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Planning and Optimization of Resource Constrained Project Scheduling by Using Genetic Algorithm

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Abstract - *Proper planning and scheduling are the top challenges in project management . Traditional analytical and heuristic approaches are inefficient and inflexible when solving construction scheduling problems . The proposed algorithm can effectively provide the optimal combination of construction resources by the starting and finishing dates of activities subjected to the objective of scheduling .The main objective of this project is to optimize the schedule of construction project activities in order to minimize the total cost with resource constraints using Genetic Algorithm. This project describes a genetic algorithm approach to project scheduling problems in construction industry .Using MatlabR2011 a genetic algorithm model is obtained by providing a method for automatically creating a working computer program from a high level problem statement of the problem. The major advantage of the procedure is its simple applicability within commercial project management systems to improve the performance.*

Key Words: **Genetic algorithm, resource constraint scheduling, critical path method, delay , construction management.**

1.INTRODUCTION

Project planning is one of the most important aspects of construction project management in today's economy . In order to manage a construction project effectively, we must have a plan which includes what is to be accomplished , the technology involved and the expected time for construction. The goal of planning is to minimize resource expenditures while satisfactorily completing a given task.

In each project schedule has its own precedence constraints, which means that each activity can be processed when all its predecessors are finished. The purpose of project scheduler is to minimize the completion time and subject to precedence constraints. So this paper brings out the drawback in existing project scheduling methods. The representation show that precedence constraints and the objective function which measures overall performance of the project.

One of the main challenges of computer science is to get a computer to do what needs to be done , without telling it how to do it . Compared to the traditional methods , the genetic algorithm has more advantages as it can consider the objectives of project time and cost minimization. So that the new approach, employing the use of genetic algorithms has more flexibility to solve construction scheduling problems .

1.1 Need for the Study

The traditional scheduling methods such as Critical Path Method (CPM) are not enough for scheduling because they cannot take resource constraints into account. In a resource constrained project, the amount of resources needed during one or more time periods is limited to less than required by two or more activities occurring simultaneously. A need arises for a new approach to optimize projects schedules which take into consideration the shortage of resource.

1.2 Scope

This study aims is to develop a genetic algorithm optimization model to schedule project activities in order to minimize the total duration of the residential building project, subjected to both precedence and resources constraints by conducting a questionnaire survey among various engineers and contractors.

1.3 Objectives

The various objectives include:

- To conduct a site visit to understand the property and geography of site.
- To analyse and design a residential building in STAAD Pro.
- Develop a computer model to automate the schedule of construction projects.
- Develop Genetic Algorithm optimization model to optimize the schedule of resource constrained construction projects scheduling.
- Implement the model on a scheduling of a residential building project
- Comparing the result of the model with result of MS project approaches.

2. LITERATURE REVIEW

Shih and Liu [2] proposed a new scheduling model aiming for the minimization of total project cost, including resource usage and idle cost. But the model depends on providing external resources to provide planners with additional flexibility in arranging schedules and provide planners with diversity of resource supply, and also the model needs in-depth discussion on issues of determining the limit of internal resource to minimize operational costs.

Senouci and Derham [2] presented a genetic algorithm based multi-objectives optimization model for the scheduling of construction projects. But the model is valid for linear construction projects only, which characterized by repetitive activities.

Okada *et .al* [3] proposed a random key-based genetic algorithm approach to solve optimization scheduling problems, but they did not show computational experiments to show the effectiveness of the proposed approach, and it was recommended in their publication to do this in the future research directions.

3. METHODOLOGY

The detailed methodology adopted in this study is explained below. The methodology includes the identification of factors affecting the delay in construction project and to conduct a questionnaire survey . Further this data is used to develop genetic algorithm models for optimizing construction scheduling of a project.

3.1 Identification of Various Factors affecting Delay

As the initial step previous research papers were reviewed to investigate various factors causing delay in construction building project . According the literature were studied and 45 major factors were identified which is listed in Annexure A . Which include poor planning , shortage of technical persons , poor coordination , strikes in construction etc.

3.2 Preparation of Questionnaire Survey and Identification of Critical Factors

Various literature were studied and based on the preliminary investigation conducted at the outset of the study . A questionnaire was then drawn up and was divided in to two sections . Section A sought to know the general particulars of respondents while section B was focused on the effect of delay in construction project . The respondents were asked to rank the individual effect of delay based on frequency of occurrence according to their own judgment and local working experience . A four point scale is Adopted to facilitate ranking exercise and to facilitate the analysis of the responses , the following numerical values were assigned to the respondent rating . They were no prominent -0 , less prominent -1 , prominent -2 , highly prominent -3 , always prominent-4 .

After conducting the questionnaire survey the data was analyzed and the critical factors affecting delay in construction project were identified using Relative Important Index (RII) method. A four point Likert scale of 0-4 was adopted to assess the degree of agreement of each cause or scale of impact. Each factor was given a scale of 0 to 4, so that person could easily express the severity range or impact. i.e. 0 be the lowest and 4 be the highest. The scale for impact is categorized into 5 types Which are shown in Table 1.

Table -1: Assessment grades

Scale of impact	
0	Not prominent
1	Less prominent
2	prominent
3	Highly prominent
4	Always prominent

The scale value for each factor was obtained and ranked based on Relative Importance Index (RII) of the responses are computed for their impact and significance. RII is calculated using the equation

$$RII = \frac{\Sigma W}{(H \times N)}$$

Where ΣW is the total weight given to each factor by the respondents, which ranges from 0 to 4 was calculated by an addition of the various weightings given to a factor by the entire respondent , H is the highest ranking available (i.e, 4 in this case) and N is the total number of respondents that answered the question. Based on the RII value the factors were ranked and identify the most critical factors.

3.3 Preparation of Program Schedule in Microsoft Project Software

Microsoft project is a project management software program, developed and sold by Microsoft , that is designed to assist a project manager in developing a plan , assigning resources to tasks, tracking progress , managing the budget and analysing workloads. The activity schedule and time duration in MS project of a residential building were obtained is shown in Annexure C . Data will be used in Genetic Algorithm model. The steps in MS Projects are first to determine major tasks, enter them in Task Name column (enter them in chronological order). Remember, these are tasks and must contain a verb. Avoid the verb "design" since this is ambiguous and is actually a process containing many tasks (it is not a single task) then highlight rows just below

the major tasks and hit the "insert" key to insert blank rows. Enter the subtasks for each major task (if there are any). Remember to use verbs. Then highlight the subtasks (for a given major task) and click on the "right arrow" key on the toolbar (see last page for comments on toolbar icons) and enter the duration for the subtasks.

3.4 Optimization of Scheduling by Genetic Algoritham

A project such as a construction project consists of a network of activities and a node in network corresponds to an activity. Each activity in a project has corresponding duration and also needs certain amount of resources such as labour material to execute itself with them. Activity duration is usually measured in integral increments of time called planning units. The normal duration of an activity refers to the time required to complete that activity under normal circumstances.

The GA begins like any other optimization algorithm, by defining the optimization variables, the cost function, and the cost. It ends like other optimization algorithms too, by testing for convergence. In between, however, this algorithm is quite different. A path through the components of the GA is shown in the flowchart fig -1.

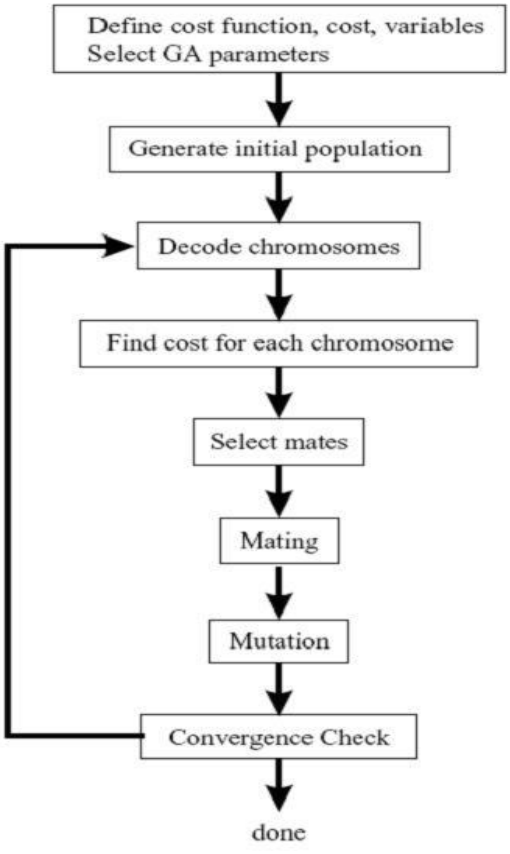

Fig-1: Flowchart showing Genetic Algorithm Process

4. RESULTS AND DISCUSSION

Questionnaire survey was conducted among 35 individuals, based on the degree of assessment about 51.7 % were responded as the shortage of skilled labour and poor communication between construction parties had high effect in construction projects whereas 33.28% people were responded as medium effect. Mistakes in design had high effect declared by 57.14% people whereas only 31.4 % declared as have only medium effect. For the case of late submission of nominated materials 42.42% were responded as medium effect and 45.7% were responded as high effect.

4.1 Critical Factors

Based on the degree of assessment the RII value was calculated and ranking was carried out according to the value. From the data obtained the value of RII varies from 37.14 to 81.90 for different factors. From the table 4.1, it was noted that poor communication between construction 23 parties and shortage of skilled labours had got an RII value of 89.10% and was indicated as rank 1. The impact of poor communication between individuals causes various conflicts and which delays the construction work. Mistakes in design and poor workmanship . To overcome this problem proper design according to specifications should adopt. Improper planning, inadequate site investigation, misinterpretation of data, unaware of future needs are some of the causes for mistake in design. So proper planning, adequate investigation of site and accurate design procedure are needed to execute the project with high precession.

4.2 Microsoft Project Scheduling

The project manager is developing a plan , assigning resources to task , tracking progress remanaging the budget and analysing workloads . In this way the construction of a residential building have 38 activity as per the planning , the construction of the residential building by conventional method can be completed by 185 days as shown in fig-2.

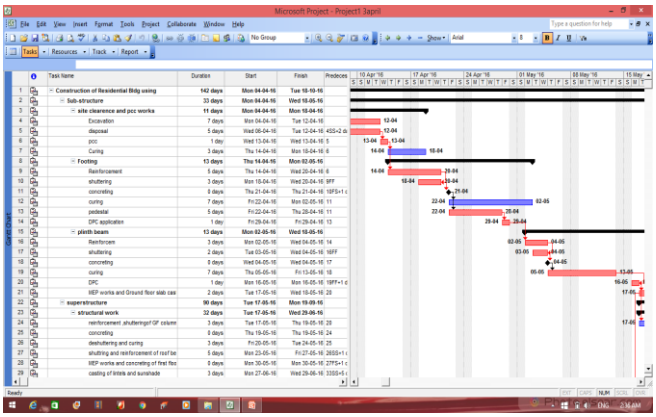

Fig-2: Planned Activities for Conventional Building

4.3 Genetic Algorithm Optimized Data

According to the scheduling data of the construction project with the help of optimizing program should developed by matrix manipulation , plotting of function and data , implementation of algorithm and creation of user interface . Model verification and validation are essential parts of the model development process if the model to be accepted and used to support decision making.

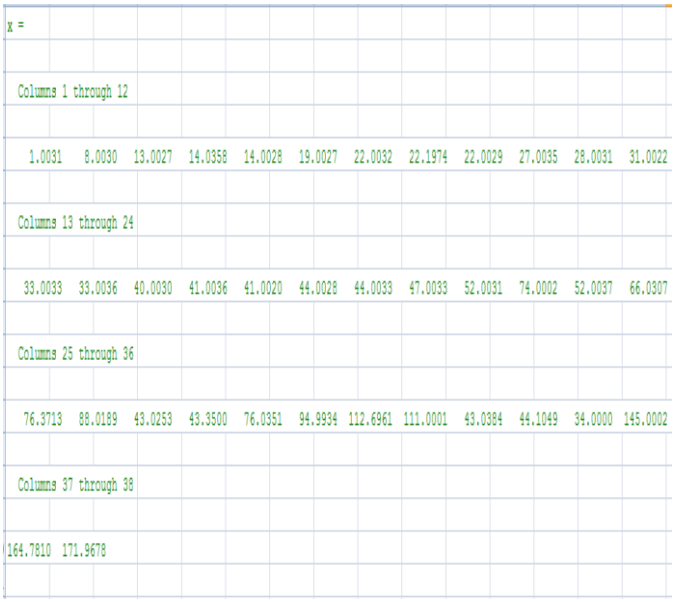

Fig-3: Program Result for Optimized Schedule

The total duration of the project is 172 days in Genetic Algorithm optimization program. No computational model will ever be fully verified guaranteeing 100% error free implementation. A high degree of statistical certainty is all that can be realized for any model as more cases as tested. The developed model was verified by more tests performed, errors were identified, and corrections were made to encountered errors. This took a long period of time, and a huge effort by the researcher to get a high degree of certainty about the model verification. Validation ensures that the model meets its intended requirements in terms of the methods employed and the results obtained. The ultimate goal of the model validation is to make the model useful in the sense that the model addresses the right problem, provides accurate information about the system being modeled, and finally to make the model accurately used.

Table-2 Comparison between solution of the problem

Solution	Total duration	No of Iteration
CPM	136	------
MS Project	185	------
CPS Optimizer	172	10- 30

5. CONCLUSIONS

An implementation of the GA developed model for residential building project scheduling has resulted in optimized output with reduced cost . A real time project solved using this optimization software shows that best converging result can be obtained . develop a genetic algorithm optimization model to schedule project activities in order to minimize the total duration of the project, subjected to precedence constraints. The problems are applied and the results are studied and compared with the results of previous studies and with the feature of "resource leveling" in the commercial construction management programs, which showed that the CPS Optimizer results meet the intended goal of achieving the best schedule with the minimum efforts. Crossover operator that suits the studied problem and creates feasible solutions. The total time duration of the project has 172 days in GA model but for MS project scheduling it has 185 days in that way the Genetic Algorithm method has more effective the MS Project.

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