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# Risk Assessment and Mitigation of International Airport Projects in Indian Scenario

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**Abstract -** *Large and complex infrastructure projects involve various risk factors and the successful implementation of such projects depends on effective management of the key risk factors. This study reviews the literature to identify essential risk variables associated with infrastructure projects. Based on these risk variables, a survey is conducted to isolate and assess the critical risk factors for International Airport Construction Projects in India. Responses obtained within the project organization are evaluated using principal component analysis to understand the latent structure of the critical risk factors. The research findings are supported by the perceptions of the senior management within the project organization, which are also discussed in this study. Based the personal interviews with the key personnel of the projects a template for cost overrun was prepared which is linked to project cost report which runs on Monte Carlo simulation technique. It can be utilized in any project to find the % of risk obtained by cost overrun. A risk management process flow for an enterprise was also suggested.*

***Key Words***: Risk, Risk Analysis, Risk Mitigation, Risk Management, Monte Carlo Simulation, Factor Analysis, Airports Construction Management.

## 1. INTRODUCTION

Due to the rapid urbanization in the world, construction activity has increased several folds. The activities range from small ones to large ones involving huge amount of money. The construction industry is a major source of national income, particularly in the developed ones. The Indian construction industry is very large and is important to various sectors of the economy.

Various construction activities useful to public that include Roadways, Railways, Ports, Water Supply systems, Power plants, Houses, Dams etc., are grouped together under the term 'infrastructure'. Such infrastructure projects being huge in nature and involving a large amount of money, any sort of wastage (either time, resources etc) would lead to huge monetary losses. The losses are due to various risks associated with such mega projects. These risks are to be identified and mitigated to avoid the losses. The loss of services given by the project during the time by which the project overruns can be enormous if put into monetary terms. Hence, to reduce the losses efficient management of a construction project is required. This entire process of risk identification and mitigation is termed as risk management.

### 1.1 Purpose & scope of study

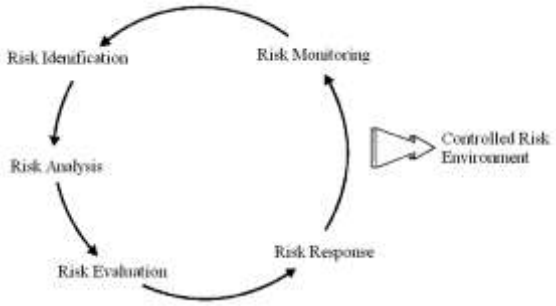



**Fig -1**: Risk Management Life Cycle

Risk, therefore, must be managed efficiently. If this is possible, then not only will project costs be more explicitly known, but profits will also be maximized. The most current risk management procedure consists of risk analysis, evaluation, and control. These three steps can be further divided to fit together into a simple circular procedure, which if followed obtains a controlled risk environment (Fig. 1). Application of various project management techniques have to be made from the conception to the completion stages which includes managing the various risks associated with the project in its every stage. Risk Management can be viewed as an integral part of project management, as shown in the Figure 2 below. [21]

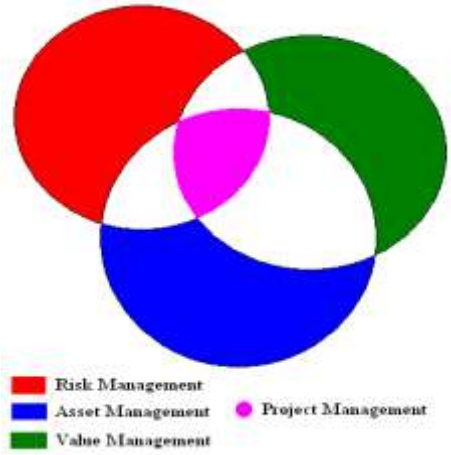



**Fig -2**: Risk Management as Integral Element of Project Management

The present study deals with developing a Risk Management Template for a Construction Enterprise. The scope of Risk Assessment and Mitigation is limited to the construction of airport projects.

## 2. DATA ANALYSIS, RESULTS & DISCUSSION

The first and foremost step in the risk analysis phase is the evaluation of the collected data, relevant to risk exposure. This data can be used to make checklist analysis obtained from historical records that the contractor experienced in past projects or to make an assumption analysis developed based on a set of hypotheses, scenarios, or assumptions or by any other information gathering techniques.

Hall and Hulett, suggested that complexity can be a source of risk. Large and complex projects usually call for multiple contracts, contractors, suppliers, and outside agencies. Complex coordination among the subprojects is a potential risk, because delay in one area can cause a ripple effect in other areas. Complex construction projects are high-risk ventures involving multiple parties with different interests, thus producing a high potential for conflict.

### 2.1 Risk Identification

This study reviews the literature to identify essential risk variables associated with infrastructure projects and various methods of risk identification and risk analysis have been discussed. This study has presented the results of a study on the identification of risk factors, their importance, and impact on an International airport construction projects (In India). A total of 48 risk variables were identified through literature. Based on these risk variables, a questionnaire was designed and a survey is conducted to gather data within the project organization and to isolate and assess the critical risk factors for International Airport Construction Projects in India. Responses obtained within the project organization were analysed using Factor Analysis through SPSS software to understand the latent structure of the critical risk factors. Results suggested that 20 risk sub factors could be grouped into four distinct risk factors (Table 1). And out of those 20 factors, 5 factors are most important, 13 factors are important and the remaining factors are least important. The measurement instrument representing four critical risk factors was subjected to reliability, construct, convergent, and discriminant validity tests. Test results indicated that it is a reliable research instrument. An importance index represented the degree of importance assigned to the risk factors (Table 2 & Table 3) by the respondents within the project organization. The importance index of four critical risk factors suggests that sub-contractor risk be viewed as the most important risk factors.

**Table -1:** Internal Consistency Analysis

| Factor Interpretation | | Cronbach's Alpha |
|---|---|---|
| **F1** | **Financial & Economic Risk** | **0.901** |
| **F2** | **Contractual & Legal Risk** | **0.941** |
| **F3** | **Sub-Contractor Risk** | **0.710** |
| **F4** | **Force Majeure Risk** | **0.859** |
| F5 | Operational Risk | 0.62 |
| F6 | Safety & Social Risk | 0.277 |
| F7 | Planning & Control Risk | 0.257 |
| F8 | Design Risk | 0.586 |
| F9 | Delay Risk | 0.531 |

**Table -2:** Importance index of each critical risk factor

| Rank | Factor | Importance Index |
|---|---|---|
| 1 | Sub-Contractor Related Risk (F3) | 76.16 |
| 2 | Contractual & Legal Risk (F2) | 67.18 |
| 3 | Force Majeure Risk (F4) | 65.8 |
| 4 | Financial & Economic Risk (F1) | 60.8 |

**Table -3:** Importance index of each risk variables

| Rank | Risk Variables | Importance Index |
|---|---|---|
| | ***Financial & Economic Risk (F1)*** | |
| 1 | Cost Over run | **66.26** |
| 2 | Unavailability of funds | **61.53** |
| 3 | Economic disaster | **61.37** |
| 4 | Financial failure of contractor | **54.05** |
| | ***Contractual & Legal Risk (F2)*** | |
| 1 | Delays in solving contractual issues | **75.73** |
| 2 | Delays in solving disputes | **73.59** |
| 3 | Delay payment on contract and extras | **68.85** |
| 4 | Change order negotiation | **66.56** |
| 5 | Permit and regulation | **60.92** |
| 6 | Inflation | **57.4** |
| | ***Sub-Contractor Related Risk (F3)*** | |
| 1 | Coordination with subcontractors | **86.56** |
| 2 | Labour productivity | **78.32** |
| 3 | Subcontractor failure | **77.71** |
| 4 | Financial failure of subcontractor | **75.88** |
| 5 | Subcontractor lack of adequate | **70.23** |

| | | |
|---|---|---|
| | number of staff | |
| 6 | Labour dispute and strike | **68.24** |
| | ***Force Majeure Risk (F4)*** | |
| 1 | Unforeseen site condition | **69.31** |
| 2 | Fire and theft | **68.09** |
| 3 | Act of God | **65.19** |
| 4 | War | **60.61** |

**Factor 3 Sub-Contractor related risk** accounted for 13.353% of the total variance and ranked first with an importance index of 76.16 (Table 2). This factor contained a combination of six variables: (i) Coordination with subcontractors, (ii) Labor Productivity, (iii) Subcontractor Failure, (iv) Financial failure of subcontractor, (v) Sub contractor lack of adequate staff; and (vi) Labor disputes and strike. All the six variables had a relatively high importance index varying from 86.56 (Coordination with subcontractors) to 68.24 (Labor Disputes and Strikes).

**Factor 2 Contractual and legal related risk** accounted for 16.122% of the total variance and ranked second with an importance index of 67.18 (Table 2). This factor contained a combination of six variables: (i) Delays in solving contractual issues, (ii) Delays in solving disputes, (iii) Delay payment on contract and extras, (iv) Change order negotiation, (v) Permit and regulation; and (vi) Inflation.

From the observations from the projects it is evident that Inflation played a big role. Market situation of some building materials like cement, steel and bitumen were very much fluctuating. There is a vast hike in prices. Probably the engineer who worked for tendering of these jobs might not have foreseen that this vast variation may happen in the prices. So, ultimately now the burden is on the shoulders of concern project manager to mitigate the risk.

**Factor 4 Force Majeure related risk** accounted for 9.841% of the total variance and ranked third with an importance index of 65.80 (Table 2). This factor contained a combination of four variables: (i) Unforeseen site condition, (ii) Fire and theft, (iii) Act of God, and (iv) War.

**Factor 1 Financial & Economic risk** accounted for 34.101% of the total variance and ranked fourth with an importance index of 60.80. This factor contained a combination of four variables: (i) Cost Overrun, (ii) Unavailability of funds, (iii) Economic disaster, and (iv) Financial failure of contractor.

Cost overrun is having the highest importance index among all the four sub risk factors listed above (Table 3). There is a chance that cost will over run in every project. Only thing is it has to be mitigated by forecasting the items that are probably going to hamper the cost schedule and may over run. A template in Visual Basic was made and linked with monthly cost report of the project. If we run the template it will simulate unit cost and quantity of the particular item using **Monte Carlo simulation** and it will give the optimized values. It also shows the error "Risk: Cost overrun will be encountered in later stages of the project" if the input value exceeds the limit. It is a template, in hand which will warn the project team about cost overrun.

## 2.2 Risk Analysis

***Risk Profiling Technique*** is a simple and quick technique to qualify risks one relative to other. The technique helps to identify the unacceptable, tolerable and acceptable risks out of given number of risks.

The basic methodology of RPT involves:

- Hazard identification
- Frequency estimation
- Consequence analysis
- Risk evaluation
- Sensitivity analysis
- Recommendations for risk reduction

As stated in PMBOK, Risk Analysis: Tools and Techniques, Risk Profiling Technique is made use of here to evaluate the severity of each of the twenty potential sub risk factors identified by factor analysis (Table 3). The working is done & the results of the above analysis are given in the Table 4. The Risk Map is shown in the Fig: 3

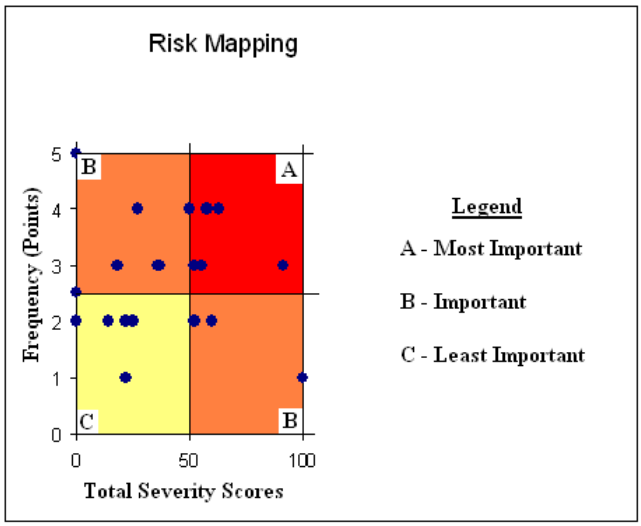



**Fig: 3** Risk Profiling Technique – Risk Map

***Monte Carlo simulation*** is a statistical technique whereby randomly generated data is used with in predetermined parameters to simulate and produce realistic project outcomes. The overall project outcome is predicted by randomly simulating combination of values for each risk and repeating the calculation, often up to 1000 times. Due to the

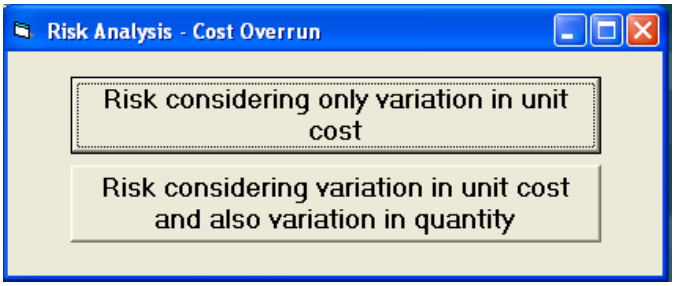
nature of the calculation it is primarily a computer based operation.

Monte Carlo Simulation Technique is made use of here to evaluate percentage of risk that will be encountered. Out of twenty sub risk factors, S32 Cost Overrun was considered and evaluated using Monte carlo simulation technique. The Simulation can also be extended for the remaining sub risk factors which can be quantified.

**Table -4:** Results of Risk Profiling Technique

| SL | Description | Position in Map | Identification |
|---|---|---|---|
| 1 | S33 Financial failure of contractor | B | Important |
| 2 | S32 Cost overrun | A | Most Important |
| 3 | S30 Unavailability of funds | B | Important |
| 4 | S35 Economic disaster | C | Least Important |
| 5 | S29 Inflation | A | Most Important |
| 6 | S43 Delay payment on contract and extras | A | Most Important |
| 7 | S44 Delays in solving disputes | A | Most Important |
| 8 | S45 Delays in solving contractual issues | A | Most Important |
| 9 | S42 Change order negotiation | B | Important |
| 10 | S46 Permit and regulation | C | Least Important |
| 11 | S28 Labour dispute and strike | B | Important |
| 12 | S9 Subcontractor lack of adequate number of staff | B | Important |
| 13 | S10 Subcontractor failure | C | Least Important |
| 14 | S11 Coordination with subcontractors | B | Important |
| 15 | S34 Financial failure of subcontractor | B | Important |
| 16 | S24 Labour Productivity | B | Important |
| 17 | S16 Unforeseen site conditions | B | Important |
| 18 | S37 War | B | Important |
| 19 | S38 Act of God | B | Important |
| 20 | S39 Fire and theft | B | Important |

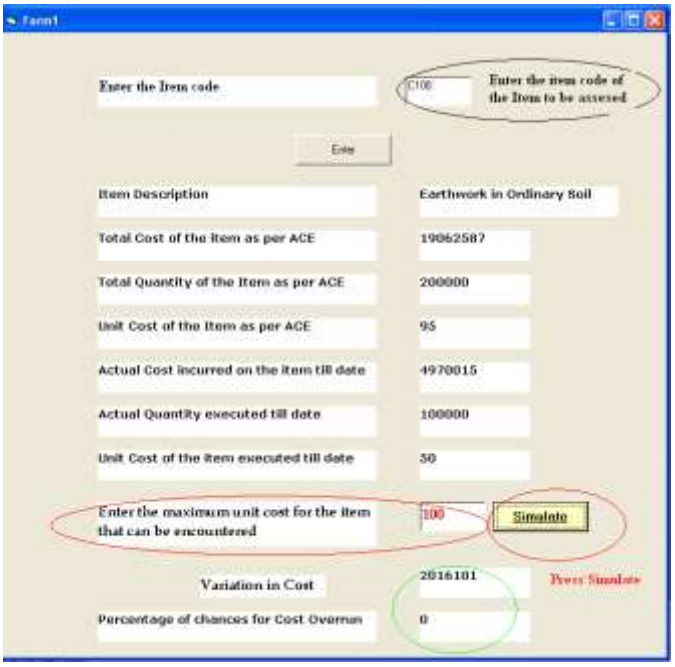
Risk Analysis –Cost Overrun Template was made in Visual basic linked to excel work sheet. The excel work sheet will be having monthly cost report data of a particular project. Normally we won't get any warning in advance in the normal traditional method of evaluation of project cost report by excel. By this template we can predict in advance the possible risk that it may encounter at any later stage of the project. The variables taken here are maximum unit cost that it can be encountered during the period of the project and maximum quantity of any item that it can be encountered during the period of the project.




**Screen Shot: 1 – Home Page**

From the above Software home page choose any of the two buttons based on the requirement. Suppose Button 1 (Risk – Considering only variation in unit cost) was chosen.

The Page 1 opens. There enter the item code of the item to be assessed. It will display all the fields required as shown in the snap shot above. Then enter the maximum unit cost for the item that it can be encountered and press simulate button. It will give us the variation in cost and percentage of changes for cost overrun. If the unit cost entered exceeds certain limit it will warns us the risk by displaying a message which is shown in the screen shot 3.

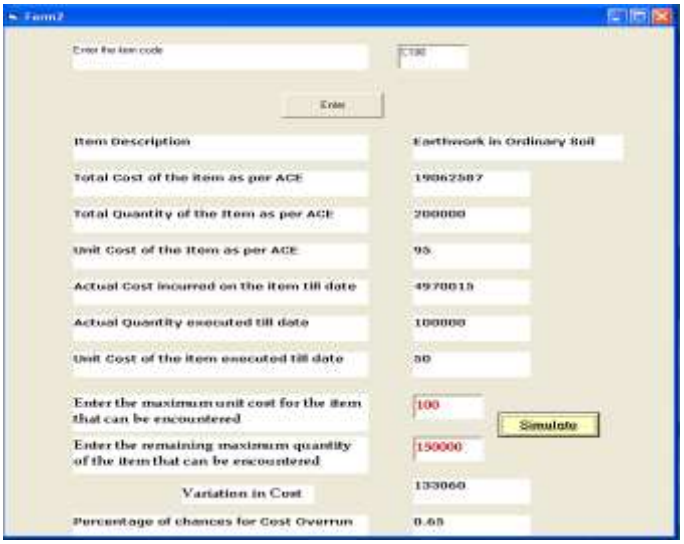



**Screen Shot: 2 – Home Page > Page 1**

From the above Software home page Screen shot 1 choose Button 2 (Risk – Considering variation in unit cost and also variation in quantity). The page 2 opens. There enter the item code of the item to be assessed. It will display all the fields required as shown in the snap shot 4 below.


**Screen Shot: 3 – Home Page > Page 1> Displaying Error Message**

Then enter the maximum unit cost and maximum quantity for the item that it can be encountered and press simulate button. It will give us the variation in cost and percentage of changes for cost overrun. If the unit cost or quantity or both entered exceeds certain limit it which leads to a negative variation in the overall cost of the item then it will warns us the risk by displaying a message which is shown in the screen shot 3.




**Screen Shot: 4 – Home Page > Page 2**

### 2.3 Risk Mitigation

Risk mitigation implies a reduction in the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action to reduce the probability and/or impact of a risk occurring on the project is often more effective than trying to repair the damage after the risk has occurred.

In the airport projects, the risk of escalation in price of construction materials like steel, cement, bitumen etc which constitute to the project cost substantially has been apparently retained and mitigated by proper planning of material requirements and control of wastage during transportation and construction.

The risk of financial failure of the sub-contractors has been mitigated by verifying the past records and experiences of the sub-contractors and as well as from the list of approved sub-contractors provide by the clients. Contract was awarded only if they satisfy all the requirements of financial, technical and other commercial aspects. Mostly sub-contracts were awarded to the parties who are having good relations in the past with the contractor.

Labour related problems in one of the airport projects site has been mitigated by the providing accommodation near to the site with school or their children, dispensary, grocery store and conveyance to the site from the accommodation. Initially getting labour had become a very big problem because there are many builders in and around various metros where they are getting a good pay nearer to their home but after providing above mentioned facilities relatively the risk was reduced.

Theft and fire damage to the property, material and equipment has been mitigated in one of the airport site which is an expansion project and security is of high concern in all respects. Very sophisticated security systems are being installed so that only approved and authorized labours and staff can enter into the work area.

### 2.4 Risk Insurance

The following risks have been apparently insured.

- Force Majeure Risks that have been insured apparently are – War, Acts of god, Fire and theft.
- Risks due to unforeseen site conditions are also been insured apparently.

## 3. CONCLUSIONS

The research findings are supported by the perceptions of the senior management within the project organization, which are also discussed in the paper. Based the personal interviews with the key personnel of the projects a template for cost overrun was prepared which is linked to project cost report which runs on Monte Carlo simulation technique. It can be utilized in any project to find the % of risk obtained by cost overrun. A risk management process flow for an enterprise was also suggested.

The results obtained are not global in nature. The results and the input data are valid for the present case study (airport projects) only. The conclusions are applicable only to airport projects. However, methodology may be extended to any other project types such as building projects, harbour projects, tunneling projects, etc. The research findings would enable management to focus on key risk factors and develop appropriate strategy to successfully manage large and complex project.

Following are the recommendations for the further study:

- The present scope of study was limited to the identification of critical risk factors during constructional phase. It can also be extended to contractual phase and operational phase of the airports.

- Samples of equal size could not be obtained from the different groups managing this project (consultants, contractors, and owner). The effect of unequal representation of respondents on items extraction through factor analysis could be explored in future research.

- In complex project such as Large International Airport Projects, where negotiations, approval, and issue of contracts are an integral part of the project management process, political risk may play an important role. However, political risk and geographical/climatic risk was not included in the context of the present research, which can be explored in future research.

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## BIOGRAPHIES

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