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Risk Assessment for Infrastructure Projects Case Study: Pune Metrorail Project

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ABSTRACT

In this paper, we discuss the method of risk measurement of project risk, based on the risk matrix method. Generally project risk management primarily deals with cost and time uncertainties and risk associated with each activity of the project network. In this paper, we have identified the major risk sources and quantified the risk in terms of likelihood, impact and severity in a complex infrastructure project such as metro rail project going on many mega cities such as Hyderabad, Kolkata and upcoming projects such as Pune metro. The methodology for this work was the response from the experts associated and involved in this and other projects in metro rail. The risk assessment for this project is carried out by risk matrix method. And risks are categorized according to the priority.

Keywords--- *P*roject risk assessment, Metro rail, Risk matrix method

I. INTRODUCTION

Risk assessment is an important part of risk management in major projects where huge amount of money is invested. For an infrastructure project, risk assessment can be carried out effectively by investigating and identifying the sources of risks associated with each activity of the project. These risks can be assessed or measured in terms of likelihood and impact. There are two different methods of the construction of metro rail one is elevated metro and second is underground metro. Now we will assess the risk associated with construction of underground metro rail. The major activities concerned with underground construction are project feasibility report, sub soil exploration as well as drainage studies of area where construction is supposed to carryout. We have developed a questionnaire survey and personally interviewed experts from the underground corridor project. In this process, we have identified the risks at various phases of the project starting from the feasibility phase to the completion of the project. This paper is organized as follows section two deals with literature survey and further section three deals with methodology and objectives. In section four we will discuss the scope and limitations of the projects.

II. LITERATURE RIVEW

Risk can be defined as a measure of the probability, severity and exposure to all hazards for an activity (Jannadi and Almishari, 2003). For an infrastructure project there is always a chance that things will not turn out exactly as planned. Thus project risk pertains to the probability of uncertainties of the technical, schedule and cost outcomes. Williams, Walker and Dorofee (1997) worked on developing methods by which risk management could be put into practice. Their methods were based on software intensive programs (SEI) along with which specific road maps were designed. These could guide and help identify various risk management methods which could be easily put into practice Complex projects like the construction of an underground corridor for metro rail operations involve risks in all the phases of the project starting from the feasibility phase to the Operational phase. These risks have a direct impact on the project schedule, cost and performance. Reilly (2005), Reilly and Brown (2004), Sinfield and Einstein (1998) carried out their research on underground tunnel projects. Reilly and Brown (2004) state that infrastructure underground projects are inherently complex projects with many variables including uncertain and variable ground conditions. As per Reilly (2005), for a complex infrastructure project like underground construction, it is very important to identify the risk events in the early phases of the project. A proper risk mitigation plan, if developed for identified risks, would ensure better and smoother achievement of project goals within the specified time, cost and quality parameters. Further, it would also ensure better construction safety throughout the execution and operational phase of the project. Mulholand and Christan (1999) explain that due to the complexity and dynamic environments of construction projects, certain circumstances are created which result in a high degree of uncertainty and risk. Often these risks are compounded by demanding time constraints. Dey (2001) developed an Integrated Project Management Model for the Indian petroleum industry where he incorporated risk management into the conventional project management model and cited it as an integral component of project management. But Dey (2001) carried out the risk analysis by finding out the respective likelihoods of the identified risks which were found to have a summation of 1 for the respective work packages on a local percentage (LP) basis. The summation of the likelihoods of all the concerned work packages was found to be equal to 1 on a global percentage (GP) basis. Nehru and Vaid (2003) carried out the risk analysis with similar concepts. As per Roetzheim (1988) as quoted by Nicholas (2007), the likelihood of the identified risks can have a value ranging from 0 to 1, which indicates a 0% or a 100% chance of occurrence. But the weightage associated with all risk sources for a work package / activity is always equal to 1. The product of the likelihood and the respective weightages is equal to the cumulative likelihood factor (CLF)

III. METHODOLOGY

Risk can be assessed either using a qualitative analysis. Qualitative risk analysis covers a range of techniques for assessing the impact and likelihood of identified risk. These approaches can be used to prioritize the risks according to their potential effect on project objectives and is one way to determine the importance of addressing specific risks and guiding risk responses. Quantitative analysis uses numerical ratio scales for likelihoods and consequences, rather than descriptive scales. There are many tools available for evaluation of risk and risk controls, ranging from experience – base judgment, checklists and risk matrices to specialist review and analysis techniques.

Anna Klemetti [5] explain that risk can be evaluated by estimating risk probability and impact in simple scales for example, from 1 to 5 or from high to low. The risks can be mapped in a probability – impact grid. On the grid, risk that require the most attention are easily detectable wherein actions to control them can be taken only if there are sufficient resources or if mitigating the risk costs are less than the product of possibility of risk's occurrences and its impact on project objectives (expected values).

Al-bahar and Crandall [1] quantified risk as the product of probability and impact where impact may be gain or loss in a construction project.

The significance of a risk is termed as 'Risk Factor' and is expressed in termed as 'Risk Factor' and is expressed in terms of its consequences or impacts on project objectives, and the like hood or consequences of those consequences arising. To calculate risk factor or levels, the descriptive like hood assessments are converted to numerical measures. P. A similar process is followed for the consequences assessments, to give an average consequence measures, C. A. risk factor RF or combined risk measure is then calculated for each risk. The significance of a risk is termed as 'Risk Factor' and is expressed in termed as 'Risk Factor' and is expressed in terms of its consequences or impacts on project objectives, and the like hood or consequences of those consequences arising. To calculate risk factor or levels, the descriptive like hood assessments are converted to numerical measures. P. A similar process is followed for the consequences assessments, to give an average consequence measures, C. A. risk factor RF or combined risk measure is then calculated for each risk.

3.1 Risk Consequence

The notion of being a function of risk likelihoods and risk impacts is known as risk consequences. There are two ways to express risk consequence. First, it can be expressed as a simple numerical rating with the value ranging between 0 to 1.

3.2 Risk Factor (RF)

The risk factor is expressed in terms of its consequences or impacts on project objectives, and the likelihood or occurrences of those consequences arising. The risk factor can be calculated by using following formula,

$$RF = P + C - (P * C) \qquad \ldots\ldots\ 1$$

Where;

RF = Risk factor.

P = Probability (occurrences) measure on a scale 0 to 1.

C = Consequences (impact) measures on scale 0 to 1.

The risk factor will be high if probability P is high, or consequences C are high or both are high. This formula only works if P and C are scales from 0 to 1. The simple matrix as shown in fig. 1 is used to combine the likelihood and consequences rating to generate initial priorities for the risk. Risk matrix is plotted using two dimensional scales from 0 to 1 of impact/consequences and occurrences/probabilities.

Risk matrix gives idea about the criticality of risk. Risk matrix groups risks in 4 categories as low, medium, high, critical. Group Low means risk is of no more importance, so it may be ignored or solve in last priority. Similarly group critical means all those risk lying in this group need more serious attention of project manager and team. These risks need to solve on higher priority.

Risk profile can be plotted with respect to the decreasing order of calculated risk factor as shown in fig.2.The project focuses on use of 'risk and priority model' for assessing various risk identified in real estate projects where prioritized in real of risk and a detailed understanding of the impact upon the success of the project should they occur and consequence and likelihood ratings, agreed risk priorities and inherent risk levels are obtained. The responses collected were in the form of opinions of experts regarding the likelihood occurrences of the various risk and there corresponding impact of the risk on the project. The opinions are in the form of scores scaling from 1 to 5 for the four case studies as shown in table 2.The numerical scores of occurrences and impact for risk are converted from scale 1 to 5 to scale 0 to 1 by using following formula:

$$\text{Required score} = (\text{responded score} * 2)/10.$$

Risk factor (RF) or combined risk measure is then calculated for each risk by using Eq.1.

The score and calculated risk factors for case study 1 are indicated in table 3 and thus similar calculations for remaining case studies are done. Risk matrices are plotted using two dimensional scales 0 to 1 of Impact/ Consequences and Occurrences / Probability which are also plotted with respect to the decreasing order of calculated risk in order to resolve it. Risk matrix (Refer fig.3) and risk profile (Refer fig. 4) are plotted for case study 1 and similar risk matrices and risk profiles are calculated for remaining case studies. As stated by Cooper, et. al[2] the scale of 1 to 5 was chosen and converted to 0 to 1.

Table.1 Scale of likelihood & Impact

Value Scale	Assessment of Likelihood (P)	Assessment of Impact (C)
1	Rare	Nil/Very minor effect
2	Considerable	Low effect
3	Medium	Medium effect
4	Frequent	High effect
5	Always	Extreme high effect

Table 2: Questionnaires Responses

Sr. no	Risks shortlisted	Responses on scale 1 to 5	
		Occurrence	impact
1	Risks due to delay in approval of detailed project report (DPR)	4	4
2	Land acquisition risks	3	3
3	Design risks	3	3
4	Technology selection risks	4	4
5	Approval & permit risks	1	1
6	Joint venture risks	2	2
7	Financial & investment risks	1	2
8	Political risks	2	2
9	Environmental related risks	1	2
10	Geotechnical risks	1	3
11	major/minor accidents	1	2
12	Unforeseen heavy rain	1	3
13	Force measures	Group insurance	

Table 3: Calculation of Risk Factors

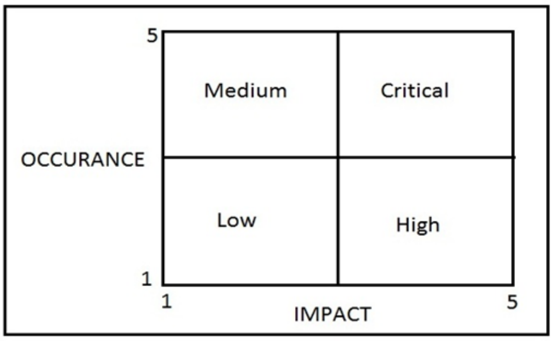
Q. No.	Occurrences		Impact		Risk Factor
	Responded Score	Scores(P)	Responded Score	Scores(C)	
1.	4	0.8	4	0.8	0.96
2.	3	0.6	3	0.6	0.84
3.	3	0.6	3	0.6	0.84
4.	4	0.8	4	0.8	0.96
5.	1	0.2	1	0.2	0.36
6.	2	0.4	2	0.4	0.64
7.	1	0.2	2	0.4	0.52
8.	2	0.4	2	0.4	0.64
9.	1	0.2	2	0.4	0.52
10.	1	0.2	3	0.6	0.68
11.	1	0.2	2	0.4	0.52
12.	1	0.2	3	0.6	0.68

Table 4: Risk Prioritization

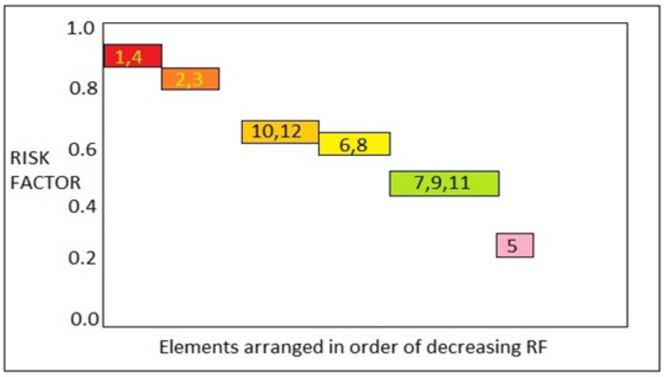
1st priority	1st and 4th risks
2nd priority	2nd and 3rd risks
3rd priority	10th and 12th risks
4th priority	6th and 8ht risks
5th priority	7th,9th and 11th risks
6th priority	5th risk

Table 5: Resultant Risk Prioritization

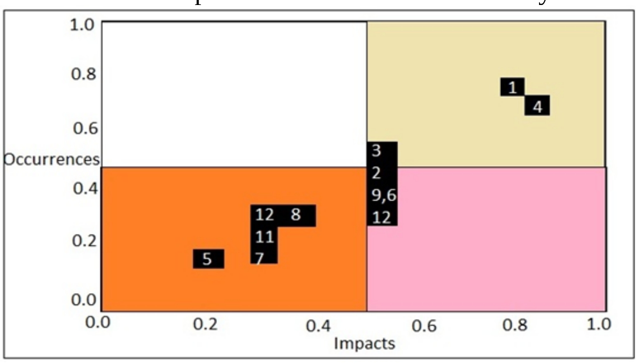
1st priority	4th and 1st risks
2nd priority	3rd ,2nd ,6th and 9th risks
3rd priority	10th risks
4th priority	8th,12th and 11th risks
5th priority	7th risks
6th priority	5th risk



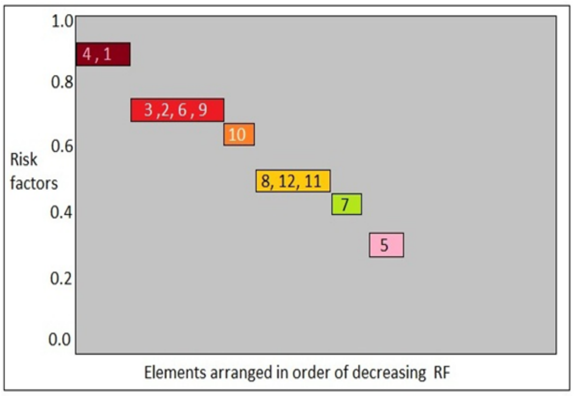
Graph 1 : Risk Occurrence Verses Impact Matrix



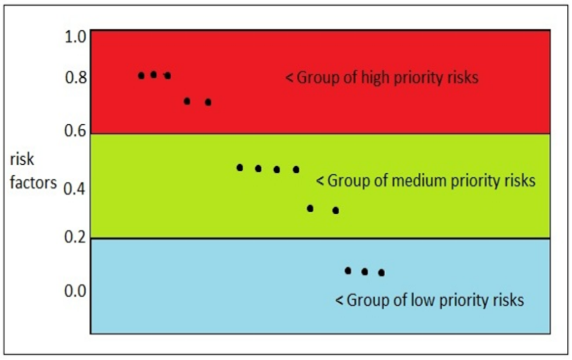
Graph 2: Risk Profile for Case Study



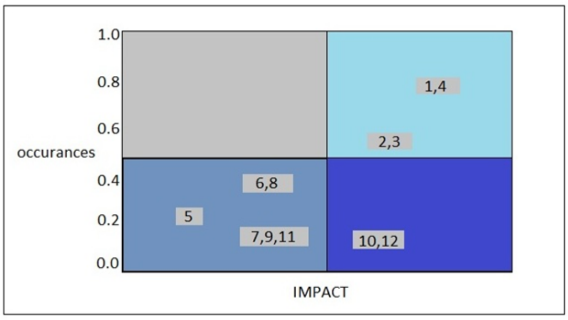
Graph 3 : Collective Risk Matrix



Graph 4 : Collective Risk Profile



Graph 5 : Risks Profile Where Elements Are Arranged In Descending Order Of RF



Graph 6 : Risk Matrix For Case study

IV. Conclusion

It can be concluded that risks can be assessed by using priority model. this will be helpful for risk monitoring and mitigation. further study for risk evaluation is requried. In this pepar it is found that

in most of the infrastructure projects delay in approval and design, selection of technology are major risk which causes delay in project. it is recommended to study these risks through risk evaluation techniques

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