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Simulation model incorporating genetic algorithms for optimal temporary hoist planning in high-rise building construction

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ABSTRACT

Temporary hoist planning is a key factor for successful project completion in a high-rise building construction. Inadequate plans for hoists in the early stages of a project can cause problems such as failing to hoist resources as required or leaving hoists idle. There are two existing approaches, simple formulas and simulation techniques, for planning temporary hoists. However, simple formulas cannot treat hoist arrangements consisting of different kinds of hoists, while the simulation technique is both time-consuming and tedious when there are many alternatives. In this study, a discrete-event simulation model incorporating genetic algorithms is proposed to support hoist planners while preparing optimal plans with minimal time and effort for high-rise building construction. To verify the applicability of the proposed model, it was applied to a real project and gave better results than a previous approach to temporary hoist planning.

1. Introduction

Over the past decade, the number of high-rise buildings constructed and their heights have increased. The report of the Council on Tall Buildings and Urban Habitat (CTBUH) by Oldfield and Wood [1] shows that the average height of the ten tallest buildings completed each year in the world has been increasing each decade: from about 150 m in 1960 to about 420 m in 2009. Developments in materials technology and structural engineering, and the necessity for efficient space utilization caused by increasing land prices and the problem of overpopulation in urban areas will maintain this trend until at least 2020.

In high-rise building construction, adequate planning of temporary hoists is a key factor for successful project completion. Hoists, together with cranes, are essential equipment for vertical transportation of construction resources, such as manpower and materials [2]. Too few hoists can cause productivity losses by failing to hoist resources in a timely fashion. On the other hand, too many hoists can incur unnecessary costs when hoists are idle. Higher buildings require more resources and have longer transportation distances. Thus, high-rise building construction has the disadvantage of longer lifting times for workers and materials compared with shorter cycle times in low-story construction. Thus, in high-rise building construction, creating adequate plans for temporary hoists is becoming a more difficult task. Planning for temporary hoists usually depends on heuristic methods, i.e., simple formulas modified by the subjective opinions of experienced practitioners. However, this heuristic method carries the risk of making inappropriate decisions that potentially cause problems such as cost increases and delays.

The simulation technique, especially discrete-event simulation (DES), provides a promising alternative solution to construction system following the criterion of a computer model of the real system based on real life statistics and operations [3]. Ever since the inception of CYCLONE technology [4], simulation models for typical construction systems have been delivered as electronic realistic prototypes for engineers to experiment on, which eventually will lead to productive, efficient, and economical field operations [3]. For the last decade, simulation techniques also have been used to assist in hoist planning handling repetitive activities in a simple way [2,5,6]. Hoist planning is substantially the evaluation of various alternatives to find the best solution. Thus, a planner using simulation has the advantage of saving both construction time and cost by evaluating various scenarios [7]. Despite this advantage, if there are many alternatives, the planner must search for an optimal solution heuristically, by trial and error, which is time-consuming and tedious. Thus, using simulation has problems that make the application of classical optimization methods difficult, or even impossible if possible alternatives increase explosively [8]. Therefore, traditional simulation is not considered as an optimization technique [9].

To alleviate this problem, genetic algorithms (GAs), which are artificial intelligence techniques inspired by the theory of evolution and biogenesis, could be part of the solution. Many hybrid mechanisms that integrate simulation techniques with GAs have been widely applied to different disciplines of research and proved efficient in finding the optimal solution [10]. GAs is relatively more adaptable to the temporary

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