



# **COMPARISION BETWEEN COST OF ACCIDENTS IN CONSTRUCTION SITE AND COST OF PREVENTIVE MEASURES THROUGH RISK ASSESSMENT**

A Thesis Submitted in Partial Fulfillment of the Requirements for the  
Bachelor of Science Degree in Civil 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).

November, 2014

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Dedicated  
To  
Our Parents

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# ABSTRACT

In the era of modern globalization and increased competition, construction project has become one of the most crucial factors for achieving success in business sector. Huge number of construction is going on and it is flourishing day by day in Bangladesh and globally. However, many construction projects suffer from delay and even stopped due to accidents in construction site. These accidents involve property damage, severe injury, and even death which subsequently cost huge money, delay in construction completion, loss of company image and so on. To prevent accidents in construction, risk management tools and techniques have been developed for successful project. Nevertheless, these techniques are used too little and many still wonder how helpful they are. The problem is more severe for construction in Bangladesh. Most of the construction companies in Bangladesh are reluctant to take preventive measure because it needs some extra cost. Since accidents cannot be seen beforehand, people do not want to invest this extra cost of preventive measures. This paper reviews the literature to identify essential costs associated with safety measures of construction projects and to compare it with costs that may arise due to accidents during construction works. The study uses risk assessment procedure used in some developed countries to identify the hazards, probable accidents, likelihood and severity of these accidents for typical building construction in Bangladesh. Using a case study, costs of accidents are estimated considering the medical cost and daily wage of injured workers, death penalty, property damage and other indirect costs. The costs of preventive measures are also estimated considering the safety measure to be taken to prevent the accidents. It has been found that costs of accidents are much higher than the cost of preventive measures. Hence, this study can be useful to build awareness to the construction people to take preventive measure during construction. This will eventually eliminate or at least minimize accidents in construction site and construction can be completed on time and budget with better health and safety.

# Table of Contents

DECLARATION.....	i
ACKNOWLEDGEMENT.....	iii
ABSTRACT.....	iv
CHAPTER ONE.....	1
1.1 GENERAL.....	2
1.2 BACKGROUND.....	2
1.3 PROBLEM STATEMENT.....	3
1.4 OBJECTIVE.....	4
1.5 Scope of the study.....	4
1.6 ORGANIZATION OF THESIS.....	5
CHAPTER TWO.....	6
2.1 GENERAL.....	7
2.2 CONDITION OF CONSTRUCTION INDUSTRY IN THE WORLD.....	7
2.3 CONDITION OF CONSTRUCTION INDUSTRY IN BANGLADESH.....	8
2.4 HEALTH.....	8
2.5 SAFETY.....	8
2.6 HAZARDS.....	9
2.7 ACCIDENT AND INJURY.....	9
2.8 RISKS IN CONSTRUCTION SITE.....	11
2.9 RISK ASSESSMENT.....	11
2.10 PURPOSE OF RISK ASSESSMENT.....	12
2.11 RISK ASSESSMENT TOOLS.....	12
2.12 PROCEDURE OF RISK ASSESSMENT.....	12
2.12.1 IDENTIFYING HAZARDS AND THOSE AT RISK.....	13
2.12.2 EVALUATING RISKS AND PRIORITIZING RISKS.....	14
2.12.3 DECIDING ON PREVENTIVE ACTION.....	15
2.12.4 TAKING ACTION.....	16
2.12.5 MONITORING AND REVIEWING.....	16
2.13 IMPORTANT FACTORS FOR CARRYING OUT THE RISK ASSESSMENT.....	17
2.14 ENGINEER'S ROLES AND RESPONSIBILITIES.....	17
2.15 EMPLOYERS' ROLES AND RESPONSIBILITIES.....	18

2.16 WORKERS' ROLES AND RESPONSIBILITIES .....	19
2.17 RISK MANAGEMENT .....	20
2.18 RISK MANAGEMENT PROCESS .....	20
2.18.1 ESTABLISHING GOALS AND CONTEXT .....	20
2.18.2 IDENTIFY RISKS.....	21
2.18.3 ANALYZING THE IDENTIFIED RISKS .....	21
2.18.4 EVALUATE THE RISK .....	21
2.18.5 TREAT THE RISK.....	22
2.18.6 MONITORING THE RISK.....	22
2.18.7 COMMUNICATION AND REPORTING .....	22
2.19 SUMMARY .....	23
CHAPTER THREE .....	24
3.1 GENERAL.....	25
3.2 METHODOLOGY .....	25
3.2.1 IDENTIFICATION OF HAZARDS AND RISK.....	26
3.2.2 EVALUATION OF RISK .....	26
3.2.3 MONETARY DATA COLLECTION .....	26
3.2.4 COST COMPARISON.....	27
3.2.5 ANALYSIS AND RESULTS.....	27
3.2.6 CONCLUSION AND RECOMMENDATION .....	27
CHAPTER FOUR .....	28
4.1 GENERAL.....	29
4.2 RISK ASSESSMENT.....	29
4.3 PROJECT DESCRIPTION .....	31
4.4 SELECTED ACTIVITIES .....	31
4.5 HAZARD IDENTIFICATION.....	31
4.6 POSSIBLE COSTS RELATED TO ACCIDENTS .....	31
4.7 CONSIDERATIONS OF COSTS .....	32
4.7.1 SEVERITY AND LIKLIHOOD .....	32
4.8 DIRECT COST.....	34
4.9 INDIRECT COST .....	46
4.10 SUMMARY .....	46
CHAPTER FIVE .....	47
5.1 GENERAL.....	48

5.2 IMPROVING CONSTRUCTION SAFETY .....	48
5.3 EFFECTIVENESS OF THE STUDY .....	48
5.4 RECOMMENDATION .....	49
References.....	<b>Error! Bookmark not defined.</b>

## LIST OF TABLES

2.1: SEVERITY CATEGORIES & DESCRIPTION (MINISTRY OF MANPOWER SINGAPORE).....	14
2.2: LIKELIHOOD CATEGORIES AND DESCRIPTORS (MINISTRY OF MANPOWER, SINGAPORE) .....	14
2.3: ACCEPTABILITY OF RISK AND RECOMMENDED ACTIONS (MINISTRY OF MANPOWER, SINGAPORE) .....	15
4.1: RISK ASSESSMENT FORM (MINISTRY OF MANPOWER, SINGAPORE) ...	30
4.2: SEVERITY LEVEL AND THEIR MEANING.....	32
4.3: LIKELIHOOD LEVEL AND THEIR MEANING.....	32
4.4: MEDICAL COST ACCORDING TO TAIRRUNNESSA MEMORIAL MEDICAL COLLEGE HOSPITAL.....	33
4.5: LINKAGE AMONG SEVERITY, LOSS LEVEL, NUMBER OF PEOPLE AFFECTED, MEDICAL COST AND REST TIME .....	34
4.6: EXPECTED MEDICAL COST INCLUDING REST TIME .....	35
4.7: TOTAL DIRECT COST OF ACCIDENTS .....	44
4.8: INDIRECT COST MULTIPLIER.....	44
4.9: COST OF PREVENTIVE MEASURES .....	45

## LIST OF FIGURES

3.1: METHODOLOGICAL FLOWCHART .....	25
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CHAPTER ONE  
**INRODUCTION**

## 1.1 GENERAL

This chapter briefly discusses about the background and the importance of this study. It also discusses different problems faced during different steps of a construction project on a construction site. At the last part the objective, the scope of the study and the organization of the thesis is mentioned.

## 1.2 BACKGROUND

Construction project has become one of the most crucial factors for achieving success in business sector. 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, equipment, 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 equipment 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. To prevent accidents in construction, risk management tools and techniques have been developed for successful project. Nevertheless, these techniques are used too little and many still wonder how helpful they are. The problem is more severe for construction in Bangladesh. 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. Hence, this study can be useful to build awareness to the construction people to take preventive measure during construction.

### 1.3 PROBLEM STATEMENT

Construction industry, one of the major economic forces of Bangladesh, has improved substantially during the last twenty years. But it is one of the most risky area for the people involved in a construction project both physically and economically. These risks arise due to present of potential hazards which lead sometimes minor or major accidents. Compared to developed countries in the world, in Bangladesh risk assessment, risk management or safety management on construction site is not given priority as much as it should be. But to provide a safe and conducive working environment and also to minimize the number of construction accidents, a proper risk management process is required. If all types of safety 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. But most of the owner of construction industry thinks that all the cost related to safety management will be an extra amount which they don't want to take depending on the probability of any kind of accidents as because no one can say that the accidents will happen for sure. But 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 equipment for the rework. All of these cause a handsome amount of loss which will decrease the productivity. So it is clearly noticeable that the potential hazards must have to be controlled so that safe workers can work safely and the construction industry may get their maximum productivity.

## 1.4 OBJECTIVE

The main objective of this study is to compare between the cost of accidents in construction site and cost of preventive measures through risk assessment. The specific objectives are:

- To estimate the cost associated with accidents 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 equipment, 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) Foundation
- 3) Working at height
- 4) Scaffolding
- 5) Out plastering
- 6) Painting work
- 7) Formwork
- 8) Concreting work

We will collect information from a 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 4: Cost analysis in risk assessment.

Chapter 5: Conclusion and recommendation.

CHAPTER TWO

**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

Construction industry is one of the most dangerous occupation in the world, incurring more occupational fatalities than any other sector. 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.

## 2.10 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.

## 2.11 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).

## 2.12 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

## 2.12.1 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.

## 2.12.2 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

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

**Table 2.2: Likelihood Categories and Descriptions**

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

### 2.12.3 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)**

<b>Risk Level</b>	<b>Risk acceptability</b>	<b>Recommended actions</b>
Low Risk	Acceptable	<input type="checkbox"/> No additional risk control measures may be needed. <input type="checkbox"/> May need frequent review to ensure risk level is accurate & does not increase over time.
Medium Risk	Moderately acceptable	<input type="checkbox"/> Carry out careful hazard evaluation to ensure risk level is reduced to as low be reasonably possible within a defined time period. <input type="checkbox"/> Interim risk control measures, such as admin controls, may be implemented. <input type="checkbox"/> Management attention is required
High Risk	Not acceptable	<input type="checkbox"/> High Risk level must be reduced to min. Medium Risk before work commences. <input type="checkbox"/> There should be no interim risk control measures <input type="checkbox"/> Risk controls not be too dependent on PPE. <input type="checkbox"/> Hazard should be eliminated before work commences. <input type="checkbox"/> Immediate management intervention is required before work commences.

## 2.12.4 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 be the person in charge of implementing them.
- b. To train or instruct them about the measures or procedures that will be implemented.

## 2.12.5 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).

## 2.13 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?

## 2.14 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

## 2.15 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).

## 2.16 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.

## 2.17 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.

## 2.18 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

### 2.18.1 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.

## 2.18.2 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.

## 2.18.3 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.

## 2.18.4 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.

### 2.18.5 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.

### 2.18.6 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.

### 2.18.7 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.

## 2.19 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 THREE**

**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

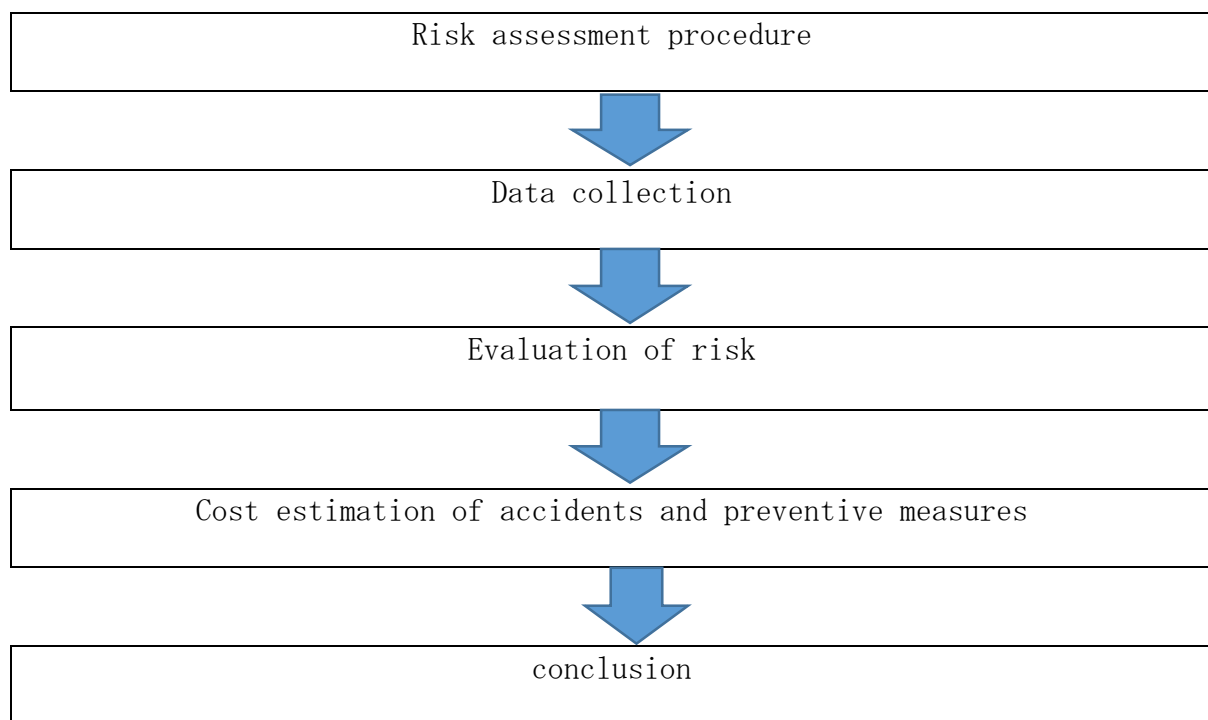


Figure 3.1 shows the methodological flowchart of the study that includes identification of hazards, evaluation of risk, monetary data collection, cost comparison, analysis & results, conclusion & recommendation. The topics are described in details below.

### 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 labors, 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 labors 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 equipment 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 FOUR**

**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)**

ACTIVITY-BASED RISK ASSESSMENT FORM											
Company: Ashik Enterprise					Conducted By: Name: Saiful Islam Designation: Contractor Date: 22.03.04						
Location: Taltala, Sher-E-Bangla Nagar, Dhaka					Last Review Date:					Next Review Date:	
Approved By: Name: Designation: Date:											
1.Hazard Identification					2.Risk Evaluation					3.Risk Control	
1a.	1b.	1c.	1d.	1e.	2a.	2b.	2c.	2d.	2e.	3a.	3b.
No.	Work Activity	Hazard		No. of Labor (per day)	Existing Risk Control[If Any]	Severity	Likely-hood	Risk level	Compensation for Accidents	Additional Risk Control	Cost for safety Measurement

### 4.3 PROJECT DESCRIPTION

Construction of a 5 storied building with no basements has been selected as a case project of this study. The construction site is located at Taltala Sher-e-Bangla nagar, Dhaka. The building is constructed by Ashik Enterprise. The building is 1000 square feet. The expected duration of construction work is about 1 years. There is also a chief engineer, a project engineer, a site engineer and a safety engineer. From this project all the hazards, probable accidents form these hazards and also the preventive safety measures are identified.

### 4.4 SELECTED ACTIVITIES

In this case study common work activities has been considered including Excavation works, Foundation work, Form works, Concreting works, Scaffolding, Working at height, Out plastering, Painting works.

### 4.5 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.

### 4.6 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.
  - 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 equipment etc.

## 4.7 CONSIDERATIONS OF 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.

### 4.7.1 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 4. Table 4.2 and 4.3 shows the severity and likelihood level and their meaning.

**Table 4.2: Severity level and their meaning**

<b>Severity</b>	<b>Loss Level</b>
1	Low
2	Medium
3	High
4	Very High

**Table 4.3: Likelihood level and their meaning**

<b>Likelihood</b>	<b>Possibility of Accident</b>
1	Low
2	Medium
3	High
4	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

**Table 4.4: Medical cost according to Tairrunnessa Memorial Medical College Hospital (TMMCH):**

Serial No.	Topic	Lump sum medical cost (per person) BDT	Rest time
1	Hand damage	500-3500	15 days
2	Leg damage	500-3500	15 days
3	Head damage	100 per stitch	10 days
4	Leg sprain	500-3500	15 days
5	Hand sprain	500-3500	15 days
6	Serious electric shock	200-1000	1 week
7	stroke	7000 per day at ICU	1 month
8	Burn of a part of a body	50 per day	1 week – 1 month
9	Eye damage	3500-7000	7 days
10	Serious cut of hand	100 per stitch	15 days
11	Serious cut of leg	100 per stitch	15 days
12	Serious cut of a part of a body	100 per stitch	15 days
13	Minor cut of a part of a body	100 per stitch	15 days
14	Backbone damage	5000-50000	1-2 months
15	Teeth damage	300-2000	4 days
16	Twist of ankle or knee	500-3500	15 days
17	Internal damage of body	5000-50000	1-2 months

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 4.4 the portion of medical cost per injured worker given by Tairrunnessa Memorial Medical College

Hospital (TMMCH) and the number of days for which the salary is paid to them is shown in the above table.

**Table 4.5: Linkage among severity, loss level, number of people affected, medical cost and rest time:**

SEVERITY	LOSS LEVEL	NO. OF PEOPLE AFFECTED (OUT OF 10)	MEDICAL COST (BDT)	AVERAGE OF MEDICAL COST (BDT)	REST TIME OF AFFECTED LABORS(DAYS)
1	LOW	2	500-2000	1250	7
2	MEDIUM	3	2000-5000	3500	15
3	HIGH	4-5	5000-10000	7500	30
4	VERY HIGH	5-10	10000+	10000	30+

#### 4.7.2 EQUATION FOR CALCULATION OF MEDICAL COST

Medical Cost (Including Wage for Rest Time Payment to the Injured Labor) = {(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.

#### 4.8 DIRECT COST

Now using this 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. Here table: 4.6 show the expected medical cost and extra wage paid by the construction industry.

**Table 4.6: Expected medical cost including rest time**

ACTIVITY-BASED RISK ASSESSMENT FROM											
Company: Ashik Enterprise					Conducted By: Name: Saiful Islam Designation: Contractor Date: 22.03.04						
Location: Taltala, Sher-E-Bangla Nagar, Dhaka					Last Review Date:					Next Review Date:	
Approved By: Name: Designation: Date:											
1.Hazard Identification					2.Risk Evaluation					3.Risk Control	
1a.	1b.	1c.	1d.	1e.	2a.	2b.	2c.	2d.	2e.	3a.	3b.
No.	Work Activity	Hazard	Possible Accident/Ill Health and Persons-at-Risk	No. of Labor	Existing Risk Control[If Any]	Severity	Likely-hood	Risk level	Compensation for Accidents	Additional Risk Control	Cost for safety Measures
1.	Earth Excavation From	Wall Collapsing	a. Death or Serious Injury Can Result b. Nearby structures can collapse	10	Shore Pilling	2	2	Low	250000 (death)	-	200000
		Falling Objects From Ground Floor to Lower	Any kind of Injury	25	Helmet	2	1	Medium	21375	-	6000

		Surface Water Runoff	A loose Material Can Fall Into The Trench	2	Water Protection or Sand Bag	2	3	Medium	Indirect cost	-	2500
		Ground Water Table	a. Weakening The Support System b. Ground Water Can Come Up Above The Excavation Level	2	Water Protection Bag	2	3	Medium	Indirect Cost	-	2500
		Underground Power Line	Death or Serious Injury Can Result	10	No Cable Laid Over The Floor and Without Conduit	4	1	Low	27500	Using Rubber Gum Boot	6000
2.	Foundation	Ground Water Table	a. Weakening The Support System b. Ground Water Can Come Up Above The Excavation Level	2	Water Protection Bag	2	3	Medium	Indirect Cost	-	2500
		Underground Power Line	Death or Serious Injury Can Result	10	No Cable Laid Over The Floor	4	1	Low	27500	Using Rubber Gum Boot	6000
		Surface Water Runoff	A loose Material Can Fall Into The Trench	2	Water Protection or Sand Bag	2	3	Medium	Indirect Cost	-	2500

3.	Working At Height	Unsafe Use Fall Protection Equipment and Human Error	Death or Serious Injury Can Occur	20	Safety Belt	3	2	Medium	78000	Helmet	10600
		Unstable Working Surfaces	Death or Serious Injury Can Occur	20	Fastening of The Worker to a Safety Hinge in Roof top	3	2	Medium	78000	Helmet	10600
		Fall Workers Near The Edges of Floors	Death Or Serious Injury Can Result	20	Guardrails	3	2	Medium	78000	Helmet+ Safety Belt	89600
4.	Scaffolding	Fall Protection	Death or Serious Injury Can Result	10	Guardrail Protection	3	2	Medium	39000	Safety Belt+ Helmet	89600
		Proper Access [Ladder, Ramp or stair access not Provided]	Serious Injury Can Result	10	-	2	1	Low	9500	Ladder, Ramp or stair	1000

		Adequate Platform Construction	Injury Requiring Medical Treatment or Ill Health Leading to Disability	-	Scaffold Must Not be Erected by Supervision of Competent Person	-	-	-	-	-	-
		Lack of Personal Fall Arrest or Guardrail Systems	Serious Injury or Life Threatening Occupational Disease	10	Safety Belt ,Helmet	3	2	Medium	39000	-	89600
		Movement or Tip Over Scaffolding	Injury Requiring Medical Treatment or Ill Health Leading to Disability	-	Stable Such as Barrels, Boxes, Loose Bricks or Concrete Blocks must be Used to Support Scaffolds or Planks	-	-	-	-	-	-

5.	Out Plastering	Person Falling From Height	Death or Serious Injury Can Result	4	Safety shed at Different Level All Around The Building	4	1	Low	5500	-	80000
		Slips or Falls on The Level	Injury Requiring Medical Treatment or Ill Health Leading to Disability	4	Safety Shed at Different Level	4	1	Low	5500	-	80000
		Materials Falling From Heights	Neighbors or Passers -by can be Injured From Falling Materials	4	Safety Scaffolding All Around The Building as 5' of Top Level	4	3	Medium	16500	-	-
		Unsafe Work Practice	Injury or Ill Health Requiring Fast Aid Treatment Only[Includes Minor Cuts And Bruises, Irritation, Ill Health with Temporary Discomfort	4	Training	3	2	Medium	5500	-	-
		Heavy Load	Muscular Strain When Lifting Plastering Materials	4	Correct Lifting Posture	4	1	Low	5500	-	-

6.	Painting Work	Person Falling From Height	Death or Serious Injury Can Result	4	Safety Shed at Different Level All Around the Building	4	1	Low	11000	-	80000
		Slips or Fall on the Level	Injury Requiring Medical Treatment or Ill-Health leading to Disability	4	Safety Belt	4	1	Low	11000	Safety Net	83600
		Unsafe Work Practice	Injury or Ill Health Requiring Fast Aid Treatment Only[Includes Minor Cuts And Bruises, Irritation, Ill Health with Temporary Discomfort	4	Training	3	2	Medium	9750	-	-
		Falling Object	Workers Feet Can Be Crushed by Painting Drum Causing Injury	4	Safety Shoes	4	1	Low	5500	-	6000



		Toxics Solvent Vapors for Mixing Paint	Exposure to Spray Paint Solvents Can Cause Ill Health	4	Organic Vapour Respirators, Safe Work Procedure	2	1	Low	2375	Mask	40
		Paint or Chemical Spill Over	Neighbors or Passers-by Can Be Injured From Spilled Over Paint or Chemical	4	Safety Scaffolding All Around The Building as 5' of Top Level	2	1	Low	2375	-	-
7.	Formwork	Broken or Sliding the Bamboo Support	Roof Work Shuttering May Be Crushed	8	Bamboo Leg Bottom sliding Protection support	2	2	Low	9500	-	-
		Crashing The Wooden Plank/ displacing the Shuttering Edge	a. Loses the Concreting Materials b. Labor or Mason Can be Injury Requiring Medical Treatment or Ill-Health Leading to Disability	8	Proper Wooden Joist Support and Proper Thick Wooden Plank Used	2	2	Low	9500	-	-

		Shuttering Materials Falling From Height	Neighbors or Passers-by Can Be Injured From Falling Shuttering Materials	8	Safety Scaffolding All Around The Building as 5' of Top Level	2	2	Low	9500	-	-
		Unsafe Work Practice	Injury or Ill Health Requiring Fast Aid Treatment Only[Includes Minor Cuts And Bruises, Irritation, Ill Health with Temporary Discomfort	8	Training	2	2	Low	9500	-	-
8.	Concreting Work	Loose Concreting Materials Falling From Rooftop	Neighbors or Passers-by Can Be Injured From Falling Materials	4	Safety Scaffolding All Around The Building as 5' of Top Level	4	1	Low	5500	-	80000
		Unsafe Vibrating use in Concreting Work	Injury Requiring Medical Treatment or Ill-Health leading to Disability	25	Use Safety Shoes	1	1	Low	3038	-	6000

		Chemical Reaction by Cement Concreting	Injury Requiring Medical Treatment or Ill-Health leading to Disability	25	Safety Apron , Helmet etc.	1	1	Low	3038	-	3600
		Personal Injury by Unsafe Work Practice	Injury or Ill Health Requiring Fast Aid Treatment Only[Includes Minor Cuts And Bruises, Irritation, Ill Health with Temporary Discomfort	25	Training	1	1	Low	3038	-	-

**Table 4.7: Total direct cost of accidents:**

<b>CASES</b>	<b>AMOUNT (BDT)</b>
SUM OF EXPECTED MEDICAL COST INCLUDING REST TIME	542489
DEATH COMPENSATION (IN 1 YEAR 1 DEATH CONSIDERED)	250000
PHYSICAL DISABILITY CONSIDERED (IN 1 YEAR 2 PERSONS ARE CONSIDERED)	100000*2=200000
<b>TOTAL</b>	<b>992489</b>

**Table 4.8: Indirect cost multiplier:**

<b>DIRECT COST (\$)</b>	<b>COST MULTIPLIER</b>
0-2999	4.5
3000-4999	1.6
5000-9999	1.2
10000+	1.1

*SOURCE: Kentucky Employers Mutual Insurance (KEMI)*

Total indirect cost (BDT) =  $1.1 * 992489 = 1091737.9$

Total direct + Total indirect cost (BDT) =  $992489 + 1091737.9 = 2084226.9$

**Table 4.9: COST OF PREVENTIVE MEASURES:**

<b>NO.</b>	<b>EQUIPMENT NAME</b>	<b>QUANTITY</b>	<b>PRICE (BDT)</b>	<b>TOTAL (BDT)</b>
1.	Safety helmet	30 pieces	200	6000
2.	Safety belt	20 pieces	180	3600
3.	Safety gumboot	10 pieces	600	6000
4.	Hand gloves	30 pairs	200	6000
5.	Welding sunglass	12 pieces	50	600
6.	Fire extinguisher	2 pieces	1500	3000
7.	Safety red tape	5 bundle	980	4900
8.	Shore piling	130 ft. (perimeter)	-	200000
9.	Water protection or sand bag	130 ft. (perimeter), 1000 sft	-	2500
10.	Safety net	130 ft. (perimeter)	-	80000
11.	Safety engineer	1	40000 (each month)	480000
12.	Mask	4 pieces	10	40
13.	Ladder	1		1000
				Total = 793640

Total cost of preventive measures (BDT) = 793640

## 4.9 INDIRECT COST

In above calculated amounts we have considered the parts which can be estimated but there are lots of sides of panic, suffering and mourning which we cannot calculate 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 or 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 4.7 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 4.8 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 =  $2084226.9/793640=2.63$

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 FIVE

### **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 2.63 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 peoples 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 RECOMMENDATION

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 8 activities containing 35 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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