Project Summary

Texas Department of Transportation

0-5326: Improved Techniques for Traffic Control for Freeways and Work Zones

Background

Bottlenecks can occur at lane drops, freeway merges, exit and entry ramps, and many other locations where there is a change in road characteristics. However, bottlenecks caused by incidents and work zone lane closures where relatively large speed variations and long queues can be expected are particularly high-risk locations. A major safety concern associated with freeway bottlenecks is increased rear-end crash potential. Rear-end type collisions comprise over half of all urban freeway crashes and about one-third of work zone crashes. Depending on the speed differentials between queued and approaching traffic, rear-end collisions can be quite severe. However, many of them could be avoided by providing effective advance warning for vehicles approaching the end of slow or stopped queues. When freeway bottlenecks are caused by work zone lane closures, rear-end crash potential can also be reduced by effective merge control. Conventional work zone traffic control that encourages early merge works well in light traffic when congestion does not develop. However, at traffic volumes higher than capacity, it may lead to excessive queues extending beyond the advance warning signs, thereby increasing the risk of rear-end crashes. Also, early merge control may lead to erratic maneuvers and road rage among drivers under congested conditions.

What the Researchers Did

In the first project phase, the research team conducted a literature review to determine current practices for merge control techniques, speed control, and advance warning for stopped traffic, and identified techniques used in Texas. Although there are technologies which have been found effective and used extensively in controlling vehicle speeds and increasing speed limit compliance under non-congested traffic conditions, there are no standard techniques for warning drivers of the potential to encounter stopped/slow traffic under congestion. The primary objective of the research was to identify and evaluate effective ways of improving traffic operations and safety on congested freeways. There was particular interest in finding condition-responsive traffic control solutions for the following three problem areas:

- end-of-queue warning,
- work zones with lane closure, and
- queue spillover at exit ramps.

Available techniques considered by this research included a combination of static and dynamic queue warning systems, dynamic merge control in advance of freeway lane closures, and various strategies such as traffic diversion and ramp metering to mitigate queue spillover at exit ramps.

Research Performed by:

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Project Completed:
8-31-07

In the second project phase, researchers conducted three evaluation studies:

- Two queue warning systems, one deployed on I-610 and another on US 59 in Houston, Texas, were evaluated in the field. The researchers made recommendations for possible improvement of the systems.
- Traffic simulations were used to assess the expected effectiveness of ramp metering and traffic diversion strategies to mitigate the negative impacts of a ramp spillover problem at the Hawkins Blvd. off-ramp on I-10 in El Paso, Texas.
- The applicability of the Dynamic Merge, a condition-responsive work zone traffic control strategy, was evaluated for a range of traffic conditions and ten different work zone lane closure scenarios. Researchers used traffic simulations to determine the type of work zone configurations where the Dynamic Merge can be expected to work well and provide benefits relative to the conventional work zone traffic control.

What They Found

The queue warning system reduced the number of vehicle conflicts, such as sudden breaking and forced lane changes to avoid rear-end crashes, by 5 to 7 percent at the study site on I-610 in Houston. The reduction at the other study site on US 59 was less significant. The speed variance was significantly reduced at both sites after the queue warning systems were deployed. More uniform speed distribution in the vehicle stream is expected to reduce the potential for rear-end crashes and result in safer traffic operations.

Simulations of the I-10 corridor in El Paso, Texas, found that traffic diversion was the best strategy to mitigate the exit ramp spillover problem at the Hawkins Blvd. off-ramp.

Results from a detailed simulation-based analysis of the Dynamic Merge showed that this strategy is not applicable to a number of lane closure scenarios. Researchers found it to be effective in only three cases from the ten lane closure scenarios considered. Based on the results, recommendations on when, where, and how to use the Dynamic Merge were provided.

What This Means

Evaluation results of the queue warning system suggest that it is a promising technology to provide effective queue warning for drivers approaching slow or stopped queues on a multi-lane congested freeway segment. However, it can still be improved by combining it with managed lane and/or advisory speed messages. The recommendations made by the researchers for the effective use of the Dynamic Merge can help the Texas Department of Transportation to decide where and how to apply this traffic control strategy to improve traffic operations and safety through work zones.

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