SAFETY MANUAL

FOR CONSTRUCTION WORKERS

LABOUR DEPARTMENT

DIRECTORATE OF INDUSTRIAL SAFETY AND HEALTH

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Chapter 1

INTRODUCTION

The most valuable asset in any organization or construction field is their employees. By improving safety and preventing accidents, the work force can be protected as well as the workers' compensation costs can be reduced.

Safety is more than just compliance with BOCW Acts, Regulations and other Government Rules. It's a state of mind that must permeate the entire company, including office and field personnel, management and hourly employees.

No construction can expect to have good safety performance unless the management ensures through personal conduct and concrete actions that safety is expected and required of all employees. That's why the management must establish and enforce safety rules to communicate its commitment to safety, and ultimately, to prevent incidents and injuries.

Construction work involves a series of occupational risks, such as work at heights, excavation work, marine work, manual & mechanical handling of work, ground improvement work by stone column methodology, lifting of materials by means of cranes and so on, which are specific to the sector. A specific approach to the occupational safety and health in the construction industry is also required as a result of the temporary character of its work place. Continuous changes of work force also call for a specific approach to occupational safety and health management at the construction site, where planning coordinating and budgeting becomes extremely important.

The risks, construction workers face largely the result of the poor planning and lack of supervision. Each of the construction work, each operation should be planned ahead of time. In addition, the workers safety and productivity and the quality of the work can only be guaranteed if there are sufficient skilled workers, appropriate tools and equipment at a given time. One of the best ways to approach planning for construction safety is to write down the measures for hazard prevention (control measures) applicable to the particular project site. As experienced in a construction site, sub-contracting of a job reaches to several levels. This ensures that good planning can eliminate the causes of many potential accidents at project site.

The specific hazards in relevant to the construction industry includes:

- Demolition Work
- Excavation Work
- Managing the Risk of Falls at Workplaces
- Managing Noise and Preventing Hearing Loss at Work
- Preventing Falls from height work
- Confined Spaces
- Hazardous Manual Tasks

All the Workplace injuries are preventable. An Occupational Safety Health Management System is the best defense against workplace injuries. This has five primary elements:

- Management Commitment and Planning,
- Employee Involvement,
- Worksite Analysis,
- Hazard Prevention and Control,
- Safety and Health Training.

This systematic approach integrates occupational safety and health objectives into the company's organizational structure. The results of a system approach include:

- An effective system supports the organization's philosophy.
- Safety and health policies and goals are clearly communicated.
- Accountability for implementing the system is understood and accepted.
- Long-term solutions are implemented rather than one-time fixes.
- Evaluation of results over time promotes continual improvement.
- An effective system positively impacts the company's bottom line.

Due to the wide scope and definition of construction work, every construction activity and site will be different, and circumstances and conditions may change even on a daily basis. Therefore, due caution is to be taken by the employer to protect the workers working in the site. Prior to preparing the Health and Safety Plan, and in consideration of the information contained here-in, the employer shall set up a Risk Assessment Program to identify and determine the scope and details of any risk associated with any hazard at the construction site, in order to identify the steps needed to be taken to remove, reduce or control such hazard. This Risk Assessment and the steps identified will be the basis or point of departure for the Health and Safety Plan. The Health and Safety Plan shall include documented 'Methods of Statement' as per definitions under Construction Regulations detailing the key activities to be performed in order to reduce as far as practicable, the hazards identified in the Risk Assessment.

No job or no task is more important than worker health and safety. If a job represents a potential safety or health threat, every effort need to be made to plan a safe way to do the task. Every procedure must be a safe procedure. Shortcuts in safe procedures by either foremen or workers need not to be tolerated. If a worker observes any unsafe condition, which may cause a potential threat to their health or safety, the employees immediately need to correct the situation when feasible or need to be informed with management. Management has the responsibility to take adequate precautions, comply with standards, and assure the safety and health of employees. If a job cannot be done safely it should not be done. Management need to provide visible ongoing commitment, resources, and leadership to assure the implementation of the Occupational Safety Health Management System. All employees need to be provided equally high quality safety and health protection. It's very essential to create a positive safety culture through employee involvement and effective policies and procedures.

This construction safety manual explains successful accident-prevention principles and techniques at various construction activities. These techniques may vary according to the size and nature of construction activities. However, the basic principles remain the same.

In detail, the following chapters are discussed with respect to various safety measures required for ensuring safety, health at construction workplace;

- Importance of Construction Site Safety Management to ensure safety in construction activities to preserve living and non-living elements of the ecological, environmental, aesthetic, and social landscape.
- Hazards and risks involved in manual and mechanical material handling and the safe practices to educate workers to prevent the injury and property damage such as periodical inspection, maintenance, Do's and Don'ts.
- Identification of confined space, dangers involved in confined space, basic principles of safety precautions for confined space work, emergency plan and the practical guidance on safe work in confined spaces.
- Handling of the electrical equipment safely, the role visual inspection before use, hazards involved in high voltages, overhead power lines, use of residual current devices, isolation devices and the importance of electrical safety signs.
- Hazards in excavation trenching tunnelling and shoring works and the safety precautions in handling of explosives and obnoxious gases.
- Requirement of familiarity with the diving equipment, safety training, all occupation-specific training and applicable safety regulations at under and above water construction. Mainly, the necessity of rescue plan in underwater and above water construction.
- Assessment of risks involved in high-rise construction, safety strategies, the role of supervision for maintaining the safety, steps to control the fall and safe way of handling the goods in high rise construction.
- The safety precautions required while working at height, scaffolding and the necessity of fall protection. As well as, the importance of PPE's and the Do's and Don'ts at working at height and scaffolding.
- While executing the demolition of any construction, the issues such as falls from height, Injury from falling materials, uncontrolled collapse, hazardous materials, noise and vibration and fire are detailed in this manual as well as the safe way of engaging the worker in this demolition activity.
- The safe method of using the explosives in construction, demolition and the related fire hazards involved in the explosives are discussed in this manual. And the shot firing rules, charging the shot, danger zone and misfires in respect of use of explosives are also explained.
- In respect to hand and portable power tools, hand operated tools often pose risk of lacerations, contusions, and muscle strain. Obviously, power tools pose higher risk of severe injury because points of contact can transfer a large amount of mechanical energy from the tool to small areas on the body. In addition, users of hand and power tools may also be exposed to hazardous airborne contaminants,

flying debris, and electrocution, among others risks. So the matter related to these hazardous is explained.

- General safety precautions involved in working with compressed gases including compressed air and the Hazards of gas cylinders, risk associated with gas cylinders and special precautions against accidents has been detailed.
- In respect of construction machinery and equipment, major hazards such as electrical hazards, amputation & caught-in hazards, chemical hazards, sharp edges, and eye hazards are discussed in detail.
- Work Permit System
- Standard Operating Procedures
- Accident Reporting and Investigation
- Personal Protective Equipment
- Occupational Health, First Aid and occupational Diseases
- Fire Prevention and Control
- Chemical Safety and Emergency Preparedness
- Training of Workers

Chapter 2

SAFETY AND HEALTH POLICY

2.1. Introduction

Safety and Health Policy, is a written document or statement, prepared by every occupier with respect to the procedures and precautions to be maintained for the health and safety of the workers at work and the organization and arrangements for the time being in force for carrying out the same.

The policy document is a must for all the construction workplace. *"the safety policy, that is to say, a policy relating to steps to be taken to ensure the safety and health of the building workers, the administrative arrangements therefore and the matters"*

Health and safety policy:

As per the statutes, the preparation of Health and Safety policy will consist of following provisions.

(1) (a) Every establishment employing fifty or more building workers shall prepare a written statement of policy in respect of safety and health of building workers and submit the same for the approval of the DISH.

(b) The policy referred to in clause (a) shall contain the following namely:

i. The intentions and commitments of the establishment regarding health, safety and environmental protection of building workers;
ii. Organisational arrangements made to carry out the policy referred to in clause (a) specifying the responsibility at different levels of hierarchy;
iii. Responsibilities of the principal employer, contractor, sub-contractor, transporter or other agencies involved in the building or other construction work;
iv. Techniques and methods for assessment of risk to safety, health and environmental and remedial measures therefore;
v. Arrangements for training of building workers, trainers, supervisors or other persons engaged in the construction work;
vi. Other arrangements for making the policy effective;

(c) The intention and commitment shall be taken into account in making decisions relating to plant, machinery, equipment, materials and placement of building workers.

(2) A copy of the policy referred above, signed by an authorised signatory, shall be sent to the DISH.

(3) The establishment shall revise the policy as often as necessary under the following circumstances, namely:

(i) Whenever any expansion or modification having implication on safety and health of the building workers is made in such building or other construction work; or

(ii) Whenever any new building or other construction work, substances, articles or techniques are introduced having implication on health and safety of building workers.

(4) A copy of the policy shall be displayed at all the conspicuous places in Hindi and a local language understood by the majority of building workers at a construction site.

2.2 Objectives

The major objectives are,

- Identify the roles and responsibilities of managers, specialist health and safety personnel and other employees
- Co-ordinate activities to identify, analyze and implement solutions to potential safety problems
- Define arrangements for promoting, planning and controlling all aspects of health and safety in the workplace

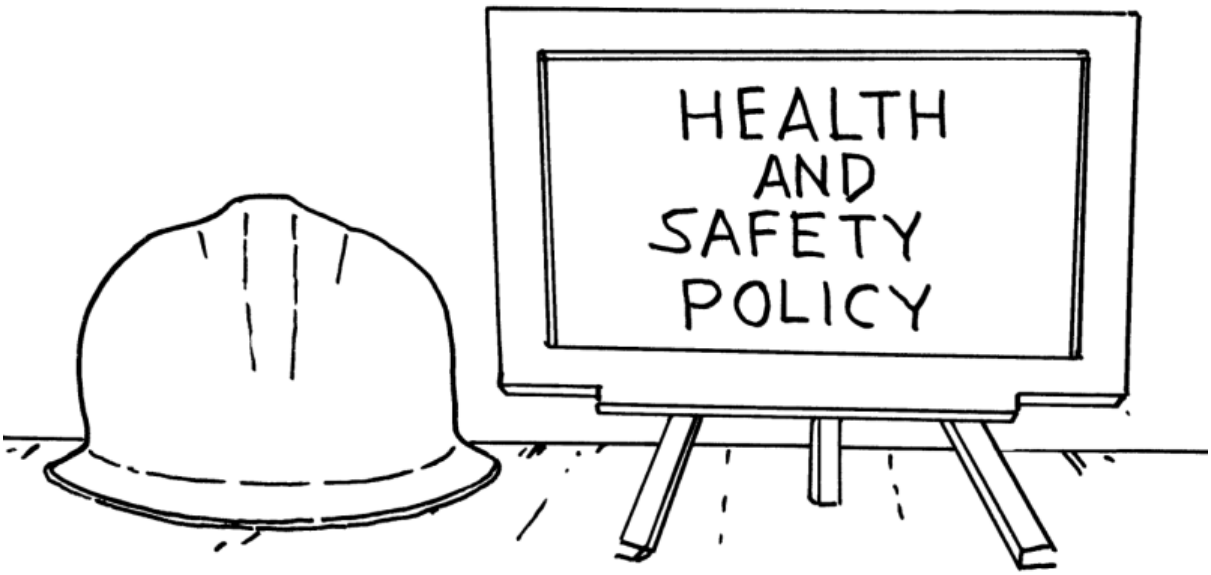


Fig. 2.1. Health and Safety Policy

2.3 Key Elements

Essentially, the policy to achieve this will consist of three Elements:

1. **General statement of intent** - Will set targets, will outline in broad terms the overall health and safety culture of the organisation and will re-state legislation principles in respect of that organisations undertaking.
2. **Organisation** - Roles and responsibilities of individuals - deals with people and their operational duties in respect of health and safety. Outline the chain of

command for health and safety management and will identify individual roles and responsibilities and the scheme of delegation

3. **Arrangements, systems and procedures** - This deals with the practical arrangements - for example: safety training, safe systems of work, environmental control, guarding, housekeeping, safe plant and equipment, noise and dust control, fire safety, maintenance or records, emergency procedures, etc.

The Safety and Health Policy should contain or deal with –

Declared intention and commitment of the top management for health, safety and environment and compliance, with all the relevant statutory requirements- This should outline in broad terms the organizations overall philosophy in relation to the management of safety and health. It should also include reference to the broad responsibilities of both management and workforce.

Organizational setup, available to implement the declared Policy clearly assigning the responsibility at different levels- This part outlines the chain of command in terms of health and safety management. Who is responsible to whom and for what? How is the accountability fixed so as to ensure that delegated responsibilities are undertaken? How is the policy implementation monitored? Other organizational features should include: individual job descriptions having a safety content; details of specific safety responsibilities; the role and function of safety committee(s); the role and function of safety representatives; and a management chart clearly showing the lines of responsibility and accountability in terms of health and safety management. The competent person(s) who is to assist with compliance with the health and safety requirements should also be included.

Arrangements for making the Policy effective- This part of the policy deals with the practical arrangements by which the policy will be effectively implemented. These include; safety training; safe systems of work; environmental control; safe place of work; machine/area guarding; housekeeping; safe plant and equipment; noise control; radiation safety; dust control; use of toxic materials; internal communication/participation; utilisation of safety committee(s) and safety representatives; fire safety and prevention; medical facilities and welfare; maintenance of records; accident reporting and investigation; emergency procedures; and workplace monitoring. Records of the formal arrangements are also required to be kept.

In particular, the Policy should specify the following –

1. Arrangements for involving the workers.
2. Intention for taking into account the health and safety performance of individuals at different levels while considering their career advancement.
3. Fixing the responsibility of the contractor, sub-contractors, transporters and other agencies entering the premises.
4. Providing a resume of health and safety performance of the factory in its Annual Report.

5. Relevant techniques and methods, such as Safety Audits and risk assessment for periodical assessment of the status on health, safety and environment and taking all the remedial measures.
6. Stating its intention to integrate health and safety in all decisions including those dealing with purchase of plant, equipment, machinery and material as well as selection and placement of personnel.
7. Arrangements for informing, educating and training and retraining its own employees at different levels and the public, wherever required.

2.4 Signing of Safety and Health Policy

The safety and health policy must be signed by top authority of the organization. A copy of the Safety and Health Policy signed by the Top authority/occupier is to be made available to the authorities.

The Policy is also to be made widely known by –

1. Making copies available to all workers including contract workers, apprentices, transport workers, suppliers, etc.
2. Displaying copies of the policy at conspicuous places.
3. Any other means of communication in a language understood by the majority of the workers.

2.5 Revision of Safety and Health Policy

The policy is required to be revised as often as may be required and the statement and any revision thereof is to be brought to the notice of all the workers in a manner most appropriate. The Safety and Health Policy is not a document that is to be written once and then forgotten. It is required to be reviewed and revised as often as may be required.
Under certain circumstances, as given below, it shall be necessarily revised –

1. Whenever any expansion or modification having implication on safety and health of persons at work is made.
2. Whenever new substances or articles are introduced in the manufacturing process having implications on health and safety of persons exposed to such substances.

In a word, the Safety and Health Policy may be described as the Constitution of the factory so far as the safety and health of the workers in it are concerned. It is a very important document, that is to be reviewed, understood, followed and be committed to, by everyone in the organization. It is to be given due respect both by employer and employee to maintain a safe and healthy environment within and in the immediate vicinity of the factory.

2.6 Checklist for Statements of Health and Safety Policy

The following questions that need to be asked about the policy document

1. Does the statement express a commitment to health and safety and are the organizations obligations towards its employees made clear?

2. Does it say which senior officer is responsible for seeing that it is implemented and for keeping it under review, and how this will be done?
3. Is it signed and dated by a partner or senior director?
4. Have the views of managers and supervisors, the competent person, safety representatives and the safety committee been taken into account?
5. Were the duties set out in the statement discussed with the people concerned in advance, and accepted by them, and do they understand how their performance is to be assessed and what resources they have at their disposal?
6. Does the statement make clear that co-operation on the part of all employees is vital to the success of the health and safety policy?
7. Does it say how employees are to be involved in health and safety matters, for example by being consulted, by taking part in inspections and by sitting on a safety council or committee?
8. Does it show clearly how the duties for health and safety are allocated and are the responsibilities at different levels described?
9. Does it state who is responsible for the following matters (including deputies where appropriate)?

Chapter 3

CONSTRUCTION SITE SAFETY MANAGEMENT

Introduction

The construction industry is one of the most hazardous industries and one of the unique features is its fragmentation. Unlike manufacturing, construction tasks are not repeatable. Each work site has its own characteristics which make construction work dynamic. Construction workers do varies types of tasks and their next job could be a completely different construction project. When compared manufacturing and construction industries in terms of work condition, and findings show that repetition, task predictability, and task standardization are high in manufacturing and very low in construction industries, which could be a reason for high accident rates in construction sites. The main objective of developing and implementing safety management is to improve safety performance which gives safe work place for people working in construction industries.

3.1 Construction Safety Management:

Management is defined as conducting or supervising of something especially the executive functions of planning, organizing, coordinating, directing, controlling and supervising any industrial or business project or activity with responsibility for others.

Construction Safety Management is a structured management approach to managing safety, taking into account the organisation's specific structures and processes related to safety of operations, including accountabilities, policies and procedures. This begins with setting the organisational safety policy. Based on the management's safety policy and strategy, the safety organisation proceeds with planning, organising, staffing, co-coordinating, communicating, budgeting for safety.

Fig. 3.1. Construction Safety Management Cycle

Planning for Safety

- Planning is the most fundamental and the first function of management process and other functions rest on it.
- Need for planning is increasing because of changes in technology, materials, methods, processes, demands, law, government policy, procedure and competition.
- It includes setting safety objectives, formulating safety policy, safety programming, budgeting and determining safe or standard procedures.
- Good planning at the design stage always helps.

3.2 Purpose /Areas of Safety Planning

- To draft health and safety policy and environmental policy for the management.
- To decide safety committee, its objectives and effective functioning.
- To decide safety targets like zero/minimum accidents, maximum working hours without accident, safety education, training and awareness programmes for the workers and the public.
- Areas of hazards and their detection, inspection, audit, risk assessment and measures for their removal or minimization.
- Accidents investigation, analysis, costs calculation and introducing safety measures to prevent their recurrence.
- Organization structure, staff, key persons and their roles for safety.
- Standards for safety equipment, tools, permissible exposures etc.
- Preparation, rehearsal and updating of on-site emergency plans.

i) **OSH objectives**

Consistent with the OSH policy, measurable OSH objectives should be established, which are:

- Specific to the *organization, and appropriate to and according to its size and* nature of activity;
- Consistent with the relevant and applicable national laws and regulations, and the technical and business obligations of the organization with regard to OSH*;*
- Focused towards continually improving workers' OSH protection to achieve the best OSH performance;
- Realistic and achievable;
- documented, and communicated to all relevant functions and levels of the Organisation*;* and periodically evaluated and if necessary updated.

ii) Hazard Prevention and control measures

Hazards and risks to workers' safety and health should be identified and assessed on an ongoing basis. Preventive and protective measures should be implemented in the following order of priority:

- Eliminate the hazard/risk;
- Control the hazard/risk at source, through the use of engineering controls or organizational measures;

- Minimize the hazard/risk by the design of safe work systems, which include administrative control measures; and
- Where residual hazards/risks cannot be controlled by collective measures, the employer should provide for appropriate personal protective equipment, including clothing, at no cost, and should implement measures to ensure its use and maintenance.

iii) Controlling Risk

Risk control is the process of continually assessing the condition of the project and developing options to permit alternative solutions. Project managers should take care to identify consequences that are likely to occur and any indicators of the start of the problem.

The following are some suggestions for risk control:

- Continually update the risk management plan.
- Implement risk avoidance actions.
- Implement risk contingency actions.
- Report on each risk issue.

3.3 Organizing for Safety

The term 'organization' is used in management in different ways

- It refers an activity, process or function of management i.e. organizing.
- It is used in a dynamic way referring to a process by which the structure is created, maintained and used.
- It is used in a static way referring a static structure (skeleton) of responsibilities and authorities i.e. relationships among individuals and positions in an organization.

i) Safety Organization

Safety organization can be defined as the structure and process by which groups of people are divided into sections or departments, each section or department is assigned specific safety function or duty.

- Authority and responsibility of everybody is clearly defined and interrelationship between them is specified for the accomplishment of organizational safely goals.
- A large unit may have safely department which may have groups of people for division of such safety function and responsibilities.
- But in a small unit (majority) if such division is not possible and only a few persons are available for safety work, they will be assigned specific duty and other departmental heads (production, purchase, personnel etc.) will be explained their role and responsibility towards safety goals.
- All supervisors shall be integrated with safety as part of their duty.

A) Directing for Safety

- It is a part of the management process which guides, inspires, instructs and harnesses people to work effectively and efficiently to achieve the goals.
- Once the objectives are decided and planning is made how to achieve them, organization structure is designed by staff, appointing qualified and experienced

persons and the organization can be said ready for action. But this action cannot begin until orders and instructions are issued i.e. the employees are 'directed' to carry the orders. This process of inspiring and guiding people what to do and how to do the best of their ability is known as 'directing'.

B) Controlling for Safety

To complete the management cycle it is important to know about the function of controlling after knowing about planning, organizing, staffing and directing.

Thus controlling is aimed at

- Monitoring the outcome of activities
- Reviewing feedback about this outcome and
- If necessary, take corrective action to achieve the outcome according to the plan.

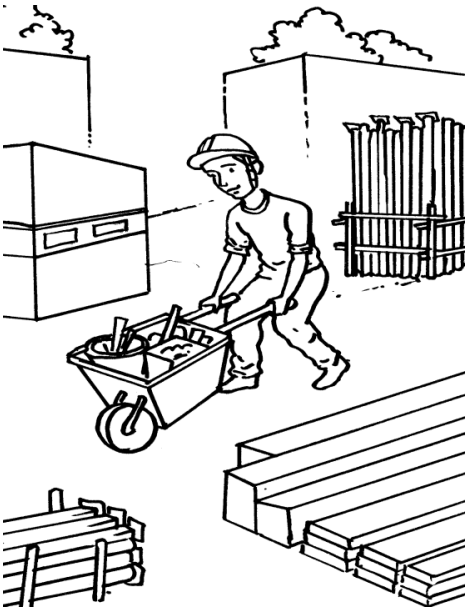


Fig.3.2. Good housekeeping practice

Control function is closely connected to planning. It can be said an effective counterpart to planning. Using these definitions, controlling for safety can be defined as "a process that verifies and guides activities towards predetermined (planned) safety goals and takes necessary action, if required, to achieve the goals.

i) Its main purpose is
    - To measure progress
    - To uncover deviations or change, delegation, mistakes, complexity etc., and
    - To indicate corrective action.

ii) Benefits : It offers
    - Guide to operations
    - Policy verification
    - Managerial accountability
    - Employee morale
    - Psychological pressure and
    - Co-ordination in action.

3.4 Job site Safety

Various measures are available to improve jobsite safety in construction industries. Several of such measures suppose to occur before construction is undertaken.

These include

- Design,
- Choice of technology and
- Education.

By altering designs, particular structures can be made safer or more hazardous to construct. For example, parapets can be designed to appropriate heights for construction worker safety, rather than the minimum height required by building codes.

Choice of technology can also be critical in determining the safety of a jobsite. Safeguards built into machinery can notify operators of problems or prevent injuries. For example, simple switches can prevent equipment from being operating when protective shields are not in place i.e. when machine guards are removed, immediately machine stops working.

Educating and training to the workers in proper procedures and hazards can have a direct impact on jobsite safety. By providing safety training

- You can avoid the workplace accidents and health issues.
- You can understand the financial costs of accidents in the workplace involved in construction injuries
- You will avoid damaged products, loss in site and injured staff.

Regular safety inspections and safety meetings have become standard practices on most job sites. Pre-qualification of contractors and sub-contractors with regard to safety is another important opportunity for safety improvement. If contractors are only invited to bid if they have an acceptable record of safety, then adequate safety on the part of contractors is ensured.

During the construction process itself, the most important safety related measures are to insure vigilance and cooperation on the part of managers, inspectors and workers. Vigilance involves considering the risks of different working practices. In also involves maintaining temporary physical safeguards such as barricades, braces, guy lines, railings, toe boards and the like.

Improving worksite safety is very important in construction sites due to the following reasons

- Job site is continually changing as construction progresses.
- Workers do not have fixed worksites and must move around a structure under construction.
- The worker's familiarity in site is less compared to manufacturing site the employer-employee relationship are less settled compared to manufacturing site as the tenure of a worker on a site is short .

Chapter 4

ACCIDENT REPORTING AND INVESTIGATION

4.1 ACCIDENT REPORTING

Accidents in construction has always been a matter of concern for the not only the Government but also for the employer and contractors, as construction sector workforce are migrating & casual in nature, mostly not on pay-role. This is because, a major constraint of variation in the manpower requirement on daily basis it is not feasible for the employer/contractor to employ permanent workers. Also, another constraint with the employer/contractor is that at various stages of construction the activities varies and so do the set of skill required in workers, resulting in requirement of different group of workers at different stages and this variation is significant & rapid. And also, construction sector is mostly project based sector, wherein not only new infrastructure development but also maintenance is now a day outsourced on requirement basis. Finally, the workers when are not getting permanent/regular employment migrates from one employer/ location/ construction site to other and are also not solely dependent on construction work employment. All the above factors contributes to construction sector being broadly unorganized.

Being an unorganized sector accident reporting and investigation is crucial and critical in construction industry due to following major reasons, but not restricted to:

1. Most of the construction activities are not notified and establishments are not registered
2. Details of construction workers are not maintained appropriately by the employer
3. Track of witness is difficult because of migrating workforce
4. Lack of adequate training and awareness on OSH in every level
5. It is extremely difficult for the monitoring authority to keep a close eye on each and every construction site.

Reporting of the accident can be broadly classified under following two categories:

1. Statutory Reporting – Statutory reporting of the accident in construction is governed by the Building and other Construction Workers' (Regulation of Employment and Conditions of Service) Act, 1996 & the Delhi Building and other Construction Workers' (Regulation of Employment and Conditions of Service) Rules, 2002 and The Occupational Safety, Health and Working Conditions Code, 2020.
   Following are required to be reported to the concerned authorities
   a. Accident
   b. Dangerous occurrences
   c. Occupational diseases
   d. Poisoning

Accidents in the statutes refer to those incidents that result to fatality, disability or absence from duty for more than 48 hours.

Based on the respective law applicable any incident if occurs are to be reported to following as per the relevant statutory provisions to the respective authorities:

i. Inspector
ii. Chief Inspector
iii. District Magistrate
iv. Local Police Station
v. Relatives of victim(s)

Reporting of accident – The Employer is required to send a notice of any accident in the prescribed format within the stipulated time to the concerned authorities under the Delhi Building and Other Construction Workers (RE & CS) Rules, 2002.

4.2 ACCIDENT INVESTIGATION

Investigation is the scientific and academic analysis of the facts that occurred during an accident with a purpose is to find

- Root cause of an incident
- Corrective measures to avoid recurrence

To identify root causes of an incident it is required to understand following terms in line with the view of an investigator:

1. Hazard as defined is ‘anything that has the potential to injure or harm’. Based on the effect hazards can be classified in two types:
    a. Hazards to Safety - Cause an immediate injury/harm.
    b. Hazards to Health - Cause harm by exposure over time mostly health effect.

Based on where the potential of the hazard lies and can be initiated from, hazards can be groups in following three groups:

a. Physical Object Hazard – If potential is in the object itself when touched or inhaled can result in harmful effect. For example, sharp edge object, hot surface, reactive chemical, toxic gases, moving heavy object, exposed charged electric connection, tripping object in walkway, etc.
b. Hazardous Work Type – Where work itself is hazardous in nature like confined space working, working at height, underwater working, midstream working, working in extreme weather conditions, etc. For example, hazards in welding operation on a structure carried out in a normal condition (i.e. in an open area on a ground with no moisture on the ground) will vary significantly to the same welding operation if carried out at a height with scaffold or in confined space or in the same location just after a heavy rain. Such type of work requires permits, specific qualification of workers and relevant additional safety measures.
c. Unsafe Acts – If action of an individual (i.e. either worker working in a job or someone in the vicinity/allied job) has a potential to lead to harmful effect, root cause will not be the object with which or the conditions in which the accident happened, but the wrong action i.e. unsafe act will be the root cause. For example, over speeding of vehicle, use of wrong tools, bypassing limit switched, un-insulated electric connection, un-ergonomic work posture, etc. To address this legislative &/or company norms are defined, breach of which attracts penalties.

2. Mechanism of Injury– It is the method in which an injury/loss occurs i.e. sequence in an event from very first step of initiation of potential of hazard, right through its propagation and transmission, to its end result of injury/loss. Every hazard may lead to one or more injury. Following elements cover the ways an injury/loss can occur.
    a. Slips/trips
    b. Struck against/by
    c. Contact with/by
    d. Caught in/on/by/between
    e. Exposure to
    f. Fall to same/lower level

3. Incident – An incident is an unplanned, undesired event that adversely affects completion of a task. The affects can be an injury, property damage, health problem, interruption of process, system/machine breakdown, etc. Incident is a universal set of all events that can lead to a loss or injury including the indicators

to such events i.e. near miss. Every incident is required to be investigated including near miss to ensure any untoward events should not reoccur because of same cause(s). There are basically three categories in which causes of incidents can be categorised into, they are:

a. Unsafe Act
b. Unsafe Condition
c. Failure of system, equipment or machinery

Details of terminologies discussed above will aid in finding the root cause of the incident under investigation and also to determine the corrective actions to address the issues for good. Investigation is a method to identify facts and figures of the incident so that following can be revealed:

1. What happened?
2. How it happened?
3. How it would have been avoided?

The Delhi Building and Other Construction Workers '(Regulation of Employment and Conditions of Service) Rules, 2002 provides for the 'Procedure for enquiry into causes of accident or dangerous occurrence', which is to be carried out by the concern responsible under the law for certain cases. However, as every incident has to be investigated, methodology in revealing the above details is a five step activity. Following are the 05 steps to be followed in the investigation:

1. Analyse the injury

As soon as the report of the incident is received by the concern responsible for investigation, the victim(s) should be immediately visited and the injuries should be analysed for its type and severity. Type of injury indicated the type of hazard along with severity of injury indicates the potential of the hazard. Following can be revealed during this step:

a. Whether the injury is restricted to single victim or extends to multiple individual;
b. Whether it is due to exposure to hazardous substance;
c. Whether it was due to sharp edged object or impact of an object;
d. How deep is the injury;
e. Whether it is external injury or internal; etc.

2. Interview victim and witnesses

Victim(s) and witnesses should be interviewed at the earliest possible so that investigation is benefited from the freshness of the memory which will ensure maximum and accurate inputs. As far as possible those interviewed should not be provided with opportunity to discuss the matter too much with others or their view may get influenced by opinion of others in the matter and they may get confused about their own observations.

The interview should reveal the facts about what, how, when, where and why it happened. In order to get clear picture of the event at the end of this step, the investigator should be in a position to answers following questions:

a. What was victim(s) doing at the time?
b. Whether he was supposed to do that job?
c. Whether SOP for the job is available?
d. Whether SOPs were followed?
e. Whether proper instructions were given?

f. Whether appropriate tools and equipments used?
g. Whether job was effectively supervised?
h. Where did the incident happen?
i. What were the steps involved?
j. What was the condition around at the time?
k. What where witnesses doing at the time?
l. Who identified the incident first?
m. What was the response?
n. How it could have been avoided?

These are not the questions for those interviewed, but detailed answers to the questions should be available with investigators by the end of interview. The questions of interview will vary from incident to incident and person to person. The sequence and set of questions will depend upon the response of the person interviewed.

Generally, it is human tendency to avoid trouble and it is preconceived notion that becoming potential witness by talking and revealing much will put me to the trouble. This does not only restricted to the witnesses but in some cases victim(s) also have the same state of mind. Therefore, investigator has to first gain the trust of the victim(s) and witnesses before proceeding to the interviews.

3. Analyse the scene

The scene should be analysed to gather information about

a. The conditions of infrastructure, material, machine, equipments, tools and workplace environment
b. Resemblance to the statement of victim(s) & witnesses
c. Source of initiation of event
d. What safety preventive measures was present
e. Where & why safety preventive measures failed

This step provides for the evidence to the event. The evidence can be a detail or physical object. Details can be in form of data, status or condition. The same should be kept in record as document or photograph for further review. The details provided during interview should be cross verified during this step. The details in interview will also support in a way as to where to look for the evidence.

4. Determine the cause(s)

There are various ways to determine the causes of the incident, some of the methods used are:

a. Root cause analysis
b. Why-Why analysis
c. Fault tree analysis
d. Failure Mode Effective analysis
e. Fish-bone diagram

Most common among them is root cause analysis. All the information gathered using previous steps are to be used for determining the cause of the incident. The purpose should be to identify the source of the event.

There can be more than one cause and most possibly causes contributing during the intermediate steps of the event can also come into existence which should also be considered equally.

5. **Identify corrective actions**

   Once cause(s) to the incident has been determined the corrective actions to avoid reoccurrence of any further incident due to the same cause(s) should be identified. There can be two types of corrective actions that can be taken:

   a. Temporary/Immediate
   b. Permanent/Long term

   A temporary corrective action are meant for instant control but is not the true solution of the issue, however imminent danger can be addressed for the time being till permanent solution is not implemented. For permanent corrective action the matter should be deliberately discussed and effective solution to the issue should be identified and put in to implementation.

A follow-up of the matter is a critical element in investigation. Follow-up should include the following:

a. From victim about the condition, recovery and assistance
b. For implementation of corrective actions both immediate and permanent

Finally, the all details of investigation should be documented and records of the same should be kept for legal compliances and future review. The records should include

1. Investigation Report
2. Statement of victim and witnesses
3. Evidences collected at the scene
4. Statutory formats
5. Segregated records

Chapter 5

HAZARD IDENTIFICATION AND RISK ASSESSMENT

5.1 INTRODUCTION

At construction sites, there are many such operations which are hazardous in nature and can cause injury or death or illness to the workers. These can take place by electrical shock, fall from height, injuries from tools, equipment, machines or materials. There may be chance of hit by movement of construction vehicles, injuries from material handling operations (manual or mechanical), illness due to hazardous substance like dust, chemicals etc. Even a sharp edge of a tool, a nail protruding from a piece of wooden plank also can cause serious injury.

The process of hazards and risk analysis is to identify and analyze the hazards, the event sequences leading to hazards and the risk associated with hazardous events. Techniques ranging from the simple qualitative methods to the advanced quantitative methods are used to identify and analyze the hazards.

A Hazard Identification and Risk Assessment (HIRA) works as an essential program for emergency managers in preparing its plan and to assess the risks of various hazards. In overall, it is a systematic work assessment tool that can be used to assess the risks of various hazards.

5.2 HAZARD & RISK AT CONSTRUCTION SITES

Hazard & Risk are the basic elemental part of any job activities. Similarly, construction site involves several on-site activities starting from site preparation to various activities at site. It is the responsibility for each individual to look for the associated hazards and develop the control measures.

5.2.1 SITE PREPARATIONS:

Preparation of a site is an important aspect of construction. It should be an effort to prepare a good site layout by making easy access and easy movement of vehicles within the site.

Site Layout: A poorly managed construction site can lead to many accidents, which may arise from:

(i) Fall of tools or materials,
(ii) Collision between the equipment or workers,
(iii) Use of wrong tools, materials or equipment.

To avoid the above causes of accidents, a well-planned layout of the site is a must. While preparing the site layout, it also must be considered that overcrowding the site is avoided. Enough space shall also be planned for the movement of men, material and construction equipment within the site.

Movement of construction Vehicles

It is a common sight on the construction site that many vehicles (transport trucks, cranes, forklifts, etc.) carrying construction materials move in haphazard manner, which results in number of injuries, accidents and mishaps. Construction sites often operates muddy and

uneven ground, where driver visibility might be poor. People walking on the site are injured or killed while moving or reversing the vehicles. Occasionally, there are the instances when many workers, particularly drivers and operators are killed by overturning of vehicles.

Therefore, maximum attention shall be given on the movement of vehicles at construction sites.

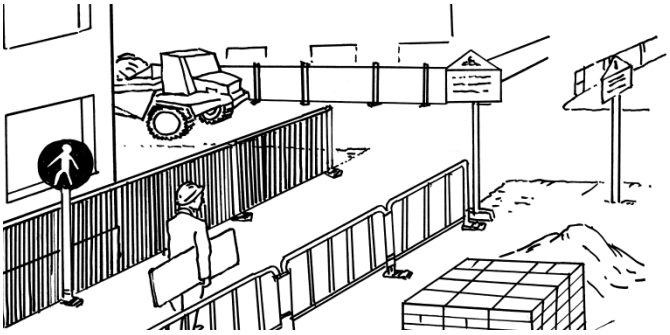


Fig. 5.1 Movement of vehicles at construction sites

A standard practice should be developed, while moving the vehicles on the construction site like:

i. There shall be separate vehicles and pedestrians' walkways and kept apart. If possible, separate them by barricading or using barriers.
ii. Adequate clearance should be provided around vehicles.
iii. As far as possible, avoid reversing the vehicles. It is better to use one-way system.
iv. A signaller shall be posted while moving or reversing the vehicle.
v. Vehicles used on the sites shall have reversing sirens.
vi. The vehicles shall be driven by an experienced and licensed driver.

5.2.2 ACTIVITIES AT SITE

The activities and type of operations carried out in a construction site are many and they vary in nature. However, all the activities should be carried out with due regard to safety. Among the various activities at site, the routine activities at construction sites pertain to:

I. Excavation activities,
II. Scaffolding work,
III. Crane Operations,
IV. Hoisting Operations,
V. Forklift Operations,
VI. Ladder Safety,
VII. Electrical Safety

5.2.3 MISCELLANEOUS HEALTH AND SAFETY HAZARDS ON CONSTRUCTION SITE

Height
Slips and trips
Equipment, machinery, tools and transport

Electricity
Fire
Manual handling
Noise
Chemical substance
Dust

5.3 PROCEDURES FOR HAZARD IDENTIFICATION AND RISK ASSESSMENT IN CONSTRUCTION:

There are some basic steps about how the risk assessment should be under taken like:

I. Initiating the HIRA
II. Identify the hazard
III. Identify all parties affected by the hazard and determine how they can be affected
IV. Evaluate or assess the risk
V. Monitor & Review

Step 1: Initiating the HIRA -

When a hazard is identified, the first option is to eliminate it first. Number of approaches (and combinations thereof) to risk assessment can be adopted to perform the HIRA. The approaches to risk assessment at work are based upon:

1. Observation of the workplace environment (e.g. means of access, conditions of floors; machinery safety; dust and fumes, temperature, lighting; noise; etc.)
2. Identification of tasks carried out at the workplace (to identify all tasks so that they are all included in risk assessment).
3. Consideration of tasks carried out at the workplace (evaluation of risks from the different tasks).
4. Observation of work in progress (check that procedures as laid down or predicted, and ensure that no other risks arising).
5. Consideration of patterns of work (to access exposure to hazards).
6. Consideration of external factors which could affect the workplace (e.g. weather consideration for outdoor workers).
7. Review of psychological, social and physical factors which might contribute to stress at work, and other factors in the workplace organization and environment.
8. Maintaining the organizational conditions at work, like safeguards (system to assess the risk), implementation of usage of PPEs.

Step 2: Identification of hazards-

It is the most important element of the risk assessment process and shall be performed in a systematic manner.

Gathering of information and analysis of work- This should be conducted by the safety in-charge/ practitioner or person responsible for health and safety at workplace.

During the physical assessment or after the assessment- If the hazard identification is not carried out carefully, the subsequent analysis of risk and the development of risk control measures become pointless. The identification of hazards is the essential part of any risk assessment process, it also must assess about the way people think about the work. It

should develop the workers confidence in work so as to enable them to act more safely and proactive in hazard awareness.

Techniques of Hazard Identification-There are many techniques and tools that can be used as part of the hazard identification process like observation, communication, discussion, information and records.

Hazard Identification is a critical step in Risk Analysis. Many aids are available, including experience, engineering codes, checklists, detailed process knowledge, equipment failure experience, hazard index techniques, What-if Analysis, Hazard and Operability (HAZOP) Studies, Failure Mode and Effects Analysis (FMEA), and Preliminary Hazard Analysis (PHA). In this phase all potential incidents are identified and tabulated.

Step 3: Identify the group of people affected by hazard and determine how they can be affected-

Next, it is needed to identify who might be harmed; it helps in identifying the best possible way to manage the risk. In each case, identify how they might be harmed, e.g. what type of injury or ill health might occur.

Consequence assessment needs to be taken in to account to determine the potential for damage or injury from specific incidents. A single incident can have many distinct incident outcomes.

Likelihood assessment should be done to estimate the frequency or probability of occurrence of an incident.

Estimates may be obtained from historical incident data on failure frequencies or from failure sequence models, such as fault trees and event trees.

Risks arising from the hazards must be evaluated for its tolerability to personnel, the facility and the environment.

The acceptability of the estimated risk must then be judged based upon criteria appropriate to the particular situation. The Five Steps of Hierarchy to assess the hazard should include as followed:

A. Look for the hazards
B. Decide who might be harmed, and how
C. Evaluate the risks and decide whether existing precautions are adequate or more should be done
D. Record of findings
E. Review the assessment and revise it if necessary

The various occupations and associated hazards during the construction activities are depicted below:

OCCUPATIONAL HAZARD		
S.NO.	**OCCUPATIONS**	**HAZARDS**
1.	Brick masons	Dermatitis, awkward postures, heavy loads
2.	Stone masons	Dermatitis, awkward postures, heavy loads
3.	Carpenters	Wood dust, heavy loads, repetitive motion

4.	Electricians	Heavy metals in solder fumes, awkward posture, heavy loads
5.	Painters	Solvent vapors, toxic metals in pigments, paint additives, awkward posture
6.	Plumbers	Lead fumes and particles, welding fumes
7.	Concrete finishers	Awkward postures
8.	Paving, surfacing operators	Asphalt emissions, gasoline and diesel engine exhaust, heat
9.	Roofers	Roofing tar, heat, working at heights
10.	Structural metal installers	Awkward postures, heavy loads, working at heights
11.	Welders	Welding emissions
12.	Drillers, earth, rock	Silica dust, whole-body vibration, noise
13.	Air hammer operators	Noise, whole-body vibration, silica dust
14.	Pile driving operators	Noise, whole-body vibration
15.	Hoist and winch operators	Noise, lubricating oil
16.	Crane and tower operators	Stress, awkward postures
17.	Excavating and loading machine operators	Silica dust, whole-body vibration, heat stress, noise
18.	Grader, dozer and scraper operators	Silica dust, whole-body vibration, heat noise
19.	Truck and tractor equipment operators	Whole-body vibration, diesel engine exhaust

Step 4: Evaluate or assess the risk

Having identified the hazards, it is to be decided what to do about them. And, it is required to do everything ‘‘reasonably practicable’’ to protect people from harm.

Risk Assessment**:**

Risk is presented in variety of ways to communicate the results of findings to make decision on risk control. Risk analysis uses likelihood and severity in qualitative method, and, the result in a risk matrix format, which is an effective way of communicating the distribution of the risk throughout the worksite and area in a workplace.

Risk can be calculated using the following formula:

Relative Risk = L x S

Where, L = Likelihood & S = Severity

RISK RATING

One of the most best and simple method of risk assessment is to rate the remaining risk as high, medium or low, depending on how likely the activity is to cause the harm and how serious that harm might be.

LEVEL OF RISK

1. Low risk factors - Need to be considered, but there is a lesser chance that those may cause the consequences to go beyond controllable limits. And, even if exposure occurred, the injury would be relatively slight.
2. Medium risk factors -Such types of risks are one that could cause issues, but still there is a lower chance that these will cause work to fail. It is more likely that harm might occur and the outcome could be more serious
3. High risk factors-These are the risks that have the highest probability to occur. These can cause work to fail, and it is needed to plan for such risks ahead of time. If injury is likely to arise that injury might be serious or even a fatality.

In order to do a ‘‘risk rating’’, normally matrix scoring system is used. Numerical scores are given to the different elements (e.g. consequence, exposure, likelihood) of risks and these scores are added or multiplied to get a rating for the risk.

METHODOLOGIES OF RISK ANALYSIS-

A qualitative analysis is used to describe the magnitude of potential severity and the likelihood that those severities will occur. These scales can be adapted or adjusted to suit the circumstances. Different descriptions may be used for different risks.

Likelihood of an occurrence: This value is based on the likelihood of an event occurring.

Likelihood (L)	Example	Rating
Most likely	Most likely result of Hazard	5
Possible	Chances of occurring but not unusual	4
Conceivable	Might occur at some time in future	3
Remote	Has not been known to occur in recent years	2
Inconceivable	Practical impossible, never has occurred	1

Severity of hazard: Severity are based upon an increasing level of severity to an individual’s health, the environment, or to property.

Severity (S)	Example	Rating
Catastrophic	Many fatalities, irrecoverable property damage, loss in productivity	5
Fatal	One fatality, property damage	4
Serious	Non-fatal injuries, permanent disablement	3
Minor	Disabling but not permanent in nature	2
Negligible	Minor injuries, cuts, abrasion requiring first aid	1

The relative risk value can be used to prioritize necessary actions to effectively manage work place hazards. The priority of the control elements can be defined as per the numerical value of Relative Risk, the hazard and control methods can be formulated

Risk	Description	Control
1-4	May be considered as “Acceptable”. However, a consistent watch may be made on its projecting hazard.	Low
5-12	A planned approach may be developed to control the hazard. Action must be documented and completion time limit may be decided.	Medium
13-20	Risk requires an attention; action may be followed up and completion time limit may be decided.	High
21-25	Risk requires an immediate attention; action must be documented and completion time limit may be decided.	Very high

Risk Assessment combines the consequences and likelihood of all incident outcomes from all selected incidents to provide a measure of risk. The risk of all selected incidents are individually estimated and summed to give an overall measure of risk. Hazard Identification & Risk Assessment matrix 5 by 5 is given below.

Hazard Ranking System							
			Severity				
			1	2	3	4	5
			Minor Injury	Serious Injury	Notifiable Injury	Major Injury	Fatality
Likelihood	5	Likely	Medium 5	Medium 10	High 15	High 20	High 25
	4	Probable	Medium 4	Medium 8	High 12	High 16	High 20
	3	Possible	Low 3	Medium 6	Medium 9	High 12	High 15
	2	Remote	Low 2	Medium 4	Medium 6	Medium 8	Medium 10
	1	Improbable	Low 1	Low 2	Low 3	Medium 4	Medium 5

A	High Risk
B	Medium Risk
C	Medium Risk
D	Low Risk

Fig. 5.2 Risk Matrix

ELIMINATION OR REDUCTION OF THE RISK

It involves identifying the opportunities to reduce the likelihood and/or consequence of an accident Where deemed necessary. Risk-reduction measures include those to prevent incidents (i.e. reduce the likelihood of occurrence) to control incidents (i.e. limit the extent and duration of a hazardous event) and to mitigate the effects (i.e. reduce the consequences). Preventive measures, such as using inherently safer designs and ensuring asset integrity, should be used wherever practicable.

The general hierarchy of risk reducing measures is:

a. Prevention (by distance or design)
b. Detection (e.g. fire and gas, Leak detection)
c. Control (e.g. emergency shutdown and controlled depressurization)
d. Mitigation (e.g. fire-fighting and passive fire protection)
e. Emergency response (in case safety barriers fail)

Components of Risk Assessment: The components of a risk assessment study are:

I. Hazard identification and specification
II. Risk Review
III. Recommendations on mitigation measures

Hazards should be controlled at their source, where the problem is created. This method is often referred as engineering control. If this does not work, hazards can often be controlled along the path to the worker, between the source and the worker. This method can be referred to be as administrative controls. And, if this is not possible, hazards must be controlled at the level of the worker through the use of personal protective equipment (PPE), although this is the last level control.

Selecting a suitable control: Selecting a control may involve the followings:

1. Evaluating and selecting short- and long-term controls;
2. Implementing short-term measures to protect workers until permanent controls can be put in place; and
3. Implementing long term controls when reasonably practicable.

For example, suppose a noise hazard is identified. Short-term controls might require workers to use hearing protection. Long term, permanent controls might remove or isolate the noise source.

Step 5- Monitor & Review

A HIRA acts as an essential document of emergency management process. The risk assessment is used to prioritize the risks requiring further action plan to prevent, mitigate, accept, or transfer the risks associated with hazards or threats.

<u>HIERARCHY OF CONTROL:</u>

The Risk control strategies start from the implementation of Hierarchy of control

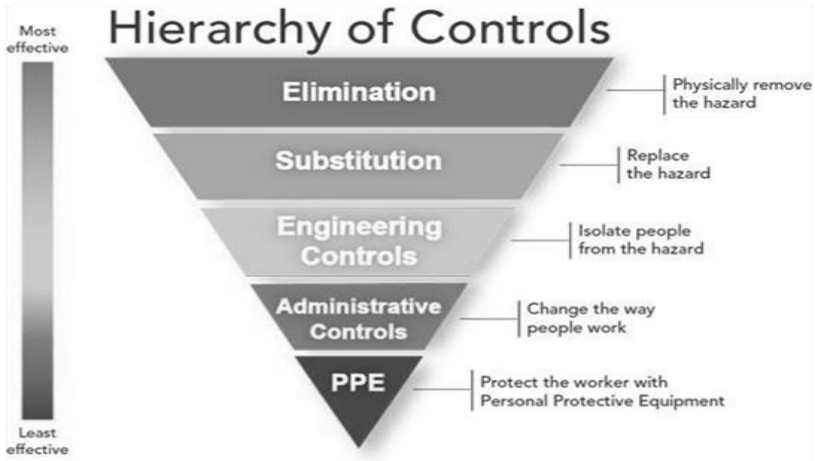


Fig. 5.3 Hierarchy of control

I. Elimination - Getting control over a hazardous job, tool, process, machine or substance is perhaps, Elimination is the better option of protecting the workers.
II. Substitution - Sometimes doing the same work in a less hazardous way is possible. Controls must protect workers from any new hazards that are created.
III. Engineering control: Engineering control often involves the following considerations like:

Redesign - Jobs and processes can be reworked to make them safer. For example, containers can be made easier to hold and lift.

Isolation - If a hazard cannot be eliminated or replaced, it can sometimes be isolated, contained or otherwise kept away from workers. For example, an insulated and air-conditioned control room can protect operators from a toxic chemical.

Automation - Dangerous processes can be automated or mechanized.

Barriers - A hazard can be blocked before it reaches workers. For example, special curtains can prevent eye injuries from welding arc radiation. Proper equipment guarding will protect workers from contacting moving parts.

Absorption - Baffles can block or absorb noise.

Lockout systems- Can isolate energy sources during repair and maintenance. Usually, the further a control keeps a hazard away from worker.

Dilution - Some hazards can be diluted or dissipated. For example, ventilation systems can dilute toxic gasses before they reach operators.

IV. Administrative controls:

1. Safe work procedures - Through the completion of a Job Hazard Analysis in the work process, sometimes hazards are identified and cannot be eliminated or engineered out a particular task. In such conditions, Safe Work Procedures may be adopted containing step by step instructions that allow workers to conduct their work safety when hazards are present.
2. Supervision and training – Initial training on safe work procedures and refresher training should be offered. Appropriate supervision to assist workers in identifying possible hazards and evaluating work procedures.
3. Job rotations and other procedures- This can reduce the time that workers are exposed to a hazard.
4. Housekeeping, repair and maintenance programs - Housekeeping includes cleaning, waste disposal and spill cleanup. Tools, equipment and machinery are less likely to cause injury if they are kept clean and well maintained.
5. Hygiene - Hygiene practices can reduce the risk of toxic materials being absorbed by workers or carried home to their families. Personal clothing should be kept in separate lockers to avoid being contaminated by work clothing.

V. Personal Protective Equipment:

PPE must be chosen to provide appropriate protection against each of type of hazard present. Workers must be trained to use and maintain equipment properly.

5.4 DOCUMENTING HIRA:

Management of hazards identified in the workplace can be done through effective management. Ultimately, the individual or team who identified the hazard must ensure that hazard is properly communicated to the workplace authority appropriately.

Chapter 6

STANDARD OPERATING PROCEDURE (SOP) AND WORK PERMIT SYSTEM

6.1. Introduction

All the works exposed by the construction workers has some degree of hazard. This degree of hazard determines the type of safeguards required to protect the worker. Most routine work has defined standard operating procedures. Many job tasks that expose workers to serious hazards are non-routine, maintenance-type activities that must be managed to control risks. These hazards are controlled through written standard operating procedure and work permits.

Standard operating procedures and Safe work permits are administrative controls and it must be developed, implemented, and managed properly in order to be effective at managing risk.

6.2. Standard Operating Procedure

Construction is an industry filled with potential dangers. The good news is that you can minimize them by using the appropriate safe work practices.

Awareness

Before any worker no matter his or her role or experience level can set foot on a construction site, he or she must be fully aware of the possible hazards. Ignorant workers are perhaps the biggest dangers in any industry, as their unknowing mistakes put everyone else at risk. Understanding of perils at hand and sustaining a perpetual state of alertness is perhaps the number-one best way to prevent accidents. Every single person that steps foot onto a construction site should be aware of the risks associated with the job and how to prevent them with their knowledge of construction site safety.

It is the construction manager's job to make sure that every worker is aware of the dangers that come with working on a construction site and they must protect workers from these dangers. Any manager that fails to tell their crew and staff about how to avoid getting hurt and how to ensure safety is failing as a manager. Ensuring the safety of the construction workers and everyone on the site should be the number one priority of any construction manager. If the workers have no concept of construction site safety, they shouldn't be allowed on the construction site.

Minimize and manage risk

Due to the nature of construction work, it's impossible to eliminate all safety risks. However, many common safety issues can be avoided by conducting regular safety audits and having procedures in place to report, assess and address potential risks.

Site security

Restricted site access should not only be put in place to simply protect equipment from damage or theft. Security in and outside of work hours is integral to protect pedestrians from potential construction hazards. This includes supervision or authorized site visitors.

Strict security and safety protocols will also protect contractors from liability and negligence in the case of a safety incident or security breach.

Entry and exit points

Separate entry and exit points should be established for heavy machinery/vehicle access, to strengthen pedestrian safety at high traffic points.

Standard operating procedure assessment

Standard operating procedure be prepared for all high risk construction projects, before work commences. The SWMS should outline the scope of work involved, any potential safety issues, and how risks will be prevented and managed.

The site SWMS should be clearly displayed at the construction site, so that all safety protocols are readily available including a 24 hour emergency contact number and a map or directions to the site office. Visible signage should also indicate site amenities (such as toilets), entry and exit points, and first aid or emergency fire equipment.

Documentation

To enforce construction site safety, you have to make sure you have proper documentation of everything that is going to be done on-site. There are some legal hoops most construction companies must jump through to begin building, and it is essential that all proper registrations and licenses are earned before work begins. Supervisors and contractors who will be charged with particularly difficult tasks, like blasting, certainly should provide evidence of their certification well in advance of their employment on the job site. Not only does this prevent accidents due to improper training, but it protects the construction firm from legal action and public scrutiny. Any safety hazards that make their way to the media will look bad for construction firms.

No construction worker wants to work for a construction firm that doesn't put its worker's safety first. Any news of workers getting hurt on the job due to lack of safety practices will have new prospects running away from your construction firm. Implementing measures to practice construction site safety methods prevents falls and such things from happening. For falls, there are a number of factors including the failure or misuse of protection equipment, unstable working surfaces, and human error. Also, documenting all work in the field using cloud and mobile technology is making it easier than ever before to mitigate future lawsuits.

Communication

Accidents are more likely to occur when workers are unsure what to expect. Direct discussion of the day's goals and activities will cut down on surprises that could cause bodily harm. Construction firms would be wise to equip workers with devices, like smart phones, walkie-talkies, or headsets, which allow fast and efficient communication

among team members. Without proper communication between everyone on the construction site, workers won't know what to expect. Clear and concise communication with everyone not only makes the project go by faster but also helps keep each person informed. Informing the staff and making sure everyone is doing their job is a proper way to communicate and make sure they understand construction site safety.

Environmental conditions

Extreme weather conditions can cause serious safety hazards. On-site emergency plan should provide clear guidelines for workers who need to stop work in the event of natural disaster, severe environmental conditions or other emergency circumstances.

Falling objects

It is your responsibility to secure objects onsite and minimize the risk of them falling. Construction safety doesn't end once the project is completed, and your workers have gone home. All parties involved in the construction process have a responsibility in ensuring that the right equipment and quality materials are used, so that safety risks are avoided long into the future.

Supervision

Ideally, construction workers would fully understand the ramifications of inadequate safety precautions and thus act in a manner to ensure site-wide well-being but this is not a perfect world. Every site must have a strong supervisor who is willing and capable of enforcing safety standards with no exceptions. This foreman must keep tabs on all employees throughout the day and correct those who fail to commit to proper construction site safety procedures.

Conduct daily site inspections and safety meetings

Jobsites should be inspected before and after each workday to address any safety concerns such as tools left lying around or damaged equipment. Jobsites should also be inspected throughout the day to identify any potential hazards and monitor workers to make sure they are working safely.

Hold a brief safety meeting before work begins each day to go over what tasks are scheduled to be performed along with the safety procedures to be followed. Be sure to address any concerns or issues and acknowledge the good practices observed from the prior day.

Good or bad, your company already has a safety culture, but there's always room for improvement. Having a rock-solid safety culture means making the commitment to put safety first. Instituting programs and procedures that reinforces that commitment takes time, employee engagement and making adjustments to improve.

Implement good housekeeping practices

Housekeeping and worksite safety go hand-in-hand to make one of the most important construction safety practices. Housekeeping practices implies that a workplace is kept in an organized, uncluttered, and hazard-free condition. Housekeeping is an essential component to workplace safety and sometimes it is disregarded.

Poor housekeeping can contribute to on-site accidents. Construction sites should be cleaned of any clutter, debris, spills and dust. Organization is just as important as cleanliness, with good housekeeping practices, accidents like tripping over loose objects or slipping on wet surfaces can be avoided. Keeping a site clean and organized is an ongoing operation and should be done throughout the workday.

Establish a strong safety culture

You don't want potential or current workers to get the impression that you only care about safety if regulatory authorities threaten to issue fines for non-compliance. Use your words and actions to demonstrate that staying safe is an ongoing priority. Make it so that people quickly associate excellent safety measures with your company.

You might hold monthly team meetings that reward people for working safely and urge attendees to weigh in with their thoughts about how to make improvements. Many companies also keep running tallies of the number of working hours completed without incidents. Seeing the total rise keeps people motivated and highlights how preventing accidents is a collective effort.

6.3. Work Permit System

A safe work permit is a written record that authorizes specific work, at a specific work location, for a specific time period. The permits are used for controlling and co-ordinating work to establish and maintain safe working conditions. They ensure that all foreseeable hazards have been considered and that the appropriate precautions are defined and carried out in the correct sequence. The work permit is an agreement between the issuer and the receiver that documents the conditions, preparations, precautions, and limitations that need to be clearly understood before work begins.

Further, the permit to work is a documented management system to ensure work is done safely and efficiently.

Usefulness of work permit

Work permits provide written information on the prevalent hazards connected with the job performance. It spells out the suitable remedial measures to be adopted to encounter the hazardous conditions that are prevailing or that can be encountered while performing the job. It also stipulates various conditions and limitations on the part of personal protective equipment to be used at different stages of work.

It is important to note that a safe work permit does not reduce risks of incidents by itself. Rather, it specifies the hazards and the risk control measures that workers must be aware of, before they start work.

In General, the following will get the benefits from a work permit program,

- Any construction site that has a significant risk because of particular hazards.
- Any prime contractor who lets out or sub-contracts work to others to do maintenance or other hazardous work.
- Organizations that have individual employees working in isolated areas and performing non-routine work.

Works that require permit

Normally all maintenance, repair, construction work shall be carried out with a proper work permit. Jobs where work permit is required include but not limited to followings:

- Major and minor maintenance work
- Inspection
- Construction
- Alteration
- Any hot work
- Cleaning activities of process equipment
- Entry into confined space
- Excavation
- Vehicle entry into process areas
- Work at height
- Handling of materials using mechanized means in operating areas
- Erection and dismantling of scaffold
- Isolation and energisation of electric equipment/ facilities

Who issues permits & to whom

Permits are issued by supervisors having proprietary responsibility of areas and equipments. It is generally issued in the name of a Supervisor or Technician who is to carry out the required job under the known hazardous conditions. The various stages of work permit system are as follows.

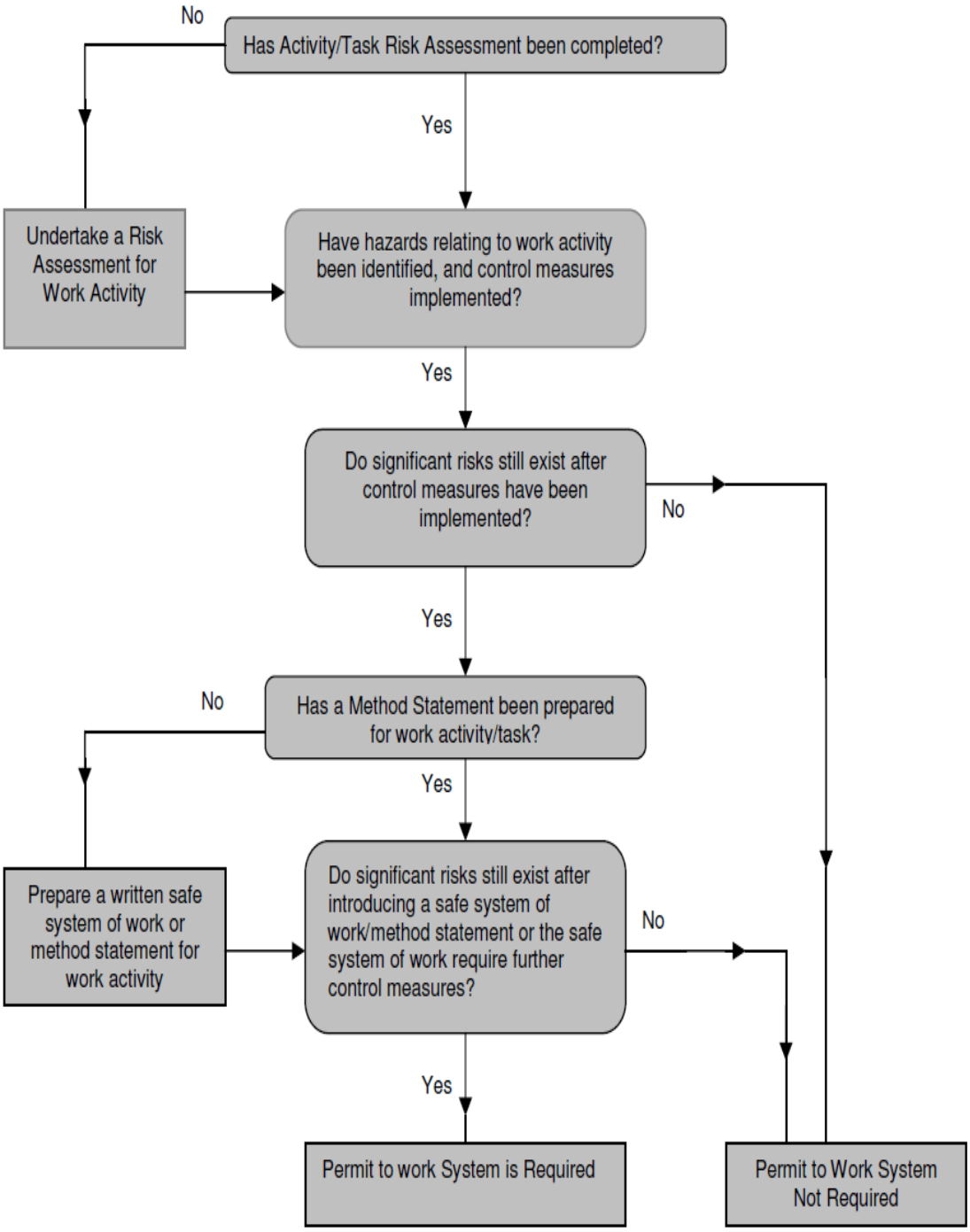


Fig.6.1. Flow chart for work permit system

A permit contains written information and instructions pertaining to hazards that are to be avoided in a particular operation. It indicates that all hazards have been considered in advance and that foreseeable appropriate precautionary measures have been taken. People responsible to execute a job defined in the permit are to review them from the point of compliance.

The general Information contains in the work permit are:

- Exact work locations.
- Work to be done.
- Date and time the work is to start and end Hazards.
- Correct sequence of work procedures.
- Personal protective equipment required.
- Emergency equipment needed.
- Signature of authorized person(s).
- The precautions to be taken.
- Date and time the permit is issued.
- Preparatory requirements, such as testing, equipment and machinery to be shut down/locked out, ventilation, etc.

6.4. TYPES OF WORK PERMIT

Depending on the type of construction work and the hazardous operations carried out, various types of permits have been developed to suit the needs. However, the most commonly used permits are:

a) Hot Work Permit or Fire permit
b) Confined Space Entry Permit or Safe Entry Permit
c) Excavation Permit
d) Electrical Work Permit
e) Safe Work Permit or Work at Height Permit- and so on

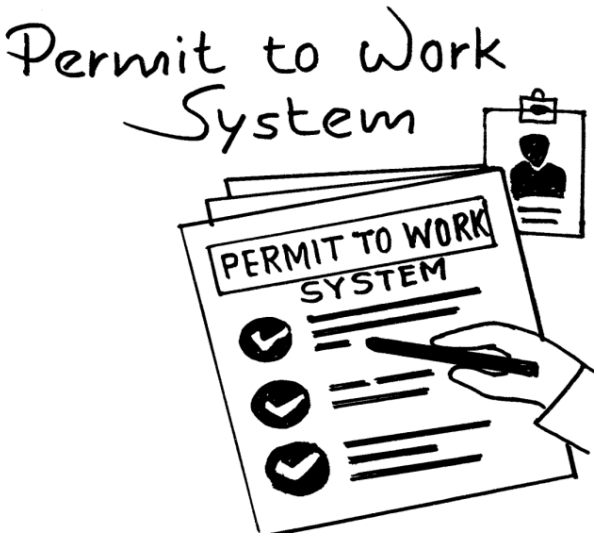


Fig.6.2.Work permit

Permits and their issue

a) Hot Work Permit or Fire permit

Hot work permits are used when heat or sparks are generated by work such as welding, burning, cutting, riveting, grinding, drilling, and where work involves the use of pneumatic hammers and chippers, non-explosion proof electrical equipment (lights, tools,

and heaters), and internal combustion engines. Three types of hazardous situations need to be considered when performing hot work:

(a) The presence of flammable materials in the equipment;

(b) The presence of combustible materials that burn or give off flammable vapours when heated; and

(c) The presence of flammable gas in the atmosphere, or gas entering from an adjacent area, such as sewers that have not been properly protected. (portable detectors for combustible gases can be placed in the area to warn workers of the entry of these gases.)

It will be the responsibility of the originator, i.e. the Operating Department to make the area or equipment, (where hot work is intended to be carried out) free from fire hazard and explosion. Therefore, before a hot work permit is released, generally the following points are given utmost consideration:

a) The equipment/area and their surroundings are tested to determine the explosive range. This can be achieved by testing with an explosive meter or taking air samples and tested in the Laboratory. In case of presence of explosive mixture in the air, no hot work will be permitted till such time the area is made free of explosive content by cleaning, ventilating, purging etc.

b) All pits, pumps, openings etc. in the vicinity of construction sites are covered with fire proof material to prevent sparks entering and causing explosion and fire.

c) The area and the surrounding are sufficiently wetted to facilitate extinguishment of sparks, hot slugs etc as they fall.

d) Adequate first-aid and fire-fighting equipment are kept readily available for use in case of need. If the crew carrying out the repair work do not know how to operate the fire fighting equipment, men with fire fighting knowledge are made available at the work spot during the repair work.

b) Confined Space Entry Permit or Safe Entry Permit

No person shall be permitted to enter into a place classified as a confined space unless and until all measures have been taken to make the equipment/vessel adequately safe for working.

Usually the Supervisor having the proprietary control over the equipment/vessel issues a Safe Entry Permit and authorizes entry and work in, on and around a confined space. Before issuing such a permit, it will be his responsibility –

a) To isolate the equipment/vessel from all sources, through which any energy, stock or harmful substances can get introduced, by disconnecting, blinding, blanking etc.

b) To drain, clean, wash and purge the equipment / vessel to make it free from toxic gases and other harmful substances.

c) To test the air inside the vessel to determine presence of explosive mixture, oxygen content etc.

c) Excavation Permit

In most of the construction sites, pipe lines, electrical cables, telephone cable etc are run under ground. In some cases, where goods are not stable or contaminated, digging and excavation work may cause accidents and/or property damage. Hence, to prevent such accidents, injuries or property damages the digging and excavation works are controlled by permit system. The construction sites having permit systems to control excavation work, forbid as a rule, any excavation work whatsoever, within the construction premises without a valid Excavation permit.

Here again, the originator of the permit will be the Supervisor having proprietary responsibility of the area where excavation work is intended to be carried out. The originator after preparing the Excavation Permit in triplicate, indicating the exact location where the excavation work will be carried out in the site. One copy of the permit is retained by the originator and one copy to the agency executing the job and one copy to safety department. The triplicate copy, in fact, is held in the possession of the person who actually carries out the job at the work site. The permit is required to be produced for inspection and checking when demanded by the concerned authorities.

d) Electrical Work Permit

Work on electrical installations, equipments and apparatus is considered to be very hazardous. Therefore, it is of utmost importance that sufficient safety precautions are taken before carrying out any work on, electrical circuits, lines and equipments. More so, when the power is of high voltage. Hence, to exercise greater control over such work and to ensure that adequate precautionary measures are taken before commencement of work on electrical equipment, an Electrical Work Permit known as ‘Permit-to-work’ has been developed.

Before issuing permit-to-work and authorizing work, the originator ensures that the apparatus concerned is made dead, isolated from all live conductors and has been connected to earth. To make an apparatus/equipment dead, all the relevant switches, isolators, breakers, fuses, back fee switches etc are opened out and the isolated section earthed at each isolation point.

e) Safe work Permit or Work at Height Permit

Many accidents are caused due to falls while working at heights and roof tops. Most of the accidents result in fatalities or very severe injuries. These phenomena are more acute in construction industries. Therefore, to put a curb on the rising trend of fall accidents it was felt necessary to bring about certain controls over such works and provide adequate safe guards for the people working at higher elevations.

6.5. General work permit procedure

Safe work permits are usually made out in either duplicate or triplicate. When a duplicate system is used, one copy of the permit is retained by the issuer at the work site and the other is held by the worker/department doing the work. The permit should always be

available at the work site. The permit is handed back to the issuer at the end of the shift or when the work is completed. In a triplicate permit system, the third copy is used by the safety department to audit the work to see if the requirements of the permit are being met. The triplicate permit system is the best method by considering safety of the organization. The format of work permits generally various based on the construction sites and based on the hazards in the work location.

6.6. Multiple permits

Since most of the work permits contain same or similar contents, the construction sites tend to use one single permit form with different headings for various works by striking out the irrelevant headings. But, it has been experienced that the procedure had created confusion and misunderstandings and resulted in accidents. Therefore, it is desirable that different formats are used for different work permits rather than using one single format with different heading.

6.7. Permit validity

In case when the work could not be completed within the same shift, the permit can be transferred on the name of another person who would be continuing the job. The fact, that the permit has been transferred to another person is noted on the permit. Generally, the validity of the permit is one shift only, the permit need to be renewed if required for beyond one shift.

The permit systems need to be continuously monitored by suitable methods, preferably by Electronic Monitoring method. If the concern authority noticed any violation on the permit system during any point of work, the permit needs to be suspended/cancelled immediately by DISH.

6.8. Return of permit

On completion of the job, the person in-charge of the repair job at the time, ensures that, all men working on the equipment/apparatus have been withdrawn, all earth and other connections made by him or his men have been removed and he returns the permit the cancellation. The permit issuing authority, on receipt of the permit for cancellation, rechecks the equipment/apparatus and cancels the permit. He then energises the equipment/apparatus made dead earlier for repair work, by removing the earth's made for the purpose and closing all the switches, isolators, breakers, fuses, back feed switch etc opened earlier and puts the equipment in service.

6.9. Pitfalls Of Work Permit

The various factors leading to ineffective permit systems are:

- The type or format of the permit does not cover all the potential hazards.
- The issuing procedure is inadequate.
- The person signing the permit has not inspected the operation to see if the isolation, lock-out or testing has been done.
- Workers are not following or don't understand the requirements of the permit, especially the expiry time.

- The employer is not enforcing or auditing the work permit system.
- Permits are prepared too far in advance, or after the work have begun.
- A responsible person is not inspecting the operation after the permit has been issued.
- The system is too complex.

A safe work permit is an effective tool to identify and control hazards, prevent injuries, and avoid costly mistakes. The permit system in a construction sites plays an important role in minimizing accidents occurrences, in that it helps the people concerned to convert a known hazardous work situation into a safe work environment.

Chapter 7

TRAINING AND EDUCATION

7.1 Introduction

The construction industry has a high risk of occupational accidents and injuries and is regarded as one of the most unsafe industries worldwide. Plenty of studies highlight the lack of occupational safety training as one of the major factors behind the poor level of occupational safety in the construction industry. The importance of safety training for enhancing workers safety competency levels as well as skills.

The aim of this manual is to ensure the protection of workers and prevent work-related injuries, illnesses, and deaths by providing training, outreach, education and assistance. Many manuals, booklets, training aids and standards, which have prevented countless workplace tragedies, include explicit safety and health training requirements to ensure that workers have the required skills and knowledge to safely do their work. These requirements reflect and belief that training is an essential part of every employer's safety and health program for protecting workers from injuries and illnesses. Researchers conclude that those who are new on the job have a higher rate of injuries and illnesses than more experienced workers.

Training is one of the most important components and it gives employees an opportunity to learn their jobs properly, bring new ideas into the workplace, reinforce existing ideas and practices, and it helps to put our Safety and Health Program into action.

7.2 Management commitment

Every construction industry shall provide the necessary funds and scheduling time to ensure effective safety and health training is provided. The commitment of management will include paid work time for training and training in the language that the worker understands. Both management and employees will be involved in developing the program.

To most effectively carry out their safety responsibilities, all employees must understand:

1. Their role in the program,
2. The hazard sand potential hazards that need to be prevented or controlled.
3. The ways to protect themselves and others.
4. Company shall also achieve said goals by:
    a) Educating everyone on the natural and system consequences of their actions;
    b) Educating all managers, supervisors and employees on their safety management system responsibilities;
    c) Educating all employees about the specific hazards and control measures in their workplace;
    d) Training all employees on hazard identification, analysis, reporting and control procedures;
    e) Training all employees on safe work procedures and practices.

The training program will focus on health and safety concerns that determine the best way to deal with a particular hazard. When a hazard is identified, first try to remove it entirely. If that is not feasible, train the workers to protect themselves, if necessary, against the remaining hazard. Company may be decide in a such way that a safety or health problem can best be addressed by training (or by another method combined with training), and follow up by developing specific training goals based on those particular needs.

The training should be appropriate to the work and the duration shall be so decided that it gives the worker enough time to acquire necessary skill and knowledge, to enable him/her to perform his work safely, preferably not less 48 hours.

7.2.1. Employees

At a minimum, employees must know the general safety and health rules of the worksite, specific site hazards and the safe work practices needed to help control exposure, and the individual's role in all types of emergency situations. Ensure all employees understand the hazards to which they may be exposed and how to prevent harm to themselves and others from exposure to hazards.

The construction company shall commit available resources to ensure employees receive safety and health training during the following circumstances below:

- Whenever a person is hired --general safety orientation including an overview of company safety rules, and why those rules must be followed.
- Whenever an –Employee is given a new job assignment --during formal classroom training, and again, when the supervisor provides specific task training. It’s extremely important that supervisors emphasize safety during initial task assignment.
- Whenever new work procedures are begun --during formal classroom training and supervisor on-the-job training
- Whenever new equipment is installed --if new hazards are introduced.
- Whenever new substances are used --hazard communication program may apply.
- The bottom line --train safety whenever a new hazard is introduced to the employee.

Employees must know they are responsible for complying with all company safety rules, and that most accidents will be prevented by their safe work practices. They must be very familiar with any personal protective equipment required for their jobs. They must know what to do in case of emergencies.

Each employee needs to understand that they are not expected to start working a new assignment until they have been properly trained. If a job appears to be unsafe, they will report the situation to their supervisor.

7.2.2. Supervisors

Supervisors will be given special training to help them in their leadership role. They will be taught to look for hidden hazards in the work under their supervision; insist on the maintenance of the physical protection in their areas and reinforce employee hazard training

through performance feedback and consistent enforcement when necessary.

The construction industry shall commit necessary resources to ensure supervisors understand the responsibilities below and the reasons for them:

- Detecting and correcting hazards in their work areas before they result in injuries or illnesses
- Providing physical resources and psychosocial support that promote safe work
- Providing performance feedback and effective recognition and discipline techniques
- Conducting on-the-job training

Supervisors are considered the primary safety trainers. All supervisors will complete train-the-trainer classes to learn training techniques and how to test employee knowledge and skills. They will also receive training on how to apply fair and consistent recognition and discipline. Supervisor training may be provided by the supervisor's immediate manager, by the Safety Department, or by outside resources.

7.2.3. Managers

All line managers must understand their responsibilities within respect to Safety and Health Program. This may require classroom training and other forms of communication. Formal classroom training may not be necessary. The subject can be covered periodically as a part of regular management meetings.

Managers shall be trained in the following subject areas:

- The elements of the safety management system, and the positive impact the various processes within the system can have on corporate objectives;
- Their responsibility to communicate the safety and health program goals and objectives to their employees;
- Their role that includes making clear assignments of safety and health program responsibilities, providing authority and resources to carry out assigned tasks, and holding subordinate managers and supervisors accountable;

Training will emphasize the importance of managers' visibly showing their commitment to the safety and health program. They will be expected to set a good example by scrupulously following all the safety and health rules themselves.

7.3 Effective Training

Safety culture must support training. A culture of consequences is essential. To help make sure that efforts in safety and health are effective and have developed methods to measure performance and administer consequences. Supervisors and managers must understand that their first responsibility is to make sure they have met their obligations to their employees before considering disciplinary action.

Top Managers/ Employers shall be educated on the elements (processes) within the safety accountability system. The safety committee shall be trained on, and continually evaluate, on safety accountability system. Training will focus on improving the

Safety and Health Program whenever hazardous conditions and unsafe or inappropriate behaviors are detected.

Safety orientation shall emphasize that compliance with safety policies, procedures, and rules as outlined in the safety plan is a condition of employment. Discipline shall be administered to help the employee increase desired behaviors, not to in any way punish. An explanation of the natural and system consequences of behavior/performance shall be addressed in every safety training session.

7.4 Types of Training

Required rules-related training shall be conducted according to appropriate government guidelines and shall also make sure additional training is conducted as deemed appropriate.

In general safety training will be conducted on the following levels:

- **General Safety Education:** General safety information is communicated to employees. No measurement of knowledge, skills, and abilities (SKA's) are required.
- **Specific Safety Training:** Specific safety information and instruction on performing safe procedures and practices. SKA's are measured /tested. Employees' must meet established criteria for SKA's to successfully complete the course.

7.4.1. New Employee Orientation.

The format and extent of orientation training will depend on the complexity of hazards and the work practices needed to control them. Orientation shall include a combination of initial classroom and follow-up on-the-job training.

- For some jobs, orientation may consist of a quick review of site safety and health rules; hazard communication training for the toxic substances present at the site; training required by relevant standards, e.g., fire protection, lockout/ tagout, HIRA etc; and, a run-through of the job tasks. This training shall be presented by the new employee's supervisor or delegated employee.
- For larger tasks with more complex hazards and work practices to control them, orientation shall be structured carefully. You shall make sure that our new employees start the job with a clear understanding of the hazards and how to protect themselves and others.

Company shall follow up supervisory training with a buddy system, where a worker with lengthy experience is assigned to watch over and coach a new worker, either for a set period of time or until it is determined that training is complete.

Whether the orientation is brief or lengthy, the supervisor will make sure that before new employees begin the job, they receive instruction in responding to emergencies. All orientation training received will be properly documented.

7.4.2. On-the-Job Training (OJT)

On the Job Training (OJT) relates principles and theories to work skills that are then

taught and applied in the work environment. OJT is designed to reinforce formal classroom training. All new-hire employees require training to perform their jobs effectively. In this regard, OJT is an essential supplement to formal classroom training. OJT assignments may be provided concurrently with formal training to emphasize and complement material covered in formal training courses. Time allotted to accomplish OJT assignments should be compatible with the new current knowledge, skill, and experience levels. The supervisor should assess the employee's ability to successfully complete OJT training.

7.4.3. Contract workers.

They shall receive training to recognize specific workplace hazards or potential hazards.

7.4.4. Experienced workers.

They shall be trained if the installation of new equipment changes their job in any way, or if process changes create new hazards or increase previously existing hazards.

7.4.5. All workers.

All workers shall receive refresher training as necessary to keep them prepared for emergencies and alert them to ongoing housekeeping problems.

7.4.6. Personal Protective Equipment (PPE).

Workers needing to wear personal protective equipment (PPE) and persons working in high risk situations will need special training. Supervisors and workers alike must be taught the proper selection, use, and maintenance of PPE. Since PPE sometimes can be bulky, employees may need to be motivated to wear it in every situation where protection is necessary. Therefore, training will begin with a clear explanation of why the equipment is necessary, how its use will benefit the wearer, and what its limitations are. Remind your employees of your desire to protect them and of your efforts, not only to eliminate and reduce the hazards, but also to provide suitable PPE where needed.

Individual employees will become familiar with the PPE they are being asked to wear. This is done by handling it and putting it on. Training will consist of showing employees how to put the equipment on, how to wear it properly, and how to test for proper fit and how to maintain it. Proper fit is essential if the equipment is to provide the intended protection. We shall conduct periodic exercises in finding, donning, and properly using emergency personal protective equipment and devices.

7.4.7. Vehicular Safety.

All workers operating a motor vehicle on the job (on or off premises) shall be trained in its safe vehicle operation, safe loading and unloading practices, safe speed in relation to varying conditions, and proper vehicle maintenance. You shall emphasize in the strongest possible terms the benefits of safe driving and the potentially fatal consequences of unsafe practices.

7.4.8. Training on Emergency Action Plan.

Train employees to respond to emergency situations. Every employee at every worksite shall understand:

- Emergency telephone numbers and who may use them;
- Emergency exits and how they are earmarked;
- Evacuation routes;
- Signals that alert employees to the need to evacuate.

Practice evacuation drills at least semi-annually, so that every employee has a chance to recognize the signal and evacuate in a safe and orderly fashion. Supervisors or their alternates will practice counting personnel at evacuation gathering points to ensure that every worker is accounted for. You shall include procedures to account for visitors, contract employees, and service workers such as cafeteria employees. At sites where weather or earthquake emergencies are reasonable possibilities, additional special instruction and drilling will be given.

7.4.9. Periodic Safety and Health Training.

At some worksites, complex work practices are necessary to control hazards. Elsewhere, occupational injuries and illness are common. At such sites, you shall ensure that employees receive periodic safety and health training to refresh their memories and to teach new methods of control. New training will also be conducted as necessary when appropriate standards, rule, code change or new standards are issued.

Where the work situation changes rapidly, weekly meetings will be conducted as needed. These meetings will remind workers of the upcoming week's tasks, the environmental changes that may affect them, and the procedures they may need to protect themselves and others.

7.4.10. Identifying types of training.

Specific hazards that employees need to know about should be identified through total site health and safety surveys, job hazard analysis, and change analysis. Accident and injury records may reveal additional hazards and needs for training. Near-miss reports, maintenance requests, and employee suggestions may uncover still other hazards requiring employee training.

7.5. Monitoring the Training Program

Monitoring the employee's progress through the developmental period is critical to ensure success of the training program. Monitoring provides information to the supervisor regarding the benefits and effectiveness of the training received. In addition, it provides information on the ability of the employee to achieve training goals and objectives. Both the employee's supervisor and training staff play major roles in the monitoring process. To ensure adequate monitoring of the safety training program the actions below must occur.

- The supervisor will ensure that each employee has completed the necessary prerequisites before the start of work.
- The supervisor will review the employee's performance of task assignments.
- The supervisor will conduct a review with the new-hire employee following each required training activity. This review provides the supervisor with information on the progress of the employee and can assist in identifying areas requiring

further training.

- When the supervisor determines that the new-hire employee has sufficient experience to successfully complete a task, the on job training review may be discontinued.
- The supervisor and employee will complete training documentation.

7.6. Safety and Health Training Program Evaluation

An evaluation of the effectiveness of the training program will be conducted periodically. Staff from the training department will interview managers, supervisors and employees who have participated in the program to determine the effectiveness of the training, and to obtain suggestions for program improvement.

Evaluation will help determine whether the training provided has achieved its goal of improving employee safety and performance. When carefully developed and carried out, the evaluation will highlight training program strengths and identify areas of weakness that need change or improvement.

- Evaluation will include analysis of employee attendance at training sessions. Training will not work for an employee who does not show up. Absenteeism can signal a problem with the worker, but it can also indicate a weakness in training content and presentation.
- Compare pre-and post-training injury and accident rates overall. The periods of time being compared must be long enough to allow significant differences to emerge if training has made a difference.
- Determine whether the training provided has achieved its goal of improving employee safety performance. Evaluation will highlight training program strengths and identify areas of weakness that need change or improvement.

The safety team/coordinator will evaluate training through the following methods:

- Observing employee skills;
- Surveys and interviews to determine employee knowledge and attitudes about training;
- Reviewing the training plan and lesson plans;
- Comparing training conducted with hazards in the workplace;
- Reviewing training documents;
- Comparing pre-and post-training injury and accident rates.

If evaluation determines program improvement is necessary, the safety committee/ coordinator will develop recommendations.

Important to note here is it's often easier to conduct an activity than to judge it. But do not ignore this evaluation phase. It will allow you to calculate your training program's bottom line profitability. Have the goals of training been achieved? Do the results warrant offering the training again at some later date? How can the program be improved? Once you have made the effort to provide employee safety and health training, you certainly want to be able to answer these questions.

7.7. Topics to be covered to construction workers training:

Some of the topics may include:

- Statutes, Standards and Policy
- Safety & Health Policy
- Construction Site Management
- Hazard identification & Risk Assessment
- Work Permit System-Working at Height- Scaffolding, Fall Protection, Confined Space, LOTO etc
- Safety in High Rise Construction
- Excavation, Trenching, Tunnelling and Shoring
- Demolition
- Under water construction & above water construction
- Construction Machinery and Equipment
- Hand and Portable Power Tools
- Material Handling - Manual and Mechanical
- Electrical Safety
- Use of Explosives and Fire Hazards
- Working with Compressed Gases
- Accident Investigation & Reporting
- Personal Protective Equipment
- Occupational Health, First-Aid and occupational Diseases
- Fire Prevention and Control
- Chemical Safety and Emergency Preparedness
- Additional topics based on the specific job requirement can be included.

Chapter 8

MECHANICAL AND MANUAL MATERIAL HANDLING

8.1. Introduction

Material handling is the job done by every worker from unloading raw materials, transferring and using at the site.

Mechanized material handling equipment has come into the industry to eliminate the human handling or to assist the person to handle move, varied and heavy objects. Mechanical handling of materials reduces manufacturing cost and increases the productivity. At the same time mechanical handling has, a new set of hazards and injuries.

The accidents in material handling are almost due to human failure or unsafe acts rather than mechanical failures or unsafe conditions.

Types of material handling methods are as follows:

i) Manual handling

ii) Mechanical material handling

Hazards of material handling:-

The accidents and injuries that are common in unsafe material handling work are:

a. Dropping or slipping of objects on the foot.
b. Body organs Pressed in between objects and lifting tackles.
c. Cuts due to sharp edges.
d. Burns due to hot or corrosive substance.
e. Sprains while lifting materials by wrong method.
f. Scalp injuries while working in confined spaces

8.2 Manual Handling:

Manual handling means using physical strength to move materials. This method increases the possibilities of injuries and ads to the cost of product.

To reduce the number of material handling injuries and increase the efficiency, material handling to be minimized by combining and eliminating operations or mechanization.

Even after all elimination and mechanization there will be still objects to be lifted manually for which the following factors are to be taken into consideration for safe acts in materials handling.

Factors to be considered before attempting to lift a load

1. Material to be handled, terrain or the surface.
2. The distance to be moved.
3. The direction of the load to be taken.
4. Volume and weight, shape and size.
5. Frequency.
6. Mode of handling.

Training and constant supervision will reduce the unsafe acts:

1. Inspect materials for sleeves, jagged edges burns, rough or slippery surfaces.
2. Get a firm grip on the object.
3. Keep fingers away from material resting points, especially when setting down on the rollers.
4. When handling timber, pipe or other long objects keep hands away from the ends to prevent them from being pinched.
5. Wipe of greasy, wet, slippery or dirty objects before trying to handle them.
6. Most strains and back injuries occur while lifting and setting down objects by hands.

8.3 PROPER METHOD OF MANUAL HANDLING:

a. Consider the size, weight and shape of the object to be carried. Do not lift more than the object that can be handled comfortably. If necessary get help from others.

b. Set feet firmly. One foot can be slightly ahead of the other for increased effectiveness. Feet should be enough apart to give good balance and stability (approximately the width of the shoulder).

c. Get close to the load as possible. Bend legs about 90 degrees at the knees.

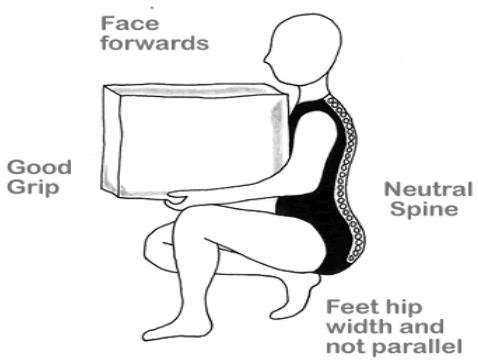


Fig. 8.1. Manual material handling

d. Keep the back as straight as possible. Bend at the hips, not the middle of the back.

e. Grip the object firmly. Maintain the grip while lifting or carrying. Before changing or adjusting the grip, keep the object down again.

f. Straighten the legs to lift the object, and at the same time bring the back to a vertical position. Look upward when beginning to lift.

g. Never carry a load you cannot see over or around. Make sure the path of travel is clear. Carry the object close to the body.

h. Never turn at the waist, to change the direction or to put an object down. Turn the whole body and crouch down to lower the object.

8.4 Principles of lifting:-

The basic principles of lifting technique as follows:

- Size up the load and make sure that the path is clear
- Do not attempt to lift the load alone if it is too heavy or awkward, get help.
- Keep the load close to the body.

- Use your thigh and leg muscles, not the back, as the load is to be lifted in one smooth movement.
- Have feet shoulder width apart, with the load between them.

Fig.8.2. Principle of lifting

8.5 Ergonomics in manual handling:-

Manual material handling tasks may expose workers to physical risk factors if these tasks are performed repeatedly or over a long period of time, it can lead to fatigue and injury. The main risk factors, or conditions associated with the development of injuries in manual handling tasks include: -

i) Awkward posture (e.g. bending, twisting)
ii) Repetitive motions (e.g. bending, twisting)
iii) Forceful exertions (e.g. carrying or lifting heavy loads)
iv) Pressure points (e.g. grasping (contact form) loads, leaning against parts or
v) Surfaces that are hard or have sharp edges)
VI) Static posture (e.g. maintaining fixed position for a long time)

8.6 Team Lifting and Carrying

a. When two or more men are involved to carry a single object, they should adjust the load so that it rides in level and so that each person carries an equal part of the load. Trial lifts can be made before proceeding.

b. When two men carry long sections of pipe or any lengthy material, they should not carry on the same shoulder and walk in unison. Shoulder pads will prevent cutting of shoulders and help to reduce fatigue.

c. When a gang of men carries a heavy object like a rail, the foreman or the leader should direct the work and special tools such as tongs should be used.

d. Normally the gang leader has different signals, like blowing whistle or hand clapping for different operations of which the men are familiar.

e. New employees and men who move slowly need special attention.

8.7 Handling materials of Specific Shapes

Sheet metal:

Sharp edges of sheet metal is to considered and leather hand gloves and safety boot to be used

Barrel and Drum:

Barrel lifting handle or manila rope to roll up or down on a ramp to be used.

Glass panes:

Hand gloves and long leather sleeves, apron, leg guard and safety boot to be worn.

Long objects:

Long pieces of pipes, bars, timber should be carried over the shoulders with the front end raised to prevent striking other employees. Shoulder pads to protect abrasion on the shoulder to be used.

Scrap metals:

The irregularly shaped jagged, mingled objects and strips or pieces may fly when piece is removed from a pile. Workmen should wear goggles, leather gloves, safety boot, leg guard and apron.

Gas cylinders:

Compressed gas cylinders should be handled carefully. Do not drag the cylinders on floors.

Boxes, cartons & sacks:

The best way to handle boxes and cartons is to grasp the alternate top and bottom corners.

While handling materials manually the safety equipments should be appropriate to the type of material. Where toxic or irritating solids are handled, workmen should take daily showers to remove the materials from the persons.

8.8 MECHANICAL MATERIAL HANDLING EQUIPMENTS AND ACCESSORIES

Cranes:

EOT or MOBILE cranes they should not be over loaded. EOT crane is to be used to lift and move materials and not to be used as side pulling. Cranes should not be stopped with jerky motion, where the swinging material will fall due to displacement of slings.

Crane movements, while material is being moved or repair work is being done should be governed by a standard code of signals transmitted to the crane operator. Signals must be given by the signaller and when the signal is not clear, crane should not be operated.

The operator should move the hoisting apparatus only on signals from the proper person, but to stop signal should be obeyed regardless of who gives it, otherwise it would result an accident. The operator should be governed absolutely by the signal.

Crane rigger should be distinguishable from others, for easy spotting by the crane operators. Employees who work near cranes or assist in hooking on or arranging loads should be instructed to keep out from and under load. The Hand Signal standard practices is given below.

Recommended Hand signal as per IS 13367 (Part I): 1992

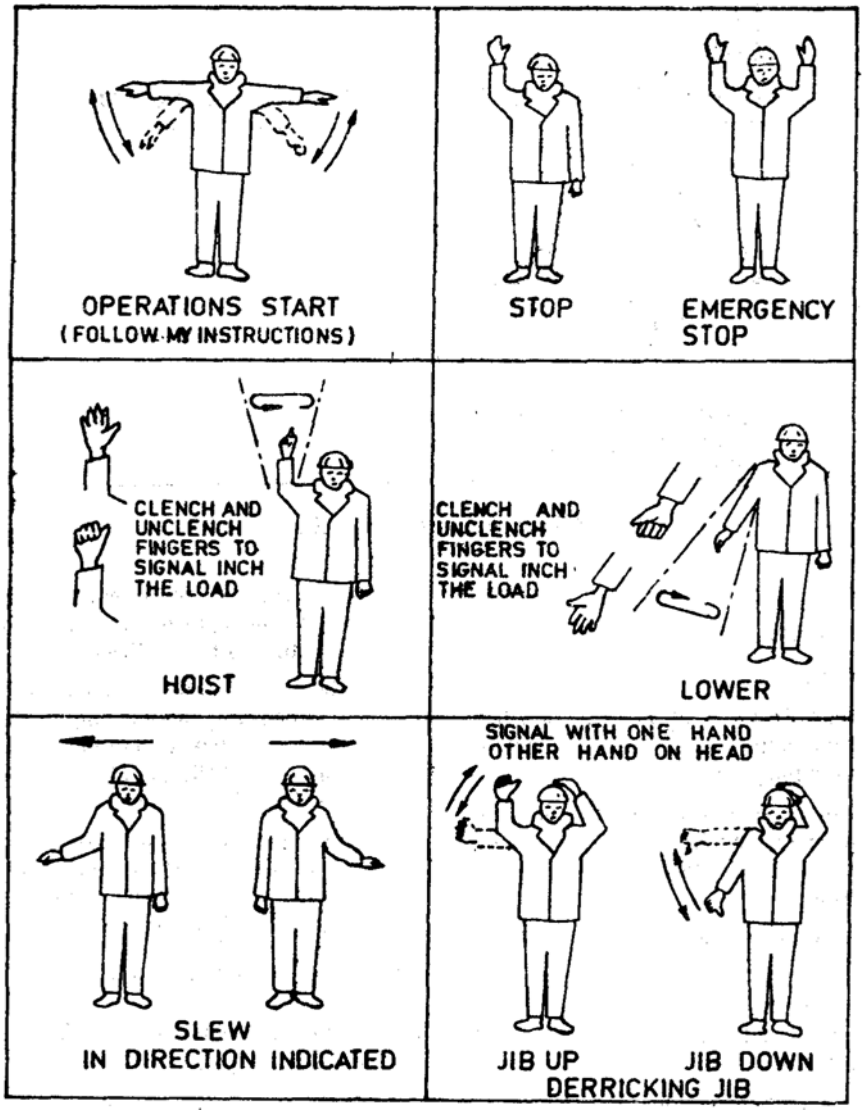


Fig. 8.3 Hand signal

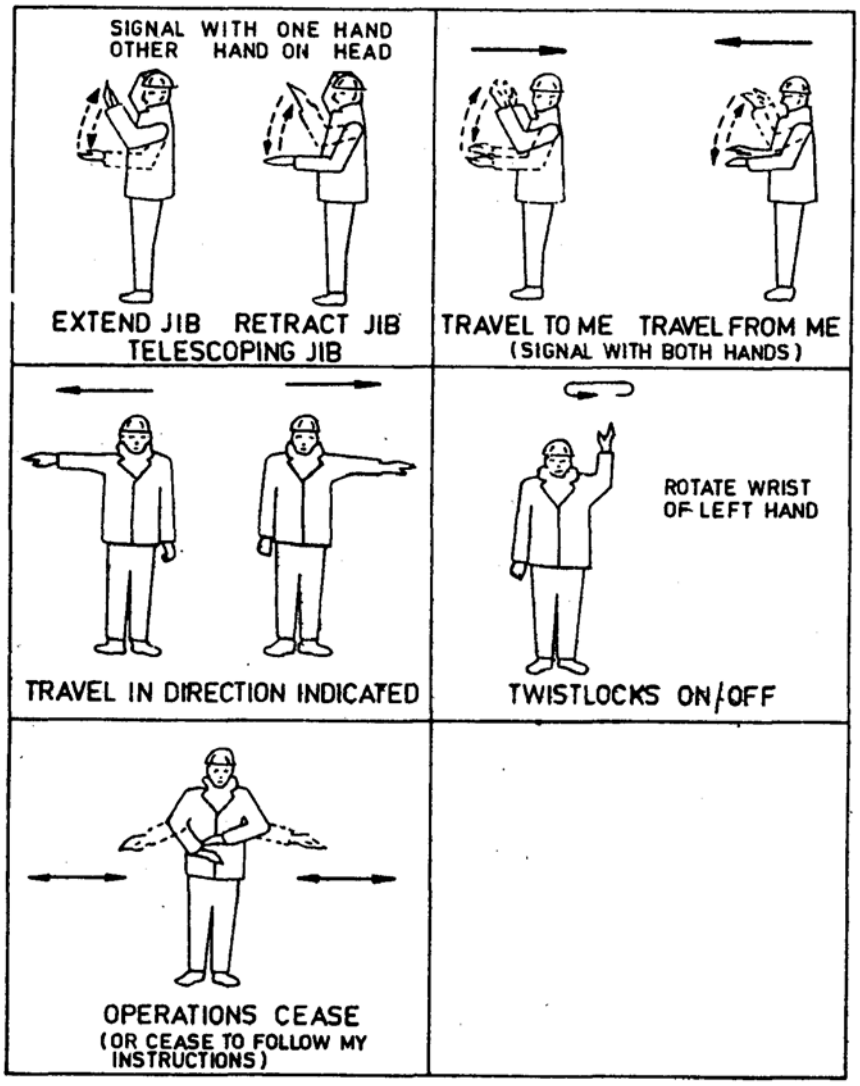


Fig. 8.4 Hand signal

8.9. LIFTING OPERATIONS

a) Risk assessment shall be made before starting the activity.
b) Operator of valid license having skill & training shall be permitted to operate the lifting appliances as per statutory requirement.
c) All lifting appliances shall be inspected by a third-party competent person as per statutory requirement.
d) Overload/ over-twist shall not be allowed during lifting operation.
e) Positioning of crane shall be on firmed & level ground to avoid settlement of ground.
f) A lifting plan shall be prepared, checked, and issued by competent authorized persons prior to any lifting operation.
g) Lifting work permit shall be obtained before any lifting activity & shall ensure the closing of permit after operation.
h) Angle & radius of crane shall be maintained as per lifting plan.
i) Trained & experienced banks man shall be deployed in lifting activity.
j) All safety devices in crane shall be in good working condition.
k) Only authorized person shall be allowed inside the lifting area.

l) Hand signal shall be used between lift coordinator and crane operators.
m) Crane operators and lift coordinators shall be briefed about the lift plan.

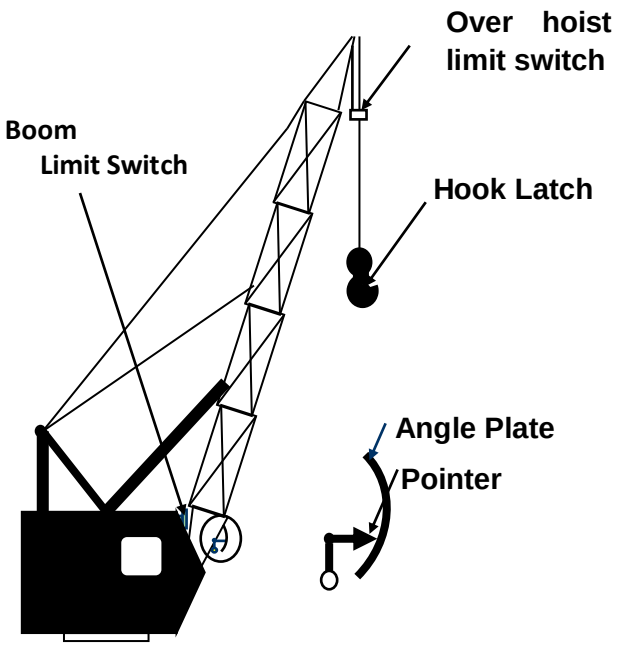


Fig. 8.5 Crane operations

n) Cordoning off area shall be done in and around the working area.
o) All foreign material shall be removed from the lifted load before lifting
p) Tag line shall be used for balancing the lifted load.

8.10 SAFE ACTS IN OPERATING A CRANE

1. No one but an authorized operator be allowed to use any crane.
2. When on duty, authorized operator should remain in the crane cabin ready for prompt service.
3. Operator should never go on top of the crane or permit anyone else to do so without opening the main power disconnect switch and looking it 'OFF' with a padlock.
4. Before moving the trolley or crane bridge, operator should be sure that the hook is high enough to clear obstacles.
5. Operator should never permit the crane to bump into another crane or the buffers.
6. Operator should examine the crane at the start of every shift for loose or defective gears, keys, runway railings, warning bell, signs, switches, down shop leads and cables and report defects. Make sure that the crane is kept clear and well lubricated.
7. While hoisting equipment is in operation, the operator should not be permitted to perform any other work and he should not leave his position at the controls until the load has been safely landed or returned to ground.
8. Operator should not carry the load over men on the floor, sound the bell when necessary.

9. Operator should not allow men to ride on a load or on crane hooks.

10. If the power goes off, move the controller to ‘OFF’ position until power is available again.

11. Fire extinguisher should be kept filled and in working condition.

8.11 SAFETY RULES FOR CRANE OPERATORS

1. Never pick up a load which is beyond the rated load capacity of the crane.
2. Never move the load or the crane unless you understand the signal.
3. Do not allow the load to swing.
4. When hoisting or lowering the load have clear space between load and adjacent machineries or objects.
5. Do not smoke while operating a crane.
6. Never leave a load suspended.

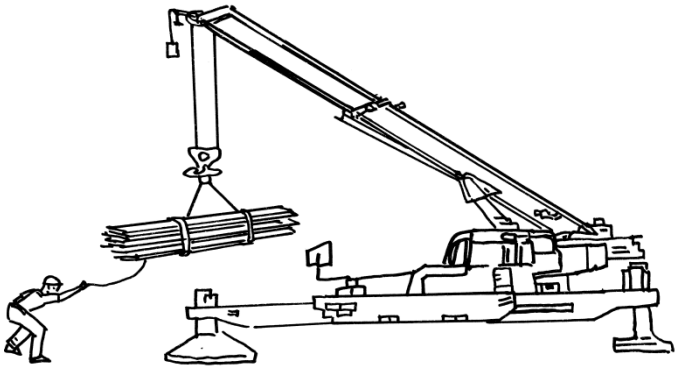


Fig. 8.6 Safe lifting with guide rope

8.12 SAFETY GUIDELINES FOR SLINGERS

1. Check the slings before taking it for use at the beginning of each shift.

2. A sling that has a stretched leg should not be used.

3. Choose the proper sling (SWL, wire or chain) according to the weight of the object to be lifted.

4. Use proper attachments so that, when lifted the object will not fall or tilt.
5. Satisfy yourself before giving orders to crane operator that all slings are securely holding.
6. Distribute the load equally on the legs of the sling.
7. The slings are not kinked, twisted or knotted.
8. Cylinders should be carried in a special cradle.
9. The hook should be centered on the load before hoisting signal given.
10. Slings should be lying on the center of the crane hook.
11. Hands should be kept out of pinch points, while hooking or unhooking.
12. Before slinging a load, find out if the unloading position is clear.
13. Sharp edged objects usually lifted with chain slings. When suitable chain slings are not available, wire rope sling with proper packing to protect the wire rope must be used.
14. Loose articles, should not be left on the load while moving the load.
16. When using shackle the pin should be fully screwed.
17. Machined objects should be lifted with manila rope slings. When using wire rope slings give wooden packing between the load and the sling.

18. Never carry load over men.
19. Always guide the load in moving. Go before long objects. When the load has to be raised and moved due to obstruction tie a line to the load and guides it.
20. Do not attempt to lift the load when the load is away from vertical reach of the crane hook.

8.13 WIRE ROPES INSPECTION WIRE DEFECTS AND INSPECTION

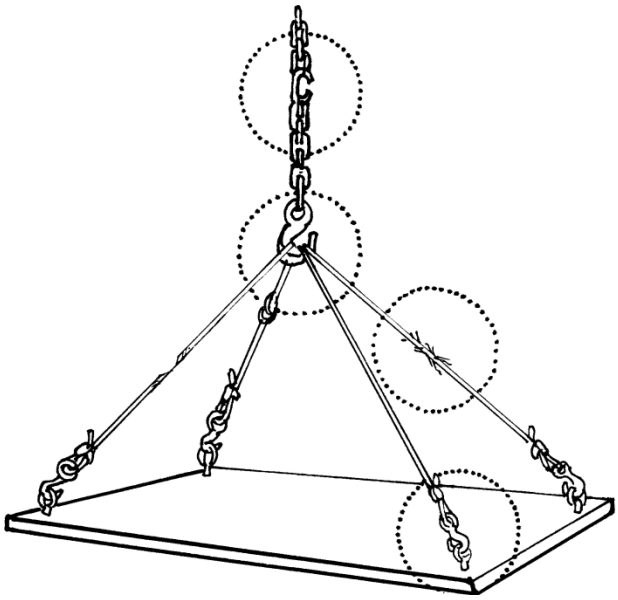


Fig. 8.7 Inspection of Wire ropes & accessories

Wire rope with one or more of the following defects shall be removed or replaced immediately. If one wire rope of a set (for example, multi – leg sling) requires replacement, the entire set of ropes shall be replaced.

Defect	Description
Corrosion	Any development of slight corrosion should be noted and watched closely. Severe corrosion shall be cause for replacement.
Broken wires	Six randomly distributed broken wires in one rope lay, or three broken wires in one strand in one rope lay, shall be cause for replacement. In standing ropes, more than two broken wires in one lay in areas beyond end connections, or more than one broken wire at an end connection, shall be cause for replacement. In running ropes, six randomly distributed broken wire in one lay or three broken wires in one stand in one lay shall be cause for replacement.
End attachments	Development of broken wires in the vicinity of attachments shall be cause for replacement. If this condition is localized in an operating rope, and the section in question can be eliminated by making a new attachment, this shall be done rather than replacing the entire rope.

Abrasion	Abrasion, scrubbing, flattening, or preening, causing the loss of more than one – third of the original diameter of the outside wire, shall be cause for replacement. 1mm FOR ROPE DIA UPTO 19mm 1.5mm FOR ROPE DIA UPTO 22-38mm 2mm FOR ROPE DIA UPTO 32-38mm
Kinking	Severe kinking, crushing, bird-caging, or other damage resulting in distortion of the rope structure shall be cause for replacement.
Heat	Evidence of heat damage resulting from contact with a torch, or any damage caused by contact with electrical wires shall be cause for replacement.

Chapter 9

ELECTRICAL SAFETY

9.1 Introduction

Construction sites are considered as one of the most dangerous places for workers. Life risks, potential hazards are numerous. According to Cindy Lovell, “the construction industry accident fatality rate stands at more than double that of the all sector average.” She added that “construction sites are a health and safety nightmare”. Many factors make construction work challenging for workers and engineers such as weather and safety concerns.

Electrical hazards are a major cause of death and serious injury on construction sites. It serves as a practical guidance to construction filed workers, employers, designers, manufacturers, importers, suppliers (including hirers), electrical contractors and electricians on eliminating or reducing the risk of electrocution and electric shock to any person.

High power is necessary for all the electrical equipment used on a construction site, like heavy-duty machinery and the complex network of electrical installations. This can either be interlinked or standalone. Here is a list of common electrical activities involved at construction sites:

i) Temporary power supply
ii) Fixed wiring
iii) Electrical switchboards
iv) Circuit breakers
v) Overhead solutions
vi) Generators
vii) Underground solutions
viii) High voltage solutions

i) Temporary power supply:

A construction site has high power requirements and it is wrong to assume that you will access power instantly and setting it up will be easy. It might be that it is located in a rural location or there are several geographical challenges. We need to set-up power supply temporarily but with help of expertise of a trained electrician to power up construction site as and when required basis.

Installation of the temporary wiring is done from the main source to the rest of the construction site where it is necessary. A construction site is already full of dangers at every corner, this electrical wiring should not add to it.

ii) Fixed wiring:

Fixed wiring is essential for all the electrical activities necessary on the site. This includes ensuring all the vital spots of a construction site have electrical power to use the heavy-duty equipment. This means installing power cables, sockets, distribution boards, etc.

It is vital to isolate the permanent wiring in the case of demolition work since it can be live. On the other hand, take necessary steps to ensure it is not active prior to approaching the space. It is also necessary to avoid damaging the permanent wiring during the construction work by isolating it properly and protecting it from common threats.

Fig.9.1 Electrical hazard

iii) Electrical switchboards:

A switchboard is an essential hub that is necessary to direct the electricity stream for the needs at the site. This will act as a source of power for the entire site with well-defined sections like the main power unit and that necessary for the distribution.

iv) Circuit breakers:

Circuit breakers provide protection against circuit overload and fire. Every final sub-circuit must be protected by a circuit breaker except final sub-circuits exceeding 50A, which may be protected with high rupturing capacity (HRC) fuses.

A construction site also requires basic safety measures to be implemented. An electric shock is one of the most common threats. This can be avoided by installing a circuit breaker in place. This type of system is designed to minimize the risk and protect those working with electrical devices.

v) Overhead solutions:

Installing an overhead distribution is one of the most cost-effective solutions and is also preferred by professionals to provide temporary power to the working site.

The right way to install it is to ensure it does not cross vital roads or access paths; especially those used by heavy machinery. In the case where it is essential for the wire to cross the road, it is a good idea to raise it high enough for the large vehicles to pass without any issue.

vi) Generators:

Generators are a common sight in this type of zone. Its portable nature ensures you can power your electrical devices in the remotest places. However, setting it up is something that should be best left to the professionals.

vii) Underground solutions:

It is highly likely that there will be a requirement for power underground as well. You can trust industrial electricians to meet your power requirement by connecting a power source underground.

viii) High voltage solutions:

They have innovative methods of meeting your high demand for power and do so by ensuring you have the least downtime. They will be able to supply you with high voltage power irrespective of the distance and power requirements.

9.2. Hazards in electrical activities at construction site

In construction site, working with electricity or activities involved are also one the major reason of any incident or Fatal.

Major Hazards involve in Electricity activities are:

a. Electrical Shock
b. Electric burn
c. Electrocution
d. Arc flash/arc blast.
e. Fire
f. Explosions

In other means, the following is a list of common causes for electrical hazards at construction sites:

- Improper grounding
- Exposed electrical parts
- Inadequate wiring
- Overhead power lines
- Damaged insulation
- Overloaded circuits
- Wet conditions
- Damaged tools and equipment

➢ **Electrical Shock :**

Whenever you work with power tools or on electrical circuits there is a risk of electrical hazards, especially electrical shock. Anyone can be exposed to these hazards at home or at work. Workers are exposed to more hazards because job sites can be cluttered with tools

and materials, fast-paced, and open to the weather. Risk is also higher at work because many jobs involve electric power tools.

If you are in contact with a live wire or any live component of an energized electrical device and also in contact with any grounded object you will receive a shock. Plumbing is often grounded. Metal electrical boxes and conduit are grounded.

Static electricity hazards, including lightning can be a source of ignition, and injuries. It can result in shock to personnel and damage to equipment directly. It may also lead to fires. Some operations (e.g. handling or transporting liquids, solids, or gases in portable containers or piping systems) generate static electricity hazards.

The danger from electrical shock depends on:

i) The amount of the shocking current through the body,
ii) The duration of the shocking current through the body, and
iii) The path of the shocking current through the body.
iv) Whether skin is wet or dry

Effects of Electrical Current on the Body:

AC current (mA)	Effect on human body
1	Slight tingling sensation
2-9	Small shock
10-24	Muscles contract causing you to freeze
25-74	Respiratory muscles can become paralysed; pain; exit burns often visible
75-300	Usually fatal; ventricular fibrillation; entry & exit wounds visible
>300	Death almost certain; if survive will have badly burnt organs and probably require amputations

Note**:** Effects are for voltages less than about 600 volts. Higher voltages also cause severe burns

- **Electric Burn:**

The most common shock-related, nonfatal injury is a burn. Burns caused by electricity may be of three types:

- Electrical burns,
- Arc burns, and
- Thermal contact burns.

Electrical burns can result when a person touches electrical wiring or equipment that is used or maintained improperly. Typically, such burns occur on the hands. Electrical burns are one

of the most serious injuries you can receive. They need to be given immediate attention. Additionally, clothing may catch fire and a thermal burn may result from the heat of the fire.

- **Electrocution:**

At construction sites, workers are exposed to live wires or electricity while they are doing repair work on homes or buildings. A wide variety of jobs require workers to handle devices that have active electricity running through them. There are typically three main types of electrical accidents that occur on a construction site:

- Contact with overhead power lines
- Contact with transformers and live wires
- Contact with electrical currents while working with tools, machinery and appliances

- **Arc flash/arc blast:**

Arcing faults in electrical equipment are multi-energy events (i.e., involving heat, blast, light, and sound) that generally produce high levels of energy release in a short-duration. It takes place due to phase to phase and phase to earth fault conditions. It may cause heavy flashover which may result in severe injury to employees in the close vicinity.

Arc blast occurs due to high-voltage arcs can also produce considerable pressure waves by rapidly heating the air and creating a blast. A high-voltage arc can also cause many of the copper and aluminium components in electrical equipment to melt. These droplets of molten metal can be blasted great distances by the pressure wave. Although these droplets harden rapidly, they can still be hot enough to cause serious burns or cause ordinary clothing to catch fire, even if you are 10 feet or more away.

- **Fire:**

Electricity is one of the most common causes of fires and thermal burns in homes and workplaces. Defective or misused electrical equipment is a major cause of electrical fires. If there is a small electrical fire, be sure to use only a Class C or multipurpose (ABC) fire extinguisher, or you might make the problem worse. All fire extinguishers are marked with letter(s) that tell you the kinds of fires they can put out. Some extinguishers contain symbols, too.

Most result from problems with fixed wiring. Problems with cords, plugs, receptacles, and switches also cause electrical fires. The flow of electrical current generates heat; the higher the current, the greater the heat. Without a fuse, the equipment might be damaged and the wiring would eventually become hot enough to melt its insulation and start a fire.

Static electricity hazards, including lightning can be a source of ignition, and injuries. It can result in shock to personnel and damage to equipment directly. It may also lead to fires.

- **Explosions:**

A high-voltage arc can produce a considerable pressure wave blast. In addition, such an explosion can cause serious ear damage and memory loss due to concussion.

Thermal burns may result if an explosion occurs when electricity ignites an explosive mixture of material in the air. This ignition can result from the build-up of combustible vapours, gasses, or dusts. The risk of explosion hazards associated with electrical equipment .e.g. Hydrogen filled generators, Pressurized gas cylinders, Stored energy hazards including capacitor bank explosion potential etc,.

9.3. Safety precaution at construction site:

During working on electrical equipment/ installation, the following safety measures shall be followed as applicable in National Rules & Code.

(1) Before commencement of any building or other construction work, the employer shall take adequate measures to prevent any worker from coming into physical contact with any electrical equipment or apparatus, machines or live electrical circuit which may cause electrical hazard during the course of his employment at a building or other construction work.

(2) The employer shall display and maintain suitable warning signs at conspicuous places at a building or other construction work in Hindi and in a local language understood by the majority of the building workers.

(3) In workplaces at a building or other construction work where the exact location of underground electric power line is not known, the building workers using jack hammers, crow bars or other hand-tools which may come in contact with a live electrical line, shall be provided by the employer with insulated protective gloves and footwear of the type in accordance with the national standards.

(4) The employer shall ensure that, as far as practicable, no wiring, which may come in contact with water or which may be mechanically damaged, is left on ground or floor at a building or other construction work.

(5) The employer shall ensure that all electrical appliances and current carrying equipment used at a building or other construction work are made of sound material and are properly and adequately earthed.

(6) The employer shall ensure that all temporary electrical installations at a building or other construction work are provided with earth-leakage circuit breakers.

(7) The employer shall ensure that all electrical installations at a building or other construction work comply with the requirements of any law for the time being in force.

Apart from the above guidelines, following practices shall be adopted to achieve the minimum level of health and safety.

- The construction field workers/employee, employers, designers, manufacturers, importers, suppliers (including hirers), electrical contractors and electricians shall follows the National laws, standards and codes as applicable:
- The training shall be provided to employees exposed to an electrical hazard when the risk associated with that hazard is not reduced to a safe level by the applicable electrical installation requirements. Such employees shall be trained to understand the specific hazards associated with electrical energy.

- Employees/contractors working on/near electrical equipment shall be trained in emergency response/first aid.
- Prior to carrying out any activity related to operation, maintenance or testing of electrical equipment, it shall be ensured that there is an appropriate Job Safety Analysis (JSA) supported with Hazard Identification and Risk assessment (HIRA) done and recorded.
- Fire and explosion hazards associated with electrical equipment shall be assessed and managed
- The employer shall display and maintain suitable warning signs at conspicuous places at a building or other construction work in English/Hindi and in a local language understood by the majority of the building workers
- Permit to Work (PTW) and Lock Out Tag Out (LOTO) Procedures to be followed
- All electrical work shall be done in compliance to Standard Operating Procedure (SOP)/ Standard Maintenance Procedure (SMP).
- "MEN ON LINE" "DO NOT SWITCH ON" "DANGER" or "CAUTION" board as applicable shall be used during maintenance works on the electrical equipment
- Checklist should be made available and filled up copies recorded.
- In construction work where the exact location of underground electric power line is not known, the workers shall be provided by the employer with insulated protective gloves and footwear of the type in accordance with the national standards.
- The employer shall ensure that, as far as practicable, no wiring, which may come in contact with water or which may be mechanically damaged, is left on ground or floor at a building or other construction work.
- All cables and wires shall be adequately protected mechanically against damages. In case the cable is required to be laid underground, it shall be adequately protected by covering the same with bricks. Plain cement Concrete (PCC) tile or any other approved means.
- Isolation and subsequent confirmation test shall be carried out to verify absence of voltage.
- All cable glands, armouring and sheathing of electric cables, metal circuits and their fittings, metallic fittings and other non-current carrying parts of electrical equipment and apparatus shall be effectively grounded
- Authorized Work Area cordoning off by barricading tape/Hard barricades shall be done prior to maintenance/testing
- Proper illumination shall be provided if the work has to be continued during dark hours.
- Hazard/flashing lights shall be installed if the work involves HV testing at 1 kV and above.
- The room in which work is being carried out should have adequate ventilation system and emergency exit points. Adequate communication systems should be made available
- Appropriate PPE and adequate safety apparel like arc suits shall be worn.
- Certified and insulated tools shall be used while performing electrical work.
- After completion of work the Removed material shall be stored / shipped to safe location.

- After completion of work Permit issuer shall physically check and ensure that the following are cleared before closing of PTW:
    a. Grounds
    b. Tools
    c. Spares
    d. Personnel
    e. Debris
    f. Scrap
- All Electrical equipment spares and tools should be inspected and maintained at regular intervals as per approved schedule.

Working on or near electrically energized equipment

The safety measures for working on or near Electrically energised equipment are as follows:

- Work on or near any live conductor should be carried out only in case of exceptions, after a thorough HIRA has been carried out.
- When working on or near energized electrical equipment it shall be ensured that no other work should be performed within the prohibited approach boundary.
- Assumes that every electric line is energized though it is new line or deadline. And always opened jumper of energized line.
- To avoid electrocution or electric shock, one must isolate the line by removing jumper, LOTO system, provide earthing, provide insulation, double earthing for equipment.
- Testing which calls for Voltage injection is allowed within the prohibited approach boundary provided proper test equipment's and PPE are used and the personnel are competent and qualified.
- Permission to work on such locations requires authorization from a senior authorized person/Engineer in-charge regardless of the PPE used or design of equipment.
- Recommended PPE: Helmet, voltage rated hand gloves, safety shoes, safety goggle with face shield, FR (Flame Resistant) coat, gas mask, acid resistant aprons.

Testing for absence of voltage

The safety measures for testing for absence of voltage are as follows:

- All circuits are considered energized until verified dead by testing it with appropriate instruments such as non-range selectable voltage indicators (Common DC/AC range voltmeter while verifying whether LV circuits are de-energized)
- All Cable Compartments of switchgears shall have back charge indicators. These back charge indicators shall be checked for no voltage before accessing the cable compartment. The healthiness of these back charge indicators must be monitored as per Standard Operating Procedure (SOP)/ Standard Maintenance Procedure (SMP).
- Ensure metallic segregation of Bus side (source) and Cable side (load) Compartment before entering any compartment for maintenance testing inspection. Metallic segregation shall be ensured between cable side (load) compartments.
- Ensure that all test instruments or equipment used are designed and certified to meet the requirements and are rated in all aspects for the category of the task to be performed.

- Practice of “Test Before Touch” (TBT) and performance of positive confirmatory test of the instrument before every use should be followed. Insulation healthiness level of test instrument should be confirmed before using them as it is likely to be in contact with a live 220 kV line. Insulation should be physically checked for cleanliness, dryness and free of cracks/breakages. Always store such instruments in protected cases.
- Recommended PPE: Helmet, Shoes, voltage rated hand gloves, safety shoes, safety goggles with face shield and Flame Resistant coat.

Dismantling of electrical raceways and cables

The safety measures for dismantling of raceways and cables are as follows

- The identification, cutting, and removal of electrical raceways and cables often involve a high level of risk in determining that cables are not damaged while removed cable trays and that in case of cable removal the correct cable is removed.

- The cable left behind after removal of cable tray must be adequately supported and protected from damage by adjacent equipment, moving parts, UV rays, hot pipe lines, etc.

- Maintain proper labelling and identification of cables at both ends to avoid the error of mistaken identity (Refer Lockout Tag out Procedure).

- Test for the absence of voltage at the source and destination ends of each cable. Follow live cable identification procedures and positively identify each cable before it is cut.

- Ensure all protection and isolation system are working.

- A good practice would be to positively identify other cables in the vicinity

Relocation of equipment

The safety measures for relocation of equipments are as follows

- Before relocation of equipment / electrical systems from one place to another a formal risk assessment should be carried out.

- When equipment / electrical system are relocated to a new place it shall be ensured that it will work in a safe manner.

- Alternate power supply should be made available during relocation work wherever applicable/possible. This will improve availability and reduce pressure of time constraint while carrying out replacement job.

Excavations and drilling in walls

The electrical safety measures excavation and drilling in walls are as follows

- Ensure that the electrical lines, conduits, and cables in the area of work activity are identified before performing excavation and drilling of floors, roofs, walls.

- Up-to-date maps / drawings/electronic tracers systems may be used for locating underground / concealed cables

- GIS system may be referred to wherever it is available.
- Prior to excavation and penetration, it shall be ensured that there is an appropriate Job Safety Analysis (JSA), Permit to Work (PTW) and Lock out Tag out (LOTO) compliance supported with Hazard Identification and Risk Assessment (HIRA).

9.4. Management of electrical hazards

The management of electrical hazards are as follows

a) Shock Hazard :

The following technologies should be adopted to complement the overall shock protection program and to minimize the risk of shock:

- Voltage-rated gloves shall be worn wherever a shock hazard is present.
- Proper design, installation, and maintenance of equipment earthing which is critical to managing shock hazards shall be ensured.
- Installation of RCCB (Residual Current Circuit Breakers)/ELCBs (Earth Leakage Circuit Breaker) shall be carried out based on the company's standards / procedures. Periodic test of RCCB/ELCB should be carried out.
- Battery-powered tools instead of AC power driven tools to be used wherever possible.
- Double-insulated equipment
- Shrouding and barriers
- Insulated or voltage-rated tools
- Voltage-rated PPE (e.g., gloves or helmets)
- Insulated mats for floors
- Insulated, flexible barriers for exposed equipment parts
- Identification of multiple voltage sources inside cabinets
- Segregated voltages to prevent accidental contact where multiple voltage sources exist in one unit, terminal blocks, and marshalling boxes
- Finger-safe terminals to prevent finger contact
- Prohibited approach boundary limit for circuit parts and conductors shall be crossed only by a qualified and competent person under the written authorization from management.

b) Arc / Flashover Hazards:

Arcing faults in electrical equipment are multi-energy events (i.e., involving heat, blast, light, and sound) that generally produce high levels of energy release in a short-duration

- It takes place due to phase to phase and phase to earth fault conditions. It may cause heavy flashover which may result in severe injury to employees in the close vicinity.
- Company power shall clearly specify the level of Incident Energy above which the recommended PPE's (such as cool coat, face shield with goggles, safety shoes, hand gloves and insulated electrical hand tools) are to be used.
- Areas where dangers of Arc/Flashover hazards can occur should be identified.
- There should be warning boards wherever use of arc suit is mandatory.

- This phenomenon can occur at low voltage levels as well. Areas where dangers of Arc/flashover hazards can occur should be identified. There should be warning boards wherever use of arc suit is mandatory.

c) Static Electricity Hazards

The following techniques should be adopted to manage the static electricity hazards:

- Static electricity hazards, including lightning can be a source of ignition, and injuries. It can result in shock to personnel and damage to equipment directly. It may also lead to fires.
- Some operations (e.g. handling or transporting liquids, solids, or gases in portable containers or piping systems) generate static electricity hazards.
- Certain maintenance activities (e.g. steam cleaning, industrial vacuuming, and sandblasting), generate static electricity hazards.
- Ensure proper earthing and bonding of earthing conductors to equipment and structures to prevent generation of static electricity.
- Each site shall be equipped with adequate lightning arrestors.

d) Fire and explosion hazards:

Assess and manage the risk of explosion hazards associated with electrical equipment .e.g. Hydrogen filled generators. These should include, but are not limited to:-

- Provision and maintenance of drawings and documents describing the limits of the hazardous area and its classification.
- Selection and procurement of electrical and non-electrical equipment appropriate for the area classification.
- Maintenance of the mechanical integrity of the installation, including grounding and bonding.
- Promptly arresting the leakage of combustible gases and liquid and avoid accumulation of combustible waste.
- No hot work to be carried out without “HOT WORK PERMIT”
- In the absence of Work Permit System in that particular site, a system should be put in place to ensure that hot work is conducted in a safe and secure manner.

e) Temporary wiring:

The following techniques should be adopted to manage the temporary wiring hazards

- Temporary wiring shall be done with all safety systems, ELCBs, warning signs, in place and in working condition.
- Knowledge of source isolation points shall be known to the working personnel.
- Wiring for temporary supply shall be done with proper plug and socket arrangement.
- Proper earthing should be applied to all equipment and tools used.
- Temporary wiring will be allowed only in the following cases:
    a) Construction, remodelling, demolition of buildings and / or structures. Maintenance, repair of equipment
    b) Emergencies, testing activities, experiments and developmental work

c) Temporary wiring shall be removed immediately upon completion of construction, or the purpose for which it was installed

- Special precautions should be taken in case of temporary wiring installation.
- All armoured cables shall be properly terminated by using suitable cable glands.
- Multi stranded conductor cables shall be connected by using cable lugs/sockets. Cable lugs shall preferably be crimped. They shall be of proper size and shall correspond to the current rating and size of the cable. Twisted connections will not be allowed.

f) Earthing

The control techniques of earthing are:

- All extraneous metal parts of an electrical installation and adjacent metal work shall be connected to earth.
- The design of the earth system shall take into account the protection of life from raised voltages on external parts and the correct operation of the electrical protection systems.
- Dual earthing should be provided.
- Appropriate means shall be used to test the integrity of earthing systems periodically.
- The design of the system should consider the requirement to test wherever possible.
- Proper symbols and colour codes should be used for earthing system.
- Earthing System should be theft proof. In case of theft it should be replaced immediately.

g) Overhead lines

To control the risks and dangers of overhead lines are:

- Work in areas where overhead lines are present should be monitored carefully. A formal risk assessment / Job Safety Analysis shall be carried out and adequate precautions taken before such work is permitted.
- Adequate precautions should be taken while using long length equipment and tackles in these areas.
- Reduction in clearances should be considered while working in vicinity of HV lines.
- Personnel working in these areas should be aware of Induction Voltages present.
- Personnel should be alert to fault occurring on adjacent lines. Working at height Procedure shall be followed.

h) Maintenance requirements for portable electric tools and equipment:

Attachment plugs, receptacles, cover plates, and cord connectors shall be maintained such that the following criteria are met:

- There are no breaks, damage, or cracks exposing energized conductors and circuit parts.
- There are no missing cover plates.
- Terminations have no stray strands or loose terminals.
- There are no missing, loose, altered, or damaged blades, pins, or contacts.

Chapter 10

WORK AT HEIGHT

10.1 Introduction

Falls from height are one of the biggest causes of workplace fatalities and major injuries. Common causes are falls from ladders and through fragile roofs. Work at height means work in any place where, if there were no precautions in place, a person could fall a distance liable to cause personal injury.

Before working at height you must work through these simple steps:

- Avoid work at height where it is reasonably practicable to do so;
- Where work at height cannot be avoided, prevent falls using either an existing place of work that is already safe or the right type of equipment;
- Minimise the distance and consequences of a fall, by using the right type of equipment where the risk cannot be eliminated.

Employers and those in control of any work at height activity must make sure that the work is properly planned, supervised and carried out by competent people. This includes using the right type of equipment for working at height.

Fall Protection

Generally, fall protection can be provided through the use of guardrail systems, safety net systems, or personal fall arrest systems.

F*ig*. 10.1. Guardrail system

10.2 Guardrail Systems

Guardrail systems are barriers erected to prevent workers from falling to lower levels. Top rails, or equivalent guardrail system members, must be enough in accordance with the national standards. When mid-rails are used, they must be installed at a height midway between the top edge of the guardrail system and the walking or working level. Guardrail systems must be capable of withstanding a force in accordance with the national standards.

Fig.10.2. Fall protection

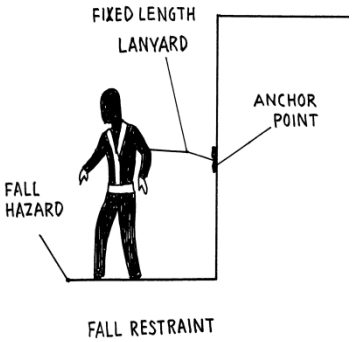
10.3 Personal Fall Arrest Systems

A personal fall arrest system is a system used to safely stop (arrest) a worker who is falling from a working level. It consists of an anchorage, connectors, and a body harness. It also may include a lanyard, deceleration device, lifeline, or suitable combinations of these.

10.4 Personal Fall Arrest System Components

Snap-hooks – Snap-hooks must be the locking type and designed and used to prevent disengagement from any component part of the personal fall arrest system.

Horizontal Lifelines- Horizontal lifelines must be designed, installed, and used under the supervision of a qualified person, as part of a complete personal fall arrest system that maintains a safety factor of at least two.



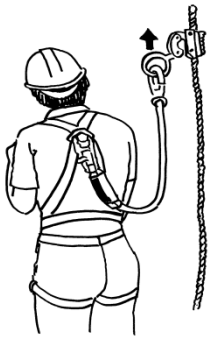


Fig.10.3. Anchoring of full body harness

Anchorages- Anchorages used to attach personal fall arrest systems must be designed, installed, and used under the supervision of a qualified person, as part of a complete personal fall arrest system which maintains a safety factor of at least two. Alternatively, the anchorages must be independent of any anchorage being used to support or suspend platforms and must be capable of supporting sufficient strength conforming the national standards or be capable of supporting at least twice the expected impact load.

10.5 Safety Net Systems - When safety nets are used, they must be installed as close as practicable under the walking or working surface on which workers are working and never more than 30 feet below that level. Drop-testing is required to ensure that safety nets and safety net installations are working properly. Do not use defective nets. Inspect nets at least

once a week for wear, damage, or deterioration of components such as net connection points. To work properly, a safety net must have safe openings. Mesh openings must not exceed 36 square inches, and must not be longer than 6 inches on any side. Each opening, measured center-to-center of mesh ropes or webbing must not exceed 6 inches.

FALL PREVENTION

10.6 Fall Restraint Systems

Generally fall restraint system is recognised as a means of prevention. This system is comprised of a body belt or body harness, an anchorage, connectors, and other necessary equipment. Other components typically include a lanyard, a lifeline, and other devices. For a restraint system to work, the anchorage must be strong enough to prevent the worker from moving past the point where the system is fully extended, including an appropriate safety factor.

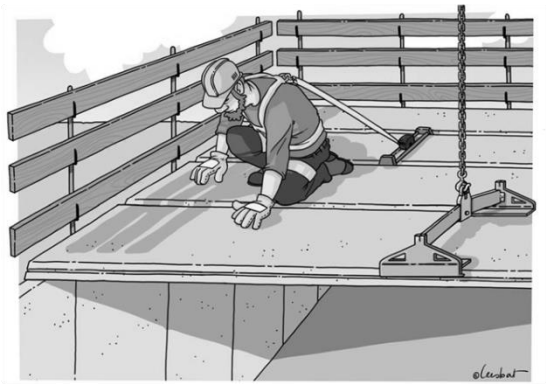


Fig.10.4. Fall protection system

10.7 Scaffolding

Scaffolding shall be erected, dismantled, moved, and modified only under the direction of a qualified person and by employees who have received appropriate and specific training for the work they are to perform. Determination and designation of competent persons for scaffold work are the responsibility of the site except where local regulations set other criteria. The employer shall ensure at a construction site of a building or other construction work that no scaffold is erected, added, altered or dismantled except under the supervision of a responsible person for such erection, addition, alteration or dismantling. The scaffolds so constructed shall conform with the requirements of National Standards and Codes as applicable.

Categories and Classification:

- Tube and coupler scaffold
- Suspended scaffold
- Mobile scaffold

Specifications of Scaffolds as applicable to the Indian Standards - IS 3696-1, 1987: Safety requirements for the erection, use and dismantling of scaffolds and IS 3696-2, 1991: Scaffolds and Ladders - Code of Safety, Part 2: Ladders

All elevated structures/ working platform areas shall be guarded on all sides. Railings and toe boards shall be provided on the platform.

- Scaffolds shall be designed to support at least 4 times the anticipated weight of Men and material
- Make certain that all scaffolds are in plumb and level at all times.
- Scaffolds shall be secured from tipping when the scaffold height exceeds four times its minimum base dimension.
- Landing platform should be provided at every 9 meter of height.
- The employer shall ensure at a construction site of a building or other construction work that—

  (a) Every scaffold and every component thereof is of adequate construction, made of sound material and free from defects and is safe for the purposes for which it is intended for use;

  (b) In case bamboo is used for scaffolding, such bamboo is of suitable quality, good condition, free from protruding knots and stripped off to avoid any injury to building workers during handling such bamboo;

  (c) All metal scaffolds used in building or other construction work conform to be relevant national standards.

Specifications of Scaffolds applicable to Tube-and-Coupler Scaffold:

- Minimum height of first horizontal member (Ledger) of scaffolds from the Ground/Kicker lift member shall be 2.2 meters. When scaffold is more than 6 meter height or carrying heavy load, kicker lift should be provided.
- The mid rail and Top rail shall be at height 600 mm and 1200 mm respectively and toe boards (150mm) shall be securely attached to the platform.
- Wall scaffoldings shall be secured between structure and scaffolding, at least every 10 meters of length and 8 meters of height.
- Minimum overlap of vertical members (standards) and/ or horizontal members (Ledgers) shall be 600 mm with at least two couplers.
- Base plate 100 x 100 x 3 mm shall be used to support all vertical pipes of Scaffolds.
- Sole plate of 300 x 300 x 6 mm shall be used at all unpaved area to support base plate.

10.8 Mobile Scaffolds

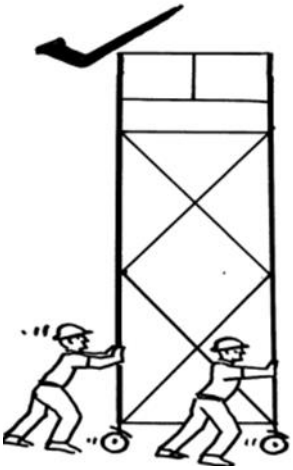


Fig.10.5. Mobile scaffold

- Attach castors with plain stems to the panel or adjustment screw by pins or other suitable means. Mid rail and Top rail shall be at height 600mm and 1200 mm respectively.
- Apply castor brakes at all times when a scaffold is not being moved.
- Remove all material and equipment from platform before moving scaffolding.
- Do not try to move rolling scaffolding without sufficient help. Watch out for holes in the floor and for overhead obstructions.
- Do not use brackets on rolling scaffoldings without first considering the overturning effect.
- Mobile Scaffolds shall be designed to restrict maximum height verses length to 4:1

Chapter 11

SAFETY IN HIGH RISE BUILDING CONSTRUCTION

11.1 Introduction

Any building/ structure of more than 15 m height is considered as High Rise Building and specific safety precautions are required to be taken.

The International Conference on Fire Safety defines high rise building as any structure where the height can have a serious impact on evacuation.

11.2 NEED OF HIGH RISE BUILDING:

High rise buildings are becoming prominent these days due to following reasons

1. Scarcity of land due to increasing demand, especially in metro cities.
2. Demand for business and residential space is increasing
3. Technological advancement innovations in structural Engineering
4. Desire for aesthetics in urban setting cultural and
5. Status attached by human aspiration to build higher.

11.3 SAFETY IN DESIGN

The construction of a high-rise building requires a lot of planning. One of the aspects that need to be covered during the planning stage is safety. For high-rise buildings, safety becomes a factor that needs to be managed head-on. There are risks that need to be mitigated before the structure is constructed and is deemed safe for its occupants.

11.4 SAFETY CONSIDERATIONS FOR THE CONSTRUCTION OF HIGH-RISE BUILDINGS:

Structural Integrity

The structure of a high-rise building must be able to handle a much bigger load than one or two-story houses, so structural integrity becomes an essential factor to get safety right from the planning stage. Calculations related to the design of the building, its weight-bearing capacity, and the overall load capacities of the structure are usually done multiple times before the project is started. This is also the reason why high-rise structures use steel reinforcement inside concrete. The addition of steel pilings in the foundations adds strength and load capacity. At the same time, the use of steel pile reinforcement also helps with the building’s fire resistance. The pre-fabricated cages are designed to be fire resistant as well.

Temporary structures

Most accidents in high-rise buildings occur during the construction phase. This is because, in general, temporary structures and processes used in construction are more susceptible to failure than permanent structures themselves. The failure of temporary structures is due to the following factors:

i. Foundations for temporary structures are also less known
ii. Personnel involved are mostly uneducated labourers.
iii. Temporary structures are not subjected to testing.
iv. The structures are dismantled and reused many times because of which their components get damaged at critical locations.
v. Contractor does not follow all the requirements.

Unauthorised changes-

Contractors often modify or substitute components or the sequence of erection because of the following reasons-

i. To use available materials or equipment
ii. To avoid delay, to make up for lost time
iii. To overcome site or fabrication constraints

Risk management in construction

Many methods are available to reduce high-rise construction risks. They are required to be followed according to the hierarchy, in decreasing order of importance and effectiveness:

(a) Elimination of scaffold risks-
Apartment blocks are fabricated, or cast and cured at ground level, and then picked up and stacked one on top of another by cranes.

(b) Substitution of risky products or processes by less risky ones-

Using Climbing formwork, Mast climbers, single and double

(c) Engineering controls for risk mitigation-

(i) Preventing workers from falling – Providing Guardrails and toe-boards at open sides and around voids, Roof brackets and slide guards, Warning lines (tapes) and barricades, Covers on holes, Lifelines and anchors for work positioning systems.

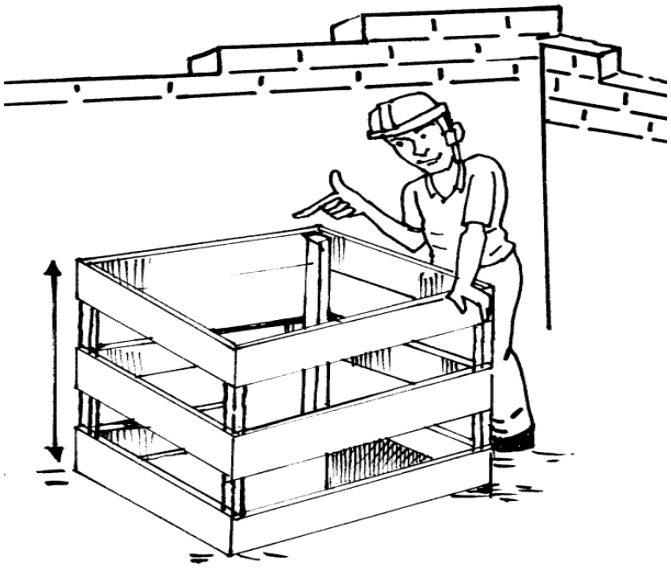


Fig.11.1. Protection for floor opening

(ii) Preventing workers from hitting the ground and dying ("Passive fall arrest") - Lifelines and anchors for fall restraint and fall arrest systems, Safety nets and air cushions. The lifelines and anchors must be designed and positioned for maximum forces and deflections under worst case scenarios.

Further, the pendulum effect in slipping sideways or from other critical positions and worker hitting the ground or other solid object, must be carefully examined, and lifeline configurations and anchorage points may be correspondingly provided.

(d) Administrative controls for risk mitigation:
It is necessary that Budget for safety management is provided. Administrative controls includes providing training, putting up posters, Warning signs, developing Safe work procedures, Rotation of workers while doing fatiguing and difficult jobs, Implementing Tag out and lockout for critical work.

(e) Personal Protective Equipment (PPE) – It consists of helmet, overalls, goggles, ear-plugs, gloves, safety shoes, gas mask, belt, full body harness, etc. Belts and harnesses are referred to as "active fall arrest" equipment.

Even with all these risk control measures, there will be some residual risks left. These can be controlled and managed only by strict supervision and inspection, to ensure that the controls are implemented, maintained and applied properly, and that the PPE are used by the workers correctly and all the time.

Rescue and emergency preparedness:

During construction, there may crop-up emergencies such as accidents, natural or man-made disasters.etc. These situations are especially critical in high-rise construction. Fires and explosions are common examples of such emergencies.

As a practice it is necessary that safety controls include appropriate rescue equipment and personnel trained in proper rescue procedures. These may include: First aid equipment, tripods and lifting equipment to shift workers from enclosed spaces, resuscitation equipment, fall rescue equipment, etc.

11.5 CONSTRUCTION TECHNIQUES AND SAFETY REQUIREMENTS

Conventional

Fig.11.2.Conventional technique

This is the common method of construction. The standard method of having barricades, guardrails, mid-rails is used.
The conventional method is labour intensive and speed of construction is relatively slow. The safety issues of concern in this method are:

i. No scheme arrangements/drawings are available
ii. There is large dependence on quality of wooden members, Strength of fittings/connections,
iii. No criteria for inspection can be made
iv. It is highly labour intensive
v. Requires Skilled manpower,
vi. Requires Edge protection when working at height,
vii. A lot Wooden waste is generated and therefore fire hazards
viii. Poor housekeeping because of nails, wooden pieces, etc.

Shear Wall

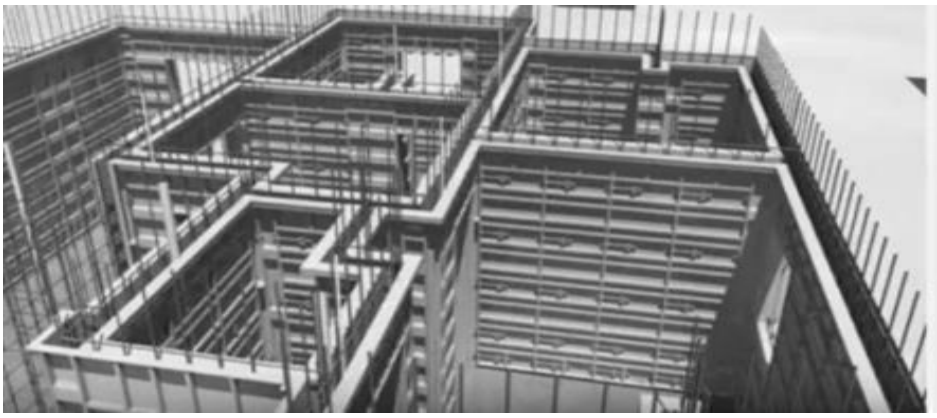


Fig.11.3. Shear wall technique

This method of construction deploys shear wall technique and is suitable for construction of buildings of more than 25 floors. The method is faster than the conventional method and provides for better safety of workers.

The safety issues are:

i. Safety consideration during the design stage itself is required
ii. The precautions are required to be taken for fall prevention during steel fixing and the erection of formwork.
iii. Care is required to be taken to prevent collapse of the formwork / false work.
iv. Care is required to be taken to prevent of materials falling during the striking of formwork.
v. Manual handling of shutters, reinforcing bars etc. are safety issues of concern
vi. Prevention of Arm and back strain for steel fixers is required.

Tunnel Form Work

This method of construction of high rise buildings is very fast with Good Safety considerations for workers

Fig.11.4. Tunnel form work

1. In this method also the Safety requirements are to be considered in design stage itself
2. Requires lifting & erection of Heavy Structure
3. Requires use of heavy equipment & machineries
4. Care is required to be taken for fall prevention during steel fixing and the erection of formwork.
5. Precautions are required to be taken to prevent collapse of the formwork / false work.
6. Edge protection are required to be in place,
7. It is necessary to take care of arm and back strain for steel fixers

Precast

Fig.11.5. Precast structure technique

This technique uses precast structure to construct the high rise building. This method is very fast but requires a great deal of planning and safety considerations right at the design stage. In addition the following safety issues are important:

i. Safety requirements in design,
ii. Safe methods of lifting & erection of heavy panels are required
iii. It requires use of heavy equipment & machineries
iv. Care is required to be taken for fall prevention during steel fixing and the erection.
v. Edge protection are to provided
vi. The Arm and back strain for steel fixers is a matter of concern.
vii. Safety issues are to be considered during casting of structures and their transportation.

11.6 Important Safety consideration with reference to the Access from Highways/Important Roads

For high rise buildings and buildings other than residential, the following additional provisions of means of access shall be ensured:

a) The width of the main street on which the building abuts shall not be less than 12 m and one end of this street shall join another street not less than 12 m in width;

b) The approach to the building and open spaces on all its sides up to 6 m width and the layout for the same shall be done in consultation with the Chief Fire Officer of the city and the same shall be hard surface capable of taking the mass of fire engine, weighing up to 45 tonnes. The said open space shall be kept free of obstructions and shall be motorable.

c) The main entrance to the plot shall be of adequate width to allow easy access to the fire engine and in no case shall it measure less than 6 m. The entrance gate shall fold back against the compound wall of the premises, thus leaving the exterior access way within the plot free for movement of fire service vehicle. If the main entrance at the boundary wall is built over, the minimum clearance shall be 4.5 m. A turning radius of 9 m shall be provided for fire tender movement.

FIRE PROTECTION IN HIGH RISE BUILDING

A high rise building during construction shall be provided with the following fire protection measures, which shall be maintained in good working condition at all the times:

a) Dry riser of minimum 100 mm diameter pipe with hydrant outlets on the floors constructed with a fire service inlet to boost the water in the dry riser and maintenance should be as per the requirements laid down in good practice.

b) Drums filled with water of 2 000 litres capacity with two fire buckets on each floor; and

c) A water storage tank of minimum 20 000 litres capacity, which may be used for other construction purposes also.

11.7 SAFETY REQUIREMENTS FOR ERECTION OF CONCRETE FRAMED STRUCTURES (HIGH-RISE BUILDINGS)

Handling of Plant

I. Mixers

1. All gears, chains and rollers of mixers shall be properly guarded. If the mixer has a charging skip the operator shall ensure that the workmen are out of danger before the skip is lowered. Railings shall be provided on the ground to prevent anyone walking under the skip while it is being lowered.

2. All cables, clamps, hooks, wire ropes, gears and clutches, etc, of the mixer, shall be checked and cleaned, oiled and greased, and serviced once a week. A trial run of the mixer shall be made and defects shall be removed before operating a mixer.

3. When workmen are cleaning the inside of the drums, and operating power of the mixer shall be locked in the off position and all fuses shall be removed and a suitable notice hung at the place.

II. Cranes

1. Crane rails where used shall be installed on firm ground and shall be properly secured. In case of tower cranes, it shall be ensured that the level difference between the two rails remains within the limits prescribed by the manufacturer to safeguard against toppling of the crane.

2. Electrical wiring which can possibly touch the crane or any member being lifted shall be removed, or made dead by removing the controlling fuses and in their absence controlling switches.

3. All practical steps shall be taken to prevent the cranes being operated in dangerous proximity to a live overhead power line. In particular, no member of the crane shall be permitted to approach within the minimum safety distances. If it becomes necessary to operate the cranes with clearances less than those specified above, it shall be ensured that the overhead power lines shall invariably be shut off during the period of operation of cranes. Location of any underground power cables in the area of operation shall also be ascertained and necessary safety precautions shall be taken.

4. Cranes shall not be used at a speed which causes the boom to swing.

5. A crane shall be thoroughly examined at least once in a period of 6 months by a competent person who shall record a certificate of the check.

6. The operator of the crane shall follow the safe reach of the crane as shown by the manufacturer.

7. No person shall be lifted or transported by the crane on its hook or boom.

8. Toe boards and limit stops should be provided for wheel barrows on the loading/unloading platforms. Material should be loaded securely with no projections.

9. Concrete buckets handled by crane or overhead cableway shall be suspended from deep throated hooks, preferably equipped with swivel and safety latch. In the concrete buckets, both bottom drop type and side drop type, closing and locking of the exit door of the bucket shall always be checked by the man-in-charge of loading concrete in the bucket to avoid accidental opening of the exit door and consequent falling of concrete.

10. Interlocking or other safety devices should be installed at all stopping points of the hoists. The hoists shaft way should be fenced properly.

11. When the bucket or other members being lifted are out of sight of the crane operator, a signalman shall be posted in clear view of the receiving area and the crane operator.

12. A standard code of hand signals shall be adopted in controlling the movements of the crane, and both the driver and the signaller shall be thoroughly familiar with the signals. The driver of the crane shall respond to signals only from the appointed signaler but shall obey stop signal at any time no matter who gives it.

13. If a travelling gantry crane is operating over casting beds, a warning signal which sounds automatically during travel should be provided to avoid accidents to workmen crossing or standing in the path of the moving loads.

III. Trucks

When trucks are being used on the site, traffic problems shall be taken care of. A reasonably smooth traffic surface shall be provided. If practicable, a loop road shall be provided to permit continuous operation of vehicles and to eliminate their backing. If a continuous loop is not possible, a turnout shall be provided.

IV. Concrete Pumps (Air Compressor Operated)

Safety requirements in accordance with good practice shall be followed.

V. Formwork

1. Formwork shall be designed after taking into consideration spans, setting temperature of concrete, dead load and working load to be supported and safety factor for the materials used for formwork
2. All timber formwork shall be carefully inspected before use and members having cracks and excessive knots shall be discarded.
3. As timber cantering usually takes an initial set when vertical load is applied, the design of this cantering shall make allowance for this factor.
4. The vertical supports shall be adequately braced or otherwise secured in position that these do not fall when the load gets released or the supports are accidently hit.
5. Tubular steel cantering shall be used in accordance with the manufacturer's instructions. When tubular steel and timber cantering is to be used in combination necessary precautions shall be taken to avoid any unequal settlement under load.
6. A thorough inspection of tubular steel cantering is necessary before its erection and members showing evidence of excessive resting, kinks, dents or damaged welds shall be discarded. Buckled or broken members shall be replaced. Care shall also be taken that locking devices are in good working order and that coupling pins are effectively aligned to frames.

7. After assembling the basic unit, adjustment screws shall be set to their approximate final adjustment and the unit shall be level and plumb so that when additional frames are installed the tower shall be in level and plumb. The cantering frames shall be tied together with sufficient braces to make a rigid and solid unit. It shall be ensured that struts and diagonals braces are in proper position and are secured so that frames develop full load carrying capacity. As erection progresses, all connecting devices shall be in place and shall be fastened for full stability of joints and units.
8. In case of timber posts, vertical joints shall be properly designed. The connections shall normally be with bolts and nuts. Use of rusted or spoiled threaded bolts and nuts shall be avoided.
9. Unless the timber cantering is supported by a manufacturer's certificate about the loads it can stand, cantering shall be designed by a competent engineer.
10. Cantering layout shall be made by a qualified engineer and shall be strictly followed. The bearing capacity of the soil shall be kept in view for every centering job. The effect of weather conditions as dry clay may become very plastic after a rainfall and show marked decrease in its bearing capacity.
11. Sills under the supports shall be set on firm soil or other suitable material in a pattern which assures adequate stability for all props. Care shall be taken not to disturb the soil under the supports. Adequate drainage shall be provided to drain away water coming due to rains, washing of forms or during the curing of the concrete to avoid softening of the supporting soil.
12. All centering shall be finally, inspected to ensure that:

    a) Footings or sills under every post of the centering are sound.
    b) All lower adjustment screws or wedges are sung against the legs of the panels.
    c) All upper adjustment screws or heads of jacks are in full contact with the formwork.
    d) Panels are plumb in both directions.
    e) All cross braces are in place and locking devices are in closed and secure position.
    f) In case of CHHAJAS and balconies, the props shall be adequate to transfer the load to the supporting point.

13. During pouring of the concrete, the centering shall be constantly inspected and strengthened, if required, wedges below the vertical supports tightened and adjustment screws properly adjusted as necessary. Adequate protection of centering shall be secured from moving vehicles or swinging loads.

14. Forms shall not be removed earlier than as laid down in the specifications and until it is certain that the concrete has developed sufficient strength to support itself and all loads that will be imposed on it.

Only workmen actually engaged in removing the formwork shall be allowed in the area during these operations. Those engaged in removing the formwork shall wear helmets, gloves and heavy soled shoes and approved safety belts if adequate footing is not provided above 2 m level. While cutting any tying wires in tension, care shall be taken to prevent backlash which might hit a workman. The particular order in which the supports are to be dismantled should be followed according to the instructions of the site engineer.

VI. Ramps and Gangways

1. Ramps and gangways shall be of adequate strength and evenly supported. They shall either have a sufficiently flat slope or shall have cleats fixed to the surface to prevent slipping of workmen. Ramps and gangways shall be kept free from grease, mud, snow or other slipping hazards or other obstructions leading to tripping and accidental fall of a workman. Ramps and gangways meant for transporting materials shall have even surface and be of sufficient width and provided with skirt boards on open sides.

VII. Materials Hoists

1. The hoist should be erected on a firm base, adequately supported and secured. All materials supporting the hoist shall be appropriately designed and strong enough for the work intended and free from defects.

2. The size of the drum shall match the size of the rope. Not less than two full turns of rope shall remain on the drum at all times. Ropes shall be securely attached to the drum.

3. All ropes, chains and other lifting gear shall be properly made of sound materials, free from defects and strong enough for the work intended. They shall be examined by a competent person who shall clearly certify the safe working load on each item and the system.

4. Hoist ways shall be protected by a substantial enclosure at ground level, at all access points and wherever persons may be struck by any moving part.

5. Gates at access points should be at least 2 m high wherever possible. Gates shall be kept closed at all times except when required open for immediate movement of materials at that landing place.

6. All gates shall be fitted with electronic or mechanical interlocks to prevent movement of the hoist in the event of a gate being opened.

7. Winches used for hoists shall be so constructed that a brake is applied when the control lever or switch is not held in the operating position (dead-man's handle).

8. The hoist tower shall be tied to a building or structure at every floor level or at least every 3 m. The height of the tower shall not exceed 6 m after the last tie or a lesser height as recommended by the manufacturer. All ties on a hoist tower shall be secured using right angled couples.

9. The hoist shall be capable of being operated only from one position at a time. It shall not be operated from the cage. The operator shall have a clear view of all levels or, if he has not, a clear and distinct system of signalling shall be employed.

10. All hoist platforms shall be fitted with guards and gates to a height of at least 1 m, to prevent materials rolling/falling from the platform.

11. Where materials extend over the height of the platform guards, a frame shall be fitted and the materials secured to it during hoisting/lowering. (Care should be taken to

ensure that neither the frame nor materials interfere or touch any part of the hoisting mechanism.)

12. The platform of a goods hoist shall carry a notice stating:

a) The safe working load; and

b) That passengers shall not ride on the hoist.

13. All hoist operators shall be adequately trained and competent, and shall be responsible for ensuring that the hoist is not overloaded or otherwise misused.

14. All hoists shall be tested and thoroughly examined by a competent person before use on a site, after substantial alteration, modification or repair of hoists, and at least every 6 months.

15. Every hoist shall be inspected at least once each week by a competent person and a record of these inspections kept.

VIII. Pre-stressed Concrete

1. In pre-stressing operations, operating, maintenance and replacement instructions of the supplier of the equipment shall be strictly adhered to.

2. Extreme caution shall be exercised in all operations involving the use of stressing equipment as wires/strands under high tensile stresses become a lethal weapon.

3. During the jacking operation of any tensioning element(s) the anchor shall be kept turned up close to anchor plate, wherever possible, to avoid serious damage if a hydraulic line fails.

4. Pulling-headers, bolts and hydraulic jacks/rams shall be inspected for signs of deformation and failure. Threads on bolts and nuts should be frequently inspected for diminishing cross section. Choked units shall be carefully cleaned.

5. Care shall be taken that no one stands in line with the tensioning elements and jacking equipment during the tensioning operations and that no one is directly over the jacking equipment when deflection is being done. Signs and barriers shall be provided to prevent workmen from working behind the jacks when the stressing operation is in progress.

6. Necessary shields should be put up immediately behind the pre-stressing jacks during stressing operations.

7. Wedges and other temporary anchoring devices shall be inspected before use.

8. The pre-stressing jacks shall be periodically examined for wear and tear.

IX. Erection of Prefabricated Members

1. A spreader beam shall be used wherever possible so that the cable can be as perpendicular to the members being lifted as practical. The angle between the cable and the members to be lifted shall not be less than 60°.

2. The lifting wires shall be tested for double the load to be handled at least once in six months. The guy line shall be of adequate strength to perform its function of controlling the movement of members being lifted.

3. Temporary scaffolding of adequate strength shall be used to support precast members at predetermined supporting points while lifting and placing them in position and connecting them to other members.

4. After erection of the member, it shall be guyed and braced to prevent it from being tipped or dislodged by accidental impact when setting the next member.

5. Precast concrete units shall be handled at specific picking points and with specific devices. Girders and beams shall be braced during transportation and handled, in such a way, so as to keep the members upright.

6. Methods of assembly and erection specified by the designer shall be strictly adhered to at site. Immediately on erecting any unit in position, temporary connections or supports as specified shall be provided before releasing the lifting equipment. The permanent structural connections shall be established at the earliest opportunity.

X. Heated Concrete

When heaters are being used to heat aggregates and other materials and to maintain proper curing temperatures, the heaters shall be frequently checked for functioning and precautions shall be taken to avoid hazards in using coal, liquid, gas or any other fuel.

XI. Structural Connections

i. When reliance is placed on bond between precast and *in-situ* concrete the contact surface of the precast units shall be suitably prepared in accordance with the specifications.
ii. The packing of joints shall be carried out in accordance with the assembly instructions.
iii. Levelling devices, such as wedges and nuts which have no load bearing function in the completed structure shall be released or removed as necessary prior to integrating the joints.
iv. If it becomes necessary to use electric power for *in-situ* work, the same should be stepped down to a safe level as far as possible.

XI. General

Workmen working in any position where there is a falling hazard shall wear safety belts or other adequate protection shall be provided.

11.8 SAFETY REQUIREMENTS FOR ERECTION OF STRUCTURAL STEEL WORK

1. Safety Organization

The agency responsible for erecting the steel work should analyze the proposed erection scheme for safety; the erection scheme should cover safety aspects right from the planning stage up to the actual execution of the work.

2. **Safety of Work persons**

General

a. While engaging persons for the job, the supervisor should check up and make sure that they are skilled in the particular job they have to perform.

b. The helmets shall be worn properly and at all times during the work and shall conform to the accepted standards

c. The safety goggles shall be used while performing duties which are hazardous to eye like drilling, cutting and welding. The goggles used shall conform to the accepted standards and should suit individual workers.

d. The welders and gas cutters shall be equipped with proper protective equipment like gloves, safety boots, aprons and hand shields. The filter glass of the hand shield shall conform to the accepted standards and should be suitable to the eyes of the particular worker.

e. When the work is in progress, the area shall be cordoned off by barricades to prevent persons from hitting against structural components, or falling into excavated trenches or getting injured by falling objects.

f. Warning signs shall be displayed where necessary to indicate hazards, for example (a) '440 VOLTS', (b) 'DO NOT SMOKE', (c) 'MEN WORKING AHEAD', etc. Hand lamps shall be of low voltage preferably 24 V to prevent electrical hazards.

g. All electrically operated hand tools shall be provided with double earthing.

h. Anchors for guys or ties shall be checked for proper placement. The weight of concrete in which the anchors are embedded shall be checked for uplift and sliding.

- Split-end eye anchors shall only be used in good, solid rock.
- The first load lifted by a guy derrick shall be kept at a small height for about 10 min and the anchors immediately inspected for any signs or indications of failure.
- When a number of trusses or deep girders are loaded in one car or on one truck, all but one being lifted shall be tied back unless they have been tied or braced to prevent their falling over and endangering men unloading.

i. The erection gang shall have adequate supply of bolts, washers, rivets, pins, etc, of the correct size.

Enough number of bolts shall be used in connecting each piece using a minimum of two bolts in a pattern to ensure that the joint will not fail due to dead load and erection loads. All splice connections in columns, crane girders, etc, shall be completely bolted or riveted or welded as specified in the drawing before erection.

j. Girders and other heavy complicated structural members may require special erection devices like cleats and hooks, which can be shop assembled and bolted or

riveted or welded to the piece and may be left permanently in the place after the work.

k. If a piece is laterally unstable when picked at its centre, use of a balance beam is advisable, unless a pair of bridles slings can be placed far enough apart for them to be safe lifting points. The top flange of a truss, girder or long beam may be temporarily reinforced with a structural member laid flat on top of the member and secured temporarily.

   On deep girders, and even on some trusses, a safety 'bar' running their full length will aid the riggers, fitters and others employed on the bottom flange or bottom chord to work with greater safety. This can be a single 16 mm diameter wire rope through vertical stiffeners of such members about one metre above the bottom flange and clamped at the ends with wire rope clamps. If the holes cannot be provided, short eye bolts can be welded to the webs of the girder at intervals to be removed and the surface chipped or ground to leave it smooth after all work on the piece has been completed.

l. Safety belts shall always be available at work spot to be used whenever necessary. The rope shall be chemically treated to resist dew and rotting. These shall not be tied on sharp edges of steel structures. They shall be tied generally not more than 2 m to 3 m away from the belt.

m. On a guy derrick or climbing crane job, the tool boxes used by the erection staff shall be moved to the new working floor each time the rig is changed. On a mobile crane job, the boxes shall be moved as soon as the crane starts operating in a new area too far away for the men to reach the boxes conveniently.

   While working a tall and heavy guy derrick, it is advisable to control tension in guys by hand winches to avoid jerks, which may cause an accident.

n. The proper size, number and spacing of wire rope clamps shall be used, depending on the diameter of the wire rope. They shall be properly fixed in accordance with good practice .They shall be checked as soon as the rope has been stretched, as the rope, especially if new, tends to stretch under the applied load, which in turn may cause it to shrink slightly in diameter. The clamps shall then be promptly tightened to take care of this new condition. In addition, the clamps shall be inspected frequently to be sure that they have not slipped and are tight enough.

o. When the men can work safely from the steel structure itself, this is preferable to hanging platforms or scaffolds, as it eliminates additional operations, which in turn, reduces the hazard of an accident.

   i. To aid men working on floats or scaffolds, as well as men in erection gangs, or other gangs using small material, such as bolts and drift pins, adequate bolt baskets or similar containers with handles of sufficient strength and attachment to carry the loaded containers, shall be provided.
   ii. The men should be trained to use such containers, and to keep small tools gathered up and put away in tool boxes when not in use. Material shall not

be dumped overboard when a scaffold is to be moved. Rivet heaters shall have safe containers or buckets for hot rivets left over at the end of the day.

p. During the erection of tall buildings, it is desirable to use nylon nets at a height of 3 m to 4 m to provide safety to men. The safety net should be made from man or machine-made fibre ropes which are UV stabilized and conforming to the acceptable standard.

q. Safety against Fire

A fire protection procedure is to be set up if there is to be any flame cutting, burning, heating, riveting or any operation that could start a fire. For precautions to be observed during welding and cutting operations, reference may be made to good practice.

i. The workers should be instructed not to throw objects like hot rivets, cigarette stubs, etc, around.
ii. Sufficient fire extinguishers shall be placed at strategic points. Extinguishers shall always be placed in cranes, hoists, compressors and similar places. Where electrical equipments are involved, CO2 or dry powder extinguishers shall be provided.

r. Riding on a load, tackle or runner shall be prohibited.

The load shall never be allowed to rest on wire ropes. Ropes in operation should not be touched. Wire rope with broken strand shall not be used for erection work. Wire ropes/manila ropes conforming to acceptable standards shall be used for guying.

s. Lifting Appliances

Precautions as laid down in “Cranes” above shall be followed.

t. Slinging

i. Chains shall not be joined by bolting or wiring links together. They shall not be shortened by tying knots. A chain, in which the links are locked, stretched or do not move freely shall not be used. The chain shall be free of kinks and twists. Proper eye splices shall be used to attach the chain hooks.
ii. Pulley blocks of the proper size shall be used to allow the rope free play in the sheave grooves and to protect the wire rope from sharp bends under load. Idle sling should not be carried on the crane hook along with a loaded sling. When idle slings are carried they shall be hooked.
iii. While using multi-legged slings, each sling or leg shall be loaded evenly and the slings shall be of sufficient length to avoid a wide angle between the legs.

u. Riveting Operations

i. Handling rivets- Care shall be taken while handling rivets so that they do not fall, strike or cause injury to men and material below. Rivet catchers shall have false wooden bottoms to prevent rivets from rebounding.
ii. Riveting dollies- Canvas, leather or rope slings shall be used for riveting dollies. Chain shall not be used for the purpose.
iii. Riveting hammers- Snaps and plungers of pneumatic riveting hammers shall be secured to prevent the snap from dropping out of place. The nozzle of the hammer shall be inspected periodically and the wire attachment renewed when born.
iv. Fire protection- The rivet heating equipment should be as near as possible to the place of work. A pail of water shall always be kept already for quenching the fire during riveting operations and to prevent fires when working near inflammable materials.

v. Welding and Gas Cutting

i. For safety and health requirements in electric gas welding and cutting operations, reference may be made to good practice.
ii. All gas cylinders shall be used and stored in the upright position only and shall be conveyed in trolleys. While handling by cranes they shall be carried in cages. The cylinders shall be marked ‘full’ or ‘empty’ as the case may be. Gas cylinders shall be stored away from open flames and other sources of heat. Oxygen cylinders shall not be stored near combustible gas, oil, grease and similar combustible materials. When the cylinders are in use, cylinder valve key or wrench shall be placed in position. Before a cylinder is moved, cylinder valve shall be closed. All cylinder valves shall be closed when the torches are being replaced or welding is stopped for some reason. The cylinder valve and connections shall not be lubricated.
iii. Gas cutting and welding torches shall be lighted by means of special lighters and not with matches. The cables from welding equipment should be placed in such a way that they are not run over by traffic. Double earthing shall be provided. Before undertaking welding operations near combustible materials, suitable blanketing shall be provided and fire extinguishers kept nearby. Welding shall not be undertaken in areas where inflammable liquids and gases are stored.
iv. Gas lines and compressed air lines shall be identified by suitable colour codes for easy identification, to avoid confusion and to prevent fire and explosion hazards.

11.9 Safety of Structures

General

A. The structure itself should be safeguarded during its erection. The first truss of the roof system shall be guyed on each side before the hoisting rope is detached from it. After the subsequent trusses and roof purlins are erected, protective guides shall be firmly established and the required wind bracings shall be erected to prevent the whole structure being blown over by a sudden gale at night. Bracing and guying

precautions shall be taken on every structure until it is complete. Guying shall be specifically done for trusses and structural components which after their erection form an erection device. On structures used for temporary material storage overloading shall be avoided.

B. Erection of columns shall be immediately followed by vertical bracing between columns before the roof structure is erected.

With reference to the National Building Code 2016 following safety measures need to be followed

1. Staircase Construction

While staircase is under construction, depending on the type of construction, namely, concrete or brickwork, etc. suitable precautions shall be taken by way of support, formworks, etc, to prevent any collapse. Workmen or any other person shall not be allowed to use such staircases till they are tested and found fit for usage by the Authority/engineer-in-charge. Till the permanent handrails are provided, temporary provisions like ropes, etc, shall be provided on staircases prior to commencement of use of such staircases.

2. Lift Wells

Till the installation of the lift is completed, lift wells shall be protected with check boards or railings together with notice boards, danger lights, etc, to prevent persons accidentally falling into the wells. The handrails provided shall be capable of withstanding pressure exerted due to normal bumping of an individual against the same.

One or more escape staircase connecting to outdoors at ground level, should be pressurized, to enable mass evacuation of high rise buildings.

Chapter 12

CONFINED SPACE

12.1 INTRODUCTION

Confined space means a space that:
The term 'confined space' has any of following defining features as, any space;

a. In which a person can bodily enter;
b. Contains material that has the potential to engulf an entrant
c. Contains or has a potential to contain a hazardous atmosphere
d. Has walls that converge inward such that the entrant could be trapped
e. Which has limited entry / egress; and
f. Which is not meant for occupancy.

- Generally, it is a place which is substantially (though not always entirely) enclosed with a reasonably foreseeable risk of serious injury from hazardous substances or conditions within the space or nearby.
- Some confined spaces are fairly easy to identify, for example, closed tanks and sewers. Others are less obvious but may be equally dangerous, for example closed and unventilated or inadequately ventilated rooms and silos, ducts, culverts, tunnels, boreholes, bored piles, manholes, shafts, excavations, sumps, inspection pits, cofferdams, and building voids.

12.2 Confined space activity in construction sites:-

Crawl Spaces and Attics as Confined Spaces

Crawl spaces and attics can be both confined spaces and permit-required confined spaces under the new standard. For instance, working in an attic and applying a large amount of spray foam (or another chemical) in a short period of time can expose a worker to low oxygen levels or a hazardous atmosphere.

In addition, changes to the entry/exit, the ease of exit, and air flow could create a confined space or cause the space to become permit-required.

12.3 Hazards in Crawl Spaces and Attics

The most likely hazards are as follows:

(a) Flammable Substances and Oxygen Enrichment;
(b) Toxic Gas, Fume or Vapour
(c) Oxygen deficiency
(d) The Ingress or Presence of fluids
(e) Presence of Excessive Heat,
(f) Excessive Humidity

Crawl spaces can present many confined space hazards, including:

- Atmospheric hazards (e.g., flammable vapours, low oxygen levels)
- Electrocution (e.g., using electrical equipment in wet conditions, unprotected energized wires)

- Standing water
- Poor lighting
- Structural collapse
- Asbestos insulation

Working in attics can also present confined space hazards, such as:

- Atmospheric hazards (e.g., poor ventilation)
- Heat stress
- Mechanical hazards (e.g., attic ventilators, whole house fans)
- Electrical hazards (e.g., damaged or frayed wires, open electrical boxes)
- Slip, trip and fall hazards

12.4 Confined Spaces in Pits

Even though a pit is typically open on top and over 4 feet deep, it can still be a confined space or permit-required confined space. Additionally, pits can be completely underground or below grade, such as a utility vault within a sewer system or a pit within a pit in a wastewater treatment plant.

Pits are found in many environments. Examples include sump pits, valve pits or vaults (e.g., wastewater treatment plants, municipal water systems), electrical pits/vaults, steam pits/vaults, vehicle service/garage pits, elevator pits, dock leveller pits, industrial chemical waste pits, and many more.

Fig.12.1. Confined space in pit

12.5 Confined Spaces in Sewer Systems

Types of sewer systems include sanitary (domestic sewage), storm (runoff), and combined (domestic sewage and runoff). Sewer systems are extensive and include many different components that are considered confined spaces, including pipelines, manholes, wet wells, dry well vaults, and lift/pump stations.

12.6 Hazards Associated with Sewer Systems

Sewer systems can present a confined space hazards, including:

a. Atmospheric hazards (low oxygen, toxic or flammable gases).
b. Chemicals in piping and from roadway runoff (may harm lungs, skin, or eyes).
c. Engulfment and drowning.
d. Electrocution (e.g., using electrical equipment in wet working conditions).

e. Slips, trips, and falls.
f. Falling objects.
g. High noise levels, low visibility, limit to communication, and long distances to exits.

12.7 Safety precautions for confined space work

- Avoid entering confined spaces, e.g. by doing the work from outside;
- If entry to a confined space is unavoidable, develop and implement a safe system of work; and
- Devise an appropriate emergency plan before the work starts.

12.8 Safe system of work

If entry to a confined space is unavoidable, a safe system for working inside the space should be developed.

A “Responsible person” should be appointed to carry out a risk assessment of the conditions and the work and activities to be conducted in the confined space, and identify the necessary safety precautions to be taken according to the findings to avoid posing hazards to workers. The “Responsible person” should make recommendations on safety precautions to be taken having regard to the nature of the confined space, the associated risk and the work involved.

Make sure that the safe system of work, including the precautions identified, is developed and put into practice. Everyone involved will need to be properly trained and instructed to make sure they know what to do and how to do it safely.

12.9 Suitable persons for the work to be appointed

Suitable workers should meet the following requirements:

- Must have received training;
- Must have sufficient experience in the type of work to be carried out;
- Must have a suitable build for the work if the risk assessment highlights exceptional constraints as a result of the physical layout;
- Must be fit to wear breathing apparatus and there is no medical advice against an individual’s suitability to work in a confined space.

Entry Procedures

- Contractors will ensure that no work will be undertaken in Confined Spaces unless a Permit to Work and has been prepared and issued.
- Only persons who have been thoroughly trained, experienced and are physically fit shall be allowed to work in Confined Spaces.
- Persons with any of the following medical conditions shall not be allowed to work in confined spaces:
  (a) A history of fits, blackouts or fainting attacks,
  (b) A history of heart disease or disorder,
  (c) High blood pressure,
  (d) Asthma bronchitis, or shortness of breath€ exertion,
  (e) Deafness,
  (f) Disease involving giddiness or loss of balance,
  (g) Claustrophobia or nervous or mental disorder,
  (h) Back pain or joint trouble that would limit mobility in confined spaces,

(i) Deformity or disease of the lower limbs limiting movement,
(j) Chronic skin disease,
(k) Serious defects in eye sight or lack of sense of smell,

- No smoking shall be allowed in or within 2 meters of the opening to any confined space and suitable warning signs shall be positioned.
- Before any confined space work commences the following equipment shall be available for use:
  (a) Multi Gas Monitor; or other suitable gas monitoring equipment.
  (b) Sufficient sets of Self-Contained Breathing Apparatus to enable rescue to be carried out;
  (c) Full Body Type Harness for each worker;
  (d) Tripod and Lifeline Hoist Rope; for work in situations where a vertical exit from the confined space is required.
  (e) Flame-proof lighting. (Hand lamps not more than 24volts.);
  (f) Resuscitation Equipment;
  (g) Ventilation Equipment.

The persons involved in the confined space working operations shall need to be thoroughly trained and certified as being competent in the use of the above detailed item of equipment.

12.10 Isolation

Disconnect and properly lock off the power supply of all the machinery and equipment that could cause hazards in a confined space; blank off pipelines and service pipes with contents that could cause hazards; take effective steps to prevent an ingress or in-rush to the confined space of hazardous gas, vapour, dust, fume or free flowing solid and liquid.

12.11 Cleaning and cooling before entry

A confined space should be adequately purged before the entry of workers to ensure that no sludge or other deposits will give off hazardous gas, vapour, dust or fume during the course of work. If steam cleaning is used, sufficient time should be allowed for cooling to ensure that it is safe to work in the confined space.

12.12 Size of the entrance

Size of the entrance should be big enough to allow workers wearing all the necessary equipment to get in and out easily, and provide safe access and egress in an emergency.

12.13 Provision of ventilation

The number of openings may increase and therefore improve ventilation. Mechanical ventilation may be necessary to ensure an adequate supply of fresh air. Do not use oxygen to freshen the air inside the confined space as this will greatly increase the risk of fire or explosion. Adequate supply of fresh air is of particular importance if compressed gas or burning equipment is used inside the confined space because of the dangers from build-up of engine exhaust.

12.14 Checking the atmosphere

This is necessary in order to check that the air is free from both toxic and flammable gases, and that there is no deficiency in oxygen and the air is fit to breathe. Testing should be

carried out by a ‘Responsible Person’ using a suitable gas detector which is correctly calibrated. Provision of special tools and lighting

Non-sparking tools and specially protected lighting are essential where flammable or potentially explosive atmospheres are likely. In certain confined spaces (e.g. inside metal tanks), suitable precautions to prevent electric shock include the use of extra low voltage equipment.

12.15 Provision of personal protective equipment

Where the use of “approved breathing apparatus” is recommended in a risk assessment report, or entry into a confined space for underground pipe work is required, it is required to ensure that any person entering or remaining in the confined space:

- is properly wearing an approved breathing apparatus of a type that gives appropriate protection given the nature of the confined space;
- is wearing a suitable safety harness connected to a lifeline that is strong enough to enable him to be pulled out, and that the free end is held by a person staying outside the confined space who has sufficient physical strength to be capable of pulling the worker out of the confined space in an emergency.

12.16 Liaison and rescue

When work is being carried out in a confined space, another person should be assigned to station outside the confined space to maintain communication with the worker inside. Sufficient number of rescue personnel should also be made available outside the confined space. These persons need to be properly trained in rescues, physically fit and readily available to carry out rescue tasks, and capable of using any rescue equipment provided, e.g. breathing apparatus, reviving apparatus, lifelines and fire-fighting equipment. They should also be adequately protected against any harm.

12.17 Shut down

It may be necessary to shut down adjacent plant before attempting emergency rescue.

12.18 First-aid procedures

Qualified first-aiders need to be available to make proper use of any necessary first-aid equipment provided.

12.19 Mock Drills

Mock Drills for the rescue should be conducted periodically for gaining practical experience and making sure that the rescue personnel understand and are familiar with the necessary rescue procedures.

Chapter 13

EXCAVATION

13.1 INTRODUCTION

Generally speaking, an excavation is a hole in the ground as the result of removing material. A trench is an excavation in which the depth exceeds (is bigger than) the width.

Working in trenches and excavations is hazardous to both the workers who work inside them, and to workers on the surface. The hazards include:

- Cave-ins or collapses that can trap workers.
- Equipment or excavated soil falling on workers (e.g., equipment operated or soil/debris stored too close to the excavation).
- Falling into the trench or excavation.
- Flooding or water accumulation.
- Exposure to a hazardous atmosphere (e.g., gas, vapour, dust, or lack of oxygen).
- Contact with buried service lines such as electrical, natural gas, water, sewage, telecommunications, etc.
- Contact with overhead electrical lines.
- Slips, trips and falls as workers climb on and off equipment, or from inappropriate access and egress methods.
- Being struck by moving machinery, or by falling or flying objects.
- Hazards related to materials handling (e.g., lifting, struck by, crushed between, etc.).

Definitions of soil types vary by as per national standards. In addition, some standards have not defined soil types. However, some of the general category are as follows:

(i) Stable Rock- Solid rock, Shale or cemented

Type A- Soft and hard murrum

Type B- Clay and cohesive soil

Type C- Sandy soil, broken rock, gravel and Black cotton soil

(ii) Loose sand

The soil type is determined by the characteristics of the soil's consistency, ease of removal, appearance, ability to excavate with hand tools vs. machine, water seepage, whether the soil has been excavated before, etc.

The employer or supervisor is responsible for the work, and must take the necessary steps to identify all the hazards and risks before beginning any work. These steps include to:

- Identify the soil type(s) related to the excavation or trench you are going to dig. Soil properties often vary widely within a single trench (e.g., the soil type changes from top to bottom and along the length of a trench).

- Look for the legislative requirements that apply in your jurisdiction and the type of protective measures to be taken.
- Locate all buried services. Contact the owners of any underground utilities/services that may be in that location and ask them to identify and mark the location.
- Identify and locate overhead power lines.
- Make sure these services are de-energized as necessary.
- Know all of the contact numbers of these services if there is an emergency.
- Check areas adjacent to the site for potential hazards and sources that can impact the stability of soil. Be aware that nearby vehicles and equipment can cause the soil to vibrate and then collapse.
- Determine if nearby buildings or structures and their foundations may put pressure on the soil and affect the walls of the trench.
- Test for hazardous gas, vapours, and dust before entering.
- Test for oxygen levels in the space before entering, and during the work as required.
- Plan appropriate organization of the work site, and good housekeeping practices including moving debris and excavated soil far enough away from the excavation site.
- Remove water from the excavation.
- Protect workers from falling into the excavation.
- Identify appropriate personal protective equipment including high visibility apparel for vehicular traffic and make sure every worker wears them as required.
- Have a worker above ground when a worker is working in the trench to warn those in the trench of danger and to provide emergency help.
- Prepare work permits for work in confined spaces, as appropriate.
- Have a means of exit provided from the inside of the trench, usually no more than 8m (25 ft) away than any worker in the trench.
- Plan for adverse weather conditions (e.g. hot or cold environments, storms, etc.).
- Prepare an Emergency Action Plan and rescue procedures.
- Keep first aid boxes at the site.
- Educate and train workers about all existing and potential hazards and risks and appropriate safety measures.

In general, trenches that are 1.2 metres (4 feet) deep or greater require a protective system unless the excavation is made entirely in stable rock. The factors to consider include:

- Soil type
- Depth of cut
- Water content of soil
- Changes due to weather or climate
- Surcharge loads (e.g., spoil, other materials to be used in the trench) and
- Other operations in the area

There are two basic methods of protecting workers against cave-ins:

- Sloping
- Temporary protective structures (e.g., shoring, trench boxes, pre-fabricated systems, hydraulic systems, engineering systems, etc.)

13.2 Sloping

Sloping involves cutting back the trench wall at an angle that is inclined away from the work area of the excavation. The angle of slope required depends on the soil conditions. Benching is a similar method to sloping.

Employers should know as much as possible about the jobsite and the materials they will need to have on hand to perform the work safely. A safety checklist may prove helpful when employers are considering new projects. Factors to consider may include:

- Traffic
- Proximity and physical condition of nearby structures
- Soil classification
- Surface and ground water
- Location of the water table
- Overhead and underground utilities
- Weather
- Quantity of shoring or protective systems that may be required
- Fall protection needs
- Number of ladders that may be needed
- Other equipment needs.

The information can be collected by test borings for soil type or conditions, and consultations with local municipal authorities and utility companies.

The workers are required to be protected from cave-ins by:

- Sloping and benching the sides of the excavation;
- Supporting the sides of the excavation; or
- Placing a shield between the side of the excavation and the work area.

In many cases the type of protective system needed is well known and simple to use. Designing a protective system requires consideration of many factors, including: soil classification, depth of cut, water content of soil, weather and climate, and other operations in the vicinity. Examples of protective systems that can be used to comply with the Excavation standards include:

Excavations made in type A (Soft and hard murrum) Soil

- All simple slope excavations 20 feet (6Mt) or less in depth will have a maximum allowable slope of 3/4:1.
- All benched excavations 20 feet (6Mt) or less in depth will have a maximum allowable slope of 3/4 to 1 and maximum bench dimensions as indicated.
- All excavations more than 8 feet (2.5Mt) but not more than 12 feet (4.5Mt) in depth with unsupported vertically sided lower portions will have a maximum allowable slope of 1:1 and a maximum vertical side of 3 1/2 feet (1.1Mt).
- All excavations 20 feet (6Mt) or less in depth which have vertically sided lower portions that are supported or shielded will have a maximum allowable slope of 3/4:1. The support or shield system shall extend at least 18 inches (0.5Mt) above the top of the vertical side.

Excavations Made in Type B (Clay and cohesive) Soil

- All simple slope excavations 20 feet (6Mt) or less in depth will have a maximum allowable slope of 1:1.
- All benched excavations 20 feet (6Mt) or less in depth will have a maximum allowable slope of 1:1 and maximum bench dimensions as indicated.
- All excavations 20 feet (6Mt) or less in depth which have vertically sided lower portions will be shielded or supported to a height at least 18 inches (0.5Mt) above the top of the vertical side. All such excavations will have a maximum allowable slope of 1:1.

Excavations Made in Type C (Sandy soil, broken rock, gravel and Black cotton) Soil

- All simple slope excavations 20 feet (6Mt) or less in depth will have a maximum allowable slope of 1 1/2:1.
- All excavations 20 feet (6Mt) or less in depth which have vertically sided lower portions will be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations will have a maximum allowable slope of 1 1/2:1.

Trench box or shield can also be deployed accord to the feasibility dictated by the site conditions.

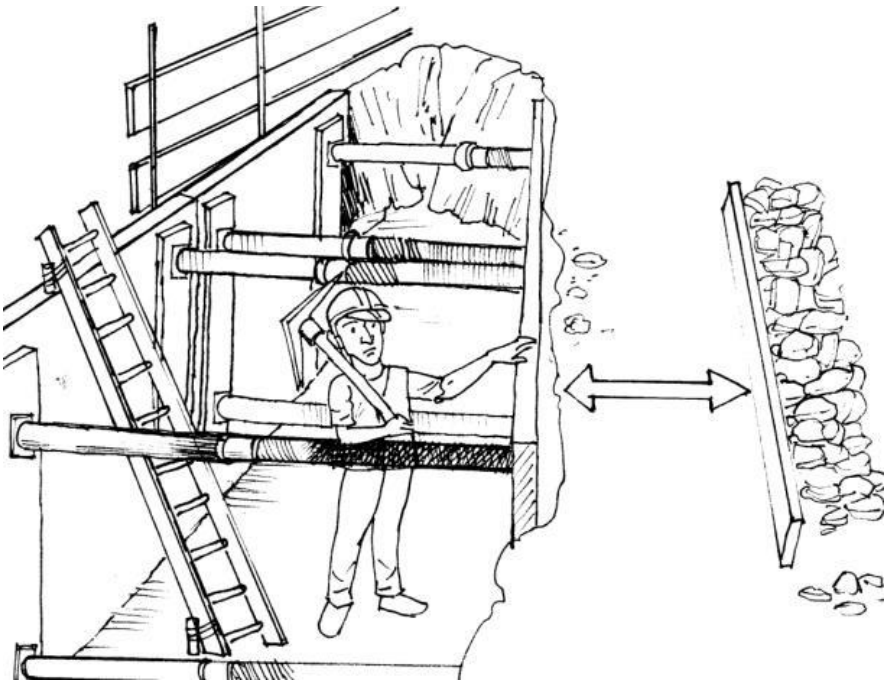


Fig.13.1. Application of trench box

13.3 Temporary protective structure

Saskatchewan Labour defines a temporary protective structure as “a structure or device in an excavation, trench, tunnel or excavated shaft that is designed to provide protection from cave-ins, collapse, sliding or rolling materials, and includes shoring, trench boxes, trench shields and similar structures.”

- Shoring is a system that supports the sides or walls. Shoring requires installing aluminium, steel, or wood panels that are supported by screws or hydraulic jacks. Some systems can be installed without the workers entering the trench. This option provides additional safety for those workers. Wherever possible, install the shoring equipment as the excavation proceeds. If there is any delay between digging and shoring, no one should enter the unprotected trench.

- Trench Boxes are commonly used in open areas that are away from utilities, roadways, and foundations. Trench boxes can be used to protect workers in cases of cave-ins, but not to shore up or support trench walls. They can support trench walls if the space between the box and the trench wall is backfilled with soil and compacted properly. Otherwise, a cave-in or collapse may cause the trench box to tilt or turn over. Workers should not be present in the box when it has to be moved.

- Other: In some cases, the trench or excavation walls are made of rock but are not entirely stable. Support the walls by using rock bolts, wire mesh, or a method that provides equivalent support.

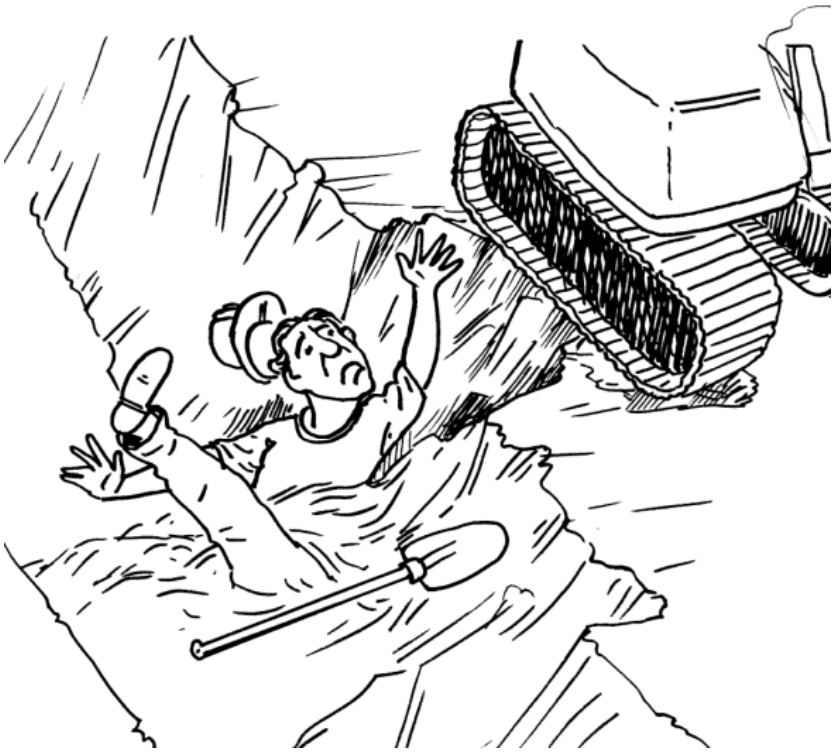


Fig.13.2. Unstable soil conditions

The following are some points to consider. Each circumstance will be different, so be sure to adapt the questions to suit your situation.

Underground/Utility Services

- Know the contact numbers?
- Located, identified and informed respective parties?
- Grounded, isolated, de-energized, or protected from unplanned release?

Housekeeping

- Excavated material, pipes etc. are placed 1 metre away from the edge of the excavation or trench wall?
- Are pumps available to remove water?
- Is the base and foot of the ladder secure, and free of garbage or water?
- Are materials placed on the site obstructing the worker's or vehicle's ability to move freely?
- Are established traffic controls used, where required, including adequate signage, personnel, and lighting?
- Has the excavation been marked to make the workers and others aware of the excavation (e.g., fence, flags, or other safeguards)?
- Are sanitary facilities available at the site, as appropriate?

General Safety precautions

- Are proper barriers or guardrails in place to protect anyone or equipment falling into the excavation or trench?
- Has the air in the excavation been tested for low oxygen, and hazardous gasses and vapours?
- Is a safe means of entry/exit provided such as a sufficiently long and secured ladder placed at appropriate distances (within 25 feet of all workers)?
- Are cracks visible in the ground around the trench or excavation that may indicate soil movement?
- Are there any signs of water seeping into the trench or excavation?
- Are workers wearing appropriate PPE (e.g., hard hats, respirators, safety boots, hearing protection)?
- Are high visibility vests or clothing provided and worn by all exposed to vehicular traffic?
- Are first aid boxes available at the site?
- Are operators qualified to operate the heavy machinery/equipment?
- Does a competent person regularly inspect the excavation (at the start of each shift before work begins or after any event likely to have affected the strength or stability of the excavation)?
- Is there a competent person stationed at the surface of the trench to warn workers in the trench of danger and to provide emergency help?

Chapter 14

EXPLOSIVES

14.1 INTRODUCTION

Explosive – Any mixture or chemical compound which is capable of producing an explosion by its own energy. This includes black powder, dynamite, nitro-glycerine compounds, fulminate, or explosive substance having explosive power equal to or greater than black powder.

Uses of Explosives

They are also used frequently in the construction industry for the development of

- New roads,
- Excavation of ground for the foundations of buildings or basement areas and
- In demolition work.

Types of Explosives

There are many types of explosives used in India and these include ANFO (**ammonium nitrate fuel oil**), which is a mixture of Ammonium Nitrate and Fuel Oil (Diesel), pumped emulsion which is a liquid explosive, gelignite based cartridge explosives, and shock tube compressed gas explosives. Explosives require initiation and this is achieved through the use of detonators, detonating cord and in rare cases detonating fuse.

Hazards of Explosives

- Explosion
- Fire hazards
- Fly materials
- Falling materials
- Collapse of structure due to explosion

14.2 TRANSPORTATION OF EXPLOSIVES:

- All the relevant state and local laws and rules and regulations framed there under shall be complied and necessary license obtained.
- Loading, unloading and handling of explosives shall be supervised by qualified personnel.
- At the time of loading or unloading of explosives, no electrical switch should be operated.
- For carrying small quantity (up to 5 kg of explosives) specially designed insulated containers may be used. These containers shall be constructed of finished wood not less than 50 mm thick or plastic not less than 6 mm thick or pressed fiber not less than 10 mm thick.
- Metal components, including nails, bolts, screws, etc, shall not be used in the construction of the containers, which shall be waterproof and provided with lids.
- The containers shall be provided with suitable non-conductive carrying device, such as rubber, leather or canvas handle or strap.

- Each explosive container should be clearly and indelibly marked to indicate: manufacturer's name or trade mark, name of the explosive, lot number, date of manufacture, expiry date, and the words ' EXPLOSIVES, HANDLE WITH CARE '.
- The vehicles used for transporting explosive shall be driven only by a licensed driver who is physically fit and is familiar with the precautions to be taken while carrying the explosives in his vehicles.
- The interior of the body shall not have any exposed metal parts, except those of copper, brass and other non-sparking metals, and shall preferably be lined with wood.
- The exterior of the body shall be conspicuously marked on both sides and ends with the word ' EXPLOSIVES ', painted is not less than 100 mm high letters in white over a red background in English and local language.
- All electrical wiring and equipment of vehicles shall be adequately insulated and protected against mechanical damage to prevent short circuiting.
- Two carbon dioxide fire extinguishers, each. Of not less than 3 kg capacity, conforming to Indian Standard shall be carried on each vehicles.
- The extinguishers shall be securely mounted on the vehicles in such a manner that they can be readily removed for use in an emergency
- A motor vehicle carrying explosives shall not be re-fuelled except in emergencies and even then only when the motor has been stopped and other precautions have been taken to prevent accidents.

All motor vehicles used for transportation of explosives shall be carefully inspected at the beginning of the day's work to ensure that:

- The vehicle is in good condition in all respects for safe transportation of explosives;
- The chassis, engine and body are clean and free from surplus oil and grease; the fuel system of the vehicle, including the fuel tank(s) is free from leakage;
- All electrical wiring and equipment are in sound condition; lights, brakes and steering mechanism are in good working order;
- The tire extinguishers are serviceable and in position on the vehicle; and
- Driver is trained in the use of extinguishers on his vehicle.
- All vehicles used for transporting explosives shall be maintained in good working condition

Safety Precautions

Safety precautions shall be observed for transportation of explosives are as follows

- No metals except approved metal truck bodies shall be allowed to come in contact with cases of explosives.
- Metal, flammable, or corrosive substances shall not be transported with explosives.
- As far as possible, transportation of any other material along with explosives shall be prohibited.
- Smoking shall be prohibited in the vehicle carrying explosives and in its vicinity.
- No unauthorized person shall be allowed in the vehicle carrying explosives.
- Explosives and detonators of blasting caps shall not be permitted to be transported in the same vehicle.
- Detonators and other explosives for blasting shall be transported to the site of work in the original containers or in securely locked separate non-metallic container and shall not be carried loose or mixed with other materials.

- Care shall be taken in loading and unloading of explosives and the filled containers shall not be handled roughly or dropped.
- Drivers shall not leave the vehicles unattended while transporting explosives.
- The speed of the vehicle shall not exceed 25 km/h on rough roads and 40 km/h elsewhere.
- Vehicles, transporting explosives shall not be taken into a garage, repair shop or parked in congested areas, public parking or similar places.
- Explosives shall not be transported in trailers. Further, any trailer shall not be attached to a motor truck or vehicle when it is being used in transporting explosives.
- Explosives shall not be transported on public highways during darkness, except in emergencies and even then only when the written approval of the project authorities has been obtained. Such vehicles shall be fitted with adequate warning lights on both ends, while operating in darkness.
- Explosives shall not be transferred from one vehicle to another on public highways except in cases of emergency.

14.3 STORAGE OF EXPLOSIVES

- Storage of explosives is regulated by the Indian Explosives Act and provision there under should be strictly observed.
- Explosives shall be stored only in a magazine which is clean, dry, well ventilated, reasonably cool, correctly located, protected against lightning in accordance with Indian Electricity Act and Indian Explosives Act and rules and regulations framed there under substantially constructed bullet and fire resistant and securely locked.
- The storage should be done in such a way that the first stored should be used first and to have this facility, the explosives should be stored in sequence.
- Blasting caps, electric blasting caps or primers shall not be stored in the same box, container or room with other explosives.
- Explosives fuse or fuse lighters shall not be stored in a damp or wet place or near oil, gasoline, cleaning solutions or solvents or near radiators, steam pipes, or other sources of heat.
- Smoking and use of matches, naked lights and readily flammable articles or open fires/flame shall be prohibited within the fenced area around it. Suitable notices to this effect shall be conspicuously posted at appropriate locations.
- An area up to a distance of not less than 8 m on all sides of the magazine shall be maintained free of all vegetation, debris and combustibles.
- Oily cotton rags/waste and articles liable to spontaneous ignition shall not be allowed in or near the magazine.
- Metallic objects and metal tools that are capable of producing sparks shall not be stored or used inside or in the immediate vicinity of the magazine.
- Boxes of explosives shall not be thrown down or dragged along the floor and may be stacked on wooden trestles.
- Where there are white ants, the legs of the trestles should rest in shallow copper, lead or brass bowls, containing water.
- Packages containing explosives shall not be allowed to remain in the sun.

- Empty boxes or packing materials shall not be stored or permitted to be around, inside or in the vicinity of the magazine.
- Adequate quantity of water and fire-fighting equipment shall be provided in the magazine. Guards shall be properly trained in handling such equipment.
- Signboards reading " DANGER-HIGH EXPLOSIVES " " PROTECTED AREA " " NO SMOKING ", etc, shall be prominently displayed in front of the magazine.
- The following shall be hung up in the lobby of the magazine: a) A copy of Explosives rules, b) A statement showing the stock in the magazine, and c) Certificate showing the last date of testing of the lightning conductor.

14.4 HANDLING AND USE OF EXPLOSIVES

- Handling of explosives shall be avoided during thunderstorm or when thunderstorm is expected.
- Any package containing explosives shall not be dragged, dropped or handled roughly.
- Sparking metal tools shall not be used to open kegs of explosives.
- Smoking shall not be permitted nor matches, open lights, fire, flame, or any other device capable of producing sparks or flame shall be carried while handling or using explosives.
- Explosives shall not be placed where these may be exposed to flame, excessive heat, sparks or impact.
- The covers of the explosive cases or packages shall be replaced every time after taking out part of the contents as long as any explosives are left in them.
- Explosives shall not be carried in the pockets or folds of clothing by any person.
- No person shall strike, tamper with, or attempt to remove or investigate the contents of a blasting cap or an electric blasting cap or attempt to pull out the crimped safety fuse out of a blasting cap.
- Children and unauthorized or unnecessary persons shall not be present where explosives are being handled or used.
- The blasting powder, explosives, detonators, fuses, etc, shall be in good condition and not damaged due to damp moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed immediately.
- No attempt shall be made to reclaim or use fuses, blasting caps, electric blasting caps or any other explosives which have been water soaked, even if these have been dried out. The manufacturers shall be consulted.

Chapter 15

DRILLING AND BLASTING

15.1 DEFINITIONS

Blaster — The Licensed person assigned the duty of loading and blasting the explosives.

Detonator — Any device containing a detonating charge that is used for initiating detonation in an explosive.

Electric Blasting Cap — A shell containing a charge of detonating compound which is ignited by an electric current from two projecting insulated leg wires.

Explosive — Any mixture or chemical compound which can produce an explosion by its own energy.

High Explosive — An explosive which explodes with detonation and detonates at velocities varying from about 1500 to 7500 m/s and produces large volume of gases at exceptionally high pressure.

Magazine — Any building or other structure used for the storage of explosives.

Missed Hole — A drilled hole containing an explosive charges that failed to explode.

Blasting Wires — Wires between the firing switches, for use in blasting where the power source is an electric circuit.

Primer cartridge — An explosive cartridge with a detonator or igniting agent inserted therein.

Stemming — Inert material packed between the explosive charge and the outer end of the shot hole.

Benching — The operation of removal of the lower portion of the tunnel profile after the top heading has been excavation and where drilling vertically down is possible.

Cut Hole — The group of holes fired first in a round to provide additional free faces for the succeeding shots.

Trimmer Hole — Holes at the periphery of an excavation, fired to give the excavation its final outline.

Drilling Pattern — It is an arrangement showing location, direction and depth of the holes drilled into the face of a tunnel.

Mucking — The operation of removal of the blasted stones/material after the blast has taken place.

Scaling — An operation to remove all loose bits of rock from the blasted surface, after the blasting is over.

Over break — The portion blasted beyond the lines of the intended section.

15.2 DRILLING OF HOLE

- All drillers shall have adequate experience and operating knowledge about each drill before he operates it.
- Drilling of holes shall be done as per the drilling pattern and slightly greater diameter than the diameter of cartridges of explosives used.
- Proper care should be taken to maintain the drill holes angle.
- The depth of each hole should be maintained as per design.
- Charging of drilled holes and drilling shall not be carried out simultaneously in the same area.
- The number and depth of holes should be checked for physical dimension by using dummy references after drilling.
- Driller and its helper must use respiratory protection (Dust Masks), eye protection (Goggles) and ear protection (ear muff) in addition to other safety gears like helmet, safety shoes and reflective vest during drilling operation.
- Only wet drilling or minimize the dust to covering the holes with wet gunny bag.

DRILLING OF HOLE AFTER BLASTING

- The face of rock shall be carefully examined before drilling after blasting to determine the possible presence of unfired explosive.
- No attempt shall be made to drill the hole if undetonated (misfire) explosives are suspected**.**
- Drilling shall not be resumed after blasts have been fired until a thorough examination has been made by shot fired.
- Charging of drilled holes and drilling shall not be carried out simultaneously in the same area.

LOADING AND STEMMING OF HOLES

- At the time of preparing the priming cartridge the electric detonators should have their leading wires twisted together or shunted until the series connection of charging hole is done.
- Priming cartridge shall be prepared at the nearest convenient dry place.
- Priming should not commence at any place unless all electric power in that place has been cut off.(About 30m)
- Priming cartridge shall be prepared at the nearest convenient dry place.
- Detonators, once inserted into a priming cartridge, shall not be taken out.
- Loading and drilling shall not be carried out at the same time in the same area.
- During loading of holes all Non –electrical connectors at loading site of explosive shall be disconnected.
- Stemming of hole shall be done with the help of non-metallic stick like wooden or P.VC. or fibrous material.
- Stemming material should be of inert to electricity.
- Stemming of priming cartridge and explosive cartridge shall not be forced down in a hole.
- No person shall -remove, or attempt to remove, any charged hole or detonator lead in any condition.
- Do not charge blast holes while equipment or drills are operating within 20m of the blast site.

CONNECTION OF BLAST HOLES FOR DETONATION

- Only persons designated by the blaster-in-charge ie Shot firer shall participate in connect the blast hole.
- Connection of excels and electric detonator shall be done by shot firer only.
- All other persons shall vacate the blast site.
- Trained Blast crews shall only use connections for blast the hole that are approved by the blasting engineer/shot firer or blaster.
- Blast holes connections shall not begin until all holes have been loaded and stemmed.
- The blast site is clear of all vehicles and unnecessary people, and no hazards that might delay the blast exist in the blasting zone.
- The blaster-in-charge, and one other crewmember, shall independently inspect and double-check all connections of holes.
- To prevent mistakes in connection of blasting holes caused by rushing to meet a blasting time limit; blasting work schedules shall allow adequate time for careful blast connection work.

CONTINUITY CHECKING OF CHARGED HOLES

- Continuity must be checked by a competent person (Shot firer) only.
- Continuity checked with the help of Ohm-meter that should be of calibrated one.
- Never check the Continuity of single charged holes.
- Blasting cable used for connecting the blasting holes to be checked for its continuity and insulation prior to connection.

FIRING OF CHARGED HOLES

- After loading completed, before final connection to the exploder is made, ensure that no one in the blasting zone.
- At blast time, if the blast area is secure, the blaster-in-charge shall fire or instruct the designated shot firer to fire the blast.
- FINAL connection to exploder shall be made 2 minute after the 2nd siren.
- Firing shall be done by licensed blaster using exploder away at a safe distance from working site.
- Key of the exploder should always be retained with the /shot firer / blaster or competent person designated to carry out the blast.
- Blasting will be done during the day light only 9am to 5pm.

PERMISSIBLE LIMIT OF EXPOSURE OF CHEMICALS

a. The working environment in a tunnel or a shaft shall not contain any of the hazardous substances in concentrations beyond the permissible limits as laid down in Delhi BOCW (RECS) Rules, 2002.
b. The responsible person shall conduct necessary test before the commencement of a tunnelling work for the day and at suitable intervals to ensure that the permissible limits of exposure are not exceeded and a record of such test is maintained and is made available for inspection.

15.3. De-fuming and post blasting procedure

After firing the round, the blast area shall be de-fumed by ventilation fans of adequate capacity to allow dissipation of fumes and dust generated by the blast. Blasting engineer will then check the condition of the blast area, particularly for misfires if misfires are found, the blaster will immediately treat the misfires, either by re-blasting or flushing the misfire with water to remove any explosive material remaining. Once the area has been checked and cleared, the blasting engineer will give all clear signal to resume work and start mucking. In case of misfires the hole will be cleaned with wooden or plastic rod and washed with water jet. In certain cases, if the explosive cartridge cannot be removed from the misfire hole, then a hole will be drilled parallel to the misfire hole at 600 mm distance for secondary charging and blasting to remove misfired hole

- Entry of unauthorized persons will be restricted till fumes are diluted.
- Check for misfire will be carried out.
- Fire cables will be withdrawn.
- Inspection of fracture/blasted rocks will be done.
- Water will be sprinkled on blasted area for fumes suppression.

Following precautions will be taken for the ventilation purpose:

I. The required quantity of fresh air shall be insured at the heading face. The quality of the air at the heading should be checked daily at least twice with the help of an air analyzer and documented for inspection. The check of the air tightness of joints and control of the air ducts for leaks shall be performed periodically. Any deficiency discovered shall be repaired.
II. Ventilation ducts shall be firmly fixed to the vaults in such position, that a minimum clearance shall remain between the duct and the extremities of vehicular traffic deployed in the underground works.
III. All parts of the works shall be maintained in a state, which shall not be injurious to the health of the personnel. The air in underground works shall not contain less than 19.5% of oxygen (by volume) and shall maintain concentration of gases, vapours or dust within permissible limit that are safe for the health of workman.
IV. Intermediate fans in the main tunnel shall be provided as require to ensure satisfactory removal of contaminated air. All ventilation ducts shall be maintained in the airtight condition
V. If required, the ventilation system shall be kept in operation for complete excavation of tunnels in order to maintain the fresh air volume requirements stated hereinafter.
VI. The main ventilation system shall be designed to allow the flow to be reversed and shall be operated as follows:
    a. The system shall be operated on alternate blowing and exhaust modes during remaining activities of tunnelling covering.
    b. Immediately prior to the blasting, the system shall be put in the exhaust mode of operation. Blasting fumes shall be discharged in such a way that they can neither escape to any other working place nor can they be re-circulated in the fresh air supply system.

The ventilation system shall be designed to cater the air requirement for following loads:

i. Maintaining the proper air quality inside the tunnel restricting the noxious gases inside the tunnel. (4.25 cum per person per minute)
ii. Dust during the shotcretening process.
iii. Diesel engines running inside the tunnel (4.5 cum per KW per minute)
iv. De-fuming post blasting process.

15.4 DECLARING AREA SAFE FOR ACCESS

- 5-10 minutes after blasting is done, blasted area shall be inspected by blasting in charge. This examination shall look for:-
    - Dangerous rock conditions
    - The presence of undetonated explosives and/or initiators
    - Abnormal blast conditions and any other hazards
- If misfires or other hazards are present, the blasting-in-charge shall supervise the removal of the hazard by the most appropriate means available.
- When the area is clear of hazards the blaster-in-charge shall give the all clear signal allowing work to resume in the area.

15.5 MISFIRE HANDLING PROCEDURE

When blasting misfires occur, or are suspected, their existence and extent must be carefully established under the direction of the blaster-in-charge. Under these circumstances, the blaster-in-charge shall:

- Ensure that no one enters the blast area, and it remains secured, for at least 30 minutes.
- Develop a plan involving minimum people to safely re-fire, wash out, or recover un-shot explosives, before any other normal work resumes near the blast site.
- Record the location of any potentially un-detonated explosives on the blast report.
- No forceful attempt shall be made by anyone to remove explosives from any misfired hole.
- None of the drillers are allowed to work near the misfired hole until one of the two following operations has been carried out by the blaster in charge:
- If the blasting circuit related to those misfired holes is intact then Misfired holes should be re-connected and fired.
- If the blasting circuit connecting to the misfired holes is burnt or fired, unexploded explosives shall be removed from the hole with the help of compressor or water jet. The hole thereafter shall be charged and re-blasted.
- Even after the above method if the explosives could not be taken out from the misfired hole, a hole(s) shall be drilled parallel to the misfired hole(s) keeping a distance of 60 cm and 30 cm less than the depth of the hole charged and fired.
- If any explosives found in the blasting muck same to be collected and handed over to shot firer / blaster.
- The relieving hole shall preferably be drilled by the same drill operator who drilled misfired hole and in the presence of a shot firer/ blaster.
- Expand the blast security area if fly rock potential is increased when misfires are re-blasted.

15.6 WARNING SYSTEM

- First Siren: - For evacuation of person siren shall rung for duration of 1-2 minutes, before final connection.
- Second Siren: - The second Siren shall be rung for duration of 1-2, after final connection and at least 20 minutes after the first siren.
- Third Siren: - After inspection of blast area and found satisfactory for blast then siren shall be rung for duration of 30 second

15.7 EXPLOSIVE STORAGE AT SITE

The blasting in-charge / Shot firer shall thoroughly review and understand all regulations (The Explosive Act /rules, Metallic-ferrous Mines Regulations/act, IS 4081, etc) with regard to:

- Storage requirements,
- Locking requirements,
- Inventory record keeping requirements,
- Explosive loss reporting requirements. Immediately report by calling CISF commandant, nearest Police station & district magistrate.

15.8 TRANSPORTATION AND STORAGE OF EXPLOSIVE MATERIAL AT SITE FOR BLASTING

Explosive Vans

- Explosives and detonators shall be transported in independent (separate) vehicles and in insulated containers, and in separate compartment.
- Explosives shall be transported by vehicles which are having explosive carrying license
- The Specification of explosive van for carriage of explosives has to comply with all the requirements as mentioned under the statutes prescribed by The Petroleum and Explosives Safety Organisation.
- The interior of the body shall not have any exposed metal parts except those of copper, brass and other non-sparking metals and shall preferably be lined with wood.
- The transporting driver shall have adequate knowledge's of emergency handling procedures and have valid hazardous carrying licenses
- Explosives van shall be marked on sides, the front, and the rear with the word "Explosives" in red letters.
- Explosive van shall be provided with minimum 2 fire extinguishers of minimum 2kgs capacity. One for electrical fire and the other for engine fire,
- Vehicle or container carrying explosives shall NOT be left unattended.
- Use of Cell Phones & Walkie -Talkie and Smoking & Creating Open Flames is strictly prohibited in the vehicle carrying explosives and in its vicinity.

Transportation of Explosive and Detonator from explosive van to blast site

- Explosives and detonators shall be brought to the working places in separate, tight, well-insulated wooden containers,
- Detonators shall be carried out in securely locked wooden Box / container.
- Detonator leads should remain connected in such a way that they are electrically continuous.

- During the time of transportation –Carrier shall be so arranged that there is no other person with him, either in the man cage, or while going to work site..
- Explosive cartridge and detonator should not be transported by at a time or by one person or by other means.
- Rubber mat should be placed on the floor of man cage to minimize the any statics charge.
- Carrier should wear of appropriate PPE.(Gumboot, Helmet, Cotton Cloths)
- The case or container carrying detonators shall also be kept not less than 06 m apart from any case / container of explosives.
- Ensure that all electrical equipment and sources of radio frequencies are turned off while at the blast site
- Remove all sources of flame and heat in the blasting area, including the strict enforcement of a no smoking policy.
- Do not charge blast holes while equipment or drills are operating within 20m of the blast site.
- All people are prohibited for the Use of Cell Phones & Walkie -Talkies and Smoking & Creating Open Flames is strictly prohibited in the vehicle carrying explosives and in its vicinity.

MAGAZINE

- Approval of the Chief Controller shall be obtained separately for the construction & storage of explosive in magazine.
- The basic considerations in the construction of magazines shall be security to ensure that the contents are kept out of the hands of unauthorised persons, to maintain them in good conditions and to reduce the risk of accidental explosion, as specified in the table of safety distance in Schedule VIII of The Explosive Rules.. Naturally a site obscured from public view either by natural or artificial means is preferred.
- Apart from the rules and regulations concerning the storage of explosives, certain conditions should be observed from the point of view of care for the materials concerned for example, improper storage may lead directly to misfires later on. In all cases, places of storage should be dry, well ventilated and protected from extremes of temperature as much as possible.
- Safety Fuse and detonators should be kept in perfect condition for obtaining good results. Therefore, at all times during transport, handling and storage, they should be protected from moisture and contact with oil, grease, kerosene or other liquids. Detonators shall not be stored with other explosives.

15.9 PROTECTIVE MEASURES

For Fly Rock Hazard: - To control the fly rock hazards following protective measures shall be adopted while carrying out blasting operations.

- Using with Rubber Mats / MS steel plates / Rubber tires / Sand bags adequacy to cover the top surface of the blast area.
- Loading of charge weight per blast hole with charge per delay and total number of charge hole as per approved or trial blast.

- Display the warning Signs to warn and cordon off to unauthorized entry to blasting zone.
- Keep and maintain safe distance from the charged face for the blasting.
- Short firer / Blaster will final check before going to Blast a Charged face
- Use protective area for the blast / Taking a proper shelter at the time of blasting.
- Use personnel protective equipment during the time of blasting.
- Flag men will be posted at all possible entries to blasting zone throughout the process of blasting.
- Movement of personnel and vehicle will be restricted within the blasting zone prior, during and after the blasting process.

FOR EXISTING STRUCTURES

In order to safeguard the existing structures, the following limitations shall be kept in mind while planning for blasting in hard rock and ensure in any condition P.P.V. (Peak particle Velocity) is below the acceptable limit

Description	**Max Allowable PPV (mm/Sec)**	**Max allowable vibration Amplitude (MM)**
Structures in “good” condition and Road / Pavements/ Open areas	25	0.2
Structures in “Fair condition)	12	0.15
Structures in poor condition and Heritage structures/bridges and water supply structures	5	0.1
Fresh Concrete:- • Less than 2 days old • 2 to 8 days old • More than 8 days old	 5 25 50	 0.1 0.2 0.2

- Recording of ground vibration & noise level will be carried out by using seismograph.

DRILLING EQUIPMENT / MACHENERIES:-

- All drilling equipment shall be’ kept in safe & good working order condition and maintained and provide safe access. The technical specification of drilling equipment shall be kept ready at site.

Chapter 16

UNDER AND ABOVE WATER CONSTRUCTION

16.1 Introduction

Primarily employers should conduct a comprehensive risk assessment for the kind of construction work, and take into account the hazards identified and evaluated during the assessment to develop a safe system of work. To prevent any person from falling from height, suitable safety measures should also be developed and implemented. Besides, effective rescue and emergency arrangements should be well established for work over water so as to safeguard the workers in an emergency situation.

16.2 SAFE SYSTEM OF WORK

- A task-specific risk assessment for work over water should be conducted and reviewed periodically by a competent person.
- All potential hazard(s) involved in the work over water, e.g. drowning, overturning of mobile plant/equipment into water and collapse in confined spaces, should be identified, listed out and addressed.
- A safety plan for work over/near water, including but not limited to the following, should be established:
  - Planning of work;
  - Formulation of method statements/safe working procedures;
  - Emergency preparedness, e.g. contingency plans, Rescue/evacuation arrangements and drills.
  - The safety plan for work over/near water should be regularly reviewed and, where necessary, revised as appropriate.
  - Safe work methods should be properly implemented according to the safety plan.
  - Implementation of safe work methods should be adequately monitored and supervised.
  - Necessary safety information, instruction and training should be provided to workers.

16.3 Safe use of lifting appliance/Mobile Plant

- Lifting appliances and lifting gear should be tested and examined by a competent examiner before use and at regular intervals and inspected by a competent person at regular intervals.
- Lifting appliances/mobile plant should be operated by qualified operators.
- Operators of lifting appliances/mobile plant on vessels should be authorized by the master or owner of the vessel/ the site management before carrying out any work.
- Operation of lifting appliances/mobile plant should be supervised by works supervisors.
- Lifting appliances on vessels should be fixed and securely anchored

- No lifting appliance/mobile plant or lifting gear should be loaded beyond its safe working load.
- Lifting appliances/mobile plant and lifting gear should be properly maintained in safe working order.

16.4 Life jackets/buoyancy aids

- Lifejackets/buoyancy aids should be provided to and worn by workers with risk of falling into water.
- Lifejackets should be thoroughly checked by the user before each use.
- A lifebuoy with sufficient lifeline (not less than 30 meters) should be provided and the locations of the lifebuoys should be at less than 50-metre intervals along the edges of places where work is being carried out over side or in an exposed position on vessels where there is a reasonably foreseeable risk of falling or being washed overboard. To avoid any delays to rescue operations, lifebuoys should not be tightly tied. The lifejacket/buoyancy aid should preferably be provided with a whistle and/or a self-activating light (for night work) in order to aid locating the wearer and facilitating rescue.
- The lifejackets/buoyancy aids should be inspected and checked periodically by a competent person.
- The lifejackets/buoyancy aids should be properly maintained in a good serviceable condition according to the manufacturer's instructions.
- All inflatable lifejackets should be serviced by an authorized agent at least once a year.

Fig.16.1. Steps of using buoyancy aids

16.5 Working in Heights

- Suitable guard-rails and toe-boards should be installed at edges. Openings should be properly covered where persons are liable to fall from height, to land surfaces or into water.

- Suitable working platforms, with suitable guard-rails and toe- boards, should be provided for work Safety harnesses with continuous and effective anchorage system should be provided when it is impracticable to provide a suitable working platform, access and egress and safe place of work at height. Safe means of access and egress should be provided for the working platform.

16.6 Safe means of access and egress

Safe means of access and egress should be provided between a vessel and

i. Another vessel;
ii. The shore;
iii. A workplace on land/over water.

16.7 Efficient lighting should be provided at all means of access and egress

- Means of access and egress and their approaches should be free from obstruction and, as far as practicable, kept clear of any substance likely to cause a slip, trip or fall.
- Ramps of adequate strength should be provided for the access of vehicles from Land to vessels, or vice versa.
- Ramps for vehicles should not be used as access gangways for people unless a suitable Separation is provided.

16.8 Rescue and emergency Arrangements

- Rescue/evacuation teams (including first aiders) of suitable capacity should be organized to deal with emergency situations.
- The occurrence of an emergency situation should be informed immediately to the rescue team for immediate launching of appropriate rescue procedures.
- Serious emergency situations should be reported immediately to the public emergency authorities, i.e. Fire Services Department and/or Police, for assistance.
- Sufficient rescue/evacuation boat(s) should be provided and kept ready for immediate use in case of emergency.
- Rescue facilities, including sufficient stretcher(s), portable resuscitation equipment and first aid facilities, should be provided and kept readily accessible for emergency use
- Emergency procedures, including rescue/evacuation procedures, should be formulate and reviewed regularly in the safety plan for, but not limited to, adverse weather (Cyclone, thunderstorm, heavy rainstorm, etc.), fire, injuries of workers, etc.
- An emergency contact list (internal and external) should be displayed on board.
- An effective communication system should be established between front-line workers and supervisory staff in case of emergencies, including:
  i. Provision of sufficient communication equipment;
  ii. Formulation of relevant procedures;
  iii. Provision of necessary information to supervisors/workers concerned.
  iv. Necessary information on adverse weather should be made available from any specific data/forecast to be prescribed with due regard to the peculiar site location/situation) or other reliable sources and timely/effectively communicated to personnel/workers likely affected by the weather.
  v. Shelters, vessels for evacuation from adverse weather, etc, should be provided

in the vicinity of workplaces over water.

vi. Evacuation procedures should be timely launched with due regard to impending adverse weather.

16.9 Safety Training

- Workers should undergo Mandatory Basic Safety Training for land-based construction work and/or Shipboard Cargo Handling Basic Training for marine construction work at sea.
- Job specific safety training and regular refresher training should be provided to workers to enhance/maintain their safety awareness of potential hazards associated with work over water, including those during adverse weather.
- Specific safety training should be provided to workers on the use and checking procedures of lifejackets, and rescue arrangements for persons who fall into water.
- Supervisors/workers should be trained on emergency and evacuation procedures, including the conduct of regular drills, in respect of work over water.
- Specific safety training should be provided to all members of the rescue/emergency team in connection with rescue procedures and the use of rescue equipment.
- Essential safety information and contingency arrangements should be provided (such as by issuing portable safety cards) to workers engaged in work over water on vessels.

Chapter 17

DEMOLITION

17.1 INTRODUCTION

Physical injuries and death caused by workplace accidents cause severe social and economic problems. Every year, more fatal accidents occur in the field of building around the world, with one worker dying every 10 minutes as a consequence an occupational accident. Because of its labour-intensive nature and high risks, the construction industry faces significant financial losses as a result of workplace accidents.

17.2 Definition

"Demolition is the science and engineering in safely and efficiently tearing down of building and other man-made structure and also carefully preserving valuable elements for reuse purposes."

Hazards

- Collapse of structure
- Fly materials
- Falling materials
- Hit by materials
- Collapse of equipment, machinery, noise, dust, electric shock, explosion, etc.

PPEs

The following minimum personal protective equipment (PPE) for demolition workers shall be provided:

- Safety helmet.
- Safety glasses/goggles
- Heavy-duty gloves.
- Safety boots with steel toe caps and preferably with penetrant-resistant soles
- Appropriate respiratory equipment (as necessary to prevent inhalation of dust and/or particulates
- Additional PPE, specific to the job task, shall be provided when necessary (e.g., face shield, earplugs, welding goggles/mask).
- Full-body harnesses and lanyards (with lifelines where required) shall be used whenever a worker could fall more than 1.8 m (6 ft).

17.3 Before any demolition work is commenced and also during the progress of the work

- All roads and open area adjacent to the work site shall either be closed or suitably protected. Appropriate warning signs shall be displayed for cautioning persons approaching the demolition area. The area shall be cordoned off properly.
- Protection of adjacent building, underground service lines should be ensured. Underpinning operations shall not be permitted unless adequate measures against collapse of structure are ensured.

- Before demolition operations begin, shall ensure that the power on all electric service lines is shut off and the lines are cut or disconnected at or outside the demolition site. If it is necessary to maintain electric power during demolition operation, the required service lines shall be adequately protected against damage.
- No floor, roof or other part of the building shall be overloaded with debris or materials that may render it unsafe.
- Entries to the demolition area shall be restricted to authorized persons only

Before the demolition starts

- All utility services, such as electricity, gas, water and fire protection systems, shall be isolated and properly locked and tagged prior to demolition work. The utility services' main supply shall be disconnected outside the boundary of the demolition work. Tanks and vessels shall be completely disconnected from inlet, outlet and overflow points.
- It shall be determined if any type of hazardous chemicals, gases, explosives, flammable materials, or similarly dangerous substances have been used in any pipes, tanks, or other equipment on the property. When the presence of any such substances is apparent or suspected, testing and purging shall be performed and the hazard eliminated before demolition is started.
- Prior to demolition of a multi-storey building, an engineering survey shall be made, by a structural engineer, of the structure to determine the condition of the framing, floors and walls, and possibility of unplanned collapse of any portion of the building. Any adjacent structure where personnel may be exposed shall also be similarly checked. The demolition crew shall have in writing evidence that such a survey has been performed.
- Adjacent structures, public buildings, pedestrian walkways, parking lots, etc., shall be protected from potential demolition debris. Bracing shall be installed, where needed, to ensure stability of adjacent structures.
- Barricades shall be erected around the demolition work area. Signs with the words "Danger - Demolition in Progress" in local language and English shall be erected at each approach to the demolition area

Stability during demolition

- Frequent inspections shall be performed during demolition activities to identify hazards that may develop from weakened or overloaded floors, unsupported walls, loose material, etc. Steps shall be immediately taken to prevent premature collapse of any part of the structure. Personnel shall not be permitted to work where such hazards exist until they are corrected by shoring, bracing or other effective means.
- Masonry, concrete and other debris shall not be permitted to fall upon a floor so as to exceed the safe load capacity of the floor.
- Lateral supports shall not be removed from more than one story of wall before starting to demolish it. When a wall from which supports have been removed is left standing, including during overnight and off-work hours, adequate bracing shall be provided to prevent collapse.

- Structural or load-supporting members on any floor shall not be cut or removed until all stories above it have been completely demolished and removed.
- Personnel shall not be permitted to work on top of a roof, wall, etc., when weather conditions could create a hazardous environment.

17.4 Work area clearance:

- Safe means of access and egress from all work areas shall be provided
- Work areas, ladders, stairways and walkways shall be kept clear of material and debris.
- Nails in timber shall be removed or bent over.
- Glass in windows, doors, partitions, etc., shall be completely removed prior to structural demolition.

17.5 Structural steel removal:

- A demolition procedure for steel structures (e.g., storage tanks, silos, towers, pipe racks) shall be developed and submitted prior to demolition.
- Steel frame construction shall be demolished column length by column length and tier by tier.
- Any structural steel member being removed shall not be under any stress other than its own weight.
- Steel members shall be chained or lashed in place prior to cutting or dismantling to prevent uncontrolled swinging or dropping.

17.6 Tanks, vessels and piping:

- Vessels, tanks, pipes, etc., that may have contained hydrocarbons or other toxic/flammable materials shall be isolated, flushed, and ventilated to remove residual materials. Subsequent gas tests shall be conducted and work permits issued prior to burning or cutting.
- The use of cold cutting techniques for dismantling tanks, vessels and piping requires a Cold Work Permit

17.7 Heavy equipment guards:

Heavy equipment, such as cranes and bulldozers, shall be equipped with wire mesh guards over windows and solid protection over the driver's position to protect the operator from flying/falling debris.

17.8 Safety Precautions

- Prior to permitting employee or workers to start demolition, an engineering survey shall be done and any adjacent structure where employee exposed shall also be checked. The employer shall have in writing, evidence that such a survey has been performed.

- A definite Plan of Procedure for demolition work shall be prepared by contractor and finalised in consultant with competent engineer. A copy of the Survey Report and the Plans / Method of operation shall be maintained at job site for the duration of the demolition operation.
- Post completion of above mentioned points Contractor shall implement the plan in actual practise.
- Any device or equipment such as Scaffolds, Ladders, Derrick, etc., shall be constructed, installed, inspected, maintained and operated in accordance with the regulations governing.
- Demolition shall be conducted under competent supervision and safe working conditions. Prior commencement of each stage the supervisor shall brief the worker in detail regarding the safety aspects.
- Demolition in those structures which are damaged by fire, flood, explosion, or other cause shall be shored or braced.
- All electric (MCB & meters), gas, water and other service lines shall be shut off before demolition starts. These utility services shall be notified in advance.
- Caution boards and barricading shall be placed before the operation.
- All the roads and open areas adjacent to work site shall be protected and Caution Boards / Danger Sign in local language to be displayed. Unauthorised entry shall be efficiently kept under control.
- Provisions shall be made for at least two independent exits for escape of workmen during emergency.
- During night, red lights or luminescent sign shall be placed around all barricades.
- Walkways and passageways shall be provided for workmen and they will be strictly instructed to use these only. Such walkways shall be kept adequately lighted and free from debris and other materials.
- Demolition shall always proceed in floor by floor in descending order (top to bottom). Wall shall be removed part by part.
- While breaking roof slabs, workmen are not allowed to sit on the same floor but on a separate platform and if in case, they must fasten their lanyard or independent lifeline.
- Debris shall not be allowed to be thrown from height. Removal of debris promptly using by Metal Chutes installed at an angle of more than 45^0 from top to bottom.
- Only experienced workmen shall be engaged for demolition operation.
- All materials which are to be removed causes dust formation, shall be sprinkled with water to ossify it.
- If asbestos, hazardous materials, hazardous chemicals, gases, explosives, flammable materials or similarly dangerous substances found at work site then testing and removal / hazard elimination shall be performed.

Chapter 18

CONSTRUCTION MACHINERY AND EQUIPMENT

18.1 ERECTION EQUIPMENT

A. SAFETY GUIDELINES OF LIFTING APPLIANCES AND GEAR

- Employers should have a well-planned safety programme to ensure that all the lifting appliances and lifting gear are selected, installed, examined, tested, maintained, operated and dismantled:
  - (a) with a view to preventing the occurrence of any accident;
  - (b) in accordance with the requirements laid down in the national laws, regulations and standards.
- Every lifting appliance including its constituent elements, attachments, anchorages and supports should be of good design and construction, sound material and adequate strength for the purpose for which it is used.
- Every lifting appliance and every item of lifting gear should be accompanied at the time of purchase with instructions for use and with a test certificate from a competent person or a guarantee of conformity with national laws and regulations concerning:
  - (a) The maximum safe working load;
  - (b) Safe working loads at different radii if the lifting appliance has a variable radius;
  - (c) The conditions of use under which the maximum or variable safe working loads can be lifted or lowered.
- Every lifting appliance and every item of lifting gear having a single safe working load should be clearly marked at a conspicuous place with the maximum safe working load in accordance with national laws and regulations.
- Every lifting appliance having a variable safe working load should be fitted with a load indicator or other effective means to indicate clearly to the driver each maximum safe working load and the conditions under which it is applicable.
- All lifting appliances should be adequately and securely supported; the weight-bearing characteristics of the ground on which the lifting appliance is to operate should be surveyed in advance of use.

B. INSTALLATION

- Fixed lifting appliances should be installed by competent persons:
  - (a) So that they cannot be displaced by the load, vibration or other influences;
  - (b) So that the operator is not exposed to danger from loads, ropes or drums;
  - (c) So that the operators can either see over the zone of operations or communicate with all loading and unloading points by telephone, signals or other adequate means.
- A clearance of at least 60 cm or more, as prescribed by national laws or regulations, should be provided between moving parts or loads of lifting appliances and:
  - (a) Fixed objects in the surrounding environment such as walls and posts; or

(b) Electrical conductors-The clearance from electrical conductors should be more for high voltages in accordance with the requirements of national laws and regulations

- The strength and stability of lifting appliances should take into account the effect of any wind forces to which they may be exposed.
- No structural alterations or repairs should be made to any part of a lifting appliance which may affect the safety of the appliance without the permission and supervision of the competent person.

C. EXAMINATIONS AND TESTS

- Lifting appliances and items of lifting gear, as prescribed by national laws or regulations, should be examined and tested by a competent person:
  (a) Before being taken into use for the first time;
  (b) After erection on a site;
  (c) Subsequently at intervals prescribed by national laws and regulations;
  (d) After any substantial alteration or repair.
- The manner in which the examinations and tests are to be carried out by the competent person and the test loads to be applied for different types of lifting appliances and lifting gear should be in accordance with national laws and regulations.
- The results of the examinations and tests on lifting appliances and lifting gear should be recorded in prescribed forms and, in conformity with national laws and regulations, made available to the competent authority and to employers and workers or their representatives

D. SAFETY IN CRANE AND DERRICK OPERATION

Travelling cranes or fixed tower cranes should be installed on good solid foundations and they should be braced properly beyond' permissible free standing height.

- No crane should be used unless a competent person has inspected and tested it and furnished a certificate specifying the maximum safe working load.
- Access to and egress from the operator's stand should be safe from any position of the crane.
- Cranes should not be used to pull out fixed objects with a slanting pull, drag objects or move vehicles.
- Before being put into use for the first time, jib cranes with variable radius should undergo tests of stability and of all movements such as travel, swinging, raising and lowering the load, braking the crane and braking the load.
- Jib cranes should not be operated in dangerous proximity to electric power lines.
- Derricks should be erected on a firm base and adequately secured against displacement.
- Suitable devices should be used to prevent masts from lifting out of their seating.
- The mast of guy derricks should be supported by adequate guys spaced equally.
- When a derrick is not in use, the boom should be lowered to prevent it from swinging.
- No crane should be used in weather likely to endanger its stability.

- Electrically operated derricks should be effectively earthed from the soleplate or framework.
- Counterweights should be so arranged that they do not subject the backstays, sleepers or pivots to excessive strain.
- When derricks are mounted on wheels:

  (a) A rigid member should be used to maintain the correct distance between the wheels;

  (b) They should be equipped with struts to prevent them from dropping if a wheel breaks or the derrick is derailed.

- The length of a derrick jib should not be altered without consulting the manufacturer.
- The jib of a scotch derrick crane should not be erected within the backstays of the crane.

E. CRITICAL CRANE LIFT

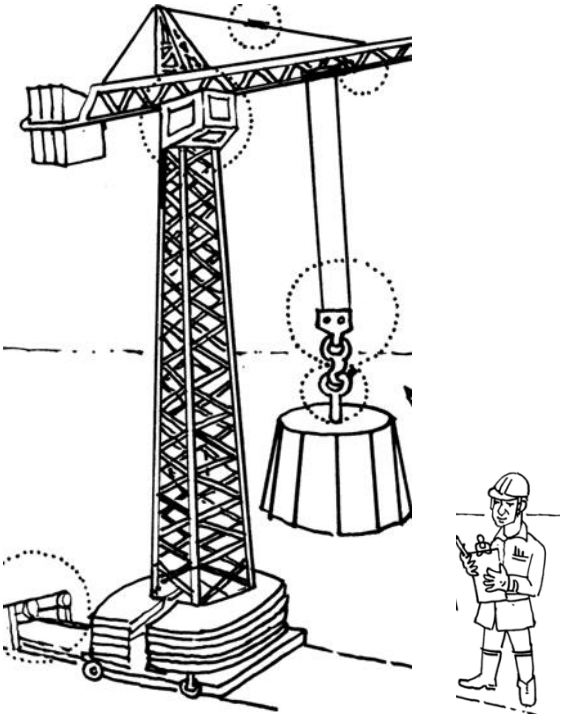


Fig18.1. Crane testing

- A Critical Lift Plan shall be completed and approved and made available on-site prior to any critical crane lift.
- Critical crane lifts include, but are not limited to, lifts:
  a. When any part of a crane whose boom or boom attachment is to be within 10 m (33 ft) of hydrocarbon or pressurized piping. This includes cranes having to suspend a load over a vessel, piping or equipment containing hydrocarbons, steam or other pressurized liquids.
  b. When any part of a crane whose boom or boom attachment is to be within 10 m (33 ft) of any populated/traffic areas. This includes cranes having to

suspend a load over pedestrians, vehicle traffic, occupied construction equipment or occupied buildings.

c. When any part of a crane whose boom or boom attachment is to be within 10 m (33 ft) of a railway line.
d. Requiring an attachment to the main boom.
e. When any load that exceeds 85% of the crane's rated load capacity or manufacturer's specifications for that specific lift.
f. Occurring at night (i.e., between sunset and sunrise).
g. When an explosion, fire or high heat hazard is present.
h. When the crane is operating near energized power lines.
i. Involving high level or long reach lifting.
j. On barges, vessels or hydrocarbon-loading piers.

- Certified Rigger shall be in-charge of coordinating all critical crane lifts.
- Night time crane lifts require prior written approval from the DISH, except during a test and inspection (T&I) or shutdown.
- The work area for night time crane lifts shall be provided with proper lighting sufficient to perform the lift safely

F. SAFETY IN HOISTS OPERATION

Hoists used for transporting workers should be provided with safety catches. This is a device whereby if the wire-rope snaps, the cage is held on to the vertical guides by the catch.

- Hoists must be enclosed at ground level by substantial enclosures and gates at least 2 m high and the enclosures should be extended to accommodate the engine or motor.
- Gates of the same height of 2 m must be provided at all the landing stages.
- The complete hoist way throughout its height shall preferably be enclosed with wire mesh in order to contain the accidentally dislodged material from the hoist platform.
- There must be only one operating position for the hoist and driver must be trained in the job and be able to see the platform of the hoist throughout its travel.
- All material carried on the platform must be so placed as not to be dislodged and any moveable equipment, wheel-barrows etc, must be scotched.
- The safe working load must be plainly marked on the hoist and never exceeded.
- Every hoist must be fitted with an automatic device which will support the platform in the event of any failure of the ropes or gear.
- Every hoist must be inspected once in the week.
- Check wire ropes of hoist frequently
- Hoist towers should be designed according to national laws and regulations.
- Hoist shafts should be enclosed with rigid panels or other adequate fencing:
  (a) At ground level on all sides;
  (b) At all other levels at all points at which access is provided;
  (c) At all points at which persons are liable to be struck by any moving part.
- Where necessary to prevent danger, adequate covering should be provided above the top of hoist shafts to prevent material falling down them.

- Outdoor hoist towers should be erected on adequately firm foundations, and securely braced, guyed and anchored.
- A suitable ladder way should extend from the bottom to the top of outdoor hoist towers, if no other ladder way exists within easy reach.

G. LIFTING AND HOISTING MACHINERY

The erection of the hoisting machinery is a specialised job which should be carried out under a competent authority. The stability of crane is important as it may overturn due to bad or improper sequence of operations. The safe working load of a jib should be marked or painted on it to prevent overloading. Limit switches or electronic control should be fitted on cranes for safe lifting, swinging and turning of the load with the boom. Very often the operator is guided by a hand signal. He should be familiar with the signal system. It is a safe practice that the load to be handled is first lifted as a trial, and if successful then handled further.

H. MOBILE CRANES

In the case of a mobile travel crane, the specified gradient should be maintained. When the crane moves down the hill, its engine should be kept running with the gear on. The out-riggers should be used if the radius exceeds the rated load. The brakes should be 'ON' when a rubber tyre crane is operated. The pressure in the pneumatic tyre should be maintained correctly in all wheeled machines. It is advisable to equip the crane with the following accessories:

a) Anemometer to indicate wind pressure,

b) Anchors for rail mounted cranes,

c) Limiter to prevent failure of ropes,

d) Safety stops to restrict crane travel,

e) Swinging radius indicator to indicate safe load at a given radius,

f) Heel indicators to control crane heeling, and

g) Electrical/mechanical safe limits to compare the weight actually hoisted and the load admissible at various swing radii.

SAFE OPERATING PROCEDURES

a. The crane should be kept on a level and firm ground. The ground should be stable. If it is soft, the area under the wheels should be made solid with stones or wooden sleepers. This also applies to the crane or crawled tracks.
b. While travelling through soft ground, the wheel track climbs better with the load behind.
c. While travelling uphill or downhill, the boom should always be kept downhill. This prevents the boom from falling back on the super structure.
d. The capacity plate should be consulted before lifting a load at a particular radius. The boom should not be raised more than 75° from horizontal. The maximum operating radius should not be exceeded.

e. Before starting operation at the beginning of the day's work, always pick up a capacity load up to 0.3 m above ground to test the drift, if any, due to faulty brakes.
f. A jerky start or stop of a fully loaded crane can overturn it or bend the boom. Also, a fast swing increases the tendency of tipping if the machine is stopped abruptly.

I. TOWER CRANES

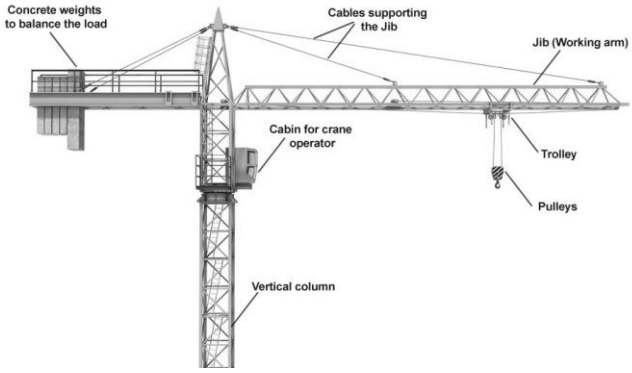


Fig.18.2 Tower crane operation

- Where tower cranes have cabs at high level, persons should only be employed as crane operators who are capable and trained to work at heights.
- The characteristics of the various machines available should be considered against the operating requirements and the surroundings in which the crane will operate before a particular type of crane is selected.
- Care should be taken in the assessment of wind loads both during operations and out of service. Account should also be taken of the effects of high structures on wind forces in the vicinity of the crane.
- The ground on which the tower crane stands should have adequate bearing capacity. Account should be taken of seasonal variations in ground conditions.
- Bases for tower cranes and tracks for rail-mounted tower cranes should be firm and level. Tower cranes should only operate on gradients within limits specified by the manufacturer. Tower cranes should only be erected at a safe distance from excavations and ditches.
- Tower cranes should be sited where there is clear space available for erection, operation and dismantling. As far as possible, cranes should be sited so that loads do not have to be handled over occupied premises, over public thorough fares, other construction works and railways or near power cables.
- Where two or more tower cranes are sited in positions where their jibs could touch any part of the other crane, there should be direct means of communication between them and a distinct warning system operated from the cab so that one driver may alert the other to impending danger.
- The manufacturers' instructions on the methods and sequence of erection and dismantling should be followed. The crane should be tested in accordance with national laws or regulations before being taken into use.
- The climbing operation of climbing tower cranes should be carried out in accordance with manufacturers' instructions and national laws or regulations. The

freestanding height of the tower crane should not extend beyond what is safe and is permissible in the manufacturers' instructions.

- When the tower crane is left unattended, loads should be removed from the hook, the hook raised, the power switched off and the boom brought to the horizontal. For longer periods or at times when adverse weather conditions are expected, out of service procedures should be followed. The main jib should be slewed to the side of the tower away from the wind, put into free slew and the crane immobilised.
- A wind speed measuring device should be provided at an elevated position on the tower crane with the indicator fitted in the drivers' cab.
- Tower cranes should not be used for magnet, or demolition ball service, piling operations or other duties which could impose excessive loadings on the crane structure.

J. LIFTING ROPES

- Only ropes with a known and adequate safe working capacity should be used as lifting ropes.
- Lifting ropes should be installed, maintained and inspected in accordance with manufacturers' instructions and national laws or regulations.
- Repaired steel ropes should not be used on hoists.
- Where multiple independent ropes are used, for the purpose of stability, to lift a work platform, each rope should be capable of carrying the load independently.

K. ELEVATORS

Elevators should not be used for movement of workers till the installations are certified safe. Slings should be inspected by a qualified craftsman. Ropes and chains employed on work sites should be inspected regularly. Riding on loaded hooks, brackets etc, by workers should be strictly prohibited.

18.2 TRANSPORT, EARTH-MOVING AND MATERIALS-HANDLING EQUIPMENT

A. GENERAL PROVISIONS

- All vehicles and earth-moving or materials-handling equipment should:

  (a) Be of good design and construction taking into account as far as possible ergonomic principles particularly with reference to the seat;

  (b) Be maintained in good working order;

  (c) Be properly used with due regard to safety and health;

  (d) Be operated by workers who have received appropriate training in accordance with national laws and regulations.

- The drivers and operators of vehicles and earthmoving or materials handling equipment should be medically fit, trained and tested and of a prescribed minimum age as required by national laws and regulations.
- On all construction sites on which vehicles, earthmoving or materials handling equipment are used:

  (a) Safe and suitable access ways should be provided for them;

(b) Traffic should be so organised and controlled as to secure their safe operation.

- Adequate signalling or other control arrangements or devices should be provided to guard against danger from the movement of vehicles and earth-moving or materials-handling equipment. Special safety precautions should be taken for vehicles and equipment when direction backwards.
- The assistance of a trained and authorised signaller should be available when the view of the driver or operator is restricted. The signalling code should be understood by all involved.
- When earth-moving or materials-handling equipment is required to operate in dangerous proximity to live electrical conductors, adequate precautions should be taken, such as isolating the electrical supply or erecting overhead barriers of a safe height.
- Preventive measures should be taken to avoid the fall of vehicles and earth-moving or materials-handling equipment into excavations or into water.
- Vehicles and earth-moving or materials-handling equipment should not travel on bridges, viaducts, embankments, etc., unless it has been established that it is safe to do so.
- Where appropriate, earth-moving or materials-handling equipment should be fitted with structures designed to protect the operator from being crushed, should the machine overturn, and from falling material.
- All vehicles and earth-moving or materials-handling equipment should be provided with a plate or the like indicating:
  a. The gross laden weight;
  b. The maximum axle weight or, in the case of caterpillar equipment, ground pressure;
  c. The tare weight.
- All vehicles and earth-moving or materials-handling equipment should be equipped with:
  (a) An electrically operated acoustic signalling device;
  (b) Search lights for forward and backward movement;
  (c) Power and hand brakes;
  (d) Tail lights;
  (e) Silencers;
  (f) Reversing alarm.
- Operators of vehicles and earth-moving or materials-handling equipment should be adequately protected against the weather or accidents due to impact, crushing or contact with a moving load by a cab:
  a) Which is designed and constructed in accordance with ergonomic principles and provides full protection from adverse weather conditions;
  b) Which is fully enclosed where dusty conditions are likely to be encountered;
  c) Which provides the driver with a clear and unrestricted view of the area of operation;

d) Which is equipped with a direction indicator and a rear-view mirror on both sides.

- The cab of vehicles and earth-moving or materials-handling equipment should be kept at least 1 m from a face being excavated.
- When cranes and shovels are being moved, out of service, the boom should be in the direction of travel and the scoop or bucket should be raised and without load, except when travelling downhill.
- On earth-moving and materials-handling equipment, motors, brakes, steering gear, chassis, blades, blade-holders, tracks, wire ropes, sheaves, hydraulic mechanisms, transmissions, bolts and other parts on which safety depends should be inspected daily.
- Vehicles and earth-moving or materials-handling equipment should not be left on a slope with the engine running.
- Deck plates and steps of vehicles and equipment should be kept free from oil, grease, mud or other slippery substances.
- Dredge-type excavators should not be used on earth walls more than 1 m higher than the reach of the excavator if they are installed at the bottom of the wall.
- Bucket excavators should not be used at the top or bottom of earth walls with a slope exceeding 60°.

B. GUIDELINE FOR FORKLIFT

- Forklifts shall be used in accordance with the manufacturer's instructions.
- Forklifts with additional special equipment or equipment in place of the forks shall meet the manufacturer's specifications.
- Forklifts shall have a valid inspection sticker
- Forklifts shall be equipped with overhead protection, seatbelts, a fire extinguisher and a backup warning alarm.
- Forklift operators shall conduct forklift pre-use inspections. Inspections shall include checking the functionality of backup warning alarm and safety devices.
- Forklifts shall only be used on stable road/surface conditions. Loads shall always be in the "uphill" position when travelling up an inclined surface.
- Forks shall be tilted back and raised no more than 15-20 cm (6-8 inches) above the ground to maintain stability when travelling with loads.
- Loads shall not exceed the manufacturer's rated lifting capacity (e.g., as indicated on the data plate).
- Unstable or insecure loads shall not be transported. Loads shall not be raised or lowered while the forklift is moving.
- Diesel or gasoline powered forklifts shall not be used in closed buildings, warehouses or poorly ventilated areas.
- Forklifts shall not be left unattended with the engine running. When forklifts are parked the forks shall not be in a raised position.
- Operators shall travel in reverse when the load obstructs the operator's forward view. Operators shall travel in reverse when going down an inclined surface, keeping the load "uphill."

- Personnel other than the operator shall be prohibited from riding on the forklift, including on the forks.
- Personnel shall not be raised or lowered by a forklift, unless contained within an attachment specifically designed for this purpose and model of forklift used.
- Personnel shall not place any part of their body between moving parts of the forklift.
- Electric (battery) powered forklifts shall be recharged in well-ventilated areas to prevent the possible build-up of hydrogen gas (flammable) in the battery charging area.

C. GUIDELINE FOR EXCAVATOR (INCLUDING BACKHOLES AND TRENCHING EQUIPMENT)

- Personnel shall not work within the boom radius while an excavator is in operation or where they could be struck by any part of the excavator.
- Outriggers, if provided, shall be fully extended when operating a mechanical excavator.
- Excavators shall maintain a clearance of at least 0.6 m (2 ft) from any fixed object while performing a swinging motion.
- Mechanical excavators shall not be used within 3 m (10 ft) of any pipeline, equipment, cable or other obstruction.
- Spotters wearing high-visibility (e.g., reflective) vests shall be used during excavation activities to assist and guide the operator as needed.
- Booms shall be latched and secured before travel.
- Only mechanical excavators designed by the manufacturer to perform lifting shall be used to raise, lower or suspend a load.

D. GUIDELINE DOR DUMPER AND DUMP TRUCKS

- Personnel shall not ride in the skip or on the engine cover of dumpers and dump trucks.
- Dump bodies shall be fully lowered before leaving the dump area.
- Dumper skip latches shall be in good working order. The release mechanism shall function smoothly.
- Dumpers and dump trucks shall be regularly maintained with particular attention to brakes, steering and skip release mechanisms. Proper towing eyes with shackles or pins shall be provided if they are used for towing.
- Dump bodies shall be fully lowered when repair or maintenance are being performed. Dump bodies shall be blocked if they are to be in the raised position for an extended period. Hydraulic rams shall not be used to support a raised body for an extended period.

E. POWER SHOVELS AND EXCAVATORS

- If necessary to prevent danger during inspection or repair, the jib of power shovels should be equipped with a ladder protected by a guard-rail and toe-board.
- Brake pedals for all motions on power shovels should have two independent locking devices.
- Power shovels should be equipped with an emergency quick-acting stop device independent of the controls.

- Excavators that are equipped with a unit for deep digging should either be so designed that the bucket teeth cannot come nearer the boom than 40 cm or be provided with a reliable stop that prevents this from happening.
- Excavators that are designed to be used for lifting with lifting gear should be provided with a plate in the cabin and on the boom bearing a clearly legible and durable text giving the maximum safe working load of the lifting gear fitted.
- Excavator that is equipped for use as mobile cranes should:
  (a) Be examined and tested in accordance with national laws and regulations for mobile cranes;
  (b) Be fitted with an automatic safe working load indicator, when practicable.

F. BULLDOZERS

- Before leaving a bulldozer the operator should:

  (a) Apply the brakes;

  (b) Lower the blade and ripper;

  (c) Put the shift lever in neutral.

- At the close of work bulldozers should be left on level ground.
- When a bulldozer is moving uphill the blade should be kept low.
- Bulldozer blades should not be used as brakes except in an emergency.

G. SCRAPERS

- The tractor and scrapers should be joined by a safety line when in operation.
- Scraper bowls should be propped while blades are being replaced.
- Scrapers moving downhill should be left in gear.

H. ROAD ROLLERS

- Before a road roller is used the ground should be examined for bearing capacity and general safety, especially at the edges of slopes such as embankments.
- Rollers should not move downhill with the engine out of gear.
- When a roller is not in use:

  (a) The brakes should be applied;

  (b) The engine should be put into bottom gear if the roller is facing uphill;

  (c) The engine should be put into reverse if the roller is facing downhill;

  (d) The contact should be switched off;

  (e) The wheels should be blocked.

I. LIFTING ROPES

- Only ropes with a known and adequate safe working capacity should be used as lifting ropes.
- Lifting ropes should be installed, maintained and inspected in accordance with manufacturers' instructions and national laws or regulations.
- Repaired steel ropes should not be used on hoists.
- Where multiple independent ropes are used, for the purpose of stability, to lift a work platform, each rope should be capable of carrying the load independently.

J. HYDRAULIC MACHINES

The use of hydraulically operated equipment is now very common on construction sites. The ease of operations, better control and better breaking force has made it very popular. Unlike, cable controlled equipment, hydraulically operated equipment are safer due to less chances of breaking cables etc. Hydraulic pump, oil cooler, pressure relief valves and actuating cylinders are mounted on construction equipment. The relief valves make operation safe provided they are not tampered. The hazards that are identified on these equipments are:

a) Burst of hoses, and
b) Fire.

Hydraulic fluid, if it leaks or falls on the hot part of engine, the machine can catch fire. Hence hydraulic equipment should have a fire extinguisher on them and all hoses should be protected from external damages. Hydraulic equipment needs skill observation. Any wrong or hasty movement of control lever can cause accident. Hydraulic machines need good and timely maintenance. Lack of maintenance like failure of brakes, hydraulic system, etc, also results in accidents. Hence proper training must be given to operator, mechanic etc, before they handle the equipment

18.3 PLANT, MACHINERY AND EQUIPMENT

Construction of tall buildings requires the use of cranes, hoists, elevators, etc. The location of these machines should be carefully selected. If located inside the structure, the floor openings and other spaces should be provided with guard rails.

A. GENERAL PROVISIONS

- Plant, machinery and equipment, including hand tools, both manual and power-driven, should:

  (a) Be of good design and construction, taking into account, as far as possible, health and safety and ergonomic principles;

  (b) Be maintained in good working order;

  (c) Be used only for work for which they have been designed unless a use outside the initial design purpose has been assessed by a competent person who has concluded that such use is safe;

  (d) Be operated only by workers who have been authorised and given appropriate training;

  (e) Be provided with protective guards, shields, or other devices as required by national laws or regulations.

- Adequate instructions for safe use should be provided where appropriate by the manufacturer or the employer, in a form understood by the user.
- As far as practicable, safe operating procedures should be established and used for all plant, machinery and equipment.
- Operators of plant, machinery and equipment should not be distracted while work is in progress.

- Plant, machinery and equipment should be switched off when not in use and isolated before any major adjustment, cleaning or maintenance is done.
- Where trailing cables or hose pipes are used they should be kept as short as practicable and not allowed to create a safety hazard.
- All dangerous moving parts of machinery and equipment should be enclosed or adequately guarded in accordance with national laws and regulations.
- Every power-driven machine and equipment should be provided with adequate means, immediately accessible and readily identifiable to the operator, of stopping it quickly and preventing it from being started again inadvertently.
- The machines or equipment should be so designed or fitted with a device that the maximum safe speed, which should be indicated on it, is not exceeded. If the speed of the machine is variable, it should only be possible to start it at the lowest speed appropriate.
- Operators of plant, machinery, equipment and tools should be provided with personal protective equipment including, where necessary, suitable hearing protection.

B. MACHINE GUARD

GENERAL REQUIREMENT

- Moving machinery parts shall be guarded. This includes flywheels, shafts, pulleys and belt/chain drives.
- Guards shall be installed on equipment before arrival on-site and maintained in position during operation.
- Guards removed for routine maintenance or for repair shall be reinstalled before the equipment is returned to service.
- Guards shall be constructed so that no part of the body can contact the moving surface.
- Guards shall be constructed of sufficient strength to contain a failure of the rotating part(s) being guarded.
- Guards shall be non-combustible and shall be otherwise designed in such a way not to create a potential source of ignition.
- Shafting under bench machines shall be enclosed by stationary casing at sides and top, or sides and bottom, as the location requires.

C. POINT OF OPERATION GUARDS

- Point of operation guards shall prevent entry of hands or fingers reaching through, over, under or around the guard.
- Guards shall be fastened to the equipment in a manner not easily removed by the operator.

D. WOOD WORKING MACHINES

- Shavings, sawdust, etc, should not be removed by hand from woodworking machines or in their vicinity while the machines are working.
- Where provided, chip and sawdust extraction systems should be maintained in efficient working order.
- Mechanical feeding devices should be used whenever practicable.
- All cutters and saw blades should be enclosed as far as practicable.

- Circular saws should be provided with strong, rigid and easily adjustable hood guards for the saw blades and with riving knives of suitable design matched to the saw blade in use. The width of the opening in the table for the saw blade should be as small as practicable.
- Portable circular saws should be so designed that when the blade is running idle it is automatically covered.
- On band saws all the blade, except the operating portion, should be enclosed. Band wheels should be enclosed with stout guards.
- Band saws should be provided with automatic tension regulators.
- Planning machines should be provided with bridge guards covering the full length and breadth of the cutting block and easily adjustable in both horizontal and vertical directions.
- Thicknessing machines should be provided with sectional feed rollers or a kick-back preventer which should be kept as free as possible.
- Woodworking machines should be properly spaced to avoid accidental injury when handling large boards or long planks.

E. ENGINES

- Engines should:
  - (a) Be constructed and installed so that they can be started safely and the maximum safe speed cannot be exceeded;
  - (b) Have remote controls for limiting speed when necessary;
  - (c) Have devices to stop them from a safe place in an emergency.
- Internal combustion engines should not run for long periods in confined spaces unless adequate exhaust ventilation is provided.
- When internal combustion engines are being fuelled:
  - (a) The engine ignition should be shut off,
  - (b) Care should be taken to avoid spilling fuel;
  - (c) No person should smoke or have an open light in the vicinity;
  - (d) Fire extinguisher should be kept readily available.
- Secondary fuel reservoirs should be placed outside the engine room.

F. SILOS

- Silos should:
  - (a) Be erected on adequate foundations;
  - (b) Withstand the stresses to which they are subjected without any deformation of walls, floors and other load-bearing parts.
- All places in silos to which workers have to go should be provided with safe means of access such as stairs, fixed ladders or hoists.
- Facilities should be provided to enable the quantity of material in the silo to be assessed without entering the silo.
- On silos, notices should be conspicuously displayed:
  - (a) Containing details of the requirements for entry;
  - (b) Calling attention to the danger of sinking in fine materials.
- If the material in the silo is liable to cause a blockage, agitators, compressed air or other mechanical devices should be preferably provided. To clear blockages,

equipment such as poles, long-handled tools, rammers or scraper chains should also be available for emergency use.

- Silos for material liable to spontaneous combustion should be provided with fire-extinguishing equipment.
- In silos in which explosive mixtures of gases or dusts are liable to form:
  - (a) All electrical equipment including hand lamps should be flameproof;
  - (b) Only non-sparking tools should be used;
  - (c) Explosion vents should be provided in the walls.
- Entrances of silos should be kept closed and locked.
- Workers should not enter a silo unless:
  - (a) The discharge opening is closed and secured against opening and filling is stopped;
  - (b) They are duly authorised to do so;
  - (c) They wear safety harnesses with lifelines securely attached to a fixed object;
  - (d) Another authorised person provides constant surveillance and is in attendance with suitable rescue equipment.

G. CONCRETE MIXTURE AND BATCH PLANT

- Concrete mixers should be protected by side railings to prevent workers from passing under the skip while it is raised.
- Hoppers into which a person could fall, and revolving blades of trough or batch-type mixers, should be adequately guarded by grating.
- In addition to the operating brake, skips of concrete mixers should be provided with a device or devices by which they can be securely blocked when raised.
- While the drum of a concrete mixer is being cleaned, adequate precautions should be taken to protect the workers inside by locking switches open, removing fuses or otherwise cutting off the power.
- Concrete buckets for use with cranes and aerial cableways should be free as far as practicable from projections from which accumulations of concrete could fall.
- Loaded concrete buckets should be guided into position by appropriate means.
- Concrete buckets positioned by crane or aerial cableways should be suspended by safety hooks.
- When concrete is being tipped from buckets, workers should keep out of range of any kick-back due to concrete sticking to the bucket.
- Concrete bucket towers and masts with pouring gutters or conveyor belts should:
  - a) Be erected by competent persons;
  - b) Be inspected daily.
- The winch for hoisting the bucket should be so placed that the operator can see the filling, hoisting, emptying and lowering of the bucket. Where this is not practicable, a banks-man should direct the operator.
- If the winch operator cannot see the bucket, he should, where practicable, be provided with an adequate means indicating its position.
- Guides for the bucket should be correctly aligned and so maintained as to prevent the bucket from jamming in the tower.

- Scaffolding carrying a pipe for pumped concrete should be strong enough to support the pipe when filled and all the workers who may be on the scaffold at the same time, with a safety factor of at least 4.
- Pipes for carrying pumped concrete should:
    a. Be securely anchored at the ends and at curves;
    b. Be provided near the top with air release valves;
    c. Be securely attached to the pump nozzle by a bolted collar or equivalent means.

H. PRESSURE PLANT

- Pressure plant and equipment should be examined, tested and issued with a certificate by a competent person in cases and at times prescribed by national laws or regulations.
- National laws or regulations should be laid down and enforced as regards the materials, design, construction, installation, inspection, testing, maintenance and operation of steam boilers and other pressure plant as necessary.
- Only persons tested and certified by the competent authorities should operate steam boilers.
- Compressors should be equipped with:
    (a) Automatic devices that will prevent the maximum safe discharge pressure from being exceeded;
    (b) A quick-release valve;
    (c) Suitable arrangements for preventing contamination where persons are working in confined spaces.
- Compressors in which explosive mixtures of gas may form should be protected against sparking.
- Where compressor cylinders are equipped with water-cooling jackets it should be possible to observe the water flow.
- Intercoolers and after coolers should be able to withstand safely the maximum pressure in the air-discharge piping.
- Where necessary to prevent danger, air-discharge piping of compressors should be provided with:
    (a) A fusible plug;
    (b) Insulating covers to protect workers against burns, and to prevent fire risks.
- Where necessary to prevent danger, an oil separator should be provided between the compressor and the air receiver.
- where stop valves are installed in air-discharge piping:
    (a) They should be easily accessible for inspection and cleaning;
    (b) One or more safety valves should be installed between the compressor and the stop valve.
- All working parts, including speed governors, safety valves and oil separators, should be inspected and cleaned at suitable intervals.
- Air receivers should be equipped with:
    (a) A safety valve;
    (b) A pressure gauge;
    (c) A drain cock.

- Air receivers should be provided with suitable openings for inspection and cleaning.
- Air receivers should be examined and tested at appropriate intervals by a competent person.
- The safe working pressure should be marked in a distinctive colour on the pressure gauge.
- Where necessary to prevent danger, a pressure-reducing valve or a stop valve, or both, should be inserted in the piping between the air receiver and the compressor.
- Between the receiver and each consuming appliance there should be a stop valve.
- Cylinders for compressed, dissolved or liquefied gases should be properly constructed with sound material, fitted with appropriate safety devices in accordance with national laws or regulations, inspected and tested by a competent person as prescribed and stored, transported, handled and used in conformity with the prescribed safety measures.

I. CONVEYORS

- Conveyors should be so constructed and installed as to avoid hazardous points between moving and stationary parts or objects.
- When conveyors that are not entirely enclosed cross over places where workers are employed or pass beneath, sheet or screen guards should be provided to catch any falling material. Adequate fencing should be provided at transfer points. Emergency stopping devices should be fitted at convenient locations easily accessible for workers.
- Power-driven conveyors should be provided at loading and unloading stations, at drive and take-up ends, and at other convenient places, if necessary to prevent danger, with devices for stopping the conveyor machinery in an emergency.
- Where two or more conveyors are operated together, the controlling devices should be so arranged that no conveyor can feed on to a stopped conveyor.
- Screw conveyors should be enclosed at all times. The cover should not be removed until the conveyor is stopped.
- When a conveyor is discharging into a bunker or hopper, the feeding conveyor should be equipped with an overload switch.

J. CRUSHER PLANTS

- Crusher plants should be located at a safe distance from the construction work area to avoid injury to workers and damage to the workers resulting from dust, sand, gravel, noise and vibrations.
- Crusher plants should be provided with an overriding power isolation switch next to the crusher unit and visible from it, to prevent starting the plant inadvertently during repair or maintenance.
- Electrical motors, switches, connections and all instrumentation should be dust and moisture proof.
- Equipment, plant and machinery should be cleared daily of dust and sand.
- Access roads to the crusher hopper and screens should be cleaned by water spraying or other effective means.
- Power cables should be laid out either underground or at safe elevation and marked with bright colour indicators to avoid damage resulting from poor visibility.

- Earth-moving equipment working at a crusher plant should be cleaned and maintained after each work shift.

K. POWER GENERATORS

- Power generators should meet national laws and regulations for safe and reliable operation.
- Power generators should be rated to meet the maximum anticipated load.
- Power generators should be located in enclosed and properly ventilated areas.
- Power generators should be provided with an overriding power switch to avoid accidental remote starting during maintenance.
- Power generators should be provided with adequate silencers and exhaust piping.
- When located near workers' accommodation, power generators should be housed in a concrete room or properly insulated area in accordance with national laws and regulations to minimise noise disturbance.

L. SAFETY GUIDELINE OF PORTABLE AIR COMPRESSOR

- Daily checks shall be performed on the compressor's pressure relief valve, fuel, oil and water levels. The air reservoir shall be drained of trapped water prior to use.
- Compressors shall be equipped with an easily accessible and visible emergency shutdown switch or button.
- Goggles and full face shield shall be worn when compressed air is used in special leaning/purging tasks.
- Compressed air shall not be used to remove dust or dirt from clothing or individuals. A compressed air hose shall not be directed towards an individual for any reason.
- Horseplay with compressed air shall be strictly forbidden.
- Air compressors supplying breathing air shall:
    a. Have the air intake for the compressor located at a site free of air contaminants (e.g., upwind of any internal combustion engines).
    b. Have pressure relief valve(s) on air receiver(s).
    c. Include a high-efficiency breathing air filter and water/oil traps before the filter in the air delivery system to remove moisture, oil mist and particulates.
    d. Have continuous inline carbon monoxide (CO) monitoring with an audible alarm set to 35 ppm if an oil lubricating compressor.
    e. Operate at a maximum as per manufacturer's specifications.
    f. Be fitted with air intake filters to remove particulates.
    g. Be adequately grounded to prevent formation of static electricity.
    h. Have cleaning and inspection programs and written operating procedures developed/provided by the user's management.
    i. Oxygen, not less than 20% not more than 23% by volume.
    j. Carbon monoxide, not more than 10 parts per million (ppm) by volume.
    k. Carbon dioxide, not more than 0.1% by volume.
    l. Oil mist, not more than 5 mg/m^3 at standard temperature and pressure (STP).
    m. Particulates, not more than 5 mg/m^3.
    n. Water vapour, not more than 0.76 mg/L.

Chapter 19

HAND AND PORTABLE POWER TOOLS

19.1 Hand and Portable Power Tools

Hand and power tools are a common part the work in construction industry. These tools help to easily perform tasks that otherwise would be difficult or impossible task. However, these simple tools can be hazardous and have the potential for causing severe injuries when used or maintained improperly. Special attention toward hand and power tool safety is necessary to reduce or eliminate these hazards.

19.2 Hazards

Hand tools are tools that are powered manually. Hand tools include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance.

Some examples include the following:

- If a chisel is used as a screwdriver, the tip of the chisel may break and fly off, hitting the user or other employees.
- If a wooden handle on a tool, such as a hammer or an axe, is loose, splintered, or cracked, the head of the tool may fly off and strike the user or other employees.
- If the jaws of a wrench are sprung, the wrench might slip.
- If impact tools such as chisels, wedges, or drift pins have mushroomed heads, the heads might shatter on impact, sending sharp fragments flying toward the user or other employees.

The employer is responsible for the safe condition of tools and equipment used by employees. Employers shall not issue or permit the use of unsafe hand tools. Employees should be trained in the proper use and handling of tools and equipment.

Employees, when using saw blades, knives, or other tools, should direct the tools away from aisle areas and away from other employees working in proximity. Knives and scissors must be sharp; dull tools can cause more hazards than sharp ones. Cracked saw blades must be removed from service.

Wrenches must not be used when jaws are sprung to the point that slippage occurs. Impact tools such as drift pins, wedges, and chisels must be kept free of mushroomed heads. The wooden handles of tools must not be splintered.

Iron or steel hand tools may produce sparks that can be an ignition source around flammable substance. Where this hazard exists, spark-resistant tools made of non-ferrous materials should be used where flammable gases, highly volatile liquids, and other explosive substances are stored or used.

Power tools must be fitted with guards and safety switches; they are extremely hazardous when used improperly. The types of power tools are determined by their power source: electric, pneumatic, liquid fuel, hydraulic, and powder actuated.

Fig.19. 1 Hand tool operation

To prevent hazards associated with the use of power tools, workers should observe the following general precautions:

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not using them, before servicing and cleaning them, and when changing accessories such as blades, bits, and cutters.
- Keep all people not involved with the work at a safe distance from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.
- Maintain tools with care; keep them sharp and clean for best performance.
- Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance when operating power tools.
- Wear proper apparel for the task. Loose clothing, ties, or jewellery can become caught in moving parts.
- Remove all damaged portable electric tools from use and tag them: "Do Not Use."

19.3 Guards

Principles of guarding

The exposed moving parts of power tools need to be safeguarded. Belts, gears, shafts, pulleys, sprockets, spindles, drums, flywheels, chains, or other reciprocating, rotating, or moving parts of equipment must be guarded.

Machine guards, as appropriate, must be provided to protect the operator and others from the following:

- Point of operation.
- In-running nip points.
- Rotating parts.
- Flying chips and sparks.

Safety guards must never be removed when a tool is being used. Portable circular saws having a blade greater than 2 inches in diameter must be always equipped with guards. An upper guard must cover the entire blade of the saw. A retractable lower guard must cover the teeth of the saw, except where it contacts the work material. The lower guard must automatically return to the covering position when the tool is withdrawn from the work material.

Operating Controls and Switches
The hand-held power tools must be equipped with a constant pressure switch or control that shuts off the power when pressure is released.

These tools also may be equipped with a “lock-on” control, if it allows the worker to also shut off the control in a single motion using the same finger or fingers. It is recommended that the constant-pressure control switch be regarded as the preferred device. Other hand-held power tools such as circular saws having a blade diameter greater than 2 inches (5.08 centimetres), chain saws, and percussion tools with no means of holding accessories securely must be equipped with a constant-pressure switch.

19.4 Electric Tools

Employees using electric tools must be aware of several dangers. Among the most serious hazards are electrical burns and shocks. Electrical shocks, which can lead to injuries such as heart failure and burns, are among the major hazards associated with electric powered tools.

Under certain conditions, even a small amount of electric current can result in fibrillation of the heart and death. An electric shock also can cause the user to fall off a ladder or other elevated work surface and be injured due to the fall. To protect the user from shock and burns, electric tools must have a three-wire cord with a ground and be plugged into a grounded receptacle, be double insulated, or be powered by a low voltage isolation transformer.

Three-wire cords contain two current carrying conductors and a grounding conductor. Any time an adapter is used to accommodate a two-hole receptacle, the adapter wire must be attached to a known ground. The third prong must never be removed from the plug. Double-insulated tools are available that provide protection against electrical shock without third-wire grounding. On double insulated tools, an internal layer of protective insulation completely isolates the external housing of the tool.

The following general practices should be followed when using electric tools

- Operate electric tools within their design limitations.

- Use gloves and appropriate safety footwear when using electric tools.
- Store electric tools in a dry place when not in use
- Do not use electric tools in damp or wet locations unless they are approved for that purpose.
- Keep work areas well lighted when operating electric tools.
- Ensure that cords from electric tools do not present a tripping hazard.

In the construction industry, employees who use electric tools must be protected by ground-fault circuit interrupters or an assured equipment-grounding conductor program.

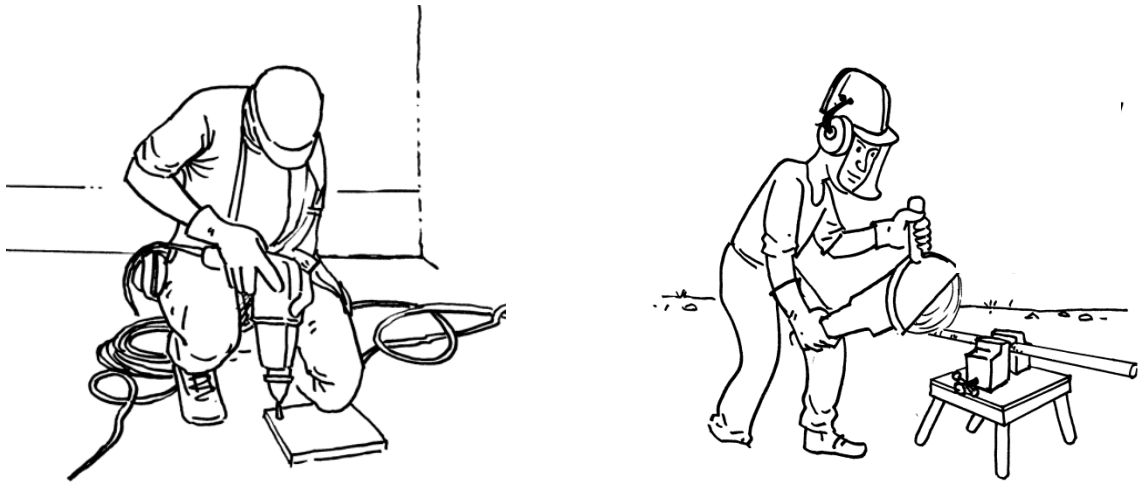


Fig.19.2 Working with portable tools

19.5 Portable Abrasive Wheel Tools

Portable abrasive grinding, cutting, polishing, and wire buffing wheels create special safety problems because they may throw off flying fragments. Abrasive wheel tools must be equipped with guards that:

(1) Cover the spindle end, nut, and flange projections.
(2) Maintain proper alignment with the wheel; and
(3) Do not exceed the strength of the fastenings.

Before an abrasive wheel is mounted, it must be inspected closely for damage and should be sound or ring-tested to ensure that it is free from cracks or defects. To test, wheels should be tapped gently with a light, non-metallic instrument. If the wheels sound cracked or dead, they must not be used because they could fly apart in operation. A stable and undamaged wheel, when tapped, will give a clear metallic tone or “ring.”

To prevent an abrasive wheel from cracking, it must fit freely on the spindle. The spindle nut must be tightened enough to hold the wheel in place without distorting the flange. Always follow the manufacturer’s recommendations. Take care to ensure that the spindle speed of the machine will not exceed the maximum operating speed marked on the wheel.

An abrasive wheel may disintegrate or explode during start-up. Allow the tool to come up to operating speed prior to grinding or cutting. The employee should never stand in the plane of rotation of the wheel as it accelerates to full operating speed. Portable grinding tools need to

be equipped with safety guards to protect workers not only from the moving wheel surface, but also from flying fragments in case of wheel breakage.

While using a powered grinder

- Always use eye or face protection.
- Turn off the power when not in use.
- Never clamp a hand-held grinder in a vise.

19.6 Pneumatic Tools

Pneumatic tools are powered by compressed air and include chippers, drills, hammers, and sanders. There are several dangers associated with the use of pneumatic tools. First and foremost is the danger of getting hit by one of the tool's attachments or by fastener the worker is using with the tool. Pneumatic tools must be checked to see that the tools are fastened securely to the air hose to prevent them from becoming disconnected. A short wire or positive locking device attaching the air hose to the tool must also be used and will serve as an added safeguard.

If an air hose is more than ½-inch (12.7 millimetres) in diameter, a safety excess flow valve must be installed at the source of the air supply to reduce pressure in case of hose failure.

In general, the same precautions should be taken with an air hose that are recommended for electric cords, because the hose is subject to the same kind of damage or accidental striking, and because it also presents tripping hazards.

When using pneumatic tools, a safety clip or retainer must be installed to prevent attachments such as chisels on a chipping hammer from being ejected during tool operation. Airless spray guns that atomize paints and fluids at pressures of 6,890 kPa or more per square inch must be equipped with automatic or visible manual safety devices that will prevent pulling the trigger until the safety device is manually released.

Eye protection is required, and head and face protection are recommended for employees working with pneumatic tools. Screens must also be set up to protect nearby workers from being struck by flying fragments around chippers, riveting guns, staplers, or air drills. Compressed air guns should never be pointed toward anyone. Workers should never “dead-end” them against themselves or anyone else. A chip guard must be used when compressed air is used for cleaning.

Use of heavy jack hammers can cause fatigue and strains. Heavy rubber grips reduce these effects by providing a secure handhold. Workers operating a jack hammer must wear safety glasses and safety shoes that protect them against injury if the jackhammer slips or falls. A face shield also should be used. Noise is another hazard associated with pneumatic tools. Working with noisy tools such as jackhammers requires proper, effective use of appropriate hearing protection.

19.7 Hydraulic Power Tools

The fluid used in hydraulic power tools must be an approved fire-resistant fluid and must retain its operating characteristics at the most extreme temperatures to which it will be exposed. The exception to fire-resistant fluid involves all hydraulic fluids used for the insulated sections of derrick trucks, aerial lifts, and hydraulic tools that are used on or around energized lines. This hydraulic fluid shall be of the insulating type.

The manufacturer's recommended safe operating pressure for hoses, valves, pipes, filters, and other fittings must not be exceeded. All jacks—including lever and ratchet jacks, screw jacks, and hydraulic jacks—must have a stop indicator, and the stop limit must not be exceeded. Also, the manufacturer's load limit must be permanently marked in a prominent place on the jack, and the load limit must not be exceeded.

A jack should never be used to support a lifted load. Once the load has been lifted, it must immediately be blocked up. Put a block under the base of the jack when the foundation is not firm and place a block between the jack cap and load if the cap might slip.

Chapter 20

WORKING WITH COMPRESSED GAS CYLINDERS

20.1 General Description

"Compressed gas" means any permanent gas, liquefiable gas or gas dissolved in liquid under pressure or gas mixture which in a closed gas cylinder exercises a pressure either exceeding 2.5 kgf/cm^2 abs. (1.5 Kgf/cm^2 gauge) at +15°C or a pressure exceeding 3 Kgf/cm^2 abs. (2 Kgf/cm^2 gauge) at +50°C or both.

Explanation: - Hydrogen Fluoride falls within the scope of compressed gas although its vapour pressure at 50°C is 1.7 to 1.8 atmospheric gauge.

Compressed gases can be toxic, flammable, oxidizing, corrosive, or inert. In the event of a leak, inert gases can quickly displace air in a large area creating an oxygen-deficient atmosphere, toxic gases can create poison atmospheres, and flammable or reactive gases can result in fire and exploding cylinders. In addition, there are hazards from the pressure of the gas and the physical weight of the cylinder. A gas cylinder falling over can break containers and crush feet. The cylinder can itself become a missile if the cylinder valve is broken off.

Compressed gases can cause fires, explosions, oxygen deficient atmospheres, toxic gas exposures as well as the innate physical hazard associated with cylinders under high pressure. Special storage, use, handling and disposal procedures are necessary to ensure the safety of researchers using these chemicals and equipment.

20.2 Types of Compressed Gas Cylinders

Compressed gas cylinders come in different shapes and designs, which are mostly based on the pressure of the gases they contain. In general, they are grouped as high-pressure cylinders, low-pressure cylinders, and cryogenic containers.

High pressure cylinders

These are generally made of steel or aluminium, and can withstand up to 10,000 psi. Examples are nitrogen, helium, hydrogen, oxygen, and carbon dioxide cylinders.

Low-pressure cylinders

These are lighter than high pressure and can withstand up to 500 psi. Examples are liquefied petroleum gases (LPG, like propane) and refrigerant gases.

Cryogenic containers

These containers operate at a pressure of 20 – 500 psi. They have relief valves to help vent pressure as the temperature increases. Examples are nitrogen, oxygen, argon, carbon dioxide, etc.

20.3 Colour coding

All gas cylinders shall be painted externally in accordance with National Standard such as IS 4379 to provide means for visual identification of the gaseous contents. The colour identification shall consist of a ground colour and colour bands as per National Standard such as table shown below from IS 4379.

Name of Gas	Ground Colour	Colour of Band
Acetylene	Maroon	None
Air	French grey	None
Argon	Peacock blue	None
Carbon dioxide	Black	White or Aluminium paint
Helium	Middle brown	-
Liquefied petroleum gas (LPG)	Signal red	-
Nitrogen	French grey	Black
Oxygen	Black	-
Propane	Signal red	-

20.4 General cylinder safety

- Accept only properly identified cylinders and do not rely on colour codes.
- Wear safety equipment appropriate for the hazard potential of the gas before beginning work.
- If a cylinder or valve is noticeably corroded, the vendor should be contacted for instructions.
- A leaking cylinder should be removed and isolated in a well-ventilated safe area. It may be necessary to call in trained emergency response personnel.
- If the leak is at the junction of the cylinder valve and cylinder DO NOT try to repair! Instead, contact the supplier.
- Cylinders together with their valves and other fittings and identification colours shall be maintained in good condition.
- No lubricant shall be used in any fittings of the cylinders.
- No cylinder shall be subjected to any heat treatment or exposed to a high temperature or to the sun or stored with flammable or explosive material.
- Every cylinder containing compressed gas shall have its valve securely closed so as to prevent leakage. Valves fitted to the cylinders containing LPG and highly toxic gases shall be provided with security nut on the outlet to act as a secondary means of safeguard against leakage of gas.

20.4.1 Flashback Arrestor

A flashback arrestor or flash arrestor is a gas safety device most commonly used in oxy-fuel welding and cutting to stop the flame or reverse flow of gas back up into the equipment or supply line. It protects the user and equipment from damage or explosions. These devices are mainly used where oxy-fuel gas mixtures are handled and used.

Flashback arrestors as safety products are essential to secure the workplaces and working environment.

20.5 Work in Compressed Air

1. Work in compressed air shall be carried out only in accordance with measures prescribed by national laws or regulations.

2. Work in compressed air shall be carried out only by workers whose physical aptitude for such work has been established by a medical examination and when a competent person is present to supervise the conduct of the operations.

20.5.1 Pneumatic Tools

1. The hose of the compressed air shall not be directed towards a person's body. Compressed air shall not be used for cleaning of dust on the clothes of the workers. The compressed air line shall not be bent to stop the flow of air. This may cause building of pressure resulting in bursting of pipe and injury to the person. The operator shall use earmuffs on regular basis. The person cleaning certain area with compressed air shall be given safety goggles, dust respirators and ear plugs. Other workers shall not be present in the area which is being cleaned.

2. All the pneumatic drills shall be equipped with the additional lateral handles to avoid accidents wherein the back twisting torque exceeds 15 Nm. Compressed air hoses shall be suitably covered or hung from the ceiling

20.6 Hazards of gas cylinders

1. High pressure
2. Flammable or explosive properties of the gas in the cylinder
3. Deterioration or corrosion of cylinder material
4. Unsafe handling of gas cylinders
5. Gas toxicity
6. Cylinder weight
7. Damaged nozzle
8. Use of gas cylinder with overdue hydro test.
9. Unsafe storage of cylinders - direct exposure to sunlight, inadequate ventilation, etc.
10. Physical or mechanical damage.

20.7 Risk associated with gas cylinders

1. The cylinder may rupture or explode due to the high pressure and may cause serious injury or property damage.
2. If flammable gas leaks and leaks fire, the cylinder may explode.
3. Cold burn can be caused due to exposure to cryogenic gas or liquified gas leak from the cylinder.
4. The cylinder may rupture or burst due to material deterioration or corrosion.
5. Exposure of personnel to toxic gases can occur when the cylinder leaks.
6. Due to the heavy load of the gas cylinder, it may injure personnel during manual lifting and shifting.
7. A damaged nozzle will cause gas to leak and the cylinder can fly off, projectile and strike neighboring property or injure personnel.

8. If the cylinder is used without hydro test or after overdue date, there is a risk of explosion or rupture.
9. Direct exposure to sunlight or inadequate ventilation during storage, the gas cylinder may explode due to rise in internal pressure.
10. With unsafe handling of the cylinder, physical or mechanical damage can cause serious incidents due to the rupture or explosion of the cylinder.

20.8 Do’s and Don'ts of Handling Compressed Gas Cylinders

To control the hazards associated with the ***compressed gas cylinders***, following the ***Safety Dos and Don'ts*** will help you prevent unwanted events and damage to personnel or property.

20.8.1 Do’s

1. Use a soft pad or a ramp to unload the ***gas cylinders***.
2. The cylinder cap and key must be in place when handling the cylinders.
3. Separate the different cylinders according to gas properties such as acetylene (DA), oxygen, LPG, etc. during storage.
4. Store empty and full cylinders separately in a dry, cool and ventilated place.
5. All cylinders should always be secure and protected from the weather and away from combustible materials.
6. Proper tagging and labeling must be ensured when storing gas cylinders.
7. Label the storage area.
8. Use a trolley or hand truck or cart to move or shift the gas cylinders.
9. Always keep gas cylinder secured, chained, or tied in an upright position.
10. Maintain minimum separation between the flammable gas cylinder and the oxygen or combustible source.
11. The cylinder must be lifted using the cylinder cage or cradle.
12. Flame arresters must be used at both ends of the tubes and oxygen cylinders
13. Regularly inspect the pipe, cylinders, and valves for any signs of wear, crack.
14. The cylinder should be handled by at least two people during localized manual movement.
15. Leak cylinders should be removed from the site immediately to a safe location.
16. Provide ‘No smoking” sign near the storage of flammable gas cylinders.

20.8.2 Don’ts

1. Avoid hitting or drop or impact during handling and transportation.
2. Don’t transport or shift or move cylinder without putting nozzle safety cap.
3. Don’t drag, roll or slide the cylinders while handling, even over short distances.
4. Don’t use cylinders as a roller to shift or move other material.
5. Don’t lift the cylinder manually by holding the nozzle valve wheel; it may cause accidental gas discharge from the cylinders.
6. Don’t use a cylinder without a pressure gauge.
7. Don’t tamper with pressure-relief devices.
8. Don’t expose the cylinder to heat and direct sunlight.

9. Don’t use oil or grease to lubricate the nozzle or valves of oxygen and other oxidizing gas cylinders.
10. Don’t damage the cylinder valves and fittings by using for lifting.
11. Don’t strike a cylinder valve with a hammer to open it.
12. Don’t store gas cylinders under direct sunlight.
13. Don’t apply force to connect the cylinder that does not fit.
14. Don’t transport cylinder on a bicycle or two-wheeler.
15. Don’t remove the original hazard identification label.
16. Don’t use a gas cylinder after the hydro test date has expired.
17. Don’t use a gas cylinder without proper identification.
18. Cracked tubes should not be used with the cylinders.
19. Cylinder valve keys should not be removed for accessibility reasons.

20.9 Electrical installations

In premises for filling and storing flammable gases in cylinders all electric meters, distribution boards, switches, fuses, plugs and sockets, all electric fittings, fixed lamps, portable hand lamps and motors, shall be of flame proof construction conforming to IS: 2148 or such other specifications as laid down under various applicable Statutes.

20.10 Special precautions against accidents

(1) No person shall commit or attempt to commit any act, which may tend to cause a fire or explosion in or about any place where gas under pressure in a cylinder is stored, handled or transported.

(2) Every person storing compressed gas cylinders and every person in charge of or engaged in the storage, handling and transport of such gas cylinders, shall at all times.

(a) Comply with the provisions of these rules and the conditions of any licence relating thereto.

(b) Observe all precautions for the prevention of accident by fire or explosion.

Chapter 21

CHEMICAL SAFETY

21.1 INTRODUCTION

Construction workers are exposed to various chemical hazards in their day to day activities on the site. Activities like change of job on daily basis, simultaneous operations and movement of workers on a jobsite require chemical management systems to minimize the risk. There are two primary problems when it comes to addressing and protecting construction employees for personal injuries sustained from chemical exposure. The first issue is that many workers do not realize they were exposed to any chemical at all, until a health condition related to toxic exposure presents itself. Employees may not be able to recall when they were exposed, at what location, or under what circumstances they came into contact with a hazardous chemical.

Unlike other common types of injury on the construction site, including falls or abrasions that are treated with emergency care (and documented by employer at job site/ a clinic or hospital), the worker may leave the job site and never know that they have been exposed to a potentially life-threatening chemical. One that could contribute to serious chronic diseases, organ failure or cancer over time. This is why safe work procedure and regulatory provisions are critical to protecting workers from chemical exposure.

21.2 CHEMICALS AT CONSTRUCTION SITE

Construction materials commonly containing lead include paints, alloyed metals, mortars, electric wire and its insulation, lead sheeting, solder and drywall used in medical facilities. Renovation and repair activities also can uncover lead in piping, certain types of cable wires, flashings, metal coatings. Grinding and abrasive blasting can result in exposures to lead dust. Cutting and welding can result in exposure to lead fumes.

Lead is a metal found in construction materials and on a variety of job sites. Typically, exposures to lead occur by inhalation or ingestion. However, the body can absorb organic lead vapour through skin. It also can attack the central nervous system and other internal organs. Lead poisoning symptoms include male impotence, irritability, muscle pain, cramps, fatigue, trouble in concentrating and confusion. Clothing can become contaminated with lead dust, resulting in its spread to other parts of the job.

Construction workers' risk of developing silicosis, an occupational disease caused by exposure to **silica**, a naturally occurring mineral, is higher than general industry. Workers become ill by inhaling dust containing crystalline silica. Typical tasks where workers often inhale dust-containing silica include cutting concrete, sandblasting and demolition work. Silica also may be contained in materials brought to a job site. Over a period of time, silica dust can accumulate in the lungs,

where fibrous structures and scar tissue develop around the trapped silica particles. As this disease progresses, breathing may become difficult and, in some cases, results in death. There is no cure for silicosis; prevention is the only control method.

The best way to protect the workers from silica is:

i. Limit exposure.
ii. Substitute less hazardous materials for silica sand.
iii. Use water/ water jet attached to a concrete saw to control dust in the air.
iv. Ventilation controls
v. Conduct Job Hazard Analysis
vi. Train all employees on the hazards associated with silica.

21.2.1 Construction raw materials

There are two main sources of potential chemical risk directly from the materials used at the building site. First group is used for the production of composites – these are harmful mineral binders, mainly based on Portland cement with additives. The second group consist of ready construction materials produced from potentially harmful substrates.

Mineral binders

Portland cement clinker contains a product that is a threat to both people and the environment. Clinker and dust from the production of Portland cement is a strongly alkaline environment after reaction with water.

The product obtained is strongly alkaline (12-13 pH). For humans, the greatest risk is the contact of these compounds with the humid environment: eyes, respiratory tract, and moist skin. This impact is defined in terms of health risk as STOT - SE (Specific Target Organ Toxicity – Single Exposure). This means there is a risk of serious eye damage or severe irritation of the respiratory tract or skin. In some cases, allergic reactions may occur due to the content of Cr (chromium). This risk increases with a longer period of cement storage, since then the efficiency of the chromium reducer decreases.

21.2.2 Harmful ingredients of paints

Paints are substances that form protective or decorative coatings on the surface of objects. They consist of many components, of which one can distinguish: binders (resins), thinners, pigments. Each of these elements has a different role in coating formation.

A. Resins

1. Resins, i.e. binders are found in all types of paints, varnishes and emulsions.

2. They are responsible for the formation of a film on the surface of an object and give the paint properties such as gloss, strength, flexibility, adhesion, resistance to weather conditions.
3. Binders may be synthetic or natural, e.g. polyurethanes, epoxy resins, vinyl acetate.

Polyurethane paints protect the objects against corrosion and mechanical damage, they also work well on substrates such as plaster, concrete, wood and plastics. Chemically highly reactive isocyanates are the basic raw material for the synthesis of polyurethanes. The most dangerous are their pairs, which get into the body through the respiratory system. They are also partially absorbed through the skin. Prolonged exposure to iso-cyanates causes occupational asthma.

Epoxy resin belongs to synthetic resins. It is an important component of paints and varnishes, adhesives or putty. They are resistant to high temperature, high load, strong chemical substances, and widely used in industry. Epoxy resin irritates eyes and skin, and can cause burns. Upon contact with the respiratory system, it causes its damage.

Vinyl paints are durable and cover well. They can be used on various substrates: plasters, drywall, and wood. Their base is polyvinyl acetate, which has an irritating effect on mucous membranes; it causes eye tearing as well as smell disorders. After it has been absorbed into the body, usually through the respiratory tract but also through the digestive system, it causes dizziness, drowsiness, coughing. Polyvinyl acetate causes dysfunction of the central nervous system.

B. Solvents

Solvents are liquids that dissolve film-forming substances that form a binder of paints and varnishes. Most often they are: gasoline, benzene, turpentine, ethyl alcohol. They exhibit high volatility and thus can create high concentrations in the air. Benzene is highly toxic. It causes damage to the nervous system. It is absorbed mainly from the respiratory tract, rarely through the skin and from the gastro-intestinal tract. It is considered to be carcinogenic; it damages the bone marrow. Solvents cause permanent damage to hearing.

C. Pigments

The main task of pigments is to protect the organic resin against UV radiation and corrosion. Not all pigments are toxic, but some of them contain heavy metals such as cadmium or lead.

Cadmium naturally occurs in zinc and lead ores, and has highly toxic properties. It protects against corrosion very well; this is why it is widely used in industry. In Cadmium poisoning (mainly occurs mainly in metallurgy), the body accumulates the element in the internal organs (liver, kidneys, pancreas), thus damaging them. It causes serious foetal defects and is therefore particularly dangerous for pregnant women.

All lead compounds are poisonous. It penetrates the body through the digestive and respiratory system causing lead poisoning, which is a chronic poisoning with lead and its salts. Lead accumulates in the brain, kidneys and liver, damaging these organs. Among the chronic effects of lead, lead neuropathy is mentioned (dementia, hallucinations, muscle tremors, concentration and memory disorders), as well as atherosclerosis and cardiac infarction resulting from it.

21.2.3 Other Chemicals

There are many types of chemicals that construction workers can be exposed to on a daily basis, including pesticides and pest control substances, fuel and mechanical oils and lubricants, or bacterial exposure from sewage or wastewater. Four commonly used chemicals and compounds that pose a significant health risk to construction labourers are PVC, mercury, lead and flame retardants.

Polyvinyl Chloride (PVC) is commonly used in construction to coat pipes and electrical wiring as an insulator. It is also used in flooring, taping compounds, ductwork, block insulation, sheet roofing and shingles. The bi-product of manufacturing, and emissions released when PVC begins to break down, include ethylene dichloride, vinyl chloride and dioxin. Prolonged exposure to PVC and dioxin contributes to various health hazards

Wood-based materials can be harmful. For their production, formaldehyde is used, which is dangerous both at the production stage and in the use of rooms. Formaldehyde is released into the atmosphere as a gas that can cause disease in high concentrations. People exposed to this gas emission may experience chest pain, weakness, watery eyes, as well as sensitization and irritation. Formaldehyde can cause cancer in humans.

Fumes and gases

Carbon monoxide (CO) is a silent killer, making it one of the most dangerous threats on the construction site. CO is colourless, odourless and undetectable meaning that whether it’s present on its own or among other “regular” gases and smells. Within minutes of inhaling carbon monoxide, the person can become unconscious and suffocate. Construction workers and welders are especially at risk. There is an increased risk of CO exposure in exhaust of portable generators, welding fumes etc. It should be constantly stressed upon the importance of appropriate prevention methods against CO poisoning, since it can threaten the lives due to its asphyxiating in nature.

21.4 Chemical Management for the Construction Industry

Contractors and those working in construction settings and worksites must be informed about the hazardous chemicals they may be exposed to. Close the gap on health and workplace safety with contractors/ sub-contractors by using tools to share information on the hazards of chemicals on the worksite. Identify occupational health and safety hazards is the first step to being proactive in prevention in the field of construction. Many hazardous products when improperly handled may cause acute or chronic health effects in workers. Communicating controls reduces risk when using hazardous products.

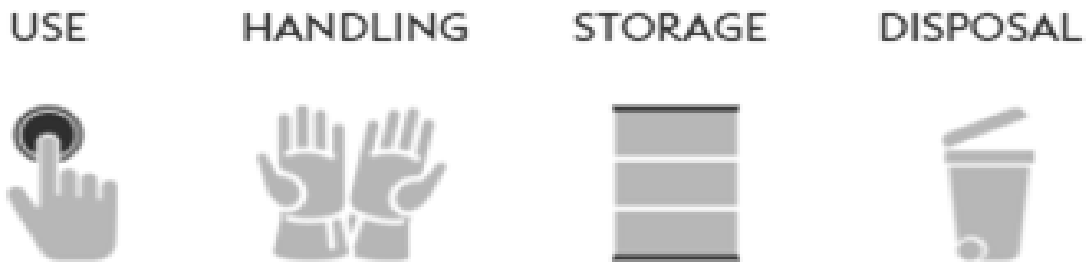


Fig.21.1. Steps in chemical management

Using proper communication mediums like supply of SDS (Safety Data Sheet), Safety pamphlets, display notices etc., keep everyone informed about hazardous chemicals, so information is accessible to everyone.

It is the responsibility of safety teams on construction sites to ensure the safe practices. It is required to include provisions and procedures for handling and storing hazardous chemicals and materials. Specific best practices include:

a. Provide Correct Training

Construction workers must be aware of the hazardous materials they will be likely to handle and be exposed to on site and of the specific measures and precautions they must take when exposed to these materials to protect their health and safety. Specific training must be provided regarding the materials they will encounter and the best practices of handling, use and storage of such materials.

b. Ensure Proper Chemical Storage

Any hazardous materials including caustic soda, lead paints, solvents, glues, adhesives etc. must be stored in secure, dyked chemical storage cabinets. The use of a lockable chemical storage cabinet minimizes the risk of un-authorized personnel handling hazardous materials and also reduces the risk of fire, explosion, leaks, spills as well as contamination of soil. Best practices for handling and storage of hazardous materials must include:

i. Display of Safe work practices with chemicals
ii. Proper signage and labelling on to the containers
iii. Keep the containers always in closed condition.
iv. While storing the chemicals, chemical compatibility shall be considered necessarily.
v. Filled and empty containers shall be stored separately.
vi. The chemical storage area should be inspected on a daily basis.
vii. The filled chemical containers should be stored in a SS trey so as to easy identification of the leaking containers. In case of leak, the leaking containers shall be removed immediately.
viii. Fire preventing measures shall be ensured at the store places.

c. Limit the Use & Storage of Hazardous Materials

While planning the processes and materials to be used, the management will act proactively in procuring and usage of the materials in consultation with safety and project development team. Procurement and safety teams should work actively to minimize the use and emission of hazardous materials.

d. Minimize the level of welding and soldering conducted in confined spaces.

- Choose paints, solvents and other building materials which are less hazardous to the environment and personnel, not just based on their cost and durability.
- Estimate the required level of hazardous chemicals or liquids required and store only the minimum quantity on site.
- Minimize the use of processes which emit harmful gases and vapours and consider alternative approaches to these processes.

e. Waste management plan

The project and construction site should have an effective waste management plan. In particular, while handling of chemicals, there may be various instances, in which leak, spill and contamination may take place. This may require cleaning, mopping and decontamination of the area. The facility shall ensure

i. The standard procedure for handling with waste categorically.
ii. Availability of neutralizing agent to deal with leak/ spill of chemicals.
iii. The trained workers to deal with waste.
iv. Availability of personal/ equipment decontamination facility at site.
v. Provision of PPEs at site.

f. Maintain an Emergency Response Plan

It is imperative to maintain an appropriate emergency response plan with suitable equipment provided on site to deal with minor leaks and spills – spill kits, bunds, drain seals, containment barriers etc. and specific procedures to follow and external spill removal agencies and emergency services to contact in the event of a chemical or oil spill.

21.5 Measures for personal protection against chemical substances

In addition to the standard overalls, hard hats and rigger boots that construction workers are required to wear on site, any workers who are required to handle or encounter hazardous materials must be provided with specific protection personal equipment to reduce the risks of injury or illness from their encounter with the hazardous chemicals

In relation to the chemicals used at site, hazards and worker exposure conditions should be identified and supply & usage of proper PPEs should be ensured conforming to the Indian Standards.

Personal protective equipment against hazards from chemical substances are: protective clothing, Hand/ foot protection, face and eye protection, respiratory protection. These should be used in situations where threats cannot be avoided or sufficiently mitigated by means of collective protection or appropriate organization of work.

Chapter-22

PERSONAL PROTECTIVE EQUIPMENT

22.1. Introduction

Controlling a hazard at its source is the best way to protect employees. Depending on the hazard or workplace conditions, the use of engineering or work practice controls to manage or eliminate hazards to the greatest extent possible. When engineering, work practice and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment (PPE) to their employees and ensure its use. Personal protective equipment, commonly referred to as “PPE”, is equipment worn to minimize exposure to a variety of hazards. Examples of PPE include such items as gloves, foot and eye protection, protective hearing devices (earplugs, muffs) hard hats, respirators and full body suits.

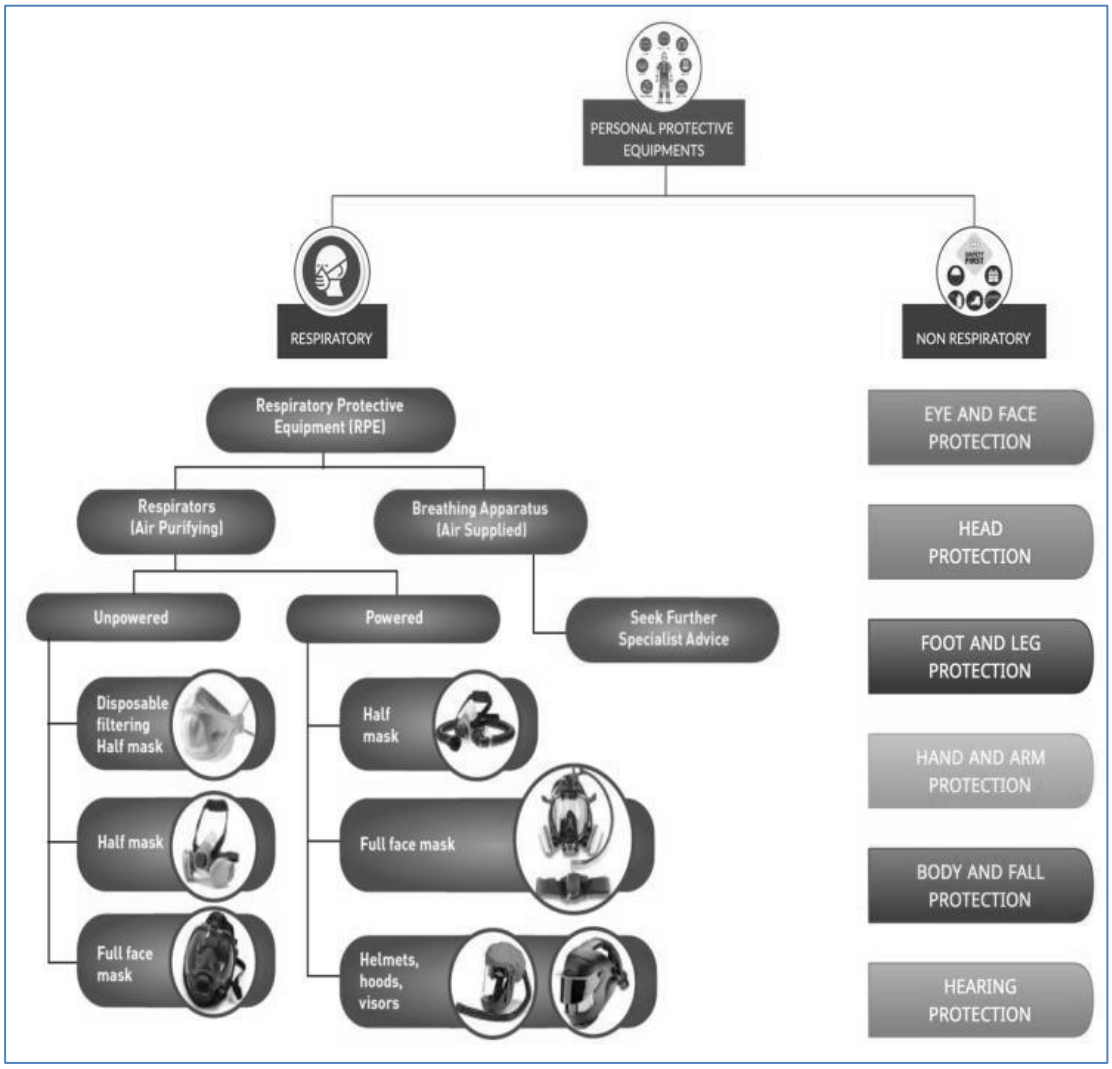


Fig.22.1. Classification of Personal Protective Equipments for the construction workers

To ensure the greatest possible protection for construction employees in the workplace, the cooperative efforts of both employers and employees will help in establishing and maintaining a safe and healthy work environment. Following responsibilities are important for effective and efficient application of PPE in construction sector

- Employers are responsible for
    - Identifying and providing appropriate PPE for employees.
    - Training employees in the use and care of the PPE.
    - Maintaining PPE, including replacing worn or damaged PPE.
    - Periodically reviewing, updating and evaluating the effectiveness of the PPE program.
- Employees should:
    - Properly wear PPE,
    - Attend training sessions on PPE,
    - Care for, clean and maintain PPE as per specification
    - Inform a supervisor of the need to repair or replace PPE

22.2 Eye and Face Protection

Construction Employees can be exposed to a large number of hazards that pose danger to their eyes and face. Employers to ensure that employees have appropriate eye or face protection if they are exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, potentially infected material or potentially harmful light radiation.

22.3 Types of Eye Protection:

Selection of suitable and appropriate eye and face protection for the construction workers should take into consideration the following elements:

- Ability to protect against specific workplace hazards.
- Should fit properly and be reasonably comfortable to wear.
- Should provide unrestricted vision and movement.
- Should be durable and cleanable.
- Should allow unrestricted functioning of any other required PPE.

Some of the most common types of eye and face protection include the following

- **Safety spectacles/Glasses:** These protective eyeglasses have safety frames constructed of metal or plastic and impact-resistant lenses. Side shields are available on some models.
- **Goggles:** These are tight-fitting eye protection that completely cover the eyes, eye sockets and the facial area immediately surrounding the eyes and provide protection from impact, dust and splashes. Some goggles will fit over corrective lenses.

- **Welding shields:** Constructed of vulcanized fiber or fiberglass and fitted with a filtered lens, welding shields protect eyes from burns caused by infrared or intense radiant light; they also protect both the eyes and face from flying sparks, metal spatter and slag chips produced during welding, brazing, soldering and cutting operations. Welding shield requires filter lenses to have a shade number appropriate to protect against the specific hazards of the work being performed in order to protect against harmful light radiation.
- **Laser safety goggles:** These specialty goggles protect against intense concentrations of light produced by lasers. The type of laser safety goggles an employer chooses will depend upon the equipment and operating conditions in the workplace.
- **Face shields:** These transparent sheets of plastic extend from the eyebrows to below the chin and across the entire width of the employee's head. Some are polarized for glare protection. Face shields protect against nuisance dusts and potential splashes or sprays of hazardous liquids but will not provide adequate protection against impact hazards. Face shields used in combination with goggles or safety spectacles will provide additional protection against impact hazards.

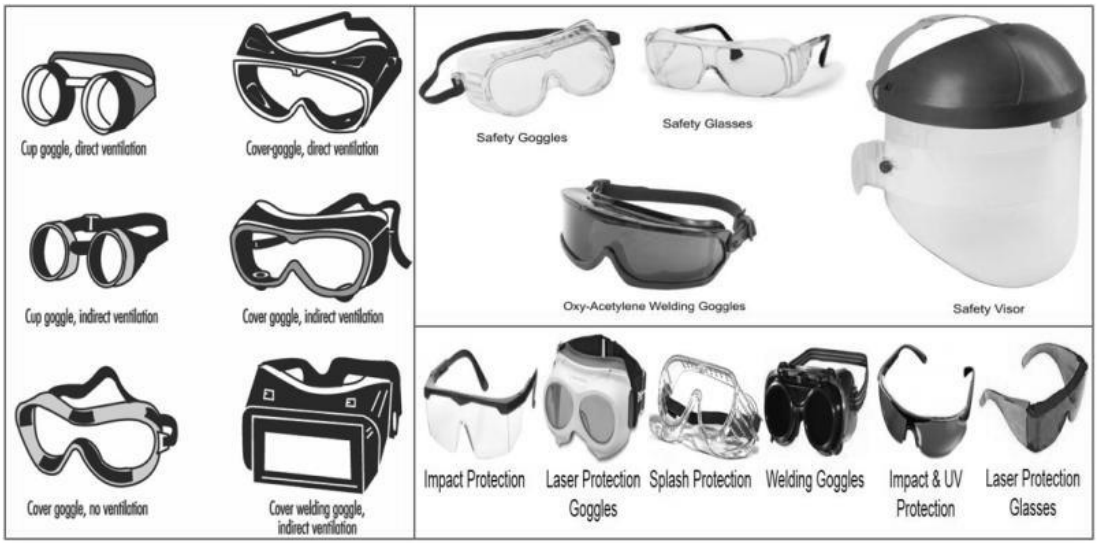


Fig.22.2. Example of Eye and Face PPEs for the Construction Workers

22.4 Protection against Hot work Operation

The intense light associated with welding operations in the construction sector can cause serious and sometimes permanent eye damage if operators do not wear proper eye protection. The intensity of light or radiant energy produced by welding, cutting or brazing operations varies according to a number of factors including the task producing the light, the electrode size and the arc current.

22.5 Head Protection:

Protecting construction employees from potential head injuries is a key element of any safety program. A head injury can impair an employee for life or it can be fatal. Wearing a safety helmet or hard hat is one of the easiest ways to protect an employee's head from injury. Hard hats can protect employees from impact and penetration hazards as well as from electrical shock and burn hazards. Employers must ensure that their employees wear head protection if any of the following apply:

- Objects might fall from above and strike them on the head;
- They might bump their heads against fixed objects, such as exposed pipes or beams; or
- There is a possibility of accidental head contact with electrical hazards.

Whenever there is a danger of objects falling from above, such as working below others who are using tools or working under a conveyor belt, head protection must be worn. Hard hats must be worn with the bill forward to protect employees properly.

In general, protective helmets or hard hats should do the following:

- Resist penetration by objects.
- Absorb the shock of a blow.
- Be water-resistant and slow burning.
- Have clear instructions explaining proper adjustment and replacement of the suspension and headband.

Head protection that is either too large or too small is inappropriate for use, even if it meets all other requirements. Protective head gear must fit appropriately on the body and for the head size of each individual.

Types of Hard Hat:

Hard hats are divided into three industrial classes:

Class A hard hats: Provide impact and penetration resistance along with limited voltage protection (up to 2,200 volts).

Class B hard hats: Provide the highest level of protection against electrical hazards, with high-voltage shock and burn protection (up to 20,000 volts). They also provide protection from impact and penetration hazards by flying/falling objects.

Class C hard hats: Provide lightweight comfort and impact protection but offer no protection from electrical hazards.

Fig.22.3. Load Carrying Helmet

Another class of protective headgear on the market is called a “bump hat,” designed for use in areas with low head clearance. They are recommended for areas where protection is needed from head bumps and lacerations. These are not designed to protect against falling or flying objects. Periodic cleaning and inspection will extend the useful life of protective headgear. A daily inspection of the hard hat shell, suspension system and other accessories for holes, cracks, tears or other damage that might compromise the protective value of the hat is essential. Paints, paint-thinners and some cleaning agents can weaken the shells of hard hats and may eliminate electrical resistance.

Hard hats with any of the following defects should be removed from service and replaced:

- Perforation, cracking, or deformity of the brim or shell;
- Indication of exposure of the brim or shell to heat, chemicals or ultraviolet light and other radiation (in addition to a loss of surface gloss, such signs include chalking or flaking).

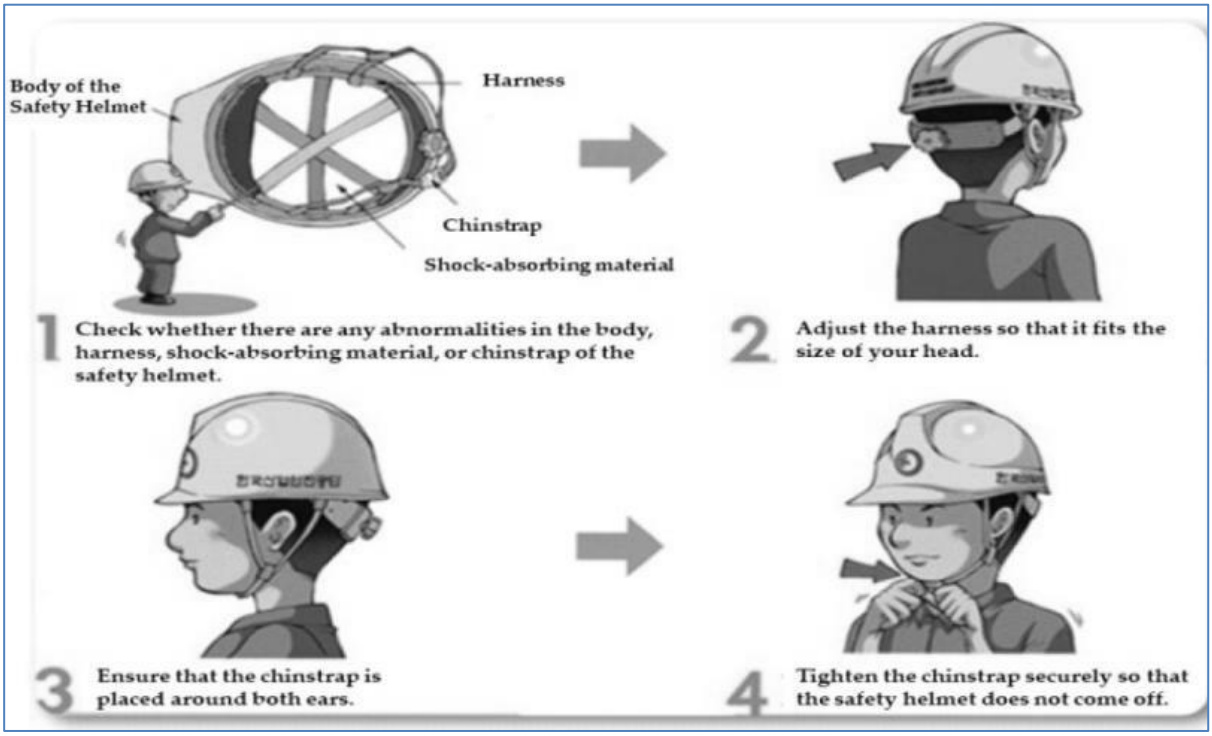


Fig.22.4. Head Protection and How to Use Hard Hat by Construction Workers

22.6 Foot and Leg Protection:

Employees who face possible foot or leg injuries from falling or rolling objects or from crushing or penetrating materials should wear protective footwear. Also, employees whose work involves exposure to hot substances or corrosive or poisonous materials must have protective gear to cover exposed body parts, including legs and feet. If an employee's feet may be exposed to electrical hazards, non-conductive footwear should be worn. On the other hand, workplace exposure to static electricity may necessitate the use of conductive footwear.

Examples of situations in which an employee should wear foot and/or leg protection include:

- When heavy objects such as barrels or tools might roll onto or fall on the employee's feet;
- Working with sharp objects such as nails or spikes that could pierce the soles or uppers of ordinary shoes;
- Exposure to molten metal that might splash on feet or legs;
- Working on or around hot, wet or slippery surfaces; and
- Working when electrical hazards are present.

Foot and leg protection choices include the following:

- **Leggings**: protect the lower legs and feet from heat hazards such as molten metal or welding sparks. Safety snaps allow leggings to be removed quickly.
- **Metatarsal guards**: Protect the instep area from impact and compression. Made of aluminium, steel, fibre or plastic, these guards may be strapped to the outside of shoes.
- **Toe guards**: Fit over the toes of regular shoes to protect the toes from impact and compression hazards. They may be made of steel, aluminium or plastic.
- **Combination foot and shin guards**: Protect the lower legs and feet, and may be used in combination with toe guards when greater protection is needed.
- **Safety shoes**: Have impact-resistant toes and heat-resistant soles that protect the feet against hot work surfaces common in roofing, paving and hot metal industries. The metal insoles of some safety shoes protect against puncture wounds. Safety shoes may also be designed to be electrically conductive to prevent the build-up of static electricity in areas with the potential for explosive atmospheres or nonconductive to protect employees from workplace electrical hazards.
- **Electrical hazard, safety-toe shoes** are nonconductive and will prevent the wearers' feet from completing an electrical circuit to the ground. These shoes can protect against open circuits of up to 600 volts in dry conditions and should be used in conjunction with other insulating equipment and additional precautions to reduce the risk of an employee becoming a path for hazardous electrical energy.

Care of Protective Footwear:

As with all protective equipment, safety footwear should be inspected prior to each use. Shoes and leggings should be checked for wear and tear at reasonable intervals. This includes looking for cracks or holes, separation of materials, broken buckles or laces.

22.7 Hand and Arm Protection:

If a workplace hazard assessment reveals that employees face potential injury to hands and arms that cannot be eliminated through engineering and work practice controls, employers must ensure that employees wear appropriate protection. Potential hazards include skin absorption of harmful substances, chemical or thermal burns, electrical dangers, bruises, abrasions, cuts, punctures, fractures and amputations. Protective equipment includes gloves, finger guards and arm coverings or elbow-length gloves. Employers should explore all possible engineering and work practice controls to eliminate hazards and use PPE to provide additional protection against hazards that cannot be completely eliminated through other means.

Types of Protective Gloves:

There are many types of gloves available today to protect against a wide variety of hazards. The nature of the hazard and the operation involved will affect the selection of gloves. The variety of potential occupational hand injuries makes selecting the right pair of gloves challenging. It is essential that employees use gloves specifically designed for the hazards and tasks found in their workplace because gloves designed for one function may not protect against a different function even though they may appear to be an appropriate protective device.

The following are examples of some factors that may influence the selection of protective gloves for a workplace.

- Type of chemicals handled.
- Nature of contact (total immersion, splash, etc.).
- Duration of contact.
- Area requiring protection (hand only, forearm, arm).
- Grip requirements (dry, wet, oily).
- Thermal protection.
- Size and comfort.
- Abrasion/resistance requirements.

Gloves made from a wide variety of materials are designed for many types of workplace hazards. In general, gloves fall into four groups:

- Gloves made of leather, canvas or metal mesh;
- Fabric and coated fabric gloves;
- Chemical- and liquid-resistant gloves

Leather, Canvas or Metal Mesh Gloves:

- **Leather gloves:** Protect against sparks, moderate heat, blows, chips and rough objects.
- **Aluminized gloves:** provide reflective and insulating protection against heat and require an insert made of synthetic materials to protect against heat and cold.
- **Aramid fiber gloves:** protect against heat and cold, are cut- and abrasive-resistant and wear well.

- **Synthetic gloves:** of various materials offer protection against heat and cold, are cut- and abrasive-resistant and may withstand some diluted acids. These materials do not stand up against alkalis and solvents

Fabric and Coated fabric Gloves:

- **Fabric gloves:** protect against dirt, slivers, chafing and abrasions. They do not provide sufficient protection for use with rough, sharp or heavy materials. Adding a plastic coating will strengthen some fabric gloves.
- **Coated fabric gloves:** are normally made from cotton flannel with napping on one side. By coating the unnapped side with plastic, fabric gloves are transformed into general-purpose hand protection offering slip-resistant qualities. These gloves are used for tasks ranging from handling bricks and wire to chemical laboratory containers

Chemical and Liquid Resistant Gloves:

Chemical-resistant gloves are made with different kinds of rubber: natural, butyl, neoprene, nitrile and fluorocarbon; or various kinds of plastic: polyvinyl chloride (PVC), polyvinyl alcohol and polyethylene. These materials can be blended or laminated for better performance. As a general rule, the thicker the glove material, the greater the chemical resistance but thick gloves may impair grip and dexterity, having a negative impact on safety.

Hand Arm Vibration (HAV) Protection for the construction workers:

Finger exposed gloves are not recommended. Gloves which meet or exceed ISO 10819 criteria are recommended, but using certified Anti Vibration gloves alone will not solve the HAV problem.

Care of Protective Gloves:

Protective gloves should be inspected before each use to ensure that they are not torn, punctured or made ineffective in any way. A visual inspection will help detect cuts or tears but a more thorough inspection by filling the gloves with water and tightly rolling the cuff towards the fingers will help reveal any pinhole leaks.

22.8. Body Protection:

Any construction employees who face possible bodily injury of any kind that cannot be eliminated through engineering, work practice or administrative controls, must wear appropriate body protection while performing their jobs. In addition to cuts and radiation, the following are examples of workplace hazards that could cause bodily injury:

- Temperature extremes;
- Potential impacts from tools, machinery and materials;
- Hazardous chemicals.

There are many varieties of protective clothing available for specific hazards. Employers are required to ensure that their employees wear personal protective equipment only for the parts of the body exposed to possible injury.

Fig.22.4. Reflective clothing and jacket

22.9 Fall Protection:

Falls are among the most common causes of serious work-related injuries and deaths. If a fall hazard cannot be eliminated, effective fall protection shall be planned, implemented, and monitored to control the risks of injury due to falling.

- Fall Restraint: The technique of securing an employee to an anchorage using a full body harness and lanyard short enough to prevent the person's center of gravity from reaching the fall hazard.
- Personal Fall Arrest System: A system comprised of, at a minimum, an anchorage, full body harness, lanyard, and connectors used to arrest an employee from free falling from an elevated level.

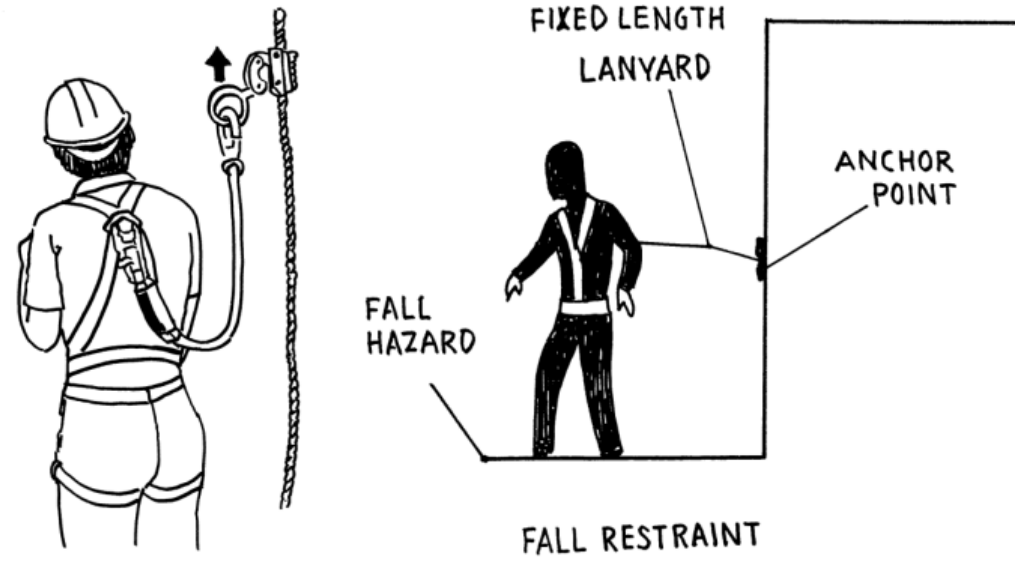


Fig.22.5. Fall Restraint and Fall Arrest System for Construction Workers

22.10 Hearing Protection:

Hearing protectors or hearing protective devices (HPD), the last line of defense against hazardous noise, are a form of noise control in that they block the path of the noise from the source to the ear. It is estimated that 1.3 billion people suffer from hearing loss due to noise exposure. Worldwide, occupational noise exposure is responsible for 16% of cases of disabling hearing loss in adults. Occupational Noise Induced Hearing Loss (NIHL) can limit an individual's ability to communicate with others and can lead to increased social stress, sadness, diminish confidence, poor self-identity, and bad interpersonal relationships. For industrial noise, elimination or reduction of noise through engineering or administrative control is the best way of occupational NIHL intervention. NIHL is 100% preventable with appropriate measures. Hearing protection Devices are the secondary level of protection measure. Both earmuffs and earplugs are commonly used as personal HPDs among the workers. In this article, different types of HPDs have been described briefly.

- Earplugs: Earplugs can be classified by size, shape and construction materials such as; custom molded, pre-molded and expandable. Most of them are manufactured from soft plastic, PVC, silicone and Polyurethane.
- Expandable earplugs: They are considered the most comfortable. Since they are porous and soft. They are made from slow recovery closed cell foam. They offer high attenuation since they expand against the outer ear canal and form an acoustic seal with less pressure. Expandable earplugs are mainly of disposable type. They are also available in fiberglass or silicon material. It may be corded or non-corded.
- Pre-molded earplugs: They are molded to fit the ear canal. They are available in disposable and re-useable types and come in foam or PVC material. One type is shaped like a half ball with a narrow stem to which a thin cord can be attached to hold the plugs together.
- Custom-molded earplugs: Earplugs can also be custom molded from an impression taken from the ears.
- Electronic earplugs: This is special type of earplug with state-of the art sound level dependent technology fitted with Environmental microphones to help improve situational awareness and communications in challenging environments. It is costlier that other type of earplugs.
- Ear caps or Semi-Inserts or Semi-aural or Banded Ear plugs: They consist of flexible tips, made from silicone, vinyl or foam in mushroom, hollow bullet or conical shape, attached to a lightweight plastic headband. They are easily removed and replaced. They can be used under the chin and behind the head.
- Earmuffs: Ear muffs are made from rigid cups, are mostly oval shaped, and are designed to cover the external ear completely. They are held in place by a preformed or spring-loaded adjustable band and are sealed round the rim of each cup, with a soft foam-filled or liquid-filled circumaural cushion, to achieve a continuous seal contact. There are also earmuffs available, which can be attached to the safety helmet directly. In hot and humid environment, they are much uncomfortable more than earplugs and may restrict head movement. Hair, beards, spectacles frame can alter the protection.

- Passive Earmuffs: The material and structure of the earmuff device is used to decrease the sound level that is transmitted through the ear canal. Materials, such as a cupped foam coated in hard plastic, will block sound due to the thick and dampening properties of the foam. Ear muffs are also available which can reproduce music or messages from external units.
- Active Noise Control Earmuffs: They are now available which cancel the low frequency band noise inside the cups by out-of-phase generated sound. They provide good attenuation at low frequencies (up to 20 dB) and also serve as classical passive earmuffs with good attenuation at high frequencies. They are still expensive and have the possibility of electronic failure.

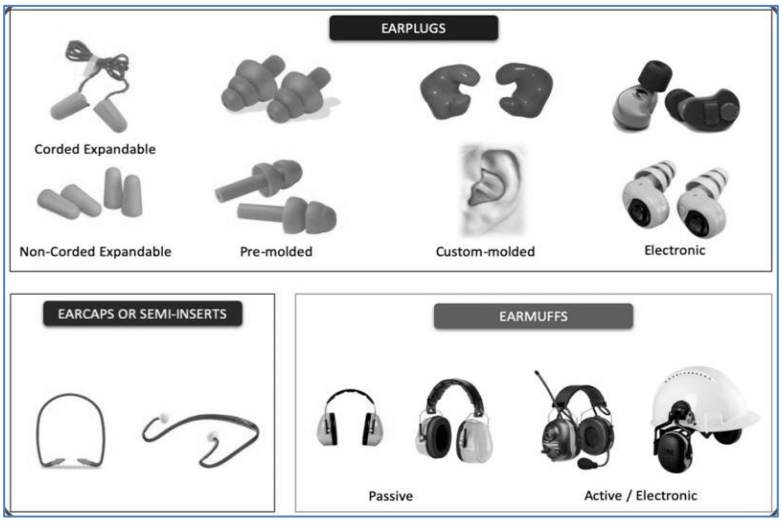


Fig.22.6. Hearing Protective Devices for Construction Workers

How to use earplug correctly: Roll-Pull-Hold-Check Technique:

- Roll: The earplug up into a small, thin snake like object with fingers. Clean your hand before rolling it.
- Pull: The top of the ear upward and backward with the opposite hand to straighten the ear canal. The rolled-up earplug should slide right in.
- Hold: The earplug in with the finger as far as it will go. Count to 20 or 30 out loud while waiting for the plug to expand and fill the ear canal. Your voice will sound muffled when the plug has made a good seal.
- Check: The fit when you are all done. The entire foam body of the earplug should be within the ear canal. Try cupping your hands tightly over your ears. If, sounds are much more muffled with your hands in place, the earplug may not be sealing properly. Take them out repeat the procedure with great care.

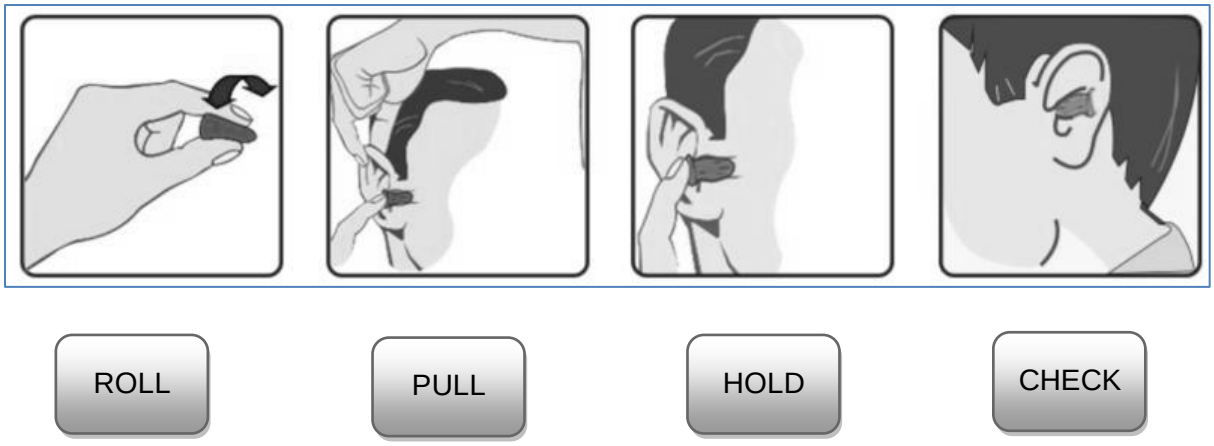


Fig-22.7. Steps for wearing Hearing Protective Device (Earplug)

22.11 Respiratory Protection Equipments for the Construction Workers:

Occupational lung diseases like pneumoconiosis are one of the most important public health problems in the construction industries worldwide. Occupational lung diseases are mainly caused by long-term, repeated, exposure, but even a severe, single exposure to a hazardous agent can damage the respiratory system. It has also been established by various epidemiological studies that respiratory diseases like asthma, Chronic Obstructive Pulmonary Diseases (COPD) are also associated with the occupational exposure of hazardous agents. Some agents of occupational lungs diseases like Asbestos are causally associated with the development of respiratory and non-respiratory occupational cancer. The best way to prevent occupational lung diseases is to avoid the inhaled substances that cause lung diseases. So, selection of proper filtering face mask or particulate respirator is of utmost importance.

Filtering Face Mask:

A filtering half mask or filtering face piece or protective mask is one in which the face-piece consists entirely or substantially of filter material or comprises a face-piece in which the main filter(s) form an inseparable part of the device. It belongs to personal protective device that is worn on the face, covers at least the nose and mouth, and is used to reduce the wearer's risk of inhaling hazardous airborne particles.

22.12 Conclusion:

Employers should make sure that each construction employee has the detailed information about applicability, knowledge to wear and use PPE before they are allowed to perform work. If an employer believes that a previously trained employee is not demonstrating the proper understanding and skill level in the use of PPE, that employee should be provided adequate training. The employer must document the distribution and maintenance of PPEs.

Chapter 23

FIRE PREVENTION AND CONTROL

23.1 INTRODUCTION

Fire is a chemical reaction of Fuel, Energy and Oxygen and is represented by fire tetrahedron also called fire pyramid.

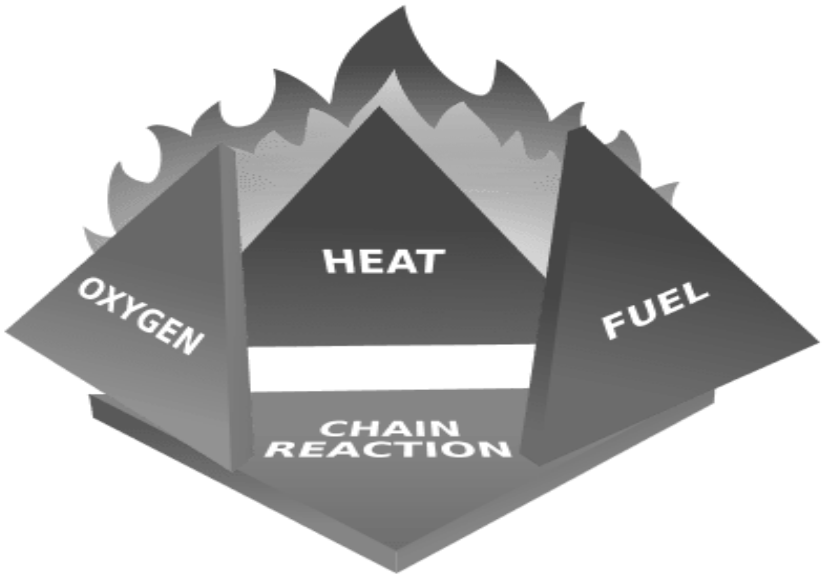


Fig.23.1. Fire Tetrahedron

Earlier fire was represented by fire triangle with three elements i.e. oxygen, heat and fuel, but it was later identified that another element plays a vital role in existence and spread of fire which is chain reaction. Hence, now fire is defined by the four elements which are

1. Sufficient heat for raising the material to the ignition temperature
2. Adequate oxygen for sustaining combustion
3. Combustible material or fuel
4. Exothermic chain reaction in the combustible material.

To understand the characteristics of fire these elements plays a vital role and also provides for the methods to put fire out.

1. Cooling to reduce heat availability for fire to spread and eventually sustain.
2. Smothering to cut off oxygen supply by barricading the fuel from air supply.
3. Starvation to remove/restrict fuel supply because without any material to burn fire cannot exist.
4. Interference to chain reaction by eliminating free radicals in fuel.

To put out fire any one or more of above mentioned methods can be utilized To do so for cooling, smothering and interference to chain reaction different fire extinguishing agents are used like:

- Sand
- Water
- CO_2
- Foam
  - Mechanical Foam
  - Chemical Foam
- Dry Chemical Powder

To deliver these agents to the source of fire various mechanisms are used out of which some are portable while other are fixed installation type. Some of the commonly used mechanisms are:

1. Fire extinguishers
2. Hose real
3. Fire hydrant
4. Portable fire pumps
5. Fire tenders

Fig.23.2. Fire Extinguishers

Each type of mechanism has its suitability at different stages of fire which can be understood by fire growth curve.

Fire extinguishers are used as first line of control and hence are effective in incipient and smouldering stages. Whereas, other mechanisms are mostly used in fire at flaming stages onwards.

Fig.23.3. Fire tender vehicle

Fire is a prominent hazard with high risk in a construction site. Prevention and control of fire on a construction site is extremely crucial because of following issues:

1. Random stacking of construction material
2. Fire load and its distribution cannot be determine exactly
3. Non availability of established fire fighting system
4. Non availability of qualified fire fighters
5. No clear path of approach for fire fighting
6. No clear path for escape for rescue
7. Migrating workers not adequately trained and competent for fire emergencies

The constraint with the construction sites are that most of the above issue cannot be even addressed completely. Therefore, it is not possible to ensure prevention of fire on a construction site and hence, in case of fire outbreak preparedness not only to control but also to contain spread of fire, shall be considered at par with the prevention.

In view of the above, it is required that special emphasise to be given to the fire prevention and its control measures on a construction site. This chapter will cover various aspects of fire safety in construction under two major parts:

1. Prevention – This part will cover the planning which include requirement determination, resource availability and training.
2. Control – This part will cover the management and preparedness in case of fire emergency.

23.2 Prevention

Prevention can only be achieved with effective planning, for which loads of data and competency is required to achieve the adequate level of prevention inspite of the constraints with construction stated above.

To start with the planning first question is ‘Who is going to plan?’. Competency to plan the fire prevention system for construction sites having high potential and diversity need in-depth knowledge and expertise. The planning in discussion should not be restricted to only one time (i.e.

initial) but should be a continuous activity, as the prevention requirements will vary with variation on the construction site which will happen regular and on day-to-day basis. Therefore, team of qualified and experienced professional from following backgrounds should be planning and continuously assessing the fire prevention:

1. Construction
2. Stores
3. Fire
4. Safety
5. Security

Once the planning team has been identified the next question arises is 'How the planning is done?' .Although, the planning is a difficult task because everything going to be worked out will be based on the data available and estimation. However, following steps will help in achieving the estimation as close to the accuracy as possible:

1. Identification of combustible items in construction site – There are varieties of materials used in the construction some are used as part of building material whereas some are used as accessories and support, irrespective of whether that can be consumed or not. Some of the common combustible items used in construction sites are:
    a. Wood
    b. Oil based Paint
    c. Paper
    d. Tar
    e. Plastic
    f. Diesel
    g. Rubber
    h. Engine/lubrication Oils
    i. Cotton
    j. Electric cables
    k. Ply
    l. Pressurised gas cylinders
    m. Mica
    n. Explosive

Based on the construction activities planned the combustible materials and their maximum quantity that can be available at any instant of time can be determined.

1. Identifying ignition source – In construction site commonly following ignition sources can possibly be present that can lead to fire outbreak:
    a. Spark from grinding/cutting
    b. Spark from welding
    c. Flame from gas welding
    d. Electrical short circuit/overloading
    e. Faulty equipment/machines
    f. Spark from exhaust of internal combustion engines
    g. Radiant heat
    h. Smoking

    There is a possibility of existence of more than one ignition source at a location. Every ignition point has an amount of energy limited to its type and maximum capacity, whereas every combustible material has a specific requirement for ignition like flash point and ignition conditions. Based on the activities planned location of the ignition sources can be identified. Exceptionally, for smoking it is impossible to identify the location if not strictly prohibited/restricted.

2. Locating combustible material – In construction activities material is received at a location convenient for use based on two primary criteria i.e. space availability and minimum post receive movement. But, considering fire prevention and control requirements other criteria should also be considered such as;
   a. Ignition source
   b. Requirement of fire prevention
   c. Accessibility for fire control
   d. Means of containment for restricting spread

   Location of combustible material also provides for the location of fire sources required to identification of controlling fire hazards and containing outbreak along with formulation of SOPs and emergency response.

3. Determination of Class of fire: The fire in the combustible material will define the Class they belong to i.e. Class A/B/C/D as per national and international standards. This classification along with the fire load of each combustible material will be basis of determining amount of fire extinguishing medium needed and type of fire fighting system required. Fire extinguishing medium also called agent commonly used in construction are water, Chemical/Mechanical Foam Compound mixture, Carbon Dioxide (CO2) and Dry Chemical Powder (DCP).
   When the construction is in initial stage for most of the construction sites and in the construction activities of projects like road, canal, bridge, etc. where structure itself does not have fire fighting system required during its use, portable fire fighting system is used. Some of the portable fires fighting systems used in such construction sites are as under:

   a) Fire extinguishers
   b) Fire tenders
   c) Trolley mounted fire pump
   d) Fire buckets
   e) Fire beaters

   In construction sites where the structure is designed to have its own fire fighting system during its use, at later stages the system constructed can be used for fire fighting. Fire fighting systems in such structures are as under:
   a) Fire hydrant
   b) Fire hose
   c) Sprinklers
   d) All fire fighting system listed under previous condition

   If fire extinguishers are provided care should be taken to ensure the required it is suitable for the class of fire, capacity and quantity requirements, failing which may result to failure in fire control.

4. Fire Load calculation: Fire load also termed as fire load density is defined as the heat energy that could be released per square meter of the floor area, by the complete combustion of the contents of the unit area and any combustible parts of the unit therein.

Total fire load is the total amount of energy that could be released by complete combustion of the combustible material in an area. This can be calculated using following formula

$$Q = \sum k_i m_i h_{ci}$$

where, Q = Total fire load in (MJ or KJ)

k_i = proportion of the content or building component i that can burn

m_i = mass of item i (kg)

h_{ci} = calorific value of the item i (MJ/kg or KJ/kg)

Whereas,

$$\text{Fire load or Fire load density} = \frac{\text{Total Fire Load}}{\text{Area under consideration}}$$

There are two types of fire load i.e. localised fire load and distributed fire load. Localised fire load determined the concentrated of the combustible material mostly in storage locations, whereas distributed fire load is the total fire load in the site. For the construction sites at initial stage localized fire load is vital, but by the end the distributed fire load also contributes significantly.

Further, fire load can also be categorised as fixed fire load and contents fire load. Fixed fire load refers to the combustible material permanently positioned and becomes part of the structure, whereas contents fire load refers to the material occupying the area/compartment.

Fire load can be calculated in following ways:

a) Using calorific value of the combustible material if known
b) Using wood equivalent factor of the combustible material from the list and multiplying it with the calorific value of wood (i.e 18.5 MJ/kg)
c) If data not available fire load can be calculated by multiplying mass of the materials using 15 MJ/kg for low calorific value materials like wood products, cotton, paper, etc and for other material using 40 MJ/kg.

Fire load calculation provides for the area of concern based on fire load density, class of fire and fire spread rate. It also provides for the base of fire control design.

5. Identification of probable fire emergencies – Another crucial step in planning is to identify, to the extent possible all types of fire emergency scenario, based on the information/data available from previous steps. These emergencies can arise from the self actuation of a fire hazard, due to process or because of possibility of unsafe act including smoking.

   As there is huge diversity in construction sector because different project/structure involves altogether different material, activities, terrain and manpower, hence the fire emergencies also vary from site-to-site. Some of the common fire emergencies in construction are as under:

   a) Fire in combustible solid material at storage
   b) Fire in combustible solid material at intermediate storage
   c) Fire in fuel at storage

d) Fire in fuel during refilling
e) Fire in liquid or gaseous fuel driven machines/equipments
f) Fire in combustible material installed in the structure
g) Fire due to electrical fault
h) Fire due to temporary lighting and luminaries
i) Fire in gas cylinder during operation
j) Fire in confined space
k) Fire at higher elevation

There can be other fire emergencies specific to the construct site which can be determined based on the fire potential hazards so identified during previous steps. This step provides for the details required for developing emergency action plan.

6. Requirement determination – Resources are not restricted to the restricted to the man, machine and material but extends to the system and procedures too. Based on the information/data collected/calculated, requirement for fire prevention and control is determined. The requirement includes the following:
   a. Quantity of fire fighting medium/agent
   b. Type of fire fighting system/gears/equipments
   c. Monitoring devices
   d. Location of fire fighting system
   e. Area classification
   f. Standard Operating Procedure
   g. Qualification & skill requirement of workers and fire emergency response staff
   h. Strength of fire emergency response staff and their availability
   i. Segregation of stores and temporary structures
   j. Emergency Action Plan
   k. Rescue equipments
   l. Fire safety norms & instruction manuals
   m. Display of norms/instructions
7. Resource availability – Resources so determined should be made available at the construction site at their desired/prominent locations. Special care should be given to its proper and optimum use by setting up a monitoring mechanism i.e. training, inspection and supervision. Also, maintenance of the fire fighting system, monitoring devices and rescue gears should be strictly followed as per the manufacturer's manual and relevant standards to meet out the performance requirements.

8. Training –Standard Operating Procedure (SOP) and Emergency Action Plan defines responsibilities of every sole in the site about their roles set therein for prevention and control of fire. The training should cover not only the technical (theoretical and practical) aspect of the fire prevention and control, but also include the information about their roles and responsibilities.
   Accordingly, the training modules should be prepared. Training modules shall be balanced with the theoretical and practical part of training. Separate training modules for different categories and level of workers should be prepared

Training should be provided by competent trainers to ensure the qualification and skill requirement determined should be achieved. The training should not be restricted to only one time i.e. initial, as the human nature is to get negligent, ignorant and reluctant over a period, hence refresher i.e. periodic retraining should be conducted with a separate training module developed in this regard.

23.3 Control

Prevention is the primary goal in safety, but as due to issues mentioned initially and also the fact that if hazard exists risk cannot be eliminated, one should be prepared for the untoward incident because of preventive measures frailer or residual risk. The control has two elements:

1. Management – The resources made available needs to be managed for effective implementation, optimum utilisation and preparedness. This includes:
    a. Maintaining adequate resources supplies
    b. Ensure quality of resources
    c. Collect feedback to access performance and scope of improvement
    d. Review the requirement
2. Preparedness – In case of any fire outbreak/emergency addressing it during incipient or initial developing stage is important to minimize spread and losses. The effective preparedness depends upon following key elements:
    a. Early detection and alarm
    b. Prompt response
    c. Correct and adequate resources
    d. Coordination and communication
    e. Actions as per roles and responsibilities
    f. External support

The desired level of preparedness can be achieved by ensuring all elements listed above are at their best. This can be ascertained by following:

a) Places with risk of fire outbreak shall be under round the clock monitoring either by continuously manning the location or by installing continuous monitoring devices.
b) Manual or automatic alarm system to be provided.
c) Routine inspection and maintenance including calibration for the detection and alarm system should be carried out to check its readiness.
d) Conducting mock drills for all possible emergencies for assessing performance and identifying scope of improvement.
e) Fire fighting gears and material should be maintained in good working condition and sufficiently available.
f) Coordination and communication with command centre, rescue team, medical team and external agencies is the most important element in fire emergency. This requires leadership quality, team spirit, communication skills, technical acquaintance and appropriate communication devices. Therefore, competent person equipped with suitable communication system shall be given responsibility for this.

g) Everyone should be contributing as per the instructions of the in-charge of emergency response by fulfilling roles & responsibilities assigned to them.
h) Arrangements for obtaining external support should also be made well in advance by seeking help from local administration or neighbouring industries.

The approach in fire prevention and control purely depends upon the adequate planning and its implementation. Better planning and preparedness results to the effective prevention and control of fire. But, another step in fire prevention is learning from past incidents. Therefore, every fire incident shall be thoroughly investigated for identifying root causes and its contributing factors, so that preventive measures can be reviewed to avoid such reoccurrences.

Chapter 24

FIRST AID

The construction industry is one of the major industries having the highest rate of occupational diseases and work-related injury. The hazards associated with construction work include physical, chemical, biological, ergonomic, psycho-social along with different traumatic injuries from impact, slip, trip, and fall.

- Chemical Hazards: Dusts, fibers, fumes, mists, vapours, gases
- Physical Hazards: Heat and cold, noise, radiation, vibration and barometric pressure
- Biological Hazards: Virus, bacteria, parasites and fungus, toxic substances of biological origin
- Ergonomic Hazards: Repetitive Movement, Awkward Posture and grip, Bodily Reaction, etc.
- Safety Hazards: Slip, Trip, Fall, Falling materials, Collapses, Electrical Accident, Mobile Plant
- Social Issues: Migratory worker, limited social support, drug addiction, alcoholism, smoking

Prevention of Occupational Diseases and Injuries of the Construction Workers:

Primary Prevention: Action to avoid or remove the cause of a health problem before its onset

  - Health Promotion: Health Education on Prevention of Occupational Diseases, Environmental Modification, Nutritional Intervention, Lifestyle and behavioral Changes to stay healthy
  - Specific Protection: Elimination of Different Health Hazards at Construction Site, Risk Reduction approach by substitution, engineering & administrative control, Use of Proper Personal Protective Equipments, Training and Retraining of the workers on Health and Safety related issues, Immunization against vaccine preventable diseases

- **Secondary Prevention:** Action to detect a health problem at an early stage and thus facilitate its cure or reduce or prevent its dissemination or effect in the long term
  - Early Diagnosis by Medical Surveillance and Management of the diseases
  - First Aid Services and prompt medical response to occupational injuries

- **Tertiary Prevention:** Action to reduce the chronic effects of a health problem by minimizing the functional impairment resulting from an occupational diseases or injuries
  - Disability Limitation
  - Rehabilitation

Evidence Based Guidelines of First Aid for Common Medical Emergencies at Construction Site:

During the construction activities, the workers are prone to various types of health issues, which need to be addressed in time.

Basic principles of First Aid:

- Don’t panic
- Calm and quiet
- Call the ambulance / emergency services
- Look your surroundings
- Always Ask for help
- If sure, do the needful

Few first aid measures are being discussed below-

1. **Abdominal injury**
    - Don't panic, stay calm and call for help
    - Call ambulance help line number like 102 in India or any other medical helpline number
    - Loosen any tight clothing, especially at waist and neck
    - Try to control bleeding if any, by applying pressure
    - Cover any wound with sterile gauge piece
    - Get to the hospital immediately
    - Do not allow the patient to eat, drink or smoke
    - In case of penetrating injury do not try to pull or push stuck object if any
    - If not sure, don't do anything, just call for help and assist to get in hospital at earliest
2. **Amputation**
    - Don't panic, stay calm and call for help
    - Call ambulance help line number like 102 in India or any other medical helpline number
    - Apply direct pressure on the wound to control bleeding
    - Cover wound with sterile gauge piece or clean cloth and apply pressure bandage
    - Place the amputated part in a clean plastic bag
    - Place the plastic bag containing amputated part in another container with ice and mark with date and time of packaging with victim details
    - Get to the hospital immediately with victim and amputated part
    - Do not put any antiseptics or liquids or home remedies on the amputated area and part
    - Ice shall not be come in direct contact with the amputated part
    - If not sure don't do anything, just call for help and assist to get in hospital at earliest

3. **Altitude sickness**
    - Don't panic, stay calm and call for help
    - Call ambulance help line number like 102 in India or any other medical helpline number
    - Keep the victim warm and hydrated
    - Do not ascend any further with symptoms
    - Descend to the altitude where the victim last woke up symptom free
    - Stop the victim from smoking or chewing tobacco and alcohol consumption
    - If not sure don't do anything, just call for help and assist to get in hospital at earliest
4. **Backbone or spinal injury**
    - Don't panic, stay calm and call for help
    - Call ambulance help line number like 102 in India or any other medical helpline number
    - Assure no movement of the injured person and advise the victim not to move
    - Support the head of the victim by holding each side of the head by spreading your fingers so that you do not cover their ears
    - Maintain this neutral position so that the victim's head, neck, and spine are in a straight line
    - While maintaining the neutral position ask someone, if available, to put rolled-up blankets, towels, or clothes on either side of the head
    - If there is no breathing, no pulse, no response, start CPR immediately till the medical help arrives
    - Do not allow the patient to eat, drink or smoke
    - Do not massage or rub with any pain relief gel or ointment
    - If not sure don't do anything, just call for help and assist to get in hospital at earliest
5. **Bleeding from wound**
    - Don't panic, stay calm and call for help
    - Call ambulance help line number like 102 in India or any other medical helpline number
    - Assure no movement of the injured person and advise the victim not to move
    - Remove any loosely attached clothing or debris on the wound. Don't remove large or deeply embedded objects
    - Place a sterile bandage or clean cloth on the wound. Press the bandage firmly with palm to control bleeding. Apply constant pressure for 10-15 minutes / until the bleeding stops
    - Secure the bandage with adhesive tape. If possible, raise an injured limb above the level of the heart
    - Don't remove the gauze or bandage. If the bleeding seeps through the gauze or other cloth on the wound, add another bandage on top of it
    - In case of severe bleeding from a wound, apply a tourniquet if you're trained in how to do so. When emergency help arrives, explain how long the tourniquet has been in place

- Immobilize the injured body part as much as possible
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

6. Burn

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- Assess your safety before helping a victim
- Immediately get the person away from the heat source to stop the burning
- Cool the burn with cool running water for 20 minutes. Do not put ice or ice-cold water directly on the burned area
- Remove any clothing or jewellery that's near the burnt area of skin but don't try to remove anything that's stuck to the burn
- Cover the burn by placing a layer of cling film / sterile gauze over it. Burns on the limbs – elevate the limbs higher than the heart
- Don't try touching/pricking the blister bubbles resulting from the burn
- Don't apply any home-made ointments or butter or toothpaste or any other doubtful remedies
- In case of large area of burn, place clean, dry, non-fluffy, lint-free cloths lightly over the burn
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

7. Burn-chemical

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- Assess your safety before helping a victim
- Try to remove the chemical and contaminated clothing from contact with the skin and eyes, but be very careful not to touch or spread the chemical
- Use gloves or other protective materials to cover hands and, if possible, carefully cut away clothing such as t-shirts, rather than pulling them off over the head
- As soon as possible, rinse the affected area continuously with clean water or an amphoteric irrigating agent at least for 15 to 20 min. Make sure the water can run off the affected area without pooling on the skin
- In case of eye injury by chemical agent: hold your face under running water for 15 to 20 minutes and allow the water stream to flood into your eyes or thoroughly rinse the eyes continuously with an amphoteric irrigating agent at least for 15 to 20 min. Use your fingers to hold your eyelids apart (make sure there is no trace of the chemical on your fingers)
- Remove any clothing or jewellery that's near the burnt area of skin but don't try to remove anything that's stuck to the burn
- Cover the burn by placing a layer of cling film / sterile gauze over it. Burns on the limbs – elevate the limbs higher than the heart

- Don't apply any home-made ointments or butter or toothpaste or any other doubtful remedies
- In case of large area of burn, place clean, dry, non-fluffy, lint-free cloths lightly over the burn
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

8. Breathing difficulties

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- Check the person's airway, breathing, and pulse. If necessary, begin hand-only cardio pulmonary resuscitation
- If the patient is responsive, stay calm and reassure the patient
- Assist the person take the position, he or she finds most comfortable
- Ensure fresh air by opening the windows and doors and dispersing crowds
- Assist the person loosening tight clothing
- Make sure the airway stay open, if the person lost consciousness
- If there are open wounds in the neck or chest, they must be closed immediately, especially if air bubbles appear in the wound. Bandage such wounds at once.
- Continue to monitor the person's breathing and pulse until medical help arrives
- Do not give the person food or drink
- Do not place a pillow under the person's head. This can close the airway
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

9. Chest pain

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- Check the person's airway, breathing, and pulse. If necessary, begin hand-only cardio pulmonary resuscitation
- If the patient is responsive, stay calm and reassure the patient
- Assist the person take the position, he or she finds most comfortable
- Ensure fresh air by opening the windows and doors and dispersing crowds
- Assist loosening tight clothing
- Assist the person to use any prescribed medicine for chest pain like Nitroglycerin, if he or she has some
- If not contraindicated, give the person aspirin 300 mg tablet and ask to chew it slowly
- Continue to monitor the person's consciousness, breathing and pulse until medical help arrives
- Do not give the person food or drink
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

10. Cut injury

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- Stop bleeding by applying pressure to the area using a dry and clean bandage, towel or handkerchief at least for 10-15 minutes
- In case of cut injury in hand or arm, raise it above the head to help reduce the flow of blood
- In case of cut injury in a lower limb, lie down and raise the affected area above the level of the heart
- After the wound has stopped bleeding, clean the area with normal saline or drinking quality running tap water
- Dry the area with clean towel or gauge piece and apply a sterile dressing
- Keep the dressing clean by changing it as often as necessary
- Call for help immediately, if you cannot stop the bleeding, bleeding from an artery, persisting or significant loss of sensation near the wound, having trouble moving any body parts, cut injury in face, palm and sole
- In case of cut injury more than 5 cm or lot of tissue damage, or having a high risk of wound infection or presence of sign of wound infection consult with a doctor
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

11. Cardio pulmonary resuscitation

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

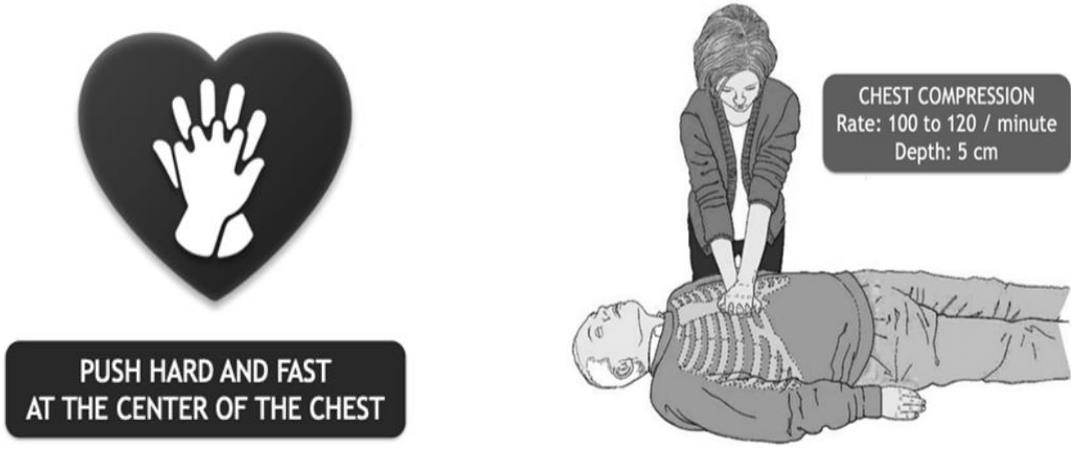
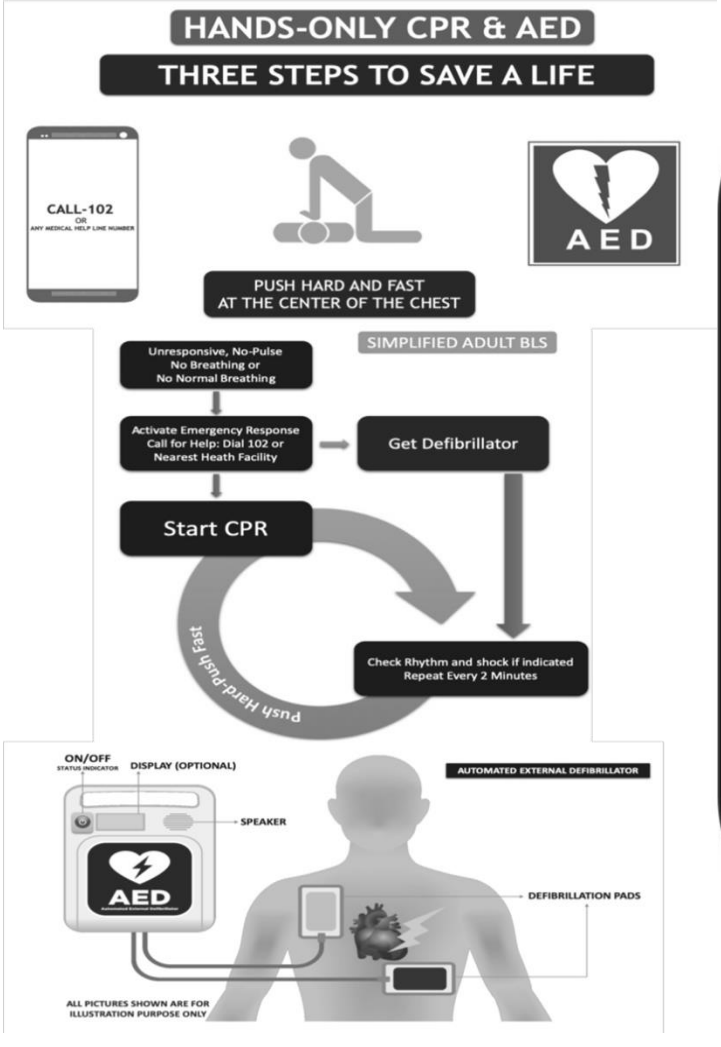


Fig.24.1. Two Steps to save a life- CPR Method

12. Cardio pulmonary resuscitation with AED

- Don't panic, stay calm and call for help
- call ambulance help line number like 102 in India or any other medical helpline number
- If not sure don't do anything, just call for help and assist to get in hospital at earliest



AED OPERATION ALGORITHM

1. Secure the area and verify the victim is NOT in water.
2. Open and/or turn the AED "ON" and Voice Instruction will start.
3. Stop CPR and continue with next steps very quickly
4. Expose the victim's chest and dry the skin if necessary.
5. Open the AED pads and attach the pads to the victim's chest. One pad on the upper right chest and another one under the left armpit by the left nipple.
6. Instruct all bystanders to move away while the AED analyses the victim's rhythm. "DO NOT TOUCH" the patient during this analysis.
7. If the AED determines to deliver a shock, it will verbally instruct not touch the victim and shock will be delivered automatically in case of fully automatic AEDs. Otherwise, The semi automatic type AED will advise you to deliver a shock. Ensure that no one is in contact with the victim. Press the Shock button.
8. If the AED does NOT detect a shockable rhythm, it will tell you to resume CPR.
9. After performing CPR for 2 minutes, the AED will instruct to stop CPR and will analyse the rhythm again.
10. Repeat step 8 or 9 as advised by the AED.

AED: AUTOMATED EXTERNAL DEFIBRILATOR

Fig.24.2. AED procedure

13. Dehydration

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- Encourage the person to drink plenty of water
- Prepare oral rehydration salt (ors) [who recommended] solution by dissolving the ors in prescribed volume of water as mentioned in the sachet
- Encourage the person to take 2200 to 4000 ml of who recommended ors solution over 4 hours
- If pre-packed ors sachet not available, prepare an ors solution at home. Take 1 litre of clean water in a container. Add six level teaspoons (1 teaspoon equivalent 5 grams) of sugar and half level teaspoon of salt. Stir the mixture till the sugar dissolves
- Advice the person to take rest and take food as usual
- Monitor the health status and level of response
- Do not give caffeinated, carbonated and alcoholic drinks
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

14. Drowning

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- If the victim is unresponsive and not breathing start hand only CPR immediately
- Victim that drown may bring up stomach contents, so be prepared to roll them onto their lateral side to clear their airway
- If the victim becomes responsive and start breathing or coughing or opens eyes, turn them to lateral side recovery position
- Victim must be warmed up with clothes or blankets and their wet clothes must be changed
- Monitor the health status and responsiveness of the victim
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

15. Eye injury

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- Don't rub the eye
- Wash the eye thoroughly with lots of clean water or recommended eye wash solution
- Do not apply any tight pressure pad over the eye. Just cover it using a sterile eye pad
- To reduce pain, over the counter medicine like Paracetamol may be taken, if not contraindicated for any reason
- Consult with an ophthalmologist as early as possible

- If not sure don't do anything, just call for help and assist to get in hospital at earliest

16. Electric shock/electrocution

- Don't panic, stay calm and call for help
- Call ambulance help line number like 102 in India or any other medical helpline number
- In case of high voltage electrocution, do not approach! Stay at least 25 metres away from the casualty until the power has been switched off by an official agency
- Do not touch the casualty if they're still in contact with the electrical source as you are at risk of electrocution
- Identify the connection and turn off the source of electricity
- Try to move the casualty away from the source or remove the source from the victim using a dry insulating material like wooden pole while standing on a dry insulating material, such as a book, newspapers or rubber matting
- If the victim is unresponsive start CPR immediately till the medical help arrives or victim reaches hospital
- If the victim is responsive put them into the recovery position continually monitor and record vital signs - breathing, pulse and responsiveness - until help arrives
- In case of electric burn follow standard burn first aid and go to hospital immediately
- If not sure don't do anything, just call for help and assist to get in hospital at earliest

17 First aid centre for the Construction Workers

The following first aid services should be taken from first aid centre:

- Medical Surveillance and Bio-monitoring
- Proper Occupational Health Centre proving preventive, promotive and curative services
- Emergency Care Services and management
- Adequate wholesome potable drinking water
- Proper Sanitation services
- First Aid services including First Aid Boxes and Appliances, Ambulance Room
- Immunization Services
- Ambulance Services
- Referral Services
- Employee Welfare Services
- Family Welfare Services
- Health education including advisory services on family planning, personal hygiene, environmental sanitation and safety
- Medical record, upkeep and maintenance
- Notification of occupational diseases, poisoning and to the concerned authorities
- Others as decided by the Competent Authority

Chapter 25

OCCUPATIONAL HEALTH

The construction industry is one of the major industries having the highest rate of occupational diseases and work-related injury. The hazards associated with construction work include physical, chemical, biological, ergonomic, psycho-social along with different traumatic injuries from impact, slip, trip, and fall. These hazards can cause or associated with occupational and work-related diseases. According to the International Labour Organization (ILO) it is estimated that 60000 fatalities occur at construction sites every year, globally.

As in other industries, occupational health hazards for the construction workers can be grouped into Chemical, Physical, Biological, Ergonomic, Social and safety Issue.

25.1 Chemical:

Chemical hazards in the construction site are often airborne and present in the form of dusts, fumes, mists, vapours or gases; thus, exposure usually occurs by inhalation. Some airborne contaminants absorbed through the intact skin (e.g., some organic solvents and pesticides). Some Chemical hazards also present in semi-liquid or liquid state (e.g., glues or adhesives, tar) or as powders (e.g., dry cement). Skin contact with chemicals in this state can occur in addition to possible inhalation of the vapour resulting in systemic poisoning or contact dermatitis. Chemicals might also be ingested with food or water, or might be inhaled by smoking. Several illnesses have been linked to the construction trades, among them:

- Asbestosis, Lung Cancer and asbestos induced non-respiratory diseases among asbestos insulation workers, steam pipe fitters, roofers, building demolition workers
- Silicosis among tunnel builders, sand blasters, and rock drill operators
- Skin allergies among masons and others who work with cement
- Bronchitis among welders, woodworkers
- Lead poisoning occurs among bridge rehabilitation workers and painters
- Neurologic disorders among painters and others exposed to organic solvents and lead.
- Toxic substances of plant origin come from poison ivy, poison oak, poison sumac and nettles, all of which can cause skin eruptions.
- Nano materials, found as additives in many newer construction products to improve their performance. Exposures to nano-materials can occur during construction activities such as mixing, spraying, grinding, cutting, or sanding these materials.

25.2 Physical:

Physical hazards are present in every construction project. These hazards include heat and cold, noise, radiation, vibration and barometric pressure. Construction work often must be done in extreme heat or cold, in windy, rainy, snowy, or foggy weather or at night. Ionizing and non-ionizing radiation is encountered, as are extremes of barometric pressure.

- **Noise:** The sources of noise are engines of all kinds (e.g., on vehicles, air compressors and cranes), winches, rivet guns, nail guns, paint guns, pneumatic hammers, power saws, sanders, routers, planers, explosives and many more. Noise is present on demolition projects by the very activity of demolition.
- **Temperature:** Heat and cold hazards arise primarily because a large portion of construction work is conducted while exposed to the weather, the principal source of heat and cold hazards. Roofers are exposed to the sun, often with no protection, and often must heat pots of tar, thus receiving both heavy radiant and convective heat loads in addition to metabolic heat from physical Labour. Heavy equipment operators may sit beside a hot engine and work in an enclosed cab with windows and without ventilation. Those that work in an open cab with no roof have no protection from the sun.
- **Vibration:** Pneumatic hammers, many hand tools and earth-moving and other large mobile machines also subject workers to segmental (Hand Arm Vibration) and whole-body vibration.
- **Radiation:** The principal sources of non-ionizing ultraviolet (UV) radiation are the sun and electric arc welding. Exposure to ionizing radiation is less common, but can occur with x-ray inspection of welds. Lasers are becoming more common and may cause injury, especially to the eyes, if the beam is intercepted.
- **Barometric Pressure:** Those who work under water or in pressurized tunnels, in caissons or as divers are exposed to high barometric pressure. Such workers are at risk of developing a variety of conditions associated with high pressure: decompression sickness, inert gas narcosis, aseptic bone necrosis and other disorders

25.3 Biological:

Biological hazards are presented by infected to different virus, bacteria, parasites and fungus, exposure to toxic substances of biological origin or animal attacks. Excavation workers, for example, can develop histoplasmosis, an infection of the lung caused by a common soil fungus. Construction workers can develop Tetanus also. Since there is constant change in the composition of the Labour force on any one project, individual workers come in contact with other workers and, as a consequence, may become infected with contagious diseases—influenza, COVID-19 or tuberculosis, for example. Construction workers are also high risk population for animal bite, snake bite, and others including attacks by wasps, hornets, fire ants, etc.

25.4 Ergonomic:

Some of the common ergonomic problems in construction are the result of job demands that push the human body beyond its natural limits. Workers who must often lift, stoop, kneel, twist, grip, stretch, reach overhead, or work in other awkward positions to do a job are at risk of developing a work-related musculoskeletal disorder (WMSD). These can include back problems, carpal tunnel syndrome, tendinitis, rotator cuff tears, sprains, and strains.

25.5 Prevention of Occupational Diseases and Injuries of the Construction Workers:

- **Primary Prevention:** Action to avoid or remove the cause of a health problem before its onset
    - Health Promotion:
        - Health Education on Prevention of Occupational Diseases
        - Environmental Modification
        - Nutritional Intervention
        - Lifestyle and behavioral Changes to stay healthy
    - Specific Protection
        - Elimination of Different Health Hazards at Construction Site
        - Risk Reduction approach by substitution, engineering control, administrative control
        - Use of Proper Personal Protective Equipments
        - Training and Retraining of the workers on different Construction Health and Safety related issues
        - Immunization against vaccine preventable diseases
- **Secondary Prevention:** Action to detect a health problem at an early stage and thus facilitate its cure or reduce or prevent its dissemination or effect in the long term
    - Early Diagnosis by Medical Surveillance and Management of the diseases
    - First Aid Services and prompt medical response to occupational injuries
- **Tertiary Prevention:** Action to reduce the chronic effects of a health problem by minimizing the functional impairment resulting from an occupational diseases or injuries
    - Disability Limitation
    - Rehabilitation

CHAPTER 26

EMERGENCY ACTION PLAN

26.1 INTRODUCTION

An Emergency Action Plan (EAP) or emergency preparedness is a plan, in the form of a written document, which details a workplace's preparedness in response to an emergency. It comprises agreed, recorded and rehearsed strategies, enabling those on site to respond effectively and reliably.

In other words, it is a chain of command to handle the emergency situations and to minimize the effects and ease the severity of the situation.

On a construction site, emergencies and disasters can strike anywhere, anytime causing potentially catastrophic injuries to workers and/or damage to property. Therefore, it is required that the facility/ project site have an emergency plan so that quick and effective action can be taken in the event of a problem to ease the severity of the situation and to limit the consequences.

Emergencies that may need to be planned for include (but are not limited to):

A. Serious injuries or Poisoning
B. Fire or Explosion,
C. Chemical leak or spill,
D. Electrocution,
E. Structural collapse.
F. Flood or Earthquake

Emergency planning should begin before the commencement of any works on site. The initial emergency plan may be based on a generic plan adapted to particular project. As the project progresses it may be amended to take account of changes progressively, in particular, if an emergency or near miss has occurred.

The Emergency Preparedness and Response Plan must outline the emergency management system in the event of a major crisis / disaster.

26.2 DEVELOPMENT OF PLAN

When developing the plan for emergency procedures, the followings must be taken in to account:

- The type of work being done on site (e.g. Like routes to downstairs during demolition);
- The plant and equipment being used (e.g. Consider tower crane drivers, people working on suspended access equipment or where the exit may be obstructed by equipment);
- The number of people likely to be present on the site at any one time. On sites where many people work, escape routes need to be wide enough to allow everyone to get through doorways or downstairs easily without becoming overcrowded; and

- The physical and chemical properties of substances or materials on or likely to be on the site (e.g. Work at petrochemical installations or at sites where flammable paints or glues are in use may require an increased standard of ventilation).

Planning shall begin before any work commences on the project. Development should include the following considerations:

1. Hazard Identification/Assessment

The process of hazard identification and assessment shall involve a thorough review that should include, but not be limited to, the following points:

a) Transportation, materials handling, hoisting, equipment or product installation, temporary structures, material storage, start-up, and commissioning activities
b) Environmental concerns
c) Taking in to account of similar projects and consultation with the client regarding potential hazards while working in or adjacent to operating facilities
d) Resources such as Safety Data Sheets (SDS) to determine potential hazards from on-site materials
e) Proximity to traffic and public ways

As the construction sites are frequently fast-changing, the process of hazard assessment must be ongoing to accommodate the dynamic environment. Once hazards are identified, the next task is to assess the potential or risk involved in each. For each hazard identified, ask:

i. The chances of occurrences
ii. The situation, when it can be undesired.
iii. Consequences, if not controlled

For each potential hazard identified, it is important to identify the resources necessary for an appropriate emergency response. For most events in construction, a simple analysis based on the experience of the people involved on the project is likely sufficient.

2. Emergency Resources

It is important to identify the available resources and contingency plans in place to make up for any deficiencies. The main elements of emergency plans shall be: -

I. Leadership and Administration.
II. Role and Responsibilities of Key Personnel.
III. Emergency action.
IV. Light and Power.
V. Source of energy control.
VI. Protective and rescue equipment.
VII. Communication.
VIII. Medical care.
IX. Mutual Aid.
X. Public relation.
XI. Protection of vital records.

XII. Training.
XIII. Periodical revision of plan.

The most important resource on most projects will be a rescue and evacuation plan, however, it is important to know the facilities or limitations available in that location. While ensuring the available resources, it is required to observe:

- The availability of a rescue team.
- Response time of the rescue team
- The action plan of site personnel

Other on-site resources such as fire extinguishers, spills containment equipment, and first aid kits must be maintained and clearly identified. Construction equipment may be included among potential emergency resources. Personnel, especially on-site medical staff or workers trained in first aid, should be included in the plan.

There may be situations where outside resources are so far away that an adequate response is not possible. In these situations, resources like fire protection or ambulance/medical resources may have to be obtained and kept on site.

People, equipment, facilities, and materials needed during emergency response shall be well documented. The people supplying these resources must be made aware of their role in the plan. Moreover, well designated assembly points shall be kept declared in the plan.

3. Emergency Response team

A team consisting of experienced, skilled and competent persons shall be formed and kept ready for their respective roles. The team shall be informed with the probable scenarios of emergency. They shall be trained in order to handle such situations.

4. Communication Systems

An important key to effective emergency response is a communications system which can relay accurate information. In this regard, highly reliable communications equipment must be used. Availability of backup system is also a smart choice. Along with a good communication procedure, effective procedures and trained personnel are also the key elements of EAP.

A communication system must be made up of strategically placed equipment and properly defined responsibilities. The emergency response plan posted in a conspicuous place on the project must identify the designated equipment and the people to operate it.

The number and location of siren and communication system can be decided upon the characteristics and size of the site shall and people working at many sites. Various locations or bigger site will probably need bells or sirens at a number of places to raise the alarm. Small sites with only two or three people working, air horn may be adequate;

Type and location of emergency communication systems must be documented in the plan. It shall include location of communication facility, a list of site personnel and other equipment

available. Emergency phone numbers and the site address/location should be posted at the designated control centres. On large sites, the location of emergency phones must be clearly marked.

26.4. ADMINISTRATION OF THE PLAN

Chief incident controller and site incident controller play a major role in tackling with Emergency. Task of administering and organizing the plan is vital to its effectiveness. The person who has this task will normally be the person in charge of the emergency response operation. It is their task to ensure

a. that everyone clearly understands their roles and responsibilities within the emergency response plan

b. that emergency resources, whether people or equipment, are kept at adequate levels in step with the progress of the project.

It is very important to review the emergency plan on a regular basis and especially after an emergency has occurred. Changes may be necessary where deficiencies became apparent as the plan went into operation.

26.5 EMERGENCY RESPONSE PROCEDURE

An emergency can be reported from any source -- a worker on site, an outside agency, or the public. The procedures must be able to respond to the ongoing situation.

The following list covers basic actions to take in an emergency. These steps apply to almost any emergency and should be followed in sequence.

a. Stay calm- Situation influences others.
b. Assess the situation -Determine what happened and what the emergency is.
c. Take command- The senior person should take control at the site till arrival of the Chief incident controller. This action also helps to maintain order and prevent panic.
d. Provide protection -Eliminate further losses and safeguard the area. Control the energy source. Shut down the equipment running; protect victims, equipment, materials, environment, and accident scene from continuing damage or further hazards. Preserve the accident scene
e. Aid and manage- Manage personnel at the scene. Organize the workforce for both a headcount and emergency assignments, to identify the missing, control panic, and assign people to emergency duties.
f. Maintain contacts- Keep emergency services informed of situation.
g. Guide emergency services- Explain ongoing and potential hazards and cause(s), if known. Lead them to emergency scene.

Communication of the Procedure

To be effective, an Emergency Response Procedure must be clearly communicated to all site personnel. The following activities should be considered:

a. Review the procedure with new site subcontractors and new workers to ensure that it covers their activities adequately.

b. Review the procedure with suppliers to ensure that it covers any hazards that the storage or delivery of their materials might create.
c. Review new work areas in operating plants with owner/client to ensure that new hazards are identified and covered in the procedure.
d. Review the procedure with the statutory authorities or Health and Safety Representative on a regular basis to address new hazards or significant changes in site conditions.
e. Display the procedure in a conspicuous location.

The Emergency Response Procedure for a construction project must continually undergo review and revision to meet changing conditions.

26.6. POST EMERGENCY PROCEDURE

After control of emergency the Site Incident Controller will communicate to the Chief incident controller about the end of emergency. The Chief incident controller will declare “All clear” by instructing the Administration/ time office to sound “All Clear Sirens”.

Post emergency procedure is a critical step in the plan. As part of site emergency planning, construction companies should have measures in place to deal with post-traumatic stress also.

Debriefing is critical to the success of future emergency response planning. It is necessary to review how well the plan worked during emergency. It is also necessary to review the plan and correct the deficiencies observed while executing the plan.

26.7 MOCK DRILL OF THE PLAN

Due to lack of resources or lack of coordination or lack of clarity of roles among the stakeholders, most of the times organizations in times of emergency or during a life-threatening hazardous situation, find themselves at back foot. Sensitization of employees is highly essential factor considering the fact of emergency situation like collapse of facility, fire, chemical disaster, flood, cyclone, tsunami, or earthquake or any such untoward incidents having the potential to cause injury and death. The activities in response to deal with depend on type of emergency situation. This is the reason that mock drill should be conducted to inculcate the vibes of emergency preparedness, optimum utilization of resources, mobilization of coordinated activities, and related aspects after identifying the gaps. The emergency mock drill of the plan shall follow the following procedure.

a. Inform all the employees about importance and procedure of mock drill and the signal to be given.
b. Fix the date and location of the emergency for mock drills without knowledge of the employees.
c. Mock drills will be monitored by observers (who will be one of the Senior Officers or officers from outside organization) not involved in the exercise.
d. Raise the alarm for Emergency.
e. After hearing the siren site controller with required number of employees will move to emergency site to combat emergency.

f. He will depute persons for calling the fire Brigade.
g. Rescue/evacuation team should work in co-ordination with emergency team.
h. Office clerk will be responsible for head count.
i. Chief / Site Incident Controller will address system about drills to the employees assembled at Assembly Point.
j. All clear signal should be given once situation in under control and safe to occupy.

CHAPTER 27

LEGAL COMPILANCE

Employers must be familiar with the various Acts, Standards and Codes related to constructions activities, to ensure the safety and health of their workers.

The following are specifically applicable in the construction site(s)

1. The Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Act, 1996
2. The Delhi Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Rules, 2002.

The important legal provisions as per the BOCW Act, 1996 and DBOCW Rules, 2002 are as follows:

Duties of employer as per BOCW Act, 1996.-
(1) Every employer shall,—

a. ensure that workplace is free from hazards which cause or are likely to cause injury or occupational disease to the employees;
b. comply with the occupational safety and health standards declared under section 18 or the rules, regulations, bye-laws or orders made under this Code;
c. provide such annual health examination or test free of costs to such employees of such age or such class of employees of establishments or such class of establishments, as may be prescribed by the appropriate Government; (d) provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of the employees;
d. ensure the disposal of hazardous and toxic waste including disposal of e-waste;
e. issue a letter of appointment to every employee on his appointment in the establishment, with such information and in such form as may be prescribed by the appropriate Government and where an employee has not been issued such appointment letter on or before the commencement of this Code, he shall, within three months of such commencement, be issued such appointment letter;
f. ensure that no charge is levied on any employee, in respect of anything done or provided for maintenance of safety and health at workplace including conduct of medical examination and investigation for the purpose of detecting occupational diseases;
g. relating to factory, mine, dock work, building or other construction work or plantation, ensure and be responsible for the safety and health of employees, workers and other persons who are on the work premises of the employer, with or without his knowledge, as the case may be.

(2) Without prejudice to the generality of the provisions of sub-section (1), the duties of an employer shall particularly in respect of factory, mines, dock, building or other construction work or plantation include—

a. the provision and maintenance of plant and systems of work in the workplace that are safe and without risk to health;
b. the arrangements in the workplace for ensuring safety and absence of risk to health in connection with the use, handling, storage and transport of articles and substances;
c. the provision of such information, instruction, training and supervision as are necessary to ensure the health and safety of all employees at work;
d. the maintenance of all places of work in the workplace in a condition that is safe and without risk to health and the provision and maintenance of such means of access to, and egress from, such places as are safe and without such risk;
e. the provision, maintenance or monitoring of such working environment in the workplace for the employees that is safe, without risk to health as regards facilities and arrangements for their welfare at work.

Duties of architect, project engineer and designer.-

1. It shall be the duty of the architect, project engineer or designer responsible for any building or other construction work or the design of any project or part thereof relating to such building or other construction work to ensure that, at the planning stage, due consideration is given to the safety and health aspects of the building workers and employees who are employed in the erection, operation and execution of such projects and structures as the case may be.
2. Adequate care shall be taken by the architect, project engineer and other professionals involved in the project referred to in sub-section (1), not to include anything in the design which would involve the use of dangerous structures or other processes or materials, hazardous to health or safety of building workers and employees during the course of erection, operation and execution as the case may be
3. It shall also be the duty of the professionals, involved in designing the buildings structures or other construction projects, to take into account the safety aspects associated with the maintenance and upkeep of the structures and buildings where maintenance and upkeep may involve such hazards as may be notified by the appropriate Government.

Notice of certain accident as per Rule- 210 of DBOCW Rule, 2002. –

1. Where at any place in an establishment, an accident occurs which causes death, or which causes any bodily injury by reason of which the person injured is prevented from working for a period of forty-eight hours or more immediately following the accident or which is of such nature as prescribed in DBOCW Rules, 2002.

2. Where a notice given under sub-section (1) relates to an accident causing death of five or more persons, the authority to whom the notice is sent shall make an inquiry into the occurrence within one month of the receipt of the notice.

Notice of certain dangerous occurrences.-

Where in an establishment there is any dangerous occurrence of such nature, (whether causing any bodily injury or disability, or not) the employer shall send notice thereof to such authorities, and in such form and within such time, as may be prescribed by the appropriate Government.

Notice of certain diseases as per Rule 230 of DBOCW Rules, 2002.-

1. Where any worker in an establishment contracts any disease specified in the Schedule-II, the employer of the establishment shall send notice thereof to the inspector, in form XIII prescribed in DBOCW Rules, 2002.
2. If any qualified medical practitioner attends on a person, who is or has been employed in an establishment, and who is, or is believed by the qualified medical practitioner, to be suffering from any disease specified in the Third Schedule, the medical practitioner shall without delay send a report in writing to the office of the Chief Inspector-cum-Facilitator as prescribed in DBOCW Rules, 2002 .

Duties of employee. -

Every employee at workplace shall,—

a. take reasonable care for the health and safety of himself and of other persons who may be affected by his acts or omissions at the workplace;
b. comply with the safety and health requirements specified in the standards;
c. co-operate with the employer in meeting the statutory obligations of the employer under this Code;
d. if any situation which is unsafe or unhealthy comes to his attention, as soon as practicable, report such situation to his employer or to the health and safety representative and in case of mine, agent or manager referred to in section 67, safety officers or an official for his workplace or section thereof, as the case may be, who shall report it to the employer in the manner as may be prescribed by the appropriate Government;
e. not wilfully interfere with or misuse or neglect any appliance, convenience or other thing provided at workplace for the purpose of securing the health, safety and welfare of workers;
f. not do, wilfully and without reasonable cause, anything, likely to endanger himself or others; and
g. perform such other duties as may be prescribed by the appropriate Government

Prohibition of employment of certain persons in certain building or other construction work.-

No person, about whom the employer knows or has reasons to believe that he is a deaf or he has a defective vision or he has a tendency to giddiness, shall be required or allowed to work in any such operation of building or other construction work which is likely to involve a risk of any accident either to the building worker himself or to any other person.

Further the provision pertaining to Safety and Health in the Occupational Safety, Health is briefed under the below mentioned provisions.

Chapter VII of BOCW Act, 1996- Occupational Safety and Health- Section 38 to 41.
Chapter VI to XXIV of Delhi BOCW Rules, 2002- Safety & Health Provision Rules: 34 to 232.

The above legal compliances are very much essential for ensuring Safety, health and welfare at workplaces and to reduce the accidents/ incidents and improve the occupational health standards of the construction workers.

CHAPTER 28

LIST OF INDIAN STANDARDS APPLICABLE TO CONSTRUCTION SITES

Standards on Occupational Safety and Health in Construction Industry in India are as follows:

S. No	Indian Standard	Subject
1.	IS 3696-1, 1987	Safety requirements for the erection, use and dismantling of scaffolds

2.	IS 3696-2, 1991	Scaffolds and Ladders - Code of Safety, Part 2: Ladders
3.	IS 3764, 1992	Code of safety for excavation work
4.	IS 4081, 1986	Safety Code for Blasting and Related Drilling operations
5.	IS 4014-2, 1967	Code of Practice for Steel Tubular Scaffolding, Part II: Safety Regulations for Scaffolding
6.	IS 4081, 1986	Safety Code for Blasting and Related Drilling operations
7.	IS 4082 1996	Recommendations On Stacking And Storage Of Construction Materials And Components At Site
8.	IS 4130 1991	Safety Code for Demolition of Buildings
9.	IS 4138, 1977	Safety Code for Working in Compressed Air
10.	IS 4756, 1978	Safety Code For Tunnelling Work
11.	IS 4912, 1978	Safety Requirements for Floor and Wall Openings, Railings and Toe Boards
12.	IS 5121, 1969	Safety code for Piling and Other Deep Foundations
13.	IS 5916 1970	Safety Code For Construction Involving Use Of Hot Bituminous Materials
14.	IS 7272-1, 1974	Recommendation for Labour Output Constants for Building Work, Part I: North Zone
15.	IS 7293, 1974	Safety Code for Working with Construction Machinery
16.	IS 8989 – 1978	Safety Code for Erection of Concrete Framed Structures
17.	IS 7969, 1975	Safety Code For Handling And Storage Of Building Materials
18.	IS 10291- 1982	Safety code for dress divers in civil engineering works
19.	IS 10067 -1982	Material Constants In Building Works
20.	IS 10302, 1982	Unified Nomenclature of Workmen for Civil Engineering
21.	IS 13415 -1992	Protective Barriers in and Around Buildings - Code of Safety
22.	IS 13416-1- 1992	Recommendations for preventive measures against hazards at workplaces, Part 1: Falling material hazards prevention
23.	IS 13416-2-1992	Recommendations For Preventive Measures Against Hazards At Workplaces, Part 2: Fall Prevention
24.	IS 13416-3- 1994	Recommendations for preventive measures against hazards at workplaces, Part 3: Disposal of debris
25.	IS 13416-4- 1994	Recommendations for preventive measures against hazards at workplaces, Part 4: Timber structures

26.	IS 13416-5- 1994	Recommendations for preventive measures against hazards at workplaces, Part 5: Fire protection
27.	IS 13430- 1992	Code of practice for safety during additional construction and alteration to existing buildings
28.	IS 15883-1- 2009	Construction project management - Guidelines, Part 1: General
29.	IS 15883-2- 2013	Construction project management - Guidelines, Part 2: Time Management]
30.	SP 70- 2001	Handbook on Construction Safety Practices

List of Indian Standards applicable for PPEs

Head

S.No	Indian Standard	Subject
2	IS 2925 : 1984	Specification for industrial safety helmets

Eye and Face

S. No.	Indian Standard	Subject
1	IS 1179 : 1967	Equipment for eye and face protection during welding
2	IS 5983 : 1980	Eye protectors
3	IS 7524 : 1980 Part 1	Method of test for eye protectors:- Non - optical tests
4	IS 8521 : 1977 Part 1	Industrial safety face shields – with plastic visor

Ears

S.No	Indian Standard	Subject
1	IS 9167 : 1979	Specification for ear protectors

Respiratory

S. No.	Indian Standard	Subject
1.	IS 9473 : 2002	Respiratory protective devices – Filtering half masks to protect against particles – specification

2.	IS 9563 : 1980	Carbon monoxide filter self rescuers
3.	IS 9623 : 1980	Recommendations for the selection, use and maintenance of respiratory protective devices
4.	IS 10245:Part 1 to 4	Breathing apparatus
5.	IS 15322 : 2003	Particle filters used in respiratory protective equipment – Specification

Hands

S. No.	Indian Standard	Subject
1.	IS 2573 : 1986	Specification for leather gauntlets and mittens
2.	IS 4770 : 1991	Rubber Gloves – electrical purposes – specification
3.	IS 6994 : 1973	Specification for safety gloves – leather and cotton gloves

Body

S. No.	Indian Standard	Subject
1	IS 3521 : 1999	Industrial safety belts and harnesses – Specification
2	IS 4501 : 1981	Specification for aprons, rubberized, acid and alkali resistant
3	IS 15809: 2008	Specification for High Visibility Clothing

Feet and Legs

S. No.	Indian Standard	Subject
1.	IS 5557 : 1999	Safety Rubber boots – Specification
2.	IS 11226 : 1993	Leather safety foot wear having direct moulded rubber sole – Specification
3.	IS 14544 : 1998	Leather safety footwear with direct moulded PVC soles – Specification
4.	IS 15298 : 2016 Part (1 - 8)	Safety, protective and occupational footwear for professional use – Specification for safety footwear

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