Abstract

Modern supply chains in the construction industry heavily rely on the efficiency of transportation and material distribution. PD. XYZ, a small to medium-sized building materials company based in Cirebon, West Java, faces significant challenges related to fuel waste caused by suboptimal delivery routes. Observations conducted during the period of January to February 2025 clearly show that the company's Average fuel costs exceeded the predetermined budget by 9%. This over-budget condition indicates an urgent need for a more efficient and measurable distribution system.

A Fishbone Diagram analyzed in this study identifies several key factors contributing to this inefficiency, including route planning that is still based solely on drivers' experience and intuition, which leads to inefficient delivery routes. Additionally, incidents of product damage during transportation that require return processes further increase operational costs. The absence of standardized policies or methods for route planning also exacerbates the inefficiency. Although PD. XYZ applies a cross-subsidy strategy from retail sales to cover these excess operational costs, this approach is not sustainable in the long term and may reduce the company's maximum profit potential.

The primary objective of this study is to identify and implement the most effective strategy to optimize delivery routes at PD. XYZ, with a focus on minimizing fuel expenses. The complex problem faced by the company is modelled as a Vehicle Routing Problem with Heterogeneous Fleet, Split Delivery, Multi Trip, and Multi Product (VRPHFSDMTMP). This model accurately reflects PD. XYZ's operational reality, which involves the use of a heterogeneous vehicle fleet, the ability to split deliveries of a single order across multiple vehicles, multiple trips within a delivery period, and the delivery of various product types in a single route. These characteristics make the routing problem highly complex and demand a sophisticated solution approach.

To address the VRPHFSDMTMP problem, this study proposes a method that integrates Mixed Integer Linear Programming (MILP) with a Greedy Algorithm. The approach was selected for its ability to combine the strengths of each method: MILP excels at generating globally optimal solutions through strict *mathematical formulations, while the Greedy Algorithm offers high computational efficiency crucial for PD. XYZ's operational needs that often require rapid route decisions. In practice, LINGO software is used to implement the MILP formulation, considering critical factors such as vehicle capacity, product quantity, and customer demand. The initial solution generated by MILP typically produces "single node" routes (D-i-D), which are then refined using the Greedy Algorithm through a merging process that consolidates multiple single node visits into more efficient "multi node" routes (D-i-j-D).*

The results of this study definitively demonstrate that applying the MILP and Greedy approach successfully reduces both fuel costs and total travel distance. Before optimization, the Average weekly fuel overrun reached IDR 109,000. After implementing the proposed method, this Average was reduced to IDR 83,840 per week, representing a 16.16% savings compared to actual costs. Furthermore, the generated routes are not only more structured and efficient but also enhance fleet utilization particularly in split delivery and multi-trip scenarios that frequently occur at PD. XYZ.

Further sensitivity analysis shows that vehicle capacity directly impacts total distance, fuel consumption, and operational costs. Larger vehicle capacities reduce the number of trips, which in turn decreases total distance and fuel use highlighting the importance of optimal fleet allocation. Overall, this study makes a substantial contribution to developing practical solutions for delivery operations involving diverse fleet conditions and customer demands. The proposed MILP and Greedy method have proven effective in reducing operational costs and can be adapted by other companies with similar delivery activities, with a recommendation to implement routine data collection and comprehensive digital order tracking as essential inputs for optimization models.

***Keywords**: VRP, Heterogeneous Fleet, Multi Trip, Split Delivery, Cost Minimization*