

Hazards Identification and Risk Assessment in Metro Railway Line Construction Project at Hyderabad

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Abstract— The construction industry has the largest number of injuries compared to other industries. Thus, reducing accidents and determining construction risks are extremely important. One of the essential steps for construction safety management is hazard identification, since the most unmanageable risks are from unidentified hazards. This paper aims to rank the risk of construction hazards.

Keywords— Construction Industry; Metro Railway Line construction; Risk assessment; Hazard identification; risk matrix.

I. INTRODUCTION

In present scenario for any industry to be successful it should meet not only the production requirements but also maintain the safety standards for all concerned. The construction Industry is susceptible to a wide range of hazards in its various operational areas. In India the construction industry has contributed an estimated US\$ 308 billion to the National GDP in 2015-16

Hazard identification and risk assessment is systematic approach to protect the health and minimize danger to life, property and environment.

This paper highlights report on HIRA applied in the construction site of Metro Rail Line project at Hyderabad. It includes the methodological steps to identify hazard related to materials, operations and conditions. Assess the risk level of the hazards and apply or suggest the possible remedies and corrective actions to reduce the risk.

II. METHODOLOGY

The main motto of hazard identification is to identify & evaluate the hazards & the unintended events, which could cause an accident. In hazard identification & quantification of probability of occurrence it is assume that they will perform as designed in the absence of unintended events (component & material failure, human errors, external event, process unknown) which may affect the process behavior.

The steps of hazard identification and risk assessment are:

Step 1 Hazard Identification

The purpose of hazard identification is to identify and develop a list of hazards for each job in the organization that are reasonably likely to expose people to injury, illness

or disease if not effectively controlled. Workers can then be informed of these hazards and controls put in place to protect workers prior to them being exposed to the actual hazard.

Step 2 Risk Assessment

Risk assessment is the process used to determine the likelihood that people exposed to injury, illness or disease in the workplace arising from any situation identified during the hazard identification process prior to consideration or implementation of control measures. Risk occurs when a person is exposed to a hazard. Risk is the likelihood that exposure to a hazard will lead to injury or health issues. It is a measure of probability and potential severity of harm or loss.

Step 3 Risk Control

Risk control is the process used to identify, develop, implement and continually review all practicable measures for eliminating or reducing the likelihood of an injury, illness or diseases in the workplace.

Step 4 Implementation of Risk Controls

All hazards that have been assessed should be dealt in order of priority in one or more of the following hierarchy of controls

The most effective methods of control are:

1. Elimination of hazards
2. Substitute something safer
3. Use engineering/design controls
4. Use administrative controls such as safe work procedures
5. Protect the workers i.e. By ensuring competence through supervision and training, etc.

Each measure must have a designated person and date assigned for the implementation of controls. This ensures that all required safety measures will be completed.

Step 5 Monitor and Review

Hazard identification, risk assessment and control are an on-going process. Therefore regularly review the

V. METHODOLOGY

Standard Procedures can be used to find out hazard in Construction Site given in (Safety at Work 7th Edition by John Ridley and John Channing) using Job Safety Analysis. It is an accident prevention technique that should be used in conjunction with the development of job safety instruction; safe system of work; and job safety training. The technique of Job Safety Analysis (JSA) has evolved from the work study techniques known as method study and work measurement.

The method study engineers aim is to improve methods of production. In this they use a technique known as SREDIM principle:

- Select (Work to be studied);
- Record (how work is done);
- Examine (the total Situation);
- Develop (best method for doing work);
- Install (this method into the company's operation);

Maintain (this defined and measured method).

Work measurement is utilized to break the job down into its component part and, by measuring the quantity of work in each of the component parts, make human effort more effective. From experience standard times have evolved for

particular components operation and these enable jobs to be given in a time.

The basic procedure for job safety analysis is as follows:

1. Select the job to be analyses. (SELECT)
2. Break the job down into its components parts in orderly and chronological sequence of job steps. (RECORD)
3. Critically observe and examine each component part of the job to determine the risk of accident. (EXAMINE)
4. Develop control measure to eliminate or reduce the risk of accident. (DEVELOP)
5. Formulate written and safe systems of work and job safety instructions for the job. (INSTALL)
6. Review safe systems of work and job safe practices at regular intervals to ensure their utilization. (MAINTAIN)

From a practical viewpoint, this information can be recorded on a job safety analysis chart of the sort shown in Figure 2. This is a typical job safety analysis chart. The detailed format with process is given in result analysis.

VI. JOB SAFETY ANALYSIS RECORD CHART (Evaluation in Construction) (Table 1)

Job Safety Analysis Record Chart		
Job Title: Department: Analyst/Reviewer		Date of job analysis: Time of job observation:
Description of Job:		
Accident Experience:		
Maximum Potential Loss:		
Legal Requirements:		
Relevant codes of practice/Guidance notes/Advisory Publication:		
Sequences of job steps	Risk identified	Precautions advised
Suggested safe system of work:		
Suggested review date:		
Suggested job safety instructions:		
Suggested training program:		
Signed:		Date:
Department:		Function:

VII. POSSIBLE RESULT AND DISCUSSION

In this possible result and discussion, only most hazardous activity is taken from the site to give an example of job safety analysis procedure.

Table 2: Sample Job Safety Analysis

Activity: List the task required to perform the activity in the sequence they are carried out	Hazards: Against each task list the hazards that could cause injury when the task is performed	Risk Control Measures: List the control measures required to eliminate or minimize the risk of injury arising from the identified hazard
Job Safety Analysis for Excavation	1. Exposure to or contact with underground utilities (electrical cable, pipeline, etc)	1. First Refer Engg. Drawings as per site excavation Plan 2. Seek information about the underground utilities and check for the same before excavation. Obtain Excavation Permit Engineer/Supervisor shall be responsible for any violation of the requirement 3. Insulated tools, rubber hand gloves, mask, goggles and safety shoes 4. Use hand digging initially till underground facility located if drawings not available.
Job Safety Analysis for Under Ground Piping Fabrication And Installation	1. Incompetence 2. Lack of knowledge 3. Improper supports 4. High noise 5. Flying partials 6. Electrocuton 7. Slip & trip,	1. Safety Induction, 2. Follow work method statement, 3. Trained work force 4. Tool box talk. 5. Place sufficient adjustable tripod stand or four legged stand with suitable/workable height. 6. Use ear protective muff. Post ear protection signage. 7. Ensure wheel guard for grinding machine, Dead man switches for the grinding machine, 8. Use tight fit safety goggle for the job.
Job Safety Analysis for Concreting	1. Vibration or toppling of machine. 2. Manual handling of cement bags. 3. Physical contact with cement slurry or wet concrete	1. Position the machine on a firm level ground with proper anchoring. 2. Helmet/Goggle/Safety shoes/Hand gloves. 3. Use mechanical means to carry cement bags from godown to site. 4. Use safe method of manual handling.
Job Safety Analysis for Rigging	1. Unstable ground 2. Equipment failure	1. Ground condition shall be made suitable for crane. 2. Outriggers shall be fully extended & load bearing pads shall be used during lifting operation. 3. Crane operator has to assess lifting area with rigging supervisor before lifting operation. 4. Lifting is not allowed in harsh weather condition. 5. All lifting tools, tackles shall be protected from sharp edge to avoid damage to slings. 6. Sufficient taglines shall be used with lifting load to avoid swinging the load. 7. The lifting capacity of rigging appliances vs. job to be lifted shall be evaluated about its safe lifting. 8. Crane load chart shall be posted in operator's cabin. The SWL to be mentioned on the crane. 9. The SLI should be in working condition
Job Safety Analysis For Structural Steel Erection Selection of crane, Lifting tools & tackles Lifting of structural steel	1. Mechanical failure of crane. 2. Failure of crane tools & tackles due to overloading. 3. Improper securing & imbalanced load. 4. Poor hand signal to the operator	1. Quarterly inspection & current color tag for crane, man basket, lifting tools & tackles. 2. Management should authorized experienced operator & riggers. 3. Daily inspection of crane by operator & reviewed by equipment supervisor. 4. Valid third party certificates for crane, man basket & lifting tools, tackles. 5. Lifting Plan to be prepared for critical lifting 6. Check the load to be lifted 7. Check the SWL of the crane with maximum boom length & radius to work. 8. Check the SWL of the slings, shackles & Chain Pulley Block. 9. Use correct slinging procedure; load should be properly balanced.
Job Safety Analysis for Confined Space Entry Preparing for Entry Opening Man-hole, Nozzles, Install exhaust blower, fresh air blower	Incompetency/untrained human resources Injury to workers	1. HSE Induction training to be imparted and should be in possession of HSE Induction card. 2. Specific training on "Confined Space Entry" to be imparted. 3. Only physically and mentally fit persons allowed entering the confined space. 4. Display cautionary board "Confined Space", "No Unauthorized Entry". 5. Tool Box Talk to be conducted. 6. Ensure communication system. 7. PTW to be followed. 8. Ensure the emergency rescue procedure and resources are available and workers are aware. 9. Use proper standard tools, do not use fabricated tools 10. Use plant and machinery wherever possible instead of manual lifting.
Job Safety Analysis for cutting Gas Cutting	Unsafe Storage and Handling of gas cylinders Fire and Explosion	1. The gas cylinders should be stored in separate shed having weather protection. 2. The gas cylinders should be segregated gas wise and full, empty. 3. Trolley shall be used to transport gas cylinders from place to place. 4. Ensure only trained person shall handle the gas cylinders.

		<ol style="list-style-type: none"> 5. Always store the cylinders in an upright position and chained. 6. The cylinders should be chained in the trolley also. 7. The cylinder should have valve cap/guard. 8. Fire protection and fire fighting system to be available. 9. No smoking board should be displayed. 10. Cylinders should not be rolled on the ground. 11. Cylinders should not be dropped down from the vehicle. 12. Gas cutting to be done by the trained gas cutter and not by helper. 13. Oxygen and acetylene cylinders shall be stored separately in upright position and well secured, with related signs, in weather protection shed. 14. Gas cylinders should have colour code. 15. Rubber hoses should have colour code. 16. Clamps/jubilee clips should be used for connecting hoses. 17. Cap/guard shall be fixed when the cylinder not in use. 18. Valve guard should be fixed when cylinders are in use. 19. Ensure ISI/CE marked flash back arrestors are installed to the cutting torch as well as cylinder side
Job Safety Analysis for Fire Welding		<ol style="list-style-type: none"> 1. Welding to be done by trained welder, not by helper. 2. Ensure proper house keeping all the time. 3. Ensure proper earthing connections. 4. Ensure that all cables, electrode holder, electrode ovens are in good conditions. 5. Welding return to be connected with proper clamp to job as close as possible from the welding joint. 6. Ensure fire watch, adequate firefighting equipment and fire blankets are in place. 7. Ensure the welding machines are equipped with ELCB, DB. 8. Never place electrode oven on wooden surface when in use. 9. Electrode stubs shall be properly collected in containers, tins. 10. Toolbox talks before starting the job. 11. Weather protection shed to be provided for welding machine. 12. Welding cables should be coiled properly and to be routed away (segregated) from power cable. 13. Flammable material should be removed or covered with fire retardant blanket.

VIII. ASSESSMENT OF CONSTRUCTION PROJECT LEVEL RISK CATEGORIES

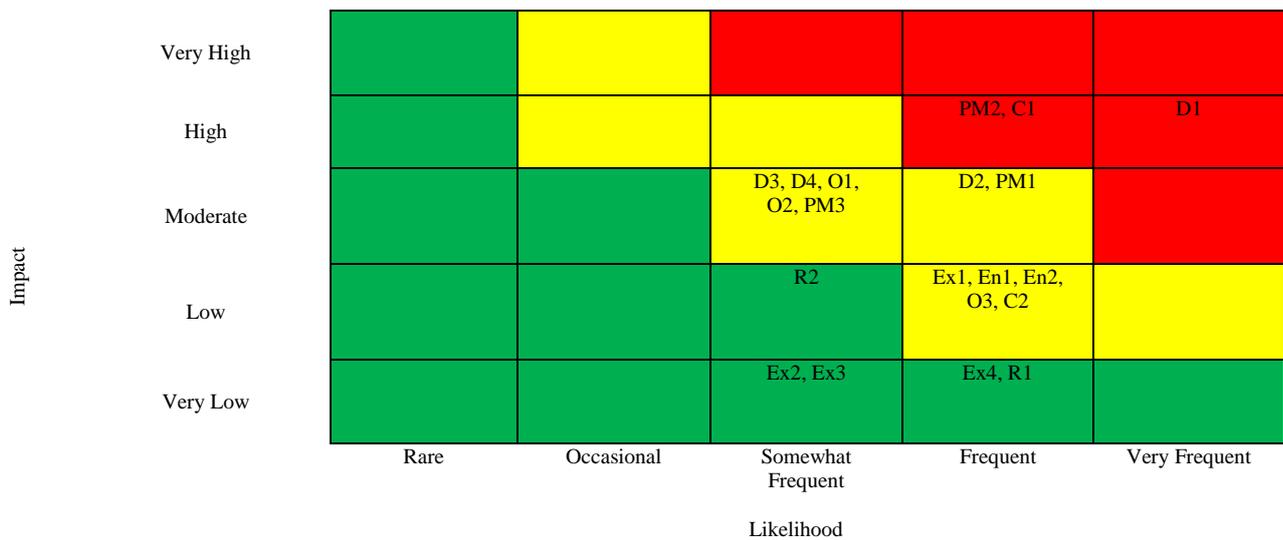
Table below shows that the controllable risk sources as identified in the study could be further broken down into seven sub-categories: design risks, external risks, environmental risks, organizational risks, project management risks, right of way risks, and construction risks which fall within the control of the project team.

Table: Risk Categories

	Categories	Likelihood 1 (Rare)-5 (Very Frequent)	Impact 1 (Very low)-5 (Very High)
DESIGN RISK			
D1	Design errors and omissions	4	5
D2	Design process takes longer than anticipated	3	4
D3	Stakeholders request late changes	3	3
D4	Failure to carry out the works in accordance with the contract	3	3
EXTERNAL RISKS			
Ex1	New stakeholders emerge and request changes	2	4
Ex2	Public objections	1	3
Ex3	Laws and local standards change	1	3
Ex4	Tax change	1	4
ENVIRONMENTAL RISKS			
En1	Environmental analysis incomplete	2	4
En2	New alternatives required to avoid, mitigate or minimize environmental impact	2	4

ORGANIZATIONAL RISKS			
O1	Inexperienced workforce and staff turnover	3	3
O2	Delayed deliveries	3	3
O3	Lack of protection on a construction site	2	4
PROJECT MANAGEMENT RISKS			
PM1	Failure to comply with contractual quality requirements	3	4
PM2	Scheduling errors, contractor delays	4	4
PM3	Project team conflicts	3	3
RIGHT OF WAY RISKS			
R1	Expired temporary construction permits	1	4
R2	Contradictions in the construction documents	2	3
CONSTRUCTION RISKS			
C1	Construction cost overruns	4	4
C2	Technology changes	2	4

Figure 2: Risk Matrix



Once the risks and probabilities are determined, the risk score can be calculated. Risk score is detailed in Table: Risk Categories. The probability and impact matrix (Figure: Risk Matrix) illustrates a risk rating assignment for individual risk factors in the identified risks categories. The risk matrix shows the combination of impact and probability that in turn yield a risk priority (shown by the red, yellow, and green colour). Qualitative risk analysis can lead to further analysis in quantitative risk analysis or directly to risk response planning. Twenty risk factors were established to be significant under the internal risks categories. Under the design risk category, design errors/omissions and design process delays were the most frequently mentioned risk factors attributed to the contractors. Under the project management risk category, scheduling errors and failure to comply with contractual quality requirements were the most frequently mentioned risk factors. Under the construction risk category,

construction cost overruns and technology changes were the most frequently mentioned risk factors attributed to the contractors. Respondents believed that these risk events are responsible for poor quality of work, delays and associated losses. Risks with high impact and high probability, such as D1 (design errors and omissions), C1 (construction cost overruns), and PM2 (scheduling errors, contractor delays) are required further analysis, including quantification, and aggressive risk management.

IX. CONCLUSION

In this paper effective Job Safety analysis approach is elaborated effectively, also the risk matrix is shown to represent different type of risk which is further categories into subcategory. An effective risk management process encourages the construction company to identify and quantify risks and to consider risk containment and risk reduction policies. Construction companies that manage

risk effectively and efficiently enjoy financial savings, and greater productivity, improved success rates of new projects and better decision making.

Risk management in the construction project management context is a comprehensive and systematic way of identifying, analyzing and responding to risks to achieve the project objectives. The research results show that the above said Construction Company significantly differ from the construction companies in India in the adoption of risk management practices. To management the risk effectively and efficiently, the contractor must understand risk responsibilities, risk event conditions, risk preference, and risk management capabilities.

Qualitative methods of risk assessment are used in construction companies most frequently, ahead of quantitative methods. In construction project risk management, risks may be compared by placing them on a matrix of risk impact against a probability. Mitigation options are then derived from predefined limits to ensure the risk tolerance and appetite of the construction company.

The risk management framework for construction projects can be improved by combining qualitative and quantitative methodologies to risk analysis.

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