*International Research Journal of Innovations in Engineering and Technology (IRJIET)*

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 24-34, March-2022

https://doi.org/10.47001/IRJIET/2022.603004

# Value Engineering and Multi-objective Genetic Algorithm Optimization: Expectations and Reality in Construction Industry in Egypt

**[1]Dr. Khaled Muhammad Ali Muhammad, [2]Dr. Marwa F. Shaheen, [3]Dr. Ramy Mahmoud Ragab Mahmoud**

[1,2]Lecturer at Civil Engineering Dep., Pyramids Higher Institute, Cairo, Egypt

[3]Lecturer at Mechatronic Engineering Dep., Pyramids Higher Institute, Cairo, Egypt

***Abstract* - Without doubt, construction industry is concerned with satisfying its customers' needs by delivering projects that achieve their objectives and reach their expectations on a specific time, within the specified budget. In spite of the established housing programs constructed by governmental authorities, there is a real and irritating housing problem for the middle and low incomes in Egypt. This problem is attributed to lots of reasons. Most important one is the inability of the low incomers to cover the high cost of supplies and limited time needed for construction projects that is known as time–cost trade-off (TCT) problem. This highlighted the urge to develop innovative and creative solutions that can deliver housing projects that meet the needs of the users achieving their satisfaction at the most-cost effective way simultaneously. This aim will be reached through incorporating both the concepts of Value Engineering and multi-objective optimization strategies in developing housing projects for the middle/low-income people. This paper tries to spot the light on VE methodology and risk management in brief. Also, highlighting the role of genetic algorithms as an important solution for multi-objective optimization which is a simple method that collect the characteristics of the project, direct costs such as (labor, material, equipment, and subcontractors, etc.), indirect costs and with using multi elitism genetic algorithms techniques, that improve time-cost trade-off problem, and deals with all the costs of the project.**

***Keywords:*** Value Engineering, Projects Management Time costs qualities relationships, constructions project in Egypt, Low-Cost Housing Projects, Time-cost trade, genetic Algorithm.

## I. INTRODUCTION

Value Engineering (VE) was developed during World War II as a remedy for the shortages of labor and materials. During the war, General Electric Company (GE) faced the problem of scarcity of critical materials to fulfill the demand of the war equipment [1]. To overcome that problem, GE had to use substitute materials for those in shortage, many of these substitutes were less expensive and better in performance The VE methodology goes through multiple steps, which are: preparation, information, analysis, creation, evaluation, development, presentation, and follow-up. Shublaq [2] defines value engineering as "A specialized cost control technique, performed by a group of experienced professionals. The technique involves an intensive, systematic and creative study to reduce cost while enhancing reliability and performance and is used to achieve the best functional balance between cost, quality and performance of a product, system or facility"[3].

Though VE started in manufacturing engineering, it spread quickly to other disciplines and reached its way into the construction engineering by 1970[4]. As the idea of VE became widely accepted in the civil engineering and construction industry, it was applied to many different situations and scenarios and problems. Nowadays, VE is being widely used in the US, England construction industries as well as other countries like China, Saudi Arabia, and Egypt. In the last 60 years, VE has pushed its way into the construction field with its creative solutions and cost reducing potential [5].

In the last 60 years, VE has pushed its way into the construction field with its creative solutions and cost reducing potential.

The most important goal of construction industry is to provide people‘s daily needs both directly and indirectly. Manpower, machines, different materials, other resources are mandatory to produce a specific product such as buildings [6]. Many obstacles are faced in construction industry including budget limitation, time limit, the requested quality, sustainability, safety issues, Etc. And that led to multiple objectives needed to be achieved in a single construction project, maximum productivity, specific quality, and safety, all with minimum cost as possible and minimum duration. To reach the optimal solution for these objectives, several strategies have been developed. Multi-objective optimization

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 24-34, March-2022
https://doi.org/10.47001/IRJIET/2022.603004

approaches tried to balance between each objective to reach the main goal we desire in every project [7].

Critical path method is an existing approach in which we calculate one time and one cost for every stage and activity of the project. Then the project has one cost and one duration (one schedule). But if the project exceeded the time limit, we would have to minimize some critical activities to reduce the project duration. On the other hand, if we managed through the time limit but there are cost overruns, we should maintain the critical path, and resort to non-critical activities by changing methods of construction used in each activity in order to maintain the critical path time. And for that we will need to propose different construction methods for each activity to create satisfactory alternatives for these activities. To get optimal results. If the duration and cost of the project are not met at the same point, it will lead to multi-objective problem, we must change the methods of achieving critical and non-critical activities [8].

Multi-objective Genetic algorithms serve as reliable technique that gathers the characteristics needed (labor, material, equipment, sub-contractor) and apply this to the project that is composed of many activities, each activity is made of a few construction methods. In the end, it tries to solve the multi objective (time –cost) problems.

**What to expect from value engineering and value methodology?**

As we mentioned earlier VE is a specialized cost control technique, performed by a group of experienced professionals. The technique involves an intensive, systematic, and creative study to reduce cost while enhancing reliability and performance and is used to achieve the best functional balance between cost, quality and performance of a product, system or facility. It is a functional balance between cost, quality, and performance [9].

The philosophy are based on these works of Lawrence Miles who, in 1950s were a purchases engineering with the General Electric Companies. Miles, found that using substitutes solution and alternatives material succeeded in providing equal or better performances at a lower costs [10]. Based on these observations and proposed systems called Value Analysis which were defined as organized approaches to the identifications and eliminations of unnecessary costs that provide neither use, nor life, nor quality, nor appearances, nor customers feature. Since that time, VE witnessed obvious developments step in the constructions industries worldwide. These took the form of setting out the rule, drawing the boundary of the disciplines, stating its objective, defining the relevant terminology, adoptions and implementations by governments authorities, modifying contract to includes value engineering services clauses, initiating professionals societies, benchmarking, academic researches and publications [11].

The basic elements of VE are function, quality, and cost.

$$\text{Value} = (\text{Function}) / (\text{Cost})$$

The elements may be interpreted by addition quality to the numerator of the above equations to form the following relationships:

$$\text{Value} = (\text{Function} + \text{Quality}) / (\text{Cost})$$

Where: Function = the specific purposes that a design or an item must perform.
Quality = The Client's or user's need, desire, and expectation.
Cost = the total life cycles costs of the products.

Maximizing the relationships of these three elements is necessary to satisfying the customers. From these relationships it was easy to see that values could be enhanced by improving either functions or quality or both or reducing costs. Decisions that improve qualities but increasing costs to the point which the products are no longer marketable was as an unacceptable as an one reduces costs at the expense of required qualities or performances. As well as, if added costs do not improve quality or enhances the ability for performing the necessary function, then values is decreased. Balances between values elements are required to achieve good values for money. From these relationships, Value is defined as the more cost-effective way to accomplish a function that meet the user's need, desires, and expectation [12].

## II. THE VALUE ENGINEERING METHODOLOGY

### 2.1 Pre-Study Phase

The objective of this study phase were to make sure that all parties were well co- ordinate, the studying was properly target and there was sufficient data available to the study. The activities that occur during these phases include: orientations meeting, finalizing the teams structures, selecting the teams members, deciding on study duration, determining study locations and condition, gathering information, sites visits, costs estimates verification, preparations of model and efficiency data.

### 2.2 Workshop Phase

During this phase the multi-disciplinary teams are mobilized to conducts the VE studies following the procedures set down in the five-step job plans subsequently described. The team's structures are tailored to suit the particular projects types, but generally include a VE Team Coordinator "qualified value specialist or equivalent", relevant designs engineers,

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 24-34, March-2022

https://doi.org/10.47001/IRJIET/2022.603004

operations expert, quantity surveyor/cost engineering and customer's representatives. Where constructability issue is of concerns constructions managers can participate[13]. The suitable size was recognized as be between six to twelve members, overlay big team must be avoided. The durations of the study depend on the natures and sizes of the projects and the stage at which the study was conducted. The multistep step job plans consist of: Information Phases, Function analysis phase, Creativity Phases, Evaluation Phases, Developments Phases and Presentation Phases [14].

1. Information phase: in this phase, data package is completed, and the scope statement is reviewed.
2. Function analysis phase: this phase aims to identify functions, classify functions, develop function models, function hierarchy or FAST model, cost functions, establishment of function worth and value index. Functions for study are selected at this phase.
3. Alternative Comparison: this phase is done to define comparison criteria so that alternatives can be compared. This phase is preferred to be performed using brainstorming initially and then through a detailed definition of each criteria. Weights of criteria are developed by VE Team.
4. Creative phase: in this phase, plenty of ideas by function are created.
5. Evaluation phase: alternative ideas are ranked and rated and ideas for development are selected.
6. Development phase: this phase includes conducing benefit analysis, completing technical data package, creating implementation plan and preparing final proposals.
7. Presentation phase: oral report is presented as well as written report.
8. Report: depending on the budget, topic, and significance of the VE workshop, a formal report may be prepared. Generally, the most cost-effective method is to have the flipcharts photo-reproduced, copied, collated, and distributed. This provides a full record of deliberations, scores, recommendations, etc.

### 2.3 Post-study phase

Within six to ten working day a preliminary VE reports can be submitted which is contains all the detailed proposal and summaries, narrative on the processes and so on. Concurrently with the report‘s preparations, and for a period after its issue, decision makers are considering the recommendation from the VE teams. Following an appropriates period for reviews, an implementations meeting must be held for determining whether proposal is to be accepted or rejected, and for establishing subsequent action[15].

## III. RESULTS AND DISCUSSIONS

**What do we lack to achieve the best outcomes through using VE in Egyptian construction projects in general?**

For Egyptian construction projects; there is gap (mismatch) between theoretical and practical studies because:

- The teamwork was not chosen based on specialty of VE study.
- The systematic theory was not applied in practice as in theoretical study.
- The VE study was facing many obstacles to clarify the important database of study (especially the cost because the price was fluctuating).
- The study showed valuables of VE in all stages of project.
- The importance of job analysis to the content of project.
- The VE study help not only to reduce total cost of project, but also to eliminate the unnecessary items in the project which lead to reduce the cost of maintenance and working over project.
- Improve quality and value of project.
- It also could increase the cost of some items to improve quality and value of project.
- Start VE study upon owner request.
- The VE study depends on the owner request and knowledge of VE.
- If the VE study continued to work over different stages of project, then the mistakes of design could be overcome.
- The good quality results would be less if the VE was not conducted.

Here comes the need to start using Multi-objective Genetic algorithms as a simple more reliable way to achieve the best outcome without affection of the quality or time specified or requiring much cost.

**Optimization:**

Optimization is a set of techniques for solving complex problems through defining an objective function, identifying the constraints, and setting the variables[16]. Optimization is implemented through various techniques, linear programming, non-linear programming, integer programming, dynamic programming, combinatorial optimization, heuristics, and other techniques. Some of the optimization techniques are traditional methods that yield optimum solutions, whereas others are non-traditional that yield near optimum or approximate solutions.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 24-34, March-2022

https://doi.org/10.47001/IRJIET/2022.603004

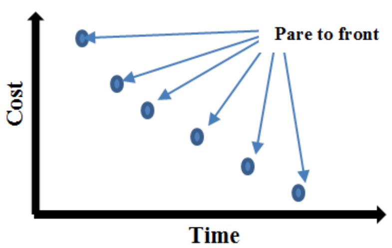
**Genetic algorithms:**

Genetic algorithms are an important tool in planning and managing the activities and different phases of a project[17]. GAs is used to help decision making in identifying optimal or near optimal solutions and alternatives for problems in constructions projects. Genetic algorithms are search procedures which combine an artificial survival-of-the-fittest strategy with genetic operators abstracted from nature[18], to form a strategy that is satisfactory for a various optimization problem. GAs solve optimization problems in the same manner as a certain species would do to adapt to changes in its environment after many generations.

Multi-objective Genetic algorithms and how does using it could be effective in application of VE?

With evolutionary techniques being used for single-objective optimization for over two decades, the incorporation of more than one objective in the fitness function has finally gained popularity in the research rim [19]. There is no clear definition of an ―optimum‖ in multi-objective optimization as in the case of single-objective issues; and does not necessarily have to be an absolutely superior solution corresponding to all objectives due to the incommensurability and conflict among objectives. The ‗best'‘ solution generated from optimization would correspond to human decision-makers‘ subjective selection from a potential solution pool.

The concept of the Pareto optimum is the widely accepted tool for comparing two solutions in multi-objective optimization that have no unified criterion with respect to optima. Such solutions (normally referred to as non-dominated or Pareto optimal solutions) do necessitate improvement in any objective function without sacrificing at least one of the other objective functions. The region defined by Pareto optimal solutions is called the Pareto front, and the objective of multi-objective optimization is to establish the entire Pareto front for the problem instead of a single best solution.




Applying the GA method for a specific problem involve five preliminary aspects: First, setting the chromosome structure; Second, deciding the criteria for evaluation; Third, developing an initial population of chromosomes (initial solutions); fourth, choosing an offspring generation mechanism (process to generate new potential solutions); and Last aspect: coding the procedure in a computer Julia program.

**(I) Create genes in chromosome structure of bridge**

This stage consists of two main steps (1): creating work breakdown structure and relationships between different activities of the project (2): Using (VBA) programming (Global Relation matrix, cost matrix, duration matrix) for creating basic matrices which Serve as:

(a) The basic data needed to make permutation for genetic algorithm.
(b) The basic data which is exported to the Julia language to obtain the necessary calculations for each step of the project.

In order to produce an infinite number of schedules that had different costs and times of the project.

**Global Relation matrix:**

This has its own characteristics which distinguished it from other matrices, where we find that the number of rows does not reflect the number of activities in the project but we find there are activities in the project that have more than predecessor so, this eventually leads to copy the row of this activity number of times equal to the number of predecessor activities, and for this reason, cannot specify the length of this matrix so it has a dynamic length. In this matrix, the user enters all the activities of the project and its coding does not take into account the arrangement, also enters the predecessor activities with its relationship, thus input in this matrix divide in to four items (1) activity name (2) predecessor activity (3) type of logical relationship (4) delay.

**Cost matrix and duration matrix:**

In this section, we used discrete points to relate cost and time of activities, because our GA technique would be more similar to real conditions, In assigning chromosome values, an executive mode is selected for its relevant gene haphazardly, each gene has its cost and its duration so, we must collect all the costs and times of each activity in the project and put them in a certain form to make them easier to deal with the software programs. In These Matrices, we find that the number of rows equal to the number of activities in the project, so that, we are able to access the activity data through the matrix index row. so, we should collect laborers, materials, equipment‘s, and bands, and also by determining (the bill of quantity for each activity, the unit price cost, crew size, productivity) we can get the total cost and duration for each activity so, it is important to put them in a certain design in to be able to allocate them easily in each construction method (gene), and to know the

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 24-34, March-2022
https://doi.org/10.47001/IRJIET/2022.603004

time and the cost of each method for each activity by using (VBA) Language we put this data (times, costs) in the two matrices and export them to Julia program.

| D1 | D2 | D3 | D4 | D5 | TIMES TO JULIA |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 0 0 0 0; |
| 2 | 2 | 3 | 2 | 0 | 2 2 3 2 0; |
| 6 | 3 | 2 | 2 | 0 | 6 3 2 2 0; |
| 7 | 5 | 4 | 4 | 0 | 7 5 4 4 0; |

| C1 | C2 | C3 | C4 | C5 | COSTS TO JULIA |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 0 0 0 0; |
| 4070 | 9581 | 9636 | 15224 | 11154 | 4070 9581 9636 15224 11154; |
| 27931.2 | 6468 | 8316 | 12936 | 9240 | 27931.2 6468 8316 12936 9240; |
| 9548 | 15004 | 20460 | 30008 | 13640 | 9548 15004 20460 30008 13640; |

**Maximum number of options for each activity vector:**

The vector collects the maximum number of construction techniques for each activity, and the length of this vector is equal to the number of activities in the project, in each activity, we randomly choose construction method but it is limited from one to maximum number of options for each activity in this vector to create chromosome, that represents a possible solution to our problem.

**Create single random chromosome or plan (schedule):**

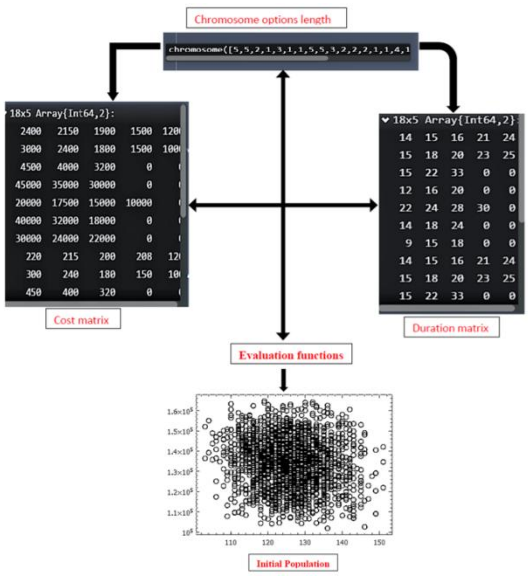
Each chromosome have its own characteristics and we will be using objected oriented programming to descript the characteristics of each chromosome which represents a possible solution to our problem so it have its own (direct cost, indirect cost, fitness values, total coat, total time, and activities options) [20]. So, it is necessary for us characterize scripts (class or strut) to be able to collect all these characteristics. Activities options represented as Array, total time as integer, (direct cost, indirect cost, fitness values, and total coat) as Float number.

**(II) Deciding the evaluation criteria (objective function)**

To evaluate objective functions for each chromosome, we find that each activity take and different time and cost, which leads to change the total cost and total deadline of the project during allocated construction mode for each activity in the project, its cost calculated automatically then we collect all construction method costs for each activity in a certain matrix so called cost matrix which we created it by (VBA), then, In Julia programming we can access it. After each activity has its cost, the total cost is the summation of those costs which selected randomly for each chromosome (First objective). By using CPM calculation for each chromosome, we can have the total time [21]. In this paper it was necessary to search for algorithm which can evaluate the chromosomes during a random change of the construction method of activities, so we introduced a new algorithm, which have the ability to produce an infinite number of schedules that have different costs and time. This Julia(project completion date algorithm) focuses only in calculation on the completion time of the project, it is specially processed for this Objective, and not finding more details, such as floats, critical path and critical activities [22]. So we do not need to calculate the back ward path for CPM algorithm because we do not need data from back word path during run our (GA) algorithm and its generations, also save consuming time that it takes to get to the results .and we are taking in our account all the logical relations and delays, which the user may be required To link the activities together Where it plays an important role to get the results which will be more accurate for first objective.

**(III) Generating an initial population of chromosomes (initial solutions)**

GA operates on a group of individuals. Generally, the algorithm designers need to define how many individuals will be in the population, which is often represented by a variable pop size [23]. We need to generate pop size individuals to start the evolving process. This procedure is called (initialization). The size of the initial population has consequences in terms of computational complexity and exploration abilities. Large numbers of individuals increase diversity, thereby improving the exploration abilities of the population. However, the more the individuals, the higher the computational complexity per generation.




While the execution time per generation increases, it may be the case that fewer generations are needed to locate an

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 24-34, March-2022

https://doi.org/10.47001/IRJIET/2022.603004

acceptable solution. A small population, on the other hand will represent a small part of the search space. While the time complexity per generation is low, the EA may need more generations to converge than for a large population. So, here we are facing a trade-off that needs to be approximated feeding the algorithm with ―enough‖ chromosomes, in order to obtain ―good‖ solutions. ―Enough,‖ for us, is directly related to instances in the search space and Diversity. We use (2000) chromosome in our time cost trade off problem for our project.

**(IV) Selecting an offspring generation mechanism (process to generate new potential solutions)**

**Pareto Front-Non dominated Set (efficient set):**

Solutions to a multi objective optimization problem can be mathematically expressed in terms of non-dominated or superior points [24]. If solution S1 is better than S2 in terms of all objective values, we say that the solution SI dominates S2 or the solution S2 is inferior to SI. Any member of the feasible region that is not dominated by any other member is said to be non-dominated or non-inferior. This non dominated set is the so-called pareto-front. The members of the pareto-front are not ominated by any other members in the solution space; therefore, these solutions have the least objective conflicts of any other solutions, which provide the best alternatives for decision making. Basically, we can treat TCTP as a multi objective optimization process, which tries to minimize both project duration and cost. Each member in the population has its own total project duration and cost; therefore, a nondominated set (a trade-off curve) can be determined such that there are no other members in the population that have better objective values in both time and cost than the members in the non-dominated set.

**Convex hull boundary:**

After we defined the trade-off curve (Pareto-optimal points), we sorted the array of non-dominated and do loop for each point in this array after sorting, then determine the cost slop between each point and other points in array the Pareto-front vector. And take the point that have minimum cost slop the line between them represent one segment from convex hull boundary, it is applied to all non-dominant points.

**Convex hull boundary:**

After we defined the trade-off curve (Pareto-optimal points), we sorted the array of non-dominated and do loop for each point in this array after sorting, then determine the cost slop between each point and other points in array the Pareto-front vector and take the point that have minimum cost slop the line between them represent one segment from convex hull boundary, it is applied to all non-dominant points.

**Fitness evaluation:**

**Minimum Perpendicular Distance for each schedule (chromosome)**

After we determine the convex hull points we connect between each consecutive two points by straight line is called segment, all segments between all points is called convex hull boundary we want finding the perpendicular distance between every individual and every segments in convex hull boundary, In the fact, There are many ways to find it but we present in this research the simple algorithm to find it.

**Fitness for each individual:**

In order to calculate the fitness of each chromosome by using this method, first we must be find the equation of straight line for each two points consecutive in the convex hull array (points non dominated individuals), this is done by finding the slop of straight line between the two points, it is a result of dividing the difference between the costs values for the two consecutive chromosomes in the convex vector and its total duration, then the equation will take this shape:

$$Y=mX+C$$

ut, in order to apply this technique we should converting the above shape equation to the general formula and calculate the values of the constants as following:

$$AX+BY+C=0$$

$$A=m,\ B=1,\ C=C$$

We can apply that at Julia language by creating empty vector for each constant (A [ ], C [ ]), and we find constant (B) always equals 1 then after finding the value of the slop the code multiply it in (-1) and push it in the constant A [ ] vector then calculate the constant C and push it in the second constant vector C [ ] so, for each array (A, C) we find that those arrays contain the number of element equal to the number of equations ( # of segments in convex hull), This number changes every generation but it remains constant in the current generation, where it expressed the number of points in the convex hull array ( # of segments in convex hull =➔the **length of convex hull vector -1**).

**Second:** After we prepare the general equation formula for each segment the Julia code do nested loop, first loop is specific to population size where the code pass through each individual and determined perpendicular distance from each individual to each segment by using this formula:

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 24-34, March-2022
https://doi.org/10.47001/IRJIET/2022.603004

$$d = \frac{|\,Am + Bn + C\,|}{(A^2 + B^2)}$$

Second loop specific to the segments of convex hull boundary where each individual has number of perpendicular equal to the number of equation segment for so the Julia code push each perpendicular distance in the empty array called fitness _vector= [d1, d2, d3…………., d n], where n represent the number of segments and individual fitness equal to the minimum distance from fitness _vector, where our concern is how close the chromosome of convex hull boundary so, we assign the minimum distance value, so, the less value of the perpendicular distance the greater value of fitness chromosome.

**Determine the probability of selection (Pi) for each individual within the parent population**

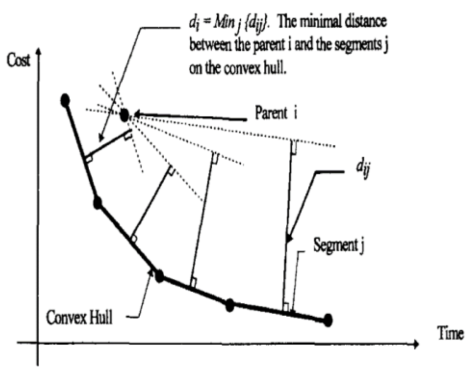
**Roulette Wheel Selection:**

Parents are selected according to their fitness. The better the chromosomes are, the more chances to be selected they have. Imagine a roulette wheel where are placed all chromosomes in the population, everyone has its place big accordingly to its fitness function Then a marble is thrown there and selects the chromosome. Chromosome with bigger fitness will be selected more time. The fitness values (j) and the probability of selection (Pi) for each individual within the parent population.

$$f\text{i}=dmax-di$$

$$Pi=f\text{i}/Zf\text{i}$$

Where fi= fitness value of parent i;di= minimal distance between the parent i and each of the segments j of the convex hull, di = min (dij, for all j); dmax = the maximum di in the generation, dmax = max(di , for all i); and Pi =probability of selection of parent i.

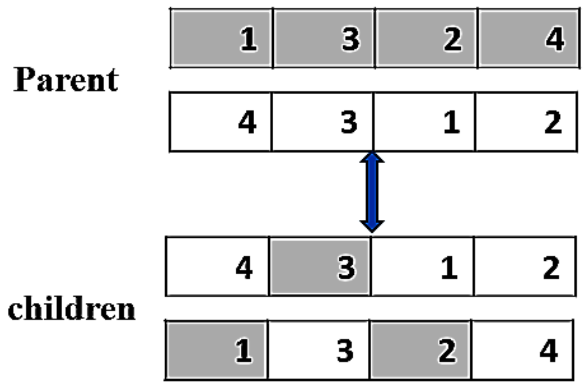



**Crossover:**

Crossover (marriage) is by far a more common process and can be conducted by selecting two parent chromosomes, exchanging their information, and producing an offspring [18]. Each of the two parent chromosomes is randomly selected in a manner such that its probability of being selected is proportional to its relative merit. This ensures that best chromosomes have higher likelihood of being selected, without violating the diversity of the random process [26]. Also, the exchange of information between the two parent chromosomes is done through a random process. Uniform crossover can use multiple parents to generate multiple offspring. Readers may speculate the way to implement it. Apart from that, in two-parents-one offspring uniform crossover, we can define a probability p for the offspring to inherit genes from the first parent, and 1− p for the other offspring to inherit genes from the other parent. This type of uniform crossover is called parameterized uniform crossover and this is our technique in this research.

**Mutation:**

Mutation is the process of randomly changing the values of genes in a chromosome [27]. The main objective of mutation is to introduce new genetic material into the population, thereby increasing genetic diversity. Mutation should be applied with care not to distort the good genetic material in highly fit individuals. For this reason, mutation is usually applied at a low probability. Alternatively, the mutation probability can be made proportional to the fitness of individuals: the less fit the individual, the more it is mutated.




**Elitist Multi objective Genetic Algorithm:**

In this paper we keep the individuals on the trade-off curve nd do selection N-Nr-o times to reproduce a new generation (N-NrO), NrO is (the number of individuals on the trade-off curve). Crossover and mutation are then applied to the reproduced new individuals according to the specified crossover and mutation rates Pc and Pm to create a new generation. The primary reason for this is their ability to find multiple Pareto-optimal solutions in one single simulation run

International Research Journal of Innovations in Engineering and Technology (IRJIET)
ISSN (online): 2581-3048
Volume 6, Issue 3, pp 24-34, March-2022
https://doi.org/10.47001/IRJIET/2022.603004

which enjoy better spread of solutions and better convergence near the true Pareto-optimal front compared to Pareto-archived evolution strategy [28].

```
procedure MULTIOBJECTIVEGA (N, N_gen, l_1, u_1, …, l_n, u_n, f_1, …, f_k, g_1, …, g_p, h_p+1, …, h_m, p_c, p_m)
  ▷ generate initial population
  for i = 1 … N do
     P ← P ⟨ INDRAND(l_1, u_1, …, l_n, u_n) ⟩
  end for
  for g = 1 … N_gen do
     ▷ initialize vectors of nondominated and dominated individual indexes of P in relation to
     f_1^pen, …, f_k^pen , respectively J_B and J_R
     J_B ← ⟨ ⟩, J_R ← ⟨ ⟩
     for i = 1 … N do
        if P[i] is nondominated in P in relation to f_1^pen, …, f_k^pen then
           J_B ← J_B ⟨i⟩
            ▷ update P_aux
           if P[i] is dominated by solutions already stored in P_aux then
               ▷ P[i] does not enter in P_aux
           else
               if P[i] dominates solutions in P_aux then
                   ▷ eliminate dominated individuals from P_aux
               P_aux ← P_aux■⟨P[i]⟩
        else J_R ← J_R ⟨i⟩
     end for
     ▷ perform crossover and replace parents by children
     ▷ perform mutation
  end for
  ▷ update P_aux
  return feasible individuals from P_aux that are nondominated in relation to f_1, … f_k
end procedure
```

**The Julia program** Repeat the above procedure until the trade-off curve remains the same for 30 or more generation based on number of activity (variable) in the project in our example only 18 activity.

This will active while the length of non-dominated array doesn't change for the constant number that the user determined of generation then break the main function as following:

```
function (model: Genetic +information)
        reset model(model)
        create initial population(model)
        evaluate pop (model)
pareto front=non dominated set (model population)
Elitism=copy (pareto front)
x=length (Elitism)
stop condition =0.0
while stop condition!=30 if length(pareto front)==1
one pareto front (pareto front)
else if length (pareto front) ==0.0
                  break
else
time cost curve=sort nondominated (pareto front)
convex curve= convex hull (time cost curve)
fitness values (convex curve model)
end
groupings = Any[]
grouper = @task group chromosomes(model)
while! is task done(grouper)
group = consume(grouper)
group!= nothing && push!(groupings, group)
end
crossover population (model, groupings)
mutate population(model)
model gen_num
evaluate pop (model)
empty! (pareto front)
pareto front= nondominated set(model population)
append!(Elitism pareto front)
final result = nondominated set(Elitism)
Elitism=final result
y=length (final result)
if y==x
stop condition+=1
else
stop condition=0.0
x=y
end
x
stop condition
end
indirect costs (Elitism)
return Elitism
end
```

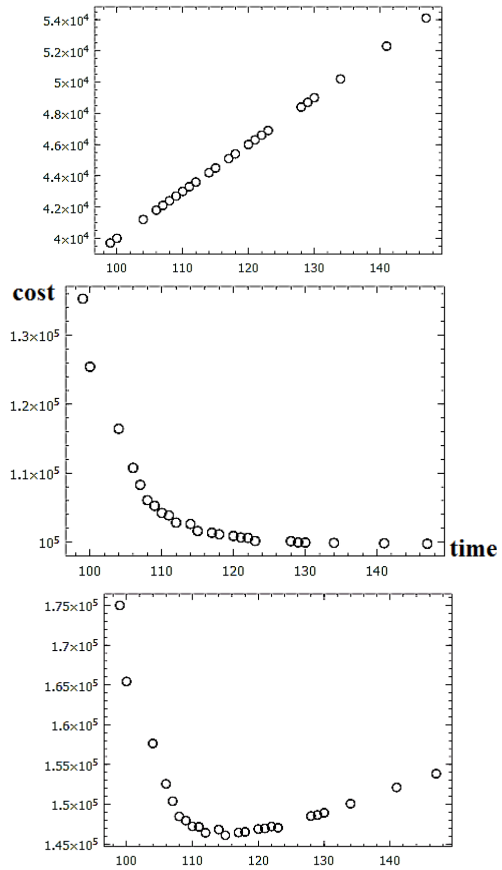



**Figure (end): The optimal schedule**

**ISSN (online): 2581-3048**
**Volume 6, Issue 3, pp 24-34, March-2022**
https://doi.org/10.47001/IRJIET/2022.603004

If we took a closer look at these two curves, we find that the two relationships reverse each other, the direction of one of them up and the other down but the two curves together influence the project So, there is a question here, what is the shape of the curve which reflects the total cost of the project? [29-30] For the answer to this question: If we gathered the two relations with each other, the final curve takes shape as follow: The Total cost curve is high then decreasing then again back on the rise according to the sum of the values (direct cost-plus indirect cost), and thus we get the total cost curve. If we noticed this curve, we find that it has a point in the middle of its convex, At this point the cost will be less as possible (minimum cost), and the time at this point called (The optimum project duration).i.e. The time which has minimum total cost. In general, the optimum project duration can be determined as the project duration that results in the least project total cost.

## IV. CONCLUSION

Value Engineering may be applied during all stages of project‘s designs developments cycles. In despite of, the greatest benefits and resources savings are typical achieved early in the developments and conceptual designs stage. VE can be applied much than once during the life of the projects. Early applications of VE help for getting the projects started in the directions, and repeated applications help to filters the project‘s directions based on changing data. It was important available and compares qualities element of these designs with the owner‘s requirement. The application of Pareto Laws 25/85 state that is around 25 % of the function constitutes around 85% of these costs. The function (25%) was the subjects of values engineering. Likewise, it is noticed the first 7 items (out of 17) form 62.53% of the total costs. These mean 37.6% of the function form 62.53% of the costs which was very close to Pareto Laws. As conclusions, the areas of value engineering analysis and studies would be controlled by the first seven functions. Further, he can do analysis of the function and suggests alternative and calculates costs models after applications of value engineering techniques.

In the end multi-objective approach proved the strong liability to optimize total time and total cost simultaneously by using accurate GAs concepts and tools. This algorithm shows its efficiency by searching only a small fraction of the total search space. We believe that using these tools based on solid algorithms may be a corner stone in the way to minimize the gap between researchers and practitioners. And will definitely aid in application of value methodology and engineering in Egypt. However, this method is new in Egypt a new way for solving the problem, reliable as it uses the fundamental data of any construction project, also it can be described as a high speed programming language used for solving one of the most difficulties, we face in construction management which is time –cost optimization problem.

## REFERENCES

[1] Usama EI Sadawi, ―A Value Engineering Methodology for low income Housing Projects in Gaza Strip‖, The Islamic University – GAZA, August 2008.
[2] Shublaq Emad., ―40 hrs Approved Value Methodology Training Workshop, MOD-I, Sydney, Australia, 2003.
[3] A.J. Dell'Isola. ―Value Engineering Cost Effectiveness... A Tool for the Designer tool‖, Vol. 1 No. 5, February 1969.
[4] Srinath Perera, Gayani Karunasena, Kaushalya Selvadurai, ―Application of value management in construction industry‖, Built-Environment-Sri Lanka - Vol. 04, Issue 01, 2003.
[5] Nick Rich, ―Value analysis Value Engineering‖, Lean Enterprize Research Centre,United kingdom, January 2000.
[6] NIU Ting, LUO Fuzhou, ―Application of value management when allocating Construction site‖, Management School, Xi‘an University of Architecture and Technology, P.R.China, 710055.
[7] Technical Section, ―Value Engineering manual‖ Engineering Division, Division of Highways, West Virginia Department of Transportation, January 2004.
[8] Muthiah Kasi. C.V.S., ―An Introduction to Value Analysis and Value Engineering for architects, engineers and Builders‖, University of Wisconsin Extension Independent study.
[9] V.N. Heggade, ―IT-propelled value engineering in construction‖, The Indian Concrete Journal, April 2002.
[10] George H. Fridholm, ―Value Engineering—Dynamic Tool for Profit Planning‖, Chairman of George Fridholm Associates.
[11] U.S. General Services Administration Public Buildings Service, ―Value Engineering Program Guide for Design and Construction‖, Volume 1 Internal Operations and Management, PBS-PQ250 December 1992.
[12] The federal facilities council ad hoc task group on integrating Sustainable design, life-cycle costing, and value engineering Into facilities acquisition. Washington, D.C., ―Sustainable Federal Facilities A guide to integrating Value engineering, life cycle cost in, and Sustainable Development‖, Report No.142, 2001.
[13] Pergamon Press Ltd, ―Value engineering‖, Vol.1 No. 5 England February 1969.
[14] Office of Quality Assurance, ―Value engineering Program‖, Connecticut department of transportation

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 24-34, March-2022
https://doi.org/10.47001/IRJIET/2022.603004

Bureau of engineering and construction, November 2009.

[15] Abdulaziz S. Al-Yousefi, ―value Engineering application benefits in sustainable construction.‖, Saudi Arabia, January 2000.

[16] N.C. Narayanan, ―Value Engineering the DMAIC way‖, Indian Value Engineering Society (INVEST), 2nd Asian Value Engineering Conference – 2001.

[17] Habeeb Adekunle Quadri, ―A Rationale for Value Engineering Decisioneering in the Project Management Office‖, PM World Journal, Vol. I, Issue IV, November 2012.

[18] Charles Anthony Mitchell, ―Developing a Standard Approach to the Value Engineering Process for the Civil Engineering Industry: a Theoretical, Case Study and Industry Perspective.‖ Dublin Institute of Technology, 25 April 2013.

[19] Boo Young Chung, Syadaruddin Syachrani, Hyung Seok (David) Jeong, and Young Hoon Kwak, ―Applying Process Simulation Technique to Value Engineering Model: A Case Study of Hospital Building Project‖, IEEE Transactions on Engineering Management, Vol. 56, No. 3, August 2009.

[20] Ayodeji Emmanuel Oke, Deji Rufus Ogunsemi, ―Value Management in the Nigerian Construction industry militating factors and the perceived benefits‖, Oke and Ogunsemi, Federal University of Technology, P. M. B. 704, Akure, Nigeria.

[21] Amit Sharma, Harshit Srivastava, ―A case study analysis through the implementation of Value Engineering, International Journal of Engineering Science and Technology (IJEST)‖, PEC University of Technology, Chandigarh (India).

[22] Aini Jaapar, Roshna Takim, nor Azmi Ahmad Bari and Intan Rohani Endut, ―Value Management guidelines for the Malaysian construction industry‖, university technology MARA, Malaysia.

[23] Ibrahim Abd Elrashed, Amin Saleh, Nevin Mohamed, Ehab Zaky, Abdallah Hosny, "AGENETIC ALGORITHMS FOCONSTRUCTION TIME-COST TRADE-OFF PROBLEMS OF LARGE NETWORKS"

[24] Feng, C., Liu, L., and Burns, S., "Using genetic algorithms to solve construction time–cost trade-off problems", ASCE Journal of Computing in Civil Engineering, 11(3): 184–189, 1997.

[25] Hegazy, T., "Optimization of Construction Time-Cost Trade-Off Analysis using Genetic Algorithms", Canadian Journal of Civil Eng., CSCE, Canada. Dec.1999.

[26] M, D.X., Ng, S.T. and Kumaraswamy, M. M., "Applying a Genetic Algorithm-Based Multi-objective Approach for Time-Cost Optimization", Journal of Construction Eng. And Management, ASCE, 130(2), 168-176. 2004.

[27] Chen, P.H., Weng, H.J. A Two-Phase GA Model for Resource-Constrained Project Scheduling. Automation in Construction, 18(4), (SCI, EI), 485-498. July 2009.

[28] Sedigheh Nader Abadia,*, Emad Roghanianb, Hadi Aghassic. 2010. A Multi-Mode Resource-Constrained Optimization of Time-Cost Tradeoff Problems in Project Scheduling Using a Genetic Algorithm., Journal of Optimization in Industrial Engineering 8 (2011) 55-64

[29] Kelly, J.E., Jr. 1961. Critical path planning and scheduling: mathematical basis. Operations Research, 9(3): 167–179.

[30] Koumousis, V.K., and Georgiou, P. 1994. Genetic algorithms in discrete optimization of steel truss roofs. ASCE Journal of Computing in Civil Engineering, 8(3): 309–325.

## AUTHORS BIOGRAPHY

**Dr. Khaled Muhammad Ali Muhammad**
Lecturer at Civil Engineering Dep., Pyramids Higher Institute, Cairo, Egypt.
Born in Cairo, Egypt on 1/10/1986.
ID (EGY) No. 28610010129531
E-Mail: khaledelkhateeb@yahoo.com, dr.khaledmuhammadali@phi.edu.eg

**Dr. Marwa F.Shaheen**
Lecturer at Civil Engineering Dep., Pyramids Higher Institute, Cairo, Egypt.
ID (EGY) No. 28006101301889
E-Mail: Shaheen20007@yahoo.com, dr.marwashaheen@phi.edu.com

**Dr. Ramy Mahmoud Ragab Mahmoud**
Lecturer at Mechatronic Engineering, Dep., Pyramids Higher Institute, Cairo, Egypt
Born in Cairo, Egypt on 10/6/1984
ID (EGY) No. 28406102104597
E-Mail: Ramy.marzouk17@feng.bu.edu.eg

*International Research Journal of Innovations in Engineering and Technology (IRJIET)*

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 24-34, March-2022

https://doi.org/10.47001/IRJIET/2022.603004

**Citation of this Article:**

Dr. Khaled Muhammad Ali Muhammad, Dr. Marwa F. Shaheen, Dr. Ramy Mahmoud Ragab Mahmoud, "Value Engineering and Multi-objective Genetic Algorithm Optimization: Expectations and Reality in Construction Industry in Egypt" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 3, pp 24-34, March 2022. Article DOI https://doi.org/10.47001/IRJIET/2022.603004

*******