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# Cost Estimation of Construction Project Using Monte Carlo Simulation

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***Abstract:*** *Construction Industry is a high risk Industry and involves considerable investment. There are plethora of risks and uncertainty in the construction industry due to which the actual cost exceeds the budgeted amount. This places strain on the client and in the process of completion of project, keeps on borrowing the funds finally leading to insolvency of the client in most of the projects. Hence, it is very important to have a proper cost estimation of the project taking the identify and foreseeable risks and uncertainties into This paper has analysed the cost of construction project by using the Monte Carlo Simulation. The research examines the effect of correlation between the various project costs by using Monte Carlo Simulation.*

***Key Words:*** *Risk Management, Construction, Monte Carlo Simulation, Project Cost.*

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## I. Introduction

The Construction industry is one of the key economic industries in India and is the main motivating force in Indian national economy. The Indian construction industry is an integral part of country's economy and its growth and a conduit for a substantial part of India's development investment. The construction sector employs approximately 31 million people, accounts for some 11% of GDP and, after agriculture, is the largest employment sector in the country. In general, it has been growing at 9.11% year on year, primarily due to the strength of increased domestic and international manufacturing activities and industrial growth. Construction sector accounts for nearly 45% of the total investment in infrastructure and is expected to be the prime beneficiary of the surge in infrastructure investment in the near to medium term. Development of adequate infrastructure to achieve/sustain high GDP growth is a priority for the Government of India. Despite slippages from targets, investments in infrastructure reported a compounded annual growth rate (CAGR) of 18% over the last three years, with the spending increasing to Rs. 4.0 lakh crore in FY 2009-10 from 2.4 lakh crore in 2006-07 ( ICRA, 2011).

Projects could not be delivered in the planned schedule and within estimated budget because of improper utilization of project management tools and techniques. The behaviour of construction projects is haphazard. By previous estimates, over 40% projects have reportedly been suffering from poor performance across the country (Iyer and Jha, 2005). Gunawan (2010) stated that the Indian construction projects are worst in time and schedule performance where average schedule overrun is the highest.

George F. Jergeas and JanakaRuwanpura (2011) listed a number of reasons for cost and schedule overruns prominent among them being 1)lack of realism in initial cost estimates 2) length and cost of delays are underestimated 3)Contingencies are set too low and 4) Changes in scope are not sufficiently taken into account, etc.Considering these uncertainties, which exist in construction project, three time estimates may provide better realistic time estimates of project activities.

Assaf and Al-Hejji (2006) opined that there are 73 attributes of delays recognized by all stakeholders of construction. In India, most of the infrastructure projects are delayed due to want of various approvals, land acquisition, various resources related delays and fund availability. Meena and Babu (2015) outlined an approach to find the causes and effects of delay on construction projects. Discussion on various delay analysis techniques, viz. Impacted-as-planned, time delay impact analysis, collapsed as-built, window analysis, as-planned vs. as-built have been done in the past to decide on the claim for the delays. Although many methods have been developed and adopted to analyze and measure construction schedule delays, no single method is accepted for all project participants and suitable for all delay situations (Yang and Kao 2009).

**1.1 Risks in Construction Industry**

A risk can be defined as any exposure to possible loss. Because every construction project is different, each offers a multitude of varying risks. To ensure the success of a project, a contractor commencing a construction project must be able to recognise and assess those risks. And then the contractor must be able to manage those risks.

Real Estate generates a considerable amount of employment. It is linked with secondary sectors like cement, tiles, paints, bricks, etc. This involves a huge amount of money and therefore leads to uncertainty among the stakeholders. There are many cases where chances of risks involved with the construction sector are very high, and these uncertainties and risks, can further lead to stalling/ holding up of the construction works. Such projects malign the growth of the industry. There are many risks involved in the construction industry like business risk, financial risk, technology risk, political risk and many others. These risks lead to loss in the value of the project. There are various tools that can be used to formulate the prevention strategies to reduce the likelihood of a project becoming overrun like Scope definition, correct structuring of the construction activities, scope change management process, risk management process, milestone trend analysis and earned value analysis.

Types of Risks Prevailing in Construction Industry:

- Land Acquisition Risk
- Delays in Project Development
- Project cost Risk/ Cost Overrun
- Technology Risk
- Regulation and Administrative Risk
- Commercial Risk
- Operations and maintenance Risk
- Financial Risk
- Political and Social Risk
- Force Majeure
- Market Risk
- Corruption Risk
- Contractual Risk

**1.4 Estimated Time and Cost Breakup of Different Activities in a Project- Case Study**

The study has been conducted in a residential building in IDA Bollaram, Secunderabad, India. It is an ongoing project involving construction of residential towers. The scope of the work is construction of civil, structure and external development works, and coordination, supervision and management of other speciality works and separate works, of which civil activities alone is taken into consideration.

The data has been collected from the site. The optimistic and pessimistic time and cost has been estimated by considering 95% Degree of Confidence (5% level of significance of significance). The analysis has been done on @Risk (Palisade) i.e. Monte Carlo Simulation using 5000 iterations.

Monte Carlo simulation, is a forecasting model used to depict the impact of riskand uncertainty on cost and time in construction projects.

When range of values are there as a result, understanding of the risk and uncertaintyin the model starts. The key feature of a Monte Carlo simulation is that it can estimate, based on how the ranges of estimates have been created – how *likely* the resulting outcomes are.

**1.5 Objectives of the Study**

1) To calculate the planned duration of the construction project using various probability distribution functions using risk management tool.
2) To analyse the probability of project completion and comparison with base duration of the project.
3) To analyse the total impact on project finish date

The details of activities and the three estimate of time and cost for each activity is presented in table-1
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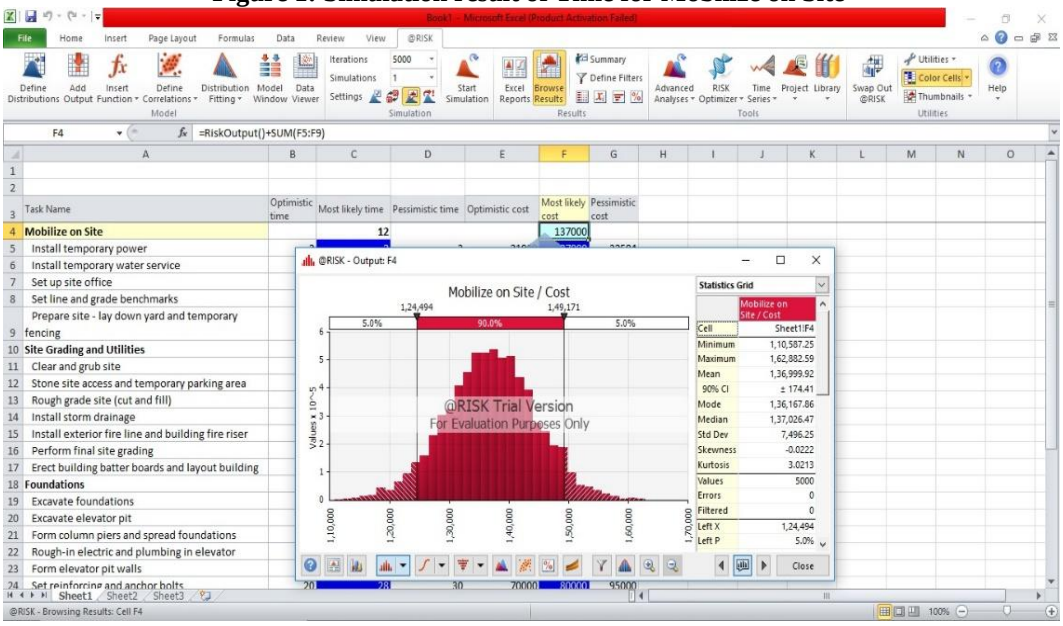
**Table-1:** Estimate of Time and Cost for Each Activity

| Activities | Time (in days) | | | Cost (in Rs.) | | |
|---|---|---|---|---|---|---|
| | *Optimistic* | *Most likely* | *Pessimistic* | *Optimistic* | *Most likely* | *Pessimistic* |
| Mobilize on Site | | **12** | | | **137000** | |
| Install temporary power | 2 | 2 | 3 | 21000 | 27000 | 32584 |
| Install temporary water service | 1 | 2 | 3 | 13500 | 15000 | 17598 |
| Set up site office | 2 | 3 | 5 | 31000 | 33000 | 35000 |
| Set line and Benchmarks | 3 | 3 | 4 | 1759 | 2000 | 2365 |
| Prepare site laydown yard and temporary fencing | 2 | 2 | 3 | 56987 | 60000 | 78000 |
| Site Grading and Utilities | | 61 | | | 106500 | |
| Clear and grub site | 2 | 3 | 3 | 9586 | 10000 | 11000 |
| Stone site access and temporary parking area | 1 | 2 | 3 | 1750 | 3000 | 4000 |
| Rough grade site (cut and fill) | 6 | 7 | 8 | 4800 | 5500 | 6500 |
| Install storm drainage | 12 | 14 | 16 | 5869 | 6000 | 7800 |
| Install exterior fire line and building fire riser | 11 | 14 | 15 | 61253 | 70000 | 75900 |
| Perform final site grading | 10 | 14 | 16 | 1896 | 3000 | 3650 |
| Erect building batter boards and layout building | 6 | 7 | 8 | 8000 | 9000 | 9100 |
| Foundations | | 198 | | | 1213000 | |
| Excavate foundations | 13 | 14 | 15 | 126580 | 135000 | 145000 |
| Excavate elevator pit | 13 | 14 | 18 | 64000 | 65000 | 67000 |
| Form column piers and spread foundations | 25 | 28 | 32 | 144000 | 155000 | 169000 |
| Rough-in electric and plumbing in elevator | 22 | 28 | 35 | 9867 | 10000 | 11000 |
| Form elevator pit walls | 21 | 28 | 36 | 8569 | 9000 | 12000 |
| Set reinforcing and anchor bolts | 20 | 28 | 30 | 70000 | 80000 | 95000 |

After performing simulation, the following results are obtained

**Figure 1: Simulation result of Time for Mobilize on Site**



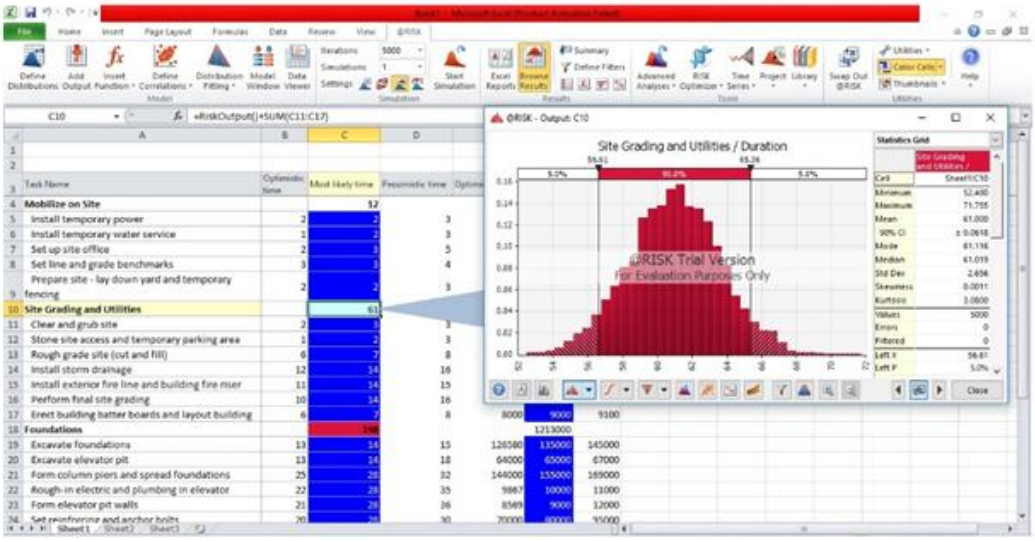



**Figure 2: Simulation result of Cost for Mobilisation on Site**

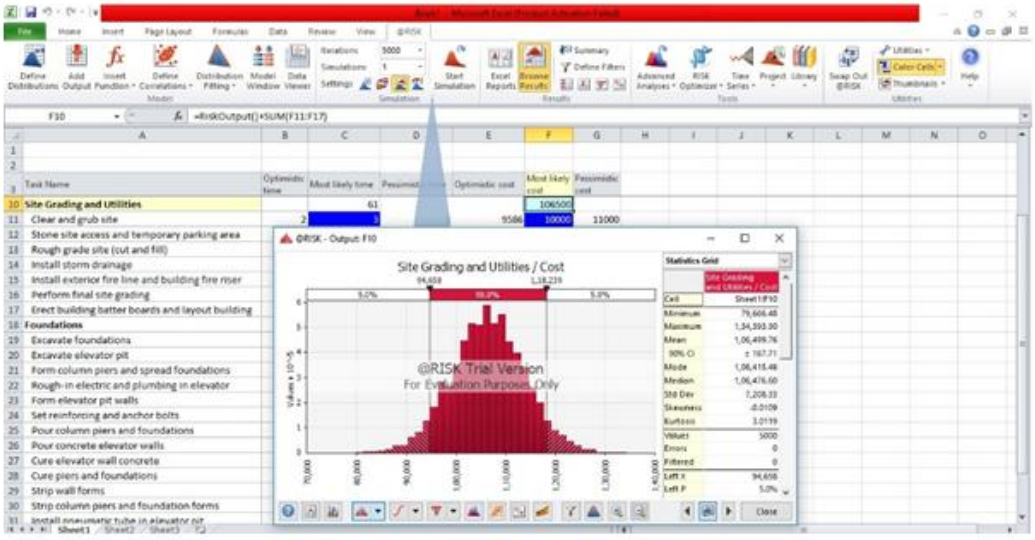



**Figure 3: Simulation result of Time for Site Grading and Utilities**

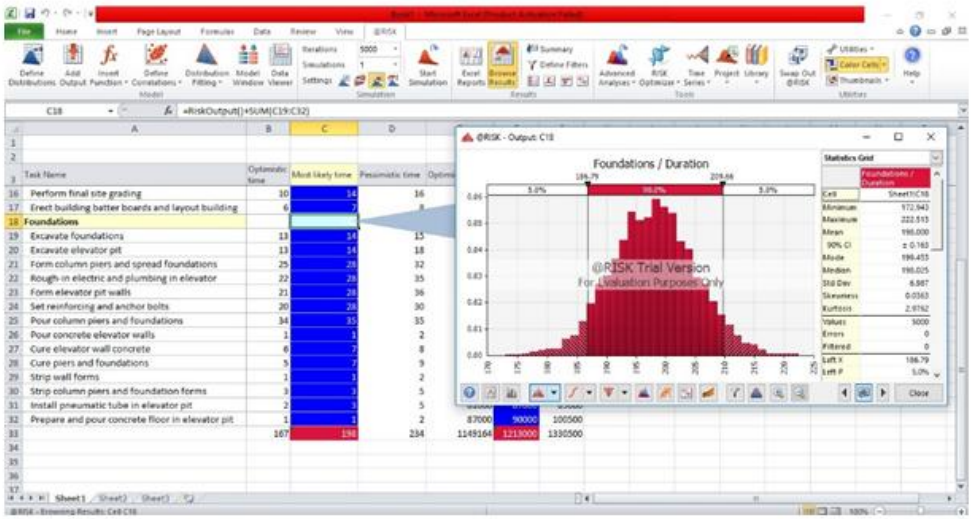



**Figure 4: Simulation result of Cost for Site Grading and Utilities**

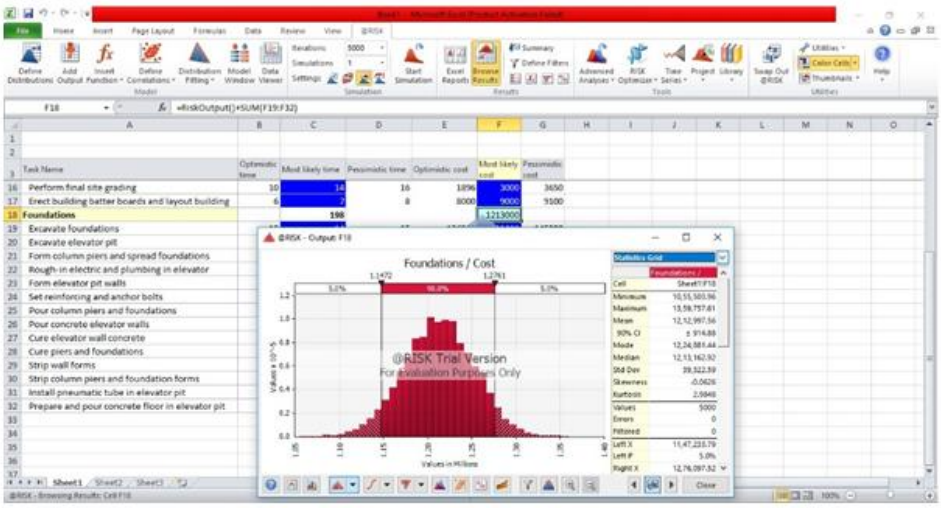



**Figure 5: Simulation result of Time for Foundation**

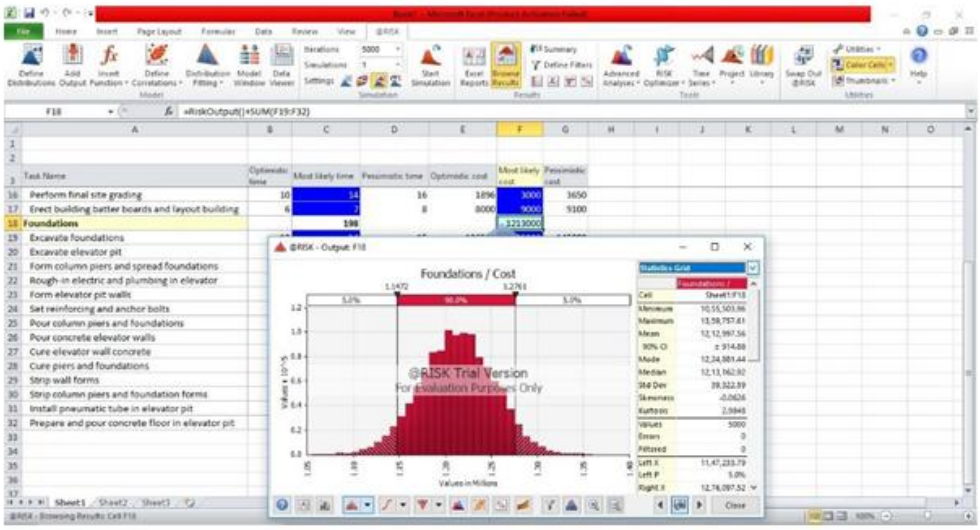



**Figure 6: Simulation result of Cost for Foundation**

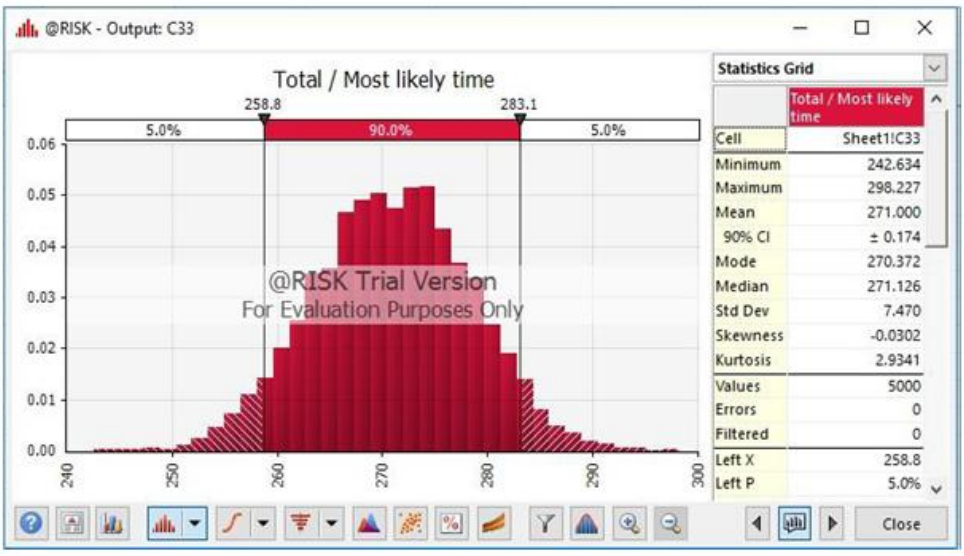



**Figure 7: Simulation result of Time for Overall of all the activities considered**

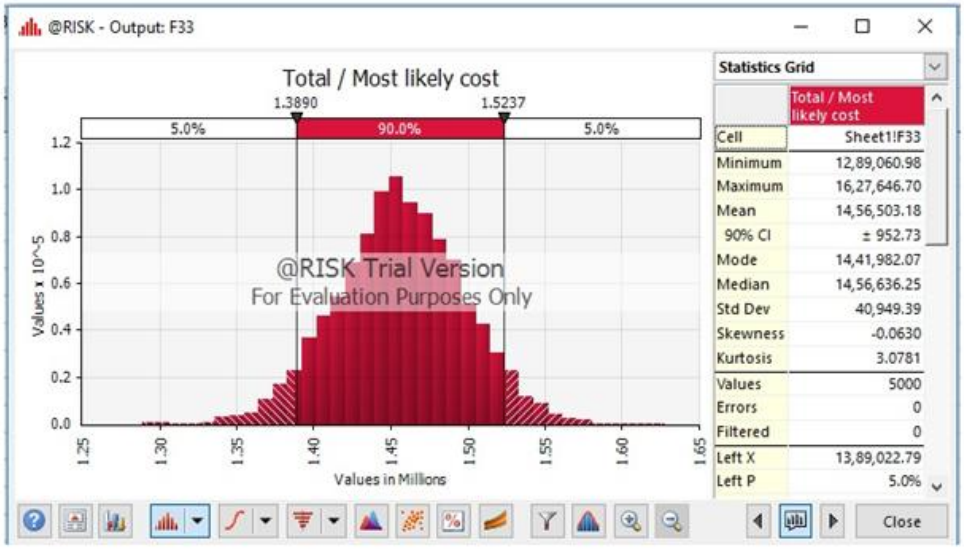



**Figure 8: Simulation result of Cost for Overall of all the activities considered**

## II. Conclusion

With the help of this study forecasting can be made that with 95% confidence level:

- Baseline time in which the project can be completed : 271 days
- Minimum time in which the project can be completed : 243 days
- Maximum time in which the project can be completed : 299 days
- Baseline cost in which the project can be completed : Rs. 14,56,500.00
- Minimum cost in which the project can be completed : Rs. 12,90,000.00
- Maximum cost in which the project can be completed : Rs. 16,28,000.00
- Minimum and Maximum time in which the project can be completed has been deviated by the baseline by 10.33%
- Minimum and Maximum Cost in which the project can be completed has been deviated by the baseline by 11.43% and 11.77% respectively

The research helped us to understand how Monte Carlo Simulation can be used for time and cost estimation in construction projects. The past studies mainly talk about the estimation of the distribution of time and cost elements has to be done subjective by experts, but in this paper we analyses id historical data can be used for Monte Carlo Simulation.

It's been found that historical data can be used for a Monte Carlo Simulation to give the planning team an idea about the variation of time and cost. This study can also be used in risk management process and helps the team to take better decision on risk mitigation strategy.

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