

# **An Optimization Model and Multi-Stage Solution Approach for the Scheduling of Ready-Mix Concrete Production and Distribution**

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## **Abstract**

This study presents an optimization-based decision-support framework for ready-mix concrete (RMC) production and delivery scheduling in Qatar. A Mixed-Integer Linear Programming (MILP) model, implemented in IBM ILOG CPLEX Optimization Studio, is developed to address the operational complexity of coordinating batching, loading, transportation, and delivery activities under real-world constraints. The proposed approach supports a transition from semi-manual, experience-driven planning to a systematic, model-based optimization methodology. The model explicitly incorporates Ministry of Interior (MOI) traffic restrictions, truck availability, plant loading capacities, delivery time windows, and route limitations. To enhance computational efficiency and practical applicability, a multi-stage heuristic optimization approach is integrated with the MILP formulation. The objective is to minimize deviations between requested and actual delivery times while ensuring schedules that are feasible and reliable. Computational results demonstrate that the proposed framework achieves minimal delivery time deviations, with most discrepancies occurring as early arrivals rather than delays. These results confirm the model's effectiveness in improving schedule reliability, optimizing resource utilization, and enhancing coordination between production and transportation operations. Overall, the study provides a robust optimization framework that supports more efficient and timely RMC delivery processes, offering practical value to the Qatari construction industry and similar urban environments with traffic constraints.

## **Keywords**

Ready-Mix Concrete, Mixed-Integer Linear Programming, Heuristic Optimization, Traffic-Constrained Logistics, Construction Operations

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## **Biographies**

**Rawan Elshakry** is a graduate of the Master's program in Engineering Management at Qatar University. She received her Bachelor's degree in Industrial and Service Management Engineering from Nile University, Egypt, a research-oriented university. Her academic background integrates engineering management principles with industrial systems analysis and decision-making methodologies. She currently works at Qatar Building Company (QBC) as a Stakeholder Engineer, where she supports coordination among project stakeholders and contributes to engineering-related activities within large-scale construction projects. This professional experience provides practical insight into construction operations and project execution environments.

**Kadir Ertogral** is an Associate Professor in the Mechanical and Industrial Engineering Department at Qatar University, Qatar. He received his Ph.D. in Industrial and Systems Engineering from Lehigh University, USA, in 2001. His academic and research expertise lies in operations research and industrial engineering applications. His research interests include supply chain and logistics management, strategic fleet sizing, vendor-buyer models, and energy systems. Dr. Ertogral's work focuses on developing analytical and optimization-based approaches to support decision-making in complex industrial and logistics systems.