



Work Zone Safety

Did You Know?

Work zone safety is such a significant issue in the transportation industry that it is celebrated and promoted every April during the National Work Zone Awareness Week (NWZAW). This year, NWZAW is April 15-19, 2013. A national event is being held in Washington, DC to raise public awareness of the dangers for workers and motorists during roadway construction, maintenance, and utility work.

In 2010, over 87,000 crashes occurred in work zones nationwide, resulting in over 37,000 injuries. The most common type of work zone crash is a rear-end crash in the advance warning area of a work zone. This is commonly caused by work zone-related congestion that is not expected by the motorist. The number of fatalities in work zones across the nation has decreased over the years, from 716 in 2008, to 680 in 2009, and then to 576 in 2010¹. On average, one out of five people killed in work zone crashes is a highway worker. The other four out of five are motorists or their passengers. Despite the decrease in fatalities, work zone safety should still remain a concern even on military installations.

Work zones are areas of major and minor roadway construction, maintenance, or utility work. It is essential that work zones have the proper traffic control to ensure the safety of the road users and the workers. Traffic safety in work zones is often overlooked on military installations, especially on minor roads or short-term work areas. Following are typical maintenance and short-term work, frequently found on installations, where workers are at risk:

- ✓ Bridge inspection
- ✓ Cleaning drainage facilities - catch basins, drop inlets, etc.

¹ The National Work Zone Safety Information Clearinghouse, www.workzonesafety.org

- ✓ Routine and emergency debris cleanup
- ✓ Emergency repairs
- ✓ Guardrail repair
- ✓ Mowing in the highway right-of-way
- ✓ Pavement marking installation and removal
- ✓ Small pavement repairs
- ✓ Post mounted delineators - repair, replacement, installation
- ✓ Raised pavement markers - new installations and lens replacement
- ✓ Shoulder rumble strips - installation
- ✓ Small roadside signs - repair, replacement, installation
- ✓ Snow removal and ice prevention
- ✓ Surveying
- ✓ Routine and emergency traffic signal repairs
- ✓ Vegetation control

OSHA/MUTCD Standards

The Occupational Safety and Health Administration (OSHA) standards (29 CFR 1926, Subpart G) require that all traffic control signs or devices in work zones conform to the *Manual on Uniform Traffic Control Devices (MUTCD)*, Part 6 Temporary Traffic Control. In addition, military installations must comply with the *MUTCD* standards in accordance with Multi-Service Regulation (AR 55-80, OPNAVINST 1210.2, AFMAN 32-1017, MCO 11210.2D and DLAR 4500.19): DoD Transportation Engineering Program.

This bulletin focuses on general work zone features that are common to military installations. The *MUTCD*, specifically Part 6 Temporary Traffic Control, should be referenced for more detailed information on work zone safety. This bulletin provides guidance as taken

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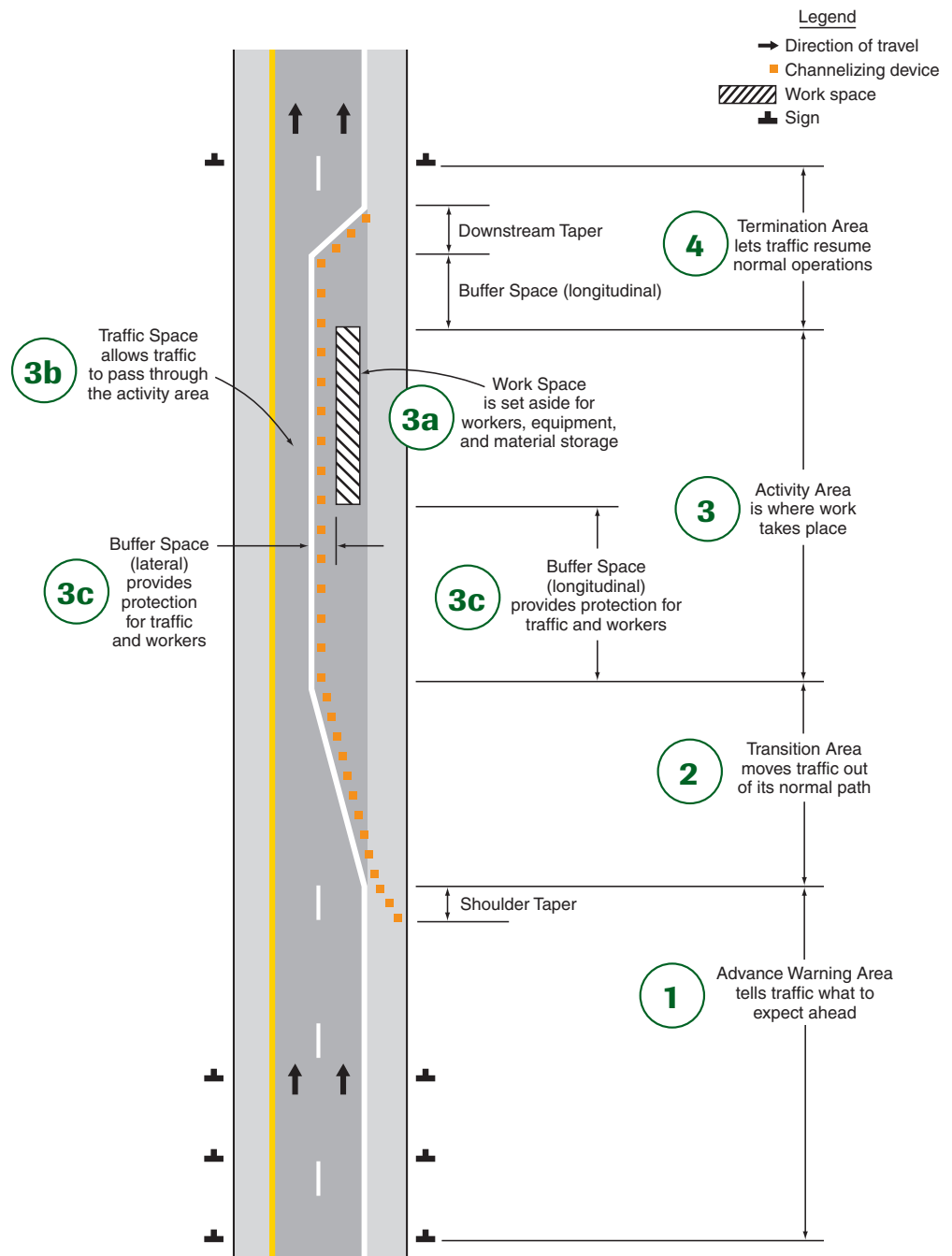
from the *MUTCD*. Installations should also reference their state's Supplement to the *MUTCD* for any state-specific additional requirements for Work Zone Traffic Control. Additionally, SDDCTEA Pamphlet 55-17 Chapter 12 provides information on work zones.

Temporary Traffic Control

TTC Zones

A Temporary Traffic Control (TTC) zone is an area where construction activities or unplanned incidents require changes to expected traffic patterns. A TTC zone is applicable to a broad range of activities, including work zones, road incidents, crashes, physical training, troop formations, convoy operations, planned special events, parades, or any other event that temporarily disrupts the normal traffic flow. While work zones can encompass the same physical area as a TTC zone, work zones are just one type of activity that requires a TTC zone. Convoy operations, troop formations, and other traffic-disrupting activities may often require safety measures similar to those required for work zones, e.g., advance warning signs or flaggers with high-visibility safety apparel (to name a few). It is important that TTC zones are set up and operated properly for safety reasons. TTC zones are divided into four areas (Exhibit 1).

Exhibit 1: Component Parts of a Temporary Traffic Control Zone



1. Advance Warning Area - Road users are informed of the upcoming work zone by signs or lights. Exhibit 2 shows the *MUTCD*-recommended distances for placement of advance warning signs.
2. Transition Area - Road users are redirected from their normal path usually by the use of tapers.
3. Activity Area – This area is made up of:
 - a. The work space - for workers, equipment, and material and usually delineated by channelizing devices or temporary barriers,
 - b. The traffic space - where motorists are routed, and
 - c. Buffer spaces (longitudinal or lateral) - defined by channelizing devices and separates the road users from the work space. The length of a longitudinal buffer space is determined by the posted speed limit (Exhibit 3).
4. Termination Area - Road users go back to their normal travel route.

Exhibit 2: Recommended Advance Warning Sign Minimum Spacing

Road Type	Distance Between Signs**		
	A	B	C
Urban (low speed)*	100 feet	100 feet	100 feet
Urban (high speed)*	350 feet	350 feet	350 feet
Rural	500 feet	500 feet	500 feet
Expressway/ Freeway	1,000 feet	1,500 feet	2,640 feet

* Speed category to be determined by State or local highway agency. On urban streets, the effective placement of the first warning sign in feet should range from four to eight times the speed limit in mph, with the high end of the range being used when speeds are relatively high. When a single advance warning sign is used (in cases such as low-speed residential streets), the advance warning area can be as short as 100 feet. When two or more advance warning signs are used on higher-speed streets, such as major arterials, the advance warning area should extend a greater distance (see figure in chart above).

** Distances are shown in feet. The A dimension is the distance from the transition or point of restriction to the first sign. The B dimension is the distance between the first and second signs. The C dimension is the distance between the second and third signs. The first sign is the sign in a three-sign series that is closest to the TTC zone. The third sign is the sign that is furthest upstream from the TTC zone.

Exhibit 3: Stopping Sight Distance as a Function of Speed

Speed*	Distance
20 mph	115 feet
25 mph	155 feet
30 mph	200 feet
35 mph	250 feet
40 mph	305 feet
45 mph	360 feet
50 mph	425 feet
55 mph	495 feet

* Posted speed, off-peak 85th-percentile speed prior to work starting, or the anticipated operation speed.

What's Wrong with These Photos?

Answers on page 9.



Expanding on these areas:

✓ Advance Warning Area

- ◆ The advance warning area may vary from a single sign or high-intensity rotating, flashing, oscillating, or strobe lights on a vehicle to a series of signs in advance of the TTC zone activity area.
- ◆ The distances contained in Exhibit 2 are approximate, are intended for guidance purposes only, and should be applied with engineering judgment. These distances should be adjusted for field conditions, if necessary, by increasing or decreasing the recommended distances.
- ◆ The need to provide additional reaction time for a condition is one example of justification for increasing the sign spacing. Conversely, decreasing the sign spacing might be justified in order to place a sign immediately downstream of an intersection or major driveway such that traffic turning onto the roadway in the direction of the TTC zone will be warned of the upcoming condition.
- ◆ Option: Advance warning may be eliminated when the activity area is sufficiently removed from the road users' path so that it does not interfere with the normal flow.

✓ Transition Area

- ◆ Transition areas usually involve strategic use of tapers, which because of their importance are discussed separately in detail.
- ◆ Option: Because it is impractical in mobile operations to redirect the road users' normal path with stationary channelization, more dominant vehicle-mounted traffic control devices, such as arrow boards, portable changeable message signs, and high-intensity rotating, flashing, oscillating, or strobe lights, may be used instead of channelizing devices to establish a transition area.

✓ Activity Area

- ◆ The buffer space is a lateral and/or longitudinal area that separates road user flow from the work space or an unsafe area, and might provide some recovery space for an errant vehicle.
- ◆ Guidance: Neither work activity nor storage of equipment, vehicles, or material should occur within a buffer space.

✓ Termination Area

- ◆ An END ROAD WORK sign, a Speed Limit sign, or other signs may be used to inform road users that they can resume normal operations

Tapers

Tapers are made with pavement markings and/or crashworthy channelizing devices such as cones, barrels, etc. Types of tapers and taper length criteria are shown in Exhibits 4 and 5.

Exhibit 4: Types of Tapers and Buffer Spaces

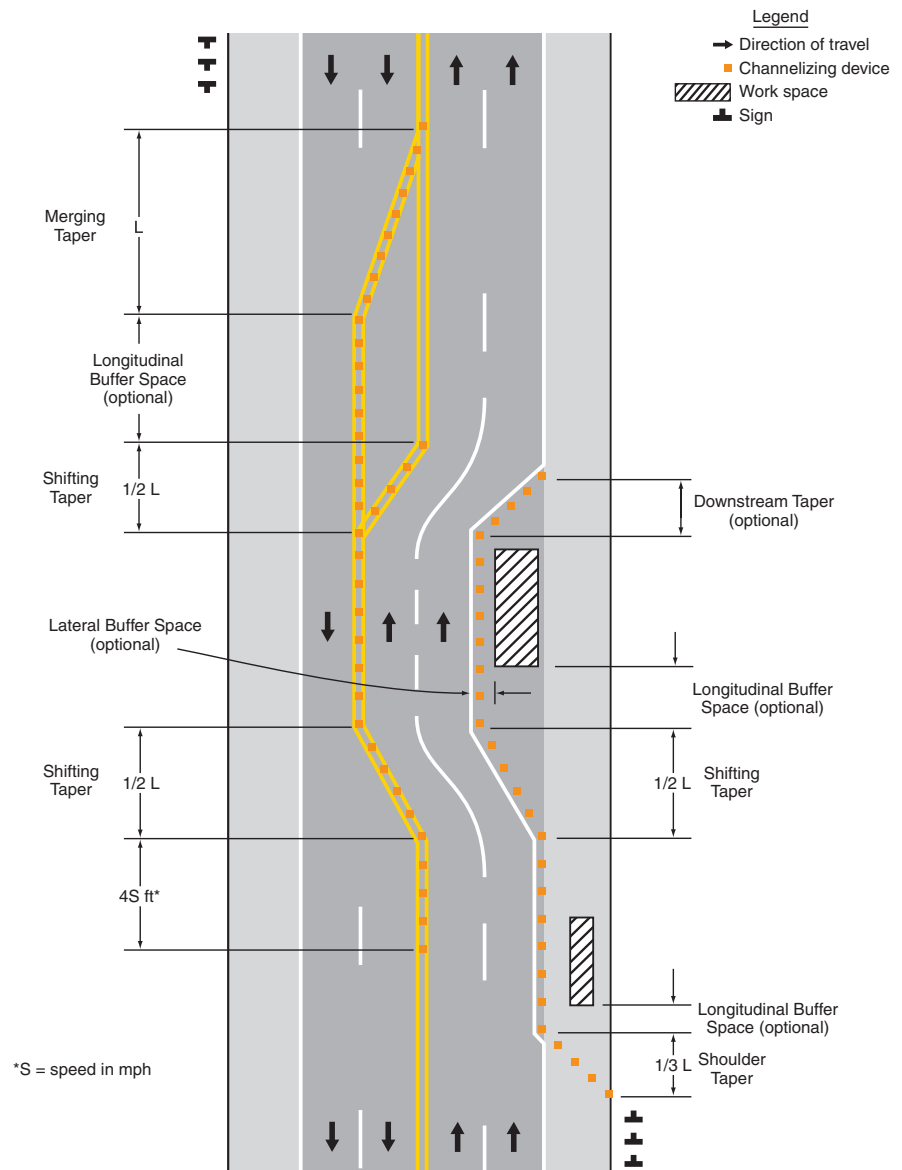


Exhibit 5: Taper Length Criteria for Temporary Traffic Control Zones

Type of Taper	Taper Length
Merging Taper	at least L
Shifting Taper	at least 0.5 L
Shoulder Taper	at least 0.33 L
One-Lane, Two-Way Traffic Taper	50 feet minimum, 100 feet maximum
Downstream Taper	50 feet minimum, 100 feet maximum

Note: Use Exhibit 6 to calculate L

Exhibit 6: Formulas for Determining Taper Length

Speed (S)	Taper Length (L) in feet
40 mph or less	$L = \frac{WS^2}{60}$
45 mph or more	$L = WS$

Where: L = taper length in feet

W = width of offset in feet

S = posted speed limit, or off-peak 85th-percentile speed prior to work starting or the anticipated operating speed in mph

TTC Principles

The *MUTCD* has seven fundamental TTC principles that will assist road users and help protect workers within TTC zones. Refer to the *MUTCD* for specific factors to consider for each principle.

1. General plans or guidelines should be developed to provide safety for road users, workers, and equipment.
2. Road user movement should be inhibited as little as practical.
3. Road users should be guided in a clear and positive manner while approaching and traversing TTC zones.
4. Routine day and night inspections of TTC elements should be performed to provide acceptable levels of operations.
5. Attention should be given to the maintenance of roadside safety during the life of the TTC zone.
6. Each person whose actions affect TTC zone safety, from the upper-level management through the field workers, should receive training appropriate to the job decisions each individual is required to make.
7. Good public relations should be maintained.

TTC Plans

Trained and/or certified personnel should prepare TTC plans, based on *MUTCD* criteria, to safely facilitate road users through the work zones. Before the work zone is created, the TTC plans should be understood by all responsible parties. The plans should have sufficient details that align with the complexity of the work being completed.

TTC Devices

Only the TTC devices common to military installations are described here. The *MUTCD* has a comprehensive listing of TTC devices with details including installation, location, and maintenance requirements. The needs for TTC devices can vary depending on the work location, duration, traffic volumes, and roadway usage. In general, the closer the work is to road users, the greater the number of required TTC devices.

The duration of work is a major factor in determining the number and types of TTC devices.

- ✓ Long-term stationary – work is more than 3 days. Retroreflective and/or illuminated devices shall be used. In general, larger channelizing devices, detours, diversion, temporary signals, or temporary traffic barriers are used.
- ✓ Intermediate-term stationary – work is 1-3 days or nighttime work is more than 1 hour. Retroreflective and/or illuminated devices shall be used.
- ✓ Short-term stationary – work is 1 hour to 1 day (daylight hours only). This includes most maintenance or utility operations.
- ✓ Short duration – work is less than 1 hour. Vehicles with appropriate signing and lighting, and channeling devices easy to install and remove should be used in lieu of numerous signs or temporary pavement markings that take longer to install.
- ✓ Mobile – Work that is continuously moving such as pothole patching, roadway cleaning, or some utility operations. TTC devices that could be used for mobile operations include: flaggers, shadow vehicle with appropriate signing and devices (high-intensity rotating, flashing, oscillating, or strobe lights).

The following pages describe different types of traffic control devices. Exhibit 7 shows some undesirable traffic control devices.

Exhibit 7: Undesirable Traffic Control Devices

Devices that are damaged or have lost a significant amount of their retroreflectivity and effectiveness must be replaced	
Homemade	
Torn, Nonretroreflective	
Torn, Scratched	
?! ?! ?!	

Signs

Placement and use of signs should adhere to *MUTCD* criteria. Signs should be located far enough in advance of the work area to allow vehicles to move smoothly and efficiently around work areas. The exact placement of signs is based on roadway characteristics, such as curves, vegetation, billboards, driveways, etc. They must clearly inform motorists of the upcoming activity and guide them safely through it. Signs must be retroreflective.

- ✓ Regulatory signs for TTC zones shall follow the same standards for other regulatory signs.
- ✓ Warning signs in TTC zones shall have a black legend and border on an orange background (except for the Grade Crossing Advance Warning, W10-1 sign and signs that should have fluorescent yellow-green backgrounds).
- ✓ Guide signs shall follow the standard colors identified in the *MUTCD*.
- ✓ Portable changeable message signs can be used to display various messages including upcoming detours or road closures. These shall only display traffic operational, regulatory, warning, or guidance information and never advertisements.
- ✓ Arrow boards shall be a sign with a matrix of elements capable of either flashing or sequential displays.

Temporary Pavement Markings

These consist of temporary painted pavement markings or temporary raised pavement markers, edge lines, channelizing lines, stop lines, crosswalks, etc.

Temporary Traffic Control Signals

These can be used to control road user movement through TTC zones.

Channelizing Devices

Channelizing devices are used to alter or channel the normal vehicular or pedestrian traffic flow. These include drums, tubular markers, vertical panels, cones, and barricades. All channelizing devices must be crashworthy, i.e. made of lightweight materials and cause minimal damage to vehicles if hit. They must not break apart or be capable of penetrating the passenger compartment of a vehicle. Concrete barriers are not crashworthy, so the ends of the barriers must be protected by a crashworthy device. Particular attention should be given to maintaining the channelizing devices to keep them clean, visible, and properly positioned at all times. See Exhibit 8 for work zone channelizing devices.

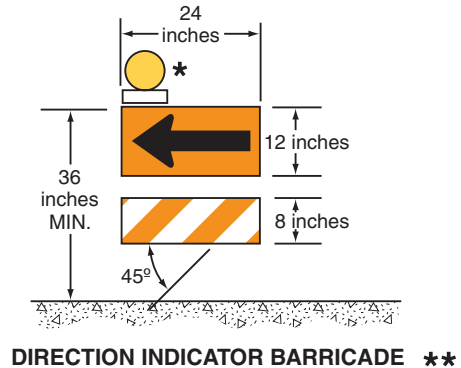
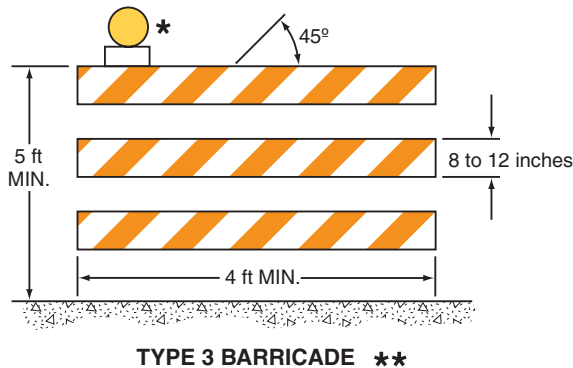
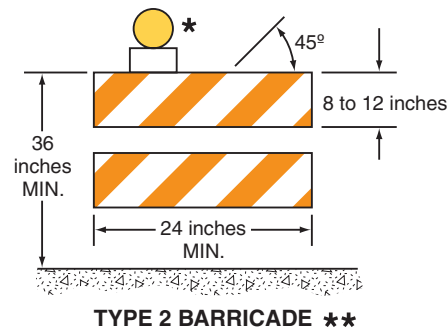
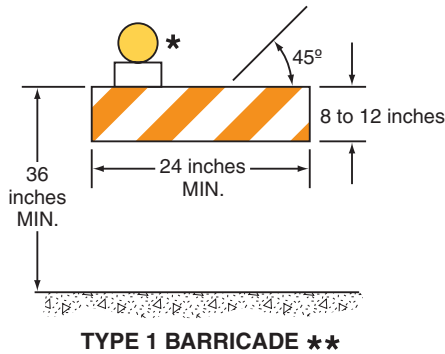
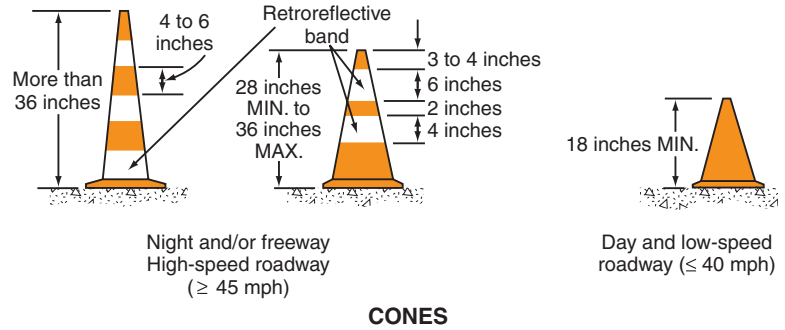
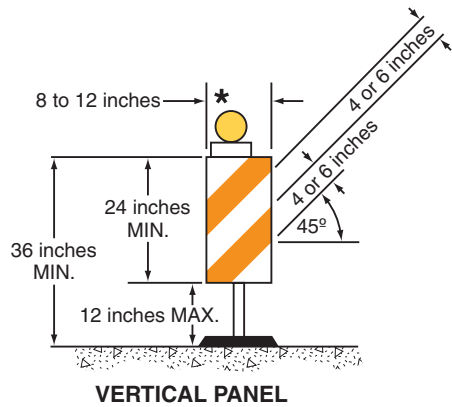
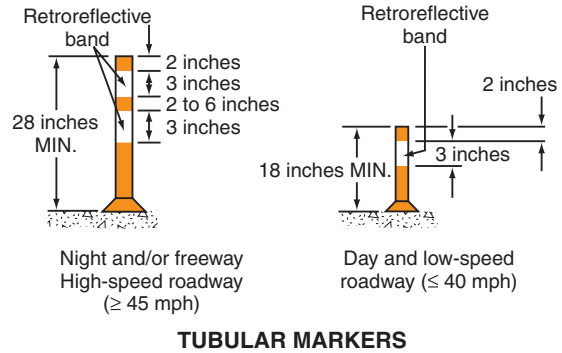
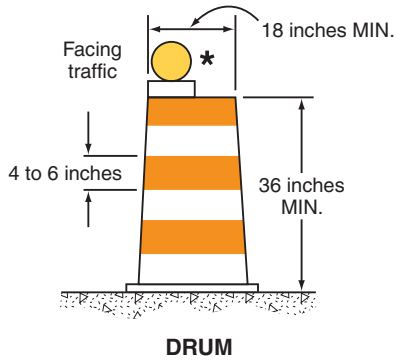
Lighting Devices

Lighting devices can be used to supplement retroreflective signs, barriers, and channelizing devices.

Floodlights

Floodlights can be used when night work is required. Glare must be controlled so worker and motorist visibility is not impacted.

Exhibit 8: Work Zone Channelizing Devices



* Warning lights (optional)

** Rail stripe widths shall be 6 inches, except that 4-inch wide stripes may be used if rail lengths are less than 36 inches. The sides of barricades facing traffic shall have retroreflective rail faces.

Warning Lights

These consist of Type A, B, C, and D and are portable, powered, yellow, lens-directed, enclosed lights. These are mounted on channelizing devices or signs in a manner that, if hit by an errant vehicle, they will not be likely to penetrate the windshield.

Temporary Traffic Barriers

Barriers shall be supplemented with standard delineation for improved visibility if used for channelizing. Temporary traffic barriers and their end treatments shall be crashworthy.

Crash Cushions

Crash cushions shall be crashworthy and designed for each application to stop or redirect errant vehicles under prescribed conditions. They should be inspected periodically, and if damaged, shall be promptly repaired or replaced.

Work Zone Mobility

Work zone mobility involves the efficient movement of road users through or adjacent to a work zone area with little delay, without compromising worker or road user safety.

Speed Control

Speeding in work zones causes fatalities and injuries. Reduced speed limits are often necessary for the safety of the workers and motorists. Traffic speeds through work zones can be controlled through properly posted regulatory speed limits, work zone speed limits, lane reduction, law enforcement, or flaggers.

Detours / Road Closures

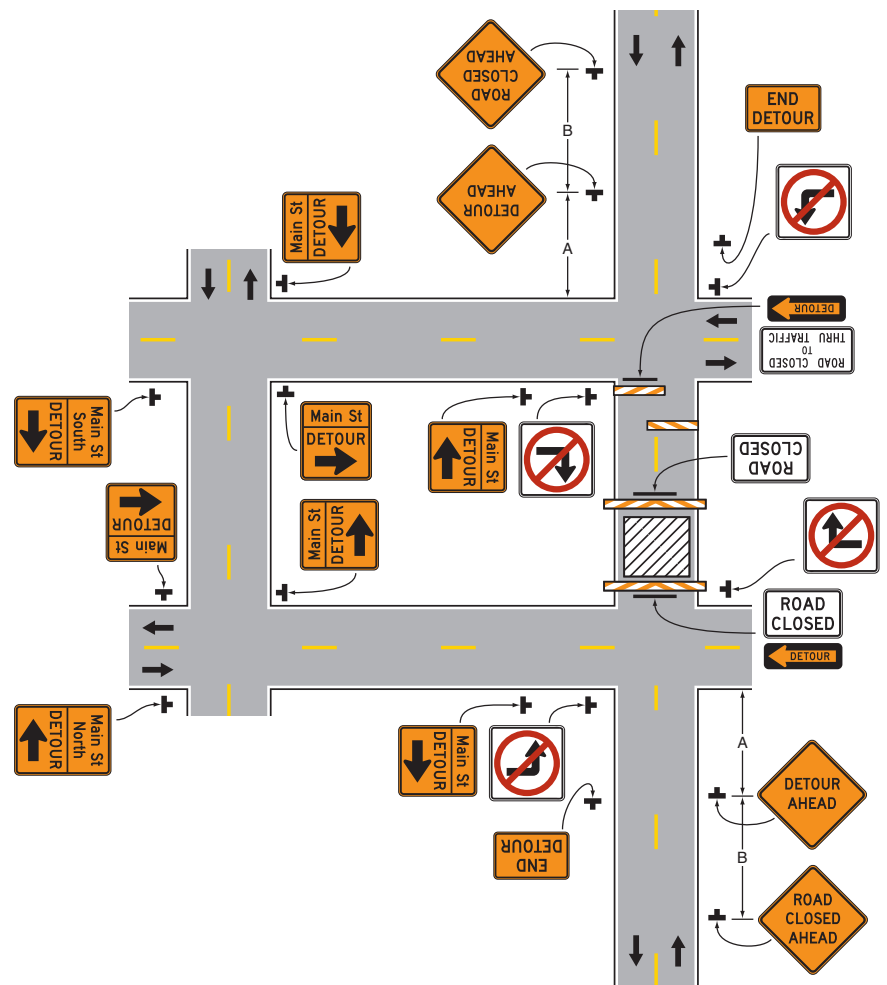
Sometimes a full, temporary road closure is needed for workers to fully access roadway facilities. In these situations, traffic is detoured onto an existing highway so road users can avoid a TTC zone.

When planning a full road closure and its associated detour, consideration should be given to:

- ✓ Impacts to businesses or events being held nearby.
- ✓ Local residents who can be affected by the noise or lights since full closure projects are often scheduled on a 24-hour basis.
- ✓ Increased traffic densities on the alternate routes. These traffic increases must be assessed, planned for, and managed. Capacity improvements and operational enhancements (such as signal timing) may be required.
- ✓ Availability of adequate alternate routes. This is the most critical factor in full road closures.
- ✓ Public outreach efforts to help ensure the success of the road closure.
- ✓ Good traffic management plans and appropriate signage.

Detour routes should be clearly marked to allow the road users to safely traverse the route and return to the original roadway. Exhibit 9 shows a typical detour route scenario applicable to military installations.

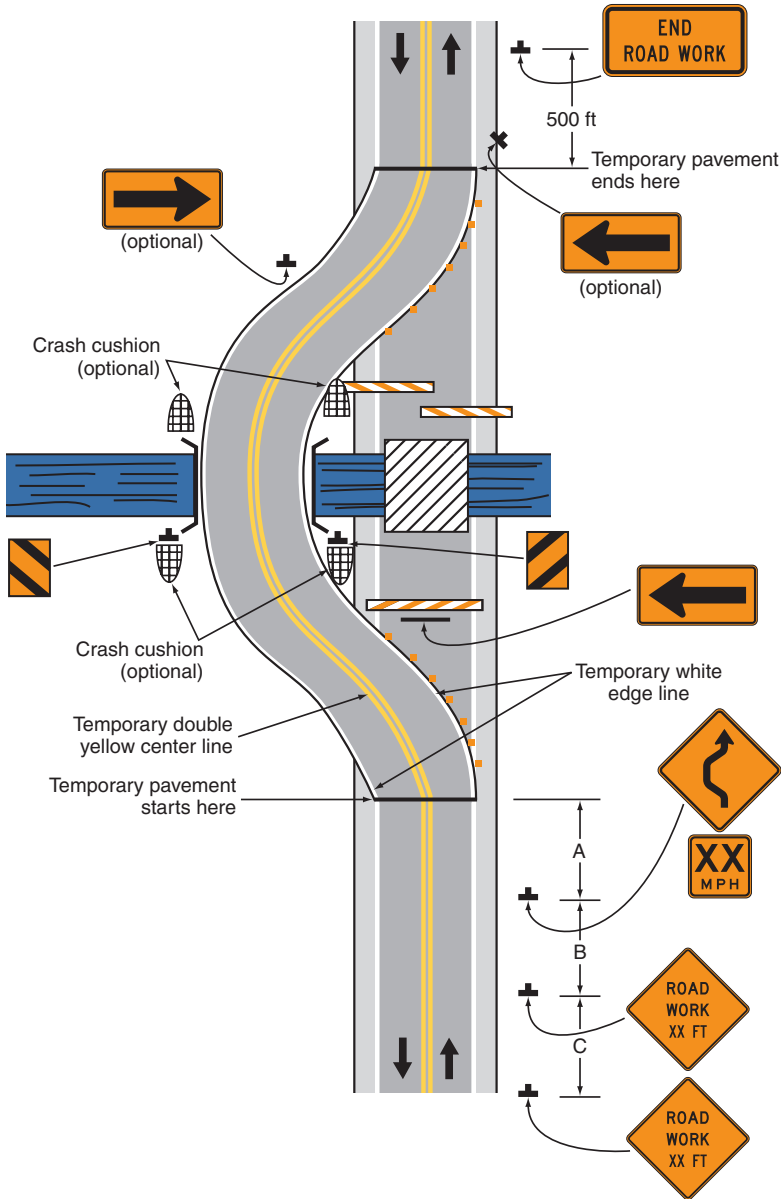
Exhibit 9: Detour Route Example



Diversions

A diversion is a rerouting of road users onto a temporary highway or alignment around the TTC zone. When traffic is diverted, pavement markings that no longer apply shall be removed and temporary crashworthy barriers and end treatments shall be used. Exhibit 10 shows a diversion scenario that is typical on installations.

Exhibit 10: Roadway Diversion Example



Answers from page 3.



This photo lacks proper tapers, signing, and temporary pavement markings. Even though the work zone is not technically in the roadway, it should be properly signed for work adjacent to the highway.



This work zone abruptly closes the shoulder without any form of signing or delineation to indicate the closure. Although the road appears to be a lower-classification road, it should be properly signed to indicate that it is closed.

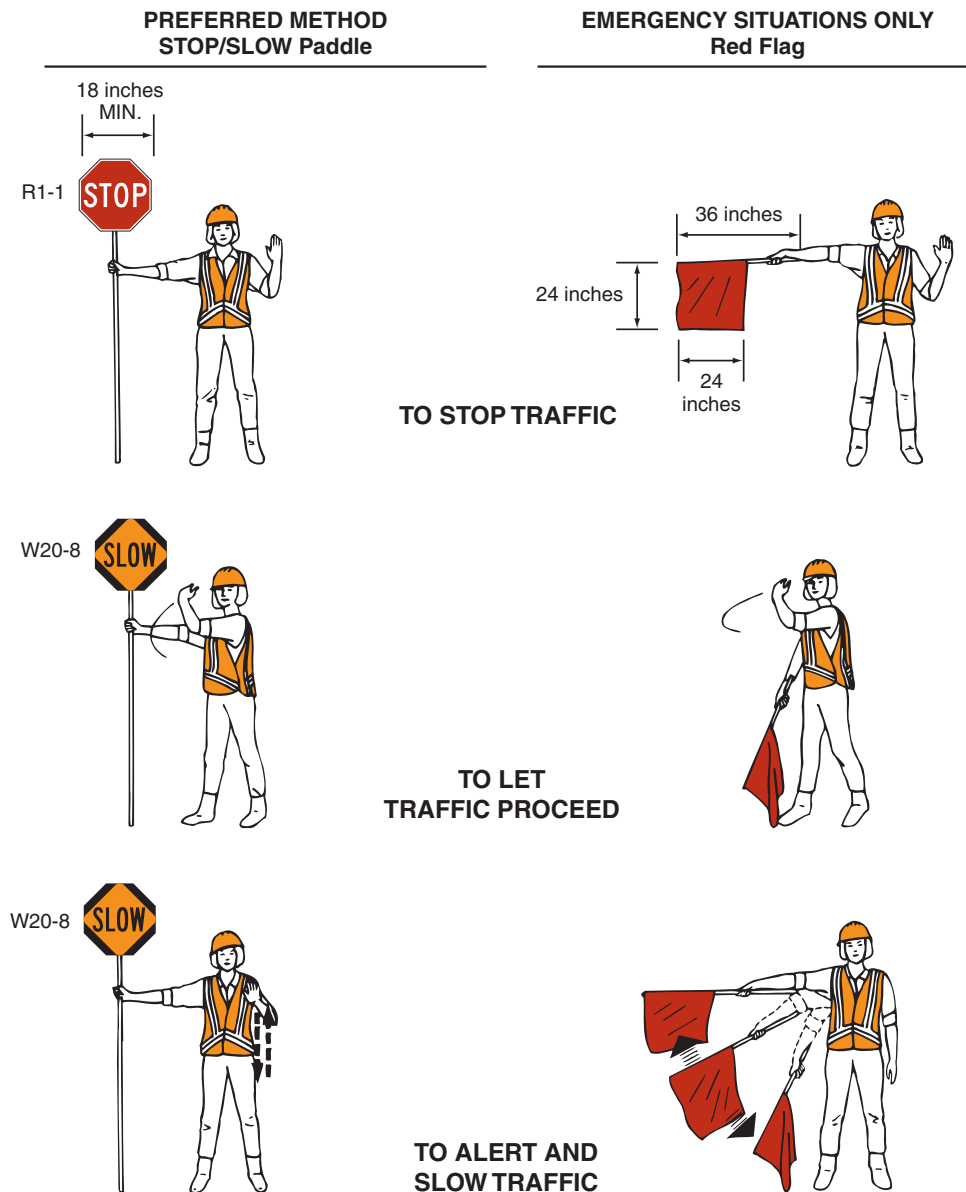
Flagging Operations

Of all the various highway workers, flaggers have the most exposure to the public and are responsible for motorist safety. They should be properly trained and qualified in safe traffic control practices and public contact techniques. Flaggers should have the ability to:

- ✓ Clearly receive and communicate specific instructions
- ✓ Move and maneuver quickly from danger
- ✓ Control signaling devices
- ✓ Understand and apply safe traffic control practices
- ✓ Recognize dangerous traffic situations and warn workers in time to avoid injury

The primary hand-signaling device for flaggers should be an octagonal-shaped STOP/SLOW paddle. The *MUTCD* Part 6E describes the locations of flagger stations, other less common automated devices, and detailed procedures for safely controlling traffic. Exhibit 11 shows common flagger hand signals.

Exhibit 11: Flagger Hand Signals



Pedestrian Mobility

Pedestrian access must also be considered in work zones. When work affects a sidewalk, pedestrian access should remain possible. See Exhibits 13 and 14 for pedestrian detours. In some cases, it is acceptable for pedestrians to use a sidewalk on the opposite side of the roadway, provided crosswalk accommodations are available. However, there are cases where sidewalk work requires temporarily relocating a sidewalk. When this occurs, provide a barrier to define the temporary walkway, and provide temporary curb ramps where needed (See Exhibit 12). The temporary walkway should be accessible to the extent of the existing sidewalk, and must be detectable.

Because printed signs and surface delineation are not usable by pedestrians with visual disabilities, blocked routes, alternate crossings, and sign and signal information should be communicated by providing audible information devices, accessible pedestrian signals, and barriers and channelizing devices that are detectable to pedestrians traveling with the aid of a long cane or who have low vision.

Where channelizing devices are used to channelize pedestrians, there shall be continuous bottom and top surfaces to be detectable to users of long canes. The bottom of the bottom surface shall be no higher than 2.5 inches above the ground to facilitate drainage. The top of the top surface shall be no lower than 32 inches above the ground. Barrier examples include a continuous temporary traffic barrier, longitudinal channelizing barricades, curbing, sections of lumber, or chain link fence with a bottom rail, any of which are placed along the edge of the sidewalk or walkway to provide a pedestrian edging at ground level.



Pedestrian access should be maintained in work zones.

Exhibit 12: Temporary Curb Ramp - Parallel to Curb

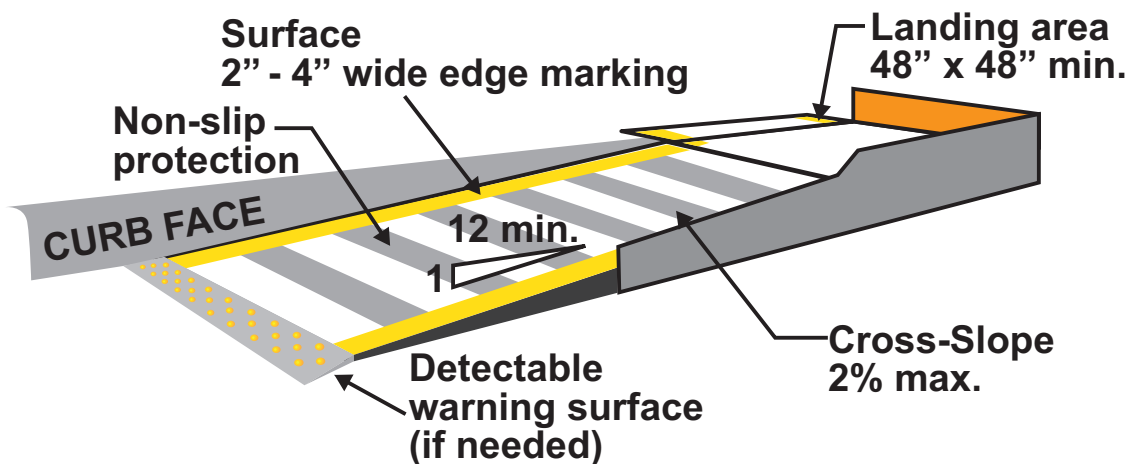


Exhibit 13: Sidewalk Detour or Diversion

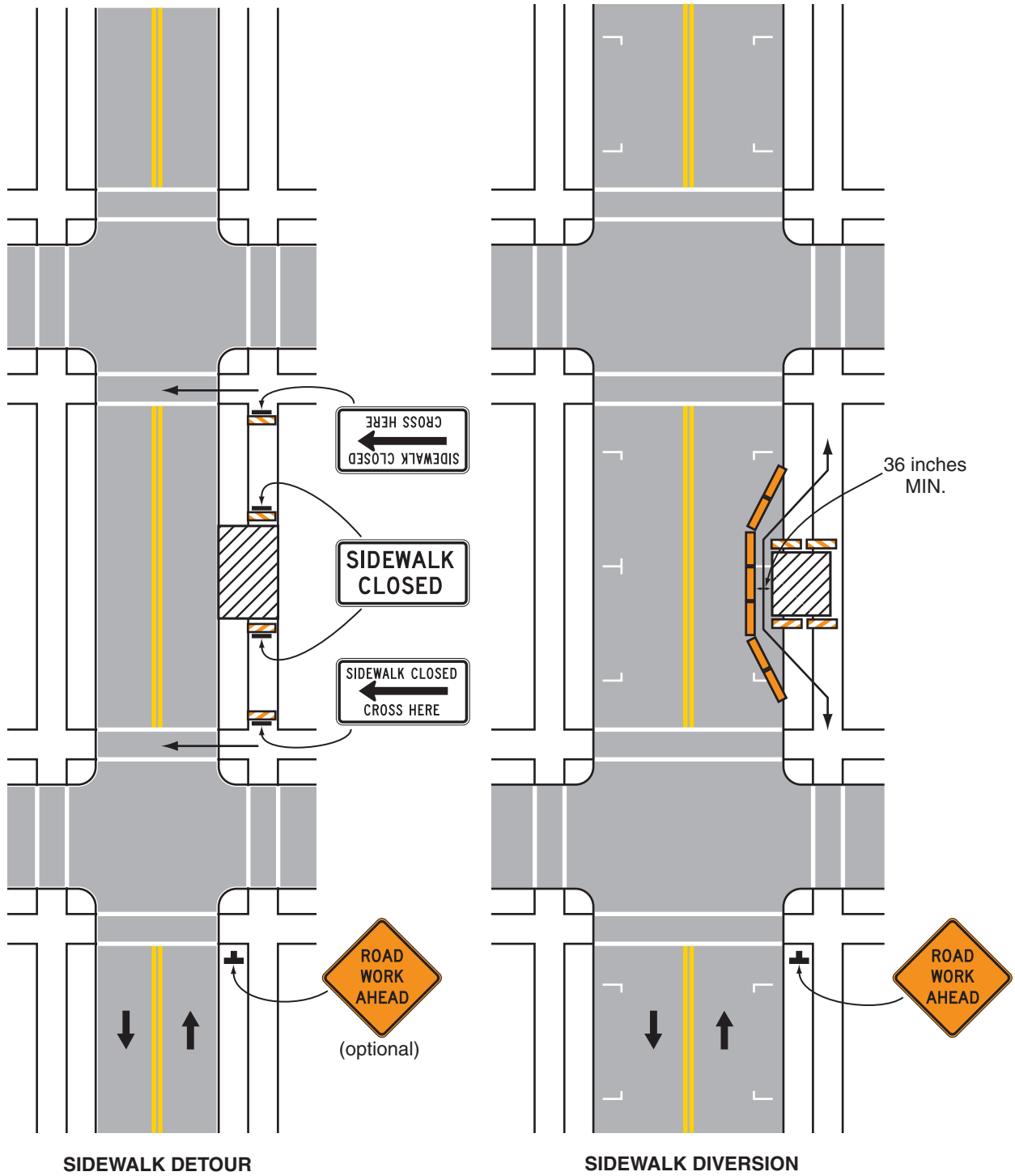
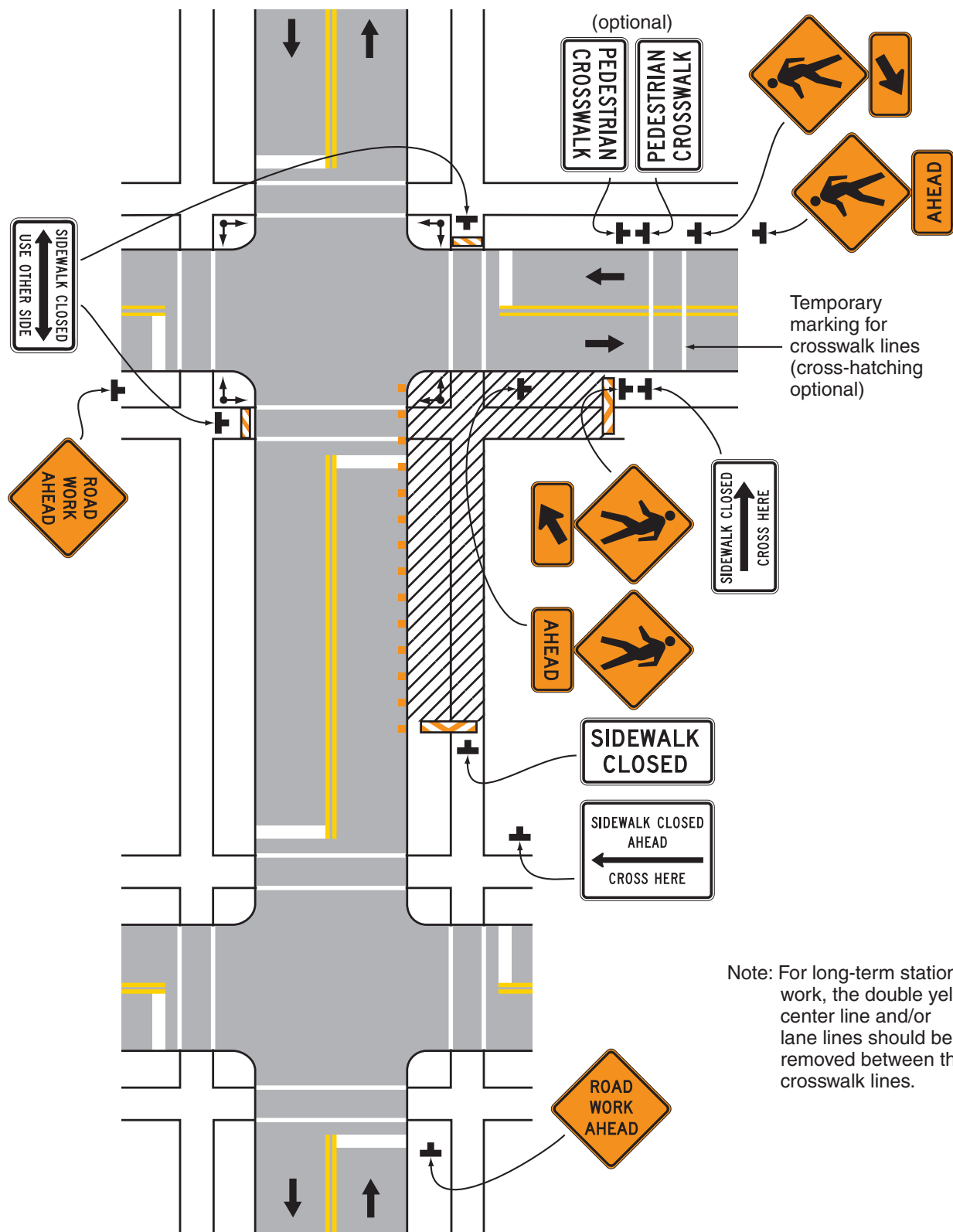


Exhibit 14: Crosswalk Closures and Pedestrian Detours



Note: For long-term stationary work, the double yellow center line and/or lane lines should be removed between the crosswalk lines.

Worker Safety

Worker safety within the TTC zone is just as important as motorist safety. Workers are vulnerable due to their close proximity to roadway users traversing through a traffic pattern change. Almost 20% of the fatalities in work zones are workers. In recent years, the primary cause of these fatalities were:

- ✓ Runovers/backovers (often by dump trucks) – 48%
- ✓ Collision between vehicles/mobile equipment – 14%
- ✓ Caught in between/struck by Construction Equipment and Objects – 14%

To improve worker safety, considerations should be given to activity area planning, visibility/safety apparel, training, safety planning, temporary traffic barriers, speed reduction, road closures, and appropriate lighting.

Activity Area and Safety Planning

Planning the internal work activity area is important to minimize workers' exposure to risks. An internal traffic control plan should be developed to address the flow of construction workers, vehicles and equipment inside the work zone.

Work zones should be set up so equipment flows in one direction to minimize backing maneuvers of construction vehicles. Any back-up maneuvers should be controlled by spotters. Entrance and exit routes for workers and work vehicles should be clearly identified. The plan should also address safe walking areas for workers on foot. In addition, overhead and underground utilities should be relocated to prevent contact by workers or equipment.

A safety specialist should conduct a basic assessment of hazards at the work site to identify worker risks and determine proper engineering, administrative, or personal protection measures.

Visibility/Safety Apparel

All workers near vehicular traffic or construction equipment must wear high-visibility safety apparel that meets requirements of the American National Standards Institute (ANSI) 107–2004 Class 2 or 3 risk exposure. Classes of safety apparel is shown in Exhibit 15.

Exhibit 15: Safety Apparel Classes

Class 1	
Class 2	
Class 3	

- ♦ ANSI Class 1 apparel is obsolete (although commonly available). This apparel is the incorrect color and lacks sufficient surface area.
- ♦ ANSI Class 2 apparel - required as a minimum for all workers within the highway right-of-way. Typical use is on lower speed, lower volume, and secondary road environments.
- ♦ ANSI Class 3 apparel - offers the greatest visibility and is recommended for high-risk environments including, but not limited to, high speed roadways, highly congested areas, complex lane shifts, bad weather, and/or in complex work zones. Class 3 vests are required to have sleeves, but retroreflective pants may be worn in addition to a Class 2 vest to also meet Class 3 standards.

Worker Training

All workers should be trained in safe practices, alertness, common sense, and a sense of responsibility. Workers are responsible for their own safety and the safety of motorists, pedestrians, and bicyclists. Workers with specific responsibilities related to temporary traffic control should be adequately trained in the proper techniques, device usage, and placement. Training resources are shown below.

Information on Work Zone Training

<http://www.fhwa.dot.gov/workzones> - The FHWA Work Zone Mobility and Safety web site provides a vast amount of information about the FHWA Work Zone Program and work zone specific topics.

http://www.ops.fhwa.dot.gov/wz/outreach/wz_training/index.htm - FHWA has developed a compendium of work zone training and guides.

<http://www.ops.fhwa.dot.gov/wz/outreach/outreach.htm> - This page provides information about nationally available work zone training programs.

<http://www.workzonesafety.org/training> - The National Work Zone Safety Information Clearinghouse has a section on its website for information about work zone training courses and programs available nationwide. Information about state flagger training requirements and links to available training videos are also provided.

Contact Us

We can review work zone traffic control plans for your installation.

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OFFICIAL BUSINESS

Reference List

- ✓ Joint Regulation DOD Transportation Engineering Program (AR 55–80, OPNAVINST 11210.2, AFMAN 32-1017, MCO 11210.2D, and DLAR 4500.19)
- ✓ Federal Highway Administration, Manual on Uniform Traffic Control Devices (*MUTCD*), Chapter 6 Temporary Traffic Control, 2009 http://mutcd.fhwa.dot.gov/pdfs/2009/pdf_index.htm
- ✓ National Work Zone Safety Information Clearinghouse: www.workzonesafety.org
- ✓ FHWA Work Zone Mobility and Safety web site: <http://www.fhwa.dot.gov/workzones>
- ✓ SDDCTEA, “Better Military Traffic Engineering, SDDCTEA Pamphlet 55-17, 2011

Continuing Education	Phone	Web Site
Pennsylvania State University; The Pennsylvania Transportation Institute	(814) 865-4700	www.pti.psu.edu
University of Maryland; MD Transportation Technology Transfer Center	(301) 403-4623	www.ence.umd.edu/ttcc
Georgia Institute of Technology	(404) 385-3501	www.gatech.edu
Northwestern University Center for Public Safety	(800) 323-4011	www.northwestern.edu/nucps/index.htm
Texas A&M University	(979) 845-3211	www.tamu.edu
University of Washington; College of Engineering	(206) 543-2100	www.engr.washington.edu/epp