ANALYSIS OF RISK MANAGEMENT IN CONSTRUCTION SECTOR USING FAULT TREE ANALYSIS AND FAILURE MODE EFFECTS ANALYSIS

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Abstract - *Construction is a risky industry and there is no other industry that requires proper application of business practices much as construction industry. Risks have a significant impact on a construction project's performance in terms of cost, time and quality. As the size and complexity of the projects have increased, an ability to manage risks throughout the construction process has become a central element preventing unwanted consequences. The main objective of this research is to gain understanding of risk factors that could be for the building projects. By using combined Failure mode effects analysis (FMEA) i.e. inductive method and Fault Tree analysis (FTA) i.e. deductive method, the risks has been analyzed without any shortcomings and remedial measures being taken. The results of this study recommended that there is an essential need for more standardization which addresses issues of clarity, fairness, roles and responsibilities, allocation of risks, dispute resolution and payment. More effort should be made to properly apply risk management in the construction industry. Based on the findings, a number of recommendations facilitating more effective risk management can be developed for the industry practitioners.*

*Key Words***: Risk, Fault Tree analysis, Failure mode effects analysis, Cost, Time, Quality, etc

1.INTRODUCTION

Construction industries in the Indian market have to be competitive and efficient, in order to return to the value to the project stakeholders. Completing projects faster than the normal duration is always challenging task to the management as it often demands many paradigm shifts. For too long construction projects have failed to achieve the time, cost and quality targets that clients and consultants aim for. Innovative construction techniques and materials can take time whilst budget constrains reduce overall quality. Depending upon the uncertainties and the consequences, the risks are accepted routinely and measures are taken to minimize their consequences. Despite risk management being a growing element of major projects, there is no standard to which reference may be made for techniques, factor and approaches and it was dislack of information that lead to the research described in this study.

2. RISK MANAGEMENT

Risk management in a project encompasses the identification of influencing factors which could negatively impact the cost schedule or quality objectives of the project, quantification of the associated impact of the potential risk and implementation of measures to mitigate the potential impact of the risk. The riskier the activity is the costlier will be the consequences in case a wrong decision is made. Proper evaluation and analysis of risks will help decide justification of costly measures to reduce the level of risk. It can also help to decide if sharing the risk with an insurance company is justified. Some risks such as natural disasters are virtually unavoidable and effect many people. In fact, all choices in life involve risks. Risks cannot be totally avoided but with proper management these can be minimized.

3.DETERMINATION OF RISK

There are two methods to determine risks in a project, namely the qualitative and quantitative approach.The quantitative analysis relies on statistics to calculate the probability of occurrence of risk and the impact of the risk on the project. The most common way of employing quantitative analysis is to use decision tree analysis, which involves the application of probabilities to two or more outcomes. Another method is Monte Carlo simulation, which generates value from a probability distribution and other factors. The qualitative approach relies on judgments and it uses criteria to determine outcome. A common qualitative approach is the precedence diagramming method, which uses ordinal numbers to determine priorities and outcomes. Another way of employing qualitative approach is to make a list of the processes of a project in descending order, calculate the risks associated with each process and list the controls that may exist for each risk. Here we have used reliability based analysis for the risk determination.

4.FAULT TREE ANALYSIS (FTA)

Fault tree analysis (FTA) is a top down, deductive reasoning failure analysis in which an undesired state of a system is analyzed using Boolean logic to combine a series of lower-level events. This analysis method is mainly used to understand how systems can fail, to identify the best ways to

reduce risk. The method is employed in other contexts, as diverse as risk factor identification relating to social service system failure.

4.1 GATE SYMBOLS

The gates symbol typically works as follows:

- **OR gate** - the output occurs if any input occurs.
- **AND gate** - the output occurs only if all inputs occur (inputs are independent).
- **Exclusive OR gate** - the output occurs if exactly one input occurs.
- **Priority AND gate** - the output occurs if the inputs occur in a specific sequence specified by a conditioning event.
- **Inhibit gate** - the output occurs if the input occurs under an enabling condition specified by a conditioning event.

4.2 FTA THROUGH MINIMAL CUT SETS

A minimal cut sets is a smallest combination of component failures which, if they all occur, will cause the top event to occur. By the definition, a minimal cut set is thus a combination of primary events sufficient for the top event. The combination is a smallest combination in that all the failures are needed for the top event to occur. If any one of the failures in the cut sets does not occur, then the top event will not occur. Any fault tree will consists of finite number of minimal cut sets, which are unique for the top event. One component minimal cut sets, if there are any, represent those single failure which will cause the top event to occur. For an end component minimal cut sets, all end components in the cut sets must fail in order for the top event to occur.

The minimal cut set expression for the top event can be return in the general form,

$$T=M_1+M_2+M_3+........M_k$$

Major risks with delay due to time are shown in figure 1. Figure 1 represents the risk which involved in time that causes delay in project completion. The possible reasons were Wrong material scheduling, Demand of skilled Labor, Waterline, Increase in cost during execution, Flood, Rework due to unskilled labor, Road construction delays, Social work, 4 way road construction, Unanticipated other works, Telephone cable laying, Electrification, Internet, Insufficient data, Demand of skilled Labor, Neighbor issue, Improper planning, Rain, Unanticipated public construction, Insufficient tools and guides, Unavailability of equipment and software, Delay in Material Procurement, Remote Area, Insufficient financial, Congested Area, High cost of skilled labor, Transportation Issues Strike, Delay in design department, Insufficient labor, Cascading work delays, Cascading due to pending delays, Unavailability of skilled labors, Shortage of Material.
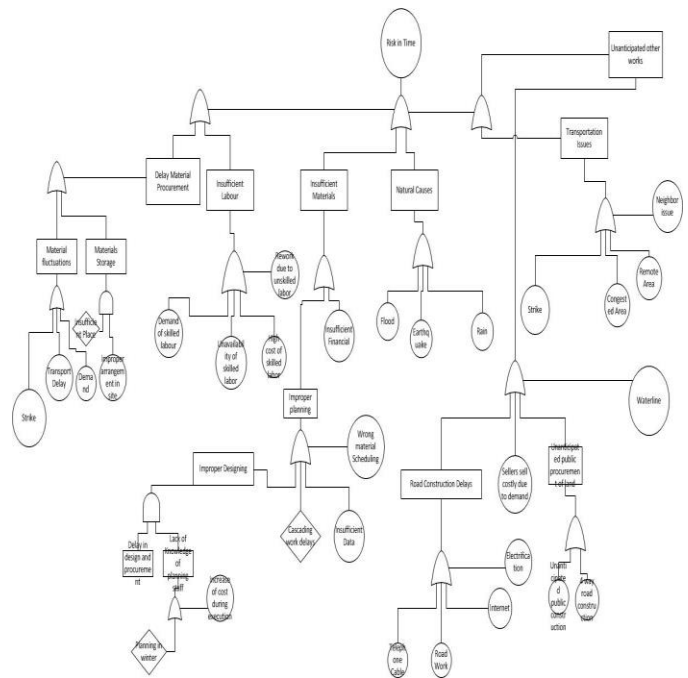

Figure.1 Fault Tree with Top event –Time risk

5.FAILURE MODE AND EFFECT ANALYSIS

FMEA is a bottom-up technique used to identify, prioritize, and eliminate potential failures from the system, design or process before they reach the customer. FMEA was developed as military procedure MIL-P-1629 and published on 9. November 1949, titled Procedures for Performing a Failure Mode, Effects and Criticality Analysis. Later in 1960's it was used in aerospace and rocket industry. In 1974 FMEA become military standard Mil-Std-1629. In the late 1970's Ford Motor Company introduced FMEA to automotive industry. Now it has been used to find risk possibilities in the construction industry, as it is large contributor of GDP and development to our country.

5.1 RISK PRIORITY NUMBER

For calculating the risk in FMEA method, risk has three components which are multiplied to produce a risk priority number (RPN):

1. Severity (S): Severity is described on a 10-point scale where 10 is highest.
2. Occurrence (O): Occurrence is described on a 10-point scale where 10 is highest.
3. Detection (D): Detection is described on a 10-point scale where 10 is highest.

$$RPN= S*O*D.$$

RPNmin= 1, while RPNmax= 1000.

6.RESULTS AND DISCUSSION

6.1 ANALYSIS OF VARIANCE IN SAMPLES

Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences between group means and their associated procedures (such as "variation" among and between groups). ANOVA provides a statistical test of whether or not the means of several groups are equal, and therefore generalizes the t-test to more than two groups.

Source of Variation	SS	Degree of Freedom	Mean Square	F Value	Calculated Values
Between Rows	9855 5.35	2	49277. 67	4.1	82.134
Between Columns	3502 27.30	5	70045. 45	3.3 3	116.74 9
Residual/ Error	5999. 66	10	599.96 6		

Table -1: Overall Probability values

F < Calculated value
There is a significant difference in the events.

6.2 FAULT TREE ANALYSIS

While considering the calculations of overall probability, the values obtained for the Poisson and Normal distributions in Figure.3
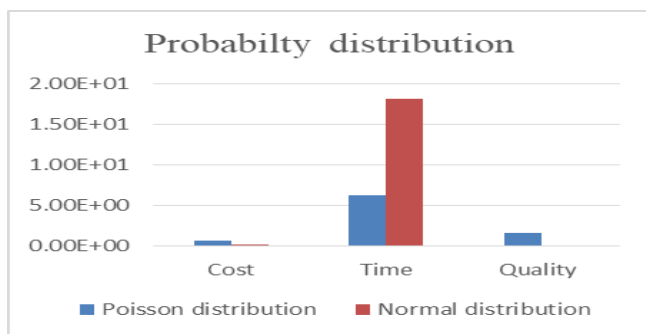

Figure.3 Overall Probability values

Figure.3 comprises of the values obtained for the events by the Poisson and Normal distribution. From the calculation we have concluded that the probability of occurrence and the deviation is much more in the undesired event "Time" when comparing to the other undesired events. So it needs more attention.
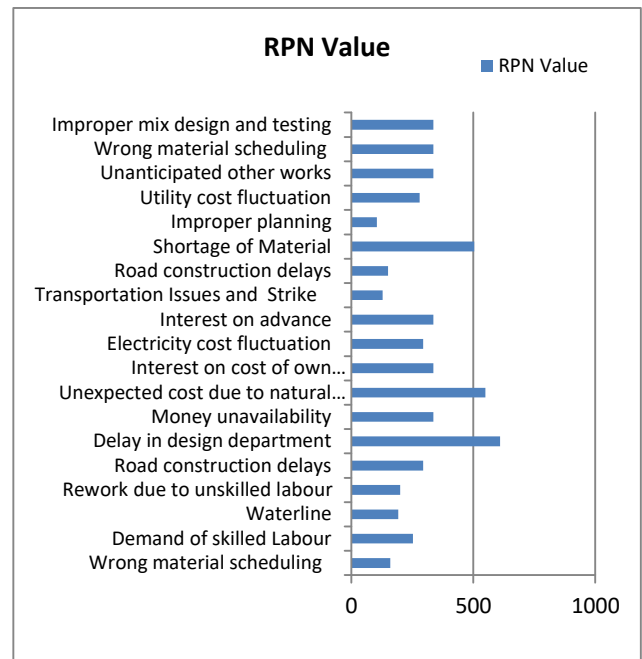
6.3 FAILURE MODE EFFECTS ANALYSIS:

Figure.2. RPN Values

Figure.2 represents the failure modes and the rankings. The RPN values were exhibited in the table which shows the severity of occurrence of the particular events that causes risk by delay for the project due to various failures.

7.CONCLUSION

In this study, identifying the risk factors faced by construction industry is based on collecting information about construction risks, their consequences and corrective actions that may be done to prevent or mitigate the risk effects. Risk analysis techniques like fault tree analysis has stated that undesired event 'time' is more risky than other cost and quality risks. Failure modes effects analysis has been done to find the risk priority in the failure modes of possible effects based on undesired event 'time'. Its causes has been analysed for risk severity and found that material shortage and design delays are risk possibilities for risk due to time.

Risk preventive measures are found to be having a constant price contract signed with material providers for reducing cost fluctuations of construction materials. Planning transportation cost in advance would reduce transportation problems and hence avoids delay in time. Always maintaining a pre-set amount of material in stock would counter issues like strike. Scheduling the construction activities according to climatic issues will avoid the unexpected cost due to natural events. Design co-ordination will cause by both client and contractor will allow to solve the design issues in construction sector.

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