Strategies

on Improving Worker Safety in Work Zones

This document describes strategies and resources for improving worker safety in work zones. The document presents several key challenges and offers countermeasures for addressing each challenge. It also provides the advantages and disadvantages of each.

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Refer to http://www.workzonesafety.org for a copy of this document.

Strategies on Improving Worker Safety in Work Zones

Background

The national *Manual on Uniform Traffic Control Devices* (MUTCD) contains standards and guidance on the design and application of signs, channelizing devices, and other traffic control devices required to guide travelers in and through work zones. Although the MUTCD requirements help ensure that work zones are designed and operated in a safe manner, some work zones present safety challenges that require additional vigilance and efforts. Therefore, the federal regulation 23 CFR 630 Subpart K encourages state highway agencies to consider the use of other traffic control measures that can help reduce work zone crashes and improve worker and traveler safety. A number of measures identified in the regulation specifically address worker safety. These measures fall under five main categories:

- enhanced flagger station setups;
- temporary traffic signals;
- pace or pilot vehicles;
- intrusion alarms; and
- worker training.

The following sections highlight the issues and conditions for each category in which special attention might be warranted and summarize the methods for addressing those issues and conditions.

Enhanced Flagger Station Setups

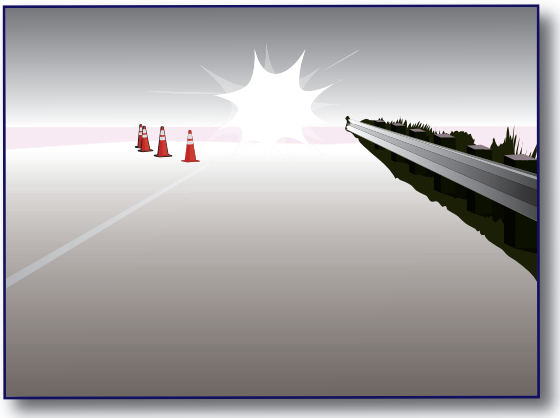
Due to the nature of the activity itself, workers performing flagging duties at work zones are highly vulnerable. Flaggers are positioned at the beginning of the activity area facing oncoming traffic and control alternating one-lane operations past work zones on two-lane highways. Flaggers can also be used in other types of work zones and setups, such as to intermittently stop or slow traffic to allow construction vehicles to enter and exit the work space.

The national MUTCD outlines the proper location and traffic control device setup used to delineate work zone flagger stations. The MUTCD also requires that flagger stations be illuminated at night to allow the station and flagger to be seen by approaching traffic. Even with the guidance provided in the MUTCD, a number of key considerations and implementation challenges can exist at a flagger station. The following subsections describe the more common challenges encountered and discuss ways to address them.

Improved Flagger Visibility at Flagger Stations

Because of the key role flaggers play in maintaining a safe operating work zone, it is critical that drivers be able to detect and recognize when flaggers are present so that the drivers can respond appropriately to flagger directions. As noted above, the national MUTCD specifies how advance warning signs and channelizing devices are to be positioned to warn the drivers of a flagging operation and to create a well-identified flagger station. Flaggers must wear approved high-visibility apparel and use approved devices and hand gestures to control traffic.

It is important to recognize that a number of situations can compromise flagger station visibility during the day. As noted in the national MUTCD, flagger stations are to be located so that approaching road users will have sufficient distance to stop. Positioning the flagger station just beyond a curve or over a hill can violate this principle and must be avoided. Even with proper advance warning signs, motorists approaching a flagger station that is hidden from view will have to react much more quickly than if they have a longer viewing distance. This increases the chance that a driver will fail to stop or slow in time for the flagger. Locating the flagger station so that drivers are looking directly into the rising or setting sun can also make it difficult for drivers to see that they are approaching a flagger station and even to see the flagger.



At night, the national MUTCD requires the flagger station to be illuminated to be visible to approaching motorists. However, such lighting must be properly positioned and aimed to function properly and maximize safety. Light sources located behind a flagger will create shadows at the flagger station and make it difficult for the approaching driver to detect the flagger. This detection is hampered even more if the light source has been improperly aimed at the eyes of approaching motorists. Portable light towers can also be so bright that they "wash out" the flagger, which also decreases safety.

Decision Sight Distances (ft)		
Speed (mph)	Rural Roads	Urban Roads
30	220	490
40	330	690
50	465	910
60	610	1150
70	780	1410
80	970	1685

Fortunately, a number of countermeasures are available to help ensure that motorists and workers can more readily see a flagger at a flagger station. First and foremost, a flagger station should be positioned so that it is before curves or hills and so that there is as much sight distance to the station as possible. Preferably, there would be decision sight distance to the flagger station and flagger which provides an additional margin for error beyond stopping sight distance. If the terrain does not allow this criteria to be met, supplemental signing may be helpful. For example, portable changeable message signs (PCMS) can be positioned upstream of the flagger station to increase attention on the FLAGGER AHEAD/BE PREPARED TO STOP message.

For visibility problems caused by motorists looking into the rising or setting sun, the safest countermeasure is to avoid the dawn and dusk time periods by not scheduling work activities during those times. Recent advances in stop/slow paddles now include flashing light-emitting diodes (LEDs) embedded into the sign face, and such technology may increase flagger conspicuity in those situations where it is not possible to suspend work activities during poor visibility periods. To date, however, the extent to which LED flashing paddles are effective in this regard has not been verified. LED flashing paddles may also aid in flagger conspicuity during nighttime flagging operations. However, care must be taken to ensure that the flashes are not excessive so that they do not blind approaching motorists who have adapted to dark conditions.

Flagger visibility at night can also be increased with the use of high-visibility garments. The national MUTCD requires flaggers to wear ANSI (American National Standards Institute) Class 2 or Class 3 high-visibility garments. Several states require nighttime flaggers to use only Class 3 garments. A few companies are currently marketing high-visibility vests with LEDs to increase the likelihood that drivers will detect and recognize the presence of a flagger at night. Even with these supplemental devices, though, it is the set up of the lighting system at the flagger station that will ultimately determine the conspicuity of the flagger and the driver's ability to see and respond to the flagger's directions. Care must be taken to ensure that lighting levels are neither too dim nor too bright at the flagging station and are positioned in a way that does not create shadows around the flagger or glare for oncoming traffic. Several states have established minimum lighting levels based on previous national research. For example, the Illinois Department of Transportation requires a vertical luminance of 10 foot candles (108 lux) for overhead lighting of flagging stations on nighttime projects. To implement this requirement effectively, project engineers or inspectors should verify that the minimum levels have been met using light meters.

Minimizing Flagger Risks from Errant Vehicles

Another key consideration in establishing safe flagger stations is minimizing the risks to flaggers from errant vehicles approaching the work zone. Flaggers are generally unprotected and are highly vulnerable in the event that a vehicle fails to stop. One of the most important countermeasures to address this concern is to position flaggers in the safest possible position that includes a clear and easily accessible escape path. In addition, flaggers should be trained to be continuously aware of their locations relative to the escape paths.

Another countermeasure that some agencies and contractors are using is the automated flagger assistance device (AFAD). These devices are portable traffic control systems designed to be operated by a flagger located off the roadway. There are two types of AFADs. One type uses a remotely controlled STOP/ SLOW sign to control the right-of-way, while the other type utilizes remotely controlled red and yellow lenses and a gate arm to control right-of-way. Both types of AFADs allow flaggers to be positioned off of the roadway away from moving traffic, thereby reducing the likelihood of a flagger getting struck by a vehicle. The national MUTCD allows for AFADs to be used to control alternating one-lane operations, and provides guidance on the advanced warning signing required when they are used. Research is underway to determine driver understanding and compliance levels of these devices. Temporary traffic signals (discussed in the next section) are also sometimes used in lieu of flagging operations to remove flaggers from direct exposure to approaching traffic.

The table on page 4 summarizes the countermeasures available to address safety concerns at flagger stations.

Challenges	Countermeasures
Ensuring adequate flagger and flagger station visibility	• Use approved high-visibility apparel • Position station before curves and hills to maximize sight distance • Avoid operations that require flagging during dawn and dusk periods • Use supplemental PCMSs to increase attention of flagger ahead message • Use STOP/SLOW paddles with flashing LEDs • Establish criteria for nighttime flagger station lighting and verify with light meters • Avoid lighting the flagger station from behind • Avoid creating glare and overbright conditions
Minimize risks to flaggers from errant vehicles	• Position flagger stations so that flaggers have clear and easily accessible escape routes • Use AFADs to move flaggers away from traffic

Temporary Traffic Signals

Traditionally, fixed temporary signals have been installed to control alternating one-lane traffic at bridge rehabilitation and reconstruction projects where alternating traffic flows occur continuously for several months and it is impractical to utilize flaggers on a 24/7 basis. Temporary signals may also be useful at alternating one-way work zones where a clear escape path for a flagger is not available in the event there is an errant vehicle. However, advances in technology have resulted in the development of portable traffic signals that can be easily brought in for shorter duration projects. Communications between the signals can be provided by hard wiring for fixed temporary signals, radio frequency transceiver, or preset timing.

Appropriate signal timing is critical to the success of temporary traffic signals. Excessive wait times can lead to confusion, frustration and decreased compliance. Therefore, some experts suggest that the cycle length for temporary traffic signals not exceed four minutes. In the case of signal malfunction, temporary signals typically default to flashing red mode.

Use of Pace or Pilot Vehicles

In some alternating one-way work zones, the travel path that vehicles should follow may not be totally clear. In other situations, the nature of the work activity may require that vehicles pass by or around the work operation at a fairly slow speed. If the distance from the beginning of the work zone to the location of the work operation is long, the

the potential exists for vehicles to reach speeds higher than considered safe by the time they reach the work operation. When such concerns exist, a pace or pilot vehicle may be used to control traffic speeds. Pace or pilot vehicles force following vehicles to travel at speeds no greater than that of the pace or pilot vehicle. A pace or pilot vehicle can lead vehicles around and through hazards in the work zone, and ensure positive guidance is provided.

The pace or pilot vehicle must have a PILOT CAR FOLLOW ME (G20-4) sign mounted on the rear of the vehicle, and a flagger must still be present at each end of the work zone to control traffic until a pace or pilot car is available. In addition, a reduced spacing of channelizing devices may be desirable near the work area to deter impatient drivers from attempting to pass the pace or pilot car while traveling through the work zone. Pace or pilot car operations require additional manpower to keep the pace or pilot car moving back and forth between flagging stations. In addition, pace or pilot car drivers should be rotated periodically to promote driver alertness.

Intrusion Alarms

Work zones where it is not possible or appropriate to provide positive protection devices such as concrete barriers are at risk for intrusions from passing motorists. Collisions between vehicles and workers on foot are likely to be severe and often result in major injuries or death. Vehicle intrusions are of special concern on high-speed facilities such as freeways and expressways because of the lack of time available for workers to escape to safety in the event of an intrusion. Nighttime work zones are also a concern, due to the combination of a greater percentage of impaired drivers and often higher operating speeds.

Intrusion alarms are one type of countermeasure of interest to both agencies and contractors for reducing the chance of these types of collisions. Conceptually, intrusion alarms consist of a method of detecting when a vehicle has entered a work space, and an audible, visual, and/or tactile alarm to notify downstream workers of the intrusion. Theoretically, an intrusion alarm may give workers additional time to seek safety. In order to be effective, intrusion alarms must be audible over the ambient noise of traffic and work equipment. In addition, intrusion alarms that give off a large number of false alarms may deteriorate their perceived reliability and reduce their credibility with workers.

Early intrusion alarm systems used pneumatic hoses or infrared beams positioned along the merging taper and edge of the work space. Unfortunately, these systems were not very reliable and created many false alarms, and so were not commercially viable. More recently, intrusion alarms have been mounted on work zone barricades, cones, drums, and delineators. They consist of a tilting motion detector that is activated when a vehicle strikes the work zone device (as shown in the photograph). When an intrusion is detected, a siren provides a warning to workers. Unfortunately, these devices also appear to suffer from operational limitations. Testers of these devices indicate that the siren is not always loud enough to be heard in a highway work zone environment. Also, placement and pick up of these devices is more complicated than normal devices, making them less desirable to use by field personnel.

Finally, it should be noted that intrusion alarms can be manually operated. Specifically, dedicated spotters watch approaching traffic and provide notification of work zone intrusions by sounding a horn or alarm. The effectiveness of this technique is limited to the immediate vicinity in which the spotter is stationed.

Applying Worker Safety Strategies in Common Work Zone Conditions

The table below summarizes the various worker safety strategies discussed in this document and the work zone conditions where their use should be considered. The table should be considered illustrative and not prescriptive. Other work zone conditions may benefit from consideration of these strategies as well. Engineering judgment must always be applied to determine if the strategies are appropriate for a particular work zone.

Worker Safety Strategy	Work Zone Conditions
Enhanced flagger station setups	• Work zones on east-west two-lane highways where sun glare is an issue • Work zones on two-lane highways in hilly, winding terrain • Nighttime flagging operations (all roadway types)
Temporary traffic signals	• Alternating, one-way work zones that will last for several days • Alternating one-way work zones where flaggers have no clear escape path(s)
Pace or pilot vehicle operations	• Alternating one-way work zones on two-lane highways where the travel path is not clear • Alternating one-way work zones on two-lane highways where vehicle speeds past the work operation must be kept low
Intrusion Alarms	• Work zones where workers on foot are near active travel lanes without positive protection

Worker Training

Worker training is an extremely important safety strategy. The type and amount of training depends on job duties and responsibilities. Training is needed to operate most tools and machinery. Training should provide information on the use of personnel protection equipment, occupational hazards and health risks, and other pertinent topics. With regards to highway workers, key training areas can include:

- basics of temporary traffic control typical applications;
- traffic control setup and removal;
- flagger safety; and
- night work risks, high-visibility apparel, lighting, and flagging.

Many resources are available to ensure that workers receive proper work zone safety training, including commercial training services and products. The National Work Zone Safety Information Clearinghouse has many training resources relevant to highway worker safety at http://www.workzonesafety.org/. These include a variety of free training resources developed through the national Work Zone Safety Grant program (see at http://www.workzonesafety.org/fhwa_wz_grant). As part of the grant effort, the *Roadway Safety Program+* is a valuable software training tool that can be downloaded free of charge.

In addition to all the topics listed above, it contains safety training modules on:

- excavation, equipment operation, and electrical work;
- runovers/backovers, falls, sprains/strains, struck/crush injuries; and
- health issues associated with outdoor working environments.

The FHWA also maintains a database of worker training programs available at: **http://ops.fhwa.dot.gov/wz/outreach/wz_training/worker_safety.htm**.

Many unions and trade associations also offer highway work zone safety training.

Depending on the duties of the worker, training pertaining to the various worker safety training programs should provide instruction consistent with the requirements described in *ANSI/ASSE A10.47-2009: Work Zone Safety for Highway Construction* standard. The training should also be consistent with other national standards pertaining to highway work zone design and operation (e.g., the *Roadside Design Guide*, the national MUTCD, etc.).

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How Can I Locate More Information Regarding This Topic?

Ellis, R.D., S. Amos, and A. Kumar. *Illumination Guidelines for Nighttime Highway Work*. NCHRP Report 498. TRB, National Research Council Washington, DC. 2003.

American National Standard for High-Visibility Apparel and Headwear. Publication ANSI/ISEA 107–2004. American National Standards Institute and International Safety Equipment Association.

Work Zone Safety for Highway Construction. Standard A10.47-2009. American National Standards Institute, Washington, DC. 2009.

Roadside Design Guide. American State Highway and Transportation Officials, Washington, DC. 2006

Roadway Design Manual, Chapter 2 Basic Design Criteria, Decision Sight Distance. Texas Department of Transportation, Austin, TX. May 2010.

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Laborers' International Union of North America
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