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Safety Management at Construction Projects: A Case Study of Infrastructure Projects

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Abstract

Workers in construction project are exposed to high level of risk due to work conditions. Therefore, it is important to implement an efficient safety management system to minimize the risks and improve the working condition. the absence of efficient safety management system will increase the level of risk which may jeopardize health and life of works. Safety management system are also important to minimize the lost-time injury and reduce the cost and time impact associated with injuries or fatalities.

This paper will review the safety management system for construction projects. Furthermore, it will focus on procedures and measures implemented to control risk on construction projects. In this paper, examples of different types of hazards at construction projects are presented, along with methods of reducing or eliminating the risk associated with these hazards.

Key words: risk, hazard, health, safety, fatality, injury.

1. Introduction

Workers on construction projects are vulnerable and exposed to a high level of risk. The high level of risk is associated with the nature of construction activities. Construction projects involve different types of hazards, such as working at height, working in the vicinity of a live road, etc. The frequent exposure of laborers to such conditions without any safety measures can result in accidents that will impact the workers directly and the company's performance indirectly. Therefore, it is essential to impose a safety management system for every construction project to ensure the safety of work and improve the performance of construction companies.

This paper will briefly review some aspects of the safety management system. Also, it will discuss an actual example of a risk encountered at the workplace and the control measures and procedures applied to reduce the level of risk. The safety of workers at a workplace must be considered a priority, and everything possible must be done to maintain the health and safety of workers. Maintaining safety on a construction project should not be viewed as the sole procedure or duty of the safety officer or safety engineer. It is essential to spread the safety culture among workers, managers, and everyone. Everyone should contribute to creating a safe working environment. This paper will discuss the following points:

- Safety management system
- The importance of safety at construction projects
- Defining the risk and hazard
- How to deal with risk
- Risk assessment: how it is done and why it is important
- Reporting of accidents or incidents
- Explanatory examples of risk from a case study project

2. Occupational Health and Safety Management System

The function of occupational health and safety management system is to manage and handle health and safety risks systematically. A successful OHSMS relies on a set of elements such as policy development, responsibility, accountability, planning and implementation, and evaluation. Each component plays a significant role in developing a successful OHSMS.

The first step in developing an OHSMS is composing a comprehensive policy that complies with international and local standards.

Moreover, the developed policy should carefully consider the nature of business and include procedures and arrangements to maintain safety and health. The developed policy must be designed to accomplish the safety and health of all workers, comply with international or local safety laws, ensure the contribution and participation of all management and workers in all elements of OHSMS, and ensure the continuous improvement of OHSMS.

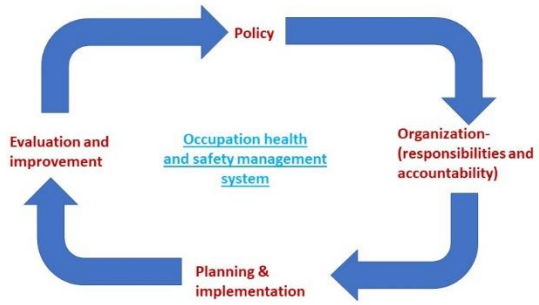


Figure 1

A safety policy remains a written text without implementation by the organization. Implementing a policy will involve assigning duties, responsibilities, accountability, and authority to ensure proper implementation of a safety policy at the workplace. Assigned persons to maintain health and safety at a workplace shall possess a rich knowledge of OHSMS. Furthermore, the leadership should grant them real authority to eliminate any hazards and safeguard the health and safety of workers. In a construction project, the health and safety at the field will be monitored by a sufficient number of health and safety engineers/officers.

The number of health and safety engineers/officers is determined based on project size and the expected level of risk. Once the safety constitution (policy) is created and duties assigned to a specific staff, then implementation of the policy can be performed at the workplace.

Evaluation of the performance of the implemented OHSMS is critical to identifying weak points or defects in the implemented OHSMS. Furthermore, it is essential to improve OHSMS and safety at the workplace.

3. Importance of Safety at construction projects

Fatalities, injuries, and health issues are the results of poor occupational health and safety measures at a construction project or any workplace. According to the International Labor Organization (ILO), almost 2.78 million people die yearly due to work-related accidents and diseases. Furthermore, approximately 374 million injuries and illnesses are recorded annually worldwide. The implementation of appropriate OHSMS will significantly reduce the fatalities, injuries, and health issues associated with work. The statistics of the ILO emphasize the importance of OHSMS and the urgent need for the implementation of appropriate OHSMS at each and every workplace. The construction sector usually contributes in a large portion of fatalities in comparison to other sectors. Figure No. 02 presents the contribution of different economic sectors to fatalities in the UK in 2018. The construction sector is the top contributor to fatalities in the UK in 2018.

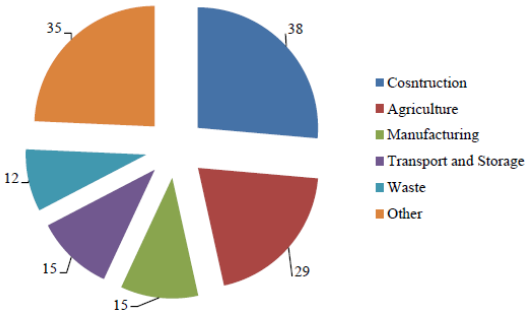


Figure 2 (Occupational Fatal Injuries in UK 2017-2018) [5]

Human life should be the top priority for every company. Aside from human life or injuries, poor OHSMS may cause heavy financial losses

due to time lost, injuries, compensation paid to workers or their families, and the loss of reputation due to the periodic occurrence of accidents. It is important to note that work-related injuries and sickness cause massive losses to the world GDP, which is estimated to be 3.90% of the world GDP [5].

4. Important terms in the safety industry

Health and safety Engineers/officers must possess profound safety knowledge, and they must be familiar with local and international safety codes. Solid knowledge and experience are critical, and they allow for better identification and deterrence of different hazards at the workplace.

4.1 Risk and Hazard

Risk and hazard are related to each other, and it can be confusing to differentiates them. Hazard is the source of harm, so it is an activity or act that can cause harm, such as the activity of lifting and shifting materials. Shifting materials by a crane is a source of possible harm that may result in fatality or injury. On the other side, risk is the probability of people being harmed as a result of exposure to a hazard.

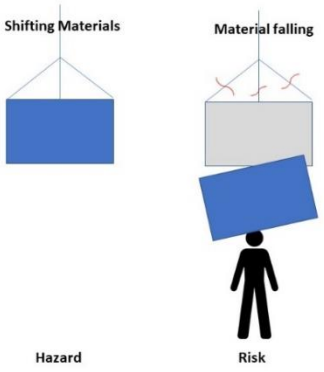


Figure 3

Figure No. 3 gives an example of a hazard and risk. The hazard depicted in figure no. 03 is the shifting of material from one location to another. The shifting of materials is a source of potential harm, and it is a hazard. The potential harm can be the falling of material or the toppling of the crane. While the risk is the likelihood that a worker or crane operator may get harmed due to the shifting of materials. Identification of hazards and risks is essential for controlling and reducing levels at a workplace through suitable measures.

4.2 Accident and Incident

An incident or near-miss is an unexpected event that may result in property damage but doesn't cause injury [1]. It is important to note that the incident should be investigated. The incident or near-miss investigation is important to determine the root cause of the unwanted event. Furthermore, it is important to determine and implement immediate preventive measures to avoid the repentance of similar events in the future. The reoccurrence of the same event in the future may result in injuries or even fatalities.

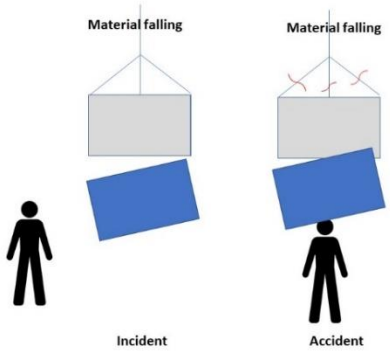


Figure 4

Unlike incidents, accidents result in an injury or fatality [1]. The reporting of incidents and accidents is critical for improving health and safety at work. It is important to know what goes wrong and how to prevent the occurrence of similar events again in the future.

5. Dealing with risk at a workplace

Each organization should have efficient OHSMS to deal with risk. The company safety policy should specify the procedure for deterring risk at a workplace. Policy is not enough without the

practical execution of safety policy at a workplace. The safety engineer or officer will be responsible for the execution of safety policies at a workplace. Dealing with risk requires the identification of a hazard and the potential risk. The identification of hazards requires a solid knowledge of the on-going activities and potential hazards associated with each activity. Upon determining the hazard, suitable procedures must be implemented to reduce or eliminate the risk at a workplace. A daily inspection of a workplace by a competent safety person is necessary to ascertain the implementation of safe procedures and to report any violations.

5.1 Types of control measures

The risk at a workplace will be dealt with through a set of control measures. Figure No. 5 presents the hierarchy of control. The most effective measures are at the top of the control hierarchy. Therefore, engineers should always attempt to implement the most effective control measures, if possible, at the workplace. The most effective control measures are the elimination of the risk. An example of risk elimination is the removal of dangerous chemicals from the workplace. If elimination of the source of risk is not possible, then we activate substitution of the hazard. The idea of risk substitution is to replace the source of occupational risk with something less risky, such as the use of non-toxic glue instead of toxic glue.

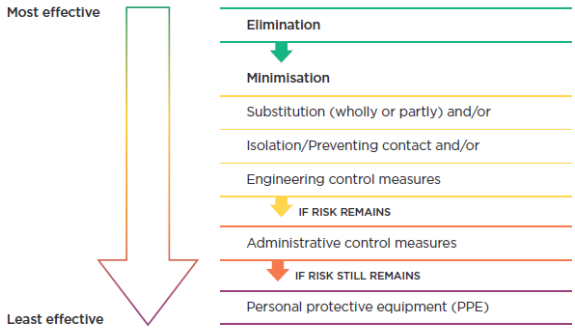
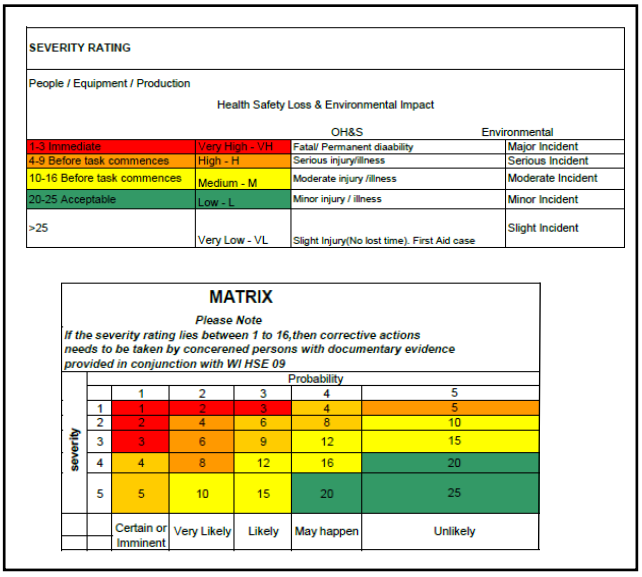


Figure 5 [7]

It is not always possible to eliminate or substitute the risk. Therefore, isolation of the hazard is used to minimize the risk level. In this measure, we aim to prevent contact with the source of risk. An example of hazard isolation is the construction of a separate access for workers away from moving equipment, which minimizes the likelihood of workers being hit by moving equipment. Next control measure is engineering control measures and it can be also used to reduce the risk. Engineering measures are utilized by implementing physical control to minimize the risk, such as the installation of a guard on cutting machinery. Administrative control measures involve the implementation of safe work methods and procedures to minimize the risk, such as prohibiting labor from working outside at midday during the summer in hot countries. The least effective measure is the wearing of personal protective equipment such as a helmet, jacket, goggles, mask, etc.

5.2 Risk assessment

Risk assessment aims to carefully examine work activities, any possible hazards that can cause harm to labor, and the efficiency of precautions implemented to reduce the risk [6]. If precautions are not enough, then additional measures should be taken to reduce the risk level to an acceptable level. The purpose of any risk assessment is to ensure that all hazards are identified at the site and enough measures are taken to eliminate or minimize the risk. A risk assessment should be prepared by an experienced person who can identify all the possible hazards for a specific activity. All defined hazards must be studied to evaluate the risk level, and suitable control measures should be determined and applied at a workplace to minimize the risk.



SEVERITY RATING

People / Equipment / Production

Health Safety Loss & Environmental Impact

		OH&S	Environmental
1-3 Immediate	Very High - VH	Fatal/ Permanent diaability	Major Incident
4-9 Before task commences	High - H	Serious injury/illness	Serious Incident
10-16 Before task commences	Medium - M	Moderate injury /illness	Moderate Incident
20-25 Acceptable	Low - L	Minor injury / illness	Minor Incident
>25	Very Low - VL	Slight Injury(No lost time). First Aid case	Slight Incident

MATRIX

Please Note
If the severity rating lies between 1 to 16,then corrective actions needs to be taken by concerened persons with documentary evidence provided in conjunction with WI HSE 09

severity \ Probability	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25
	Certain or Imminent	Very Likely	Likely	May happen	Unlikely

Figure 6

Risk level and residual risk can be determined by the use of a risk matrix. In the risk matrix, risk severity and probability should be determined to calculate the risk severity rating. Figure 6 presents the risk matrix. Risk severity is measured on a scale of 1 to 25. Very high risk will be given a value of 1 to 3, and low risk will be given a value of 20–25, as shown in figure 6. On the other hand, the probability of risk occurrence should be evaluated. For example, a certain or imminent risk will have a value of 1. The risk severity rating is severity times probability. If the severity rating is less than 16, then corrective actions are required.

Table 1

activity	hazard	severity	probability	Severity rating	Corrective action	Residual risk
Laying pipe inside a trench	***Soil collapse *Falling hazard of pipe *labour falling on trench**	2	2	4	***Using of sheet piles to stabilize soil. *Providing barrication around trench *Providing lifting supervisor, flag man, certified crane. *Providing proper access to trench**	10*3=30 (Low risk)

Table No. 1 presents a simple example of a risk assessment of a pipe-laying activity. In this example, the possible hazard is listed in the second column, and then the severity rating is determined. The severity rating was found to be very high, and corrective action is needed to reduce the risk to an acceptable level. The presented example is simple, and each activity at the workplace should be investigated and treated in the same way to reduce the risk and ensure a safer working environment.

5.3 Daily inspection

Daily site inspections are critical, and they can significantly improve the construction site condition. Humans tends to be less cautious and relaxed with time; therefore, daily inspection is important to ensure that all safety measures are implemented without any deviation. A daily site inspection should be conducted by a competent safety engineer or officer to verify the implementation of safety control measures as per the approved risk assessment and in compliance with local or international codes.

Figure 7

The safety officer or engineer should take immediate action to remove any hazards identified during the site inspection. Actions taken can vary depending on the risk level, and one of these actions is stopping the work until a proper measure is taken. Maintaining safety at a construction site is the responsibility of all. Therefore, engineers and the construction team should cooperate with safety engineers to preserve the safety at the workplace.

5.4 Safety SOR/NCR reports

Safety site observation reports are usually issued when the construction team is not responding to the request of the safety engineer to correct safety violations. SOR is a written report that details a safety-related violation at the workplace. SOR can be issued internally by the contractor or by the Engineer (consultant) against the contractor in construction projects. The contractor or the construction department should take immediate corrective and preventive actions to rectify the safety violation and prevent repentance of same violation in the future.

A non-conformance report is another tool used to report safety violations. NCR is considered a stronger tool as it can result in fining the contractor for not implementing appropriate control measures to rectify the violation at site. The type and name of reports can vary, but the purpose is for all these reports is to deter the contractor from committing safety violation at field.

5.5 Reporting of accident/incident

It is essential to investigate and report any accident, incident, or near-miss that occurs at the construction site. Investigation and reporting are important to avoid the repentance of similar accidents or incidents, which contribute to a safer and better working environment [1]. An appropriate investigation should be conducted by an experienced safety engineer to determine the root cause of the incident or accident. Furthermore, it is important to decide the corrective or preventive actions to avoid similar events in the future. Gathering information during the investigation of an accident or incident should rely on a close examination of the site condition, interviewing the injured person and witnesses, reviewing established procedures, and reviewing the training records of impacted persons to gain a clear understanding of the causes of the accident or incident and take the appropriate actions.

A swift investigation should be done for major accidents that resulted in serious injury or fatality. The investigation must be precise, with clear corrective or preventive action with immediate effects. All recorded accidents, incidents, or near-misses must probably be archived.

6.0 Case study:

The case study will be an infrastructure project that involves the construction of roads and bridges with complete infrastructure. A set of hazards, possible risks, and possible control measures that can be implemented at the construction site are exhibited in this part of the paper.

6.1 Examples of hazards and possible control measures

6.1.1 Deep excavation

Deep excavation is a hazard because it is a source of harm. Deep excavation can result in various risks, such as soil collapse, falling of labor inside the excavation, tripping, etc.

Therefore, it is important to implement sufficient control measures to prevent accidents and minimize the risk.

Figure 8

A bunch of control measures can be implemented to treat every possible risk. For example, soil collapse can be prevented by providing benching (steps) to stabilize the soil and reduce the possibility of collapse. In some cases where benching is not possible due to area restriction, sheet piles or secant piles can be used as another option. Furthermore, the excavation should be barricaded with a plastic or concrete barrier to prevent the access of unauthorized persons, which minimizes the falling risk. Appropriate access to the bottom of the excavation must be provided to prevent the tripping risk of labor.

6.1.2 Work in the vicinity of a live road

Working near a live road will pose a high risk to workers. There is a high probability that a vehicle will swerve and collide at the working area, which jeopardizes the lives of laborers. The probability increases on high-speed and congested roads. Therefore, special attention should be given to this type of dangerous work.

Figure 9

For this type of work, a concrete barrier should be used to protect the laborers from moving vehicles. Moreover, flash lights and warning sign boards should be provided in the working zone to warn the drivers. If the working zone is extended to parts of the road, then a special traffic diversion and partial road closure should be implemented at the site. Traffic diversion and partial road closures should comply with local safety specifications and traffic manuals, if available.

6.1.3 Lifting activities

The shifting of materials is inevitable in any construction project. Shifting of materials is associated with serious risks to labor. Inappropriate lifting of materials by crane poses a serious risk to laborers and the crane operator. The possible risk associated with lifting materials could be the falling of lifted material or the toppling of a crane.

Figure 10

The lifting of materials should be performed by an experienced operator. The crane used for lifting should be equipped with the necessary computer or lifting charts to assist the operator in determining the lifting capacity of the crane. Also, used chains and belts should be in good condition with sufficient capacity to carry the load without failure. Furthermore, a lifting supervisor must possess experience and be capable of maintaining a safe and efficient lifting procedure. The lifting supervisor will be responsible for checking the ground condition below the crane, checking the crane third-party certificate, ensuring the lifting is performed as per the approved lifting plan, etc. [3].

6.1.4 Work at Height

The primary risk associated with working at height is falling. The falling of tools or anything from height can pose serious harm to laborers. Therefore, sufficient control measures must be implemented to eliminate the risks that arise from working at height.

Figure 11

A proper platform shall be provided with edge protection, as shown in figure 11. Furthermore, laborers should be equipped with safety harnesses to avoid any falling risks. Moreover, all gaps in the platform shall be closed to prevent the falling of tools or any item from height.

6.1.5 Work under the sun

Working under the sun, especially in the summer, can result in negative health consequences. Scorching heat can cause dehydration of labor, especially in hot countries. Cold water should be provided during the working hours. Water should be mixed with ice to keep the water temperature acceptable for drinking. Furthermore, in some countries, working outside is prohibited at midday during the summer. Ceasing the work outside during noontime can reduce the exposure of laborers to high temperatures, which will reduce labor fatigue and dehydration. Each construction site should employ a professional first aider or nurse to provide immediate first aid for urgent cases.

Figure 12

6.1.6 Equipment and machinery

Equipment and machinery are important tools in the construction or industrial sectors. Despite the benefits of using equipment and machinery in construction, it can pose a serious risk to laborers. Table No. 02 presents a number of hazards and associated risks that can result from using machinery in the construction and manufacturing industries. It is important to determine hazards of a specific machine. Determining the hazard will help in determining

the risk and the necessary control measures. Used equipment and machinery should be in good condition, daily maintained and checked by the maintenance team. Furthermore, it should be thoroughly inspected and certified by a specialist third party to confirm the safety of used equipment.

Table 2 [4]

Hazard	Risk
Rotating shafts, pullies, sprockets and gears	Entanglement
Hard surfaces moving together	Crushing
Scissor or shear action	Severing
Sharp edge – moving or stationary	Cutting or puncturing
Cable or hose connections	Slips, trips and falls (e.g. oil leaks)

Grinder as a tool is a source of various hazards, such as moving parts, sharp edges, shearing action, and cable connections. It is important to look into each hazard separately and determine the necessary action to minimize the risk associated with each hazard. For example, a moving disc can pose a severing risk. Minimizing the severing risk will involve providing a guard to separate the moving disc from the labor.

Figure 13

6.1.7 Welfare facilities

Welfare facilities such as rest area and rest rooms (toilets) must be provided at construction projects. Rest room must contain tables and chair for labors to take food and rest. Rest rooms should be distributed and placed close to labors. Periodic cleaning of rest rooms (toilets) and rest area shall be ensured always.

Figure 14

7.0 spreading safety culture among employee's

Companies and construction project management should spread the safety culture among employees. Spreading safety culture through conducting periodic tool box, safety induction and continuous education. Employees should sense the importance of safety measures for maintaining health and safety for everyone. Employees should feel the responsibility and importance for maintaining and adhering to safety measures all time even in the absence of supervision.

8.0 Conclusion

Injuries and fatalities are common on construction projects. Therefore, appropriate safety control measures should be implemented at every construction project to minimize the risk and preserve labors life, health and prevent unwanted incidents. The safety at a construction project must be a shared responsibility, safety engineer should guide the employees and project management, and they should put every possible effort to ensure a safe working condition.

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