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RISK MANAGEMENT IN CONSTRUCTION PROJECTS – A LITERATURE REVIEW

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Abstract: This paper aims to contribute a detailed study over the risks and the procedures followed in risk management. Risk is a measure of consequence of uncertain event, situation or condition which may occur in the construction field. The project risks, uncertainties and other factors which affect the project should be identified and evaluated in a systematic way for the successful completion of the project. The project risk management is the act and science of managing risks which will help to achieve the project objectives without much changes. The review contains the different factors of risks, identification, methods of analyzing, response of risks.
Index Terms: Risk, Risk management, Risk analysis

I. INTRODUCTION

In the early days, the construction projects were generally of short-duration, and the environment was much more stable. Nowadays, there are infrastructure projects, having project life spread over many years. These projects involve large capital outlay, generate unbalanced cash flows and involve complex contractual arrangements. The stability of modern construction projects constantly subjected to certain sensitive and volatile, external and internal environments. The construction industry having unique features compared to any other industries. That's why they are usually considered as high risk business. The construction projects may face, the lack of adequate environmental information and many other data, experience etc. Similar construction projects may have totally different risk characteristics in different region.

The success or failure of a project largely depends upon the effectiveness and the efficiency with which the risks and uncertainty are managed. Compared with many other industries, the construction industry is subjected to more risk due to the unique features of construction activities, such as long period, complicated processes, abominable environment, financial industry and dynamic organization structure.[3]

Risk management aims to identify sources of risk and uncertainty to determine their impact and develop appropriate management response. Risk management may be described as "a systematic way of looking at areas of risk and consciously determining how each should be treated. The aim of risk management is to identify sources of risk and uncertainty, to determine their impact, and to develop appropriate management response. Most of the construction projects are taking place in complex and challenging environment. A reliable way to analyze the associated risks is vital to make success. This paper explains various stages of risk management and different methods of assessment.

II. RISK MANAGEMENT:

Project Risk Management is the art and science of managing risks caused by unforeseen changes(uncertainties) which may require deviations from the planned approach and may therefore affect the achievement of the project objectives.[1] An effective risk management method can help to find out and analyses the risks which may occur during the construction period and also help to manage them during the stages of construction. High quality risk management in construction projects requires, full specification of the project, a clear perception of the risks being borne by each party, sufficient experience to manage risks, good co-ordination and mutual understanding between each parties. The quality of project risk management is improved if risks are identified and evaluated in a systematic way, risks are allocated to the parties best able to control them and parties who are expected to bear risk receive adequate reward for doing so.[7]

A construction project can say as successful when it is completed on time, within budget and in accordance with the specifications. Risk engineering is a term associated with the use of the approach outlined here for identifying and measuring risk to the extent that it is useful to do so, and developing the insight to change associated risks through effective and efficient decisions.[6] A systematic approach to risk management has five stages which are as follows:

i. Plan Risk Management
ii. Risk Classification

iii. Risk Identification
iv. Risk Analysis and assessment
v. Risk Response

Firstly, the detailed formulation of a program of action for the management of risk has to be done, which is the risk planning or Plan Risk Management. Then the risks should be classified and identify those risks which occur often in most of the similar projects. Different methods of analysis and assessment will be done to assess and evaluate the effects of these risks. Appropriate risk response policies should be developed and applied to reduce and control thieves, risks. Risk Management can be defined by the principle steps as a continuously monitored integrated formal process for defining objectives, identifying sources of uncertainties analyzing these uncertainties and formulating managerial responses, to produce an acceptable balance between risk and opportunities.[2]

i. PLAN RISK MANAGEMENT:

Plan of risk management or risk planning is the process of developing and documenting an organized, comprehensive and interactive strategy. It includes the methods for identifying and analyzing risks, developing risk response plans and monitoring and controlling how risk have change. Therefore, risk planning is the detailed formulation of action for the management. Risk planning includes the entire risk management process, with activities to identify, analyze, respond, monitor and control risks.

ii. RISK CLASSIFICATION:

Construction projects usually considered as a high risk business due to the lack of environmental information and construction experience. Similar construction projects may have totally different risk factors which depends on the type, the characteristics of the work site and the project team, and many other conditions. A systematic frame work for classifying the risks in construction projects is necessary, because risk factors in construction projects cover such huge areas. Sources of risks are generally independent and mutually exclusive.

Classification of risk can be done by numerous ways, in accordance with the nature of the risks, with their occurrence in different construction stages, accordance with their origin and to the location of their impact in the project. One type of the classification is given as shown in Fig.1.

In this classification risks are classified mainly into three, external environment predictable risks, external environments unknown uncertainties and internal environment. External environment subdivided into political, WTO (World Trade Organization) & legal, Design & Specifications, Financial & Economic. External environments unknown uncertainties subdivided into Act of God, Ecological, Safety and Health. Internal Environment subdivided into Scope changes, time overrun, cost overrun, technology changes, communication failure, resources failure, contractor failures etc.

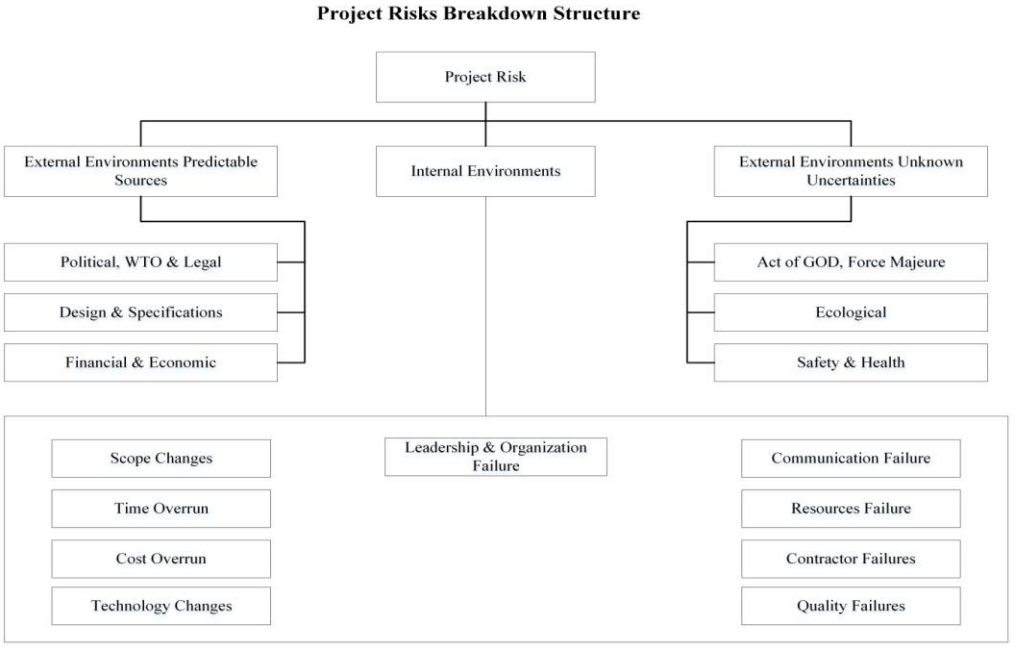

Figure 1: Project Risk Breakdown structures [1]

iii. RISK IDENTIFICATION

Risk factors are also known as risk sources and they are divided into risk events. Risk factors and risk events are varying from project to project. Some of the risk factors and risk events are explained below in table 1.

Table 1 : Identification of risk events

Risk Factor	**Risk Events**
Project Scope risks	i) High complexity
	ii) Ill-defined project scope
	iii) Frequently changing scope requirements
	iv) No project charter
	v) No delegation of authority
	vi) Ineffective control systems
Design and specifications risks	i) Inadequate design information
	ii) Incorporation of new construction technology
	iii) Unrealistic specifications
	iv) Likelihood of design changes
	v) Difficulties in interaction of design with method of construction
Quality risks	i) No quality assurance plan
	ii) No soil investigation
	iii) No method statements
	iv) Poor quality materials
	v) Untrained manpower
Time overrun risks	i) Inaccurate activity time estimates
	ii) Unrealistic time schedule
	iii) Incomplete work breakdown structures
	iv) No formal sequencing plan
	v) Poor allocation of resources
Cost overrun risks	i) Inaccurate time estimates
	ii) Inadequate cost planning and control
	iii) No extra work control and no analysis of changing
	iv) Constantly changing market conditions
	v) Incomplete project closure
Leadership risks	i) No project vision
	ii) No team building
	iii) Poor motivation of participants
	iv) High turnover of critical team members
	v) Indecisiveness

iv. RISK ANALYSIS / RISK ASSESSMENT:

Risk analysis is a systematic process to estimate the level of risk, which involves the overall ranking of risks using qualitative risk assessment approach and qualifying the risk exposures for mitigating high exposure risks. Risk analysis is the process to estimate the probability of occurrence and the consequence of the risk and to convert the risks to a corresponding risk level. The approaches or methods of risk analysis vary with the purpose project and the data available. The choice of technique for risk analysis is dependent on the nature of the problem being modelled, the amount and reliability of information available and the nature of the output required.[1] The nature of the output that required is decided by the nature, need of client and the type of the decision to be made.

The risk analysis may be done by collecting the detailed information from variety techniques like comparison with similar systems, experience and interviewing analysis of plans and related documents, data from engineering and other models, specialist and expert judgment, etc. The purpose of this analysis is to reduce the uncertainty. The further analysis may be lead to modifications to the project specifications and base plan and should lead to contingency plan to manage project risks

METHODS OF RISK ANALYSIS AND ASSESSMENT TECHNIQUES:

There are different methods to assess the risk by expert judgment, classical models and conceptual models. Expert judgement method includes the Delphi method, normal group techniques, ABC analysis. Classical models include probability analysis, Monte Carlo simulation etc. and conceptual models includes fuzzy logic. The different methods are explained below

i. DELPHI TECHNIQUE:[5]

In the Delphi method, details about the risks collected from the experts and the identity of experts is not revealed to each other. The procedure of risk assessment of Delphi method is as explained: For the purpose of analyzing and assessing qualitative risks an expert team has to be formed by selecting a panel of experts from inside and outside of the organization. Collecting the feedback of each experts and compile them to check the unanimity among their replies. The process will continue until receiving the predictions and feedbacks which will be supported by every member of the expert team. In this technique, individual feedback needs to be collected by the experts.

ii. NOMINAL GROUP TECHNIQUE: [1]

In this technique, selection of a panel of experts to be done to study the subject and give their views and writings. Discussions to be between the experts by arranging meetings between the panel members. Meetings are held to discuss about the risk and share the ideas combine their replies. The process to be repeated till a near unanimity is reached among the experts. Differences of opinions should overcome in the proceeding discussions.

iii. ABC ANALYSIS TECHNIQUE: [5]

The risks are classified and identified according to their effective contribution to the overall risk potential. This will enable a specific target oriented investigation into the project risk situation. With the help of ABC Analysis method determine the few "A Risks" which have the greatest effect on the project situations. Approximate, simplified time schedules and cost estimates can be used to determine and calculate the A-risks. Special attention should be paid to the conditions and variations of these assumptions and boundary conditions, these being the defined basis for project handling.[5]

iv. PERT/PDM[1]

Program Evaluation and review technique [PERT] or Precedence diagraming Method [PDM] is used to quantify uncertainties in project duration. PERT or PDM are the tools which can be used to determine the probability of completion of the project on varying time period. In these methods, the duration of the project is computed by adding the duration of critical path activities. In order to evaluate uncertainty in project time originators of PERT assumed that the means of distribution of critical activities lying on a critical path, follow the normal distribution and thus the pattern of variation of project time approximates the normal distribution with characteristics as mean, variance and standard deviation. The effect of variation of non-critical activities is not considered.

v. MONTE-CARLO SIMULATION[1]

Simulation can be explained as a method of solving, decision making in problem by designing, constructing and manipulating model of real system. This method is useful for solving business problems, where

many values of variables are not known. Simulation may be defined as technique that uses a computerized symbolic model in order to represent actual decision making under uncertainty. In Monte Carlo Simulation method, the selection of random number within the simulated model.

vi. SENSITIVITY ANALYSIS

Sensitivity analysis is based on the view that only those projects that can be withstand the possible changes in future in the critical elements which have a vital bearing on the costs/benefits of the project need to be undertaken. It is also known as 'What If' analysis, in which the factors which are likely to change during the project have to be identified.

The changes in the NPV or other criterion chosen to be evaluated and measured in percentages and it will provide information in the extent to which the project remains viable under different situations. In this type of analysis, one variable is varied at a time. All the other variables have either been assumed to be constant or their expected values have been used.

vii. BREAK EVEN ANALYSIS

Break Even Analysis is a costing technique which shows the relationship between total cost and levels of output by classifying various cost elements into fixed and variables. The amount of cost and profit or loss at various levels output are given by this analysis. The mathematical approach of this analysis based on the equation.

Sales – Variable Cost = Fixed cost & Profit.

The by-product of this analysis are break-even charts which helps to control over business profit and is a tool of financial analysis. This helps in showing the impact on profit position of the change in cost, price and volume with reasonable accuracy. The uses of this analysis are the rate analysis, analysis of sales, demand, profit, computing the alternating project, etc.

viii. DECISION TREE ANALYSIS

Decision tree approach is one of the ways to analyze a decision or valuing project flexibility. Decision tree depict in the form of a tree, the decision points, change events and probabilities involved in various courses that might be undertaken.

A common problem occurs in business when a new product is introduced, whether to install an expensive permanent equipment or to undertake cheaper temporary equipment on rental basis. The expensive equipment ensure production at the lowest possible cost, since the cheaper equipment will involve a higher manufacturing cost but lower capital investments and will result in lower losses if the product does not sell as estimated.

FUZZY LOGIC [4]

The demand for construction of infrastructures have increased worldwide and has resulted in the undertaking of numerous construction projects and they are riskier, competitive since their surrounding environments are complicated. So they require more attention. Insufficient information and ineffective management of project risks not only cause project cost overrun, completion delays and even termination prior to completion, but also negatively impact the project team's reputation.[4]

The laws of probability apply if certain assumptions are met including: knowledge of probable future states, rationality, frictionless transactions, random events, repeatability, comparability, optimization goal[3].Fuzzy logic risk analysis model is used in risk analysis because the modelling of vague input is successfully done with the use of membership functions. Fuzzy logic has an inherent ability to explain its reasoning and ensures that all factors are considered in a harmonized manner. Fuzzy set theory is highly subjective.

Fuzzy logic can be beneficial to describe real world relationships that are inherently fuzzy. [8] The difference between traditional set and fuzzy set theory lies in the degree of membership which elements may possess in a set [3]. Fuzzy number is a fuzzy subset of real numbers, which can be viewed as an extension of confidence interval.[4] To avoid the difficulty to present the degree of performance experts use linguistic variables which are merely approximate. Linguistic variables have an important role in fuzzy logic. Linguistic variables such as age, quantity etc. Whose variables are words or sentences in a natural or synthetic language like small, medium, large, right quantity etc. can be interpreted as fuzzy set.

The effects and occurrence probability of risk factors in construction projects should be integrated to evaluate the overall project risk. This integrated computation is presented as

$R = E \times W$.[4] where, R = Project Risk Value

E = Impact of the Risk factors
W = Probability of occurrence

The project risk value is defined as the product of the impact of the factors and the probability of occurrence. The results of the project value application are mainly used for comparison, either for preparation of the bid for project selection or initiation or for the allocation of more resources for risker item.

ix. RISK RESPONSE: [1]

Risk response is done by risk mitigation strategy. Risk mitigation measures plan to minimize the loss, damage or disruption in a project due to unforeseen events. The mitigation measures are explained below.

i. Risk Transfers:

Project risks can be transferred to someone who is more capable of dealing with such problems, such as specialist subcontractors, designers, material suppliers or by passing the risk to insurance firms. Risk transfer can be explained with some examples like, risk can be transferred to a contractor or designer by the client. Risk can be transferred to a subcontractor by the contractor etc.

ii. Risk deferred:

Certain project risks can be deferred by time. To reduce or minimize the adverse effects of such activities, they can be moved to later date. For example, road bitumen paving scheduled during the rainy season can be postponed to a season when the road is drier.

iii. Risk Reduction:

The aim of project risk reduction is to reduce the probability of risk occurrence or the impact on the project or both of these. Project risk can be reduced by adopting some modifications for the project. like well-defined specifications, detailed site survey, detailed design, completing design before execution, minimizing client variation etc.

iv. Risk acceptance:

Once the risks have been identified and their adverse effects assessed, a contingency plan to encounter them has to be organized, developed and implemented as part of a good risk management strategy. Such a risk will generally comply with one of the several criteria, such as no alternative available, cost to transfer risk is very high, probability of occurrence of risk is low but it can have a heavy impact, etc. Unidentified risks fall in the category of risks accepted by the client.

v. Risk avoidance:

Once project risks have been identified, they can be avoided in some cases, by taking appropriate action such as changing designs, materials, technology and construction methods that may involve additional costs

vi. Risk sharing:

Taking a risk may be resorted to when it is impractical for one party to control the risk. It may be better to manage such a risk with two or more parties. Alternatively, the client can retain part of the risk.

CONCLUSION

The various risk factors and events influences the project time, cost and quality. Therefore, the management of risk having an important role in construction projects. The importance of risk management and the different stages were discussed in this paper. Effective management of risks can improve the quality of the project and help the timely completion within the budget. For the effective management requires a reliable risk assessment and risk treatment plan. Among the methods of risk assessment, fuzzy logic has been used to solve uncertainty problems, when probability information is limited.

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