FIRE SAFETY MANAGEMENT IN A METRO CONSTRUCTION SITE

Final year project report

Submitted by

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APPROVAL SHEET

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ABSTRACT

Fire situations pose one of the most serious problems in a major construction site with the potential loss of lives & property as well as damage to the environment. A metro construction requires highly sophisticated machinery such as the TBM (Tunnel Boring Machine) tagging along the numerous hazards with it and worker's unfamiliarity adds to the risk of safety. Mining and Boring are itself one of the most hazardous activities in construction. Accidents happen without warning, and there is always a need to be ever prepared and alert in a hazardous location. A fire outbreak may occur due to the carelessness, non-compliance, or lack of awareness of the work force or management on fire safety. In an emergency situation, time is the most critical factor and results in the main difference between life and death. The three most crucial aspects in fire safety management are the education and training of the workers and management; effectiveness and implementation of fire and evacuation drill procedures; and provision of proper signage indicating exit routes and location of firefighting equipments. Communication is a crucial factor in handling an emergency. It is the practice in plant that any employee can raise the alarm, so allowing the earliest possible action to be taken to control the situation. Well trained personnel and well equipped mobile appliances are of no value if there are no reliable means to direct them to the right place and right time. This thesis aims to study the various fire hazards in the site and analyzes the respective measures in place to counter its occurrence. It identifies the various plausible hazards for a lucid understanding on the danger that they pose to the workers and site. The major hazardous areas are prioritized on the basis of the level of danger it poses to life and property. Apart from identifying the hazardous areas, the study also describes the type of hazard, cause of its occurrence, and also furnishes recommended firefighting procedures for its mitigation. It elaborates on the various firefighting facilities installed in each hazardous area and how they are to be operated during an emergency

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KISHOR KOSHY K

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Fire is without doubt the most potential destructive force in a construction site considering the extent of damage it can bring to health, safety and environment of people. Any outbreak of fire endangers the life and property including of the ones that are not involved in the construction work. In order to reduce the risk of its occurrence, there should be a careful control on the hazardous materials used, stored in the site. Hazardous substances have varied flammable properties and are to be managed accordingly. An illiterate worker is either fortunate to be alive or is unhappy performing work under the guidelines of a responsible employer. Fire is bound to occur when the materials used are flammable, but the risk of a fire outbreak can be minimized by reducing

Many serious fires occur in existing buildings during maintenance and construction work. Due to the increased fire risks during these periods of time, additional fire precautions may be needed. Dependent upon the nature of the work to be carried out and the size and use of the workplace, it may be necessary to carry out a new fire risk assessment to include all the new hazards that will be created during the construction work. In some cases, the increased risk will be due to the increase of sources of ignition of additional materials. In other cases , it will be due to the effect on the controls in place at the premises. Some work may require the isolation of smoke detectors or an alarm system. Normally well controlled escape routes may become cluttered by equipment, materials or workers .Particular attention should be paid to:

- Accumulation of flammable waste and building materials.
- The obstruction or loss of exits and exit routes.
- Fire doors being propped open, wedged open or removed.
- Openings created in fire resisting structures
- Isolation of fire detection or fixed firefighting systems.
- Introduction of additional electrical equipment, or other sources of ignition.
- Use of hot work process.
- Introduction of flammable products, for example , adhesives or flammable gases.

- The addition of new people to the premises that may be unfamiliar with fire arrangements, for example, alarm, routes, roll calls, assembly points.
- People working in unusual locations, for example, the roof, basement or duct areas.
- People working outside normal working hours.

In all workplaces there is a need to actively review and revise the fire risk assessment. This may lead to changes to the fire safety measures that apply and the fire /emergency plans. This aspect of fire safety is absolutely vital in construction sites or any other other workplace where layout changes are constantly taking place. Dependent upon the amount of changes occurring, fire safety should be inspected at a frequency of weekly or daily

Checks and assessment should be made to ensure that the fire plan for means of escape is still

appropriate and that the following fire safety measures are not being compromised, leading to increased risk:

- Escape routes
- Access to fire alarms
- Audibility of fire alarm systems
- Access and availability of fire-fighting equipment
- Suitability of fire safety signage
- Need for and suitability of escape lighting
- New staff and the need for ‘fire induction’.
- Fire protection/fire resistant structures within the building.
- Introduction of new fire hazards, for example ,hot works.
- Correct storage /use of flammable materials.
- Site security /arson prevention.

Objectives of Fire Safety

The main objectives of fire safety are

• To minimise both the probability and the consequences of postulated fires.

• To detect and suppress fire with particular emphasis on passive and active fire protection system and adequate capacity for the systems necessary to achieve and maintain safe plant shut down with or without off-site power.

• To ensure that a failure, rupture or an inadvertent operation does not significantly impair the safety capability of the structures, systems and components.

• To address not only the direct effects of flame, radiant heat and explosion but also to the potential for the release of hazardous materials and hazardous combustion products in the event of fire and the potential for the release of water and other fire fighting media contaminated during fire fighting. To meet these objectives, there are

Passive Fire Safety Systems (PFSS)- The Passive Fire Safety Systems are those systems, where no moving components are involved and which are provided to detect, prevent spread, or suppress fire. The examples are fire barriers, fire seals, fire detectors, fire retardant paint etc.

Active Fire Safety Systems (AFSS) - The Active Fire Safety Systems are those systems where moving components are involved and which are provided to protect against fire. The examples are fire pumps, fire hydrants, sprinklers, extinguishers, etc.

The occurrence of fire in a metro construction site requires the apt and timely response of the workers, management, emergency services and also the visitors of the site. The visitors will be in higher risk as they will be unfamiliar with the environment. It may be in their best interests to enable all actions related to self-rescue prior to the engagement of the emergency services. The tunnel workers will be familiar with the systems installed for the respective emergencies and should take immediate and appropriate actions to implement the procedures. The workers will call in for the emergency services and generally follow a pre-planned procedure. The major hazard lies in tunnels where the underground workers, in case of a mishap may be affected by toxicity, flammability or excessive concentration of a gas such as CO, SO2, HCN, H2S, O2 etc. As fire is the main area of focus in this thesis, flammable and excessive concentration of gases in the tunnels are elaborately studied. Each year there are a number of fires on construction sites and buildings . Many could be prevented by effective and efficient planning and control of work activities.

The world's largest tunnel called the Gotthard tunnel is being built in Switzerland with a length of 57 km. Besides its advantage of reducing the time lag to about 1 hour, it also lowers the emissions from heavy goods vehicles that are said to affect the environment drastically. Fire is the biggest challenge since it threatens the vault structure, which may collapse. Passive fire protection plays a crucial role in maintaining the stability of the structure. BASF, a renowned chemical company produces fire resistant mortar that helps the tunnel to withstand extreme temperature (1300-1400 degrees) and flames for over 90

minutes. Currently, Delhi metro rail projects are rapidly growing. According to statistics, there are six cities operating metro up to June 2014 spanning about 273.54 kilometers. Although Metro supposed to be mass rapid transit system, Indian metro trains are slower than their counterparts in other parts of the world, as they are mostly over ground and have sharp curves. For example, Bangalore metro has a maximum speed of 40.5 km/h on curves with average speed of 30 km/h and Hyderabad Metro will have average speed of 25 km/h. From 1998 to 2014 media reports, over hundred people have died in metro rail transit projects

The site has various cutting machineries which uses electricity at high volts and therefore requires industrial sockets for its transmission. The barricades are earthed for shock protection and all electrical panels fitted with shock protection devices.

1.2 TUNNELING METHODS

1.2.1 TUNNEL BORING MACHINE –TBM

This method has been developed basically in Austria. Loosening and rock deformation is reduced by shotcreting a layer of 25-50 mm of concrete. The main priority of the process is the stabilization of the rock and maintaining its inherent strength or otherwise to provide support. There are two major shield methods around: earth pressure balanced (EPB) and slurry type shield machine. The "head" has a working chamber filled with soil or slurry between the cutting face and bulkhead to stabilize the cutting face under soil pressure .The "head" has a working chamber filled with soil or slurry between the cutting face and bulkhead to stabilize the cutting face under soil pressure. The EPB type shield machine turns the excavated soil into mud pressure and holds it under soil pressure to stabilize the cutting face. It has excavation system to cut the soil, mixing system to mix the excavated soil into mud pressure, soil discharge system to discharge the soil and control system to keep the soil pressure uniform. Therefore, EPB may not be applicable for the rocky soil that is difficult to turn the excavated soil into slurry. It can be used at ground predominated by clayer soil. The slurry type shield machine, on the other hand, uses the external pressurized slurry to stabilize the cutting face, similar to bored piles or diaphragm walls using bentonite to contain the trench wall. The slurry is circulated to transport the excavated soil by fluid conveyance. Besides having excavation system, the slurry type shield machine has slurry feed and discharge equipment to circulate and pressurize slurry and slurry processing equipment on the ground to adjust the slurry properties.

1.2.1.1 Safety features:

Detection and Early warning:

The TBM considering the chances of a fire emergency, automatic smoke detectors with foam suppression systems and water spray barriers are to be incorporated with the detection systems. For the easy detection of a mishap, the tunnel environment should be continuously monitored and the results should be directed to the control cabin of the TBM. There should be both audible and visual warning systems available in the facility so that workers become aware of the situation as soon as possible. In case of an emergency, the workers within the TBM or the tunnel, should be provided emergency equipments. Storage facilities of such equipments (first aid equipments,breathing apparatus etc.) should be managed within the TBM.

Conveyor belts:

Conveyor belts are potential fire hazards as they can create fire by friction, and therefore should be fitted with pull cords for emergency stop. They should also be equipped with all the necessary guardings such as nip guards and guard rails to prevent any accidents. Cameras should be fitted in where spoil is discharged in the conveyor belt, muck skips and in areas of locomotives within the TBM

Lighting:

Back- up power supplies in the failure of the main power supply. Emergency lighting should be appropriate and available in all suitable and necessary access walkways of the tunnel. Moreover, traffic lights should be provided at the end of the gantry.

Control cabin:

CCTVs should be present to access the cameras fitted in the hazardous points of the TBM. Effective and efficient communications systems between the control cabin and all critical locations and are also recommended to be air conditioned.

Lifting and working platform:

The working platforms should be constructed in such a way that it does not create any obstruction for the segment erector operators in terms of visibility. Lifting devices for segments should be secured against free fall, and also for dangerously moving parts, electrical isolators and lock-off devices fitted.

Access:

Easy access from one trailer to the next without having to step into the segment unloading area or ring build area. It is always important to keep the corridors free from obstructions at all times. Potential hazards can be avoided by careful design and planning of workstations with access to these areas restricted. The most crucial area of access is the ring building area. It is recommended that once the contractor takes possession of the TBM, can make any modifications for safety after the consultation with the TBM manufacturer especially of electrical and mechanical components. Where possible, an onsite representative of the TBM manufacturer should carry out major maintenance operations. Another important inclusion is to the addition of carefully designed electrical cabinets to prevent damage to the equipments and water in flow. DCP fire extinguishers should be kept at about fifteen meters apart throughout the length of the tunnel.

Storage:

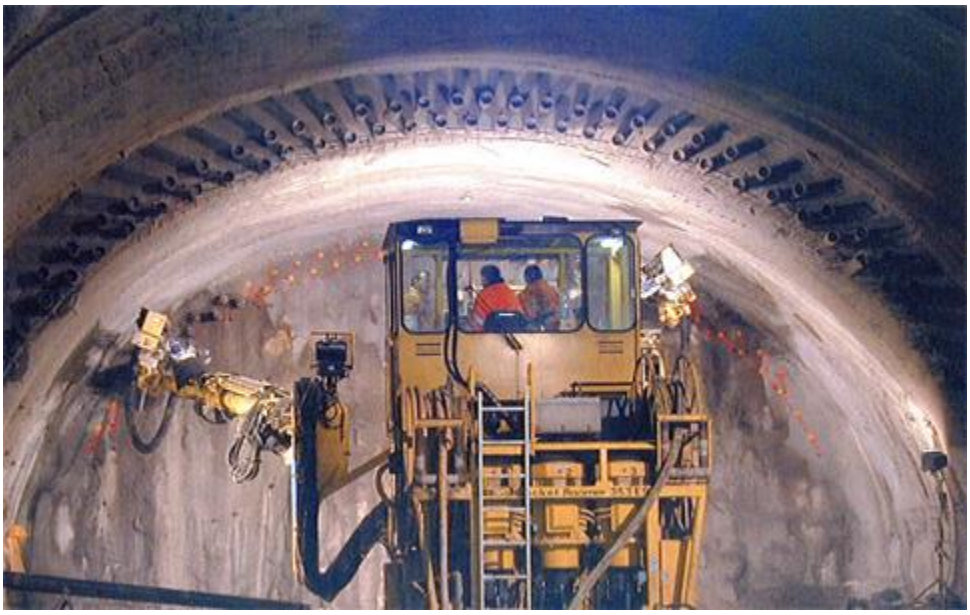
Another important factor to be considered in the design stage is the storage of combustible materials. The storage of such materials should be kept minimum to reduce the fire load .The hydraulic circuits on the TBM require large quantities of hydraulic oil. The hydraulic systems are to be designed to be fire resistant as the oil heat produced during pumping of the oil poses as a major fire hazard in the TBM. The inclusion of mineral oil should be avoided as they can produce very high temperatures and smoke. Conveyor belts should be fire resistant materials including the hoses and couplings.

Similar precautions should be taken at the grease pumps and storage areas. Diesel fuel should not be allowed to be stored in the TBM or underground. Strict control should be made for the supply of fuel for diesel operating vehicles.

House keeping:

Care should be taken to ensure that oil rags or any other type of combustible material should be removed from the TBM at short intervals. Its also provides the right mindset towards a safe working environment.

1.2.2 NEW AUSTRIAN TUNNELING METHOD



1.2.2.1 Principle Factors Of NATM

Strength of the rock mass: The method relies on the inherent strength of the rock mass and its geology as it acts as the primary support for the surrounding structure of the tunnel.

Shotcreting: The tunneling process causes the rock mass to deform or loosen. In order to reduce such movement, application of a layer of shotcrete of about 25 mm is done soon after the removal of the rock mass.

Measurements: Every loosening and deformation of the rock mass should be measured so as to be aware of a possible collapse. This method requires the installation of sophisticated measuring instruments which are embedded in the primary lining. Examples of such kind are load cells, extensometers, and reflectors.

Primary lining: it is an active support and the tunnel is strengthened by this lining that combining the strength of rock bolt,wire mesh and lattice girders.

Closing of invert: For soft ground tunnels, it is very important to close the invert inorder to complete the arch action and provide lateral ring support.

Rock mass classification: For the primary support and design, it is crucial to have a geologist to produce information about the soil strength and its properties.

1.2.2.2 Classification on the Rock mass type

The properties of the rock type alone cannot help to judge whether the rock mass is favorable or non-favorable for excavation. There are a number of factors that it is dependent on such as water holding capacity, compressive strength, dip and stike of the rocks etc. There are different classifications of rock mass ,however the most common classification are RQD,RMR and Q factor of the rock mass.

Rock Quality Designation index (RQD)

It is estimated by drilling a core rock mass of at least 2.15 inches diameter with a double tube core barrel. RQD will be defined by the percentage of intact core pieces which provides a quantitative estimate of the rock mass quality. It was developed by Deere in 1967.

RMR value

It depends on the following factors:

1. Groundwater conditions
2. Condition of discontinuities
3. Orientation of discontinuities
4. Spacing discontinuities
5. Uniaxial compressive strength of rock material
6. Rock Quality Designation (RQD)

Table 1.1 RMR value scale and corresponding soil condition:

RMR value	100-81	80-61	60-41	41-20	<20
Rock class	I	II	III	IV	V
Description	Very Good	Good	Fair	Poor	Very Poor

Q Factor:

It depends on the following factors:

1. Block size
2. Inter block shear
3. Active stress
4. Reduction for joint water flow
5. Presence of weakness zones

It varies from 0.01 (poor rock) to 1000 (exceptionally good)

1.2.2.3 Components And Sequence Of Execution In Natm

a. **Sealing Shotcrete** -25 to 50mm normally- *Shotcreting* is a method in concrete work in which the concrete mix is applied in layers under the pressure of compressed air.

b. **Attaching of Girder**- 3 bars of steel reinforcement – There are some cases where soil stabilization might require additional support to forepoles, in such cases, girders are use .They are made of rolled metal or lattice steel and can be according to the excavation geometry.

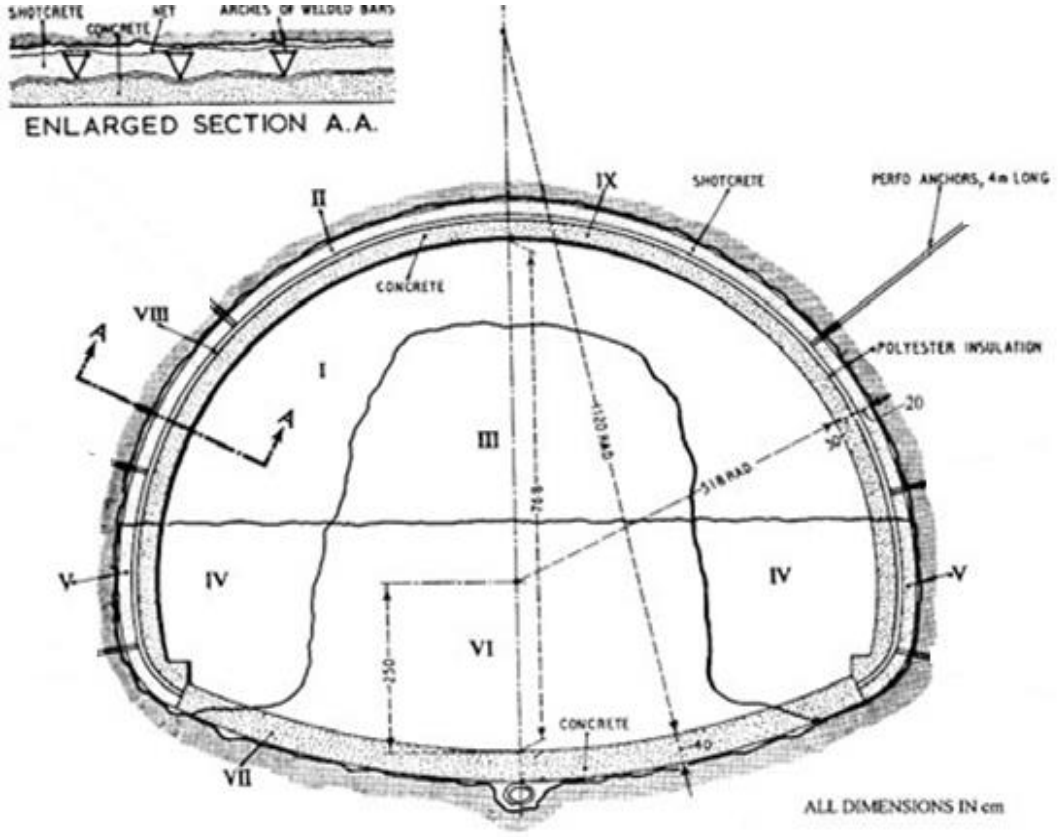
c. **Attaching wire mesh-** 6mm thick wires is to further stabilize the excavated portion.

d. **Primary lining of shotcrete of 150 mm**

e. **Pipe Forepoling-** Forepoles are iron structures, the direction and size of the forepole varies according to the project. After the drilling, the drill pipe is cleaned and prepared for grouting. Finally the forepoling is completed with the introduction of the steel tube through the drill pipe.the process is repeated for each new excavation.

1.2.2.4 Excavation in soft grounds

For a strong ground mass,the excavation can be performed throughout the face of the rock mass ,but in case the mass is soft, it should be done in divided segments.
The excavation of a soft ground will start with a top bench with the central part to provide support and second part to provide lining or shotcreting. It is then followed by removing the central part ,and then the shotcreting of the surrounding area and goes on to the left and rights of the cross sectional geometry. Each segments are denoted by roman numbers. The picture below depicts what has been explained so far on the excavation that is to be done on soft grounds that are vulnerable to forces of high magnitude.Shotcreting must be done with atmost care with the guidance of an expert as it requires a crucial layer of shotcreting which cannot be less or more in the case of soft grounds.



1.2.3 CUT AND COVER METHOD

The methodology of the cut & cover is simple in terms of conception. The first step is to excavate the trench keeping its slopes appropriately retained. The next step taken is to construct the permanent bearing structure of the station or tunnel beginning upwardly from the foundation onwards. Lastly, the soil removed is backfilled on to the constructed

structure to the surface of the ground and the area is reinstated. The work is divided into the following phases:

1. A geotechnical/geological investigation and tests (on site and laboratory ones) are conducted in order to identify the characteristics of the soil in the area where the structure is to be constructed.

2. Based on the tests conducted in the previous stage, a design is prepared related to the temporary retaining and excavation.. Moreover, the design of the permanent bearing structure is carried out.

3. Prior to the advent of the main works, the required archaeological excavations are carried out, all the PUO pipes (related to water supply, power supply, telephone connection etc.) and the eventual traffic diversions are executed.

The temporary retaining of the excavation usually consists of circular concreting piles, whose diameter is in the order of 0, 80 – 1, 00 m., spaced at 1,50,-2,50m along the perimeter of the anticipated excavation prior to its commencement. The pile row is connected at its pile cap by means of a strong concreting beam. The excavation process is done using conventional mechanical means (excavators, hammers etc.) up to a fixed depth, e.g. 3,5m and then anchors are placed at holes, which are drilled at the soil through piles. These anchors are long enough (in the order of 15-25m) and they are pre stressed using the force provided for by the design. Then a wire mesh is applied along the perimeter of the trench and a shotcrete is placed. Subsequently, the excavation continues up to the next level and another series of anchors is placed and prestressed. This cycle continues up to the final level of the excavation, where the structure will be founded. If there is ground water at the surface of the trench, then the said water is discharged through systematic holes/piping at a depth of 3-4m. on the retaining structure/excavation and they are pumped using the appropriate drainage system.

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

Fig 2.1

Author's name	Book or thesis	Year	Institution
Richard W Bukowksi	*A review of international fire Risk prediction methods*	Oct 1992	Building and Fire Research Laboratory, National Science and Technology Gaithersburg USA.
Rapporteur Alfred Haack	*Technical Report – Part 1 Design Fire Scenarios*	*2004*	The European thematic network in fire tunnels
Robert Andrew Hart	*Numerical modeling of tunnel Fires and water mist Suppression*	*Dec 2005*	University of Nottingham
Anders Lonnermark	*On the characteristic s of fire in tunnels*	*2005*	Lund University, Sweden
Alan Beard and Richard Carvel	*"The handbook of tunnel fire safety*	2005	Thomas Telford Publishing,

2.2 REVIEW OF EXPERIMENTS

A Doctoral Thesis by Anders Lonnermark on '*The characteristics of fires in tunnels*' helps us to understand the concept of fires and its change in behavior in a confined space. He goes on to conduct 4 experiments measuring the maximum heat release rate, temperature, and velocity of radiation. The fuel used in the test was a mixture of cellulose and plastic and it was studied that the combustion of ordinary (non -hazardous) materials produced high heat release rates and temperature that were comparable to hazardous goods. So therefore when such an atmosphere starts to spread over a long confined space, the consequences can be deadly. However a lot depends on the way how the evacuation of the passengers or workers are designed. HRR or heat release rate is said to be the most important parameter in fire and gives a clear idea in defining a fire hazard and relates the other parameters such as the ventilation rate, temperature, smoke etc. A number of tests were conducted on different types of vehicles with loads of wood and tarpaulins with a pre calculated energy content. The tests showed that the heavy vehicles with maximum load had the highest heat release rate. Thus the experiment was successful in drawing relation between the energy content and the HRR. Another study conducted was on the flame spread in tunnels. When a fire was allowed to break out in a tunnel, it was studied that the flame spread and the length wasn't affected when it was exposed to natural ventilation, but became slightly longer when the fire came in contact with the ceiling.

'Numerical modeling of tunnel fires and water mist suppression', a thesis done by Rober Andrew Hart focused on 3D and 2D modeling of tunnel fires and gave a elaborative description on the various firefighting systems and their effectiveness in tunnels. In underground tunnels, various types of active firefighting are used such as deluge water spray systems, foam and various types of hand held fire extinguishers. However statistically, has not effectively suppressed fire. Mist suppression has been studied deeply to analyze the effectiveness of various droplet sizes. Tests were conducted on the usage of mist in tunnels with ventilation of 1.2m/s and 1.4 m/s. It was observed that, with the increase in the ventilation rate, it became difficult to extinguish the fire efficiently. With adjustments in the mist discharge, effectiveness was able to be increased. It provides an account on the effect of various parameters such as ventilation, turbulence to fire behavior.

Fire in Tunnel Reports is a collection of thesis and practical tests that are conducted and performed by a group of institutes in Europe known as the European thematic network in fire tunnels. It provides the design aspects that are to be studies in tunnels in case of a fire. Although none of their tests have been universally accepted, it however draws conclusions on the design characteristics worth to be noted.

Some key design fire scenarios relevant to the fire safety in tunnels are listed below:

(1) Design fire scenario for ventilation design and assessment

Smoke flow rates should be used to design the ventilation in tunnels. Smoke flow rates is basically the volume flow in the plume of fire, from a design fire and the existing gas temperatures downstream .

Next is the design scenario for egress

(2) Design fire scenario for egress analysis considers the concentration and temperatures at height for the presence of toxic gases and the rate of thermal radiation. The egress time will be calculated and will be displayed along with alarms so that the occupiers are made alert of the dangerous situation and evacuate as soon as possible.

(3) Design fire scenario for thermal action on structures studies the structural load and its fire resistance assessed by conducting practical tests with materials in and around the tunnels and with possible materials that a passenger might carry with them.

The handbook of tunnel fire safety is considered to be first of its kind which gives an overview of all the fire hazards that can happen within a tunnel and provides an insight on the causes that could lead to a chain of disastrous situations. It includes all the necessary measures that need to be taken in order to prevent a fire occurrence.it also gives an account on the mandatory legal requirements such as those mentioned in BS 6164. It studies the behavior of fire in various atmospheric conditions within the tunnel and closely captures the nature of fire in the different conditions. This provides an idea on how fire is expected to behave in tunnels. It is studied that the fire behavior does vary with the depth of the tunnel with lesser oxygen as we move to the bottom.

CHAPTER 3

METHADOLOGY

3.1 DETERMINING FIRE HAZARDS

3.1.1 FIRE IN TUNNELS:

Hazards:

- flammable gases
- oxygen enrichment
- Transformer oil, diesel fuel, control fluid, seal oil
- Electrical system
- Heat path damaged insulation
- Dry grasses
- Accumulation of waste materials etc.

Causes Of Fire:

1. Most Fires break out from welding operations or electrical systems by sparks, hot slag, and flame from the torch. Sparks can be carried over a long distance by wind or dropped at the very spot of the source. Slag falls on surface and takes time to cool down whereas a welding torch flame can cause many substances to ignite at a distance from it.
2. Oxygen enrichment even by a few percentage can cause clothing and other combustible materials to ignite. It can be caused by the damage, loose contact of oxygen lines resulting in its leakage. The leakage of oxygen cylinders used in gouging or flame cutting operations has caused several fatalities and remains one of the most common serious dangers. Another cause could be the misguided use of oxygen instead of air in ventilation hoses will increase flammability of clothing and other combustible materials.
3. A flammable atmosphere presents a risk of fire or explosion. Such an atmosphere can arise from the presence in the confined space of flammable liquids used in underground operation can give out gases that may increase the chances of fire or explosion. Presence of dust in a flammable atmosphere can cause a dust explosion that may spread over a long distance resulting in the disintegration of the structure.
4. The work might involve use of a flammable substance, a quantity of which is thereby introduced into the confined space. For example, an opened container of a flammable solvent based paint may be hazardous in a confined space. Liquids or solids can flow into the confined space, drowning or suffocating the occupants or causing other injuries such as burns. Solids in powder form may also be disturbed in a confined space resulting in an asphyxiating atmosphere.
5. Unwanted material accumulated near flammable or ignition sources may cause a fire to spread over a large area
6. Operation of Internal Combustion Engines from vehicles or machines in a confined space may release whose exhausts contain carbon monoxide, carbon dioxide and nitrogen dioxide is likely to seriously contaminate the atmosphere and promote the chances of fire

Fire Fighting Equipments Installed:

- Fire hose
- DCP fire extinguishers -4 kg

Control Measures:

1. The fresh air supply in a free tunnel is not less than 6m3 /min for each building.
2. Free air flow movement inside such tunnel is not less than 9m3/min.
3. The oxygen level shall not be less than 19.5% in the working environment.
4. The contractor shall inform in writing to the Director General within 30 days, prior to the commencement of any tunneling work.
5. The contractor shall appoint a responsible person for safe operation for tunneling work as per Rule 121 & 125 of BOCWR.
6. The contractor shall ensure

   i) Every compressed air system in a tunnel is provided with emergency power supply for maintaining continued supply of compressed air as per Rule 155 of BOCWR

   ii) watertight bulkhead doors are installed at the entrance of a tunnel to prevent flooding.

   iii) reliable and effective means of communication such as telephone or walkie-talkie are provided and maintained for arranging better effective communication at an excavation or tunnelling work as per Rule 136 of BOCWR.

   iv) All portable electrical hand tools and inspection lamp used in under ground and confined space at an excavation or tunneling work is operated at a voltage not exceeding 24V.
7. Only flame proof equipment of appropriate type as per IS:5571:2000 and or other relevant national standard is used inside the tunnel.

3.1.2 FIRE IN GENERATOR AREA:

Hazards:

- Overloading
- Faulty appliance/control system
- Oil leakages
- Hydrocarbons
- Lightning
- Mechanical damage
- Quality of electrical components
- Electrical panels

Fire Fighting Equipments Installed

- 2 DCP extinguisher -4 kg
- 2 CO2 extinguisher – 8 kg
- 6 sand buckets

Control Measures:

1. Adequate insulation

2. Proper prevention maintenance

3.1.3 FIRE IN DIESEL YARD

Hazards:

- High temperature
- Accumulation of waste materials
- Smoking
- Proper arrangement
- Unauthorized entry
- Sealing of containers

Fire Fighting Equipments Installed:

- 2 DCP Extinguishers- 4 kg
- 3 sand buckets

Control Measures:

- When considering the storage or use of flammable liquids, the following safety principles should be applied:

a. Ventilation- plenty of fresh air
b. Ignition- Control of ignition sources
c. Containment- suitable containers and spillage control
d. Exchange- try to use a less flammable product to do task
e. Separation- keep storage away from process areas, by distance or a physical barrier, for example ,a wall or partition.

- In a suitable container, to prevent spills and sealed to prevent loss of vapour.
- In a suitable cabinet, bin or other store container.
- In a designated area of the workplace.
- Away from ignition sources, working or process areas.
- In a 30 minute fire resistant structure
- Provided with hazard warning signs to illustrate the flammability of the contents
- Prohibition signs for smoking and naked flame
- Not contain other substances or items.

3.1.4 FIRE IN GAS CYLINDER SHED

Hazards:

- High temperature

- Accumulation of waste materials
- Smoking
- Proper arrangement
- Unauthorized entry
- Sealing of containers

Fire Fighting Equipments Installed:

- 2 DCP Extinguishers -5 kg
- 4 sand buckets

Control Measures:

- Storage area should be in clear open area outside.
- Stored in a secure compound -2m high fence.
- Safe distance from toxic, corrosive, combustible materials, flammable liquids or general waste.
- If stored inside building, kept away from exit routes, consideration should be given to fire resisting storage.
- Well- ventilated area – 2.5% of total floor and wall area as vents, high and low.
- Oxygen cylinders at least 3m away from flammable gas cylinders.
- Acetylene may be stored with LPG if quantity of LPG less than 50 kg.
- Access to stores should be controlled to prevent LPG etc being stored unsafely in the general workplace.
- More than one exit (unlocked) may need to be available from any secure storage compound where distance to exit is greater than 12 m.
- Lock storage compound when not in use.
- Protection from sunlight.
- Flameproof lighting
- Empty containers stored separate from full.
- Fire extinguishers located nearby- consider powder.

Transport Requirements:

- Upright position.
- Secured to prevent.

- Protection in event of accident. For example, position on vehicle.
- Transport in open vehicle preferably.

3.1.5 FIRE IN ELECTRICAL PANELS

Hazards:

- Overloading
- Sudden power surge say by lightning
- Poor quality of electrical components
- Poor earthing
- Flashing, sparks
- Electrical arcing
- Flammable gases and other environmental hazards

Fire Fighting Equipments Installed:

- 2 DCP Extinguishers- 4 kg
- 4 sand buckets

Control Measures:

- Should always be locked when not in use.
- Use of suitable fuses
- Proper and timely maintenance

- Periodic inspection and testing

3.2 HAZARDOUS OPERATIONS:

3.2.1 WELDING:

Hazards:

- Overloading
- Poor quality of welding machine components
- Improper handling can cause fire back
- Leakage of gases used for welding may lead to explosion.
- High pressure and current can cause machine to flash back
- Improper housekeeping
- Poor handling of welding machine
- Close proximity of tires

Control Measures:

- Should be kept upright on a custom built stand on trolley fitted with a bracket to accommodate hoses and equipments or otherwise secured.
- Metal cap in place when valve not in use.

- Hose clamp or clip shall be used to connect hoses firmly on both sides.
- Pressure regulators and dial gauges.
- NRV and flashback arrestors at both ends of cylinder torch
- DCP or CO2 extinguisher not less than 5 kg near to welding zone.
- Oxygen cylinders and flammable gas cylinders shall be stored separately at least 6.6 meters apart or separated by 1.6 m high partition
- Flammable substance shall not be stored within 50 feet of cylinder storage areas.
- Electrical arc welding not to exceed 300 A on a hand welding operation.
- Not more than 110 V and shall be double insulated.

3.2.2 PAINTING:

Hazards:

- Fire and explosion
- Poor housekeeping
- High temperature

Control Measures:

- Electric equipments that includes wirings, plugs, sockets, clocks, radios used should be assessed and certified to be used in different flammable zones.

- Suitable ventilation arrangements should be provided in order to prevent the atmosphere to go beyond the flammable limits.
- Cleaning and proper housekeeping should be performed timely.
- Adequate earthing should be given to all conductors of electricity
- Minimum amount of paints should be stored. 50 liters of highly flammable paints and 250 liters of flammable paints.
- Mixing or dispensing of paints should not be done without assessing the area and its surroundings. It should be mixed within a storage area without sufficient ventilation and non-assessed electrical equipments

3.2.3 SPECIAL PURPOSE VEHICLES:

Hazards:

- Presence of flammable gases such as methane, H2S etc.
- Mechanical breakdown
- Hydraulic fuels
- Electrical fault
- Collision with nearby objects
- Operating errors

Control Measures:

- All internal combustion engines should all internal combustion engines must be equipped with an effective spark arrester
- All such machines operating in a fixed location must have a clearing of all flammable materials of at least 10 feet in all directions
- Lights including the emergency lights should be explosion proof
- Smoking should be prohibited in the tunnel prohibition,
- Provision of fire extinguishers,
- Additional clearance of flammables during welding, and cutting or welding only under special short-term permit.

Every year, construction workers are at risk of fire or any emergency situation considering the hazards that they interact with. The National Institute of Safety and Health, NIOSH, reports 358 fire and explosion fatality cases from 1992 to 2003 in the US. The most common cause of death among them were welding ,open flames, motor vehicle clashes, cutting/drilling, electrical sparks, open flames, and striking of underground pipelines.

Table 3.1- Fire and Explosion Deaths and Incidents in Construction, 1992-2003.

Types of incident	Deaths (%)	Incidents (%)
Chemical explosions	161 (45%)	132 (42%)
Fires	97 (27%)	84 (27%)
Pressurized container explosions	60 (17%)	57 (18%)
Arc flashes/blasts	40 (11%)	40 (13%)
Total	358 (100%)	313(100%)

* Source: U.S. Department of Labor, Bureau of Labor Statistics CFOI Research File.

It is noted that welding has claimed the most number of lives in fire and explosion incidents in the construction industry with 15% of the chemical explosions. Many of them involved welding on empty tanks and pipelines. When we look further into welding to determine the actions that led to such deadly incidents, following data was observed

Table 3.2 -Causes of Fatal Arc Flash/Blast Incidents

Cause	**# Incidents* (%)**
Electrical malfunctions/shorts	7 (18%)
Contact with overhead power lines	6 (15%)
Contact with other energized wires	6 (15%)
Other	21 (53%)

*** Source: U.S. Department of Labor, Bureau of Labor Statistics CFOI Research File.**

Next danger recognized was the explosion due to gas release from ignited tires. Tires when exposed to fire directly or indirectly through its rims, can cause fire by pyrolysis

3.3 EMERGENCY STRUCTURE

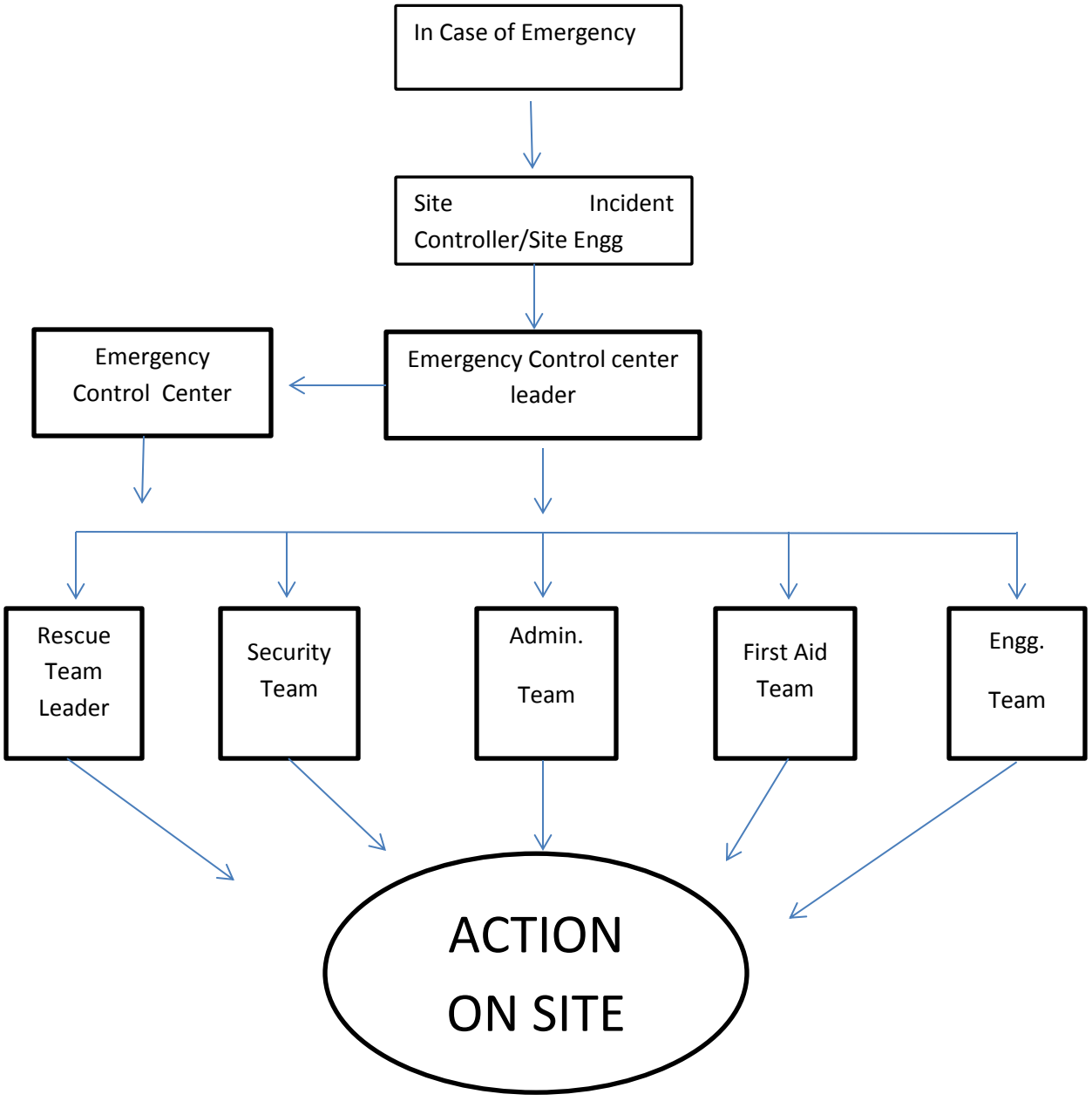
A major emergency can be defined as an accident/incident that has potential to cause serious injuries or loss of life. It may cause extensive damage to property, serious disruption both in production and working of factory and may adversely effect the environment. The following factors may cause major emergency:-

(i) Equipment failure.
(ii) Human error.
(iii) Vehicle crash.
(iv) Sabotage.
(v) Earthquake.
(vi) Natural Calamities.
(vii) Fire

Emergency planning is an integral part of the overall loss control program and is essential for any organization. The same is important for effective management of an accident / incident to minimize losses to people and property, both in and around the facility. The

important aspect in emergency management is to prevent by technical and organizational measures, the unintentional escape of hazardous material out of the facility and minimize accident and losses. Not only are unrecognized hazardous conditions which could aggravate an emergency situation be discovered, the emergency planning process also brings to light deficiencies such as lack of resources necessary for effective emergency response. Emergency planning also demonstrates the organization's commitment to the safety of employees and increases the organization's safety awareness.

Fig 3.1



3.3.1 FUNCTIONS/ DUTIES OF EMERGENCY CONTROL TEAM LEADER AND MEMBERS

Emergency Control Team Leader

Project Leader has been identified as the Emergency Control Leader in the absence / as a substitute the (Site in Charge) has been identified as the alternate Emergency Control Team Leader.

Functions Of The Emergency Control Team Leader

1. The Emergency Control Team Leader is authorized to declare an emergency
2. Inform the concerned officers in FEMC PRATIBHA JV Office and seek necessary assistance in terms of co-ordination with Government authorities, Delhi Municipal Corporation, Delhi State Pollution Control Board,Delhi Fire Brigade, Police Head Quarters etc.
3. Inform the Finance Department at HO to co-ordinate with insurer/Surveyor/Loss assessor and hasten up settlement of claims,if any.
4. Constitute a Committee to examine/investigate the situations that resulted in the incident and to identify steps to be taken to prevent re-occurrence of such incidents in future.

Functions of the Fire Fighting/Rescue Team – Firefighting team should initiate the action for controlling the fire. They are the trained fire fighters having knowledge of various types of fires.

Functions of the Security Team – The main function of the team is to cordon off the site and control of the site and control the mob. The team members also help the fire fighting team.The team members should guide external agencies like Fire Brigade to the pla of emergency.

Function of the Adminstration Team – Adminstration arranges all the welfare activities required at the time of emergency. They need to arrange ambulance and first aid. They Liaison with hospitals and local fire brigade for additional help if require.

Function of the First Aid Team – The team members should know how to give the first aid .Their main function is to give first- aid till the victims get external medical help.

Function of the Engineering Team – Engineering Team switched off the power in order to control the emergency. They need to provide all the technical support to control the emergency such as arranging Plant, Slings and Power etc.

Functions Of Site Incharge

1. Facilitate conducting ROLL CALL – of Site personnel by checking against Head count
2. Provide advice on and initiate technical corrective actions depending on the type of emergency.
3. Give instructions to discontinue / shut down operations of both the Batching Plants in a planned phased manner.
4. Give instructions to discontinue operations involving cranes
5. Render necessary support services to the Project Manager.

Functions Of Plant And Equipment Department

1. Discontinue / Shutdown Plant operations on getting information about emergency.For example stop compressors, moving machinery ,all cranes etc.
2. Make sure that cranes and other lifting machinery do not obstruct the movement of Fire Brigade vehicles,Ambulances etc.
3. If any vehicle breakdown takes place ,then arrange to use cranes to clear the pathway for Fire tender ad Ambulance.
4. Facilitate use of cranes for retrieving fallen objects, parts of collapsed structures (if any)

Functions Of Adminstration Manager/Pro

1. Keep the list of persons who are on duty during the particular shift with a view to facilitate Roll call at assembly points (and thus ensure that all persons are accounted for)
2. Depute Time Keeper to take Roll Call
3. Contact / Liaise with local Police ,Government Authorities ,Municipal Corporation Officials, Pollution Control Board Officials and share authentic information about the incident.

4. Facilitate effective Public Relations with a view to contain /prevent misinformation about the incident.
5. Interact with the local press reporters/agencies .Share authentic information about the incident.
6. Organize to use Public Address system to warn the local population about the emergency and actions to be taken by them for example – "DO NOT PANIC" or "STAY INDOORS " or " FOLLOW INSTRUCTIONS OF FEMC PRATIBHA JV" or WAIT FOR INSTRUCTIONS"

Functions Of Chief Safety Manager / Safety Manager

1. Coordinate all the activities
2. Provide support and information needed by Emergency Control Team Leader / Members.
3. Co-ordinate with and guide the Delhi Fire Brigade Team on arrival at the site through the site roads.
4. Provide guidance /assistance in starting trailer mounted Fire water pump (if required)
5. Contact Company Doctor, Ambulance service of GOVT HOSPITAL and seek necessary assistance.
6. Function as the facilitator of the Site Team conducting an investigation on the causes of the incident so that such incidents are not repeated in future.
7. Ensure the proper proceedings of EMERGENCY operation.

Functions Of Electrical Manager/ Engineer

1. Make sure that electricity to the affected areas of the site are selectively switched off.
2. Make sure that Diesel Generator set is ready for start up .if required.
3. Provide necessary support to the Emergency Control Team Leader to control the Emergency.

Functions Of Storage Manager/Officer

1. He shall arrange to ensure that the stores issue counter is open and necessary items to facilitate emergency control are issued/delivered to the concerned persons.
2. If any emergency/short notice purchase is needed then Procurement officer shall arrange to procure all such items immediately.

3.3.2 EMERGENCY CONTROL CENTRE

SITE SAFETY OFFICE at the site is identified as the "EMERGENCY CONTROL CENTER"

The "EMERGENCY CONTROL CENTRE" should be equipped with the following –

1. A copy of the location map/plot plan of the work site showing locations of various units at the site:
2. A list of important telephone numbers e.g Fire Brigade ,Hospital, Ambulance ,Police etc.
3. Current updated list of residential telephone numbers/Mobile numbers of each Emergency Control Team Member.
4. A telephone connection with means to contact Fire Brigade Ambulance services, Police and FEMC-PRATIBHA JV Managers/officers who are identified as Emergency Control Team Members.
5. Walky-talkies/Mobile phone

Preparation For Emergency

- The current up to date copy of the site layout/plot plan showing the locations of the various units within the premises is to be kept displayed at the entrance to the site.
- We could consider and invite the personnel from the Delhi fire station to familiarize themselves with the location of various units at the site to ascertain ability of entry of fire foam ,fire extinguisher.

3.3.3 SITE LEVEL EMERGENCY

- The site level emergency information given by Walkie talkies & mobile phone if the emergency situation is difficult to control within a short period of time or is uncontrollable and is likely to adversely affect the persons working in areas/ plants/departments/ construction sites in the complex and the population working or residing nearby.
- If the site level emergency information given all persons working/present at the construction site(including visitors) shall stop work immediately and switch off the machines and equipment on which they are working and leave them in a safe condition.
- Persons involved in hot jobs shall extinguish welding/gas cutting torches and close cylinder valves.

- Electrical switches shall be switched off
- Persons working at height shall come down calmly after leaving their machines and equipment in a safe condition.
- All persons shall walk quickly to the security gate/Assembly point.
- Persons should not panic, Assemble if possible with your contractor/subcontractor , near the assembly point and await further instructions.
- In case you are driving a vehicle and receive the emergency information then move your vehicle to the side of the road and apply hand brake and turn the engine off.
- Park the vehicle and proceed on foot to the safe place
- All contractors/sub-contractors shall educate train their crew in emergency procedures and ensure that they are aware of these procedures. Records of training will be maintained in the contractors/sub contractor's supervisor's office.
- All visitors and drivers shall also be educated in these procedures by the personnel to whom they are reporting.

When Reporting Any Emergency State:

- The nature of Emergency
- The telephone number you are calling from or you location in the premises
- Your name and name of your company

Emergency Evacuation And Assembly Point

- A continuous siren will be sounded. When the siren is sounded you must.
- Immediately shut off the all-welding gases at the main shut off valve, discontinue.
- Unloading of diesel (if in progress), by closing the isolation valves,extinguish
- All sources of ignition and exit the site through the main entrance gate and assemble near assembly point
- Foremen to take charge of team and report to the Site engineer/manager
- Do not stop to collect personal belongings
- Turn off generators, compressors and other power equipment, unless these
- Provide power for emergency services
- Turn off all heat producing equipment and shut cylinder valves
- Attack fire with the equipment provided, if it is safe to do so.
- Obey the instructions of the site fire safety co-ordinator /Principal Contractor's representative or Supervisory staff.

Office staff will be available at the Assembly points to verify that all Employees have been evacuated and to give further instructions. Do not re-enter the site until the all – clear siren is given/until you are told that it is safe to do so. The all-clear siren is three series short siren blasts, Pause three short siren blast and pause .Three short siren blasts.

In the event of a power failure or the need for a specific evacuation procedure, emergency response team members will give instructions.

Emergency Control Mock Drill/Trial Exercise

With a view to test the efficacy/ effectiveness of the emergency plan,it will be helpful if the plan is tested during a pre-planned mock exercise .Such an exercise will help in reinforcing confidence on the level of preparedness to meet an contingency, identify weaknesses during the implementation so that the Plan could be revised /updated. Such a mock exercise could be conducted once in a month.

3.3.4 TUNNEL EVACUATION IN EMERGENCY

- In case of any emergency in the tunnel call for help & raise continuously emergency alarm at least one minute.
- Inform Emergency Control Leader & team for further action.
- Call P&M manager/Engineer for arrangement of rescue bucket/equipment's for evacuation of victims ,if required.
- Call Doctor/Male nurse for first aid & onward medical treatment.
- Call 102 for ambulance, if required, send victims to hospital
- Employees shall assembled near Emergency assembly point. Time office staff will be available at the Assemble points to verify that all Employees have been evacuated and to give further instructions. Do not re-enter the site until the all-clear siren is given/ until you are told that it is safe to do so.
- Foremen/Supervisor to take charge of team and report to the Site Engineer/Manager.
    1. Do not stop to collect personal belongings
    2. Turn Off generators, Compressors and other power
    3. Segregate the area and remove the maximum possible inflammable materials from the spot.

3.3.5 FIRE IN OFFICE/STORE

- Proceed to nearest safe exit.
- Disconnect Electrical connections
- Be aware of smoke noxious fumes.
- Think first of your safety and safety of others
- Use blankets,tarps as shield
- Crawl on hands,kneels.
- Post emergency numbers(101)
- Try to put out fire only if it is small and tame.

Alert fire department when necessary, leave the fire-fighting to professionals

3.3.6 FIRE IN DIESEL STORAGE AREA

- The individual responsible for or who discovers the fire of the diesel storage area.
- Shall report the incident immediately to the site safety personnel and the Project manager.
- The Chief SHE Manager & Team will assess the severity of the fire and act as required .The sand dry ,chemical powders,CO2 ,foam fire extinguisher shall be used to contain fire.
- In case of large fire the incident shall be reported to the interested parties /Pollution Control Board.
- When dry chemical powder is used for the containment of the time fire then after the fire is Contained the contaminated soil shall be taken out and stored in empty containers
- Or shall be stored in the designated area specially prepared for such types of materials storage during emergency.
- The containment material shall be disposed off at the specified location only after the required treatment is given to such material as per the guidance of the client or pollution control board.
- When water is used for the containment of the fire the polluted firewater will be stored temporarily in a tank either fabricated or made on the ground.
- The Works Manager in consultation with the client or Pollution control Board will determine the exact method or treatments or polluted firewater and shall be disposed off as per their guidance and approval.

3.3.7 MAJOR FIRE AT MAIN ELECTRICAL SUB STATION

- Cut off supply and raise alarm
- Inform Chief SHE Manager & Team in charge and nearest fire station
- Use Co2 /DCP for extinguishing the fire.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 FIRE FIGHTING AND EMERGENCY EQUIPMENT RESOURCES

Besides the well laid out fire water network, the site has the city's fire station that is always ready to meet any eventuality. The fire station is equipped with multipurpose mobile appliances for carrying out fire fighting and rescue operations .Other fire fighting equipments include portable fire extinguishers, fire hoses, fire buckets. The details of the various fire fighting resources are given below:

4.1.1 FIRE TENDERS

4.1.2 PORTABLE FIRE EXTINGUISHERS

As per the recommendation of Tariff advisory committee different type of fire extinguishers have been providing at different location of the plant.

ANATOMY OF PORTABLE FIRE EXTINGUISHERS

Fig 4.2

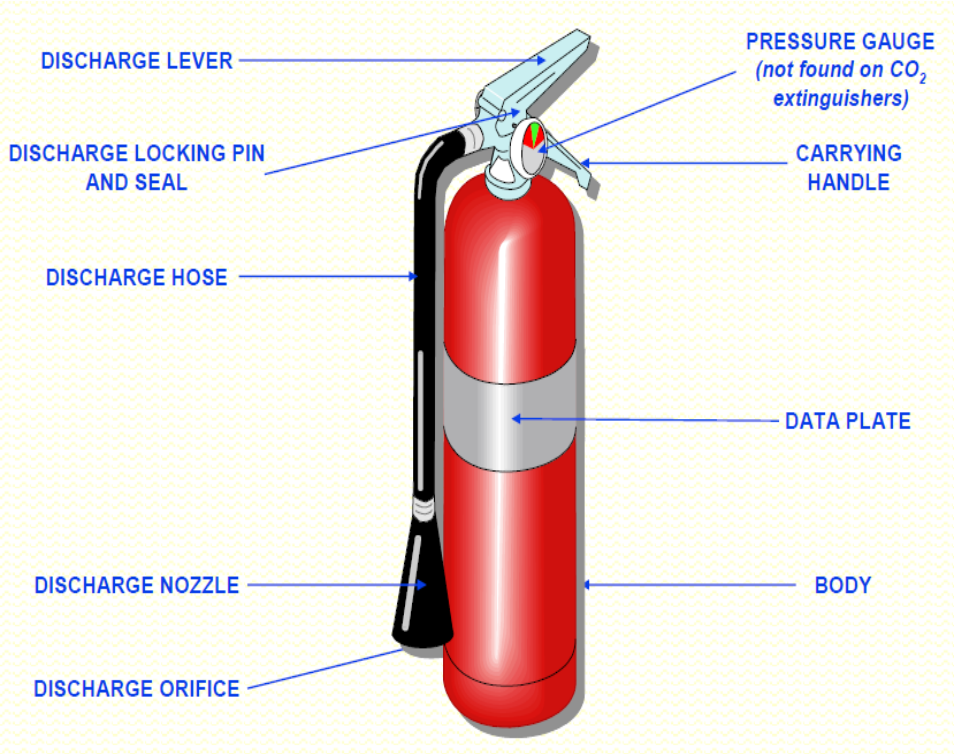


Table 4.1

Type of Fire Extinguisher	**Classification of Fire**				
	Class A (Fire in ordinary combustible materials such as wood, paper, textiles, grass, coal etc.)	**Class B (Fire in flammable liquids such as oils, solvents, diesel, kerosene, paint, petrol etc.)**	**Class C (Fire in involving gaseous substance such as Hydrogen, Ammonia, LPG, Acetylene etc.)**	**Class D (Fire involving metals such as magnesium, aluminum, sodium, zinc etc.)**	**Electrical Equipment**
Water	✓ (YES)	X (NO)	X (NO)	X(NO)	X (NO)
Foam	✓ (YES)	✓ (YES)	X (NO)	X (NO)	X (NO)
Dry Powder	✓ (YES)	✓ (YES)	✓ (YES)	✓ (YES)	✓ (YES)
Carbon dioxide	X (NO)	(YES)	X(NO)	X(NO)	✓ (YES)

Dry Chemical Type Fire Extinguishers:

Dry chemical powder type fire extinguishers are suitable for fighting fire of class B & C fire like that liquids, petrol, diesel, kerosene, electrical equipments, paints, butane, chlorides, and vinyl chloride natural gases etc. and also suitable for chemical spillage and electrical fires.

- It is nontoxic and non-conductive.
- It extinguishes fire by:
  a) Inhibition of combustion chain reactions.
  b) Flame separation
  c) Radiation shielding by cloud.
  d) Smothering action

Method Of Operation:

- Fire extinguisher smoothly shell be removed from clamp.
- Fire extinguisher shell be kept safe distance from self body and fire spot.
- Keep the extinguisher in up wind direction on the floor and proper hold the squeeze grip nozzle in your left hand.
- First shell be removed seal and pull safety clip by self hand..
- Strike right hand on the knob of the cap for fire extinguisher operating.
- During Punch the knob, Beware that any part of your body must not be bring over lapping to the extinguisher cap assembly.
- In case of trolley type DCP type Fire Extinguisher gradually first shall be removed seal and safety pin from the valve of CO2 gas cylinder and after cylinder valve shall be opened.

- DCP used on fire in direct jet on fire in sweeping motion**.**

<u>Foam Type Fire Extinguisher</u>:

The Mechanical Foam Type Fire Extinguisher follows the flame knockdown technique for spill fires involving flammable and volatile liquids like petrol, paints and alcohols. The Mechanical Foam Type Fire Extinguisher forms a thick blanket of foam over the burning surface thereby cutting off the oxygen supply and smothering the fire

Features :

- Uses flame knock down technique
- Immediately smothers fire
- Mechanical operation makes it easy to use
- Light weight
-

Widely Used For :

- Flammable and volatile liquid
- Petrol
- Paints
- Alcohols

Foam is a homogenous mass of tiny air / gas filled in water bubbles of low Specific gravity, which when applied in the correct manner and in sufficient. Quantities form a co mpact fluid stable blanket. This is capable of floating on the surface of flammable liquids and preventing oxygen in air from coming in contact with liquid. Foam constitutes water, foam compound and air. (Water + Foam Compound + Air = Foam)

Method Of Operation:

- Fire extinguisher smoothly shell be removed from clamp.
- Fire extinguisher shell be kept safe distance from self body and fire spot.

- Keep the extinguisher in up wind direction on the floor and proper hold the nozzle in your left hand.
- First shell be removed seal and pull safety clip by self hand.
- Strike right hand on the knob of the cap for fire extinguisher operating.
- During Punch the knob, Beware that any part of your body must not be brought ov er lapping to the extinguisher cap assembly.
- In case of trolley type FOAM type Fire Extinguisher gradually first shall be remov ed seal and safety pin from the valve of CO2 gas cylinder and
  after cylinder valve shall be opened.
- Foam used on fire in direct jet at the base of flame in sweeping motion.

Carbon Dioxide Type Fire Extinguishers:

The Co2 Gas Fire Extinguisher works upon the quick and efficient flame knockdown property of CO2 gas which makes it ideal for tackling fire involving flammable liquid for instance oil, paints, varnish, solvents and even industrial gases. The Co2 Type Fire Extinguisher uses CO2 gas which rapidly starves the fire of oxygen thereby extinguishing it within seconds. As it does not leave any residue, it is ideal for fire involving sensitive electrical equipment.

Features :

- Uses inert gas i.e. CO2
- Flame knockdown property
- Leaves no residue
- Ideal for tackling liquids

Widely Used For :

- Computer Rooms
- Telecommunications Facilities

- Clean Rooms
- Data Storage Areas
- Irreplaceable document and art storage rooms
- Laboratories
- Offices (for protection of sensitive electronic equipment

Method Of Operation:

- Fire extinguisher smoothly shell be kept in upright position at safe distance from fire spot.
- First shell be removed seal and pull safety lock pin from operating valve and prope r hold discharge horn by self hand and turn the operating valve anti-clockwise**.**
- Fire extinguisher shell be kept safe distance from self body.
- Direct the jet (Discharge Co2 gas) at the base of flames in sweeping motion.

4.1.3 FIRE BUCKETS

Fire buckets filled with dry sand are provided in different locations of the plant of 9 litre capacity each.

4.1.4 HOSE REELS

Hose Reels are considered for location mainly within tunnels as first aid for fire contingency. These are mounted on the side of the tunnels and are connected to the water supply at all times Each hose reel shall have sufficient length to reach affected fire area. They are located 30m apart and cover all throughout the tunnel.

4.1.5 SELF CONTAINED BREATHING APPARATUS (SCBA)

Precautions To Be Taken:

SCBA, by its nature , is filled with air at high pressure hich could prove dangerous if not handled properly.

Therefore:

- Timely maintenance is required
- Training to users is essential
- Select the best apparatus
- Preserve the certificates

SCBA-Components

- Facemask
- Pneumatics
    i. Lung demand valve
    ii. Pressure Reducer
    iii. Gauge & Whistle Warning Unit
- Carrying System
    i. Harness
    ii. Back plate
- Cylinder
- Accessories

Pre- Donning SCBA Check

1. Check that air cylinder has atleast 80% of its rated pressure
2. Operation checks

- **High Pressure Test**

Open cylinder valve slowly to pressurizes the system. Close cylinder valve &observe the pressure gauge, Pressure shall not drop more than 10 bar in 1 minute.

- **Low Pressure Test**

Open cylinder valve slowly to pressurize the system. Close cylinder valve & observe the pressure gauge, press center of rubber of demand valve to activate positive pressure vent apparatus, observe the drop in PG. Whistle unit should sound at preset pressure.

NOTE: checked when working condition of 10 minute remain.

Preparation Of Use

1. Fully open all the harnesses
2. Check the threads of the cylinder &the pressure reducer and the sealing O ring.
3. With the apparatus in horizontal position slide the cylinder in the support strap from top to the pressure reducer.
4. Lift the unit in upright position and screw the hand wheel on pressure reducer into the cylinder port.
5. Keep the unit in horizontal position.

Putting On Apparatus:

1. Put on apparatus with harness fully extended
2. Pull down the shoulder straps until the apparatus feels comfortable
3. Fasten the waist belt until apparatus sits securely
4. Wear the shoulder strap of the mask and connect the demand valve

5. Make sure that the demand valve is switched off manually.
6. Open cylinder valve slowly but fully
7. Check the pressure gauge. The gauge should read minimum 80% of its full capacity.
8. Wear the mask and tighten the harnesses by holding the breath. (Spread out the straps,place chin the face piece,place the straps over head,tighten the lowr straps first and then others.)
9. Now the first breath will activate the demand valve and then breath normally.

After Use:

1. Switch off the demand valve and remove the face piece.
2. Unfasten the waist belt
3. Loosen the shoulder straps by lifting both the buckles
4. Remove the apparatus slowly from back
5. Close the cylinder valve
6. Vent the air in the hoses
7. Charge the cylinder with a refilled cylinder

Routine Checks:

1. Physical checks for damages on all the harnesses, Face piece ,Valves, Connectors, Cylinder supports and Demand valve.
2. Warning Whistle
3. Leak from the system

Cleaning The BA Set:

1. Dirty components has to be cleaned and dried every time after use.
2. Masks and demand valve must always to be cleaned and disinfected
3. Be careful about the concentration and the reaction time of the disinfectant used.

4. While drying the temperature of 60 degree Celsius must not be exceeded.

Duration Of Use:

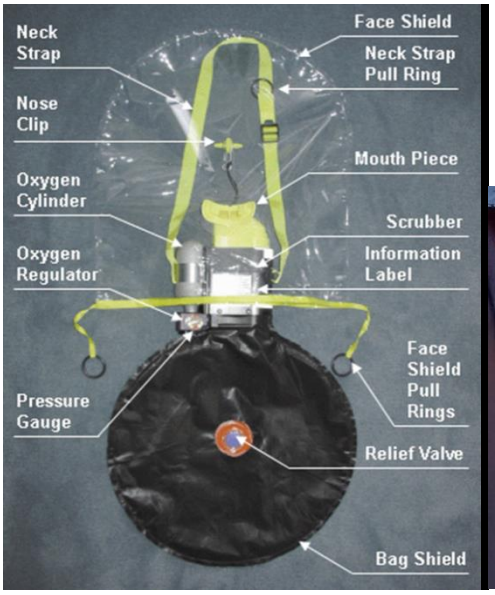
The maximum duration for set which can provide safe breathing to a person depends on the type of SCBA set and the pressure in the cylinder.See the table for effective duration of SCBA for different pressure.

$$\text{Effective working duration} = \frac{\text{6 liters x pressure in bars}}{\text{40 LPM}} - 10 \text{ minute}$$

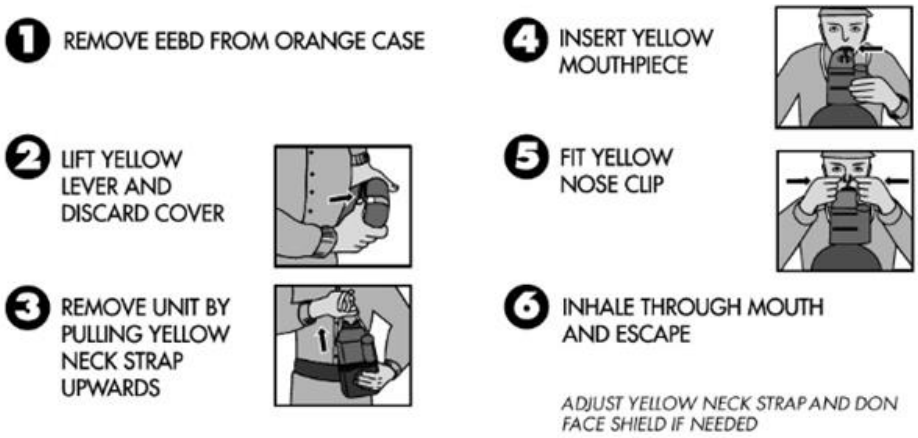
Table 4.2 SCBA Pressure Vs Time

Cylinder pressure (Bar)	Total Duration (minutes)	Effective Working duration(minutes)	Escape time (minutes)
300	45	35	10
280	42	32	10
250	37.5	27.5	10

4.1.6 EMERGENCY ESCAPE BREATHING DEVICE (EEBD)



The EEBD is a non-rechargeable self-contained breathing unit which provides the wearer with 15 minutes of oxygen for emergency escape only. It can be donned quickly by removing the unit from the vacuum bag, pulling the actuating ring and placing the hood down over the head. Oxygen is generated by the breakdown of a sodium candle which is housed in the life support pack. A carbon dioxide scrubber, also in the life support pack, removes carbon dioxide that is exhaled by the wearer.



To fit the neck strap, simply place the neck strap over the head and, if necessary, pull upward on the O-ring to shorten the neck strap.

To fit the face shield, open the face shield by putting a hand inside the face shield and then pull the face shield over the head and pull outward on the O-rings to tighten the face shield around the neck. If moisture on the inside of the face shield distorts your vision, simply press or rub the face shield against the face with your hand.

4.1.7 EMERGENCY RESCUE BUCKET

They are buckets used to carry injured workers from the tunnel to the ground level in order to get immediate and critical aid from first aiders and to be sent to the nearest hospitals. They are always located close to the cranes and has a maximum capacity of carrying 5 persons at a time

4.2 COMMUNICATION

Communication is a crucial factor in handling an emergency. It is the practice in plant that any employee can raise the alarm, so allowing the earliest possible action to be taken to control the situation. Well trained personnel and well equipped mobile appliances are of no value of there are no reliable means to direct them to the right place and right time. For the fire defense of the construction site following complex systems are provided:

4.2.1 TELEPHONE: There is a widely distributed network of telecommunication telephone across the length and breadth of the site ,so that anyone who notices a fire can inform the SHE HEAD .It is necessary to check that the telephone is in working condition by watching the dial tone before dialing.

While transmitting a fire call furnish following information

- Your name and section/department
- Area where fire has occurred and nature of accident
- Material involved in fire

If accident is serious involving human lives or endangering more number of employees, pass on this information also as this would be useful for getting correct type of fire fighting vehicles and manpower quickly.

4.2.2 CELL PHONE: In case of a fire or any other incident Fire station is to be informed by dialing from your mobile. For correct dialing and transmitting the call, instructions given above for communication through are to be followed.

4.2.3 EMERGENCY ALARM SYSTEM: For instant communication about an outbreak of fire or any other disaster or accident, emergency alarm systems to be used. Help of emergency team and other departments can be summoned by operating fire point. The emergency alarm system consists of an alarm switch at strategic locations ,when pressed operates the alarm.Once the alarm is sounded, information is send to all in the work site and also to the a Main Fire station adjacent to the site. .After sounding the alarm, the worker is required to move to the nearest loud phone/telephone point and announce the nature of emergency to the site head.

4.3 FIRST AID

First aid is first aid assistance .It is the help given to the injured before the doctor or nurse takes over. Calmly and sensibly applied first aid may reduce suffering; prevent an injury from worsening and save life. In general following actions are to be done promptly to safe life or to prevent aggravation of injuries already suffered.

i. Remove the person from danger
ii. Assist respiration or breathing where necessary
iii. Control patient comfortable and seek to reduce shock and
iv. Provide safe transportation to Plant Medical Unit.

4.3.1 FOR BURNS:

In order to provide first aid,it is necessary to identify the degree of burn, To distinguish a minor burn from a serious burn, the first step is to determine the extent of damage to body tissues. The three burn classifications of first-degree burn, second-degree burn and third-degree burn will help you determine emergency care.

- **1st-Degree Burn**

The least serious burns are those in which only the outer layer of skin is burned, but not all the way through.

•The skin is usually red

•Often there is swelling

•Pain sometimes is present

Treat a first-degree burn as a minor burn unless it involves substantial portions of the hands, feet, face, groin or buttocks, or a major joint, which requires emergency medical attention.

- **2nd-Degree Burn**

When the first layer of skin has been burned through and the second layer of skin (dermis) also is burned, the injury is called a second-degree burn.

•Blisters develop

•Skin takes on an intensely reddened, splotchy appearance

•There is severe pain and swelling.

If the second-degree burn is no larger than 3 inches (7.6 centimeters) in diameter, treat it as a minor burn. If the burned area is larger or if the burn is on the hands, feet, face, groin or buttocks, or over a major joint, treat it as a major burn and get medical help immediately.

- **3rd-Degree Burn**

The most serious burns involve all layers of the skin and cause permanent tissue damage. Fat, muscle and even bone may be affected. Areas may be charred black or appear dry and white. Difficulty inhaling and exhaling, carbon monoxide poisoning, or other toxic effects may occur if smoke inhalation accompanies the burn.

4.3.2 CLOTHES ON FIRE:

If the clothes catch fire, the person may run about terrified, thus fanning the flames which can flare up towards his face. Get the person on the ground at once .If he is panicky this may have to be done by tripping him up. Smother the fire by wrapping round firmly and closely by a thick cloth or blanket. Pour cold water on burns.

Immediate Action Steps:

- **For Minor Burns:**

  Including **first-degree burns and second-degree burns** limited to an area no larger than 3 inches (7.6 centimeters) in diameter, take the following action:

1. Cool the burn. Hold the burned area under cool (not cold) running water for 10 or 15 minutes or until the pain subsides. If this is impractical, immerse the burn in cool water or cool it with cold compresses. Cooling the burn reduces swelling by conducting heat away from the skin. Don't put ice on the burn.
2. Cover the burn with a sterile gauze bandage. Don't use fluffy cotton, or other material that may get lint in the wound. Wrap the gauze loosely to avoid putting pressure on burned skin. Bandaging keeps air off the burn, reduces pain and protects blistered skin.
3. Take an over-the-counter pain reliever. These include aspirin, ibuprofen (Advil, Motrin, others), naproxen (Aleve) or acetaminophen (Tylenol, others). Use caution when giving aspirin to children or teenagers. Though aspirin is approved for use in children older than age 2, children and teenagers recovering from chickenpox or flu-like symptoms should never take aspirin. Talk to your doctor if you have concerns.

Minor burns usually heal without further treatment. They may heal with pigment changes, meaning the healed area may be a different color from the surrounding skin. Watch for signs of infection, such as increased pain, redness, fever, swelling or oozing. If infection develops, seek medical help. Avoid re-injuring or tanning if the burns are less than a year old — doing so may cause more extensive pigmentation changes. Use sunscreen on the area for at least a year.

Caution

•Don't use ice. Putting ice directly on a burn can cause a person's body to become too cold and cause further damage to the wound.

•Don't apply egg whites, butter or ointments to the burn. This could cause infection.

•Don't break blisters. Broken blisters are more vulnerable to infection.

- **For Major Burns:**

Call 6444. Until an emergency unit arrives, follow these steps:

1. Don't remove burned clothing. However, do make sure the victim is no longer in contact with smoldering materials or exposed to smoke or heat.
2. Don't immerse large severe burns in cold water. Doing so could cause a drop in body temperature (hypothermia) and deterioration of blood pressure and circulation (shock).
3. Check for signs of circulation (breathing, coughing or movement). If there is no breathing or other sign of circulation, begin CPR.
4. Elevate the burned body part or parts. Raise above heart level, when possible.
5. Cover the area of the burn. Use a cool, moist, sterile bandage; clean, moist cloth; or moist cloth towels.

Get a tetanus shot. Burns are susceptible to tetanus. Doctors recommend you get a tetanus shot every 10 years. If your last shot was more than five years ago, your doctor may recommend a tetanus shot booster.

4.3.3 FRACTURES:

A fracture is a broken bone. It requires medical attention. If the broken bone is the result of major trauma or injury, Call for emergency help if:

- The person is unresponsive, isn't breathing or isn't moving. Begin cardiopulmonary resuscitation (CPR) if there's no respiration or heartbeat.
- There is heavy bleeding.
- Even gentle pressure or movement causes pain.
- The limb or joint appears deformed.
- The bone has pierced the skin.
- The extremity of the injured arm or leg, such as a toe or finger, is numb or bluish at the tip.
- You suspect a bone is broken in the neck, head or back.
- You suspect a bone is broken in the hip, pelvis or upper leg (for example, the leg and foot turn outward abnormally).

Don't move the person except if necessary to avoid further injury. Take these actions immediately while waiting for medical help:

1. Stop any bleeding. Apply pressure to the wound with a sterile bandage, a clean cloth or a clean piece of clothing.
2. Immobilize the injured area. Don't try to realign the bone or push a bone that's sticking out back in. If you've been trained in how to splint and professional help isn't readily available, apply a splint to the area above and below the fracture sites. Padding the splints can help reduce discomfort.
3. Apply ice packs to limit swelling and help relieve pain until emergency personnel arrive. Don't apply ice directly to the skin — wrap the ice in a towel, piece of cloth or some other material.
4. Treat for shock. If the person feels faint or is breathing in short, rapid breaths, lay the person down with the head slightly lower than the trunk and, if possible, elevate the legs.

4.3.4 **BLEEDING**:

If possible, before you try to stop severe bleeding, wash your hands to avoid infection and put on gloves. If the wound is abdominal and organs have been displaced, don't try to push them back into place — cover the wound with a dressing.

For other cases of severe bleeding:

1. Have the injured person lie down and cover the person to prevent loss of body heat. If possible, position the person's head slightly lower than the trunk or elevate the legs and elevate the site of bleeding.
2. While wearing gloves, remove any obvious dirt or debris from the wound. Don't remove any large or more deeply embedded objects. Your principal concern is to stop the bleeding.

3. Apply pressure directly on the wound until the bleeding stops. Use a sterile bandage or clean cloth and hold continuous pressure for at least 20 minutes without looking to see if the bleeding has stopped. Maintain pressure by binding the wound tightly with a bandage or clean cloth and adhesive tape. Use your hands if nothing else is available. If possible, wear rubber or latex gloves or use a clean plastic bag for protection.
4. Don't remove the gauze or bandage. If the bleeding continues and seeps through the gauze or other material you are holding on the wound, don't remove it. Instead, add more absorbent material on top of it.
5. Squeeze a main artery if necessary. If the bleeding doesn't stop with direct pressure, apply pressure to the artery delivering blood to the area. Pressure points of the arm are on the inside of the arm just above the elbow and just below the armpit. Pressure points of the leg are just behind the knee and in the groin. Squeeze the main artery in these areas against the bone. Keep your fingers flat. With your other hand, continue to exert pressure on the wound itself.
6. Immobilize the injured body part once the bleeding has stopped. Leave the bandages in place and get the injured person to the emergency room as soon as possible.

If you suspect internal bleeding, call 6444 or your local emergency number. Signs of internal bleeding may include:

- Bleeding from body cavities
- Vomiting or coughing up blood
- Bruising on neck, chest, abdomen or side
- Wounds that have penetrated the skull, chest or abdomen
- Abdominal tenderness, possibly accompanied by rigidity or spasm of abdominal muscles
- Fractures
- Shock, indicated by weakness, anxiety, thirst or skin that's cool to the touch.

4.3.5 INTERRUPTED BREATHING:

Once breathing has stopped, a person can live only for a very few minutes. Interruption to breathing can be caused by smoke, gases, electric shock, drowning, poison and other causes. The rescue worker must be familiar with means of resuscitation to relieve the causality's suffering from lack of oxygen or any other respiratory difficulties.

Resuscitation with exhaled air (mouth to mouth) is the preferred technique because it can be applied promptly without special equipment special equipment and is feasible even in cause where victim cannot be moved. Proper elevation of the lower jaw to assure an uninterrupted airway is more important. This is best accomplished by lifting victim's lower jaw and clamping nostrils with thimbs.Rescuer breathes short. Smooth, even breaths to inflate victim's lungs 12 to 20 times a minute, allowing victim to exhale between breaths.

One must learn following alternate methods of manual resuscitation

- **HOLDER NEILSON'S METHOD**
- **SCHAFFER'S METHOD**
- **SYLVESTER'S METHOD**

i. Holder Neilson's Method

Referred to as a "back pressure arm lift," you should perform the Holger-Nielsen technique for someone on his or her stomach.

Before placing the victim on the stomach,

1. Check to make sure there is nothing blocking the airways of the nose and mouth.
2. Carefully place the victim face down, bending the elbows and placing the hands overlapping beneath the head.

3. Turn the victim's head to one side and place it on his or her hands. Try to extend the victim's head out as far as possible, with the chin jutting out.
4. Kneeling at the victim's head, place your hands in the middle of the back just below the imaginary line between the armpits.
5. Lean forward, placing your body weight onto the middle of the victim's back and then release. Immediately draw the victim's arms upward and toward you until you feel resistance.
6. Repeat this as many as 16 times.

ii. Schaffer's Method -

1. Lay the victim on his belly with one arm extended directly overhead and the other arm bent at elbow, with the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing,
2. Pull the tongue forward, but do not hold it. Kneel, straddling on the victim's thighs, with your hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and fingers in a natural position and the tips of the fingers just out of sight.
3. Keep your arms straight, lean forward slowly over the victim bringing the weight of your body gradually to bear on the victim for about 2–3 seconds,
4. Release the pressure slowly and return to the first position by sliding your palms sideways as shown in fig 1.2 Repeat this procedure about 12–15 times a minute. It will help victim to restore breathing gradually. A victim may require 1–3 hours to re-establish the natural breathing.
5. After the victim starts natural breathing, the artificial respiration should be stopped, keep a watch on the victim till he breaths naturally.

iii. Sylvester's Method -

1. Place the victim on his back.
2. First loosen his clothes around the chest and stomach.
3. Remove false teeth, if any and put a pillow under the shoulders, so that his chest will be rise up and head will titled backward.
4. The tongue should be drawn forward. Grasp the victim just below the elbows.
5. Draw his arm over his head until horizontal, retaining them for two seconds.
6. Next, bring the victim's arms down on each side of his chest and pressing inwards upon it.
7. Leaning upon his arm so as to compress his chest.
8. Remain in his position for two seconds and then again keep repeating the two motions at the same rate
9. If one more person is present, he should be asked to draw out victims tongue at each action of the victim's lungs inflating and deflating.
10. Be careful in this method to avoid any injury to internal organs resulting from excessive and sudden pressures.
11. Do not give any thing to drink to a victim until he is conscious.

CHAPTER 5

CONCLUSION

Construction is itself one of the most hazardous area in the field of safety. To add to it tunneling has increased the need of stringent safety measures for safe working. The main hazard that may cause a widespread damage can occur in tunnels. With the use of various types of sophisticated machinery, the risks of such a danger is increased. Fire is a natural phenomenon and is controlled by certain natural laws. Since fire cannot act contrary to these laws, an understanding of the natural laws that govern fire behavior is a major advantage. Fire loss prevention and control are fundamentally about developing systems and practices within a facility to increase the opportunities to avoid fires, limit the development and spread of fires, and allow for the rapid and effective control of fires. Deaths of and injuries to personnel are a portion of human loss from an uncontrolled fire. Human loss also concerns non-measurable items such as pain, suffering, and grief. The costs also include measurable items such as hospital expenses, disability compensation, and other benefits. There are engineering aspects included herein, but the goal is not to provide a detailed understanding of the site. Safety professionals especially fire men is found to have learned about the location of the various hazardous areas according to priority and also the location of the various firefighting equipments so that testing and maintenance can be made easier. They are also provided with knowledge on what extinguishing agent should be used for the different types of fire. It has provided a guideline to all safety workers to ensure their safety from the hazards that they deal with on a daily basis by giving a detailed. account on how to operate the various firefighting equipments and also the first aids that are to be carried out in case of an emergency. It also has proved to aid developing comparisons with the existing fire installments and the recommended installments. With India yet to have found the best safety measures for its work force, its time that attention is focused on to the area of safety in the construction field where workers when compared to other countries are less educated and have lesser stringent working measures. However, on a positive note there has been some advancements in the application of fire safety in the upcoming construction industries which is a good sign for the future and provides hope for better working conditions to the aspiring workers in the coming years.

5.1 TRAINING AND MOCK DRILLS

Training has a very vital role in fire Prevention and Protection. The celebrated fact prevails that any deadly conflagration starts with a very small spark/fire.If it is controlled /extinguished in its incipient stage break out of a big fire can be averted. It is therefore tried that action for containment, control or extinguishment of a fire must start immediately after its detection.This is possible, only when person who detects it, starts action immediately by virtue of his/her training and confidence.The topics that a worker is trained for before he starts to work are as follows:

1. **Hazard identification procedure**

   Hazards on site:

- Falls
- Earthing works
- Electricity
- Machinery
- Handling materials
- Transport
- Site Housekeeping
- Fire

2. **Personal Protective Equipments**

- What is available?
- How to obtain it?
- Correct use and care

3. **Health**

- Site Welfare facilities
- Potential health hazards
- First Aid/CPR

4. Duties of the Contractor

- Brief outline of the responsibilities of the contractor by law
- Details of Contractor's accident prevention policy
- DMRC's SHE manual
- Building and other Construction Welfare Law

5. Employee's Duties

- Brief outline of responsibilities of employee under law
- Explanation of how new employees fit into the contractor's plan prevention (induction and orientation)

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