

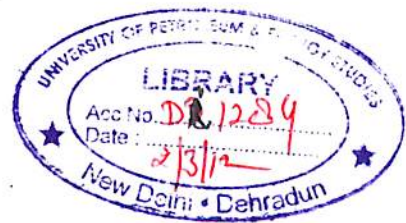
**Hazard Identification and Risk Analysis in Delhi Metro  
Construction**

By

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**M. Tech (HSE)**

**R070207019**



College of Engineering

University of Petroleum & Energy Studies

Dehradun

May, 2009

# Hazard Identification and Risk Analysis in Delhi Metro Construction

A thesis submitted in partial fulfilment of the requirements for the Degree of

Master of Technology

In

(Health Safety and Environment Engineering)

By

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Approved

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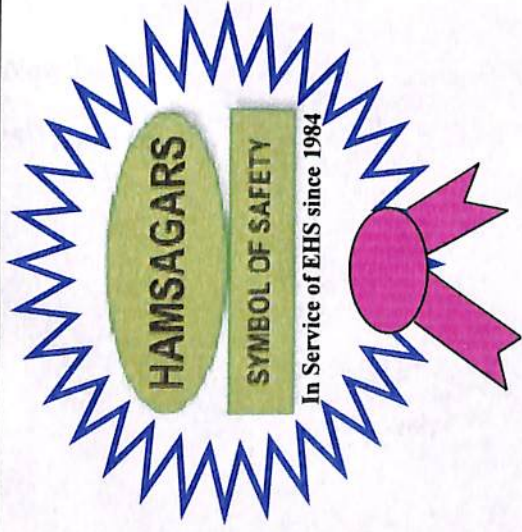
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# CERTIFICATE

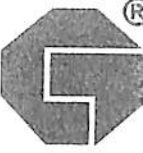
*Certified that Ms. Shradha Mishra, M. Tech. (HSE), UPES,*  
**R070207019 has successfully completed a Project**  
**on "Hazard Identification and Risk Analysis in Delhi**  
**Metro Construction" under my Guidance.**

Delhi,  
Date: 24<sup>th</sup> April 2009.

Prof. Dr. Ram S. Hamsagar

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## CERTIFICATE

This is to certify that the work contained in this thesis titled “ **Hazard Identification and Risk Analysis in Delhi Metro Construction**” has been carried out by SHRADDHA MISHRA under my supervision from 16<sup>th</sup> March 09 to 25<sup>th</sup> April 09 in *Gammon India Ltd, New Delhi* and has not been submitted elsewhere for a degree.

Place: New Delhi

Date: 25<sup>th</sup> April 09

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## **Abstract**

Construction is integral part of infrastructure development as well as economic development of country. Construction involves various types of activities for which safety consideration and controls are required. To ensure the safety in construction adequate precautions are required to avoid incident and accidents, occupational illness and harmful effects on environment. The biggest motivation for applying risk management lies in the financial benefits- reducing losses in order to improve the profitability of the organization.

Hazard in the workplace changes from day to day and different from one activity to another. In order to effectively manage the Health Safety and environment in workplace it is required to carryout the hazard identification and risk assessment on a regular basis.

Keeping the above things in mind this paper focused on the hazard identification and risk assessment and its control measure in Delhi Metro construction. Hazard identification and risk assessment conducted are discussed in detailed manner including probabilities and consequences and its control measures by using RBI Matrix for semi quantitative assessment.

To identify associated, Occupational health & safety (OHS) hazards and risks of activities, considerations are as follows: Document / Record review, Consultation with cross section of employees/ workman, Applicable OHS Legislation, Site assessment and observations of tasks, past accident and incident records.

## Acknowledgement

No significant achievement can be a solo performance especially when starting a project from ground up. The project Report on "Hazard Identification and Risk Analysis in Delhi Metro Construction" has by no means an exception. Apart from my effort, the success of this project depends largely on the encouragement and guidance of many others. I take this opportunity to express my gratitude to people who have been instrumental in the successful completion of this project.

I express my sincere gratitude with profound sense of joy and satisfaction to Dr. B. P Pandey (Dean- College Of Engineering) for providing impressive and learning environment for studies. I would like to thank my internal guide Dr. Ram Hamsagar for his faith and support to me in making this project worth useful. I do not have the appropriate word to express my deep sense of ever indebtedness to him. And I also thank my external guide Mr. Vijay B. Patil (CSHE Manager) for his guidance and interest in this work. He provided me full freedom to use the resources and, keeping watchful eye on the progress of this work. I am also thankful to all those who directly or indirectly supported me.

Finally I would like to thank my beloved parents, my sister and friend who directly or indirectly supported me to complete the thesis work.

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A handwritten signature in black ink, appearing to read 'Shraddha Mishra', written over a horizontal line.

## Table of content

<b>Content</b>	<b>Page No.</b>
<b>List of table</b>	
<b>Abstract</b>	
<b>Appendix</b>	
<b>1. Introduction</b>	<b>1</b>
<b>2. Basic concept</b>	
<b>2.1 Hazard identification</b>	<b>2</b>
<b>2.2 Risk Assessment</b>	<b>3-4</b>
<b>2.3 Risk control</b>	<b>5</b>
<b>3. Literature Review</b>	<b>6-8</b>
<b>4. Procedure for the study</b>	
<b>4.1 Methodology</b>	<b>9</b>
<b>4.2 Procedure</b>	<b>9</b>
<b>4.3 Purpose</b>	<b>9</b>
<b>4.4 Consequences to be considered</b>	<b>10</b>
<b>4.5 Risk Assessment tool</b>	<b>11-13</b>
<b>5. Hazard Identification and Risk Assessment work sheet</b>	<b>14-45</b>
<b>6. Results and Discussion</b>	<b>46-49</b>
<b>7. Conclusions &amp; Recommendations</b>	<b>50-51</b>
<b>8. Bibliography</b>	

## List of table

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
Table 1	Risk Levels	12
Table 2	Summary of Results	48
<b>Work Sheet</b>		<b>14-45</b>

- A. Barricading board
- B. Fixing of diversion & caution signs
- C. Fixing of Blinkers
- D. Storage of Gas Cylinders, Paint and Thinners
- E. Cement storage
- F. Batching plant
- G. Laboratory
- H. Piling
- I. Steel Yard
- J. Welding
- K. Gas Cutting
- L. Excavation
- M. Pile chipping
- N. P.C.C. Concreting
- O. Pile Cap
- P. Pier & Pier Cap
- Q. Work at Height
- R. Loading and unloading
- S. Lifting Operation
- T. Crane operation
- U. Precast Segments
- V. Launching segment
- W. Pre stressing
- X. Grinding
- Y. Electrical work
- Z. Drilling operation
- AA. DG operation
- BB. Scrap yard
- CC. Office activities
- DD. Mock Drill for fire
- EE. Testing of lifting tools and pressure vessels

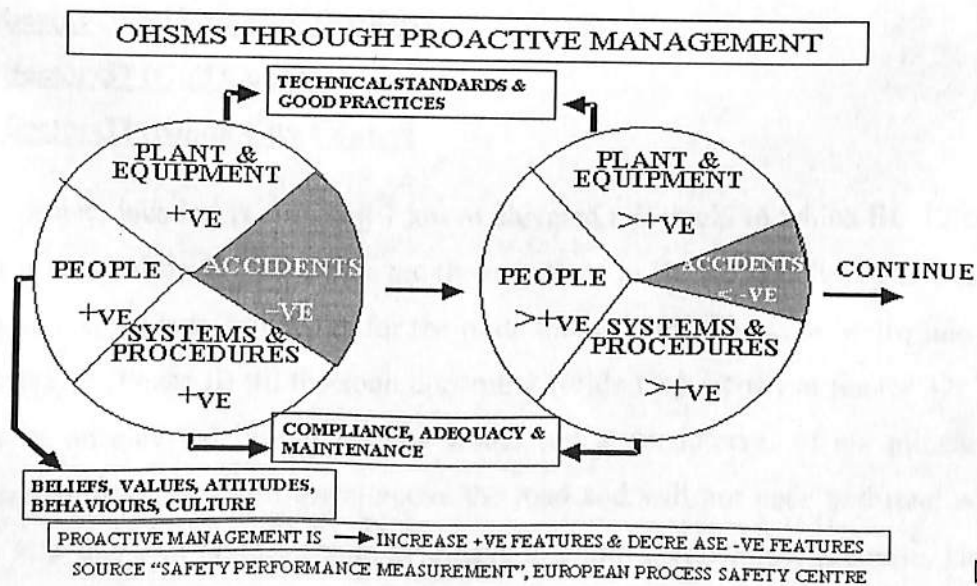


## Chapter I

### Introduction:

Risk Assessment is a vast system of tools that enable to pre-create in minds, all potential Risks Chances of occurrence and damage to life and property of disasters at work sites. In any advanced Risk Assessment, we subject EHS-Policy, planning, procedures, control systems, inspections, monitoring, auditing and people with their skills and physical stress factors and all and enable see through hazards before they manifest as accidents so as to identify shortcomings in the System and the People and take effective steps. Risk Assessment is a Proactive Management system in contrast to the Reactive approach to accident prevention that involves investigating an accident and taking corrective steps.

Risk Assessment is a Proactive Accident Prevention technique and is depicted by the following diagram of Occupational Health and Safety Management System (OHSMS) from the European Process Safety Centre's Model:



**Figure 1**

This project, Hazard identification and risk analysis has been done in Delhi metro construction of contract no. BC 12 And BC 13, Part Design & Construction of viaduct & structural work of elevated stations on New Ashok Nagar Noida Corridor of Phase II of Delhi MRTS project. The NOIDA extension has a total cost outlay of 736 crore. The execution of the BC – 12 and 13 project is done by Gammon India ltd – JMC JOINT VENTURE for laying of Metro Line (Mass Rapid Transport System of Delhi Metro Rail Corporation Ltd.) from New Ashok Nagar (Delhi) to Noida (Uttar Pradesh) Corridor. It covers Sector 15, Sector 16, Sector 18, Botanical Garden, Golf Course and New City Centre on New Ashok Nagar - Noida Corridor of Phase II of Delhi MRTS project. Delhi Metro Rail Corporation Limited (DMRC) is the employer of this project and Gammon India ltd is contractor of this project. Company which is engaged by GIL – JMC joint venture to perform work at the site or to provide labour, equipment, facilities or material, to be used at the site.

The proposed route for the Noida Metro is

Station 1: **Sector-15 (Gol Chakkar)**

Station 2: **Sector-16 (HCL Office)**

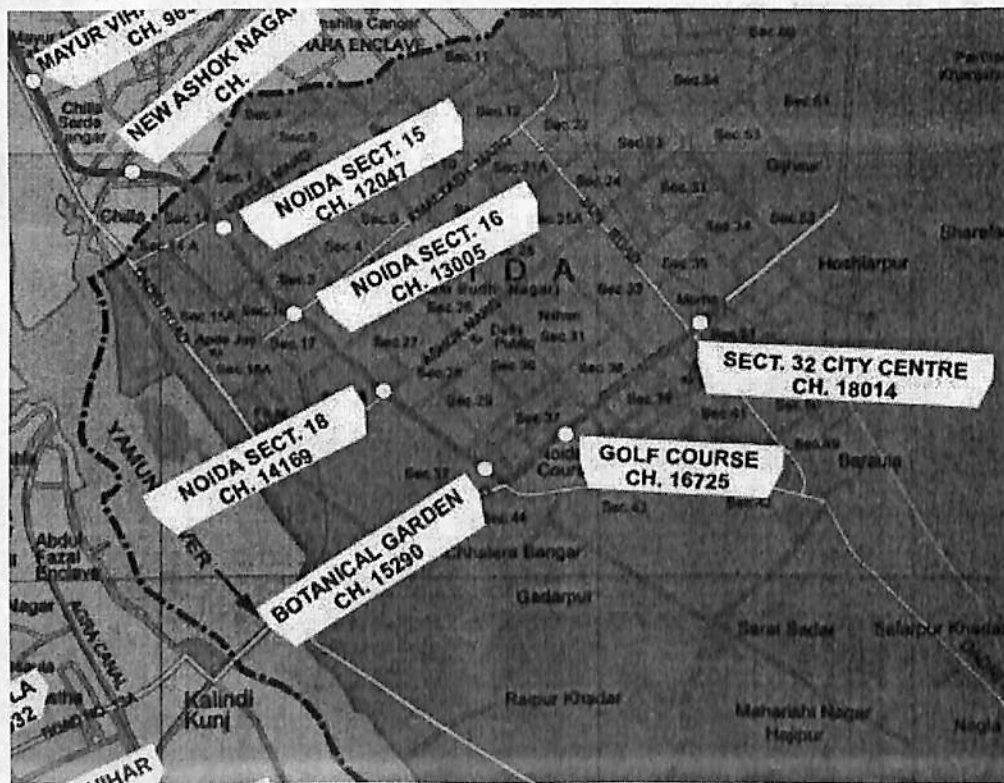
Station 3: **Sector-18 (Atta)**

Station 4: **Sector-38A (Botanical Garden)**

Station 5: **Sector-37 (Golf Course)**

Station 6: **Sector-32 (Noida City Center)**

This project location is covering 7 km of elevated rail track. In which BC 12 covers 2.67 km and rest is covered by BC 13. There are three stations in BC 12 and three stations are in BC 13. Noida Metro work is in full swing for the route that extends the Delhi Metro line coming to New Ashok Nagar (Phase II) till the soon upcoming Noida City Center at Sector 32. The whole stretch will be on elevated line and trains would run at an interval of six minutes between stations, meaning the metro will travel above the road and will not need and road widening or demolition. Flip side will be that commuters have to climb up/down for the train. How good it will be for older people that we will have to wait and watch.



Location of BC 12 and BC 13 DMRC Project Site

The Overall Life Cycle of the DMRC Project as applicable to **GIL JMC Joint Venture Operations** has the following components:

- (a) **Transportation, Receipt of Raw Materials from Suppliers at Batching Plant and Casting Yard and the Work Site.**
- (b) **Batching Plant and Casting Yard Operations including Batching, Casting, Stores and Bulk Storages Including Fuel / Lube Oil / Gas Cylinder Storages, Fabrication, Electrical / Mechanical Maintenance, DG Operation and Quality Control of Raw Materials and the Finished Products.**
- (c) **Transportation of RCC Mix to Construction Sites.**
- (d) **Construction Site Activities i.e. Civil, Mechanical, Electrical Work including Operation of Plant and Machinery with related Infrastructure established in line with DMRC Guidelines.**
- (e) **Installation and Commissioning Work at Site.**
- (f) **Storages of Preserved Soil maintained at identified places for backfilling at later date.**
- (g) **Transportation of Solid Waste to Dumping Site and maintenance of Site to avoid Public Nuisance.**

## Chapter II

### Basic concept

#### 2.1 Hazard Identification:

Hazard identification is the most important step in the risk management process. A hazard which is not identified cannot be controlled. Accordingly, it is crucial that this step is as comprehensive as possible. Hazard identification must be conducted in close consultation with the people performing the activity.

Hazard identification consists of the qualitative review of possible accidents, which may occur based on previous accident experience or judgment where necessary. There are several formal techniques for this, which are useful in their own right to give a qualitative appreciation of the range and magnitude of hazards and indicate appropriate mitigation measures. In QRA, hazard identification uses similar techniques, but has the more precise purpose of selecting a list of possible failure cases, which are suitable for quantitative modelling. Hazard scenarios may address the following: who, what where, when, why and how. This provides an intermediate product that expresses the condition and the consequences that will be used during risk analysis.

Some Hazards involved in a construction industry are as follows:

Hazard Areas	Types & Nature of Accidents
i. Steel work and steel frame erection	i. Falls, cuts, Hits, Contusions
ii. Roofing	ii. Falls
iii. General construction including scaffolding	iii. Falls, Structural Collapse, Cuts, hits, Contusions
iv. Refurbishment	iv. Cuts
v. False work, formwork etc.	v. Cuts
vi. Excavations and foundation work	vi. Falls, Cuts, Hits, Contusions
vii. Cleaning and maintenance	vii. Cuts, Dust in eyes & inhalation
viii. Window cleaning	viii. Falls, Cuts
ix. Demolition.	ix. Falls, Cuts, Hits, Contusions, Dust.

## **2.2 Risk Assessment:**

The objective of Risk Assessment is foresee and assess the potential Accident causes to enable us to take measures to control Accidents and minimize their consequences as far as possible in the event of causation of accidents in terms of health effects and property damages.

**Semi Quantitative Risk Assessment:** involves adopting some level of Quantification like in RBI-Matrix, Accident Analysis etc., wherein we try to give some element of Quantification using some Qualitative Scale for determining Chance and Damage consequence or develop patterns of Accidents showing Cause-Effect relations.

The principle is the same as for Qualitative assessments, but numerical scores rather than a grade are assigned to probability and consequences.

The probability or likelihood of the event is rated on a scale of 1 to 5 as follows:

1. Safe
2. Low chance
3. Medium chance
4. Medium High chance
5. High chance

Similarly the consequence or the severity of the event, should it happen, are also then rated on a scale of 1 to 5 as follows:

1. Safe-No damage to life and property
2. Low damage consequence to life and property
3. Medium damage consequence to life and property
4. Medium High damage consequence to life and property
5. High damage consequence to life and property

## OHS Risk Classification

The OHS risk based on total score shall be classified to following levels

( Note: OHS Risks other than Trivial, Tolerable Moderate shall be considered as “non-tolerable OHS risks” and to be addressed by the management systems through specific control measures.)

<b>Risk Level</b>	<b>Action and Time Scale</b>
<b>TRIVIAL</b>	No action is required and no documentary record needs to be kept.
<b>TOLERABLE</b>	No additional controls are required. Consideration may be given to a more cost-effective solution or improvement that imposes no additional cost burden. Monitoring is required to ensure that the controls are maintained.
<b>MODERATE</b>	Efforts should be made to reduce the impact / risk, but the cost of prevention should be carefully measured and limited. Risk reduction measures should be implemented.
<b>SUBSTANTIAL</b>	Work should not be started until the impact / risk has been reduced. Considerable resources may have to be allocated to reduce the risk where the risk involves work in progress, urgent action should be taken.
<b>INTOLERABLE</b>	Urgent action should be taken. Work should not be started or continued until the impact / risk has been reduced.

## 2.3 Risk Control:

Risk control must be achieved by using a predetermined hierarchy of controls. The primary aim of risk control is to eliminate the risk and the best way of achieving this is to remove the hazard. If this is not possible the risk must be minimized by using one or more of the other control options from the hierarchy. The risk control measure selected must be the highest possible option within the hierarchy to minimize the risk to the lowest level as reasonably practicable. Existing controls should be re-evaluated to determine if the most appropriate control measure is in place.

The hierarchy of controls includes:

Preference	Control	Example
1.	Eliminate	Removing the hazard, eg taking a hazardous piece of equipment out of service.
2.	Substitute	Replacing a hazardous substance or process with a less hazardous one, eg substituting a hazardous substance with a non-hazardous substance.
3.	Isolation	Restricting access to plant and equipment or in the case of substances locking them away under strict controls.
4.	Engineering	Redesign a process or piece of equipment to make it less hazardous. Isolating the hazard from the person at risk, eg using a guard or barrier.
5.	Administrative	Adopting standard operating procedures (SOPs) or safe work practices or providing appropriate training, instruction or information.
6.	Personal Protective Equipment	The provision and use of personal protective equipment could include using gloves, glasses, earmuffs, aprons, safety footwear, dust masks.



## **Chapter III**

### **Literature Review**

- **Resilient Design of Rail Tunnels**

**Paul Scott, National Director, Faber Maunsell Fire & Risk Engineering**

This paper considers the design of an urban rail tunnel leading into a station, where the operator engineering standards comparing the risk informed solution. This assessment focuses on whether additional risk reduction measures, beyond those already proposed. The two alternative design solutions described in this paper differ significantly, both in the level of provision of safety systems.

- **Quantification And Communication Of Construction Safety Risk**

**Matthew R. Hallowell, Kiewit Center Graduate Fellow, Ph.D. Candidate, School of Civil and Construction Engineering, Oregon State University**

This paper presents a method for quantifying construction safety risk and risk mitigation ability using scales that define risk in terms of safety and health. Most safety risk literature focuses on risk analysis and the relative risk levels among trades or industries. The probability and severity scales presented in this paper can be used to quantify relative risk levels by multiplying the probability score by the corresponding severity score. In an effort to assess their benefit to the industry, several construction safety and risk management experts were asked to review the scales and describe their benefits and limitations.

- **Delhi Metro construction debris injures man**

This literature is on a malfunctioning crane at a Delhi Metro construction site resulted in some construction material falling on a passing car, seriously injuring the driver. full review of all Metro construction activities has been ordered by DMRC in construction sites close to public roads and public access areas.

- **The Metro Railways (Construction of Works) Act, 1978**

An Act to provide for the construction of works relating to metro railways in the metropolitan cities and for matters connected therewith.

- **Safety hazard identification on construction projects**

**Carter, Gregory' Smith Simon D.**

This study shows Hazard identification is fundamental to construction safety management, unidentified hazards present the most unmanageable risks. This paper presents an investigation indicating the current levels of hazard identification on three U.K. construction projects. Maximum hazard identification levels were found to be 72.8% for a project within the railway industry.

- **Subjectivity In Data Extraction - A Study Based On Construction Hazard Identification, Simon D Smith, Philip Beausang, David Moriarty and Jennifer M Campbell**

In this study it was found the maximum hazard identification level for a construction project within the rail sector the level was 72.8% and a construction project in the light rail sector. These unidentified hazards pose significant risks for the simple reason that nonidentified hazards will lead to non-controlled risks. Method statements describe how a given work task is to be undertaken. They are often paper-based and generally include some form of hazard identification and/or risk management documentation such as a Risk Assessment. The overall aim of the paper is to understand the extent of subjectivity in data extraction and to propose a possible solution to using data that exhibits variable subjectivity.

- **Modeling of risk acceptance criteria for tunnel and underground engineering.**

**Ounfang, Hu; Hongwei, Huang**

The application of risk analysis into tunnel and underground engineering in China is a little later than other developed countries. The risk analysis and assessment of Yangtze Channel Tunnel Channel Tunnel, popularly called the "Chunnel," a three-tunnel railroad connection running under the English Channel, connecting Folkestone, England, and Calais, France. The tunnels are 31 mi (50 km) long. There are two rail tunnels, each 25 ft Click the link for more information. In Shanghai is the first example which is began in 2002 and finished in 2003. Risk analysis is a systematical science which is composed of three main subjects: risk identification and measure, risk assessment and decision-making, and risk management and control.

- **Risk Assessment, Management and Monitoring of Infrastructure Systems**

Y. Fujino and T. Noguchi

In this paper the concept of risk assessment and management of urban infrastructures are discussed. Focus of discussion is put on the risk due to natural disaster and infrastructure deterioration, and on the sustainability of infrastructure. The concept of risk assessment is herein presented first, followed by examples of risk assessment and management due to natural disasters. The last part introduces infrastructure monitoring as an essential tool for risk reduction.

- **Risk Management: A New Approach To Improving Safety, Sweden National Report, Strategic Direction Session , J. Hansen and L. Nilsson.**

The field of risk management has consequently expanded from traditional safety, security, quality and efficiency into general management. As a management discipline, risk management provides a structured, iterative sequence of steps for risk identification, analysis, evaluation and treatment. The risk management process forms a loop to provide decision-making support that introduces continual systematic analysis and evaluation.

- **Risk and Uncertainty in Construction An Overview**

S. AbouRizk, PhD, PEng.

Assess investment outcome- Consider results of investment against original objectives and Compare risk impacts with those anticipated.

- **Delhi Metro Rail accidents - a time line**

Collapse of an under construction flyover may be a one-of-its-kind accident in the decade old history of the Delhi Metro but the mass transport system of the national capital has witnessed many small accidents.

## **Chapter IV**

### **Procedure for the study**

#### **4.1 Methodology:**

To identify associated, Occupational health & safety (OHS) hazards and risks of activities consider the following:

- a.) Document / Record review
- b.) Consultation with cross section of employees / workman
- c.) Applicable OHS Legislation
- d.) Site assessment and observations of tasks
- e.) Previous incident records

#### **4.2 Procedure**

- Identify the activity
- Identify who is at the risk
- Identify the hazard
- Identify the associated risk
- Evaluate the severity and probability
- Identify existing and required control measures

#### **4.3 Purpose:**

The purpose of this study of hazard identification and risk assessment is to identify all the significant hazard, which may occur during the construction phase, and rank them accordingly to their severity. Having ranked the risk by severity will give an idea to introduce appropriate measures to mitigate the effects of that rank. The work sheet has been shown the severity, probability and control measures (ref. Chapter V).

#### **4.4 Consequences to be considered:**

The important consequences to be considered are as follows:

- increased insurance premiums
- fines
- compensation claims
- damage to property or machinery – replacement costs
- loss of production – time
- loss of the employee's time.

#### **cost to employees:**

Individual employees can suffer:

- death
- serious injury
- pain and/or long-term suffering
- disability.

#### 4.5 Risk Assessment tool:

The risk assessment tool for this study is RBI Matrix ( Risk Based Inspection). Risk assessment has been carried out in term of likelihood and consequences. And risk is evaluated on scale of 5 as shown In the Matrix.

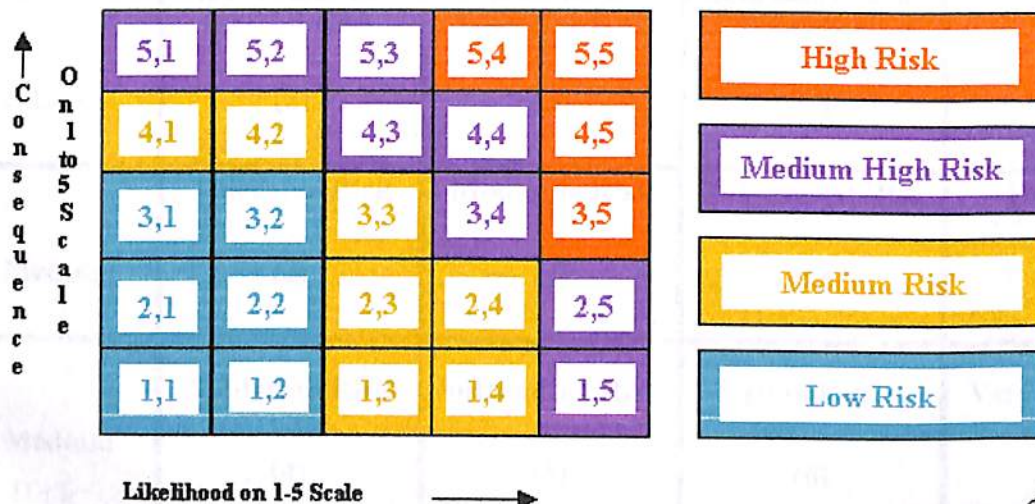


Figure 2

The probability or likelihood of the event is rated on a scale of 1 to 5 as follows:

1. Safe
2. Low chance
3. Medium chance
4. Medium High chance
5. High chance

**Risk Levels are derived from**

<b>Consequence Level →</b>	<b>2. Low</b>	<b>3. Medium</b>	<b>4. Medium High</b>	<b>5. High</b>
<b>Risk Likely- ↓ hood</b>				
<b>2. Low</b>	<b>Trivial Risk (2)</b>	<b>Tolerable Risk (3)</b>	<b>Moderate Risk (4)</b>	<b>Substantial Risk (5)</b>
<b>3. Medium</b>	<b>Tolerable Risk (3)</b>	<b>Moderate Risk (4)</b>	<b>Substantial Risk (5)</b>	<b>High Risk (6)</b>
<b>4. Medium High</b>	<b>Moderate Risk (4)</b>	<b>Substantial Risk (5)</b>	<b>High Risk (6)</b>	<b>Very High Risk (7)</b>
<b>5. High</b>	<b>Substantial Risk (5)</b>	<b>High Risk (6)</b>	<b>Very High Risk (7)</b>	<b>Intolerable Risk (8)</b>

**Table 1**

Clearly the higher the resulting number, the less acceptable the level of risk. The matrix shows where action needed to be taken to reduce either the probability or the consequences in order to reduce the risks to an acceptable level.

Employers themselves can use these numbers to set in-house criteria, if desired, along the following lines, and as indicated by the shaded areas in the above matrix.

- Risks with a rating above 7 are totally unacceptable and the work will not be undertaken until the risk has been reduced.
- Where the risk rating is between 5-6, immediate action must be taken, including a stoppage of work if necessary, to reduce the risk level.
- If the rating is between 3-4, the risk is acceptable provided that everything reasonably practicable has been done to reduce the risk.
- With a rating of 2 or less then the risk is acceptable, provided that the assessment is reviewed at regular intervals and further reduced if possible.



## Chapter V

### Hazard Identification and Risk Assessment work sheet

Activities involved in metro construction and related hazard, their severity (consequences), their probabilities (likelihood) and RISK LEVEL are as follows:

#### A. Barricading board

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/MH/M/L	Probability Explanation	Probability Rating H/MH/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Loading and unloading of barricading board	Fall of boards	Injury	M	Rare chances	L	3	Material shall be handled by authorized / trained riggers.  Proper rated, tested slings & shackles shall be used for the job.  Tag line shall be ensured.
		Hitting overhead cables	Electrocution	MH	Rare chance	L	4	Min 2 meters gap from the overhead cables while loading or unloading.  Ensure there is no loading or unloading during night time.  Ensure availability of a signalman.  No direct touch with the metallic portion, use rope as a tag line.
2.	Fixing of barricading board and placing	Tripping	Injury	M	Rare chances	L	3	Proper training shall be given to employees  Use of PPEs like hand gloves, safety shoes with steel toe and safety helmets.
		Hit by vehicle	Injury	M	Can happen	L	3	Use proper signboards indicating work in progress

### B. Fixing of diversion & caution signs

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Loading, unloading (manually), Fixing	Fall of material	Physical Injury and Material Damage	M	Can happen	L	3	Training shall be give to all employees engaged in loading and unloading.  Proper PPE's shall be used

### C. Fixing of Blinkers

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Electrical wiring, lighting, energizing	Short circuit, fire	Physical Injury, Material Damage, Operation Loss	MH	Can happen	L	4	Proper electrical connection should be done by trained electrician. Regular check up shall be done.

### D. Storage of Gas Cylinders, Paint and Thinners

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Storage of Gas Cylinders, Paints and Thinners	Leakage of compressed gas	Health Effect	M	Rare chances	L	3	While storing properly check cylinders.
		Fire and Explosion in compressed gas cylinders	Burn Injury	H	Rare chances	L	5	Segregated storage
		Contact with paint and thinner while handling	Skin irritation	L	Rare chances	L	2	PPE's used and trained personnel
		Fire in Paint and Thinner	Burn Injury, Material Loss	M	Rare chances	L	3	Segregated storage

### E. Cement storage

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating HM/H/M/L	Probability Explanation	Probability Rating HM/HM/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Cement storage	Dust	Ill Health	M	May Happen	M	4	PPE Provided

## F. Batching plant

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Transporting of materials	Hit by machine to the workers working nearby	Body Injury	H	May Happen	L	5	PPE, Trained worker
		Dust	Health effect	M	Can Happen	M	4	Water sprinkle, PPE
2.	Construction of Batching Plant tank	Hit to helper by JCB during excavation of B/P tank	Injury	H	Can Happen	L	5	Operator trained and experienced signalman deployed to control crane movement
		Fall of person while lifting the cement bag	Injury	M	Can Happen	L	3	Training given to all workers engaged in cement bag lifting
3.	Production of concrete	Skip fall down during lifting due to wire rope broken,  Dumping the raw materials while concreting may cause direct hit	Injury	M	Can Happen	L	3	Batching done in presence of QC people  Ensure first while dumping any material after prior approval of the concern  The training given to operators for ensuring speed limit of transit mixer

		of scrapper bucket to truck,  Toppling of Loaded transit mixer due to rash turn						
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### G. Laboratory

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Testing	Hand burn during testing of cement while mixing,  Standard weights fall during weighing / calibration,  Compression testing blast due to excessive load	Injury	M	Can Happen	L	3	Hand gloves for mixing cement & other material  Training & ensure that during such activities no one should be around during calibration  Ensure the system in testing machine in such a way that crushed material should not spread out all around during testing
		Fall from height	Injury	L	Can Happen	L	2	Trained personnel and PPE's used
		Water leakage from false ceiling falling on electrical switch board,	Property damage, Physical injury due to electric shock	H	Rare chances	L	5	All electrical connections checked,,  housekeeping done,  ceiling conditions checked

		materials						
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### H. Piling

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Preparation of site access and working	Operational Hazards	Medical aid injury	M	Can Happen	L	3	Training and check proper working radius & do not allow any one to enter within working area.
2.	Utility checking after marking pile foundation by manual excavation	Operational Hazards	Medical aid injury	M	Can Happen	L	3	Trained Operators
3.	Casing driving	Operational Hazards	Medical aid injury	M	Can Happen	L	3	Ensure proper safety and all material used for driving / lifting must be tested
4.	Boring	Operational hazards	Physical injury	M	Can Happen	L	3	Crane / rig operator qualified & provided with proper signals for such activities  Proper signaling & training before doing such activities  Proper disposal of muck and avoid day hours for such activities  No activities shall take place w/o presence of supervisor
		Bentonite Spillage leading to slip and fall	Physical Injury, Material Damage	M	Can happen	L	3	Housekeeping done, spillage contained and disposed as per requirements
		Fall into bore	Physical	M	Can	L	3	Proper fencing to be provided.

		without cover	Injury		Happen			
5.	Steel fixing and cage fabrication	Hit by flying objects, hot metal	Physical injury, Burns	H	Can Happen	L	5	No shifting or lifting material without information of foreman  Provide proper screening to welder & ensure safe distance  Proper training & ensure safe practice & use PPE
6.	Cage lowering	Sudden fall of cage	Physical injury	H	Can Happen	L	5	Ensure the durability & quality of material being used for such activities  Needs proper training & provide proper PPE
7.	Tremmie lowering	Operational Hazards	Medical Aid injury	M	Rare chances	L	5	Ensure proper safety & use PPE  Training & such activities should take place in presence of In-charge
8.	Flushing	Slip and fall	Physical Injury, Back Injury	M	Unlikely event	L	3	Ensure safe practice & make barricaded area leak-proof all around
9.	Fitting of concrete hopper into tremmie pipe	Operational hazards	Physical Injury	M	Rare event	L	3	Training
10.	Concreting	Usage of improper materials resulting in damage	Property and material loss	H	Can Happen	L	5	Ensure proper manufacturing trademark for purchasing and using such materials

## I. Steel Yard

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Trailer Movement	Movement in constraint area, hitting property, personnel; fall of material	Material and Property damage, Physical injury	H	Can happen	L	5	Wooden sleeper shall be placed on the bed of trailer to keep the material. The total weight of materials in each despatch shall not exceed the capacity of trailer. The loaded material will finally tied up with the trailer by polyester rope / slings.
2.	Reinforcement cutting, bending and shifting	Exposure to metal particle	Cut injury, Physical injury	M	Unlikely chances	L	3	Proper PPE's should be used. Training shall be given to all employees working in steel yard
		Improper handling of heavy reinforcement bar	Physical injury	M	Can happen	L	3	Maintain good housekeeping; Trained personnel working under supervision
		Tripping hazard	Physical Injury	M	Can happen	L	3	Training shall be given to all employees working in steel yard, PPE's used
3.	Bar Bending	Piece hit	Injury	L	Can Happen	L	2	PPE's used
		Hit injury by machine to workers working near machine	Physical Injury	M	Can happen	L	3	Persons working around the machine should always face the equipment
4.	Unloading of materials	Falling of steel structure while unloading	Physical Injury and Property damage	H	Can happen	L	5	Unloading of material shall be done with proper set of lifting tools & tackles.  Material should be stacked properly & height of stacked material should not exceed more than 1.5



								<p>m.</p> <p>Proper PPE's such as safety shoes, hand gloves, nose mask, safety helmets shall be used. OCP – Crane Operation</p>
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**j. Welding**

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Welding	Electric shock, fire hazard	Burn, eye irritation	M	Can happen	L	3	<p>It will be ensured that working lead and return lead are provided without any break and welding cables holder and earthing holder shall be in good condition</p> <p>Power circuit shall be maintained properly</p> <p>Welding should be avoided on wet places or with wet shoes or wet gloves</p> <p>Power cables of welding shall be inspected for any kind of damage</p> <p>Portable tools shall be checked by the user before commencing the work. If any deficiency found that should be rectified by electrician</p>
		Heat, radiation effect and fumes	Burn,	M	Can Happen	L	3	<p>Asbestos Aprons shall be worn to reduce the heat/radiation.</p> <p>While working in reflective zone, welding booth shall be used to reduce the reflection/arc radiation effect to others.</p> <p>Wheel guard for grinding and welding machine shall be ensured and ear plug shall be</p>

								used.  In case of welding to the materials which can generate toxic fumes, exhaust ventilation must be provided.
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### K. Gas Cutting

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating HM/HM/L	Probability Explanation	Probability Rating HM/HM/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Gas Cutting	Fall from vehicle / cylinder trolley during transportation which cause explosion	Injury	M	Unlikely event	L	3	All gas cylinder shall be kept upright and cylinder shall not strike each other at the time of transport, proper loading of cylinders shall be ensured. Tyre of cylinder trolley shall be maintained in good condition and  cylinder shall never be rolled on ground it has to be carried out by cylinder trolley only
		Fire due to use of improper lighting tools & torch	Burn	M	Highly unlikely event	L	3	Only striking lighter shall be used to light the torch and torch shall be checked for any kind of damages prior to start the job.
		Fire explosion and flying particles	Burn, Physical Injury	M	Rare chances	L	3	All flammable materials shall be removed from the nearby area of Gas cutting and sufficient preventive measures shall be taken during Gas cutting (fire extinguisher, fire bucket, standby fire watch)  Flash back arrester, non returnable valve shall be provided/back fire arrester shall be provided to all the

								<p>outlets of cylinders.</p> <p>Pressure gauges (both for working pressure and cylinder pressure shall be maintained)</p> <p>Cylinder key should be always in cylinder and proper faced shield for grinder and goggles for gas cutters shall be provided.</p>
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### L. Excavation

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating HM/HM/L	Probability Explanation	Probability Rating HM/HM/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Excavation	Hit by equipment	Injury	M	Can happen	L	3	<p>Proper PPEs shall be used.</p> <p>Movement of equipment shall be controlled by the concerned supervisor.</p> <p>Unauthorized person will not allow to enter into the work area.</p>

### M. Pile chipping

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating HM/HM/L	Probability Explanation	Probability Rating HM/HM/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Pile chipping	Exposure to flying particles	Physical Injury	M	Rare Chances	L	3	Use PPEs like safety goggles, mask and ear plugs
		Impact of abrasion	Physical Injury, Bruises and Cuts	M	Rare Chances	L	3	Use hand gloves; Engage only skilled workers for chipping job

## N. P.C.C. Concreting

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating HM/H/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Leveling of area	Hit injury by machine to worker working near the machine	Physical Injury	M	Rare Chances	L	3	Use of goggles and mask. Nobody should be allowed to work without safety goggles, safety helmet, safety shoes & hand gloves. Wheel loader should be equipped with reverse horn.

## O. Pile Cap

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Layout Instrument Setting	Improper handling of equipment	Physical Injury	M	Rare Chances	L	3	Use proper PPEs. Training shall be given to persons who are handling survey instrument
2.	Earth leveling, erection of staging, bottom shutter fixing	Exposure to dust	Breathing Uneasiness	L	May happen	M	3	Use of PPEs like mask and safety goggles
3.	Earth leveling and Buffing of shutter	Fall of material	Physical Injury, Material Damage	M	Can happen	L	3	Close supervision should be provided. Proper PPEs should be used.
4.	Bottom shutter fixing	Fall of material	Physical Injury, Material	M	Rare chances	L	3	

			Damage					
5.	Roof fixing & binding, side shutter fixing, survey checking	Tripping hazard	Physical Injury	M	Can happen	L	3	Use of PPE like hand gloves and safety shoe and goggles. The persons engaged in shutter fixing and binding must be skilled and identified
		Improper handling of roof, shutter	Physical Injury	M	Can happen	L	3	The shutter fixing activity shall be carried out under the strict supervision of concern engineer & supervisor; OCP – Shuttering
6.	Concreting	Cuts during Cleaning of concrete bucket	Physical injury	L	Unlikely event	L	2	Use of hand gloves
		Improper handling of bucket and crane	Physical Injury	L	Unlikely event	L	2	Use of PPE and procedure as directed during supervision
7.	De-shuttering	Exposure to concrete	Breathing uneasiness, skin irritation	L	May happen	M	3	Use of hand gloves and masks
		Improper handling of crane and shuttering material	Physical injury	M	Can happen	L	3	Use of PPE & work procedure as directed during supervision; OCP - Shuttering

## P. Pier & Pier Cap

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Layout	Opening of survey instrument box and setting of instrument	Physical Injury	M	Rare chances	L	3	Use of PPE, Trained personnel working under supervision
2.	R/F fixing and binding, checking	Separation of bar diameter wise	Physical Injury	M	Rare Chances	L	3	Work done as per specifications and under supervision; PPE's used
		Improper handling of R/F	Physical Injury	M	Rare Chances	L	3	Work done as per specifications and under supervision; PPE's used
3.	Shutter fixing and survey checking	Splash during Cleaning of shutter	Physical injury and Eye injury	L	Highly unlikely chances	L	3	Use of goggles
		Improper fixing of shutter and mishandling of equipment	Physical Injury	M	Rare chances	L	3	Use of PPE

### Q. Work at Height

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Work at Height	Trips, falling from height	Injury	MH	May Happen	M	5	Proper access ladder provided for workers working at height and safety harness ensured, where work has to be carried out above 2m height and tied with fixed structure  Proper scaffolding provided.

### R. Loading and unloading

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Loading and unloading	Fall of products	Injury	M	May Happen	L	3	Training shall be given to all employees
		Entanglement	Injury	MH	May Happen	L	4	Training shall be given to all employees
		Hit by product	Injury	L	May Happen	L	2	Training shall be given to all employees

### S. Lifting Operation

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Lifting Operation	Slings may break, Crane or Hydra may collapse	Injury/Property Damage	H	Can Happen	L	5	Operators to make sure that Crane/Hydra are positioned properly and angle of boom is proper for weight being lifted  Outriggers are provided with crane, shall be fully

							<p>extended</p> <p>Lifting materials weight checked before lifting and good condition/ rated lifting tools and tackles used with colour coding.</p> <p>Competent and trained slinger/ Banksman shall be deployed for the job and the Crane has limit switch</p> <p>All lifting tools provided with a safety latch and no equipment used under high wind/ heavy rain or if the whether condition is bad.</p>	
		Slippage of girders during erection of truss in cement godown	Injury	M	Can Happen	L	3	Crane operator qualified and lifting done in presence of skilled foreman or supervisor
		Exposure to cement dust during mixing / preparing cement and sand grout for batching concrete	Health Effect	H	Can Happen	L	5	Use of PPEs like dust mask and safety goggles
		Hit to leg by Plate compactor during compaction	Injury	MH	Can Happen	L	4	Trained operator of such machines and provided PPE to avoid such incidents



### T. Crane operation

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1	Crane operation	Fall	Injury/Product Damage	H	Can Happen	L	5	Test certificates, Trained personnel
2.	Gantry crane	Chain break	Injury/Product Damage	H	Can Happen	L	5	Test certificates
		Toppling	Injury/Product Damage	H	Can Happen	L	5	Provide stop ends at both the ends of rails
		Fall	Injury	H	Can Happen	L	5	Test certificates available. Hoops to be provided on ladder

### U. Precast Segments

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Preparation of casting yard	Hit injury to workmen	Physical Injury	M	Can happen	L	3	Excavator will be equipped with reverse horn.  Person working around the machine should always face the equipments.  Access to machines shall be controlled by concern supervisor.  Only authorized operators having valid license shall operate the machine

2	Placing of track sleepers	Slippage of wire rope during sleeper handling	Human Injury	MH	Can happen	L	4	Wire ropes used for lifting shall be inspected before use by competent person; PPE's used
3	Rail track welding	Electrical Shock, Fire hazard	Human injury, Burns	M	May happen	M	4	<p>Power circuit shall be maintained properly. The job should be grounded to the main earth. Insulation of the welding holder shall be inspected. Welding should be avoided on wet places or with wet shoes or wet gloves. Power cables of welding shall be inspected for any kind of damage. Portable tools shall be checked by the user before commencing the work. If any deficiency found that should be rectified by electrician. All electrical connections shall be routed through ELCB's and shall be kept away from Gas cylinder storage area. Asbestos cloths or sheets shall be used when welding patters are likely to be contained to the floor. The welding transformer shall be kept in well ventilated area to facilitate cooling of the transformer. All cable joints shall be rigidly made to avoid any kind of spark causing fire. Appropriate fire extinguisher shall be kept nearby to avoid fire hazard.</p> <p>Welding to be checked before removal of slings.</p>

								Proper checking and maintenance of crane. Only trained persons to be allowed on rope ladder. Use of proper PPE's.
4.	EOT Erection	Plate girder hit the man during lifting	Physical Injury	M	May happen	M	3	Welding to be checked before removal of slings. Proper checking and maintenance of crane. Only trained persons to be allowed on rope ladder. Use of proper PPE's.
		Breakage of grinding wheel during grinding	Operation loss, physical injury	M	Highly unlikely event	L	3	Use of standard materials for grinding. Proper holding of job and checking the expiry date of the grinding wheel. Use of proper PPE's. Training to be given to grinders and helpers.
5.	Shutter erection	Fall of shutter during erection	Physical Injury	H	Rare chances	L	5	Skilled workman will be deployed for material Handling / Shifting. In lifting operation tag / guide rope to be used in case of lifting / shifting with crane / hydra. Only Certified / Inspected / Calibrated Equipment and authorized operator / person will be deployed
6.	Buffing of shutter	Exposure to flying particles and dust	Eye and Physical Injury	M	Can happen	L	3	Dust Mask , Gloves , Ear plug / Ear muffles to be ensured for concerned

7.	Segment Casting	Shuttering fall down	Damage to property and physical injury	H	Highly unlikely chances	L	5	Only trained persons should be engaged for erection of shutter. The work should be carried out in close supervision. Only trained persons should be engaged for erection of shutter. The work should be carried out in close supervision. Unwanted and loose materials to be removed immediately from the working platform and other will be stacked / stored properly. Close inspection will be carried out by execution and HSE site personnel. Proper PPEs should be used during shuttering work. Training shall be given to all workers. Oil spillage shall be removed immediately. Training shall be given to all workers.
8.	Reinforcement Cage Lowering	Tilting of cage	Physical Injury	M	Can happen	L	3	Training Provided and supervision done
		Falling of cage due to straightening of hooks used for lifting of cage	Material damage and loss of operation	M	Highly unlikely chances	L	3	Proper and checked hooks to be used and supervision
		Fall of cover blocks or loose bar on cage	Property damage and physical injury	M	Rare chances	L	3	Supervision and tested equipment use
		Workers hand struck	Hand and Physical	MH	Can happen	L	4	Trained personnel and PPE's use

		inside the cage & shutter	Injury					
9.	Concreting	Hydra crane hit the worker during concrete pump placing	Physical Injury	M	Can happen	L	3	Trained personnel; Supervision done and PPE's used
		Concrete pipe fallen on workers foot during conc. Pump pipe line fitting.	Physical Injury	M	Can Happen	L	3	PPE's used
10.	Shifting of segment from bed to stocking yard	Failure of EOT brakes during lifting of segment	Physical Injury and Property damage	M	Can happen	L	3	Proper maintenance of EOT; PPE's used and checking done
		Gantry crane hit the person on trench	Physical Injury and Property damage	M	Can happen	L	3	Proper alarming system on the EOT while travelling
		Segment fallen due to improper tightening of bolts	Physical Injury and Property damage	MH	Can happen	L	4	Proper training of workers
		Collapsing of EOT main girder due to loosening of bolts	Physical Injury and Property damage	H	Can happen	L	5	Use of HT bolts of good quality, tightening of bots regularly.

## V. Launching Segments

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Erection of launching girder	Fall of cribs on the worker during staging	Physical Injury	H	Can happen	L	5	Proper bracing of cribs before opening the sling.
		Main girder hit a worker	Physical Injury	H	Can happen	L	5	Holding rope to be used while lifting of the heavy objects Working place to be cleaned before lifting
		Sling breakage / lifting hook breakage during lifting	Physical Injury, Material and Property Damage	H	Can happen	L	5	Tested slings, proper welding of lifting hooks
		Toppling of crane while lifting main girder due to land settlement	Physical Injury, Material and Property Damage	H	Can happen	L	5	Ground to be well compacted before lifting the object
		Collapsing of crane boom during lifting	Physical Injury, Material and Property Damage	H	Can happen	L	5	Crane to be operated for safe working load/radius Operator to be trained enough not to give jerk to heavy material Proper maintenance of the crane
2.	Erection of Girder support	Spanner / bolt falling from top during bolting of main girder	Physical Injury, Equipment Damage	M	Can happen	L	3	Safety nets to be used Barricading to be done in working area
		Fall of worker from	Physical	H	Can	L	5	Proper ladder

		height	injury		Happen			Safety belt provided
		Toppling of Liner	Physical Injury/ Property Damage	H	Can Happen	L	5	High capacity Crane and good quality slings to be used. Levelled surface for base plate of liner. Cross beam for arresting fall of liner. Plate nailing must on base plate. Locking of all supports by bracing.
3.	Front support erection	Toppling of front support	Physical Injury/ Property Damage	H	Can happen	L	5	Front support should be locked with pier. Either utilize shear rods of pier for front support arresting or anchor rods may be used.
4.	Lifting of box Girder	Improper seating of girder on front support and liner support	Physical Injury/ Property Damage	H	Can happen	L	5	Right capacity of crane and height of boom. Check the level of box girder before lifting by water leveler. Fix rope on both sides for controlling the direction of segment during lifting.
		Fall of worker during bolting of box girder with front support	Physical Injury/ Property Damage	H	Can happen	L	5	Proper working platform should be made.
5.	Joining of box girders	Fall of worker during bolting of box girder with front support	Physical Injury/ Property Damage	H	Can happen	L	5	Proper working platform should be made.  Proper lighting arrangement.  Trained personnel. Nuts and bolts should be

								tightened using mech. Torque wrench of specified capacity.
6.	Lifting of sliding beams	Fall of worker	Physical Injury	H	Can Happen	L	5	Life line for workers working on top of girder
7.	Lifting of segments	Fall of worker	Physical Injury	H	Can Happen	L	5	Worker climbing on top of segment must wear safety belt with proper anchoring. Proper ladder for bringing persons from top of segment
8.	Lowering of segments for tightening nuts	Fall of segment from the hoist	Physical Injury/ Property Damage	H	Can Happen	L	5	Support of cribs during fastening of nuts on bottom of segments. Check threads of bolts on slings before start of fastening of nuts.  During lowering/ lifting of segments, no worker should stand below.
9.	Alignment of segments	Fall of jack parts	Physical Injury/ Property Damage	MH	Can Happen	L	4	Special care for shifting of jacks- at least 2-3 persons should be there
10.	Epoxy glueing of segments	Skin effect	Physical injury	M	Can Happen	L	3	Plastic hand gloves/ goggles should be used
11.	Grouting	Dust during mixing of cement	Health effect	M	Can happen	L	3	Use of nose mask
12.	Auto launching	Unbalancing of girder	Physical Injury/ Property Damage	H	Can happen	L	5	Proper counter weight should be ensured over the last box girder. Proper alignment of rails for rear trolley movement for



								ensuring smooth movement.
13.	Launching works of segments	Slippage of segments from trailer during transportation due to improper tying	Property damage, Human Injury	M	Can happen	L	3	Proper loading of segments on trailer
		Accident of trailer during transportation of segments	Delay in operation, Damage to property, Human injury	M	Rare chances	L	3	Good/trained drivers; Traffic marshals deployed
		Fallen of worker while climbing on segment for fixing of lifter	Physical Injury	MH	May happen	M	5	Trained worker and PPE's used
		Brake failure of lifting crab / lifting bars / wire ropes	Property and Material damage, Human injury	H	Highly unlikely chances	L	5	Proper maintenance & replacement of bars as per manufacturers
		Epoxy glue comes in contact with the eye / skin of worker	Skin irritation; First aid injury	L	Rare event	L	2	Use of PPE
		Workers hand trapped in between two segments	Physical Injury	MH	Highly unlikely chances	L	4	Proper instructions and training
		Hydraulic hose bursted due to	Material and	M	Rare event	L	3	Preventive maintenance of jacks, pumps and calibration gauges

		improper handling, tightening for temp. prestressing	Property damage, Physical injury					
		Dismantling of girder support	Physical Injury/ Property Damage	H	Can happen	L	5	Proper access to top of support. All interlinking should be properly cut off. Capacity of crane should be checked. No body should be allowed stand in front of the support. First remove jack, then stool and slide the support from bottom. The process should be without any jerk.

### W. Pre stressing

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Cutting of HTS Wire	Exposure to sparks, metal particles	Physical injury	M	Can happen	L	3	Right tools and use of PPEs
		Improper handling of HTS coil and improper decoiling	Material / Property damage, Physical injury	M	Rare event	L	3	Use of PPEs, Coil to be handled as per guidelines and under strict supervision, Trained labor to be engaged
2.	Introduction / Threading of HTS wire	End may hit eye or body	Physical Injury	M	May happen	M	4	Training
3.	Hydraulic jacks, shifting and fixing	Leakage of hydraulic oil man can slip	Physical / Back injury	M	Can happen	L	3	Proper cleaning arrangement and preventive maintenance of jack

		Hydraulic hose, damage wheels jack is in operation and hit man working nearby	Physical / Back injury	M	Can happen	L	3	Use of PPE. Testing and stability of hose as to checked
		Improper handling of jack may fall at man	Physical / Back injury	M	Can happen	L	3	Use proper sling, hooks, lifting supervision required
		Jack may slip	Physical Injury	H	Can Happen	L	5	Proper lifting arrangement of jack. Proper anchoring of pre stressing cables.
		Breakage of strands/ puller in temp prestressing	Physical Injury	H	Can Happen	L	5	No person should stand in front of jack. Proper working platform around front support.
4.	Stressing	Oil Leakage leading to slip and fall	Back injury	M	Rare chances	L	3	Preventive maintenance of jacks and hydraulic hose; housekeeping done and PPE's used
		Wedges slip and wire come out of jack and may hit the man	Physical Inuury	M	Rare chances	L	3	Master wedges as to set before use. After certain repetition wedges as to changed as manufacturers specification

## X. Grinding

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Grinding	Exposure to sparks	Minor burn, physical injury	L	Rare chances	L	2	Use of proper PPE
		Wheel may break and hit to body	Physical injury	M	Highly unlikely event	L	3	Use only good quality grinding wheels used; job hold properly and as per requirements, wheel guard is kept in place, expiry date of grinding wheels checked; trained operators and PPE's are also used

## Y. Electrical work

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1	Testing and energisation	Short circuit, flash, sparking.	Burn, eye irritation	M	Rare chances	L	3	<p>Ensure that testing instruments are set in adequate testing range</p> <p>Lock out &amp; tag out, Permit to work system to be implemented</p> <p>Keep live line working to a minimum and avoid redundant testing</p> <p>Use insulated hand tools &amp; adequately insulated rubber hand gloves for maintenance and repairing</p> <p>Use adequately insulated rubber hand gloves</p>

2.	Distribution boards installations.	Flash, Electrical shock, Sparking.	Burn, eye irritation, property damage	M	Highly unlikely chances	L	3	<p>Use adequately insulated rubber hand gloves.</p> <p>Ensure phase separation barriers are in position</p> <p>Ensure adequate insulated and tested tools and test leads / or probes</p> <p>Do not defeat the Electrical &amp; Mechanical inter locks</p> <p>Do not use flexible wire as test lamp lead. Use adequately insulated rigid wires</p>
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### Z. Drilling operation

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HMM/M/L	Probability Explanation	Probability Rating H/HMM/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Drilling operation	Electric shock	Injury	M	Unlikely event	L	3	Earthing provided
		Fumes	Health effect	L	Rare chances	M	3	PPE provided
		Hit by chips	Injury/eye injury	L	Rare chances	M	3	Goggles provided

### AA. DG operation

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	DG operation	Slip	Injury	L	Rare chances	L	2	
		Noise	Hearing impairment	L	Rare Chances	L	2	Acoustic enclosure provided
		Fumes	Health effect	L	Unlikely event	L	2	Chimney of adequate height provided and DG is located in separate area

### BB. Scrap yard

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Scrap yard	Manual handling of heavy items	Back pain	L	Unlikely event	L	2	Trained operators and light loads are handled manually
		Sudden falling of materials/ rolling over of drums while handling	Physical injury	L	May happen	M	3	Segregated storage, PPE's used, Trained personnel deployed under supervision
		Touching of sharp edges of metallic scrap	Cut injury	L	Has been observed	M	3	Segregated storage, PPE's used, Trained personnel deployed under supervision

### CC. Office activities

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Office activities	Glare from computer screens	Eye strain	L	Rare chances	L	2	Work rest cycle suggested & practiced, Anti-glare screens / monitors used
		Sudden falling of files, documents	Physical injury	L	Unlikely event	L	2	Records and documents maintained in an orderly manner
		Electric shock from electric points, gadgets, cables etc.	Physical injury	M	Rare chances	L	3	Earthing done; Cables and joints are inspected and rectified as necessary
		Improper posture while sitting	Back pain, ergonomic effect	M	Unlikely event	L	3	Ergonomically designed chairs and tables provided in workplaces
		High & Low temperature conditions during summer & winter months respectively	Discomfort	M	Rare chances	L	3	Desert coolers / AC's and Room heaters provided
		Long working hours	Stress	M	Rare chances	L	3	Work rest cycle provided; provisions of BOCWA/R followed related to working hours

### DD. Mock Drill for fire

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Mock Drill for fire	Exposure to fire	Burn injury, Property damage	M	Rare chances	L	3	Trained fire fighters, Mock Drill carried out in safe area
		Portable fire extinguisher suddenly falling	Physical injury	M	Rare chances	L	3	Trained fire fighters, PPE's used
		Exposure to fumes of extinguishing media	Breathing uneasiness	L	May happen	M	3	Trained fire fighters, Extinguisher used from safe distance, Masks used

### EE. Testing of lifting tools and pressure vessels

SL. No.	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/HM/M/L	Probability Explanation	Probability Rating H/HM/M/L	Risk Level 1/2/3/4/5/6/7/8	Risk Controls Existing and Required
1.	Testing of lifting tools and pressure vessels	Improper testing leading to field failure later on, sudden bursting of pressure vessel or flying of valve, sudden failure of test load	Physical injury, property loss, loss of working hours	M	Unlikely chances	L	3	Testing done by Client / DMRC approved Competent Person in presence of company staff well versed in testing method to witness the same; periodic maintenance also carried out



## Results and Discussion

Risk Assessment	SR = Severity Rating - When it can lead to fatality or permanent disability Or when Property Loss is more than Rs 100,000	High = H	PR = Probability Rating - When it occurs frequently or Chances approx. more than 75%	H	5	6	7	8
	When it can cause serious injury or permanent disability when Property Loss is more than Rs 50,000 but less than Rs 100,000	Medium High = MH	Chances between 50% to 75%	MH	4	5	6	7
	- When it can lead to temporary disability or doctor visit is required Or when Property Loss is more than Rs 10,000 but less than Rs 50,000	Medium = M	-When it occurs occasionally or Chances between 10% to 50%	M	3	4	5	6
RL = Risk Level, 2 = Trivial, 3 = Tolerable, 4 = Moderate, 5 =Substantial, 6=High risk, 7 = Very High Risk, 8 = Intolerable Risk	- When it can lead to First aid Injury Or when Property Loss is less than Rs 10,000	Low = L	-When it has never occurred before or chances less than approximately 10%	L	2	3	4	5
					L	M	MH	H

(Source: SHE Plan of Gammon India ltd. For DMRC construction Project)

### **Severity Rating**

- High Severity, When it can lead to fatality or permanent disability Or when Property Loss is more than Rs 100,000
- Medium High Severity, When it can cause serious injury or permanent disability when Property Loss is more than Rs 50,000 but less than Rs 100,000
- Medium Severity, When it can lead to temporary disability or doctor visit is required Or when Property Loss is more than Rs 10,000 but less than Rs 50,000
- Low Severity, When it can lead to First aid Injury Or when Property Loss is less than Rs 10,000

### **Probability Rating**

- High Probability, when it occurs frequently or Chances approx. more than <sup>75</sup>50%.
- Medium High Probability, Chances between 50% to 75%.
- Medium Probability, when it occurs occasionally or Chances between 10% to 50%.
- Low Probability, When it has never occurred before or chances less than approximately.

## Summary of Results:

<b>SL. No.</b>	<b>Risk Level (Numeric) 1/2/3/4/5/6/7/8</b>	<b>Risk Level Descriptive</b>	<b>Total No of Activity, Product, Service</b>	<b>% of each Risk Level to total Number studied</b>
<b>1.</b>	<b>2</b>	<b>Trivial Risk</b>	<b>14</b>	<b>9.3</b>
<b>2.</b>	<b>3</b>	<b>Tolerable Risk</b>	<b>85</b>	<b>56.7</b>
<b>3.</b>	<b>4</b>	<b>Moderate Risk</b>	<b>13</b>	<b>8.7</b>
<b>4.</b>	<b>5</b>	<b>Substantial Risk</b>	<b>38</b>	<b>25.3</b>
<b>Total</b>	<b>-</b>	<b>-</b>	<b>150</b>	<b>100</b>

**Table 2**

Delhi Metro construction involves various activity, product and services which have various hazard concerns. Every activity, product, service has got specific risk level. This risk level is given to each according to their severity and probability of occurrence.

Severity of activity, product and service are rated according to consequences of their occurrence. Probability is based upon chance of occurrence.

- Risk level of 14 Activity, Product and Service is found 2, which can lead to fatality or permanent disability or when Property Loss is more than Rs 100,000 and its Chances approx. more than 50%.

Ref: Work Sheet D, G, I, O, R, W, Z, AA, BB.

- Risk level of 85 Activity, Product and Service is found 3, which can cause serious injury or permanent disability when Property Loss is more than Rs 50,000 but less than Rs 100,000 and its Chances between 50% to 75%.

Ref: Work Sheet A, B, D, F, G, H, I, J, K, L, M, O, P, S, U, V, W, X, Y, AA, BB, CC, DD.

- Risk level of 13 Activity, Product and Service is found 4, which can lead to temporary disability or doctor visit is required or when Property Loss is more than Rs 10,000 but less than Rs 50,000 and its chance between 10% to 50%.

Ref: Work Sheet A, C, E, F, R, S, U, V.

- Risk level of 38 Activity, Product and Service is found 5, which can lead to First aid Injury Or when Property Loss is less than Rs 10,000 and its chance very less.

Ref: Work Sheet D, F, G, H, I, Q, S, T, U, V.

## Chapter VII

### Conclusions & Recommendations

#### **.1 Findings and Recommendations:**

Out of the 150 numbers of Activities, product and service studied for Risk assessment, the above table shows the Risk Levels in Numeric and Descriptive Scales. Following are the conclusions:

- i. There are no Activity, Product and Services where Risk ranking is above 5 which means there are no unacceptable Risks.
- ii. There are 38 Nos. (25.3%) of Risk Level of 5 that corresponds to Substantial Risk and requires immediate action must be taken, including a stoppage of work if necessary, to reduce the risk level.
- iii. There are 13 Nos. (8.7%) of Risk Level of 4 that corresponds to acceptable Risk Level provided that everything reasonably practicable has been done to reduce/control the risk.
- iv. There are 85 Nos. (56.7%) of Risk Level of 3 that corresponds to acceptable Risk Level provided that everything reasonably practicable has been done to reduce/control the risk.
- v. There are 14 Nos. (9.33%) of Risk Level of 2 that corresponds to Trivial Risk Level provided that the assessment is reviewed at regular intervals and further reduced if possible.

## **7.2 Conclusions:**

The Risk Assessment study of Delhi Me6tro shows that, the Activity, Product and Service studied for Risk Levels, 66% are 3 and below meaning acceptable Risk.

This shows that Delhi Metro has a very high standard of Safety.

Special attention is needed for 38 items corresponding to 25% of Activity, Product and Service studied which are having Risk Level of 5 that corresponds to Substantial Risk.

### **Benefits gained by me from the Project work:**

- i. I got a deep insight in to one of the major and very successful construction activities in Delhi Metro that has earned World acclaim for its management excellence in any Public Sector organization,.
- ii. I got a sound idea of Risk Assessment using a 1-5 scale of Frequency and Consequence of accidents.
- iii. I learnt the qualitative and quantitative technical details of Risk assessment.

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## APPENDIX

### Important Terms and definitions

#### **RISK:**

- Danger; (exposure to) the possibility of loss, injury, or other adverse circumstance. A chance or possibility of danger.
- Combination of the likelihood and consequence(s) of a specified hazardous event occurring.

#### **Risk has two parameters:**

1. Risk of occurrence of an accident ,
2. Risk of damage consequences to life and property.

#### **Frequency, Probability, Chance and Likelihood:**

- Frequency or Failure Rate ( $\mu$ ): Is the period of occurrence of an accident.
- Frequency is a number of occurrences per unit of time- Normally one year. So frequency is normally expressed as number of times an accident occurs per year.

#### **Probability, Chance and Likelihood:**

- Are generally synonymous. The word Probability is more scientific term and denotes chance of occurrence of an accident out of a total of one chance. It can also be expressed per hundred.
- Probability, Chance or Likelihood have no unit but just a number.

#### **Accident:**

- Accident is an undesirable and unplanned event.
- Undesired event giving rise to death, injury, damage or other loss.



**Some basic functional definitions:**

- **Safety** – the freedom from unacceptable risks of personal harm, i.e the avoidance of accidents and incidents.
- **Health** – Physical wellbeing of a person and the freedom from any illness caused working condition.
- **Hazard** – A situation with the potential to cause harm including human injury, damage to property, plant or equipment, damage to the environment, or economic loss.
- **Loss** - avoidable waste of any resource
- **Control** – compliance with requirement and standards
- **Risk** – chance of loss
- **Risk analysis** – assessment of the potential severity of loss along with the probability and exposure of hazard
- **Environmental protection** – control of harm or damage done to anything (living and nonliving) in the environment
- **Risk control** – anything done to reduce loss from the business. It includes:
  - The elimination or reduction of loss exposures
  - The minimization of loss when loss- producing events occur
  - The termination or avoidance of risk
- **Major Injury Accident-**
  - any fracture, other than to the fingers or toes
  - Any loss of limb or part of limb
  - Dislocation of the shoulder, hips, knee, or spine
  - Loss of sight
  - Penetrating injury to the eye
  - Any other injury that
    - leads to unconsciousness
    - requires resuscitation
    - requires admittance to hospital for more than 24 hours
    - or which causes more than 10 days absence from work.

- **Dangerous Occurrence-**

- Collapse or failure of lifting appliances or hoist or conveyors or other similar.
- Collapse of crane, derrick, winch, or other appliance used in raising or lowering goods.
- Explosion or fire causing damage to structure of any room or place in which person are employed.
- Electric short circuit or failure any electrical machinery, plant or apparatus, attended by explosion or fire causing damage.
- Collapse in whole or part from any cause whatsoever of any roof, wall, floor, structure or foundation forming part of the construction.
- Collision with any object by any bulldozer, dumper, excavator, grader, lorry, shovel or any mobile machinery used in handling of substance on the construction site.