Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Intelligent Work Zone Using Automatic Queue Detection Systems

Research Objectives

The first objective of the study will be to determine whether the AQD system is performing adequately. For example, the researchers will ascertain whether the correct messages are being displayed on the PDMS for given traffic conditions at the AQD detectors.
The second objective of the study will be to ascertain how the drivers react to the messages displayed on the PDMS. It is expected that when the drivers are informed that a queue is present ahead of them, they will slow down. The amount of speed reduction will be quantified as a function of distance from the PDMS.
The third objective of the study will be to determine if crash rates are lower on the SWZ equipped with the AQD system and will compare them to crashes on work zones without the AQD system using statistical theory.

Research Benefits

The functionality of the current AQD system will be validated using empirical data. In addition, any potential modifications and improvements will be identified. The efficacy of the systems as measured by a reduction in average vehicle speed as a function of distance from the PDMS and the message displayed on the PDMS will be quantified. The crash reduction rates associated with the AQD systems will be quantitatively identified. The NDOT benefit/cost procedure for the AQD system deployment will be validated. This will help NDOT refine the criteria used to justify the deployment of the AQD systems and determine when AQD systems should be used in work zones, etc.

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Background

Freeways are expected to provide uninterrupted, reliable, and safe travel conditions to the traveling public. However, there are occasions when repair and rehabilitation work causes lane closures that may interrupt the traffic flow. Because lane closures reduce capacity, there is the potential that during certain parts of the day, the volume/capacity ratio will be greater than one – resulting in queue formation upstream of the lane closure. The location of the end-of-queue may vary over time and this may lead to unsafe situations, especially with fast-approaching vehicles.

Drivers on freeways may not expect to suddenly come upon a queue. Therefore, transportation agencies have protocols for placing signage and other markers indicating work zones are ahead. While identifying the work zone location is straightforward, it is often not clear where the end-of-queue is located. If drivers have inadequate sightlines (e.g., cresting a hill), they may come upon the queue unexpectedly, resulting in sudden braking and increased risk of a rear-end crash.

Conclusion

It was found that overall, the AQD systems had an error rate of 0.7% – 2.3%. Drivers reduced their speeds in response to the PDMS warning message, and the decrease was found to be statistically significant in the range of 3.5 to 7 mph. This was approximately 90% greater than the reduction in speed that occurred when the PDMS did not display any message. In summary, it was found that the AQD systems were operating correctly and, more importantly, they were effective in reducing the space mean speeds of vehicles approaching work zones. Results from the traffic crash analysis showed that most crashes occurred in the activity area of the work zone and were rear-ends. A crash was more likely to occur on weekdays, off-peak hour, in the daytime, no worker present at rural Interstate work zones. A crash was more severe when drivers were driving impaired, during the daytime, on weekdays, with more vehicles involved. Given that the data was obtained in the midst of the COVID-19 pandemic, its impact on the work zone traffic crashes were also studied.

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Final report is available at:
NDOT Research Website

NDOT Recommendations Based of Completed Research

This research validated the Department's use of Intelligent Work Zone Using Automatic Queue Detection (AQD)Systems functionality, benefits, and efficiency of operations at freeway work zones within the State of Nebraska. The research validation resulted with the following;

a. The functionality of the current AQD system.
b. The efficacy of the systems as measured by a reduction in average vehicle speed as a function of distance from the PDMS and the message displayed on the PDMS
c. The crash reduction rates associated with the AQD systems
d. The NDOT benefit/cost procedure for the AQD system deployment

This research quantified and justified the used of Department funds to deploy AQD systems in work zones. The Department will continue using AQD systems.

- *As provided by Matt Neemann, Lead TAC Member*

Research Readiness Level (RRL) Assessment

RRL 5

Level 5: Standard Practice–
Research/Technology fully implemented and understood. No follow-up is necessary.

Technology Transfer

Publications

- Li Zhao, Laurence Rilett, and Mm Shakiul Haque. A Calibration and Validation Methodology for Simulation Models of Intelligent Work Zones. The 101st Transportation Research Board Annual Meeting, No. TRBAM-22-03066. Washington D.C., January 2022.

- Li Zhao and Laurence Rilett. Verification and Efficacy of Automated Queue Detection Systems on High-Speed Intelligent Work Zones. The 101st Transportation Research Board Annual Meeting, No. TRBAM-22-02243., Washington D.C., January 2022.

This brief summarizes Project SPR-FY21(007)
"Intelligent Work Zone Using Automatic Queue Detection Systems"
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