Supplemental Devices to Enhance Flagger Safety

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Improper flagging techniques and driver misunderstanding of flagger messages can compromise the effectiveness and safety of a flagger. Supplemental devices may be necessary to complement the standard traffic control and flagging techniques outlined in the *Manual on Uniform Traffic Control Devices* (MUTCD) to ensure that drivers understand what actions are expected of them at work zones controlled by flaggers. The Texas Transportation Institute recently evaluated a reusable, temporary stop bar and a freestanding, oversized Stop/Slow sign paddle at lane closures on two-lane, two-way highways where flaggers were used to alternate one-way traffic. Operational data on distances from the flagger at which vehicles stopped, speeds through the work zone, and approach speeds were analyzed. The data showed that the temporary stop bar and oversized paddle were useful in helping drivers decide when and where to stop in front of the flagger. However, the stop bar and sign paddle had no significant effect on reducing approach speeds or speeds through the work zone. The flaggers who actually used the supplemental devices commented that the oversized Stop/Slow paddle helped drivers respond to their commands better and that the temporary stop bar helped identify a point at which drivers were to stop.

There is growing concern about the effectiveness and safety of flaggers in work zones. Improper flagging techniques or driver misunderstanding of messages may result in inaccurate driver expectancy. This leads to inappropriate driver response, with consequences as serious as collisions with other vehicles or with flaggers.

Standard requirements and procedures for flagging are presented in the *Manual on Uniform Traffic Control Devices* (MUTCD) *(1)*. However, it appears that even though flaggers perform a critical role in work-zone traffic control, flagging duties are often assigned to the newest members of the work crew, who may have had little or no training in proper flagging techniques. This may cause inconsistent messages to be sent to drivers, compromising flagger performance and safety. A need therefore arises to complement standard MUTCD traffic control and flagging techniques with supplemental devices to improve driver understanding of actions expected of them at the work zone. Two such devices, a reusable temporary stop bar and an oversized Stop/Slow paddle mounted on a freestanding base, were evaluated as part of a study to improve flagger safety sponsored by the Texas State Department of Highways and Public Transportation. This paper presents the results and conclusions from this research effort.

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DESCRIPTION AND PURPOSE OF DEVICES STUDIED

Temporary Stop Bar

The temporary stop bar used in this study consisted of six interlocking sections of white rubber, each approximately 6 in. wide, 40 in. long, and 0.4 in. thick. The sections were placed three long by two wide, making the stop bar a total of 12 in. wide and 10 ft long.

The stop bar, or stop line, is most often found at Stop-sign or traffic-signal-controlled intersections. Stop bars have also been used at some major work zones involving lane closures on two-lane, two-way highways where it is necessary to alternate one-way traffic for an extended period of time. These stop bars are normally painted on the pavement and are therefore not commonly used at work operations lasting only a few days or less. The rubber stop bar, however, can be easily placed, picked up, and reused again and again.

The purpose of the stop bar is to identify the point at which vehicles should stop if instructed to do so by the flagger. The stop bar may also help communicate the flagger's message to stop to an approaching motorist.

Oversized Sign Paddle

The sign paddle used in this study consisted of a 30 × 30-in. standard Stop sign (R1-1) and a 36 × 36-in. black-on-orange Slow sign mounted back to back on a freestanding wooden frame. The top portion of the wooden frame was manually rotated by the flagger to allow either sign to face oncoming traffic. Figure 1 shows the oversized sign paddle. The signs were mounted at a height of 6 ft from the bottom of the signs, approximately the same height as normal Stop or warning signs.

The evaluation of the oversized Stop/Slow paddle is of special significance because of the latest revision to Section 6F-2 of the MUTCD. The March 1986 revision states that the sign paddle should be the primary hand-signaling device and that flag use should be limited to emergency situations and spot locations that can best be controlled by a single flagger *(1)*.

Previous research on driver understanding of work-zone flagger signals and signaling devices has indicated that Stop/Slow paddles are an effective method of transmitting messages to a driver *(2, 3)*. Nevertheless, many workers complain that

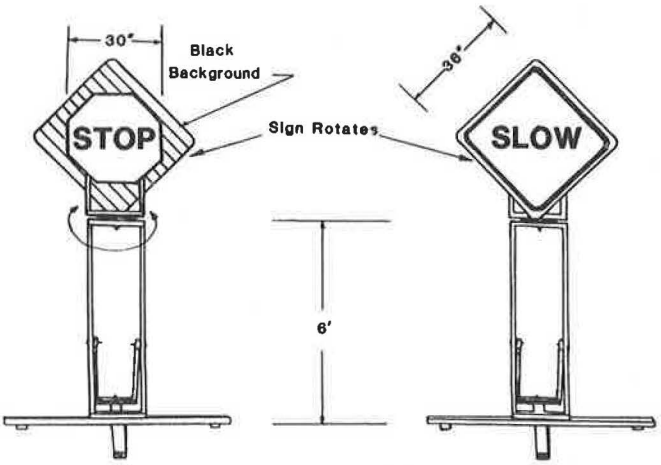

FIGURE 1 Freestanding oversized Stop/Slow paddle.

the typical hand-held sign paddle is too heavy and difficult to use in strong winds. Also, the paddle does not appear to have the attention-getting value of the more commonly used flag *(3)*.

This situation is remedied by using the oversized Stop/Slow paddle because the flagger stands next to the freestanding sign paddle, combining the high comprehension of a sign paddle with the high visibility of a flagger. The flagger does not hold the paddle, but merely changes the sign when necessary.

The oversized Stop/Slow paddle has the obvious advantage of being easier to identify from a greater distance than the typical 18 × 18-in. hand-held paddle. The oversized paddle also provides an additional Slow message to vehicles as they are leaving the restricted one-lane section.

STUDY PROCEDURE

Site Description

The reusable temporary stop bar and oversized sign paddle were evaluated at a work-zone location on a two-lane, two-way rural highway near Port Arthur, Texas. At this location, a lane was closed and flaggers were used to alternate one-way traffic through the work zone. The site was a straight and level section of highway and there was virtually no development in the general area. The average annual daily traffic (AADT) at this site was approximately 7,000 vehicles per day. At the work zone, the eastbound lane was closed over a 3/4-mi section to allow a shoulder to be added. Flaggers with two-way radios were used at each end of the work zone to alternate traffic through the restricted section.

The following advance signing was used at the approaches to the work zone: *(a)* Road Construction Ahead (with a 40-mph advisory speed plate), *(b)* Be Prepared to Stop, *(c)* One Lane Traffic Ahead (with 1,000-ft supplemental plate), and *(d)* Flagman Ahead. The signs were spaced at approximately 500-ft intervals.

Data Collection and Analysis

Three different treatments were examined during this field study in both the open and closed lanes.

1. *Existing*: Consisted of the standard MUTCD setup with flaggers using only flags and hand signals to communicate with approaching vehicles.
2. *Temporary stop bar*: Same as the existing setup with addition of the temporary stop bar across the lane of traffic being stopped by the flagger. The flagger was allowed to stand anywhere behind the stop bar.
3. *Oversized Stop/Slow paddle*: Same as the existing setup with addition of the oversized Stop/Slow paddle just off the roadway adjacent to the flagger.

Three types of data were collected during the field study for each of the three treatments.

1. *Vehicle stopping points at work-zone approaches*: Distances between the flagger and the stopping point of the first vehicle (measured to the front of the vehicle) as well as distances between the stop bar and the first vehicle when the stop bar was in use were measured to the nearest foot.
2. *Vehicle through speeds at work-zone approaches*: Vehicles approaching the work zone that were instructed by the flagger to proceed through the work zone without stopping were timed with a stopwatch over a 200-ft section located just before the position of the flagger. The times were recorded and later converted to speed in miles per hour.
3. *Vehicle approach speeds to the work zone*: A car-following technique using a vehicle equipped with a time-speed-distance measuring instrument was used to record travel speeds of approaching vehicles. The approach speeds were recorded at 500-ft intervals from approximately 3,000 ft in advance of the work zone to the point at which the vehicle came to a stop.

Data were collected over a 2-day period. Each treatment was studied for approximately 2 hr in the open and closed lanes each day. Table 1 shows the order in which the treatments were studied. This order allowed each treatment to be studied over a different time period than that on the first day.

TABLE 1 TREATMENT ORDER

Time Period	Open Lane	Closed Lane
Day 1		
8:00 a.m.–10:00 a.m.	Existing	Stop bar
11:00 a.m.–1:00 p.m.	Sign paddle	Existing
2:00 p.m.–4:00 p.m.	Stop bar	Sign paddle
Day 2		
8:00 a.m.–10:00 a.m.	Stop bar	Sign paddle
11:00 a.m.–1:00 p.m.	Existing	Stop bar
2:00 p.m.–4:00 p.m.	Sign paddle	Existing

RESULTS

Stopping-Point Data

Stopping-point data collected on the first vehicle directed to stop by the flagger are summarized in Table 2. The data suggest that the temporary stop bar and the oversized Stop/Slow sign paddle were useful in helping drivers decide when and where to stop in front of the flagger. The variability of the distance between the flagger and the first stopped vehicle was greatly reduced when the stop bar and sign paddle were used.

As can be seen in Table 2, the standard deviations of stopping distances from the flagger were reduced when either the stop bar or the sign paddle was used, as compared with the existing conditions with no supplemental devices. Less variability was evident in the closed lane, most likely because of additional visual information behind the flagger (e.g., cone taper, work area) that helped drivers decide where to stop. In the open lane, this additional visual information was not present, so the variability in how far away drivers stopped from the flagger was greater. It appears that the supplemental devices were especially useful in the open lane. When the standard deviations of stopping distances in the open lane were compared for the existing condition and for use of the stop bar and the sign paddle, it was found that use of these devices reduced the standard deviations by two-thirds.

TABLE 2 DISTANCE BETWEEN FLAGGER AND FIRST STOPPED VEHICLE

	Closed Lane			Open Lane		
Treatment	*N*	Avg Distance (ft)	Standard Deviation	*N*	Avg Distance (ft)	Standard Deviation
Existing	44	57	32	54	67	99
Stop bar	46	47	21	45	43	38
Sign paddle	51	50	23	45	38	32

NOTE: *N* = sample size; 1 ft = 0.305 m.

The temporary stop bar was very effective in identifying a point behind which the drivers were to stop. Only 5 of 91 vehicles (5.5 percent) encroached on the stop bar, and no vehicles stopped beyond it. Thus, the flaggers were able to regulate the distance between themselves and the first stopped vehicle. Flaggers generally stood 20 to 30 ft behind the stop bar.

Vehicle Speeds Through the Work Zone

Speed data collected on approaching vehicles that were directed by the flagger to proceed through the work zone are summarized in Table 3. As can be seen, neither the average nor the standard deviation of the through speeds was significantly different among any of the three treatments.

TABLE 3 APPROACH SPEEDS OF VEHICLES DIRECTED BY FLAGGER TO PROCEED THROUGH WORK ZONE

	Open Lane		Closed Lane	
Treatment	Avg Speed (mph)	Standard Deviation	Avg Speed (mph)	Standard Deviation
Existing	51.0	9.1	45.2	7.3
Stop bar	49.3	7.8	46.2	8.9
Sign paddle	48.1	8.5	45.9	7.2

NOTE: 1 mph = 1.61 km/hr.

The stop bar, whose purpose is to identify a stopping point, was not expected to have an effect on through speeds. It was expected, however, that the oversized Slow sign might reduce through speeds. As seen in Table 3, this was not found to be the case. Apparently drivers proceeded through the work zone at what they believed to be a comfortable and reasonable speed. The slightly lower through speeds in the closed lane can be explained by the lane-changing maneuver required at the beginning of the lane closure.

It should be noted that flaggers made no attempt to slow traffic by using hand or flag signals during any of the treatments. Also, the geometrics of the site and location of the work crew relative to the through lane allowed for relatively high speeds.

Vehicle Speeds Approaching the Work Zone

Speed profile data collected on vehicles approaching the work zone showed no substantial difference among the three treatments in either the open or the closed lane. Again, drivers approached the work zone at whatever speed they believed to be comfortable, regardless of the treatment in place.

Flagger Comments

The flaggers using the supplemental devices during the field study commented that the oversized sign paddle helped drivers respond better to the Stop and Proceed commands. Many of the flaggers would point to the sign paddle as vehicles approached rather than use hand or flag signals, which have been misunderstood by drivers.

SUMMARY AND RECOMMENDATIONS

Results have been presented of field studies evaluating the use of a temporary stop bar and a freestanding oversized Stop/Slow paddle as supplemental devices to enhance flagger safety. The purpose of these supplemental devices is to improve driver understanding of actions expected of them at work zones controlled by flaggers, such as a lane closure on a two-way, two-lane highway.

On the basis of these limited studies, the temporary stop bar and oversized sign paddle appear to be effective devices in helping drivers understand when and where to stop in front of the flagger if instructed to do so. The stop bar and sign paddle, however, appeared to have little effect on speeds of vehicles instructed to proceed through the work zone or on speeds of vehicles approaching the work zone.

It should be noted that the sign paddle constructed and tested in these studies does not conform to the standards presented in Section 6F of the MUTCD. Specifically, the shape of the paddle should be an octagon, not a diamond, because the message to stop is more critical than the message to travel at a slower speed. In future implementations of such a paddle, a standard-shaped sign should be used.

The stop bar and sign paddle were evaluated independently. It is recommended, however, that they be used together by placing the stop bar approximately 30 ft in advance of the flagger and sign paddle. In addition, a more portable design for the sign paddle should be developed. It is possible that a small trailer could be modified to hold such a paddle that could be towed from site to site.

ACKNOWLEDGMENT

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