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Determination of Construction Time, Construction Cost and Overall Project Quality in Construction Progress of Multi-Mode Activities from Various Algorithm

Nitin Kumar Singh[1], Dr. M. K. Trivedi[2],
[1, 2]*Department of civil engineering, MITS Gwalior, Madhya Pradesh*

Abstract: ***In the last few decade a extensively studies have been carried out over the optimization problem. A vast study is carried in the field of time-cost trade off optimization. As the industry is emerging day by day so extra factors in the optimization field is growing with a tremendous level. So keep in mind the importance of time and cost the third most important factor quality is also carried out with the terms. And combinedly this study transform itself in time-cost-quality trade off optimization. Among from the various studies the three rare number models are selected and all the parameters are evaluated by one by with the help of algorithm used in themselves. All the three objective function are thoroughly focused simultaneously.***

Keywords: Time-cost-quality trade-off; Generalized precedence relations; Critical path; Multi-objective optimization; Evolutionary algorithm; Genetic algorithm; Ant colony optimization; Particle swarm optimization.

I. INTRODUCTION

The Competition is growing a lot now a days in business environment, efficient planning and scheduling is the basic need for the survival of the company. Resource management is a crucial part of project planning of any company. Cost and time both are the backbone of construction project planning. If the obsolete methods are used in utilization of technology and resources for the production it will affect the worse for the productivity and increase the project duration. For instance, using productive resources or technologies may save time, but this causes an increase in the cost. On the other hand, reduction of either time or cost may decrease quality of construction projects. So delivering of a project needs a specific management through which high quality of yielding can be deliver. To manage and control the resources on a given activity of a company one should need project management very deliberately, within time, cost, and quality constraints. Very few projects are completed without incurring trade-offs on time, cost, and quality. A successful project manager needs to keep a balance between the three constraints so that the outcome of the project is not compromised. However many times situations arise like where the project completion time need to be compressed because of unavoidable reasons leading in the project. So keeping balance in these three objective is a difficult task in the project delivering.

1) *Construction Time:* It is defined as the total duration needed for the completion of the entire project from zero level to the finished product. So the actual time required for the entire activities to get completed is termed as Construction Time. Critical path is chosen for the construction. The longest path is knowns as Critical path. Construction time totally depends upon resources available for the construction and depend directly on them. More the resources lesser is the time required for the all-inclusive construction.
2) *Construction Cost:* Expenses incurred in the overall construction duration is termed as Construction cost. Further it is divided among two categories direct cost and indirect cost. Cost which are directly levied to construction are termed as Direct Cost (labour, material, machines etc). And the cost which is used in construction from second path not directly is termed as Indirect cost (Stationary, Cleaning, laboratory, safety and medical etc).
3) *Construction Quality:* It's one of the crucial part in construction. It measures the characteristic of the provided benchmarks for the quality. The main aim is to evaluate the variance between acquired result and desired results so one can make selection on the way to accurate any variations. As the quality obtained is not upto mark it will lead to additional cost of the project and will postpone the construction time (work has to redone). So enhancing the quality of work is the major aspect in day to day construction work.

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In todays world above three parameters are effectively carried out in the optimization, as quality is needed in the project construction very much now a days. To enhance these parameters optimization is carried out with high precision. All the values are focused in an appropriate value according to the provided objective functions.

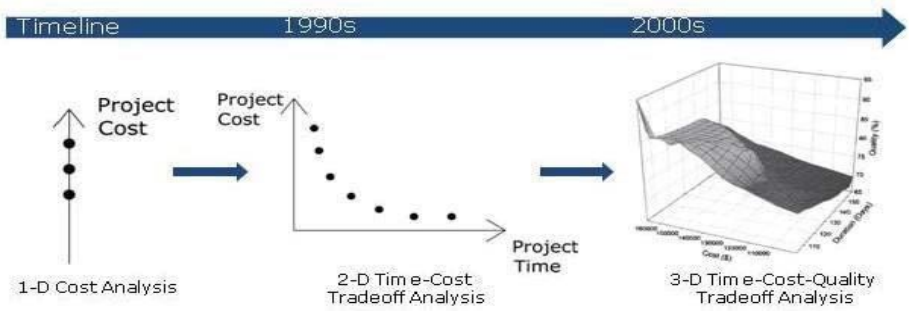

Fig 1 Evolving generation in Time-Cost-Quality trade off

II. OPTIMIZATION TECHNIQUE

In this research three different types of algorithm are studied. These algorithm are optimization based which try to produce an optimum solution for the provided multi-objective optimization problem. In all these techniques Matlab is widely used for coding. Generally a pseudo code is developed in the matlab which use to run the algorithm for solving the multi-objective optimization problem. The using of Matlab reduces the chances of error to nil. It is a very sophisticated software which handle the data of optimization very carefully in the provided respected manner. Matlab is data evaluation and visualization instrument which has been designed with robust support for matrices and matrix operations. As well as this, Matlab has excellent graphics capabilities, and its own powerful programming language. Reasons that Matlab has to end up such a critical tool are thru the usage of sets of Matlab programs designed to support a particular project. These sets of programs are called toolboxes, and the particular toolbox of interest to us is image processing toolbox. Somewhat give an explanation of whole Matlab's capabilities, we will limit ourselves to only those features apprehensive with handling of pictures. We will provoke features, commands and procedures as required.

1) *Genetic Algorithm:* Genetic algorithm is an evolutionary algorithm that is used to find the optimal and accurate solutions. It is a search method that is used for computing the approximately true solutions to optimize the problems. GA are a certain class of evolutionary algorithms inspired thru evolution. It is based on the theory of evolution that was given by Darwin “Survival of the fittest”. This theory mainly defines that those individuals which are adaptable to changing environment are thus fits in that scenario will move further and the rest of the weak population will be eliminated.
2) *Particle Swarm Optimization:* Theory of particle swarm optimization (PSO) has been developing swiftly. PSO has been used by many packages of numerous troubles. The algorithm of PSO emulates from behaviour of animals societies that don’t have any chief of their group or swarm, consisting of chicken flocking and fish education. Typically, a flock of animals that don't have any leaders will locate food by means of random, follow one of the participants of the institution that has the closest function with a food supply (potential solution). The flocks acquire their satisfactory situation concurrently through communication amongst contributors who have already got a higher scenario. Animal which has a better situation will inform it to its flocks and the others will move simultaneously to that location. This would happen repeatedly until the best conditions or a food source discovered. The system of PSO algorithm in locating superior values follows the work of this animal society. Particle swarm optimization consists of a swarm of particles, in which particle represent a ability answer.
3) *Ant colony Optimization:* Ant colony optimization (ACO) is one of the maximum recent techniques for approximate optimization. The inspiring source of ACO algorithms are actual ant colonies. More particularly, ACO is inspired by the ants’ foraging behaviour. At the middle of this conduct is the oblique communiqué between the ants by using chemical pheromone trails, which enables them to find short paths between their nest and food resources. This characteristic of actual ant colonies is exploited in ACO algorithms in order to solve, for instance, discrete optimization issues.

Depending on the point of view, ACO algorithms may belong to different classes of approximate algorithms. Seen from the artificial intelligence (AI) attitude, ACO algorithms are one of the maximum a hit strands of swarm intelligence. The aim of swarm intelligence is the design of clever multi-agent systems by taking idea from the collective behaviour of social insects along with ants, termites, bees, wasps, and other animal societies which include flocks of birds or fish colleges.

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III. RESEARCH METHODOLOGY

In our study we have gone through from various model for the calculation of construction time , construction cost and overall project quality for delivering the best suited result for the construction process activities. In the research all the various models are compared with each other with all the main three aspect i.e. construction time , construction cost and overall project quality and a recommendation is provided for delivering the best suited final model for carrying out the studies further.

For carrying out our result we studied about the three model for the computation of the result. Various factors are calculated on the basis of the formulae provided in the models. All the study is carried out with excessive of hard work and stipulation. The models has optimized the time, cost and quality with respect to the objective functions which are illustrated in the provided models.

Description	Time Formulae	Cost Formulae	Quality Formulae
Model 1	Minimize project time = Max_i (ES_i + d_i)	Minimize project cost = $\sum_{i=1}^{n} Cos\ t_i$	Maximize project quality = $\sum_{i=1}^{l} \text{wt}_i \sum_{k=1}^{k} \text{wt}_{i,k}\ \text{X}\ Q_{i,k}^{n}$

Table No. 1

Where,

1) T_i is duration of the activity if i ϵ(1; 2; ... ; l) on the critical path for a specific option of execution methods; l is the total number of critical activities on a specific critical path.
   ES_i is the earliest start of activity i, d_i is the duration of activity i.
2) Cos t_i is the cost of activity i for a specific option of execution methods and n is the total number of activities.
3) $Q_{i,k}^{n}$ = performance of quality indicator (k) in activity (i) using resource utilization (n); $\text{wt}_{i,k}$ = weight of quality indicator (k) compared to other indicators in activity (i); and wt_i= weight of activity (i) compared to other activities in the project.
4) M_i^n = material cost of activity (i) using resource utilization (n); D_i^n = duration of activity (i) using resource utilization (n); R_i^n = daily cost rate in Rs./day of resource utilization (n) in activity (i); B_i^n = subcontractor lump sum cost for resource utilization (n) in activity (i), if any

Description	Time Formulae	Cost Formulae	Quality Formulae
Model 2	$Min\ Time = S_i$	$Min.Cost = \sum_{i=1}^{n} \sum_{k=1}^{r_l} x_{ik} c_i$	Max Quality = $(\sum_{i=1}^{n} \sum_{k=1}^{r_l} w_i x_{ik} q_{ik}) / \sum_{i=1}^{n} w_i$

Table No. 2

Description	Time Formulae	Cost Formulae	Quality Formulae
Model 3	Min. Project Cost = $\sum_{i=1}^{l} T_i^n$	$Min.Cost = \sum_{i=1}^{n} \{(M_i^n + D_i^n X R_i^n) + B_i^n\}$	$Max.\ Project\ qualit = \sum_{i=1}^{l} \text{wt}_i \sum_{k=1}^{k} \text{wt}_{i,k}\ \text{X}\ Q_{i,k}^{n}$

Table No. 3

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IV. RESULTS AND DISCUSSION

As the result carried out is a computational task, various algorithm provided their result with varying varieties in the solution. Every result evaluated is differ from each with some variation. But all the result provides the impact in the solution. So we have to choose the approximate solution from these option.

S.No.	Activity	Alternative	Act. weight (wt_A)	IW(1) ($wt_{A,k}$)	QP(1) ($Q^m_{A,k}$)	IW(2) ($wt_{A,k}$)	QP(2) ($Q^m_{A,k}$)	IW(3) ($wt_{A,k}$)	QP(3) ($Q^m_{A,k}$)
1.	Excavation	1	0.160	0.45	97	0.30	99	0.25	93
		2			70		73		71
2.	P.C.C. Work	1	0.164	0.20	94	0.35	91	0.45	89
		2			83		88		84
3.	Steel work	1	0.190	0.30	95	0.45	94	0.25	95
		2			85		87		89
4.	Shuttering	1	0.057	0.40	99	0.30	78	0.30	94
		2			90		85		88
		3			85		90		86
5.	Concrete casting	1	0.133	0.35	89	0.35	92	0.30	94
		2			83		83		87
6.	Painting	1	0.043	0.40	90	0.50	78	0.10	73
		2			85		90		94
		3			90		95		95
7.	Water proffing & testing	1	0.024	0.40	70	0.50	85	0.10	90
		2			95		88		85

Table 4. Activity Description Chart

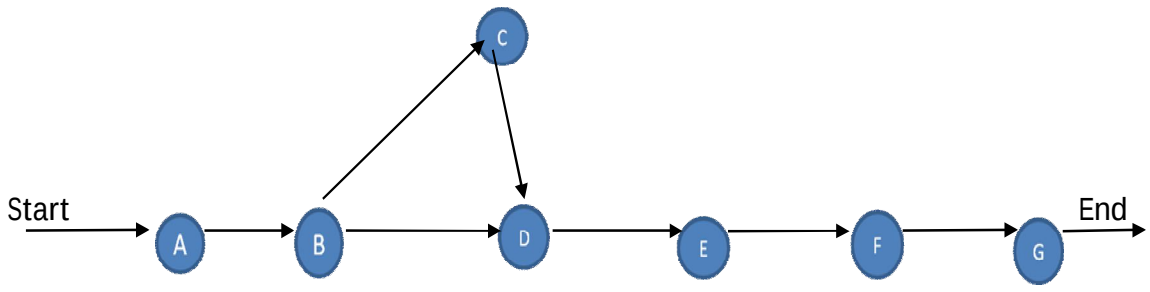

Fig 2: Network diagram of activities for Case study

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S. No.	Activity	Duration	Early Start	Early Finish	Late Start	Late Finish
1	A	50	0	50	0	50
2	B	35	50	85	50	85
3	C	120	85	205	85	205
4	D	120	90	210	205	325
5	E	120	210	330	325	445
6	F	15	330	345	445	460
7	G	20	345	365	460	480

Table 5. Computation of earliest and latest activity time

1) *Solution of model no. 1 (GA):* These results are generate by changing the limits of time, cost and quality in coding of GA, as per result we are reducing the duration limits of project in the above code and getting proposed time, cost and quality for completion of the work at some point when we are decreasing the duration of the project cost of the project increased. After applying different limits we found economical solution which is 331 days with 36956750 Rs. Cost having PQI of 2.514.
2) *Solution of model no. 2 (PSO):* After applying different limits, particle swarm optimization algorithm evaluated a result for the project is 360 days with 40578397 Rs. Cost. Having PQI of 1.801 which is optimum solution provided with varying limits. This result is little bit nearer to the effective solution which is provided in the earlier optimization technique. As this is one solution from our various research.
3) *Solution of model no. 3 (ACO):* By applying ant colony optimization the result evaluated from the study is completely different from the above two optimization techniques. The optimum result produced from this optimization technique is 249 days with 43714628 Rs. Cost having PQI of 1.313.

V. CONCLUSION

Study is carried out for the multi-objective optimization problem, the different algorithm are analysed with three various objective functions to evaluate the value. A case study having 7 activities with different alternative and quality indicator is analysed separately from these algorithm. The result evaluated from Genetic Algorithm is more efficient and beneficial having highest quality of Project Quality Indicator (PQI) , with provide less duration and an effective costing. As comparing the output of the algorithm, result obtained from GA as compare to ACO and PSO is effective. So undoubtedly the result obtained in the genetic algorithm is as per our need.

As from the research carried out in the provided step we can draw a conclusion that algorithm having a high PQI provides a greater quality of work. PQI is responsible for the quality work which is carried out in project while construction. In daily life, new algorithm are evolving out which provides a better result but a decision making problem arise to select the algorithm from the list. In our studied we tried to explain the difference in result evaluate from the same case study with different approach.

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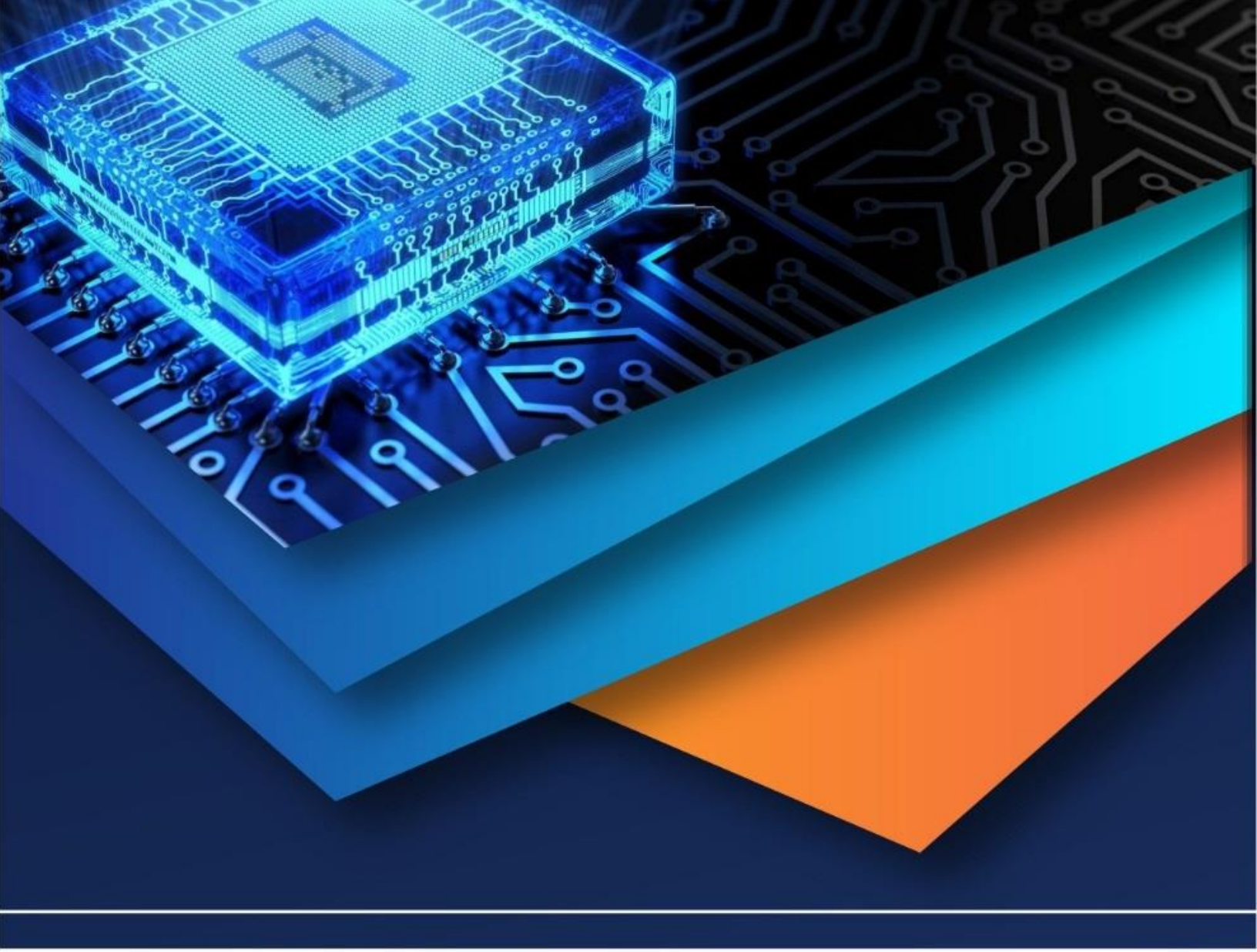

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