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# Cost-Time Optimization of a Construction project using Genetic-Algorithm approach

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ABSTRACT

People's daily necessities are provided for both directly and indirectly by the construction sector. A construction project often entails the use of various resources (such as equipment, materials, labour, etc.) to create a finished product (such as a building, a bridge, a water distribution system, etc.) that meets the needs of the intended consumers. Budget restrictions, contractual time restrictions, safety and health concerns, sustainability ratings, local building rules, and the desired degree of quality are just a few of the challenges faced in construction projects. As a result, there are several goals for a construction project, including maximum productivity, lowest cost, shortest duration, and specified quality, safety, and sustainability. When attempting to combine multiple objectives into the best possible answer, decision-making can be challenging. In this thesis, a GA model with 152 decision variables, 462 constraints, and 361 optimal solutions was suggested. This study suggests dynamic programming-based GA for equipment management issues because we thought it would be able to address these issues more effectively than conventional approaches. The method's objectives were to reduce overall project costs and increase equipment performance so that, in the event of equipment failure, backup equipment would be accessible. Furthermore, it was decided to treat the equipment failure rate as a fuzzy variable to increase the method's dependability. The model was put to the test using a real hydroelectric project in India. The new approach outperformed the conventional methods in searching in the same environment.

**Keywords :** Multi-Objective Cost-Time Optimization, Genetic Algorithm.

## I. INTRODUCTION

The idea of optimization is new to science and engineering. One of the major sectors that benefits from it for the efficient and cost-effective execution of projects is the building industry, for instance. Heating, ventilation, and air conditioning systems, structural systems and components, building layout, acoustic design, and the layout of construction sites are all subject to optimization. Regarding HVAC systems, energy consumption optimization is often carried out.

In structural design, optimization is carried out to maximise stability, stiffness, and strength while minimising the cost of materials and construction. In terms of building layout, optimization often entails maximising reach ability and accessibility as well as satisfying perceptual needs, such as seclusion and visual openness. Due to concerns about energy loss, the compactness of a building's perimeter may be maximised simultaneously. Optimization in acoustic design often involves reducing reverberation duration. The planning of building sites often aims to maximise reach ability. Despite the fact that optimization is a well-known topic, it is often presented in single objective form, with the aim being referred to as "the cost function." The optimization when two or more constraints are met together with the minimising of the cost functions is an extension of this. In the construction sector, optimising many goal functions rather than just lowering a cost function is of utmost importance. The associated functions are concurrently reduced in the first scenario (or maximized). This work was completed thanks to the multi-objective optimization approach (MO).

The MO has been more well-known recently, particularly over the last 10 years, as a result of the expanding technological need for optimization in multiple different sectors. For instance, while designing a structure, both the construction expenses and the energy consumption of the building during its lifetime are subject to reduction. In many situations, multi-objectivity is a crucial computational tool for successful project execution in the construction sector. This makes sense given that there are numerous competing and subject to achieving optimum satisfaction criteria in building design, such as cost, utility, aesthetic appeal, and sustainability.

Understanding the importance of project management and the construction sector independently is the primary goal of this chapter. Today, regardless of the industry to which the company belongs, project management is a crucial component of organisational management in almost all businesses. On the other hand, the construction industry is expanding continuously throughout the world and satisfies both the essential and luxurious wants of the populace. Thus, this thesis aids in the implementation of the most important project management effort in the world's fastest-growing construction sector. This chapter goes into great detail on the various project management types and approaches. The various project management approaches have been described in detail based on the industry and level of complexity (Gentile, 2012). A thorough review of the traditional and modern methods to project management and its growing scope has been done. The project cycle is also recognised. There is extensive coverage of the ideas and principles behind the cyclical, waterfall, and agile project management approaches, as well as the benefits and drawbacks of using each, as well as the types of businesses that each is most suited for. Considering that effective project management requires effective leadership, several leadership philosophies are also examined in relation to how they might be applied (Yousif et al., 2015).

The majority of construction projects run late, over budget, and with creep because of shoddy communication protocols and weak control mechanisms. It is important for each project manager to use a proactive strategy to finish the project (Loosemore, 2003). In the business, project management aids in planning even modest projects and shows improved levels of techniques that can guarantee timely completion of the project within the anticipated budget. The compilation of construction documents, risks associated with unsolved issues, incorrect pricing methods during the stage of schematic design, and other practical on-site challenges can all be handled with the aid of project management. Any construction project's objective must be clearly stated before project management can be implemented (Sears et al., 2010). The project's goal statement should then be written in a clear and concise manner. The project scope should then be determined, and it must be distinct from the goal. Additionally, Before analysing the project life cycle, project management helps partition the project into separate stages to ensure that each step is independently reviewed for needs. These phases, which could comprise the following, can also be thought of as numerous important parameters for the construction project.

1. Project Deliverables: These must outline the concrete goods, services, or outcomes that the project is expected to provide. These deliverables must be specified in the project together with the deadlines by which they must be completed.
2. Important Dates: These would include not just the project's end date but also other completion dates for smaller projects.
3. Project completion criteria: This could be used to determine whether a project is nearing completion. The project manager's ability to assess the project's current state and contrast it with any delays will also be put to the test. The whole team can accurately define the different project stages and pursue certain project objectives thanks to the establishment of project criteria.
4. Project Expectations - Setting expectations for staff members enables them to understand tasks and other project requirements.
5. Potential elements of risk - It assists in identifying potential problem areas and may encourage the creation of some checks and balances to help solve the issues.

Managing Projects in the Construction Sector The world's attention has recently been drawn to developments in the construction business. The world's largest industry right now is the construction sector. It is expanding quickly across all Economies. It combines the production and service sectors and regularly engages with the final consumers. Being a part of the manufacturing sector, it includes features like timely service delivery, a wide selection of high-quality products, low failure rates, and affordable service costs (Bairi, 2012). In reality, though, the majority of projects show signs of unjustified time and cost extensions. Project management is a crucial prerequisite for the building sector and can aid in correcting the mismanagement that is occurring at the moment.

## II. PROPOSED METHOD

### 2.1 Proposed Model

This thesis's model is built on a genetic algorithm. It basically consists of a starting population that changes over time through a number of iterations. Chromosome, the final result, is symbolised by a collection of integer numbers known as Genes. The starting population is produced at random, after which the fitness is determined for each potential outcome and the subsequent operations are carried out:

Crossover and selection

・Operator Mutation.

The project's total length must remain the same if the user expects it to finish by the deadline, even if the critical route may vary with each iteration. The chromosome of this approach is the number of days to be moved for each non-essential activity if the user wants to prolong the deadline.

The fitness function is used to assess and rank the quality of people in order to lower the total cost of resources (feasible solutions).

Resource selection criteria:
As previously established, there are three divisions of activity's direct cost:
1. Materials expense
2. Cost of human resources
3. Machinery price

Up to nine resources, three for each category, or whatever number the user selects, may be used with the model. The user should choose the resources with the greatest price disparity between the cost of the pool and the cost of the extra resources, or those whose pool is little and he must receive more resources from outside.

**2.1.1 Model Constraints**: This model has two different kinds of constraints:
1. Hard limits are limitations that cannot be overcome. The deadlines for each project are one of the three hard restrictions in this paradigm.
2. Soft constraints are limitations which can be violated with a specific cost attached. They are the additional resources required in this model.

Equipment and Human Resource: If the total number of resources needed is less than the pool limit, a surcharge based on the resources that don't, together with their associated costs, will be imposed. The model will automatically choose the resource with the least incremental cost rather than the resource with the highest cost in order to minimise expenses as much as possible.

**2.1.2 Model's Variables**

The variable in this model is the total number of days that will be moved for each activity. The start date of the activity will be adjusted by the value supplied in the variable fields when these variables are added to it.
Model's assumptions and limitations:
The user must consider a few assumptions when using this model:

- Throughout the course of the activity, the same amount of resources will be required.
- The model can only support one predecessor with a finish-to-start connection if the user explicitly provides the start date.
- The amount of additional resources required is not constrained, but the model can be changed to do so.
- The approach solely reduces the direct costs because the indirect costs are unaffected by changes in project time. However, any project may be changed to take longer if the user wishes to do so while spending less money directly and indirectly.

## III. RESULTS AND DISCUSSION

Four points, cmax, tmax, cmin, and tmin, make up a quadrilateral's four extreme points for a certain population. These extreme points are reproduced in the succeeding generations to a perfect minimum point. In order to lower the size of the quadrilateral generated and arrive at the ideal location, the constants in the fitness function are adjusted for each new population. The length and time of each activity are recorded in a matrix B(5x2x5) together with all of the data. In the Matlab, two functions are produced. First one (Func(x) to determine the population's fitness value. The built-in Matlab function for the genetic algorithm is utilised in the vectorized scenario, which implies that the fitness function (func(x)) receives data from the entire population of one generation. The matrix in this case is (populationsizeX7). which include random data produced by the PSO-WCA algorithm. The maximum value of decision variables over a series of populations is determined using the PSO-WCA function in its vectorized form, and the fitness in the fitness function is then determinedA new function called function calling(x), which is called in the definition of the fitness function, is constructed to determine the choice variable's lowest and maximum value. The fitness function is called in this manner for each group of populations, passing the entire population. The variables' maximum and lowest values are computed, and fitness values are returned. In our scenario, the

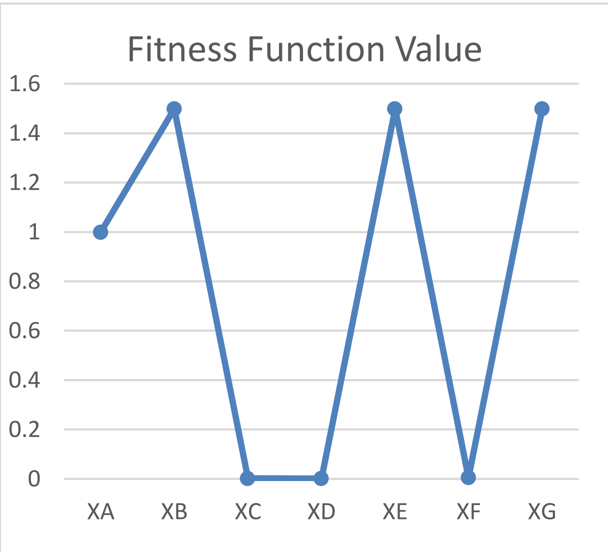
PSO-WCA function is used to solve integer problems with variables having lower and upper bounds of [1,1,1,1,1,1] and [3,5,3,3,4,4,3,4], respectively.

Sensitivity Analysis of Decision Variables:

The choice variable in the issue has discrete values. The time and expense of the activity have altered if a Xi changes. The fitness value changes when the choice factors are changed, as seen in the table below. The initial choice is the best one. The next rows modify the variables and show their fitness value.

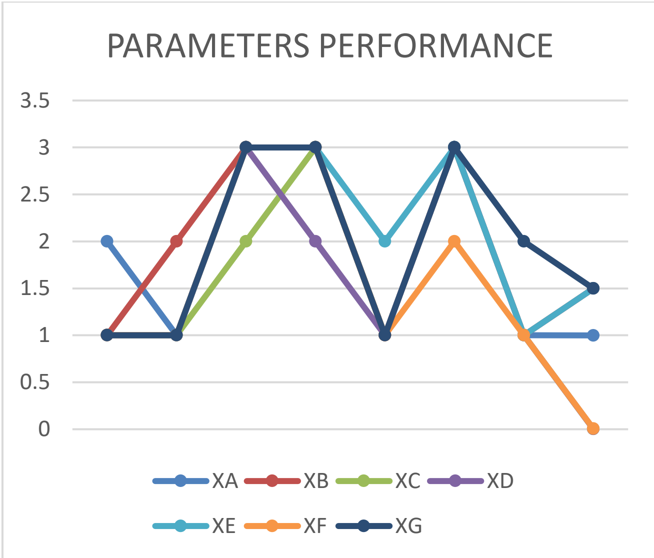
TABLE I
FITNESS FUNCTION ANALYSIS

| Variable Changed | XA | XB | XC | XD | XE | XF | XG | Fitness Function Value |
|---|---|---|---|---|---|---|---|---|
| - | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 0.001 |
| XA | 2 | 1 | 3 | 3 | 1 | 3 | 1 | 0.9900 |
| XB | 1 | 2 | 3 | 3 | 1 | 3 | 1 | 1.4885 |
| XC | 1 | 1 | 2 | 3 | 1 | 3 | 1 | 0.0010 |
| XD | 1 | 1 | 3 | 2 | 1 | 3 | 1 | 0.0025 |
| XE | 1 | 1 | 3 | 3 | 2 | 3 | 1 | 1.4885 |
| XF | 1 | 1 | 3 | 3 | 1 | 2 | 1 | 0.004 |
| XG | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 1.4880 |




Analysis of Optimization Technique Sensitivity: Determining the ideal population size-

Iterations and population variation were used to determine the ideal population size. The population ranged in size from 1 to 120. The best solution was seen to vary initially before starting to converge and becoming same for population sizes bigger than 104. Therefore, we may say that 104 people would be the ideal population size.




## IV.CONCLUSION

It is quite challenging for the building contractor to create an environmentally friendly construction design that takes several parameters into account at once. Many Industry professionals rely on the performance of competing products will undoubtedly be harmed by the ecologically friendly approach.

This paper suggests a novel approach that uses Integration of simulation, evaluation, and optimization effective multi-objective environment, cost, and time optimization It could be a useful technique for lowering environmental effects with little project concessions Cost and time effectiveness. The case study indicates that the obtained solutions don't just lower GWP connected to construction impacts, but they may also get the same or better price and timing displays. This technique offers building plans that permits contractors to compromise on desired objectives and help allay concerns about continuing applications that are environmentally friendly. a contractor is able to they base their final judgments on their tastes and project characteristics. Along with the capacity for making decisions, Another reliable instrument is the recommended method for building planning that demonstrates the competence and accountability of a contractor company. Contractors could use this technique to demonstrate that building is carried out in a manner that is economical, in a timely manner. Additionally to the building, the combining simulation, evaluation, and multi-objective Optimization might be used in various disciplines. This Integration will be particularly beneficial for sectors where a number of commercial goals, numerous viable solutions, and Complex activity interactions must be taken into account.

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