Flashing Arrowboards in Advance of Freeway Work Zones

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The results of controlled field studies conducted by the Texas Transportation Institute to evaluate the effectiveness of flashing arrowboards located in advance of lane-closure work zones are reported. The distances in advance of the work zone ranged from 450 to 4000 ft. The effects of the supplemental arrowboard were compared with the effects of arrowboards placed in the closure at the end of the taper in each blocked lane. The results indicate that a supplemental arrowboard placed in advance of the beginning of a taper can be extremely effective in shifting traffic from the closed lane if the sight distance to the arrowboard improves the effective sight distance to the work zone. The supplemental arrowboard can be placed up to 2500 ft in advance of the taper to increase the effective sight distance to the work zone. Placement more than 2500 ft in advance of the work zone may result in drivers moving back into the blocked lanes.

Arrowboards have been the subject of many recent research reports that cover a wide range of topics, including design, human-factors considerations, and application guidelines. The results have been very positive and indicate that arrowboards do have a very high target value and that motorists respond positively to arrowboard displays. Two of these reports differ on the most effective placement of a flashing arrowboard. Knapp and Pain (1) recommend the placement of the arrowboard at the beginning of the taper; Graham, Megletz, and Glennon (2) recommend that the most effective arrowboard placement is 100-500 ft in advance of the beginning of the taper. A study was therefore conducted on I-35 in Austin, Texas, to further evaluate arrowboard placement.

STUDY APPROACH

Controlled field studies were conducted by a group of Texas Transportation Institute researchers on I-35 in Austin, Texas, to evaluate the effectiveness of flashing arrowboards used in advance of work zones that require a lane closure. Figures 1 and 2 show the two work sites and the relative location of all traffic-control devices used at each site. Thirteen controlled field studies were conducted at the two work sites. Seven arrowboard arrangements were studied at site 1 and six at site 2.

The Texas State Department of Highways and Public Transportation (TSDHPT) required one arrowboard to be located and operating in each of the closed lanes at the end of or within the taper. This requirement restricted the capability of the study to isolate the effects of only the arrowboard in advance of the beginning of the taper. Data collected at each site while arrowboards were in this required arrangement represented the base response. These data included the effects of the advance signing and permitted a comparison to be made between the base signing effectiveness and the response to a supplemental arrowboard positioned in advance of the beginning of the taper.

The data collected during each of the studies consisted of freeway volume counts, lane distributions, and sight distances to the arrowboards. Volume counts and lane distribution data were collected at count stations located upstream from the first taper. Stations were also located at all freeway access points in order to record entering and exiting vehicles; this provided a closed system for data analysis. The lane distribution data provided information concerning lane occupancy at each station so that the effects of the arrowboards could be determined. The sight distances to the arrowboards were determined by an observer traveling in a vehicle equipped with a distance-measuring instrument. These data, when compared with each arrowboard arrangement studied, reflected the relations between the lane distribution of each supplemental arrowboard location and the corresponding effective sight distance.

The data for each arrowboard arrangement were collected during 60-min intervals. After each set of data was collected, the supplemental arrowboard was repositioned. A 15-min gap between arrowboard repositioning and data collection was provided in order for the data to represent normal traffic flow.

The data representing the effectiveness of a supplemental arrowboard were collected when the additional arrowboard was positioned at distances ranging from 450 to 4000 ft in advance of the beginning of the taper.

STUDY RESULTS

The results from both sites indicated that the sight distance to an arrowboard, and thus the driver's perception of a lane closure, influence the lane-changing behavior of approaching motorists. The data collected during the supplemental arrowboard studies are shown in Figures 3 and 4.

It can be seen, from these figures, that the advance signing and arrowboard placement normally used by the Austin District of SDHPT reduced the traffic in the closed lane 40 percent at site 1 (Figure 3) and approximately 30 percent at site 2 (Figure 4). With these percentages representing the base signing effectiveness measured at 2000 ft in advance of the beginning of the taper, a comparison of the effects of the supplemental arrowboard at different locations was made for each site. Figures 3 and 4 each show one such comparison. At site 1, when the supplemental arrowboard was placed 2000 ft in advance of the beginning of the taper, there was a 60 percent reduction in traffic in the closed lane (20 percent less than normal). At site 2 a 65 percent reduction (35 percent less than normal) resulted after the supplemental arrowboard was placed 2000 ft in advance of the beginning of the taper. This reduction of traffic in the closed lane was caused by the advanced arrowboard placement and an increased effective sight distance. The effective sight distance in this case is the sight distance to the arrowboard that indicates a downstream hazard or work zone to the motorist.

Figures 5 and 6 show the relation between traffic remaining in the closed lane and effective sight distances to the work zone. The bar graphs represent the percentage of traffic remaining in the blocked lane at 2000 ft in advance of the beginning of the taper for each of the supplemental arrowboard arrangements studied. The line graph, in comparison, illustrates the effective sight distance to the work zone for each of the corresponding supplemental arrowboard arrangements. The effective sight distance and percentage of remaining traffic in the blocked lane for the required arrowboard locations are illustrated as base levels (horizontal lines) on the graph.

FINDINGS

The national Manual on Uniform Traffic Control De-

vices for Streets and Highways (MUTCD) (3) section on flashing arrowboards deals primarily with minimum design standards. The need for and the location of an arrowboard are optional. The possible need for a supplemental arrowboard upstream from the beginning of a cone taper is not addressed. The need for and location of arrowboards or even a supplemental arrowboard depend on the horizontal and vertical alignment upstream from a work zone and should be determined during the preparation of a traffic control plan.

Figure 1. Site 1 base condition.

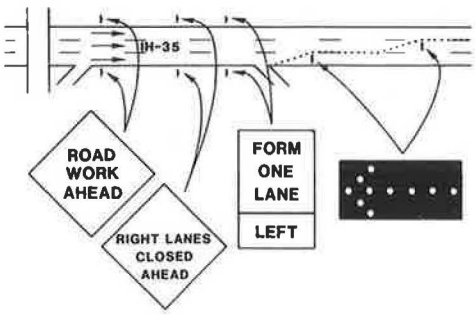
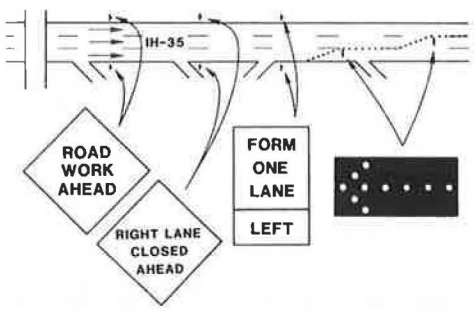


Figure 2. Site 2 base condition.



The results of the studies indicate that the use of a supplemental flashing arrowboard in advance of the beginning of a cone taper for right-side and left-side closures can be effective in shifting approaching traffic out of a closed lane. This improved effectiveness is, however, based on the supplemental arrowboard providing an increased effective sight distance to the work zone.

It is desirable to use a supplemental arrowboard when the effective sight distance to the work zone is less than 1500 ft. However, since the sight distance to each work zone varies with vertical and/or horizontal alignment, it is not possible to establish a set standard location for a supplemental arrowboard.

In one study, when a supplemental arrowboard was positioned at 4000 ft in advance of the beginning of the taper, some of the traffic that had vacated the blocked lane returned to the blocked lane before reaching the closure. Therefore, whenever a supplemental arrowboard is used, a field evaluation should be conducted to ensure a minimum sight distance (1500 ft) and to determine whether traffic is moving back into the closed lane. If vehicles are returning to the closed lane, the distance from the beginning of the taper to the supplemental arrowboard is excessive and the supplemental arrowboard should be relocated closer to the beginning of the taper.

RECOMMENDATIONS AND CONCLUSIONS

The research indicates that the placement of an arrowboard in advance of the beginning of a taper is beneficial only when the effective sight distance to the work zone is improved. The minimum allowable sight distance for urban freeway operation is 1000 ft [this has been supported in related studies such as that by McGee and others (3)]. The desired minimum sight distance to the work zone is 1500 ft.

Locating an arrowboard in advance of the beginning of the taper does not necessarily increase sight distance. The vertical and/or horizontal geometrics at each work site would control the sight distance and the resulting placement of a flashing arrowboard. Figure 7 illustrates a situation in

Figure 3. Effectiveness of supplemental arrowboard placement at site 1.

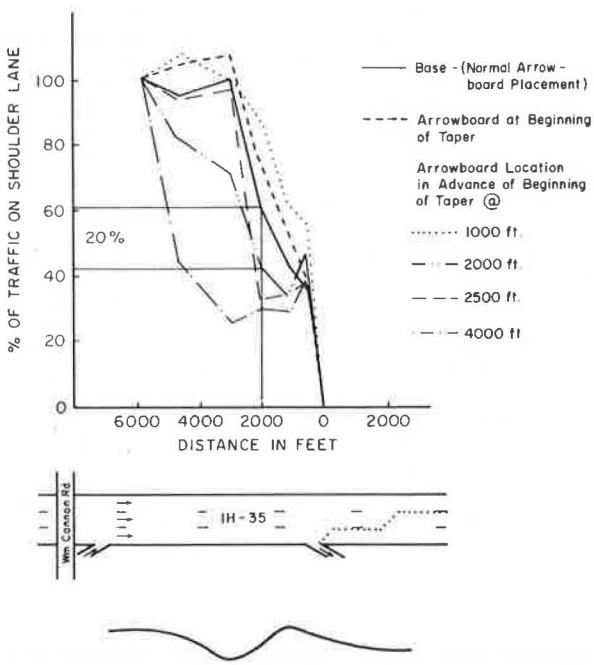


Figure 4. Effectiveness of supplemental arrowboard placement at site 2.

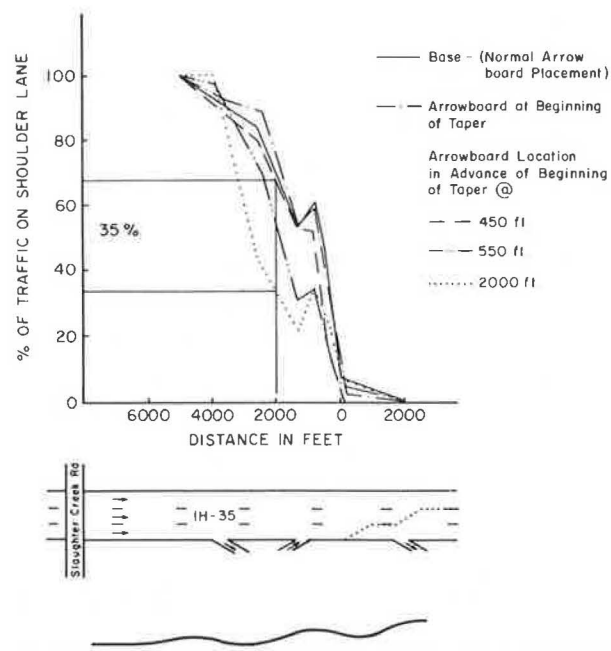


Figure 5. Site 1 supplemental arrowboard placement: lane distribution versus sight distance.

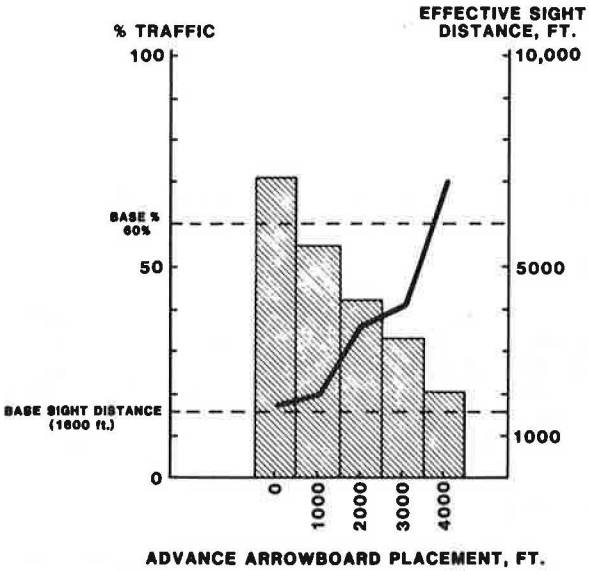
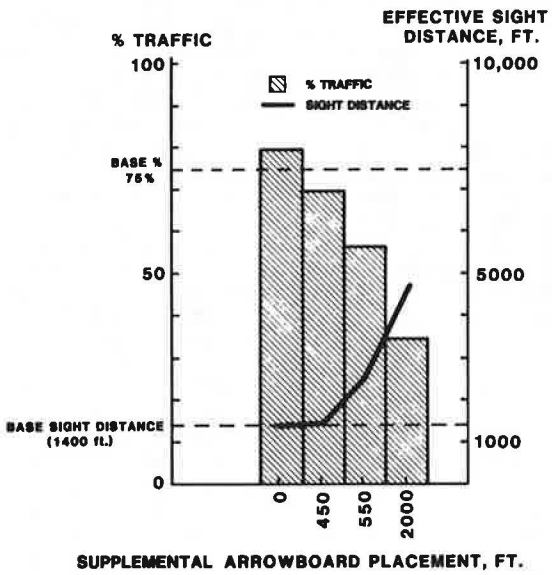


Figure 6. Site 2 supplemental arrowboard placement: lane distribution versus sight distance.



which a supplemental arrowboard does not improve the sight distance to the work zone. Figure 8 shows a situation in which placing a supplemental arrowboard in advance of the taper increases the effective sight distance and is beneficial.

Work zones on a level tangent section of roadway would not require a supplemental arrowboard because the sight distance to the work zone is not critical (less than 1500 ft). Figure 9 shows this situation.

In conclusion, an arrowboard should be used at the cone taper for lane closures on urban freeways. The location of the arrowboard at the taper (at the beginning, within, or at the end) depends on the sight distance. When the sight distance to the work zone is less than 1500 ft, it is desirable to place a supplemental arrowboard on the shoulder in advance of the beginning of the taper for right-side or left-side lane closures. The supplemental arrowboard can be placed up to 2500 ft in advance of the cone taper to increase the effective sight distance to the work zone. The supplemental arrowboard should not be placed more than 2500 ft upstream because drivers have a tendency to reenter the closed lane before they reach the closure.

Figure 7. Typical work zone where critical arrowboard sight distance is not improved (controlled by geometrics).

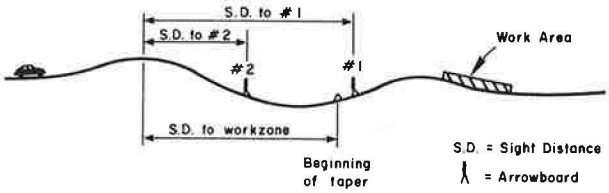


Figure 8. Typical work zone where critical arrowboard sight distance is improved.

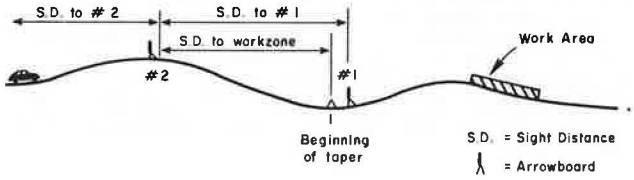
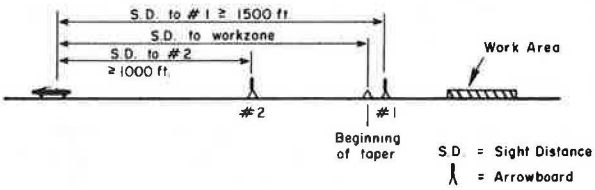


Figure 9. Typical work zone where critical sight distance is not improved (not controlled by geometrics).



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