# A Crew Model using GAIIPDM in Repetitive Projects

**Jeeno Mathew, Brijesh Paul**

***Abstract*: Several indistinguishable or comparative tasks/works in a project are generally alluded to as repetitive projects. A project have group of tasks which is repetitive in nature in all over the project or a similar plan in different positions are commonly known as repetitive project. In repetitive project businesses, distinctive crew choices are accessible for each task, and selecting the best choice to a task is a noteworthy test for administrators of a project. Since acquiring optimum results is found computationally escalated for this type of problems, a modified Genetic Algorithm based technique is developed to schedule projects to satisfy different goals like minimizing total task time and the total expenditure of the project, with the constraints of precedence connections between different tasks, precedence connections between different sites and the due time within which different tasks to be finished. The performance of the proposed method is compared with solutions created using existing algorithms like simple GA and ABC. Exact solutions generated by solving the developed mathematical model is utilized for validating the solutions acquired by modified GA. The computational outcomes demonstrate that the proposed GAIIPDM methodology performs significantly well in terms of quality of solutions.***

***Keywords*: ABC, GA, GAIIPDM, Repetitive Projects.**

## I. INTRODUCTION

Present day project companies are facing tight competition in terms of quality, cost and delivery times. Satisfying the customer demands and maintenance of profit levels are some of the major challenges faced by these companies and hence, proper scheduling plays an important role in this regard. Most of the projects are repetitive in nature. So project managers are keen to find out the finest choice for scheduling the repetitive projects in a short span.

Selinger [1] and Russell *et al.* [3] developed two distinctive scheduling strategies to satisfy the goal of minimizing the total project task time in which the first author pursued to maintain the work continuity of crews while the second one enabled the crew work interruptions. Mosenhli *et al.* [2] and Hegazy *et al.* [4] also prepared two different classes of accessible methodologies for minimizing the total expenditure of the project in which crew work continuity and crew work interruptions are respectively applied as in the previous case. These two techniques are designed for optimizing just a single objective at any given moment.

In many situations, repetitive projects will involve a large number of decision parameters and nonlinear limitations. This prompted many researchers to develop heuristic techniques for planning the projects which is repetitive. Khaled Nassar [6] built a technique to limit the total project task time and the break of days so as to dole out the crew to repetitive tasks by using genetic algorithm. In order to minimize project task time, total project expenditure, or both of them, Long and Ario Ohsato [7] proposed a method with the constraints of precedence connections among different project tasks and constraints of resource work continuity. A.Senouci and Hassan R.AlDesham [8] tackled a similar issue utilizing the pareto optimality guideline. Fatma A. Agrama [10] presented a model where the project managers need to create ideal/close ideal building plans to fulfill the goals like minimizing of total project task time, crew work interruption and the number of synchronized groups in repetitive project works. Fatma A. Agrama [9] proposed another model to help the arrangement of a non-identical multi-story construction in which a two variable multi objective optimization is considered. The first model is dependent on an ideal balance achieved between the goals of complete task time of the project and the number of interruption days whereas the second model is based on cost parameters such as a compromise between the complete expenditure of the project and the complete penalty cost corresponding to the crew work intermissions.

R.Y Huang *et al.* [11] developed a technique to maximize the NPV in a repetitive project industry where the best possible work arrangement between workgroups is accommodating and keeping up work progression of resources. S.L Fan *et al*. [12] also built up a model similar to the previous one where the goal is to minimize the total project expenditure Jeeno Mathew *et al.* [21] developed a genetic algorithm based methodology for scheduling repetitive projects in which penalty cost is also considered. An optimization software (OSS) was developed by Remon Fayek Aziz [13] for maximizing the NPV of a project.

Though we could see distinctive models discussing exact and heuristic procedures for scheduling repetitive project work problems, most of the discussions are only on a single objectives like minimization of the inactive crew hour, maximization of the NPV or maximization of learning effects by work continuity in a repetitive project industry. There are only exceptionally less number of articles which deals with optimization of multiple objectives.

**Revised Manuscript Received on September 25, 2019**.

***** Correspondence Author

**Jeeno Mathew***, Research Scholar, Mechanical Engineering department, Mar Athanasious College of Engineering Kothamangalam, Mahatma Gandhi University, Kerala, India. Email: jeenomathew19@gmail.com

**Dr. Brijesh Paul**, Professor, Mechanical Engineering department, Mar Athanasious College of Engineering Kothamangalam, Kerala, India. Email: brijeshpaul@gmail.com

In multi objective optimization, the decision maker has to react to multiple objectives. For the most part, all goals cannot at the same time reach at their ideal levels because all the objectives are conflicting in nature. The delaying of tasks due to various reasons is another real challenge in the project industries which influence the clients. In this situation, a fine is being charged for each slack day of every task in all sites to avoid the monetary misfortune of the clients. But there are only few articles that discuss this kind of problems. So to build up a technique by considering the penalty cost corresponding to the dragging of the task is extremely significant in the case of scheduling repetitive projects in a multi objective optimization problem.

## II. MODEL

This paper considers an organization does the similar type of jobs in different sites of the project (e.g.- Pipeline networks, Housing projects etc.). A project is split up into different project sites and each site consist of several tasks and the particular tasks are repeated in different project sites (Vanhoucke M. [14]). In this model, we consider an organization is having '*S*' distinctive sites in which work is going on and each site is divided into '*N*' different tasks. Every site is demonstrated by a network, where a set of '*N'* tasks have priority order relationships and these connections are continuing in '*S'* sites. Normally a resource group is allocated to the individual task of every site. The resource group performs the similar task sequentially and persistently in different project sites (Harris R.B *et al.* [15]). Various resource alternatives are available for each task and each group has an independent task time and expenditure per unit amount of work. To carry out the action, the selected resource moves along various project destinations. Finding out an optimal schedule to minimize the different objectives like the total project task time, total project expenditure and both of them are considering in this study and also it involves a circumstance where if a task is deferred, the organization should pay a penalty cost to the client relating to that movement for each dragging days from the due date.

A mathematical model is proposed by Jeeno Mathew *et al.* [21] to solve the problem for satisfying the objectives like minimizing total project task time, total expenditure of the project and minimize both expenditure and task time on a repetitive project scheduling problem with the constraints of precedence connectivity among different tasks and precedence connectivity among different sites. In addition to the above mentioned objectives, the penalty cost corresponding to each task in every lagging project site is considered.

Nomenclature

$i$ Task

$j$ Project site

$k$ Crew

$t_{ki}$ Task time for unit amount of work of k[th] crew of task i

$T_{ij}$ Task time of task *i* in site *j*

$T_{tj}$ Task time of precedence task *t* in site *j*

$lag_{tj}$ Lag time of task *t* in site *j*

$ST_{ij}$ Begin time of task i in site j

$LT_{ij}$ Delay time of task i in site j

$DD_{ij}$ Due date of task *i* in site *j*

$FT_{ij}$ Finish time of task *i* in site *j*

$PT$ Total project task time for the project

$c_{ki}$ Direct expenditure for unit amount of work of $k^{th}$ crew of task *i*

$C_{ij}$ Direct expenditure for task *i* in site *j*.

$p_i$ Penalty expenditure for task *i* per day

$ic$ Indirect expenditure per day.

$C_D$ Total direct expenditure.

$C_p$ Total penalty expenditure.

$C_I$ Total indirect expenditure.

$C_o$ Total initial expenditure.

$C$ Sum of direct, indirect and penalty expenditure.

$qw_{ij}$ Work quantity of task *i* in site *j*.

$wt_t$ Weightage given to the task time.

$wt_c$ Weightage given to the expenditure.

Objectives

Minimize total project task time

$$Z_1=\text{Min}\{\text{Max}\sum_{i=1}^{N}\sum_{j=1}^{S}(ST_{ij}+T_{ij})\} \quad (1)$$

Minimize total project expenditure

$$C=(C_D+C_p+C_I+C_o) \quad (2)$$

$$Z_2=\text{Min}((\sum_{i=1}^{N}\sum_{j=1}^{S}[(C_{ij})+(\text{LT}_{ij}\times p_i)])+(ic\times PT)+Co) \quad (3)$$

Minimize the cumulative impact of both total project task time and total project expenditure

$$TE=\sqrt{}((wt\_t\ (((PT-Z_1)/Z_1)\hat{}2))+(wt\_c\ (((C-Z_2)/Z_2)\hat{}2)) \quad (4)$$

In equation 4, the objective *TE* is found out using decision maker's predetermined weights ($wt_t, wt_c$) that consider the overall significance of total project task time(*PT*) and total expenditure(*C*) respectively. The weightage assigned to the task time and expenditure ( $wt_t$ , $wt_c$ ) are chosen independently, in the range [0.0, 1.0] by managers, and they ought to fulfil the condition ($wt_t$+$wt_c$=1.0). The trade-off solutions obtained from equation 4, PT and C represent the total project task time and the total expenditure of the project. $Z_1$ and $Z_2$ represent the absolute solutions corresponding to the single objectives like minimize the total project task time and the total expenditure and it is acquired separately by solving equations 1 and 2 with respect to its constraints. The objective function match up with equation 4 is a numeric technique which calculates the most limited separation among the solution corresponding to the selected schedule(*C*, *PT*) and the individual optimum solutions ($Z_1$, $Z_2$).

Retrieval Number C6179098319/2019©BEIESP
DOI: 10.35940/ijrte.C6179.098319



Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

So this equation searches the beneficial trade-off arrangement that would look for the lowest comparative variation from the perfect arrangement. (Tabucanon M.T. [16]).

Constraints

Task time to complete task *i* of $k^{th}$ crew in project site j

$$T_{ij} = t_{ki} \times qw_{ij} \quad (4)$$

Direct expenditure for task *i* of $k^{th}$ crew in project site j

$$C_{ij} = c_{ki} \times qw_{ij} \quad (5)$$

Delay time of task i in site j

$$LT_{ij} = Max\,(0, FT_{ij} - DD_{ij}) \quad (6)$$

Precedence relationship among different tasks

$$ST_{tj} + T_{tj} + lag_{tj} \leq ST_{ij} \quad (7)$$

Relationships among tasks of different sites

$$\boldsymbol{ST_{ij} + T_{ij} \leq ST_{i(j+1)}} \quad (8)$$

## III. METHODOLOGY

The real test for the project decision makers in this case is to choose an ideal crew scheduling choice from accessible search space. The possible options make a huge search space where every arrangement speaks to a suitable alternative for finishing the project. A. Senouci *et al.* [8] explains about an example in which 95 trillion (i.e $5^{20}$) feasible choices are possible when a project comprising of 20 different tasks and for every task 5 distinctive crew alternatives are available. So here an endeavor is made to build up a heuristic based arrangement procedure for this sort of issues, since the computational complexity is too high for getting definite arrangements in repetitive project scheduling. A modified Genetic Algorithm based technique is developed to solve the problem under study and the mentioned method is compared with existing methodologies like Genetic Algorithm [18] and Artificial Bee Colony algorithm [19]are discussing in this paper. Though complex, exact solutions are also obtained for smaller size problems, by solving the developed mathematical model using a solver and these solutions are used to validate the proposed methodology.

## IV. GAIIPDM

Here we propose a modified GA where Genetic Algorithm with *Initially Improved Population and Dynamic Mutation* (GAIIPDM*)* is applied.

In this work, task time for the unit amount of work is taken as decision parameters. A chromosome in a population is made up of different genes which will be the decision variables. The initial population of GAIIPDM is randomly produced. The chromosome representation of GAIIPDM is shown in fig1.

| | | | | | | |
|---|---|---|---|---|---|---|
| $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ | ………….. | $t_N$ |

***Fig 1.* Chromosome representation of GAIIPDM.**

Each chromosome contains *N* decision parameters and speaks to a potential arrangement compares to a generated plan. The separation among the maximum task time for the unit work quantity of the $i^{th}$ task of $k^{th}$ crew ($t_{ik}^{max}$) and the minimum task time for the unit work quantity of the $i^{th}$ task of $k^{th}$ crew ($t_{ik}^{min}$) of considerable number of crews in a task is applied to find out the chromosome size. If the decision parameters are in a range of $[t_{ik}^{min}, t_{ik}^{max}]$, then the size of the chromosome can be decided from the connection exhibited in the following equation where n represents the number of bits in a decision parameter.

$$2^{n-1} \leq (t_{ik}^{max} - t_{ik}^{min}) \times 10^{a} \leq 2^{n} - 1 \quad (9)$$

Here '*a'* denotes the needed accuracy which indicate the scale of decision parameter is segmented into at least $(t_{ik}^{max} - t_{ik}^{min}) \times 10^{a}$ equal size ranges (Leu S.S *et al.* [17]). Then find out the crew choice according to each task and select corresponding $t_{ik}$ and $c_{ik}$ of each activity. A task in which *Q* crew alternatives are available, at that point a specific group will be chosen by the relation as shown below.

$$P(i) = R(i) \times [Q/(2^{\wedge}(n) - 1)] \quad (10)$$

Where *R(i)* is the decimal value corresponding to the binary substring of task *i* and *P(i)* is the crew choice will be select. If $(Q-1) \leq P(i) \leq Q$, then the decision maker will be opt for the choice *Q*.

The fitness of each chromosome in the population is determined by the assistance of a scheduling algorithm. The scheduling algorithm is designed to find out the total project task time and total project expenditure incurred by using a particular set of project crews.

After the fitness evaluation of the initial population, each chromosome generates a new chromosome using equation 11 and a greedy selection process is used to compare the fitness of both chromosomes and select the fittest one (18). It will repeat on every chromosomes of the initial population.

$$V_{pi} = X_{pi} + \varphi_{pi}\,(X_{pi} - X_{ri}) \quad (11)$$

Here $V_{pi}$ is a new feasible solution modified from its previous solution $X_{pi}$ in which '*p*' and '*r*' represent chromosomes in population, *'i'* represents the activity. Here '*r*' and '*i'* are randomly chosen indexes. Although *r* is determined randomly, it has to be different from '*p*' the present chromosome. $\varphi_{pi}$ is a random number between [-1,1]. Then check the fitness of the new chromosome originated from the existing one and do the procedures as mentioned above.

By the use of GA operators [20], a new population is set up in the next generation and after that determine the ideal plausible schedule from different generations. Roulette wheel selection technique is followed for selection of chromosomes. As discussed earlier, we consider three different objective functions; minimize total project task time, minimize total project expenditure and a combination of expenditure and task time. Therefore, the fitness of the chromosomes will be project task time, project expenditure, and a cumulative impact of both task time and expenditure respectively. The single point cross over operation and the bit flip mutation are used as cross over and mutation operators. The detailed parameter setting for these operators are explained in the next section.

**Table- I: Input data for quantity of work of problem1**

| Work Quantity | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N1 | N2 | N3 | N4 | N5 | N6 | N7 | N8 | N9 | N10 | N11 | N12 | N13 | N14 | N15 | N16 | N17 | N18 |
| S1 | 4.5 | 30 | 5 | 2 | 0.25 | 10 | 3 | 1 | 2 | 0.5 | 4 | 3 | 1.5 | 4 | 6 | 2 | 1 | 6 |
| S2 | 1 | 40 | 10 | 4 | 0.5 | 25 | 2 | 2 | 2 | 1 | 4 | 6 | 1.5 | 2 | 6 | 2 | 1 | 6 |
| S3 | 4.5 | 35 | 0 | 2 | 0.25 | 15 | 3 | 1.5 | 2 | 0.5 | 6 | 0 | 1.5 | 1 | 6 | 2 | 1 | 6 |
| S4 | 2.5 | 0 | 10 | 3 | 0.5 | 20 | 4 | 1 | 2 | 0.5 | 2 | 7 | 1.5 | 2 | 6 | 2 | 1 | 6 |
| S5 | 5.5 | 30 | 5 | 4 | 0.25 | 15 | 4 | 2.5 | 2 | 0.5 | 0 | 2 | 1.5 | 4 | 6 | 2 | 1 | 6 |

**Table- II: Input data for expenditure per unit amount of work of problem 1**

| Expenditure for unit amount of work | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crew Choice | N1 | N2 | N3 | N4 | N5 | N6 | N7 | N8 | N9 | N10 | N11 | N12 | N13 | N14 | N15 | N16 | N17 | N18 |
| Choice1 | 130 | 30 | 180 | 440 | 2164 | 48 | 255 | 1560 | 235 | 620 | 540 | 326 | 390 | 390 | 265 | 120 | 1460 | 227 |
| Choice2 | 70 | 13 | 160 | 380 | 1825 | 42 | 143 | 1300 | 160 | 70 | 450 | 242 | 150 | 300 | 214 | 88 | 680 | 193 |
| Choice3 | 50 | - | 135 | 340 | 1434 | 30 | 66 | 1000 | 135 | - | 400 | 110 | - | 250 | 170 | 40 | 290 | 167 |
| Choice4 | - | - | 110 | 320 | 991 | 12 | - | 900 | 85 | - | 350 | - | - | 200 | 137 | - | - | 148 |
| Choice5 | - | - | - | 300 | 496 | - | - | 660 | 60 | - | - | - | - | - | 102 | - | - | 92 |

**Table- III: Input data for task time per unit amount of work of problem 1.**

| Task time for unit amount of work | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crew Choice | N1 | N2 | N3 | N4 | N5 | N6 | N7 | N8 | N9 | N10 | N11 | N12 | N13 | N14 | N15 | N16 | N17 | N18 |
| Choice1 | 1 | 0.1 | 0.4 | 1 | 4 | 0.2 | 1 | 2 | 0.5 | 2 | 0.5 | 1 | 2 | 1 | 0.5 | 0.5 | 1 | 0.5 |
| Choice2 | 4 | 0.4 | 0.6 | 2 | 5 | 0.3 | 3 | 3 | 0.8 | 4 | 0.85 | 3 | 5 | 2 | 0.9 | 0.7 | 3 | 1 |
| Choice3 | 5 | - | 0.8 | 4 | 6 | 0.5 | 4 | 4 | 0.9 | - | 1 | 5 | - | 3 | 1.2 | 1 | 4 | 1.3 |
| Choice4 | - | - | 1 | 5 | 7 | 0.8 | - | 5 | 1.1 | - | 1.2 | - | - | 4 | 1.4 | - | - | 1.5 |
| Choice5 | - | - | 0 | 6 | 8 | - | - | 6 | 1.2 | - | - | - | - | - | 1.6 | - | - | 2 |

The performance of GAIIPDM is by and large dependent on the setting of the GA parameters [20]. It is particularly vital to set these parameters precisely so as to obtain high quality solutions. The major parameters impacting the performance of GAIIPDM are population size, the number of iterations, cross over rate, mutation rate etc. The population size is fixed as four times the number of decision variables. Based on a pilot study the cross over rate was fixed as 0.8. The dynamic mutation is applied in GAIIPDM where up to hundred generations, mutation rate is fixed as 0.06, then between 100 to 250, 250 to 500, 500 to 1000 and more than 1000 generations mutation rate becomes 0.05, 0.03, 0.02 and 0.01 respectively.

## V. COMPUTATIONAL STUDY

In this paper the proposed GAIIPDM algorithm is compared with the existing methods such as simple GA and ABC algorithm. For effective evaluation, all related algorithms were programmed in the MATLAB (R2014a) platform and the test problem is solved by simple GA, ABC and GAIIPDM. For the proposed algorithm validation and comparison, a repetitive project scheduling problem with multiple crew option in each activity is considered. A project consists of 18 tasks in a project site and five repetitive sites in which work is going on with the input data taken from Jeeno Mathew *et al*. [21] as shown in Table I, Table II and Table III where "*N1, N2, N3….*" are different tasks, "*S1, S2, S3….*" represents different sites. 5 different crew choices are possible for 18 tasks and it is represented as "choice1, choice 2…."and it's expenditure and task time for the unit amount of work are shown in table II and table III respectively. A specific due date to complete the work is given for every task in each project site. If a task is not completed it's corresponding due date, then a penalty cost relating to each lagging day is added to the total expenditure of the project. The penalty cost with respect to each task is captured randomly from a rectangular distribution U [35,400]. The initial cost of Rs. 4400 and the indirect cost per day of Rs. 500 are assumed for this problem. The delivery times are also produced randomly in this example. The objective of this example is to minimize the total project task time, the total project expenditure and the cumulative impact of both.

For the validation purpose of the proposed method, the problem discussed above is worked out with CPLEX optimization software. A comparison of the results obtained from test problems using the GA method, ABC algorithm method and GAIIPDM method along with the results from CPLEX optimization software are shown in tables IV, V and VI. In table VI, the cumulative impact of both task time and expenditure is found out using equation 4 where planner-specified weights ($wt_t$, $wt_c$) are assumed as 0.5. The results indicate that satisfactory solutions are obtained from these algorithms for the three objectives which are close to the optima.

**Table- IV: Comparisons of results with the objective of minimize project task time.**

| Parameters | GA | ABC | GAIIPDM | CPLEX optimization software |
|---|---|---|---|---|
| Task time (days) | 70 | 69 | 69 | 69 |
| Expenditure (Rs) | 131323 | 131302.5 | 131623 | 131623 |
| Crew Option | 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-3-1-1 | 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-2-1-1 | 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1 | 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1 |

**Table- V: Comparisons of results with the objective of minimize total expenditure of the project.**

| Parameters | GA | ABC | GAIIPDM | CPLEX optimizatio n software |
|---|---|---|---|---|
| Expenditur e(Rs) | 121414 | 126169.5 | 122134 | 120933.5 |
| Task time (days) | 87 | 94 | 89 | 87 |
| Crew Choice | 1-1-1-1-5-1 -1-3-5-2-3-1-1-1-1-2-3 -1 | 1-1-4-1-5-2 -1-2-3-2-1-1-1-1-2-2 -3-1 | 1-1-2-1-5-1 -1-3-5-2-2-1-1-1-1-3-3 -1 | 1-1-1-1-5-1 -1-2-5-2-3-1-1-1-2-3-3 -1 |

**Table- VI: Comparisons of results with the multi objective optimization of minimize both total project expenditure and total task time.**

| Parameters | Simple GA | ABC | GAIIPDM | CPLEX optimization software |
|---|---|---|---|---|
| Cumulative impact | 0.074 | 0.0768 | 0.0706 | 0.0685 |
| Task time (days) | 73 | 70 | 71 | 72 |
| Expenditure (Rs) | 126497 | 130052.5 | 128723 | 127340 |
| Crew Option | 1-1-1-1-3-1-1-1-1-1-1-1-1-1-1-1-3-1 | 1-1-1-1-1-1-1-1-5-1-1-1-1-1-1-2-1-1 | 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-2-1 | 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-3-1 |

Table VII shows the percentage deviation of the results of the three algorithms with optimum results. The percentage deviations of the objective function values of GAIIPDM are obviously smaller than that of GA and ABC algorithm, which shows that the optimization capacity of GAIIPDM is better.

**Table- VII: Comparison of percentage deviation of algorithms with CPLEX Optimization software in test problem**

| Objectives (Minimize) | GA | ABC Algorithm | GAIIPDM |
|---|---|---|---|
| Task time | 1.45 | 0.00 | 0.00 |
| Expenditure | 0.40 | 4.33 | 0.99 |
| Cumulative impact | 7.99 | 12.04 | 3.06 |

Another project consisting of 100 activities and repeated at ten sites were considered for checking the performance of the proposed algorithm. The problem considers five different crew options for each task. The input data for the problem is shown in table VIII. The precedence relationships between all successive tasks are specified as finish to start. In this problem, $5^{100}$ crew options are available and hence an optimal solution cannot be obtained using solvers. The results of the problem solved using the proposed GAIIPDM is shown in table IX.

**Table- VIII: Input data for problem 2**

| Parameters | Values |
|---|---|
| Indirect cost | Rs 500 per day; |
| Original cost | Rs 440000 |
| Penalty cost | Rs U [30,80] |
| Due date | Days U[25,200] |
| Duration for unit amount of work | Days U[1,10]; |
| Cost for unit amount of work | Rs U[50,1500]; |
| Work quantity | U[1,10]; |
| Weight given to task time | 0.5 |
| Weight given to expenditure | 0.5 |

**Table- IX: The result obtained from problem 2 using GAIIPDM**

| Objective (Minimize) | Task time (Days) | Expenditure (Rs) | Cumulative impact | Crew option |
|---|---|---|---|---|
| Task time | 2950 | 69843711 | - | 2-2-1- 2-1-1-3-2-1-3-5-2-3-3-2 -1-1-2-3-4-2-3-1-3-1-1-2-2-4-4-4- 1-2-4-1-2-1-4-1-1-2-1-1-4-2-4-1-2-1- 2-2-1-3-2-2-1-3-3-3-2-2-5-1-3-2-2-5-1-1-2-1-2-3-4-1-3-2-1-3-3-2-1-3-1-1-3-1-4-1-1-1-4 -1-1-4-5-2-1-4-1 |
| Expenditure | 3082 | 64849829 | - | 1-2-2-2-2-2-1-1-1-5-2-2-2-4-2-2-1-1-1-5-1-2-1-2-2-1-2-1-2-2-2-3-1-2-2-1-1-1-1-2 -1-3-2-2-2-1-4-3-3-1-1- 2-2- 2-1-4- 4-2- 4-2-2-1-3-2-1 -2-3-2-2-2-5-3-3-1-5-5-5 -4 -1-5-2-1-4-3- 4--4- 1- 4- 1-3-1-3-3-4-2-1-1-5-2 |
| Cumulative impact | 2960 | 65000272 | 0.00289 | 1 -2- 2-1-3-1-1-2-2-1-1- 1-1-1-1-4-2 -2- 2-2-2- 1-3-1-2-1-1-5-2-5-1-3- 1 -1-1-1-1-1-3- 3-1-3-1 --1-4-1-3-3-1 -1-2-3-2-4-3-2-2-2-2-1-2- -2-3- 1- 5- 2-1-2- 4- 3- 3-2-3-2-1-2-4-1-3- 4-4 -2- 1-2-2- 2- 2-5-2-1-3-3-3 -5-1-3-2 |

## VI. CONCLUSION

A strategy for planning repetitive projects with the goal of limiting total task time of the project, total expenditure of the project and two of them simultaneously are exhibits in this paper. The present model in which if a specific task isn't finished at the delivery time in a site, at that point, a fine amount corresponding to the delay period is put together to the total expenditure of the project. The technique considers the time limit in which the activity should be finished for each task in every site, precedence connections among different project sites and precedence connections among different tasks. The mentioned technique is applied to a test problem from literature and the solutions obtained are validated using exact solutions obtained by solving the mathematical model using CPLEX solver. A comparative study of the generated solutions is also conducted with the solutions generated using existing algorithms like GA and ABC algorithm.

## REFERENCES


1. Selinger S. (1980). Construction planning for linear projects, Journal of the Construction Division, ASCE 106 (2), 195– 205
2. Moselhi O. and El-Rayes, K.(1993). Scheduling of repetitive projects with cost optimization, Journal of construction engineering and management, ASCE, 119 (4), 681–697.
3. Russell A. D., Caselton W.F. (1988). Extensions to linear scheduling optimization, Journal of Construction Engineering and Management, ASCE 114 (1), 36–52.
4. T. Hegazy, N. Wassef. (2001). Cost optimization in projects with repetitive non serial activities, Journal of Construction Engineering and Management ASCE 127 (3) 183–191.
5. Huang R. Y. and Sun K.S. (2005). An Optimization Model for Workgroup-Based Repetitive Scheduling, Proceedings of the Tenth International Conference on Structural Engineering, Scotland
6. Khaled Nassar (2003). Evolutionary optimization of resource allocation in repetitive construction schedules, Journal of Management in engineering .
7. Luong Duc Long, Ario Ohsato (2009). A genetic algorithm-based method for scheduling repetitive construction projects, Journal of Automation in Construction 18, 499-511.
8. Senouci A. ,Hassan R Al Desham (2008). Genetic algorithm based Multi-objective model for scheduling of linear construction projects, Journal of Advances in engineering software.
9. Fatma A. Agrama (2015). Versatile Multi-objective Genetic optimization for Non identical Multi-storey building projects, International conference on Industrial Engineering and operations management.
10. Fatma A. Agrama (2014). Multi-objective genetic optimization for scheduling a multi storey building, Automation in construction 44, 119-128.
11. Huang R. Y. and Sun K. S. (2009). A GA optimization model for work group based scheduling, Advances in Engineering software 40,212-228.
12. Fan S. L., Sun K .S. and Wang Y. R. (2012). GA optimization model for repetitive project with soft logic, Automation in construction 21, 253-261.
13. Remon Fayek Aziz (2013). Optimizing strategy software for repetitive construction projects within multi-mode resources, Alexandria Engineering Journal Volume 52, Issue 3,Pages 373–385.
14. Vanhoucke M. (2006). Work continuity constraints in project scheduling, Journal of Construction Engineering and Management ASCE 132(1) 14–25.
15. Harris R. B ., Ioannou P. G. (1998). Scheduling projects with repeating activities, Journal of Construction Engineering and Management ASCE 124 (4) 269–278.
16. Tabucanon M. T. (1988). Multiple criteria decision making in industry, Studies in production and engineering economics, 8, Elsevier Science Publishers B.V. Amsterdam, The Netherlands, 339 pages.
17. Leu S. S. , Hwang S.T. (2001) Optimal repetitive scheduling model with shareable resource constraint, Journal of Construction Engineering and Management ASCE 127 (4), 270–280.
18. Karaboga D. (2005). An idea based on Honey Bee Swarm for numerical optimization, Technical report-TR05.
19. Michalewicz Z. (1996). Genetic Algorithms + Data Structures = Evolution Programs, Springer- Verlag Berlin Heidelberg, New York, 337 pages.
20. Kalyanmoy Deb (1995). Optimization for engineering design: Algorithms and examples, PHI,New Delhi.
21. Jeeno Mathew, Brijesh Paul, Dileeplal J., Tinjumol Mathew(2016) Multi objective optimization for scheduling repetitive projects using GA, Journal of Procedia Technology 25, 1072-1079.


## AUTHORS PROFILE

**Jeeno Mathew** is working as an Assistant Professor in the Department of Mechanical Engineering, St. Joseph's college of Engineering and Technology Palai, Kerala, India. He completed his BTech and Mtech from MG University, Kerala and presently he is pursuing his PhD in MG University, Kerala under the guidance of Dr. Brijesh Paul, Professor, M.A College of Engineering Kothamangalam. Mr. Jeeno Mathew has publications in 5 international journals, 7 national and international conferences. He is a life time member in ISTE.

**Dr.Brijesh Paul** is working as a Professor in the Department of Mechanical Engineering, M.A College of Engineering Kothamangalam, Kerala, India. Dr. Brijesh Paul has a PhD in Industrial Engineering from IIT Madras. His MTech in Maintenance Engineering is also from IIT Madras and an MBA in Marketing management from University of Madras. Dr. Brijesh Paul is a research guide in both MG University and APJ Abdul Kalam Technological University, Kerala. He has publications in 12 international journals, 35 national and international conferences. Dr. Brijesh Paul is a member of AICTE expert committee for approval of technical institutions and PG coordinator for MTech Program in Industrial Engineering in MA College of Engineering Kothamangalam.