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A Prediction Method of Vertical Lifting Loads based on Long-Term Time Series Analysis for High-Rise Building Construction

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Abstract

As recent building have been getting higher and larger, vertical lift planning and operation are key factor for successful project. Although many studies have been trying to set up a construction lift planning system at early stage before lift installation, but there are not regarding lift management for on-going project using operation data from the field. In this study, to predict lifting event which may be generated during remained construction schedule, long-term time-series based data analysis was conducted. Data was collected embedded lift monitoring sensor and database. The pattern analysis was carried out reflecting characteristics of Tact based finishing work control. And this study shows an effective value of activity oriented time-series analysis to lift management on high-rise building construction. Lastly, this study has served as a key lead of lift monitoring based decision-making for vertical lift zoning. Therefore, it is anticipated to settle as a system based data-centric construction management technique in the field.

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1. Introduction

In high-rise building construction, finishing work comprises approximately 15–20% of the total construction cost. The most critical problem in the finishing work phase in high-rise building construction is lift management in terms of the manpower and materials required. The main reason for lift management problems is the long distance required in vertical transportation and the increase in materials required for finishing work.

In the Republic of Korea, high-rise buildings over 500 m generate an additional cost of over \$20 million due to finishing work delays of over 3 months. These additional costs are incurred very frequently, which demonstrates problems in the current lifting plans used in most high-rise construction projects.

The existing method for lift management, including the lift load for each construction phase and the peak time period, is based on a simple method that is generally used in buildings under 300 m. However, a method to correct the existing errors in lift management is required for high-rise building construction.

2. Research trends

Sacks et al. proposed an automated lift equipment monitoring system [1], and Cho et al. carried out a study on construction lift operation planning in terms of lifting height and loading [2]. In terms of metaheuristic approaches, Shin proposed the optimal operation of temporary construction lifts in super high-rise building construction based on a simulation and genetic algorithm [3]. Before these studies, most research focused on the use of tower or mobile cranes, and studies on construction lifts tended to emphasize lift planning rather than lift operation.

As super high-rise construction becomes more popular in Korea, there is a growing need for systematic construction planning and site management. Government and private corporations are actively undertaking studies on the operational planning of construction lifts and tower cranes. For example, Kim studied how to calculate the number of construction lifts necessary at super high-rise construction sites [4], and Cho proposed an algorithm to calculate the lifting time according to the acceleration and deceleration capabilities of construction lifts [2]. While many studies have been conducted on construction lift planning, few data-based methods have been introduced on the system, management, and algorithm of construction lift operation.

3. Operational lift management

3.1. Problems of plan-based lift management

Both temporary lift-based finishing materials and worker management have a direct impact on construction delays and cost increases due to the nature of high-rise projects having long vertical distances of over 500 m. With lift equipment that lifts 100 m/min, it takes 4 minutes to reach the top of a 400 m mast (i.e., the maximum height that can be reached according to the current technology level). The operating time is increased by 6% per stop at each floor, with 15 seconds as the average stopping time per story. In the construction of high-rise buildings, the efficiency degradation of lift operation increases exponentially.

Solving the problems caused by the characteristics of vertical lifting in high-rise construction projects cannot be expected in the short term. At present, lift-based vertical transportation planning and construction for high-rise projects are established using a heuristic model based on the following criteria. The current heuristic equations used for high-rise construction are as follows in equations (1) and (2).

$$\text{Number of lifting} = \text{Material quantities} \times \text{Total floor area} \quad (1)$$

$$\text{Number of lifting} = \frac{\text{Total Labor}}{\text{Boarding Capacity}} \quad (2)$$

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