Abridgment

Analysis of Delay and User Costs at Unwarranted Four-Way Stop Sign Controlled Intersections

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ABSTRACT

A study was conducted to examine the operational characteristics of traffic controls at low-volume, low-speed intersections with unwarranted four-way stop sign control. The research involved the collection of traffic volume and delay data at eight selected four-way stop sign controlled intersections in three cities in northwestern South Carolina. These data and various unit delay values and unit cost factors were used to quantify the delays and road user costs experienced by motorists at these intersections. The delay and road user costs that would result from two-way stop sign control at the intersections were estimated based on field data collected at similar intersections and compared with the delay and road user costs associated with four-way stop sign control. This comparison of delay and road user costs showed that four-way stop sign control at the eight intersections selected for study caused 26,430 hr of additional delay and $296,610 in additional road user costs annually. Four-way stop sign control produced an average of 3,300 hr of additional delay per intersection and $37,080 per intersection in additional road user costs annually. Therefore, it was concluded that unless an accident problem susceptible to correction by four-way stop sign control exists, the unwarranted use of four-way stop sign control results in unnecessary delay and road user costs to the driving public and that the intersection traffic control should be changed to two-way sign control. Also, traffic engineers should resist efforts by the public to have four-way stop sign control installed at intersections where it is not warranted.

The purpose of the stop sign is to inform the motorist of a requirement to stop. Ideally, stop signs should protect the continuous flow of through traffic on the major route. Stop signs should not be installed for speed control (1). Nevertheless, community groups often exert pressure on their elected officials to install stop signs, particularly unwarranted four-way stop signs, for speed control. Citizens and public officials believe that four-way stop sign control will reduce vehicle speeds and significantly increase the safety of their community, but they apparently are unaware of the magnitude of the increased delay and additional road user costs associated with this type of intersection traffic control. Although the stop sign is not recommended for speed control, some traffic engineers apparently approve four-way stop sign installations because of a lack of concern for the increased delay and higher road user cost involved or because of their desire to demonstrate a concern for community safety by installing a traffic control device that has a reasonably low initial cost. However, it should be noted that under some circumstances warranted four-way stop sign control of intersections can provide accident savings that justify the increased delay and higher road user cost.

Unwarranted four-way stop sign control causes greater delay and road user costs than does two-way stop sign control because of the requirement that all vehicles come to a complete stop. In addition, increased fuel consumption and vehicle emissions result from the unnecessary stopping maneuvers associated with unwarranted four-way stop sign control. Therefore, the overall impact of unwarranted four-way stop sign control is undesirable from several standpoints. The installation of four-way stop sign control should be strictly limited to intersections that clearly warrant this type of traffic control.

PURPOSE AND OBJECTIVES

The purpose of the study reported here was to evaluate certain operational characteristics of traffic at four-way stop sign controlled intersections that did not meet accepted minimum warrants for the installation of four-way stop sign control. To fulfill this purpose, the specific objectives were (a) to collect traffic volume and delay data at selected four-way stop sign and two-way stop sign controlled intersections, (b) to quantify delay and road user costs at the selected four-way stop sign controlled intersections, (c) to estimate the delay and road user costs associated with two-way stop sign control at the selected four-way stop sign controlled intersections, and (d) to present information on the comparison of delay and road user costs at intersections with different forms of intersection traffic control.

DATA COLLECTION

The primary criterion for selecting the four-way stop sign controlled intersections for this study was the failure of an intersection to meet the minimum warrants for multiway stop sign control (1). The eight four-way stop sign controlled intersections selected for study were located in Anderson and Oconee counties in northwestern South Carolina. Three intersections were located in the Oconee County town of Seneca that had a 1980 population of 7,436. Three intersections were located in Walhalla, the county seat of Oconee County, that had a 1980 population of 3,977. Two intersections were located inside the corporate limits of Anderson, a city that had a 1980 population of 27,965.

Data were collected on traffic volume and vehicle

delay characteristics at each intersection during weekdays so the data would represent typical traffic conditions. The two components of intersection delay measured were stopped-time delay and the delay associated with speed change cycles. The procedures followed in conducting the stopped-time delay studies were those described in the Manual of Traffic Engineering Studies (2); these procedures represent a widely adopted method of obtaining information on stopped-time delay. This method involved the counting of vehicles stopped on an intersection approach at successive time intervals.

Speed change cycle delay, which is defined as the additional time required to decelerate from a specific approach speed and then accelerate back to the initial approach speed above the time required to travel through the intersection at the initial approach speed, was computed for each intersection approach. In this analysis all vehicles approaching a four-way stop sign controlled intersection were assumed to be traveling at the speed limit and then come to a complete stop. The unit values of delay used in the analysis of the speed change cycle delay were obtained from Winfrey's Economic Analysis for Highways (3). The speed change cycle delay was combined with the stopped-time delay to obtain total intersection delays.

The operational restrictions imposed by intersection traffic control devices create additional road user costs for motorists. It has long been recognized that traffic congestion and the associated delay are not only inconvenient but add to the cost of transporting goods and passengers. A highway improvement that reduces congestion and delay can result in a significant reduction in road user costs. Therefore, quantifying road user costs is an important part of a study of the economics of intersection traffic control. The two types of costs considered in this study were those associated with the operation of the vehicle and the value of motorists' time. Vehicle operating costs are defined as those direct road user costs that result from the operation of a vehicle. Because all vehicles must stop at four-way stop sign controlled intersections, the vehicle operating costs calculated were those resulting from vehicles decelerating from the initial speed to a stop and accelerating back to the initial speed plus vehicle idling costs while stopped. This study used the widely accepted methods provided by the AASHTO "Red Book" (4) for quantifying vehicle operating costs.

The AASHTO methods involved the application of cost factors to the traffic volume and delay data collected at each four-way stop sign controlled intersection. AASHTO provided cost factors that represented 1975 conditions and price levels. Before applying these cost factors, they were updated to March 1982 conditions and price levels using procedures recommended in the Red Book (4). These procedures are based on the consumer and wholesale price indexes published by the U.S. Bureau of Labor Statistics.

The daily volume of vehicles passing through each intersection was multiplied by the appropriate updated AASHTO cost factor to obtain the speed change cycle costs generated at an intersection. Because of the low percentages of single-unit and tractor-semitrailer trucks in the traffic stream at the intersections involved in the study, the daily speed change cycle costs at the intersections resulted primarily from passenger vehicle speed change cycles.

Idling costs are incurred when a vehicle is stopped at an intersection. The amount of cost is dependent on the vehicle type and the length of time the vehicle is stopped. To calculate the daily vehicle idling cost at an intersection, the unit values of idling cost recommended in the Red Book (4) were updated and used. Each unit cost value per idling hour was multiplied by the daily stopped-time delay to obtain the daily idling costs at an intersection.

This study also placed a value on the time associated with traveling through an intersection by multiplying unit values of time by the amount of time consumed and by a vehicle occupancy factor. The unit values of time used were $3.00 per traveler hour for the occupants of passenger vehicles and $6.00 per traveler hour for the occupants of single-unit and combination tractor-semitrailer trucks. All passenger vehicles were considered to have an average occupancy of 1.6 adults per vehicle and all trucks were considered to have an average occupancy of 1.2 adults per vehicle. The total road user costs at each four-way stop sign controlled intersection were calculated by combining the vehicle operating cost from speed change cycles and vehicle idling with the time cost.

IMPACT OF TWO-WAY STOP SIGN CONTROL

The delay and road user costs associated with four-way stop sign control were compared with the delay and road user costs resulting from two-way stop sign control. Estimation of the delay and road user costs that would result at the four-way stop sign controlled intersections if they were controlled by two-way stop signs required the collection of additional delay data at two-way stop sign controlled intersections. The additional delay data were analyzed to obtain numerical values of the stopped-time delay per vehicle and the frequency and magnitude of all speed change cycles associated with two-way stop sign control. The selection of intersections where the additional delay data were collected was done on the basis of similarity of traffic volumes, approach speeds, turning movements, traffic stream characteristics, and abutting land uses at the intersection and at a particular four-way stop sign controlled intersection examined previously. Each intersection was located as close as possible to a particular four-way stop sign controlled intersection to take advantage of similarities in traffic characteristics and environmental conditions in a given area. Four two-way stop sign controlled intersections were analyzed. Each of the four-way stop sign controlled intersections had a highway in common with one of these two-way stop sign controlled intersections.

The stopped-time delay that was measured at the two-way stop sign controlled intersections was used to estimate the stopped-time delay that would result if the four-way stop sign controlled intersections were controlled by two-way stop signs. The stopped-time delay per vehicle on the minor approaches was determined for each two-way stop sign controlled intersection and these values were applied to the traffic volume on the minor approaches of the four-way stop sign controlled intersections.

The frequencies and magnitudes of the speed change cycles that occurred at the two-way stop sign controlled intersections were applied to the traffic volumes on the four-way stop sign controlled intersections to estimate the speed change cycle delay that would result if the four-way stop sign controlled intersections were controlled by two-way stop signs.

The analysis of the economic impact of two-way stop sign control at the four-way stop sign controlled intersections focused on road user costs. These road user costs consisted of the vehicle operating costs from speed change cycles and vehicle

idling plus the time cost to vehicle occupants. The methods and procedures used to calculate the road user cost that would result from two-way stop sign control were the same as those described previously for four-way stop sign control. A more detailed description of the study techniques employed, the methods used for computing total intersection delay and road user costs, and the results obtained from the study has been presented by Byrd (5).

SUMMARY AND CONCLUSIONS

This study investigated the operational characteristics of selected unwarranted four-way stop sign controlled intersections. Field data were collected on traffic volume and delay characteristics at eight intersections currently operating with four-way stop sign control in northwestern South Carolina. Stopped-time delay studies were conducted on all of the approaches to the intersections. The traffic volume and delay data were then used in conjunction with unit delay and cost factors obtained from previous research to quantify delay and road user costs at each intersection.

The annual delay at the eight four-way stop sign controlled intersections was calculated to be 42,660 hr or 5,330 hr per intersection. Sixty-eight percent of this delay resulted from speed change cycles and the remaining 32 percent was stopped-time delay. The annual road user cost that resulted at all eight four-way stop sign controlled intersections was $477,960 or $59,750 per intersection. Fifty-four percent of this cost resulted from vehicle operating costs during the speed change cycles. Time costs represented 44 percent and vehicle idling costs accounted for the remaining 2 percent of the road user costs.

To estimate the magnitude of the possible benefits of two-way stop sign control at the eight four-way stop sign controlled intersections that did not meet the minimum traffic volume warrant of the Manual on Uniform Traffic Control Devices (1), intersections with comparable traffic characteristics and currently operating under two-way stop sign control were analyzed. Using the data obtained at these intersections, the delay and road user costs that would result from two-way stop sign control at the four-way stop sign controlled intersections were estimated. These estimates were then compared with the delays and road user costs that existed with four-way stop sign control to determine the impact that two-way stop sign control would have on the delay and road user costs at these intersections. These comparative analyses showed that the installation of two-way stop sign control would reduce intersection delay and intersection road user costs 62 percent.

Unwarranted four-way stop sign control at the eight intersections selected for study, assuming 100 percent driver obedience of stop signs, caused 26,430 hr of additional delay and $296,610 in additional road user costs annually. Neglecting differences in traffic volumes at the intersections, unwarranted four-way stop sign control caused an average of 3,300 hr of additional delay per intersection and $37,080 per intersection in additional road user costs annually.

This study was conducted on low-volume, low-speed intersections with unwarranted four-way stop sign control in northwestern South Carolina. In the context of this study, low-volume intersections were considered to be intersections with fewer than 8,000 vehicles per day on all approaches. Low-speed intersections were considered to be intersections with approach speed limits of 35 mph or less. The following conclusions, which were derived from this study, may apply to intersections similar to the ones investigated but not to all intersections with four-way stop sign control.

1. The unwarranted use of four-way stop sign control causes motorists to experience substantial amounts of additional and unnecessary delay and road user costs.
2. The installation of two-way stop sign control at an intersection operating with unwarranted four-way stop sign control can produce significant delay reductions and road user cost savings.
3. The total delay to the minor highway traffic at unwarranted four-way stop sign controlled intersections would not be significantly changed by the installation of two-way stop sign control.

The effectiveness of four-way stop sign control as a safety measure is dependent on individual intersection characteristics. If an intersection is operating with unwarranted four-way stop sign control that is not a needed safety measure, the driving public is forced to pay unnecessary road user costs and suffer delay. In addition, it has been established previously that the use of unwarranted four-way stop sign control results in increased fuel consumption and vehicle emissions. Therefore, this study concluded that unwarranted four-way stop sign control at low-volume, low-speed intersections should be changed to two-way stop sign control when highway safety will not be seriously compromised. Also, traffic engineers should use the information on additional delay and road user costs associated with four-way stop sign controlled intersections to resist the efforts of the public to have four-way stop sign control installed at intersections where it is not warranted.

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