TIME DELAY AND COST OVERRUN ANALYSIS: OPTIMIZATION USING GENETIC ALGORITHM IN CONSTRUCTION PROJECTS

A Thesis

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CERTIFICATE

This is to certify that the work which is being presented in the project titled ***"Time Delay and Cost Over-Run Analysis: Optimization using Genetic Algorithm in Construction Projects"*** 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 **Jyoti (Enrollment No.162609)** during a period from July 2017 to May 2018 under the supervision of **Dr. Gyani Jail Singh** (Assistant Professor), Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

In India, the construction site is the second biggest economic industry after that to agriculture. The delay in the construction industry is a worldwide phenomenon. Delays and cost overruns in most construction projects are either simple or complex. In order to avoid project delays, various factors causing delays should be properly analyzed and managed. The report discussed delays in construction projects; therefore, many delays in many projects were considered. The questionnaire was prepared on the basis of various factors that caused delays in the construction industry. The collected list contains 86 reasons for the delay, divided into seven different groups. The questionnaire was sent to different owners, consultants and contractors to sort the various factors. These data are used to analyze the Relative Importance Index (RII) for different delays and cost overruns.

The purpose of this study is to compile the views and results of different researchers, clearly showing that each study group evaluates different factors differently, resulting in delays and cost overruns. As a result, these factors rank the opportunities / impacts of the construction project accordingly. In this research work, an optimization algorithm named as Genetic algorithm (GA) is used to reduce the duration as well as the cost of the construction project. The simulation is performed in MATLAB environment and the cost as well as time is reduced for the I.T.I construction site in Shimla.

Keywords: *Delay, cost, GA, RII,II, construction sites.*

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ABBREVIATIONS

GUI	Graphical User Interface
RAM	Random Access Memory
MATLAB	Matrix Laboratory
DI	Delay Index
RNC	Reason for Non-compliance
CPM	Critical Path Method
I.I	Impact Index
R.I.I	Relative Impact Index
TCO	Total Cost of Ownership

CHAPTER 1

INTRODUCTION

1.1 GENERAL

India is a developing country and the projects construction and factories plays an important role. In the construction projects, time and cost are the two most important considerations in the planning of every project. The project's goal is to complete the project on time and to complete the project's objectives within the budget. Finishing a project in the shortest amount of time and at the lowest cost is a key element of any construction. Over time, the complexity of the project also increases, so the need for project manager is constantly increased in order to minimize the delay and cost for obtaining the quality work. The key path to this network is an important issue for the project dispatcher as it relates to the duration of the entire project.

The project manager is very much concerned about the critical path the project completed on time, especially if the delay would result in a fine (liquidated damages, opportunity costs and loss of goodwill). It is required to reduce the critical activity so that delay in construction is minimized. This is possible by increasing the number of resources above the ground level.

The delay is the case of an unfinished project within the contractual period of the contract. The project is going according to plan and is seen as a common problem in shrinking projects. It is rare to see a construction project completed on time. The delay can result in work interruption and increased productivity losses, with the exception of project completion delays, time-related costs, third-party claims, waiver or termination of the contract. Delayed costs are high and always cause disputes and claims. Therefore, it is important to track the progress of the project to avoid the possibility of delay or identification at an early stage.

When there are some delays, you may need to compress key activities by adding more active resources to above normal levels. Often, by allocating more resources at the expense of a higher direct cost of activity, you can accelerate the performance of some or all of your activities, or shorten the duration. The collapse of such activities can be obtained by working more shifts, extending work days, using larger and more efficient equipment and increasing the size of the workforce. Therefore, the main focus of the project progress planner is how to find the most cost-effective way to complete a project within the stipulated time of completion. This type of problem is often referred to as a time cost trade-off.

The relationship between time and cost is called the time cost trade-off curve. There are many factors that affect project time and cost. Due to inflation, economic and social pressures, labour performance, contractor implementation mistakes, design mistakes, natural events such as climate change and other existing uncertainties, the time and cost of the activities may be subject to significant changes. Therefore, the total project time and costs can vary widely depending on these uncertainties.

In most of the cases, the project was completed for the first time, forcing us to use specialist advice to predict project parameters. Experts use their own judgment, experience and project information as per their knowledge. Practically, language terms such as roughly, more or less or about often appears in the statements used by these experts. These terms apparently exhibit some inaccuracy that naturally leads to a range of possible values, rather than a deterministic estimate using a single value. So, uncertainty and project parameters are indivisible. The different options for possible duration and activity costs can be associated with a project; the problem is finding the best solution. As a combinatorial optimization problem, considering the number of possible permutations involved, finding the optimal decision is difficult and time-consuming. The research aims to develop an effective way to achieve project time-cost optimization with optimal time and cost, combined with the ambiguity of the real-world dynamic conditions.

1.2 TYPES OF DELAYS

The delay is a serious problem for the construction industry. It is expensive for both the contractor and developer. The developer loses money by missing potential revenue Project use and contract management and management costs increase management. The loss of the contractor was due to the increase in overhead and bundling the capital. Therefore, to identify the factors that cause the delay in the construction project is of crucial importance.The delay are mainly classified into four different types as per their operation:

1. Compensable delays
2. Non-excusable delays
3. Excusable delays
4. Concurrent delays

1. Compensable delays

These types of delay occurred because of the agent or the owners. The general form of compensable delay is insufficient drawings and the requirements, but the compensable delay may occur from the agent's failure for responding in a timely fashion for requesting regarding the shop drawings or the information, the agent's variation in materials or design and the disruption of owner's or amendments in the work sequence. The contractor is answerable to additional time and the additional money that resulted as of the compensable delays.

2. Non-excusable delays

Generally, these are occurring via contractors/sub-contractors or the suppliers of materials with no owner's fault. The contractor may try compensation for the delay of the supplier or the subcontractor, but also when the compensation is suitable for the owner. So, non-compensable delays normally resulted in no extra money and no extra time being approved to the contractor.

3. Excusable delays

These are also termed as force majeure delays with the third basic delay category. Excusable delays are generally known as 'Act of God' as it is not the accountability of some exact party. Number of contracts allow having time extension for any excusable delay with no extra money.

4. Concurrent delays

If one factor has delayed the construction, than it becomes simple to measure time as well as money being resulted from that very user. The most difficult situation is when the one of the factor delays the project at similar time or the time of overlapping period known as concurrent delays.

1.3 TYPES OF COSTS

All projects incur costs. Project costing is a key factor in making project decisions. As a project manager, you need to be aware of the type of costs that impact your project.There are five types of costs in a typical project:

1. Fixed
2. Variable
3. Direct
4. Indirect
5. Sunk

1.Fixed Costs

Fixed costs are those that don't change for the duration of the life-cycle of a venture.

2. Variable Costs

Variable costs, as the name suggests, are costs that change during the project life-cycle. Construction projects usually have a long duration and can easily span several years.

3. Direct Costss

Direct costs are expenses that come out of the project budget directly. For example, if you have outsourced some of your development work, the developers are expected to put in a specific amount of time, which is then billed for. The developer salaries are direct costs.

4. Indirect Costs

Indirect costs are those that are shared across multiple projects. Indirect costs are sometimes also referred to as Oversight costs. For example, in software development projects, it is common for a project manager or an architect to be partially allocated across several projects. Hence, the cost of the project manager or architect will be shared among the projects they are allocated to.

5. Sunk Costs

Sunk costs are those that have been incurred in a project, but have not produced value towards the project's objectives.

1.4 TIME AND COST OPTIMIZATION TECHNIQUES

1.4.1 Heuristic Methods

Heuristic approaches are non-computational approaches that require less computational effort. Since they are predicated on the rules of thumb, they could engender plausibly good solutions albeit they do not ascertain optimality. Heuristic approaches have been applied in solving a variety of quandaries due to their simplicity and facilitate of application. However, when applied to construction TCO, heuristic approaches are only felicitous for minuscule projects, as each iteration involves four steps: to recognise CPM; to cumulate different activities on CPM; to calculate respective cost and cull the least one; to set reduction time and re-test CPM. Consequently, the number of tribulation may elevate sharply with an incrementation in the number of activities, and the calculation would be prone to error. Moreover, the solutions engendered do not provide a range of possible solutions and cannot guarantee to be the ecumenical optimum

1.4.2 Mathematical Methods

Mathematical methods convert heuristic rules into constraints and objective functions, and use linear programming (LP), integer programming (IP) or dynamic programming to solve the quandary. Linear programming can only be used when postulating a linear relationship between time and cost for each activity in the network. Albeit these methods are more efficient and precise than heuristic methods, they require a plethora of computational effort

when the number of activities becomes too immensely colossal or the network becomes too involute. Moreover, formulating constraints and objective functions is time-consuming and prone to errors. In fact, the popular software for mathematical methods conventionally has a inhibited number of variables and constraints. As a result, only a few construction managers utilize them to solve astronomically immense and involute quandaries encountered in day-to-day practices.

1.4.3 Genetic Algorithms

The GA approaches codify the time and cost of each activity germane to TCO as a gene along a finite-length string. The GA uses objective functions rather than derivatives or other auxiliary erudition. In integration, the GA utilizes probabilistic transition rules as compared to other deterministic models. All these should contribute to the robustness, and hence result in a more precise TCO model over the Time-cost optimization heuristic or mathematical techniques. An extensive literature review has revealed that GA approaches have been utilized in solving construction TCO quandaries.

1.5 NEED OF STUDY

Different construction sites will face a variety of issues and delay the project, which is one of the major issues. Often, if a project is postponed an extra cost is added into the construction of project. The usual practice is to use the percentage of the project cost as a subsidy for the profit or contract price, which is usually based on judgment. There is a different risk of delays in the project. For a customer or owner, a deferral means that the asset cannot be used when the asset is intended to be used, resulting in an alternative cost of accommodation being certified or deferred income from the asset. Financing costs for the project may also increase, and delays may increase the contractor's claim based on the contractual assignment of the risk of delay. For contractors, the delay means an increase in overheads, such as on-site staff and facilities, and the affordability of the supply chain, which can mean delaying reliance on delays.

Delayed payment and bundling of resources can also create cash flow issue and economic failure risks. Thus it become important to analyse the delay failure in construction site,

which affects the time and cost. In order to avoid project delays, various factors causing delays should be properly analyzed and managed. Different recommendation or delay management strategies will help the construction project proceed smoothly. There has been some research done in other developed countries, and few in India. As a result, Indian construction projects need to conduct more surveys to recommend guidelines to reduce project delays.

1.6 SCOPE OF THE PROJECT

This research is needed to assess the degree of understanding and the use of these deferred concepts for emergence and on-site operations. The scope of the project includes different reasons for investigating the delay in construction projects in India.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

Delay happens in most construction project. Few researchers began to focus their attention on finding a solution to existing shortcomings of delay analysis techniques. A number of solution method and delay analysis techniques were proposed.

2.1.1 Time delay analysis

Aziz [1] studied the Ranking of Delay Factors in construction project after Egyptian Revolution and conclude through questionnaire survey number of factors were identified in construction projects. Entirely, 99 (ninety-nine) measures have been considered too short out the questionnaire survey and then these measures are recognized and classified into nine main class. The data have been collected by the experts from private, community and the construction held in the locality. The analysis of the data has been performed on the basis of RII (Relative Importance Index) ranking & simple %. The classes have been made as per the level of delay taken after the Egyptian revolution dated on 25/1/2011. The factors that are considered in this work are depends upon consultant associated measure class, contractor associated measure class, Design associated measure class, equipment associated measure class, external associated measure class, labor associated measure class, Material associated measure classes, owner associated measure class and project associated measure class. It is concluded that the delay can be minimized:

1. The developer must have to pay the payment to his contractor on time.
2. It is prohibited to pay any type of inducement for any beneficiary.
3. Contractors shall not be granted the job in which they are unable inadequate expertise.

4. The contractor should also pay more attention to preparing effective plans and arrangements. During construction, plans and programs may be revised if necessary. Only well-planned and programmed projects can be successfully implemented.
5. Site management and supervision should be properly conducted. Managers should be assigned to complete the project within the required timeframe while meeting the required quality and estimated costs
6. The delivery of on-site construction equipment and materials shall not be late for the scheduled sequence of work.
7. In general, there may be many subcontractors working under the lead contractor for large projects. If a subcontractor performs with their capacity and reliability, the project can be completed on schedule duration. If subcontractors are unable to fulfil their contract due to their lack of experience or ability, the project may face an extension. High sub-construction may result in a high risk of delays;
8. Inspection and testing by consultants is a significant activity during construction as lower inspections may result in lower work quality.

Rauzana [2] discussed that the construction of a project is mainly depends upon the three factors, namely the owner, contractor and the planner of project. The main aim of the owner is to complete the project on time without any obstructions. Before starting the project, every project is planned that how to continue the project, resources, manpower, etc. The problem arises if the planned work is not scheduled properly. The data has been collected from the distributing questionnaires and from the 20 contractors. The secondary type of information has been gathered from the public work. From the data obtained it has been concluded that what are the factors that are responsible to delay the project progress. The score is given on the basis of influence.

1. For very low impact the score is 1
2. For medium impact the score is 2
3. For high impact the score is 3
4. For very high impact the score is 4

The end result showed that the foremost reason of the factors, which influence delays in the finishing point of projects in Aceh Besar is community and cultural factor.

The author's take the questioners list that comprises of personal data, project data and the inhibiting issues comprises of the issues taken in completing the project. The data are processed in SPSS 21.0 and determine the factors that are responsible to delay the construction of project.

To determine the delay mean of delay has been performed by using the formula written below:

$$E_m = \frac{\sum_{j=1}^{m} Y_j}{m}$$

Here E_m signifies the Mean

m- total number of respondents

Y_j-Respondents's frequency

J= index class of the respondents (1,2,3……)

Y1- Answer frequency very high impact

Y2- Answer frequency impact

Y3- Answer frequency medium impact

Y4- Answer frequency very low impact

It has been concluded that the main measure which is considered in the completion of the Acch Besarwas project is the mean value of 3.50.

González et al [3] analyzed the delay occurs in the construction sites that is turns affects the cost of the project. In this research, the authors collect data at the beginning of every week by considering the critical and noncritical conditions abbreviated as (A_c and A_{NC}). The programmed activities have been analysed by the manager at the end of the week. It

has been analyzed that the work such as physical, quality wise is performed or not. If the work is satisfactory, then stopping the work otherwise go to the next step. In the next step the manager has been analyzed the cause of delayed projects and worked upon it. The region of non complacence (RNC) that were considered are listed below:

Table 2.1. Reason for non-compliance (RNC) [3]

RNC	Narration
Design	Wraps up the delay cause with the issues of documentation and project design, like omissions, changes, errors, details lacking in drawings and complexity.
Labour	Comprises of low productivity, absenteeism and worker's shortage.
Equipment and Materials	Delay leads to shortage or lack of materials and machines for externals reasons which are not attributable for the supplier failure.
Subcontracts	Delay resulted in reduced productivity or deadlines being missed by the subcontractors.
Weather	Consists of unfavourable weather condition delay that affects the project normal operation.
Planning	Occurred by deprived planning, project scheduling, control, and project disruption because of oversights or the mistakes in the process of project planning.
Accomplishment of work	Covers implementation tasks errors and unfortunate methods of construction.
Others	Includes attributable delay to the reasons not completed by the existing RNCs.

The RNC has been measured for every incomplete work in a week. This will helps to analyze both the critical and global actions. The delay between planned work and actually scheduled has been calculated by using the delay index (DI). The technique that has been used has been shown in figure below.

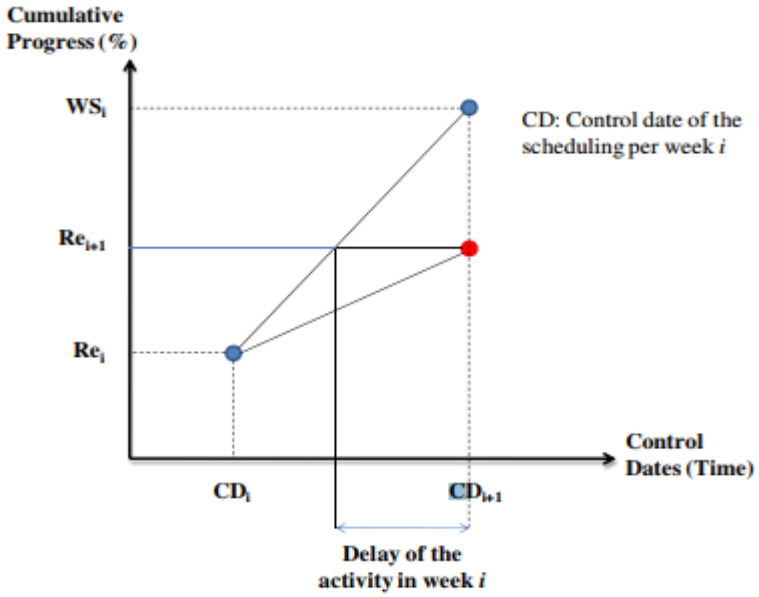


Fig. 2.1. Delay index computation [3]

Here WSi signifies the growing planned progress for a taken week.

Rei represents week initial point.

Rei+1- the progress lies between Rei and WSi

Thus DI can be calculated by using the formula written below:

$$Delay\ index = \frac{WS_i - Re_{i+1}}{WS_i - Re_i}$$

Alaghbari et al [4] The main issues causes to delay in the construction site in Malaysia. Initially a questionnaire set has been prepared and studied. The researchers took 31 measures that are set up into four main classes. The classes are comprises of contractor, owner, consultant and outer aspect. It has been found that the cost is the primary problem

whereas the delay is the secondary problem. The reason of delay has been ranked as per their preference and then classifies the kinds of delay.

Table 2.2. Factors affecting the construction project delay in Malaysia [4]

Factors	Means	Rank
Budget problem	1.44	1
Lack of materials on location	1.67	2
Inferior site management	1.67	2
manufacturing mistakes and imperfect work	1.71	3
Material delivery delay on site	1.73	4
Problems of co-ordination	1.83	5
Lack of labour	1.85	6
Less labour outcomes	1.87	7
Poor skills and knowledge of workforce	1.88	8
Shortage in the skills of sub-contractor	1.96	9
Shortage in the skills of site-contractor	2.10	10
Shortage of tools as well as equipments at the site	2.22	11

Kraiem et al [5] discussed the time factor that is considered as one of the main components in the construction site. The researchers mainly focused on concurrent delay. Here, concurrent delay means, that two or more than two delay occurs on site

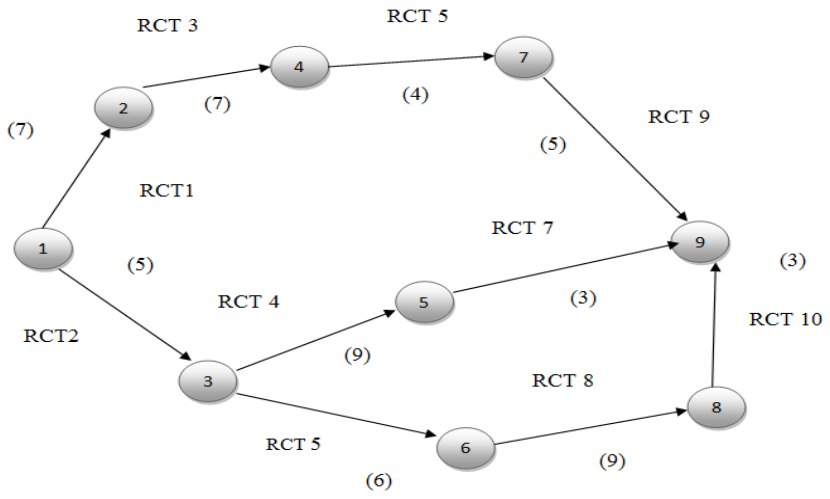


Fig. 2.2. Network [5]

The concurrent delay is divided into four types named as:

1. Excusable and non-excusable delay.
2. Excusable and compensable delay.
3. Excusable, non-excusable and compensable delay.
4. Non-excusable and compensable delay.

An example of concurrent delay is explained below:

Let us imagine that the developer is not capable to provide the required materials on time and on the same day, the labours that installed materials are on strike. This is known as concurrent delay that comprises of compensable delay and executable delay. The network that has been considered by the researchers is shown above.

Assaf et al [6] outlined the major reason of delayed in huge building projects continued in Saudi Arbia (S.A) along with their relative importance. It has been determined that contractor, and developer are usually agreed on the position of the individual delay issues. The authors performed the work in two classess, namely in first phase study of previous work has been done and in second phase a questioner has been made as per the delay observed in the construction sites. The data has been collected from the building project constructed in Saudi Arabia. The cost of the project is higher than 10,000,000 Saudi riyals. The gathered data has been analyzed by using an important index that have been determined by using the formula written below:

$$II = \sum_{j=1}^{4} \frac{a_j x_j}{3}$$

Here, II represents the importance index, a_j represents the constant expressing the weight of the jth response. x_j represents the response of frequency.

In this paper, the researchers considered 56 reasons that are categorized into nine groups. The researchers have found that the financial class has the highest rank that causes delay and the lowest rank is given to the environment class.

Kadry et al [7] discussed that construction delays and cost overrun factors are based on two parallel namely complementary data collection and analysis processes. The first is quantitative flow. In Quantitative Data Analysis a detailed analysis based on the project progress using the window delay analysis method has been performed. The analysis is a review of the project update description to capture the root causes of the various delay events. Quantitative analysis clearly quantifies the actual level of delay in each project for individual cause of delay and is a key strength of the study as compared to most previous reviews that rely on qualitative assessment of the causes of delay. The parallel qualitative analysis process is based on a semi-structured interview with 18 experts covering 36 projects spanning 16 countries with high geopolitical risk indices. Working in areas with high geopolitical risks poses unique challenges that have led to unconventional delays in construction. Data is collected from the18 research experts interviewed.

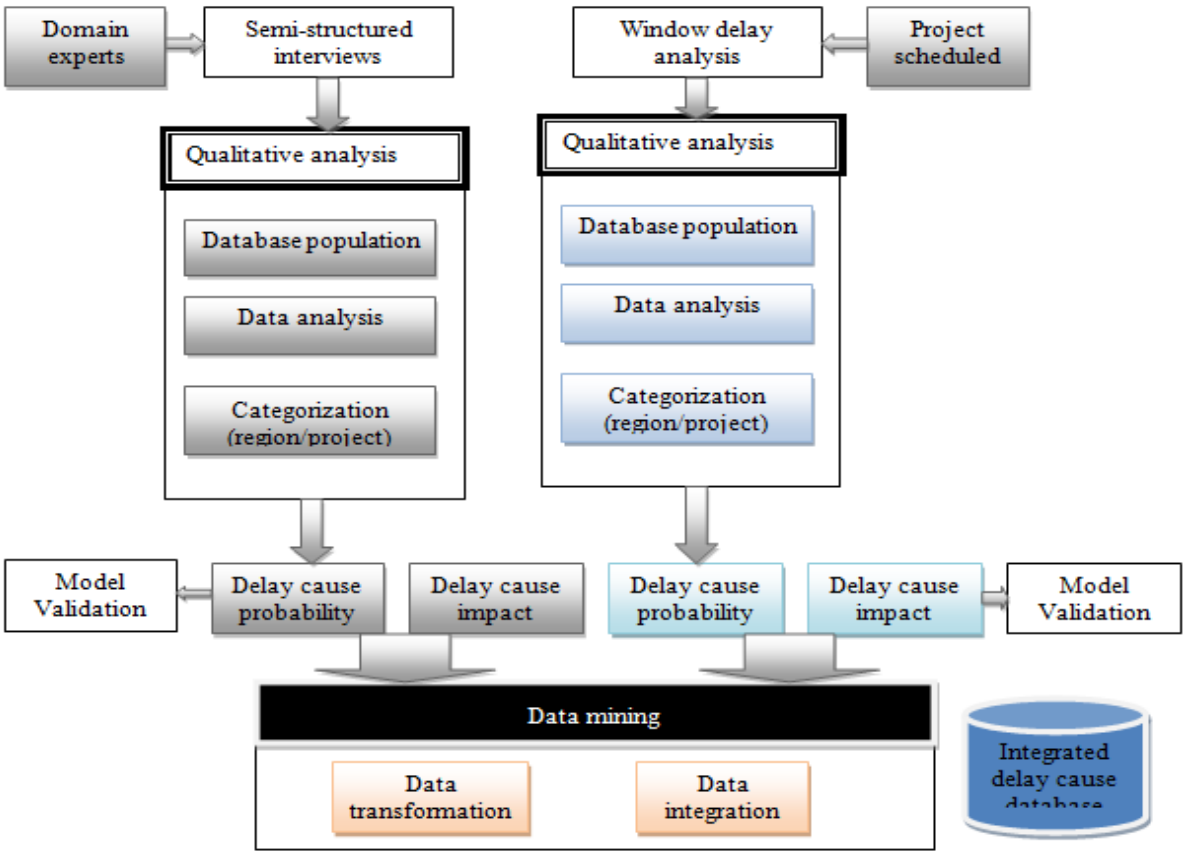


Fig. 2.3. Methodology [7]

The results of this analysis are incorporated into the database and this database can be used to predict the most likely reason for the delay based on the similarity of the matches with the existing ones. Such knowledge can help to create an appropriate environment so risk mitigation and treatment actions can deliver the desired results. The difference between qualitative and quantitative is to reflect the method used to quantify the impact of each delay on the project, not the actual number of projects used.

Abd El-Razek et al [8] concluded that the main reasons for the delay are believed to be that the contractors financed the construction during the construction period, the contractor pays the delay, the design changes of the owners and agents during the construction period, partial subsidies during the construction period, and management without the professional construction contract. Contractors and owners do not agree with the reason for the delay when the consultant is in the middle.

Salunkhe et al [9] studied a number of methods that affects the construction of delay factors. Every study has its own analytical scheme that provides unique outputs. These outputs are derived form the questioner data. A number of statistical techniques such as RII (Rank Correlation Coefficient, Relative Importance Index), II (Important Index), FI (Frequency Index), SI (Severity Index) and MS (Mean score) are analyzed to know the delay effects in construction projects.

Marzouk et al [10] analyzed the causes of construction delays in Egypt. The feedback of construction experts obtained through interviews and questionnaire surveys. Frequency Index, Astringency Index, and Paramountcy Index computed and according to the most astronomically immense value of them the top ten delay causes of construction projects in Egypt are conclude. Statistical analysis carried out utilizing analysis of variance ANOVA method to test delay causes, obtained from the survey. The most prime delay causes groups of construction projects in Egypt are arranged according to their acceptation to five levels Very High, High, Medium, Low, and Very Low. The survey results discussed. Determinately, commendation has made to construction projects, parties to carry out delay debasement in construction projects.

Hamzah et al [11] studied showed that the authentic progress of a construction project is more gradual than the orchestrated schedule or tardy finish of the projects. The magnification of delay factors, not only circumscribed to technical factors, but additionally factors in project management proportion both from the aspect of the processes involve and performance of human postures, mentality, skills and comportment.

Amoatey et al [12] studied showed that the critical factors that contribute to project delays in Ghana are; delay in payment to contractor/supplier, inflation/price fluctuation, price increases in materials, inadequate funds from sponsors/clients, variation orders and poor financial/capital market. The critical effects of delays are cost overrun, time overrun, litigation, lack of continuity of client and arbitration. Measures aimed at reducing cost of housing projects in Ghana can translate into paramount benefits to the poor and support achievement of regime objective of providing affordable housing to low income denizens. The results will avail project managers and policymakers appreciate the effects of these delays on project outcomes and hopefully amend the efficiency of project management in Ghana. It will withal provide academicians in Ghana and other developing countries with another case on causes of state housing construction delays from a developing country's context.

Orangi et al [13] concluded that the cost overrun and time overrun issues in the linear construction projects in Victoria, Australia so as to develop felicitous erudition-predicated management by rational project orchestrating protocols, control and obviation measures Perpetual research revealed a set of root causes in Victoria-predicated pipeline projects, which include design changes, design errors, poor communication, customer/ end-utilizer cognate issues, subsurface investigation inadequacies, issues regarding sanctions/ approbations, weather conditions, procurement delays, site management quandaries, subcontractor issues, rework, cultural and heritage management issues. Rational orchestrating with systematic risk management arrangements will be subsidiary for efficacious management of infrastructure projects in Victoria and elsewhere similarly.

2.1.2 Cost overrun analysis

Aljohani et al [14] The on cost overruns in construction projects in different countries and identifies the main underlying causes. A total of 173 causes of overruns were identified in 17 cases, mainly due to frequent design changes, financing of contractors, delays in payment of completed work, lack of contractor experience, underestimation of costs, inadequate bidding documents Poor material management.

Authors have studied 17 project phases to know the cost over-run. But the researchers has found out that out of 17 projects the cost over-run is find in only 6 projects. The amount of factor being considered from 16 studies has reached 366 factors.

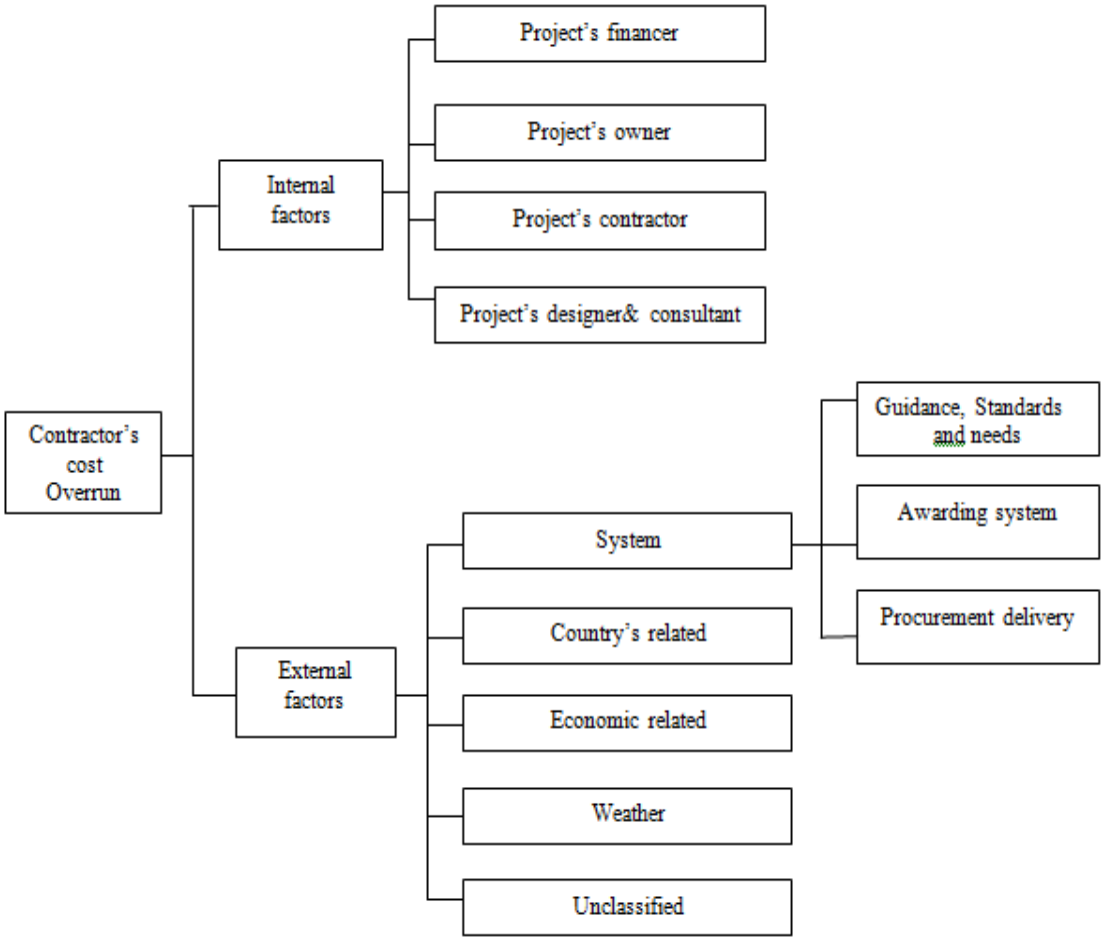


Fig. 2.4.Cost overrun causes [14]

When the factors are removed which are significant a duplication, and the integrated factors having a same meaning jointly, the decreased number of factor is 175 and the classification is as per the headline as depicted in below figure. The causes are accordingly categorized as Internal and external projects. Every class is consisted of different sub classes, project owner, project finance and the consultants are sub classified for the internal reasons whereas system, economic related, country related, weather related and unclassified are the sub categories for external causes.

Internal factors are categorized into below sub-factors.

1. Project's financier
2. Project's Owner
3. Project's Contractor
4. Project's Designer and Consultants

Similarly, the External Factors can be categorized into below factors:

1. Country Related
2. System
    a) Guidance, standards and needs
    b) Awarding system
    c) Procurement delivery
3. Weather
4. Unclassified

Rambodu and Verster [15] researched the factors affecting cost overruns, and conducted a questionnaire survey and personal interviews with professionals in the construction industry. The survey investigated the factors that affected the excessive cost of public sector construction projects. The results show that the factors that affect the cost of construction projects can be divided into three kinds: the very critical factor, the moderate key factor and the less critical one. The results will significantly reduce the occurrence of cost overruns and improve cost-effective industry projects.

Subramani et al [16] conclude the variety of cost overrun factors by using questionnaire survey. Through the questionnaire to draw a variety of cost overruns. The reasons are listed based on the probability of occurrence and the severity of the impact. The importance of each cause is based on the cumulative effect of occurrence. The result has been slowdowns in decision making, poor schedule management, material / machine price increases, poor contract management, imprecise estimation methods, and long lead time for design and bidding / tendering were the main reasons for the cost overruns.

Katre and Ghaitidak [17] surveyed various research papers and divided the work into two parts named as factors influencing programme overruns of projects and factors influencing cost overrun. The aim of this study is to find the influencing factors that are Time and cost overruns in the buildings project. The research goal has been achieved Passed valid questionnaires. The study identified , (1) low labour productivity (2) delay in the settlement of bills (3) Lack of equipment maintenance (4) Material procurement programming, strikes, riots and so on external factors are the most critical factors that affect the project's extension. This study shows that delay in the primary handling on the site is main factors that lead to cost overruns and being found that contractors delayed material delivery and equipment resulting in cost overruns. This research is also clarify the high cost of price inflation overruns.

For the owners, the reason for the impact of the project is the plan changes during the construction of the project; the ability to understand technical terms etc. Also from a financial point of view, if the owner delays the payment of completed work will also affect the further work of the project. Improper planning and scheduling of the contractor has a greater impact on the duration and lack of the project. Experience can affect the ability to make decisions, leading to rework and financing problems. Incorrect drawings of consultants, later revision of specifications, less coordination with contractors Time limit in the project.

1. Training courses and workshops should be conducted to improve the management skills of project participants.
2. Material prices and labour rates should be continuously updated.

3. Adequate time should be known for preparing possibility studies, planning, design, information documentation and tender submission. This can be used to avoid or reduce delay
4. Progress payment should be paid on time.

Mahadik [18] studied the various factors affecting the project cost by suing cost reduction approach. In this paper, researchers classified cost into three types named as Fixed cost, direct cost and sunk cost. The cost can be reduced by using the following techniques:

1. Value engineering.
2. Material engineering.
3. Budget control.
4. Cost optimization scheme.
5. Cost mitigation methods at site.

2.1.3 Time and cost optimization using genetic algorithm

Tatar and Patil [19] established a non-linear program to know the best possibilities that can be applied on the project to reduce time and cost. Thus, a hypothetical analysis has been made by the authors that all the functions are linear. The research has been depends upon the generally used technique known as the critical path technique. A number of terms has been considered to reduce time,cost parameters some of them are:

- Normal cost
- Normal time
- Crash cost
- Crash time
- Critical path

Crash cost has been determined by using the formula written below:

$$Cost\ slope = \frac{Crash\ cost - Normal\ cost}{Normal\ time - Crash\ time}$$

Here,

C_T Signifies the Crash time of an action

C_c Signifies the Crash cost of an action

N_T Signifies the Normal time of an action

N_c Signifies the Normal cost of an action

It is concluded that the NLIP scheme perform well than the deterministic method. It is suggested to utilize the Meta heuristic approach to decrease the computation time and to enhance the speed.

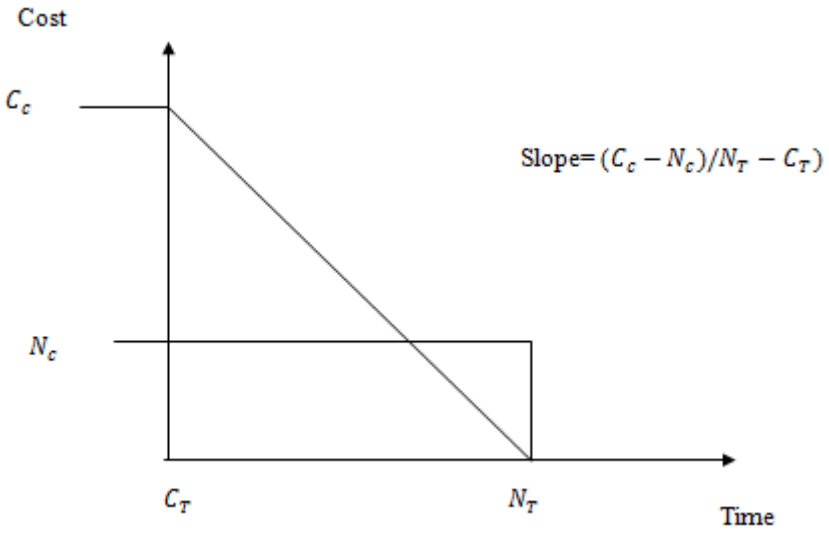


Fig. 2.5. Activity cost function [19]

Le-Hoai et al [20] Arranged duration and cost of project closing is the two main causes of victorious project and victorious project management. This research has involved a questionnaire survey to elicit the sundry technically skillful persons. The causes of this situation by interviewing 87 Vietnamese construction experts. Twenty one causes of delay and cost overruns right with the building and industrial construction project where conclude and ranked with reverence to frequency, rigor and consequentiality indices. Spearman's rank correlation test prove that there are no differences in the viewpoints between three

principal parties in the project. A contrast of causes of time and cost overruns done with sundry culled construction industries in Asia and Africa.The factor analysis technique applied to relegate the causes, which yielded 7 factors:

1. Slowness and Lack of constraint
2. Incompetence
3. Design
4. Market and Estimate
5. Financial ability
6. Government
7. Worker.

Li and Love [21] Time delay and cost over-run quandaries are arduous to solve because they do not have unique solutions. If a project is running abaft the plan, one option is to compress some activities on the critical path so that the final completion time can be met. As combinatorial optimization quandaries, time-cost optimization quandaries are opportune for applying genetic algorithms (GA). Two methods have been used to solve time-cost optimization quandaries. One method requires one to visually identify several activities on the critical path and enumerate possible alternatives of allocating minimize time to the activities, each alternative representing a feasible solution in which activities are compressed to meet the reduction of the total project duration. Linear programming algorithms employ probing methods to identify local optimum solutions for the quandary. In authentic-world time-cost optimization quandaries, time reductions on the critical path may affect other paths through the network.

Zheng et al [22] consummating a construction project with the least time and cost is critical in a competitive environment. To reduse the total costs related with schedule compression, contractors are often urged to establish the optimal time and cost relationships for construction activities when orchestrating decisions are made. Being a potent implement to locate the ecumenical optimum (rather than local optimum), the the Genetic Algorithms (GA) could be adjusted to set up the wellness of arrangements by assessing the target capacity and its imperatives.

2.2 SUMMARY OF LITERATURE REVIEW

1. Find out the most consequential reason of time and cost overrun for perpetual residential projects.
2. Establishing a set of mundane consequential causes of the delay and cost overrun of residential projects.
3. Common issues that are attributed to time and cost overrun in projects.
4. The study focuses to formulate recommendations for amending construction performance.
5. Optimization of time and cost by utilizing Genetic Algorithms.

2.3 OBJECTIVES

Objectives of the present work based on the literature review are:

1.To identify delay and cost over-run factors in construction projects.

2.To quantify relative importance of time delay and cost over-run factors, and to demonstrate the ranking of factors, synthesis by using GUI (graphical unit interface) and categories according to their importance level on delays.

3.A case study for the cost optimization of the time schedules considering realistic project characteristics such as nonlinear nature of the cost-duration relationships using GA (Genetic algorithms).

2.4 ORGANIZATION OF THESIS

The first chapter has described the general overview of the time delay and cost overrun analysis, their need, features, scope and types of delays and types of costs involved in construction projects.

The second chapter presents the literature review in the field of time delay and cost overrun along with their outcomes and methodology process. The summery of work done by different authors have been discussed on the basis of which objectives are made.

The third chapter comprises of work plane that is prepared before the staring of the thesis and the methodology of the proposed work. The flow of the work performed from the starting of the work up to the process to calculate the performance parameter.

The fourth chapter described the results obtained for the proposed work.The performance of the time and cost in construction. Also the find out the critical factors effect the delay and cost overrun in projects.

The fifth chapter presents the conclusion and future work of the proposed work followed by the references and screen shots of the code used in the proposed work

CHAPTER 3

METHODOLOGY

3.1 GENERAL

The purpose of the study is to critically review and identify the applicability of past studies on determining the factor causing time delay and cost overrun in current projects. When projects are delayed, they are either extended or accelerated and therefore, incur additional cost.

The questionnaire was designed to evaluate the importance of the identified causes. The questionnaire was distributed to contractors, consultant and clients. In the field survey respondent were asked to indicate the level of importance of each cause using five points like scales ranging from 1-5.

The questionnaire study conducted the investigation in two phases. The first phase included a literature search. The first phase identified 45 causes for time delay and 41 causes of cost over-run in construction projects. In the second phase a questionnaire was developed using these delay causes. The scope was limited to, industry expert, contractor, architecture and public owner. Total 25 responses were collected, Out of these, 1 response was collected by the Project Manager and 9 responses were collected from the Site Engineers, 10 responses by contractor,2 by owner and 3 by the consultant. Their comments were used to revise and prepare the final questionnaire.

Responses to the questionnaire were then collected and analyzed. The analysis included ranking the problem in terms of degree of occurrence and level of influence by using GUI in Mat lab.

3.2 WORK PLAN

The research area of this dissertation is time delay, cost over-run analysis in construction projects. Initially the researcher papers are studied and the information related

to our projects are gained and hence the project work is started. From the questionnaire, literature survey and experts find out the factors causing delay, cost over-run. Then, the data collected that are responsible for delays and cost over-run of construction projects. From the collected data through GUI critical factors are finding out which cause delay and cost overrun of the projects. Obtaining results and analyzing the factors causing delay using:

- Importance index by using mat lab (Graphical user interface)
- Relative importance index.

After finding the critical factors of time delay and cost overrun, the construction site is selected. After the investigation of site, there are identifications of the major components of the project to fit the site. After the completion of site selection and screening of the project, GA is implemented in MATLAB. There is reduction of cost and time for the original cost of the project more efficiently with the help of Genetic Algorithm.

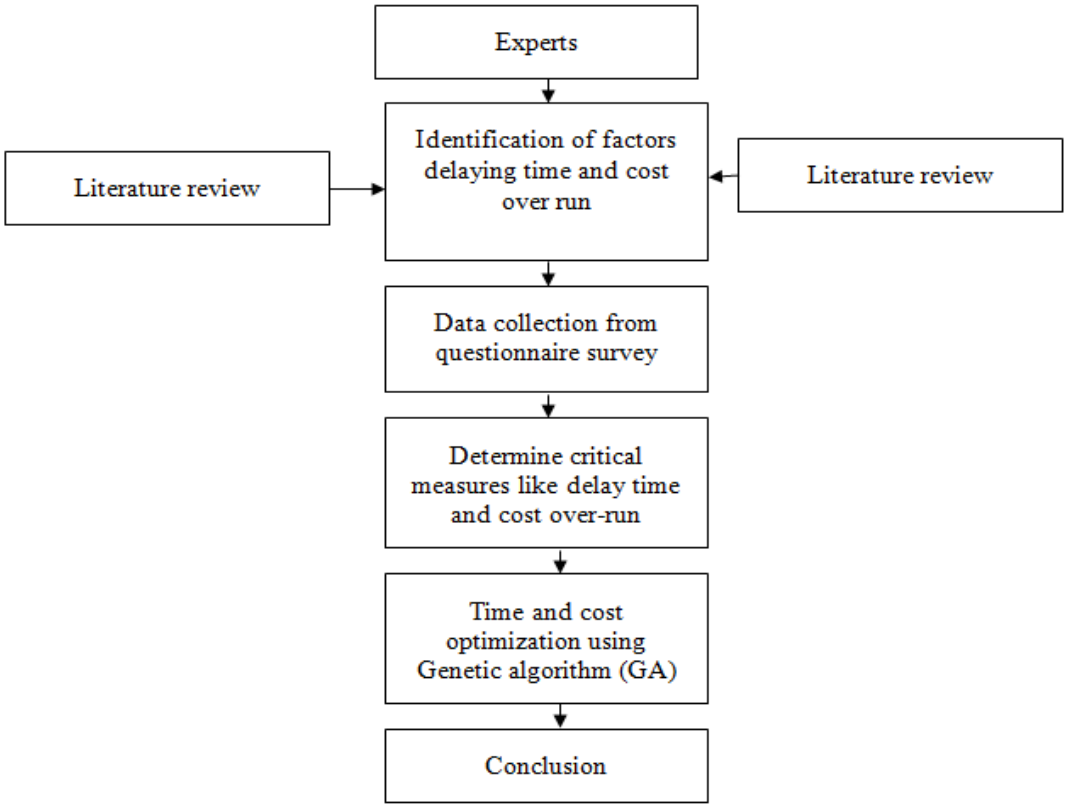


Fig. 0.1. Sequential diagram of work plan

3.3 METHODOLOGY OF PROPOSED WORK

3.3.1 Analysis

- **Relative importance index (RII)**

$$\mathrm{RII} = \frac{\sum W}{AN}$$

Where w = weighting given to each factor by the respondents and ranges from 1 to

5 where '1' is 'very little effect' and '5' is 'very high effect'

N = total number of respondents.

A= highest weight (i.e. 5 in this case)

- **Impact index by using GUI**

$$\mathrm{I.I} = \frac{\text{Maximum no. of respondent scoring}}{\text{Total number of respondents}}$$

- **Implementation Procedure for GUI**

There are two sheets in the project. The first sheet is all the questions which have been asked from different people. The second sheet is answers which are stored in the form of 0 and 1. 1 for yes and 0 for no.

1. Read sheet data for all questions
2. Bifurcate sheet questions of delay and cost over-run in construction projects.
3. Display them in the GUI in different segments
4. For each question in each type, there are five answers
   a) Very little effect (1)
   b) Little effect (2)
   c) Average effect (3)
   d) High effect (4)

e) Very high effect (5)

5. Identify the question selected in the GUI and search the question in the question sheet loaded at step 1
6. Extract all answers in that section
7. Find all 1's in the answer sheet
8. For each 1 identify at which option 1 has been selected
9. For all answers, find maximum 1, as for example

   For question –

Project location	6	9	3	7	0

The maximum value is 9

Hence the value would be little effect (2) and little effect option increment by 1and impact index is calculated by maximum value divided by the total number of respondent.

10. In such a manner for each question there would be an increment in the answer options.

    The code for the same segment is as follows:

$$\text{totalpts} = [\text{opt1 opt2 opt3 opt4}];$$

$$[\text{mval}, \text{myopt}] = \max(\text{totalpts});$$

11.The total points for each set is plotted at the end to find out the critical factors to delay the time and cause cost overrun.The screenshot of GUI code is shown in figure below:

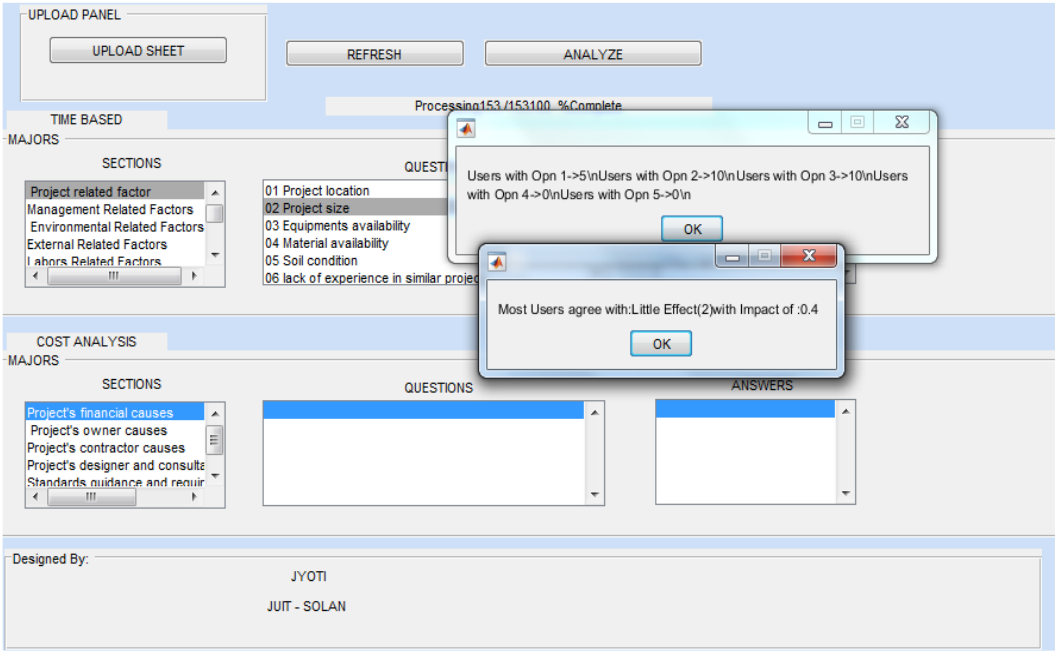


Fig. 3.2. GUI analysis by using Mat lab [24]

12.Last step is to apply genetic algorithm along with three elements named as fitness function, mutation and crossover function. The screenshot of Genetic algorithm code is shown in figure below:

```
clc;
close all;
clear all;
[filename,pathname]=uigetfile('*.xlsx','Select a data file');
[k,i,data]=xlsread(strcat(pathname,filename));
disp(data);
[r,c]=size(data);
allcost=data(3:r-1,5);
disp(allcost);
allcost=cell2mat(allcost);
cost=allcost;
options = gaoptimset('PopulationSize', 50,'SelectionFcn'...
    ,@selectionstochunif,'MutationFcn',{@mutationuniform, 0.05},'CrossoverFcn'...
     ,{@crossoverintermediate, 0.8});
 costnew=[];
 labelling=[];
```

Fig. 3.3.Screenshot of Genetic algorithm code [24

3.3.1 List of major causes of delay in project

Table 3.1. Causes for delay in project

Sr. No	Category Name	Factor ID	Delay factor description	Number of respondents scoring					
				Very little effect (1)	Little effect (2)	Average effect (3)	High effect (4)	Very high effect (5)	Impact index
a	Project related factor	01	Project location	6	9	3	7	0	0.360
		02	Project size	5	10	10	0	0	0.400
		03	Equipments availability	6	5	6	6	0	0.240
		04	Material availability	5	1	11	4	1	0.500
		05	Soil condition	3	7	11	4	0	0.440
		06	Lack of experience in similar project	8	10	5	3	0	0.384
		07	Construction technology	1	7	10	7	0	0.400
		08	Unfavorable contract clauses	3	5	13	4	0	0.520
		09	Payment delays	0	0	4	8	1	0.615
		10	Amount of interference (skills)	3	8	11	2	0	0.458
b	Management Related factors	11	No of change order	2	7	12	3	0	0.500
		12	Time to make a decision	2	6	8	9	0	0.360
		13	Productivity of labour and equipments	0	5	11	8	0	0.458
		14	Unavaibility of labour	0	2	7	13	0	0.590
c	Environmental related Factors	15	Weather condition	0	0	7	10	1	0.555
		16	Soil condition	0	7	12	4	0	0.521
		17	Labour strike	8	5	8	2	0	0.347
		18	Shortage of human resources	1	5	13	6	0	0.520
d	External	19	Accident during construction	5	10	7	3	0	0.400

	related factors	20	Change in government regulation and laws	1	2	10	9	0	0.454
		21	Change in specification during execution	0	10	14	1	0	0.560
		22	Inefficient decision making	0	4	17	4	0	0.680
		23	Construction technologies	1	6	13	5	0	0.520
		24	Low productivity of labour	2	4	14	5	0	0.560
e	Labors related factors	25	Shortage of labour	0	6	5	12	0	0.521
		26	Personal conflicts between labour	5	4	12	4	0	0.480
		27	Unqualified/inadequate experienced labour	2	9	10	4	0	0.400
		28	Labour injuries on site	5	13	5	2	0	0.520
		29	Shortage of equipment	2	2	16	3	0	0.666
f	Equipment related factors	30	Frequent equipment breakdowns	0	7	15	2	0	0.625
		31	Low efficiency of equipment Inadequate modern equipment	2	6	8	7	0	0.347
		32	Design changes by owner or his agent during construction	0	5	10	8	0	0.434
g	Design related factors	33	Unclear and inadequate details in drawings	1	3	10	9	0	0.434
		34	design complexity	0	9	10	4	0	0.434
		35	mistakes and delays in producing design documents incomplete project design	1	8	6	7	0	0.363
		36	Inadequate contractor experience	0	2	15	8	0	0.600
h	Contractor related factors	37	Ineffective project planning and scheduling	1	1	11	7	0	0.550
		38	Poor communication and coordination between owner and consultant	4	2	7	12	0	0.480
		39	Poor financial control on site	1	5	4	13	0	0.565
i	Owner related	40	Change orders	1	7	8	8	0	0.333
		41	Delay in approving design documents	0	4	13	6	0	0.565

factors	42	Funding problems	0	2	6	6	1	0.400
	43	Improper project feasibility study	0	8	9	5	0	0.409
	44	Additional work	0	7	13	3	0	0.565
	45	Selecting inappropriate contractors	0	4	10	8	0	0.454

3.3.2 List of major causes of cost overrun in project

Table 3.2: Causes of cost over-run in projects

				Number of respondents scoring					
Sr. No	**Category name**	**Factor ID**	**Delay factor description**	**Very little effect (1)**	**Little effect (2)**	**Average effect (3)**	**High effect (4)**	**Very high effect (5)**	**Impact index**
a	Project's financier causes	01	Owner financial difficulties	1	4	6	9	1	0.428
		02	Too small s design budget	6	2	10	6	0	0.416
		03	Slow and delay payment of completed work	0	1	8	14	1	0.583
		04	Owner lack of experience	2	2	10	9	0	0.434
		05	Inadequate project preparation and planning	0	3	7	14	0	0.583
		06	Premature tender documents	1	4	13	6	0	0.541
b	Project's owner causes	07	Unrealistic/inaccurate duration of contract period	0	2	13	7	0	0.590
		08	Frequent design changes	0	4	6	14	0	0.583
		09	Change in scope of the project	0	7	9	8	0	0.375
		10	Change order by client	2	4	11	6	0	0.478
		11	Change in material specification and type	0	5	8	8	0	0.380

		12	Additional work	0	3	8	10	0	0.476
		13	Contractual claims	1	6	11	5	0	0.478
		14	Insufficient information /investigation about ground condition	1	6	12	3	0	0.545
		15	Wrong/inappropriate choice of site	1	2	8	12	0	0.521
		16	Lack of coordination between project's parties	1	7	2	15	0	0.600
		17	Lack of communication between project's parties	1	7	6	9	0	0.391
		18	Lack of contractor's experience	2	2	9	8	0	0.425
		19	Incorrect preparation and planning by contractor	2	3	5	12	1	0.521
		20	Wrong method of cost estimate	0	5	7	10	0	0.454
		21	Inaccurate cost estimate	1	1	9	11	1	0.478
		22	Lack of cost planning, monitoring and controlling during pre and post contract stages	1	3	6	10	0	0.500
		23	Contractor's poor site management and supervision skills	1	5	7	6	0	0.368
c	Project's contractor causes	24	High interest rates charged by bank on loans received by contractors	3	3	9	8	0	0.391
		25	Cost of rework	0	5	13	7	0	0.520
		26	Shortage of available labour	0	8	10	7	0	0.400
		27	Increase in man power cost	0	8	13	2	1	0.541
		28	Increase of material prices/equipments prices	0	1	11	10	1	0.478
		29	Late delivery/supply of materials equipments by the contractor	0	3	6	15	0	0.625
	Project's designer and consultant	30	Deficient tender documentation	2	4	4	15	0	0.600
d		31	Inaccurate cost and time estimate	3	1	7	13	0	0.541
		32	Lack of experience of technical consultants	1	7	12	4	0	0.500

	causes								
e	Standards guidance and requirements causes	33	Absence of construction cost, specifications, and productivity standard data	1	6	11	7	0	0.440
		34	Inadequate mode of financing projects.	2	2	10	11	0	0.440
		35	Inappropriate Government policies	0	1	16	4	1	0.727
f	Environmental and social related condition	36	Effect of weather condition	0	1	7	6	1	0.464
		37	High transportation cost	1	2	10	9	1	0.434
		38	Social and cultural impacts	4	8	10	2	0	0.416
		39	High inflationary pressure	3	7	14	1	0	0.560
		40	Unsettlement of the monetary rate	2	11	10	2	0	0.440
		41	Delay in issuing information to the contractor ,project ‘s inspection and handing over	2	2	14	7	0	0.560

3.3.3 Ranking of delay factors

Delay and cost over -run factors are ranked using GUI based on their Relative Importance Index value as shown in Table 3.3-3.4.

Table 3.3 Ranking of time delay factors

DELAY FACTOR DESCRIPTION	R.I.I	RANK
09 Payment delays	0.720	1
15 Weather condition	0.712	2
14 Unavailability of labour	0.672	3
39 Poor financial control on site	0.672	4
20 Change in government regulation and laws	0.664	5
25 Shortage of labour	0.656	6
36 Inadequate contractor experience	0.648	7
13 Productivity of labour and equipments	0.64	8
33 Unclear and inadequate details in drawings	0.64	9

41Delay in approving design documents	0.64	10
45 Selecting inappropriate contractors	0.632	11
32 Design change by owner or his agent during construction	0.624	12
37 Ineffective project planning and scheduling	0.616	13
38 Poor communication and coordination between owner and consultant	0.616	14
42 Funding problems	0.616	15
31 Low efficiency of equipment inadequate modern equipment	0.608	16
35 Mistakes and delays in producing design documents incomplete project design	0.608	17
40 Change orders	0.608	18
22 Inefficient decision making	0.6	19
43 Improper project feasibility study	0.6	20
44 Additional work	0.6	21
16 Soil condition	0.592	22
18 Shortage of human resources	0.592	23
12Time to make a decision	0.59	24
07 Construction technology	0.584	25
29 Shortage of equipment	0.584	26
23 Construction technologies	0.576	27
24 Low productivity of labour	0.576	28
30 Frequent equipment breakdowns	0.576	29
04 Material availability	0.57	30
34 Design complexity	0.568	31
11 No of change order	0.552	32
08 Unfavourable contract clauses	0.544	33
03 Equipments availability	0.54	34
05 Soil condition	0.528	35
21 Change in specification during execution	0.528	36
27 Unqualified/inadequate experienced labour	0.528	37
10 Amount of interference (skills)	0.52	38
26 Personal conflicts among labour	0.52	39
01 Project location	0.488	40
17 Labour strike	0.48	41
19 Accidents during construction	0.464	42
02 Project size	0.44	43
06 lack of experience in similar project	0.44	44
28 Labour injuries on site	0.432	45

3.3.4 Ranking of cost overrun factors

Table 3.4. Ranking of cost over run factors

COST OVER-RUN FACTOR DESCRIPTION	R.I.I	RANK
03 Slow and delay payment of completed work	0.736	1
29 Late delivery/supply of materials equipments by the contractor	0.712	2
05 Inadequate project preparation and planning	0.704	3
08 Frequent design changes	0.696	4
21 Inaccurate cost estimate	0.688	5
28 Increase of material prices/equipments prices	0.688	6
12 Additional work	0.672	7
15 Wrong/inappropriate choice of site	0.672	8
19 Incorrect preparation and planning by contractor	0.672	9
31 Inaccurate cost and time estimate	0.664	10
20 Wrong method of cost estimate	0.656	11
30 Deficient tender documentation	0.656	12
36 Effect of weather condition	0.656	13
37 High transportation cost	0.656	14
07 Unrealistic/inaccurate duration of contract period	0.648	15
16 Lack of coordination between project parties	0.648	16
22 Lack of cost planning, monitoring and controlling during pre and post contract stages	0.648	17
34 Inadequate mode of financing projects	0.64	18
01 Owner financial difficulties	0.632	19
04 Owner lack of experience	0.624	20
09 Change in scope of the project	0.624	21
11 Change in material specification and type	0.624	22
35 Inappropriate Government policies	0.624	23
06 Premature tender documents	0.616	24
18 Lack of contractor's experience	0.616	25
24 High interest rates charged by bank on loans received by contractors	0.616	26
25 Cost of rework	0.616	27
41 Delay in issuing information to the contractor, project's inspection and handling over	0.608	28

10 Change order by client	0.6	29
17 Lack of communication between project's parties	0.6	30
13 Contractual claims	0.592	31
26 Shortage of available labour	0.592	32
33 Absence of construction cost, specification, and productivity standard data	0.592	33
14 Insufficient information/investigation about condition	0.584	34
23 Contractor's poor site management and supervision skills	0.584	35
27 Increase in man power cost	0.584	36
32 Lack of experience of technical consultants	0.576	37
02 Too small is design budget	0.552	38
38 Social cultural impacts	0.504	39
39 High inflationary pressure	0.504	40
40 Unsettlement of the monetary rate	0.496	41

3.4 GENETIC ALGORITHM (GA)

Genetic Algorithm (GA) is a principle-based optimization technique depends upon the Genetics and natural choice. It is often used to find the optimal or near optimal results to the hard problems or they will need lifelong solutions. It is often used to solve optimization problems and used in research work and machine learning. Optimization is a scheme which is used to create a little better. In this algorithm we provide a group of inputs that are processed and provided output with optimized results. The Genetic algorithm is the algorithm that is based on the search concept inspired from the natural collection and genetics.

In GAs, we have a possible solution to a complex problem. These solutions are then recombined and mutated (as in natural genetics), new children are born, and the process repeats in different generations. A candidate solution is assigned to a fitness value on the basis of objective function value., while healthier people have higher mating opportunities and produce more "healthier" personal.

Thus this process is repeated until we will obtain a better solution. GA algorithm helps to find the solution to the problem that require a very long time to solve that particular problem. The most commonly used terms in the GA algorithm are defined below:

1. **Population:** It is a group of all probable results that are drawn for a complex problem. The population of Genetic algorithm is similar to the population for human beings.
2. **Chromosomes** - Chromosomes is the term used to resolve the known problem.
3. **Gene** - A gene is an elemental location on a chromosome.
4. **Alleles** - This is the value of a gene for a particular chromosome.

Basic structure of GA is shown in fig.3.4.

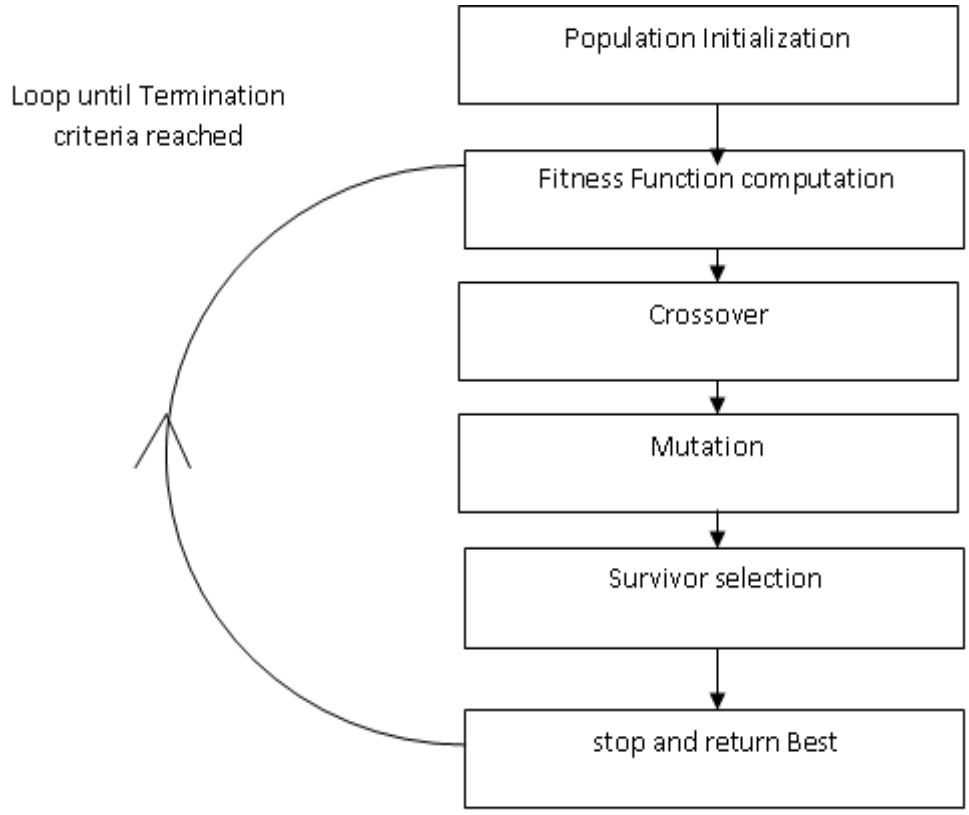


Fig. 3.4. Basic structure of GA

The algorithm used for Ga is written below:

```
Function GA ()
    {
    Initialize population;
    Calculate fitness function;
    While(fitness value != termination criteria)
            {
            Selection;
            Crossover;
            Mutation;
            Calculate fitness function;
    }
end
```

3.4.1 Basic Principle

The working principle of a standard GA is illustrated in above algorithm .The major steps involved are the generation of a population of solutions, finding the objective function, fitness function and the application of genetic operators. These aspects are described with the help of a basic genetic algorithm as below:

1. Selection: It is the process to know about the solution that is stored and allowed to generate and which ones justify to die out. In this each individual may become a parent with a possibility that is relative to its fitness. The main goal of the selection function is to highlight the better results and remove the bad results in a population while maintaining the

population size stable. It will recognize the better solution in a population and make the many copies of the better results and remove the bad solutions from the population therefore many copies of better solution can be positioned in the population.

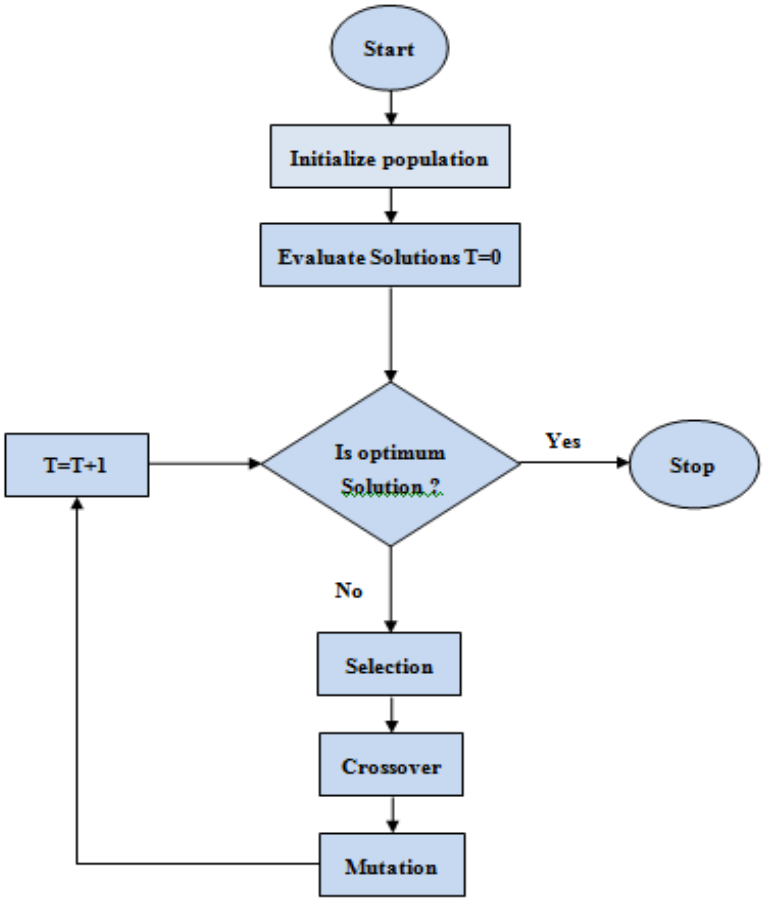


Fig. 3.5. GA flowchart

Fitness function: A fitness function value is used to measure the quantity to optimize the solution. The value is used to position an exacting solution against all the former solutions .A fitness value is allowed to every solution depending on how close it is really to the optimal solution of the difficulty.

2. Crossover: It is used to develop a novel solution from the solution obtained from the fitness function. This function exchanges the gene data among the solution in the mating pool. It represented in string form that express the required information. Every string represents the solution as shown in fig.3.6.

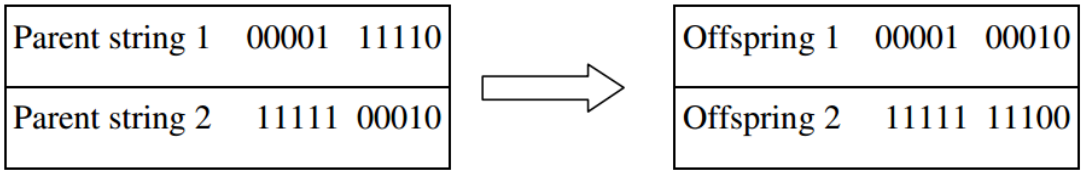


Fig. 3.6. Crossover operation

3. Mutation: It is the intermittent introduction of novel features into the result strings of the population pool to keep variety in the population. It changes a one to zero or vice versa with a probability of mutation. However, there are two main problems with this. They are

1. Depending upon the initial population chosen, there may not be enough diversity in the initial strings to ensure that the GA searches the entire problem space.
2. The GA may converge on sub-optimum strings due to a bad choice of initial population.

These problems may be overcome by the introduction of mutation operator into GA. Mutation operator changes 1 as 0 and vice versa by bit wise. Bitwise mutation is done bit by bit by flipping a coin with low probability as shown in fig.3.7.

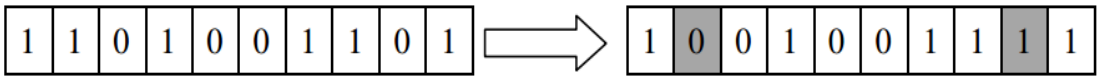


Fig. 3.7. Bitwise mutation

CHAPTER 4

RESULTS AND DISCUSSION

4.1 GENERAL

Total 25 responses have been collected from the various researchers and engineers and relative importance index has been ranked according to the ranking given. In this research work the dataset has been taken from construction site of I.T.I building at Dargi Tehsil, distt.Shimla and estimated cost and time is reduce by using Genetic Algorithm

4.2 RESULTS

The top 45 factors for delay and 41 factors for cost over-run analysis are shown in table 3.3-3.4.Top five causes for each group to delay were mention as follows:

1. Payment delays (RII=0.720)
2. Weather condition (RII=0.712)
3. Unavailability of labour (RII=0.672)
4. Funding problems (RII=0.672)
5. Shortage of labour (RII=0.664)

Top five causes for each group to cost over-run were mention as follows:

1. Slow and delay payment of completed work (RII=0.736)
2. Late delivery/supply of materials equipments by the contractor (RII=0.712)
3. Inadequate project preparation and planning (RII=0.704)
4. Frequent design changes (RII=0.696)
5. Inaccurate cost estimate (RII=0.688)

As shown in fig. 4.1 represents the time delay with respect to RII factors performed for 45 questionnaires. From the figure it is clear that the RII factor of payment delay is higher, among other questionnaires which are equal to 0.72 then the RII due to weather condition is 0.71. The RII factor for labour injuries on site is very less which is approximately equal to 0.43. The main finding of the time delay study is that the financial factor is the most influencing factor in causing delay in construction projects followed by weather condition.

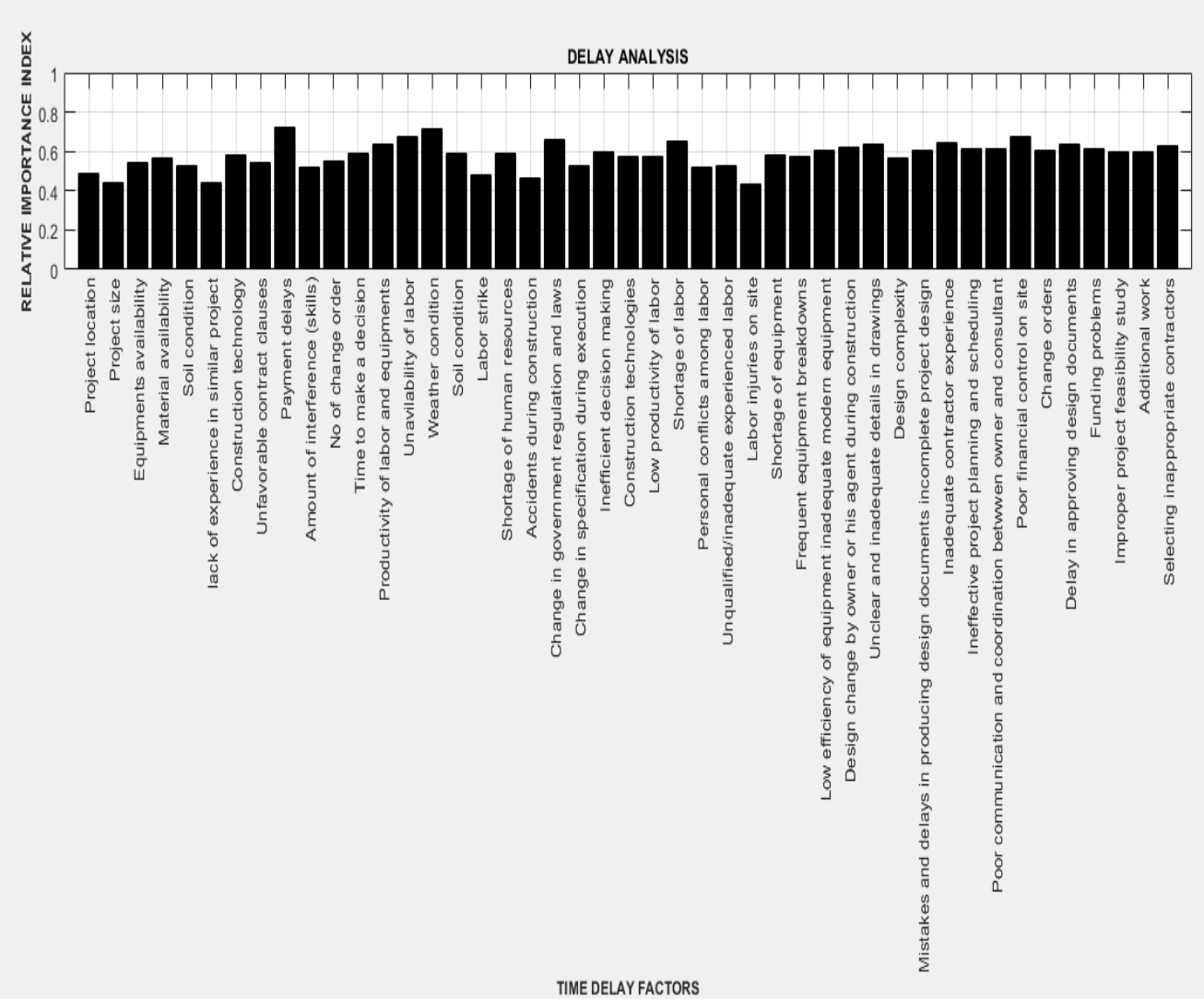


Fig. 4.1. Delay analysis

As shown in Fig.4.2 represents the RII graph for cost overrun analysis performed for 41 questionnaires. X-axis represents the number of question sets, whereas the y-axis represents

the RII factor for different questions. From the figure it is clear that slow and delay payment of completed work is very high which is equal to 0.74.The RII factor for social cultural impacts, high inflationary pressure and unsettlement of the monetary rate is 0.5.

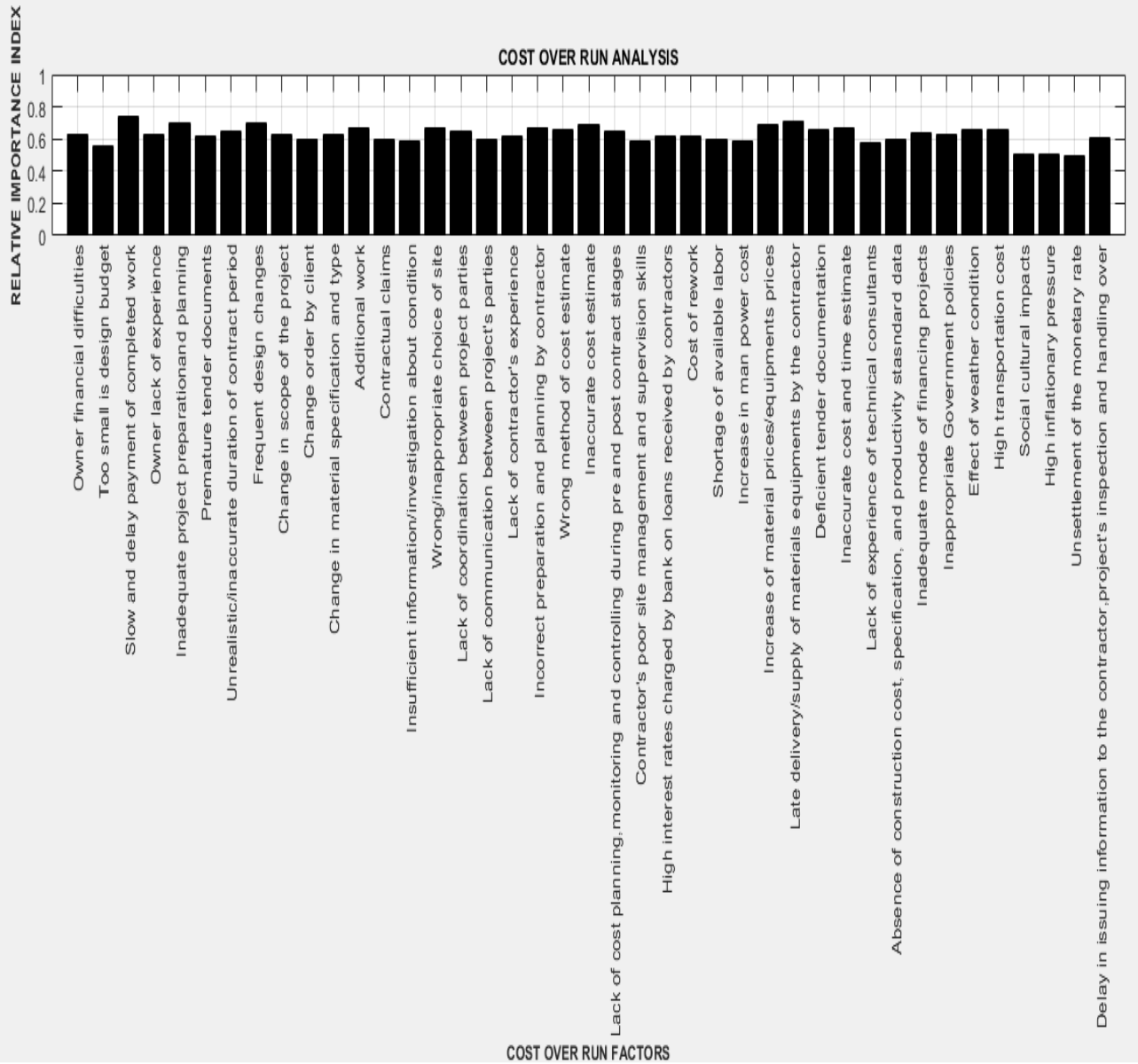


Fig. 4.2. Cost over-run analysis

The main finding of this study is that the slow and delay payment of completed work is the most influencing factor in causing cost overrun in construction projects, followed by late delivery/supply of materials equipments by the contractor.

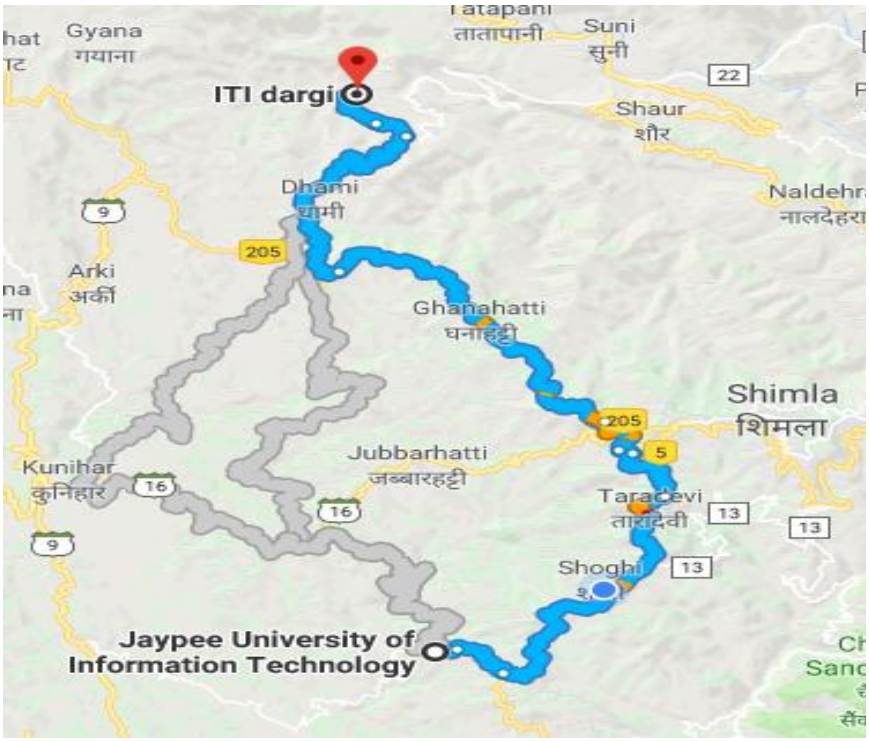
4.3 A CSASE STUDY

The construction site of I.T.I building at Dargi Distt. Shimla

4.3.1 Introduction

ITI building project,in Dargi tehsil of Shimla district of Himachal Pradesh,is located.The work is in hilly and backward area at Dargi.

4.3.2 Profile



LATITUDE 13.0077 LONGITUDE 77.6845

Fig. 4.3. Location of I.T.I building (Dargi,Shimla)from JUIT waknaghat [23]

Location	Dargi, Shimla district Himachal Pradesh
Status	Under construction
Duration	11-09-2015-10-09-2018
Client	Public Work Division
Total cost of project	40905.2061crore
Total duration of project	36 months

4.3.3 Work performance

I.T.I project is commercial building project. The project being in hilly bound area, the working season for over groundwork is considered as January to December in the subsequent year. The extension of time, delay in handing over of the land and site possession in a progressive manner in line with the construction schedule without affecting the works. There are also some political and financial reasons which affect the performance of project. Therefore following are the hindrances in the performance of I.T.I project which cause the delay and cost overrun of the project.

1. Payment delays

2. Weather condition

3. Factors related to labour and material

4. Poor financial control on site

5. Change in government regulation and laws

4.3.4 Time and cost optimization in ITI Dargi

As shown in table.4.1the dataset taken for the proposed research work. The data are collected from the construction site of I.T.I building at Dargi teh. Distt. Shimla. The data is collected for 18 numbers of activities taken from 18 numbers with an activity code started from 1 to 18. The cost taken for cutting earth work is 1 month; excavation in foundation in building portion is 1 month all other activities are mentioned in table 4.1. The total duration

calculated is 36 months, whereas the total cost calculated for the construction site is 409.05 Lac.

Table 4.1: Data set of **t**ime and cost involved in I.T.I building construction

Sr. No.	Activity Description	Activity Code	Normal Duration (Months)	Normal Cost (Rs. in Lacks)
1	Cutting in earth work	1	1	15.24
2	Excavation in foundation in building portion /in retaining wall e.t.c	2	1	4.63
3	Providing form work with steel plates(3.15mm)	3	3	12.27
4	Providing and laying cement concrete 1:6:12 for foundation and plinth	4	1	4.76
5	Providing and laying cement concrete 1:8:6/1:3:6 in R/walls & B/walls and C.C Drain	5	4	55.95
6	Providing and laying cement concrete work 1:1.5:3	6	5	42.63
7	Providing mild steel/tor steel reinforcement	7	3	69.95
8	Brick work using common burnt clay building bricks in super structure	8	3	16.3
9	Stone masonry in R/walls & B/walls	9	2	31.84
10	Providing and fixing joinery work for doors, windows	10	1	23.32
11	Paving and flooring	11	4	29.79
12	Steel work for roofing	12	1	36.84
13	Roof covering repainted sheet	13	0.5	17.49
14	Plastering and distempering	14	2	11.24
15	Painting and polishing	15	2	2.71
16	Misc work(decorative screen in corridor/plinth protection/U shape drain etc.	16	0.5	9.44
17	Road work	17	1	17.2
18	Water supply and sanitary fittings	18	1	7.45
	Total		**36**	**409.05**

4.3.4.1 Time optimization by using GA

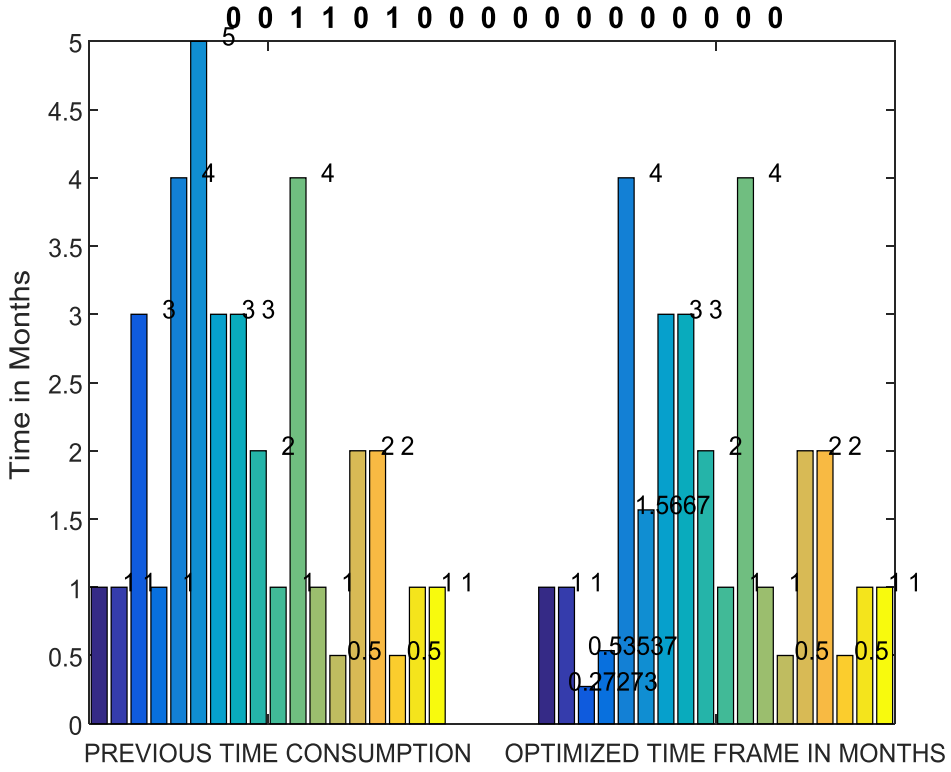


Fig. 4.4. Normal time vs. optimized time (months)

As shown in figure 4.4. that the time graph for previous time consumption and optimized time frame in months. The table 4.2. represents the binary values represent the two values zero and one. Here, zero represents that the data do not require any optimization whereas data 1 represents that the data require optimization. Here, in this research, the optimization is performed by using genetic algorithm (GA).. Thus, it is concluded that by using optimization algorithm the time is reduce from 36 month to 29.5 to complete the work.

Table 4.2. Time optimization

Sr. No.	Activity description	Normal time (months)	GA Implementation	Optimized time (months)
1	Cutting in earth work	1	0	1
2	Excavation in foundation in building portion /in retaining wall e.t.c	1	0	1
3	Providing form work with steel plates(3.15mm)	3	1	0.5
4	Providing and laying cement concrete 1:6:12 for foundation and plinth	1	1	0.5
5	Providing and laying cement concrete 1:8:6/1:3:6 in R/walls & B/walls and C.C. Drain	3	0	3
6	Providing and laying cement concrete work 1:1.5:3	5	1	1.5
7	Providing mild steel/tor steel reinforcement	3	0	3
8	Brick work using common burnt clay building bricks in super structure	3	0	3
9	Stone masonry in R/walls & B/walls	2	0	2
10	Providing and fixing joinery work for doors, windows	1	0	1
11	Paving and flooring	4	0	4
12	Steel work for roofing	1	0	1
13	Roof covering repainted sheet	0.5	0	0.5
14	Plastering and distempering	2	0	2
15	Painting and polishing	2	0	2
16	Misc work (decorative screen in corridor/plinth protection/U shape drain etc.	0.5	0	0.5
17	Road work	1	0	1
18	Water supply and sanitary fittings	1	0	1
	Total	**36**		**29.5**

4.3.4.2 Cost optimization by using GA

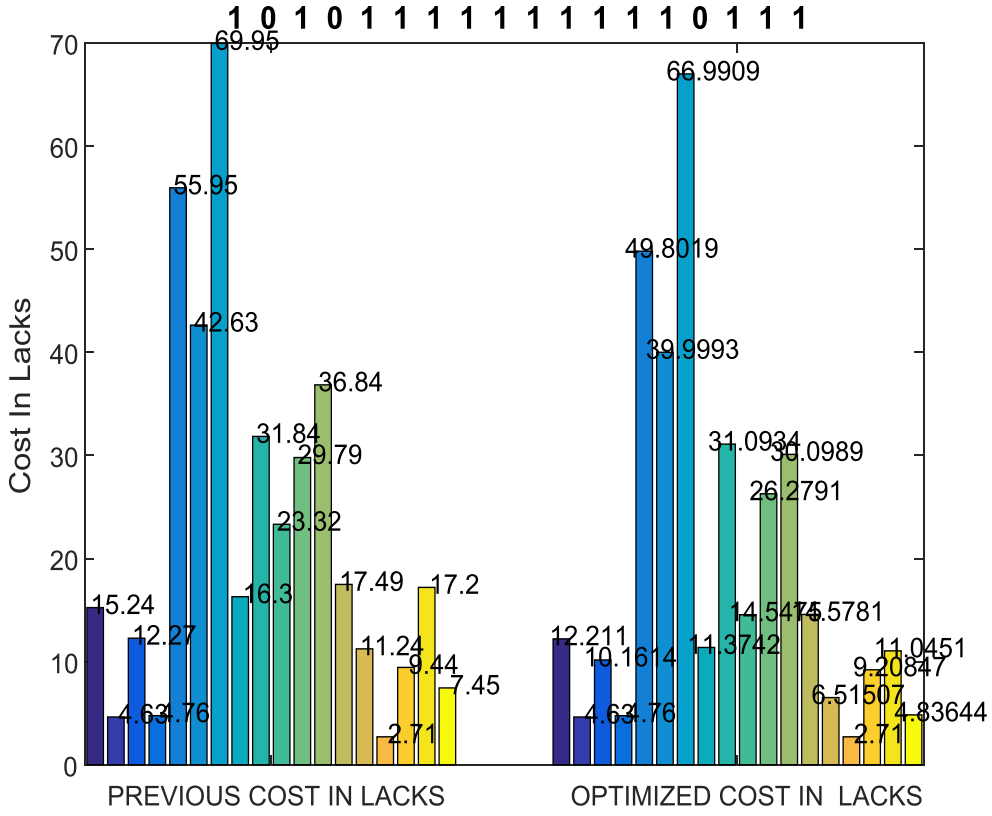


Fig. 4.5. Normal Cost vs. optimized cost

As shown in figure 4.5. represents the cost observed for the previous as well as for the proposed work. In the proposed work, the cost is optimized by using Genetic Algorithm.As shown in table 4.3. the binary values displayed above represent that, when the value is 1 means that optimization is applied to the data, whereas 0 values represents that there is no optimization technique applied on the previous data.. The cost of work is reduced from 409.05 to 347.64451 by using Genetic Algorithm.

Table 4.3. Cost optimization

Sr. No.	Activity description	Normal cost (lacks)	GA Implementation	Optimized cost (lacks)
1	Cutting in earth work	15.24	1	12.211
2	Excavation in foundation in building portion /in retaining wall e.t.c	4.63	0	4.63
3	Providing form work with steel plates(3.15mm)	12.27	1	10.1614
4	Providing and laying cement concrete 1:6:12 for foundation and plinth	4.76	0	4.76
5	Providing and laying cement concrete 1:8:6/1:3:6 in R/walls & B/walls and C.C. Drain	55.95	1	49.8019
6	Providing and laying cement concrete work 1:1.5:3	42.63	1	39.9993
7	Providing mild steel/tor steel reinforcement	69.95	1	66.9909
8	Brick work using common burnt clay building bricks in super structure	16.3	1	11.3742
9	Stone masonry in R/walls & B/walls	31.84	1	31.9034
10	Providing and fixing joinery work for doors, windows	23.32	1	14.5415
11	Paving and flooring	29.79	1	26.2791
12	Steel work for roofing	36.84	1	30.0981
13	Roof covering repainted sheet	17.49	1	10.5781
14	Plastering and distempering	11.24	1	6.515
15	Painting and polishing	2.71	0	2.71
16	Misc work (decorative screen in corridor/plinth protection/U shape drain etc.	9.44	1	9.20847
17	Road work	17.2	1	11.0457
18	Water supply and sanitary fittings	7.45	1	4.83644
	Total	**409.05**		**347.64451**

CHAPTER 5

CONCLUSIONS AND FUTURE SCOPE

5.1 GENERAL

In this study, an analytical framework has been developed to obtain the best solution in terms of time and cost. A questionnaires survey has been made on the basis of delay and cost from the construction sites. This provides the various factors that are responsible for the delay and the cost overrun of the construction sites. The rating given by different experts are different depending upon their thinking level and their considerations taken. The collected data has been analysed and a list as per their ranking has been prepared. The Relative importance index of various delays and cost over-run has been analyzed.

5.2 CONCLUSIONS

Delays and cost overrun are considered to be a serious problem in the construction industry. In the present study; the factors that causes delay and cost overrun in the construction projects examines on the basis of questioners in Himachal Pradesh. The following are the main finding of the present work.

- It is concluded that the RII for different delay factors have been analysed for the 45 questioners set; that most of the delay occurs due to payment delays (RI=0.720). The cost overrun have also been analyzed form the 41 questioners set the most of cost-over-run is due to slow and delay payment of completed work (RII=0.736).

- The financial factor is the most influencing factor in that causing delay and cost overrun in construction projects.

- The hindrances in the performance of I.T.I project which causes the delay and cost overrun are the same as found through the questionary survey. The estimated cost and time has been reduced by using Genetic Algorithm based on natural selection and the mechanisms of population genetics. GA employ a random yet directed search for locating the globally optimal solution based on maximum and minimum value selected from fitness function. Maximum and minimum costs are generated and each solution is given a weight that is proportional to the difference of the maximum cost and the cost resulted from the particular solution. The solution that yields the minimum cost is given the highest weight, and the one with maximum cost is given a weight of zero. Thus, concluded that by using optimization algorithm the time of work is reduced from 36 months to 29.5 months and the cost to complete the work is reduced from 409.05 Crore to 347.64451 Crore.

5.3 FUTURE SCOPE

In this study time delay and cost over-run has been done by calculating relative importance index and importance index and by quantifying delay and cost-overrun using GUI. Some other methodology can be adopted for delay analysis in construction projects like Computerizing Isolated collapsed.

The result obtained by using GA is better in comparison with the deterministic approach in terms of schedule flexibility, cost flexibility critical index, criticality ratio & probability of finishing. GA is the techniques that are used to compute the exact optimum solution. In order to decrease the estimated time; and to improve the speed and overall efficiency of the construction.

REFERENCES

1. Aziz, R. F. (2013). Ranking of delay factors in construction projects after Egyptian revolution. *Alexandria Engineering Journal*, *52*(3), 387-406.

2. Rauzana, A. (2016). Analysis of Causes of Delay and Time Performance in Construction Projects. *IOSR Journal of Mechanical and Civil Engineering*, *13*(5), 116-121.

3. González, P., González, V., Molenaar, K., & Orozco, F. (2013). Analysis of causes of delay and time performance in construction projects. *Journal of Construction Engineering and Management*, *140*(1), 04013027.

4. Alaghbari, W. E., Razali A. Kadir, M., Salim, A., & Ernawati. (2007). The significant factors causing delay of building construction projects in Malaysia. *Engineering, Construction and Architectural Management*, *14*(2), 192-206.

5. Kraiem, Z. M., & Diekmann, J. E. (1987). Concurrent delays in construction projects. *Journal of Construction Engineering and Management*, *113*(4), 591-602.

6. Assaf, S. A., Al-Khalil, M., & Al-Hazmi, M. (1995). Causes of delay in large building construction projects. *Journal of management in engineering*, *11*(2), 45-50.

7. Kadry, M., Osman, H., & Georgy, M. (2016). Causes of construction delays in countries with high geopolitical risks. *Journal of Construction Engineering and Management*, *143*(2), 04016095

8. Abd El-Razek, M. E., Bassioni, H. A., & Mobarak, A. M. (2008). Causes of delay in building construction projects in Egypt. *Journal of construction engineering and management*, *134*(11), 831-841.

9. Salunkhe, A. A., and Patil,R.S(2013) "Statistical methods for construction delay analysis." *Journal of Mechanical and Civil Enginee*ring 9.2, 58-62

10. Marzouk, M. M., & El-Rasas, T. I. (2014). Analyzing delay causes in Egyptian construction projects. *Journal of advanced research*, *5*(1), 49-55.

11. Hamzah, N., Khoiry, M. A., Arshad, I., Tawil, N. M., & Ani, A. C. (2011). Cause of construction delay-Theoretical framework. *Procedia Engineering*, *20*, 490-495

12. Amoatey, C. T., Ameyaw, Y. A., Adaku, E., & Famiyeh, S. (2015). Analysing delay causes and effects in Ghanaian state housing construction projects. *International Journal of Managing Projects in Business*, *8*(1), 198-214.

13. Orangi, A., Palaneeswaran, E., & Wilson, J. (2011). Exploring delays in Victoria-based Astralian pipeline projects. *Procedia Engineering*, *14*, 874-881.

14. Aljohani, A., Ahiaga-Dagbui, D., & Moore, D. (2017). Construction Projects Cost Overrun: What Does the Literature Tell Us?. *International Journal of Innovation, Management and Technology*, *8*(2), 137.

15. Rambodu,M.S., and Verster,JJP.,(2010).“Factors Contributing to Cost Over-Run of Construction Projects” *Department of Quantity Surveying and Construction Management*, ASOCSH 2010-66

16. Subramani, T., Sruthi, P. S., & Kavitha, M. (2014). Causes of cost overrun in construction. *IOSR Journal of Engineering*, *4*(6), 1-7.

17. Katre,V.Y.,and Ghaitidak,D.M.,(2016). “Elements of Cost and Schedule Overrun in Construction Projects”. *International Journal of Engineering Research and Development*, 12,64-68.

18. Mahadik U.A (2015). “Cost Reduction in Construction Projects” International Journal of Engineering Technology, *Management and Applied Sciences*, 3, 2349-4476.

19. Tatar,B.V., Patil,R.S (2010). “Time and Cost Optimization Techniques in Construction Project Management*” International Journal of Latest Trends in Engineering and Technology*,7,230-237.

20. Le-Hoai, L., Dai Lee, Y., & Lee, J. Y. (2008). Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries. *KSCE journal of civil engineering*, *12*(6), 367-377.

21. Li, H., & Love, P. (1997). Using improved genetic algorithms to facilitate time-cost optimization. *Journal of Construction Engineering and management*, *123*(3), 233-237.

22. Zheng, D. XM, Thomas Ng, and Kumaraswamy,M.M (2002) "Applying genetic algorithms techniques for time-cost optimization." *Proc., 18th Annual Conf. ARCOM*. University of Northumbria, Middleborough, UK, 2002.

23. Google.Image.https://www.google.com/maps/dir/Jaypee+University+of+Information+Technology,+Waknaghat,+Himachal+Pradesh+173234/ITI+dargi,+Himachal+Pradesh(2007).

24. *MATLAB* version 6.5.1,(2017),(compuer software),The Mathworks Inc.,Natick, Massachusetts