Optimizing Urban Logistics by Integrating a Construction Consolidation Center

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This study investigates the integration of a Construction Consolidation Center (CCC) into urban construction logistics. A CCC functions as a consolidation and distribution hub, enabling the bundling of materials and facilitating Just-In-Time (JIT) deliveries [Guerlain et al., 2019]. The overall objective of our research is to enhance the efficiency of urban construction logistics while minimizing costs and social burdens. Various scenarios and operational parameters are analyzed to quantify the benefits of a CCC for both public and private stakeholders, including the potential for reduced urban traffic and cost savings for construction companies and material suppliers.

Our problem setting involves multiple construction sites located within an urban area, which requires materials to be supplied from external locations. The CCC, typically located at the outskirts of the city, offers storage facilities and a dedicated vehicle fleet to ensure timely delivery to construction sites. Construction sites, constrained by limited on-site storage, request materials according to their project schedules, creating a deterministic demand. Suppliers determine the amount of materials to be delivered directly to construction sites or to the CCC, where the materials are stored before being dispatched to their final destinations.

We propose a mathematical model to optimize the daily delivery plans for both suppliers and the CCC. Decisions include vehicle assignment, scheduling, and route planning for two types of deliveries: (1) deliveries from suppliers directly to construction sites or to the CCC and (2) deliveries from the CCC to the construction sites. The objective of the model is to minimize total costs, which comprise

transportation costs for suppliers and the CCC, handling costs at the CCC, as well as inventory costs incurred at the CCC and construction sites.

A rolling horizon approach is adopted, inspired by [Nolz, 2021], to accommodate disturbances and unforeseen changes. Daily plans are created for an extended horizon, with the first week's plan being fixed, while subsequent plans are updated on a weekly basis.

To solve this optimization model, a two-phase solution algorithm is developed. In the first phase, we determine the mode (direct delivery or via CCC) and the delivery timing for each request. At this stage, vehicle assignment and routing constraints are relaxed to approximate transportation costs, allowing for an optimized total cost. In the second phase, further vehicle assignment and route planning are established using a heuristic algorithm, with optimization at both the daily level and across multiple days.

Experimental results are presented, comparing a baseline scenario against various operational configurations. We analyze the specific impact of CCC integration and on-site time windows, supported by a sensitivity analysis of key parameters. Ultimately, this study provides critical insights into the operational and policy implications of CCC adoption, offering a pathway for sustainable and efficient urban construction logistics.

References

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