South Carolina
Department of Transportation

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PROJECT SUMMARY

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Evaluation of Interstate Highway Capacity in Short-Term Work Zones: Phase 2

Overview

The South Carolina Department of Transportation (SCDOT) initiated a research study to develop a methodology for use in determining an updated lane closure policy within work zones along the interstate highway system. Phase 1 of the research initiated in March, 2001 presented several findings as discussed in the phase 1 final report published in 2003 (FHWA-SC-03-02). Phase 2 of this research addresses some of the research needs identified in the final report for the first phase. Specific emphasis of both phases of this research focused on determining the number of vehicles per lane per hour that can pass through short-term, interstate work zone lane closures, with minimum or acceptable levels of delay. Phase 2 added several additional data sites with differing work zone characteristics. Current policy used by the SCDOT limits short-term, interstate, work zone, lane closures to periods when traffic volumes do not exceed 1000 vehicles per hour per lane (vphpl). This volume threshold was increased from 800 vphpl based on the results of the phase 1 study. The phase 1 research indicated that work zone capacity averages 1460 passenger cars per hour per lane (pcphpl). Even adjusting for trucks, this value is higher than the 1000 vphpl threshold value currently in use and well higher than the 800 vehicles per hour per lane threshold value used prior to our phase 1 research.

Literature Review and Survey of States

The literature review focused on a broad range of topics including fundamental traffic flow relationships, capacity measurement, data collection, and factors affecting work zone capacity. Fundamental speed-flow relationships established by Greenshields remain applicable today. Recent studies have identified unique functions for three distinct zones along the speed-flow curve including uncongested, queue discharge-free flow recovery, and congested flows. A number of methods have been used to measure capacity at work zone sites. However, there is little consensus in establishing a uniform procedure. All of the methods produce differing estimates of capacity and traffic flow. Data for these methods was collected using surveillance cameras, laser gun, detector loops and traditional tube counters. Most used 5-minute count intervals.

Previous research has looked at a variety of factors that have been individually evaluated and analyzed in combination for the purpose of determining the effect on work zone capacity. However, due to such a wide array of differing conditions and lack of an extensive database, no single definitive method has been identified. Some of the primary factors to have been researched are work zone configuration, highway grade, temporal variation, presence of freeway ramps, traffic stream make-up, weather conditions, intensity/duration of construction activities, and lighting. The survey of states was helpful in providing information pertaining to threshold lane volumes used by various agencies and useful details on how specific policy values were determined. The survey response also confirms an original study premise, indicating the SCDOT threshold values of phase 1 (800 vphpl) and phase 2 (1000 vphpl) are conservative.

Data Collection and Analysis

Data collection on this project was accomplished through use of video surveillance cameras, radar speed detection, and manual queue length measurement at 23 work zone sites for phase 1 and 12 additional sites for phase 2. The sites included a variety of short-term lane closure conditions located along interstate routes throughout the state of South Carolina. Thirteen of the sites (including most of the sites collected during phase 2) experienced vehicle queues extending beyond one mile in length, while twelve of the sites did not experience a measurable vehicle queue length. Data collected at the work zones comprehensively reveals that the relationship between speed and flow rate appears to follow the multi-regime format proposed for freeways in references such as the 2000 Highway Capacity Manual (HCM). Traffic characteristics of freeway work zones were analyzed using classic methods of macroscopic traffic flow modeling. The relationships between speed, density, flow, and time headway were derived using the assumption of a linear relationship between density and speed. Phase 1 data collected at the work zones generally support this assumption, which was originally proposed by Greenshields. When phase 2 data was combined with phase 1 data, the statistical goodness of fit of the data to a Greenshields parabola was not very apparent further supporting the more recent literature that suggests the multi-regime format. The capacity analysis indicated that per lane capacity significantly increases if more than 1 discharge lane exists. A double lane closure was found to reduce the per lane capacity by 150 pcphpl. Headway analysis revealed that passenger car equivalents (PCEs) differed for various speed ranges. In general, PCEs derived compared with those outlined for rolling terrain in the HCM 2000 if speeds were maintained above 30 MPH. There was insufficient data to quantify the effects of work zone activity, intensity, and length on capacity.

Results and Recommendations

Based on the analysis, the following model was developed to estimate short-term work zone capacity:

$$C_{WZ} = (C_B + I) * f_{HV} * N$$

where C_{WZ} = the estimated capacity of a short-term work zone (veh/hr); C_B = base capacity (1425 pcphpl for 1 discharge lane, 1750 pcphpl for 2 or more discharge lanes); f_{HV} = heavy vehicle adjustment factor; N = number of discharge lanes open through the work zone, and I = adjustment factor for type, intensity, length, and location of the work activity. The model indicates that the 1000 vphpl threshold value currently used by the SCDOT is lower than values inferred from the data collection projects. The influence of trucks on capacity combined with the variability of the proportion of trucks on South Carolina interstate freeways indicate that using a fixed threshold in terms of vphpl is not advisable. The researchers recommend that threshold values should be calculated on a case by case basis using the methodology identified above.

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