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Safety Risk Management in Metro Rail Projects: Application of Hazard Identification, Risk Assessment and Fault Tree Analysis

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Abstract: *Safety in the construction industry remains one of the most widely discussed subjects and continues to be a focus of ongoing research. With frequent accidents occurring at construction sites, it becomes crucial to identify the underlying causes. A hazard refers to any recognized source of potential harm, while risk is the likelihood of harm or negative outcomes resulting from that hazard. There is several risk and hazard assessment methods have been developed. Hazard has been classified into several categories. So a great concern is needed to minimize the occurrence of this hazard and for this purpose it is very necessary work for this. Classical safety analysis techniques such as event tree analysis, fault tree analysis, failure mode effective analysis, and job safety analysis are used for risk assessment.*

In this project, Job Safety Analysis, FMEA, Safety Performance Monitoring, and the Fault Tree Model of crane accidents are applied to enhance workplace safety. Workers and others involved have the right to be safeguarded from harm resulting from any type of failure, and it is equally important to implement all necessary and reasonable control measures to ensure their protection.

For this project various Hazard Analysis and Risk analysis methodologies are used for ranking the risk by knowing its consequence and its frequency of occurrence in the Construction work place by means of analyzing all the processes which are being carried out in place.

The primary goal of this project is to identify the hazards present in the workplace and then evaluate the associated risks using various available methods. These approaches, commonly applied in the construction industry, help reduce hazards and contribute to creating a safer work environment.

Keywords: Hazard Identification & Risk Assessment, Risk Ranking, fault Tree Analysis, Job Safety Analysis, Failure Mode and Effect Analysis, Consequences Analysis etc

I. INTRODUCTION

This research focuses on developing and applying a structured safety risk management framework for metro rail projects, emphasizing the integration of hazard identification, risk assessment, and fault tree analysis. The scope includes the following dimensions: Focus on safety-critical risks such as construction accidents, electrical hazards, fire, signaling failures, and derailments. Utilization of Hazard Identification and Risk Assessment (HIRA) tools to evaluate probability, severity, and risk ranking. Deployment of Fault Tree Analysis (FTA) to model the causal pathways of critical safety incidents and estimate failure probabilities. Examination of existing safety management practices in metro rail projects. Identification of gaps in conventional safety risk management approaches. Development of a structured risk reduction hierarchy in alignment with international safety standards. Establishment of a risk register for typical hazards in metro rail projects. Determination of risk acceptability criteria based on ALARP (As Low as Reasonably Practicable). Proposing mitigation strategies (engineering, administrative, and technological measures) for high-risk scenarios. In short, the thesis covers the systematic identification, assessment, and modeling of safety risks in metro rail projects, with a strong focus on practical applications of HAZID, HIRA, and FTA in improving project safety management.

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Aim and Objectives Project work: To analyze safety risk management practices currently adopted in metro rail projects and identify gaps in conventional approaches. To conduct Hazard Identification and Risk Assessment (HIRA) for evaluating the likelihood, severity, and ranking of identified hazards, thereby establishing a comprehensive risk profile. To develop and apply Fault Tree Analysis (FTA) for critical accident scenarios in metro rail projects in order to trace causal pathways and quantify the probability of top events. To establish a safety risk register with prioritization of risks and mitigation measures in alignment with industry standards and the ALARP principle. To propose a structured safety risk management framework integrating HIRA, and FTA, aimed at enhancing accident prevention, decision-making, and operational reliability in metro rail projects.

II. LITERATURE REVIEW

Min Cheng, Yujie Lu According to author Pipe jacking (PJ) construction is a highly complex and uncertain process so that performing an accurate risk assessment is essential to the success of a project. This study presents risk assessment model which mixes fuzzy abstract thought with failure mode and Effect analysis (FMEA) to boost the effectiveness of existing risk assessment strategies for pipe jacking construction. The projected model maps the link between occurrences (O), severity(S), and detection (D) with the amount of criticality of risk events in 3 steps: fuzzification, fuzzy rule-based abstract thought, and defuzzification. A case study of a PJ construction project for water transmission in Shanghai, China is conferred to demonstrate and validate the projected technique. A complete of thirty one potential risks was known as per the PJ construction procedure and two-round metropolis form surveys. The projected technique overcomes the inherent weaknesses of ancient FMEA technique and provides a reliable and distinguishable risk ranking system by properly reflect the complexness of PJ construction setting. The study conjointly provides comprehensive risk identification and analysis tool for industrial practitioners.

Ji-won music, Jung-Ho Yu and Chang-Duk Kim had completed a Safety protection management on building construction; they mentioned that buildings grow to be higher and large, the opportunity of accident also will increase, and recurrent accidents and critical injuries are also increasing. But, it isn't always viable to manipulate all the hazardous activities in construction site. Therefore, hazard with higher possibility must be identified and prioritized in advance so engineers and managers can control the hazard in safe way. For this cause, this study adopts FMEA approach, which has been widely utilized in production enterprise. With the intention to apply FMEA approach in construction protection control, the procedure of creation work is split into sub-strategies or activities. Then FMEA approach is applied to quantitatively, examine the importance of every pastime from the protection perspective. Authors also apply FMEA approach to structural steel erection work and analyze the safety of each interest. Moreover, the quantitative analysis outcomes from FMEA manner are in comparison with the preceding coincidence information so that it will verify the evaluation outcomes.

L.Y. Ding, H.L. Yu, Heng Li, C. Zhou, X.G. Hazard identification is an essential undertaking in the hazard management of metro and underground Construction. This paper provides the safety risk identity system (SRIS) for metro production based totally on construction drawings, which may be implemented to the pre-construction danger assessment system to identify potential hazards which perceive risks automatically and offer a base for dynamic hazard early caution and control. This paper summarizes the protection dangers and danger factors of the metro construction, translates the acquisition method of danger identity rules, and the production of rule-extensions and the storage of rule structures, on which the expertise database of chance identification is based totally. It additionally develops the overall threat identification process and a collection-retrieval matching algorithm based totally on meta-policies and actuality elements. four reputation algorithms for standard image elements are proposed for the functions of metro construction drawings. The unique characteristic of SRIS is that, with the automated identity of production drawings by laptop, the engineering parameters and relations among the construction drawings and the threat identity information database can be quickly obtained. As a result, protection risks in metro production may be routinely recognized from the information database.

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III. AREA OF STUDY

The first rapid transit system in India was the Kolkata Metro, which started operations in 1984. The first elevated mass rapid transit system in India is the Chennai MRTS, which started operations in 1995. The Delhi Metro was the first modern metro in India. The Lucknow Metro is fastest built metro system in India. The Mumbai Monorail, which opened on 7 February 2014 is the first monorail in India, since the closing of the Patiala State Monorail Trainways in 1927. In 2006, the National Urban Transport Policy proposed the construction of a metro rail system in every city with a population of 20 lakh (2 million). On 11 August 2014, Union Urban Development Minister M. Venkaiah Naidu announced that the Union Government would provide financial assistance, for the implementation of a metro rail system, to all Indian cities having population of more than 1 million. In May 2015, Prime Minister Narendra Modi approved the Union Urban Development Ministry's proposal to implement metro rail systems in 50 cities. The majority of the planned projects will be implementing through special purpose vehicles, which will be established as 50:50 joint ventures between the Union and respective State Government. The Union Government will invest an estimated 5 lakh crore (US$78 billion). In new draft policy unveiled in March 2017, the Central Government stated that it wanted State Governments to consider metro rail as the "last option" and implement it only after considering all other possible mass rapid transit systems. The decision was taken due to the high cost of constructing metro rail systems. Currently, rapid transit systems operate in 15 cities and more are under construction or in planning in several cities of India

IV. PROBLEM IDENTIFICATION

Type of Construction Hazard

This development work site had numerous exercises arranged by L&T Project administration. Specialists and machines move in the different ranges with everybody concentrated on the current workload. In such synchronous actuates at undertaking site area, development mishaps can happen regularly.

On task site, a few sorts of perils watched Such as;

- Structural
- Mechanical
- Electrical
- Chemical
- Radiant Energy
- Biological
- Automated framework present nearby.

Because of these perils specialists get by from transitory or lasting disablement or some time passing each of these mishaps, however these circumstance may totally stayed away from through compelling security measures as it were

Development Site Falls-Bits of knowledge demonstrate that improvement workers are executed each year as a result of advancement site falls. Tremendous quantities of these passing or wounds which can be expected realizing security benchmarks. All things considered, advancement site falls consolidate housetop related falls, falling articles, crane falls, system falls, lift shaft falls, falls coming to fruition as a result of openings in deck,. Fruitful Proper protection apparatus and security wellbeing measures are imperative to guarantee the lives of workers.

Roof Related Falls-In development work there are an assortment of rooftop related occupations that posture incredible danger for even the most experienced specialists, for example, bay window falls, correspondence tower falls, tumbles off of rooftop structures, falls through existing openings,. Wounds can be kept away from with legitimate security safety measure and hardware. Rooftop falls are generally normal in development work, and there are numerous reasons for these development mischances. As a standout amongst the most well-known reasons for death on the development site, rooftop falls ought to be considered important and each exertion ought to be made to keep these fetal mishaps.

Crane Falls on Construction Site-Shockingly, there are times when the use of cranes results in mischief or even downfall. Overseers can fall unprecedented statures from their cranes, and afterward again cranes can lose their equality and topple, realizing the injuries of various pros.

Scaffolding Falls-Scaffolds Platforms can achieve extensive statures and must be fabricated effectively keeping in mind the end goal to guarantee the security of those working with them. Platform falls can happen for an assortment of

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reasons, however a standout amongst the most appalling happens when broken framework development is to be faulted .Scaffolding is an impermanent system used to bolster development laborers and their materials amid the development or repair of extensive structures.

Elevator Shaft Falls-Amid development, lift shaft falls can happen with lethal results. Despite the fact that there have been accounted for instances of people surviving tumbles from statures may bring about lethal in a few occurrences. In any case, numerous lift shaft falls can be effortlessly counteracted through legitimate preparing and wellbeing safety measures.

Gaps in Flooring on Construction Site-Falls made by openings in ground surface or weak deck are a huge peril for any person from an improvement bunch. The advancement handle that can incite wounds or notwithstanding passing when the falls happens. Exactly when there are openings in ground surface and are not suitably stamped, then they transform into a honest to goodness wellbeing peril for even the most experienced advancement authorities.

Falling Objects- The wounds kept up from falling articles may extend from minor scratches and slices to power blackouts, visual need, or even passing. Change laborers are at danger from falling difficulties at whatever time they are underneath where overhead work is being in movement. With a specific last target to minimize the wide variety of prosperity shields should be taken some of them are the events of falling things at a progression site.

Crane Accidents-In thickly populated urban territories where there is no spot else to manufacture anyway they will find cranes are everywhere and they have to relies on to make business structures and private structures. The usage and making of cranes have allowed individuals to make structures which could have never imagined. In spite of the way that we upgraded an impressive measure in regards to cranes with the best in class development consistently, a rate of the setbacks still happen that can realize damage or death. Harmed cranes, lightning, high winds, falls, electric stun, and diverse threats associated with crane mishap while advancement at statures. Various crane disasters can be avoided with real get ready and wellbeing philosophy. In the midst of advancement, the thriving of workers is basic than various thoughts.

Construction Related Hazards

Problem noted during MPPGCL Construction activities by Plants &equipment's Clustering plant dangers

Inhalation-Breathing in the dust and crude materials at a plant can bring about various wellbeing dangers. Breathing in bond dust is accepted to add to growth and breathing in dust can likewise bring about throat and nose disturbance. Breathing in bond dust can even bring about nosebleeds and also trouble with relaxing. You can shield yourself and your workers from this danger by wearing dust fog veils.

Eyes-Dust from bond and other crude materials utilized for delivering cement can likewise make harm your eyes, including aggravation and, in amazing cases, notwithstanding blazing. To secure your eyes, you ought to dependably wear defensive goggles when working with the crude materials utilized for blending concrete.

Skin-smolders and bothering-Introduction to wet cement can bring about aggravation and even severe singeing. On the off chance that you come into contact with wet solid, you ought to quickly wash it off your skin to maintain a strategic distance from damage. It is additionally prudent to wear gloves when working with wet cement.

Injuries-At the point when working with concrete and other overwhelming articles, you are at danger of harm. At a bunching plant, all specialists ought to wear hard caps and practice alert when managing overwhelming hardware.

V. 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.

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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 effectiveness of your hazard assessment and control measures. Make sure that you undertake a hazard and risk assessment when there is change to the workplace including when work systems, tools, machinery or equipment changes. Provide additional supervision when the new employees with reduced skill levels or knowledge are introduced to the workplace. The phase of risk identification is essential, because it establishes the bases of the risk analysis. Indeed, the data of risk identification will be the input of the evaluation and/or phases. Therefore, it is necessary to make an identification phase in an exhaustive way to get the best results.

Figure 5.3: Steps in Risk Assessment

Failure Mode and Effect Analysis (FMEA) - An FMEA is a systematic method for examining the impacts of component failures on system performance. Basically FMEA focuses on failures of systems and individual components and examines how those failures can impact facility and processes.

Fault Tree Analysis (FTA) - A fault tree is a detailed analysis using a deductive logic model in describing the combinations of failures that can produce a specific system failure or an undesirable event. An FTA can model the failure of a single event or multiple failures that lead to a single system failure.

FTA is often used to generate:

- Qualitative description of potential problems.
- Quantitative estimates of failure frequencies/ likelihoods and relative importance of various failure sequences/contributing events.
- Suggested actions to reduce risks.

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• Evaluations of recommendation effectiveness.

The FTA is a top-down analysis versus the bottom-up approach for the event tree analysis. The method identifies an undesirable event and the contributing elements (faults/conditions) that would initiate it.

VI. RESULT AND DISCUSSION

1-JSA- 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	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	Incompetence Lack of knowledge Improper supports High noise Flying partials Electrocution 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	Vibration or toppling of machine. Manual handling of cement bags. 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 go down to site. 4. Use safe method of manual handling.
Job Safety Analysis for Rigging	Unstable ground 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.

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		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,	Mechanical failure of crane. Failure of crane tools & tackles due to overloading.	1. Quarterly inspection & current color tag for crane, man basket, lifting tools & tackles. 2. Management should authorized experienced
Lifting tools & tackles Lifting of structural steel	Improper securing & imbalanced load. Poor hand signal to the operator	Operator & riggers. Daily inspection of crane by operator & reviewed by equipment supervisor. Valid third party certificates for crane, man basket & lifting tools, tackles. Lifting Plan to be prepared for critical lifting Check the load to be lifted Check the SWL of the crane with maximum boom length & radius to work. Check the SWL of the slings, shackles & Chain Pulley Block. 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.

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		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 firefighting 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 20. are installed to the cutting torch as well as cylinder side
Job Safety Analysis for Welding Welding	Fire	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

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		with fire retardant blanket.

2-Assessment of construction project level risk categories

Table 6.6 Risk matrix

Risk matrix			
18	32	48	64
8	16	27	36
3	6	12	24
1	2	4	9

Table 6.7 Risk matrix calculation

Probability	Gravity	Controls	Risk Category
1	1	1	1
1	2	1	2
1	1	3	3
1	2	2	4
1	2	3	6
2	2	2	8
1	3	3	9
2	2	3	12
2	2	4	16
2	3	3	18
2	3	4	24
3	3	3	27
2	4	4	32
3	3	4	36
4	3	4	48
4	4	4	64

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Table 6.8 Risk level categories

Risk Levels	
Very high risk	This risk is intolerable. Immediate action of prevention and protection needed to be taken. Temporary countermeasures should be taken immediately and action plan for final solution should be started and take place within 1 month.
High risk	Preventive and Corrective action to reduce the risk are required. Temporary countermeasure should within 1 month and action plan for final solution within 3 months.
Medium risk	Regular Checks are required to ensure that the risk is under control. Continuous monitoring is also required to ensure that risk is not growing further. Preventive and corrective actions can be taken.
Low risk	This is green zone which shows that the risk is tolerable. In the area the risk is under control. Risk management through PPEs utilization.

3-Failure Mode and Effect Analysis (FMEA)

Risk Priority Number (RPN): Risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard.

R = P X G X C

Where; R= Risk P = Probability of occurrence G = Gravity (degree of harm) C = Control

Table 6.1 Score rating of probability

Score/rating	Probability
1	Low
2	Medium
3	High
4	Very high

Table 6.2 Score rating of gravity

Score/rating	Gravity
1	Very slightly harmful
2	Slightly harmful
3	Harmful
4	Extremely harmful

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Table 6.3 Score rating of control

Score/rating	Control
1	Elimination or substitution that eliminates hazard
2	Engineering Controls takes place
3	Training/Procedures/PPEs in place to minimize risk
4	Either no controls to reduce risk or controls have failed

Table 6.9 Accidental statistics

S.No	Year (1 April to 31 March)	No. of accidents	No. of reportable accidents	Average no. of employees	Man days lost due to reportable accidents	Total man hours worked
1	2020-2021	11	5	219	23	541368
2	2021-2022	7	2	227	45	561144
3	2022-2023	6	1	256	19	632832
4	2023-2024	5	4	314	67	776208
5	2024-2025	8	3	283	36	699576

Table 6.10 Safety performance rating calculation

Serial number	Year	Frequency rate	Severity rate	Incident Rate	Total man hours worked
1	2020-2021	20.31	42.48	22.83	541368
2	2021-2022	12.47	80.19	8.81	561144
3	2022-2023	9.48	30.02	3.90	632832
4	2023-2024	6.44	86.31	12.73	776208
5	2024-2025	11.43	51.45	10.60	699576

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4-Hazard Identification and Risk Assessment

Risk Matrix

Probability(P) \ Severity (S)	1	2	3	4
1	1	2	3	4
2	2	4	6	8
3	3	6	9	12
4	4	8	12	16

Severity	Value	Probability	
Fatality	4	Very Likely	The event is almost certain to occur and has occurred repeatedly in the construction industry
Reportable Injury or illness resulting in > 2 days off work / Permanent Total Disability / Major Pollution	3	Likely	The event will probably occur in most circumstances
Non-Reportable Lost Time Injury/ Illness resulting < 2 days off work	2	Unlikely	The event may occur only in exceptional circumstances
Injury or illness requiring First Aid treatment. Minor Pollution	1	Very Unlikely	Very unlikely but remotely possible

Risk Rating	Risk level	Recommended actions
1 to 3	Low Risk	No additional risk control measures may be needed.
4 to 8	Medium Risk	Work can be carried out with Risk controls in place
9 to 16	High Risk	Don't start work. Risk level must be reduced to Medium / low before commencing work.

VII. FUTURE SCOPE

The Risk assessment and Hazard Identification is given by HIRA worksheet and Job Safety Analysis, FMEA and Fault Tree Analysis is also calculated and Worksheet was made which is given in the Result and Discussion part & also kept for future reference. In this project hazard Identification and Risk Assessment is use to identified the hazard and then to assess Risk, in this first we found out the hazard at workplace then the risk involved in it and also the people at risk in workplace after calculation probability and severity we found the risk level and give control measures. After that we reassess the risk and find out the residual risk which was always lower than the initial risk level. Job Safety Analysis is applied on Excavation Work, Underground Piping Fabrication and Installation, Scaffolding Erection and dismantling, Erection, Welding and Gas Cutting due to application of JSA we are getting safe and applicable work. The main application of job safety analysis is that it can be performed for all jobs in the workplace, whether the job task is non-routine or routine. Even one-step-jobs such as those in which only a button is pressed can and perhaps should be analyzed by evaluating surrounding work conditions. We also provide FMEA worksheet and calculate the risk priority number, the main application of FMEA is that it quantified the hazard and then it becomes easy to select the higher risk process and to provide counter measure to that hazard and risk. Severity Rate, Frequency Rate and Incident rate was also calculated the main application is to find out the Safe T score, which was the indicator of safety performance. This project helps in to find out the Hazard and then assess Risk related with that hazard in construction industry with similar type of process, which will be beneficial for the future scholars in many ways.

Applications of Risk Assessment and Hazard Identification

1. The risk assessment makes us aware of the risk level.
2. It helps to identify the hazardous area that needs more attention & regular checks & maintenance to be done.
3. The risk assessment also helps to reduce the accidental cost which is a kind of loss of capital for a firm.
4. Risk assessment by ensuring safety by improving safety culture helps in increase of production
5. The Risk management helps to keep the work environment as well as the workers at the workplace healthy & safe by ensuring safety.

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Risk Assessment will applied in the Construction Industry by the following ways

1. Checking for the existing hazards by inspecting the sites for detecting the unsafe work conditions.
2. By performing Risk calculation and forming the risk matrix.
3. By discussing with the concerned employees & workers in order to gain knowledge about the previous near miss incidents and accidents that has took place

VIII. CONCLUSION

In this thesis risk is calculated and find out the accident rate, severity rate, incident rate and safe T score which help to understand that what are the potential risk in job and on the basis of risk assessment method, risk has been prioritized according to which proper countermeasures have to take to minimize/eliminate the risk or reduce risk up to tolerable limit. In this thesis fault tree analysis for potential tower crane failure, the minimal segmental set and structure importance which indicate the possible approaches of mishap happening. Comprehensive analysis for tower crane with FTA, which can be used to instruct the operators making the corresponding measure to avoid the accidents. The failure mode and effect analysis on crane and tack welding prioritizes the risk control measures. Job Safety Analysis of construction site work activities gives clear idea about risk and their counter measures. This methods can also be applied in different areas of all Construction industry and risk can be rated or scored which divide risk into three different level (tolerable, acceptable, Unacceptable). On the basis of risk level which risk is unacceptable, countermeasures are recommended to improve safety measure. The result of this risk assessment method will be significant to find out the potential risk and its consequence which may occur. With this analysis, level of preparedness can be assessed, preventive & control measures can be taken ensure safety to such occurrences

REFERENCES

[1] Ji-Won Song, Jung-Ho Yu and Chang-Duk Kim, "Construction Safety Management Using Fmea Technique: Focusing On The Cases Of Steel Frame Work" Association of Researchers in Construction Management (2007) 55-63, 5 Sept 2007.

[2] T. Yuge_, S. Yanagi "Quant itative analysis of a fault tree with priority AND gates" Reliability Engineering and System Safety 93 (2008) 1577–1583 9 Feb 2008.

[3] G. Emre Gurcanli, Ugur Mungen "An occupational safet y risk analysis method at construction sites using fuzzy sets" Internat ional Journal of Industrial Ergonomics 39 (2009) 371–387, Elsevier, 9 Oct 2009.

[4] O.N. Aneziris, I.A. Papazoglou, D. Kallianiotis "Occupat ional risk of tunneling construction" Safet y Science 48 (2010) 964–972, Elsevier, 4 November 2009.

[5] Ivan W.H. Fung, Vivian W.Y. Tam, Tommy Y. Lo, Lori L.H. Lu "Developing a Risk Assessment Model for construction safet y" International Journal of Project Management 28 (2010) 593–600, Elsevier, 17 September 2009.

[6] Mohamed Abdelgawad1 and Aminah Robinson Fayek, A.M.ASCE "Risk Management in the Construction Industry Using Combined Fuzzy FMEA and Fuzzy AHP" Journal Of Construction Engineering And Management, 2010.136:1028-1036. September 2010.

[7] AmirReza KarimiAzari, Neda Mousavi, S. Farid Mousavi, SeyedBagher Hosseini "Risk assessment model select ion in construction industry" Expert Systems wit h Applicat ions 38 (2011) 9105–9111 December 2010.

[8] A. Nieto-Morote, F. Ruz-Vila "A fuzzy approach to construction project risk assessment" International Journal of Project Management 29 (2011) 220–231, 2 February 2010.

[9] Martina Murphy and George Heaney "A methodology for evaluat ing construction innovation constraints through project stakeholder competencies and FMEA" www.emeraldinsight.com/1471-4175.htm 235-245 (2011) December 2011.

[10] L.Y. Ding, H.L. Yu, Heng Li, C. Zhou, X.G. Wu, M.H. Yu "Safet y risk identification system for metro construction on the basis of construction drawings" Automation in Construction 27 (2012) 120–137, Elsevier, 15 June 2012

[11] Hao-Tien Liu, Yieh-lin Tsai" A fuzzy risk assessment approach for occupational hazards in the construction industry" Safety Science 50 (2012) 1067–1078, 26 December 2011

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[12] Amaka Chinweude Ogwueleka1 And Emaeyak I. Mendie "Evaluation Of Safet y And Quality Management In Construction Projects- A Study Of Ibom Tropicana Construction Projects" Journal of Construction Project Management and Innovation Vol. 4 (1): 826-843, 2014

[13] Amotz Perlman, Rafael Sacks, Ronen Barak "Hazard recognit ion and risk perception in construction" Safet y Science 64 (2014) 22–31, 17 November 2013.

[14] Abel Pinto "QRAM a Qualitat ive Occupat ional Safet y Risk Assessment Modelfor the construction industry that incorporate uncertainties by the use of fuzzy sets" Safet y Science 63 (2014) 57–76, 29 October 2013.

[15] Abdallah O. Bafailb, Reda M.S. Abdulaala, Mohammed R. Kabli "Construction projects selection and risk assessment by fuzzy AHPand fuzzy TOPSIS methodologies" Applied Soft Computing xxx (2014) 230–235 , 1 January 2014.

[16] Limao Zhang a,b, Miroslaw J. Skibniewski b,c, Xianguo Wua,⇑ , Yueqing Chen a, Qianli Deng" A probabilist ic approach for safet y risk analysis in metro construction" Safet y Science 63 (2014) 8–17, 16 November 2013.

[17] Tung-Tsan Chen & Chih-Hui Wang "Fall Risk Assessment Of Bridge Construction Using Bayesian Network Transferring From Fault Tree Analysis" Journal Of Civil Engineering And Management , Journal Of Civil Engineering And Management (2014).

[18] Agnieszka Dziadosza Mariusz Rejment "Risk analysis in construction project – chosen methods." Operational Research in Sustainable Development and Civil Engineering meeting of EURO working group and 15th German-Lithuanian-Polish colloquium (ORSDCE 2015) Procedia Engineering 122, 258 – 265(2015)

[19] Vladimar Muscenski "Construction Workers Injury Risk Assessment in Relation to their Experience and Age" Procedia Engineering 117,525 – 533 (2015)

[20] G. Emre Gurcanli, Senem Bilir ⇑ , Merve Sevim "Act ivit y based risk assessment and safet y cost estimation for resident ial building construction projects" Safet y Science 80 (2015) 1– 12, 1 July 2015

[21] Min Cheng , Yujie Lu "Developing a risk assessment method for complex pipe jacking construction projects" Automation in Construction 58 (2015) 48–59, 15 July 2015.

[22] James Renier T. Domingo, Ma. Theresa S. De Pano, Dominic Aily G. Ecat, Nicole Ann D.G. Sanchez, Benette P. Custodio "Risk assessment on Filipino construction workers" Procedia Manufacturing 3 (2015) 1854 – 1860,

[23] Shabtai Isaac , Tsah Edrei "A statist ical model for dynamic safet y risk control on construction sites" Automat ion in Construction 63 (2016) 66–78, 24 December 2015.

[24] Francisco J. Forteza, Albert Sesé, José M. Carretero-Gómez "CONSRAT. Construction sites risk assessment tool" Safet y Science 89 (2016) 338–354, 16 July 2016.

[25] Mehran Amiri, Abdollah Ardeshir, Mohammad Hossein Fazel Zarandi "Fuzzy probabilist ic expert system for occupational hazard assessment in construction" Safet y Science 93 (2017) 16–28, 11 November 2016.

[26] Martina Zeleňáková , Lenka Zvijáková "Risk analysis within environmental impact assessment of proposed construction activit y" Environmental Impact Assessment Review 62 (2017) 76–89, 7 October 2016.

[27] Muhammad Saiful Islam, Madhav Prasad Nepal, Martin Skitmore, Meghdad Attarzadeh "Current research trends and applicat ion areas of fuzzy and hybrid methods to the risk assessment of construction projects" Advanced Engineering Informat ics 33 (2017) 112–131, 1 June 2017.

[28] Mohamed Sayed Bassiony Ahmed Abd El-Karim,Omar Aly Mosa El Nawawy, Ahmed Mohamed Abdel-Alim " Ident ificat ion and assessment of risk factors affect ing construction projects" HBRC Journal (2017) 13, 202–216, 11 May 2017.