

Project Information

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This final report is available online at:

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Evaluating the Construction Cost and Schedule Impacts of SCDOT's Traffic Control Restrictions

This study empirically evaluated the influence of lane closure restrictions on project cost and schedule considering pay item and daily work report data for over 58 past interstate projects. The queue length implications of lane closures are investigated using a simulation-based prediction approach. While the queue length was found to be significantly dependent on the lane closure restriction specification, the empirical analysis using linear regression modeling did not reveal significant influence of lane closure specifications on project cost and productivity of critical work items. To validate these insights, four transportation contractors were invited to submit hypothetical bids and production estimates for a set of critical work items considering nine daily lane closure restriction scenarios. Contractor inputs for four projects revealed that: (a) the currently used 9am-4pm daytime construction window is not necessarily better than the nighttime-only construction window, (b) the contractors prefer extended nighttime (i.e., 7pm-7am) construction windows, as informed by lower cost and higher production rate estimates in the hypothetical bids, and (c) the project costs and production may not be highly influenced by lane closure restrictions alone. A queue length prediction model is developed for SCDOT to consider specifying lane closure restrictions based on a chosen threshold.



Project Hypothesis: Relaxing the lane closure restrictions would expedite transportation project delivery and make them less costly

Problem

State transportation agencies allow lane closures for making work zones safer to both workers as well as travelers. Lane closures however result in higher road user costs as the work zone capacity shrinks and are therefore restricted in crucial times of the day. These restrictions could lead to longer

project schedules and higher cost. The tradeoff between project cost, schedule, and user costs is under explored in the context of traffic control planning for work zones. This study focused on evaluating that tradeoff primarily using empirical data from past and current SCDOT projects.

Research

This study empirically evaluated the influence of lane closure restrictions on project cost and schedule considering pay item and daily work report data for over 58 interstate projects. The queue length implications of lane closures are investigated using a simulation-based prediction approach. Regarding cost, total project cost, unit project cost, and itemized costs for various critical pay items were statistically analyzed for their dependence on both the traffic threshold volume for lane closure restriction specification and the weekly daytime construction window hours. Further, regression models were developed to predict the project cost as dependent on the lane closure restriction specification considering preservation/re-surfacing and re-construction/full-depth patching project categories. Finally, contractors were invited to submit hypothetical bids for a few projects considering nine different lane closure restriction specifications. Contractors' inputs for four projects were assessed to validate the insights from the prior empirical analysis. The schedule impact assessment followed a similar approach focusing on production rates for various critical work items in the past projects. Contractors' inputs were also sought for production rates for a few projects considering nine lane closure restriction specifications.

For queue length prediction, parametric and non-parametric models were developed in this study. Three statistical models namely, multiple linear regression, quantile regression, and ridge regression, and four machine learning models namely, decision trees, k-nearest neighbor, random forest, and extreme gradient boost were leveraged. The framework is demonstrated for 2-to-1 (as in closure of one lane on a 2-lane freeway), 3-to-1, and 3-to-2 lane closure scenarios. In addition, the study also investigated making the models transferable to any freeway of

South Carolina (SC) to avoid the necessity for developing models for each new network.

Results

Based on the empirical analysis, traffic threshold volume or weekly daytime construction window hours were not found to be statistically significant for predicting project cost or production rates of critical payitems. The contractor bidding exercise revealed that: (a) 9am-4pm is not a long enough daytime construction window to result in cost and schedule benefits; and (b) extended nighttime construction windows (i.e., 7pm-7am) may be beneficial to contractors to result in slight cost and schedule benefits. The summary of aggregated itemized costs for a hypothetical bid received from a contractor is presented below. Production rate estimates from a contractor for a couple of payitems is also presented below.

Construction Window	Project #2
Payitem % Cost Contribution	50.25%
9pm-7am both ways	\$6,898,933
7pm-7am & 9pm-7am	\$6,897,090
9pm-7am & 7pm-7am	\$6,897,090
7pm-7am both ways	\$6,897,090
9am-4pm both ways	\$8,583,116
9am-7pm & 9am-4pm	\$7,874,640
9am-4pm & 9am-7pm	\$7,874,640
9am-7pm both ways	\$6,631,858
24 hrs	\$6,641,685

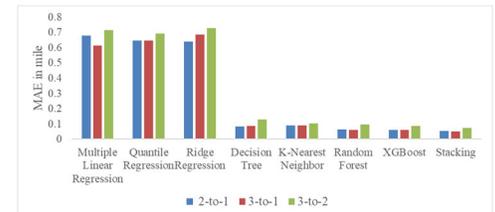
Aggregated itemized costs from a contractor's hypothetical bid

Construction Window	Production/10-hr shift	
Payitem # →	3100310	4030310
Quantity →	102980 Ton	45772 Ton
9pm-7am both ways	1000	1000
7pm-7am & 9pm-7am	1100	1100
9pm-7am & 7pm-7am	1100	1100
7pm-7am both ways	1200	1200
9am-4pm both ways	700	700
9am-7pm & 9am-4pm	850	850
9am-4pm & 9am-7pm	850	850
9am-7pm both ways	1000	1000
24 hrs	1200	1200

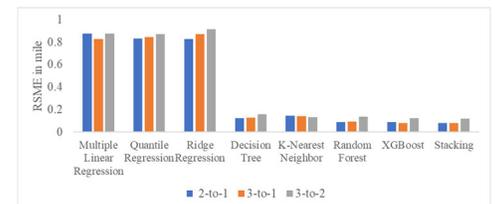
Production rate estimates for a couple of payitems from a contractor's hypothetical bid

As can be observed from the below plots, the developed queue length

prediction models revealed that the machine learning models performed better than the statistical ones with extreme gradient (XG) boost model being the best. The XGBoost model performed best for transferability evaluation too. These transferable models can be used to estimate queue length of any freeway without having to develop new models. A user-friendly Microsoft Excel-based computational tool was developed to run the regression models to predict queue length based on several work zone and lane closure restriction specification characteristics.



Comparison of mean absolute error (MAE) for various queue length prediction models



Comparison of root mean square (RMSE) for various queue length prediction models

Value & Benefit

The analysis undertaken in this project did not support the hypothesis that relaxing lane closure restrictions would lead to considerable cost and schedule benefits. It is however recommended that nighttime construction windows be extended by a couple of hours, where possible, to provide contractors longer production windows. There is evidence to suggest this would result in production rate improvement and slight reduction in cost. Contractors are concerned with getting trucks in and out of job sites during daytime due to congestion with lane closures. They also opined that inconsistent and shorter daytime construction windows prevent from scheduling daytime work.