RISK MANAGEMENT TECHNIQUE OF READY MIX CONCRETE PLANTS

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Abstract – *Ready mix concrete (RMC) is an essential material in contemporary construction and engineering projects. The systematic identification and assessment of risk and effectively dealing with the results is significant to success of RMC industry and various projects. Ready mix industries can be extremely complex and fraught with uncertainty. Like the nature of the construction companies like RMC, and the growing need of having innovation and complex projects, the risk management process has become more complex. Still there is no efficient method for the effective assessment of various risks in these sectors. In this study, an attempt is made to find out the most critical risk in RMC plants by developing a risk management model using Failure mode and effective Analysis (FMEA) technique. This was resulted in six risks with risk priority number of equal values and hence a risk prioritization was done using Analytical Network Process (ANP) with the help of super decision Software. Finally some remedial measures have been found out for the most critical risks in that plant.*

Key Words: Ready mix concrete(RMC) plants, FMEA (Failure mode and effective Analysis), Risk priority number(RPN), Super decision software, Analytical network process(ANP).

1. INTRODUCTION

Ready Mix Concrete (RMC) is a concrete delivered at site or into purchasers vehicle in plastic condition and requiring no further treatment before being placed in a position it is to be set and hardened (IS 4926-2001). Ready mix Concrete is preferred over site mix concrete because it is environmental friendly. Its manufacturing is not messy and it is time consuming. It offers solution to specific problem of customer and ensures customer satisfaction and provides concrete of desired quality. It also eliminates the storing of materials at site for manufacturing concrete required at project sites. The quality of concrete has a direct effect on the strength and durability of the structure as whole. There are things which found fewer advantages to produce concrete on a worksite than RMC. Quality of concrete is under the threat which resulting in deficient product due to some reasons. RMC is produced under the factory conditions and permits a close control of all operations of manufacture and transportation of fresh concrete. Due to its durability, low cost and its ability to be customized for different applications, RMC is now one of the most popular building materials.

In India, use and demand of RMC is growing rapidly in civil and construction business. Some of construction companies are foraying in RMC business due to its huge potential. RMC industry is exposed to various risks so risk management is implemented on various plants to minimize risk in production and delivery at sites. The critical failure mode in production process should be found out and various measures to be implemented on RMC plants. The systematic identification and assessment of risk and effectively dealing with the results is significant to success of any industry and projects. Hence, the need for a proper and most efficient technique for the risk assessment in RMC industry is very important.

In this work, control charts helps to understand the cube samples failure in the concrete production process due to its improper mix design or due to calibration and weighing on scale wrongly. To find out most critical failure mode in production process the Failure Mode and Effective Analysis (FMEA) technique is used and to take appropriate corrective actions for the improvement is done. 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 risks. The ANP technique is implemented in this work with the help of super decision software. Three RMC plants selected from pune region for this study and the results developed are analyzed to know the efficiency and effectiveness of the developed technique. And remedial measures for the identified critical failure mode are suggested.

2. LITERATURE REVIEW

Goutam Dutta et.al [1] were conducted a study on design and applications 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). Mohamed A 2 et.al [2] were conducted a study on the use of basic quality tools for improvement of the construction industry. Quality control of Ready Mixed Concrete can be divided into three convenient areas like forward control, immediate control and retrospective control. Statistical Quality Control (SQC) application proves to be an important tool which can be used effectively for quality and productivity improvement for infrastructure projects. Statistical Quality Control can be effectively applied to RMC industry for online (during production) and also offline (before and after production) quality monitoring and control.

Gupta D. Y et.al [3] was conducted study on a revolution in production of concrete. A production of ready mix concrete includes mix design of RMC, IS codes, mixing process, carrying of concrete, handling process, quality assurance and site preparation. Ready mix concrete is an industrial product which is delivered to consumer in fresh condition after the production process of RMC plant. The process of Ready mixed concrete (RMC) flows from (design, production, transportation, pouring, placement and maintenance). Agnieszka Dziadosz et.al [4] conducted a study on risk analysis in construction projects. This article presents three different methods of the risk analysis as well as highlighting their advantages, disadvantage and primary areas of applications.

Mehrzad et.al [5] were studied about assessment and risk management of potential hazards by Failure Modes and Effect Analysis (FMEA) methos in Yazd Steel Complex. In his work, the risks in different parts of the complex were evaluated by using FMEA method. Jyoti Trivedi et.al [6] were studied about the FMEA risk management technique for quality control of RMC production. 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. Gunjun joshi et.al [7] were studied about FMEA and Alternatives v/s Enhanced Risk Assessment Mechanism. In this work, the advantage 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.

3. RISK MANAGEMENT

Risk management is the identification, assessment and prioritization of risks (defined in ISO 31000 as the effect of uncertainty on objective) followed by coordinated and economical applications 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 uncertainty generally involves the following;

- Risk identification
- Risk assessment
- Risk prioritization

Risk Identification

Risk identification is one of the most important stages in risk management process. In this stage, all the potential risks that could affect the project objective are identified. It is studying a situation to realize what could go wrong at any given point of time during the projects. For risk identification, some of the methods used are checklists, Brainstorming, Tree diagram, Cause – effect Diagram, interviewing, Questionnaire surveys, etc.

Risk Assessment

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

- Fault tree Analysis (FTA)
- Cost of exposure quality risk analysis
- Failure Mode and Effect Analysis (FMEA)
- Cause-consequence Analysis
- Event tree analysis(ETA)

Failure Mode and Effective Analysis (FMEA):

FMEA is the technique which is used to identify the potential failure modes for the product or a process before the problem occurs to consider the risk. It might also rank each failure according to the criticality of a failure effect and its likelihood of taking place. FMEA is an analytical technique which explores the effect of failure of individual components in a system. In order tp calculate risk in FMEA, risk has three components which are multiplied to produce RPN (risk priority number). By doing this calculation one will be able to decide the priority to select the most severe factor. There is no threshold value for RPNs. The most common rating for severity, occurrence and detection in order to calculate risk priority number can be seen. It can be seen from results that risk priority number of the process factor with highest number, thus it needs to be corrected immediately for improvement.

Rating scale for occurrence, severity and detection

Table 3.1: Rating scale of FMEA

	1	2	3	4	5
Occurrence	Remote	Low	Moderate	High	Very high
Severity	None	Low	Moderate	High	Extreme
Detection	Very high	High	Moderate	Low	Very low

After obtaining the rating for severity, occurrence and detection, the risk priority number (RPN) is calculated for each failure mode as per equation

$$RPN = Severity*Occurrence*Detection = S*O*D$$

The factor with maximum value of RPN is considered as the most critical risk and factor 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 plants.

Risk Prioritization

In the risk prioritization step, the overall set of identified risk events, their impact assessments, and their probabilities of occurrence 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. The most commonly used risk prioritization method is the Analytical Network process (ANP).

Analytical Network Process (ANP):

The Analytical Network Process (ANP) is a structured network technique for organizing and analyzing 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. ANP provides a general framework to deal with decisions without making assumptions about the independence of higher – 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.

Table 3.2: Rating scale of ANP

Intensity Of Importance	Definition	Explanations
1	Equal Importance	Two Elements Contribute Equally To The Objective
3	Moderate Importance	Experience & Judgement Slightly Favour One Elements Over Another
5	Strong Importance	Experience & Judgement Slightly Favour One Elements Over Another
7	Very Strong Importance	An Activity Is Favoured Very Strongly Over Another
9	Absolute Importance	The Evidence Favouring One Activity Over Another Is Of The Highest Possible Order Of Affirmation
2,4,6,8	Used To Express Intermediate Values	Nil

4. METHODOLOGY OF WORK

Literature Review

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Data collection from three different RMC plants

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Questionnarie prepared and collceted

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Risk priority number on the basis of analysis of questionnaire

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Failure mode in production identified from FMEA technique and analyzing to obtain specific failure using ANP

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Remedial measures suggestion for the most specific failure mode of production

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Conclusion of work

Flow chart 4.1: Methodology of work

5. DATA COLLECTION AND ANALYSIS

The data collection for this study involves identification of important risks that are occurring in the RMC plants. These are identified by carrying out preliminary questionnaire survey. Here 3 RMC plants are selected and survey is carried out. The risk factors considered for the survey are categorized under 7 major risks.

From the collected data, the RMC plants having risks with moderate and major effects on the working of plant are selected for the risk management technique. There was only one plant (plant – 2) under this, so this technique is implemented on that plant only.

FMEA Application

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

- Operational risks
- Safety risk
- Quality risk

After obtaining the rating for severity, occurrence and detection, the risk priority number (RPN) is calculated for each risks as per the equation;

RPN= severity*occurrence*detection
= S*O*D

Table 5.1: FMEA worksheet

Major risk	Failure mode	S	O	D	RPN
Operational risks	Lack of expert in plant	4	4	3	48
	Delay due to traffic conditions	3	3	3	27
	Break down of machinery	4	4	3	48
	New technology adoption	3	2	3	18
	Wrongly designed plant layout	3	2	2	12
Quality risks	Not keeping proper checklists	4	4	3	48
	No advanced testing facilities	3	4	2	24
	Poor maintenance of material	2	3	2	12
	Inefficient mixers	4	4	3	36
	Varying moisture conditions	3	3	2	18
Safety risks	Site injure	4	4	3	48
	Mishandling of material	2	2	2	6
	Improper working practices	4	4	3	48
	Improper maintains of machinery	4	4	3	48

The task of determining the most critical risks was carried out using FMEA technique and it resulted with six risks with equal risk priority number(RPN=48)

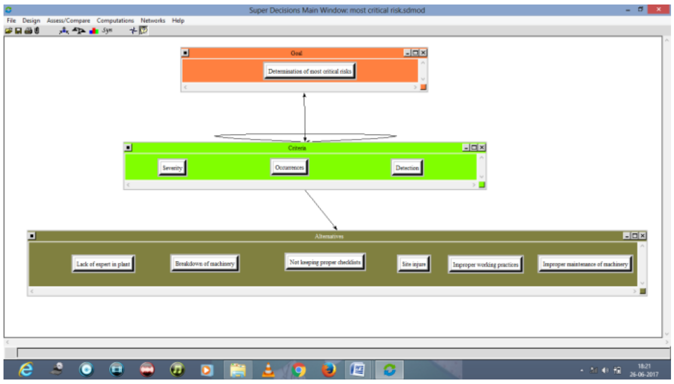
- lack of expert in plant
- Breakdown of machinery
- Not keeping proper checklists
- Site injure
- Improper working practices
- Improper maintenance of machinery

From the above six risks, it is difficult to find out most critical risks of that plant, risk prioritization was done using ANP technique with the help of super decision software.

ANP Application

The steps by steps procedure involved ANP analysis is performed with Super Decision software are;
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 as goal, criteria and alternatives. Figure below shows the decision network structure obtained from the software.



Pair wise 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 pair wise comparison, the significance/importance of risk over another is measured qualitatively.

Inconsistency Analysis

The final stage in the prioritization using the software is to calculate a Consistency Ratio (CR) to measure how consistent the judgment have been relative to large samples of purely random judgment. First of all, a comparison matrix of order (n x 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 pair wise comparison. The comparison matrices (weighted Priority Matrices) for the criteria Severity, Occurrence and detection and consistency ratio (CR) obtained from the software is shown below.

Table 5.2: ANP consistency ratio

Criteria	Consistency Ratio (CR)
Severity	0.0822
Occurrence	0.08095
Detection	0.09005

Final priority ranking of risks

The final ranking of the alternatives was obtained after performing the inconsistency analysis. The priority ranking obtained is as shown below;

Table 5.3: Final priority ranking of alternatives

Alternatives	Normal weight	Ideal weight	Ranking
Break down of machinery	0.147040	0.358840	III
Improper maintenance of machinery	0.106742	0.260495	IV
Improper working practices	0.099392	0.242559	VI
Lack of expert in plant	0.183700	0.448307	II
Not keeping proper checklists	0.053361	0.130225	V
Site injure	0.409764	1.0000	I

From the priority ranking, it can be concluded that the most critical risk among the six alternatives is the site injure with rank I.

6. CONCLUSIONS

- FMEA technique resulted in six critical failure mode with equal RPN of 48.
- Hence, to find out most critical failure mode out of these six risks, a prioritization was made with the help of super decision software was used.
- Prioritization using pairwise comparisons among the six risks resulted in identified site injuries with the top ranking.
- Remedial measures can be suggested are;
    - Provision of well awareness to each workers on drivers training, First aid training, Fire fighting training,, concrete pumping, material handling, etc.
    - Provisions of proper proactive equipment of very good quality.
    - Provision of engineering controls over plant.

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