

RISK MANAGEMENT AND ITS UTILIZATION IN CONSTRUCTION ENGINEERING

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Abstract: *The human mind has always been intimidated with structures. Construction was the first occupation known to man. Be it the gigantic and alluring olden temples built in India, Mexico, Egypt and Greece or the unassailable forts built by great rulers, each structure is a result of someone's serrated vision and efforts. But as we know that our world is filled with uncertainties, the uncertainties impact greatly in the construction phase of a project and are termed as risks. The ultimate aim of construction of a structure is to impart sufficient strength in accordance with the amount of time and cost allotted for the project. In case of risk analysis, it is to be noted that all major resources such as time, labor, material and cost are affected. This paper attempts to distinguish the type of risks and its effects on the mentioned parameters. The Covid-19 pandemic has proved that pre risk analysis and management has now become mandatory for construction projects. According to research, it was found that the Indian construction sector alone suffered losses of around 300000 Million Rupees every day during the lockdown. Different literatures are studied so as to try to study how different risks affect the construction phase and can be reduced or in best case, can be avoided without any hassle of varying the time and cost of the project. The primary aim of Risk Management is to ensure minimal deviation from the pre assigned parameters and study an interdependent relation between time and cost invariance.*

Keywords- Risk analysis, Deviation, Time and Cost Invariance

1. INTRODUCTION

The construction Industry is spread to a vast extent in India. This industry is one of the oldest occupations known to mankind. For a simple one storey construction, many resources such as material, labor, time and money are required. As the complexity of the structure increases, the requirement of all the resources increases manifolds. If the time of completion increases, the labor charges increase resulting in indirect cost overrun. If we want to decrease the time period, the indirect cost would be reduced but the direct cost will increase. Hence we can argue that no two resources are independent of each other.

The COVID 19 Pandemic affected the construction engineering industry on a very large scale as it not only affected the industry workers but also affected their consumer base. Millions of bread earners of their family

lost their jobs or suffered pay cuts and millions got affected indirectly. During these harsh times, it is difficult for people to invest in the housing sector. People are having a hard time returning loans which they took from banks. On the other hand, due to the lockdowns, daily wage laborers were forced to return to their home lands and the whole construction industry came to a halt. The only thing which didn't stop was **TIME**.

As the time passed, the unused resources started deteriorating. As the projects get delayed, the expected income is subsequently delayed. But the time value of money, which is always decreasing results in an overall loss in the project. To recover these losses in government projects, the governments will further increase taxations. Correspondingly, the corporations will further increase the real estate costs.

Broadly we have categorized risk into two categories; predictable and unpredictable. For e.g. Failure of a machine can be considered under predictable risks and the Covid-19 pandemic can be considered under unpredictable risks. We know that the construction project is a repetitive kind of activity and can be considered using CPM. On the contrary, risk is probabilistic in nature and hence it is considered by using the PERT method. In the following paper we have tried to form a mathematical model for analyzing risk using a combination of CPM and PERT.

2. LITERATURE REVIEW

Rogério Cabral de Azevedo¹, Leonardo Ensslin¹, Antônio Jungles¹, (2014), discussed the risk management methods followed in the Civil Engineering Projects. According to them, each new step gives further rise to possibilities of different risks. Decisions which are made in risk management generally deal with the risks depending upon their past experience, training and thought process. This dynamic perception and subjective judgment of different people and not following a systematic approach can impact and alter different parameters of a project. The risk management approach should be competent enough to identify the risks associated with any step and the alterations it can make in the project. It should also be able to adapt to change and try to achieve the proposed result without causing much deviation from the expected results when no risks were involved. The most important and the basic task is to identify which of the phenomenon is a risk.

Sometimes, a particular event can act as both risk and reward in different circumstances. This depends upon the event's effect on the objective of the project. This process of identifying risks is dynamic in nature and changes with different projects, but have the same output i.e. deviation of time and cost from desired initial expectations. For future evaluations, all the risks monitored during the project cycle should be in a documented form. According to them, most of the authors consider only the positive and negative effects of any event and then term it as a risk or opportunity. But almost all of the tools they developed considered only the negative effects and assessed the threats associated with any event. The tools should be able to identify and utilize opportunities as it is similar to identifying threats as it provides competitive advantage in the market.

The approach to solve any risks is categorized into 4 parts, descriptive, normative, perspective and constructivist approach. Descriptive deals with those phenomena which do not require human interference and can be solved by natural instruments. As this type of risk does not require any human judgment, the flexibility of this method increases and it can be used anywhere by anyone. Normative requires ideas of past experiences and special expertise to analyze, predict, decide and reach a conclusion to take preventive measures. This is generally done by an onsite manager. In the Perspective approach, different management models are studied and personalized depending upon the requirement with the help of an outside of the management expert. This approach is dynamic and changes with the change of information received from the organization. The constructivist approach studies the consequences of each decision made by the decision making authority on the project itself. The general procedure to identify risks is by conducting interactive sessions with professionals, stakeholders and experts by means of questionnaires and workshops. Other methods which are worth mentioning are collecting historical data from previous projects. Finally they proposed the use of Multi-criteria Decision Aid which is Constructivist Method abbreviated as M.C.D.A.-C.

Zulqarnain I.², (2014), considered Risk Management as a tool to identify risk source and its uncertainty. According to them, a company should have these 5 processes for an efficient risk management system viz. planning a systematic approach, identifying and classifying risks, prioritizing risks by use of mathematical tools such as assessing, cumulating and combining their probabilities, finding multiple solutions to similar threats and monitoring the behavior after execution of risk management throughout the life cycle of the project.

They started with the most basic question of knowing what a risk is! How do you discriminate between risk and opportunity? The answer depends upon the impact

it causes on the project's predetermined parameters. Of all the risks, distribute them into major and minor risks. Study about all the changes they can cause in terms of finances and time with a probabilistic approach. After application of the probabilistic method, study the changes in the project outcome. And lastly informing the competent people associated with the project in a documented format. Apart from the risk management system, the site manager must also keep in consideration some emergency risk situations as the risk management process is dynamic in nature and hence it should be updated on a regular basis.

In construction projects, the risk of time and cost are very important and hence they need to be prioritized. They distributed major risks in a construction project as financial Risk, completion risk, technical failure, political risk, accidental risk, natural or environmental risk, etc. Now these risks need to be categorized in high, medium and low priority, so as to apply the remedial procedures first to high priority risk and then to lower priority risks. Using this, they formed a risk matrix. Major advantage of using risk management is that it will be tedious for the first few projects but as time passes, the efficiency will outlaw the possibility of failures due to repetitive kinds of risks.

Ankan Biswas³, Abhinandan Ghosh³, Adrish Kar³, Tuhin Mondal³, Bunttee Ghosh³ and Dr. Prasanta Kumar Bardhan³, (2020), studied not only the financial impact of COVID 19 on the whole construction engineering industry in many countries such as India, China, Italy, United Kingdom, Australia, Russia, UAE and the United States of America but also gave remedial solutions. One of the peculiarities of these countries is that the mentioned countries are cash rich economies. The most common observation they found was the shrinkage of GDP of all the countries. India suffered the most loss of GDP i.e. around 24%, whereas UAE suffered the least, 1%. The basic expected reason behind this is the population density of both these nations have an enormous difference. Other countries' shrinkages were between 5-10%. In all of these countries, the construction engineering industry accounts for an approximate range of 5-10% of their GDPs.

As this industry is dependent heavily on manual labor, all the countries combined before the pandemic had around 250 million people globally contributing to the world economy through this sector. Due to the Covid-19 pandemic, unemployment on a very large scale is evident. The indirect impact of Covid-19 on the construction engineering industry is through the disruption of the supply chain management caused due to difficulty in transportation of construction material, equipment, labors and machineries.

They suggested some measures to try to bring the industry back on groove, ranging from increase of

modular construction, use of Artificial Intelligence (AI) in Construction Engineering to assisting workers with medical and financial packages. Covid-19 was a very sad and ill-fated event which shook the whole of humanity, affected millions of people, not only physically but economically, emotionally and socially also, we pray that it should not repeat. But for any such risks in future we must fully prepare ourselves. For the first time, we can understand and comply, but we need to make sure that in case we come face to face against any such risk, we are fully prepared to tackle it. The world Governments must form a proper risk management system, not only for the construction sector but for other sectors too.

Terje Aven⁴, (2015), studied and reviewed the recent advancement in the risk management approaches and perspectives. Special enhancement is given to integrative risk. They studied the risk as study of risk assessment with respect to specific activities along with parallel study of risk research done through recent developments, papers, theories, models and principles. Recent studies have more quantitative and analytical approach i.e. use of mathematical and simulation models to understand the effect of change of a particular step or variable on the end product of the project. For e.g. simulation models in ETABS can easily give the effect of change in rebar percentage or change of grade of concrete on the end values of bending moments, shear forces and response timing of a particular structure. On the other hand, if we follow documentations, researches, summaries and conceptualized reports, it gives a clear idea about similar situations and problems which occurred in the past, its consequences and suggested remedies.

They formed many different risk matrices consisting of probability of occurrence of a scenario, consequence of the scenario, severity of that consequence, previous knowledge of the scenario, judgment error of knowledge, expectations of fatalities, loss of property per unit time, etc. The solution steps included the identification of problems, generation of alternatives through analysis, discussion, processing and decision making followed with implementation. For each risk, repeat the above cycle known as the policy cycle.

Gulam Mohi Ud Din Rather⁵, (2018), argued that the construction engineering industry is a very risk prone industry as the projects are complex and dynamic in nature. Failures such as quality compromise, operational failures, cost overruns, unexpected delays are often seen. The author studied the risks and uncertainties in the construction engineering sector through different research literature surveys. He believed that risks generally arise from different sources in a construction project as there are multiple feedback processes from different individuals working on the project which may positively or negatively impact the outcome of the

project. It majorly depends on the skills, experience and thought process of the decision maker.

Risk is termed multidimensional, i.e. the probability of a certain outcome is associated with uncertainty. He categorized risk into internal and external risks. Other risks include political and social, etc. risks. Different factors affecting the risks are history of similar projects, the common vision of management, experienced staff, knowledge expertise, size of team, availability of different resources, time constraints and the complexity of the job. The author mentioned different types of risks along with the general sources of risks in a project. The paper also discusses the advantages and limitations of the risk management program. In the end, the author impacted that most of the companies do not consider risk management systems and directly use measures like risk elimination and risk transfer, but these methods are very less efficient.

Akintola S Akintoye⁶, Malcolm J MacLeod⁶ (1997), presented a paper which provided the basic structure of approach to any risk management model. They considered the risk arising activities and prepared a survey questionnaire with the help of different people associated with the project. They established that risk management not only minimize losses but also enhance the profitability of a project. They termed risk as an event which impacts the time, cost and quality of the project. The risk management is shaped by the intuition, judgment and experience of the decision making authority/ authorities. They admitted that risk management methods are not often looked upon in the construction engineering industry because of the ignorance and uncertainty towards the reliability of these unconventional methods in the construction.

Leena Pekkinen⁷, Kirsi Aaltonen⁷, (2015), published a paper on risk management in the project networks which focused on the information processing model. They intended collecting as much information as possible so as to reduce the uncertainty in any project. They divided a large complex project into small parts and studied them partly. The performed empirical analysis at each step and cumulated results. They started with selection criteria for project contractors, responsibilities of the contractors, maintaining a formal risk management documentation, a follow-up method to get updated with the project progress, database maintenance for all the information received, a consumer complaint system and an updated plan if in case there's a delay in the project. They also used informal means to collect information such as meetings, surveys, personal connections and past experience. They concluded that a risk management system can be most efficient if it is broken into parts rather than studying it as a whole.

3. METHODOLOGY

The construction engineering industry generally approaches every project in similar fashion. Hence, the set of approaches for most of the projects is usually common. When we follow a repetitive set of commands, we use the Critical Path Method (CPM). The management parameters included identifying and then categorizing types of risks according to the approach of their solutions. The basic criteria of distinguishing was probable and non-probable risks. Further we distinguished them into:

- a. Machinery/ Equipment Related Risks
- b. Human Related Risks
- c. Resource Related Risks

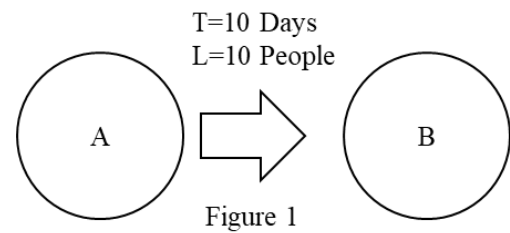
Risk is generally uncertain in nature and hence we would consider the Program Evaluation and Review Technique (PERT) for analysis of different risks. The effect of these three is studied with respect to time and cost of the project and they're prioritized into high, medium and low risks. All the above mentioned risks are probabilistic in nature and hence we can assume use of scientific and mathematical models using probabilistic approaches to find the delay in time and variation of direct and indirect cost associated with the change in time.

For risks of non-probabilistic nature such as floods, earthquakes, pandemics, etc. old researches, theories, papers and past experiences come into picture. A comprehensive study of similar events in the past and their solutions needs to be maintained so as to study the variation of cost and time due to the non-probabilistic events in nature.

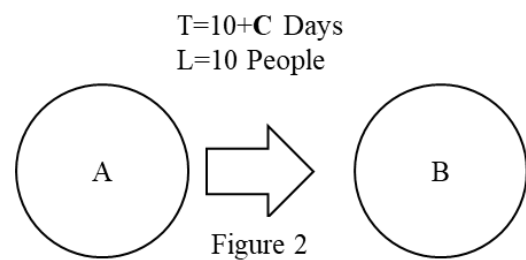
Now, the priority depends upon the severity of the situation. For e.g. a human related risk becomes severe if any individual or group of people die due to any accident. This risk is medium when a group of labors are unavailable due to illness or other reason. It is low when only 1 person is unavailable or ill for a short duration of time. It is to be noted that unavailability of any labor or labors majorly affects the time duration of the project and minor effects are observed on cost of project. This exact study model can be followed for other individuals such as site engineer, project manager and stakeholders.

On the contrary a risk in any equipment or machinery not only contributes towards time overrun but also cost overrun as many of the steps are stuck due to unavailability of equipment along with extra financial requirements for repair and maintenance of machineries. Now depending upon the cost and time curve, we can distinguish between high, medium and low priority machine failures.

For E.g. Figure 1 shows an activity A to B



If the machine breaks down, the time for the work to resume will increase. It can be shown in Figure 2.



Now to overcome this the manager needs to be well versed with the risk management system. The below table represents the time duration for repairing the machine and the costs associated with delaying the project for C Days.

Days C	Repair Cost	Labor Cost/Day	Additional total Cost
5	5000	500	7500
10	2000	500	7000
15	500	500	8000

Table 1

Now, it depends upon the site manager to prioritize either reducing cost overrun of the project by delaying the time of completion or by reducing time overrun by spending more money for quick repair of machinery.

Resource related risks sometimes get converted into opportunities. It depends upon the cost and availability of materials. If the government decides to decrease certain tax on some materials or fuel, subsequently prices of other things decrease resulting in cost of the material. Similarly if due to any laws/bills passed by the Governments regarding the minimum wages of laborers, the cost may increase and result in cost overrun.

Further work and development on this system can be done by consideration of a small scale construction project. In the near future we would like to practically conduct and make a systematic modular and practical approach towards risk management on a construction site.

4. CONCLUSIONS

As it is now evident that risk management is a very important process in the civil engineering industry, but rarely followed during the construction phase. The Covid-19 has exposed this loophole and caused heavy damage financially due to poor risk management systems. Risk management systems contribute to the decision making process with the help of scientific methods along with past experiences of similar risks. But one cannot ignore the possibility of uncertainty of events and hence sometimes the whole system of risk management may just not be useful if there are no deviations from the assumed path.

Hence we would suggest that companies should have a generalized risk management system obtained from general risks observed on different construction projects, but there should compulsorily be a risk management plan for important and large scale projects. The governments should always have a risk management system for all of their projects as it is observed that most of the time Government Projects suffer time and cost overrun due to negligence towards risk management approach of companies working on those projects.

5. REFERENCES

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