International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
Research Symposium on
"Advancements in Engineering, Science, Management, and Technology"
Volume 5, Special Issue 04, April-2019.

A Review of the Risk Management in Construction of Highway Projects, with specific reference to India

Shailendra Kumar[1] and Satyaprakash[2]

[1]*Border Road Organisation (BRO), HQ: DGBR, Ring Road, Naraina, Delhi Cantt, New Delhi*
[2]*Department of Civil Engineering, Sharda University, Greater Noida,*

Abstract - This study seeks to study and identify various risks associated with highway EPC projects during construction / improvement of national highways. Further these risks are ranked based on their likelihood of occurrence and affecting project objectives. Risk fault tree diagrams are developed for identified critical risks and based on the opinion expressed by experts; the probability of occurrence is determined. Fuzzy mathematics is used to obtain possibility of occurrence of causative events to risk events.Response from experts of Public & Private sectors are obtained and processed to prioritise the risks, assessing the impact of risks on various phases of highway EPC project. In place response measures are studied and discussed and improvements are suggested wherever felt necessary.

Keywords EPC, Risk management, Highway projects, NHAI, NHIDCL

I. Introduction

Engineering, Procurement and Construction (EPC) is a form of contract frequently used in the construction industry. In this form of contract, the EPC contractor is made responsible for all the activities from design, procurement of materials, construction and commissioning of assets to maintenance thereof up to a specified period. The asset thus created, is transferred to the Government / Developer after expiry of the specified time.

Risk is the cumulative effect of various associated uncertainties that are likely to affect the objectives of the projects. A highway EPC project has long gestation period so risk of uncertainties plays a very significant role in determining success of highway EPC project. Perceived risks also determine the willingness of private parties to take up an EPC project.

Expansion of infrastructure is the most essential requirement for economic growth of any country. Among other infrastructure, Highway is one the most important infrastructures, which has its effect of overall economy and development of the country. In India, there are two independent bodies via., National Highway Authority of India (NHAI) and National Highways and Infrastructure Development Corporation (NHICDL) under the Ministry of Road Transport and Highway (MoRTH) responsible for development and upgradation of national highway. However, the roads along the borders are not developed by these two organisations, but Border Road Organisation (BRO), under Ministry of Defence, is responsible for strategically important roads in the bordering parts of the country.

All the highway projects, including that being maintained by BRO, four modes of execution are in practice under which projects are awarded to private developers viz.

- **BOT (Built,Operate and Transfer) Toll**: In this mode, the developer builds the highway, operates it for a specified duration and transfers it back to the government.Under this arrangement, the private party,
- Bears construction risks and build the road
- Operate and maintain the road
- Collect toll and recover the cost
- Handover the built road to the government, after recovering the cost

- **BOT Annuity:**The annuity(regular payments) fee arrangement is known as BOT-Annuity. Under this mode, the toll revenue risk is covered by the government, while the private player is paid a pre-fixed annuityat regular intervals in lieu of collection of toll tax for construction and maintenance of roads. This mode is similar as BOT Toll except in collection of toll tax.
- **EPC (Engineering Procurement and Construction):**Under the EPC model, the government pays private players, the agreed amount as per the tender, to lay roads. The private player builds the road, but the road is owned by the government, even during construction period. The private player has no role in the ownership of the road, toll collection or maintenance (after the defect liability period) which are taken care of by the government. Under this mode, the private party is responsible for,
- Design of the project
- Procurement of the material
- Construction of the road
- Operation and maintenance of the road during the defect liability period
- **HAM (Hybrid Annuity Model):** HAM has been introduced by the Government to overcome the deficiency of other construction models. HAM combines EPC (40 per cent) and BOT-Annuity (60 per cent). The government releases 40 per cent of the total project cost in five tranches linked to milestones. The balance 60 per cent is to be arranged by the developer.

Amongst all the above methods, the EPC mode of contract is the most common form of contracts. It is used in construction of a large scale and complex infrastructure projects. The private party (contractor) is obliged to deliver a complete facility to the fund provider within a specified period for a guaranteed agreed price. The facility thus developed must perform to the satisfactory level of the end-user and in case of failure to deliver by the private party within guaranteed and agreed time-frame and specified cost, the party is liable to pay a penalty, as per the agreed terms and in the process, contractor incur monetary liabilities.

II. Features of EPC Mode

In EPC mode of execution, a complex design and construction are involved, due to this effect procurement of a set of equipment and machineries are involved for a single unit of contract implementation. The main features of EPC mode are:

- The contractor is responsible for designing, building and transferring the project to the owner, at end of construction period
- Financial returns to the contractor through payments made by the Government.
- Government responsible for collecting toll revenue and maintaining road.
- Government handling financing risk, O&M risk and revenue risk.
- Considerable strain on Government finances until toll stabilizes.

Several contractors have suffered heavy losses and due to this affect refused to enter in to EPC contracts in some jurisdictions. However due to its flexibility, value and certainty, EPC contract will be used on large scale infrastructure projects in most jurisdictions [1].

Risk-The environment in which decision-making takes place can be divided in to three types [2],

- Certainty- It means where each action is known to lead to a particular outcome
- Risk- Risky situation leads to several known outcomes occurs with a specific probability.
- Uncertainty- It is described as a situation in which there are no information/historic data relating to the situation.

The operative company converts uncertainty to risk and its aim is to identify, analyse,evaluateand operate on risks.

EPC Project Risk-EPC construction contemplates a turnkey approach and the employer looks to the contractor as the single point of contact for all facets of the project. Based on risk mitigation strategy in an infrastructure project risk can be classified as listed below [3],

- Transferable risk – This can be fully transferred to the private sector.
- Retained risk – This risk is borne by government
- Shared risk- This risk is shared by both the government and the private sector.

The risks involved during the execution of infrastructure projects have a wide range of sources and can also be classified into followings categories[4]**,**

- Technical, quality or performance risk, Example-Inexperience designers, change in standards, change in technologies etc.
- Organisational risks, Example- Inadequacy of funding, resource conflicts with other projects in organisation, lack of prioritisation of projects etc.
- External risks, Example- Poor geological condition, weather, force measure risks, change in regulatory requirements etc.
- Project management risks, Example- Poor allocation of time and resources.

III. Risk Management in construction project

Risk management is a system which aims to identify and quantify all risks, to which a business or project is exposed, so that a conscious decision can be taken on how to manage the risk [5]**.**The main issue related to risk management is how to deal with it and most importantly how to quantify it. Its principal aim is to ensure that risks are managed efficiently. Risk management system must be practical and cost effective.

Risk management framework-With the introduction of risk management the project may incur additional expenses which will be compensated through the holistic advantages of Risk Management [6]. In the planning stage the possible risks can be identified and mitigated through their timely incorporation. This has a positive impact on the set timelines andaccordingly on the project cost. The stages for process of risk management are mentioned below in Table 1[2],

Table 1: Stages for Risk Management Framework

Stages	**Process**
Risk identification	Identify the source and types of risks
Risk classification	Consider the type of risk and its affects
Risk analysis	Assess the impact of risk by using various risk measurement techniques.
Risk attitude	Any decision about risk will be affected by the attitude of the person or organisation taking the decision.
Risk response	Consider how the risk should be managed by.

IV. Various stages for Risk Management Framework

Important stages of risk management framework are elaborated below,

- **Identification of risk**–The feasibility study involves the process of risk identification. Various factors like climate, topographical and geographical conditions, resources, transportation, potential natural calamities, environmental conservation, available resources, utilities and so on are considered while selecting the site for the proposed project.Risk identification is carried out both in line with the progress of project and forward looking because all risk is not completely identified. [4]
- **Analysis Risk**- It is the most important task of risk management to analyse any risk and provide an integral solution to the project manager. The essence of risk analysis is that it attempts to consider all possible options and to analyse various outcomes. By giving specific weighted number to each option, the risk can be quantified and responded [2]**.**

- **Assessing Risks**- The risk assessment in construction project has been applied differently from project to project by using various model of risk assessment to evaluate the risk in the certain activity of the project [5]**.**The quantitative measurement and Qualitative assessment of specific risks and their interrelationship of their effect is carried out for assessing risks. The following methods can be used for risk assessment and risk comparisons in construction projects**,**
- **Key performance indicators**- It causes quantitively measurable circumstances which creates a basic for comparisons. For example, in case of real estate sector key performance indicators are average operating cost, average rent, average interest on outside capital etc.
- **Qualitative Assessment**- In this method, risks are assessed subjectively according to probability of their occurrence and the amount of loss or damage.
- **Probable maximum loss**- The assessment of risk due to major damage or loss in case ofdangerous occurrence within a risk scenario is carried out.
- **ABC Analysis**- The goal of the risk analysis is to find out factors caused the largest part of the project value. Accordingly, a greater planning and control of expand time is rationalized.
- **Risk Map**- It represent the risk possible of enterprise and prioritize the risks to be tackled.
- **Risk Prioritisation**-After identification of critical risks in EPC projects next step in risk management is prioritisation of risk. Prioritisation is most difficult task in the risk management and requires determination of probability of occurrence of risk during the lifetime of project.
- **Risk modelling and assessment**- On infrastructure projects, simulation and sensitivity analysis is often used for technical and financial risk assessment. Non-availability of past data from similar projects often leads to inadequate modelling of important risk factors while applying such methods in EPC projects of a specific sector. Several risks inducing factors in EPC projects could be sector specific in nature. Therefore, to cover sector specific details of a sector such as highways, scenario modelling of various identified critical risks of EPC projects is required.

The risk assessment model consists of various components [7]**,**

- **Scenarios modelling** - To assess quantitative & qualitative long-term effects of critical risk factors, subjective knowledge and experience of experts can be effectively incorporated in risk prioritisation process. Therefore, prioritisation of risks based on systematic processing of experts' judgement is carried out for EPC projects. Scenario modelling enables clear structuring of risk event by depicting risk into its causing events, their relationships, and their occurrence structure.

Scenario modelling with Fault Tree approach is used in this research work for prioritisation of identified critical risks in EPC projects.Deterministic description of the occurrence of the top event in terms of the occurrence of other lower order events is developed in fault tree. A basic Risk fault tree model of a risk is presented in **fig 2.1**.

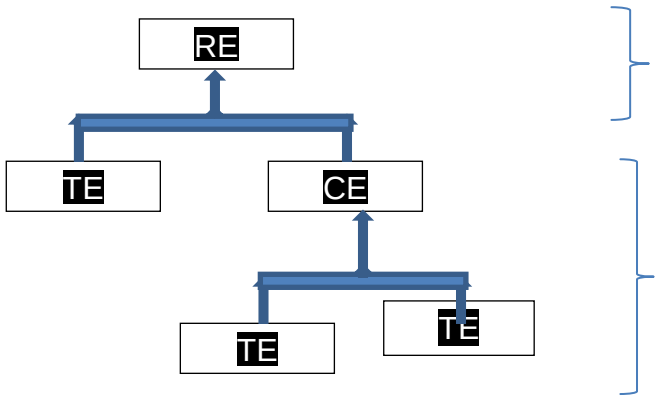

Fig 1: Risk Fault Tree Model

The complex risk events (RE1, RE2….) are further decomposed into risk factors. The risk factors, which lead to the occurrence of complex risk events, are shown as component events (CE1, CE2…), and then as terminal events (TE1, TE2….) in the fault tree. The events for which further decomposition is not possible are treated as terminal events. The lower level events (component events and terminal events) in the risk fault tree are characterized with probability of their occurrence.

- **Fuzzy Delphi probability prediction-** Generally it is difficult to quantify judgemental variables. Fuzzy sets provide a convenient way to model linguistic variables. The uncertainty of variables can be expresses as probabilities or as Fuzzy numbers. Limitation of using probability analysis is that the impact of qualitative aspects on projects is difficult to quantify. For overcoming the above difficulties, possibilities theory could be used as an alternate approach.
- **Cause & Effect Relationship-**In construction projects, the cause & effect relationship is different than mechanised industrial project and the effect of one cause may vary from time to time or place to place. For example, nationwide strike of transport may halt work at certain place and may have nil effect on another place. Therefore, cause and effect relationship is introduced in Risk fault tree diagram. The probability of causative events and their strength relationships with higher component events can theoretically vary from zero to one.
- **Possibility Theory-**Possibility theory is based on the concept that all value within a range are possible with exact value being unknown. The range is assigned subjectively but the individual value is not assigned. The possibility of occurrence of each event is defined as a fuzzy set [0, 1]. The professional experts are asked to give their response as possibility of occurrence of basic terminal risk factor and possible cause & effect relationship between risk factor/event. They have to mark above responses in subjective form (fuzzy set). Fuzzy mathematics is used to calculate risk probabilities. Probability of terminal (basic) events is considered as possibility function (fuzzy set) and possibility of occurrence of top risk event is calculated using fuzzy mathematics.

Table 2: Classification of Fuzzy Probability Sets

Fuzzy Sets	Linguistic Explanation
EL	Extremely low
VL	Very low
L	Low
M	Medium
H	High
VH	Very high
EH	Extremely high

The seven fuzzy sets assumed in this research are presented in **Table 2** and their probability distributions are presented in **Fig 2,** probability range on x-axis. A straight-line variation between 'Extremely Low' and 'Extremely High' fuzzy probability subsets is assumed. Triangular fuzzy sets are used for this model except the 'Extremely Low (EL)' and 'Extremely High (EH)' probability fuzzy sets.

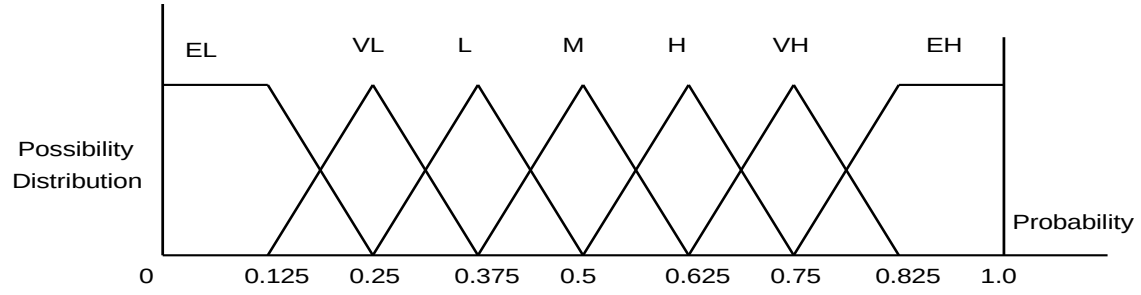

Fig 2: Fuzzy probability sets as possibility distribution

- **Fuzzy Probability Evaluation of Risk Event-**

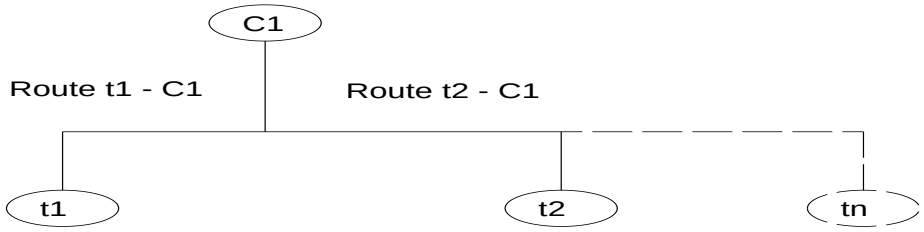

Fig 3: Fuzzy processing of fault tree

Let us consider a component event C_1**(Fig 3)**, which is being affected by N terminal events. The possibility of occurrence of terminal events is obtained from experts in subjective form (fuzzy sets). Let the Possibility of occurrence if t_1 be P (t_1).

Possibility of occurrence of C_1 in case t_1 occurs (cause & effect relationship of c_1-t_1 route) is also obtained from experts in subjective form. Let it be P ($c_1|t_1$). Similarly, for next terminal events t_2, t_3….t_n, probability fuzzy sets P (t_2) & P ($c_2|t_2$), P (t_3) & P ($c_3|t_3$) …… P (t_n) & P ($c_n|t_n$) are also obtained.

For illustration, consider two terminal events affecting component event. The chance of realisation of c_1 through $t_1 – c_1$ route is,

$$P(t_1\text{-}c_1) = P(t_1) \times P(c_1|t_1)$$

Similarly, chance of realisation of c_1 through $t_2 – c_1$ route is,

$$P(t_2\text{-}c_1) = P(t_2) \times P(c_1|t_2)$$

Therefore, Possibility of occurrence of c_1,

$$P(c_1) = P(\text{route } t_1 - c_1 \text{ OR route } t_2 - c_1)$$

$$= P(t_1\text{-}c_1) + P(t_2\text{-}c_1) - P(t_1\text{-}c_1) \mathbf{x} P(t_2\text{-}c_1)$$

V. Risk response strategies

The response to the risk can be grouped into four basic forms which are used in India by the government officials and project managers as the various risk response strategies[2]**,**

- **Risk retention**-Risk that produces small, most suited to retention. Transferring all risk may not be economical and it is preferable to retain a part of the risk in certain circumstances. Example- a reduction in insurance premium with corresponding retention of the risk.

- **Risk reduction/ mitigation-** It seeks to reduce the chance and effect of an adverse risk event to an acceptable limit. Taking an early action to reduce the chance of risk occurring or its impact on the project is more effective than trying to repair the consequences afterits occurrence. To reducethe risk exposure, it is shared to other parties. Example- The general contractor will attempt to reduce the risk of liquidated damage (LD) by imposing LD clause in sub contract agreement. Mitigation cost should be appropriate, given the likely probability of the risk and its consequence [4]. Example of mitigation process are,

- Adopting fewer complex processes
- Conducting a greater number of engineering test
- Choosing stable contractor

- **Risk transfer-** Risk transfer is seeking to shift the effect of a risk to a third party together with ownership of response. It does not reduce the criticality of the risk rather it just passes to another party. In actual it is not eliminated rather handled by an expert of the field. The most common form of risk transfer is by means of insurance. Also,a contract may be used to transfer liability for specified risks to another party.

- **Risk avoidance**- It is synonymous with refusal to accept risks. Example-The use of exemption clause to avoid specific risk. It is done by changing the project plan to eliminate the risk or changing condition to protect the project objectives from its influence. Some risk events that occurs in beginning of the project may be dealt with by this response strategy. Following are the example of avoidance [4]**,**

- Reducing scope to avoid high risk activities
- Adding resources or time
- Adopting a familiar approach instead of an innovative one
- Avoiding an unfamiliar sub-contractor

Risk managementin construction industryrely heavily on contract and the construction industry has a very bad reputation of involvement in numerous dispute and claims. Contracting risks to other parties does not mean they are managed since nothing is done to deal with these risks rather there will be increase in the cost of contract [8]**.** It is estimated that contract clauses raise the project cost by 8-20%. This supports to find alternatives method in managing risks. The studies show that construction risks are mainly handled with experience, assumption and human judgement.

References

[1] Indrasen Singh,EPC/ Turnkey contracts in highway sector.https://www.nbmcw.com/tech-articles/roads-and-pavements/3768-epc.turnkey-contracts-in-highway-sector.html#login-model (2009)

[2] Hsu-Hsun Hsiao,Risk management in BOT projects.Submitted to the department of civil and environmental engineering in partial fulfilment of the requirement for the degree of Master of Science in civil and environmental engineering at the Massachusetts of technology (2000)

[3] M Kakati, Pallav Baruah,Optimalrisk allocation in public-privet partnership (PPP) projects in India.WEI International Academic Conference Proceedings, Boston, USA (2016)

[4] H. Maniar, Risk Analysis of Infrastructure Projects – A Case Study on Build-Operate-Transfer Projects in India. The IUP Journal of Financial Risk Management II (4), pp (2010).

[5] Shahid Iqbal, Rafiq M. Choudhry, Klaus Holschemacher, Ahsan Ali & Jolanta Tamošaitienė, Risk management in construction projects. Technological and Economic Development of Economy, 21:1, 65-78, DOI: 10.3846/20294913.2014.994582(2015)

[6] Martin Schieg, , Risk management in construction project management. Journal of Business Economic Management,7:2,77-83 https://doi.org/10.1080/16111699.2006.9636126 (2005)

[7] A.V. Thomas, Satyanarayana N. Kalidindi, L. S. Ganesh, Modelling and assessment of critical risks in BOT road Projects. Construction Management and Economics ISSN 0144-6193 print/ISSN 1466-433X online © 2003 Taylor & Francis Ltd http://www.tandf.co.uk/journals DOI: 10.1080/0144619032000064127 (2003)

[8] Jonathan K. Fabi, Jacob A. B. Awolesi,A Study of Risk Management Practice of Highway Projects in Nigeria. Journalof Economics and Sustainable Development www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) Vol.6, No.18 (2015)