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Construction Safety – A Monograph

Operating Plants Safety Division

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Construction Safety – A Monograph

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Introduction

Construction may be defined as the process of manufacturing, testing and assembling the components of a facility, the erection of civil works and structures, the installation of components and equipment and the performance of associated tests.

Construction activity is as old as the civilization itself. It has developed through the ages and produced fine monuments such as the massive Pyramids, the Colosseum, exquisite ancient temples, the Taj Mahal and modern wonders of complex and tall structures, dams and bridges-marvels of modern engineering and industries- a testimony of ingenuity and excellence of designers, architects and construction engineers. At the same time construction of factories and big plants brought in growing complexities with multiplicity of disciplines, technologies and construction equipment and unskilled man power posing greater hazards and challenges.

At present construction is the second largest activity, next to agriculture in India, which employs illiterate/semi-literate migrant labour intensively. There is no established pragmatic method of screening workforce prior to deployment at construction sites. Accidents resulting into loss of life and limbs have been rampant. This makes construction safety management a herculean task.

As construction is a complex and dynamic activity, a high degree of commitment to safety by project management, rigorous and pro-active measures are essential to prevent accidents at construction sites. Persistent efforts by the government, regulatory bodies as well as project management are needed for sustainable and committed safety at work place. The ultimate aim is to continually augment our efforts in achieving zero accidents at construction sites.

The first edition of the monograph on construction safety was published by AERB in its silver jubilee year i.e. December 2007 with an objective to create awareness about the hazards associated with the construction activities amongst safety professionals, project management, workers, regulators and all others who have a stake in the safety at construction sites.

In view of the continual development of construction technologies and the need for enhancement of industrial safety in DAE units based on further experience gained by AERB in regulating the units, the need for revision of the monograph was felt.

This document touches upon the legislative frame work for construction safety in the units under the regulatory purview of AERB and briefly covers the management issues, human, organizational & technical factors, safety measures in various construction activities, guidelines on personal protective equipment and selected case studies of accidents from which important lessons can be learnt.

1.0 Legislative Framework

Comprehensive legislations, robust management systems, competent managers, inspirational leaders for safety and pro-active measures are necessary to meet the needs of contemporary construction industry. A dedicated safety management and a disciplined approach to ensure compliance with safety rules & procedures will certainly prevent the majority of accidents at construction projects. Some of the important available legislations in India are the Factories Act, 1948, the Atomic Energy (Factories) Rules, 1996, the Building & Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Central Rules, 1998. To enforce the safety provisions in construction projects of the units under the regulatory purview of AERB, notifications/directives from time to time based on the requirements have been issued by the Chairman, AERB. AERB Safety Guidelines on 'Control of Works' also underlines various requirements to be adhered to by the principal employer and contractor to protect the health and ensure the safety of the workers from industrial activities.

The prime objective of the legislations and notifications is to regulate the engagement of labour workforce in construction industry and to provide safety, health and welfare measures to workers. Inspectors of AERB oversee safe working conditions and practices at DAE units under the regulatory purview of AERB.

2.0 Construction Safety Management

It is well recognized that the construction is dynamic is nature and highly accident prone. The major issues which need to be addressed by project management are:

i) Illiterate/semi-literate and unskilled/semi-skilled workforce, with rural background.

ii) High turnover due to temporary employment varying from days to months.

iii) Lack of proper training and difficulties in wearing personal protective equipment.

iv) Exploitation of workers by contractors and sub-contractors.

v) Young untrained workers attempting to do the job through shortcuts.

The above issues should be addressed by the project management during the entire life cycle of the project. Few measures are listed below for safety management of the project.

2.1 Safety Policy & Safety Plan

Safety begins with the attitude that accidents are preventable and that requirements for safe work practices must be followed. Individuals controlling the work should integrate safety into regular work practices and regularly emphasize the importance of safety over that of expediency. In this regard, project management should develop a health and safety policy

to convey the management commitment and intent of the organization towards health and safety. In order to meet the requirement of health and safety policy, a health and safety plan should be developed. Health and safety plan should identify and enumerate the control measures to mitigate the risks to the workers arising out of health and safety issues. After approval of the safety plan by the Project Director, the plan should be considered as a reference document for implementation, control and monitoring of health and safety aspects of the project.

2.2 Roles, Responsibility and Authority

Project management should define, document and communicate the roles, responsibilities and authorities of all personnel who manage, perform and verify activities having an effect on health and safety risks including principal contractors and their sub-contractors.

Ultimate responsibility for health and safety should rest with top management. They should exhibit a visible management commitment and felt leadership towards health and safety. Top management should clearly transmit the message to the line management and people down the level in the organization that it considers safety as core value. Such messages when reaches to all the levels in the organization enable to create a positive health and safety culture.

The line management personnel who are responsible for execution of activities are directly responsible for health and safety in the work under their control.

Management should provide adequate resources (human resources, organizational infrastructure, technology and financial resources) necessary to effectively manage the health and safety requirements of the project.

2.3 Safety Organization

A robust safety organization helps in effective implementation of safety aspects. Therefore, it is imperative to have such a setup at every construction site. In this context, following need to be ensured:

- A well-defined safety professional organization should be available at every site. Their responsibility is to guide the management on health and safety issues and facilitating the implementation of health and safety in the project site.

- Head of the Safety organization should be a departmental position and other functionaries can be a combination of departmental and contractor's safety personnel in an approximate ratio of 1:3. There should be a well-defined interface between the safety setup of Department and Contractor.

- Safety organization should comply with all the requirements such as safety surveillance, safety training, safety enforcement measures, safety audit etc. related to all works.

- Safety functionaries should be exclusively assigned with only safety related duties.

- The qualification, experience and the minimum number of safety professionals deployed should be as per the notification issued by AERB.

2.4 Safety Communication

Communicating occupational health and safety information effectively is crucial to prevent worker injuries and illness. The health and safety hazards and risks may be communicated in the following ways:

- Sharing of accident case studies
- Collecting feedback on health and safety from workers and appropriately addressing them for continual improvement
- Health and safety posters and displays
- Health and safety campaigns
- Sharing of results of the audits, inspections and other monitoring systems
- Safety signage etc.

Open communication with the workers motivate them to work safely and project management should always be ready to listen to their suggestions for improvement. The top management should clearly communicate that it considers safety as core value and it would not allow it to get compromised.

2.5 Safety Culture

Safety culture is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of an organization. Project management should develop a safety culture that will give appropriate priority to safety realizing that safety has to be managed like other areas of the business. The presence of a positive safety culture is the most important factor in preventing injuries and in ensuring safe working conditions / practices. Management should always recognize importance of best established practices for development of sustained positive safety culture.

2.6 Safety Monitoring Programme

The objective of the safety monitoring programme should address assurance of effective implementation of safety measures in execution of works. There are proactive and reactive

safety monitoring measures. Following are some of the safety monitoring measures that should be in place at sites:

Safety Inspections/audits should be carried out to observe the physical conditions of work and the work practices and procedures followed by workers and suggest measures to be adopted for removing the unsafe physical conditions and preventing unsafe actions by workers.

Specific surveillance should be ensured with respect to testing of equipment, portable power tools, electrical equipment and tools, hand tools, surveillance of material handling equipment, transport equipment, earth moving equipment, gas cylinders etc. to comply with various statutory requirements.

As a part of reactive monitoring measure, all incidents including near miss cases should be thoroughly investigated, direct and root causes determined and corrective action planned.

The safety organization should monitor, maintain records and follow-up corrective actions to ensure effective implementation of the safety monitoring programme.

2.7 Training/Orientation

Safe place of working and safe system of working are the two important requirements in reducing accidents in construction site. Though safe place of working can be provided, safe system of working can only be provided through proper training to the workmen. Project management should ensure that all workers are competent to perform the assigned work safely on the basis of appropriate education, training and experience. Safety training should be made a part of all construction jobs. It should include

- Hazards associated with work
- First aid
- Fire prevention & protection measures
- Accident Prevention
- Usage & maintenance of safety equipment etc.

The training/orientation programme like induction training, on the job training, refresher training, job specific pre-job briefing should be carried out as mandatory requirements in line with the procedure made for training. Induction cum orientation training should cover the overall safety aspects of the unit, general instruction of the various hazards of the unit and the particular work, and the general do's and don'ts. Workers should be given demonstrations on use of personal protective equipment (PPE), use of tools etc. Records of training/re-training should be maintained. Refresher training should be carried out

periodically. Pre-job briefing on day-to-day basis prior to start of specific hazardous jobs should be conducted in order to make the workers aware of the hazards and the precautions to be taken.

2.8 Certification of Construction Workers

Accident frequency decreases with increased experience and greater safety awareness. In order to ensure that every worker on the job site has undergone safety awareness and job related hazards training before permitting them to begin the work, an accepted method of certification of construction workers need to be followed for the construction works.

As line managers provide a link between the workers and health and safety practice in the workplace, it is essential that regular in-depth training is provided to these line managers. Certification should cover all these line managers also with respect to safety orientation. The certification can be after training and evaluation of performance.

2.9 Engineering Solutions

Appropriate engineering solutions for preventing inherent unsafe conditions like unguarded floor openings, unguarded working platforms, faulty access ladders etc. should be thought of and applied. It is one of the most effective hazard control techniques wherein the workers are isolated from the hazard rather than removing the hazard altogether. Common examples include mechanical guards, interlocking systems and safeguarding devices such as fences, safety mats etc. An established system to ensure the safety of work places should be available such as approved procedures, use of best practices, periodic checks etc. to maintain the work place in a safe manner.

Self-Elevating Working Platform

Protection for lift-shaft opening

2.10 Safety Work Permit

In order to ensure safety in all hazardous jobs such as excavation, work at height, work in confined spaces, working with chemicals, welding and gas cutting, electrical works etc., safety permit should be taken. The permit procedures should be well established and practiced. The importance of permit system should be impressed upon by the line management. The record of permits should be maintained in a systematic manner and should be verified periodically by safety officials.

3.0 Human, Organizational and Technical Factors for Construction Safety

The success and sustainability of the safety management system in a construction site is entirely dependent on the consideration of human, organizational and technical factors in the safety management system. Human factors are those human elements that influence human performance on safety of the project during construction. Some of the human elements are human abilities/ capabilities, work environment, motivation, communication, behavior etc. Project management should work towards developing and improving these human factors to reduce human error and enhance safety performance.

Human error is a consequence and not a root cause for any accident. Investigations of several accidents at construction sites have identified improvement in organizational factors as one of the most effective means of mitigating accident in the workplace. Organizational factors means factor(s) relevant to the performance of an organization that influences the safety of the project during construction. Manager and employees (including contract workers) are two main components of an organization, which plays an important role in the safety of an organization. Hence organization have a crucial role in preventing workplace accidents by giving due importance to occupational health & safety, ensuring employees have the necessary information, training and supervision to carry out their jobs safely. Management system, organization structure and resources are the organizational factors which are predominantly required to achieve higher safety in an organization by inherently taking care of the human errors.

Apart from focusing on human and organizational factors, project management should also work towards using engineering solutions and latest construction technologies in construction work, as these would be beneficial in minimizing construction injuries. Some of the other technical factors on which the project management should work upon are the usage of safe tools and equipment so as to provide safe working area for the workers thereby enhancing safety during construction.

A balanced attention to human, organizational and technical factors while developing and implementing safety management system is the key for continual improvement in safety performance. Human, organizational and technical factors mentioned in this section have been briefly described in section 2.

4.0 Documentation

The documents that need to be prepared at any construction site are construction safety manual, job hazard analysis reports, checklists and supporting documents like procedures for vehicle control movement, training manual, safety work permit system etc. which are need based and specific to each site.

4.1 Construction Safety Management Manual (CSMM)

Construction projects have significant health and safety hazards, which need to be managed systematically since the project inception stage to achieve adverse incident free completion. Construction safety management manual describes about the health and safety measures that will be put in place by the project management to create a safe and healthy work environment at construction project site for the protection of all personnel involved in the project construction activities. Construction safety management manual should be made prior to start of construction activity. This manual should include safety policy, organization chart & responsibilities, safety manpower qualifications & experience, training & competency to perform assigned duties, job safety procedures to prevent/control hazards due to various agencies in the construction environment, job control/work permit system, job inspection/supervision & enforcement and accident reporting & investigation system.

4.2 Job Hazard Analysis (JHA) Reports

Job hazard analysis is one of the best methods for identifying all possible hazards associated with a job and the safety measures to be taken for each possible identified hazard. Before start of construction activity, detailed job hazard analysis (JHA) should be carried out for all critical jobs and a checklist should be prepared based on the job hazard analysis carried out. In job hazard analysis, first a job is selected and then it is broken into different steps. For each step, hazards are identified and accordingly safety measures to be taken for each hazard are brought out.

4.3 Supporting Documents

Documents like procedures for controlling the movement of earth moving machinery & lifting machinery, control measures to prevent fall of person/material from height, safety training procedures, safety work permit procedures for blasting, excavation, welding & gas cutting, concrete handling activities, erection activities at height etc. should also be made available.

The project management approves the above documents. The approved documents are reviewed by the representatives of Atomic Energy Regulatory Board periodically during

the construction phases of the project on a sample basis. The reports are revised based on experience and review observations.

5.0 Construction Activities – Hazards and Safety Measures

It is a fact that the accidents can be eliminated by providing safe working place and establishing safe ways of working at the construction site. A brief description of different types of construction activities, their associated hazards and safety measures to be taken for prevention of accidents are highlighted here. In this monograph, those type of construction activities have been discussed where the rate of fatalities/injuries are high in DAE units. AERB's stipulations through notifications wherever issued are provided for reference in this monograph.

5.1 Rock Blasting

The blasting works involve risks related to storage, transportation, handling and use of explosives, blasting accessories and agents. The hazards involved during blasting are fly rock, dust, fumes, ground vibration etc. from an explosion that may cause personal injuries, damage to adjacent property etc.

Major safety measures to be taken during blasting are:

i) The blaster should be a qualified and competent person for carrying out blasting work. He should know about the dangers involved.

ii) Blasting in the open site should only be carried out during the fixed hours every day/fixed day in the week. Workers & residence of adjacent property should be informed about the blasting so that they will not be unnecessarily disturbed by it.

iii) Before blasting, sufficient warning should be given to enable the people working in the area to get off the danger zone at least 10 minutes before the blasting starts. The danger zone should be suitably cordoned off and flag men posted at important points.

iv) A loud wailing note of not less than 1 minute duration should be sounded on sirens to warn the worker/public before commencement of firing. The end of firing operations should be followed by sounding an all clear signal on the sirens as a continuous long note of not less than 1 minute duration.

v) The blaster should not return to blasting site after firing, until sufficient time have elapsed. All holes should be carefully inspected by authorized persons for residual undetonated explosives after firing.

vi) No loose material, such as tools, drilling implements, etc. should be left on the rock surface to be blasted.

vii) Care should be taken that the blasting point is free of detonating gas, inflammable objects, sparking or damage wiring system, stray currents.

viii) Blasting operations in the proximity of overhead power lines, communication lines, utility lines, or other structures should not be carried out without notifying the owner of such lines and taking precautionary measures as deemed necessary.

ix) Explosives and blasting equipment should be stored only in clean, dry, well-ventilated, suitably constructed bullet/magazine which should be fire resistance and securely locked. Stock book should be kept accurate and maintained. Licence should be obtained for storage of explosive as per the Explosive Act, 1984.

x) Blasting caps, electric blasting caps or primers should not be stored in the same box, container or room with other explosives. Precautions against lightening should be provided in accordance with Indian Electricity Act, Rules and Regulations.

xi) The explosives should be transported in specially designed vehicles bearing a special sign or inscription entitled "DANGER EXPLOSIVES" and also detonators separated from other explosive should be transported in separate compartment.

5.2 Excavation

Excavation is among the most hazardous construction operations. Excavations are needed for the foundation of structures, installation and repair of utility lines, replacement of water and sewer lines etc. An excavation may be defined as any man-made cut, trench, or depression in the earth's surface formed by earth removal.

Cave-ins pose the greatest risk and are much more likely than other excavation related accidents to result in worker fatalities. Other hazards to be considered include accidental contact with utility lines, crushing and striking hazards posed by mechanized equipment, and hazardous atmospheres.

Working in excavations is an extremely dangerous operation which can be made safe by an awareness of the hazards and the precautions to be taken and careful management of the process.

Minimum safety requirements stipulated by AERB during excavation work are as follows:

i) Means for rapid access and egress should be provided. All trenches 120 cm or more in depth should at all times be supplied with at least one ladder for every 30 m along the trench. Ladder should be extended from bottom of the trench to at least 1 m above the surface of the ground.

ii) Workers should not be exposed to dangers of being buried by excavated material or collapse of shoring. Measures to prevent dislodgment of loose or unstable earth,

rock or other material from falling into the excavation by proper shoring should be ensured.

iii) Measures should be taken to prevent persons who are not engaged in excavation work, from approaching excavation areas by placing warning signals, barricades etc. near the site of the excavation.

iv) Excavated material should not be dumped within 1.5 m of the edges or half of the depth of the trench whichever is more.

v) Excavated area should have illumination level of at least 20 lux for night work.

5.2.1 Trench

The hazards associated with trench work are collapsing of the sides / caving in and burying/ partially burying those in the trench. Trench provides confined space to work & collapse occurs quickly without warning. The probability of locating & rescuing a person in time is very low which increases the severity of the hazard. Main hazards associated with trench work are:

i) Collapse of the sides;
ii) Worker being struck by falling materials;
iii) People falling into the trench;
iv) Unsafe means of access;
v) Vehicles falling into the trench;
vi) Workers being electrocuted.

Important Control measures required to prevent the above hazards are:

i) Underground utilities (such as water pipelines, sewers, gas mains, electrical conduit system) should be located and protected, wherever necessary, before the start of excavation.

ii) Material should not be kept near the trench.

iii) Shoring (supporting the sides of the trench) and/or proper slopes to the trench walls should be provided.

iv) During shoring all loose rocks/boulders to be either secured properly or removed permanently.

v) Trench sides in the work should be thoroughly inspected before start of work.

vi) Ladder access at suitable intervals with proper support in the trench should be provided and ladder should extend above the ground level.

vii) Dewatering provisions should be considered while excavating a trench near a water body.

viii) Temporary electrical connections provided in the trench area should be in compliance to the requirements of the Indian Electricity Act, Rules and Regulations.

ix) Suitable and safe access such as ramp should be provided for material transportation by vehicles.

x) Vehicles should be prevented from approaching too close to the edge of the trench by providing suitable stop blocks.

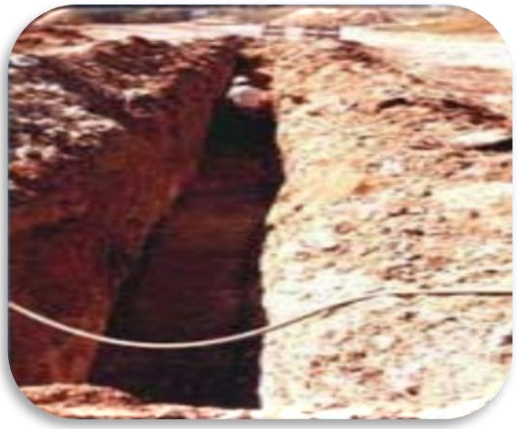
xi) Proper barricading of trenches with warning signals should be provided.

xii) At all approaches and exits of the sites of excavations, danger and warning signals should be placed. In busy or otherwise risky locations a flagman with a red flag should be posted to warn the workers and the approaching vehicles and guide them in proper direction.

xiii) Excavation area should be adequately lighted for night work.

xiv) During night, a red danger light should be displayed at a conspicuous place near the excavation site to warn approaching traffic and men.

Trench with proper shoring and access



Trench without shoring and access

5.2.2 Shaft

Hazards mentioned for trench work are also applicable to the work related to shafts along with one additional & potential hazard called “Dangerous Working Atmosphere”. Dangerous atmosphere may result from lack of oxygen, increase in carbon dioxide level (number of persons working for a long time), Carbon Monoxide level (use of

Petrol/Diesel/Kerosene operated machines) which can lead to serious accidents. Important control measures to prevent the hazard are**:**

i) Test for oxygen level inside the shaft before start of work every day.

ii) In case of fuel operated machines, frequent monitoring of the air along with a proper ventilation system for the shaft should be ensured to provide a healthy working atmosphere.

iii) Effective communication system between the ground staff & the persons working in the shaft should always be there to ensure safe working environment.

5.2.3 Disposal of soil

The disposal of soil involves the removal and transportation of excavated material with use of heavy equipment and vehicles from current location to a permitted off-site location or disposal facility. The main hazards to be considered include crushing and striking hazards posed by mechanized equipment and dumpers, tripping of materials etc. Managing traffic with the heavy vehicle movement is another aspect that needs to be looked into.

Important safety precautions to be followed for disposal of soil are:

i) The excavated material should be dumped sufficiently away from the edge of the excavated pit to avoid the excavated material slipping and falling into the pit.

ii) As far as practical, earth should be removed mechanically from an earth mound/excavated heap. Wherever manual removal of earth is involved, earth should be removed from the top by maintaining a slope equal to the angle of re-pose of the earth.

iii) When excavated rocks, soil etc. are being filled into tippers, trucks etc., the drivers of such vehicles should come out of the driver’s cabin and stay away at a safe distance.

iv) Areas should be earmarked for dumping the excavated material away from the location of excavation pits. Adequate illumination should be provided at the dumping locations for vehicular movement.

v) Dumping of excavated soil should be done under proper supervision. Authorized signalman should guide the drivers of tippers, trucks etc. during the loading/unloading operation.

vi) At all approaches and exits of the sites of excavations, danger and warning signals should be placed. A flag man with a red flag should be posted to warn the workers and the approaching vehicles and to guide them in proper direction.

5.3 Work at Height

Majority of the accidents at construction sites are related to fall of persons working at a higher elevation.

5.3.1 Scaffold

The most common way of providing a platform to work at height is scaffold. Potential hazards associated with the scaffolding works are:

i) **Fall of person**: Persons working on a platform at a height may fall and get serious injury.

ii) **Fall of materials:** Materials/tools may slip & fall from working platform & can injure persons working below.

iii) **Scaffold collapse:** This is one of the potential hazards associated with work at height, which can result in multiple casualties.

Important measures to be taken to prevent the above hazards are:

i) Guard rails should be fitted to the working platform and should be secured to prevent their outward movement.

ii) The platform should be strong enough to bear the loads of workmen & materials.

iii) The ground should be checked for firmness & if necessary base plates should be used for support.

iv) Toe board should be fitted on the working platform to arrest fall of materials /tools.

v) Frequently used tools should be tied to the worker else kept inside a covered & secured toolbox on the platform.

vi) Persons should not be allowed to work under the scaffold and if at all it is necessary to carry out work, then safety net should be provided to arrest the fall of materials & tools.

vii) Experienced & skilled persons should erect scaffold.

viii) Scaffold should be secured to the permanent structure at sufficient points to avoid movements.

ix) Scaffold should not be over loaded with excess manpower or materials.

x) Movement of cranes, vehicles & heavy equipment near the scaffold structure should not be allowed without supervision.

iv) Care should be taken to prevent accidental approach of working platform to live electric overhead line.

xi) Experienced workers should carry out dismantling of scaffold as per procedures and sequence of operation.

xii) All persons while working at height should use personal protective equipment like safety belt with full body harness, helmet etc.

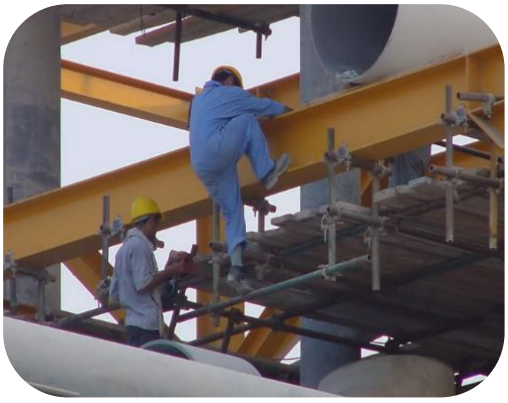
xiii) Working platform should be free from unnecessary materials.

xiv) The quality check/examinations for the condition of members of scaffolding, tie rods, bolts etc. should be carried out and the scaffolding should be certified for safe use.

xv) Width of the platform should be sufficient (about 1 m) enough to accommodate the personnel and material required for the specific job.

xvi) The platform/walkways should not have any openings/gaps.

xvii) A system of issuing height passes to persons deployed to work at height should be followed in construction sites. The height pass should be issued after conducting medical examination of persons and rig walk test to ensure the physical fitness to work at height. Only medically fit persons should be allowed to work at height.



Non-availability of access to higher elevation, compel workers to use wrong practices

Wide and secured platform while working at height along with proper PPEs ensures safe working condition

5.3.2 H-Form Work

The H-Form work is a mould used to shape the concrete and support the concrete until it attains sufficient strength. It is an engineered system used for concreting works. The hazards associated with this system are falling of members, fall of persons from the platform, etc. A typical H-Form used for wall concreting is shown in the photograph. The hazards are mainly associated during shuttering and de-shuttering operations. Accidents leading to death are mainly caused due to improper usage, lack of quality assurance, use of non-standard components, etc.

H-Form work shuttering on the wall

Measures to be taken to avoid accidents during usage of H-Form work are as follows:

i) Strength and stability should be assessed before taking up any modification works of the H-Form work.

ii) Shuttering/De-shuttering procedures should be clearly laid out. Check lists should be used to comply with the procedures.

iii) Quality assurance programmes for non-standard components should be in place.

iv) Mock-up exercises should be carried out before actually installing at work spot.

v) Persons using the H-Form work should be fully aware of safety provisions.

vi) The shuttering/de-shuttering works should be carried out under strict supervision.

vii) Proper lifting machinery should be used.

viii) Complete assembly of the H-forms should be done on ground where after it should be lifted as a single unit by crane and fixed firmly at the concreting location. Reverse of this procedure is to be followed for de-shuttering.

5.3.3 Ladder

Access to different elevations, scaffold platform is provided by ladders and also the same is used as a working platform for some kind of work. Main hazards associated with the use of ladder are:

i) **Slip of ladder:** This is the most common form of hazard associated with the ladder as it may slip while the person is climbing on it or working from it at a height.

ii) **Fall of person:** A person may fall while climbing on the ladder due to loss of balance while carrying materials or due to missing a rung in the ladder.

iii) **Ladder Collapse:** The ladder may give away under the load of the person resulting in severe injuries.

iv) **Electrocution:** The metallic ladder may come in contact with live electrical lines and the person working on it may get electrocution.

Important measures to be taken to prevent the above hazards are:

i) Every ladder should be of good construction, sound material and of adequate strength for the purpose for which it is used.

ii) The ladder should stand evenly on its stiles on a firm and level surface.

iii) Ladder should be securely tied near its upper end and its lower end to the permanent structure when used for access to platforms.

iv) Ladders leading to landings or walkways should be extended at least 1 m above the top landing.

v) Ladder should be placed approximately at an angle of 75^0 to the horizontal when it is used for access as well as working platform.

vi) Ladders with missing/defective rungs should not be used.

vii) Two ladders should not be joined to carry out work at a height.

viii) Ladders should be inspected thoroughly for any defects before start of work and on regular intervals.

ix) Use of metallic ladders or wooden ladders with metallic parts should be prohibited in the areas where live electric lines are available.

x) Rungs & footwear of persons should be free from slippery materials such as oil/mud to avoid slipping from the ladder.

xi) Make shift ladders should not be used.

xii) Persons should face the ladder while climbing up or getting down.

A Ladder for access to height with secure working platform

Improper placement of ladder on uneven surface

5.4 Erection of Structures

The most serious accidents that occur during erection work of structures are due to fall of workers from the structures, fall of materials from structures on persons working below and collapse of the structure or a part of the structure.

Important measures to be taken to prevent the above hazards are:

i) Safe access should be provided to the structures under erection.

ii) Properly inclined ladders secured at the top and bottom should be used for vertical movements.

iii) A suitable working platform with guard rails & toe guards should be provided.

iv) If work is to be carried out for a short time and where working platform is not feasible, then the workmen should use safety belts secured to a permanent member of the structure to prevent fall. Where a rigid member is not available for securing the safety belt hook, proper lifelines should be provided for the purpose, with the lifelines firmly attached to nearby strong structures.

v) Frequently used tools should be tied to the worker else kept inside a covered & secured toolbox on the platform.

vi) Working under the structure should be prevented and if at all it is necessary to carry out work, then safety net should be used to arrest the fall of materials & tools.

vii) Structures/ platforms should not have openings uncovered/unbarricaded.

Minimum safety precautions for working at height as stipulated by AERB in its notification should be followed during erection of structures.

Erection of Structure

Safe work practice for erection of structure

5.5 Concrete Batching Plant

Concrete Batching Plant

A concrete batching plant is a combination of equipment that combines various ingredients to form concrete. Some of these inputs include water, air, admixtures, sand, aggregate (rocks, gravel, etc.), fly ash, silica fume, slag and cement. A concrete plant can have a variety of parts and accessories, including mixers (either tilted drum or horizontal or in some cases both), cement batchers, aggregate batchers, conveyors, aggregate bins, cement bins, chillers, cement silos, batch plant controls, dust collectors etc. The main hazards are exposure to cement dust, wet concrete, ammonia, silica, high noise and unguarded rotating/moving machineries (like conveyors) etc.

Important safety precautions to be taken while working in concrete batching plant are as below:

i) In order to avoid the workers from being in contact with the moving parts of machinery such as conveyors, screens etc. machine guarding should be provided.

ii) Health hazard from cement dust or wet cement should be controlled by avoiding engagement of workers in dusty areas and ensuring usage of PPEs especially filter respirators, goggles, gloves and boots.

iii) Exposure to silica during chipping, drilling and sawing of concrete materials should be reduced with engineering controls such as wet methods and local exhaust ventilation.

iv) When workmen are working/cleaning the inside of the drum of mixer, the power of mixer should be switched off and "Do not operate" tag should be provided.

v) Safety precautions required for confined space working should be followed when cleaning and working in mixer drums, hoppers etc.

vi) Safety/warning sign boards should be made available to prevent persons approaching operating crushers/belt conveyors etc.

vii) Do's and don'ts while handling refrigerants like ammonia and admixtures used in concrete mixing should be displayed promptly.

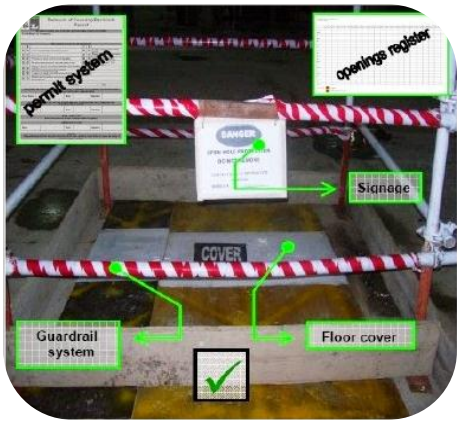
viii) Emergency procedures during ammonia leaks, fires etc. should be made available.

5.6 Unguarded Opening

Openings are needed to be kept in the constructed floor of the building for material movement or equipment erection. If these openings are not covered/barricaded properly, man or material may fall through these. Thus either the man falling through the opening gets serious injury or any person working below the opening gets injury due to fall of material through the opening.

To prevent fall of person or material through opening, every opening in the floor of a building should be provided with suitable fencing/railing of 1 meter height on all exposed sides with toe guard of 15 cm vertical height. Where barricades cannot be installed, safety net should be installed close to the level at which there is a danger of a fall.

Unguarded Opening



Guarded Opening

5.7 Use of Material Handling Equipment

During construction, large numbers of material handling equipment like cranes, chain pulley blocks, hoists, lifts and other lifting accessories are used for transferring/lifting of different construction materials, heavy structures etc. Various types of hazards such as crush injury due to fall of material, caught in-between moving part of crane, collapse of crane, overturning of crane are associated with these material handling equipment that may cause loss of life and property. To prevent the hazards associated with the material handling, the following important measures need to be taken

i) No lifting machine, chain, rope or lifting tackle should be taken into use for the first time unless it has been tested and examined by a competent person and a certificate of such a test and examination specifying the safe working load and signed by the person making the test and the examination is kept available for inspection.

ii) Cranes should be operated only by authorised persons who are well trained and experienced.

iii) Regular inspection and maintenance of material handling equipment should be scheduled and carried out. Load testing of crane at specified load should be carried out by Competent Person at least once in twelve months.

iv) Standard signals given by an authorized signalman should be used so that the operator and user are able to synchronise their communication.

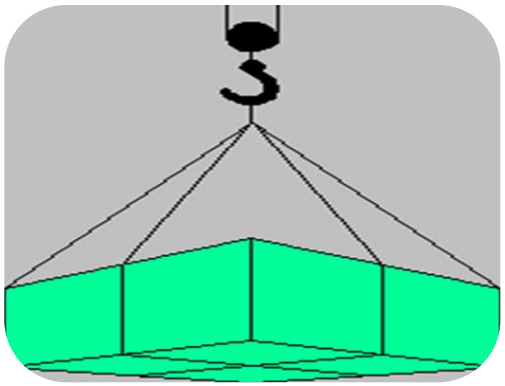
v) Care should be taken to prevent accidental approach to live electric overhead line.

vi) The load to be lifted should not exceed the Safe Working Load (SWL).

vii) The load to be lifted should be secured tightly to prevent falling during lifting.

viii) Material handling operations should be carried out under supervision. Lift area should be cordoned off during the lifting operation. No one should be under/close to any working crane or suspended load.

Insufficient clearance between crane boom and electric line



Secured load lifting by tying at several places of the load

5.8 Temporary Electrical Works

Before commencement of any building or other construction work, adequate measures should be taken to prevent any worker from coming into physical contact with any electrical equipment or apparatus, machines or live electrical circuit which may result in injuries or property damage or both during the course of his employment at a building or other construction work. For safe use of the temporary electrical wiring, the following important measures need to be taken:

i) Frayed and/or bare wires should not be used for temporary electrical connections during construction. All temporary wiring should be installed and supervised by a competent electrician.

ii) Adequate protection should be provided for all electrical wiring laid on floor which may be crossed over by construction machinery or by the workmen.

iii) As far as practicable, no wiring, which may come in contact with water should be left on ground or floor.

iv) The main switch board from which temporary electrical connections are taken for lighting, power operated machinery etc. should made of sound material and to be properly and adequately earthed. They should be located in an easily accessible and prominent place. A fire extinguisher should be provided near the switch board.

v) Suitable warning signs should remain displayed at conspicuous places to alert the workers of the potential dangers and to protect them from the risks of electrical accidents.

vi) Residual current device (RCD) of 30mA rating for human shock prevention should be provided for all temporary electrical installations in addition to other protective devices.

Safe Power Distribution Board

Unsafe Power Distribution Board

5.9 Use of Portable Electrical Equipment

During construction activities, many portable electrical equipment like grinder, drill machine etc. are used. Main hazard associated with the portable electrical equipment are electrocution. For safe use of the portable electrical equipment, the following important measures need to be taken;

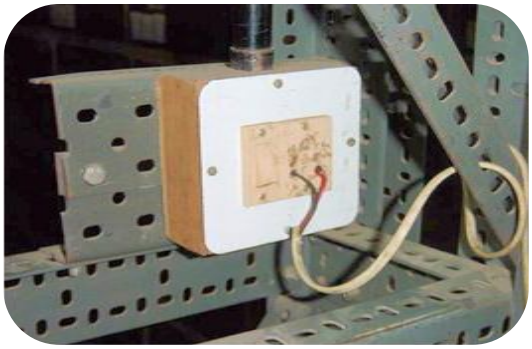
i) All portable appliances, which are powered by single phase AC supply, should be provided with three core double insulated cable and three pin plug top.

ii) All connections to portable equipment or machines from the panel/distribution board/extension board should be taken using 3 core double insulated PVC flexible copper wire in one length.

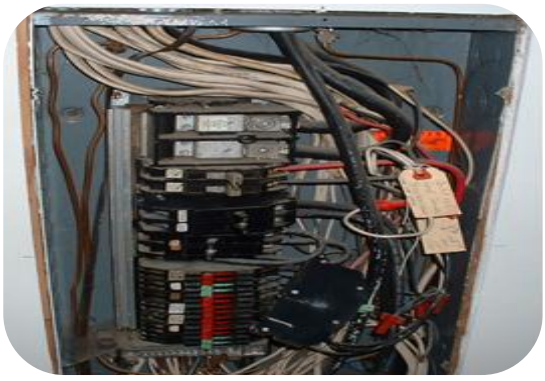
iii) Earth Leakage Circuit Breakers (ELCB) should be provided on the distribution board.

iv) The condition of equipment should be checked before its use.

v) Special care should be taken during monsoon to avoid accidents.



Wrong practice of using only two live wire connections and ignoring the earthing point, for the electrically operated machines. This increases electrocution hazard.



A clumsy arrangement of cables for electrical connection of equipment, which increases fire hazard.

5.10 Working in Confined Space

During construction, different works are required to be carried out inside the confined spaces like boiler, pipeline, pit, reactor or process vessel, storage tank etc. Conditions like oxygen deficiency, toxic atmospheres, high temperatures etc. may occur inside the confined space with limiting access/egress path and these conditions may lead to serious health hazard to the people working inside the confined spaces.

Important safety requirements for working in confined space are:

i) No person should be allowed to enter in any confined space until measures are taken to remove any gas, fume, vapour or dust, which may be present, below its permissible limit and to prevent any ingress of such gas, fume, vapour or dust and the same is certified by a competent person.

ii) The oxygen content inside the confined space should also be measured and arrangement should be made for forced air supply inside the confined space to protect the health and safety of workers while working there. The test should be carried out as often as in necessary during the course of work to ensure its continued safety.

iii) In case absence of adequate mechanical ventilation, the person while entering the confined space should wear Self Contained Breathing Apparatus (SCBA) set, if hazardous substance is likely to be present or oxygen deficiency is likely to occur during the course of work.

iv) No portable electric light above 24V should be used.

v) If any inflammable gas, fume or dust is likely to be present, only light of flameproof construction should be used.

vi) All workers required to enter into confined spaces should be instructed about the hazards involved, the necessary precautions to be taken, and the use of protective and emergency equipment.

vii) Workers entering a confined space must wear a chest or full body harness with a retrieval line attached to the center of their backs near shoulder level or above their heads. The other end of the retrieval line should be held by a rescue person outside or attached to a mechanical device outside the confined space. No single person should be allowed to enter into the confined space. Buddy system should be followed for working inside confined space. Persons entering inside the confined space should work as a team of two. Backup persons should also be available outside to assist whenever required including arrangements for resurrection and first aid.

viii) Means of communication should be made available and well established between personnel inside the confined space and those outside.

ix) Permit to work system addressing the above aspects and other hazards should be followed to regulate the entry or work inside the confined spaces. The work should be supervised by a responsible and knowledgeable person.

Confined space with safe arrangement for access and egress

Confined space inside equipment

5.11 Welding & Gas Cutting

Cutting and welding operations (commonly referred to as hot work) are widely performed during construction activities. Potential health hazard, and property loss result from the fumes, gases, spark, hot metal and radiant energy produced during hot work. Hot work equipment, which utilizes electricity or compressed gases, requires special awareness and training on the part of the worker to be used safely. Welding and Cutting operations present a variety of hazards, not only to those carrying out the operation but in many instances to others in the vicinity. The hazards associated with hot work can be reduced through the implementation of effective control programs. Cutting and welding job should be controlled by permit to work system. The possibility of electric shock is one of the most serious risks encountered by a welder. Accidental contact with the 'live' electrical components, including the electrode and the work piece, can result in serious burn injury or more seriously electric shock. Electric shock can kill either by direct action on the body or by resultant fall, if working at height.

Important Safety Measures during Gas Cutting:

i) The gas cylinders should be kept well away from any fire or hot areas. The rubber hoses, joints, gas torches, valve connections should be checked for leakage of gas.

ii) Gas cutting operations should be done by qualified and authorized persons only.

iii) The gas cutter should use personal protective equipment like goggles, hand gloves, safety shoes etc.

iv) Proper routing of rubber hose should be done before the start of the work to avoid damage to other personnel/equipment movements. The rubber hose should not come in contact with any hot material and it should not be taken through hot areas.

v) Gas cutting on drums, barrels, tanks or other containers should be taken up only after ascertaining that they have been emptied, cleaned thoroughly and made free of flammable material.

vi) A non-return valve at each gas inlet into the mixing zone (blow pipe) should be provided to prevent back feeding of oxygen to the fuel gas line and vice versa. Flashback arrester/flame arrester should be provided with gas flow regulator to prevent propagation of flame from the mixing zone (blow pipe) to the gas cylinders (through rubber hose pipes).

vii) Before starting any gas cutting, a written permit clearance should be obtained indicating special precautions including firefighting details.

Important Safety Measures during Arc Welding:

i) Correct and proper electric earthing should be done for the welding machine, the casing and the job to be welded. An authorized and trained electrician should check all connections. Only qualified and authorized welders should be engaged for welding.

ii) The welding cable should be in good condition without any insulation damage. The welding cable connections should be tight. The cable should not be laid on wet surface.

iii) All welding work should be started only after obtaining welding permit from authorized agency indicating special precautions including the availability of firefighting measures near the job.

iv) During carrying out welding, welder should use personal protective equipment like welding screen, hand gloves etc.

v) If welding work is to be carried out at a height, then necessary arrangements should be in place to prevent sparks dropping down below.

vi) For welding in confined areas like inside of tanks, pipes etc., proper ventilation should be provided along with other precautions required for safe working in confined space.

vii) For welding work on overhead equipment such as crane etc. a separate earth cable should run up to the work place and should be connected to work place.

Gas Cylinders not properly placed & worker without proper PPE

Gas Cylinder properly placed & worker with proper PPE

5.12 Work in and around water bodies

Work in and around water bodies may be required to carry out for making provisions related to water intake to the facility and /or for making provisions for final discharge from the facility. In this practice, drowning of workmen is the potential hazard which needs to be addressed.

Important safety precautions to be taken while carrying out work in and around water bodies are as below:

i) All necessary rescue equipment such as life buoys and life jackets should be provided and kept available for use at any time.

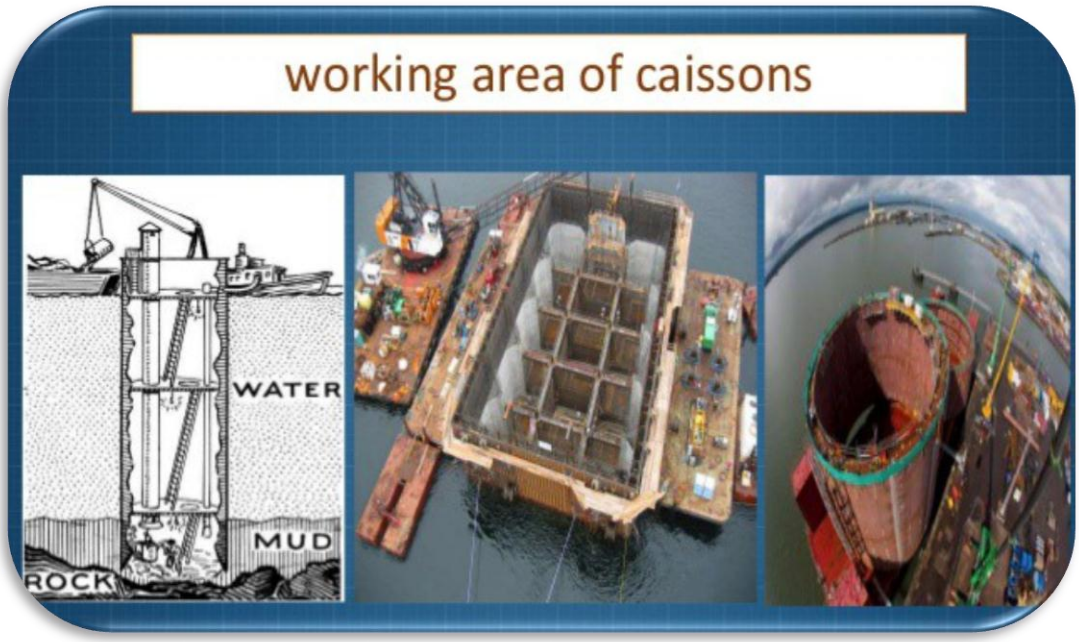
ii) All necessary steps should be taken for prompt rescue of any person in danger and adequate provision should be made for prompt first-aid treatment of all injuries likely to be come across during the course of work.

iii) Proper record of entry/exit to and from water bodies should be maintained on shift basis and search operation should be conducted as soon as any person is detected as missing.

iv) For Caisson Work;

a) Safe means of access should be provided to the place of work in the caisson and adequate means should be provided to safely reach the top of caisson in the event of inrush of water.

b) The work relating to construction, positioning, modification or dismantling of caisson should be done under the supervision of a responsible person.



Caisson work areas

6.0 Personal Protective Equipment (PPE)

The primary approach should be to prevent a hazard to the workmen. Wearing of personal protective equipment play an important role in reducing the effects of accidents at site. It should be the last line of defence when engineering controls are not further possible. In the construction work, the basic requirements for the protection of the workers are safety helmet, safety shoes and other protective equipment depending upon the nature of work. The selection of the right protective equipment as per national/international standards and right usage reduces consequences of accidents.

6.1 Principles of PPE

6.1.1 The quality of personal protective equipment should ensure absolute and full protection from the possible hazard and it should be designed in such a way and out of such a material that it can withstand the hazard against which it is intended to be used.

6.1.2 The selection of right type of PPE requires consideration of the following:

- Nature and severity of the hazard.
- Type of containment, its concentration etc. for respiratory protection.
- Expected activity of the workman and duration of work.
- Comfort in using PPE.
- Ease of maintenance.
- Conformity to National /International Standards etc.

6.1.3 Enforce the usage of PPE by workman through proper training and awareness programmes.

The AERB Safety Guidelines for Personal Protective Equipment should be referred for further information.

7.0 Suggestions for improvement in Accident Prevention Programme

Safety Work Cycle of three frequencies-daily, weekly & monthly consisting of following features are suggested to be followed at construction sites:

- Morning safety meeting.
- Inspection prior to start of work.
- Patrolling by line management & higher management
- Guidance and supervision during work.
- Safety process discussions.
- After-work site clean-up.
- Daily End of Work check-up analysis of any unusual occurrences.
- Planning for next day's jobs and review of adequate safety measures.

8.0 Case Studies of Accidents

Case Study-1: ***Accident due to Caught Between Objects***

Brief Description:
During the cleaning of the belt at the tail pulley area of conveyor of sand screening section of batching plant, one worker was trapped between the tail end pulley belt roller and ground. The trapped person sustained multiple injuries.

Probable Cause of the Accident:
There was no arrangement to prevent unauthorised access to the tail end pulley of the belt conveyor. The space available for working in that area was congested. The deceased person tried to clean the belt at the tail pulley end while it was in motion. In this process, his right hand got trapped/caught in between the belt and the ground. He was dragged under the roller and the belt end where he got entangled.

Lessons learnt to prevent such accident:
- Belt guard with locking arrangement should be provided to prevent unauthorised access.
- Loose cloths should not be worn during working in conveyor.

Case Study-2: ***Accident due to electrocution***

Brief Description:
Workers were working in the cable tunnel for job related to lighting system of the tunnel. One of the workers was assigned the work of termination of lighting cable in the emergency lighting junction box, which was in charged condition. As the junction box was located at a higher elevation from the floor and due to non-availability of safe access, the worker over-reached the JB by stepping on the lower cable tray. He lost the balance and got in touch with live core of cable leading to electrocution.

Probable Cause of the accident:
Contractor had mobilized the manpower without following the standard work procedure for working on an electrical system viz. isolating an energized circuit and obtaining work permit. Worker had been given authorization as an Assistant Electrician by the contractor based upon oral examination and no on-job training and field check list was undergone by him for carrying out jobs on electrical systems. Significant time was lost in shifting the worker from the tunnel as the layout of the tunnel was very congested and no communication system was available inside the tunnel.

Lessons learnt to prevent such accident:
- Work Permit system for working on charged electrical system.
- Authorized/licensed electricians to work on charged systems.
- Communication system to be always available near the working areas.

Case Study-3: ***Accident due to Failure of Chain Pulley Block***

Brief Description
During lifting of a pipe spool of 20 inches in diameter and weighing about 260 kgs by a chain pulley block of capacity 2 ton, the load hook of the chain pulley block suddenly got detached from the swiveling block. The pipe spool fell down and the elbow of the pipe spool hit the rigger.

Probable Cause of the accident:
As per the Operating and Maintenance manual of the Chain Pulley Block, the bottom block with swivel consists of 14 nos of 5 mm (5D) balls which holds the hook in position for lifting or lowering the load and swiveling of the hook. 5D balls are kept in position by a grub screw. For the affected chain pulley block, the grub screw was missing and instead of 14 balls only one ball was present. There was no punch mark on the head of the grub screw to prevent its slippage. The cause of the detachment of the hook was due to missing of the balls from the swiveling blocks and subsequent to the missing of the grub screw.

Lessons learnt to prevent such accident:
- Checklist for inspection of chain pulley block should be made incorporating all critical parameters like availability of grub screw, punching marks etc.

- Person should not stand below the hanging load or come close to it.

Case Study-4: ***Accident due to fall of an object***

Brief Description:
A bundle of reinforcement rods weighing about 205 kg were being lowered to ground (Elevation 12000 mm) by Tower Crane. A Fitter was in that location for unloading the bundle from the crane. During the lowering process, an ISMB 100 beam, about 2 metre long, weighing abut 23 kg, that was kept on two climbing brackets at the Elevation 20400 mm level, was dislodged by the hook block of the Tower Crane. It fell on the fitter, causing injury on right forehead.

Probable Cause of the accident:
The ISMB 100 beam, length of about 2 metres and weighing about 23 kg was kept on two climbing brackets that were about 1.5 metres apart at EL 20400, on the outer wall of vault. The beam was to be used for fixing the supports for the shuttering to be done at higher elevation for concreting. The beam was at a height of about 8.4 m above the working floor. The beam was tied by coir ropes at both ends with the climbing brackets. It was not positively fixed by fasteners to the climbing brackets. When the material was lowered by Tower Crane, the hook came down and the load swinged due to rotary movement of the crane boom as well due to lowering operation. At that time, swinging load might have come in contact with the two climbing brackets and ISMB 100 resting on them and dislodged the beam to fall down and cause injury to the fitter.

Lessons learnt to prevent such accident:
- All structural members should be rigidly fixed at all levels to prevent their fall.
- For safe movement of material through tower crane from one place to another, signalman should be placed in such a location that he should be able to visualize the whole area and operation clearly.

Case Study –5: ***Accident due to fall through an opening***

Brief Description:
One worker fell from El 108 m to El 100 m through a hatch block opening of length 2.2 m x width 0.5 m.

Probable Cause of the accident:
The hatch block opening was covered by one old 12 mm thickness plywood sheet of length 2.4 m x width 0.4 m. Below the plywood 4 nos. of 10 mm rods were kept loosely. When the worker kept his feet on the plywood, due to his weight, plywood sheared and he fell down through the opening. The opening was not barricaded by any guardrail, which could have prevented the fall of the victim. Also multiple agencies were using that opening for material lifting and lack of communication was there among the contractors.

Lessons learnt to prevent such accident:

- Every opening in the floor of a building, or in a working platform should be provided with suitable means to prevent fall of persons or materials by suitable fencing/railing of at least 1 metre height.
- No plywood or wooden plank should be used for covering any opening.

Case Study –6: ***Accident due to fall from height***

Brief Description:

Erection of pre-fabricated MS/SS panels above the 4 m height CS structure was being carried out. Panels were placed over the welded cross-beams. Worker was performing the welding work of the cross-beams by sitting on the partly erected panels. While working in such unsafe position, he lost balance and fell through a height of 4 m. His head got struck with a metallic plate lying on the floor just below the work area. He suffered serious head injuries.

Probable Cause of the accident:

Work area was not provided with safety measures needed for working at height (scaffold, anchoring point for safety belt etc.). Worker was not wearing the safety helmet at the time of accident. Metallic plate lying on the floor was used by some other contractor and the same was not removed from the location after completion of their work. The identification of special safety requirements during the work of multiple agencies at the same work location were not identified.

Lessons learnt to prevent such accident:

- No work at height should be carried out without permit to work at height. All safety measures required for work at height should be in place before approving the work permit.
- Area below the assigned place of work should be made clear of all unwanted materials.

9.0 Conclusion

This monograph is revised based on the experience gained through inspection and safety regulation of different construction facilities by AERB in accordance with the Factories Act & Rules and the continual development of construction technologies. The available literature on construction safety was reviewed and relevant information was provided. Hazards associated with different construction related activities where rate of fatality/injury is high like excavation, work at height, working in confined space, use of material handling equipment, temporary electrical works and control measures to avoid the hazards are described briefly in this monograph. Illustrative figures are also presented at appropriate places. New case studies of accidents due to fall from height and electrocution along with the lessons learnt from the accident are also added to create awareness to prevent recurrence of such accidents. It should, however, be noted that the information provided in this monograph is very brief and it is essential that details are checked from

AERB documents, relevant reference books, Indian Standards, manuals etc. for comprehensive safety management of construction work sites.

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- ***The Building and Other Construction Workers' Central Rules, 1998***
- ***Various AERB Notifications concerning construction safety***
- ***Relevant AERB Guidelines on construction safety***
- ***Relevant Indian Standards on Construction Safety***