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Production scheduling and truck dispatching of ready mixed concrete

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Abstract

In this research, we develop an integrated model that combines ready mixed concrete (RMC) production scheduling and truck dispatching in the same framework. The model is formulated as a mixed integer network flow problem with side constraints, which is characterized as NP-hard. To solve realistic problems, we develop a solution method, which incorporates a mathematical programming solver. To evaluate the model and the solution method, numerical tests using real operating data from an RMC firm in Taiwan are performed. The test results show that the model and the solution algorithm would be useful for actual operations.

Keywords: Ready mixed concrete; RMC truck; Scheduling; Time space network; Network flow problem with side constraints

1. Introduction

Ready mixed concrete (RMC) is the primary material required for buildings and public infrastructure work. Given heavy urban development and increased demand for constructions purposes, the industry is growing, market competitiveness is increasing and difficulty of operating on RMC business in Taiwan is also increasing. The profits obtainable are therefore vulnerable. Under such a condition, only efficiently managed carriers can continue to exist.

In recent years, RMC production has become more automated, but in Taiwan production scheduling and truck dispatching is still handled manually by experienced staff. Effective production scheduling and efficient truck dispatching are significant issues for a carrier's RMC plant and construction site management, requiring the carrier to address both timeliness and flexibility, while satisfying construction site operating constraints.

As shown in Fig. 1, the RMC supply process can be divided into five major components:

- Material production
- Product loading

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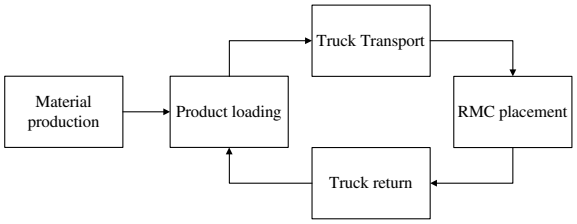

Fig. 1. RMC operating procedure.

- Truck transport
- RMC placement
- Truck return

The RMC production and placement activities must be connected by trucks to form an operation cycle.

RMC is produced to meet customer demand. In other words, it cannot be generated and stored in advance; it is unstorable. If the truck travel time exceeds the cold-joint time (the time within which the concrete hardens), the concrete is rendered useless and must be dumped, which raises the operating cost. Therefore, to conform to quality and legislation requirements, RMC must be poured within a certain time constraint. In practice, truck service is limited to a given region; the trucks must be carefully dispatched in order to prevent cold joints in the concrete. Consequently, RMC production scheduling and truck dispatching not only affects transshipment efficiency, but also the operating cost. Owing to the many complex factors and constraints involved, systematic optimization approaches to the solving of such an integrated problem have rarely been developed.

There have been only a few studies in the literature devoted to RMC production or truck dispatching scheduling. Zayed and Halpin (2001) applied a simulation technique to concrete batch operations. They analyzed alternative solutions and resource management. Wang et al. (2001) presented a simulation model. They found that the truck's arrival pattern was the most important factor in determining the productivity of the RMC placement equipment. Cheng and Feng (2003) presented a new method, that integrated a simulation with a genetic algorithm, to find the best resource combination for construction operations. Feng and Wu (2000) and Feng et al. (2004) built a model based on a genetic algorithm and a simulation technique, to find the best dispatching schedule for minimizing the total waiting time of RMC trucks at a construction site which would also satisfy the needs of RMC deliveries at different construction sites.

Lu et al. (2003) developed a simulation model for resource provision planning and production planning for a Hong Kong RMC plant. The aim was to meet the given demand for a number of sites requiring concrete within a working day. Naso et al. (2004) developed a model for ready-made concrete delivery. They proposed a hybrid genetic algorithm to solve the problem. Matsatsinis (2004) designed a decision support system for the dynamic routing of the various types of vehicles that are necessary for the daily distribution of the RMC product. Zayed and Minkarah (2004) designed a linear programming model to optimize the production of concrete, so as to maximize profit.

In the afore-mentioned research, the production and dispatching processes of RMC firm operations have mainly been fixed independently. Simulation techniques, genetic algorithms and linear programming approaches have been used to partially solve this type of problem in practice. However, these two activities are correlated with each other. In response to intense market competition, it is important for carriers to merge their production and truck dispatch schedules in an integrated framework from a system perspective. Therefore, in this research, we develop a network flow model that integrates RMC production scheduling and truck dispatching together. The objective is to minimize the operating cost, subject to the related operating constraints. The model is expected to be a helpful planning tool allowing the carrier to determine the most appropriate RMC production and truck dispatching schedule for its own operations. To assist in building the model, we employ a time-space technique that formulates the truck fleet flows in the dimensions of time and space. The model is formulated as a mixed integer network flow problem with side constraints, that is characterized as NP-hard. We develop a solution method, incorporating the usage of a mathematical programming solver to solve realistic problems.