers representative shall be invited as an Observer for the Safety Committee Meetings.

3.3.4 HSE Induction

- In order to accomplish safe execution of project all workers at such hazardous construction sites need to undergo HSE Induction Programme of the site.
- The principle objectives of Induction course is:
- To provide good understanding and identification of the hazards associated with job.
- To provide clear understanding of the safe way to perform the job
- To evoke correct and prompt response in any emergency situation.
- The objective of the programme should be written down and communicated to

3.3.5 HSE Promotion

The objective of safety promotion is to

- Develop and maintain safety awareness amongst all personnel of the Site.
- Commitment to safety and ensure active participation of every employee in the management HSE implementation program.

3.3.5.1 Posters and Signs

Posters and signs shall be adopted as visual aids for accident and fire prevention. Posters published by the National Safety Council carrying topical message on HSE will be displayed at prominent locations. The following safety signage will be displayed wherever necessary at Site.

3.3.5.2 Safety Handbook and Brochures

To increase safety awareness and as part of personnel safety training, safety handbook or brochures will be issued.

3.3.5.3. Safety PEP Talks and Tool Box Meeting on Safety Tool Box Meeting

The Tool Box Meeting shall be held to discuss the hazards anticipated during execution and its control measures prior to starting any new Job. The Safety Engineer or his deputy shall monitor that the meetings are held as required depending on the work status of the Subcontractor. Mainly, the working plan and procedures for the day or the week are explained and confirmed including the following:-

3.3.5.4 Basic HSE Rules and Requirement

- Report all incident/accident/dangerous occurrences and injuries to your Site-in-charge immediately, no matter how slight they may be. If in doubt about the safe or proper way to do a job, talk to your site Engineer/ Supervisor before starting.
- Be on the alert for unsafe conditions or acts. Correct those, which you can and report the rest to your site-in-charge immediately.
- Be familiar with your surroundings, the operations, and the locations of other personnel. Know the emergency phone numbers and the location of first aid kits, fire extinguishers and other emergency equipment and their usages.
- Do not leave your work area unless your work or personal needs require it.
- When you are relieved from your job that has unusual, partially, or fully concealed hazards, inform your replacement. Be specific and make sure they understand the location and nature of the hazards they face.
- Horseplay on the job is prohibited. Do not distract or interfere with another person who is performing his / her job. This is when injuries can occur.

- Don’t run on the job except in an emergency. When walking through a job site.

- Warehouse or shops alert for tripping hazards, hoses, cables, projecting materials and uneven walking surfaces, be aware of safety rules and procedures at the site. Safety rules are designed to protect you.

- Do not allow to work under the influence of intoxicants, alcohol, illegal drugs, or any substance that can affect your capability to work.

- Do not enter or allow others to enter areas, which have been barricaded.

- Wear safety harness in all elevated areas (above 2 mtr) that require fall protection.

- Hardhat and safety shoes are a must, However, Labour working with slush and cement will be permitted to use gumboots with steel toe (ankle) shoes.

- Child labour will not be entertained.

- Electrical connection to be made only by an authorized electrician. Operating the plant / machines without authority is not permitted.

3.3.5.5 General HSE Requirements

- Where work activities may conflict with or impacts upon other work activities take steps to discuss the matter with relevant parties and establish a consensus. Ensure that both parties and their teams are fully aware of potential hazards together with appropriate precautions.

- All plant and equipment shall be inspected before work commences and at periodic intervals thereafter. All plant and equipment shall be safe before and during use.

- Only competent personnel are permitted to operate plant and equipment and such persons shall be tested by a competent person and issued with an Appointment Certificate authorizing them to operate specified plant and equipment.

- Only qualified and appointed personnel (Such as riggers and scaffolds) shall do skilled work.

- Method statements/ risk assessments shall always examine the people, equipment, materials and the environmental aspects of the proposed work.

- Such method statements / risk assessments shall always be referred to sub-contractor / contractor safety departments for review and comment.

- Ensure that an emergency / rescue plan to cater for any mishap (injury, fire, etc.) is available, known to all people and capable of immediate activation.

- Maintain good housekeeping at all times. Provide and maintain adequate hygiene and welfare facilities such as toilets, hand washing measures, drinking water, and canteen shelter, food waste bin/s and defined smoking area.

- A specific task related risk assessment shall be completed for this work activity and appended to the method statement. The risk assessment shall be completed on the approved format.

- Hazardous area should be barricaded with the attachment of appropriate warning symbols.

- Work area should be always kept clean. Unwanted scrap or tools should not be left unattended that may be hazardous to others.

- Personal protective equipment should be used wherever required. All warning symbols should be well obeyed and regarded.

- In order to blow dust and dirt from clothing, skin or work surfaces, compressed air or oxygen should not be used which may result in an injury.

- It should be ensured that all-electrical cords: hoses and leads are well protected or elevated such that there are no obstruction to stairways and walkways.

- All project emergency procedures should be thoroughly under stood and obeyed.

- Only proper ladders, ramps, stairways should be used and barricaded area should never be crossed.Work materials should be properly constructed. Boxes, keys. Barrels and similar unstable objects should not be used for this purpose.

- Scrap materials should be disposed of immediately as these create fire and accident hazards.

3.3.6 Entrance Requirements in tunnel

3.3.6.1 Personal Protective Equipment

Personal protective equipment (PPE) refers to protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. Protective equipment may be worn for job-related occupational safety and health purposes, as well as for sports and other recreational activities. "Protective clothing" is applied to traditional categories of clothing, and "protective gear" applies to items such as pads, guards, shields, or masks, and others. PPE's required before entering the work area. In addition to above PPE's water proof clothing along with reflecting warning vest shall be worn. Minimum PPE required for entry in to the tunnels

3.3.6.2 General Requirements

- Alone persons are not allowed to work underground
- Smoking is prohibited
- Alcohol and illegal drugs (Tobacco) possession or use is absolutely forbidden at the site
- Visitors are allowed only
    - With permission.
    - With guides
    - After attending Tunnel Safety Induction course

3.3.6.3 Access and Egress in Tunnel

3.3.6.3.1 Tally Board

- All persons entering into the tunnel must comply with rules of Tally board system
- You will get one tokens after submission of your ID-card.
- Enter with tokens before entering to shaft place your ID card on the board and keep token with you.

- When you exit ,surrender tally token take your ID card.
-
- 

Figure 3.1: tally board

- Workmen who are found medically unfit are informed about the results through their subcontractors and recorded in a separate Register. All workmen found medically fit shall be provided an Identity Card.
- After issue of Identity Card the workmen shall be given Safety Induction and job specific training suitably based on his designation and location of work.
- There shall be provision for a dedicated access controller who shall be posted at the entry of underground (either in adit or in shaft).
- Responsibility of access controller:
- Entry and exit control, both pedestrian and traffic.
- Should maintain a register IN and OUT.
- Updated Head count for all the personnel (including visitors and external agencies) at any point of activity.
- Check whether all entrants are possessing valid identity Pass or token.
- Check whether all personnel are donning required PPEs at the entry.
- Responsible to see that no intoxicated workmen or staff is entering working place.
- Communicate to all concerned during any Emergency.
- Responsible to restrict the entries at gate.
- Use proper walk way provided
- Do not walk on the train track

- Only ride in the Man Rider.
- Do not ride on any other machinery on the surface and tunnel which is not identified for that purpose.
- Tunnel may be wet and slippery
- Stay in designated area
- Be aware of material spillage from wagons and conveyors
- Be on the alert for tunnel haulage equipment
- Hauling equipment always has right of way

3.3.7 Industrial Health and Hygiene

Hazards to health on a construction site arise from the use of a number of materials, substances and processes if they are not properly controlled. Some of the occupational diseases are caused by the inhalation/ ingestion of dust, fibers, and toxic fumes. Due care shall be taken to prevent occupational diseases.

3.3.7.1 Pre Medical Examination:

All the persons working underground and above ground throughout the project shall be medically examined as recommended by company appointed medical practitioner at tie up hospital and only after they are declared medically fit, they shall be allowed to go underground. Individual case records shall be available at First Aid centre for any ready reference in future. Frequency for Medical fitness of the person working in underground sites can be maximum once in two years or as per project guide line. The medical test shall be done as per the medical checklist prepared in consultation with the medical practitioner, conforming the job nature to certify the person fit for work.

3.3.7.2 First Aid Box

Will be established at every site and will be equipped with adequate medicines to treat injuries and illnesses, which may arise during the work at site, it will be manned by a trained person. First aid box will be kept in neat and tidy condition. First Aid Facility with 24 hr Paramedic coverage

3.3.7.3 Medical Emergency

In case of any medical emergency, the injured will be sent to hospital with which company has tied up. Awareness regarding first aid room, first aid box, and tie-up hospital will be done by displays, toolbox talks and circulars.

3.3.7.4 Ambulance:

An Ambulance equipped with First Aid box, stretcher, oxygen cylinder and respiratory mask shall be present at site round the clock with full working condition.

3.3.7.4 Occupational Disease

Every worker exposed to hazardous material shall be provided with the necessary PPE. Any case of Occupational Disease if found, shall be immediately reported to the Project Manager.

3.3.8 Environmental management plan

The preparation of Environment Management Plan (EMP) is mandatory as per the Contract Document. An Environment Management Plan has been prepared and submitted to the employer. This plan serves as a guide for mitigating environmental issues during Project. The site shall implement the EMP in every activity wherein environmental issues are involved and any other enhancement measures as directed by PIA and CSC.

3.3.8.1 Environmental compliance report

An Environmental Compliance Report (ECR) in the prescribed format on compliance with the environmental mitigation measures shall be submitted monthly to the clients.

3.3.8.2 Environmental monitoring

- Air Monitoring (SPM.RSPM)
- Testing of water quality.
- Archaeological and
- Historical Preservation
- Landscape and Greenery
- Felling of Trees
- Fly Ash us

3.3.9 Labour Welfare Measures

Drinking Water:

Drinking water shall be made available in number of places to cater the labour strength. All the drinking water storage tanks are to be cleaned at least once each fortnight.

Sanitary:

- Toilet facilities shall be provided for Gents and Ladies separately at site with proper drainage arrangements.
- During work in under ground
- Incase Vertical Shaft - till the passenger cage facility is available - Urination can be done in designated place e.g. preferably near the dewatering sump and the same area will be disinfected with diluted phenyl or similar kind of mild disinfectant periodically (NOT TO USE BLEACHING POWDER).
- For using toilet facility the person(s) has to come out of the area and use respective toiletries as provided in above ground area.
- Incase passenger case is available all the time For using toilet facility the person(s) has to come out of the area and use respective toiletries as provided in above ground area.

Change Room / Rest Room:

- Suitable covered area shall be provided for the workmen as change room / rest room in an appropriate place based on the site condition.
- Such area shall be kept clean and hygienic all the time.
- Shall have the facility of Drinking water.
- Shall be facilitated with sit outs and cup boards.
- Shall be properly ventilated and will have sufficient illumination.

Washing Facility:

- ❖ Washing facility shall be provided with fresh water for all the worker working in underground.
- ❖ Such facility shall be made available at above ground preferably near by the Change Room at suitable location as per site condition.
- ❖ Shower and bathing facility shall be made available.
- ❖ Also there shall be a facility for washing clothes.
- ❖ The wastewater coming from washing area shall be drained into a soak pit constructed for the specific purpose. The soak pit will be maintained regularly to avoid clogging and over flowing.

3.3.10. Communication and Warning Signals

Communication:

- **Above Ground** - Emergency situation once received will be communicated through Emergency Siren as per siren diagram. Such siren diagram shall be prepared as per site condition and site Emergency Response Plan. To intimate all Emergency Response Committee (ERC) & Emergency Response Team (ERT) members, Public Address (PA) system shall be available from Emergency Control Room (ECR). In addition to this "Walkie Talkie" also can be used (with restricted procedures) if necessary, which shall be kept at ECR.

- At important locations (e.g. P&M, Store, Time office, Main office, site office(s), Toilet, & PM Office block etc.) amplified speakers are to be installed in connection to the PA, from where the addresses can be heard.

- Under Ground**:** irrespective of length and bends in the tunnel, and in shafts arrangement shall be made for transmitting of warning signals by any one of the following means:
- Electrical operated Buzzer system.
- Voice communication through telephone.
- Mechanical Bell.
- The emergency signaling will be as per the DGMS approved Signal Code.

- Unto 100m length of the tunnel only one of the systems mentioned above shall be provided, whereas in tunnels of length more than 100m at least two systems shall be installed as back up communication.
- The communication cables running shall be along the opposite sides of vehicular movement of the tunnel.

Warning signals**:**

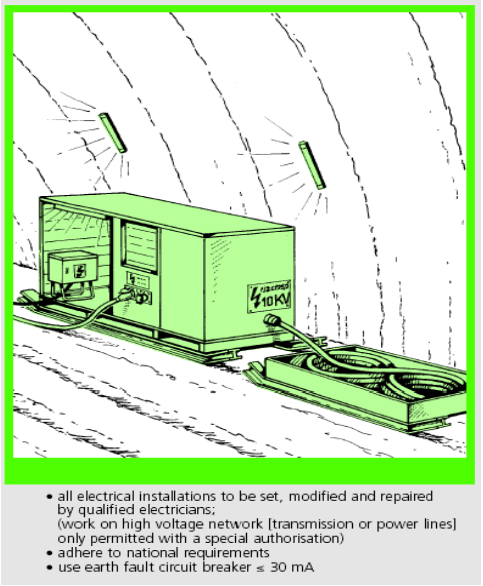
- Red and green signals of adequate size and brightness shall be provided at suitable intervals and locations on straight lengths and curves, cross over points to regulate the construction traffic.
- "Auto Glow" warning signals, arrow directions, Emergency Exit Path shall be displayed at vulnerable locations.
- Locations of Fire Fighting Equipment shall be displayed at different places suitably at every 50m length.
- Electrical junction boxes and other installations shall be marked reflective Danger symbol.
- Pedestrian path way and traffic movement shall be distinguished with reflective barriers and cones.

Inspections:

- In all the cases as above the system(s) shall be subject to daily checks regarding proper serviceability.
- The checks shall be carried out every day immediately prior to the commencement of tunneling and underground work under the supervision of responsible person.
- Any deficiencies found shall be attended immediately.

3.3.11 Electrical Installations

- The entire electrical installations shall be carried out accordingly to the existing Indian Electricity Rules as modified time to time.
- The detailed electrical installations are described in the chapter Electrical Safety of this manual.
- A passageway not less than 60cm shall be maintained in front of switchboards.
- Rubber mats shall be provided in front and back of switch boards.



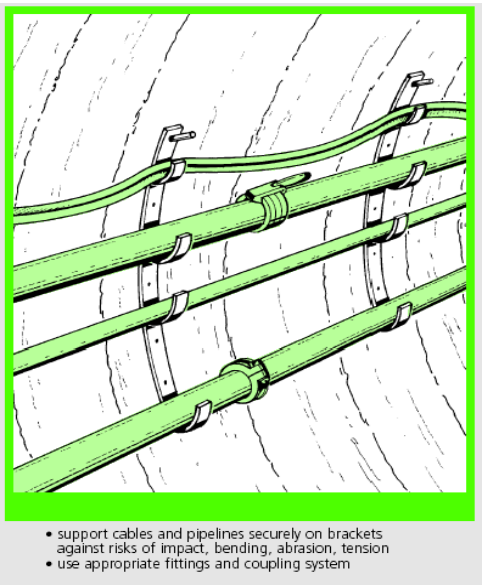


Figure 3.2&3.3: installation of electrical system

- No one shall be permitted at the back of switch boards when the current is ON.
- In no case space in front or back of switch board shall be allowed to be used as

a change room, locker or storage room.

- Each electrical equipment shall bear the essential details of voltage, ampere and circuit diagrams etc.

3.3.12 Lighting

Requirements:

- Adequate lighting shall be provided at the face and any other point where work is in progress, at equipment installations, such as pumps, fans and transformers.
- A minimum of 50 lux shall be provided at tunnel heading during drilling, mucking and scaling.
- When mucking is done by tipping wagons a minimum of 30lux shall be provided for efficient and safe working.
- The lighting in general in any area inside the tunnel or outside an approach etc shall not be less than 10 lux.
- While measuring lux level it is to be followed that such measuring is done while keeping the lux meter in the horizontal plane at a level of 91.4 cms above the floor.

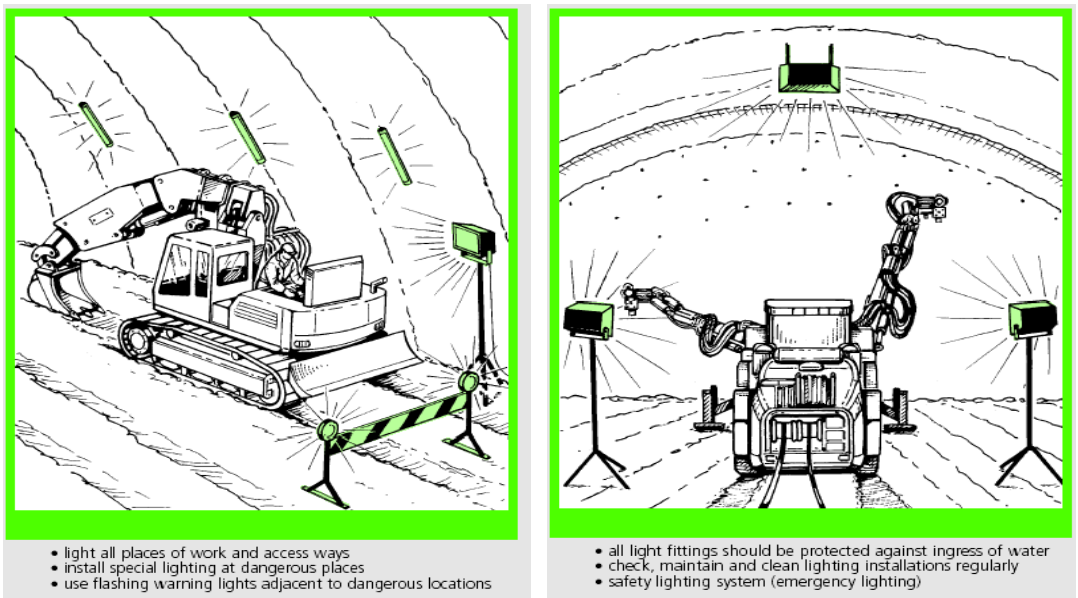


Figure: 3.3 lighting in inside the tunnel

Precautions:

- Glaring effect must be considered while choosing the light fittings.
- Shadows must be taken care, which are not necessarily caused by lack of light, but more probably by placing light fittings too wide apart or in the wrong positions.
- Care shall be given so that shadow is not so pronounced that it either conceals a hazard or appears to indicate one that is not really there.
- Inside the tunnels and cavern there shall be provision of Emergency Light (battery operated) at every 50m and every junction.
- Emergency and main area lamps shall not be chosen from mercury / fluorescent and sodium lamps because such lamps require a "Warming Up" time (6 to 20 minutes) to relight if there is a sudden interruption in the electricity supply.
- It shall be ensured that at least one cap lamp or hand lamp is provided for every batch of ten people.
- All supervisors and gang mates shall be provided with cap lamp or hand torch.
- Temporary Lights –
- Most tunnel and cavern activities are WET or damp, hence it is mandatory to provide perfect ground for short circuit.
- Steel forms, drill carriages, switches shall be properly grounded to avoid any electrocution.
- The switches shall be located on a high ground.
- Use of Hand Lamps in Under Ground –
- Equipped with strong cover of glass or other transparent material.
- Dust and water proof.
- Equipped with a strong guard over the cover.
- The exterior of all lamp sockets shall be non – metallic.
- All electrical apparatus including portable tools shall be connected only to an electrical supply system which shall have proper earthing and grounding.

3.3.13 EMERGENCY RESPONSE PLAN

EMERGENCY

Any sudden or unexpected situation which may lead to any major accident or fire which result loss of life or property damage or serious effect to the environment .proper preparation helps to ensure safety and survival. A written emergency response or action plan is the best preparation tool for handling emergency.

Types of Emergency

- Ground collapse at the face
- Failure of temporary or permanent support
- Flooding or leaking from utilities
- Gas release, Fires and Explosion
- Oxygen deficiency
- Building/Surface subsidence
- Accidents from moving equipment
- Plant and power failures/collapse
- Electrical hazard

Emergency Equipment

Emergency Equipment's such as First Aid kit, Fire Extinguisher, Emergency number display, Telephone facility (Land line), emergency lighting, rescue bucket, siren, etc. shall be located at one common point easily accessible at the time of emergency.

There can be more than one such common point depending upon the nature and area of work.The First Aid kit / cupboard shall be under the supervision of the First Aider.

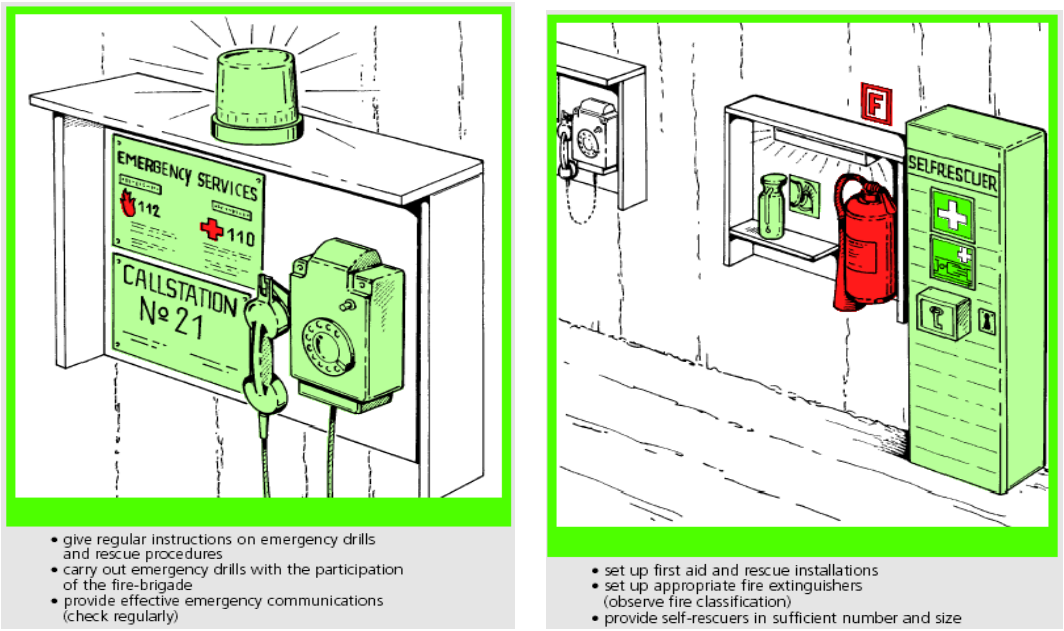


Figure3.4: emergency equipment's

Emergency Escape Breathing Device (EEBD)

EEBD is an important lifesaving appliance which is used for escaping an area with hazardous conditions such as may be fire, smoke, poisonous gases etc. All tunnels, cargo ships and passenger vessels must carry EEBD at different locations, complying with amendments of safety code. It is important to understand the construction and working of EEBD before buying one. The Emergency Escape Breathing Device (EEBD) contains breathing oxygen for a time period of at least 10 minutes, along with a low pressure audible alarm (whistle type). Most of the EEBD manufacturers provide time duration of 15 minutes to escape out from danger. However, it is to note that EEBD should never be used for firefighting purpose or lifesaving purpose.

Constructional Features of EEBD

EEBD includes the following:

- Cylinder: It consists of small cylinder carrying oxygen, along with a demand valve and low pressure alarm.

- Hood & face piece: Fresh air or oxygen comes inside the hood and the face piece, which are connected to the cylinder through a demand valve.

- Clear window: A clear window is provided in the face piece and is made up of flame resistant material for clear sighting and smooth escaping.

Ambulance

Wherever possible the Ambulance shall be used for transporting the injured from the tunnel to the hospital. In case the commercial vehicles cannot be used any vehicle capable of running in that condition can be transformed in Emergency vehicle by loading it with emergency equipment and can be used to remove the injured from the tunnel.

Location of Fire Extinguishers &Fire Hose Reels

- Fire extinguishers of ABC/CO2 type will be made available at the following locations.
- TBM, Locomotives, Man Riders, Shaft bottom, Hoist & Transformers
- Standard hose reel length of 30m and fixed at every 50 meters.
- Do not damage or misuse the hose reels

In The Event Of Emergency

- DO NOT PANIC
- Evacuation may be necessary
- Procedures are established to assist you
- Trained Rescue personnel are available
- Look for the symbol

In The Event Of Fire

- **Minor**
    - Use nearby firefighting equipment
    - Call Fire Fighting Team to assist
    - Inform supervisor/c
- **Major**
    - Use nearby firefighting equipment
    - Use nearby fire alarm to communicate
    - Inform Supervisors/tunnel manager

Dangerous Occurrence

- Render first aid
- Remove/isolate causes if possible and if safe to do so
- Inform supervisors/tunnel manager/Safety personnel
- Never endanger your own safety where a casualty concerned

Evacuation Procedures

- Tunnel manager/Supervisors/Safety Personnel will decide on evacuation
- If the siren is activated leave the work place via the nearest escape route
- In the event of fire or heavy smoke, leakage of gases/oxygen deficiency use the Self Rescuer
- Walk quickly or evacuate with the man rider and proceed to come out from tunnel to surface
- Do not return to the work place for valuables
- Use proper access way to come out from the tunnel

- Proceed to Assembly Point on the surface for head count
- Do not leave the assembly area unless instructed to do so by the Incident Commander

EMERGENCY EXITS AND EMERGENCY SIGNS

During any emergency it is important to ensure all underground workers are safely evacuated to surface. In the event that someone is trapped underground, it is important to be able to locate the worker. To account for every site personnel, a tally board at each entrance to the underground work place is displayed and updated with the names of persons working in the tunnel and their work locations.

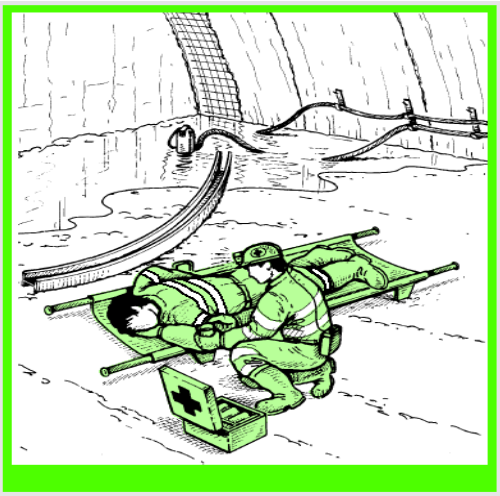
- An emergency exit in a structure is a special exit for emergencies such as a fire: the combined use of regular and special exits allows for faster evacuation, while it also provides an alternative if the route to the regular exit is blocked by fire, etc.
- It is usually a strategically located (e.g. in a stairwell, hallway, or other likely place) outward opening door with a crash bar on it and with exit signs leading to it. The name is a reference to when they are frequently used, however a fire exit can also be a main doorway in or out. A fire escape is a special kind of emergency exit, mounted to the outside of a building.
- An emergency exit signs and fire safety signs to make sure your employees know where go in an emergency. The Occupational Safety and Health Administration (OSHA) require that every facility have at least two exit routes to be considered safe. These routes should be clearly marked with OSHA-approved fire exit signs and evacuation signs so that employees know where to go, and fire fighters can locate emergency equipment.

Rescue Chain

- Chapter on Emergency procedure of this manual shall be followed.
- FIRE plan shall be prepared separately in each and every tunnel and Cavern activity and the same shall be followed.

On-the-spot-measures
(on principle: do not move injured person unless in further danger)

Emergency call



First Aid
(if casualty unconscious turn head to side to prevent suffocation)

Transport to medical centre

Figure 3.5: rescue team operations

3.3.14 Hazard Identification and Risk Assessment

A risk assessment is simply a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm. Workers and others have a right to be protected from harm caused by a failure to take reasonable control measures.

Purpose: A hazard Identification and Risk Assessment (HIRA) is an organized effort to identify and analyze the significance of hazardous situations associated with a process or activity. Specifically HIRA studies are used to pinpoint weaknesses in the design and operation of facilities that could lead to accidental releases, fires or explosions and counter measures

Accidents and ill health can ruin lives and affect your business too if output is lost, machinery is damaged, insurance costs increase or you have to go to court. You are legally required to assess the risks in your workplace so that you put in place a plan to control the risks.

3.3.15 Work Permit System

The tunnel department shall work within the guidelines set out by the health and safety management plan.in tunnel construction works, the permit to work is inevitable.

Compressed air /entry into cutter head

Confined space

Excavation (permit to dig)

Hot works

Heavy lifting works

Work at height

3.3.16 Standard Operating Procedure (SOP)

The term standard operating procedure or SOP, is used in a variety of different contexts, including healthcare, safety, aviation, engineering, education, industry, and military.

Sometimes uses the term standing rather than safe Operating Procedure, because a construction SOP refers to a unit's unique procedures, which are not necessarily standard to another unit. "Standard" could imply that there is one (standard) procedure to be used across all units.

Procedures are ongoing processes with unlimited ending time frames, while projects have definite starting and ending points. Installing a unit, or establishing a business, is a project with tasks that ends at point the unit or business is standing. The term SOP means the procedures that are executed after the unit or business stands.

3.3.17 Fire Prevention and Fire Protection

The essence of fire prevention lies in the elimination or control of materials likely to ignite. In the confined area of a tunnel, strict observance of precautions is essential. The amount of combustible materials (timber, paper, rubber, etc.), flammable liquids (oils, chemicals, solvents & primers, etc.) & compressed gases should be kept to the minimum consistent with the safety requirements.

Combustible Materials

Combustible materials stored in a tunnel should have suitable fire fighting equipment conspicuously located nearby. They should not be stored in the vicinity of any shaft or the tunnel opening.

Flammable Liquids

Flammable liquids should always be stored in tightly sealed, properly labelled and secured metal containers. Such liquids should be stored in a separate container.

Cylinders containing Oxygen should be segregated from the cylinders of flammable gases, e.g. Acetylene, LPG, etc. Gas cylinders are liable to damage

from mechanical impact, which could cause leakage from valves or cylinder rupture leading to an explosion. Cylinders should therefore be protected by suitable means while handling, storage & use and protected against the risk of impact by falling or being struck by other plant, equipment, etc.

Gas Cutting & Welding

While carrying out gas cutting inside the tunnel, full precautions should be taken in fire prevention and high standards of safety devices should be used.

Fire protection as a minimum hand held fire extinguishers strategically placed in areas through the tunnel works. They were installed in positions and marked such that they are clearly visible and easily accessible. Within tunnel there shall be a fire hydrant system installed, this system shall be taken off the TBM /NATM cooling water feed supply line. This line shall be a 102 mm steel steel pipe with hydrant taken off every 50m.fire hoses and nozzles shall be located at each hydrant, hoses being a standard 25 m length. Pressure with in this shall 10 bars with a volume of 30 m3/hour; the water supply for the system shall be from a mains filled storage tank with water being pumped from this tank to the TBM.

- The TBM has as a hand held fire extinguishers that could strategically placed in areas throughout the TBM .they installed in positions and marked such that they are clearly visible and easily accessible.
- Hydraulic pump stations and associated storage tanks .these areas are fitted with AFFF (FOAM) bulk system with both automatic and manual discharge systems.
- HV electrical control panels .these areas shall be protected by dry chemical powder systems, with both automatic and manual discharge systems.
- Both the above systems shall incorporate an audible/visible alarm and fault panel, operated from a low voltage supply systems.
- On the rear gantry of the TBM a water curtain system shall be installed .in this event of a fire on the TBM shall reduce the smoke dispersing along the tunnel and aid the workers escape .this system shall be manually operated by workers

as they exit the TBM .Training for the above operated system shall be given to TBM operating personnel.

- All locomotives shall be fitted with a water automatic fire suppression systems mounted with in the engine compartment.
- A good regime of good housekeeping shall be undertaken through the tunnel works, this shall minimize the risk of fire from the accumulation of waste materials.
- Storage of flammable materials underground shall be restricted; any solvents/flammable fluid required for daily tunnel operation shall be storage in a secure steel cupboards/chest.
- Flammable liquids shall be contained in tightly sealed and properly labeled metal containers. Such liquids should be stored apart from other combustible materials and safe distance from areas of high activity and electrical installations.
- Means should be provided to contain spillage of container of flammable liquids .drip pans should be provided to catch any leakage from containers and these pans should be emptied as necessary to prevent spillage on to the floor. All firefighting equipment shall undergo routine testing and maintenance, regular inspection and check sheets for record purpose. Tunnel personnel shall undertake training in the fire emergency procedures, fire drills shall be held familiarize them with the tunnel evacuation and firefighting system.

Figure 3.6: fire point at site

3.3.18 Traffic Management

To ensure the safe and efficient movement of traffic and also to ensure the safety of workmen and public at construction sites. All workers should wear high visibility jackets. The main objective of this is to increase the protection of men from speeding vehicular traffic. Traffic management plans includes provision for traffic diversion and selection of the alternative routes for transport of equipment. If necessary road widening is also carried out before the commencement of the work.

Traffic control devices

Traffic control devices in the construction zones perform the crucial task or warning ,informing and alerting the riders .primary traffic control devices used in work area are signs, delineators, barricades, cones ,drums, cylinders, pylons ,pavement markings, flash lights etc. they shall be such that they are easily understood without any confusion are clearly visible during day and night conform to the prevailing speeds .a team of trained traffic marshal will be deployed with necessary equipment's

Signs

Regulatory Signs

A regulatory signs means legal instructions on the traffic. They shall be used in only in consultation with the local police and authorities. The most common types for use in construction zones are

DON'T ENTER

ROAD CLOSED

GIVE WAY TO PEDESTRIANS

SPEED LIMIT

Warning signs

The most common type of warning signs to alret the drivers of the possible dangers ahead in construction zones. Sometimes it might be advisable to explain these signs

with the help of a rectangular definition plate or size appropriate to the size of warning training.

LANE CLOSED

TWO WAY TRAFFIC

Guide signs

Guide signs in construction zones all have different background colors than that normal informatory signs. These sighs shall have black message and arrows on yellow back ground. Commonly used guide words are

DIVERSION

ROAD AHEAD

SHARP DEVIATION OF ROUTE

3.4 Assessing and Evaluating the Hazards and Risk during Tunneling Work

3.4.1 Potential Hazards in NATM

Drilling and Blasting

The advancement of long tunnels through hard rock well before tunnel boring machines were invented relied entirely on the drill-and-blast method. Today, the drill-and-blast method is still widely practiced and used in building shorter tunnels through hard rock where the use of tunnel boring machines is not justified and too expensive. The drill-and blast-method is also used in combination with full face drilling with tunnel boring machines.

In the drill-and-blast method, a drilling jumbo is used to drill a predetermined pattern of holes to a selected depth in the rock face of the proposed tunnel's path. The drilled holes are then filled with explosives such as dynamite. The charges are then detonated, causing the rock to crack and break apart. The loosened debris or muck is then dislodged and hauled away. Other tools such as a pneumatic drill or hand tool are then used in smoothing out the surface of the blasted rock

Drilling Hazards

- Being knocked over /crushed
- Rock fall
- Dust and noise

Control measures

- All drilling equipment shall be kept in good working condition. Safe handling and proper lifting methods shall be used.
- Only wet drilling shall be permitted.
- Jumbos and other drilling platforms shall be carefully designed, built and maintained to provide safe working conditions.
- The jumbo should be provided with a suitable railing around the top deck
- Keep away from area
- Wet drilling
- Hear protection

Charging Hazards

- Accidental detonation by drilling into explosives
- Being knocked over or crushed by drilling boom
- Falling

Control measures

- Only charged after whole the face has been drilled
- Work can carry only by under supervision of authorized blasting specialist.
- Use of working platforms

Blasting Hazards

- Fly rock
- Air blast and ground shock
- Toxic fumes
- Accidental explosions

Pre Blasting

- Responsibilities of Shot-firer
- Connecting the explosive charges
- Final checking before blasting
- Work with Tunnel Foremen & Safety Super ensure adequate safety measures are take
- Safety vehicle with light and siren evacuating personnel in cavern

Control Measures

- keep away from area
- switch off ventilation completely before firing
- switch on ventilation at full capacity after blasting
- Evacuate team or provide shelter(containers or niches

Inspection of Blast Results

- Check for Misfires, Dangerous and Loose Rocks Conditions
- Shotfirer and Tunnel Foreman will inspect the cautiously for dangerous signs
- Safety Supervisor to ensure SF/TF carry out ins
- Should there be no initiation of explosives; mi re-entry time must not be less than 30 mines.
- After initiation, minimum retry time must not b than 15mins (after ventilation)
- Blast inspection team shall enter tunnel with appropriate breathing apparatus.

Use of Explosives

- booster charges in temp cavern on site
- Reduced transport hazards to public Use of Bulk Emulsion
- Non-explosives until being charged.
- Less toxic fumes
- Mechanized charging minimizes human
- Exposure at drilling face

Control of Dust and Fumes

- Ventilation
- Gas/dust monitoring
- Minimum entry time after blasting (with ventilation)

SCALING and MUCKING

Mucking

The process involved in loading and hauling or transporting the muck away from the face or worksite is called "mucking." The muck is removed through a conveyance system or a muck bucket, muck box, muck cart, or muck car. If the muck is simply discharged adjacent to the work site or tunnel face and doesn't actually deploy the involvement of mucking equipment, the process is referred to as casting.

Once the muck has been transported to the surface, it passes through the conveyor via a horizontal, inclined, vertical, or combination of horizontal and vertical route to its final destination point. The final destination point may be a waste rock or ore stock pile where the muck is then fed to a processing plant or where it may be dispatched to another final location for re-use. The movement of the muck through a horizontal or included path is called "haulage" and its movement through a steep incline or vertical path is known as a hoisting.

Hazards

- Being struck or crushed
- Falling Material
- Dust and Noise
- Tripping and falling

Control Measures

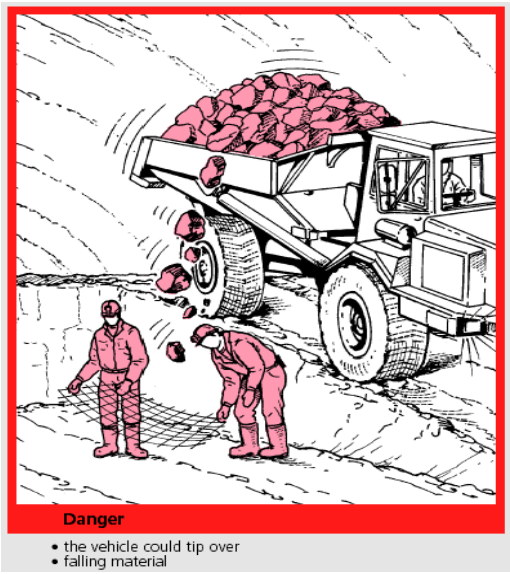
- The workmen shall be kept away from the vicinity of the cars being loaded to prevent injury due to rock falling off the car.
- Loading of muck into the dumper shall be done evenly and the muck shall not be piled dangerously high above the sides or piled on the side of the car.
- Catalytic converter can be fitted to all dumpers to minimize CO emission while engaged for UG mucking operation.
- Periodical gas monitoring shall be done during mucking operation and suitable ventilation to be ensured at the face.
- Traffic cones / barricades shall be used to ensure the smooth flow of traffic.
- Reflective jackets shall be worn by the workers working inside the tunnel.

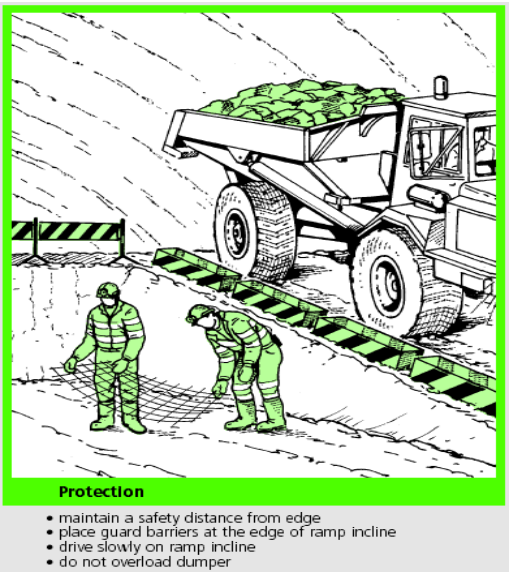
- Traffic signal man shall be posted at the crossings and junctions inside the Cavern / Tunnel so that the vehicles coming from opposite direction should not collide.
- Sufficient times shall be given for the fumes to clear before permitting the labourers to work for mucking operation.
- Do not enter into loading area and the loading zone shall be well lighted.

TRANSPORT

- The loading and unloading area shall be barricaded and no one shall be allowed to work in the vicinity and the dumper should not be overloaded.

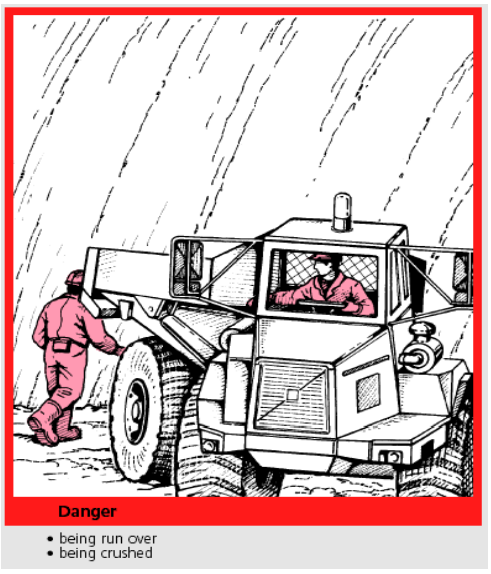
INCORRECT **CORRECT**

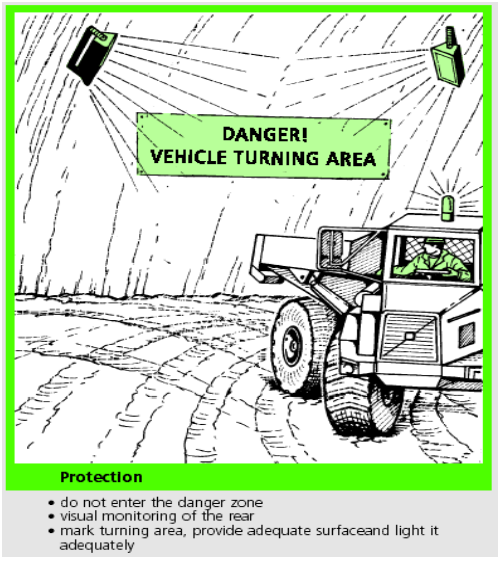




INCORRECT **CORRECT**

- If there is an Excavation suitable distance shall be provided from the edge and shall be guarded so that the vehicles do not come near the edge of excavation.Turning area provided in the tunnel shall be adequately lit and CAUTION board shall be provided. No one shall enter in that danger zone.





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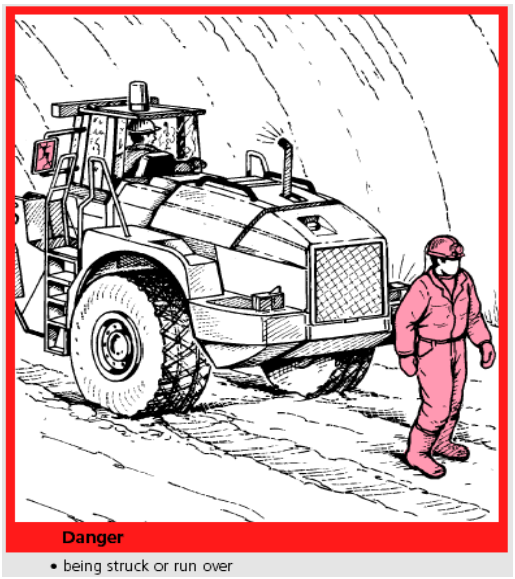


INCORRECT CORRECT

❖ **Separate passage shall be there for pedestrians and vehicles.**

❖ While reversing the signaler / helper shall be in visible range of the driver.

❖ No reversing shall be done without helper or signaler.

INCORRECT CORRECT

- Conveyor belt area and walkways shall be separate.
- Emergency OFF switches shall be placed at regular intervals.

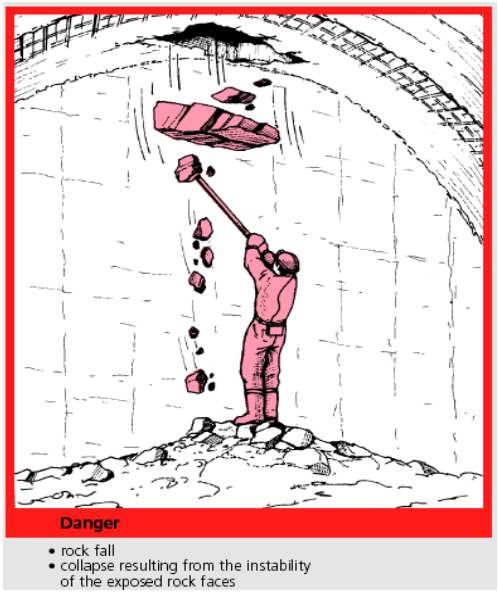
Scaling

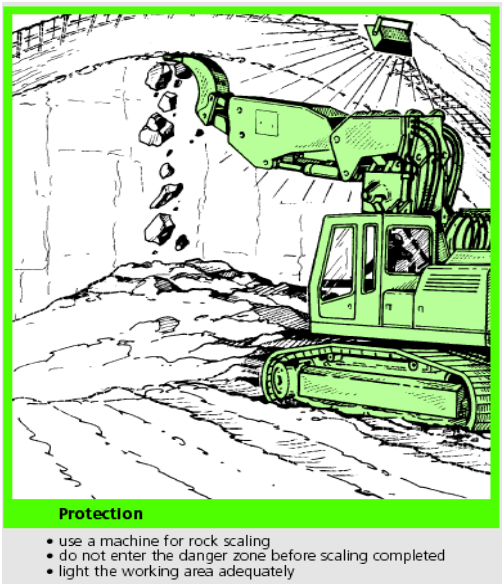
Hazards

- Rock fall
- Collapse as result from instability of exposed rock surface

Control Measures

- Loose pieces of rocks and other debris shall be sealed down from the sides of the face of excavation and the area made safe before preceding the work.
- Scaling shall be done only by the experienced crews under the direct supervision of a competent supervisor.
- Rock supports must be ensured as per the recommendations made by the geologist.
- There should not be the prolonged time interval between the two operations (Loose removal & rock support) as the risk of accident increases with such delays.





INCORRECT **CORRECT**

Periodical Inspections

- Except for premature explosion, rock falls are the most serious of all underground accidents.
- Careful and frequent inspection of walls and roofs as well as tunnel support

shall be carried out.

- Thorough scaling of loose rocks at all weak spots are the best prevention against the rock falls.
- Periodic inspection of unsupported section of any underground structures shall be done from a travelling scaling platform to locate the weak spots.
- Supported section shall also be inspected regularly to make sure that the weakness of the perorations has not spread beyond the support.
- Loose rocks shall be supported / removed forthwith.
- It is to be checked and ensured that no member is under distress for any supports.
- The entire sealing platform shall be secured with the safe ladder.
- Use machine for rock scaling and do not enter danger zone before scaling is completed

SHOTCRETING

Shot Crete is concrete (or sometimes mortar) conveyed through a hose and pneumatically projected at high velocity onto a surface, as a construction technique.

Shot Crete is usually an all-inclusive term that can be used for both wet-mix and dry-mix versions. In the pool construction trade however, the term "shot Crete" refers to wet-mix and "gunite" refers to dry-mix; in this context, these two terms are not interchangeable (see "Shot Crete vs. gunite" discussion below).

Shot Crete undergoes placement and compaction at the same time due to the force with which it is projected from the nozzle. It can be impacted onto any type or shape of surface, including vertical or overhead areas.

Hazards

- Falling from heights
- Rebound & dust
- Chemical additives

Control measures

- Use working baskets
- Use protective clothing
- Use shotcrete robot where possible
- Wear protective hardhat for shortcreting
- Wear respiratory protection

Rock bolting

Rock bolt is a anchor bolt, for stabilizing rock excavations, which may be used in tunnels or rock cuts. It transfers load from the unstable exterior, to the confined (and much stronger) interior of the rock mass in tunneling and underground mining .steel rod inserted in a hole drilled into the roof or walls of a rock formation to provide support to the roof or sides of the cavity. Rock bolt reinforcement can be used in any excavation.

There are three major ways of anchoring the rock bolts: mechanical, grouted, and friction. The most common form of mechanically anchored rock bolt uses an expansion shell. A wedge attached to the bolt shank is pulled into a conical expansion shell as the bolt is rotated. This forces the shell to expand against the wall of the borehole. The two mechanisms by which the shell is anchored against the borehole wall are friction and interlock. A preload can be applied to the rock surface by tensioning the bolt with an attached hanger or face plate, which are designed to distribute the load uniformly onto the surrounding rock.

Hazards

- Falling from heights
- Noise

Control Measures

- Use working platforms
- Use eye and hearing protection

3.4.2 Potential Hazards in TBM

1. Conveyor Hazards

Control measures

- All chains, sprockets, gear and in-running nips must be closed
- Maintenance and repair work must not be carried out while the belt is in motion
- Emergency stop ropes are provided along the conveyor belt
- Restarting of belt only from the TBM operator cabin
- The buildup of spoil on belts and rollers will be controlled to avoid muck spillage
- Be aware of muck spillage
- Operators are advised to wear snug fitting clothing to prevent clothing being caught
- Keep hands and body clear of conveyor
- Wear protective gear when advised

2. Segment Handling Hazards

Control measures

- Only authorized persons are allowed to handle the segments
- No persons are allowed in the segment feeder area when the segments are in transit to the erector
- Persons must stay out of the areas beneath hanging or supported loads
- Crossing of safety barriers are not allowed

- Be aware of crushing, pinching, impacting
- During ring construction the zone around the erector must be visible to the erector.
- Do not stay in this zone

3. Thrust/ Jacking Rams Hazards

Control measures

- The operator must be qualified and authorized
- Avoid pinch points or crush points that can be created by the thrust rams
- The TBM operator must make sure that no person is in the area of the last constructed segmental ring before operating the TBM thrust rams.

Grout Pumps

Control measures

- Only authorized persons are allowed to operate grout pumps
- Never reach into moving parts when the motor is running
- Operator must inform unnecessary people to keep out of the danger zone
- Never try to open while the grout lines is under pressure

Electrical Hazards

Control measures

- Only qualified electrician may carry out work on electrical parts
- For repair or maintenance work, follow Lockout -Tag out procedure.
- Warning signs must be displayed

- Do not switch on or off if you are not authorized or instructed to do so.

3.4.3 General Hazards in Tunneling

Air quality underground

- Fixed and mobile automatic gas detectors will be fitted and available in the working areas to monitor the following gases: Oxygen (O2), Methane (CH4), Hydrogen Sulfide (H2S), Nitric Oxide (NO2), Carbon monoxide (CO) and Carbon Dioxide CO2.

- The Shift Engineer/Safety Officer will record all gas readings on his shift report & displayed near entrance.

- The Man lock Operator will monitor fixed detectors and the Shift Engineer/Tunnel manager will monitor the mobile detectors throughout the intervention work.

Parameters for Air Monitoring

- Oxygen – 19.5 to 23%
- Nitrogen Dioxide – Less than 5ppm
- Lower Explosive Limit – Less than 10%
- Carbon Monoxide – Less than 25ppm
- Dust – Less than 10mg/m3 (Long term)

Hazards

- Oxygen deficiency
- Dust
- Toxic gas (CO, CO2, NO)
- Heat and fire

Table:-2 Oxygen Deficient Atmospheres

19.5%	Minimum acceptable oxygen level
15-19%	Decreased ability to work strenuously, impair coordination, early symptoms
12-14%	Respiration increases, poor judgment
10-12	Respiration increases, lips blue
8-10%	Mental failure, fainting, nausea, unconsciousness
6-8%	8minutes-fatal,6minutes-50% fatal,4-5 minutes possible recovery
4-6%	Coma in 40 seconds, death

2. Toxic gas (CO, CO2, NO)

Hydrogen Sulfide

- Sewer gas, stink gas (rotten eggs)
- Colorless, flammable gas. Strong odor BUT Fatigues your senses.
- Deadly! Very high concentrations lead to cardiorespiratory arrest because of brainstem toxicity. Affect nervous system.
- Heavier than air
- IDLH H2S = 100 ppm
- 8 hr. PEL = 10 PPM
- Alarm Point = 10 ppm

3.4.4 Ventilation

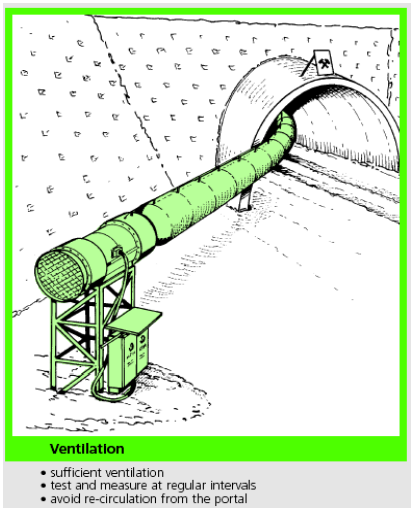
Necessity:

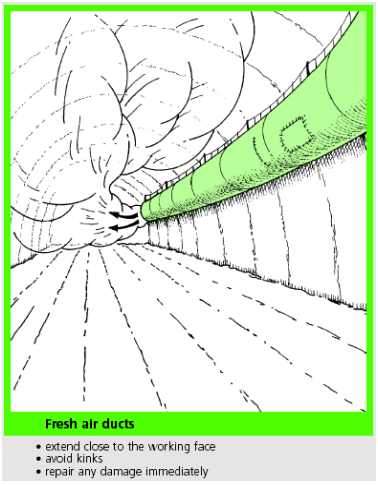
- The purpose of ventilation in tunnel, cavern and any underground activity is to make the working space safe for workers by keeping the air fresh and repairable and by eliminating harmful and obnoxious dust, dynamite fumes and other gases.
- National safety regulations concerning ventilation in underground works are applicable. If more stringent, the following rules will prevail.

Ventilation Fans and Ducts:

- Ventilation fans and ducts of suitable capacity as per design requirements will be installed.
- The ventilation fans are operated by a Trained and dedicated Operator, who will also be a trained electrician.

- During normal times the fans are operated in forced mode.
- The direction of airflow shall not be altered without the consent of HSE In charge or UG Team Leader, except in case of a fire in the underground.
- In general, the fresh air will be supplied by ventilation fans in force mode through ducting of flexible or semi rigid nature which is supported on both the sides by a catenary wire rope assembly of 8 mm Ø supported into shaft wall.
- In the cavern and access ramps these ducting pipes will be carried by an overhead catenary wire rope assembly supported with dowels in the crown.
- The contaminated air or polluted air will be routed through the excavated heading & shaft opening to surface.
- As a secondary arrangement, small capacity fans will be fixed at suitable locations (e.g. middle bench connection, etc) to ensure some quantity of fresh air directing to the face for keeping the face cool as and when required.
- In case of Cavern the ventilation shall be detailed & stage wise as per work progress like, heading or crown, First bench, Second bench etc.





Other Requirements:

- The entire ventilation system shall be inspected at least once in a week by a competent person.
- No Petrol driven engine shall be used under any circumstances in any tunnel, shafts or Cavern.

- If any part of a tunnel is known or suspected to have a hazardous atmosphere it shall be tested before allowing work in that area.
- The temperature in underground works shall not exceed 25°C or the outside temperature if greater.
- Ventilation ducts shall be ready to use immediately after the blasting at distance of maximum 40m from the face.
- Noise level due to fan shall frequently monitor and there shall be engineering controls to address the same.
- Test for flammable or explosive gases or vapour shall be conducted:-
    - At minimum distance of 10cm from the roof, floors, walls & face.
    - In the exhausted air.
    - In the work area.

3.4.5 Dust Control:

- Adequate steps shall be taken to prevent the liberation, accumulation and propagation of air borne dust. Only wet drilling shall be permitted inside the tunnel and other underground works. Besides wet drilling there shall be adequate ventilation to reduce the concentration of dust in air and periodic medical checkups shall be done for the workers working in dusty areas, such checks shall be conducted at least once in three months and the results shall be recorded in the register provided.
- In addition water spraying over air borne dust also shall be done to minimize the concentration. The air borne dust concentration at the working face shall be tested once a month and if it exceeds 10µg/m3 ventilation shall be adequately improved. Air borne dust is considered as nuisance dust containing not more than 1% free silica and also does not contain other toxic impurities.

3.4.6 Slips, Trips and fall

- A slip or fall can cause injury to the arms, legs, back, neck or head. Neck and head injuries can cause damage to the spinal cord and nervous system. Many employees have suffered permanent disabling injuries as a result of a fall. Poor ‘housekeeping' in the construction leads to slips, trips and falls. Unwanted materials, Oil spills, engine parts, air lines and hoses left on the workshop floor can all result in preventable accidents. Metal bins should be provided for waste disposal. These should not be allowed to overflow.
- Your employer can reduce the risk of slips, trips and falls by providing a suitable non-slip floor surface, good lighting and safe work procedures.
- You must follow instructions and safe work procedures provided by your employer, which may include:
- Sweeping things like metal shavings up regularly
- Cleaning all spills immediately – oil spills should be soaked up with a dry absorbent, and then put into a waste container
- Making sure there are no trailing electrical cords on the floor
- Keeping the workshop floor free of equipment, vehicle parts, tools and rubbish.

3.4.7 Noise

- Employees in the construction industry work with noisy tools and machinery such as wheel removers, compressors, grinders and drills. While in an automotive workshop, you may be exposed to noise levels exceeding 85 decibels or dB (A) that could lead to hearing loss.
- The employer can reduce noise levels by isolating noisy machinery from employees not involved in its operation. Enclosing the source of the noise in a sound absorbing box, or erecting sound absorbing barriers, will help. And by keeping machinery and equipment in good order so it operates efficiently, noise can be considerably reduced.
- If the noise cannot be removed at its source or sufficiently reduced by other means, your employer must provide personal hearing protection (earmuffs or earplugs) in addition to other risk controls.

CHAPTER 4

Results & Discussions

This project study focuses on to identify the hazards present in the various operations carried out in the underground metro tunnel Construction and to give control measures. The work is in progress and measures to prevent accidents are taken. Guidelines of safety measures like checklists, work permit and other formats given by Pratibha are implemented. Pratibha Construction is an ISO 9001, ISO 14001:2004 and OHSAS 18001:2007 certified company and strictly follows the guidelines made for the Environmental Management and Occupational Health Safety for each and every operation in the company. I have understood the various hazard related to the work in Construction site and to immanent safety in work practices adopted.

This Training has provided me an exposure of industrial environment which cannot be possible in the class room. It has helped to make me aware about the developments being made in the construction industry, as the needs of the industry are changing due to rapid change in the technology management practices, competitive quality & productivity etc. Industrial training has helped me to enhance my knowledge, psychology of the workers, their habits & their approach to the problems. Apart from that, that it has given me good exposure to the developments relevant to my subject of studies.

Health and Safety of the employees are important aspects of an organization's smooth and effective functioning. Good Health and Safety performance ensures an accident free industrial environment. Awareness of safety still needs improvements in India considerably. Safety is a serious issue that has to pay special attention in this, particularly in the construction industries. Any accident can result in property damage, loss of productivity, severe bodily injuries, permanent or temporary disability of workers, financial loss at best, or may involve loss of life depending on severity of accident.

The main operations studied are NATM Operation, TBM Operation, and Tunnel Activities which include gas cutting, welding, reinforcement, concrete pump operation, chipping, grinding, de-watering, and vehicular movement.

FIRE& SAFETY ASPECTS:

a. **HSE Policy:**
    - Organization having safety policy.
    - Annual report.
    - There is SHE department.

b. **Safety & health organization:** Head of safety department/safety officer report to the chief executive was existing.

c. **Safety committee:**

    This industry has safety committee.

d. **Accident reporting:**

    Accident data for the last 3 years for reportable & non-reportable accident .

    Safety inspection:

    Safety inspections were carried out, there were having such records.

e. **First aid:**

    There were maintaining first aid boxes for workers.

f. **Safe operating procedures:**

    SOP's were there for all the operations.

Condition

a. Housekeeping: Poor working conditions, floors are slippery so it can cause accidents**.**

b. Noise: Absence of personal protective equipment along with ear muffs/plugs

c. Ventilation:

- Dust/Fumes/Hot air is generated in the process
- No natural ventilation
- Exhaust dilution ventilation system present in the plant

d. Source of water: Water supply from bore well to the hydrants

e. Work permit system:

Work permit system was there but there were some risky activities going on without any work permit.

f.PPE:

- The workers been trained in proper use of PPE,
- PPE are given to workers exposed to dust/fumes and gases

g. Fire department: There was not any separate **fire safety** department.

g. **Fire protection:** fire extinguishers were provided. Fire extinguishers were there but only DCP & FOAM type extinguishers.
h. **Inspection & maintenance** of fire extinguishers is done by external authorities.
i. **Fire hydrant and fire hose reel:** No fire hose reel hose was not present in respective areas of site.
j. **Fire Detectors and alarms:** Fire detector and alarms were present there at various points in TBM but few of them were not working.
k. **Emergency preparedness:** There was a well design ON-SITE emergency preparedness plan but necessary to exercise mock drills and awareness regarding emergency.
l. **Color coding:** Color coding was there but not for all the pipes.

MAJOR& MINOR OBSERVATIONS FROM THE SITE
Major observations

1. Safeguards need to be more structured and properly maintained
2. Inadequate housekeeping facilities in the toilets and the diesel yard premises.
3. Lack of fire safety training was observed..
4. Fire extinguishers were installed in site but limited.
5. No fire hose reel hose was installed in around the unnelarea.
6. No fire fighting facilities observed inside the tunnel..
7. Empty LPG gas cylinders were present near the ignition source

Minor observations

1. Excessive spillage from the machines
2. Absence of accident / Incident Statistic Display at locations
3. Improper ergonomics were observed.

Chapter 5

Conclusion

The fundamental objective has been to understand the safety observations & corrective actions among workmen and employee's in various stages of a project. It had taught me the enhanced acceptance of responsibility for safety. The project of Delhi metro underground construction made me focusing on better understanding of the various safety aspects, behavior and accidents also tries to identify the hazards & risks associated in different areas. It has also helped me to understand the diverse challenges encountered by the HSE Department during the course of the entire project tenure. The Project benefits in the aspect that has equipped me with suitable knowledge about the role of HSE during the phases of the project.

This Project was likewise great to figure out what my qualities and shortcomings are. This helped me to characterize what abilities and information I need to enhance in the impending time and when hazards cannot be eliminated or sufficiently reduced by engineering controls or safe working procedures alone, you may need to wear personal protective equipment (PPE) to improve protection.

PPE may include safety glasses or goggles, earplugs or earmuffs, protective gloves, overalls or other close fitting clothing. Safety shoes or boots with reinforced toe-caps will protect your feet if any heavy or sharp items are dropped.

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