Comparison of Cost of Accidents in Construction Site Against the Cost of Mitigation Measures Through Risk Assessment

Civil and Environmental Engineering

By

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An undergraduate thesis submitted to the Department of Civil & Environmental Engineering of Islamic University of Technology, Board Bazar, Gazipur in partial fulfillment of the requirements for the degree

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Thesis approved as to style and content for the degree of B.Sc. Engineering (Civil and Environmental Engineering)

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DECLARATION

We hereby declare that the undergraduate project work reported in this thesis has been performed by us and this work has not been submitted elsewhere for any purpose (except for publication).

October, 2013

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Dedicated

To

Our Beloved Parents

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ABSTRACT

Construction industry is booming day by day and it becomes one of the major economic forces of Bangladesh. Nevertheless, successful completion of construction project is a great challenge in terms of delays in project completion, cost overruns, and even failure. Apart from these, accidents in construction sites become another major concern which often leads to huge loss of properties, ill health/death of people, bad image of company and sometimes project failure. This problem is more severe in Bangladesh. Though risk management tools and techniques which have been developed to improve project success, are used too little, and many still wonder how helpful they are. Moreover, since accidents cannot be seen beforehand and protective measures involve additional cost, people are sometimes reluctant to adopt safety measure for their construction work. This paper aims to identify costs associated with safety measures of construction projects and compare it with costs that may occur because of accidents during construction works. In this study 50 hazards has been identified that consist risk of accidents during a construction work. Then the probable accidents relating to these hazards are enlisted and costs are estimated according to the likelihood of occurring and severity of the accident. Costs of accidents include medical cost of injuries, daily compensation for injured workers, death penalty, property damage and so on. On the other hand, costs of safety measures include PPE, safety guard, safety engineer and so on. Obtained results that using safety measures can save money, goodwill, delay of work and many other unexpected situations. It is important to implement required health and safety practices and training effectively to ensure that all workers acknowledge and follow these requirements regulations when working. This study will encourage construction people to adopt safety measures for their works and thus minimize accidents construction sites.

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CHAPTER ONE

INTRODUCTION

1.1 GENERAL

This chapter briefly discusses about the background of the study and the importance of safety in construction sites. It discusses worksite safety and health that are currently practiced along with their shortcomings. Finally, the objective, scope of the study and organization of the thesis are presented accordingly.

1.2 BACKGROUND

Construction industry is one of the major economic forces of Bangladesh. There are a lot of developers' companies in the capital city Dhaka as well as in other districts. The first aim of these companies is to get highest output with minimum input that means the best productivity. For construction operations input may be different human and non-human resources labor, materials, equipments, capital, designs etc (Shou Qing, 1999). For achieving this goal these companies have special management team whose duty is to manage different steps of work in such a way that the highest output can be overcome. But the fact is construction works are of high risk both working process and usage of various equipments and large machineries. Risk can appear at any stage of life cycle of a construction project: at appraisal, sanction, construction and operation (Perry and Hays, 1985). Different accidents may happen which leads to serious physical injury to the workers at site and if severe can cause death and also a huge amount of loss because of the damage of the goods.

So safety management is also required along with construction management. If we are able to identify the hazards on construction site then after evaluating these risk we can take preventive action. There are two major categories of hazards on construction site namely (1)the risk of physical injury or physical injury hazard, where the agents are normally associated with the process of works or equipment used and climatic conditions, (2)the risk of ill health or health hazards, where grouped under chemical,

physical and biological hazards (Davis and Thomas, 1996). After evaluation of these hazards we can make decision for taking action to reduce or protect those risks.

1.3 PROBLEM STATEMENT

In Bangladesh, work site safety and risk management or safety management in construction site is not given priority as much as it should be. However to provide a safe and conductive working environment and also to minimize the number of construction accidents, a proper risk management process is required. If all types of safeties are ensured, then workers will be able to works without any fear which will increase the working speed. Some personal protective equipment may be provided which will protect the workers from some accidents. The knowledge of safety awareness among the workers at construction site is very important. This knowledge can be gained from training. According to Hinze (1997), training should be at the core of every safety program. All for these works a handsome amount of money is required.

Most of the owners of construction industry think that all the cost related to safety management will be an extra amount which they don't want to spent depending on the probability of any kind of accidents that may happen during construction. Nevertheless, the fact is if somehow any accident occurs at the construction site, it causes a lot of loss and negative impact on to the construction company. The most obvious loss is delay in project completion due to hamper of normal workflow caused by that accident. In addition, accidents can cause the company to pay more due to overtime work, increase the number of workers to expedite the progress of the work, replace the injured worker with replacement worker and also for the treatment of these injured workers. Accident may require additional materials or equipments for the rework. All of these cause a significant amount of loss which will decrease the productivity.

Since accidents are not known before hand, people are reluctant to take preventive measures. Hence, it is very important to do a relative comparison between possible costs of accidents in construction site and cost of preventive measures to be taken. The comparison may encourage construction people to rethink about the necessity of

safety in construction site and take proper preventive measures in order to ensure safety in their workplace.

1.4 OBJECTIVE

The main objective of this study is to estimate the cost of accidents and thei risk assessment of construction project. The specific objectives are:

- To estimate the cost associated with accident that may occur in construction site.
- To estimate the cost of safety measures to be taken to mitigate the accidents.
- Relative comparison between these two costs.

1.5 SCOPE OF THE STUDY

This study will focus on the costs related to any probable accident on construction site which may be of workers' minor or major injury or death, the loss of equipments, goods and machineries and also the costs involved with safety measures to mitigate the loss. As because construction project work is combination of a lot of steps, so we will try to focus on some of these steps like:

1) Earth Excavation
2) Works with heavy equipments
3) Stone Crushing
4) Shuttering Related Works
5) Reinforcement erection and placement
6) Concreting Works
7) Partition wall/Brick Wall
8) Scaffolding
9) Out Plastering
10) Painting
11) Carpentry works
12) Plumbing Works

13) Electrical Works
14) Working at Height

We will collect information from different construction site, and will conduct some questionnaire survey with Site Engineers and Workers.

1.6 ORGANIZATION OF THESIS

The rest of the part of the thesis has been organized as follows.

Chapter 2: Literature review; the chapter will discuss about hazards of construction site, risk assessment process, risk management process.

Chapter 3: Methodology.

Chapter 5: Cost analysis in risk assessment.

Chapter 4: Conclusion and recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

This chapter discusses about health and safety on construction site. The hazards from which different possible accidents occurs. It also discusses about risk on construction site, risk assessment process, engineers', employers' and workers' role and responsibilities at the time of risk assessment and at last risk management process on construction site.

2.2 CONDITION OF CONSTRUCTION INDUSTRY IN THE WORLD

Over the next 7 years the global construction industry will grow from $7.2 trillion to over $12 trillion. In a report called Global Construction 2020 by Global Construction Perspectives and Oxford Economics major global and regional construction trends are analyzed by key countries. The report shows that developing or emerging countries will overtake developed countries in market share by 2020. The global construction industry currently represents about 13% of global GDP and this number will increase to 15% in 2020. Countries poised to undergo the largest growth include China, India, Russia, Brazil, Poland and the US. Construction workers have one of the most dangerous jobs in the United States, according to the United States Department of Labor (DOL). Despite federal regulation of this industry, thousands of construction workers are killed and injured on the job each year. The statistics supplied by the U.S. DOL's Occupational Safety & Health Administration (OSHA), says 721 workers died in calendar year 2011. In an average around 150,000 workers are seriously injured and around 1,000 workers are died per year. They are trying to reduce it by forcing the construction industries to take all necessary safety measures. Administrative penalties are fines imposed on different construction industries for health and safety violations are around $ 2,000 to $ 70,000 in 2013 in USA.

2.3 CONDITION OF CONSTRUCTION INDUSTRY IN BANGLADESH

The construction industry of Bangladesh has improved substantially during the last twenty years. About 10% of GDP of the country comes from this sector alone. It absorbs a very big labor force as well as enhances big job opportunities for engineers, architects, managers, foremen, supervisors, technicians, electricians, machine operators, drivers etc. Most construction firm owners directly or indirectly force workers to work without any safety gear and in hazardous conditions which lead to frequent accidents at construction sites. According to Safety and Rights Society, an organization working with work-place accidents, said a total of 142 workers' death in 2010, 97 workers' deaths in first six months of 2011, 790 workers' injury and 487 workers' death in first six months of 2012 on construction sites of Bangladesh were reported in newspapers. However, quarters concerned said the number of deaths at construction sites is much higher than the reported figure as the Dhaka Medical College morgue and its emergency department alone receives one or two such victims every day.

2.4 HEALTH

Health is the general condition of a person in mind, body and spirit, usually meaning to be free from illness, injury or pain. The World Health Organization (WHO) defined health in its broader sense in 1946 as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO, 2006). In this study health means being free from illness, injury or pain which can be caused by construction activities.

2.5 SAFETY

Safety is related to external threats, and the perception of being sheltered from threats. According to the business Dictionary, safety is defined as a relative freedom from danger, risk, or threat of harm, injury, or loss of personnel and/or property, whether caused deliberately or by accident. Safety can also be defined as the control of recognized hazards to achieve an acceptable level of risk. In this study, safety means

freedom from danger, harm, and injury to the person involved in construction activities.

2.6 HAZARDS

A hazard is the potential for harm. In practical terms, a hazard is often associated with a condition or activity that, if left uncontrolled, can result in an injury or illness. HSE (2004) define hazard as any source of potential damage, harm or adverse health effects on something or someone under certain conditions at work. Basically, a hazard can cause harm or adverse effects (to individuals as health effects or to organizations as loss of property or equipment). In this study hazard mean anything which has the potential to cause harm to people on construction sites.

2.7 ACCIDENT AND INJURY

The terms accident and injury refer to separate phenomena, mutually interrelated as cause and effect (exposure and outcome) (Andersson, 1999). The terms 'accident' and 'injury' are hereby used in accordance with the definition adopted at the first World Conference on Accident and Injury Prevention (WHO, 1989); that is, an accident is an unintentional event which results or could result in an injury, whereas injury is a collective term for health outcomes from traumatic events (Andersson, 1999). Rejda (1992) defined an accident as a "sudden, unforeseen and unintentional" event, which may result in physical harm to a person and/or damage to a property.

The following is a list of the possible injuries of construction workers resulting from construction site accidents:

a. Head injury: Unfortunately, hard hats are not barriers to all forms of head injuries that can happen at a construction site. Traumatic brain injury (TBI), closed head injury, concussion and coma may result from a variety of hazardous situations at a work site. These conditions can lead to long-term complications and death.
b. Closed head injury: This occurs when the head sustains a blunt force by striking against an object. Most head injuries are closed head injuries. A

concussion is a type of closed head injury that is very common amongst construction workers.

c. Concussion: A concussion is caused by a blow to the head that results in a temporary loss of awareness. When a concussion occurs, it is due to cerebrospinal fluid being unable to cushion the brain from the skull during impact. Some concussions have serious long-term effects, and the risk for long-term effects increases in individuals who have suffered from multiple concussions.
d. Severed nerve: Nerve damage can occur as a result of injury or swelling, and in extreme cases, nerves may be completely severed. When this occurs, a variety of medical conditions may result that cannot be repaired. A severed nerve may cause paralysis on the affected limb or a loss of sensation. Construction workers rely on their physical capabilities to perform day-to-day work. When these capabilities are limited, their entire livelihood can suffer.
e. Spinal cord injuries: The spinal cord carries sensory signals and motor control to most of the skeletal muscles in the body, and almost every voluntary muscle in the body below the head relies on the spinal cord for control. An injury to the spinal cord usually has severe repercussions on the rest of the body. A spinal cord injury can be a life-altering event for the injured and his/her family as round-the-clock care may be necessary after a spinal cord injury.
f. Paralysis: Paralysis occurs when all muscle function is lost for one or more muscle groups. This can be caused by a spinal cord injury, and depending on the type of injury, paralysis may affect just a small part of the body or the entire body. Any form of paralysis will be disruptive to one's life. Routines that were once simple will be incredibly difficult, and your whole quality of life will change if you are paralyzed in a construction accident.
g. Severe cuts: With a variety of tools being used in a busy environment, it is not surprising that serious cuts are common amongst construction workers. Open gashes can become infected and lead to more serious consequences.
h. Burns: Burn injuries are a very real risk at construction sites because of huge amounts of heated water, steam, chemicals and electricity at construction sites. Burns can cause serious long-term consequences, and burn injuries are both slow to heal and extremely painful, with the pain lasting throughout the healing process and for years to follow. Burn survivors often require extensive

medical care, and families of burn victims must often do battle with a sudden unexpected injury that has forever changed their lives.

i. Loss of limb: Suffering a loss of limb is a tragedy for anyone, but for construction workers who rely on their limbs for their livelihood, a loss of limb is particularly devastating.
j. Amputations: Amputations are sometimes necessary following an accident to preserve life. As a surgical measure, amputation controls pain or a disease process and is a preventative measure.
k. Dislocations: Dislocations are a risk inherent in many forms of physical work such as construction and often cause damage to ligaments. Dislocations may require physical manipulation to return the bones to their proper position. Healing from a dislocation can cause construction workers to miss a great deal of work.
l. Broken bones: Broken bones are not only painful but take a long time to heal and require time off from work.
m. Blindness: Construction accidents can result in vision loss or complete blindness. Obviously, the repercussions of losing one's sight are huge and require you to leave work indefinitely in most cases.

2.8 RISKS IN CONSTRUCTION SITE

Risk in construction means the probability of loss associated with physical phase of a construction site. The health and safety executive defined risk as the chance high or low that somebody will be harmed by the hazards (HSE, 1998). Health and safety commission (1995) defined risk as the likelihood that harm will occur. Risk is the probability of unwanted event, combination of hazard, unpredictability, and partiality of the actual result differ from the expected result and the probability of loss (Lim, 2003).

2.9 RISK ASSESSMENT

The Health and Safety Executive (HSE, 1998) defined risk assessment as a process that identifies the hazards associated with particular activities/tasks, evaluates the effects of exposure to these hazards and implements the measure needed to control the risk of injury/ill health to as low a level as possible. In addition, risk assessment has been defined as a structured process that identifies both the likelihood, and extent, of adverse consequences arising from a given activity, facility or system (Kaplan and Garrick 1981; Gillett 1998). The assessment of risks informs risk control decisions, the implementation of which is monitored and reviewed to ensure that risk is controlled and remains within tolerable limits (Lingard and Rowlinson 2005). Assessing risks allows someone to prioritize the action to be taken to control them. In other words, risk assessment is about deciding who might be harmed and then judging how likely it is something goes wrong, and how serious the consequences could be (Mondarres et al, 1999).

It is a systematic examination of all aspects of work that considers:

a. What could cause injury or harm?
b. Whether the hazards could be eliminated and, if not,
c. What preventive or protective measures are, or should be, in place to control the risks.

Without risk assessment, there is no effective prevention possible. Carrying out a risk assessment identifies dangers and the chance of harm happening. Based on this, the proper measures can be taken to prevent or reduce the chance of the harm occurring.

2.9.1 PURPOSE OF RISK ASSESSMENT

The purpose of carrying out a risk assessment is to enable the employer to take the measures necessary for the safety and health protection of workers. These measures include:

a. Prevention of occupational risks.
b. Providing information to workers.
c. Providing training to workers.

d. Providing the organization and means to implement the necessary measures.

2.9.2 RISK ASSESSMENT TOOLS

There are many risk assessment tools and methodologies available to help enterprises and organizations assess their risks. The choice of method will depend on workplace conditions, for example the number of workers, the type of work activities and equipment, the particular features of the workplace and any specific risk. The most common risk assessment tools are checklists, which are a useful tool to help identify hazards. Other kinds of risk assessment tools include: guides, guidance documents, handbooks, brochures, questionnaires, and "interactive tools" (free interactive software, including downloadable applications which are usually sector-specific).

2.10 PROCEDURE OF RISK ASSESSMENT

The European Agency for Safety and Health at Work (EU-OSHA) proposes a model of five steps performing risk assessment, these are:

Step 1: Identifying hazards and those at risk

Step 2: Evaluating risks and prioritizing risks

Step 3: Deciding on preventive action

Step 4: Taking action

Step 5: Monitoring and reviewing

2.10.1 IDENTIFYING HAZARDS AND THOSE AT RISK

The identification of the hazards in all aspects of work should be approached by:

a. Walking around the workplace and looking at what could cause harm
b. Consulting workers and/or their representatives about any problems they have encountered.

c. Examining systematically all aspects of the work, that is:
    - Looking at what actually happens in the workplace or during the work activity (actual practice may differ from the works manual).
    - Thinking about non-routine and intermittent operations (e.g. maintenance operations, changes in production cycles).
    - Taking account of unplanned but foreseeable events such as interruptions to the work activity.
d. Considering long-term hazards to health, such as high levels of noise or exposure to harmful substances, as well as more complex or less obvious risks such as psychosocial or work organizational risk factors
e. Looking at company accident and ill-health records
f. Seeking information from other sources such as:

The identification of all those who might be exposed to the hazards:

For each hazard it is important to be clear about who could be harmed; it will help in identifying the best way of managing the risk. Account should be taken of workers interacting with the hazards whether directly or indirectly, e.g. a worker painting a surface is directly exposed to solvents, while others workers in the vicinity, engaged in other activities, are inadvertently and indirectly exposed. This doesn't mean listing everyone by name, but identifying groups of people such as 'people working in the storeroom' or 'passers-by'. Cleaners, contractors and members of the public may also be at risk.

Particular attention should be paid to:

a. Gender issues
b. Groups of workers who may be at increased risk or have particular requirements:
    - Workers with disabilities
    - Migrant workers
    - Young and old workers
    - Pregnant women and nursing mothers
    - Untrained and inexperienced staff
    - Temporary and part time workers

It is important to identify how these people might be harmed, i.e. what type of injury or ill health may occur.

2.10.2 EVALUATING RISKS AND PRIORITIZING RISKS

The next step is to evaluate the risk arising from each hazard. This can be done by considering:

a. How serious that harm is likely to be that means the severity (e.g. Minor, Moderate, Major)
b. How often (and how many) workers are exposed.
c. How likely it is that a hazard will cause harm (e.g. whether it is improbable, possible but not very likely, probable, or inevitable over time)

Severity: Severity is the degree or extent of injury or harm caused by accidents/incidents arising from workplace hazards. It is classified into three categories: minor, moderate, major.

Table 2.1: Severity Categories & Description (Ministry of manpower, Singapore)

Severity	Description
Minor	No injury, injury or ill-health requiring first aid treatment only includes minor cuts & bruises, irritation, ill-health with temporary discomfort
Moderate	Injury requiring medical treatment or ill-health leading to disability includes lacerations, burns, sprains, minor fractures, dermatitis, deafness, work-related upper limb disorders
Major	Fatal, serious injury or life-threatening occupational disease includes amputations, major fractures, multiple injuries, occupational cancer & acute poisoning & fatal diseases

Likelihood of occurrence of an accident, incident or ill health is classified into three categories: remote, occasional, frequent.

Table 2.2: Likelihood Categories and Descriptors (Ministry of manpower, Singapore)

Likelihood	Description
Remote	Not likely to occur
Occasional	Possible or known to occur
Frequent	Common or repeating occurrence

2.10.3 DECIDING ON PREVENTIVE ACTION

Having evaluated the risks, the next step is to put in place preventive and protective measures. Among the things to be considered at this stage are:

a. Whether risks are preventable or avoidable. Is it possible to get rid of the risk? This can be done, for instance, by:
   - considering whether the task or job is necessary,
   - removing the hazard,
   - Using different substances or work processes.

b. If risks are not avoidable or preventable, how risks could be reduced to a level at which the health and safety of those exposed is not compromised.

Table 2.3 shows the acceptability of risk and recommended actions for different risk levels, which can be used to guide the selection of risk reduction.

Table 2.3: Acceptability of Risk and recommended Actions (Ministry of manpower, Singapore)

Risk Level	Risk acceptability	Recommended actions
Low Risk	Acceptable	• No additional risk control measures may be needed. • May need frequent review to ensure risk level is accurate & does not increase over time.
Medium Risk	Moderately acceptable	• Carry out careful hazard evaluation to ensure risk level is reduced to as low are reasonably

		possible within a defined time period. • Interim risk control measures, such as admin controls, may be implemented. • Management attention is required.
High Risk	Not acceptable	• High Risk level must be reduced to min. Medium Risk before work commences. • There should be no interim risk control measures • Risk controls not be too dependent on PPE. • Hazard should be eliminated before work commences. • Immediate management intervention is required before work commences.

2.10.4 TAKING ACTION

After the most appropriate preventive and protective measures have been identified, the next step is to put them in place effectively.

Effective implementation involves the development of a plan specifying:

a. The measures to be implemented
b. The means allocated (time, expenses etc)
c. Who does what and when
d. When actions are to be completed, and
e. A date for reviewing the control measures.

It is important to involve workers and their representatives in the process:

a. To inform them about the measures implemented, about how they will be implemented, and who will the person in charge of implementing them
b. To train or instruct them about the measures or procedures that will be implemented.

2.10.5 MONITORING AND REVIEWING

Arrangements for monitoring and reviewing the protective and preventive measures should be introduced following the risk assessment to ensure that the effectiveness of these measures is maintained, and the risks controlled. The information generated by monitoring activities should be used to inform the review and revision of the risk assessment. Risk assessment should not be a once-and-for-all activity. The assessment needs to be reviewed and revised, as necessary, for a number of reasons, including:

a. The degree of change likely in the work activity
b. Changes which might alter the perception of risk in the workplace, such as a new process, new equipment or materials, change of work organization, and new work situations including new workshops or other premises
c. Once the new measures have been introduced following the assessment, the new working conditions should be assessed in order to review the consequences of the change. It is essential that the risk is not transferred, that is to say that in providing a solution to one problem, another problem should not be created
d. The assessment no longer being applicable because the data or information on which it is based is no longer valid
e. The preventive and protective measures currently in place being insufficient or no longer adequate, e.g. because new information is available regarding particular control measures
f. As a result of the findings of an accident or “near miss” (a near miss is an unplanned event that did not result in injury, illness, or damage - but had the potential to do so).

2.11 IMPORTANT FACTORS FOR CARRYING OUT THE RISK ASSESSMENT

Persons carrying out risk assessments at work should have knowledge of and/or information on:

a. Hazards and risks which are already known to exist, and the way that they arise
b. The materials, equipment and technology used at work
c. Working procedures and organization and interaction of workers with the materials used
d. The type, likelihood, frequency, and duration of exposure to the hazards. In some cases this may mean the application of modern, validated techniques of measurement
e. The relation between exposure to a hazard and its effect
f. The legal standards and requirements relevant to the risks present in the workplace
g. What is regarded as good practice in areas where there are no specific legal standards?

2.12 ENGINEER'S ROLES AND RESPONSIBILITIES

a. Plans, schedules and provides work direction as required for preparation of designs, processes, reports, correspondence and related data and assures the efficiency, adequacy and conformance to overall objectives of all phases of very complex engineering problems.
b. Support the development and formulates the basis for studies in the fields by analyzing and evaluating all data pertinent to problems.
c. Evaluates data as to scope, effect on existing installations, economic value, and long range planning and budgetary considerations.
d. Leads the activists of project proposal that include development of scope, functions, interrelationship, integration, physical solution definition, cost estimate, etc.
e. Leads project execution for project proposal, initiatives, studies and continuous improvement of solutions and Problem solvers.
f. Initiates detailed work outline and makes decision as to basic approaches, processes and/or equipment.
g. Performs work and/or delegates work to other engineers for final development of specialized or technical proposals and proposed projects.

h. Brings all elements of a project together, makes certain that all elements proceed satisfactorily on schedule and within the money allowed; and initiates corrective action as required.
i. Reviews cost estimates, recommendation from vendors, consultants, and licensors.
j. Discusses, coordinates and resolves problems with personnel throughout subsidiaries and with outside of company organizations.
k. Acts as technical consultant when required.
l. Recommends new installations or modifications to improve existing facilities and standardization within broad fields of endeavor.
m. Estimates costs, prepares justifications and completes expenditure requests as required. Reviews work of engineers directed.
n. Checks that reports are written according to established methods of good report presentation. Takes recommendations for further study or report changes.
o. Approves reports for transmittal to supervisor

2.13 EMPLOYERS' ROLES AND RESPONSIBILITIES

Employers should carefully prepare what they are going to do in order to meet their responsibilities to make a risk assessment, and put in place the measures necessary for the safety and health of workers. It is recommended that they do this through an action plan for the elimination or control of risks. The action plan should include:

a. Commissioning, organizing and coordinating the assessment
b. Appointing competent people to make the assessments
c. The person carrying out the risk assessment can be:

- The employers themselves.
- Employees designated by the employers.
- External assessors and service providers if there is a lack of competent personnel in the workplace

d. people can demonstrate their competence by showing that they have the following abilities:
   - An understanding of the general approach to risk assessment,
   - The capacity to apply this understanding to the workplace,
   - The ability to identify situations where they would be unable to adequately assess the risk without help, and be able to advise on the need for further assistance

e. consulting workers' representatives on arrangements for the appointment of those who will make the assessments

f. Providing the necessary information, training, resources and support to assessors who are the employer's own employees

g. Ensuring adequate coordination between assessors (where relevant)

h. Involving management and encouraging the participation of the workforce

i. Determining the arrangements to be made for reviewing and revising the risk assessment

j. Ensuring that the preventive and protective measures take account of the results of the assessment

k. Ensuring that the risk assessment is documented

l. Monitoring the protective and preventive measures to ensure that their effectiveness is maintained

m. Informing workers and/or their representatives of the results of the assessment and of the measures introduced (making the records available to them).

2.14 WORKERS' ROLES AND RESPONSIBILITIES

It is important that workers participate in the risk assessment. They know the problems and the details of what really happens when they perform their tasks or activities, so they should be involved in the assessment. Their practical knowledge or competence is also often needed to develop workable preventive measures.

Workers' participation is not only a right, it is fundamental to make the employers' occupational health and safety management effective and efficient.

Workers and/or their representatives have the right/duty to:

a. Be consulted on arrangements for the organization of the risk assessment and for the appointment of those undertaking the task
b. Participate in the risk assessment
c. Alert their supervisors or employers regarding perceived risks
d. Report any changes in the workplace
e. Be informed of the risks to their safety and health and of the measures necessary to eliminate or reduce these risks
f. Be involved in the process of deciding on the preventive and protective measures to be put in place
g. Ask the employer to put in place appropriate measures and to submit proposals to minimize hazards or to remove the danger at source
h. Cooperate to help the employer to ensure that the working environment is safe
i. Be trained/receive instructions on the measures to be put in place
j. Take care as far as possible of their safety and health and that of others persons affected by their acts in accordance with the training and the instructions given by the employer

In addition, it is important workers representatives are trained so that they understand risk assessment and their role in it.

2.15 RISK MANAGEMENT

Risk Management is defined in the standard (AS/NZS 4360:2004) as "the systematic application of management policies, procedures and practices to the tasks of establishing the context, identifying, analyzing, assessing, treating, monitoring and communicating".

Risk management is an activity which integrates recognition of risk, risk assessment, developing strategies to manage it, and mitigation of risk using managerial resources. Some traditional risk managements are focused on risks stemming from physical or

legal causes (e.g. natural disasters or fires, accidents, death). Financial risk management, on the other hand, focuses on risks that can be managed using traded financial instruments. Objective of risk management is to reduce different risks related to a pre-selected domain to an acceptable. It may refer to numerous types of threats caused by environment, technology, humans, organizations and politics.

2.16 RISK MANAGEMENT PROCESS

Risk management is done by following some steps given below (Heinz-Peter Berg, 2010):

1. Establishing goals and context
2. Identify risks
3. Analyzing the identified risks
4. Assessing or evaluating the risks
5. Treating or managing the risks
6. Monitoring and reviewing risks and the risk environment regularly
7. Continuously communicating, consulting with stakeholders and reporting

2.16.1 ESTABLISHING GOALS AND CONTEXT

The purpose of this stage of planning enables to understand the environment in which the respective organization operates, that means to thoroughly understand the external environment and the internal culture of the organization. The analysis is undertaken through:

a. Establishing the strategic, organizational and risk management context of the organization,
b. Identifying the constraints and opportunities of the operating environment.

2.16.2 IDENTIFY RISKS

The appropriate risk identification method will depend on the application area (i.e. nature of activities and the hazard groups), the nature of the project, the project phase,

resources available, regulatory requirements and client requirements as to objectives, desired outcome and the required level of detail.

The use of the following tools and techniques may further assist the identification of risks:

- Examples of possible risk sources,
- Checklist of possible business risks and fraud risks,
- Typical risks in stages of the procurement process,
- Scenario planning as a risk assessment tool ,
- Process mapping, and
- Documentation, relevant audit reports, program evaluations and / or research reports.

2.16.3 ANALYZING THE IDENTIFIED RISKS

Risk analysis involves the consideration of the source of risk, the consequence and likelihood to estimate the inherent or unprotected risk without controls in place. It also involves identification of the controls, an estimation of their effectiveness and the resultant level of risk with controls in place (the protected, residual or controlled risk). Qualitative, semi-quantitative and quantitative techniques are all acceptable analysis techniques depending on the risk, the purpose of the analysis and the information and data available.

2.16.4 EVALUATE THE RISK

Once the risks have been analyzed they can be compared against the previously documented and approved tolerable risk criteria. When using risk matrices this tolerable risk is generally documented with the risk matrix. Should the protected risk be greater than the tolerable risk then the specific risk needs additional control measures or improvements in the effectiveness of the existing controls.

The decision of whether a risk is acceptable or not acceptable is taken by the relevant manager. A risk may be considered acceptable if for example:

- The risk is sufficiently low that treatment is not considered cost effective, or
- A treatment is not available, e.g. a project terminated by a change of government, or

- A sufficient opportunity exists that outweighs the perceived level of threat.

If the manager determines the level of risk to be acceptable, the risk may be accepted with no further treatment beyond the current controls. Acceptable risks should be monitored and periodically reviewed to ensure they remain acceptable. The level of acceptability can be organizational criteria or safety goals set by the authorities.

2.16.5 TREAT THE RISK

An unacceptable risk requires treatment. The objective of this stage of the risk assessment process is to develop cost effective options for treating the risks. Treatment options which are not necessarily mutually exclusive or appropriate in all circumstances are driven by outcomes that include:

- Avoiding the risk,
- Reducing (mitigating) the risk,
- Transferring (sharing) the risk, and
- Retaining (accepting) the risk.

2.16.6 MONITORING THE RISK

It is important to understand that the concept of risk is dynamic and needs periodic and formal review. The currency of identified risks needs to be regularly monitored. New risks and their impact on the organization may to be taken into account.

This step requires the description of how the outcomes of the treatment will be measured. Milestones or benchmarks for success and warning signs for failure need to be identified. The review period is determined by the operating environment (including legislation), but as a general rule a comprehensive review every five years is an accepted industry norm. This is on the basis that all plant changes are subject to an appropriate change process including risk assessment.

2.16.7 COMMUNICATION AND REPORTING

Clear communication is essential for the risk management process, i.e. clear communication of the objectives, the risk management process and its elements, as well as the findings and required actions as a result of the output. Risk management is an integral element of organization´s management. However, for its successful adoption it is important that in its initial stages, the reporting on risk management is visible through the framework. The requirements on the reporting have to be fixed in

a qualified and documented procedure, e. g., in a management handbook. Documentation is essential to demonstrate that the process has been systematic, the methods and scope identified, the process conducted correctly and that it is fully auditable. Documentation provides a rational basis for management consideration, approval and implementation including an appropriate management system. A documented output from the above sections (risk identification, analysis, evaluation and controls) is a risk register for the site, plant, equipment or activity under consideration. This document is essential for the on-going safe management of the plant and as a basis for communication throughout the client organization and for the on-going monitor and review processes. It can also be used with other supporting documents to demonstrate regulatory compliance.

2.17 SUMMARY

In this chapter risk assessment and risk management process is shortly discussed. In the developing countries like Bangladesh most of the construction industry doesn't perform all of these. As a result sometimes probable accidents occurs which results loss of a handsome amount of money. But after performing these assessment and management process if they are able to take safety measures then, the probable accidents will be able to prevent. In our study we will try to show the comparison between the costs involves with probable accidents and the costs involves with safety measures which should be taken to prevent those probable accidents.

CHAPTER 3

METHODOLOGY

3.1 GENERAL

The chapter discusses about the procedure that has been followed to conduct the study. It also includes the risk evaluation between different accidents in construction sites. A survey of costs regarding different safety measures and accident will be carried out and analysis of costs on happening of accidents comparing to the costs of safety measures will be conducted. Then a reasonable conclusion will be shown.

3.2 METHODOLOGY

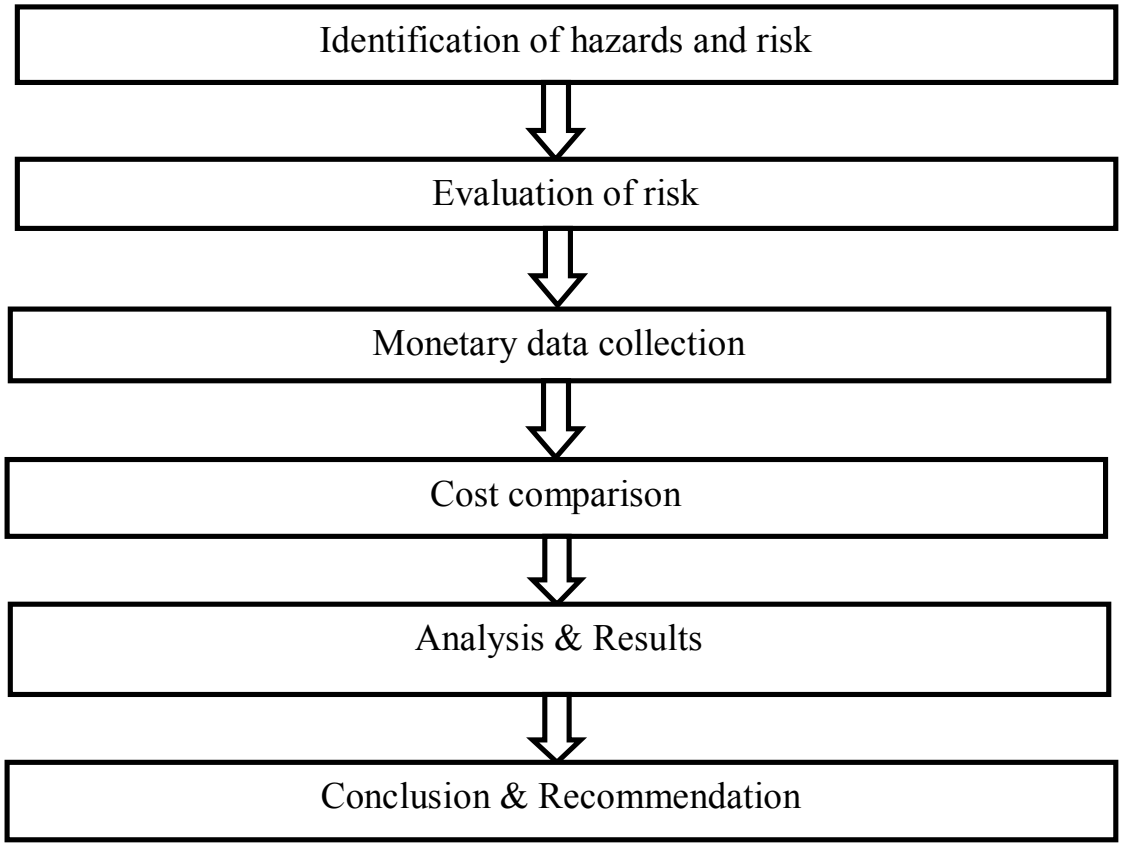

Figure 3.1: Flowchart of the methodology of the study

Figure 3.1 shows the methodological flowchart of the study that includes identification of hazards, evaluation of risk, monetary data collection, cost

comparison, analysis & results, conclusion & recommendation. The topics are described in details below.

3.2.1 IDENTIFICATION OF HAZARDS AND RISK

In Bangladesh, day by day construction technology is improving. We can see the increasing rate of developer companies in Bangladesh in a significant way. Although in many sectors of constructions it is getting better, very less activities are seen regarding safety during construction.

In various stages labours, passers-by & surroundings are negatively affected due to this lack of safety measures. The investors or employers are now prepared to invest a lot for higher productivity, so if the safety measures are not noticed by them significantly. But we can say that somewhere this safety measures can improve productivity too. As skilled labours and other workers would like to work in a safer environment.

Many accidents during construction happen because of reasons which can easily be minimized with available safety measures. As these safety measures involve some handsome amount of money and the probability of accidents is not fixed thus employers try to save some money by avoiding this safety measures.

The next task is to find out the risks relating to the hazards.

3.2.2 EVALUATION OF RISK

The risks of different activities during construction shall be evaluated on the basis of scales like severity, likelihood and risk level. This evaluation shall help to the investigation of categorizing of different safety measures according to the level of risks it involves as the budget relating to safety may be tight.

To evaluate risks relating to identified hazard checklist which has been taken from the guideline named “Workplace Safety and Health, Risk Management: Risk Assessment guidelines” published by ministry of man power Singapore has been used. Also an

evaluation program done by Cityscape International Limited helped to evaluate risks of hazards and accidents.

After evaluation of risks has been conducted the relating costs of accidents and safety measures are then to be found out.

3.2.3 MONETARY DATA COLLECTION

Data was collected from the ongoing project of 14 storied building with 2 basements of Cityscape International Limited. The primary safety equipments costs like Safety Hamlet, Safety belt , Safety gum boot, Safety T shirt, Safety Sun glass, Hand gloves, Safety Shoe, Welding helmet, Welding Hand Protector, Welding sunglass, Safety red tape, Staff Safety Shoe, Fire extinguisher, Fire Bucket, Staff T shirt were collected from the company.

Also the Costs of injury of different accidents and rest time of workers which happened in the construction site was given by the company. An interview was taken from Chief engineer and his staff of the company to collect some data relating to the accident in construction sites & mitigation measures that will help to assess the risk.

Survey be will made through questionnaire distributed to respondents who involve in various types of building construction works in wide range of area in Bangladesh. The respondents are people who work as: mason, labor, carpenter, steel bender, plumber, electrician, painter, welder etc. They work at construction companies in Bangladesh both private and government.

After completion of monetary data collection it is then required to compare the monetary terms.

3.2.4 COST COMPARISON

After completion of data collection of cost involved in accidents and mitigation measures & questionnaire survey in different sites, all the necessary information and data are put in our risk assessment formulas and tables in order to arrange in a queue and compare the cost by benefit cost ratio.

3.2.5 ANALYSIS AND RESULTS

Cost comparison between accidents related costs and preventive measures by benefit cost ratio is to be done and then analyze the result. The cost benefit ratio will have to be greater than one. The results obtained from the data analysis will be explained in detail.

3.2.6 CONCLUSION AND RECOMMENDATION

The effectiveness of the risk assessment & cost comparison will be described in conclusion. How people can be benefitted using the output of this study to improve the safety of workers, engineers & general public and mitigate the accidents in construction sites at Bangladesh will be discussed in detail. Possible enhancement of this study or future research guideline will also be recommended.

CHAPTER 4

COST ANALYSIS IN RISK ASSESSMENT

4.1 GENERAL

The chapter discusses how the accidental cost and the cost related to safety measures that have been taken to mitigate that accidents are calculated. It also discusses the considerations that have been taken to perform these calculations. All the processes have been done through risk assessment.

4.2 RISK ASSESSMENT

The main purpose is to perform basic risk assessment which includes hazard identification, finding out of probable accidents, then costs of these accidents are to be calculated using the level of severity and likelihood. The probable costs of preventive measures to mitigate the accidents are then calculated. A checklist provided in a guideline of risk assessment done by ministry of manpower, Singapore has been followed to collect the necessary division of activities, hazards, probable accidents, severity, likelihood and also the preventive measures. Additionally the costs of possible accident and the preventive measure are added. Table 4.1 shows the checklist which has been taken from the guideline named "Workplace Safety and Health, Risk Management: Risk Assessment guidelines" published by ministry of man power Singapore. Following this table from a construction site specific work activities will be selected, the hazards and possible accidents related to those activities will be found out; risk level will be determined using severity and likelihood. Table 4.2 is the modification of Table 4.1 shows an example of costs of accidents and mitigation measures of an activity, excavation works. Like this one cost of all considered activities has been calculated.

Table 4.1: Risk assessment form (Ministry of manpower, Singapore)

No.	1. Hazards Identification			2. Risk Evaluation				3. Risk Control	
	Work Activity	Hazards	Possible Accidents/Ill-health and Persons at Risk	Existing Risk Control (If any)	Severity	Likely-hood	Risk Level	Additional Risk Control Measures	Action Officer, Designation (Follow-up date)

Table 4.2: Example of Risk assessment form (Excavation works)

	1. Hazards Identification			2. Risk Evaluation				3. Risk Control	
	Work Activity	**Hazards**	**Possible accidents**	**Severity**	**Likely-hood**	**No. of labor affected**	**Possible Cost of accident**	**Preventive measures**	**Possible cost of preventive measure**
1	Excavation works	Excavation without railing	Workers and visitors fall into the lower place which results serious injury or death.	4	2	8	74240	Provide railing	115040
		Underground power lines like gas, water, electricity	Electric shock. Slip which may cause minor injury.	2	3	7	38640	Pre observation before starting excavation work.	Indirect cost
		Use of defective hoe	Serious injury.	5	1	3	21360	Checking hoe before use.	Indirect cost

Data related to severity, likelihood, costs of accident and preventive measures are collected from a project of Cityscape International Limited and also from detailed discussion with experienced engineers of that project.

4.3 PROJECT DESCRIPTION

Construction of a 14 storied building with 2 basements has been selected as a case project of this study. The construction site is located at 53, Gulshan Avenue, Dhaka. The building is constructed by Cityscape International Limited. This is going to be the first green building in Bangladesh to receive LEED Platinum status. Each floor of the building is 5700 square feet. The building contains mat foundation and perimeter of the building is 112ft*75ft, it has also left 40% land according to Rajdhani Unnayan Corporation (RAJUK). The expected duration of construction work is about 3 years. There is also a chief engineer, a project manager, a project engineer, a sight engineer, an electrical engineer and a safety engineer.

From this project all the hazards, probable accidents form these hazards and also the preventive safety measures are identified.

In this case study common work activities has been considered including Excavation works, Reinforcement erection and bending, Form works, Concrete works, Scaffolding, Brick works, Out plastering, Works without railing, Works with heavy equipments and machine, Electric works, Plumbing works, Carpentry works, Fitting works, Painting works.

4.4 HAZARD IDENTIFICATION

Each and every construction activities contains a number of hazards which are responsible for accidents. All these hazards have been identified and the probable accidents that may happen due to these hazards has found out. The accidents may be reduced or mitigated or prevented if proper mitigation measures are identified and applied. Here hazards of selected activities, probable accidents due to hazards and the preventive measures which have been used to prevent the accidents are described in details.

4.4.1 EXCAVATION WORKS

Excavation is a very initial part during a construction work. In order to form the base (footing, pile, raft etc) an excavation must be performed. There are possibilities of accidents during the excavation as workers or visitors falling in the excavated portion by electric shock, slipping or for very congested area. They may cause severe injuries or may bring even death. The accident probability may be reduced by providing railing. Underground power line is another hazard which may cause minor injury. Pre observation may reduce the accident. Sometimes use of defective hoe may cause serious accident.

Table 4.3: Hazards, probable accidents and preventive measures of excavation work.

No	Hazards	Probable accidents	Preventive measures
1	Excavation without railing	Workers and visitors fall into the lower place which results serious injury or death.	Provide railing
2	Underground power lines like gas, water, electricity.	Electric shock. Slip which may cause minor injury.	Pre observation before starting excavation work.
3	Use of defective hoe.	Serious injury.	Checking hoe before use.

4.4.2: REINFORCEMENT ERECTION AND BENDING

After excavation work reinforcement are required for foundation work. In the project mat foundation was selected. It is also required for beam, grade beam, and column, slab and shear wall. So a huge amount of reinforcement is required. During reinforcement erection and bending someone may get hit by hammer, sparks, and flumes may cause illness, fire explosion can occur, physical injuries to fatal incidents may occur. To minimize accidents PPE would help, proper training is needed; caps can be used on the ends of the bars, fire extinguisher in need.

Table 4.4: Hazards, probable accidents and preventive measures of reinforcement erection and bending:

No	Hazards	Probable accidents	Preventive measures
1	Manually cutting by hammer	Hit by hammer causes injury.	Gloves, boot, protective clothes
2	Cutting by saw	Sparks and fumes can cause illness in eye and skin.	Glass, Gloves Protective clothes Boot
3	Cutting by Oxy acetylene torch.	Burns part of body. Fire explosion.	Glass, Gloves, Protective clothes, Boot, Fire extinguisher
4	Manually bending	Strain, Sprain, Injury, Back damage, Teeth damage	Proper training.
5	Sharp edge.	Injury, Death	Sign board, caps on the end of the bars.
6	Welding of rod	Burns, Eye damage, Fire spread, death	Gloves, Glass, Fire extinguisher

4.4.3: FORM WORKS

After erection and bending of reinforcement, form works is required to provide a exact shape of beam, grade beam, column, shear wall and slab. Form works or shuttering works may be done by steel sheet and pipe or wood and bamboo. During form works by steel sheet and pipe fire spreading from welding can cause burns, eye damage, skin diseases and even fatal incidents. Sometimes due to contact with streaky materials skin rashes, allergies may rise. By using PPE and training can minimize these accidents. If the shuttering materials is of wood and timber then there is probable of puncture of nails in the body which is used for joint purpose. Again the materials may fall from high position which may cause injury or death which may be

prevented by safety net. Workers working under the shuttering works may be injured hit by the falling object. Safety helmet should be provided to those workers.

Table 4.5: Hazards, probable accidents and preventive measures of form work.

No	Hazards	Probable accidents	Preventive measures
1	Sparks from welding.	Burns, Eye damage, Fire spread	Gloves, Glass, Fire extinguisher, Proper planning of storage materials.
2	Nails in timber.	Puncture the nail in the body.	Boot Checking the area.
3	Form oil, streaky materials.	Skin rashes, allergies, falling object.	Hand gloves.
4	Falling object from height.	Death, Injury.	Net, safety truss, helmet.
5	Roof, column side shuttering.	Shuttering materials fall on the body causes injury.	Checking and proper management.

4.4.4: CONCRETE WORKS

After completing of each form woks concrete work starts. Concrete works bear great importance and also during it may direct as well as indirect problem or accident can occur. Skin cancer, lung cancer, asthma, allergy, dermatitis may occur due to keep on contact with concrete after a long period of time. By using PPE these can be prevented. Minor or major injury or sometimes death may happen due to presence of sharp edge of steel, wet concrete at the time of pouring. By using safety signs, caps in bars we can reduce the rates and probabilities of these accidents.

Table 4.6: Hazards, probable accidents and preventive measures of concrete works:

No	Hazards	Probable accidents	Preventive measures
1	Cement dust from cement bag.	Lung cancer, asthma.	Using mask.
2	Sharp edge on slab.	.Serious injury	Sign board, caps on the end of the bars
3	Walking on deck during pouring	Slip and fall on wet concrete and reinforcement, twist ankle or knee	Boot, use wood or plastic to get dry and smooth surface
4	Skin and eye contact with concrete	Skin cancer, allergy, dermatitis, concrete splashed in eye.	Protective clothes, boot, protective glass, gloves
5	Working with grinding machine without goggles.	Defects in eye.	Goggles

4.4.5: SCAFFOLDING

Scaffolds are used for shuttering works, brick works, plastering works at high altitude. During scaffolding works severe injuries to fatal incident is possible due to fall of tools or raw materials, again there are normally very small space to perform those works. Using of Guard rails, diagonal braces, PPE these injuries may be reduced; also pre-planning, proper checking before starting the works is required to avoid the accidents.

Table 4.7: Hazards, probable accidents and preventive measures of scaffolding:

No	Hazards	Probable accidents	Preventive measures
1	Fall from height (human and materials).	Death, Injury.	Guard rail, Safety belt, Net, Tin shed.
2	Inadequate working place.	Injury. Ill health (disability).	Pre plan.
3	Improper Scaffolding	Fall the whole scaffold.	Checking before starting work.

4.4.6: BRICK WORKS

Bricks are used throughout the whole project works. Manual carrying or lifting of bricks results muscular strain which reduces the work speed of the worker, again continuous works may cause failure of workability in the early age. Brick work session can cause accidents that may cause minor to severe injuries, even deaths because of falling the bricks or worker from high altitude. Using PPE, net, safety truss (with tin shed), lifting machine can reduce the probability of accident.

Table 4.8: Hazards, probable accidents and preventive measures of brick works:

No	Hazards	Probable accidents	Preventive measures
1	Bricks fall from height	Injury, death	Net, tin shed, helmet
2	Manual Lifting of bricks.	Falling with heavy load.	Lifting machine.
3	Working at height	Fall from edge	Safety belt, strengthen hand rail, mid rail, scaffold

4.4.7: OUT PLASTERING

When the whole structure stands plastering works is required to provide a plane surface both inside and outside of the structure. During the work of our plastering accidents can cause injury to death due to falling object or workers from high altitude. Again carrying and lifting of mortar results muscular strain which reduces the work speed of the worker, again continuous works may cause failure of workability in the early age. Using PPE, net, safety truss (with tin shed), mechanical devices can loosen it down.

Table 4.9: Hazards, probable accidents and preventive measures of out plastering:

No	Hazards	Probable accidents	Preventive measures
1	Fall from height	Injury. Death.	Net, Tin shed, Helmet, Safety belt.
2	Carrying heavy load.	Muscular strain.	Lifting system. Use of mechanical devices.
3	Mixing and placing the mortar manually.	Skin disease.	Gloves.

4.4.8: WORKS WITHOUT RAILING

During work in the upper floor of building workers have to go through the stairs. If railing is not provided in the stairs workers may have fallen to down. Again if the rail is not provided in the lift core same accidents may happen. At the time of doing various works at the different level of the building without guard railing, workers may have fallen direct to the ground level which may cause serious injury even sometime may cause death. Due to injury sometimes worker are not able to do work. These accidents may be prevented by providing safety railing.

Table 4.10: Hazards, probable accidents and preventive measures of works without railing:

No	Hazards	Probable accidents	Preventive measures
1	Work on upper floor without guard rail	Death or serious injury.	Guard rail
2	Lift core without railing	Death or serious injury.	Guard rail
3	Going upper floor with stair without railing	Serious injury	Guard rail

4.4.9: WORKS WITH HEAVY EQUIPMENTS AND MACHINE

Construction works required a lot of heavy machineries and equipments like crane, lifting machine etc to do works faster. Again raw materials with heavy loads are required to move one place to another place like bricks, cement, sand, stones, concrete blocks, tiles, reinforcement, steel pipe, angle, tin shed etc. At the time of moving heavy machine or moving raw material with heavy load workers may be stuck by these heavy load due to lack of knowledge about the exact load. It causes serious injury, sometimes death. Proper management is required to avoid the accidents. Before using any equipments or machineries or any types of raw materials workers should have the idea about that which should be provided to them.

Table 4.11: Hazards, probable accidents and preventive measures of works of heavy load and equipments:

No	Hazards	Probable accidents	Preventive measures
1	Moving Machine equipment (Belt, rope, gear) without proper guarding.	Serious injury, death.	Proper management.
2	Loading unloading machine without load tested.	Serious injury, death.	Load test before starting work.

4.4.10: ELECTRIC WORKS

Electric works is required throughout the whole project activities. To run any electrical equipment electric power supply needed. After completing the construction works electricity also required to be supplied. During different electric works accidents can occur by short circuit, stuck by electric wire, wet condition near the power line that may cause fire, injuries for which workers may lose their workability or sometimes death. PPE, training, keeping fire extinguisher can reduce the impacts. Electric experts should be provided so that works may be done in a proper way.

Table 4.12: Hazards, probable accidents and preventive measures of electric works:

No	Hazards	Probable accidents	Preventive measures
1	Short circuit	Electric fire Burns of raw materials, Death, Injury.	Training for using fire fighting materials/ extinguisher.
2	Stuck by electric wire (high rise crane/	Injury, Death by shock.	Extra man power to supervise.

	vehicle).		
3	Use metallic tools near the power line	Injury, Death by shock.	Gloves
4	Wet condition near the power line	Injury, Death by shock.	Boot, Protective clothes, Gloves, Cover the power line.

4.4.11: PLUMBING WORKS

Plumbing works are required to provide water supply, waste disposal and sanitation facilities. To conduct the works tiles, steel pipes, plastic pipes are needed to cut down to get required shape which is done by manual saw or electrical saw machines, and also some other machineries to setup them. During these works accidents may cause serious cut of the parts of the body by different types of sharp plumbing equipments which results physical disabilities for life time. These accidents may be reduced by proper instruction and awareness which should be provided before starting the works.

Table 4.13: Hazards, probable accidents and preventive measures of plumbing works:

No	Hazards	Probable accidents	Preventive measures
1	Cutting tiles by saw machine.	Serious cut of hands.	Proper instruction and awareness.
2	Cutting steel pipe, plastic pipe by saw machine.	Serious cut of hands.	Proper instruction and awareness.

4.4.12: CARPENTRY WORKS

Carpentry works needed to provide doors, windows and furniture. During the carpentry works accidents may cause serious cut of the parts of the body by different types of sharp carpentry equipments which may be reduced by using some personal

protective equipments. Proper instruction of works can be provided by safety engineers.

Table 4.14: Hazards, probable accidents and preventive measures of carpentry works:

No	Hazards	Probable accidents	Preventive measures
1	Manually cut of woods.	Cut of parts of the hands.	Hand gloves.
2	Sharp materials used for different carpentry works.	Cut of parts of the body.	Proper instruction. Hand gloves.

4.4.13: FITTING WORKS

Fitting works are required for air conditioning facility, interior designing and also the setting up of glasses where it is required in a building. During the fitting works accidents may cause serious cut of hands by different types of sharp equipments and glass which may be reduced by some personal protective equipments. Some proper instruction of works can be provided by safety engineers.

Table 4.15: Hazards, probable accidents and preventive measures of fitting works

No	Hazards	Probable accidents	Preventive measures
1	Aluminum pipe cutting for stairs.	Serious cut of hands.	Proper instruction and awareness.
2	Handling the sharp edged aluminum materials manually.	Cut of parts of the hands.	Hand gloves.
3	Handling glass manually.	Cut of parts of the hands.	Hand gloves.
4	Setting the glass outside the building.	Fall from high place.	Safety belt.

5	Setting the aluminum frame for doors and windows and glass frame.	Cut of parts of the hands.	Hand gloves.

4.4.14: PAINTING WORKS

For beautification and weather protection of a building painting works is required. During painting works the painters should always keep in contact with chemical compounds which results internal damage of body can occur, skin diseases after a long period of time. Sometimes they may be affected instantly if the chemical compounds enter into the eyes, ears, nose and mouth. Using PPE and safety papers can lessen the accidents and its impacts.

Table 4.16: Hazards, probable accidents and preventive measures of glass works:

No	Hazards	Probable accidents	Preventive measures
1	Touching toxic solvent (spray, polish).	Skin disease.	Gloves, Safety suit.
2	Taking in chemical compound by breathing.	Internal damage of the body.	Mask.
3	Chemical split over the neighborhood	Injury of other people.	Safety paper around the working place.
4	Spray painting without Mask, goggles. (Act)	Breathing problem, defects in eye, asthma, allergy.	Mask, goggles.

After the identification of hazards, probable accidents and the preventive measures are done the portion of cost of accident and the cost of preventive measures with monetary expressions follows.

4.5 POSSIBLE COSTS RELATED TO ACCIDENTS

Each and every accident in construction site involves a handsome amount of money from which a portion is paid by the construction company and the rest portion is paid by the workers who are injured from that accident. If it is possible to prevent the accidents by using safety measures, the portion that would have paid by the construction company to the injured workers due to that accident terms as benefit.

The costs are mainly of two types:

1. Direct cost, such as:
    - ✓ Medical costs carried by company related to accidents.
    - ✓ Daily payment to the injured labors during the time they are out of work.
    - ✓ Possible strikes by labors for anyone's death.
    - ✓ Costs of outer damages because of construction site activities.
    - ✓ Death compensations.
2. Indirect costs, such as:
    - ✓ Commercial image loss of the company.
    - ✓ Police harassment.
    - ✓ Loss of materials.
    - ✓ Collapse of walls, destroying equipments etc.

4.6 CONSIDERATIONS FOR COSTS

For the calculation purpose some acts are considered. To show the minimum cost range the minimized estimation in each of the aspects are considered in cost parts calculations. The main considerations are the severity and likelihood of the probable accidents.

4.6.1 SEVERITY AND LIKLIHOOD

Severity mainly expresses how much serious the accidents can be, by experienced workmen's given data and estimation.

Likelihood is the fact that expresses the possibility of the accidents to occur during construction which we have got from experienced engineers, labors, masons etc.

Most of the severity and likelihood scale that have been considered are gotten from a risk assessment project done by Cityscape International Limited.

For simplification of calculations the severity and likelihood values are considered in a scale carrying values from 1 to 5. Table 4.17 and 4.18 shows the severity and likelihood level and their meaning.

Table 4.17: Severity level and their meaning

Severity	Loss level
1	Very low
2	Low
3	Moderate
4	High
5	Very high

Table 4.18: Likelihood level and their meaning

Likelihood	Possibility of accidents
1	Very low
2	Low
3	Moderate
4	High
5	Very high

After getting the severity and likelihood of accidents it is clearly observed that how much the workers may be affected by the accidents and the probability of those accidents. But to find out the loss from an accident it is essential to know the amount of medical cost given by the company and the actual cost that the workers have to pay.

4.6.2 MEDICAL COST

For accidents workers have to face minor or major injuries for which they have to be admitted in hospital and sometimes they have to stay there for several days for which they need money for medical fees, medicine, foods. Moreover they cannot go for work, so their source of income is terminated. Considering all of this construction company pays a portion of medical cost and also pay injured worker's some day's salary. In Table 4.19 the portion of medical cost per injured worker given by Cityscape International Limited and the number of days for which the salary is paid to them is shown.

Table 4.19: Portion of medical cost given by Cityscape International Limited and the rest time of injured worker.

No	Topics	Lump sum medical cost per person (BDT)	Rest time / unable to do work (Days)
1	Hand damage (broken)	20,000 – 30,000	10
2	Leg damage (broken)	20,000 – 30,000	10
3	Head damage	20,000 – 30,000	7
4	Leg sprain	2,000 – 2,500	3
5	Hand sprain	2,000 – 2,500	3
6	Serious electric shock	2,000 – 2500	3
7	Stroke	2,000 – 2500	2
8	Burn of a part of a body	10,000 – 15,000	5
9	Eye damage	20,000 – 30,000	15
10	Serious cut of hand	10,000 – 15,000	7
11	Serious cut of leg	10,000 – 15,000	7
12	Serious cut of a part of body	10,000 – 15,000	7
13	Minor cut of a part of a body	2,000 – 2500	1
14	Back bone damage	2,000 – 2500	1
15	Teeth damage	10,000 – 15,000	2
16	Twist of ankle or knee	2,000 – 2500	1
17	Internal damage of body	10,000 – 15,000	1

But the actual cost and rest time is more than that shown in Table 4.19. Different accident related medical cost and relating rest time periods are obtained from Khwaja Yunis Ali medical college hospital, Sirajganj is shown in Table 4.20.

Table 4.20: Costs of injury of different accidents and rest time of patient (Khwaja Yunis Ali medical college and hospital, Sirajganj)

No	Topics	Lump sum medical cost per person (taka)	Rest time/Unable to do work (Days)
1	Hand damage (broken)	Unilateral-30000/- Bilateral-55000/-	6 weeks for simple fracture. 6 month for compound fracture.
2	Leg damage (broken)	Unilateral - 95000/- Bilateral - 180000/-	6 month for simple fracture. 1.5 year for compound fracture.
3	Head damage	External fracture -30000/- to 150000/- Internal damage -100000/- to 250000/-.	15 days to 6 months for external fracture. 6 months to lifelong
4	Leg sprain	Unilateral - 4000/- Bilateral - 8000/-	4 weeks
5	Hand sprain	Unilateral - 2000/- Bilateral - 4000/-	3 weeks
6	Serious electric shock	20000/- to 100000/-	1 week to 4 weeks.
7	Stroke	Ischaemic- 30000/- Haemorrhagic- 80000/- to 200000/-	6 months to lifelong.
8	Burn of a part of a body	7000/- to 25000/-	1 month to 3 months.
9	Eye damage	10000/- to 100000/-	1 month to lifelong
10	Eye infection	3000/- to 10000/-	1 Week to 1 month.

11	Serious cut of hand	3000/- to 15000/-	2 weeks to 6 weeks.
12	Serious cut of leg	6000/- to 20000/-	2 weeks to 2 months
13	Serious cut of a part of body	5000/- to 20000/-	2 weeks to 2 months
14	Minor cut of a part of a body	2000/- to 5000/-	1 week to 2 weeks
15	Back bone damage	10000/- to 60000/-	2 months to 6 months
16	Teeth damage	1000/- to 5000/-	7 to 10 days
17	Twist of ankle or knee	3000/- to 5000/-	4 weeks to 6 weeks
18	Internal damage of body	20000/- to 100000/-	3 month to lifelong

Combining this information from Table 4.17, 4.19, 4.20 which varies case to case, a relation among severity, medical cost and days lost by affected worker has been established in Table 4.21.

Table 4.21: Linkage of Severity, Time and Cost

Severity	Loss level	Medical cost (BDT)	Time to rest (Days)
1	Very low	2000	1
2	Low	8000	3
3	Moderate	15000	6
4	High	20000	8
5	Very high	30000	14

4.6.3 LABOR NUMBERS

The considerations taken in Table 4.21 is for per person injured workers. But a number of labors are involved in each activity and each of them has the probability to face the accidents during any steps of construction activity. The labor numbers varies

from project to project. Here in the calculations the number of labors is considered relating to the project of Cityscape International Limited is shown in Table 4.22.

Table 4.22: No of labors involve in the works below (Lump Sum range)

No	Topics	Number of labors
1	Excavation	30
2	Form work	8
3	Reinforcement Erection and Bending	10
4	Brick works	10
5	Concrete works	25
6	Works on scaffolding	8
7	Out plastering	8
8	Electric works	8
9	Painting works	8
10	Carpentry works	8
11	Plumbing works	8
12	Aluminum and glass works	8

4.6.4 CALCULATION OF MEDICAL COSTS

Here is the equation by which the calculation has been done related to medical cost and wedges paid by the construction industry:

$$Cost\ (Medical\ cost\ including\ wage\ for\ rest\ time\ payment\ to\ the\ injured\ labors)$$
$$= (Medical\ cost\ per\ person + Daily\ labor\ wage\ per\ person$$
$$* Rest\ time\ in\ days) Labor\ number\ that\ may\ be\ affected$$
$$* Likelihood\ of\ the\ accident / Maximum\ scale\ of\ likelihood$$

4.7 DIRECT COST

Using aforementioned equation the total medical cost of accidents that is happened in various steps of construction activities has been found out. This amount will be the benefit if mitigation is done by using safety measures. Table: 4.23 to table: 4.36 show the expected medical cost and extra wage to pay by the construction industry.

Sample calculation process of expected cost including rest time for table 4.23:

For excavation part of construction three hazards are identified.

For excavation without railing:

Medical cost per person: 20000 (From Table 4.21 for severity 4)

Daily labor wage: 400 (Estimated by interviews)

Rest time in Days: 8 (From Table 4.21 for severity 4)

Labor number that may be affected: 8 (Estimated by interviews)

Likelihood of the accident: 2

Maximum scale of likelihood: 5

So, amount of medical cost: (20000+400*8)*8*2/5=74240

Similarly for underground power lines like gas, water, electricity amount of medical cost :(8000+400*3)*7*3/5=38640

and use of defective hoe amount of medical cost:(30000+400*14)*3*1/5=21360

Expected medical cost including rest time for excavation:
74240+38640+21360=134240

Table 4.23: Expected medical cost including rest time for excavation

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Excavation without railing	Workers and visitors fall into the lower place which results serious injury or death.	4	2	8	74240
2	Underground power lines like gas, water,	Electric shock. Slip which may cause minor injury.	2	3	7	38640

	electricity.					
3	Use of defective hoe.	Serious injury.	5	1	3	21360
					Total amount	**134240**

Table 4.24: Expected medical cost including rest time for Reinforcement erection and bending

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Manually cutting by hammer	Hit by hammer causes injury.	3	3	4	41460
2	Cutting by saw	Sparks and fumes can cause illness in eye and skin.	4	3	2	27840
3	Cutting by Oxy acetylene torch.	Burns part of body. Fire explosion.	4	2	3	27840
4	Manually bending	Strain Sprain Injury Back damage Teeth damage	4	3	4	53760
5	Sharp edge.	Injury Death	4	3	3	41760

6	Welding of rod	Burns Eye damage Fire spread death	4	3	3	41760
					Total amount	**234420**

Table 4.25: Expected medical cost including rest time for form work

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Sparks from welding.	Burns Eye damage Fire spread	4	3	2	24840
2	Nails in timber.	Puncture the nail in the body.	1	3	5	7200
3	Form oil, streaky materials.	Skin rashes, allergies, falling object.	1	4	2	3840
4	Falling object from height.	Death. Injury.	5	4	4	113920
5	Roof, column side shuttering.	Shuttering materials fall on the body causes injury.	4	2	2	18560
					Total amount	**168360**

Table 4.26: Expected medical cost including rest time for concrete work

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Cement dust from cement bag.	Lung cancer, asthma.	4	2	4	Indirect cost
2	Sharp edge on slab.	Serious injury	4	3	3	41760
3	Walking on deck during pouring	Slip and fall on wet concrete and reinforcement , twist ankle or knee	2	4	4	29440
4	Skin and eye contact with concrete	Skin cancer, allergy, dermatitis, concrete splashed in eye.	3	1	3	Indirect cost
5	Working with grinding machine without goggles.	Defects in eye.	4	2	2	18560
					Total amount	**89760**

Table 4.27: Expected medical cost including rest time for scaffolding

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Fall from height (human and materials).	Death. Injury.	5	4	3	85400
2	Inadequate working place.	Injury. Ill health (disability).	4	2	3	27840
3	Improper Scaffolding	Fall the whole scaffold.	4	2	5	43200
					Total amount	**156440**

Table 4.28: Expected medical cost including rest time for brick work

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Bricks fall from height	Injury, death	5	4	4	113920
2	Manual Lifting of bricks.	Falling with heavy load.	4	2	5	46400
3	Working at height	Fall from edge	5	4	2	56960
					Total amount	**217280**

Table 4.29: Expected medical cost including rest time for out plastering

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Fall from height	Injury. Death.	5	4	3	85440
2	Carrying heavy load.	Muscular strain.	4	2	5	46400
3	Mixing and placing the mortar manually.	Skin disease.	1	3	2	Indirect cost
					Total amount	**131840**

Table 4.30: Expected medical cost including rest time for works without railing

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Work on upper floor without guard rail	Death or serious injury.	5	2	8	113920
2	Lift core without railing	Death or serious injury.	5	2	4	56960
3	Going upper floor with stair without railing	Serious injury	5	2	5	71200
					Total amount	**242080**

Table 4.31: Expected medical cost including rest time for works with heavy equipments

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Moving Machine equipment without proper guarding.	Serious injury.	5	2	2	28480
2	Loading unloading machine without load tested.	Serious injury.	5	2	2	28480
					Total amount	**56960**

Table 4.32: Expected medical cost including rest time for electric works

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Short circuit	Electric fire. Burns of raw materials. Death. Injury.	5	4	4	113920
2	Stuck by electric wire (high rise crane/	Injury. Death by shock.	5	3	2	42720

	vehicle).					
3	Use metallic tools near the power line	Injury. Death by shock.	5	3	2	42720
4	Wet condition near the power line	Injury. Death by shock.	5	4	4	113920
					Total amount	**313280**

Table 4.33: Expected medical cost including rest time for plumbing works

No	**Hazards**	**Probable accidents**	**Severity**	**Likelihood**	**No. of labor affected**	**Cost (BDT)**
1	Cutting tiles by saw machine.	Serious cut of hands.	4	2	2	18560
2	Cutting steel pipe, plastic pipe by saw machine.	Serious cut of hands.	4	2	2	18560
					Total amount	**37120**

Table 4.34: Expected medical cost including rest time for carpentry

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost
1	Manually cut of woods.	Cut of parts of the hands.	2	4	2	14720
2	Sharp materials used for different carpentry works.	Cut of parts of the body.	3	4	3	41760
					Total amount	**56480**

Table 4.35: Expected medical cost including rest time for fitting works

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost
1	Aluminum pipe cutting for stairs.	Serious cut of hands.	4	2	2	18560
2	Handling the sharp edged aluminum materials manually.	Cut of parts of the hands.	2	4	2	14720
3	Handling glass manually.	Cut of parts of the hands.	2	4	2	14720

4	Setting the glass outside the building.	Fall from high place.	5	4	2	56960
5	Setting the aluminum frame for doors and windows and glass frame.	Cut of parts of the hands.	2	4	2	14720
					Total amount	**119680**

Table 4.36: Expected medical cost including rest time for painting

No	Hazards	Probable accidents	Severity	Likelihood	No. of labor affected	Cost (BDT)
1	Touching toxic solvent (spray, polish).	Skin disease.	3	1	2	Indirect cost
2	Taking in chemical compound by breathing.	Internal damage of the body.	4	3	3	Indirect cost
3	Chemical split over the neighborhood	Injury of other people.	3	2	2	Indirect cost
4	Spray painting without Mask, goggles. (Act)	Breathing problem, defects in eye, asthma,	3	4	4	55680

		allergy.				
					Total amount	**55680**

Up to this only medical related and rest time cost is found which is paid by Construction Company. Additionally there are probabilities of physical disabilities and death of labors for some accidents and also some accidents may injure the outside people or may damage the property of neighbors. In this study deaths of two labors and physical disability of two labors have been considered for which 500000 BDT and 200000 BDT is paid respectively per person. Outside damage compensation is considered as 500000 BDT in this three years project. These numbers and amount has been taken after consulting with the experienced manager and engineer of Cityscape International Limited.

Table 4.37: Total direct cost

Cases	Amount (BDT)
Sum of expected medical cost including rest time	2013620
Expected death compensation (in 3 years 2 deaths considered)	500000*2=1000000
Physical disability compensation (in 3 years 3 persons are considered)	200000*3=600000
Estimated costs of outer damages because of construction site activities	500000
Total	**4113620**

The sum total of direct cost of probable accidents of the project is found BDT 4113620. This amount will be termed as benefit if the proper preventive measures are taken.

4.8 COST OF PREVENTIVE MEASURES

Preventive measures depend on the hazards and probable accidents which vary from site to site. Usually in a construction site following preventive measures are taken into consideration.

- PPE (Personal protective equipments)
- Steel safety truss (Including CI sheet)
- Safety netted surroundings
- Salary of safety engineers
- Safety railing
- Safety sign
- Weekly reward cost

4.8.1 PERSONAL PROTECTIVE EQUIPMENTS

There are many safety accessories and equipment that can be used for the safety of the workers, engineers within the site and for the visitors of the construction site. The price of the equipments and their amount relevant to the considered construction site is given in Table 4.37.

Table 4.38: Cost related to personal protective equipments (PPE)

No.	Equipment name	No. of equipment	Price (BDT)	Total(BDT)
1	Safety Hamlet	400 pieces	350	140000
2	Safety belt	210 pieces	250	52500
3	Safety gum boot	270 pairs	550	148500
4	T shirt	480 pieces	220	105600
5	Safety Sunglass	210 pieces	90	18900
6	Hand gloves	260 pairs	230	59800
7	Safety Shoe	260 pairs	560	145600
8	Welding helmet	6 pieces	560	3360

9	Welding Hand Protector	6 pieces	850	5100
10	Welding sunglass	8 dozens	570	4560
11	Safety red tape	15 bundle	980	14700
12	Staff Safety Shoe	30 pairs	2200	66000
13	Fire extinguisher	8 pieces	1500	12000
14	Fire Bucket	4 pieces	220	880
15	Staff t shirt	120 pieces	180	21600
			Total	**799100**

4.8.2 SAFETY TRUSS

Safety truss is something that can be used to secure a lot of hazards and accidents. It is a skirt like part of an under construction building that is formed in different levels of the building that is formed in different levels of the building (usually uppers than level 4) that varies. It saves both the falling objects and people to ground level. Safety truss is placed after every five feet and each is ten feet length. Royal bolts are required to attach the truss with the building. CI sheet is placed continuously under the truss hook is used to attach the sheet with the truss. Welding rods are required to make the truss.

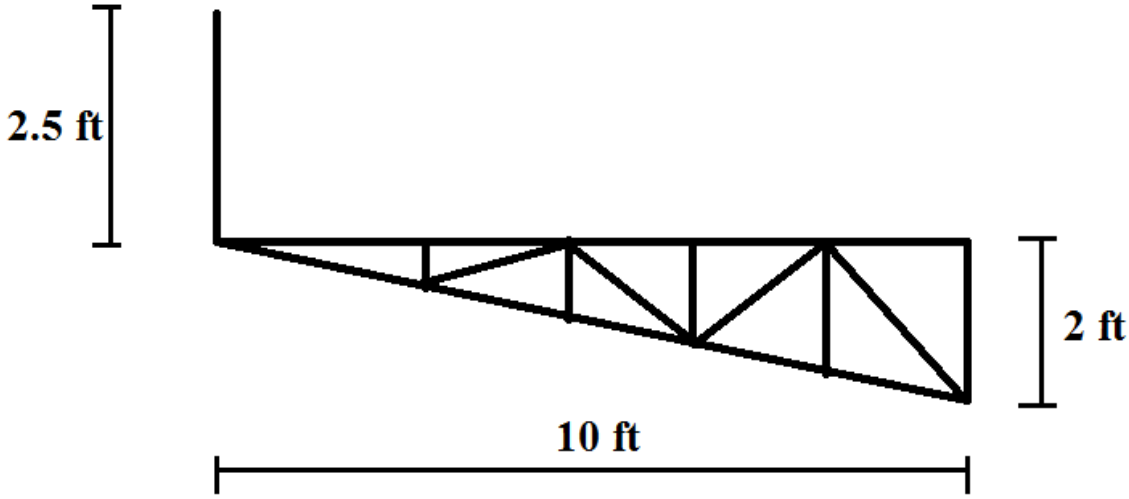

Figure 4.1: Section of safety truss

Table 4.39: Total cost of safety truss

No.	Materials	Amount of materials	Price (BDT)	Cost (BDT)
1	Angle (2"x2"x0.1875")	4000kg	70	280000
2	Royal bolt	300 pieces	175	52500
3	Welding rod	14 packet	750	10500
4	C I sheet	3740 square ft	58	216920
5	Hook	10 kg	135	1350
			Total	**561270**

4.8.3 SAFETY NETTED SURROUNDINGS

It is a barrier made by thick, durable nets. Steel pipes are required to place the net six feet away from the building. Net is attached with the pipe by hooks. It is mainly to keep the sites ingredient is mainly the falling objects having probability to go out of the construction site area and create harm to lives, territory and valuable premises of surrounding people of dwellers.

Table 4.40: Cost of safety netted surroundings

No.	Materials	Amount of materials	Price (BDT)	Cost (BDT)
1	Steel pipe	813 ft	70	56910
2	Suible clump	125 pieces	220	27500
3	Net	59200 square ft	3	177600
			Total	**262010**

4.8.4 SAFETY RAILING

Steel safety railing can be used along the edge of each floor and along the stairs side to prevent the falling of both people and large objects which can cost lives or precious equipments. It is made of steel rail box placed like fench. The dimensions of vertical part should be five feet and placed after three feet in each floor and three pieces is

placed on each stairs. The design may vary from site to site depending upon engineer's requirement.

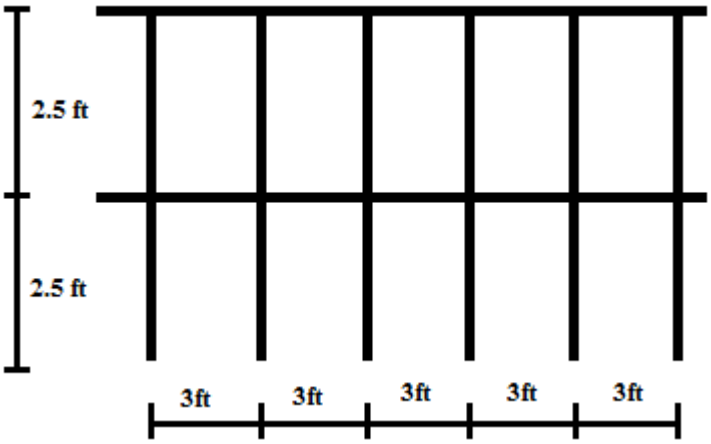

Figure 4.2: Section of safety railing on each floor

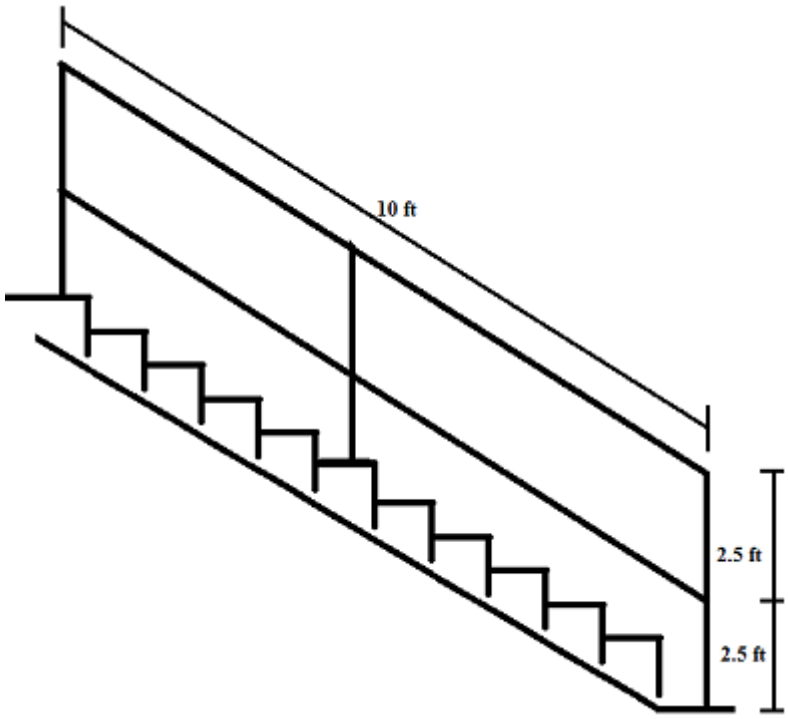

Figure 4.3: Section of safety railing on stair

Table 4.41: Cost of safety railing (for excavation, typical floor and stair)

No.	Materials	Amount of materials	Price (BDT)	Cost (BDT)
1	Railing box	23220kg	70	1625400
2	Welding rod	56 packets	750	42000
			Total	**1667400**

4.8.5 WEEKLY REWARD

Every week the company gives 300 taka as a reward to a labor who uses all the safety equipments properly and follows safety regulation carefully in order to encourage to use all personal protective equipments and to work in a systematic way so that accident due to personal fault is minimized.

4.8.6 SAFETY SIGNS

Safety signs may be used to aware the labors, staffs and visitors from any hazards. After seeing the signs they can prepare themselves how to protect themselves from those hazards. The safety signs cost in that project is around BDT 5000. It varies from project to project.

4.8.7 SAFETY ENGINEER

There should be a safety engineer whose duty is to ensure safety for every activity in a construction site. Safety engineer's duty is to perform overall risk assessment and management.

Table 4.42: Total cost related to preventive measure

No	Preventive measures	Cost (BDT)	Salvage value (25 %) (BDT)	Net cost after salvage value
1	Personal Protective Equipments (PPE)	799100	N/A	799100
2	safety truss	561270	124230	437040
3	Safety netted surroundings	262010	14228 (25 % of steel pipe only)	247782
4	safety railing (for excavation, typical floor and stair)	1667400	406350	1261050
5	Weekly reward	46800	N/A	46800
6	Safety sign	5000	N/A	5000
7	Salary of safety engineer	1080000	N/A	1080000
			Total	**3876772**

4.9 INDIRECT COST

In above calculated amounts we have considered the parts which can be estimated but there we lots of sides of panic, suffering and mourning which we cannot calculated by any simple equations or mathematics. The people working in the construction sites are loved one in their families.

The person who dies or gets disabled may be the main source of income in his family. So his death or disability brings a disaster to his family, also if we consider only economically. His school or college going sons or daughters may have to leave education and look for earnings on their fathers or brothers death. So although we can't calculate the amount but it is for sure that the amount is more than benefits that comes out in BDT.

If we highlight only the financial parts of indirect benefits the commercial loss of image of a company for delay in the works because of an accident can be considered which can be very serious loss. There may be political harassment, loss of material, strike may also occur. After working for long period labors can face cancer, lungs diseases, asthma or disability on account of not using safety measures. An initial amount may be given to these people but that is not enough to wipe out their tears o misery that may go throughout the rest of their lives. Although the indirect benefits can't be calculated, it is huge both financially and in the sense of humanity.

4.10 SUMMARY

From table 4.37 it is seen that there is a huge amount of direct cost involved in possible accidents besides the indirect costs. If the amount in table 4.41 is spent for ensuring safety the accidents costs and unwanted situations can be avoided. After the sum of all direct benefits and costs are found a benefit cost ratio can be developed to see the monetary comparison.

From calculation we get the benefit cost ratio = 4113620/3876772=1.06

Although we have calculated all the benefits in the least scales we got a Benefit Cost ratio is greater than 1. So if everything is considered thoroughly (considering the parts of indirect benefits) the ratio would have been a way higher.

As Bangladesh is a very densely populated country, its major strength lies in its manpower which if systemically used in construction industry, can lead our construction industry to a higher level. Thus, ensuring safety factors from maintaining safety measures will surely encourage people to join construction related works. If the fatality ratio decreases more veteran workers will be formed thus will enrich our manpower resources.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 GENERAL

This chapter summarizes the outcomes of the study. The effectiveness of the study and how people can be benefited from this study are discussed in short. Possible enhancements of this study and future research guideline are also mentioned in the recommendation part.

5.2 IMPROVING CONSTRUCTION SAFETY

Improving safety in construction sites will certainly encourage veteran construction workers to join various companies and thus prosper construction industry. It is shown that construction industry can save a great deal of money and can avoid risks by maintaining safety measures which should encourage companies to enhance safety rules and regulations.

In Bangladesh, industrialists think that safety means extra cost which can be saved by not following safety measures which ultimately results in losses due to different accidents and compensation. If industrialists can be encouraged to maintain safety measures by showing them that safety measures does not cause so much loss in monetary terms but does save a lot of monetary risk, for example- in the specific case of calculations where although minimum ranges of direct benefits are considered, a B/C RATIO of 1.06 is got, it will be a great prosper in construction industry. Reducing of costs relating to accidents and thus improving the environment of project site thereby it can be helpful to finish the construction operation within limited time and thus increase productivity.

5.3 EFFECTIVENESS OF THE STUDY

In today's competitive market, people are trying to complete their project with minimum duration and cost. To do so, productivity must be improved which does in reality has connection with safety of the labors. However, construction companies hardly focus on improving construction safety thus a lot of people get injured, sometimes a number of people are die. The construction industry's main target that is the productivity is also not improving. The fact is if the safety measures are not taken where necessary, the industry may have to bear a great loss or sometimes the industry may be banned by the government. So, by maintaining safety measures these great losses can be minimized which is very beneficial to the construction industry. Most of the industrialists are not known to the fact that taking safety measures into account might initially show up a good amount of cost but also will save quite a good amount of money and many unwanted situations can be avoided.

By using the tables and format that has been used any people can do assessments relating to risks and monetary terms. Enhanced safety factors will bring development in the region of productivity, time dimensions, loss reduction etc.

5.4 RECOMMENDATIONS FOR FUTURE STUDIES

The calculations done to compare the costs are done by found out data from some very well repudiated companies but if more or less different companies of different levels are taken into account a good diversity of information will come into light which will ultimately help to compare in a much larger scale. Comparison in a larger scale would surely encourage a wide range of industrialists to ensure safety measures

In all the calculations above only the direct benefits have been considered. Although a lot of amount of money is hidden in the indirect benefits. So there is a lot of scopes to work about the indirect benefits and thus a much higher B/C RATIO shall be obtained.

In this consideration 14 activities containing 50 hazards are taken into account but there can be other hazards that if taken into account, comparison will be more accurate.

Above, the medical costs are considered in a lump sum manner from the information gotten from some companies and medical costs gotten from hospitals. In reality the costs can be much larger than that paid as compensation or treatment costs, so a wide range of work can be done regarding the medical costs to make the monetary comparison much more accurate.

All in all it can be said that the study relating to construction safety has a very wide range that can be studied and revealed. With more time, information this study can go to quite an extension.

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