Repetitive Project Modelling
With Penalty and Incentive

Mohammed Shurrab, Department of Mechanical Engineering, Kyushu University, Fukuoka, Japan
Ghaleb Y. Abbasi, Department of Industrial Engineering, University of Jordan, Amman, Jordan
Osama Eljamal, Department of Earth System Science and Technology, Kyushu University, Fukuoka, Japan
Jalal T. Tanatrah, Department of Industrial Engineering, University of Jordan, Amman, Jordan

ABSTRACT

Repetitive construction activities have the same activities which are performed repeatedly. Repetitive projects include: pipelines, highways, and multi-story buildings. Repetitive projects have been modelled widely using the traditional network techniques although, they have some disadvantages. Furthermore, different approached have been developed for repetitive activities including the graphical and analytical techniques. The objective of this research is to add new enhancements on an approach called Repetitive Project Model (RPM) which is related to the repetitive construction projects. The enhancements incorporating the incentives and penalties within the RPM. This model incorporates a network technique, a graphical technique, and an analytical technique. A numerical example was demonstrated in this research paper to aid on using the suggested model in the real-life application.

KEYWORDS

Construction, Network Technique, Penalty and Incentive, Project Management, Repetitive Construction Projects

INTRODUCTION

A project is a collaborative enterprise contains a set of interrelated activities to produce the required outcome (Heagney, 2016). Repetitive projects are those projects that have repeated activities the same precedence relationships and the same duration to obtain similar units of outcome comprising the whole project (Sears et al., 2015).

A multi-stores construction building is one of the repetitive project’s application (Srisuwanrat, 2009; Schwindt & Zimmermann, 2015). The quantity of resources for each activity is carefully selected to: maintaining constant production rate and continuity of work for each crew on each activity throughout the project, allow all the time buffers required between activities of the same stage.

In any construction activity, if we select a certain quantity of resources for a particular construction activity then we have to calculate the activity duration and the associated direct cost. The duration of the activity could be reduced by allocating more resources and this in return will increase the direct cost (De Schepper, 2015; Cohen et al., 2012; Everett & Farghal, 1994). The activity production rate can be calculated by:

Production rate = required quantity of work/duration

(1)

DOI: 10.4018/IJORIS.2018010101

Copyright © 2018, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.
Hence, the duration and the direct associated costs are the most important elements since the quantity of work is usually fixed and known (Batselier & Vanhoucke, 2015; Maji & Jha 2013; Maravas & Pantouvakis, 2012) the objective is usually to finish the project at a certain duration within minimum direct cost. Hence, the constraints are to maintain production rates and continuity of work for each crew (Reda, 1990).

Different techniques were developed to model the repetitive construction projects. O’Brien et al. (1985) used the traditional critical path method (CPM) to plan large repetitive projects (e.g. schools). However, using CPM has some disadvantages for example: large number of activities is needed to idealize and exemplify the project, CPM does not maintain the continuity of work. Other graphical approaches were also used, for example, Arditi and Albulak (1986) developed a Line-of-balance scheduling approach in pavement construction.

The linear scheduling method was presented in several real-life repetitive projects applications (Ipsilandis, 2006; Chrzanowski & Johnston, 1986; Johnston 1981). Although the mentioned graphical approaches are simple and easy to visualize the project, the production rates are not considered to be decision variables.

Moreover, several researches have been presented to develop analytical models for repetitive projects. Russell and Caselton (1988) presented extensions to linear scheduling optimization including two-state variables by using dynamic programming. The model objective was to minimize the project duration. Yang and Ioannou (2001) proposed a resource-driven scheduling for repetitive projects (i.e. a pull-system approach). Optimizing strategies were also provided for repetitive construction projects (Aziz, 2014; Aziz, 2013).

The RPM (Reda, 1990) is a unified approach for modeling repetitive construction projects, and includes a network technique, a graphical technique, and an analytical technique. The network technique used is the activity on node (AON) network, where activities are represented by nodes and dependencies between activities are represented by links. The network used represents the activities and their dependencies needed to complete a typical stage of a repetitive project. The advantages of this model are a linear programming model, where the objective of RPM is to minimize the project direct cost for each feasible project duration. The RPM satisfied certain constraints, it a) maintained a constant production rate and a continuity of work for each crew, b) allowed for a time buffer between activities on the same stage and allowed for a stage buffer between concurrent activities, and c) specified a feasible project duration.

However, the disadvantage of this model is that it did not give attention to the penalty if the project was tardy, or incentive if project was early. The construction projects involve complex processes. Hence, activities’ scheduling and planning are very important to avoid any construction delays during the construction phase. A one-day delay in construction projects can cost the company millions of dollars (Bubshait, 2003). Conversely, business owners offer sometimes schedule incentives for early project completion. Penalties and incentives contracting is intended to penalize or reward the contractor based on performance or project throughput. The amount of penalties or incentives is determined by the owner, and negotiated later with the contractors. (Hickson & Owen, 2015). The objective of this research is therefore to enhance the RPM by adding new constraints to the analytical model.

The new model, proposed in this study, maintains the linearity of the model to include the penalty with incentives. The study solved certain case studies to show the demonstration of using the new proposed constraints.

**MATHEMATICAL NOTATIONS**

\( a_i \): activity production rate  
\( APF \): assigned project finish date  
\( CN_i \): normal cost of activity \( i \)
Related Content

Organizing and Describing Information Structures
www.igi-global.com/chapter/organizing-and-describing-information-structures/225451?camid=4v1a

A Hybrid Approach Based on LP Metric Method and Genetic Algorithm for the Vehicle-Routing Problem with Time Windows, Driver-Specific Times, and Vehicles-Specific Capacities

Enhancing Organizational Capacity Through the Use of Social Media
www.igi-global.com/chapter/enhancing-organizational-capacity-through-the-use-of-social-media/202239?camid=4v1a
A Heuristic Algorithm for the Inner-City Multi-Drop: Container Loading Problem
Li Pan, Sydney C. K. Chu, Guangyue Han and Joshua Zhexue Huang (2011).
www.igi-global.com/article/heuristic-algorithm-inner-city-multi/55858?camid=4v1a