Optimization of Resource in the Industry of Construction

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Abstract: Time and cost are two of the most important factors to consider in each construction project. In order to maximize performance, both the client and the contractor will work to optimize both the duration of the project and its cost. We show a model of linear entire mixed programming to solve the considered problem. The aim is to minimize the project total time, by means of the assignment of equipments of work to the different production lines of the activities to realizing. The fundamental beginning is to support the same production (rate of production in meters/day of the activity in view of the equipment of work) for the different equipments to achieve the maximum efficiency in each period of time. With the limited availability of resources, the work must be continuous and the period of time between operations and final must be kept. However, this paper also presents the bibliographical study on methodologies of the optimization of construction processes in response to the two objectives: time and cost. This will consider the use of meta-heuristic techniques, such as population based algorithms.

Key words: Optimization, construction process, heuristics, mathematical programming.

1. Introduction

The economic crisis that everybody is going through in Spain has targeted all sectors of industry, the construction industry being one of the most affected ones.

The fact that the construction industry is sensitive to the adverse financial conditions present in Spain, the limited financial resources and high competition in the market makes it necessary to perform project planning and control of works.

For years, builders have been limited to relying on experience and intuition, without regard to optimum needs of the resources used in the construction process. In small projects, the planning of resources can be developed by experience, but in large projects in which investments and, therefore, the risks are much higher, planning involves the optimization of processes that arise in the construction industry.

The principal aim of this paper is to make a bibliographical study on the methodologies raised in the associated document to support the planners and administrators in the capture of better decisions about

time-cost in an efficient way.

Indexing the type of problems that we can meet, we have two types of problems of optimization: first, we find mono-objective problems of optimization, in which the development takes us to the optimization of the resources to reach the minimal cost of the project or the minimal term of execution in an independent way. In this type of work, it is not that the term of execution or the cost of the project is ignored, but depending on the variable in study the other one is taken as a constant. These types of problems are removed since, in most cases, the reduction of the term of execution takes into account an increase of the cost or, on the contrary, a reduction of the cost. Normally, it supposes an increase of the term of execution of any project. For this reason, the type of problems we really face are those in which a formulation is in use one multi-target, since the cost of a project and the term of execution are closely associated.

The second one of the principal aims of this work is to explore the analysis of the information corresponding to a practical case that one finds nowadays in the south of Tenerife, where only time studies are made.

Another contribution of this work is the mathematical formulation by means of a model of

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linear entire mixed programming to solve the problem. The comparative study is made from the time of execution of the work to the time provided by the mathematical formulation.

2. Methodology

2.1 Bibliographical Review

We show a bibliographical review of problems of optimization developed recently, mono-objective (Table 1) [1-7] and multi-objective (Table 2) [8-15]. These tables are arranged in six columns. In the first column, it shows the title of paper accessed, in the second, it shows the name of authors, the third shows the year of publishing, in the fourth column, it appears medium publishing and, finally, the fifth and sixth columns show the methodology and aim studied in the paper.

2.2 Classification of Problems

As shown in Tables 1 and 2, the classification of problems are as following:

- title of the paper or article;
- author(s) of the paper or article;

- year of publication of the paper or article;
- way of publication of the paper or article;
- mathematical proposed model on the paper or article (genetic algorithm, colony of ants and swarm of particles);
- type or aim of the work indexed on paper or article is reduction of project cost, reduced development time or reduction both, project cost and development time of the project.

2.3 Selection of Article of Reference

Resource-constrained scheduling is for the continuous repetitive projects with steels-based production units [16]. They show the complexity of the optimization with limited resources on fully linear works. This optimization is done regardless, at any time, the cost of funds and, therefore, the project cost.

2.4 Comparison of the Real Time and the Optimized One

We proposed a model of linear programming, with which we achieve a substantial reduction of project time and the project cost.

Table 1 Mono-objective references.

Title	Author (s)	Year of publishing	Medium publishing	Methodology	Aim
Genetic algorithms for optimization of resource allocation in large scale construction project [1]	Jianwen Huang, Xingxia Wang, Rui Chen	2010	Journal of Computers	Genetic algorithms	Minimize project time
Optimizing construction planning schedules by virtual prototyping enabled resource analysis[2]	Heng Li, Neo Chan, H.L. Guo, Weisheng Lu, Martin Skitmore	2009	QUT Digital Repository	Genetic algorithms	Minimize project time
Simulation and optimization for construction repetitive projects using promodel and simrunner [3]	Chachrist Srisuwanrat, Focio G. Ioannou, Omer Tsimhoni	2008	WSC (Winter Simulation Conference) Phoenix, USA	Determinist method	Minimize project time
Research on the unlimited resource leveling optimization with PSO [4]	Zhiyong Chen, Zhida Du, Hua Zhou	2007	China Civil Engineering Journal	Particle swarm	Minimize project time
Construction project scheduling problem with uncertain resource constraints [5]	Julin He, Zhong-Ping Wan, Tang Guochun	2005	Chinese Journal of Engineering Mathematics	Simple algorithms	Minimize project time
Genetic algorithms in resource optimization of construction project [6]	Zhang Lian-ying, Luo Gang, Li Ning Lu	2001	Journal of Tianjin University	Genetic algorithms	Minimize project time
Resource leveling in construction by genetic algorithm-based optimization and its decision support system application [7]	Sou-Sen Leu, Chung-Huei Yang, Jiun-Ching Huang	2000	Journal of Automation in Construction	Genetic algorithms	Minimize project time

Table 2 Multi-objective references.

Title	Author(s)	Year of publishing	Medium publishing	Methodology	Aim
Integrating efficient resource optimization and linear schedule analysis with singularity functions [8]	Lucko Gunnar	2011	Journal of Construction Engineering and Management	Genetic algorithms	Minimize time and project cost
Optimization research: Enhancing the robustness of large-scale multi-objective optimization in construction [9]	Kandil Amr, El-Rayes Khaled, El-Anwar Omar	2010	Journal of Construction Engineering and Management	Genetic algorithms	Minimize time and project cost
Optimization study on resource equilibrium with fixed time limit for a project based on SPSO algorithm [10]	Qingfu Li, Jixian Guo, Mingxing Yi	2008	International Symposium on Intelligent Information Technology Application Workshops Washington, DC, USA	Genetic algorithms	Minimize time and project cost
Multiple resource constraint time-cost-resource optimization using genetic algorithm [11]	Habib Fathi, Abbas Afshar	2008	First International Conference on Construction in Developing Countries (ICCIDC-I) Pakistan	Genetic algorithms	Minimize time and project cost
Multi-objective optimization for large-scale highway construction projects [12]	Amr A. Kandil	2006	ProQuest, Dissertations & Theses	Genetic algorithms	Minimize time and project cost
A hybrid mechanism for optimizing construction simulation models [13]	Taoming Cheng, Chungwei Feng, Yanliang Chen	2005	Journal of Automation in Construction	Genetic algorithms	Minimize time and project cost
Development and application of a hybrid genetic algorithm for resource optimization and management [14]	O.O. Ugwu, J.H.M. Tah	2002	Engineering Construction and Architectural Management WILEY (online library)	Genetic algorithms	Minimize time and project cost
Optimizing resource utilization for repetitive construction projects [15]	Khaled El-Rayes, Osama Moselhi	2001	Journal of Management in Engineering (ASCE)	Genetic algorithms	Minimize time and project cost

3. Problem of Reference

The mathematical model is proposed by the teachers/aces [16].

It includes the following restrictions:

- Limited availability of multiple resources;
- The work must be constant and must not have dead times;
- The delivery time between operations and end must be kept.

4. Case Study

IDAM (installation of desalination seawater) of Granadilla de Abona is developed by the Consortium Ferrovial-Agromán Corporation and Cadagua.

4.1 Activities

Activity A: ML (linear meter) of placement of prefabricated girder, cover water tanks running with

precast concrete prestressed material.

Activity B: ML of placement of alveolar plate.

4.2 Available Resources and Combinations

We show the available resources and combinations in Table 3.

4.3 Choice

In Table 4, we show our selection between different combinations.

In this table, it showed: activity, sub-activity and our selection as a function of available resources and daily production combining different choices.

The symbol A in table 3 (A) reference is coefficient relating on linear meters and square meters and the value is 4 per linear meter have 4 square meters.

4.4 Plans of Work

In Table 5, we show 13 different plans works what

Table 3 Available resources and combinations.

Activity	Sub-activity	Available resources			Production
		Autoderrick crane (ud)	Lift (ud)	Workers (ud)	ML (linear meters)
A		2.00	2.00	6.00	Day ud
	A1	1.00	2.00	3.00	95.85 days
	A2	1.00	2.00	2.00	43.20
	A3	2.00	2.00	3.00	95.85
	A4	1.00	2.00	6.00	95.85
	A5	2.00	2.00	2.00	43.20A
B	B1	1.00	2.00	3.00	48.62A
	B2	1.00	0.00	3.00	48.62A
	B3	1.00	1.00	2.00	27.13A
	B4	2.00	0.00	6.00	95.85A
	B5	2.00	0.00	5.00	75.76A
	B6	2.00	2.00	5.00	75.76A

Table 4 Choice.

Activity	Sub-activity	Available resources	Available resources	Available resources	Production
		Crane	Lift	Workers	ML/day
		2.00	2.00	6.00	
A	A1	1.00	2.00	3.00	95.85
B	B4	2.00	0.00	6.00	95.85A

Total activity A = 1,349.68 ML placement of prefabricated girder; Total activity B = 1,349.68A ML placement of alveolar plate.

Table 5 Plans of work.

Number plan	Index of production							
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1	194.48A	194.48A	194.48A	194.48A	194.48A	194.48A	194.48A	8.13A
2	200.93A	200.93A	200.93A	200.93A	200.93A	200.93A	163.95A	
3	205.61A	205.61A	205.61A	205.61A	205.61A	205.61A	135.94A	
4	210.28A	210.28A	210.28A	210.28A	210.28A	210.28A	107.87A	
5	214.95A	214.95A	214.95A	214.95A	214.95A	214.95A	79.84A	
6	219.63A	219.63A	219.63A	219.63A	219.63A	219.63A	51.80A	
7	224.30A	224.30A	224.30A	224.30A	224.30A	224.30A	23.76A	
8	228.97A	228.97A	228.97A	228.97A	228.97A	224.70A		
9	233.64A	233.64A	233.64A	233.64A	233.64A	201.33A		
10	238.32A	238.32A	238.32A	238.32A	238.32A	177.97A		
11	242.99A	242.99A	242.99A	242.99A	242.99A	136.94A		
12	378.80A	378.80A	378.80A	215.48A				
13	479.25A	479.25A	379.29A					

Table 6 Restrictions of work.

ID	Distances	
	LT (days)	LD (ML)
ML girder	1.00	95.85
ML plate

Fig. 1 Duration of the project according to planning in work.

Fig. 2 Optimum of the project.

we can have with our resources.

4.5 Restrictions of Work

In Table 6, we show the restriction appointed of resource. We have to put girders, minimum one day (LT) with daily performance of 95.85 linear meters (LD) for after position plates.

4.6 Duration of the Project According to Planning in Work

Fig. 1 shows the planning of work that the construction company pretended run. They finish Activity A and after start Activity B.

4.7 Optimum of the Project

Fig. 2 shows the optimal plan using our model of linear programming.

5. Conclusions

A study of a real problem is located in limited resources point. We show a mathematical model of mixed integer linear programming. Comparing the actual execution time of the work with the time provided by the mathematical formulation, it is proposed a model of linear programming to solve the problems of the current work of Granadilla and compared it to the actual work done by the company. We concluded that while the company tried to complete the work, developing two consecutive activities at the same time, during 31 days, the problem of combinatorial optimization prepared would develop it in only 24 days, which would suppose a reduction of the term of execution in one week. And we can observe that in the majority of mono-objective consulted works, the aim is to reduce the project time.

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