APPLICATION OF GENETIC ALGORITHM FOR OPTIMIZATION OF TIME & COST WITH QUALITY CONSIDERATION OF A CONSTRUCTION PROJECT

[1]Vinayak Pavate,[2] Dr. Jaydeep Shinde, [3]Mr.Vikram Dilip Deshmukh
[1]PG student Department of Civil Engineering, Ashokaro Mane Group of institute's, Vathar, India.
[2]Professor, Department of Civil Engineering, Ashokaro Mane Group of institute's, Vathar ,India.
[3] Assistant professor Aissms institute of information technology Pune.

ABSTRACT
This research paper explores the application of Genetic Algorithms (GAs) to address the intricate challenges of optimizing time, cost, and quality in construction projects. The construction industry faces constant pressure to enhance efficiency and deliver projects within stipulated timelines while maintaining high-quality standards within budget constraints. Traditional optimization methods often struggle to handle the complexity of multi-objective problems inherent in construction project management.The proposed research leverages Genetic Algorithms, a powerful optimization technique inspired by natural selection, to concurrently address the triad of time, cost, and quality considerations. By modeling construction project parameters as chromosomes and iteratively evolving solutions, GAs aim to find optimal trade-offs among conflicting objectives. The paper investigates the adaptability and effectiveness of Genetic Algorithms in navigating the complex decision space of construction project management.Through case studies and simulations, the research evaluates the performance of Genetic Algorithms in real-world construction scenarios, shedding light on their potential to revolutionize project optimization. The findings aim to contribute valuable insights to construction practitioners, researchers, and policymakers seeking innovative approaches to enhance project outcomes.
Keywords: multi-objective problems, chromosomes, trade-offs.

1. INTRODUCTION

Simplified, optimization is the act of creating anything. fantastic more effective or an idea better. It is a grating addition to an original concept in order to improve upon it[1]. It is difficult to define precisely because of its use in so many different fields of study. Making the most use of an infrastructure or the functionality of the programme while using the least quantity of runtime and resources is the aim in computation and manufacturing An expansive meaning of optimisation[2] It's a search for the best component to start a group of elements based on a predetermined set of standards. These standards are referred to as fitness functions or objective functions in mathematics. Deterministic and stochastic algorithms are the two main types into which optimisation techniques may be divided[3]. The two groups of deterministic approaches are enumerative methods and the analytical technique based on calculus[4]. There are direct and indirect procedures in the analytical techniques. In indirect techniques, a system of equations may be solved to find the local function optima[5]. The direct technique traverses the function graph side to side in the direction indicated by the gradient in pursuit of a local optimum. Both approaches have some drawbacks[6].

 ISSN:1005-748X

They are given little choice in the initial place because they search for the best options close to a specific spot. Secondly, the use of them is contingent upon the presence of modifications[7]. As such, the range of applications for methods of analysis is restricted. There are several types of enumerative procedures. The easiest approach in a limited search area It's possible to change the object method values while also reviewing each potential answer one at a time[8]. This technique's one major drawback, despite its straightforwardness and resemblance to human thinking, is its uselessness. Many issues have a search space that is so enormous that it is not feasible to find every It's possible to change the object method values while also reviewing each type of optimisation algorithms[9]. Meta-heuristic are a class of stochastic methods to a set of function objectives that have attracted a lot of study interest lately. Known for being more sophisticated structures, their objective is to effectively and efficiently search a given region. Around fifty years ago, the first studies in this area were begun[10].

Storyline pertinent to the undertaking and figuring out how to win people over, Product assurance statement: Assessing The three traditional design and building goals of quality, cost, and programme duration were confirmed; Quality may refer to appearance, functionality, or efficiency[11]. Occasionally, excellence is more important than cost or turnaround times. Cost: might refer to one's starting or ongoing expenses; most clients have extended budgets in order to really determine the project's parameters. Time[12]: may be defined as precisely as feasible or by particular data; some customers have rigid deadlines. It was noted sure the procedures to guarantee that the creation would satisfy the requirements for which it was conducted are part of the Product Good management. The main project quality control procedures listed below are: Perfection preparing: determine the general project quality and performance requirements to regularly check to provide assurance that the project will meet the applicable qualifying standards, excellence Control: monitoring specific project results to see if they adhere to relevant quality standards and identifying ways to remove failure causes [13]. Both these processes and the procedures in the other fields of expertise are in communication with each other. This idea was covered from a variety of angles: the level of quality that counts is what the customer thinks and is prepared to pay for; our perception of quality is irrelevant. The standard: Habits, culture, and traditions, which vary widely from place to location and among groups of people,[14] are what build quality over a long amount of time. As a result, it's important to recognise that excellence is a difficult concept to describe. Instead, it is a composite phrase that is described using characteristics. A technique for getting managers to agree on key points to improve the quality of their projects was outlined. The process of measurement is what drives progress[15]. It was said that the lack of size led to issues with empathy, perception, and superior appraisal. The significance of the superiority component was underlined in the conclusion, which included 16 criteria for excellence enhancement in the Indian structure business. It may be used to metropolitan areas and used as a means of reproducing building project quality measurement. Although useful, this approach does not manipulate the true cost of compromised quality. It was urbanized and used a method to determine how well the base of a structure was piling[16].

1.1 Genetic Algorithm

Adaptation computations, or GAs, are an optimisation technique with a broad variety of applications that date from the 1980s. They initially appeared in the early 1970s. In several engineering-related domains, such as structural optimisation, irrigation network design, bridge layout, and tunnel arithmetical plan, GAs have shown to be an efficient means of resolving optimisation problems. In many aspects, GAs work better than conventional optimisation techniques[17]. Beyond fitness data and objective function values, among others, they don't need any further information. This information is used to determine how likely it is that a design will succeed or fail in a certain situation. Because it can locate the most advantageous or quasi-optimal answer elsewhere, even when the optimisation consequence is intermittent, non-differentiable, or involves the usage of any form of constraint, it also benefits from a strong position as a powerful tool in uncommon optimisation problems[18].

1.2 Types of Process to Form Genetic Algorithm

1.3.1 Time-Cost transaction

A GA system was urbanised in order to construct time-cost trade-off analyses. Every member of the community is given a value for the plan's price and time frame by the urbanised approach, and this value may be shown as a location on the duration and price plot. Next, Every point in each generation has a calculated distance separating from each section of the curved hull of that generation. Every point's performance worth, which varies with its greatest and lowest distances, influences its likelihood of being selected[19]. A framework was created that concurrently optimises the construction cost and excavation operations length by using GAs, Object-Oriented Programming, and discrete event simulation. A multifaceted GA was created in order to address the cost of time trade-off issue. The Adapted Weighted Method (AWA), which the GA used, is a fitness function that takes into account the costs and times associated with every chromosome by using values that change with each successive generation. The chromosome utilised in the composition is the same as the one used in the GA. Subsequently, the writers proposed an alteration to enhance AWA and prevent any mistakes in this approach[20]. Additionally, he discussed how fuzzy set concept was used to establish the stochastic method to multi-objective optimisation in building endeavours. A multifaceted optimisation strategy for scheduling cubic construction tasks based on genetic algorithms was provided. With the help of the approach, building managers may create and assess plans for building scheduling that are as close to ideal as possible while still cutting costs and project duration. A mathematical framework for the time-cost trade-off was put out that integrated the ideas of LOB and CPM. This algorithm's result is the crashed duration for each task, which corresponds to the lowest possible project total expense[21].

1. Time-Cost-Quality Trade-off

A novel approach that uses three interconnected mathematics frameworks to analyse the trade-off between quality, cost, and time has just been released. Their methodology is predicated on the evident correlation between completion a period of time grade evaluation, and expense[22]. The trade-off between time, money, and quality was applied to a real concrete factory construction endeavour. Constructed utilising a modified GA model, the traditional a two-dimensional time-cost compromise evaluation was superseded by the advanced multidimensional time-cost-quality trade-off assessment. In order to give the capacity to quantify and take value into consideration in constructing optimisation, the model is created as a multifaceted genetic algorithm[23]. A solution technique was created to examine the trade-offs between quality, cost, and time in managing projects. We propose three linked theories of programming with integers. A meta-heuristic approach known as magnetic scatter search was put out to address the separate time, expense, and quality compromise dilemma.. A novel multi-colony ant method using met heuristics has been presented to optimise the following goals: time, expense, and quality, in a tradeoffs scenario. To demonstrate how the current strategy may provide optimum or almost ideal answers, an example is examined. For an individual time, cost, and quality trade-off issue, a novel Multi Objectives Particles Colony Optimisation method was presented. Its complex objective was to find the Pareto's ideal front of time, expense, and quality for a project whose activities are part of a movement's connection system (CPM) from start to finish and can be finished in a range of independent or sporadic modes, each with its own limitations related to cost, time, and quality[24].

2. RELATED WORK

Pham Vu Hong Son et.al (2024) The paper introduces the Mutation-Crossover Slime Mold Algorithm (MCSMA), designed for balancing time, cost, quality, and work continuity in specific building projects. The algorithm enhances solution discovery by incorporating a mutation-crossover approach during optimization. Comparative analysis with five established algorithms reveals MCSMA's superior performance, showing increased diversification measures, spread, and hyper-volume. The model demonstrates growth, advancement, and diversity, offering improved convergence and dispersion for optimal solutions in project implementation[25].**Setenay Isikyildiz et.al (2020)** The study aimed to create a Time-Cost-Quality optimization model for construction projects using genetic algorithms. Matlab codes for a versatile genetic algorithm were developed, successfully achieving the desired success level. The model provides advanced three-dimensional time, cost, quality tradeoff analysis, surpassing traditional two-dimensional analyses. It allows selection from a set of Pareto solutions, aiding main contractors in choosing suitable subcontractors effectively[26].**Gloria Yushan Liu et.al (2020)**The construction project management faces challenges in time, cost, and quality. This study proposes a trade-off approach using a genetic algorithm (GA) to optimize time-cost-quality (TCQ). The GA minimizes a project-specific fitness function based on project parameters, achieving a balance. Applied to an offshore wind farm project, the GA optimizes parameters for accurate predictions of construction time, cost, and quality. Mathematical models, reviewed for merits, are validated through a real project, demonstrating close alignment with actual outcomes after optimization[27]. **L. Ngoc et.al (2020)**Construction projects often face delays, impacting finances. To address this, the cost and time optimization method proves crucial. Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) are advanced techniques widely employed in the construction industry. The thesis explores innovative approaches, including GA with various modifications, Linear Programming, NLIP, DCF, Maximum Flow-Minimal Cut Theory, and ANN. Global parallel GA outperforms coarse-grained parallel GA. NLIP and LOB with GA offer efficient time-cost trade-offs, while PSO excels in Pareto-compromise solutions, and DCF optimizes costs and time[28].

A. Sathya Narayanan et.al (2014) This paper explores optimizing the multifaceted time, expense, and product optimization issue in construction through a differential evolution technique. It aims to select the best subcontract designs, maximizing quality while minimizing construction cost and time. The method is compared to existing ones, demonstrating its ability to find the best result efficiently[29]. **Remon Fayek Aziz et.al (2014)** The paper introduces the Smart Critical Path Method System (SCPMS), a model combining Critical Path Method (CPM) with a multifaceted genetic algorithm (GA) for planning and managing large-scale building projects. SCPMS aims to optimize time, cost, and quality through resource optimization, offering a framework for project planners. The study includes a container case study to validate the model's capabilities[30]. **Abdulelah Saif et.al (2015)** The paper introduces a novel meta-heuristic strategy, Troublesome Data-Based Optimization (PDBO), to address the compromise between time, cost, and quality in software development projects. PDBO quickly generates optimal solutions by considering task flaws as a measure of excellence. The study evaluates five techniques, concluding that the EVO method excels in overall cost, while PDBO matches GA. GA has the shortest administrative time, and IWD performs poorly in processing time. The study suggests further modifications to enhance the PDBO method for continuous optimization challenges[31]. **R. Vallonet.al (2017)**This paper emphasizes the growing significance of software design in meeting business demands for complex and high-quality systems. The lack of conventional models for quality attributes, especially in business intelligence environments, poses challenges for developers. The researcher explores ideal architectural designs, utilizing hybrid qualitative analytical techniques to investigate software quality features. The study introduces "safe-tactics" and suggests a pruned set of strategies for effective decision-making in situations of ubiquitous restructuring. A software tool is developed based on the research outcomes[32].

Shujuan Yang et.al (2024) Optimizing decoration construction organizations is crucial for efficient and cost-effective construction. The current lack of multi-objective optimization considering dynamic scenarios in decoration engineering creates a gap between research and practical application. This paper introduces a Multi-Population Genetic Algorithm (MPGA) for optimizing construction sequences, addressing customer orders, transportation costs, and delay times. Results show the MPGA significantly improves construction efficiency and serves as a valuable reference for algorithm development in construction management, contributing to industry reform in the intelligent era[33]. **Van-Hiep Huynh et.al (2021)** The study introduces "multiple objective social group optimization" (MOSGO) for optimizing time, cost, quality, and carbon dioxide emission in construction projects. It enhances exploration and exploitation in optimization, addressing logical relationships in project activities. MOSGO outperforms MODE, MOABC, MOPSO, and NSGA-II in diversification (26.113, 40.27), hyper-volume (0.875, 0.881), mean ideal distance (0.872, 0.754), and spread (0.462, 0.689), showcasing its superior efficiency, convergence, and solution uniformity[34].**Paromik Ray et.al (2020)**This paper explores the optimization of time and cost, crucial objectives in construction projects, with a focus on Genetic Algorithm (GA). Over the last three decades, the construction sector has employed innovative techniques to enhance efficiency. GA, a non-traditional search algorithm inspired by natural selection, stands out. Despite not being intelligent, GA seeks optimal solutions by employing operators like selection, crossover, and mutation. It proves valuable in generating high-quality solutions for construction project optimization, providing effective results and optimal trade-offs between project duration and total work[35]. **S. A. Banihashemi et.al (2020)** This paper addresses the environmental pollution caused by the construction industry and civil projects. It emphasizes the need to identify and reduce environmental impacts during project implementation. The study proposes a multi-objective planning model focusing on time, cost, quality, and environmental impacts. The Leopold matrix method evaluates environmental impacts, demonstrating efficiency through a rural water supply project example. The results indicate that early planning decisions can significantly reduce costs, time, and environmental impact while enhancing project quality[36].

 ISSN:1005-748X

3. RESULTS AND DISCUSSION
1. TIME COST RELATIONSHIP

Table No. 1 Model of Time – Cost – Resources Relationship in A Time Constrained Activity 7

Activity	Duration	Name	Resource Estimation				Cost Function
			Type	Amount	Unit Price Or Rate Per Week	Uncertainty	
7	6	Beam + Slab GF Top (Formwork & Reinforced steel binding)	labour	discrete uniform 6-9	200	Uncertain no of worker due to skills variability	discrete uniform (6-9)*200*9*random uniform(1201-1800)

Table No.1 indicates that action 7 has a 25-day completion deadline. Therefore, in order to prevent time constraints from being violated, the planner must prepare the available resources. Second-hand material is fixed and unaffected by time. It will need a little bit of additional strength to anticipate the flaw. Employees experience ambiguity as a result of labour skills considerations. To guarantee the completion of six days, the number of real employees must be able to be altered within a certain range. Lastly, a price tag feature is offered to assess action 7's overall cost. With the exception of the material, for which duration is not necessary since it is time independent, the functions may be obtained by multiplying the quantity, unit price, and duration of resource usage. To show how the mock-up works, we solely select uniform and normal distributions for the model instances. The allocations used in the example should be replaced with the proper allocation applicable to the scenario when implementing this model to the actual problem.

2. RESOURCE CONSTRAINED ACTIVITY

The early on in the planning phase, resources usability might prove to be a hindrance to a plan. In addition to being cautiously predictable, the number of resources should be established first in this scenario. The resource pricing rate is still undetermined, however. Although the ways in which various resources kinds are used might vary, the longest time determination establishes the overall length of all activities. Due to our ignorance of the level of labour skills, the length of any reserve may be unknown. Lastly, cost is a result of the interplay of time, resource utilisation, resources price rate, and decision variables once again. Table No.2 is an example of this kind of system. For example, activity 10 is limited to 13 staff members. Although thirteen employees are cautiously competent to complete the assignment within the allotted time, the scheduler puts the chance of utilisation and duration at thirteen for ten days since he did not include data about the worker's skill level. Since the purpose is the product of the quantity, unit price, and the length of the resource consumption, the overall cost will vary when one or more factors change.

ISSN:1005-748X

Table No. 2 Model of Time – Cost – Resources Relationship in 10 Time Constrained Activity

Activity	Name	Resource Estimation				Cost Function
		Type	Amount	Unit Price	Estimated Time Of Resource Usage	
10	Brickwork GF	Labour	13	136	(discrete uniform 8-10)	discrete uniform (8-10)*136*13*random uniform(16424-20531)

3. UNCERTAINTY IN TIME – COST – RESOURCES PRICE RATE

There is really a distinct time-cost-resources connection that takes uncertainties into account than each of the models that were previously presented. The most complicated uncertain issue that might arise in a project is this one. This kind of confusion arises when the designer has no idea how long an activity will take, how many resources will be used, or how much they will cost. In addition, the pricing rate is subject to fluctuate based on market prices or currency conversion rates. This kind of model is comparable to activities 10 in that there is some degree of ambiguity about the necessary resource quantity. The example of this scenario is shown in Table No. 3..

Table No. 3 Model of Time – Cost – Resources Relationship in 36 Time Constrained Activity

Activity	Duration	Name	Type	Amount	Unit Price Or Rate Per Week	Estimated Time Of Resource Usage	Cost Function
36	40	external plastering	labour	10	130	(discrete uniform 20-40)	discrete uniform (20-40)*130*10*random uniform(157942-78977)

MSP RESULT

In table no.4 shows the cash flow report for project 1. This result is obtained in Microsoft Office Project (MSP). Following tables includes cost & cumulative cost as per week. Week is including into quarter Q1, Q2, Q3, Q4 for 2018 year & Q1, Q2, Q3 for 2019 year. Cost & cumulative cost total as per quarter & year is calculated. Finally, grand total of project 1 is 1,64,98,575.42 Rs. obtained.

Table No. 4 Cash Flow Report for Project 1

Year	Quarter	Week	Cost	Cumulative Cost
2018	Q1	Week 0	240515.055	240515.055
		Week 1	896785.125	1137300.18
		Week 2	247422.2275	1384722.408
		Week 3	174431.7825	1559154.19
		Week 4	0	1559154.19
		Week 5	77089.7985	1636243.989
		Week 6	93503.82825	1729747.817
		Week 7	303281.7533	2033029.57
		Week 8	68669.4775	2101699.048
		Week 9	237702.0375	2339401.085
		Week 10	1100676.705	3440077.79
		Week 11	0	3440077.79
		Week 12	0	3440077.79
	Q1 Total		3440077.79	3440077.79
	Q2	Week 13	236852.44	3676930.23
		Week 14	56459.84	3733390.07
		Week 15	4988.678	3738378.748
		Week 16	28061.31375	3766440.062
		Week 17	99225.99075	3865666.053
		Week 18	205973.0063	4071639.059
		Week 19	1027831.611	5099470.67
		Week 20	0	5099470.67
		Week 21	0	5099470.67
		Week 22	193313.8669	5292784.537
		Week 23	190479.4131	5483263.95
		Week 24	56459.84	5539723.79
		Week 25	11188.22175	5550912.012
	Q2 Total		2110834.222	5550912.012
	Q3	Week 26	27970.55438	5578882.566
		Week 27	148804.4855	5727687.052
		Week 28	280791.044	6008478.096
		Week 29	953402.4844	6961880.58
		Week 30	0	6961880.58
		Week 31	32742.798	6994623.378
		Week 32	236989.5314	7231612.909
		Week 33	84834.73063	7316447.64
		Week 34	56459.84	7372907.48
		Week 35	17403.9005	7390311.381
		Week 36	27970.55438	7418281.935
		Week 37	191959.461	7610241.396

ISSN:1005-748X

		Week 38	867022.046	8477263.442
	Q3 Total		2926351.43	8477263.442
	Q4	Week 39	317800.8281	8795064.27
		Week 40	0	8795064.27
		Week 41	73671.2955	8868735.566
		Week 42	225895.4545	9094631.02
		Week 43	45260.95	9139891.97
		Week 44	44620.84	9184512.81
		Week 45	23619.57925	9208132.389
		Week 46	40917.047	9249049.436
		Week 47	222167.9438	9471217.38
		Week 48	1135452.22	10606669.6
		Week 49	0	10606669.6
		Week 50	0	10606669.6
		Week 51	114599.793	10721269.39
		Week 52	297395.347	11018664.74
	Q4 Total		2541401.298	11018664.74
2018 Total			11018664.74	11018664.74
2019	Q1	Week 0	48264.38	11066929.12
		Week 1	10060.16363	11076989.28
		Week 2	27970.55438	11104959.84
		Week 3	96024.87242	11200984.71
		Week 4	263543.1938	11464527.9
		Week 5	1325861.916	12790389.82
		Week 6	0	12790389.82
		Week 7	0	12790389.82
		Week 8	155528.2905	12945918.11
		Week 9	64645.5395	13010563.65
		Week 10	19890.172	13030453.82
		Week 11	27970.55438	13058424.38
	Q1 Total		2039759.636	13058424.38
	Q2	Week 12	179163.8461	13237588.22
		Week 13	178169.0737	13415757.3
		Week 14	61569.42039	13477326.72
		Week 15	61569.42039	13538896.14
		Week 16	61569.42039	13600465.56
		Week 17	61569.42039	13662034.98
		Week 18	61569.42039	13723604.4
		Week 19	61569.42039	13785173.82
		Week 20	524467.0239	14309640.84
		Week 21	363324.2625	14672965.11
		Week 22	363324.2625	15036289.37
		Week 23	799433.9225	15835723.29

 ISSN:1005-748X

		Week 24	354257.2025	16189980.49
	Q2 Total		3131556.116	16189980.49
	Q3	Week 25	109344.7125	16299325.21
		Week 26	199250.215	16498575.42
	Q3 Total		308594.9275	16498575.42
2019 Total			5498919	5479910.68
Grand Total			**16498575.42**	**16498575.42**

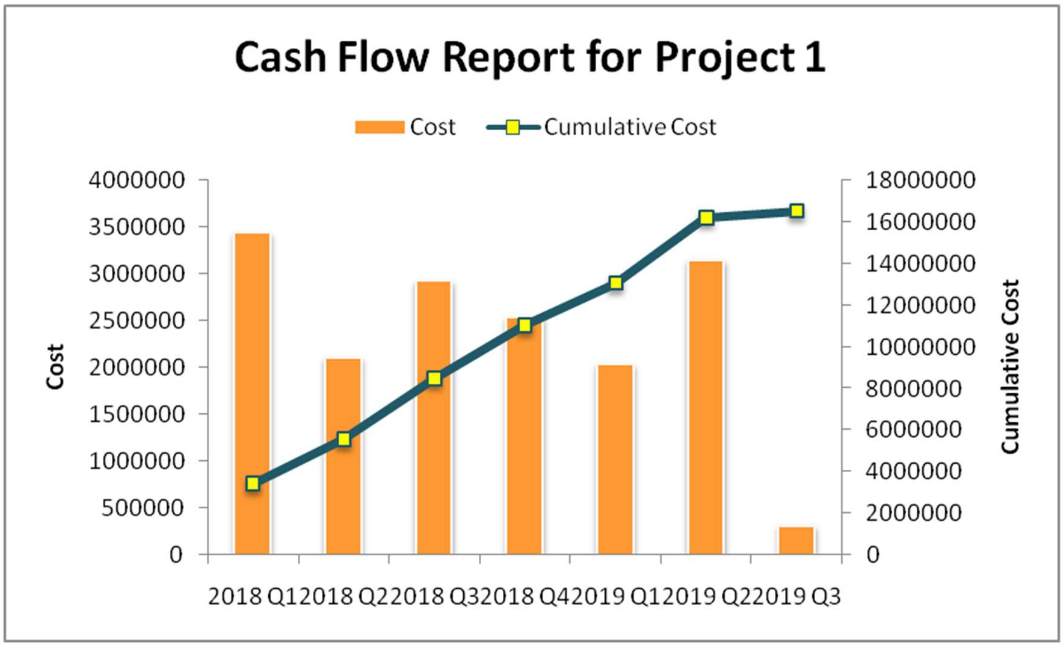

Figure No. 1 Cash Flow Report for Project 1

In figure no. 1 shows the cash flow report for project 1. This result is obtained in Microsoft Office Project (MSP). Above figure show cost & cumulative cost as per quarter. Cost of project shows in terms of bar & cumulative cost shows in terms of line. It is observed that Q1 2018 is more cost that is 34,40,077.79 Rs. as compare to other & Q3 2019 is less cost that is 3,08,594.9275 Rs. as compare to other. The cumulative cost of project 1 is 1,64,98,575.42 Rs.

MATLAB RESULTS

1. COST ANALYSIS

```
  Columns 25 through 32

    0.5842    0.0287    1.1455    0.0066    3.5921    0.0046    2.8405    0.0275

Total Cost:
   1.5442e+07
```

 ISSN:1005-748X

ACTIVITY COST GRAPH

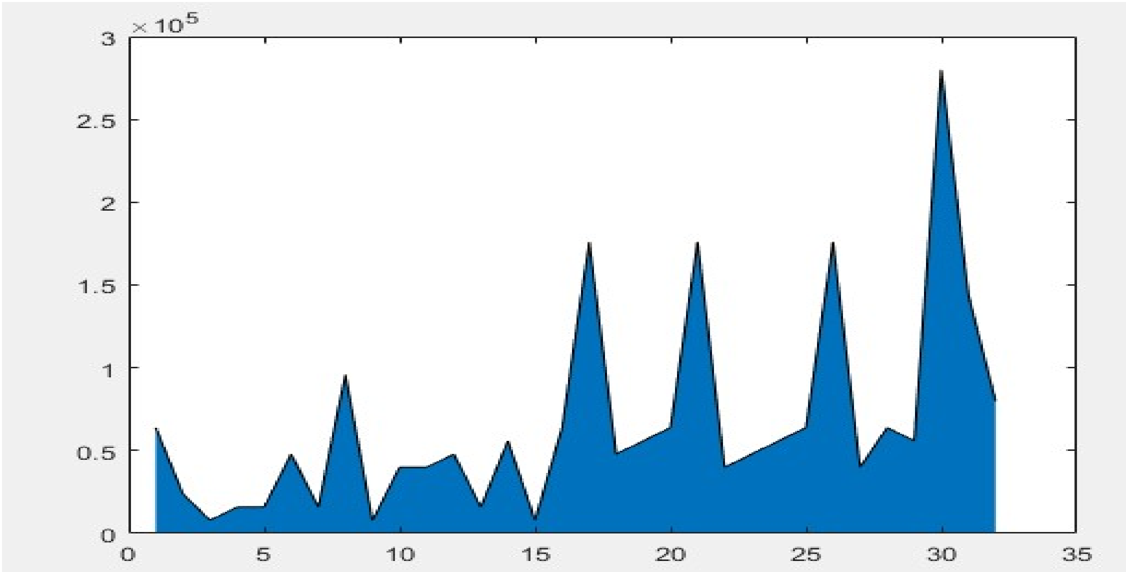

Figure No. 2 Activity Cost Graph Project

The Y-axis of the graph represents the cost in units. In this case, it represents the activity cost, material cost, and total cost. The activity cost is calculated by multiplying the duration of each activity (in days) by 8 (assuming daily labor cost is 1000 units). The material cost is calculated by multiplying the material quantity required for each activity by the corresponding material rate. The X-axis of the graph represents the index of each activity. It starts from 1 and goes up to the total number of activities. Each activity is associated with a specific duration, material quantity, and material rate. The graph will have three bars for each activity: one representing the activity cost, one representing the material cost, and one representing the total cost (which is the sum of activity cost and material cost). The height of each bar represents the cost in units. Interpreting the graph, you can visually compare the costs of different activities, observe any variations or outliers, and analyze the contribution of activity cost and material cost to the total cost. It can provide insights into which activities or materials have the highest cost impact and help in making informed decisions related to cost management.

MATERIAL COST GRAPH

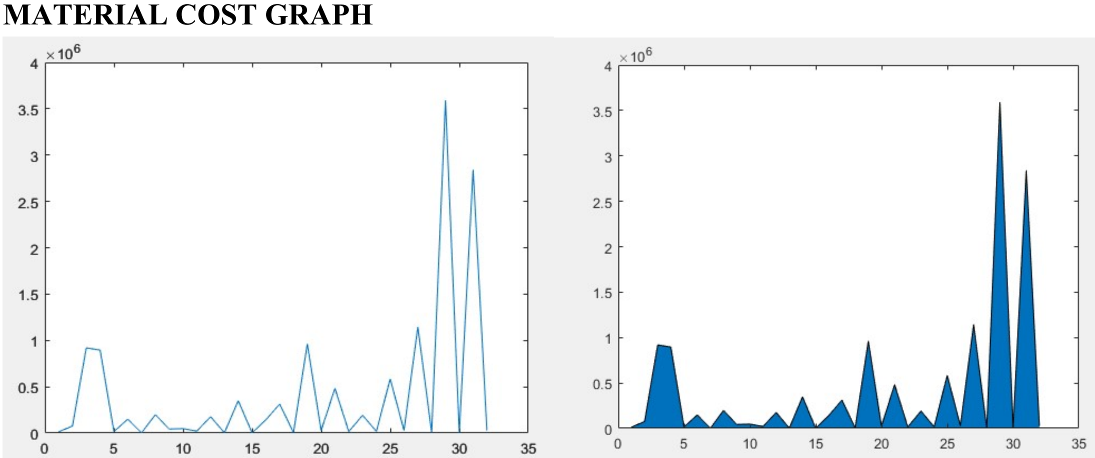

Figure No. 3 Material Cost Graph Project

The code provided calculates the material cost for various activities based on the given material quantities and rates. It then calculates the total cost by summing up the activity costs and material costs. The material cost graph interpretation would involve visualizing the relationship between the activity index (x-axis) and the corresponding material cost (y-axis). Each bar in the graph represents the material cost for a specific activity. The height of each bar represents the magnitude of the material cost for that activity. By analyzing the graph, you can identify activities with higher material costs compared to others. It allows you to visually compare the material costs across different activities and identify any significant variations or outliers. Additionally, you can observe trends or patterns in the material costs as the activity index progresses.

TOTAL COST GRAPH

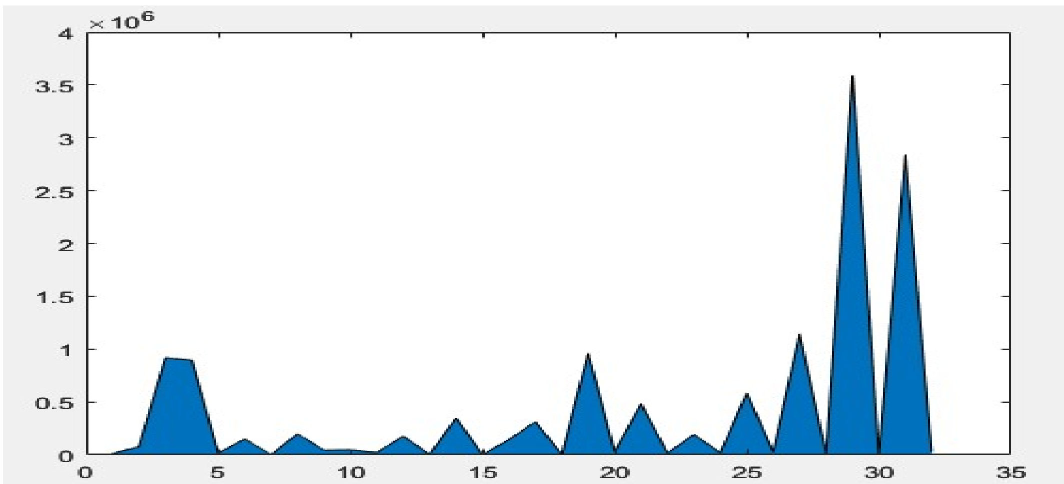

Figure No. 4 Total Cost Graph Project

The provided code calculates the total cost for a set of activities based on their durations and material quantities and rates. It assumes a daily labor cost of 1000 units and calculates the activity cost as the product of duration, 8 (assuming 8 hours of work per day), and 1000. The material cost is calculated as the product of material quantity and material rate for each activity. The total cost is then obtained by summing the activity costs and material costs. To interpret the total cost graph, it would be helpful to plot the total cost over time. Since the durations of the activities are provided, you can plot the cumulative total cost as a function of time or activity number. This graph would show how the total cost accumulates as each activity is completed. It would provide insights into the cost distribution and potential cost peaks or variations throughout the project timeline. Total Cost of Project is 15443000 Rs.

QUANTITY

1. QUANTITY GRAPH

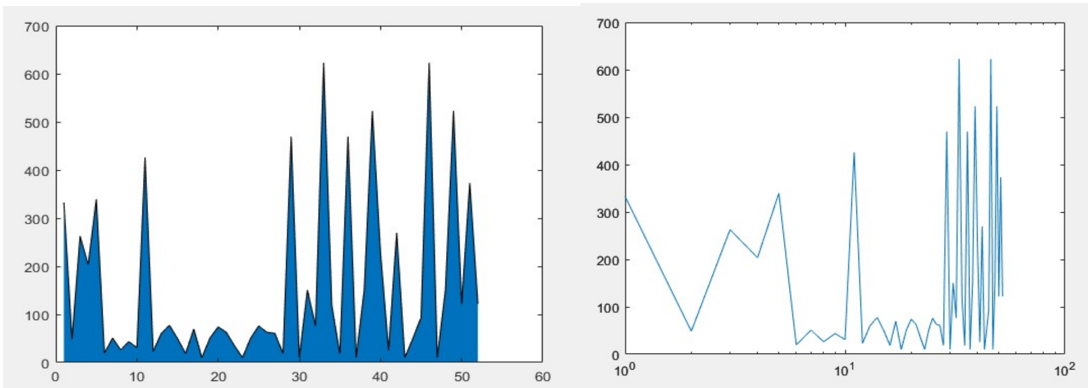

Figure No. 5 Quantity Graph for Project

The given code calculates the cost analysis for various activities based on their durations and material quantities. It then calculates the activity costs by multiplying the duration of each activity by 8 (assuming daily labor cost is 1000 units). The material costs are calculated by multiplying the material quantity of each activity by the corresponding material rate. The code then sums up the activity costs and material costs to obtain the total cost. Finally, it displays the activity costs, material costs, and the total cost.

MATERIAL RATE GRAPH

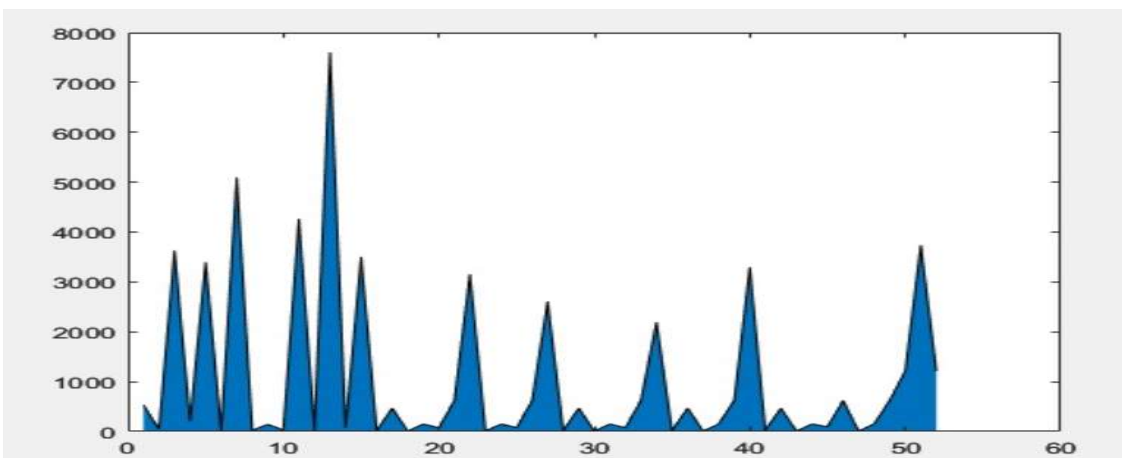

Figure No. 6 Material Rate Graph for Project

The code calculates the material cost for different activities based on the material quantities and rates provided. The x-axis of the graph would represent the different activities, while the y-axis would represent the material cost in units of currency. Each bar on the graph would correspond to the material cost for a specific activity. The height of the bar would indicate the magnitude of the material cost for that particular activity. The interpretation of the graph would involve analyzing the relative costs of different activities and identifying any significant variations in material expenses.

TIME/PERIOD/DURATION

1. TIME/PERIOD/ DURATION GRAPH

 ISSN:1005-748X

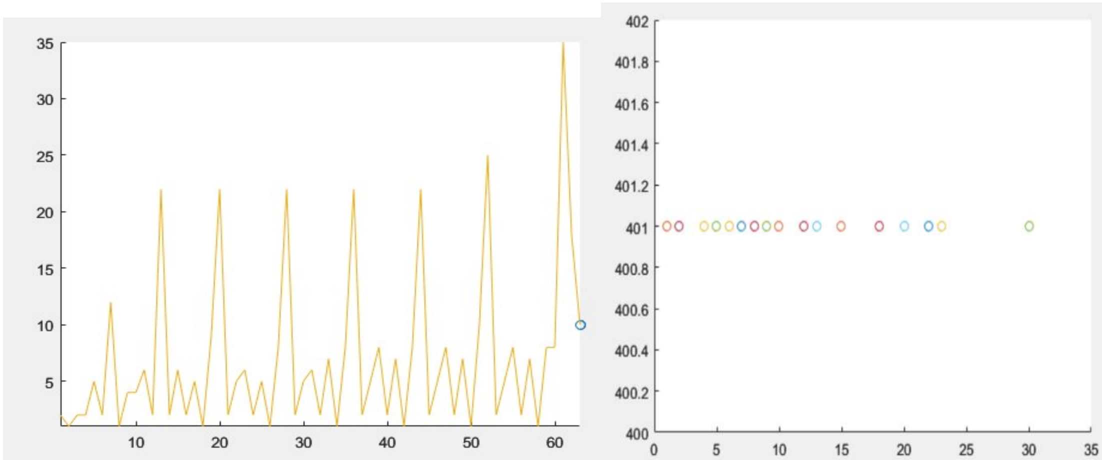

Figure No. 7 Time Analysis for Project

The given code calculates the total time required for each activity based on the provided duration for each activity. The total time required for all activitiess is found to be 435 days. This code can be used to analyze and plan the project schedule by understanding the duration of each activity and the overall time required for the project. It helps in estimating the project timeline and resource allocation. By interpreting the time/period/duration graph, one can identify critical activities that require more time and prioritize them accordingly to ensure timely completion of the project.

2. DURATION GRAPH

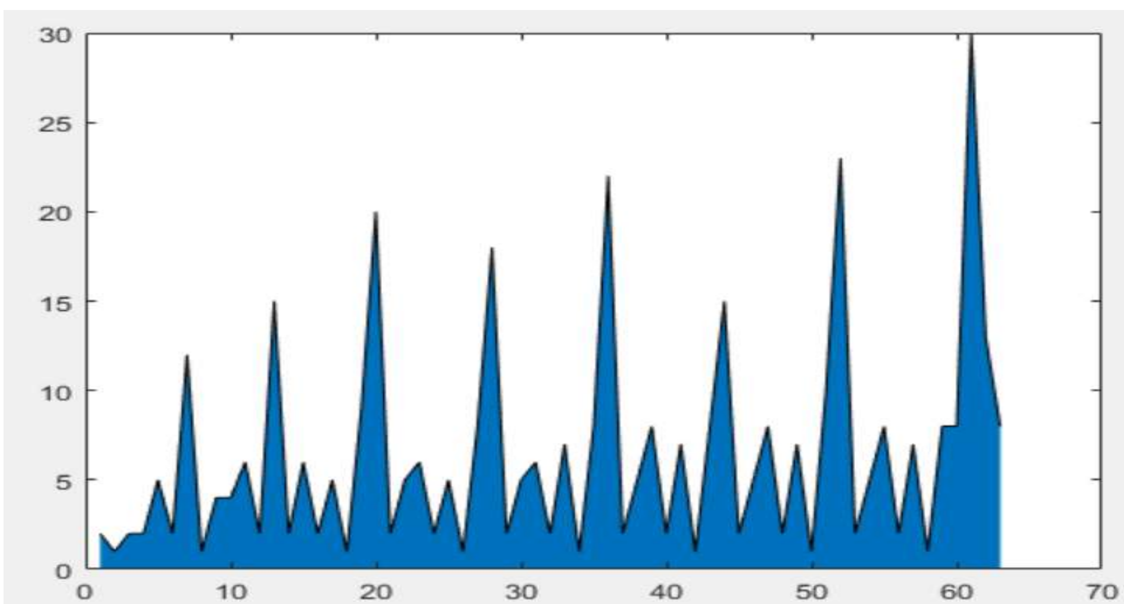

Figure No. 8 Duration Graph for Project

The code provided calculates and analyzes costs related to various activities. The Y-axis of the duration graph represents the duration of each activity in days. Each bar on the graph corresponds to a specific activity, and its height indicates the number of days required to complete that activity. The X-axis represents the different activities being analyzed. Each activity is assigned a numerical index, ranging from one to the total number of activities. The bars on the graph are positioned along the X-axis according to their corresponding activity index. By visualizing the duration graph, you can compare the durations of different activities and identify any significant variations in the time required for each task. This information can help with project planning, scheduling, and resource allocation.

Table No. 2 Percentage Difference of Cash Flow Report for Project 1 & Reduced Project 1

Cost Of Project 1	Cost Of Reduced Project 1	% Difference Between Cost Of Project 1 & Reduced Project 1
16498575.42	15442000.25	6.4 %
Days Of Project 1	**Days Of Reduced Project 1**	**% Difference Between Days Of Project 1 & Reduced Project 1**
449	401	10.69 %

Table No. 3 Percentage Difference of Number of days Report for Project 1 & Reduced No. of Days Project 1

GENETIC ALGORITHM PROPOSAL CONTROL PARAMETERS

Table No.4 Genetic Algorithm Proposal Control Parameters

Parameter	Value
Population Size	100
Crossover	0.7
Mutation Rate	0.1
Cost Analysis	20%
Activity Duration	15%
Material Quantities	15%
Material Rates	10%
Activity Costs	10%
Total Time Required	30%

RESULTS FOR GENETIC ALGORITHM PROPOSAL CONTROL PARAMETERS

```
>> q3
Genetic Algorithm Proposal Control Parameters
---------------------------------------------
Population Size: 100
Crossover Rate: 0.70
Mutation Rate: 0.10
```

NUMBER OF SOLUTION IN MATLAB SOFTWARE

```
>> q3
Best Solution:
     0     0     1     0     0     0     0     0     1     0

Optimized Project:
    3.4985
```

4. CONCLUSION

One of the most crucial factors taken into account for any building plan is time plus cost. The primary goal of building plan planning advantage control is to complete the structure in the allotted time whilst meeting its highest standards independently of the lowest possible cost. The employment of novel agreement methods, which provide incentives for optimising effectiveness, is steadily increasing at the moment. Due to innovative contracting techniques, there is growing push to improve plan performance, which calls for raising programme integrate quality in addition to instance and expense. For the purpose of teaching project performance, a principal contractor often subcontractors the majority of the jobs involved in the execution of the assignment. Selecting an incorrect bid that satisfies the job's requirements for time, money, and quality sources is always a complex and difficult process for the primary contractor. The following conclusion may be made: Time, money, and craftsmanship are the three unifying and conflicting goals of each project, and they are also the most important variables that need to be assessed in all construction projects. Because labour costs are dependent on length or time, it has been shown that labour costs are reduced when activity duration is shortened and work is altered or linked to other operations.

- The total cost of project 1 is 16498575.42 Rs. & duration of project is 448 days
- The total cost of reduced project 1 is 15442000.25 Rs. & duration of project is 401 days
- Due to reduction in duration of activity, project cost is reduced 6.3%.

Time, money, and craftsmanship are the three interconnected and often competing goals of every project, and they are the almost universally recognised critical elements that must be taken into account in all construction projects. Numerous studies have been conducted throughout the years to simulate the time-cost connection. Contracts now consider how well a project performs in terms of time and money. Many project activity modes for execution have been taken into consideration when building the initiative's network in order to achieve the project's goals. A project manager must make a lot of decisions since there are so many possible outcomes. An optimisation model for time-cost-quality trade-off optimisation in building projects is created in this work. In order to assist the decision maker in selecting the most advantageous combination of building techniques and modes that meet his needs, the research aims to determine the optimal cooperation among various and conflicting goals. Two example projects are used to illustrate the model formulation process. The findings indicate that the attendance technique finds the best answer in a fair amount of time. The current models provide a visually appealing solution to the structural multi-objective optimisation issue. Regarding the potential claim, it would be prudent to proceed with testing as soon as the construction is completed. Although this work is based on actual data from a plan that will soon be realised, it is unlikely to receive input will be obtained until the construction area is operational. Additionally, this approach is primarily appropriate for the growing number of performance requirements available on the market, which, in contrast to provisional ones, need a precise standard of quality regardless of the components or methods used.

5. REFERENCES

1) Rhinehart, R. (2018). Engineering Optimization: Applications, Methods and Analysis. . https://doi.org/10.1115/1.861opt.
2) J. Martin, "What Is Field Theory?1," *Am. J. Sociol.*, vol. 109, pp. 1–49, 2003, doi: 10.1086/375201.
3) M. Pereyra*et al.*, "A Survey of Stochastic Simulation and Optimization Methods in Signal Processing," *IEEE J. Sel. Top. Signal Process.*, vol. 10, pp. 224–241, 2015, doi: 10.1109/JSTSP.2015.2496908.
4) J. Red-Horse and R. Ghanem, "Elements of a function analytic approach to probability," *Int. J. Numer. Methods Eng.*, vol. 80, 2009, doi: 10.1002/NME.2643.
5) V. Batagelj, A. Ferligoj, and P. Doreian, "Direct and indirect methods for structural equivalence," *Soc. Networks*, vol. 14, pp. 63–90, 1992, doi: 10.1016/0378-8733(92)90014-X.
6) V. Cerdà, J. D. La Cerda, and A. M. Idris, "Optimization using the gradient and simplex methods.," *Talanta*, vol. 148, pp. 641–648, 2016, doi: 10.1016/j.talanta.2015.05.061.
7) X. Deng and B. Kahn, "Is Your Product on the Right Side? The 'Location Effect' on Perceived Product Heaviness and Package Evaluation," *J. Mark. Res.*, vol. 46, pp. 725–738, 2009, doi: 10.1509/jmkr.46.6.725_JMR6B.
8) T. Sangaramoorthy and A. Benton, "Enumeration, Identity, and Health," *Med. Anthropol.*, vol. 31, pp. 287–291, 2012, doi: 10.1080/01459740.2011.638684. [1]
9) A. Amirjanov and F. Sadikoglu, "Linear adjustment of a search space in genetic algorithm," *ProcediaComput. Sci.*, vol. 120, pp. 953–960, 2017, doi: 10.1016/J.PROCS.2017.11.331.
10) I. Osman and J. Kelly, "Meta-Heuristics Theory and Applications," *J. Oper. Res. Soc.*, vol. 48, p. 657, 2011, doi: 10.1057/palgrave.jors.2600781.
11) D. Dvir, "Transferring projects to their final users: The effect of planning and preparations for commissioning on project success," *Int. J. Proj. Manag.*, vol. 23, pp. 257–265, 2005, doi: 10.1016/J.IJPROMAN.2004.12.003.
12) J. Xin-yong, "Project Quality Cost Management in Construction Enterprises," *Port Waterw. Eng.*, 2008.
13) S. A. Taylor and T. Baker, "An assessment of the relationship between service quality and customer satisfaction in the formation of consumers' purchase intentions," *J. Retail.*, vol. 70, pp. 163–178, 1994, doi: 10.1016/0022-4359(94)90013-2.
14) P. O. Ophuis and H. Trijp, "Perceived quality: a market driven and consumer oriented approach.," *Food Qual. Prefer.*, vol. 6, pp. 177–183, 1995, doi: 10.1016/0950-3293(94)00028-

15) M. Thürer, I. Tomasevic, M. Stevenson, L. Fredendall, and C. W. Protzman, "On the meaning and use of excellence in the operations literature: a systematic review," *Total Qual. Manag. Bus. Excell.*, pp. 1–28, 2018, doi: 10.1080/14783363.2018.1434770.
16) B. S. Patil, P. Ullagaddi, and D. G. Jugati, "An investigation of factors impelling effective and continuous improvement of Indian Construction Industries Quality Management Systems," *IEEE-International Conf. Adv. Eng. Sci. Manag. (ICAESM -2012)*, pp. 405–410, 2012.
17) W. Tang, K. Man, S. Kwong, and Q. He, "Genetic algorithms and their applications," *IEEE Signal Process. Mag.*, vol. 13, pp. 22–37, 1996, doi: 10.1109/79.543973.
18) L. Osadciw and K. Veeramachaneni, "Sensor Network Management Through Fitness Function Design In Multi-Objective Optimization," *2007 Conf. Rec. Forty-First Asilomar Conf. Signals, Syst. Comput.*, pp. 1648–1651, 2007, doi: 10.1109/ACSSC.2007.4487511.
19) C.-W. Feng, L. Y. Liu, and S. A. Burns, "Using genetic algorithms to solve construction time-cost trade-off problems," *J. Comput. Civ. Eng.*, vol. 11, pp. 184–189, 1997, doi: 10.1061/(ASCE)0887-3801(1997)11:3(184).
20) A. Senouci and H. Al-Derham, "Genetic algorithm-based multi-objective model for scheduling of linear construction projects," *Adv. Eng. Softw.*, vol. 39, pp. 1023–1028, 2008, doi: 10.1016/j.advengsoft.2007.08.002.
21) J. Gonçalves, J. M. Mendes, and M. G. Resende, "A genetic algorithm for the resource constrained multi-project scheduling problem," *Eur. J. Oper. Res.*, vol. 189, pp. 1171–1190, 2008, doi: 10.1016/j.ejor.2006.06.074.
22) M. Haghighi, S. Mousavi, J. Antuchevičienė, and V. Mohagheghi, "A NEW ANALYTICAL Methodology To Handle Time-Cost Trade-Off Problem With Considering Quality Loss Cost Under Interval-Valued Fuzzy Uncertainty," *Technol. Econ. Dev. Econ.*, 2019, Doi: 10.3846/TEDE.2019.8422.
23) T. Wang, M. Abdallah, C. Clevenger, and S. Monghasemi, "Time–cost–quality trade-off analysis for planning construction projects," *Eng. Constr. Archit. Manag.*, 2019, doi: 10.1108/ecam-12-2017-0271.
24) [1] B. Pollack-Johnson and M. Liberatore, "Incorporating Quality Considerations Into Project Time/Cost Tradeoff Analysis and Decision Making," *IEEE Trans. Eng. Manag.*, vol. 53, pp. 534–542, 2006, doi: 10.1109/TEM.2006.883705.
25) P. V. H. Son and L. N. Q. Khoi, "Optimization time-cost-quality-work continuity in construction management using mutation–crossover slime mold algorithm," *Appl. Soft Comput.*, vol. 147, p. 110775, 2024, doi: https://doi.org/10.1016/j.asoc.2023.110775.
26) S. Isikyildiz and M. Author, "Multi-objective optimization of time-cost-quality in construction projects using genetic algorithm State of Art Gradient-based," vol. 34320, pp. 335–346, 2020, doi: 10.7764/RDLC.19.3.335.
27) G. Liu, E. W. M. Lee, and R. Yuen, "Optimising the time-cost-quality (TCQ) trade-off in offshore wind farm project management with a genetic algorithm (GA)," *HKIE Trans.*, vol. 27, pp. 1–12, Apr. 2020, doi: 10.33430/V27N1THIE-2019-0030.
28) P. Vu, H. Son, L. Ngoc, and Q. Khoi, "Optimization in Construction Management Using Adaptive Opposition Slime Mould Algorithm," vol. 2023, 2023.

29) A. Narayanan and S. cr, "Multi-objective optimization of construction project time-cost-quality trade-off using differential evolution algorithm," *Jordan J. Civ. Eng.*, vol. 8, pp. 375–392, Jan. 2014.
30) R. Eskander, S. Hafez, and Y. Abuol-Magd, "Smart optimization for mega construction projects using artificial intelligence," *Alexandria Eng. J.*, vol. 53, Sep. 2014, doi: 10.1016/j.aej.2014.05.003.
31) A. Saif, S. Abbas, and Z. Fayed, "The PDBO Algorithm for Discrete Time, Cost and Quality Trade -off in Software Projects with Expressing Quality by Defects," *ProcediaComput. Sci.*, vol. 65, pp. 930–939, Dec. 2015, doi: 10.1016/j.procs.2015.09.065.
32) R. Vallon, B. Estácio, R. Prikladnicki, and T. Grechenig, "Systematic Literature Review on Agile Practices in Global Software Development," *Inf. Softw. Technol.*, vol. 96, Dec. 2017, doi: 10.1016/j.infsof.2017.12.004.
33) S. Yang, D. Yu, Y. Liu, and B. Sun, *Multi-objective optimization of decoration engineering construction organization based on genetic algorithm*. 2024. doi: 10.21203/rs.3.rs-3871881/v1.
34) H. Huynh, T.-H. Nguyen, H. C. Pham, T.-M.-D. Huynh, T.-C. Nguyen, and D.-H. Tran, "Multiple Objective Social Group Optimization for Time–Cost–Quality–Carbon Dioxide in Generalized Construction Projects," *Int. J. Civ. Eng.*, vol. 19, pp. 1–18, Feb. 2021, doi: 10.1007/s40999-020-00581-w.
35) P. Ray, D. Bera, and A. Rath, "Time Cost Optimization Using Genetic Algorithm of a Construction Project," 2021, pp. 909–927. doi: 10.1007/978-981-15-4577-1_76.
36) S. A. Banihashemi, M. Khalilzadeh, A. Shahraki, M. Malkhalifeh, and R. Ahmadizadeh, "Optimization of environmental impacts of construction projects: a time–cost–quality trade-off approach," *Int. J. Environ. Sci. Technol.*, vol. 18, Jul. 2020, doi: 10.1007/s13762-020-02838-2.