International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 06 | Jun 2022 www.irjet.net p-ISSN: 2395-0072

Time, Cost, and Quality Trade-off Analysis in Construction Projects

Smruthy Lakshmanan

Student, Dept. of Civil Engineering,
Indira Gandhi Institute of Polytechnic and Engineering, Kerala, India

---

Abstract - *In a building project, the three most critical objectives are time, cost, and quality. It's crucial to strike a balance between these limits. Quality is a qualitative parameter, whereas time and cost are quantitative parameters. The TCQT model is examined in this study in order to develop a Time Cost Quality Trade off. The assumptions and conditions are based on a study of the industry. SPSS software is used to extensively analyse the survey data. Finally, this project includes a case study of a building construction project that is scheduled using Primavera.*

Key Words: TCQT, Construction, Trade-off, SPSS

1. INTRODUCTION

The primary goal of construction is to accomplish the project on time, on budget, and according to the scope of work. These characteristics of each activity instil confidence in the likelihood of the activity's work being done. It is necessary to devise a method for determining an ideal or nearly optimum set of execution selections for the project's activities in order to reduce the project's total worth and total quantity while maximising its overall quality.

According to the characteristics of the optimization problem, an effective approach based on the modified particle swarm optimization algorithm and critical path method (CPM) is employed to provide the optimal decision result. Finally, a case study on extensive repair of an instrument control system for a hot blast burner is presented to demonstrate the model's viability and applicability. When it comes to project timetables where resources play a big role, however, CPM has a lot of limitations. Apart from when we concentrate on another important component, such as Quality, it does not meet all of our criteria.

A construction project must deal with a variety of constraints, including time, financial, and scope limits. Dependencies and limitations are both critical components of every project. Projects are fundamentally a collection of interconnected tasks with a priority order and relationship to one another, resulting in dependencies. Constraints, on the other hand, occur when a project has a set of requirements, a deadline for completion, and other features that limit how you can approach the project. Simply expressed, a project constraint is anything that prevents or limits your implementation techniques. All of these constraints will have an impact on the project's quality.

In a building construction project, there are three significant but opposing objectives: time, quality, and cost. Because they are separate parameters, optimising them is a difficult task for project managers.

Because of the linear relationship between these two points, any intermediate duration might be chosen. It's likely that some position in the middle represents the perfect or optimal time-cost trade-off for this job. The cost slope of an activity is the slope of the line connecting the normal point (lower point) and the crash point (higher point). By knowing the coordinates of the normal and crash locations, the slope of this line may be computed numerically.

1.1 Project Time-Cost Relationship:

Project Time-Cost The total project expenses comprise both direct and indirect costs associated with completing the project's activities. Materials, labour, equipment, and subcontractors are all included in the project's direct expenses. Indirect costs, on the other hand, are the costs of doing work that are not directly tied to a certain activity or, in some situations, a specific project.

1.2 THE PROJECT'S SCOPE

- Identifying and evaluating the different elements that influence the time, cost, and quality trade-off in construction projects.
- Recognize the limitations of current or traditional approaches and introduce new industry developments.
- Develop a methodology for use in building projects and conduct a case study to verify the outcomes.

1.3 OBJECTIVES

To discover common and relevant elements that affect construction project time, cost, and quality.

A questionnaire survey of consultants, contractors, and engineers will be conducted.

To create statistical models using a variety of analysis methodologies and industry-standard software.

To ensure that the outputs of the statistical models are accurate.

2. Methodology

Time-cost trade-off analysis, in general, incorporates faster activity durations gained by assigning additional resources, which result in a shorter project duration and reduced indirect cost at the expense of a higher direct cost. However, there are no measurements to determine whether it has an impact on quality. It may be effective for shutting down tasks such as projects. However, additional caution should be exercised in undertakings involving construction. As a result, the project is looking at the trade-off between time, cost, and quality. The following is the methodology used:

Literature survey: A thorough review of the literature on this topic is undertaken through numerous journals. The project's nature is influenced by a literature evaluation that aids in identifying the major tactics. A literature review was undertaken using journals, textbooks, and conference papers as sources. Blogs etc.

Questionnaire preparation: Prepare a questionnaire with questions about fast-track construction and delay management. Technology selection and resource management

Identification of the company: Determine which construction projects are appropriate for data collection and questionnaire surveys. The majority of people prefer Kerala's on-going fast-track projects.

Questionnaire survey: A questionnaire survey that comprises the most pertinent data collection questions. The strategy-related questions are also included in the survey questionnaire.

Data collection: Data is gathered by a questionnaire survey, a field visit, and data from other sources, which is then sorted.

2.1 SPSS software was used to check for reliability.

SPSS is a commonly used statistical analysis application in the social sciences. Marketers, health researchers, survey firms, government and education researchers, marketing groups, data miners, and others use it. The original SPSS Manual (Nie, Bent, & Hull, 1970) was hailed as one of "sociology's most influential texts" for enabling ordinary researchers to conduct their own statistical analysis. The base Software includes statistical analysis, data administration (case selection, file reshaping, creating derived data), and data documentation in addition to statistical analysis. The data was examined using the RRI (Relative Rank Index) method. The RRI Technique is developed from Liker scales, which measure the degree of significance of variables chosen by participants and must be turned into a Relative Rank Index with a value of one or less, and is used to compare the important levels of variables. The following equation can be used to compute the RRI:

$$RRI = 1\ (\Sigma lixini = 1)$$

Where,

RRI stands for Relative Rank Index, and n stands for the maximum Likert scale score (here 5)

N = total number of answers, i=1, 2, n

Likert scale (Li) (The least important is l1, and the most significant is in)

The frequency of the I th response is denoted by xi.

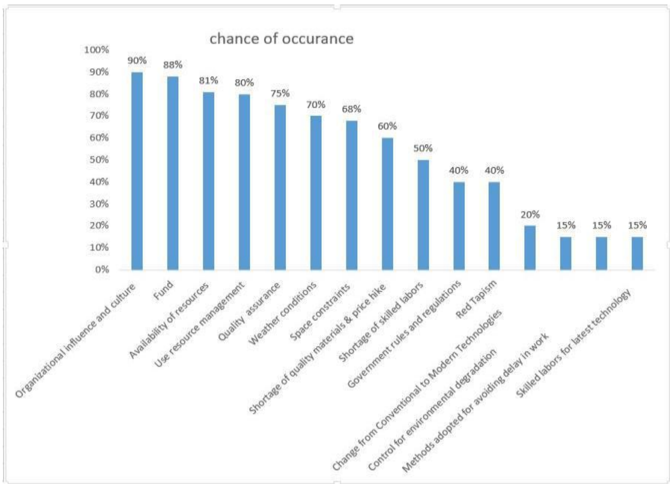

Chart -1: Graph showing risk in priority order

The volume, cost, and quality of a project's activities determine its overall performance in terms of time, cost, and quality. These characteristics of every activity create confidence in the likelihood of the activity's work being completed. It is necessary to build a strategy capable of identifying an optimal or nearly optimal set of execution selections for the project's activities in order to reduce the project's total worth and total quantity while maximising its overall quality. As a result, a Time Cost Quality Tradeoff (TCQT) model is required.

2.2 Utilizing the TCQ model

We've already examined the aspects of the TCQT models to use in each area, such as project duration, project budget, and quality requirements. We may now move on to the analytical model's time cost trade.

2.3 Activity Time-Cost Relationship

Cost slope = (crash cost – normal cost) / (normal duration – crash duration)

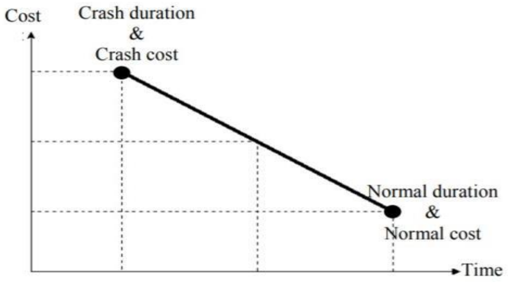

Fig -1: Activity Time-Cost Relationship

2.3 Analysis of Time Cost Trade off observations

Because we're using the Critical Path Method to solve the problem, we can characterize it as follows:

- It's impossible to predict how long an activity will take to complete.
- In CPM, the critical path isn't always obvious.
- CPM networks can be challenging for larger projects.

In the case of Cost Analysis, we can see that the same cost of the networks is completed at various times in the highlighted columns. It emphasises that the traditional critical path method may not be appropriate for this type of study. In this case, we can apply CCPM to reduce cycling time and improve cost analysis efficiency.

2.4 Oracle primavera case study analysis

Primavera P6 EPPM from Oracle is a cloud-based, software-as-a-service solution backed by a global network of Oracle Project Portfolio Management experts and the security, scalability, performance, and support of one of the world's largest cloud suppliers. It's a web-based solution for managing projects of any size that adapts to various levels of complexity across projects and automatically scales to meet the needs of all roles, functions, and skill levels in your business and on your project team.

A multi-story building project is the subject of the case study. Oracle Primavera is used to create the schedule, which divides the project into Work Breakdown Structures (WBS) and activities with durations. As a Predecessor Diagramming method, activity relations are offered (PDM). Activities with direct and indirect costs are assigned resources. The CPM approach is used for scheduling. We are incorporating our topic Time Cost into the same schedule. Trade off analysis and keep an eye on the results. In terms of time and money, the cost of making modifications from the established scope (i.e., Quality) is calculated. All resource analysis and resource levelling techniques were applied to the new CCPM-based schedule. As we all know, the CPM Schedule has constraints when it comes to managing resources and sharing them based on skills (known as ROLES), such as all procedures completed and deviations found.

2.5 Baseline for projects

A baseline is a clearly defined beginning point for your project plan in project management. It's a constant against which you may assess and compare the progress of your project. This enables you to evaluate the effectiveness of your project's adjustments, length changes, and cost changes, among other things. As a result, Baseline will aid in the graphic tracking of activity, while tabular changes such as date, duration, and cost will be presented in table form.

We've established a baseline for our schedule and attached it to it. After that, we may put our modifications in place, such as avoiding simultaneous activities. We can keep track of where we are in the process of implementing CCPM on the CPM timeline.

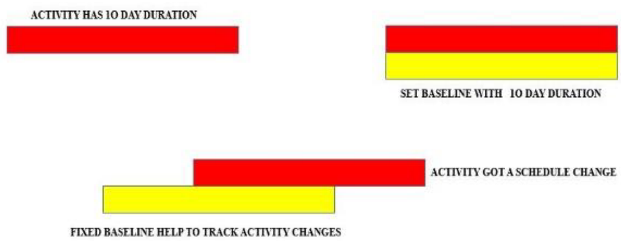

Fig -2: Relationship b/w activity duration and baseline

As a result, Baseline will aid in the graphic tracking of activity, while tabular changes such as date, duration, and cost will be presented in table form.

Table -1: Comparison b/w CPM Base Project & CCPM New Project

CPM BASE PROJECT	NEW CCPM PROJECT
The project lasted 426 days in total.	The project lasted 396 days in total.
The project will begin on March 1, 2022, and end on October 17, 2023.	Start and end dates for the project are March 1, 2022, and September 5, 2023.
Labor Costs Budgeted: Rs. 8,503,800.0 /-	Labor Costs Budgeted: Rs. 8,503,800.0 /-
Indirect Costs Budgeted: Rs. 94,500/- (Rs. 100/- per activity per day)	Indirect Costs Budgeted: Rs. 94,500/- (Rs. 100/- per activity per day)
Total Budgeted Cost: Rs. 8,598,300/-	Total Budgeted Cost: Rs. 8,598,300/-

We can cut the entire period by 30 days and get ahead of schedule by using CCPM. It never entails a reduction in activity time or cost.

2.6 Crashing

We can now apply the crashing to a new project, namely the CCPM project, and calculate the modifications. The CCPM project was designated as the baseline.

- Crashing reduces the time of activities and projects dramatically.
- Cost changes will be tracked as well.

Create a schedule baseline and tie it to the schedule. On the CCPM timetable, we can see where we are in terms of applying crash and cost trade-off.

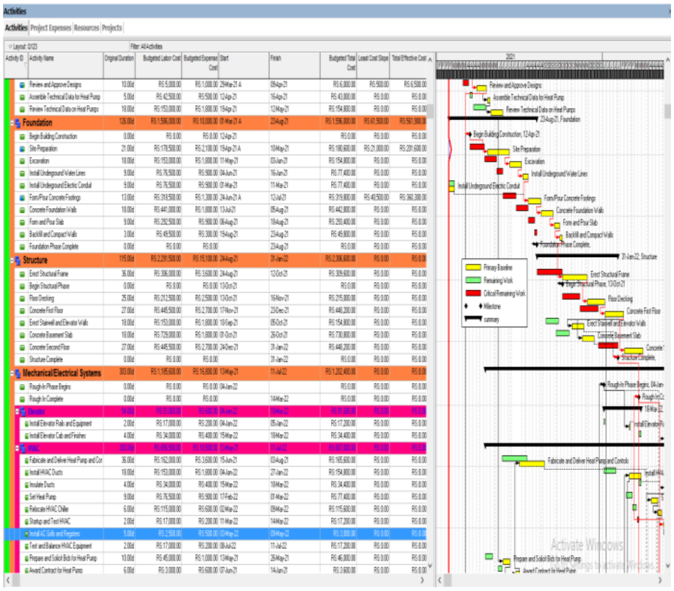

Fig -3: Time Cost Trade –Off with Crashing Schedule

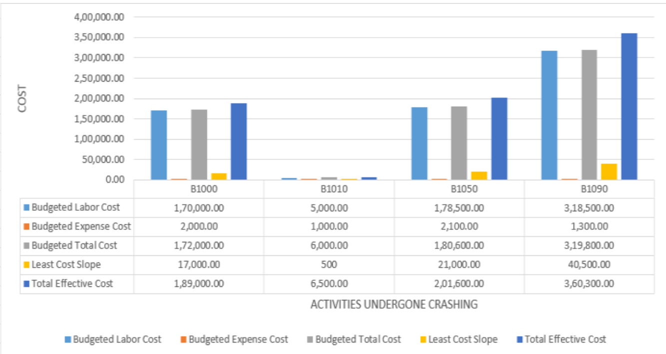

Fig -4: Graphical Representation

Activity ID	Activity Name	Original Duration	Budgeted Labor Cost	Budgeted Expense Cost	Budgeted Total Cost	Least Cost Slope	Total Effective Cost
B1000	Design Building Addition	20.00d	RS:170,000.00	RS:2,000.00	RS:172,000.00	RS:17,000.00	RS:189,000.00
B1010	Review and Approve Designs	10.00d	RS:5,000.00	RS:1,000.00	RS:6,000.00	RS:500.00	RS:6,500.00
B1020	Assemble Technical Data for Heat Pump	5.00d	RS:42,500.00	RS:500.00	RS:43,000.00	RS:0.00	RS:0.00
B1030	Review Technical Data on Heat Pumps	18.00d	RS:153,000.00	RS:1,800.00	RS:154,800.00	RS:0.00	RS:0.00
B1040	Begin Building Construction	0.00d	RS:0.00	RS:0.00	RS:0.00	RS:0.00	RS:0.00
B1050	Site Preparation	21.00d	RS:178,500.00	RS:2,100.00	RS:180,600.00	RS:21,000.00	RS:201,600.00
B1060	Excavation	18.00d	RS:153,000.00	RS:1,800.00	RS:154,800.00	RS:0.00	RS:0.00
B1070	Install Underground Water Lines	9.00d	RS:76,500.00	RS:900.00	RS:77,400.00	RS:0.00	RS:0.00
B1080	Install Underground Electric Conduit	9.00d	RS:76,500.00	RS:900.00	RS:77,400.00	RS:0.00	RS:0.00
B1090	Form/Pour Concrete Footings	13.00d	RS:318,500.00	RS:1,300.00	RS:319,800.00	RS:40,500.00	RS:360,300.00
B1100	Concrete Foundation Walls	18.00d	RS:441,000.00	RS:1,800.00	RS:442,800.00	RS:0.00	RS:0.00
B1110	Form and Pour Slab	9.00d	RS:292,500.00	RS:900.00	RS:293,400.00	RS:0.00	RS:0.00
B1120	Backfill and Compact Walls	3.00d	RS:49,500.00	RS:300.00	RS:49,800.00	RS:0.00	RS:0.00
B1130	Foundation Phase Complete	0.00d	RS:0.00	RS:0.00	RS:0.00	RS:0.00	RS:0.00
B1140	Erect Structural Frame	36.00d	RS:306,000.00	RS:3,600.00	RS:309,600.00	RS:0.00	RS:0.00
B1150	Begin Structural Phase	0.00d	RS:0.00	RS:0.00	RS:0.00	RS:0.00	RS:0.00
B1160	Floor Decking	25.00d	RS:212,500.00	RS:2,500.00	RS:215,000.00	RS:0.00	RS:0.00
B1170	Concrete First Floor	27.00d	RS:445,500.00	RS:2,700.00	RS:448,200.00	RS:0.00	RS:0.00
B1180	Erect Stairwell and Elevator Walls	18.00d	RS:153,000.00	RS:1,800.00	RS:154,800.00	RS:0.00	RS:0.00
B1190	Concrete Basement Slab	18.00d	RS:729,000.00	RS:1,800.00	RS:730,800.00	RS:0.00	RS:0.00
B1200	Concrete Second Floor	27.00d	RS:445,500.00	RS:2,700.00	RS:448,200.00	RS:0.00	RS:0.00
B1210	Structure Complete	0.00d	RS:0.00	RS:0.00	RS:0.00	RS:0.00	RS:0.00
B1220	Rough-In Phase Begins	0.00d	RS:0.00	RS:0.00	RS:0.00	RS:0.00	RS:0.00
B1230	Rough In Complete	0.00d	RS:0.00	RS:0.00	RS:0.00	RS:0.00	RS:0.00

Fig -5: Tabular report from Primavera

3. CONCLUSION

The main goal of TCQT is to achieve a balance between the competing goals of time, cost, and quality. That is dependent on the organization's attitude toward the project's nature. The main goal of such models is to determine an optimal or near-optimal set of execution options for a project's activities in order to reduce the total cost, length, and quality of the project. The generated models were applied to case studies presented in the literature to validate and verify their usefulness. The generated models produced satisfactory results when compared to those found in the literature. The approach described here is not confined to construction project planning issues. It could be beneficial for a variety of problems involving the comparison of unknown outcomes. It can also be used. For example, inventory models, investment project appraisal, production process control, and a variety of other industries.

REFERENCES

[1] Lalmi, A., Fernandes, G. and Souad, S., 2021. A conceptual hybrid project management model for construction projects. Procedia Computer Science, 181, pp.921-930.

[2] Yao, Y. and Tanaka, M., 2020. Price-quality trade-off in procurement auctions with an uncertain quality threshold. Journal of Economic Behavior & Organization, 177, pp.56-70.

[3] Welde, M., Bråthen, S., Rekdal, J. and Zhang, W. (2020). Road investments and the trade-off between private and public funding. Research in Transportation Economics, 82, p.100875. doi: 10.1016/j.retrec.2020.100875.

[4] Liu, D., Li, H., Wang, H., Qi, C. and Rose, T. (2020). Discrete symbiotic organisms search method for solving large-scale time-cost trade-off problem in construction scheduling. Expert Systems with Applications, 148, p.113230. doi: 10.1016/j.eswa.2020.113230.

[5] D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.