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Optimal schedule adjustments for supplying ready mixed concrete following incidents

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ABSTRACT

In this study, the authors develop a systematic network flow model designed to help RMC carriers effectively adjust schedules following RMC mixer breakdowns. A time–space network technique is employed to formulate the production of the RMC and truck fleet flows in the dimensions of time and space. A solution algorithm, incorporating a problem decomposition technique and the use of a mathematical programming solver, is developed to efficiently solve the problem. Finally, the model and solution method are evaluated by performing a case study. The test results show that, with the application of the model and the solution algorithm, mixer breakdowns do not lead to much deterioration in the system operating performance. In addition, the system operating cost is significantly improved (by 10.75 %) compared to that obtained using the manual approach. As a result, the model and the solution algorithm could be useful for actual operations.

1. Introduction

In the last few years, ready mixed concrete (RMC) production has become increasingly automated. The process includes procurement of materials, feed and mixing proportions, discharging, prolonged agitation during travel, delivery of concrete to the construction site, and the placement operation at the site. However, if an incident (e.g., machine malfunction, electricity problem, etc.) occurs so that some of the mixers cannot produce concrete, the supply of concrete to the RMC trucks is interrupted which interferes with the dispatch schedule. The RMC production and truck dispatching plan has then to be adjusted. Operating time and overhead costs may increase if the RMC is not delivered according to schedule. In a worst case scenario, interruption of delivery leads to the occurrence of cold-joint problems. Preventive action is needed to ensure construction security. Cold-joint problems can be handled in several ways given the nature of the load bearing structure being poured at the placement site. If the placement site is not in a major load bearing area, the surface of the concrete can be dug away manually, allowing the placement to continue after the application of adhesives to the roughed surface. However, if the placement site is at a key location, to ensure quality, the site manager must remove all concrete that has already been set. The plant must then compensate by replacing all the RMC at the placement site. Under these circumstances, both the plant and the construction site managers can lose considerable amounts of capital and resources owing to the delay in work and increased overhead costs. Various solutions can be adopted to avoid the above scenario. For example, if a plant has sufficient resources, additional machinery or trucks could help supply the needed RMC. Alternatively, the firm may have to purchase RMC from a backup contractor.

Unfortunately, most carriers in Taiwan and other countries still handle schedule adjustments for RMC production and truck dispatching resulting from temporary mixer breakdowns manually based on staff experience. The temporary schedule adjustment for RMC production and truck dispatching is typically carried out using a trial-and-error process. In particular, the planner adjusts the original RMC production and truck dispatching schedule considering such factors as the available number of mixers and production capacity, available truck fleet size, RMC demand at each construction site, concrete cold joint problems, truck queuing, overtime and so on. The process of local routing of trucks, RMC production of mixers, adjusting of the truck dispatch plan within normal and overtime periods, and supporting trucks between different sites/plants, is repeated by hand until a satisfactory solution is found. The truck routes/schedules and the RMC production schedule following incidents are generally modified, possibly with additional supporting truck trips and overtime periods, depending on the incident characteristics and the decision maker's adjustment.

This manual method is not efficient for handling temporary mixer breakdowns, particularly for arranging a large network, and could possibly result in an inferior feasible solution. To design an efficient schedule adjustment for RMC production and truck dispatching, the planner must systematically address both timeliness and flexibility in RMC production and truck dispatching, often needing to consider normal work hours and overtime to satisfy the plant and construction site operating constraints. However, owing to the many complex

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