Fault Tree Analysis in Construction Industry for Risk Management

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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. The main objective of this research is to gain understanding of risk factors that could be for the building projects in various firms. The study aims also to investigate the effectiveness of risk preventive. The findings of this work show a lack of an iterative approach to risk management, which is a weakness in current practices. By using Fault Tree method the risks has been analyzed and remedial measures are 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 have been developed for the industry practitioners.

Keywords— Risk Management, Fault Tree Analysis, Risk Mitigation.

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. It is widely acknowledged that there are and always will be difficulties in meeting every project objective and some degree of comparison is nearly always inevitable. Depending upon the uncertainties' and the consequences, they 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 lack of information that lead to the research described in this study. In the construction business, success is typically measured by three basic performance criteria often called the triple constraint: cost, schedule, and quality. So, in order to ensure greater level of success and to minimize or if not eliminate failures implementation of Risk Analysis and Management techniques is needed.

The primary objective is to study the risk in construction industry, analyzing the risk and the taking corrective measures to overcome the risk by implementing risk management. Thus this study helps to identify the key risk and the possible measures to deal with risk the construction industry is facing. All risks observed in the questionnaire can happen to any construction projects.

2, RISK MANAGEMENT

Association for project management (2002) defines risk as 'A combination or frequency of occurrence of a defined threat of opportunity and the magnitude of that occurrence'.

2.1 Analysis of Risk:

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. Fault Tree Analysis (FTA) attempts to model and analyze failure processes of engineering systems. FTA is basically composed of logic diagrams that display the state of the system and is constructed using graphical design techniques.

The Tree is usually written out using conventional logic gate symbols. The route through a tree between an event and an initiator in the tree is called a Cut Set. The shortest credible way through the tree from fault to initiating event is called a Minimal Cut Set. The basic symbols used in FTA are grouped as events, gates, and transfer symbols. Minor variations may be used in FTA software.

3, LITERATURE REVIEW

Shyh-Hwang LEE (2011) et al. suggests that it is much more difficult to manage quality in relation to construction industry due to its generic nature. This paper used FTA to evaluate the relationships among the elements of the ISO 9001:2008 standard and the root causes of defects on public construction quality assessed by Taiwan Public Construction Commission from year 2005 to 2007. AmirReza KarimiAzari (2011) et al. explains that Risk assessment is the critical procedure of risk management and recognizing a suitable model is very difficult. Using the fuzzy TOPSIS method decision criteria are obtained to improve quality. Further research will be the application of this method in project selection, performance selection, vendor selection, etc. Oleg Kaplinski (2013) suggested method of risk analysis has been presented, based on the application of utility theory. Decision maker with an aversion to risk and decision maker with predilection to risk, are then analyzed in detail. But there is a problem in operational strategies. Anjana Meel (2008) et al. explained that methods for plant-specific, real-time, risk assessment are presented using Bayesian analysis with copulas. A quantitative method is introduced to estimate human and equipment reliabilities, measures that are extremely useful when estimating risks in a plant. Soren Degn Eskesen (2004) et al. suggests that the risk management avoids major hazards. Identification of risk and selection of risk mitigation measures and implementation of risk measures are taken. But delays are occurred for the first year of implementation.

4, STUDY OF THE SYSTEM AND CONSTRUCTION OF FAULT TREE

In this study, fault tree model has been developed for cost, time and quality as shown in figure 1, figure 2, and figure 3.
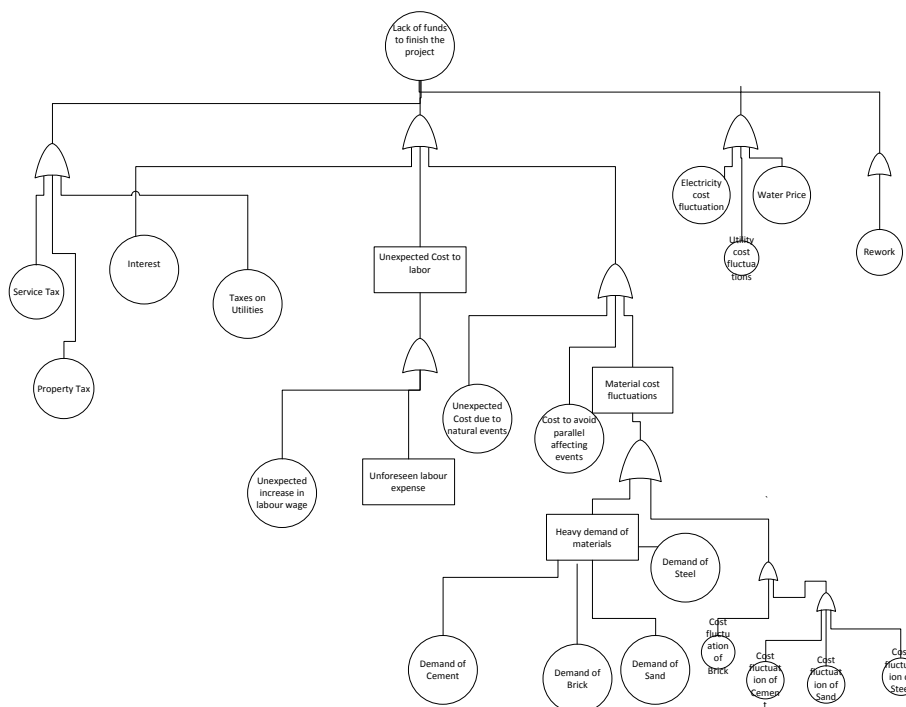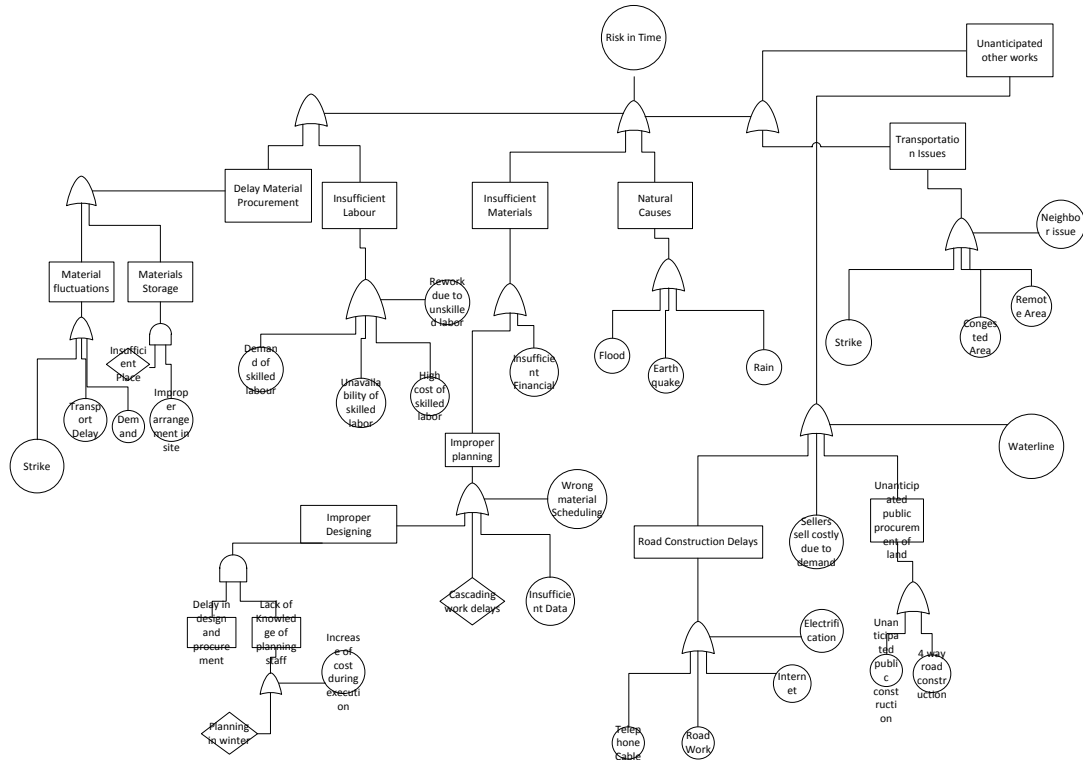

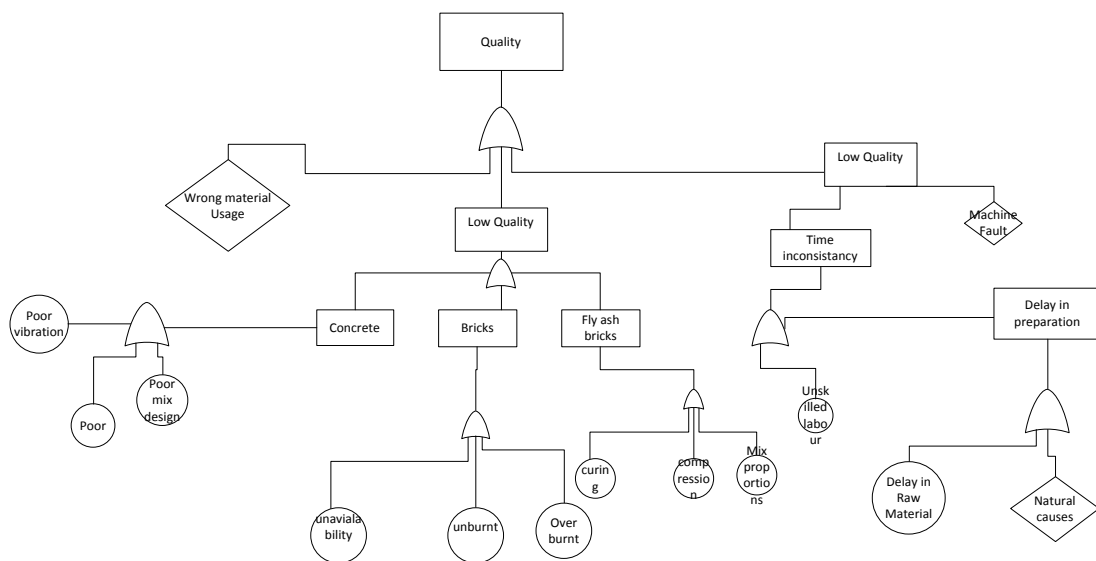Figure 1 Risk in Cost

Figure 2 Risks in Time

Figure 3 Risks in Quality

Figure 1 represents the fault tree for risk in cost, which indicates the possible failure which leads to loss in the project. Figure 2 represents the risk in time, which represents the possible failure that causes delay in project. Figure 3 represents the risk in Quality, which represents the possible reasons which disqualifies the work and also leads to delay in time and wastage of money

5, EVALUATION OF FAULT TREE

After finding the minimal cut sets for the undesired events, evaluation fault tree has to be carried out. Evaluation of fault tree is done by two methods[1]. They are

      i.   Qualitative methods

     ii.   Quantitative methods

5.1 Qualitative Methods:

Fault Tree Analysis uses tree structures to decompose system level failures into combinations of lower-level events, and Boolean gates to model their interactions. To address safety and the ways failures or undesirable events could occur; and thereby, trying to avoid them can be very challenging[1][2].

5.1.1 Determining the minimal cut sets of the fault tree:

One of the main purposes of representing the fault tree in terms of Boolean equations is that these equations can be used to determine the fault tree's associated minimal cut sets. The minimal cut sets defined the failure modes of the top event and are usually obtained when a fault tree is evaluated. Once the minimal cut sets are obtained, the quantification of the fault tree is more or less straightforward[1][2].

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

$$T=M_1+M_2+M_3+……..M_k \qquad (1)$$

The following basic minimal cut sets are determined from the fault tree using distributive law. Minimal cut sets are the basic elements of a fault tree while all redundancies are removed.

The solutions to the minimal cut sets for the undesired events such as cost, time and quality are found out and the quantitative methods are done.

5.2 Quantitative Analysis:

Probability model is employed to quantitatively analyze the fault tree. Calculating Poisson and Normal distribution for exploring the distributions obtained from the undesired events in our study. A limiting form of a Binomial distribution is Poisson distribution[1].

5.2.1 Poisson distribution:

In probability theory and statistics, the Poisson distribution is a discrete probability distribution that expresses the probability of a given number of events. We use Poisson distribution to find probabilities of occurrences of Cost, Time and Quality. A

discrete random variable X is said to have a Poisson distribution with parameter $\lambda > 0$, if for k =0, 1, 2, ... the probability mass function of X is given by:

$$f(k, \lambda) = \lambda^k e^{-\lambda} \Big/ K!$$ ....(2)

Where e is the base of the natural logarithm (e = 2.71828...) and k! is the factorial of k. By using the above mentioned formula, the calculations were done for the undesired events cost, time and quality.

5.3 Results and Discussions:

While considering the calculations of overall probability, the values obtained for the Poisson and Normal distributions were enlisted in the table I. Table I comprises of the values obtained for the events by the Poisson and Normal distribution.

Table I Overall Probability Values

Events	Poisson distribution
Cost	6.74E-01
Time	6.223091079
Quality	1.635139476

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. The preventive measures for all the undesired events were suggested in the below section.

6, RISK PREVENTIVE SUGGESTIONS FOR CONSTRUCTION INDUSTRY

Having a constant priced signed contract with material providers would reduce cost fluctuations of cement, sand, brick and steel. Using ground water after geo technical testing for the maximum extent of work and installing water purifiers would reduce the water problems while construction and after construction water necessities. If possible adopting new methods of construction can increase the quality of work and saves the money with respective to eco-friendly construction.

Timely design and preplanning of the tasks involved in the overall construction, accurate planning of materials necessary to carry out each task and the timing sequence of events with correct overflow, planning the procurement of equipment and software necessary for each event and planning for equipment availability in advance would reduce the time delay in construction.

Planning in advance for the amount that is necessary (Overall budgeting) and the sources available would reduce the time in arranging finance. Acquiring labors on contract basis so that we can hire best workers depending upon the nature of the work instead of giving all the works under one contractor.

VII. CONCLUSION

The construction industry has characteristics that sharply distinguish it from other sectors of the economy. It is fragmented, very sensitive to economic cycles, and highly competitive because of the large number of firms and relative ease of entry. It is basically due to these unique characteristics considered a risky business.

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 were investigated too. However, determination of severity and allocation of these risk factors was the main result of this research. The risk in the undesired events were cultivated and risk preventive measure been taken in order to avoid risk in the construction sector.

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