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Measuring the Effectiveness of Ramp Metering Strategies on I-12

INTRODUCTION

In recent years, more emphasis has been placed on Active Traffic Management (ATM) strategies such as speed harmonization, managed lanes, and ramp metering. Ramp metering is one of the successful active traffic control strategies, controlling the flow of traffic entering the freeway facility from on-ramps in order to avoid breakdowns at merging areas and preserve the maximum traffic flow on the mainline. From June 2010 to November 2010, the Louisiana Department of Transportation and Development (DOTD) deployed ramp metering control along a 15-mile section of I-12 in Baton Rouge, La, in order to reduce congestion, provide a safer merge operation at freeway entrances, improve travel time reliability of the corridor, and ultimately protect the investment.

OBJECTIVE

The main goal of this research study was to conduct an overall assessment of the effectiveness of the newly implemented ramp metering strategy on I-12 in the Baton Rouge area. More specifically, the study achieved the following objectives: (1) conduct a brief literature review of the most recent research findings on ramp metering applications in other states; (2) identify the ramp junctions (study area) where ramp metering was implemented along I-12; (3) collect traffic data at each of the identified ramp metering locations over a period of at least three months, including periods when ramp metering is turned on and off; (4) conduct thorough analysis to evaluate the effectiveness of ramp metering on I-12 using the collected traffic data; and (5) develop a statistical analysis model for the impact on travel along the I-12 corridor and recommend other ramp metering strategies that could optimize the metering parameters and maximize performance.

SCOPE

The research was restricted to the evaluation of the existing ramp metering control system recently implemented on I-12 in Louisiana. Data was collected on I-12 to conduct a comparative analysis and evaluate the effectiveness of the ramp metering system.

METHODOLOGY

A total of 16 ramp meters were installed in 2010 along the 15-mile corridor of I-12 in Baton Rouge, La, between Essen Lane and Walker South Road/LA 447. A simple pre-timed operation with a fixed cycle length was adopted during weekdays in the AM peak period (6:00 a.m. – 9:00 a.m.) for westbound traffic and the PM peak period (3:00 p.m. – 7:00 p.m.) for eastbound traffic. MIST detectors as well as DCMS detectors, installed along two short segments of the corridor, were used to collect speed and volume data. The study section is 15.7 miles, while traffic data is collected for 1.85 miles using MIST detectors (Western segment) and 3.17 miles using DCMS detectors (Eastern segment); both segments were separated by approximately 7 miles. The data for the before- and after-periods were collected over various weather and incident conditions.

The mainline speeds recorded at 14 detector locations within the study area were evaluated to establish a baseline for comparison between traffic conditions before and after the ramp metering implementation. For the "before" period, the data was collected for four years (from 2006 to 2010) from the MIST detectors, and for one year (from 2009 to 2010) from the DCMS detectors. For the "after" period, the data was collected for 2010, but the data for the first month were discarded from the analysis. Different types of analyses were conducted to measure the effectiveness of the ramp metering using the collected data. Statistical analysis was conducted at a 90% confidence level to determine if the "before" and "after" periods were significantly different in terms of traffic speed within the merging area. For the DCMS segment, the same null and alternative hypotheses were tested but in this case, two sample t-tests were performed. Following the speed assessments, the travel time savings

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PRINCIPAL INVESTIGATOR:
Sherif Ishak, Ph.D., P.E.

LTRC CONTACT:
Kirk M. Zeringue, P.E.
225.767.9169

FUNDING:
SPR: TT-Fed/TT-Reg

Louisiana Transportation Research Center

4101 Gourrier Ave
Baton Rouge, LA 70808-4443

www.ltrc.lsu.edu

between the "before" and "after" periods were compared using the traffic volumes and were averaged over each road segment length.

CONCLUSIONS

For the western segment of I-12 (monitored by MIST), the statistical results of the comparative before-and-after speed analysis revealed that, when all weekdays were considered for the eastbound PM peak period, nearly 47% of the cases exhibited a significant increase in speed averaging 7 mph. Meanwhile, nearly 12% of the cases showed a significant decrease in speed averaging 17 mph. For the westbound AM peak period, a significant speed increase of 5 mph was observed 43% of the cases, while a significant speed decrease of 7 mph was observed 29% of the time. Speed contours, developed to graphically depict the areas of congestion, supported these findings with more areas of congestion observed in the westbound AM peak period than those observed in the eastbound PM peak period. Travel time savings also showed that for intervals with a significant travel speed increase, the average travel time savings for all weekdays were 12.0 and 6.0 vehicle hours per mile, for the PM and AM peak periods, respectively. On the other hand, intervals with a significant decrease in speed exhibited increased average travel times of 62.0 and 25.0 vehicle hours per mile, for the PM and AM peak periods, respectively. The level of service results suggest an overall deterioration of traffic conditions for both peak periods. Overall, the assessments show some improvements in traffic conditions after the implementation of the ramp metering for the more congested eastbound PM peak period, but slightly deteriorated conditions for the westbound AM peak period, which had pre-ramp metering speeds at free-flow conditions.

For the eastern segment of I-12 monitored by DCMS, the statistical results of the comparative speed analysis for this segment of the corridor revealed deterioration in traffic conditions for both the morning and evening peak periods. Combining all time intervals, there was an average decrease in speed from 61.91 to 58.37 mph for the eastbound PM and 53.78 to 49.06 mph for the westbound AM peak periods. Again, the speed contours showed increased areas of congestion for both peak time periods. Analysis of travel time savings showed negative values for both peak periods, indicating increased travel times. For eastbound PM peak period, the travel time increase ranged from 1.81 to 3.08 vehicle hour per mile, while the travel time increase ranged from 4.47 to 12.97 vehicle hours per mile for the westbound AM peak period. The level of service results for this section of the corridor also showed worsened level of service (LOS) distributions for both peak periods. For the eastbound PM peak period, the frequency of periods with LOS A has decreased while the frequency of periods with LOS F has significantly increased for the different time intervals for PM and AM intervals.

Overall, the assessments showed that for this section of the freeway corridor, traffic conditions did not improve with ramp metering. It should be noted, however, that the analysis for the DCMS segment did not account for the effect of the on-going construction work between O'Neal Lane interchange and Walker/LA 447 interchange, which started as early as 2009. It is possible that the presence of the construction zone may have impacted the traffic conditions and obscured the benefits of ramp meters because the construction work schedule overlapped with the analysis time period.

For both segments, the analysis did not exclude the effect of incidents on traffic conditions before and after the ramp metering implementation. Capacity-reducing incidents cause non-recurring congestion and traffic breakdowns that cannot be prevented with ramp meters. To capture the performance of ramp meters, comparative analysis should be restricted to recurrent conditions (incident-free conditions) before and after the implementation of ramp metering. This, however, requires knowledge of the type, location, and duration of all incidents on the study segment for the entire analysis period. During the course of this study, the incident logs were not available for the two study segments, and therefore, incident-free conditions could not be separated from the data collection period.

RECOMMENDATIONS

- Further investigation should be made to assess the effectiveness of the current fixed time ramp meters after the construction work has been completed. This can be accomplished by turning the ramp meters on and off for a specific time period to measure the impact on traffic conditions. Bluetooth data from the BlueTOAD system can be used instead of the detector data for better data quality and direct measurements of actual travel times.

- Collection of an accurate log of the incidents along the corridor during the before and after periods to measure the impact of ramp metering on recurrent traffic conditions. This, however, requires knowledge of the type, location, and duration of all incidents on the study segment for the entire analysis period.

- Future analysis should include the segment between the DCMS and MIST segments. This requires the use of other sources of data, such as Bluetooth, since detector data are not available for that segment.

- Further investigation should consider possible improvements from more advanced ramp metering algorithms, such as dynamic and coordinated ramp metering systems.

Figure 1
Study area showing location of ramp meters and detectors