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Design of Lane Merges at Rural Freeway Construction Work Zones

INTRODUCTION

To maintain safety and mobility in work-zone lane closures, traffic control devices such as signs, barricades, and other devices are placed in advance of and within the work-zone to inform, warn, and guide drivers and help them maintain proper positioning as they transition into the appropriate lane(s). These devices also serve to promote smooth, safe, and orderly merging maneuvers and create a protective buffer for construction workers. However, empirical evidence suggests that as traffic approaching the work zone increases to capacity levels, the arrangement of traffic control may limit the efficiency of flow and contribute to driver dissatisfaction in these areas.

This research sought to develop and test a new approach to address the recognized shortcomings of current work zone lane drop merge areas. This new design, known as "joint merge," builds upon the results of several recent research studies and innovative designs used in Europe to bring a more intuitive perspective to the process of merging at lane drops. The research was also unique in that it involved a comparative field assessment of a joint merge to a conventional Manual for Uniform Control Devices (MUTCD) under live traffic conditions.

OBJECTIVE

The goals of the research were to develop and test alternative strategies of traffic control that could enhance the safety and efficiency of merging operations within lane-drop merge areas. To accomplish the research goals, a series of work objectives were established, including:

- An identification and documentation of the state-of-the-art and state-of-the-practice activities in the geometric design and traffic control at the entrance to construction work zones on rural freeways;
- Development of a merging strategy to facilitate a more efficient merge than conventional designs;
- Identification of sites on rural freeways in Louisiana to test and compare the conventional and experimental merge configuration;
- Generation of alternative traffic control schemes for the selected experimental merge design, and apply them to the appointed work zone test site;
- Recording of lane-specific speed and volume data from the work zone site; and
- An evaluation and analysis of the traffic data gathered for the experimental and conventional configuration.

SCOPE

This study involved a comparative test of the joint merge and conventional MUTCD merge designs for temporary freeway lane drop merge areas associated with construction work zones. To conduct the comparison on a quantitative basis, field data were collected over a short segment of the northbound lanes of Interstate 55 freeway in the vicinity of Hammond, Louisiana. Although this area was near Hammond, the general design, volume, and vehicle operating characteristics would generally suggest "rural" freeway conditions.

Vehicle speeds and lane presence (volume/flow) were collected using Vehicle Magnetic Imaging Recorders (VMIR) affixed to the pavement at nine separate locations at key points entering into the merge zone and immediately

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downstream where traffic occupied a single-lane. Within this arrangement traffic operating conditions could be evaluated temporally and spatially as well as by specific lane. In total, over 600 hours of data were collected for both configurations. Since the data collectors recorded continuously, it was possible to acquire data over a variety of traffic volume and environmental conditions. This would include a period of high, medium, and low traffic volume as well as a mix of weather and daylight conditions.

METHODOLOGY

The research methodology used in this study incorporated several steps including reviews of prior work, plan development, field testing, and data analysis. Findings from literature suggested a "zipping" merge configuration that effectively influenced an alternating merge pattern would be more beneficial than current merging strategies. Based on this knowledge, an experimental merge configuration was developed and tested on I-55 near Hammond Louisiana.
Over 600 hours of data were recorded over an eight-month period at several locations within the study area.

Lane-specific traffic speed and volume data were recorded and then grouped by the type of merge configuration, time of day, zone, and classification and finally by lane orientation (right or left). To assess the relationships between the various functional categories, statistical comparisons between all groupings as a function of speed and volume were conducted at a 95 percent confidence level using T-test and analysis of variance (ANOVA) procedures.

CONCLUSIONS

The overall conclusions relative to the performance of the joint merge were somewhat mixed. From a quantitative standpoint, the results do not provide overwhelming statistical evidence that that traffic operations were significantly improved as a result of its use. However, from an approach volume distribution standpoint, the joint merge showed a significant impact in its ability to more evenly distribute traffic for a greater utilization of both lanes. While this did not appear to translate into an operational improvement, it is theorized that other benefits such as higher levels of driver satisfaction (from a "fairer" merging process), fewer lanes changes within the approach zone, and a reduction in slowed/stopped queue lengths (by filling both lanes instead of one) may result in qualitative benefits without diminishing the overall flow conditions.

As anticipated, travel speeds varied by configuration and by lane volume. The conventional merge design was concluded to be more effective at maintaining speeds in the open lane and less effective at maintaining speeds in the closed lane as vehicles approached the transition zone. This conclusion was reached by examining the observed decreases in operating speed as vehicles approached the beginning of the lane-drop transition point. The comparative analyses of flow rates were inconclusive, suggesting the two-sided merge does not substantially increase the amount of traffic that can flow through the transition zone. The highest flow rates observed at the outflow point of the transition zone for the conventional and joint merge were 1,672 vehicles per hour per lane (vphpl) and 1,602 vphpl, respectively. The joint merge produced an average discharge rate of 1,511 vphpl, while the conventional merge produced an average discharge rate of 1,534 vphpl. However, this difference was not found to be statistically significant.

From a lane utilization perspective, the joint merge showed a marked difference from the conventional MUTCD merge design. On average, 43 percent of vehicles entering the transition zone traveled in the closed lane of the joint merge compared to only 18 percent in the closed lane of the conventional merge. This disparity in lane balance suggests that the more evenly balanced joint merge configuration influenced fewer lane changes within and between zones. This may also even suggest that aggressive driving decreased and motorists were comfortable driving through the joint merge traffic control configuration.

RECOMMENDATIONS

Currently, a complete understanding of the full safety effects of the joint merge remains. As such it is not possible to recommend it as an alternative to conventional merging designs.

While no conclusive findings could be made relative to its effect on capacity, the video recordings and lane usage data suggest that the joint merge strategy was understood and well received by most drivers. This would be suggestive of effective design. This finding was confirmed by discussions with potential and past joint merge facility users. Although a formal questionnaire survey was not administered to drivers, anecdotal comments from a handful of drivers who traveled through the study site when the joint merge was installed.

The joint merge traffic control plan may be suited for use in work zones with two-to-one lane closures as it has demonstrated the ability to decrease the number of lane changes, decrease aggressive maneuvers, and maintain orderly traffic behavior in advance of the work zone. More research regarding the supplemental wording to the experimental sign and the recommended changes to the joint merge traffic control plan is also suggested. It is thought that these changes could result in a better understanding of the joint merge concept and, ultimately, a safer and efficient use of roadways.