Optimizing Urban Corridors: Effects of Signal Coordination and Geometry on Traffic Efficiency and Emissions

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Abstract

Efficient traffic management is critical for reducing congestion, improving travel times, and mitigating environmental impacts in urban road networks. This study evaluates the operational and environmental effects of a simulated urban roadway segment, incorporating signal coordination and horizontal curve adjustments, using traffic data generated through AIMSUN simulation software. The objective was to assess how optimized signal spacing and roadway design influence traffic efficiency and emission reductions. Traffic simulation compared base and optimized scenarios, examining delay time, travel time, density, flow, average speed, and total travel time. Synthetic emissions data were analyzed using regression models to quantify the effects of signal distance, average speed, and vehicle type on emissions before and after the intervention. Results showed a 7.2% reduction in delay time, a 6.5% decrease in travel time, and a 6.9% reduction in density. Average speed increased by 0.76%, and total travel time declined by 7.25%. Regression analysis indicated that a one-kilometer increase in signal spacing reduces emissions by approximately 0.49 units, while a 1?km/h increase in average speed decreases emissions by about 0.8 units. Vehicle_2 emissions showed a significant reduction of 3.06 units. These findings demonstrate that coordinated signal timing and roadway adjustments not only enhance traffic efficiency but also yield measurable environmental benefits. By quantifying the emission reductions associated with operational improvements, this study contributes to evidence-based strategies for integrated traffic and environmental management, highlighting the dual benefits of mobility and sustainability.

Keywords: Traffic simulation, Signal coordination ,Signal spacing ,Urban road networks ,Traffic efficiency ,Emission reduction.