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SAFETY ACPECTS IN CONSTRUCTION

[1]Harishanker Sai Painkera,[2]Chitranjan Kumar,

[1]M Tech Scholar , [2]Assistant Proffesor,

[1]Department of Civil Engineering,

[1]Lingaya's University Faridabad, India

Abstract: The construction industry is the second largest industry after agriculture. Financial development of any nation and at the same time globally it is known fact that it is the most hazardous industry, due to its nature and various types of activities of work carried out during the course of construction. It is labour intensive and requires vigorous movement of resources like men, material and machinery within a confined space, leading to high level of accidental risks for the workforce at the site. The present poor scenario and past records of safety measures within the construction industry are leading to a high rate of accident. The primary source of these accidents prevails in the private sector in the construction industry. This paper aims to illustrate the safety performance of low and medium size projects in private sectors in general through observation. Our study focuses on general safety aspects related to construction sites like worker personal protective equipment (PPE's), machinery, excavation, height and fall protection. The findings globally suggest that there is a serious need for improvement of safety of labours in the construction industry.

I. INTRODUCTION

Construction industry being an unorganized sector imparts high risk to the workers associated with construction activities. Construction workers are exposed to a variety of hazards exists due to ever-changing locations and work environment. In spite of a lot of technological development and substantial improvement in construction safety throughout the years, the rate of accidents is still highest in the construction industry. Globally, past studies confirm that injury rates (Fatal, major and minor) are recorded highest in the construction industry compared to other industries. The most common factor that leads to death or injuries in the construction sector are: electric shock, height fall, trench collapse, equipment breakdowns (crane, shovel).

As a construction worker comes from rural areas they do not have proper training and educational background in construction safety. These workers during the course of construction are exposed to different risks involves with construction works and other occupational diseases, resulting in the delay of construction projects completion time due to legal hassles and loss in working hours. Therefore, in order to minimize the losses in terms of time and cost it should be made essential for any construction projects to have certain minimum guidelines and procedures, safety things to be followed for site activities and create awareness among workforce right from engineers, supervisors, foremen, skilled labours and unskilled labours.

1.2 AIM

- To study the current conditions of labour safety.
- The acts, rules and regulations for labour safety.
- Minding and following the rules and regulations.
- Check effectiveness of rules followed, and severity of rules ignored.

1.3 OBJECTIVE

- To discuss issues regarding labour safety.
- Study of various laws and legal provisions related to labour safety and give acomparison with respect to different contract document.
- To develop safety measures taken for each individual activity at different constructionstages.
- To provide best safety management system and monitoring process for site safety.
- To identify various socio-culture issues in safety.
- To see the use of BIM softwares and trying to contribute towards safety management.
- To add pre-fabrication as a method of construction to lower risks during large scale ormass fabrication.
- Skilled labour benefits over unskilled labour.

1.4 SCOPE

- Study of safety issues in building construction.
- Study of legal aspects related to safety management.
- Monitoring of safety management.
- Checking measures to create awareness among people of all levels involved inconstruction.
- Analyzing techniques to ensure safety at all levels.
- Greatly involving the use of BIM software's to identify future shortcomings.

I. RESEARCH METHODOLOGY

- Introduction.
  - Formulation of Aim and Objectives
- Literature Study.
  - Introduction
  - Published Books And Journals
  - Codes, Procedures And Standards
  - Key Features
- Case Study.
  - Labour Issues.
  - Legal Provisions.
  - Safety Management Systems.
  - Attitude Issues.

- Checklist for Site Safety.
- Directing, Educating, Implementing.
- Recommendations
- Conclusion

1.6 NEED FOR STUDY

- In a construction project the major aim is to complete the construction within given time and to achieve this the basic requirement is to check and leave no scope for delay by avoidable accidents of any kind.
- Labour and all other personnel at site must be safe at all times because this reason can solely become a major factor for delay of the project.
- Investing time in safety saves us the time and money we could lose in case of an accident.

LITERATURE REVIEW

The literature review aims at exploring the contents of various literatures that as a whole or part thereof will become subjects of help in the process of completion of the discussion. It identifies such areas of study which are essential for developing knowledge area in this field. It identifies books, journals published and unpublished thesis and dissertations related to the subject of safety and health in construction industry.

2.2 PUBLISHED BOOKS AND JOURNALS

INTRODUCTION TO HEALTH AND SAFETY [3]

AUTHOR: PHIL HUGHES and ED FERRETYEAR: 2007

PUBLISHER: BUTTERWORTH-HEINEMANN

The book gives complete knowledge of the health and safety management measures and different process required in the construction industry to avoid the accidents at the sites. The book was to produce a text book that mirrored the construction certificate syllabus in its revised unitized form and in single volume to the required breadth and depth, the syllabus, which follows the general pattern for safety management set by safety departments.

The book describes health and safety foundations on which appropriate safety systems may be built.

It gives a clear policy for the management of health and safety so that associated with the organization is aware of its safety aims and objectives. For a policy to be effective, it must be honored in Great Spirit.

The book tells about managers in construction organizations, setting out clear responsibilities and lines of communication factor for everyone involved in the project. The chapter also covers legal responsibilities that exist between duty holders under the CDM regulations; between people who control premises and those who use them; between contractors and those who hire them; and the duties of suppliers, manufacturers and designers of articles and substances for use at work.

There is concern among some safety professionals that many safety cultures are developed and driven by senior managers with very little input from workforce. Others argue that this safety management is sensible because the legal duties are placed on the employer. A positive safety investment is sensible because the legal duties are placed on the employer. A positive safety culture needs the involvement of the whole workforce just as a successful quality system does.

Risk assessment methods are described to decide on priorities and to sort objectives for eliminating hazards and reducing risks.

It also concerns the principles that should be adopted when deciding on suitable measures to eliminate or control both injurious and fatal safety risks at work on construction sites.

Also deal with the main hazards likely to be found on a construction site. In addition to these specific hazards, here will be more general hazards (e.g. manual handling, electricity, noise, etc.) which are discussed in more detail inother chapters.

In remaining part of the book all construction procedures and the safety precautions for the different construction activity like excavation is described.

FRAME WORK FOR PROJECT MANAGERS TO MANAGECONSTRUCTION SAFETY [4]

AUTHOR(s): Evelyn Ai Lin Teo, Florence Yean Yng Ling, Adrian FookWengChong

PUBLISHED IN: International Journal of Project ManagementVolume 23, Issue 4, May 2005,

This study proposes Policy, Process, Personnel and Incentive (3P+ I)

Frame work which may help project managers manage construction site safety. A postal survey of contractors in Singapore was conducted to test the framework. It is found that site accidents are more likely to happen when there are inadequate company policies, unsafe practices, and poor attitudes of construction personnel, poor management commitment and insufficient safety knowledge and training of workers. It is recommended that project managers paymore attention to the important factors identified in this study to help them enhance performance at construction sites and reduce the frequency of accidents.

THE ATTITUDE OF CONSTRUCTION WORKERS TOWARD THE IMPLEMENTATION OF OCCUPATIONAL HEALTH AND SAFETY (OHS) [6]

AUTHOR(s): L Widaningsih, I Susanti, and T Chandra PUBLISHED IN: IOP Publishing, ICIEVE 2017

Abstract - Construction industry refers to one of the industries dealing with high accident rate. Besides its outdoor workplace involving many workers who usually work manually, the workers' work culture and less awareness of occupational health and safety (OHS) are attributed to the high accident rate.

This study explores some construction workers who are involved in some construction projects in big cities such as Bandung and Jakarta. The questionnaire-given to the construction workers focusing on stone construction,

Wood Construction and finishing session-reveals that the construction workers knowledge and understanding of nine Occupational Health and Safety (OHS) aspects reach above 50%.

However, does not appear to reflect their knowledge and understanding of Occupational Health and Safety (OHS). The results of Focus Group Discussion (FGD) and an in-depth interview show that the fallacious implementation of Occupational Health and Safety (OHS) is attributed to their traditional "work culture".

KEY FEATURES

BENEFITS OF INVESTING IN SAFETY

Since the 2012 study, results have shown that contractors experience critical benefits fromtheir safety investments. These not only include the core project benefits on

budget, schedule and quality shown in the chart at right, but also business benefits like improved standing in the industry and the ability to contract new work, which are reported bythe majority of contractors participating in the study.

PRACTICES USED TO PROMOTE SAFETY

The chart at lower right shows the policies and organizational practices most commonly usedto promote safety by all contractors. These findings underscore the high deployment of practices pertaining directly to jobsite workers.

When it comes to less commonly used practices and policies to promote safety, including conducting job hazard analysis/job safety analysis before construction start, carrying out prompt and thorough near-miss and incident investigations, having measurable safety goals

And objectives, and prequalifying subcontractors based on safety performance, there is a broad gap between large contractors, especially those with 500 or more employees and small ones, especially those with fewer than 20 employees. In general, that gap exists to a lesser degree in all the practices and policies measured in the study. Since many of these have beendemonstrated to be highly effective practices, this highlights a need in the industry to encourage or incentivize smaller contractors to engage in them.

PREVENTION THROUGH DESIGN

Thoughtful, informed design can improve downstream construction safety, a practice formalized as Prevention through Design (Pt D). As the chart at the upper right reveals, mostof the design and construction industry are not familiar with this specific term. However,

When it is explained to them (see page 18 for the exact definition used in the survey), over half of all architects and about two thirds of contractors believe that they are practicing this atleast to some degree. This suggests that more information to raise awareness in the industry will be useful since it is not likely to require a major transformation in terms of how work is currently done.

- **Architects:** During design, architects tend to consider prefabrication and operational safety more commonly than they are performing reviews for construction safety. Concerns about increased liability are the biggest obstacle raised by them to more actively engage in this activity, and they would be mostly likely to be influenced by owners/clients requesting itand by insurance incentives.

- **Contractors:** Most contractors report using permanent safety features, such as those preventing falls, but less than half use prefabrication/modularization, parapet walls at a proper height above the roof surface or grates at skylights specifically as safety enhancements

Suggesting significant opportunities for further engagement. They are generally more open to engaging in these practices than architects are, with no obstacle considered serious by more than half of them.

TRAINING AND COMMUNICATION

The findings on training remain for the most part consistent with previous studies. Employers who require safety training are still less common than those who merely offer it, pointing to an opportunity in future studies to correlate better outcomes with training requirements.

It is notable that online safety training is currently more widely used by GCs than trade contractors, and that gap is expected to grow in the next two years.

Toolbox talks continue to be the most effective means of communicating with workers about safety, whether as a means to communicate safety messages or to provide information on safer tools, equipment, materials and processes. Training programs are also widely used and considered effective, but other means, including seminars and meetings, emails or videos are infrequently ranked first for effectiveness in these communications.

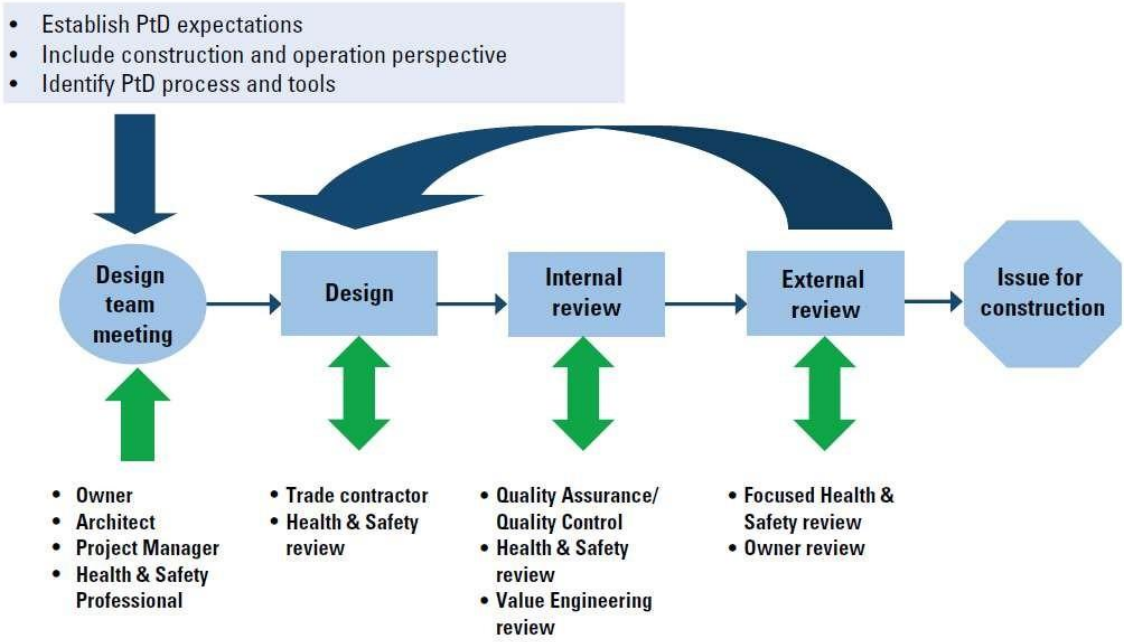
ONLINE/E-LEARNING

More contractors consider online/e-learning to be highly valuable for supervisors (40%) than for jobsite workers (31%), but the gap is notably smaller than for the three previously discussed modes of training.

While the percentage who consider this mode valuable for supervisors has remained relatively consistent since the last study in 2015 (42%), there has been an increase of 7 percentage points in those who consider it valuable for jobsite workers (24% in 2015). This may be a reflection of the broad use of mobile tools onsite (see page 34), and the increasingsophistication of those tools.

There are no significant differences for this mode by type of company, size of company, roleor use of BIM.

PREVENTION THROUGH DESIGN PROCESS



SAFETY ADVANTAGE OF PREFABRICATION

Prefabrication, often chosen for its advantages for schedule, quality control or logistics, is also one of the most effective strategies. Compared to onsite construction, prefabricating building components in a warehouse provides safer conditions through reduced congestion,

Better ergonomic positions, environmentally controlled spaces and reduced scheduledemands.

In a study Mortenson conducted to quantify the costs and benefits of prefabrication on Saint Joseph, the company concluded that the strategy had averted seven safety incidents. “Prefabrication is proven to positively impact safety,” says William Gregor, vice president ofoperations at Mortenson. “Hallways were less crowded; there were fewer lifts on the exterior and interior of the building, and significantly less material, noise and dust.” The estimate of seven safety incidents averted is based on the ratio of total onsite labor hours to total OSHA- defined, onsite safety incidents, says Gregor. This ratio was then applied to the 150,500 labor hours that prefabrication diverted offsite—where zero safety incidents occurred.

The decision to prefabricate occurs early in the design process, usually before design is 30% complete.

This is because prefabrication is most effective when a project comprises multiple repeatable items.

Prefabrication also depends on early integration of the construction perspective into the design process. Saint Joseph’s project delivery method, Construction Manager at Risk, helped with this, enabling early construction advice, accelerating decision-making and facilitating owner-architect-trade coordination.

The building components the project team identified as most conducive to prefabrication included 440 bathroom pods, 250 exterior wall panels, nearly a mile of multi-trade utility racks, and 376 patient-room headwalls. Each prefabrication effort required the design team to integrate constructability considerations, and achieved its safety outcomes in tandem with cost- and schedule-related benefits.

SAFETY ISSUES FOR CONSTRUCTION LABOUR

3.1 INTRODUCTION TO SAFETY SCIENCE

GENERAL DEFINATIONS RELATED TO SAFETY

A. SAFETY: it is the freedom from some conditions that can cause injury or death to personnel or damage to equipment and property or environment.
B. INJURY : A harmful condition sustained by the body as the result of an accident, It can take the form often abrasion, a bruise, laceration, a fracture , foreign objects in body, a puncture wound , a burn or an electric shock.
C. HAZARD: it is an inherent property of a substance or nonoccurrence, which has the potential to cause loss damage or injury to property, person or environment. e.g.: A scaffold without a toe board and guard rail.
D. RISK: it is the probability of the realization of the potential for loss, damageor injury.
E. ACCIDENT: it is an unplanned or unexpected event which cause or likely to cause injury to a person, damage to property or environment.
F. REPORTABLE ACCIDENT: When an employee is absent from work for more than one day as a result of accident is called reportable accidents.
G. SERIOUS ACCIDENT: accident which causes death or serious injury like broken limb, serious burns or hospitalization for one or more nights.
H. INCIDENT / NEAR MISS: It is an undesired event which, under slightly different circumstances, could have resulted in accident.

CAUSES OF ACCIDENTS AND PREVENTIVE MEASURES

Causes of accidents are normally due to the unsafe acts and unsafe conditions. Normally it means that most of the accidents could be avoided at the construction site and for example a percentage is being giving below that the percentage of the unsafe act is much higher and therefore all accident can be avoided by are working processes, after all some accident could not be avoided and that are natural calamities which could take at any place and anyone cannotavoid that.

- 98% of accidents were caused by unsafe actions and unsafe conditions.
- Unsafe acts 78%
- Unsafe conditions – 20%
- Natural calamities – 02%
- All accidents caused by unsafe acts and conditions are preventable.

A. UNSAFE ACTS

Unsafe acts are the mistakes which we can use to do by not following the right procedureslike operation without authority, unsafe act in while we are working at the unsafe conditions, while we using unsafe equipment and not following the safe posture and position, while loading and unloading we should also follow the unsafe loading, placing and mixing. Unsafe acts will also include the working on dangerous equipment.

- Operating without authority.
- Working at unsafe speed
- Making safety devices in operation.
- Use unsafe equipment.
- Unsafe loading, placing and mixing.
- Taking unsafe position or positive.
- Working on dangerous equipment.

B. UNSAFE CONDITIONS

Causes of accidents is also some unsafe conditions which could cause an accidents which are like inadequately guarded machines means machines must be guarded adequately so that there must not be any open space and it should be guarded properly, defective condition of machines could be dangerous and must be mended before it creates any problem, hazardous storing of materials could be dangerous. E.g. If we are putting cementbags in a room so its height must not be as much that if we take a bag from it and while taking a bag from a row if the store get disturb it does not harm the labour, ventilation must be enough for taking breath in a fresh air, dresses which labour will wear at the site should be specific for a specific works like while entering into a cement room one should wear mask so as to avoid the inhalation of harmful cement which can be hazardous.

- Inadequately guarded machines
- Defective condition of machineries
- Hazardous storing of materials
- Unsafe illuminations
- Unsafe ventilation
- Unsafe dresses

C. PREVENTIVE MEASURES

Every site has injury only thing we could do is to give best efforts to minimize the miss happenings by taking preventive measure like by using latest technology, by giving the labours training related to their trade, by enforcement of penalty and give some awards tothose who are following best safety precautions at the site, we could also conduct a training program, for the workers and have an evaluation on safety by having some meetings to check the status of safety in the organization.

- Engineering – use only the latest and uploaded technology
- Education – through job specific training.
- Enforcement – through penalty
- Enthusiasm – through safety awards
- Evaluation – through safety meetings
- Thus 5 E's are the cardinal principles of accident prevention.

ACCIDENT COST ANALYSIS

Indirect costs are 4 times more than direct costs.

If we talk about the costs analysis of the accidents it is like that the indirect costis 4 times more than the direct cost. Direct cost will include the medical treatment cost and compensation paid to the injured person and the insurance premium. But he cost which will be 4 times more than that it is the loss becauseof the delay of project cost of the repairing of material and many cost that come into picture after the accident took place, there will be a loss of the workers will get engaged into the accidents precautions activities.

DIRECT COST

- Compensation paid to injured
- Medical expenses for his treatment.
- Insurance premium

INDIRECT COST

- Lost time of injured employees
- Lost time of other employee
- Lost time of supervisors and engineers
- Residual cost due to loss of production.
- Overhead charges
- Cost of damage to material or equipment
- Cost of learning period of new worker

COLLECTIVE TECHNIQUES TO MOTIVATE WORKERS IN SAFETY

- Conducting tool box meetings
- Conducting safety contests.
- Maintain safety bulletins boards.
- Exhibiting posters.
- Circulation of journals
- Displaying safety signs and slogans.
- Group activities
- Celebrating safety day, etc.

3.2 EXCAVATION SAFTEY

The common hazards in excavation are

- Cave – ins
- Asphyxiation due to lack of oxygen
- Inhalation of toxic materials
- Fire
- Moving machinery near the edge of excavation
- Damage to underground utilities
- Rupture to pipeline and cables
- Dangerous to top adjoining building
- Edge collapse or slide

Falling of personnel or mobbing equipment's, Definitions

EXCAVATION: A man made cut, cavity, trench order oppression formed by earth removal.

TRENCH: A narrow excavation. The depth is greater than the width, but notwider than 15 Feet.

SHIELD: A structure that supports the sides of an excavation and protects against cave-ins.

SLOPING: A technique that employs a specific angle of the incline on the sideof the excavation.

3.3 WORKING AT HEIGHT AND FALL PROTECTION FALL PROTECTION

Fall protection is a concept that includes training, procedures, rules and methods intended to protect workers from fall hazards. Fall protection also includes shared responsibilities among the employer, among the employee, the owner andthe manufacture. Fall prevention and protection are two different terms. Proper fall prevention eliminates a hazardous situation and therefore removes the chance of employee exposure to a fall while fall protection follows recognition that a hazardous condition cannot be fully or adequately eliminated and therefore fall arrest equipment and procedures are needed.

Fall prevention must be initiated in the construction planning phase with a close study of operations and tools having the fall hazard potential. Fall arrest system consists of a fully body harness, shock absorbing lanyard, self-locking snap hooks and adequate anchorage points.

- Falls are the number one cause of fatalities in construction industry.
- Open sided floors are flor openings are the number one cause for falls.
- Falls from as little as 4-6 feet can cause serious injuries or death.
- 40% of fatalities were from heights over 40 feet.
- 25% of fatalities were from heights of 11- 20 feet
- 25% of fatalities were from heights of 20-30 feet.

PHYSICS OF FALL

A body in motion (free fall) can cover vast distance in a short time.Consider this,

- A body in free fall can travel 4 feet in 0.5 sec.
- A body in free fall can travel 16 feet in 1 sec.
- A body in free fall can travel 64 feet in 2 sec.

GUARD RAIL SYSTEM

Guard rail systems are vertical barriers consisting of top rails, mid rails and intermediate vertical members. It can also be combined with toe boards for preventing falling of materials. Guard rail system is commonly using for protecting floor edges and floor openings. The top edge of the guard rail must be39-45 inches above the walking/ working level. There must be also be protectionfrom falling between the top rail and the walking/working level. There must also protection from falling between the top rail and the walking/working surface. Mid-rails, screens, mesh or intermediate vertical members may be used for this protection. There are specific requirements for their installation. The protective barriers must be strong enough to support a falling employee. Wood, chain and wire rope may be used for top rails and mid-rails.

SAFETY NET SYSTEM

Safety net system consists of mesh nets, panels and connecting components. Safety net systems catch the employee if he/she does fall. These nets must be strong enough to support a falling employee. Must have sufficiently small meshopenings so the employee cannot fall through the net; must be close- enough to the edge of the working surface (the outer edge of the net between 8-13 feet from the edge of the walking/ working surface, depending on the distance to the walking/working surface) so that the falling employee will not slip from top.

WARNING LINE SYSTEMS

Warning line systems consist of ropes, wires or chains and supporting stanchions that form a barrier to warm those who approach an unprotected roof side or edge. It can use only low sloped roofs.

FALL RESTRAINT SYSTEM

Fall restraint system consists of an anchor, connector, and body harness or body belt. Unlike personal fall arrests system (designed to stop a fall) the fall-restraintsystem prevents a fall. It must be designed. Installed are used under a qualified supervision.

POSITIONING DEVICE SYSTEMS

Positioning device system enables you to work with both hands free such as well or other vertical structure. Generally used as a protection for concrete form work and rebar placing. It gives support and prevents falls.

COVERS

Covers commonly using for pretention form holes. Covers should be painted inorange so as to get proper identification at night times.

SAFETY MONITORING SYSTEM

A safety monitoring system is a set of procedures assigns to a competent person for monitoring and warning workers who maybe unaware of fall hazards. Safety monitoring systems are appropriate for roofing operations on low slope roofs less than 50 feet wide. This system is used in conjunction with controlled accesszone.

CONTROLLED ACCESS ZONES

Controlled access zones are the areas that a worker can do work under a fall protection plan without conventional fall protection. All others are prohibited toenter this area. The zone is created by erecting a control line or lines to restrict entry to the area. The entry into the controlled access zone is permitted to onlyauthorize persons.

3.4 SCAFFOLD SAFETY

INTRODUCTION

Scaffold is an elevated platform temporarily constructed for supporting men and material at construction site. It should be designed and constructed with sound material and they should with stand at least four times the anticipated weight of men and material which may be placed on them. Good wooden planks without crack or wear should be used to construct scaffold. The width and thickness of the plank should be at least 10 inches and 2 inches respectively. The overhanging of planks beyond the outer supports should not be more than 12 inch and not less than 6 inch. The planks should not have projected nails.

PRECAUTIONS

A. All scaffolds shall be erected and operated under supervision of a competent person. All scaffolding over 6 ft. in height shall have the appropriate guardrails, mid-rails and toe boards. If a person must pass underneath ½ inch wire mesh or equivalent shall extend along the entire opening. Unstable objects must not be used to support, without failure, atleast four times he maximum intended load.
B. Painter or baker scaffolds (4ft in height and less than 45 inches wide) shall have guardrails installed on all open sides and ends of the platform. No painters or bakers scaffold system extended to a walking surface height greater than 4ft will be allowed.
C. An access ladder or equivalent safe access must be provided.
D. OSHA approved scaffold planks must be overlapped a minimum of 12 inches or secured from movement. End supports of planks must extend at least 6 inches but no more than 12 inches.
E. Moveable scaffolds shall be locked in place when in use.
F.

3.5 LADDER SAFETY

PRECAUTIONS

A. No aluminum ladders are to be used or brought on site due to the potential for contact with energized electrical systems.
B. Portable ladders in use shall be tied, blocked or otherwise secured to prevent displacement.
C. The top two steps pf a step ladder shall not be used as a step.
D. The area around the top and bottom of ladders shall be kept clear.
E. Ladders shall not be used on slippery surfaces unless secured on providedwith slip-resistant feet to prevent displacement.

3.5.1 AERIAL LIFTS

A. All aerial lifts equipped with out riggers shall have the out riggers fullyextended.

B. and articulating boom lifts require that the employee be tied ofthe basket or boom when it is in use.

3.6 CRANE SAFETY

3.6.1 DEFINITIONS

A. **CRANE:** consists of a rotating structure for lifting and lowering horizontally on rubber tires or crawler treads.
B. **HOIST:** Used to lift and lower load.
C. **BOOM:** an inclined spar, strut or other long member supporting thehoisting tackle.
D. **BOOM STOPS:** a device used to limit the angle of the boom at its highest position.
E. **BRAKE:** to slow or stop motion by friction or power.
F. **BLOCK:** sheaves or grooved pulleys in a frame with hook, eye and strap.
G. **JIB:** Extension attached to the boom point to provide added boom lengthfor lifting specified loads.
H. **BOOM ANGLE INDICATOR:** an accessory device that measures the angle of boom base selection centerline to horizontal.
I. **LOAD :** the weight of the object being lifted including :
- Load block and hook
- Wire rope
- Rigging
- Boom attachments
- Ancillary attachment

J. **OUTRIGGER:** support members attached to the crane's carrier frame which is used to level the crane.
K. **PENDANTS:** stationary wire ropes used to support the boom.
L. **RADIUS:** the horizontal distance from the axis of the crane'ssuperstructure to the center of the suspended load.
M. **SUPERSTRUCTURE:** the rotating frame, gantry and boom or otheroperating equipment.
N. **COUNTER WEIGHT:** weights used for balancing loads and the weight ofthe crane in providing stability.
O. **DECK:** the revolving superstructure or turntable bed.
P. **DRUM:** the spool or cylindrical member around which cables are woundfor raising and lowering loads.

3.6.2 PRECAUTIONS

Use of cranes, including in plant overhead bridge cranes, requires Construction safety work permit. All overhead lifts shall be coordinated through project engineer facilities operations planning specialist. All mobile cranes must have the most recent annual inspection from available prior to operating. All cranes used outdoors shall remain clear of overhead power lines. Work areas must be walked down by planners and workers to identify overhead line hazards. Shouldthe situation exist that the crane has the potential to contact the overhead power lines the general contractor shall develop a two barrier control utilizing 2 of the systems described below:

A. TRAINED SPOTTERS: spotters trained in the techniques of visually determining standoff distance and in radio communication with the operator.
B. PHYSICAL BOUNDARIES: barriers that prevent the equipment fromintruding within the standoff distance.
C. DEMARACTION LINES: stakes or painted lines that provide constant reminders to equipment operators of the proximity.
D. MEASURMENT OF THE OVERHEAD LINE AND EQUIPMENT CLEARANCE: utilizing remote, not direct, measurement techniques to determine the actual clearance distance.
E. USE OF REFLECTIVE MATERIALS: enhancing visual identification of spotters by equipment operators.

SAFETY IN HOTWORKS

The most hazardous hot works are welding and gas cutting. Electrical welding and oxy-acetylene welding the common types of welding using in construction industry.

SAFETY IN WELDING AND CUTTING

Welding send gas cutting in the site be done only by experienced welders only. All welders and gas cutters and their helpers shall we are appropriate dresses. The clothes should not be oily, greasy or damp. Wearing of synthetic fiber clothing shall be avoided. Al welders and their helpers must wear the welding hoods and shields, goggles, leather hand gloves and leather or asbestos apron. All combustible material near and around the place within the reach of flying sparks are removed and where there is not possible cover by appropriate sheets. Wooden structures are thoroughly covered or wetted fire extinguishers are kept ready in hand. Avoid sing worn clothing or gloves for cleaning torch tips.

Acetylene impregnated clothing is highly flammable in the places where welding and cutting operations are carried out and where persons other than welders are working or passing shall be enclosed by means of suitable stationary or portable screens at least 2.15 m in height. Such screens shall be painted with black or light grey. Safety belts and life lines shall be used when welding is to be done at high elevation places. Welding or cutting works shall not be allowed without a valid work permit. After welding or cutting job is completed, the material should be chalk marked “HOT” to warn other employees. After completion the helper shall watch for any smoldering smoke.

ELECTRIC WELDING

Check and ensure all cables and connections in good condition. Check for properearthling pipe line containing gases inflammable liquids or conduit scarring electrical conductors should not be used for ground return circuit. Electrode older when not in use shall be placed on an insulted hook. Live electrode shall not be left on welding shield, gloves of cables. Outer surface of the electrode holders including jaw as far as possible shall be fully insulated. Frames of electric, welding machines shall be effectively grounded. Welding cable should be continuous and with full insulation. Ensure that there is a container to collectused electrodes.

OXY-ACETYLENE WELDING AND CUTTING

LPG cylinders are not allowed in the site in place of acetylene cylinders. Check oxygen and acetylene hoses thoroughly for any defects. Defective greasy or soaked hoses hall not be used. Regulators, blow

pipes or torches shall be checked thoroughly before starting welding or cutting works. In case of blow pipe getting heated. It is the indication of defection blow pipe. The work should be stopped and check the blowpipe. Proper trolley should be used for transporting the cylinder. No welding job shall be carried out unless regulator and pressure gauges are provided. Red hose for acetylene or other combustible gas and black hose for oxygen shall be used in no case they shall be interchanged as the mixture of this gas is black explosive. Care shall be taken not to allow the pressure in the oxygen cylinder to fall to a point that may permit the acetylene or combustible gas to flow back into oxygen cylinders and vice versa. Acetylene cylinders should kept in upright position to avoid the loss of acetylene with acetone in which it is dissolved. Acetylene should not be used at a pressure exceeding 15 PSL if the the cylinder becomes hot due to internal firing etc., immediately arrange for cooling it down by using water sprays.

INCASE OF BACK FIRE

Cut out the supply of gas. Cut the portion of the hose that caught fire. Extinguish the flame by water, send or extinguisher completely. Keep cylinders cool by spraying water on the repair the blow pipe for any fault in it.

CONCLUSION

Every construction site has accidents and the number increases as the negligence increase. The best effort we could do to control the accidents at site is by making the all labourers aware about the each and every safety precautions for the different construction activity and this is what I try in the chapter. Precautions for each and every activity are given in the chapter.

RESULT AND DISCUSSION

Classification of Construction Sites:

In order to ascertain accurate result pertaining to safety aspects of the construction site, it is necessary to collect authentic data from the site through observation then analyse these data by suitable tools. In this study, a random sample of 50 construction sites was selected as the main source of data. The construction sites were classified into two types:

1. Construction life-cycle
2. Building type

In the construction life cycle stage, there are three basic phases: substructure, superstructure and finishes. In terms of this classification 13 construction sites where at substructure stage,14 sites where at superstructure stage and 23 construction sites at finishes stage. The majority of construction site studied where at finishes stage where all the agency works simultaneously finish the project in space constraints. In the building type classification 22 construction sites where commercial/residential building, 18 construction sites where residential building, and 10 construction sites where industrial building. Commercial/residential building represented the largest portion of the study sample.

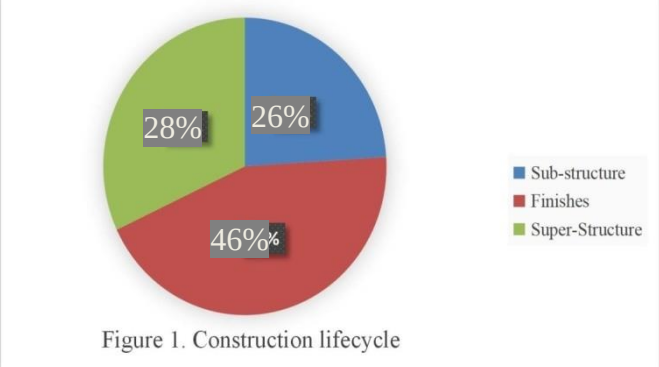


Figure 1. Construction lifecycle

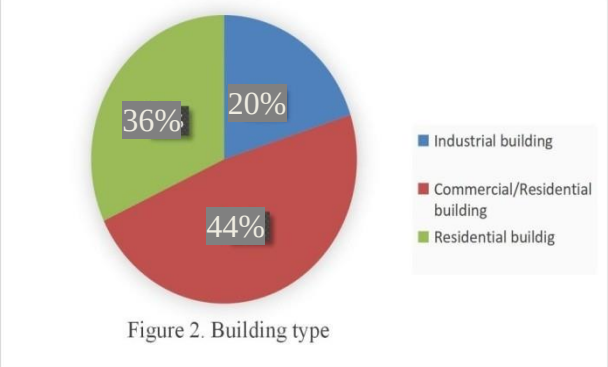


Figure 2. Building type

PRESENT SCENARIO OF SAFETY ASPECTS AND RISK ON CONSTRUCTION SITE:

The general status of safety on construction sites in the construction industry is accessed by using a checklist which was filled during the observation period. The checklist provides information on actual safety condition of the construction site and also assist to identify accident-prone areas on site. The analysis results of the checklist are summarized in Table 1. The Table 1 contains safety aspects applicable for each safety issue out of a total of 50 sites, frequency count and total percentage. There are 34 safety aspects which are categorized under five groups:

1) General construction site
2) Workers' PPE
3) Heights and fall protection
4) Machinery/equipment
5) Excavation

Out of 50 construction sites, only a few of them shares all five safety. Hence, all the safety aspects are not applicable to all different sites. The safety aspect which comes under general construction site and workers' PPE are only applicable to all 50 sites. The remaining 3 depends on the life cycle and building type. For example, during the visit of sites, the machinery was not in use or the excavation/basement work was not going on in all the sites. Hence, this group assessment is not applicable. The group with the least number of the applicable site was machinery with only 7 applicable safety site. As far as the number of safety aspects concerned it was found that general construction site includes 12, workers' PPE includes 6, Height and fall protection includes 7 and both machinery and excavation includes

4. In general, all groups showed a very poor safety record in the construction site. For example, there are five safety aspects which were not followed by even a single construction site includes: display of emergency exists, workers wearing safety glasses, workers wearing hearing protection, safety belts for workers fall protection and availability of flag person for machinery. The main four safety aspects with the highest positive effect were no slippery or muddy surfaces at 80%, no smoking workers at 88%, concrete formwork properly installed and braced at 100% and machinery equipped with handles and latches at 85.7%.

Table 1: Safety Aspects

Safety aspect	Sites	Frequency	%
A) General – construction site			
Site perimeter fenced and secured	50	20	40%
Availability of safety signs boards	50	6	12%
Display of emergency contacts/Telephone	50	0	0%
Availability of fire extinguisher	50	2	-4%
Clear approach roads to site and internal access	50	30	60%
Display of emergency exit	50	0	0
Good housekeeping	50	7	12%
Sufficient working area	50	30	60%
No slippery or muddy surfaces	50	45	90%
No loose electric cables on ground	50	20	40%
Materials are safely stored and secured	50	4	8%
Non-smoking workers	50	40	80%
B) Workers' PPE			
Workers wearing safety helmets	50	40	80%
Workers wearing safety glasses	50	0	0
Workers wearing hearing protection	50	0	0
Workers wearing hand gloves	50	2	4%
Workers wearing safety boots	50	40	80%
Workers wearing gum boots	50	2	4%
Workers wearing appropriate clothing	50	25	50%
C) Heights and fall protection			
Safety belts for workers fall protection	30	0	0
Openings on floors and roofs covered and protected	25	4	16%
Availability of protection against falling objects	20	2	10%
Stable and safely secured scaffoldings	16	10	62.5%
Crane loads do not pass over the public	5	2	40%
Concrete formwork properly installed and braced	20	20	100%
Stairways with stair rails	20	4	20%
D) Machinery			
Workers on machines wearing seatbelts	7	0	0%
Machine secured when not in use	7	4	57.11%
Availability of flag persons for machinery	7	0	0
Machinery equipped with handles and latches	7	7	100%
E) Excavation			
Safe access / exists in excavations	8	4	50%
Covered and fenced holes and piles in excavations	8	2	25%
Availability of supports to prevent soil movement	8	5	62.5%
Safe distance of materials and equipment from excavation edge	8	2	25%

GENERAL - CONSTRUCTION SITE:

In general, it is presumed that the main contractor should provide the safety Gardens and procedure. "The worker's safety is the contractor's responsibility". So he should communicate and facilitate to all the workers involved. But inorder to make more money contracted neglect safety guidelines thereby increasing the rate of incidents on site.

The positive results which were constrained from the investigation under the general construction site group are illustrated in Table 1. Firstly, 80% of the construction site did not have slippery and muddy surfaces due to the climatic condition of the area wherein the study was conducted. Secondly, 88% of the construction site does not have worker smoking on them during the site visit. On the other hand Table 1 also depicts low scoring safety aspects under this group. Only a few numbers of sites had displayed safety sign boards and emergency contact numbers which are very important because they keep us reminding about the safety measures that are to be followed on the sites and also none of the construction site display emergency exit plan. This is an indication that safety standards are not followed in the majority of the construction site and also reflect top management careless towards safety measures. Only 12% of construction site had good housekeeping which reflects low percentage and affects other safety aspects such as the presence of naked electric cable on the ground about 72%, only 40% of construction site have clear approach roads to site and internal access, only 48% of the site had sufficient working area and 90% of the construction site did not safely store materials (store their materials on adjacent streets or sidewalk) and this isthe sign of very unsafe construction sites for workers and inexperienced person entering the site. These type of storing materials is the prime cause of accidents for workers and other individuals. Only 36% of the construction site perimeters were fenced and secured, increasing the chances of accidents, especially bad housekeeping of the majority of these construction sites. We all know fire is a dangerous hazard in a construction site, unfortunately, only 2% of construction site visited had the fire extinguisher on it. These raises concern regarding the safety measures implemented in the construction industry as a whole.

WORKER'S PPE:

Minimum safety measures followed globally on the construction site are Personal Protective Equipment's (PPE'S). It is mandatory for all the workers, this includes helmets (hard hats), safety shoe (steel toed shoe), safety glasses (for eye protection), safety hand gloves and appropriate clothing. All this will protect workers from the hazard surrounding them and neglecting the use of these basic safety measures will cause accidents and injuries.

Table 1 shows infrequent use of PPE'S by workers, safety glasses and hearing protection were not used by any workers at any construction site, hand gloves and safety helmets were used by a limited number of workers at few construction sites, safety boots which are essential at the construction site were only worn by the majority of workers in 16% of construction site. It is observed that most of the workers wear regular footwear which provides minimum protection at the construction site and are considered unsafe wear in the construction environment. Only 50% off construction site

had workers wearing appropriate clothing and the majority of workers on site found to be in inappropriate clothing. Due to this, an increase in the number of accidents on the construction site becomes rational, specifically minor accident to hand and foot.

HEIGHTS AND FALL PROTECTION:

In order to construct a permanent structure, various temporary structures such as scaffolds, formworks, shoring, ramps, platform are needed to be created. These temporary structures contribute to a number of accidents in the construction industry by collapsing, workers falling from them. The main contractor, subcontractor and top management must consider height and fall risks as an absolute priority for injury prevention as it may lead to major accidents causing disablement and fatalities. All Construction sites with concrete formwork activities should make sure proper installation and brace of concrete formwork this helps to abide formwork collapse on workers and create a safe environment on construction site. On the other hand, it is observed that none of the 30 applicable construction sites on which workers working on height had a safety harness belt. Only 8% of the construction site with openings on floors and roofs had covered and protected. It is also observed that protection against falling objects due to workers working on

structure edges was found only 2 construction site out of 32 applicable sites. Out of 5 construction sites with cranes, only two didn't pass over the public space, only 10% of applicable construction site had stair rails for staircase which increases the chances of falling due to tripping thereby causing accidents. Almost all sites to be observed that concrete formworks were properly installed and braced.

MACHINERY AND EQUIPMENT:

Movement of construction material internally on the site from the stores to various location is carried out by machinery like a shovel, JCB, dumpers, forklift and cranes. Even machinery is required for unloading material on site. This operation had to be carried out by skilled workers and operators abiding by safety aspects related to various machines and equipment. On the other hand, if it is not carried out in a safe environment it leads to accidents on the construction site. All these machinery provide a hazardous work environment for all worker involved in their operations. It also imparts efficiency and speed in construction projects. The vehicle operators and co-operators to help in the construction site by using gesture, signs or flags. The presence of a flag person in a construction site is important to help the vehicle operator work more efficiently to finish the job faster and implement safety rules. In this study 7 construction site out of 50 had machinery operating in them. In this above 85% of the site, machinery was equipped with handle and latches which provide easy access to operators. In 42% of the sites, machinery was secured when not in use, care should be taken in parking the machinery when not in used in safe areas rather than near the steep excavation or hazard-prone areas. Out of the 7 sites only at one site operators used seat belts while operating the machine. This is the case of pure negligence of safety aspects not enforced by the authorities (Safety officers and construction manager) on construction site and also none of the sites are having flag person to help main operators. This is most likely because flag person generally is seen as an extra cost to the contractor.

EXCAVATION:

Excavation being very important and foremost activity on site for making foundation, temporary water storage, substructure. Safety measures in excavation depend on the area of the site, depth of excavation and type of soil. In this study lack of safety precautions in the most construction site with excavation were observed. Excavation should be supported from outside to prevent soil movement but only 50% of the applicable construction site noticed in this study whereas other sites were lacking in this safety aspects thereby increasing the probability of soil movement and collapse hazards. Safe access and safe distance of materials and equipment were found in only 2 sites out of 7 applicable sites. This makes the process of evacuation during emergency more complicated and hazardous and also becomes very likely for materials and equipment to fall into the excavation not properly handled. It is also observed that only one out of 7 applicable sites had excavation holes and piles covered with the fence. Here the likely hood of the injuring inexperienced workers is increased. These results reveal the existence of many hazards in the excavation construction site and this to be managed in order to create a safe zone for the workers to perform their work.

CONCLUSIONS AND RECOMMENDATIONS

In our study we considered five groups of basic safety aspects prevailing in the construction industry neglecting of these aspects leads to minor and major injuries at the site. In our study, we noticed a few safety aspects were found and implemented on sites whereas the majority of others are not given importance and neglected by the authorities. All different safety aspect rule which was given little importance in safety performance needs significant improvement in safety practices. Out of the 34, safety aspects explode in our study, few are not observed in any of the 50 focused construction sites like display of emergency exists, workers wearing safety glasses, workers wearing hearing protection, safety belts for workers fall protection and availability of flag person for machinery. These show the general negligence of construction manager and project owners in terms of safety consideration. In order to improve the safety performance of the construction industry in general, different participants (main contractor, subcontractors, owners, engineers, workers) must give high priority to safety aspects on construction sites. Based on the study conducted and information gathered from 50 construction sites following recommendations for the improvement of safety aspects in the construction industry are:

1. Prepare safety procedures, manuals, guidelines, and checklist for the construction industry related to typeand size of construction enforceable by law.
2. Government and private bodies exclusively deploy safety team on construction sites for inspecting,monitoring and enforcing safety aspects in the construction site.
3. Construction team (owner, engineer/architect, contractor).
4. Neglecting safety aspects in construction site are held accountable for not maintaining the safe environment in the construction site.
5. Advice to conduct safety awareness, workshops and meetings with all the participants of a constructionsite at fixed duration (weekly or monthly).
6. Promote the implementation of safety practices throughout the life cycle of building and structures.
7. Arrange safety training courses to workers by a recognised institution to develop professional skills.
8. Depute qualified safety person on site as per the nature of the job.
9. As the construction industry is growing, invent and publish other safety aspects and create awarenessamong the public.

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