Technique for the Risk Assessment of RMC Plants

Roshni Prabhakaran[1] , Nisha Babu [2]

1 Scholar, SNGCE, Ernakulum, Kerala.

2 Asst. Professor, Civil Engineering Department, SNGCE, Ernakulum, Kerala

Abstract — The systematic identification and assessment of risk and effectively dealing with the results is significant to the success of any industries and projects. Unless other industries, RMC industries can be extremely complex and fraught with uncertainty. Due to the especial nature of the construction industries like RMC, and the growing need of having innovative and complex projects, the risk assessment process has become more and more complex. Still there is no efficient method for the effective assessment of various risks in these sector. In this work, an attempt is made to find out the most critical risk in RMC plants by developing a risk assessment model using Failure Mode and Effective Analysis (FMEA) technique. This was resulted in five risks with equal priority values and hence a risk prioritization was done using Analytical Network Process (ANP) with the help of Super decisions software. Finally remedial measures were suggested for the identified critical risk.

Keywords — Risk management, RMC plants, Risk assessment, FMEA, RPN, ANP, Super decisions software

INTRODUCTION

As per Indian Standard code of practice (IS 4926 - 2003) Ready Mixed Concrete (RMC) is defined as the concrete delivered in plastic condition and requiring no further treatment before being placed in position in which it is to set and harden. RMC is a specialized material in which the cement, aggregates and other ingredients are weigh-batched at a plant& mixed in a central mixer or truck mixer, before delivery to the construction site in a condition ready for placing. Thus, `fresh' concrete is manufactured in a plant away from the construction site and transported within the estimated journey time. Today's high rise structures demands smaller column sizes, faster construction, prompting use of high grade Ready Mix concrete. Use of Ready Mixed concrete was expected to give better control on the quality of concrete as compared with the site mixed concrete. Like other industries, RMC industry is exposed to various risks. In European countries, there is an awareness and understanding about importance of risks and its management. Information gathered from RMC plants in India in places like Mumbai, Navi Mumbai, Pune, Bangalore, and Noida, established by different companies reveals that a systematic risk management approach is not practiced in Indian RMC Industry. Unless the risks are addressed properly, the RMC industry in India shall not gain credibility, confidence of customers and will also cause reduction in profit margins.

Managing of risk is an integral part of industrial management system, and fundamental to achieving efficient outputs. That is, systematic identification and assessment of risk and effectively dealing with the results is significant to the success of any industries and projects. The risk assessment process involves determining the likelihood of a dominant failure mode or modes and then evaluating the consequences of a failure. Unless other industries, RMC industries can be extremely complex and fraught with uncertainty. Although companies, project managers and risk engineers have defined many methodologies and application in order to assess project or system risk and to increase systems reliability and safety, it is very difficult to aver the existence of a complete tool or methodology that assure complete safety, reliability and riskless project or system. In addition, due to the especial nature of the construction industries like RMC, and the growing need of having innovative and complex projects, the risk assessment process has become more and more complex. Hence the need for a proper and most efficient technique for the risk assessment in RMC industry is very important.

In this work, a study is made with the traditional FMEA (Failure Mode Effective Analysis) in order to find out the most critical risk. The Failure Mode Effect Analysis (FMEA) technique is to identify risk factors for the potential failure mode in the production process of concrete and to take the appropriate corrective actions for improvement. For the prioritization of the identified risks, ANP technique is used. Analytical Network Process (ANP) is a multi-criteria decision making technique which is commonly used for the prioritization of critical risks. The ANP technique is implemented in this work with the help of the software Super decisions. Reputed RMC plants in Kerala were selected for the study and the results developed are analyzed to know the efficiency and effectiveness of the developed technique. Also remedial measures for the identified risks are suggested.

RELATED WORKS

Agnieszka Dziadosz et.al [1] conducted a study on Risk analysis in construction project - chosen methods. This article presents three different methods of the risk analysis as well as highlighting their disadvantages, advantages and primary areas of application (selection or pre-estimation). Oksana marinina et.al [2] were studied about analysis of the possibility of using modern risk assessment methods in mining industry. The article describes the components of the risk assessment process, the analysis and classification of modern approaches to the evaluation of risk events.

Dr. Chakradhar Iyunni et.al [3] were studied about the FMEA risk management technique for quality control of RMC production. In order to identify the major failure mode in production of Ready Mixed Concrete (RMC) of different grades (M20, M25, M30) FMEA is used. The risk priority number results indicated process failure in terms of irregular grading process, material testing prior use in mixing process which were the important factor to be monitored for quality control. Mehrzad et.al [4] were studied about assessment and risk management of potential hazards by Failure Modes and Effect Analysis (FMEA) method in Yazd Steel Complex. In this study, the risks in different parts of the complex were evaluated by using FMEA method and by using FMEA Worksheets (PFMEA) derived from the standard (MIL_STD-882). Gunjan Joshi et.al [5] were studied about the FMEA and Alternatives v/s Enhanced Risk Assessment Mechanism. In this work, the advantages of using Six Sigma in Risk Assessment are also pointed out and proposed a novel technique which would overcome the restrictions of existing Risk Management tools.

Goutam Dutta et.al [6] were conducted a study on design and application of Risk Adjusted Cumulative Sum (RACUSUM) for online strength monitoring of Ready Mixed Concrete. In this paper, an attempt is made to design and apply a new CUSUM procedure for RMC industry which takes care of the risks involved and associated with the production of RMC. This procedure is termed as Risk Adjusted CUSUM (RACUSUM). Ali Gorener [7] was studied about the application of strategic decision making in a manufacturing company. This paper mainly explains how to use the AHP and ANP methods for prioritize of SWOT factors. Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis is a generally used tool which examines strengths and weaknesses of organization or industry together with opportunities and threats of the marketplace environment. SWOT framework provides the basic outline in which to perform analysis of decision situations. In this study, the SWOT analysis is enhanced with AHP and ANP (Analytical Network Process) in order to prioritize the identified factors.

RISK MANAGEMENT

Risk management is the identification, assessment, and prioritization of risks (defined in ISO 31000 as the effect of uncertainty on objectives) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. The management of any risks or uncertainties generally involves the following;

- Risk identification
- Risk assessment
- Risk prioritization

A. Risk Identification

Risk identification is one of the most import stages in risk management process. In this stage, all the potential risks that could affect the project objectives are identified. It is studying a situation to realize what could go wrong at any given point of time during the project. For risk identification, some of the methods used are Check list, Brainstorming, Tree Diagram, Cause – Effect Diagram, Interviewing, Questionnaire surveys etc. They are explained as following;

- Brainstorming – An idea generation group technique is divided in two phases. (i) Idea generation phase, in which participant generate as more ideas as possible (ii) idea selection phase, the ideas are filtered, remaining only those approved by the entire group.
- Delphi Technique – Delphi is a technique to obtain an opinion consensus about future events from a group of experts. It is supported by structured knowledge, experience and creativity from an expert panel.
- Interview/ Questionnaire surveys – Unstructured, semi structured or structured interviews individually or collectively conducted with a set of experienced project members, specialist or project stakeholder.
- Checklist – It consists of a list of item that are marked as yes or no, could be used by an individual project team members, a group or in an interview.

- Influence Diagram – It is a graphical representation containing nodes representing the decision variables of a problem. A traditional influence diagram is formed by three types of nodes: utility, decision and informational. The causal relationship occurs between utility and chance nodes and represents a probabilistic dependence.
- Flowchart – Graphical tool that shows the steps of a process. This technique is applied for a better comprehension of the risks or the elements interrelation.
- Cause-and-Effect Diagrams – These are also called Ishikawa diagrams or fishbone diagram, illustrate how various factor might be linked to potential problems or effects. The diagram is designed by listing the effect on the right sides and the causes on the left sides. There are categorized for each effect, and the main causes must be grouped according to these categories.

For this work, the method of questionnaire surveys are implemented to identify the types of risks that affect the RMC plants.

B. Risk Assessment

Risk assessment is merely a method of analyzing the seriousness of a risk. There are two approaches to analyzing identified risks, and they are the qualitative and quantitative methods.

Qualitative Risk Assessment

In the first method, viz. the Qualitative Analysis, all the identified risks are plotted on a matrix. Each is given a position on the matrix chart. The probability of the risk occurring can be plotted on the horizontal bar, while the impact of the risk can be noted along the vertical bar of the axis. The probability-impact value of a risk is a product of both the values assigned for the risk. Hence, it can be seen that a risk with a value of 9, where the probability and impact rate the highest, requires immediate attention. Those with a P-I rating of 1 or 2 requires the least attention and may even be ignored, if insignificant.

Quantitative risk assessment

At times, it is not easy to be precise when drawing up measures of risk resolution with just a generalized idea of a risk. In the process of making educated decisions, a quantitative analysis is necessary. Quantitative risk assessment assigns numbers to risks based on various risk reports and data generated. When compared to present criteria, a valid decision can be made. The different methods of quantitative risk assessment are as following;

- Fault tree analysis (FTA)
- Cost of exposure quality risk analysis
- Failure mode and effect analysis (FMEA)
- Cause-consequence analysis
- HAZOP technique
- Event tree analysis (ETA)

Failure Mode Effective Analysis (FMEA) Technique

Failure Mode and Effects Analysis (FMEA) is commonly defined as "a systematic process for identifying potential design and process failures before they occur, with the intent to eliminate them or minimize the risk associated with them". It is a type of qualitative risk assessment. The FMEA technique was first reported in the 1920s but its use has only been significantly documented since the early 1960s. It was developed in the USA in the 1960s by National Aeronautics Space Agency (NASA) as a means of addressing a way to improve the reliability of military equipment. It has been used in the automotive industry since the early 1970s and its use has been accelerated in the 1990s to address the major quality and reliability challenges caused by the Far Eastern car manufacturers. In addition, the recent changes in the law on corporate responsibility have led to companies reviewing their product design safety through the use of the FMEA methodology. In doing the analysis, the system behavior is evaluated for every potential failure mode of every system component.

Where unacceptable failure effects occur, design changes are made to mitigate those effects. The criticality part of the analysis prioritizes the failures for corrective action based on the probability of the item's failure mode and the severity of its effects. It uses linguistic terms to rank the probability of the failure mode occurrence, the severity of its failure effect and the probability of the failure being detected on a numeric scale from 1 to 10. These rankings are then multiplied to give the Risk Priority Number. Failure modes having a high RPN are assumed to be more important and given a higher priority than those having a lower RPN. Among the different types of FMEAs, the process FMEA is applied for this study since the RMC industries deals with the manufacturing process of concrete. The procedure for all types of FMEA is similar and in this case the scale used for the FMEA is 1-5 rating scale for severity, occurrence and detection. The rating scale for these are as shown in the tables below.

	1	2	3	4	5
Severity	Remote	Low	moderate	High	Very high
Occurrence	None	Low	moderate	High	Extr eme
Detection	Very high	high	moderate	low	Very low

Table 1 Rating scale of FMEA

After obtaining the ratings for severity, occurrence and detection, the Risk Priority Number (RPN) is calculated for each risks as per the equation;

$$RPN = Severity \times Occurrence \times Detection$$
$$= S \times O \times D$$

The risk with maximum value of RPN is considered as the most critical risk and risk with minimum RPN is the least critical risk. Here the major consideration is given to the most critical risk, since it governs the overall performance of the plant. In case if it is difficult to identify the most critical risk, a prioritization can be carried out which is usually done with the help of ANP technique.

C. Risk Prioritization

In the risk prioritization step, the overall set of identified risk events, their impact assessments, and their probabilities of occurrences are "processed" to derive a most-to-least-critical rank-order of identified risks. The objective of Risk Prioritization is to prioritize the identified risks for mitigation. Both qualitative and quantitative methods can be used to categorize the risks as to their relative severity and potential impact on the project. To effectively compare identified risks, and to provide a proactive perspective, the risk prioritization method should consider the following factors:

- Probability of risk
- Consequence of risk
- Cost and resources required for the mitigation of risk

Risk Prioritization is a decision making tool to prioritize risks or prioritize alternatives under risky or uncertain situations. It combines decision making theory and risk analysis in making judgment, and use mathematics to quantify soft decisions. It generally involves the following steps;

- Establishing the problem criteria – Defining the problem with criteria and alternatives, formulating the decision hierarchy structure etc. involves in this stage.
- Assessing the alternatives – developing the pairwise comparisons between the alternatives to assess their importance
- Prioritizing the alternatives – involves the calculation of priority weights and formulating the priority matrix
- Validating and communicating the decision – involves discussing the decision with board, management team or with stakeholders.
- Monitoring the decision – involves periodic monitoring and reviewing of the decisions.

The most commonly used risk prioritization method is the Analytical Network Process (ANP).

Analytical Network Process (ANP)

The analytic network process (ANP) is a structured network technique for organizing and analysing complex decisions. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1980s and has been extensively studied and refined since then. It has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education. Rather than prescribing a “correct” decision, the ANP helps decision makers find one that best suits their goals and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. ANP provides a general framework to deal with decisions without making assumptions about the independence of higher-level elements from lower level elements and about the independence of the elements within a level. In fact ANP uses a network without the need to specify levels as in a hierarchy. Generally the ANP technique implements a decision scale made by Saaty, for the prioritization of the judgments. The rating scale for ANP is as shown below.

INTENSITY OF IMPORTANCE	DEFINITION	EXPLANATION
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	An activity is favored very strongly over another
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Used to express intermediate values	Nil

Table 2 Rating Scale of ANP

The procedure for using the ANP can be summarized as:

- Model the problem as a complete set of network clusters (components) and their elements that are relevant to each and every control criterion.
- Determine a complete set of network clusters (components) and their elements that are relevant to each and every control criterion.
- For each control criterion, construct the super matrix by laying out the clusters in the order they are numbered and all the elements in each cluster both vertically on the left and horizontally at the top. Enter in the appropriate position the priorities derived from the paired comparisons as sub columns of the corresponding column of the super matrix.
- Perform paired comparisons on the clusters and on the elements within the clusters themselves
- cluster and on those that it influences, with respect to that criterion
- Check the consistency of the judgments.
- Come to a final decision based on the results of this process.

Figure 1: ANP Network structure

METHODOLOGY OF WORK

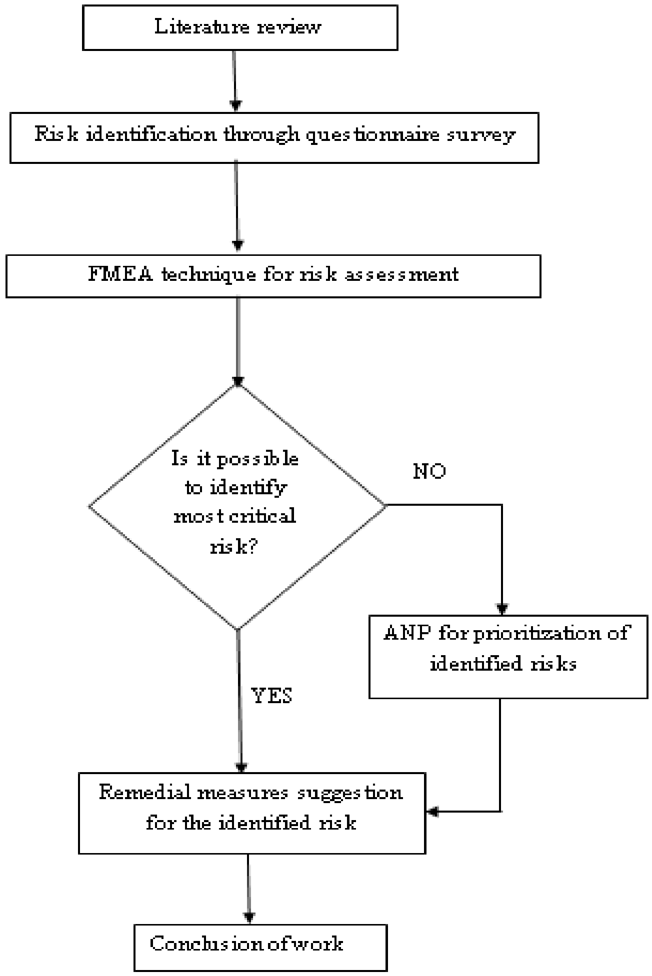

Figure 2: Frame work of the study

Data collection

The data collection for the work involves the identification of important risks that are occurring in the RMC plants. These are identified by carrying out a preliminary questionnaire survey. In this study 4 RMC plants are selected and the survey is carried out. The survey consisted of a pre-prepared risks factors with a 1- 4 scaling technique. The risk factors considered for the survey are categorized under 7 major risks, which are listed below.

- Financial risks
- Environmental risks
- Operational risks
- Political risks
- Safety risks
- Quality risks
- Procurement and storage risks

From the collected data, the RMC plant having risks with moderate and major effects on the working of plant are selected for the risk assessment technique. There was only one plant (Plant No: 4) under this, so the risk assessment method is implemented on that plant only.

FMEA Application

For the plant selected for the application of FMEA, the major risks with moderate and high rating, considered are as following;

- Operational risks
- Safety risks
- Quality risks

After obtaining the ratings for severity, occurrence and detection, the Risk Priority Number (RPN) is calculated for each risks as per the equation;

$$RPN = Severity \times Occurrence \times Detection$$
$$= S \times O \times D$$

MAJOR RISK	FAILURE MODE	S	O	D	RPN
Operational risk	New technology adoption	3	2	3	18
	Lack of experts in plant	4	3	2	24
	Improper site access	4	4	2	32
	Delay due to traffic conditions	3	4	3	**36**
	Break down of machinery	4	4	2	32
	Wrongly designed plant layout	3	2	2	12
	Difficulty in pumping	2	3	2	12
Safety risks	Site injuries	4	3	3	**36**
	Slips, trips etc. during working	3	3	2	18
	Non-medical availability	3	2	2	12
	Mishandling of materials	2	2	2	6
	Accidents during transportation	4	3	2	24
	Improper working practices	3	3	4	**36**
	Improper maintenance of machinery	4	3	3	**36**
	Improper maintenance of hydraulic equipment	3	3	2	18
Quality risks	Varying moisture conditions	3	3	2	18
	No advanced testing facilities	3	4	2	24
	Poor maintenance of materials	2	3	2	12
	Inefficient mixers	3	4	3	**36**
	Not keeping proper check lists	3	4	2	24

Table 3. FMEA worksheet

The task of determining the most critical risk was carried out using the FMEA technique and it resulted with five risks with equal risk priority number (RPN = 36).

- Inefficient mixers
- Improper working practices
- Improper maintenance of machinery
- Site injuries
- Delay due to traffic conditions

Since it is difficult to choose the most critical risk from these, a prioritization was done using ANP technique with the help of Super decisions software.

Application of ANP

The Analytic Network Process (ANP) is a powerful and flexible decision making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. ANP is generally based on the decision network structure and pairwise comparisons.

In this study, the ANP analysis is performed using the software Super Decisions. It is used here for the prioritization of alternatives. The Super Decisions software implements the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) for decision making with dependence and feedback, a mathematical theory for decision making developed by Thomas L. Saaty. The software for the decision making with dependence and feedback was developed by William Adams in 1999-2003. The Super Decisions software is a simple easy-to-use package for constructing decision models with dependence and feedback and computing results using the super matrices of the Analytic Network Process.

- **Decision Network structure**

This is the first stage in the Super decision software. In this case, a network structure is developed by breaking down the decision problem into a network of inter related decision elements. The network structure consists of clusters and nodes. Clusters are the main branches in the structure while nodes are the sub branches. Here the network structure consists of clusters as goal, criteria and alternatives. Figure below shows the decision n network structure obtained from the software.

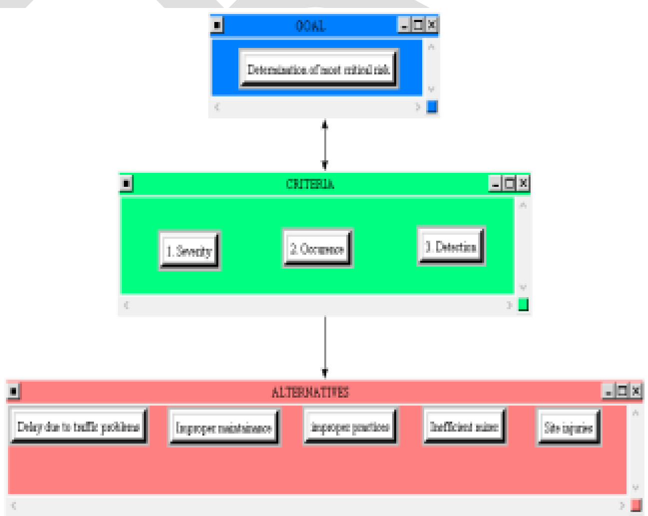

Figure 3. Decision network structure

- **Pairwise comparison**

Pairwise comparison generally is any process of comparing entities in pairs to judge which of each entity is preferred, or has a greater amount of some quantitative property, or whether or not the two entities are identical. In the ANP pairwise comparison, the significance/ importance of a risk over another is measured qualitatively. The ANP‟s pairwise comparison scale varies from 0 that indicates equal priority importance up to the score of 9, which reflect an extreme priority of an element/event over another. In this case the five risks with equal risk priority is compared with each other based on its severity, occurrence and detection of the risks. For performing the pairwise comparison, input is provided with the values obtained during the questionnaire survey. This is shown in the following figure from the software.

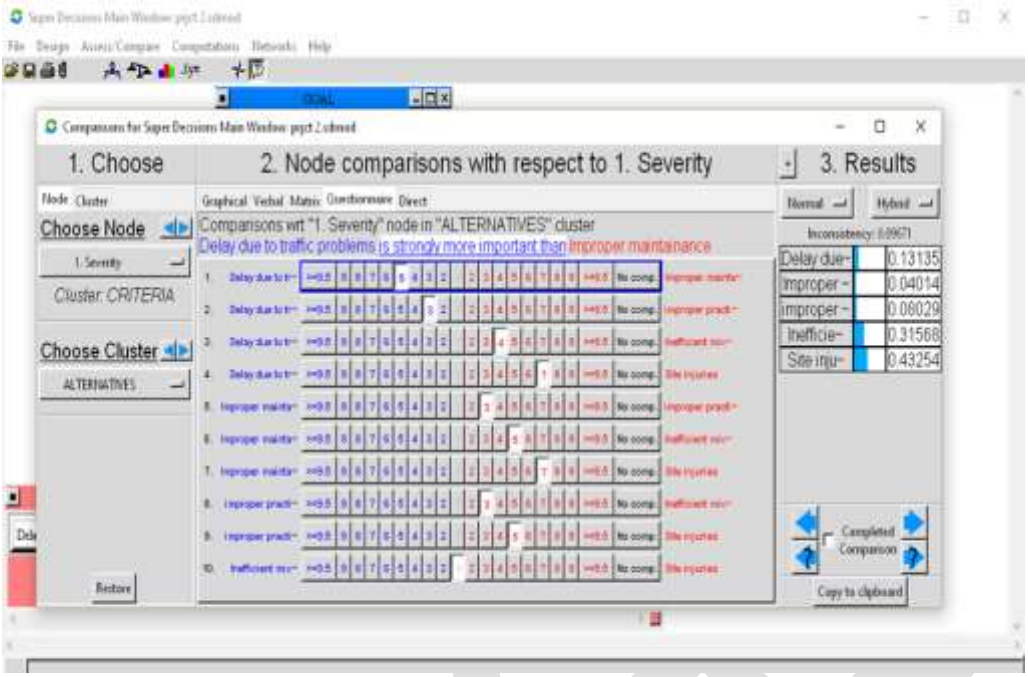

Figure 4. Pairwise comparison in software

- **Inconsistency analysis**

The final stage in the prioritization using the software is to calculate a Consistency Ratio (CR) to measure how consistent the judgments have been relative to large samples of purely random judgments. First of all, a comparison matrix of order (n × n) is formed. In this matrix, the diagonal members are always equal to one. The other members are filled based on the judgment values entered in the pairwise comparison. In order to evaluate the goodness of the judgment, consistency ratio (CR) should be defined as shown by (Saaty, 1990) as following:

$$CR = \frac{CI}{RI}$$

Where: CI = consistency index for an n × n matrix
RI = corresponding average random

$$CI = \frac{\lambda \max - n}{n-1}$$

Where: λ max = maximum Eigen value of matrix
n = number of comparisons

The RI is defined by Saaty as below;

Number of comparisons (n)	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 4. Average Random values

Usually, the consistency ratio (CR) is used to check whether a criterion can be used for decision-making. If the CR is much in excess of 0.1 the judgments are untrustworthy because they are too close for comfort to randomness and the exercise is valueless or must be repeated. Consistency applies only to the pairwise comparison matrices. The consistency is desirable to be less than 0.10. In this study, for the all alternatives, the consistency is obtained as less than 0.10. Thus means that the pairwise comparison done is acceptable. Since the inconsistency ratio obtained is less than 0.1, the prioritizations can be accepted. The comparison matrices (weighted priority matrices) for the criteria severity and consistency ratios (CR) obtained from the software is shown below.

Criteria	Consistency ratio (CR)
Severity	0.09671
Occurrence	0.09701
Detection	0.09017

Table 5. ANP Consistency ratio

SEVERITY					
	Delay due to traffic problems	Improper maintenance	improper practices	Inefficient mixer	Site injuries
Delay due to traffic problems	1	5	3	0.25	0.142
Improper maintenance	0.2	1	0.33	0.2	0.142
Improper practices	0.333	3.000	1	0.333	0.2
Inefficient mixer	4	5	3.00	1	1
Site injuries	7.0000	7.000	5	1	1

Table 6. Comparison matrix for severity

- **Final Priority ranking of the risks**

The final ranking of the alternatives was obtained after performing the inconsistency analysis. The priority ranking was done based on normalized and ideal weights of the alternatives. The priority ranking obtained is as shown below;

Alternatives	Normal weight	Ideal weight	Ranking
Site injuries	0.4789	1.0000	I
Inefficient mixer	0.1848	0.3859	II
Improper practices	0.1525	0.3184	III
Delay due to traffic problems	0.1306	0.2726	IV
Improper maintenance	0.0533	0.1113	V

Table 7. Final ranking of alternatives

From the priority ranking, it can be concluded that the most critical risk among the five alternatives is the site injuries with rank 1.

- **Graphical sensitivity analysis**

Sensitivity was performed using any element in the model. This is done as a check to confirm the final ranking of the alternative selected by the software is correct. There are different methods for the sensitivity analysis and in graphical sensitivity analysis, the priority of criteria is changed and the corresponding changes in the graph are noted. I f there is no significant changes in the graph, the ranking method can be taken as accurate. From the sensitivity analysis, it is clear that there is no change to the priority weight (0.5 or 50%) for all criteria. This means that the priority ranking was correct. The graphs obtained for the criteria severity is as following.

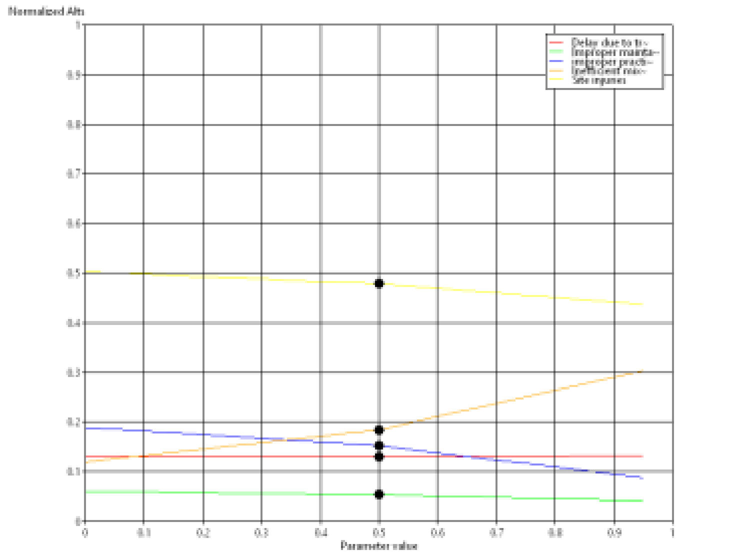

Figure 5. Sensitivity graph for severity

Hence from the overall results of the software the most critical risk in the plant 4 is identified as site injuries with the top rank under the three criteria: severity, occurrence and detection. This risk was prioritized with normalised weight of 0.4789 and with top ranking level.

RESULTS AND CONCLUSIONS

The systematic identification and assessment of risk and effectively dealing with the results is significant to the success of any industries and projects. Like other industries, RMC industry is also exposed to various risks and hence proper identification and assessment of these risks is very important for the effective working of the plant. Identification and assessment of the most critical risk is a difficult task due to the unavailability of an effective technique. This work proposed a technique for the proper and effective assessment of the critical risk in RMC plants and it includes FMEA technique with risk prioritization using ANP. Failure Mode Effective Analysis (FMEA) technique is a systematic process for identifying potential design and process failures before they occur and it is a risk rating technology based on the severity, occurrence and detection of risks. Risk prioritization involves the prioritization of risks based on a rating scale and Analytical Network Process (ANP) is a common technique for it.

In this work, the FMEA technique resulted in five critical risks with equal RPN of 36 (Site injuries, inefficient mixer, improper practices, Delay due to traffic problems and improper maintenance). Hence to find out the most critical risk, a prioritization was made with the help of Super decision software was used. Prioritization using pairwise comparison among the five alternatives resulted in identifying site injuries (normalized weight of 0.4789) with top ranking. According to the nature of the risk, some remedial measures were also suggested.

From this study, the most critical risk obtained is the site injuries. For this type of risk, the following remedial measures can be suggested.

- Provision of well awareness to each workers on the following facts;
    - ❖ Drivers Training
    - ❖ First –Aid Training
    - ❖ Fire Fighting Training
    - ❖ Lock–off and Machine Guarding
    - ❖ Concrete Pumping
    - ❖ Material Handling
    - ❖ Health Awareness

- Development of proper safety committee on the plant so that immediate actions can be taken on any site injuries or similar risks.
- Provision of proper personal protective equipment of very good quality
- Provision of engineering controls over the plant like;
  - ❖ Adequate machinery guarding
  - ❖ Proper guarding on transit mixers and on concrete pumps
  - ❖ Providing Fire Safety and Mock Drill (ERT) training programs at plant.
  - ❖ Proper up keeping of safety check lists in the plant.

In general, with proper safety management and safety measures, the critical risks in plants as well as in sites can be minimized.

REFERENCES:

[1] Agnieszk Dziadosza, Mariusz Rejment. ″Risk analysis in construction project - chosen methods″ Procedia Engineering 122, 258 – 265. July 2015.

[2] Oksana Marinina, Mariy Tochilo, ″Analysis Of The Possibility of Using Modern Risk Assessment Methods In Mining Industry ″Zeszyty Naukowe Politechniki Śląskiej, Volume 81, July 2012.

[3] Dr. Chakradhar Iyunni, .Jyoti Trivedi, ″FMEA risk management technique for quality control of RMC production″ International Journal of Advance Engineering and Research Development (IJAERD), e-ISSN: 2348 - 4470 , print-ISSN:2348-6406, May 2015.

[4] Mehrzad Ebrahemzadih, G. H. Halvani, Behzad Shahmoradi, Omid Giahil,″ Assessment and Risk Management of Potential Hazards by Failure Modes and Effect Analysis (FMEA) Method in Yazd Steel Complex ″ Open Journal of Safety Science and Technology, 2014, 4, 127-135, September 2014.

[5] Gunjan Joshi, Himanshu Joshi, ″FMEA and Alternatives v/s Enhanced Risk Assessment Mechanism″, International Journal of Computer Applications 0975 – 8887, Volume 93, No 14, May 2014.

[6] Debasis Sarkar, Goutam Dutta, ″ Design and Application of Risk Adjusted Cumulative Sum (RACUSUM) for Online Strength Monitoring of Ready Mixed Concrete ″ Indian institute of technology research and publications, W.P. No.2008-08-01 August 2008.

[7] Ali Gorener, ″Comparing AHP and ANP: An Application of Strategic Decisions Making in a Manufacturing Company″, International Journal of Business and Social Science, Vol. 3 No. 11 June 2012.

[8] F.E. Mohamed Ghazali and H.C. Wong, ″Risk Ranking for Tunneling Construction Projects in Malaysia″, KICEM Journal of Construction Engineering and Project Management, September 24, 2013.

[9] S. Baby, ″AHP modeling for Multi criteria Decision-Making and to Optimize Strategies for Protecting Coastal Landscape Resource″, International Journal of Innovation, Management and Technology, Volume 4, No. 2, April 2013.

[10] Dr. R. K. Kansal, Manoj Sharma, ″ Risk Assessment Methods and Application in the Construction Projects″, International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.3, 1081-1085. May-June 2012.