PI-0383 Optimal Scheduling of Lane Closures for Caltrans Operations

Requested by
Nagi Pagadala, Division of Traffic Operations

Prepared by
Akm Islam, Division of Research, Innovation and System Information

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Executive Summary

Background

Lane closures are a necessary aspect of road maintenance and construction activities, yet they often lead to significant disruptions in traffic flow. Both moving and static lane closures can cause reductions in traffic speed, resulting in increased congestion and longer travel times for drivers. This situation not only frustrates commuters but also has broader implications for businesses that rely on timely deliveries and efficient transportation networks.

The costs associated with lane closures extend beyond immediate delays. They include wasted fuel due to idling, increased carbon emissions from prolonged travel times, and the economic impact on local businesses faced with delivery delays. Current methods for calculating these costs are often limited and do not adequately consider all the factors that contribute to travel delays, which can lead to inefficient scheduling and planning of maintenance and construction projects.

Given these challenges, there is a pressing need for research to develop a more comprehensive tool that accurately predicts and quantifies the costs of lane closures. Such a tool would consider various influencing factors, including safety risks and accident data, to facilitate better decision-making in scheduling these activities. By enhancing the understanding of the impacts of lane closures, this research aims to promote more effective transportation management strategies.

Summary of Findings

" Enhancing Work Zone Mobility Through Design and Control of Lane Closures "

Work zones significantly disrupt traffic flow, posing challenges for both travelers and transportation agencies. Recent research highlights that nearly 20% of roads within the National Highway System experience construction during peak seasons, leading to approximately 24% of non-recurring delays on freeways attributed to these work zones. Despite the substantial time lost to congestion, many State Departments of Transportation often depend on historical experiences rather than adopting data-driven approaches for temporary traffic control (TTC). This study emphasizes the pressing need for effective TTC strategies, particularly for long-term work zones, by evaluating static late and early merge control methods using traffic data from Alabama.

The research employed VISSIM simulation to assess the operational impacts of various TTC strategies and lane-drop configurations. Results indicated that while short-term work zones tend to perform better during off-peak hours, no strategy effectively managed traffic during peak conditions, with speeds plummeting to below 10 mph in severe congestion scenarios. The study concluded that a 3-to-1 lane-drop configuration is unsuitable for long-term use and recommended scheduling shorter maintenance activities to mitigate peak-hour disruptions. These findings aim to assist agencies in planning and managing work zones more effectively in the future.

Based on the investigation's outcomes, it is recommended that long-term work zones with 3-to-1 lane closures be avoided in favor of shorter-duration closures during non-peak periods to minimize mobility impacts. When scheduling non-peak hour work zones, both late and early merge control strategies can be implemented, with late merge control showing slight advantages in operational performance. Furthermore, exploring dynamic merge control strategies across various lane closure scenarios could significantly enhance future contributions to the field. Future studies might also investigate the performance of diverse traffic control strategies during weekend lane closures and include sensitivity analyses to examine the effects of varying heavy vehicle percentages, driver behaviors, and fluctuations in traffic demand on study measures of effectiveness (MOEs). By accounting for different driver behaviors and traffic conditions, subsequent research can yield findings that are applicable to various freeway segments with distinct characteristics.

“Optimization of Long-Term Highway Work Zone Scheduling”

The rapid development of transportation systems has led to a surge in work zone projects, which require significant investments in new constructions and ongoing maintenance. While these projects aim to improve infrastructure, they often create detrimental effects on traffic flow, resulting in social, economic, and environmental challenges. In response to these issues, the Federal Highway Administration (FHWA) issued a directive in 2017 for performance-based planning, mandating that transportation departments assess and report on infrastructure performance. Despite this initiative, there remains a notable gap in metrics for evaluating congestion during special events, particularly in work zones, underscoring the urgent need for effective strategies to mitigate these impacts.

This research centers on the development of a practical optimization model designed to manage long-term work zone events, particularly focusing on their influence on network mobility in the context of elastic demand. A bi-level optimization model has been constructed and is addressed through a genetic algorithm, with the Sioux Falls network utilized as a test case. The study investigates the effects of various combinations of work zones and conducts a sensitivity analysis on the elastic demand parameter, which informs the overall understanding of traffic flow and congestion management during these critical periods.

The findings indicate that the proposed optimization model successfully minimizes the total travel delay (TTD) associated with long-term work zone activities. The bi-level model seeks to optimize the scheduling of work zone projects, with the upper level aimed at reducing TTD across the planning horizon, while the lower level focuses on traffic assignment under user equilibrium conditions. Through a comprehensive case study of the Sioux Falls network, the research reveals optimal scheduling outcomes and emphasizes the importance of considering elastic demand parameters. The results suggest that as demand sensitivity increases, some drivers may opt for alternative transportation methods, highlighting the critical interplay between work zone management and traffic demand dynamics.

Gaps in Findings

Lane closures significantly impact transportation by increasing travel times, fuel consumption, and carbon emissions. These closures incur tangible public costs, highlighting the need for better methodologies to predict and manage these effects. A comprehensive tool that optimizes scheduling can help minimize inconvenience and enhance decision-making in transportation management.

Work zone projects disrupt traffic flow and pose various social, economic, and environmental challenges. An optimization model has been developed to address the long-term impacts on mobility, focusing on congestion management, particularly during special events. However, gaps remain in understanding driver behavior and how it affects traffic patterns, suggesting a need for a more integrated approach to address these issues effectively.

Next Steps

The next steps for this research should focus on thorough data collection and the development of the predictive tool. Initially, it will be important to compile extensive data on traffic patterns, lane closure impacts, and related costs, including historical records of travel delays and accident statistics. This data will serve as the foundation for creating a robust tool that accurately predicts the implications of lane closures. Additionally, conducting pilot tests across various scenarios will help refine the tool's functionality and ensure its reliability in forecasting costs and optimal scheduling.

In parallel, engaging key stakeholders such as traffic engineers, city planners, and public safety officials will be vital to gather insights and feedback. Their involvement will help ensure the tool meets the diverse needs of all parties. Following the development phase, a comprehensive implementation plan should be created, which includes staff training and public outreach to inform citizens about changes in lane closure scheduling. Continuous monitoring and evaluation will be necessary to assess the tool’s performance and adjust over time, ultimately enhancing California's transportation efficiency and safety.

Detailed Findings

Background

Lane closures are an unavoidable aspect of road maintenance and construction activities, often leading to significant disruptions in traffic flow. These closures, whether moving or static, can substantially reduce traffic speeds, resulting in increased congestion and longer travel times for drivers. The impact of these delays extends beyond mere inconvenience, affecting the overall efficiency of transportation networks and the economy.

The costs associated with lane closures are multifaceted. Beyond the immediate delays, they encompass wasted fuel due to idling vehicles, higher carbon emissions from prolonged travel, and economic repercussions for businesses reliant on timely deliveries. Current methodologies for calculating these costs are often limited in scope, failing to account for the various factors that contribute to travel delays, such as local traffic patterns and the time of day.

This gap in knowledge underscores the need for research aimed at developing a comprehensive tool to accurately predict and quantify the costs of lane closures. Such a tool would provide a more holistic view of the impacts associated with these closures, allowing for a deeper understanding of their economic and environmental implications. By identifying the critical factors that influence traffic speed and congestion, this research can inform better scheduling practices for maintenance and construction activities.

Ultimately, enhancing the assessment of lane closure impacts is essential for effective transportation management. With a more accurate understanding of the costs and risks associated with lane closures, decision-makers can make informed choices that minimize disruptions and enhance public safety. This research aims to fill existing gaps in current methodologies, paving the way for improved planning and execution of road maintenance and construction projects.

Related Research and Resources

Enhancing Work Zone Mobility Through Design and Control of Lane Closures, University of Alabama at Birmingham UAB Digital Commons, Troyee Saha,University of Alabama at Birmingham (https://digitalcommons.library.uab.edu/cgi/viewcontent.cgi?article=3874&context=etd-collection)

Optimization of Long-Term Highway Work Zone Scheduling, Center for Advanced Multimodal Mobility Solutions and Education, Project ID: 2020 Project 02, Wei Fan (ORCID ID: https://orcid.org/0000-0001-9815-710X) Yang Li (ORCID ID: https://orcid.org/0000-0001-5358-7835)
https://rosap.ntl.bts.gov/view/dot/58261