

A Correlated Study between Time and Cost in Accordance with Fuzzy Logic

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Abstract

Objectives: To optimize the duration of the project using fuzzy mathematical model. **Methods/Statistical Analysis:** In this, a case study is scheduled, and cost estimation is done. Scheduling is done using Microsoft Project (MSP), Critical Path Method (CPM) and Line of Balance (LOB). The efficiency of both the scheduling is assessed by critical path method. Estimation is carried out using the Centre line method. The schedule and cost estimate shows the difference with respect to the actual time consumed to construct and expenses. **Findings:** The difference in schedule was the result of improper scheduling techniques and estimation procedures. The cost is increased by 25% due to increase in the time delay. The critical activity in the project is identified and crashed to decrease the duration and calculated the crash cost. The critical activity in the final stages of work is crashed heavily to reduce the time of capital investment locked in the project. **Application/Improvements:** The fuzzy logic optimizing technique was used to create correlation between time and cost with high opinion to the point of approval of the project manager.

Keywords: Crash Cost, Fuzzy Logic, Line of Balance, Project Manager, Schedule, Satisfaction Level

1. Introduction

Construction project scheduling has been developed as an influential and classy management tool. On the basis of the schedules developed during the early planning stages of projects, and taking all the possible scenarios into account, the construction management decisions are made. During the course of the project, many unpredictable events may occur. Therefore, in these situations the decision maker has to make decisions quickly during course of construction. The decisions are based on the expertness of decision managers who use software, but during the execution period, the assumptions may vary that were made during the planning stage of a project. However, the decisions which are made need to be aided by a risk management plan. In most of the situations, to minimize the risks in the planning stages, the allowances considered may not be enough to cover all the possibilities, and the planner will have to react accordingly when changes occur.

A case study, link was made among schedule and duration of the project. The schedule of the project and sticking towards it is crucial to the success of any project. But real-life scenarios have got a lot of constraints (Weather, Labour availability, Material, etc..) to complete the project in scheduled time. Spending the allocated budget is one of the primary objectives which should be studied and controlled at the stage of executing a project. This problem has been arisen to check whether the cost work ratio is in balance according to the forecast in the budget. It is evident that it is impossible to maintain cost-work ratio as predicted in the project. Some such as inflation, human workforce, natural calamities, accidents, etc., may result in possible increase or decrease in cost of the project. The actual time and cost of construction projects may be affected by the client, the project and same contract characteristics and in many cases can be very different from the contract time and cost. The substitution between the minority diverse phases of the project is a challenging job and planners are faced with

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numerous possible combinations for project delivery. Different evolution approaches are applied to optimize the multi-objective time and cost optimization problem¹⁻³.

The Project without the proper plan and schedule will incur more cost and duration, which affect the project manager and client's fulfillment. The LOB and CPM are done for scheduling the case study. The duration of the project is a result of the effective scheduling.

The LOB method is a graphical representation of the project schedule. Microsoft project is based on the networking model. The abstract estimate is prepared with the effective schedule to calculate the cost required for the project. The cost spend will change accordingly with the schedule since the labour requirement will change. Critical activities are identified in the project and then crashed to decrease the project duration. The time reduction in the project can create the crash cost. The crash cost can be resolved by introducing Fuzzy logic in the project without compromising the time and level of contentment of Project Manager. The Membership function was shown in graph with the degree of membership as an independent variable and universe of discourse as a dependent variable. By plotting graph, a curve pattern was formed to represent the membership function. Obviously both cost and time membership function play an important role to reduce time frame of the project.

2. Methodology

To achieve the objectives of this project, the following work was performed. The required data is gathered from the construction company and analyzed. From the received data scheduling is done using MSP and LOB method. Estimation for the project is done. Enhanced duration was used in fuzzy mathematical model by selecting a most favorable schedule. Both, decision variable and objective functions were the key factors to shape membership function. At last Membership function was created with the help of fuzzy logic tool. It has been shown that the conventional search method for reaching the best efficiency point had got its demerits. To overcome these demerits we use the fuzzy algorithm logics. Fuzzy logic control can provide solution to the system even if there is no mathematical method^{4,5}.

The main advantage of fuzzy mathematical model was performing multi-objective optimization of the project schedules by taking account on restriction such as

unpredicted material deficiency, time and rate. A study was performed to find the issues created due to material shortage with the help of sensitivity analysis and manual procedure for material allocation. From this research, a clear reason for cost increase and time delay of the project was determined.

The result obtained from the research showed that not just material shortage is a problem rather allocation of materials to five different activities that affect the project duration. The importance should be given for allocating the material to the activity which has low float value rather than ready to start an activity⁶. Finally results and conclusion and prepared based on the analysis of the project.

2.1 Steps of Methodology

Step 1: During the first stage, the initial step was to find a concept to enhance the management of a project, many optimization techniques were studied and finally fuzzy concept is chosen in order to optimize the cost and duration of the project.

Step 2: Various factors like optimization using fuzzy logic, scheduling, cost and duration of the project and time value of money was examined clearly with help of literature review. By considering aim of the project a methodology was created.

Step 3: Information of the company was collected to obtain better results in the case study.

Step 4: Duration of the project was determined by Scheduling using Microsoft Project and Line of balance. These two methods are used in a view to comparing schedule by repetitive and non-repetitive methods.

Step 5: From the above two scheduling, an optimum schedule is selected to reduce further duration by the optimization using fuzzy concept. Objective and decision variables are defined in this phase. Critical activities are identified and crashed to reduce the duration of the project. Crash cost is calculated for crashing activity.

Step 6: The membership function is formed at this stage. Cost and time membership function established by the value from the above steps. The equation as a model is derived using membership graph.

Step 7: Conclusion is made in this stage from the results and model obtained from the paper.

3. Time-Cost Relationship

The two important factors involved in the construction projects are time and cost. Many articles and research are done in this sector to improve the trade-off between these factors. Time overruns and Cost overruns have been a major issue in many Indian construction projects. In construction projects, time and cost are the most important factors to be considered in the planning of every project. The aim of project is to finish the projects on time, within budget and to achieve other project objectives. It is a difficult task undertaken by project managers, which include constantly measuring progress, evaluation of plans, and taking corrective measures whenever required. Optimization is a systematic effort which is made to improve the profit margins and obtain the best results under certain circumstances⁷.

The owners/clients are always encouraged to minimize the length of the project without disturbing the time. Center of attention of project managers is to concentrate on shorten the project period by crashing the PERT/CPM networks. The main objectives in time cost trade-off are always reducing the total cost. Total cost function was the key area for many researcher. Many key factors like direct cost, indirect cost, and opportunity cost was used to determine the cost function. Time value of money is not included but which is one and the same to capital cost. Capital cost will have a key collision on the cost intensive project, which leads to collapse the starting activities in a project, the capital cost will be locked for a longer period and whereas if the crash in following activities, the capital cost locked will be the shorter period⁸⁻¹⁰.

In the graph drawn, between time and cost, will represent S-curve as the both the factors will increase in relative to each other. In most of the project, S-curve for the baseline project will vary with actual project S-curve. It's the biggest challenge to the project managers to maintain the s- curve as per the baseline project. In this paper, we have focused on maintaining the relationship between the time and cost about the Project managers/ owners satisfactory level.

4. Results

A two-storied apartment building is considered for the case study of this project. Actual duration and cost of the project incurred are high when compared with the scheduled duration and cost. Table 1 show the actual and estimated duration and cost of the project.

Table 1. Project summary

	Duration	Cost
Actual	347 days	Rs. 1,00,28,651
Estimated	257 days	Rs. 80,58,827
% increase	35%	24.44%

The difference in the cost and duration is due to the lack of knowledge in the field of planning and scheduling of a project. The critical activities in the project are selected and crashed to reduce the project duration. Crash cost for each activity is calculated, and the total cost of the project is estimated with respective crash cost which is depicted in Table 2.

Table 2. Crashing Cost

	Actual	Crash
Duration	257 days	Duration 194 days
Cost	Rs.80,58,827	Cost Rs.84,03,887
Cost Variation due to crashing		Rs.3,45,060

4.1 Scheduling

With the help of the planning process, life span of activities was determined by scheduling process. The main steps to develop a schedule are as follows to find the duration required for each activity and project completion. Time intervals for each activity were created. By this, critical activities leads to delay in completion were identified. Scheduling is done in two methods which are shown in Table 3, to find the efficient method of scheduling for crashing which reduces the project duration.

Figure 1. Depicts the Line of balance schedule of the duration versus the work progress in percentage.

Table 3. Schedule of the project

Schedule	Duration
Line of balance method (LOB)	407 days
Critical path method by Microsoft Project (MSP)	257 days

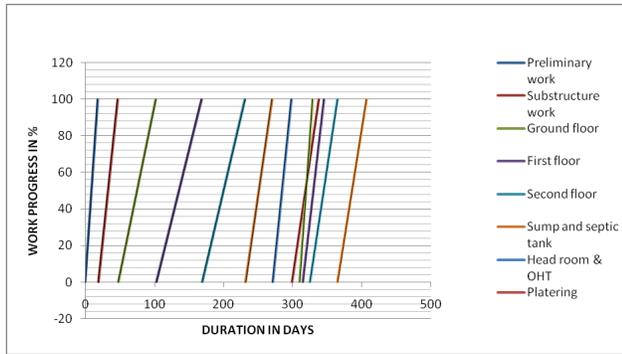


Figure 1. Line of balance schedule.

These above said methods resulted in same completion time. Network analysis of the project is made by three methods namely, 1. Manual CPM scheduling calculations 2. Primavera Project Management (P5) and 3. Optimization Programming Language (OPL) The Heuristic method provides more accurate result in comparison with OPL and P5.

Fuzzy methods are used to find minimum completion time. A robust model in fuzzy mathematical model was created by trade-off model with the option of decision makers of another decision tool. These models give idea to deal with a range of cost and duration of the project. There are two possible ways to create membership function; on one hand cost is used as an objective function and on the other hand activity to be critical. The fuzzy mathematical model includes time and cost with a limit as material restriction to give correct practical solution. By adding constraints to the analysis give more sustain to the output formed using fuzzy mathematical models¹¹.

4.2 Fuzzy Mathematical Model

The proposed optimizing technique allows imprecision in the decision process and present output in a quantitative approach. These final values can be obtained by using membership functions.

There are few Membership Functions which have been explained and out of which two are being followed here. The term fuzzyfication comprises the process of transforming crisp values into grades of membership for linguistic terms of fuzzy sets. The membership function is used to associate a grade to each linguistic term. The fuzzification is the first step in fuzzy logic processing involves a domain transformation where the crisp

inputs are transformed into fuzzy input^{12,13}. Membership Functions are mostly with linear or trapezoidal functions which is clear-cut but not accurate, which define how one decision correspond to a set of values that have been strong-minded previously or interval of possible answers. By this decision makers can use the membership function to assess their decisions and shape out how much a decision get satisfied.

Although traditional mathematical models have generate optimal solutions by using either single objective-oriented or multi-objective models, but their results have uncertainty. With the introduction of advancement in computers, multifaceted fuzzy mathematical models can be analyzed to get reliable optimal exchange between cost and time for network projects in construction. If the satisfaction level is with good percentage then it will be represented as 1 and 0 for no satisfaction level. The decision makers will get probable values for the diverse objectives in decision process.

The memberships function for duration, based on Figure 2.

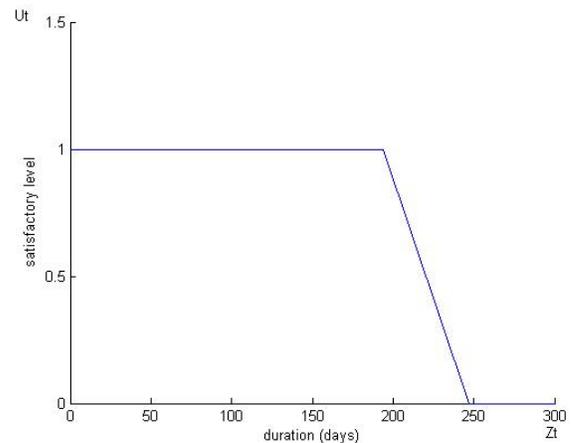


Figure 2. Membership function for duration.

$$F(x) = \begin{cases} 1, & \text{if } z \leq 194 \\ \frac{247-z}{53}, & \text{if } 194 < z < 247 \\ 0, & \text{if } z \geq 247 \end{cases}$$

Where,

Z, Duration in days

F(x), satisfactory level in accordance with required duration

The function for membership functions for cost, based on Figure 3.

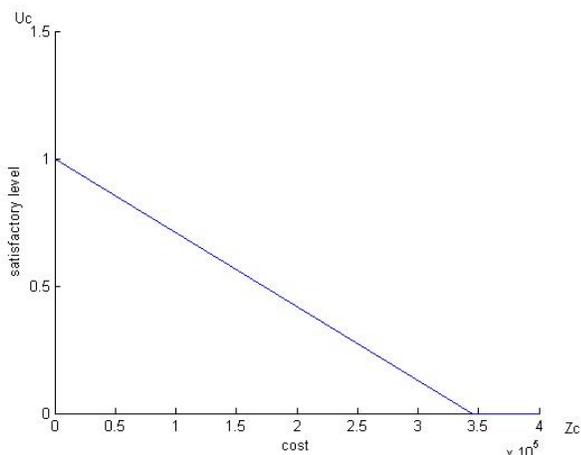


Figure 3. Membership function for cost.

$$F(x) = \begin{cases} 1, & \text{if } z = 0 \\ \frac{345060 - z}{345060}, & \text{if } 0 < z \leq 345060 \\ 0, & \text{if } z > 345060 \end{cases}$$

Where,

Z, Duration in days

F(x), satisfactory level in accordance with required cost

5. Conclusion

Scheduling of a project is crucial to complete the work as per plan. In our case study, we have taken a small residential apartment. Without scheduling, a project will take more duration and cost. In our case study, it has consumed 35% and 24.44% excess duration and cost to complete the project. In scenarios like this, there are many small construction companies which don't follow scheduling has led excess cost and duration in their project. It may even affect the company's financial stability due to the lack of awareness in scheduling.

This paper emphasizes the importance of implementing scheduling for the small construction companies to increase their profit. Scheduling does make a project to finish in a planned approach. LOB scheduling makes the non-repetitive project to close soon after than the critical path method. The LOB is more suitable for repetitive projects. Graphical representation of project is the main benefit in the LOB technique. LOB is mainly

used for the subcontractor. For all major subcontracts, it will assist the management of the subcontract and the project.

The LOB Chart is produced and it would identify the low output and productivity enabling the causes to be addressed at the time. And, if there is genuinely a case to be made for disrupting, a LOB Chart showing the lower output and productivity is the magnificent way of demonstrating it¹⁴⁻¹⁶. Critical path scheduling is a network scheduling technique which is effective to finish the project in time. Critical activity defines the finishing time of a project. To obtain the reduction in time value of money the activities are crashed by the time value of money and can be reduced by crashing the final stage activities of the project.

To obtain the reduction in time value of money the activities are crashed and to decrease the time value of money, the project is crashed by the noteworthy number of days in the final stages of the project. This makes the investment of the money in the final stage of the project little bit higher. No investor is willing to investment huge capital amount with a project and waits for the returns. This is more suitable only for commercial project.

6. References

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