TIME CONTINGENCY ASSESSMENT FOR CONSTRUCTION PROJECT

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

CONSTRUCTION MANAGEMENT

Under the supervision of

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By

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to

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WAKNAGHAT, SOLAN – 173 234

HIMACHAL PRADESH, INDIA

May-2018

CERTIFICATE

This is to certify that the work which is being presented in the project titled **"TIME CONTINGENCY ASSESSMENT FOR CONSTRUCTION PROJECT"** in partial fulfilment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in **"Construction Management"** and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Mitankshi Sharma (Enrolment No.162603) during the period from July 2017 to April 2018 under the supervision of **Dr. Ashok Kumar Gupta,** Professor & Head, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my guide and supervisor **Dr. Ashok Kumar Gupta**, Professor & Head, Department of Civil Engineering, for the continuous support in my final project study on "**TIME CONTINGENCY ASSESSMENT FOR CONSTRUCTION PROJECT",** for his patience, motivation, enthusiasm and immense knowledge. His guidance has helped me in all the time of this study and writing of this report I could not have imagined having a better advisor and mentor for my project. I would also like to thank him for leading me his precious time.

I am also very thankful to all the faculty members of the department, for their constant encouragement during the project.

I also take the opportunity to thank all my friends who have directly or indirectly helped me in my project work.

Date: Mitankshi Sharma

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ABSTRACT

Construction projects often delay due to constrain effects. Contingency plan is to be considered to prevent delaying of the project. Project schedule optimisation can be done using different tools such as Primavera, Microsoft project, to calculate the total time required in the project and to complete the project in given schedule. These optimising tools help in preventing the project delay and helps in calculating the time duration for the project. In construction project, project time contingency and project uncertainty are required for accurate scheduling in which changes made does not affect the overall duration of the project. The critical path calculated and considering the factors of constrains, project gets complete within the deadline provided.

This thesis comprises of three objectives, first, to find the factors delaying the project, second, to rank them according to their importance in delaying the project and third, to calculate the contingency time of the project using SAPA method and Monte Carlo simulation. We use stochastic allocation and project allowance method for project scheduling with the help of Monte Carlo simulation in @ Risk software and questionnaire to rank the factors affecting time delay in the project. A six floors + ground floor green building is used for the allocation of project time contingency and to calculate the contingency time of the project.

The use of project planned duration and project target duration in calculating the project time allowance or the contingency time is useful in providing the actual required buffer time to the project activities. If this approach is used on actual sites, it may prevent delay in the project schedule as the buffer time provided in the activities reduces the possibility of any delay until or unless the risk factor large in the project activity.

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CHAPTER 1

INTRODUCTION

1.1 General

The dominating, rational, open system model at the structural level in organization theory is the construction theory. There are predictable and unforeseen or unpredictable risks in most of the projects in the construction industry which restrict the skill of managers to anticipate the performance of the project. Contingency time has been used in different projects to prevent delaying of projects and for a possible heed in time estimation. Contingency time in terms of quality and productivity issue is also being used as an alternative management method. Although estimators and management personnel's have different opinion when it comes to the term contingency time, it is generally associated with the risk assessment of duration overruns. Project managers also use it to guarantee the end time of particular activity or the overall project, assuming the performance variability of the project.

The ambiguities in certain project time are originated through foreseeable risks, better addressed in consideration by the ambiguity associated to the duration of activities in the project. The PERT and Monte-Carlo simulation, are the stochastic methods that are used in this event to calculate the contingency in the project time allowance. The critical changes after the method is applied which gives the approximate new time at which the project might complete. The time duration estimates the planned duration and the target duration, and their difference is called the project time allowance.

The current tools in the construction industry rely on the critical path method which provides the details about the major activities that are to be considered. The time allowance is managed at the end of the schedule which is required for the activities in the project. In cost-contingency , if we manage such practice by using the natural tendencies like first come first serve, the project cost would not be enough for all the project as some activities may cost more than the other and the total project cost will not be enough for the whole project. Managers may think it as the project is going on perfectly weather the cost increases. But it is not in the case of time, if the schedule of the project increases this implies that the project is not performing better and there are constrains that effect the schedule of the project.

There are any criteria's that are used to assign the time allowance of the project. The first criteria are to provide a buffer in the project to sink the timeline and to make sure that the project is going as per schedule. The second criteria recommend an integer programming model to designate time allowance to the activities in the project, considering their duration a criticality and probability.

The project variable behaviour is improved by the probabilistic schedule approach and the contingency time allocation is improvised by the rational analytic approach. If the model is too complicated and too mathematical are not used practically in the field. Project contingency time is measured as a percentage of the duration of project obtained by the CPM (Critical Path Method). With an increase in use of probabilistic method in project planning, proposal of simpler probabilistic approach for time contingency allocation can contribute to find new best project management practices.

1.2 Time Contingency Definition

The main aim of a construction project is to successfully complete the project in time, in planned budget and to provide quality in the project. These three aims are interrelated to each other and affected by each other. If the project is completed in time but the cost of the project increased or the quality provided is not up to the limit, then the project cannot be said successful. If the cost remains the same and the quality is also pleasable but takes time to complete the project, then also the project is not successful. These three goals are the interrelated to each other. If the project cost increases then the project time will also increase as there will be less resources and thus increasing the time of the project.

In construction project, project time contingency and project uncertainty are required for accurate scheduling in which changes made does not affect the overall duration of the project. The critical path calculated and considering the factors of constrains, project gets complete within the deadline provided.

Contingency has no definitive definition as contractors, owner's organisation and contractors have different meaning of contingency. The word contingency apparently is the most misunderstood, miscalculated, and misapplied word in the execution of project. It is an amount of time or money or a resource that provides with a specific confidence level when added to the base estimated amount.

Time contingency can be defined as the amount of time required above the estimated time to reduce the risk of overrun of project objectives.

Two considerable class of contingency time for construction project:

1. Design Contingency - it is addressed as the changes occurring during the design process, such as inaccurate method of estimation and incomplete scope definition as well as data.
2. Construction Contingency - it is addressed as the changes occurring during a construction process. In a conventional aquirement arrangement, the contract commonly contains a variation clause to allow the improvisation and provide an optimised structure to define and suggesting the variations in the project.

There are different characterisations for contingency time in the literature; many of them focused on cost contingency. Contingency time has different meanings to different people. Despite its importance, estimating contingency time was not assiduously addressed in the literature.

There are many factors that affect the contingency time. Iyer and Jha (2006) identified 55 factors that affect the schedule of the project in which 7 factors have the most impact on the project schedule. Ibrahim Mahamid, Amund Bruland and Nabil Dmaidi also discussed about the top 5 factors that are responsible in delaying the road construction. Some techniques include the use of buffer in their project so the total project time gets unaffected. There are basically two types of buffer that are used in the project.

1. Feeding buffer which is added to non-critical chain which then is feed in critical chain to prevent the non-critical activities from delaying in the critical chain.
2. Project buffer is added at the end in the critical chain to deal with the uncertainties in the project.

Time contingency is a duration estimated to account for identified risks and is allocated within the schedule baseline. It improvises the flexibility of a schedule where the activities are at risk. The most crucial task in a construction work is to estimate the time of the project. There might be cases where the factors or risks for schedule delay are unknown. The estimation of time contingency is based on the experience and knowledge of the surrounding. The project manager or the engineer had knowledge and experience of the surrounding then the project can be completed with minimal risk and in provided time.

1.3 List of Factors Affecting Time Contingency

Time contingency can be affected by certain factors in the construction project. These factors somewhat affects the delaying of the project the main factors in detail which have affected the time contingency of the project are as follows :

1.3.1 Based on Project Condition

Based on project condition the following factors are responsible for delaying of project.

1. Project Location.
2. Design complexity in project.
3. Shortage of equipment.
4. Shortage of materials.
5. Location of the project.
6. Preparing the plan during project initial Stage or during the tenure period.
7. Finite time allowed for preparation of the schedule.
8. Project Scope Items missing or conflicts within project documents.
9. Level of Quality requirements is high.
10. Inadequacy in Experience in similar projects.

11. Inadequacy in Consultant Experience.

12. Unexpected oppressive requirements by client’s supervisors.

1.3.2 Based on Management Condition

1.3.2.1 Contractual

- Scope Changes
- Risks in contracts .
- Change orders.
- Errors, contradictions, ambiguities in the contract documents.
- Lack of detailed drawings.
- Contract type.
- Ambience of Contract.
- Dearth of dispute settlement procedures.

1.3.2.2 Time

- Delay in payments.
- Governmental Authority Constraints related risks which limit the completion date of the project.
- Imposed Holidays [i.e. president’s visit in country]
- Inaccurate planning.
- Inaccurate control & follow up.
- Workload on the contractor resources.
- Delay in commencement date.
- Delayed changes in project.

- Long time in decision making.
- Resolving litigation delay.
- High Percentile of critical activities.

1.3.2.3 General

- Amount of interference.
- Quality, inadequate supply, information timing and drawing by designer.
- Unfavourable conflict in work sequence.
- Unexpected inadequacy of pre-construction site investigation data.
- Poor dispute resolution mechanism.

1.3.3 Based on Environmental Condition

- Bad Weather conditions.
- Labour strikes.
- Unidentified geological conditions.
- Labour restrain.

1.3.4 Based on Economical Condition

- Economic stability
- Material Market rates [Escalation, Inflation or fluctuation].
- Design changes in arrears to Market Demand.

1.3.5 Based on Country Condition

- Administration [Attitude towards foreign investment, Bureaucratic delays etc.].
- Regulations and laws [e.g. export and import regulations].

- Dearth & Poor Quality of Resources.
- Change in laws and regulations.
- Political frailty and instability.
- Power group influence e.g. environmental laws.

1.3.6 Based on Factors Related to Contractors

- Lack of experienced staff and labors.
- Contractor delay in project starting.
- Poor performance of contractor.
- Capability of planning by contractor.
- Rough relationship between top management and site staff.
- Rough relationship between Labor and management.
- Rough relationship between Client and Contractor representatives.
- Inadequate control over subcontractors.
- Poor coordination between labors.
- Bad productivity of equipment's.
- Fire and Theft.
- Unforeseen events like accidents.
- Incompetent tender pricing.
- More estimated material then estimated on site.
- Poor productivity of Labor.
- Disputes between labors on site.
- Bad performance of engineer.

- Lack of coordination between contractors and engineer.
- Financial difficulties of contractors.

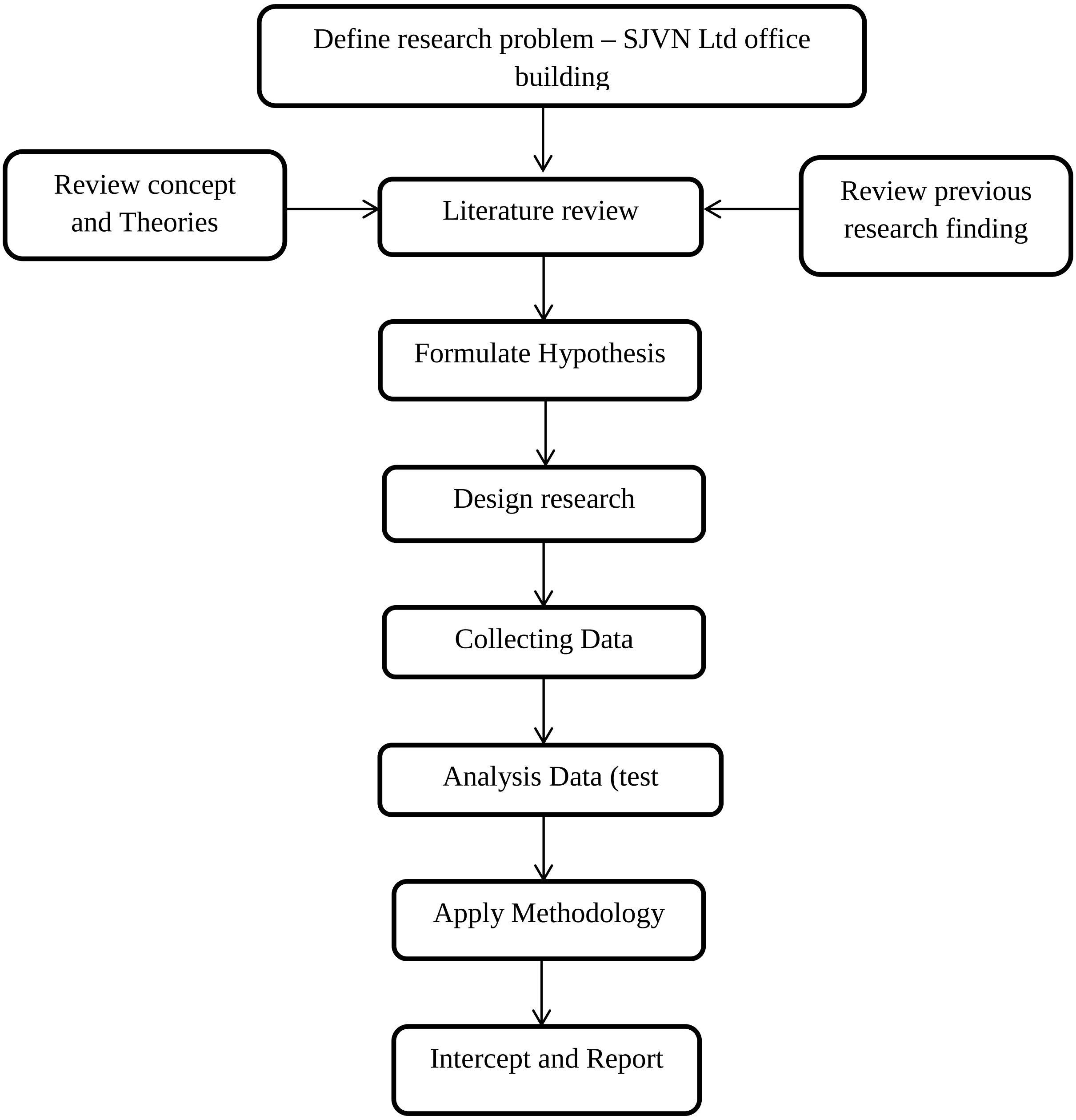
1.3.7 Based on Factors Related to Subcontractors

- Ambiguity related to technical qualifications of subcontractor
- Ambiguity related to financial stability of subcontractor
- Uncertainties related to quality of material and equipment of contractor
- Extra duration due to variability in Bid of subcontractors'

1.3.8 Based on Factor related to Planner

- Clerical errors.
- Planner's bias nature in technical issues.
- Inaccurate method of estimating.
- Planners' lack of practice.
- Planners' personality characterisation.

1.4 Work Methodology



Chapter 2
LITERATURE REVIEW

- In the paper “Probabilistic estimation and allocation of project time contingency” the author discussed about the implementation of the concept of time contingency allocation by using SAPA (stochastic allocation of project allowance method) to estimate the time contingency of a construction project. The use of Monte Carlo simulation using crystal ball software gives the probabilistic estimate for the completion of the project. It also provides us the information regarding the risk allowance in the project which was also considered in the simulation process. In conclusion portion the author recommended future study of this topic and its application in the construction sites, and to develop new software tool for planning and controlling capabilities using SAPA method (Gabrial A Barraza, 2011, ASCE)[1]

- In this paper by Hazem Yahia, Hossam Hosny and Mohammad E. Abdel Razik, the discussers use of neural network model for assessing the time contingency in Egypt which include three main factors to work upon.[2]

a) Data collection process
b) List of the main factors that affect the project
c) Discuss model development methodology.

The most important tool was planning and time schedule. The importance of planning was detailed in the paper are:

i. To offset uncertainty and change
ii. To focus attention on objectives
iii. To gain economical operation
iv. To facilitate control

The discusser tells about the 84 factors that can affect the project schedule and can delay the project construction which include all the conditions that may occur in the project such as:

a. Project condition
b. Management condition
c. Environmental condition
d. Economic, country, contractor related

The questionaries' is created and according to it the top factors that has the most chances for delaying the project is calculated by neural network method. Tope 10 important factors that affected in schedule delay are

i. Change order.
ii. Delay in payment
iii. Long time in decision making.
iv. High percentile of critical activities.
v. Delayed changes in project.
vi. Project scope items missing due to conflicts within project documents.
vii. Workload on the contractor resources.
viii. Incorrect control and follow ups.
ix. Unexpected difficult requirements by client's supervisor.
x. Contractors planning efficiency.
xi. Quality, inadequate supply, information timing and designers drawing.

The above are the factors given by the discusser that mostly delays the construction project by the two types of neural network where first handles classification problem and second handles prediction problem.

- The discusser here discusses about the main causes in delaying large building projects in Saudi Arabia and their corresponding importance. A survey was conducted through the random selection of samples of 24 contractor, 15 engineering/ architectural firms, and 9 owners from eastern region of Saudi Arabia.A total of 54 factors were used as a questionnaire to which the contractor engineer and architectural/ engineering firm were asked to rank and thus the top factors affecting the construction project in Saudi Arabia which included design error, labour shortage , unskilled labour as its most important factors of delay.(Sadi A. Assaf,1 Member, Mohammed AI-Khalil,2 and Muhammad AI-Hazm P, 1995, ASCE)[8]

- The discusser in his paper, “Owner Time and Cost Contingency Estimation for Building Construction Projects in Egypt” published in the year 2017, describes about the importance of cost and time contingency in succeeding the project and its completion within the provided schedule. The authors directed that the project manager is the main person, in command, in completing the project on time and the project manager usually allocate the project on the basis of his previous work experience. In the paper the owner’s time and cost contingency estimation for the building construction project in Egypt, the discusser present us with the fuzzy based logical model that helps the project manager in predicting the contingency cost and contingency time. In the paper the author defines the most important factors responsible for the construction schedule delay using fuzzy rule. By using the effects known, the responsible fuzzy model is developed and for its testing 10 sites data is used. The best model which gave the optimised valid and accurate result is selected for further use in determining the contingency cost and contingency time for the construction projects.[7]
- In this paper by Ousseni Bagaya and Jinbo Song in 2016[11], the questionnaire survey was carried out to find the cause of project delay in this area from 140 experts. After analysing their severity, frequency and importance index by using a quantitative statistical method, the most important delay factors were ranked as follows:

a) Financial capability of contractors

b) Financial difficulty of owners,

c) Equipment availability of contractors,

d) Slow payment for completed work,

e) Inadequate subcontractor performance by the contractor.

The test was also conducted which includes the literacy rate of the workers in this particular field.

Table 2.1 Importance index and ranking of factors of delay

Causes of delay	Client IMP.I. (Max = 2)	Client Rank (Max = 27)	Contractor IMP.I. (Max = 6)	Contractor Rank (Max = 27)	Consultant IMP.I. (Max = 4)	Consultant Rank (Max = 27)	Overall IMP.I. (Max = 4)	Overall Rank (Max = 27)	Group factors
Financial capability of contractor	1.249	1	5.187	4	3.149	2	3.195	1	Financial
Financial difficulties of owner	0.631	11	5.985	1	3.340	1	3.174	2	Financial
Equipment availability	1.174	3	5.363	3	2.966	3	3.167	3	Resource
Slow payments of completed work	0.992	6	5.600	2	2.867	4	3.153	4	Financial
Poor subcontractor performance	1.080	4	4.046	6	2.107	5	2.411	5	Contractor
Inadequate planning and scheduling	1.204	2	4.222	5	1.764	7	2.396	6	Contractor
Weather condition (heavy rains and floods)	0.936	7	3.321	7	1.371	10	1.876	7	External
Low bidding of contractor	0.466	22	2.601	10	1.874	6	1.647	8	Contractor
Unfavorable site conditions	0.625	13	2.689	9	1.521	8	1.611	9	External
Poor site management and supervision	1.027	5	2.355	14	1.381	9	1.587	10	Contractor
Slow decision making	0.198	27	2.958	8	1.005	18	1.531	11	Client
Quality assurance and waiting time for approval of test	0.501	20	2.594	11	1.082	16	1.392	12	Consultant
Delays in obtaining permit from Government agencies	0.607	14	2.393	13	1.035	17	1.345	13	Contract relationship
Slow preparation and approval of drawings	0.628	12	2.164	16	1.124	13	1.305	14	Consultant
Poor contract management	0.551	17	2.051	18	1.263	12	1.288	15	Consultant
Slow inspection of completed work	0.502	21	2.199	15	1.095	14	1.265	16	Consultant
Inadequate contractor experience	0.913	8	1.56	25	1.318	11	1.263	17	Contractor
Fluctuation of prices	0.508	19	2.407	12	0.744	25	1.219	18	Financial
Lack of communication between the parties	0.534	18	2.091	17	0.820	23	1.148	19	Contract relationship
Rework due to construction mistakes	0.672		1.558	26	1.086	15	1.105	20	Contractor
Shortage in material	0.558	16	1.797	21	0.957	19	1.104	21	Resource
Change orders	0.454	24	1.973	19	0.848	22	1.091	22	Contract
Quality of material	0.581	15	1.652	23	0.946	20	1.059	23	Resource
Mistakes or discrepancies in contract document	0.466	23	1.972	20	0.713	26	1.05	24	Contract
Owner interference	0.433		1.749	22	0.945	21	1.042	25	Client
Labor supply	0.773	9	1.336	27	0.745	24	0.951	26	Resource
Legal disputes	0.340	26	1.623	24	0.491	27	0.818	27	Contract relationship

According to the research paper studied there are very less methodologies used to prevent the project from delaying. These methodologies are yet to be used in the actual construction sites. Theoretically methods and models are generated to prevent the project delay but still the projects gets delayed which in turns affect the cost of the project and quality of the project.[12]

Buffer techniques are used to prevent project delay in which buffers are provided within or at the end of the activities to complete the project in time. It is practically used in the construction site to prevent any delay in the project. The SAPA method is still a theoretical method for providing the contingency time in the project which is still not performed in actual sites. Critical chain management is another method to schedule the contingency time, to prevent the constraints in effecting the project by marking the critical activities which can affect the duration of the project and scheduling the other activities as per the critical activities.[5]

Some of the research papers include the questionnaire form to check the factors effecting time delay of the project in some areas of the world thus preventing any other delay in the other projects in that area.

The most important factor of delay, which has occurred in many papers, is change order in the project. The other factors are related to contractor's financial problem and payment delays. Some has shortage of staff and labour and unskilled labour as their main factors for the construction delay.[3]

The CPM (critical path management method) is the most common method used in the construction sites. CPM method is commonly used for repetitive type of projects or for those projects for which fairly accurate estimate of time for completion of each activity can be made [15]. In CPM time estimate for the completion of activities are with fair degree of accuracy but mainly focuses on cost estimation of the project thus not suitable for the research and development for the scheduling of the project. CPM uses critical path which is the longest path in the project network.[5]

PERT (programme evaluation and review technique) is mostly used in scheduling purpose as in this method critical path joins the critical event which helps in managing time of a project.[13]

The objectives for the project on the basis of literature review are

1. To find the factors affecting time contingency in SJVN project.
2. To rank the factors according to their importance in schedule delay.
3. Using a methodological model for its Allocation in a construction project.

CHAPTER-3

PROJECT STATEMENT AND DATA COLLECTION

3.1 About The Project

The project that has been taken is the SJVN Ltd office building constructed at sanaan, Malyana, Shimla. The project is currently at the end of its maintenance period and is counted as a 3 STAR GREEN BUILDING. The material used in this building is mostly natural and all the points to be taken into consideration by the GRIHA norms were followed.

The construction of this building was started in Aug 2012 and according to the tender that has been given to NBCC and who further gave this contract to ERA infra construction limited. The whole project cost is about ₹300 crore. The building has 6 floors where the top floor is for the director of the entire department. It is full RCC based structure and fibre bricks are used.

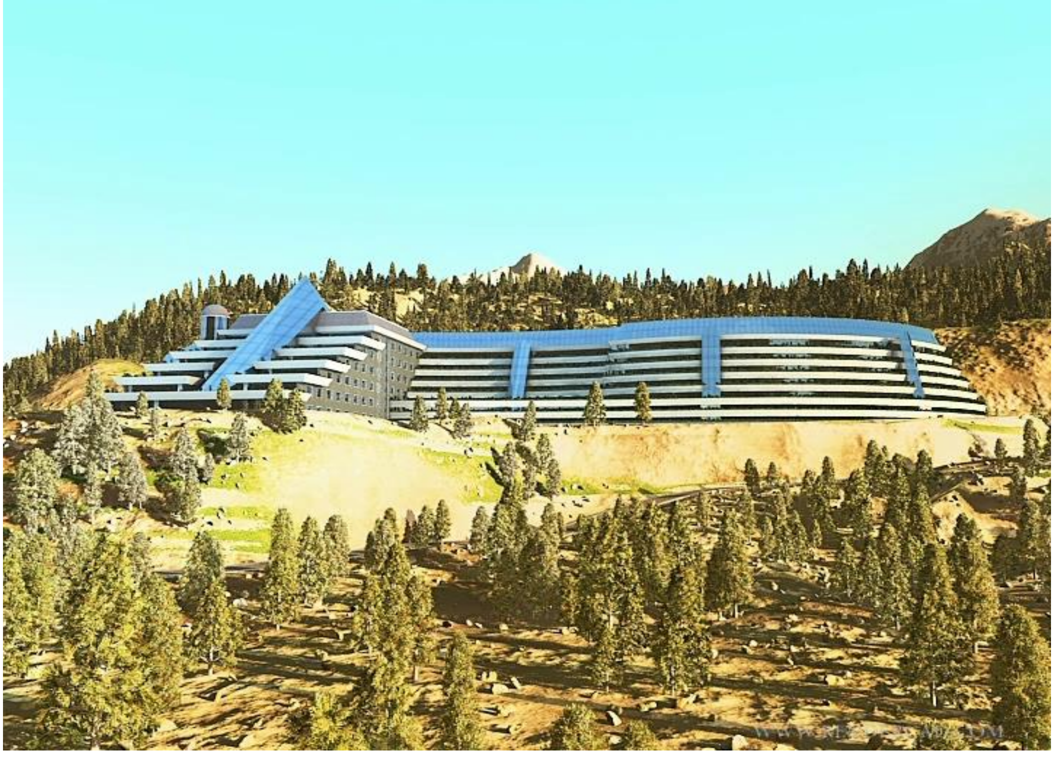


Fig 3.1 the designed animated view of the building

The building has the flow of natural light and solar glasses were used in the space frame which has skylight glass and structural steel as its member.

Fig 3.2 Front view of the building

The the building is constructed in 3200sqm area (i.e 40m X 80m) in the north-south direction of Shimla. The project was to be completed in 20 monthes as specified in the contract i.e by April 2014 the project should have been completed but due to some factors it took one and half more years for its completion. The project was finally completed in July 2016 and the maintenance period is also in its completion time.

Fig 3.3 Escalators and waterfall in the building

There are certain eye catching things about this building that make it different and more attractive from the other large building in Himachal Pradesh.

- Escalators and waterfall in the building
- Elevators with high hydraulic suspension
- Best Fire fighting system
- Attractive design of the building
- Sewage treatment plant within the structure
- Water treatment plant
- Solar water heaters
- Solar electric panels provide electricity in the building
- Kitchen bio system that helps usage of all the organic waste.

3.2 Data Collection

The data has been provided by the SJVN Ltd is the primavera data of project schedule of their building constructed at Shimla. The project schedule is the enlistment of the entire milestone; activities usually intended with start and finish date of the project. Project schedule is used in planning if the project, managing the project, estimation the project schedule and allocation of resources. It acts like a work breakdown structure that makes the work easier and inform if any changes necessary.

To develop a project schedule, the following needs to be completed:

- Scope of the project
- Activity sequence in the project
- Tasks grouped into 5 project phases (conception, definition and planning, launch, performance, close)
- Task dependencies mapping.
- Analysis of critical path.
- Milestones in the construction project.

The company has also answered few questionaries' about the factors that are responsible for the delay in their project.

CHAPTER-4

PROJECT METHODOLOGY:

In this project, the methodology used is MONTE CARLO SIMULATION using SAPA method

4.1 Monte Carlo Simulation

This concept was invented by the polish American mathematician S Ulam , probably known for his work on thermal nuclear weapon than mathematics. He developed this model for the game he was playing so as to calculate the probability of winning. This simulation method was then used in the design of the hydrogen bomb.

Monte Carlo simulation method estimates the value of unknown quantities using inferential statistic principle, E.g. population. This simulation normally is used when simulation through other approaches become difficult. In this context, Monte Carlo simulation can be considered as a methodical way of doing so-called what-if analysis. This model is used in social sciences, sciences and engineering discipline by using mathematical expressions to define the synergy in a system. These models commonly dependent on a number of input constants, which are then, processed using the mathematical formulas, resulting in many outputs. This process is simplified in the diagram below

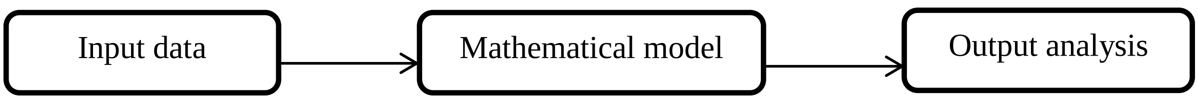


Fig 4.1 Mathematical model

The input constants for the model depend on various external factors. These factors are the reason behind the realistic models being subject to risk from the systematic variation of the input constants. As the values for the parameters are the most likely values, a base case is used also known as the deterministic model. In order for the associated risks in the project an effective model should be taken into consideration. In many cases, there are various models developed by the experimenters who can include the base case, the best possible scenario, and the worst possible scenario for the values of the input variables.

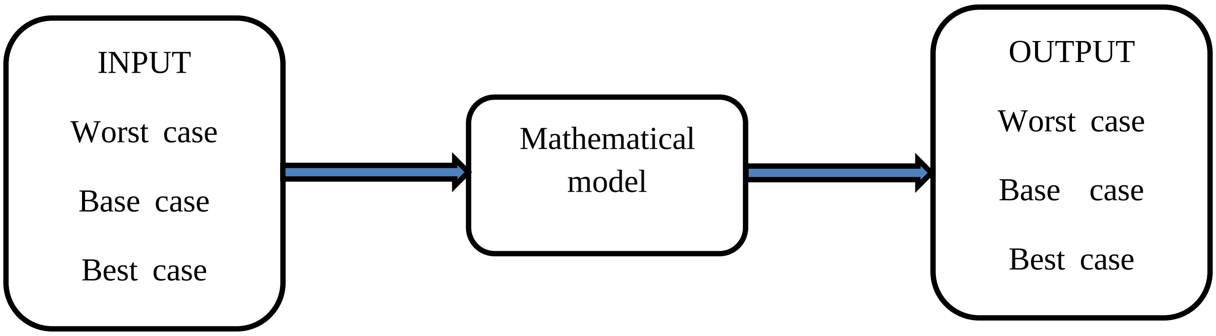


Fig. 4.2 Case based modelling.

There are many disadvantages for this approach. The adequacy of this approach is difficult to evaluate the worst and best case scenarios for every input variable. All the input variables might not be at their worst or best levels at the same time. It is difficult to make decision when more than one scenario is to be considered. Also, with the increase in the number of cases, storing and model version becomes difficult. An experimenter might be tempted to run various ad-hoc values of the input constants, often called what-if analysis, but it is not practical to go through all possible values of each input parameter. Monte-Carlo simulation can help an experimenter to investigate methodically the complete range of risks accomplice with every risky input variable.

In Monte-Carlo simulation, we identify statistic distribution by using it as a source for each of the input constants. Then, random samples are drawn from each distribution, which represents the values of the input variables. We receive a set of output parameter from every set of input parameter. In the simulation run, there is a particular outcome scenario for every output parameter. Then, from the number of simulation runs output values are collected. Finally, on the value of output constants certain statistical analysis is performed, to make decisions about the course of action. To define the output variation statistical sampling of the output constants are performed.

4.2 Probabilistic Estimation of Project Time Contingency

The project estimation of project time contingency defines the project contingency time which here is also referred as the total time allowance (TTA). The difference between project planned duration and project target duration is defined as total time allowance. The principle difference between PPD and PTD is the way they contemplate the duration variability of the activities in the project. Duration variability is illustrated by using random variables having a definite probability distribution is used rather than using specific duration value for the activities in the project.

A reasonable outcome of project duration is calculated in each trial using the simulation process considering several different activity duration as per recommended probabilistic method, a simulation is run. If there are many activities in the critical path, a normal distribution is possible undeterred by the shape of activity distribution graph for the duration. The risk level of the activity being exceeded can be determined by the different outcomes of the project duration. The project will have nil chances of exceeding if the project duration is large. For the mediocre project duration, there are 50%
chances for the project to exceed. The most chances for the project delay is the project which have small duration, as there are chances of many constrains present in the project and the chances of removing those constrains is very less. Thus, leads to increase in the project duration implying delay in the construction project. If the duration of the project is 70th duration percentile, then the chances of the project being exceeded is 30%. The acceptable risk is used for determining the PPD. To calculate the PTD value, scheduling of the project is done which provides us with the target duration. A certain percentile value can also be used as PPD according to the duration percentile, which in this case is considered as 50% or the median duration.

By scheduling the project activities at target duration, PTD can be determined. For the estimation of target duration of activities, most likely duration is considered as the deterministic approach as per the CPM calculations. As per the PERT calculations, the median duration is considered as probabilistic approach. If the approach shows positive skewness, which is common in construction projects, a shorter project duration is produced in case of most likely duration in the activity then that of the expected duration of activities.

4.3 Method of Stochastic Allocation of Project Allowance

The project time contingency is estimated by using the Stochastic Allocation and Project Allowance (SAPA) method. The activity level allocation can also be calculated by this method. The project schedule simulation provides the results for the calculation of both PPD and PTD. The calculation for PTD is calculated by using project scheduling while for PPD acceptable risk is determined, which in this case is the median duration or 50^{th} duration percentile having an acceptable risk of 50%. 50^{th} duration percentile is considered as there will be 50% chances for the project to either delay or finish on time. Median duration is also used as it is uncommon as its estimate is more difficult than expected value and most likely duration. However, values for median duration can easily be calculated using simulation results as random durations generated are analysed for each activity.

As the target duration (T_d) was calculated from the project schedule calculation thus the PTD is equal to the sum of the target duration for the critical path activities.

$$PTD=\sum T_d \qquad \text{…………….} (1)$$

PPD is the median duration or the duration acceptable risk percentile (D_p) that can be determined using distribution graph in the simulation software.

$$PPD=\sum D_p \qquad \text{……………..} (2)$$

As the PPD and PTD are calculated, TTA or the total time allowance is calculated as the difference between PPD and PTD.

$$TTA = PPD - PTD \qquad \text{……………} (3)$$

After determining the project time allowance, allocation of this allowance to the activities in the project is the main issue that arises. The activity time allowance (ATA) is determined to calculate the total time allowance (TTA). Thus, ATA can be calculated as the difference of Td and Dp.

$$ATA = Td - Dp \qquad \ldots\ldots\ldots\ldots (4)$$

As the value of D_p describes the most likely duration, as in this case, and the median duration is taken as the target duration i.e. T_d, the activity time allowance ATA is then calculated by the difference of these two.

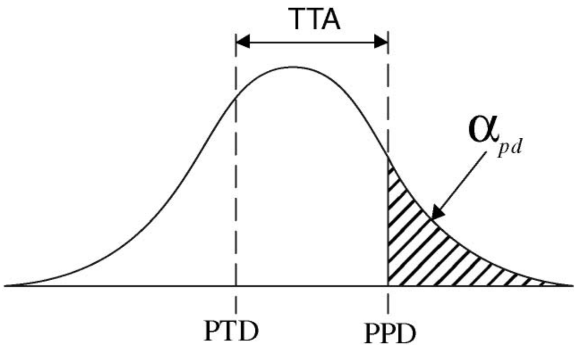


Fig 4.3 Project time contingency or total time allowance

For obtaining the activity time allowance values of D_p and T_d is to be known. The most likely duration is set as activities maximum duration percentile and median duration or 50th percentile duration is set as the target duration. The difference between these two estimates is the activity time allowance as in equation (4)

On substituting equation (1) and (3) in equation (2) and simplifying it with equation (4) the total time allowance for the project can be estimated. The total time allowance TTA is the sum of all the activity time allowance of all the activities as shown in equation (5).

$$TTA = \sum ATA \qquad \ldots\ldots\ldots\ldots\ldots (5)$$

On Calculation the total time allowance from activity time allowance using most likely duration and the median duration as represented in equation (5). An individual time allowance for each activity can also be calculated which provides us with the buffer time for each activity that should be considered for the project completion on time.

4.4 Analytical Tool

Analytical tools are the software's used in the project. Probabilistic analysis is done using Monte Carlo simulation using @RISK software. The decision tool used is basically used for Monte Carlo simulation. The project schedule is taken from Microsoft project file. @ Risk imports all the data into excel. The excel version of the Gant chart is same as that of the Microsoft project file.

Visual examination of a task is done using PERT distribution. Other distributions can also be used like histograms, logistics, expon, compound, beta, beta general etc. all these distributions and other distributions can be used using @RISK software. The tool provides us with different distribution that can be used in the project. @RISK here designs output, define input distribution, sets the number of iteration required by the user for the simulation to run.

Analysis of results is done using this tool as per the iteration provided and the number for the simulation to process is entered giving us a specific result for the specific iteration and simulation. The maximum number of iteration that can be entered is infinite, so as the number of simulation. This software is best used for Monte Carlo Simulation which deals with the random number generation.

CHAPTER-5
DATA COLLECTION

5.1 Factors Causing Project Schedule Delay

A total of 76 factors were given to the contractor, owner and engineering firm which included most of the factors that may have the chances to affect the project.

Table 5.1 Answers for Questionnaire Data

Rank the following factors according to their importance in delaying of the project, the factor that affected mostly in delaying of the project is to be ranked one and so on				
S.NO.	**FACTORS**	**PERCENTAGE EFFECT**		
		SJVN	NBCC	ERA INFRA.
1	Project location	0	0	0
2	Limited time allowed for the preparation of schedule	0	0	0
3	High level of quality requirement	5	10	15
4	Change orders	0	20	15
5	Inadequacy of detailed drawing	0	0	0
6	Inadequacy of dispute settlement procedures	0	0	0
7	Context of contracts	0	0	0
8	Payments (delays)	0	20	0
9	Imposed holidays(govt related holidays)	0	0	0
10	Inaccurate planning by any party	0	0	0
11	Client suspend works	0	0	0
12	Late changes in projects	10	10	10
13	Delay in decision making	0	0	5

14	High percentage of critical activities in base line	0	30	30
15	Interference by management	0	0	0
16	Unfavourable interference in work sequence	0	0	0
17	Poor dispute resolution mechanism	0	0	0
18	Bad weather condition	20	20	20
19	Labor strike	0	0	0
20	Design changes due to market demands	0	0	0
21	Delay due to political instability	0	0	0
22	Contractor poor performance	50	50	30
23	Shortage of experienced staff and labors	10	10	5
24	Efficiency of planning by contractors	20	20	15
25	Poor productivity of equipment	0	0	0
26	Bad relationship between top management and site staff	0	0	0
27	Bad relationship between site management and labors	0	0	0
28	Bad relationship between contractor representative and client representative	0	0	0
29	Theft	2	2	2
30	Unforeseen events(accidents)	0	0	0
31	Disputes	0	0	0
32	Contractors financial difficulties	40	40	50
33	Lack of coordination between engineer and contractor	0	0	0
34	Planners lack of experience	0	0	0
35	Wrong method of estimating by planners	0	0	0
36	Financial stability of contractors and subcontractors	20	20	20
37	Missing project scope items due to conflict between project documents	0	0	0

38	Workload on contractor	0	0	0
39	Inaccurate control and follow up	10	10	5
40	Shortage of resources	15	15	5
41	Delay in design work	0	0	0
42	Shortage of equipment	10	10	5
43	Late delivery of items	10	10	5
44	Fluctuation in cost	0	0	0
45	Uncontrollable external factors	10	10	10
46	Poor workmanship	7	5	5
47	Obtaining permit from municipality	0	0	0
48	Waiting for sample material approval	0	0	0
49	Rain effect on construction activities	20	25	30
50	Social and cultural factors	0	0	0
51	Shortage of material	30	30	25
52	rework due to construction mistake	2	2	0
54	rework due to design change	5	5	5
55	lobor supply	40	40	25
56	owners interference	0	10	15
57	slow decision making	0	0	15
58	poor subcontractor performance	30	30	20
59	delay in obtaining permits from government agencies	10	10	15
60	slow preparation and approval of drawing	5	15	20
61	legal disputes	0	0	0
62	quality assurance and waiting time for approval of tests	0	0	5
63	slow payments of completed work	0	10	15
64	damage of material in storage	0	0	5
65	material changes in types and specification during construction	5	5	5
66	mistakes in soil investigation	0	0	0

67	water table condition on sites	0	5	5
68	excessive bureaucracy in project owner operation	0	0	0
69	error committed during field const. on sites	2	5	5
70	accidents during construction	0	0	2
71	insufficient available utilities on site	15	10	5
72	in cooperative owner	0	0	0
73	unrealistic contract duration imposed by client	0	0	0
74	inaccurate BOQ	0	0	5
75	defective material provided by client	0	0	0
76	more that estimated waste of material in site	10	10	5

The above factors were sent as a questionnaire form to which they responded that amongst 76 factors 39 factors were responsible for their delaying in the project. And also they responded to what percentage these factors were responsible in their delaying. The factors that affected the project schedule, and to what percentage they affected in the schedule, has been answered as shown above.

5.2 Project Schedule

The other data collected is the project schedule in primavera which defines the scheduling of the activities before the start of the project. The activities in the project are as follows with their start and end date as provided.

Table 5.2 Project Schedule Data

S.NO.	Task Name	Duration	Start	Finish
	project	**812**	**Thu 9-8-12**	**Tue 31-12-13**
1	Development of Temp. infrastructure	114	Thu 9-8-12	Fri 30-11-12
2	Survey and layout	113	Thu 16-8-12	Thu 6-12-12
3	Bore well work	30	Thu 1-11-12	Fri 30-11-12
4	Excavation	177	Fri 14-9-12	Sat 9-3-13
5	Stone work	381	Thu 15-11-12	Sat 30-11-13
6	PCC	128	Tue 13-11-12	Wed 20-3-13
7	Reinforcement(level 0-6)	323	Mon 12-11-12	Mon 30-9-13
8	Shuttering (0-6)	314	Sat 17-11-12	Thu 26-9-13
9	RCC work (0-6)	318	Wed 21-11-12	Fri 4-10-13
10	Brick work (level 1-6)	221	Mon 1-4-13	Thu 7-11-13
11	Plaster(level 1-6)	188	Sat 25-5-13	Thu 28-11-13
12	Marble work(level 1-6)	184	Mon 1-7-13	Tue 31-12-13
13	Plumbing work	260	Sat 1-6-13	Sat 15-2-14
14	Sewage and drainage	153	Sat 1-9-12	Thu 31-1-13
15	Aluminium work	183	Thu 9-8-12	Thu 7-2-13
16	Wood work	183	Thu 1-8-13	Thu 30-1-14
17	False ceiling work	56	Wed 1-1-14	Tue 25-2-14
18	Roofing work(space frame)	145	Fri 1-11-13	Tue 25-3-14
19	Other finishing work	187	Sat 5-10-13	Wed 9-4-14
20	Road work	333	Sun 1-12-13	Wed 29-10-14
21	Paint work	167	Thu 18-7-13	Tue 31-12-13

CHAPTER 6

ANALYSIS OF RESULTS:

6.1 Factors Responsible For Schedule Delay in SJVN Ltd Project

The response that came from the contractor, owner and the construction firm are then compiled all together. The response came in percentage form for each factor which is responsible for construction delay. The results showed that the 10 most important factors or causes of schedule delay in SJVN Ltd were:

1. Contractors poor performance
2. Contractors financial difficulties
3. Labor supply
4. Shortage of material
5. Poor subcontractor performance
6. Bad weather condition
7. High percentage of critical activities in base line
8. Financial stability of contractors and subcontractors
9. Efficiency of planning by subcontractors
10. Slow preparation and approval of drawing

From the clients and contractors point of view the most important factors in the construction project are

1. Contractors poor performance
2. Contractors financial difficulties
3. Labour supply
4. Shortage of material
5. Bad weather condition

And according to the contracting firm the most important factors that are responsible for the construction delay are

1. Contractors financial difficulties
2. Contractors poor performance

3. Bad weather condition
4. High percentage of critical activities
5. Poor subcontractors performance

The compilation result with the ranking is thereby in the APPENDIX-1.

6.2 Simulation Results

For simulation to run, first, probabilistic scheduling is done in MS Project. The task name with the start date and finish date, provided by SJVN Ltd, are entered in the MS Project to develop the model logic in MS Project. This provides us with the duration for each activity and help in developing the model logic. After completing the model logic in the MS Project, summary task is entered in the model logic. This summary task is named as PROJECT, which includes all the project activity. The project is then calculated which determines the total duration of the project which in this case is 812 days. The Gant chart in MS Project outlines the critical tasks in the project by determining the critical path. The MS Project file is shown in the APPENDIX-2.

Second, in the @ RISK software, for simulation purpose the project file is then directly imported from MS Project. The file in @RISK will the directly link with the file in MS Project. For simulation to be done in the software, output is provided to the total duration of the project as calculated in the MS Project and to the final finish date in the project summary task. The minimum duration, maximum duration and the most likely duration are also calculated using @RISK software in order to define the optimistic duration, pessimistic duration and most likely duration for each activity as shown in fig 6.1, the maximum activity duration defines the maximum time an activity could take for its completion.

Table 6.1 Minimum, Most likely and Max duration for each activity

S.No.	Task Name	Duration Min	Duration M. likely	Duration Max
	project			
1	Development of Temp. infrastructure	102.6	114	148.2
2	Survey and layout	101.7	113	146.9
3	Bore well work	27	30	39
4	Excavation	159.3	177	230.1
5	Stone work	342.9	381	495.3
6	PCC	115.2	128	166.4
7	Reinforcement(level 0-6)	290.7	323	419.9
8	Shuttering (0-6)	282.6	314	408.2
9	RCC work (0-6)	286.2	318	413.4
10	Brick work (level 1-6)	198.9	221	287.3
11	Plaster(level 1-6)	169.2	188	244.4
12	Marble work(level 1-6)	165.6	184	239.2
13	Plumbing work	234	260	338
14	Sewage and drainage	137.7	153	198.9
15	Aluminium work	164.7	183	237.9
16	Wood work	164.7	183	237.9
17	False ceiling work	50.4	56	72.8
18	Roofing work(space frame)	130.5	145	188.5
19	Other finishing work	168.3	187	243.1
20	Road work	299.7	333	432.9
21	Paint work	150.3	167	217.1

In order to define the uncertainty in the project regarding the duration and to calculate the quantitative risk analysis in the project distribution for each activity is defined. The software has different defined distributions to select for each activity. Triangular and PERT distribution is used in this case to define the distribution of activities.

The distribution graph in the project defines the percentile risk in the activity, as shown in fig 6.2, which in this case outlines that 90% of the project can be completed within 862 days and there are 5 % chances for the project to complete within 761 days. There is no skewness shown in the project duration and has a standard deviation of 30.69

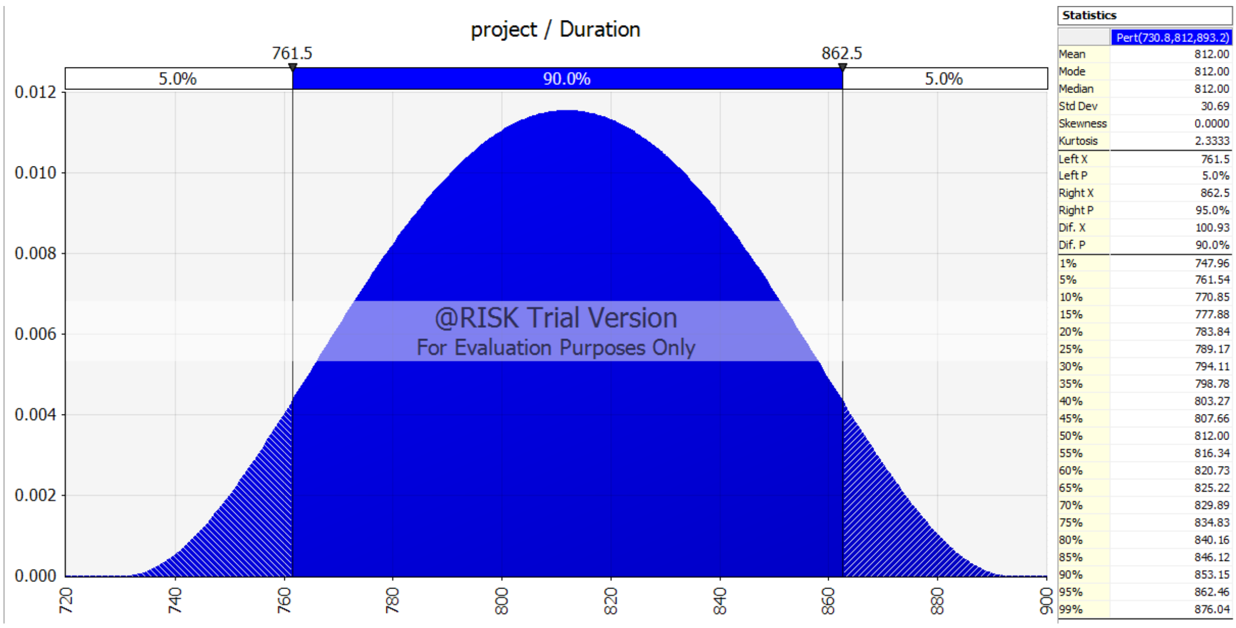


Fig 6.1   Distribution graph for the whole project duration

The triangular distribution is defined for the activities in the project which determines their skewness and standard deviation with mean, mode and median values calculated at the same time.

Following are the triangular distribution graph for each activity in the project schedule which defines the 90% chances for the completion of the project in a particular duration.

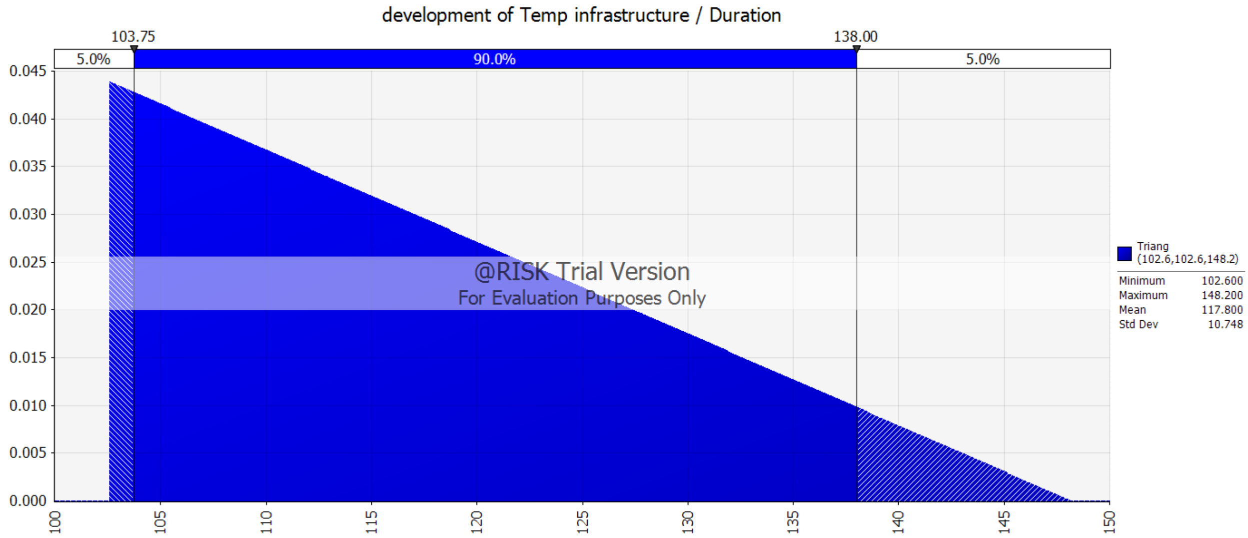


Fig 6.2 distribution graph for development of temporary infrastructure

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 138 days duration and 5% chance of its completion in 103 days. The skewness defined is positive.

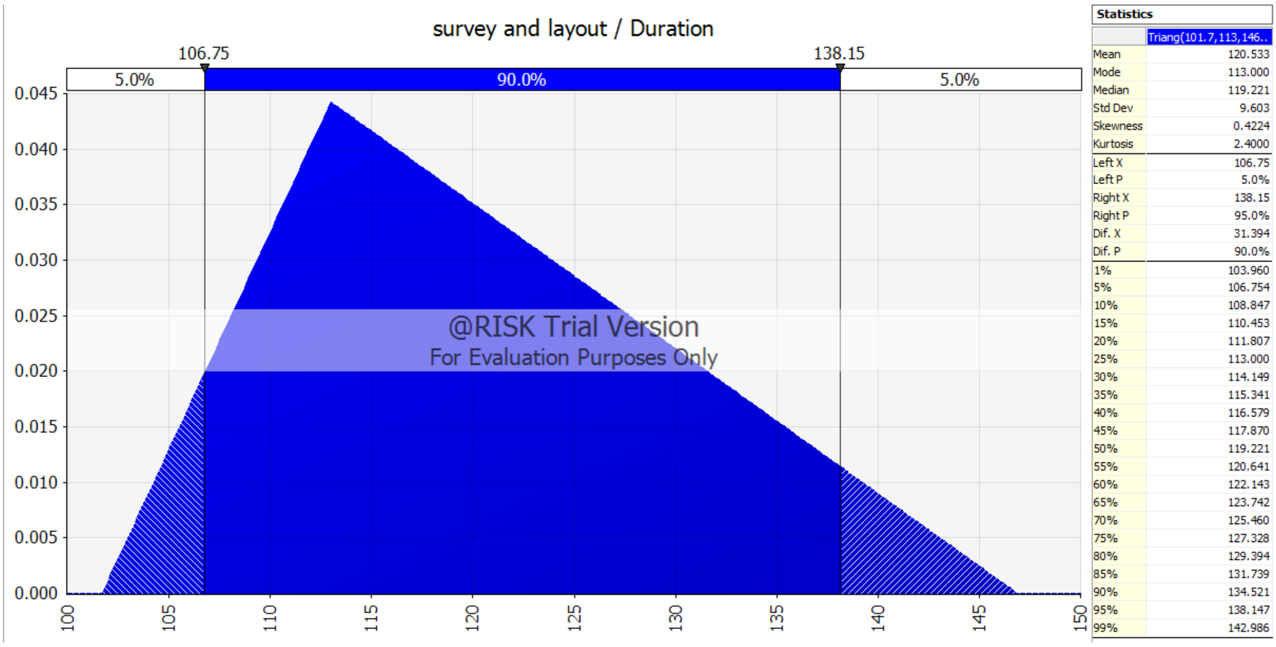


Fig 6.3 distribution graph for survey and layout

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 138 days duration and 5% chance of its completion in 106 days. The skewness shown is positive skewness of 0.4225.

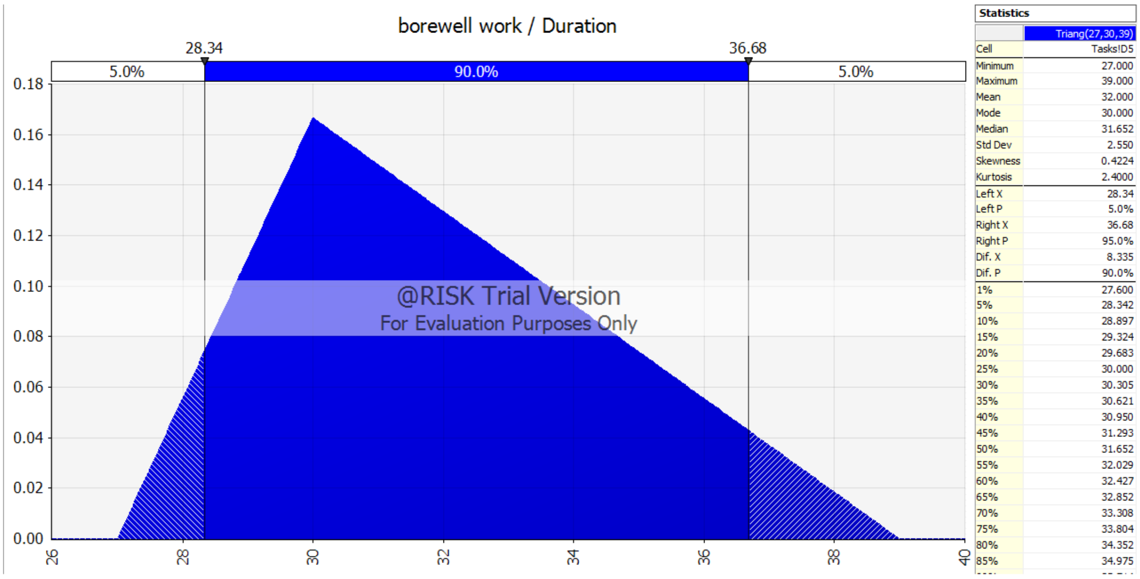


Fig 6.4 distribution graph defined for bore well work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 37 days duration and 5% chance of its completion in 29 days. The skewness shown is positive skewness of 0.4225.

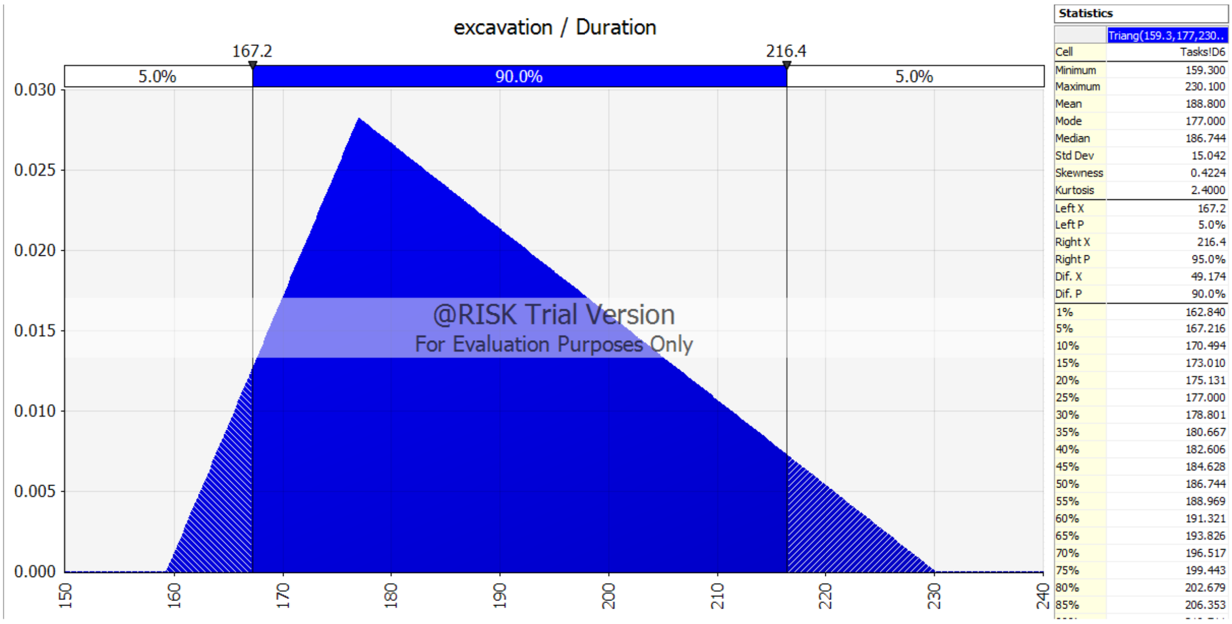


Fig 6.5 distribution graph defined for excavation

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately216 days duration and 5% chance of its completion in 167 days.

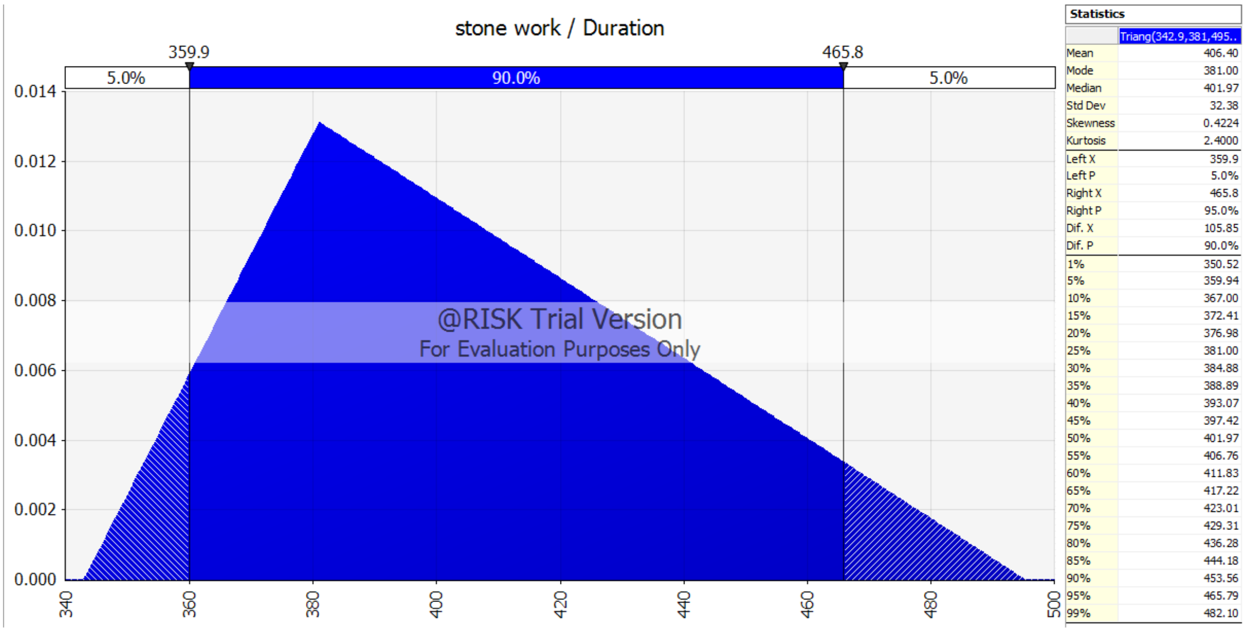


Fig 6.6 Distribution Graph For Stone Work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 466 days duration and 5% chance of its completion in approximately 360 days.

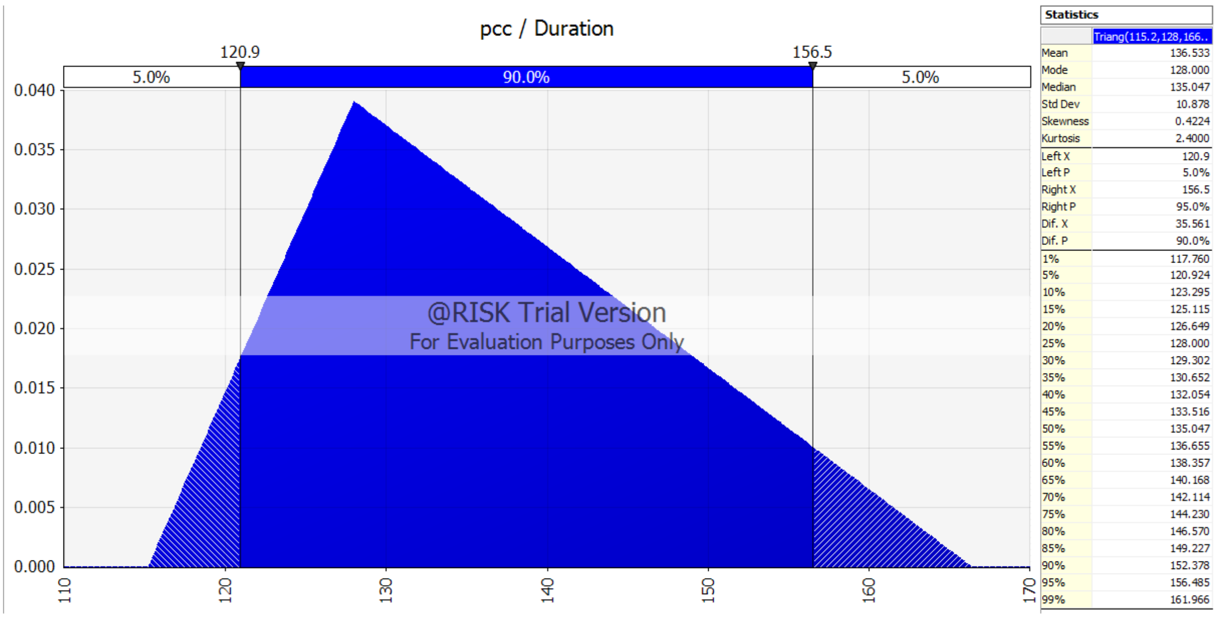


Fig 6.7 distribution graph defined for PCC work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 157 days duration and 5% chance of its completion in 121 days.

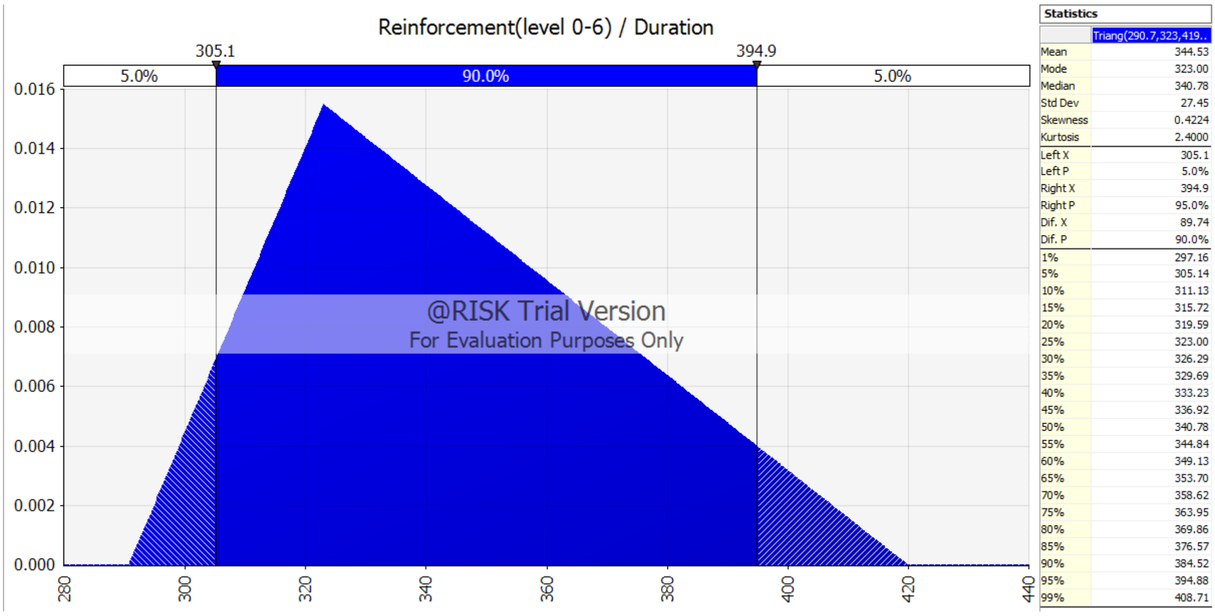


Fig 6.8 distribution graph defined for reinforcement from level 0-6

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 395 days duration and 5% chance of its completion in 305 days.

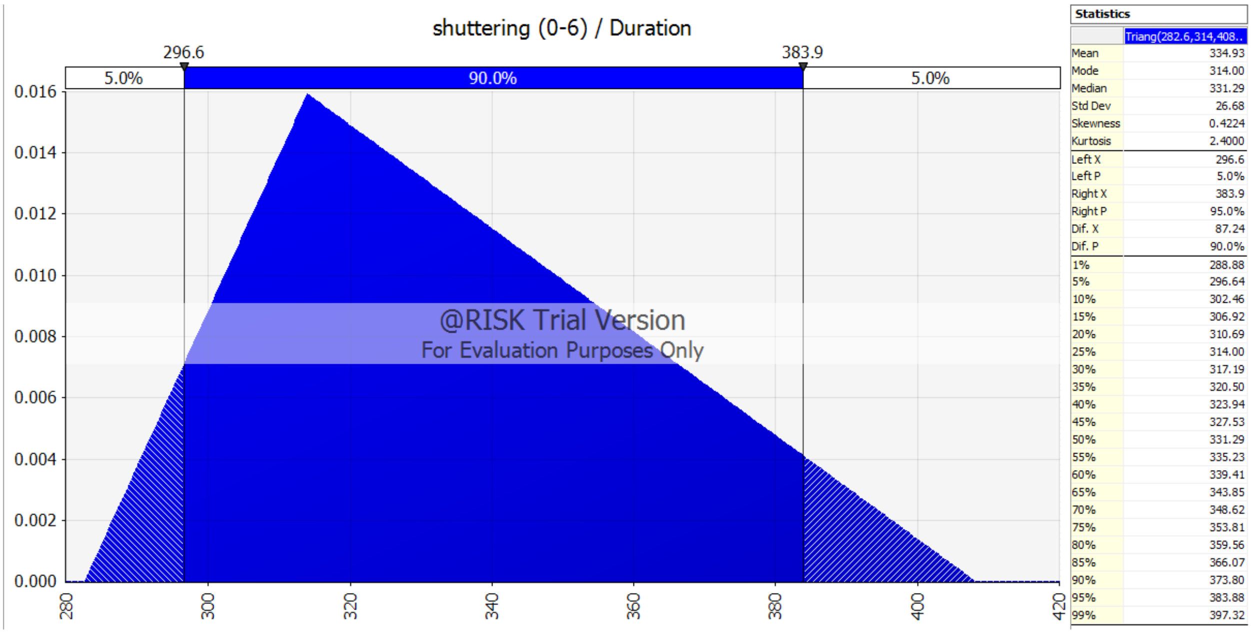


Fig 6.9 distribution graph defined for shuttering from level 0-6

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 383 days duration and 5% chance of its completion in approximately 297 days.

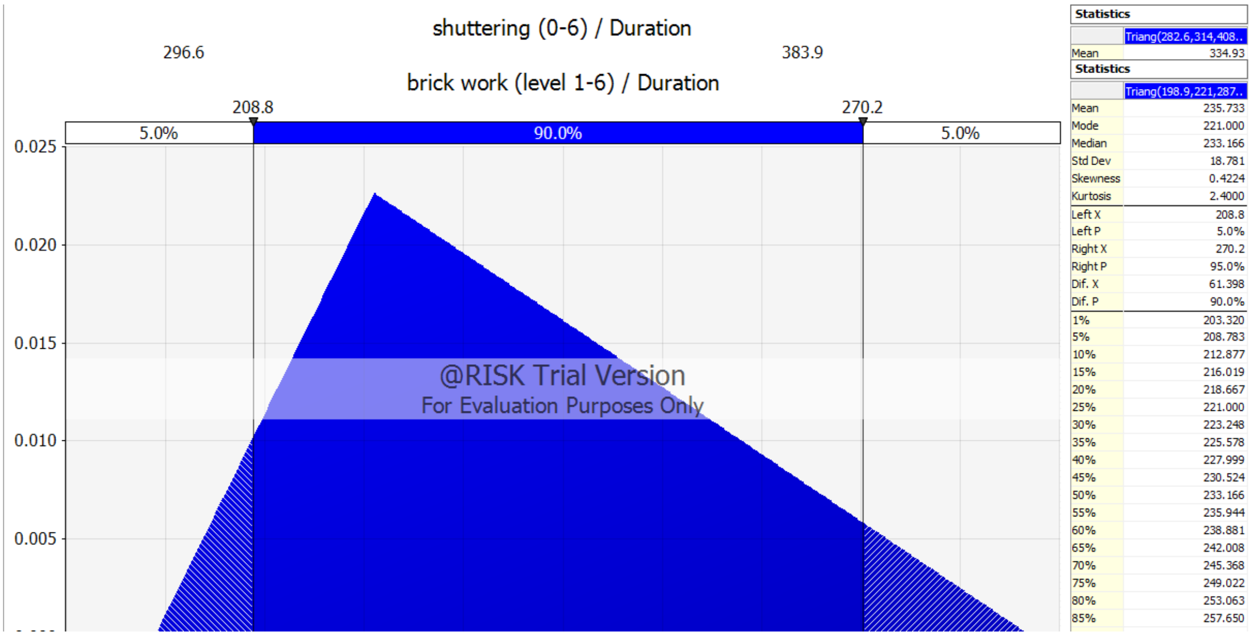


Fig 6.10 distribution graph defined for Brick work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 270 days duration and 5% chance of its completion in 209 days.

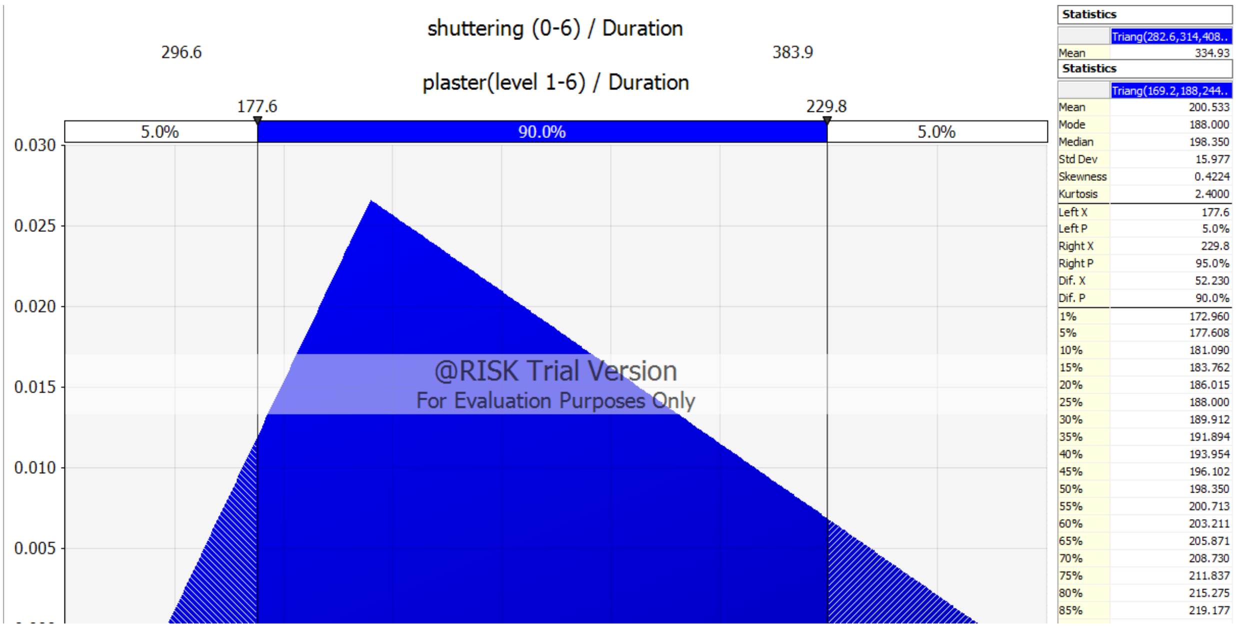


Fig 6.11 distribution graph defined for plastering from level 0-6

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 230 days duration and 5% chance of its completion in 178 days.

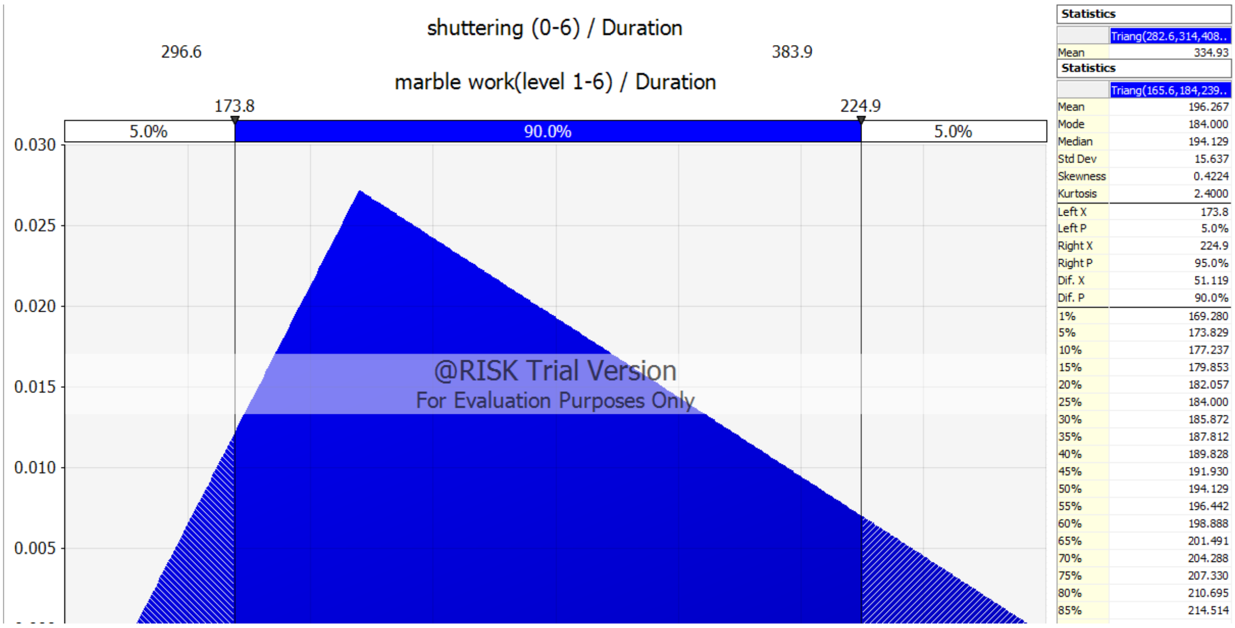


Fig 6.12 distribution graph defined from marble work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 225 days duration and 5% chance of its completion in approximately 174 days.

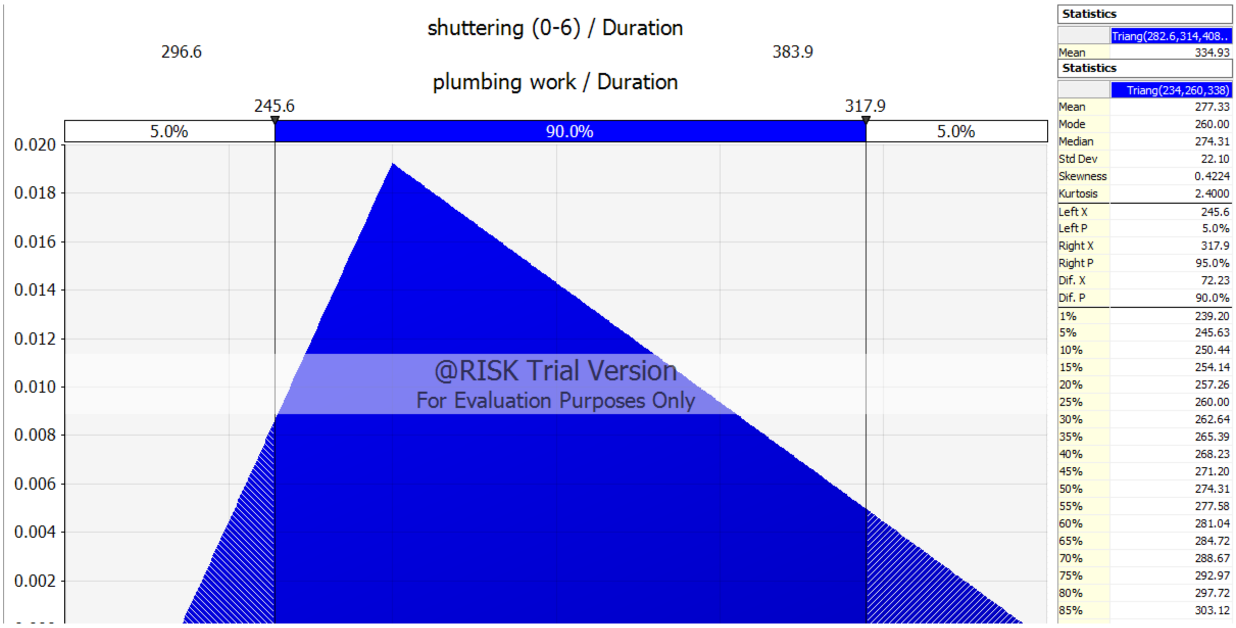


Fig 6.13 distribution graph defined for plumbing work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 318 days duration and 5% chance of its completion in 245 days.

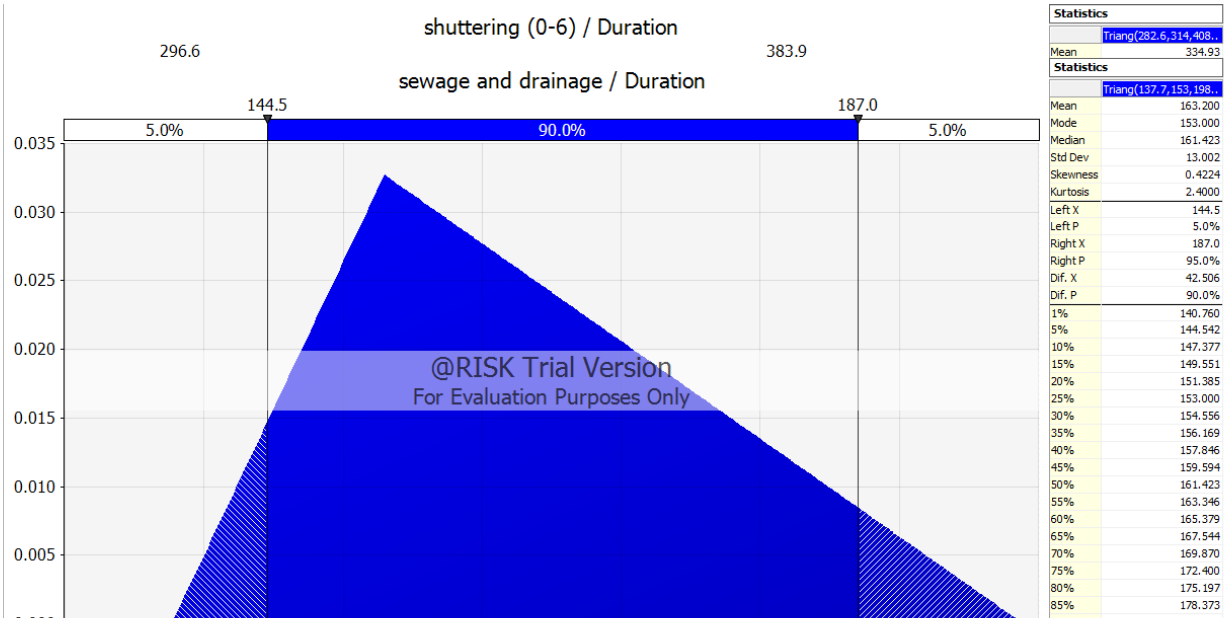


Fig 6.14 distribution graph defined for sewage and drainage

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 187 days duration and 5% chance of its completion in 144 days.

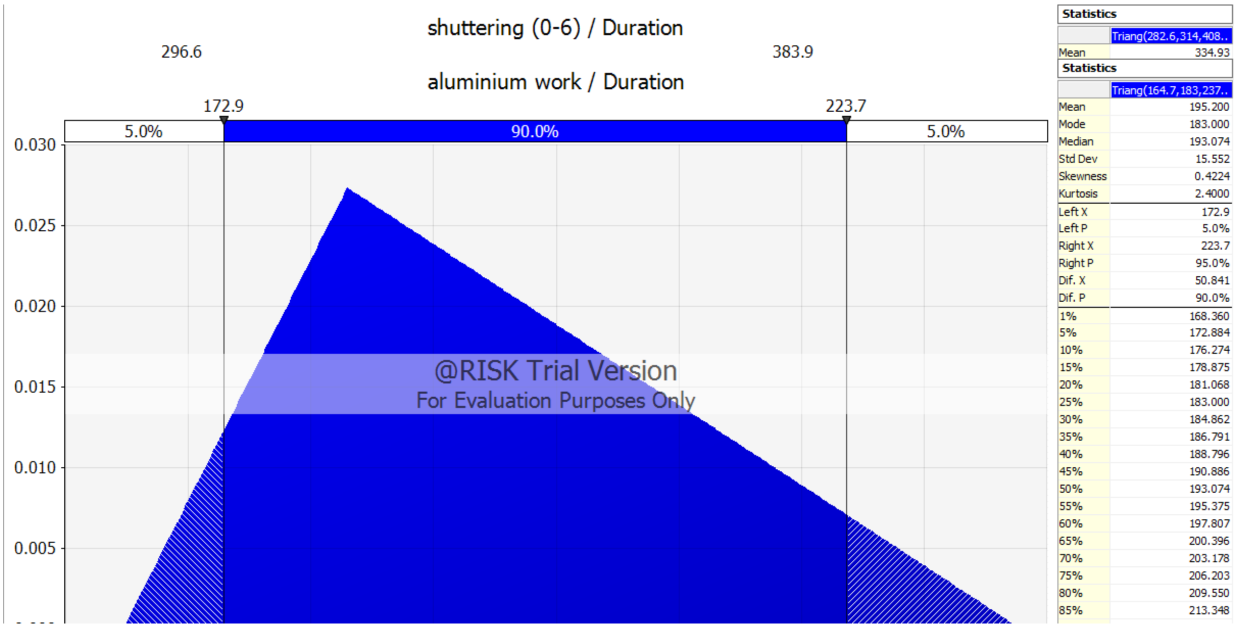


Fig 6.15 distribution graph defined for aluminium work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 224 days duration and 5% chance of its completion in 173 days.

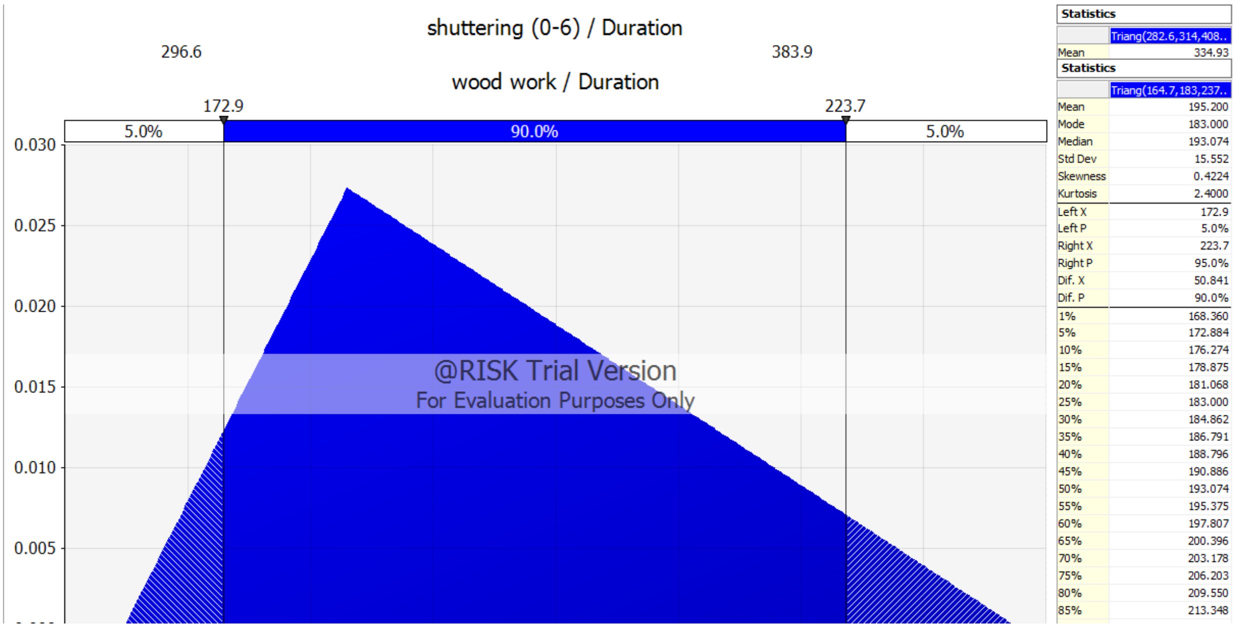


Fig 6.16 distribution graph defined for wood work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 224 days duration and 5% chance of its completion in 173days.

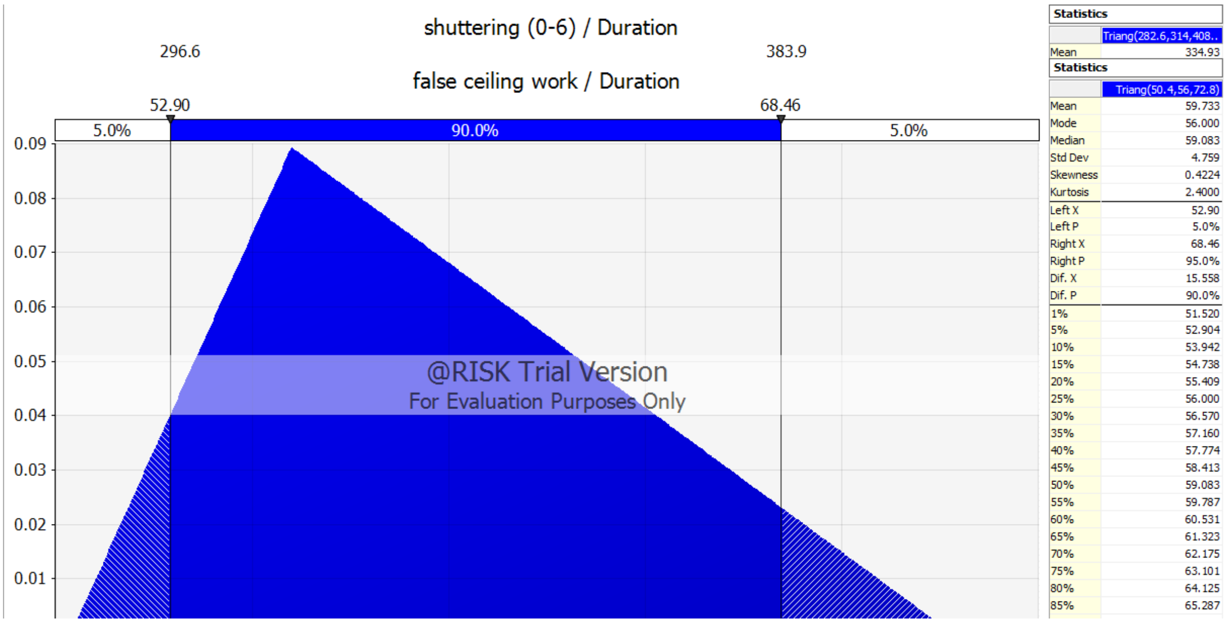


Fig 6.17 distribution graph defined for false ceiling work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 68 days duration and 5% chance of its completion in 53 days.

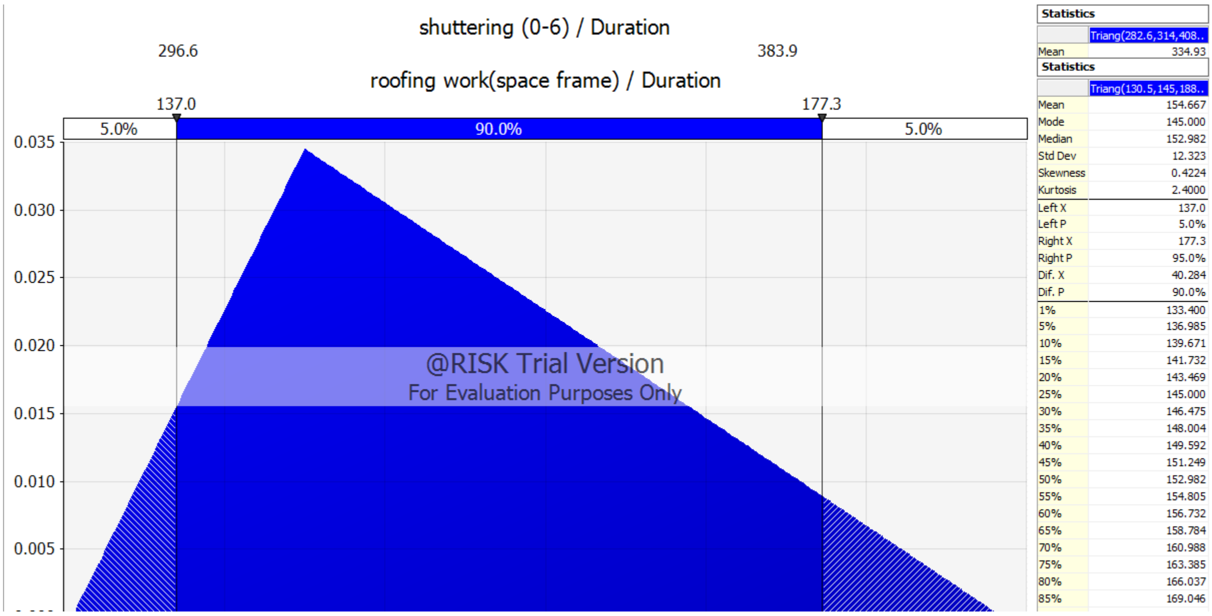


Fig 6.18 distribution graph defined for roofing work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 177 days duration and 5% chance of its completion in approximately 137 days.

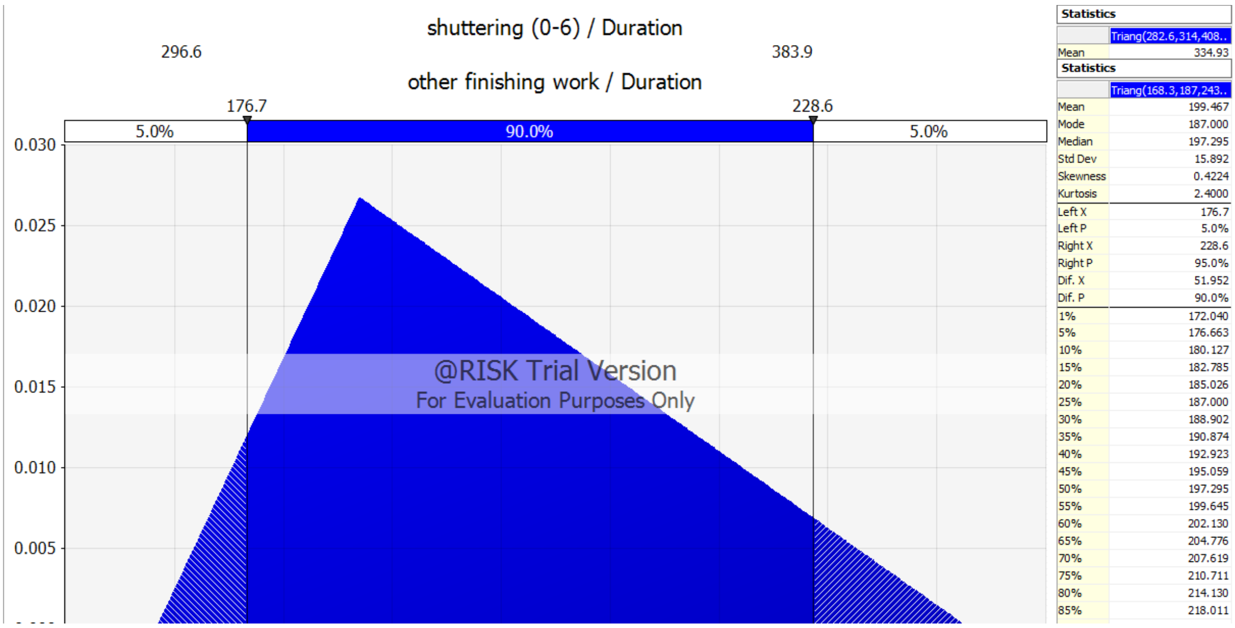


Fig 6.19 distribution graph defined for other finished work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 229 days duration and 5% chance of its completion in 177 days.

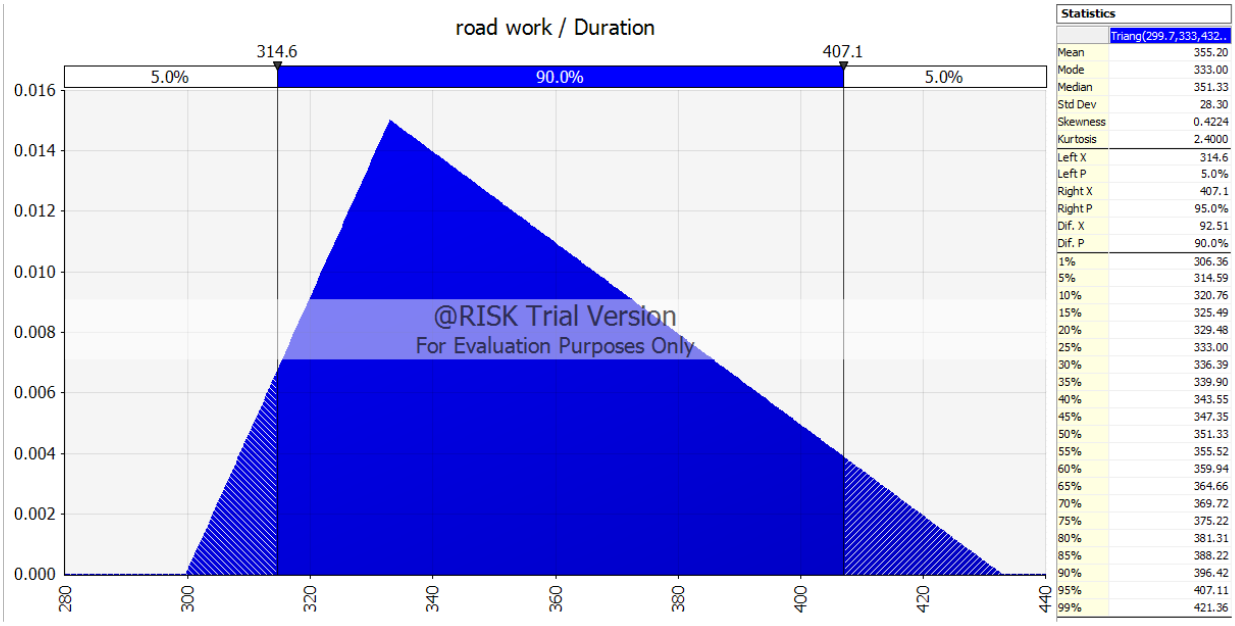


Fig 6.20 distribution graph defined for road work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 407 days duration and 5% chance of its completion in 315 days.

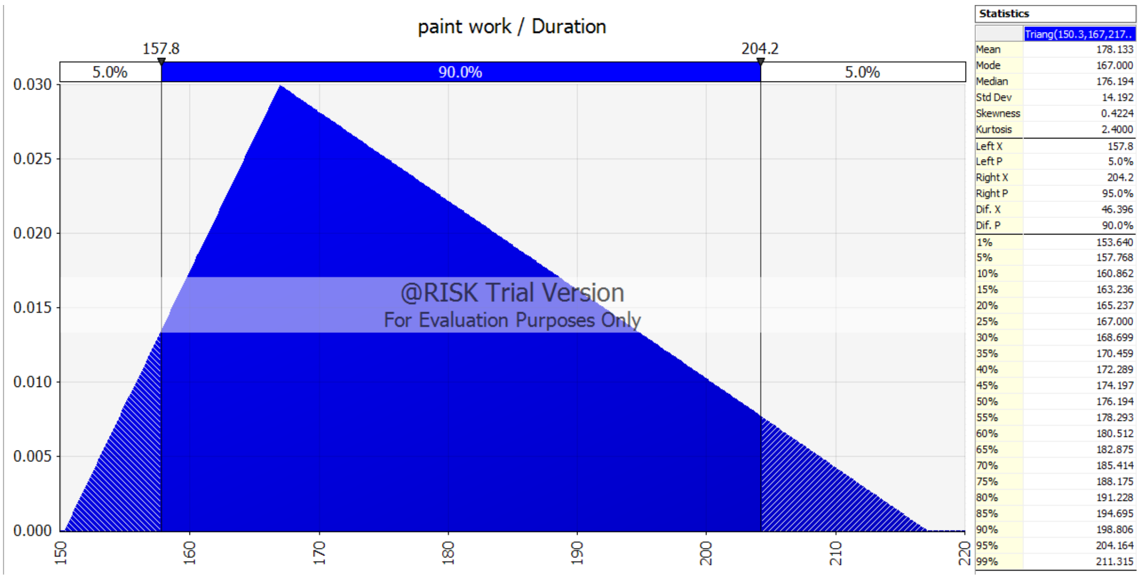


Fig 6.21 distribution graph defined for paint work

The above distribution graph describes that the survey and layout activity has 90% chance of its completion in approximately 204 days duration and 5% chance of its completion in 158 days.

After defining the distribution for each activity the simulation for the project is conducted through @RISK software. The simulation process occurs as follows:

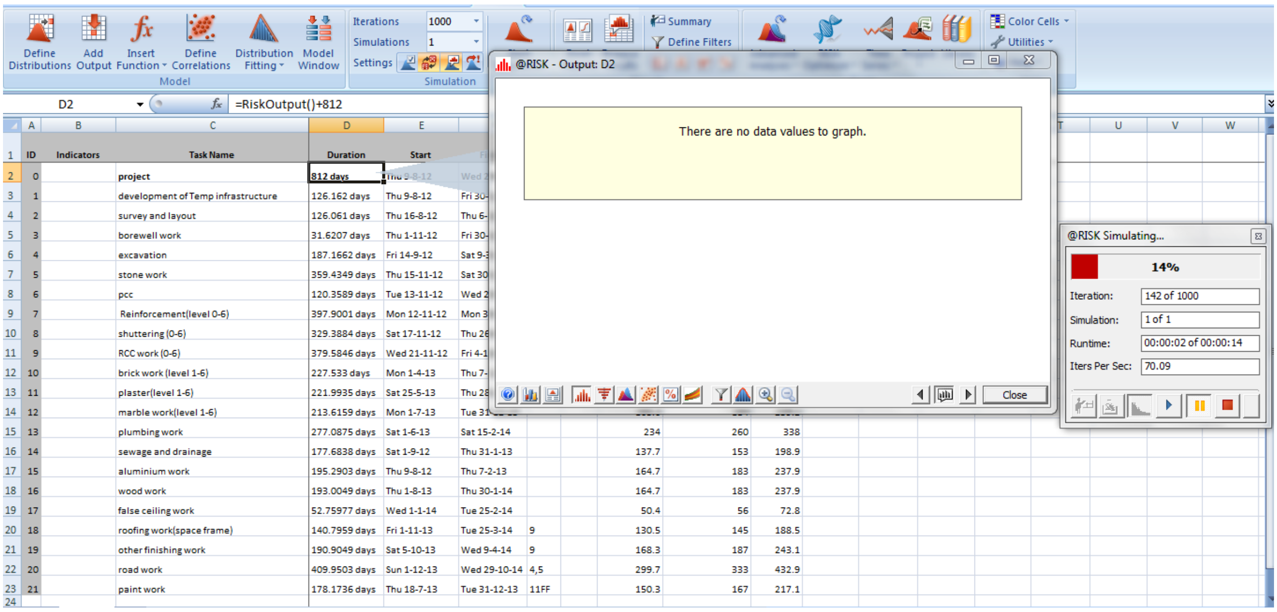


Fig 6.22 Simulation in process

The above process shows the simulation occurring in the software with 1000 iteration. Iteration in the software represents the number of times the data is simulated within a single simulation. With different iteration, the values of duration of for each activity changes but did not go beyond the maximum duration defined previously for each activity.

Table 6.2 Simulation results for 500 iteration

S.NO.	Task Name	Duration
	Project	
1	Development of Temp infrastructure	137 days
2	Survey and layout	126 days
3	Bore well work	34 days
4	Excavation	188 days
5	Stone work	349 days
6	PCC	143 days

7	Reinforcement(level 0-6)	414 days
8	Shuttering (0-6)	316 days
9	RCC work (0-6)	365 days
10	Brick work (level 1-6)	217 days
11	Plaster(level 1-6)	196 days
12	Marble work(level 1-6)	182 days
13	Plumbing work	259 days
14	Sewage and drainage	178 days
15	Aluminium work	208 days
16	Wood work	196 days
17	False ceiling work	53 days
18	Roofing work(space frame)	144 days
19	Other finishing work	217 days
20	Road work	377 days
21	Paint work	170 days

Table 6.3 Simulation result for 1000 iteration

S.NO.	Task Name	Duration
	Project	
1	Development of Temp infrastructure	119 days
2	Survey and layout	128 days
3	Bore well work	34 days
4	Excavation	196 days
5	Stone work	364 days
6	PCC	124 days
7	Reinforcement(level 0-6)	378 days
8	Shuttering (0-6)	346 days
9	RCC work (0-6)	308 days

10	Brick work (level 1-6)	225 days
11	Plaster(level 1-6)	196 days
12	Marble work(level 1-6)	205 days
13	Plumbing work	279 days
14	Sewage and drainage	163 days
15	Aluminium work	182 days
16	Wood work	171 days
17	False ceiling work	62days
18	Roofing work(space frame)	143 days
19	Other finishing work	210 days
20	Road work	333 days
21	Paint work	179 days

Table 6.4 Simulation result for 5000 iteration

S.NO.	**Task Name**	**Duration**
	Project	
1	Development of Temp infrastructure	123 days
2	Survey and layout	111 days
3	Bore well work	33 days
4	Excavation	182 days
5	Stone work	135 days
6	PCC	161 days
7	Reinforcement(level 0-6)	391 days
8	Shuttering (0-6)	383 days
9	RCC work (0-6)	332 days
10	Brick work (level 1-6)	247 days
11	Plaster(level 1-6)	201 days
12	Marble work(level 1-6)	199 days

13	Plumbing work	316 days
14	Sewage and drainage	151 days
15	Aluminium work	213 days
16	Wood work	184 days
17	False ceiling work	66 days
18	Roofing work(space frame)	152 days
19	Other finishing work	204 days
20	Road work	335 days
21	Paint work	159 days

Table 6.5 simulation results for 10000 iteration

S.NO.	**Task Name**	**Duration**
	Project	
1	Development of Temp infrastructure	130 days
2	Survey and layout	124 days
3	Bore well work	37 days
4	Excavation	214 days
5	Stone work	406 days
6	PCC	120 days
7	Reinforcement(level 0-6)	362 days
8	Shuttering (0-6)	354 days
9	RCC work (0-6)	355 days
10	Brick work (level 1-6)	264 days
11	Plaster(level 1-6)	239 days
12	Marble work(level 1-6)	179 days
13	Plumbing work	245 days
14	Sewage and drainage	153 days
15	Aluminium work	221 days

16	Wood work	189 days
17	False ceiling work	58 days
18	Roofing work(space frame)	150 days
19	Other finishing work	218 days
20	Road work	372 days
21	Paint work	156days

6.3 Results for Contingency Time

After the simulation, the total time allowance or contingency time is calculated, as discussed above, by calculating the ATA of each activity. The ATA is determined by the difference of acceptable percentile risk and target duration. The calculated activity time allowance also called as buffer in the project is as follows:

Table 6.6 project data for construction building

S.NO.	Task Name	Duration Min	Duration M. likely	Duration Max	critical index	Td	Dp	ATA
1	**Project**							
2	Development of Temp. infrastructure	102.6	114	148.2	0	114	116	2
3	Survey and layout	101.7	113	146.9	0	113	119	6
4	Bore well work	27	30	39	0	30	32	2
5	Excavation	159.3	177	230.1	0	177	187	10
6	Stone work	342.9	381	495.3	100	381	402	21
7	PCC	115.2	128	166.4	0	128	135	7
8	Reinforcement(level 0-6)	290.7	323	419.9	0	323	341	18
9	Shuttering (0-6)	282.6	314	408.2	0	314	331	17
10	RCC work (0-6)	286.2	318	413.4	0	318	335	17
11	Brick work (level 1-6)	198.9	221	287.3	0	221	233	12
12	Plaster(level 1-6)	169.2	188	244.4	0	188	198	10
13	Marble work(level 1-6)	165.6	184	239.2	0	184	194	10
14	Plumbing work	234	260	338	0	260	274	14

15	Sewage and drainage	137.7	153	198.9	0	153	161	8
16	Aluminium work	164.7	183	237.9	0	183	193	10
17	Wood work	164.7	183	237.9	0	183	193	10
18	False ceiling work	50.4	56	72.8	0	56	59	3
19	Roofing work(space frame)	130.5	145	188.5	0	145	153	8
20	Other finishing work	168.3	187	243.1	0	187	197	10
21	Road work	299.7	333	432.9	100	333	351	18
22	Paint work	150.3	167	217.1	0	167	176	9

With the calculation of the ATA, criticality index is also calculated in order to determine which activity remains in the critical path as shown in table 7.

Two activities i.e. stone work and road work, has 100% chances in remaining in the critical path and affecting the project schedule. Other activities have zero criticality index which means they did not cause any change in project schedule.

CHAPTER-7

CONCLUSION AND FUTURE SCOPE

The predictable and unforeseen risk causes the uncertainty in the project schedule. The most acceptable risks are found in the activity level which affects directly in project schedule delay by creating a variable behavior in activity duration in the project. Therefore, to plan for these risks, the project's and the activities' time allowances should be calculated by considering the duration variability of each activity rather than being determined from subjective criteria.

1. To estimate the maximum allowed planned duration at the same level of acceptable percentile risk for all the activities in the project, SAPA method gives us an advantage to obtain a fair distribution for the project time allowance.
2. To estimate the maximum allowed planned duration for all the activities in the project at the same percentile level, this approach can be used as it provides a better advantage.
3. This approach can also be used to obtain a fair distribution of the project time allowance. It also tells us that the activities which have a more risk take in large planned duration.
4. This method recommends that the target activity duration to be taken as the median duration or the 50^{th} percentile duration for the project and the planned duration is taken as the most likely duration of the project so as to obtain the same risk level. As to provide the same risk to all the activities in the project, median duration is considered. By considering the median value or 50^{th} percentile duration value for the activities there are 50% chance for the project activity to exceed and 50% chance for the project to complete on time. As a result of these considerations, the time allowance assigned to every activity will cover the difference between its estimated planned and target durations.
5. SAPA method, if used in actual construction site, can provide a better management for schedule control in construction sites including contingency time management. With the use of this approach and by obtaining target schedule as the base schedule, the negative variance in the activity can be reduced. The difference between the target duration and planned duration by

using SAPA method gives us the value of contingency time for the whole project and also the value of buffer time required for each activity.

6. After estimating the project contingency time, it is in the hands of the project manager to manage the project schedule and to check the performance in order to prevent the schedule delay for each activity or to avoid exceeding the activities' time allowances.
7. Any continuation on the target duration of every activity has to be justified as per the predictable risks in the activity extension; there should be an acceptable cause when there is performance variability in project activity and other constraint factors must be controlled in the following activities to reduce the risk of exceeding the planned project duration.
8. In order to prevent the project delay, manager should know the factors that might appear in the project depending upon the site at which the building is to be constructed or a construction project is to be constructed. Manager should have knowledge or experience in the particular area to prevent any delay in the project. If he knows all the constraints that might appear in the project, then quarter of the problem related to project delay is subsided. It is very important for the project manager and the management to know about the constraints in the project for that particular site.

Future Scope

If this approach is used on actual sites, it may prevent delay in the project schedule as the buffer time provided in the activities reduces the possibility of any delay until or unless the risk factor large in the project activity.

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