Understanding the Impacts of Work Zone Activities on Traffic Flow Characteristics

tech transfer summary

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MTC RESEARCH PROJECT TITLES
Understanding the Impacts of Work Zone Activities on Traffic Flow Characteristics

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The Midwest Transportation Center (MTC) is a regional University Transportation Center (UTC). Iowa State University, through its Institute for Transportation (InTrans), is the MTC lead institution.

MTC's research focus area is State of Good Repair, a key program under the 2012 federal transportation bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MTC research focuses on data-driven performance measures of transportation infrastructure, traffic safety, and project construction.

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This project made strides towards understanding the effects of work zones on traffic flow to help make work zone activities less disruptive for the traveling public.

Objectives

The main goals of this project were as follows:

- Study the cause and effect relationship between type of work activity (pavement- or bridge-related) and traffic flow through a work zone
- Develop traffic flow characteristic curves using real-world traffic flow and work activity data
- Study and refine the methodologies that are used with various tools that are available today

Background

As the nation's freeways age and deteriorate, they need increasing attention in the form of construction and maintenance activities that may require considerable time to carry out. These work activities adversely impact mobility and travel time for the traveling public.

Maintaining a steady traffic flow is important to motorists and to traffic engineers. Work zones on highways are inevitable, and practitioners are always seeking the best ways to minimize inconvenience for travelers who encounter these work areas.

Previous studies have estimated work zone capacity using different traffic, geometric, and work zone characteristics such as lane width, presence of heavy vehicles, driver population, weather, and number of closed lanes. However, there is little understanding of precisely how different work activities impact traffic flow.

Problem Statement

The 2016 edition of the Highway Capacity Manual (HCM) contains a revised chapter on assessing work zone impacts that recommends a new procedure to utilize free-flow speed and capacity adjustment factors to determine work zone capacity. However, the new procedure does not include specific guidance on how work activity effects can be incorporated.

Research Methodology

To assess the impacts of work zone activities on traffic flow, 11 work zone locations were selected from Missouri Department of Transportation (MoDOT) bimonthly Regional Mobility Reports. The selected work zones exhibited major and moderate travel time impacts and included a variety of work activities related to bridges and pavements.

To identify the exact work zone segments, the Missouri Analytics application from the Regional Integrated Transportation Information System (RITIS) was used. The traffic sensors affected by these work zones were identified by comparing the location information from Missouri Analytics against a sensor deployment map.

Data on traffic characteristics were collected from fixed traffic sensors distributed over Interstate highways in the St. Louis District of Missouri. Three major types of traffic information were collected for individual lanes from each traffic sensor in 30-second windows: traffic volume, speed, and occupancy.

Traffic parameters such as free-flow speed, capacity, speed at capacity, and jam density were estimated for the work zone locations. The 85th percentile speed of the traffic stream under low-flow conditions was used as the free-flow speed.

Two single-regime models (Newell-Franklin and Van Aerde) and one two-regime model (Gipps) were tested using real-world data from the selected work zone locations. A goodness of fit test was performed to determine the best fit among the three models.

Speed-flow plots were developed to determine the reduction in capacity and free-flow speed of a roadway segment due to work activity. Traffic conditions ranging from free-flow to below capacity were captured at all selected locations.

To capture a full range of traffic flow characteristics for non-work zone days, speed-flow data were queried for up to 30 days before work activity. The reduction factors for free-flow speed and capacity were computed using the work zone and non-work zone values obtained from speed-flow curves for all sites.

Further analysis was conducted for bridge- and pavement-related work activities. Speed-flow plots were compared for bridge and pavement activities for three lane closure configurations.

Key Findings

- All work zone activities in the sample studied had an adverse effect on capacity and free-flow speed of traffic.
- The range of reduction factors for capacity and free-flow speed can be extensive, depending on the nature of work activity and lane closure configurations.
- The capacity reduction factor for work zone conditions was found to be in the range of 0.68 to 0.95 while the free-flow speed reduction factor was shown to be in the range of 0.78 to 1.0.
- The variation in capacity values was found to be lower for bridge-related work (1,488 vehicles per hour per lane [vphpl] to 1,656 vphpl) than for pavement-related work (1,120 vphpl to 1,728 vphpl).
- The higher variation in the capacity values for the pavement-related work may be due to the wider range of activities that are cataloged as pavement-related work in the MoDOT database.
- In terms of capacity per lane, the four-lane-to-two-lane configurations experienced the lowest capacity, while the two-lane-to-one-lane configurations experienced the highest capacity.

Conclusions and Recommendations

- Higher flows could occur either at breakdown or prior to recovery to free-flow conditions. In most cases, the breakdown flow was found to be higher than the flow prior to recovery. Therefore, to prevent underestimation, a higher value between breakdown flow and discharge flow prior to recovery should be considered as the best estimate of capacity.
- Goodness of fit statistics showed that the Van Aerde model was the best fit model for most of the study locations. The Gipps and Newell-Franklin models were good fits for a few locations but performed poorly in other locations. Therefore, the Van Aerde model is recommended for developing speed-flow curves for various work activities.

Recommendations for Future Research

Future research should apply the proposed methodology to analyze additional work activities from other jurisdictions. However, two significant challenges exist in developing these speed-flow curves:

- Availability of observations representing both congested and uncongested conditions. Often, work activity may occur only during one of these two periods, thus making it challenging to fit a traffic flow model for all conditions.
- Availability of work activity data. Work zone information is typically archived in department of transportation (DOT) planning databases, but it is often obtained from the job descriptions contained in the original contracts. While the broad descriptions of work and total duration mentioned in contracts may be accurate, information on the actual, critical details of the activities may be insufficient or inaccurate.

Implementation Readiness and Benefits

This project resulted in a methodology for analyzing traffic flow characteristics for various work activities. The methodology offers traffic planners data-centered assistance on using work activity data to fine-tune the configuration and operation of work zones to cause the least disruption to travelers.

State work zone coordinators and traffic management centers (TMCs) generate dynamic, short-term updates of work zone schedules. Because the data are updated in real time, they tend to be quite accurate. Unfortunately, these data are not always archived and are rarely in a format that can be easily retrieved (e.g., pdf, text) or queried later. Time and effort can be saved if DOTs can archive real-time data and have tools available to easily retrieve activity information (i.e., type of work, begin and end time, and lane closure information).

The capacity and free-flow speed reduction factor findings from this project further emphasize the need to customize the new HCM adjustment factors to different activity types and unique locations within a jurisdiction. This will help planners align their work zone calculations with the new procedure outlined in the 2016 version of the HCM.

Use of the various data-driven methodologies investigated in this project will enable practitioners to incorporate work zone activity impacts in their planning, design, and operation of work zones.