CHAPTER 1

GENERAL

Whenever work is done on or near the roadway, drivers are faced with changing and unexpected traffic conditions. These changes may be hazardous for drivers, workers and pedestrians unless protective measures are taken.

Drivers do not make a distinction between construction, maintenance, or utility operations. Proper traffic control and safety are needed for all types of work.

Part VI of the National Manual on Uniform Traffic Control Devices (MUTCD) is the national standard for all traffic control devices used during construction, maintenance, and utility activities. Part VII of the Ohio MUTCD contains comparable information and is the standard used by all governmental agencies in the State of Ohio.

As a matter of fact, establishment and use of the Ohio MUTCD is required by the Ohio Revised Code. It is applicable to all streets and highways open to public travel in the State of Ohio.

The Ohio Manual sets forth basic principles and prescribes standards for the design, application, installation, and maintenance of the various types of traffic control devices required for all work activities occurring on public streets and highways. Included are requirements for color, size, shape, location, and need for the devices.

In all cases, the guidelines in this Handbook and any traffic control plan should conform to, or be of higher standards than, the Ohio MUTCD. Adequate protection of the traveling public, workers, and pedestrians will dictate the measures to be taken, consistent with the information presented herein and in the Ohio MUTCD.

Two references (1 and 2) are of particular importance. Standard Highway Signs (Federal Highway Administration, Standard Highway Signs, Washington, D. C., U. S. DOT, 1979) has layout details for each of the standard signs in the MUTCD. The Standard Alphabets (FHWA, Standard Alphabets for Highway Signs and Pavement Markings, Washington, D. C., U. S. DOT, 1977) shows the size, shape, and stroke width of the various approved alphabets. These are available from the Federal Highway Administration, HTO-20, Washington, D. C. 20590.

This Handbook has been designed to be used with, but not to replace, the Ohio MUTCD and to explain how to apply appropriate standards to various work situations. It should be useful to anyone involved with planning, designing, installing, maintaining, and inspecting traffic control. The illustrations can be used for a quick guide for various examples of traffic control. Contained are guidelines varying from planning traffic control to fit the needs of a particular work activity to the reasons for keeping accurate records.

A. Fundamental Principles

Construction and maintenance areas can present unexpected or unusual situations to the motorist as far as traffic operations are concerned. Because of this, special care must be taken in applying traffic control techniques in these areas.

According to experience, the following principles and procedures tend to enhance the safety of motorists and workers in the vicinity of construction and maintenance work areas:

- Traffic safety in construction zones should be an integral and high priority element of every project from planning through design and construction. Similarly, maintenance work should be planned and conducted with the safety of the motorist, pedestrian, and worker kept in mind at all times.

  - The basic safety principles governing the design of permanent roadways and roadsides should also govern the design of construction and maintenance sites. The goal should be to route traffic through such areas with geometrics and traffic control devices as nearly comparable as possible to those for normal highway situations.

  - A traffic control plan, in detail appropriate to the complexity of the work project, should be prepared and understood by all responsible parties before the site is occupied. Any changes in the traffic control plan should be approved by an individual trained in safe traffic control practices.

- Traffic movement should be inhibited as little as practicable.

  - Traffic control in work sites should be designed on the assumption that motorists will only reduce their speeds if they clearly perceive a need to do so. Reduced speed zoning should be avoided as much as practicable.

  - Frequent and abrupt changes in geometrics, such as lane narrowing, dropped lanes, or main roadway transitions which require rapid maneuvers should be avoided.

  - Provisions should be made for the safe operation of work vehicles, particularly on high-speed, high-volume roadways.

  - Construction time should be minimized to reduce exposure to potential hazards.

- Motorists should be guided in a clear and positive manner while approaching and traversing construction and maintenance work areas.

  - Adequate warning, delineation, and channelization by means of proper pavement marking, signing, and use of other devices which are effective under varying conditions of light and weather should be provided to assure the motorist of positive guidance in advance of and through the work area.

  - Inappropriate markings should be removed to eliminate any misleading messages to drivers under all conditions of light and weather. On short-term maintenance projects it may be determined that such removal is more hazardous than leaving the existing markings in place; if so, special attention must be paid to providing additional guidance by other traffic control measures.

  - Flagging procedures, when used, can provide positive guidance to the motorist traversing the work area. Flagging should only be employed

when required to control traffic or when all other methods of traffic control are inadequate to warn and direct drivers.

- To insure acceptable levels of operation, routine inspection of traffic control elements should be performed.

  - Individuals who are trained in the principles of safe traffic control should be assigned responsibility for safety at work sites. The most important duty of these individuals is to insure that all traffic control elements of the project are in conformity with the traffic control plan and are effective in providing safe conditions for motorists, pedestrians, and workers.

  - Modification in traffic controls or working conditions may be required in order to expedite safe traffic movement and to promote worker safety. It is essential that the individual responsible for safety have the authority to modify conditions or halt work until applicable or remedial safety measures are taken.

  - Work sites should be carefully monitored under varying conditions of traffic volume, light, and weather, to ensure that traffic control measures are operating effectively and that all devices are clearly visible, clean, and in good repair.

  - When warranted, an engineering analysis should be made (in cooperation with law enforcement officials) of all accidents occurring within work zones. Work zones should be monitored to identify and analyze traffic accidents or conflicts. As examples, skid marks or damaged traffic control devices may indicate needed changes in the traffic control.

  - Work-zone accident records should be analyzed periodically to guide officials in improving work zone operations.

  - All traffic control devices shall be removed immediately when they are no longer needed.

- The maintenance of roadside safety requires constant attention during the life of the construction zone because of the potential increase in hazards.

  - To accommodate run off the road incidents, disabled vehicles, or other emergency situations, it is desirable to provide an unencumbered roadside recovery area that is as wide as practical.

  - Channelization of traffic should be accomplished by the use of pavement markings and signing, flexible posts, barricades, and other lightweight devices, which will yield when hit by an errant vehicle.

  - Whenever practical, construction equipment, materials, and debris should be stored in such a manner as not to be vulnerable to run off the road vehicle impact.

B. Driver Information Needs in Work Zones

The usefulness of traffic control devices intended to assist motorists in guidance and navigation tasks depends on whether the devices satisfy a driver's need for information. Both the message content and the placement of the traffic control device must be carefully considered. Inappropriate messages and/or incorrect placement of signs, markings, and other traffic control devices can mislead and confuse the motorist.

In work zones there are usually three types of traffic control device message content. These include the warning of potential hazards, safe speed, and the lane or shoulder over which a vehicle should be traveling. Positive guidance principles should be considered when determining which traffic control devices will be used and where they will be located.

Research indicates that the more serious failures to meet driver needs result from:

- Providing contradictory or misleading information;

- Presenting a sign with inaccurate distance information; and

- Using nonstandard messages or using inappropriate standard signs.

C. Training

Each person whose actions affect maintenance and construction zone safety, from the upper-level management personnel through construction and maintenance field personnel, should receive training appropriate to the job decisions each individual is required to make. Only those individuals who are qualified by means of adequate training in safe traffic control practices and have a basic understanding of the principles established by applicable standards and regulations, including those of the Ohio MUTCD, should supervise the selection, placement, and maintenance of traffic control devices in maintenance and construction areas.

D. Summary

The following list of items can be used as general guidance for those involved with work-zone traffic control activities:

- To keep the motorist's respect and the agency's credibility, don't lie to the public.
- If work is not in progress or a hazard is not there, take down, fold over, or cover signs.
- If there is no need for channelizing devices, remove them.
- Do not tell drivers to expect a hazard that is not there. If you do, they may not believe other signs and devices used on the project.
- Do not assume that drivers and pedestrians will see or recognize the workers or the hazards in the work area.
- Maintain the controls as if every driver were approaching the area for the first time.
- Once you understand the philosophy of good work area traffic control, explain it to your workers or assistants so they can perform their work with a minimum of exposure to traffic, watching for problems, and reporting any damaged or missing devices.

Information provided herein can be used to supplement local, state, and national standards and to cover more and different types of work sites than those illustrated in the Ohio MUTCD. However, it should be recognized that it is not feasible to cover every conceivable situation. The objective of this Handbook is to illustrate many of the typical work sites, particularly those of relatively short duration, and to describe many common conditions encountered. Good engineering judgment must be used to arrive at the best traffic controls for a particular work site, depending on the nature of the activity, location and duration of work, type of roadway, traffic volume and speed, and potential hazard.

Hence, Traffic Engineering Division should be consulted for assistance and guidance when dealing with non-standard circumstances.

CHAPTER 2

APPLICATION

A. Traffic Control Zones

When traffic is affected by construction, maintenance, utility, or similar operations, traffic control is needed to safely guide and protect motorists, pedestrians, and workers in a traffic control zone. The traffic control zone is the distance between the first advance warning sign and the point beyond the work area where traffic is no longer affected.

Most traffic control zones can be divided into the following parts:

- Advance Warning Area,
- Transition Area,
- Buffer Space,
- Work Area, and
- Termination Area.

If no lane or shoulder closure is involved, the transition area will not be used. In this chapter, each of the "Parts" will be examined for one direction of travel. If the work activity affects more than one direction of travel, the same principles apply to traffic in all directions.

Figure 1 illustrates the five parts of a traffic control zone to be discussed in this section. The devices used in these areas, for different types and locations of work, are compared in Table 1.

1. Advance Warning Area

An advance warning area is necessary for all traffic control zones because drivers need to know what to expect. Before reaching the work area, drivers should have enough time to alter their driving patterns. The advance warning area may vary from a series of signs starting a mile in advance of the work area to a single sign or flashing lights on a vehicle.

Advance warning signs may not be needed when the work area, including access to the work area, is entirely off the shoulder and the work does not interfere with traffic. An advance warning sign should be used when any problems or conflicts with the flow of traffic might possibly occur.

AREAS IN A TRAFFIC CONTROL ZONE

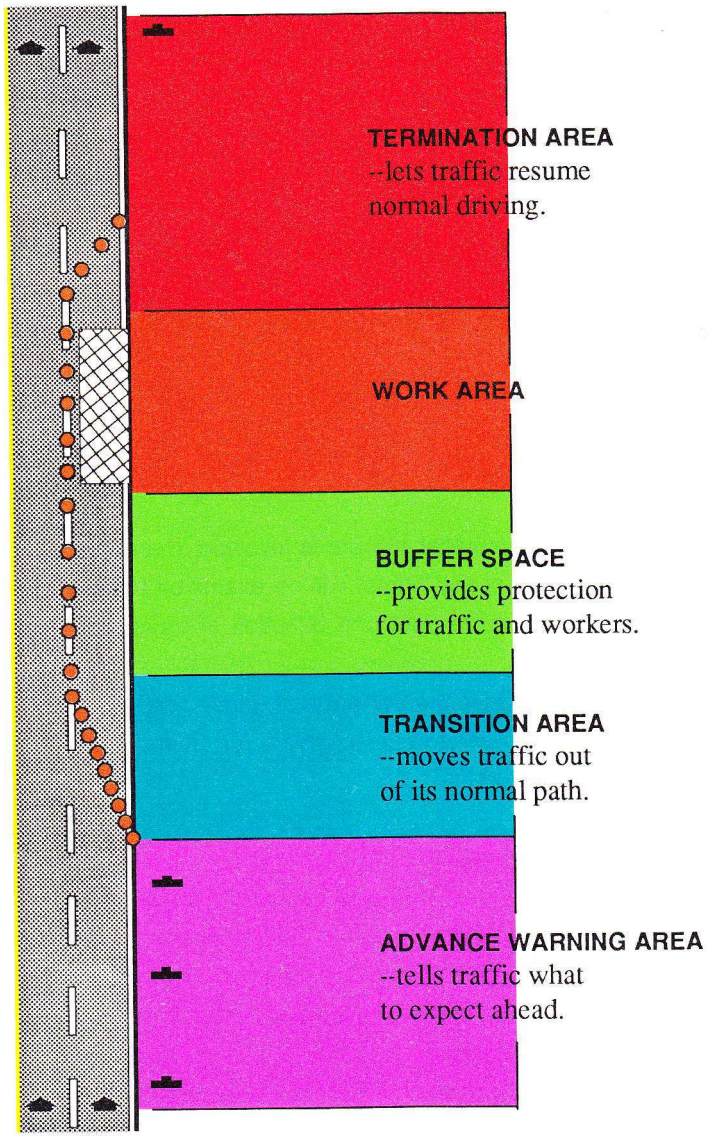
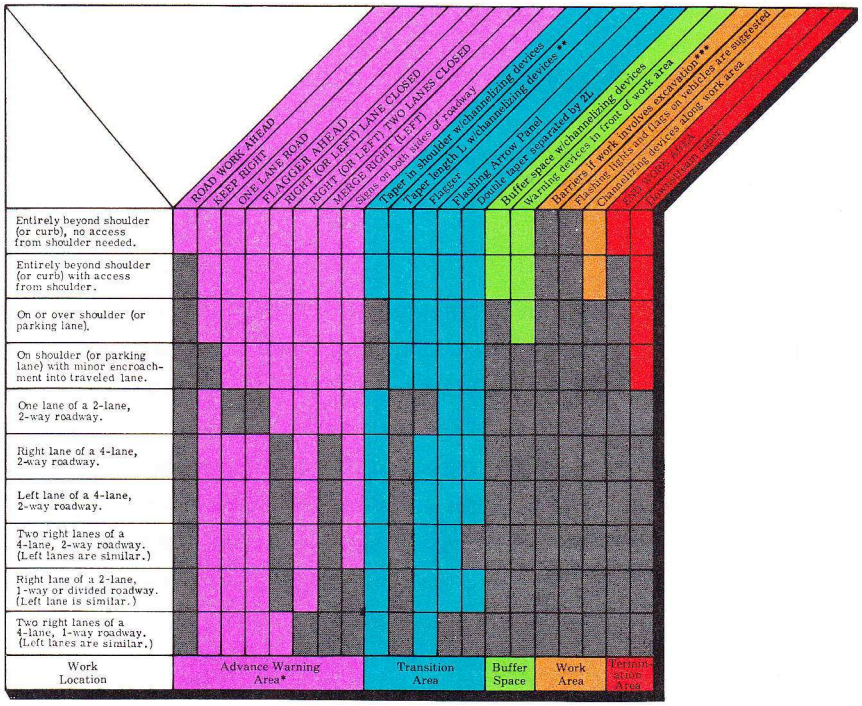


Figure 1

TRAFFIC CONTROL DEVICES FOR VARIOUS LOCATIONS OF WORK



* A consistent pattern of messages is shown in this figure. Refer to MUTCD for other acceptable messages or symbol signs.

** Old pavement markings should be removed and new markings placed in transition area for longer-term activities.

***The use of barriers is determined by an engineering analysis of the need for positive protection.

TABLE 1

Length of the Advance Warning Area

The advance warning area, from the first sign to the start of the next area, should be long enough to give the motorists adequate time to respond to the conditions. For most operations, the length can be:

- One-half mile to one mile for freeways or expressways;
- 1,500 feet for most other roadways or open highway conditions; and
- At least one block for urban streets.

For some specific applications refer to Figures 8 through 23, pages 60-79, "Typical Applications (Layouts)".

2. Transition Area

When work is performed within one or more traveled lanes, a lane closure(s) is required. In the transition area, traffic is channelized from the normal highway lanes to the path required to move traffic around the work area. The transition area contains the tapers which are used to close lanes.

The transition area should be obvious to drivers. The correct path should be clearly marked with channelizing devices and pavement markings so drivers will not make a mistake and follow the old path. Existing pavement markings need to be removed when they conflict with the transition. New markings should be added. Pavement marking arrows are useful in transition areas.

With moving operations, the transition area moves with the work area. A shadow vehicle may be used to warn and guide traffic into the proper lane. Refer to "Shadow Vehicles", page 51.

Tapers

A taper is a series of channelizing devices and pavement markings placed on an angle to move traffic out of its normal path. An example of a taper is shown in Figure 1, page 12.

Four general types of tapers used in traffic control zones are:

- Lane closure tapers are those necessary for closing lanes of moving traffic (sometimes referred to as channelizing tapers).

- Two-way traffic tapers are those needed to control two-way traffic where traffic is required to alternately use a single lane (commonly used when flaggers are present).

- Shoulder closure tapers are those needed to close shoulder areas.

- Downstream tapers are those installed to direct traffic back into its normal path.

Lane Closure Taper

The single most important element, within the system of traffic control devices commonly used in construction or maintenance areas (where a reduction in pavement width is involved), is the taper that is provided for the channelization. An inadequate taper will almost always produce undesirable traffic operations with resulting congestion and possibly accidents through the area.

The length of taper used to close a lane is determined by the speed of traffic and the width of the lane to be closed (the lateral distance that traffic is shifted). There are two formulas for determining the length of a taper (L) used for lane closures.

The minimum desirable taper length for construction and maintenance purposes should be computed by the formula $L = S \times W$, for all freeways, expressways, and other roadways having a posted speed of 45 mph or greater. The formula $L = WS^2/60$ should be used to compute taper length on urban, residential and other streets where the posted speeds are 40 mph or less. Under either formula, L equals the taper length in feet, W the width of offset in feet, and S the posted speed or off-peak 85 percentile speed.

The formulas and their criteria for application are shown in Table 2.

FORMULAS FOR TAPER LENGTH

Posted Speed	Formula
40 mph or under	$L=\frac{WS^2}{60}$
45 mph or over	L=WS

where: L = taper length

W = width of lane or offset

S = posted speed, or off-peak 85 percentile speed

TABLE 2

If restricted sight distance is a problem (e.g., a sharp vertical or horizontal curve), the taper should begin well in advance of the view obstruction. The beginning of tapers should not be hidden behind curves. Table 3 shows the taper length, the recommended number, and the spacing of channelizing devices for various speeds and widths of closing.

TAPER LENGTHS FOR LANE CLOSURES-DISTANCE L

Speed Limit M.P.H.	Taper Length Lane Width In Feet 10	11	12	Number of Channelizing Devices for Taper*	Spacing of Devices Along Taper in Feet
20	70	75	80	5	20
25	105	115	125	6	25
30	150	165	180	7	30
35	205	225	245	8	35
40	270	295	320	9	40
45	450	495	540	13	45
50	500	550	600	13	50
55	550	605	660	13	55

TABLE 3

*Based on 12-foot wide lane. This column is appropriate for lane widths less than 12 feet.

Generally, tapers should be lengthened, not shortened, to increase their effectiveness. Traffic should be observed to see if the taper is working correctly. Frequent use of brakes and evidence of skid marks is an indication that either the taper is too short or the advance warning is inadequate. Section D, "Typical Applications (Layouts)", page 57, includes several typical applications which illustrate how tapers may be placed in urban areas in the vicinity of intersections.

Two-Way Traffic Taper

The two-way traffic taper is used in advance of a work area that occupies part of a two-way road in such a way that the remainder of the road is used alternately by traffic in either direction. In this situation, the function of a taper is not to cause traffic to merge, but rather to resolve the potential head-on conflict. A short taper is used to cause traffic to slow down by giving the appearance of restricted alignment. Drivers then have time at reduced speed to decide whether to proceed cautiously past the work space or to wait for opposing traffic to clear. One or more flaggers are usually employed to assign the right-of-way in such situations.

Two-way traffic tapers should be 50 to 100 feet long, with channelizing devices spaced a maximum of 10 to 20 feet respectively, to provide clear delineation of the taper. Flashing arrows boards (in the arrow mode) should never be used with a two-way traffic taper.

Shoulder Closure Taper

When an improved shoulder is closed on a high-speed roadway, it should be treated as a closure of a portion of the roadway because motorists expect to be able to use the shoulder in the event of an emergency. The work area on the shoulder should be preceded by a taper that may be shorter than for lane closures. One-half of the length from Table 3 (page 16) is suggested as a maximum for shoulder closure tapers, provided the shoulder is not used as a travel lane. If the shoulder is being used as a travel lane, either through practice of through use caused by construction, a standard lane closure taper should be placed on the shoulder.

Downstream Taper

A downstream taper is used at the downstream end of the work area to indicate to drivers that they can move back into the lane that was closed. It is placed in the termination area. While closing tapers are optional, they may be useful in smoothing

traffic flow. They may not be advisable when material trucks move into the work area by backing up from the downstream end of the work area.

Closing tapers are similar in length and spacing to two-way traffic tapers.

3. Buffer Space

The buffer space is open or unoccupied space between the transition and work areas (Figure 1, page 12). With a moving operation, the buffer space is the space between the shadow vehicle, if one is used, and the work vehicle.

The buffer space provides a margin of safety for both traffic and workers. If a driver does not see the advance warning or fails to negotiate the transition, a buffer space provides room to stop before the work area. It is important for the buffer space to be free of equipment, workers, materials, and workers' vehicles. When designing or setting out a Traffic Control Plan the following guidelines should be considered for buffer spaces:

- Place channelizing devices along the edge of the buffer space. The suggested spacing in feet is equal to two times the posted speed limit.

- Situations occur where opposing streams of traffic are transitioned so one lane of traffic uses a lane that normally flows in the opposite direction. In these situations, a buffer space should be used to separate the two tapers for opposing directions of traffic because it could help prevent head-on collisions. Refer to Figure 16, page 70, for an example of this type of buffer space.

4. Work Area

The work area is that portion of the roadway which contains the work activity and is closed to traffic and set aside for exclusive use by workers, equipment, and construction materials. Work areas may remain in fixed locations or may move as work progresses. An empty buffer space may be included at the upstream end. The work area is usually delineated by channelizing devices or shielded by barriers to exclude traffic and pedestrians and serve as protection for the workers.

Conflicts and Potential Hazards

Conflicts between traffic and the work activity are potential hazards. These increase as:

- The work area is closer to the traveled lanes;
- Physical deterrents to normal operation exist such as uneven pavements, vehicles loading or unloading;
- Speed and volume of traffic increase; and
- The change in travel path gets more complex, shifting traffic a few feet in comparison with shifting traffic across the median and into lanes normally used by opposing traffic.

Work areas that remain overnight have a greater need for delineation than daytime operations.

Every feasible effort should be made to minimize conflicts. Some suggestions include:

- Use traffic control devices to make the travel path clearly visible to traffic.
- Place channelizing devices between the work area and the traveled way. Devices placed on a tangent (along the work area) to keep traffic out of a closed lane should be spaced in accordance with the extent and type of activity, the speed limit of the roadway, and the vertical and horizontal alignment such that is is apparent that the lane is closed. The MUTCD does not specify a spacing for the devices along the closed lane. For high-speed roadways, a range from 2S to 4S (two to four times the posted speed limit) is suggested. For low-speed or urban streets, a closer spacing may be used.
- Provide a safe entrance and exit for work vehicles.
- Protect mobile and moving operations with adequate warning on the work and/or shadow vehicles.
- Flags and flashing lights should be considered on work vehicles exposed to traffic.

5. Termination Area

The termination area provides a short distance for traffic to clear the work area and to return to the normal traffic lanes. It extends from the downstream end of the work area to the END CONSTRUCTION or END ROAD WORK sign. A downstream taper may be placed in the termination area.

For some work operations, such as single location utility or maintenance repair, it may not be necessary to display a sign as it will be obvious to drivers that they have passed the work area.

There are occasions where the termination area could include a transition. For example, if a taper were used to shift traffic into opposing lanes around the work area, then the termination area should have a taper to shift traffic back to its normal path. This taper would then be in the transition area for the opposing direction of traffic. It is advisable to use a buffer space between the tapers for opposing traffic, as shown in Figure 16 (page 70).

Avoid "gaps" in the traffic control that may falsely indicate to drivers that they have passed the work area. For example, if the work area includes intermittent activity throughout a 1-mile section, the drivers should be reminded periodically that they are still in the work area. The primary purpose of the guide sign ROAD CONSTRUCTION NEXT ___ MILES is to inform the drivers of the length of the work area. It should not be erected until work begins.

B. Planning for Traffic Control

During planning for work zones, one should strive for the greatest payoff in terms of safety and convenience at a cost commensurate with the hazards and problems involved. A properly installed traffic control zone will allow traffic to pass through or around a work zone safely. It requires time and effort for planning, installation, and maintenance. All employees involved with work-zone safety should be properly trained. These include design, traffic and construction engineers, inspectors, superintendents, and foremen.

All work-zone traffic-control planning centers around an analysis of the work activity and relating it to the provision of adequate safety and capacity. What is the likelihood of motorists failing to negotiate the work zone safely? What are the consequences of such action on pedestrians, workers, or other motorists?

Planning for traffic control through a construction zone may be more involved than for maintenance or utility zones because of the differences in traffic disruption and duration of the work. Although the requirement for safety in all zones is the same, planning for the three types of work operations will be discussed separately. The exposure of traffic to potential hazards is a function of the traffic volume and the length of time that the closure will be in effect. The goals common to all traffic control zones are:

- to minimize accidents and accident severity; and
- to minimize inconvenience and conflict as a result of the work. It should be recognized that these goals may at times be at odds.

1. Minimize Accidents

For all work zones, the first fundamental principle is that safety should have a high priority through all stages of all work. The following list is a set of guidelines that may be helpful in achieving this goal:

- Use traffic control devices that are visible and effective.
- Follow the standards in the MUTCD on the use and location of tapers and transitions. Avoid introducing severely reduced travel path geometrics at the approaches to or within the work area.
- Minimize fixed object hazards. For example, use lightweight channelizing devices and use crash cushions to protect barrier ends. Sand bags should be placed on the bottom of supports for various devices so that they do not become projectiles as a result of a collision.
- Minimize traffic conflicts with workers and equipment. Consider using a portable barrier.
- Provide night visibility with illumination, reflectorized devices, warning lights, and pavement markings. Consider floodlighting hazardous areas. However, care should be taken to insure that the floodlights are not aimed in a way that would adversely affect motorist's vision.

- Close only those lanes that must be closed and reopen them as soon as practicable to maintain maximum roadway capacity.

- Avoid severe speed reductions.

- Avoid traffic delays that could cause backups.

- Avoid scheduling work during peak hours and holidays.

- Prepare an alternate route or plan in case of an accident or other emergency. If an alternate route is not feasible, be prepared to use signs, flaggers, and radio announcements to warn traffic of the backup and to explain the delay.

- Reduce inconveniences for pedestrians and bicyclists by providing the shortest and safest path, safe clearances, and minimum grades, steps, and curbs.

- Emergency organizations, such as police, fire, and ambulance services, should be notified prior to the start of work. This will allow them to adjust their routes and/or work schedules accordingly.

- Emergency vehicles should have a high priority in passing through a work zone or using an alternate route.

- Access to police and fire stations, fire hydrants, and hospitals should be maintained at all times.

3. Utility Work Zones

Utility work may be divided into three classifications: emergency, maintenance and new construction. The guidelines for traffic control listed here are for normal situations and additional protection should be provided when special complexities and hazards exist.

Emergency Work

- Can occur at any time of day or night;

- May be caused by storm damage;

- Provide safe pedestrian walkways by separating pedestrians from vehicular traffic and work activities. Provide safe pedestrian and vehicular access across or through driveways.

- Store equipment and materials outside the clear recovery zone as defined in the Guide for Selecting, Locating, and Designing Traffic Barriers (List of References #3).

- Provide a buffer space between traffic and workers.

- Provide safe employee access to work, storage areas, businesses, residences, and within the work area. Provide a safe entrance and exit for work vehicles. This may require the use of temporary traffic signals, flaggers, or temporary portable barriers.

- Plan for the safety of workers on the project as required by safety and health regulations. (e.g., safety clothing, hardhats, etc.)

- Flags and flashing lights should be utilized on work vehicles exposed to traffic. To protect mobile and moving operations, shadow vehicles may be used and equipped with signs, flags, flashing lights, and/or crash cushions as appropriate.

2. Minimize Inconvenience

Work in or near traveled lanes often causes confusion and disruption of normal traffic. The traffic control plan should be aimed at reducing inconvenience and conflicts, as stated above. Traffic movement should be inhibited as little as practicable. Traffic control in work sites should be designed on the assumption that motorists will only reduce their speeds if they clearly perceive a need to do so. Reduced speed zoning should be avoided as much as practicable. Frequent and abrupt changes in geometrics, such as lane narrowing, dropped lanes, or main roadway transitions which require rapid maneuvers, should be avoided. Provisions should be made for the safe operation of work vehicles, particularly on high speed, high volume roadways. Construction time should be minimized to reduce exposure to potential hazards.

The following list is a set of guidelines that may be helpful in achieving this goal:

- May involve disruptions of utility service to customers;

- Work operation usually involves a small crew and a work vehicle for a short period of time;

- The work vehicle should be equipped with a yellow flashing light, a limited number of portable signs and channelizing devices in good condition, and equipment for flaggers in the event they are needed; and

- The extent of traffic control may be less than longer-term construction or maintenance, yet the safety of pedestrians, motorists, and workers should be provided.

4. Maintenance and New Construction for Utilities

The public will not easily make a distinction between maintenance and new construction. Therefore the type of traffic control used should be adequate for the nature, location, and duration of work, type of roadway, traffic volume and speed, and potential hazard. When new construction or some maintenance activities are planned (as opposed to emergency activities), the following guidelines should be considered:

- In urban areas, consider avoiding the hours of peak traffic when scheduling work.

- Maintain street and road work areas for only as long as is necessary to safely move in, finish the work, remove all utility work signs, and move out.

- Take special care to clearly mark suitable boundaries for the work space with channelizing devices so pedestrians and drivers can see the work space. If any of the traveled lanes are closed, tapers shall be used as required by the MUTCD. If a shoulder is closed, a shoulder taper is suggested.

- Pedestrians should not be expected to walk on a path which is inferior to the previous path. Loose dirt, mud, broken concrete, or steep slopes may force

pedestrians to walk on the roadway rather than the sidewalk. Repairs (temporary or permanent) to damaged sidewalks should be made quickly. This may include bridging with steel plates or good quality wood supports.

- Any work which cannot be completed during the day and which impedes traffic or presents a hazard overnight may need additional attention. Reflectorized signs and channelizing devices are required by the MUTCD. Warning lights are optional but should be considered.

- Any member of the crew who serves as a flagger should be equipped with a red flag or a STOP-SLOW paddle, a reflective vest, and should be trained for proper flagging procedures.

- Work areas involving excavations on the roadway generally should not exceed the width of one traffic lane at a time. The work should be staged and, if needed, approved bridging should be utilized. This type of activity should be fully coordinated with the Traffic Engineering Division or Public Works Department office having jurisdiction over the street or highway.

5. Highway Maintenance Work Zones

Maintenance operations are needed to preserve, repair, and restore the streets and highways and include those activities performed on travel-way surfaces, shoulders, roadsides, drainage facilities, bridges, signs, markings, and signals.

These operations may be emergencies (as a result of storms or accidents) or planned activities. They may be stationary, mobile, or moving operations. The traffic control needed will vary according to the nature, location, and duration of work; type of roadway; speed of traffic and potential hazard.

6. Traffic Control Plans for Construction Projects

A formal Traffic Control Plan (TCP) is required to be included in the plans, specifications and estimates (PS&E) for all Federal-aid projects by Federal-Aid Highway Program Manual (List of References #4.) Other construction projects should also have a TCP. These plans may range in scope from a very detailed TCP designed solely for a specific project, to a reference to standard plans, a section of

the MUTCD, or a standard highway agency manual such as this Handbook. The degree of detail in the TCP will depend on the complexity of the project and on the interaction of traffic needs and construction activities.

Highway agency design and traffic engineers will develop the TCP and include it in the PS&E. The contractor can develop a TCP, but may use it only if it is equal to or better than the TCP in the plans, and if it is approved by the highway agency.

The following people and organizations are normally involved in the development of a TCP:

- Transportation officials from local, state, and federal levels, including design, traffic, and construction engineers;
- Police and fire officials at the state and local levels; and
- Utility companies.

Once the TCP has been developed and approved but before construction starts, others should be notified, as follows:

- Businesses in the area;
- Affected public groups, such as homeowners' organizations;
- School officials, so they can change bus schedules if necessary;
- Local government officials, including the Chamber of Commerce; and
- Tow truck services.

The following factors need to be considered for the TCP:

- Economic and community
  - commercial business districts,
  - residential locations,
  - recreation areas,
  - shopping centers,

- railroad crossings,
- rural areas, and
- other work planned adjacent to or within the area of the project;

- Traffic
  - volumes,
  - peak hours including holiday, special event and recreation traffic,
  - pedestrian traffic,
  - bicycles,
  - large vehicles such as trucks and buses,
  - speed of traffic,
  - capacity of roadway,
  - traffic signal operation (effect on existing vehicle detectors); and

- Seasonal changes and weather, including
  - maintaining traffic control during seasonal shutdowns,
  - loss of visibility and damage to devices during rain or snow,
  - temperature restrictions for some phases of construction, and
  - maintenance of traffic control devices (cleaning, cutting vegetation away from signs).

A 24-hour workday may be desirable as it allows the total number of working days to be decreased. Consideration should include:

- Neighborhood objection to nighttime noise;

- Higher cost, for labor and lighting;

- Higher percentage of drinking drivers at night; and

- Limited available commercial services, such as supply of ready-mix concrete or aggregate.

The controlled staging of construction should be considered, including:

- The location of work (on roadway, shoulders, or sidewalks);
- The number of lanes required for the work activity;
- Hours of a day during which a lane may be closed;
- Whether work may progress simultaneously in both directions of traffic;
- The length of the work area (controlled staging such as guardrail removal and immediate replacement);
- Minimize time of exposure to hazards such as drop-offs;
- Time involved, such as curing of pavement or bridge decks;
- Remove or shield the motorist from hazards created by the work activity within the recovery area such as boulders, drainage basins, pipe, headwalls, blunt ends of guardrail, and sign supports; and
- Delays during traffic control set-up and take-down time (preferably during low traffic volume periods).

Traffic control planning should consider the inclusion of unit pay items in the construction contract to cover the furnishing, application, installation, and maintenance of traffic control devices of acceptable quality to comply with the agency's specifications.

Materials developed for the TCP may include but are not limited to:

- Scaled drawings of the control zone;
- List of devices selected for installation;
- Special manpower needs, such as flaggers;

- Copies of permits;
- Phone numbers of officials to be contacted in an emergency;
- Scaled drawings of construction stages, including detours; and
- Schedules for times during the day when work is permitted or when certain lanes should remain open.

7. Speed Control for Detours, Transitions, & Median Crossovers

Studies have shown that reliance upon speed zone signing alone is not an effective method of reducing travel speeds in work zones. This should be recognized during the design of the project. The following are some guidelines for determining speed limits in detours, transitions, and median crossovers:

- Detours and crossovers should be designed for speeds equal to the existing speed limit if at all possible. Speed reductions should not be more than 10 mph below the limit of the entering roadway.
- Where a speed reduction greater than 10 mph is unavoidable, the transition to the lower limit should be made in steps of not more than 10 mph.
- Where severe speed reductions are necessary, police or flaggers may be used in addition to advance signing. The conditions requiring the reduced speed should be alleviated as soon as possible.

8. Transitional Areas from Construction Zones to Sections of Older Roadways

Transitional areas from construction zones to sections of older highways should be carefully designed and located so that the driver can adjust to the reduced standards or changed conditions. It should be recognized that these transitional areas may remain in place for a period of time until the adjacent section of roadway is improved. The following factors should be considered when designing, constructing, and operating these transitional areas:

- Provide adequate sight distance and geometrics consistent with the roadway having the higher design speed.

- If channelizing devices other than portable barriers are used, they should be lightweight or yielding.

- Sign supports should be yielding or breakaway. Pavement markings should be used to provide a well defined path.

- Transitional areas should be kept clear of unnecessary hazards.

9. Pavement Drop-offs

Highway agencies have varying opinions as to which depth of pavement drop-off needs some type of treatment. They also have varying opinions as to the type of treatment that should be used. A research project is underway that may provide guidance as to where and what type of devices to use for drop-offs of different depths with varying roadway conditions.

Drop-offs should be kept to a minimum in frequency, duration, and depth. When they are inevitable, good judgment should be used to determine the treatment that will be employed. The following items should be considered when developing a TCP for a project that will have pavement drop-off conditions:

- Where possible, the contract should limit the amount of difference in elevation between adjacent lanes.

- The time that a difference in elevation will be allowed should be limited.

- Signs can be used to advise motorists of the drop-off condition.

- A fillet or wedge of gravel or paving material can be placed as shown in Figure 7 (page 56).

- Where excessive drop-offs are necessary it may be possible to close the adjacent lane with appropriate channelizing devices. If the adjacent lane cannot be closed, it may be necessary to install longitudinal roadside barriers such as guardrail or portable concrete barrier.

C. Function of Devices

Traffic control devices include signs, signals, lighting units, pavement markings, delineators, channelizing units, hand signaling signs or flags, and portable barriers which are used to warn, guide, or regulate traffic. This section discusses elements of design, proper application, and placement for various devices used. Table 4 notes how several devices may be attached to other devices and supports.

The examples of devices portrayed in this Handbook are those commonly used. They follow the MUTCD standards in dimension, copy size, and message. Alternates that are available are given in the MUTCD.

1. Signs

Typical signs that are available are shown in Part VII of the Ohio MUTCD. They are classified as regulatory, warning, and guide signs.

Regulatory Signs

Regulatory signs impose legal restrictions and may not be used without permission from the authority having jurisdiction over the roadway.

- *Design* - Regulatory signs are typically rectangular in shape with the long dimensions vertical. The standard color scheme is black lettering on a white background. A red circle with a diagonal slash may be used in conjunction with a black diagram to indicate a prohibited maneuver.

- *Exceptions* - Red is used as a predominant color for STOP, YIELD, DO NOT ENTER and WRONG WAY signs. Unique shapes and color schemes increase the target value for these important signs.

Warning Signs

Warning signs are used to give notice of conditions that are potentially hazardous to traffic. They should be used when such conditions are real, particularly

SIGNS AND DEVICES THAT MAY BE MOUNTED ON OR USED IN COMBINATION WITH OTHER DEVICES

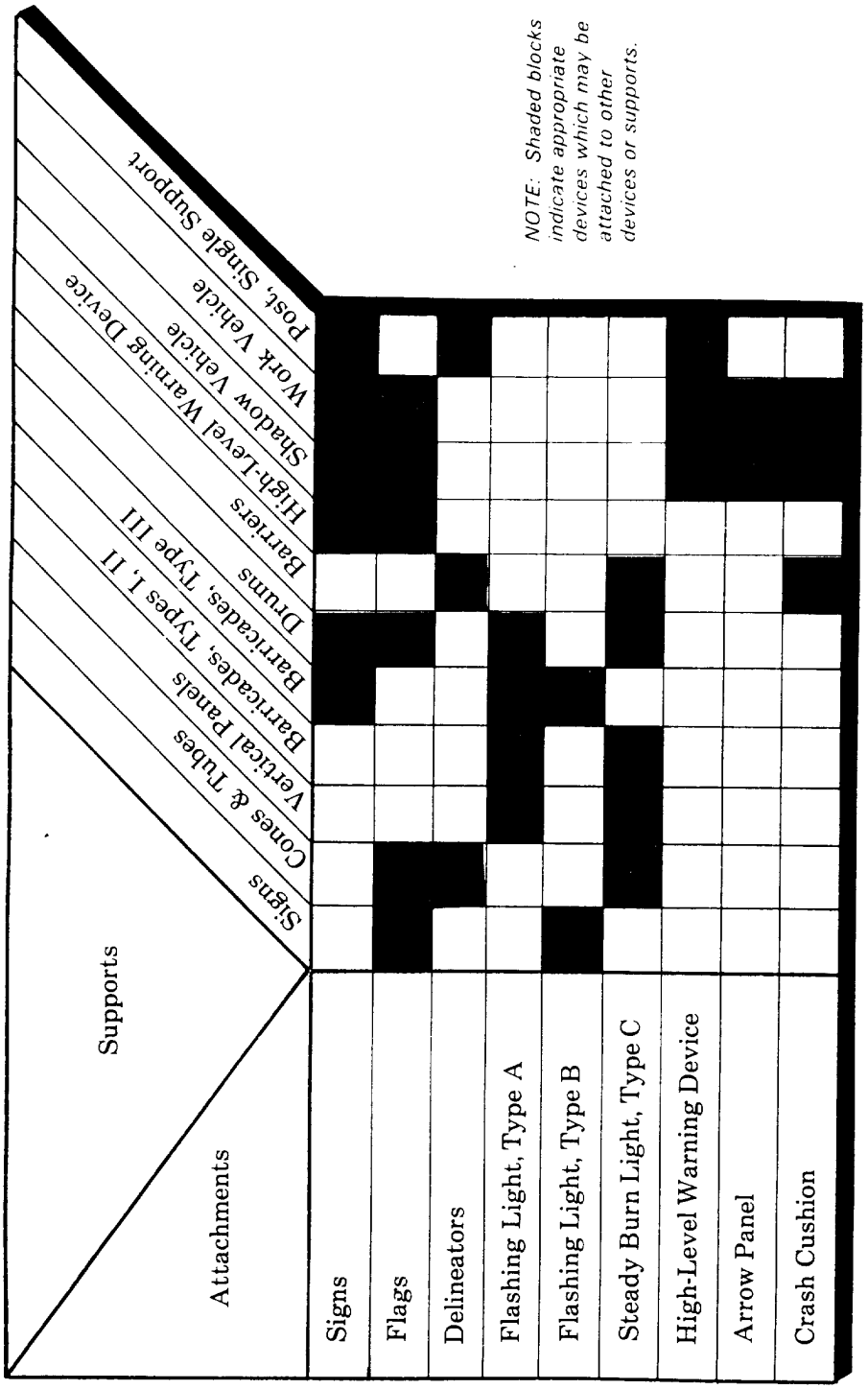


TABLE 4

when the danger is not obvious or cannot be seen by the motorist. They should not be overused or they will lose their attention-getting value. Likewise, they should not overwarn or be overly restrictive or they will lose credibility with motorists.

- *Design* - Warning signs are typically diamond-shaped with one diagonal vertical. Permanent warning signs have a black legend on a yellow background. Construction and maintenance warning signs are a special series with the black legend on an orange background. The orange color is used to indicate the temporary nature of the condition and the additional potential hazard of the work site. Traditionally, work activities have include construction, maintenance, and utility operations. However, orange colored warning signs may have application for all work activities within the right-of-way such as survey crews (other than for C & M projects) or temporary weighing stations.

- *Exceptions* - Two warning signs have unique shapes which make them easily distinguishable:

  - The railroad crossing warning sign is round with a yellow background only; and

  - The NO PASSING ZONE sign is pennant shaped.

The TURN OFF 2-WAY RADIO and END BLASTING ZONE zone warning signs are rectangular with their long dimension horizontal to better accommodate the message.

The Large Arrow sign, because of its shape, is placed on a rectangular background with the long dimension horizontal.

Mounting considerations for large warning signs on freeways and expressways may justify a change to the rectangular shape; however, such variances should have prior approval of the appropriate highway authority.

- *Placement* - Warning signs should be placed sufficiently in advance of the condition for which warning is given to permit the motorist time to understand the information and make any required response. Exceptions to this principle include the Large Arrow and the TWO WAY TRAFFIC signs.

Guide Signs (Informational Signs)

Guide signs show destinations, directions, distances, services, points of interest and other geographical or cultural information. They may be used if their placement does not distract from the more important regulatory and warning signs.

Informational signs are required at work zones as follows:

- Standard route markings, to the extent that temporary route changes are necessary.

- Directional signs and street name signs, when used with detour routing, may have a black legend on an orange background.

- Special information signs relating to the work being done shall have a black message on an orange background. Typical examples are:
  ROAD CONSTRUCTION NEXT 5 MILES,
  END CONSTRUCTION,
  DETOUR, and
  PILOT CAR FOLLOW ME.

Choosing Signs

Standard signs and messages, as shown in the MUTCD, should be used. Drivers are familiar with those signs and know how to react. Nonstandard sign messages may be confusing. All signs should be made in a quality sign shop or purchased from a reputable business. "Homemade" signs are immediately suspect and do not command any driver respect.

When choosing signs, the following should be considered:

- Choose signs that are appropriate; signs that accurately describe the work situation.

- Choose the message on signs according to what action the driver needs to take. Use larger signs when greater visibility is desired,as with high speed or volume. Avoid messages having only a local meaning since it may not be clear to strangers.

- Start with a common sign at the beginning of the work area. Then use signs with more specific messages, with the most specific sign stating what action should be taken closest to the work area. Drivers sometimes forget what they are told so the last sign in the advance warning area should tell them specifically what to look for or expect, such as a flagger or a one-lane road.

- The message "AHEAD," or an appropriate distance, is used on the warning signs. Use the end of the advance warning area as the point for deciding on the measurement on warning signs. For example, ROAD WORK 1 MILE means that the advance warning area ends in one mile and the transition or work area starts.

- The overall effect of the signs should be to make the driver aware of what he is approaching and what action may be required.

The warning area length for moving operations will vary according to geometrics and sight distance.

Sign Spacing

Where a series of advance warning signs are used, the warning sign nearest the work site should be approximately 500 feet from the point of restriction with additional signs at 500-1000 foot intervals.

A "rule-of-thumb" for the spacing between signs in a series is:

- 250 feet for urban, residential or business districts, or with speeds under 40 m.p.h.;

- 500 feet for urban arterials and rural roads, or with speeds over 40 m.p.h.; and

- 1,000 feet for expressways and freeways.

Other Considerations

The location of the advance warning area may need to be adjusted when special problems are encountered. Typical situations include:

- Urban distance restrictions can be imposed by the length of city blocks; additional advance warning may be necessary due to "extra" intersections created by alleys, shopping centers, and side streets.

- Rural, open highway: there is a need for greater warning distances and larger signs.

- Divided roadways and one-way streets with two or more lanes in one direction: signing on both sides of the roadway should be considered if a median is available. Existing overhead sign structures may be used for warning signs.

- Signs should be high enough to be seen over parked cars or traffic.

- Signs should not block the view of vehicles entering the area from gas stations, restaurants, cross roads, etc.

- All signs should be carefully placed for best visibility. Existing signs which are not needed during the work activity should be removed or covered.

Speed zone signing, either advisory or regulatory, is usually not an effective way to control traffic. Posting severely reduced speed limits that cannot be enforced is particularly ineffective. The need for speed reduction must be obvious to drivers. Drivers will slow down only if they see that they need to.

If traffic is heavy and becomes backed up, additional warning signs should be placed in advance of the backup.

A drive-through check, both day and night, should be made periodically to determine if signs have been properly spaced to allow adequate driver response time. Project personnel are normally quite familiar with the project. They should try to look at the work area as through the eyes of a stranger.

Sign Supports

Signs may be attached to posts or portable supports. Fixed sign supports should be used on long-term projects. Portable supports are more practical for short-term projects or changing activities such as flagging.

Lightweight, yielding or breakaway supports should be used for all sign installations. Construction zone sign supports should meet the breakaway requirements for permanent installations. To avoid glare from headlights, signs may be tilted back and slightly away from the roadway.

Figure 2, page 38, shows the minimum height requirements for signs attached to posts. Signs on portable supports are required by the MUTCD to be at least 1 foot above the roadway (Figure 3, page 39). Sign locations and mounting heights may be adjusted above the minimum requirements to obtain good visibility.

Single sign supports are usually adequate for signs up to 36 x 36 in. Larger signs normally require two supports to preclude twisting and turning of the assembly caused by wind or air movement resulting from trucks passing close to the sign.

Signs at Night

All signs used at night are required by the MUTCD to be reflectorized or illuminated.

- *Reflectorized* signs should be checked periodically for proper reflectivity and cleanliness. One method is to drive through the work zone at night using low-beam headlights. Another method is for the inspector to use a piece of reflectorized sign material, (inspector's guide) which has been predetermined by the agency to be of minimum acceptable quality for reflectivity. Place the inspector's guide on the sign to be inspected. Step back about 30 feet, view the sign and inspector's guide with a flashlight held close to the eye. If the inspector's guide is brighter than the sign, the sign should be cleaned and/or replaced.

  Experience has shown that beads on paint are not effective for reflectorizing signs or channelizing devices. The beads are easily worn off and they do not reflect when the surface is wet. Reflectorized sheeting having a

HEIGHT AND LATERAL LOCATIONS OF SIGNS: TYPICAL INSTALLATION

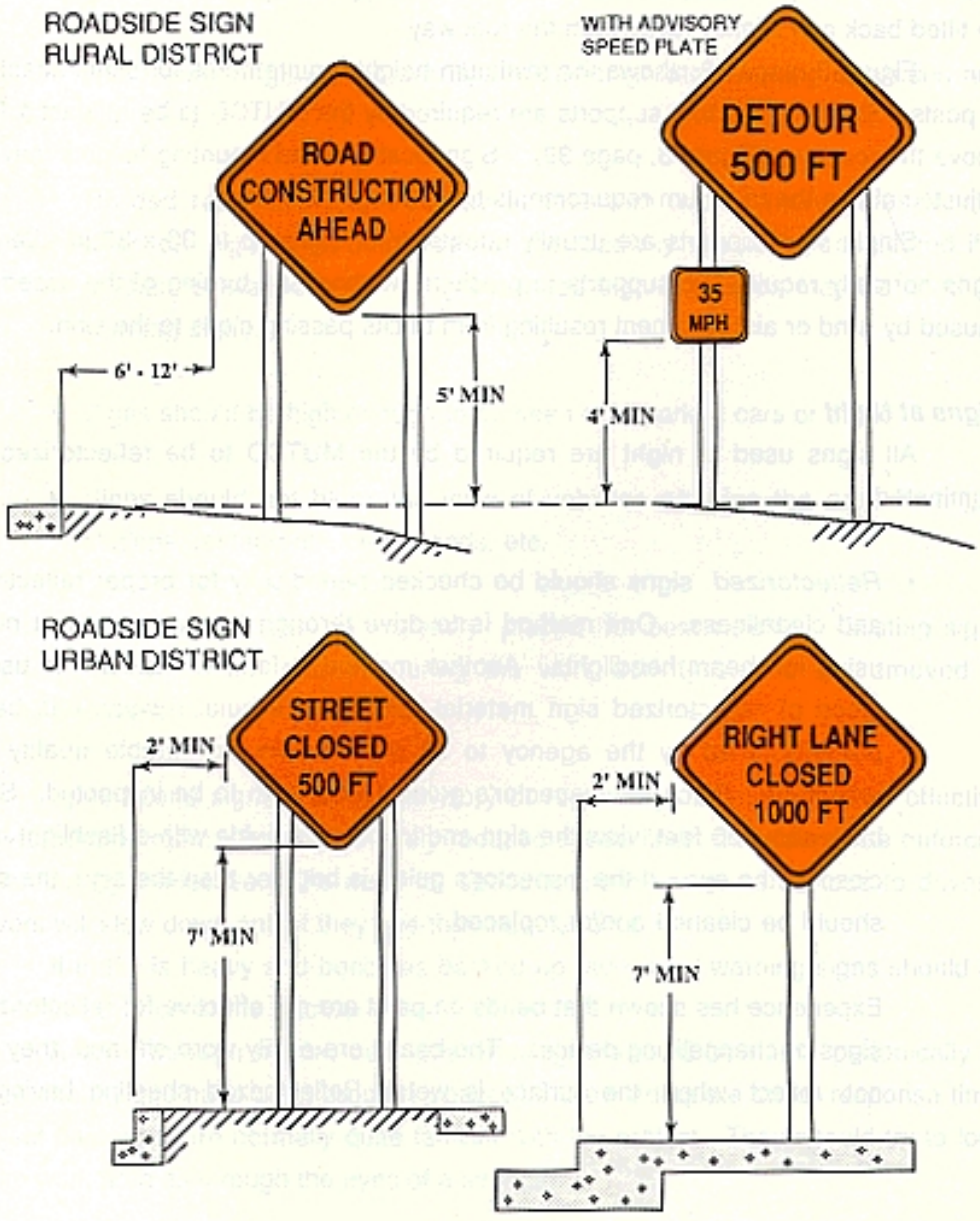


Figure 2

METHODS OF MOUNTING SIGNS OTHER THAN ON POSTS

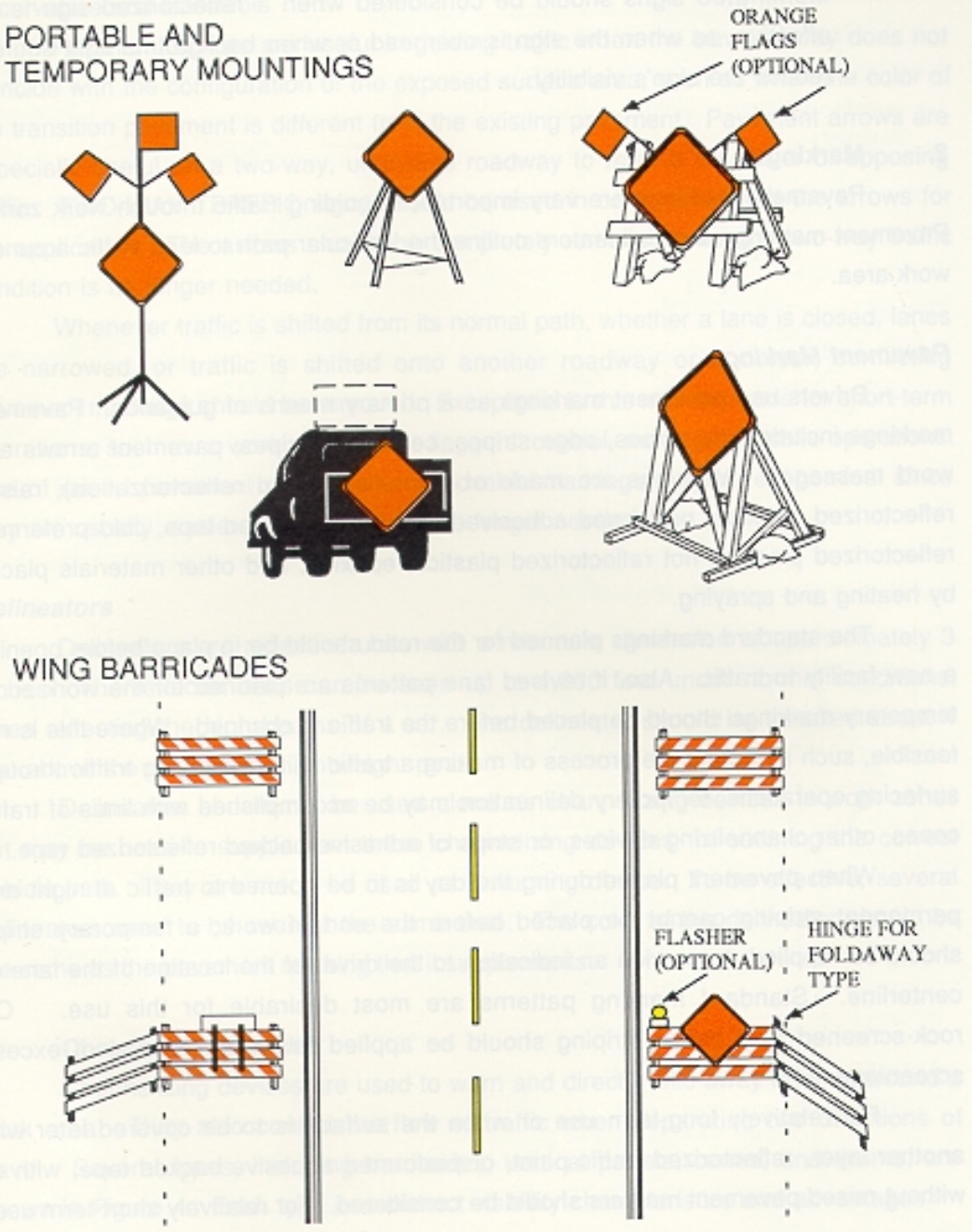


Figure 3

smooth, sealed outer surface should be used for signs and other traffic control devices. Reflectorized material should meet the agency's specifications for new material.

- *Illuminated* signs should be considered when a reflectorized sign is not effective, as when the sign is overhead or when background light sources reduce the sign's visibility.

2. Markings

Pavement markings are very important in guiding traffic through work zones. Pavement markings and delineators outline the vehicular path to lead traffic around a work area.

Pavement Markings

Drivers use pavement markings as a primary means of guidance. Pavement markings include lane stripes, edge stripes, centerline stripes, pavement arrows and word messages. Markings are made of paint (with bead reflectorization), raised reflectorized markers, preformed adhesive-backed reflectorized tape, cold preformed reflectorized plastics, hot reflectorized plastics, epoxies, and other materials placed by heating and spraying.

The standard markings planned for the road should be in place before opening a new facility to traffic. Also, if revised lane patterns are planned for the work zone, temporary markings should be placed before the traffic is changed. Where this is not feasible, such as during the process of making a traffic shift or carrying traffic through surfacing operations, temporary delineation may be accomplished with lines of traffic cones, other channelizing devices, or strips of adhesive-backed reflectorized tape.

When pavement placed during the day is to be opened to traffic at night and permanent striping cannot be placed before the end of work, a temporary stripe should be applied to provide an indication to the driver of the location of the lane or centerline. Standard marking patterns are most desirable for this use. On rock-screened seal coats, striping should be applied following removal of excess screenings.

For relatively long-term use or when the surface is to be covered later with another layer, reflectorized traffic paint, or preformed adhesive-backed tape, with or without raised pavement markers should be considered. For relatively short-term use,

smooth, sealed outer surface should be used for signs and other traffic control devices. Reflectorized material should meet the agency's specifications for new material.

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For relatively long-term use or when the surface is to be covered later with another layer, reflectorized traffic paint, or preformed adhesive-backed tape, with or without raised pavement markers should be considered. For relatively short-term use,

and when frequent shifts are to be made, adhesive-backed reflectorized tape is useful. Raised pavement markers may be used to form the pavement markings or may be used to supplement marked stripes. High speeds and volumes of traffic may justify raised markers for even comparatively short periods. They are particularly valuable at points of curvature and transition.

Pavement arrows are useful in guiding traffic when the traveled way does not coincide with the configuration of the exposed surface area, such as when the color of the transition pavement is different from the existing pavement. Pavement arrows are especially useful on a two-way, undivided roadway to remind the driver of opposing traffic. TWO-WAY TRAFFIC signs should be used in conjunction with the arrows for the application. The arrows should be completely removed once the two-way traffic condition is no longer needed.

Whenever traffic is shifted from its normal path, whether a lane is closed, lanes are narrowed, or traffic is shifted onto another roadway or a detour, conflicting pavement markings should be removed. Exceptions to this may be made for short-term operations, such as a work zone under flaggers' control, moving or mobile operations. Use of raised pavement markings or removable markings may be economical since they are usually easier to remove when no longer needed.

Delineators

Delineators are reflective units with a minimum dimension of approximately 3 inches. The reflector units can be seen up to 1,000 feet under normal conditions, when reflecting the high beams of a car. The delineator should be installed about 4 feet above the roadway on lightweight posts.

Delineators should not be used alone as channelizing devices in work zones but may be used to supplement these channelizing devices in outlining the correct vehicle path. They are not to be used as a warning device. To be effective, several delineators need to be seen at the same time. The color of the delineator should be the same as the pavement marking that it supplements.

3. Channelizing Devices

Channelizing devices are used to warn and direct traffic away from or around a work area. They also control the flow of traffic when separating two directions of travel. Several types, including barricades, vertical panels, cones, and drums, are shown in Figure 4. Each type has distinct visibility characteristics and advantages.

The MUTCD requires that channelizing devices to be used at night shall be reflectorized with a material having a smooth, sealed outer surface. This includes commercially available reflectorized sheeting and tape strips. All channelizing devices should be a lesser hazard, if struck by an errant vehicle, than the hazard marked.

Some devices require a weight, such as a sand bag, because they are easily knocked or blown over. These weights should be placed at the bottom of the device for stability and to keep the weight from being thrown as a result of collision. Neither the device nor the weight should cause excessive damage when struck by a vehicle. Also, sand bags should not be placed in a way that will limit the motorist's view of the device.

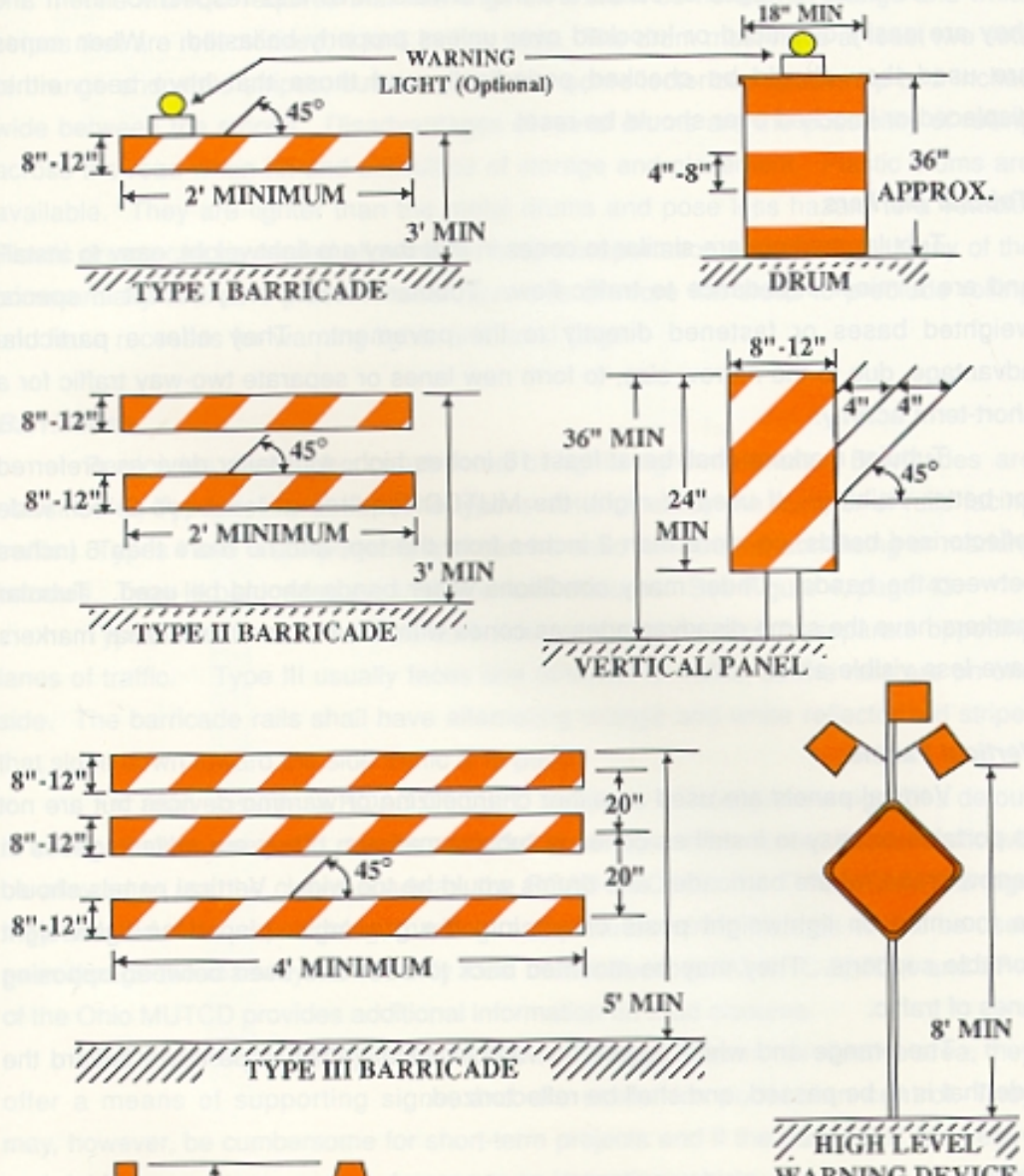
Cones

Cones are lightweight channelizing devices that may be stacked for storage, are easy to place and remove, and are a minor impedance to traffic flow. For stability, a rubber or sand collar or specially weighted base may be added. Cones cause little or no damage when hit. They shall be at least 18 inches high, but taller cones should be used on freeways and other roadways where speeds are relatively high, or wherever more conspicuous guidance is needed. Taller cones (up to 36 inches high) have good daytime visibility.

Cones can be made more effective by:

- Using fluorescent colors (daytime);
- Adding flags (daytime);
- Supplementing with other devices, such as a high-level warning device (daytime);
- Supplementing with flashing arrow panels when lane closures are involved (day and night); and
- Using wider reflectorized bands (night).

CHANNELIZING DEVICES AND HIGH LEVEL WARNING DEVICES



NOTE:
Flashing or steady burn warning lights should be used on barricades, panels, and drums as needed.

Figure 4

If used at night, the MUTCD requires that they be reflectorized with a 6-inch wide reflectorized band, no more than 3 inches from the top, or that they be equipped with a lighting device.

The disadvantages of cones are that drivers have less respect for them and they are easily displaced or knocked over unless properly ballasted. When cones are used they should be checked periodically and those that have been either displaced or knocked over should be reset.

Tubular Markers

Tubular markers are similar to cones in that they are lightweight, easy to install, and are a minor impedance to traffic flow. Tubular markers may be set in special weighted bases or fastened directly to the pavement. They offer a particular advantage, due to the narrow size, to form new lanes or separate two-way traffic for a short-term activity.

Tubular markers shall be at least 18 inches high, with taller devices preferred for better visibility. If used at night, the MUTCD requires at least two 3-inch wide reflectorized bands, no more than 2 inches from the top, and no more than 6 inches between the bands. Under many conditions wider bands should be used. Tubular markers have the same disadvantages as cones with the addition that tubular markers have less visible area.

Vertical Panels

Vertical panels are used as either channelizing or warning devices but are not as portable or easy to install as cones or tubular markers. They are advantageous in narrow areas, where barricades and drums would be too wide. Vertical panels should be mounted on lightweight posts driven into the ground or placed on lightweight portable supports. They may be mounted back to back and used between opposing lanes of traffic.

The orange and white stripes on vertical panels shall slope down toward the side that is to be passed, and shall be reflectorized.

Drums

Drums are used as either channelizing or warning devices. These devices may be highly visible, give the appearance of being formidable objects and, therefore, command the respect of drivers. Due to their size and weight, metal drums are usually limited to longer-term work operations. For stability, a small

amount of sand may be placed in the drum. Where the potential for freezing exists, drain holes should be made in the bottom to permit draining to lessen the hazard if struck by a vehicle.

The MUTCD requires that markings on a drum be horizontal orange and white stripes that are reflectorized, 4 to 8 inches wide. The drum must have at least two sets of orange and white stripes, but can also have nonreflectorized spaces up to 2 inches wide between the stripes. Disadvantages of metal drums are the possibility of rolling across the road when hit and difficulties of storage and placement. Plastic drums are available. They are lighter than the metal drums and pose less hazard to a vehicle. Plastic drums can be nested allowing for easy transportation and storage. Many of the commercially available plastic drums have one or more flat sides to preclude rolling and have recesses for warning lights and sand bags.

Barricades

Barricades should be constructed of lightweight materials. Barricades are classified as Types I, II and III. (The type is determined by the number of rails facing traffic.) Types I and II are portable and can be used for either channelizing or marking hazards. Type III barricades are used for road closures. See Figure 4, page 43.

Types I and II have rails on both sides and may be used to separate opposing lanes of traffic. Type III usually faces one direction of traffic, so the rails are on one side. The barricade rails shall have alternating orange and white reflectorized stripes that slope down toward the side traffic is to pass.

For road closures, a ROAD CLOSED sign, and a Detour Arrow sign, (if a detour is used), shall be used and may be mounted on a Type III barricade. If local traffic will be allowed to use the closed roadway, the ROAD CLOSED TO THRU TRAFFIC sign may be used. Adequate signing, marking, and protection from hazards should be used even though the roadway carries only local traffic. Sections 7C-4, /C-5, 7D-4 and 7F-4 of the Ohio MUTCD provides additional information on road closures.

Barricades may be highly visible due to the large amount of reflective area, they offer a means of supporting signs, and are useful for pedestrian control. They may, however, be cumbersome for short-term projects and if the barricades are heavy and rigid, may cause excessive damage to an impacting vehicle.

Barriers

The terms barrier and barricade are frequently confused. A barricade, as discussed above, is an item that provides a visual indication of a hazardous location or of the desired path a motorist should take. On the other hand, a barrier provides a physical limitation through which a vehicle would not normally pass.

There are four primary functions of barriers:

- Keep traffic from entering a work area or from hitting an exposed object or excavation.
- Provide positive protection for workers.
- Separate two-way traffic.
- Protect construction such as false work for bridges.

Portable roadside barriers are usually made of concrete or metal. They are designed to contain and redirect an errant vehicle. An example is shown in Figure 5. Portable concrete barriers may be precast sections with built-in connecting devices. The connecting devices must be strong enough to insure that the individual elements act as a smooth continuous barrier. For some applications it may be necessary to anchor the concrete barrier to prevent lateral movement if hit by a vehicle. This can be accomplished with drift pins or anchor bolts placed in holes drilled in the pavement or bridge structure.

Barriers may serve the additional function of channelizing traffic. When used as channelizing devices, barriers should be light in color for increased visibility. Delineators or steady-burn warning lights may be attached to the barrier for channelization. A solid edge line may be placed on the pavement adjacent to the barrier.

The need for barriers should be based on an engineering analysis. Portable concrete barriers are designed to minimize damage when they are hit. When a barrier is used in a lane closing situation, the barrier should be preceded with channelizing devices placed along a standard lane closing taper (Figure 12, page 65).

EXAMPLES OF THREE TYPES OF BARRIERS

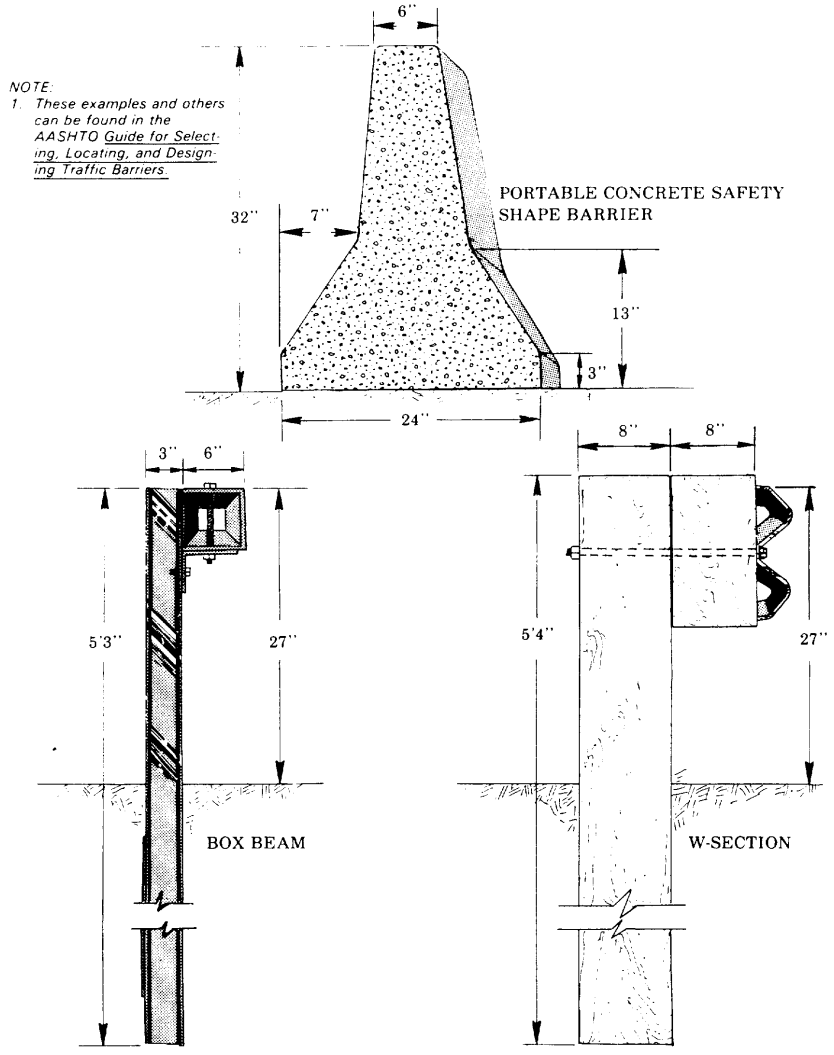


Figure 5

On construction projects, particular attention is needed for connecting portable or temporary barriers to adjacent existing barriers or guardrails. The construction plans should provide details for this. All connections should develop the full strength of the barrier system(s). Also, proper transitions must be used. For additional information see the Guide for Selecting, Locating and Designing Traffic Barriers (List of References #3).

Exposed ends of barriers should have crash cushions to protect traffic. Another way to protect traffic is to flare the ends away from the roadway by extending the barrier beyond the clear roadside recovery area (Figure 12, page 65).

High-Level Warning Devices

High-level warning devices are tall, portable stands with flags and/or flashing lights that are visible above traffic and parked cars. They have three flags, 16-inch square or larger, at least 8 feet above the roadway (Figure 4, page 43).

The devices may be used with flags only, may have a sign or flashing light attached, or may be attached to vehicles used in moving or mobile work operations.

4. Lighting Devices

Warning Lights

Most of the warning lights in use are portable, lens directed, enclosed units and may be used on channelizing devices, barriers, and signs. Detailed discussions on the use and operating requirements of warning lights are contained in Section 7G-6 of the Ohio MUTCD.

The principal types and uses of warning lights are:

- Flashing lights, Type A, are appropriate for use on a channelizing device to warn of an isolated hazard at night or to call attention to warning signs at night;

- High intensity lights, Type B, are appropriate to use on advance warning lights day and night; and

- Steady-burn lights, Type C, are appropriate for use on a series of channelizing devices or on barriers which either form the taper to close a lane or shoulder or keep a section of lane or shoulder closed, and are also appropriate on the channelizing device alongside the work area at night (see Figure 1, page 12).

Warning lights should be secured to the channelizing device or sign in such a way that they will not separate from the channelizing device or sign if impacted by a vehicle. Warning lights that come loose during an accident may become dangerous flying objects.

Flashing Vehicle Lights

Work vehicles in or near the traffic areas are hazards and should be equipped with flashing lights. The vehicle warning lights may be emergency flashers, flashing, strobe, or rotating beacons. High intensity lights are effective both day and night. The laws of the agency having jurisdiction over the street or highway should be be checked concerning requirements for flashing vehicle lights.

These lights should be used in addition to other channelizing and warning devices. However, in some emergency situations, where the work will be in progress for a short time, these lights may be the only warning device.

Flashing Arrow Panels

Arrow panels are signs with a matrix of lights capable of either flashing or sequential displays. Flashing arrow panels are effective day and night, for moving traffic out of a lane to the left, to the right, and may be used for tapered lane closures and moving operations.

These are two types of arrow panels, flashing and sequencing. Flashing arrow panels have three basic operating modes:

- left arrow,
- right arrow, and
- caution mode (four or more lamps arranged in a pattern which does not indicate a direction).

Sequencing arrow panels have several arrowheads that flash in a series, directing traffic to the right or left.

The minimum sizes for arrow panels are shown in Table 5. The flash rate should be between 25 and 40 flashes per minute. The minimum lamp "on time" should be 50 percent for the flashing arrow and 25 percent for the sequential chevron.

ARROW PANEL SIZE AND DIMENSIONS

Type	Minimum Number Minimum Size	Minimum Legibility of Panel Lamps	Distance
A	24" x 48"	12	1/2 mile
B	30" x 54"	13	3/4 mile
C	48" x 96"	15	1 mile

TABLE 5

The flashing or sequencing arrow modes should NOT BE USED under the following conditions:

- When the location of work does not require any lanes to be closed.
- When all of the work is on or outside the shoulder and there is no interference which requires the adjacent traveled lane to be closed.
- When the flagger is controlling traffic on a normal two-lane, two-way road.

Use of the arrow modes under the above conditions will lead to the loss of credibility when the arrow mode is used for lane closures or moving operations.

The caution modes may be used for stationary or moving work operations on or outside of the shoulder. The caution mode may be used in addition to other devices such as signs, channelizing devices, or flashing vehicle lights.

As large arrow panels can be seen from a mile away, they are especially effective in high-volume or high-speed areas and on the work or shadow vehicle for moving operations. For day and night use, arrow panels should be equipped with both an automatic and manual dimming device capable of 50 percent dimming. Flashing arrow panels that are used at night should be checked to insure that the device is properly dimmed; otherwise, motorists may be temporarily blinded. Circular hoods are recommended around each of the lenses to prevent side distraction at night. For more information, see Section 7G-8 of the Ohio MUTCD.

Hazard Identification Beacons

Flashing hazard identification beacons are used in work areas both day and night to alert drivers of a critical point in the highway, such as a truck crossing, and have the same meaning as permanently mounted beacons. Flashing beacons are not used for channelization. Flashing beacons with a yellow lens that is a minimum of 8 inches in diameter are brighter than flashing warning lights, Types A and B. See Sections 7G-3 and 7G-5 of the Ohio MUTCD for additional information.

Floodlights

Floodlights are used to light work activities, flagger stations and other restricted or hazardous areas at night when area lighting is not sufficient. Floodlights should be positioned or shielded to prevent glare to the drivers. The increased visibility provided by floodlighting may enable the driver to see distracting portions of the work area. In this case, steady-burning warning lights mounted on channelizing devices may be advisable. Floodlighting the work area cannot be considered as illuminating signs or devices. Each illuminated sign or device should have its own light source.

During the planning and design of a street improvement project, consideration may be given to specifying that proposed street lighting be completed as one of the earlier stages during construction. Consideration should also be given for providing temporary luminaires at certain locations such as the work activity, certain crossroads, and transitions.

5. Shadow Vehicles

Moving operations, such as lane striping or sweeping, need traffic controls that move with work operations. Shadow vehicles may be used to assist traffic control for moving operations. Signs and other warning devices may be placed

on the work vehicle (depending on the type of work) or the shadow vehicle, or both. Need for a shadow vehicle depends on the speed of traffic compared to the speed of the work vehicle, exposure to traffic of workers and the type of work activity. Portable crash cushions can be attached to the shadow vehicle to protect motorists and workers from a collision. Signs, flags, flashing lights, or arrow panels may be attached to shadow vehicles to warn traffic. Arrow panels may be used on multi-lane highways but should not be used on a two-lane, two-way road.

6. Flagging Procedures

Flagging should only be employed when required to control traffic or when all other methods of traffic control are inadequate to warn and direct drivers.

The procedures for flagging traffic are contained in Sections 7H-2 through 7H-8 of the Ohio MUTCD. Those procedures were developed over a period of time and are workable. The standard signals to be used by flaggers are illustrated in Figure 6. In addition, Figures 13, 14 and 15 (pages 66, 68, and 69) show the proper positioning of the flagger. It should be noted that the figures show the use of channelizing devices to form a lane closure behind the flagger.

Flagger Training

Attention should be given to the proper instruction of all personnel who are flaggers, starting with the basics of flagging. New flaggers should have a special introductory training session and all flaggers need periodic reminders as well as close supervision.

Flaggers need to know the correct ways to stop, slow down, or keep traffic moving. They should also know how to be courteous to the public, to explain delays or to help motorists. Some agencies give the flagger a pocket instruction card that shows the proper methods for controlling traffic.

Flagger Guidelines

Since flaggers are responsible for the safety of traffic and workers, their job is important. They can promote good public relations because they have close public contact. The image they project is often responsible for the public's attitude toward the entire work operation.

USE OF HAND SIGNALING DEVICES BY FLAGGER

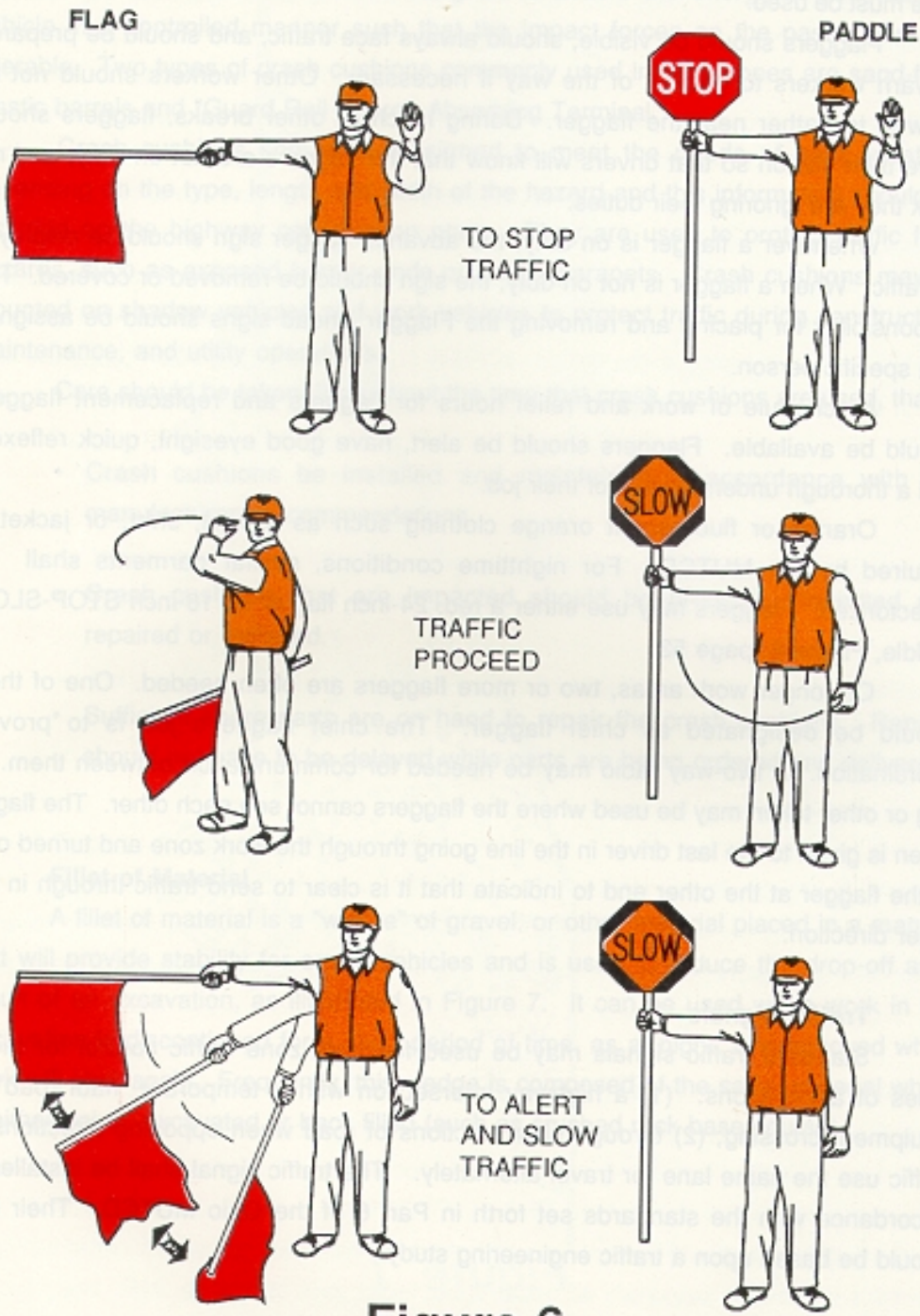


Figure 6

For short work areas where both ends can be seen at the same time one flagger may suffice. Both directions of traffic must be able to see the flagger and to recognize the person as a flagger. If this is not possible with one flagger, then two or more must be used.

Flaggers should be visible, should always face traffic, and should be prepared to warn workers to get out of the way if necessary. Other workers should not be allowed to gather near the flagger. During lunch or other breaks, flaggers should leave their station so that drivers will know that the flaggers are not on duty, and not think they are ignoring their duties.

Whenever a flagger is on duty, the advance flagger sign should be displayed to traffic. When a flagger is not on duty, the sign should be removed or covered. The responsibility for placing and removing the Flagger Ahead signs should be assigned to a specific person.

A schedule of work and relief hours for flaggers and replacement flaggers should be available. Flaggers should be alert, have good eyesight, quick reflexes, and a thorough understanding of their job.

Orange or fluorescent orange clothing such as a vest, shirt, or jacket is required by the MUTCD. For nighttime conditions, similar garments shall be reflectorized. Flaggers may use either a red, 24-inch flag or an 18-inch STOP-SLOW paddle, Figure 6, page 53.

On longer work areas, two or more flaggers are often needed. One of them should be designated as chief flagger. The chief flagger's job is to provide coordination. A two-way radio may be needed for communication between them. A flag or other token may be used where the flaggers cannot see each other. The flag or token is given to the last driver in the line going through the work zone and turned over to the flagger at the other end to indicate that it is clear to send traffic through in the other direction.

7. Traffic Signals

Standard traffic signals may be used for work zone traffic control for these types of applications: (1) a highway intersection with a temporary "haul road" or equipment crossing; (2) through short sections of road when opposing directions of traffic use the same lane for travel alternately. The traffic signal shall be installed in accordance with the standards set forth in Part 6 of the Ohio MUTCD. Their use should be based upon a traffic engineering study.

8. Miscellaneous

Crash Cushions

Crash cushions are devices designed to absorb the energy of an impacting vehicle in a controlled manner such that the impact forces on the passengers are tolerable. Two types of crash cushions commonly used in work zones are sand-filled plastic barrels and "Guard Rail Energy Absorbing Terminal."

Crash cushions should be designed to meet the needs of each location, depending on the type, length and width of the hazard and this information should be included on the highway construction plans. They are used to protect traffic from hazards, such as exposed barrier ends or bridge parapets. Crash cushions may be mounted on shadow vehicles and work vehicles to protect traffic during construction, maintenance, and utility operations.

Care should be taken, throughout the time that crash cushions are used, that:

- Crash cushions be installed and maintained in accordance with the manufacturers' recommendations.

- Crash cushions that are impacted should be promptly inspected and repaired or replaced.

- Sufficient spare parts are on hand to repair the crash cushions. Repairs should not have to be delayed while parts are being ordered and delivered.

9. Fillet of Material

A fillet of material is a "wedge" of gravel, or other material placed in a manner that will provide stability for errant vehicles and is used to reduce the drop-off as a result of an excavation, as illustrated in Figure 7. It can be used when work in the excavation is discontinued for a short period of time, as at night, and removed when work will start again. Frequently, this wedge is composed of the same material which is either being excavated or back filled (such as crushed rock base course).

CROSS SECTION VIEW OF A MATERIAL FILLET

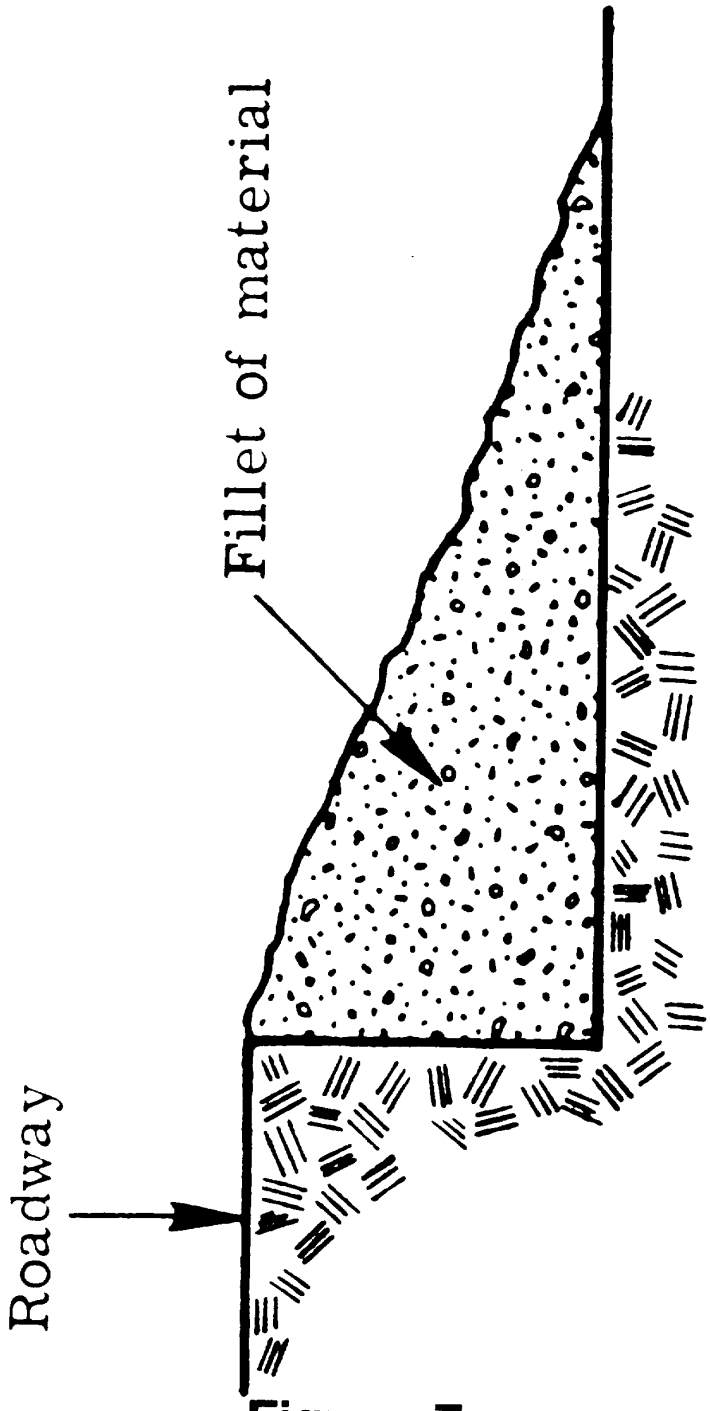


Figure 7

10. Variable Message Signs

Portable variable message sign devices capable of displaying various messages to the motorist will sometimes facilitate construction zone signing. These devices are normally trailer or truck mounted and have their own power system. As they are expensive to buy and operate variable message signs are normally used for the more complex traffic control plans.

Messages, or series of messages, can be preprogrammed into the device or can be added with an additional memory device. Some variable message signs can be programed in the field. Display panels may have one, two, or three lines of copy.

When using a variable message sign care should be taken to insure that the message is clear. A lengthy message may distract the motorist from his driving task for too long a time. The sequencing of the words in a message can also cause problems. For example, RIGHT LANE CLOSED MERGE would get a different driver response than LANE CLOSED MERGE RIGHT. Yet, the messages are similar except for the beginning point.

Variable message signs are especially useful in the following situations:

- When different messages are needed during the day due to changing work operations.
- For upstream traffic diversion when instructions vary with traffic conditions.
- For emergency conditions.

D. Typical Applications (Layouts)

Each traffic control zone is different, with variables such as speed, volume, location of work, pedestrians, and intersections changing the needs for each location. The goal of a traffic control zone is safety, and the key factor in making the control zone work is the application of proper judgment. The examples in this chapter are guides showing how to apply the standards.

Typical applications include the use of various traffic control methods, although they do not include a layout for every conceivable work situation. Typical applications may be altered to fit the conditions of a particular work area.

The layouts in the MUTCD and this Handbook represent minimum requirements. Other devices may be added to supplement the devices shown in the layout, and sign spacings and taper lengths can be increased to provide additional

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The layouts in the MUTCD and this Handbook represent minimum requirements. Other devices may be added to supplement the devices shown in the layout, and sign spacings and taper lengths can be increased to provide additional

time or space for driver response. When difficult situations or potentially hazardous conditions are encountered, typical designs may be modified to a higher-type treatment as indicated by the following:

- Additional devices
  - additional signs
  - flashing arrow panels
  - more channelizing devices
  - high-level warning devices

- Upgrading of devices
  - improved pavement markings
  - larger signs
  - higher-type channelizing devices
  - barriers in place of channelizing devices
  - variable message signs

- Improved geometrics at detours or crossovers

- Increased distances
  - longer advance warning area
  - longer tapers

- Lighting
  - steady-burn lights for channelization
  - flashing lights for isolated hazards
  - illuminated signs
  - floodlights

Five of the typical applications used in this Handbook are taken from the Ohio MUTCD. On five of the typical applications, the existing pavement markings have been either marked or changed to indicate those that should be changed for long-term projects. If the project is short-term, such as 1-day maintenance operations, the

pavement markings may not need to be removed and replaced although guidance should be provided with channelizing devices to insure that drivers don't follow the permanent markings.

Table 1 (page 13) shows the typical traffic control devices needed for various work zones. It indicates how traffic control increases as work approaches the traveled lane and as conflict with traffic increases. Some of the less complicated work zones are not illustrated. The typical traffic control devices for such zones are given in Table 1, page 13.

1. Work Entirely Beyond Shoulder or Parking Lane

Traffic control depends primarily on devices such as advance warning signs, flashing vehicle lights, and flags. An advance warning sign should be used when any of the following conditions occur:

- Work will be performed immediately adjacent to the roadway at certain stages of the activity,
- Equipment may be moved along or across the highway, and
- Motorists may be distracted by the work activity.

A typical sign for this situation could be MOWING AHEAD. If the equipment travels on or crosses the roadway, it should be equipped with appropriate flags, flashing lights and/or a Slow Moving Vehicle symbol.

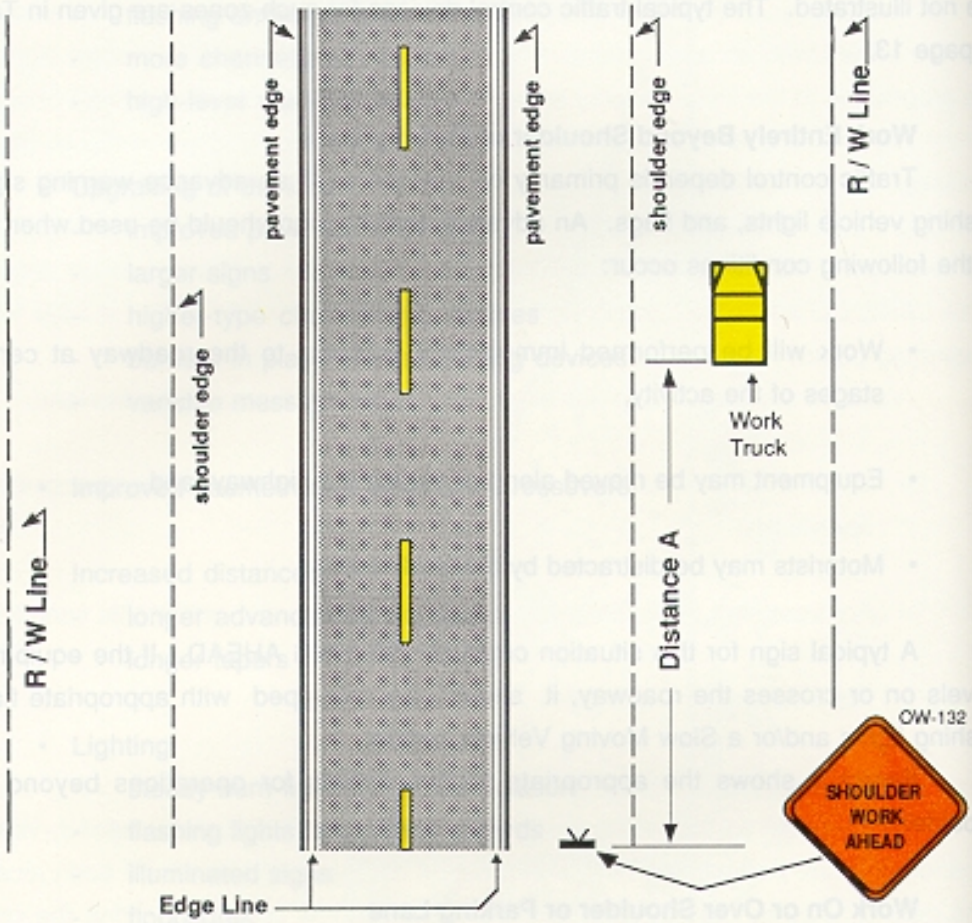
Figure 8 shows the appropriate traffic controls for operations beyond the shoulder.

2. Work On or Over Shoulder or Parking Lane

No Encroachment in Traveled Lane

There is no direct interference with traffic. When the shoulder is occupied or closed, the motorist should be advised and the workers should be protected. Usually, the single warning sign SHOULDER WORK is adequate. Refer to Figures 9 and 10 for typical applications for stationary and moving shoulder operations.

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR OPERATIONS BEYOND THE SHOULDER



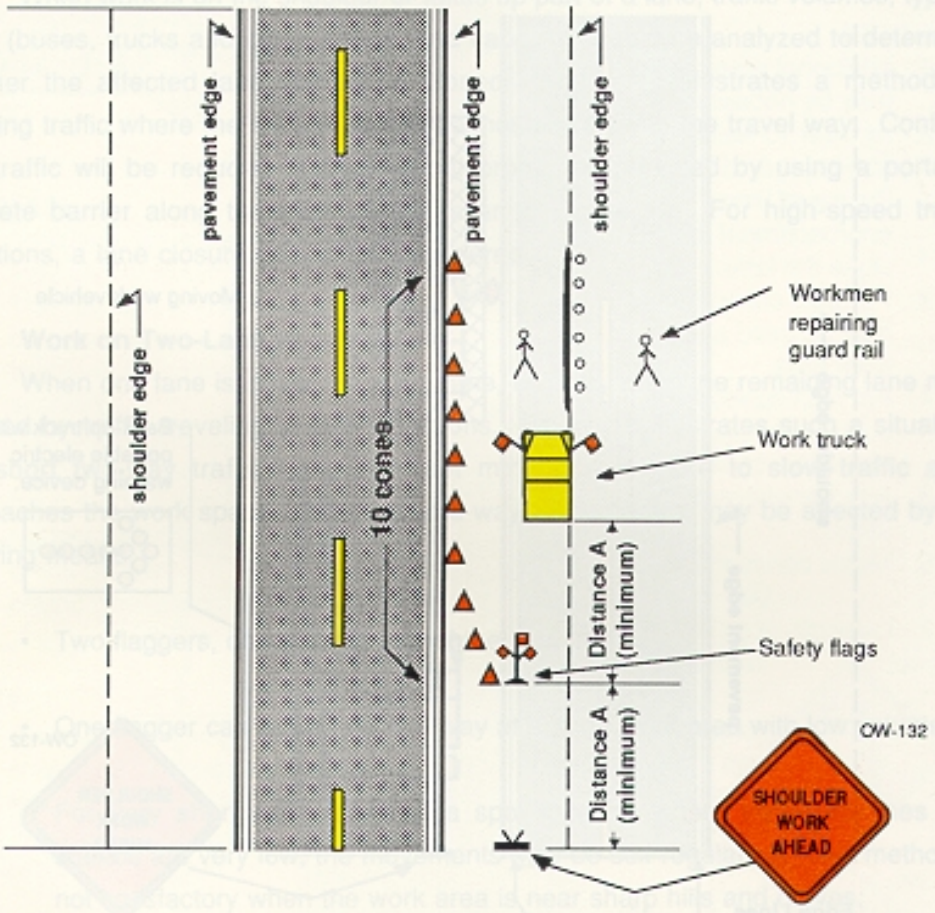
NOTES:

1. Erect signs only on that side of the road where work is being done.
2. Erect signs facing both directions for work in the median area.

TYPE OF ROADWAY	DISTANCE A - feet
Urban	200
Standard	500
Expressway	1500

Figure 8

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR STATIONARY OPERATIONS ON THE SHOULDER



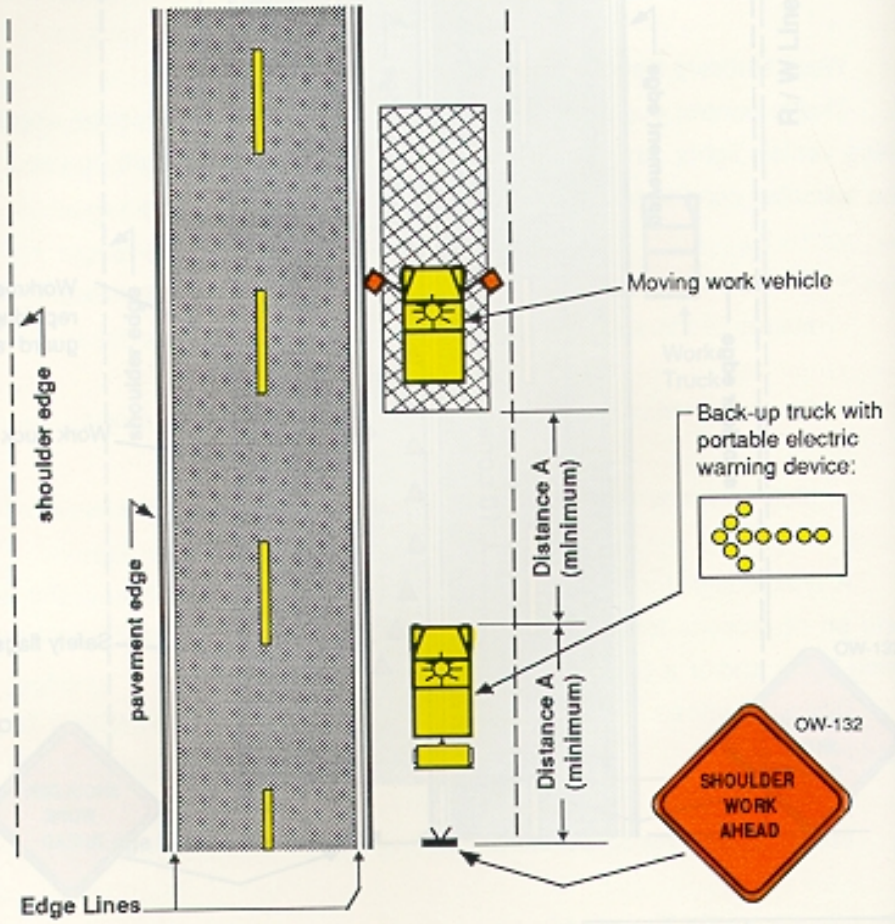
NOTES:

1. Space the cones at 50' maximum.
2. For work within the median, install the same cones and signs for both directions of travel.

TYPE OF ROADWAY	DISTANCE A - ft.
Urban	200
Standard	500
Expressway	750

Figure 9

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR MOVING OPERATIONS ON THE SHOULDER



NOTE:
1. For work within the median, use the same treatment for both directions of travel.

TYPE OF ROADWAY	DISTANCE A - feet
Urban	200
Standard	500
Expressway	750

Figure 10

When an improved shoulder is closed on a high-speed roadway, it should be treated as a closure of a portion of the road system, since the motorist expects to be able to use it in an emergency. The work area on the shoulder should be closed off by a taper for channelizing devices. However, flashing arrow panels should not be used, except in the caution mode.

Minor Encroachment in Traveled Lane

When work is on the shoulder or takes up part of a lane, traffic volumes, type of traffic (buses, trucks and cars), speed, and capacity should be analyzed to determine whether the affected lane should be closed. Figure 11 illustrates a method for handling traffic where the work area encroaches slightly into the travel way. Conflicts with traffic will be reduced and additional protection provided by using a portable concrete barrier along the work area similar to Figure 12. For high-speed traffic conditions, a lane closure should be considered.

3. Work on Two-Lane Roadway

When one lane is closed on a two-lane, two-way road, the remaining lane must be used by traffic traveling in both directions. Figure 13 illustrates such a situation. The short two-way traffic taper (50 feet minimum) is used to slow traffic as it approaches the work space. Alternate one-way traffic control may be affected by the following means:

- Two flaggers, one at each end of the work area;
- One flagger can assign right-of-way at a short work area with low volumes;
- For very short work areas at a spot location where traffic volumes and speeds are very low, the movements may be self-regulating. This method is not satisfactory when the work area is near sharp hills and curves;
- A pilot car; and
- Temporary traffic signals for long-duration projects.

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- A pilot car; and
- Temporary traffic signals for long-duration projects.

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR A MINOR ENCROACHMENT ONTO TRAFFIC LANE ON URBAN STREETS

NOTES:

1. Additional advance warning may be necessary.
2. At least 10 feet on urban streets should remain in the travel lane. If a greater encroachment is needed, close the lane.
3. Portable concrete barrier may be used along the work area.
4. For high speed traffic conditions, a lane closure should be considered.
5. A buffer space may be used.
6. Metric conversion: 500 ft.=150 m.
7. L=length of taper— refer to Table 2.

KEY: Pavement markings that should be removed for long term projects. Temporary markings to be placed as needed.

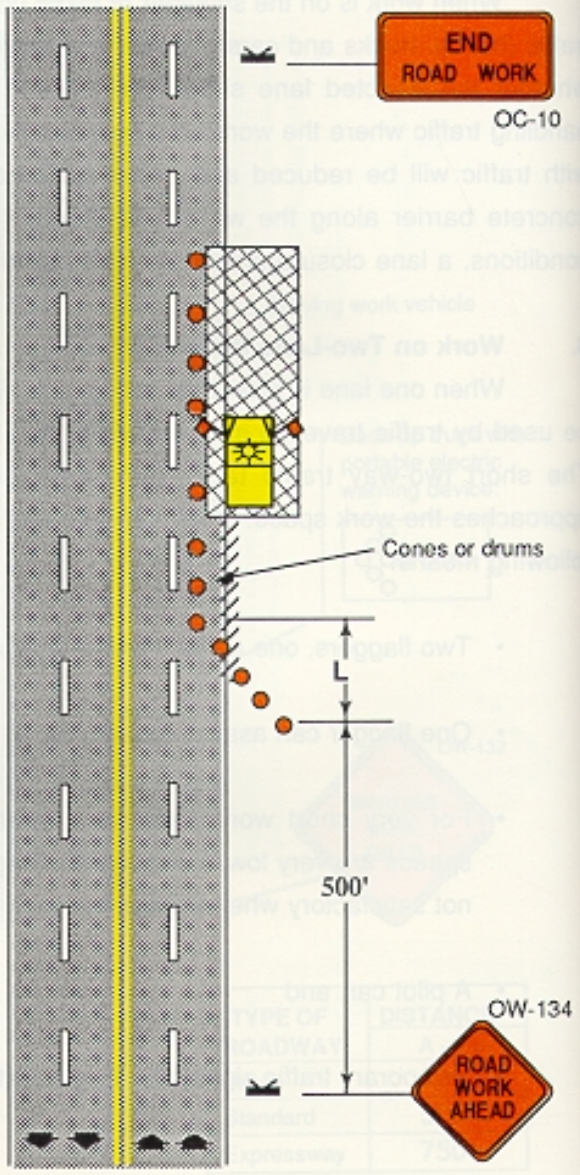
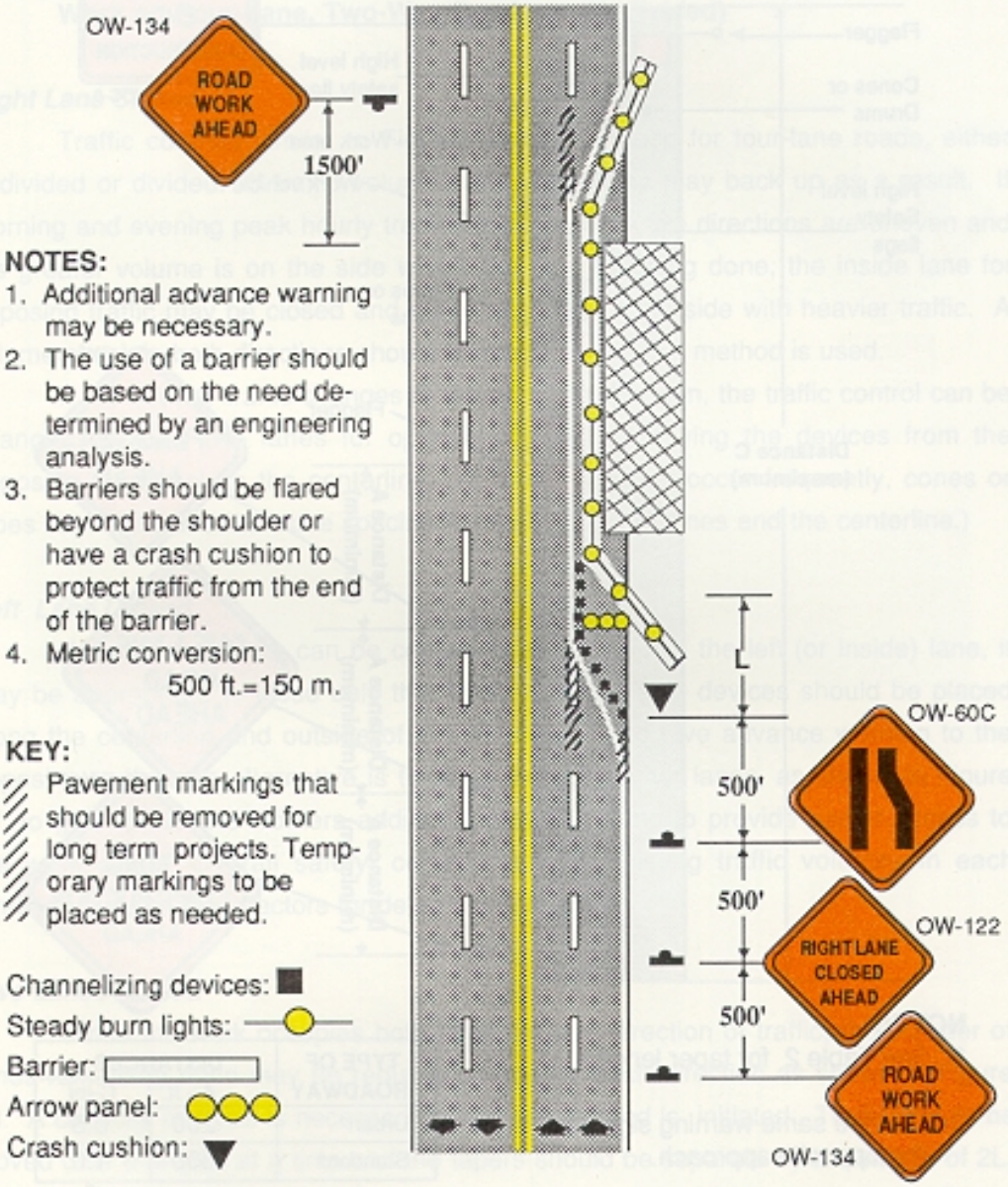


Figure 11

TYPICAL APPLICATION OF
TRAFFIC CONTROL DEVICES
FOR

USING A PORTABLE BARRIER AROUND A WORK AREA



NOTES:

1. Additional advance warning may be necessary.
2. The use of a barrier should be based on the need determined by an engineering analysis.
3. Barriers should be flared beyond the shoulder or have a crash cushion to protect traffic from the end of the barrier.
4. Metric conversion:
   500 ft.=150 m.

KEY:

Pavement markings that should be removed for long term projects. Temporary markings to be placed as needed.

Channelizing devices: ■

Steady burn lights: —●—

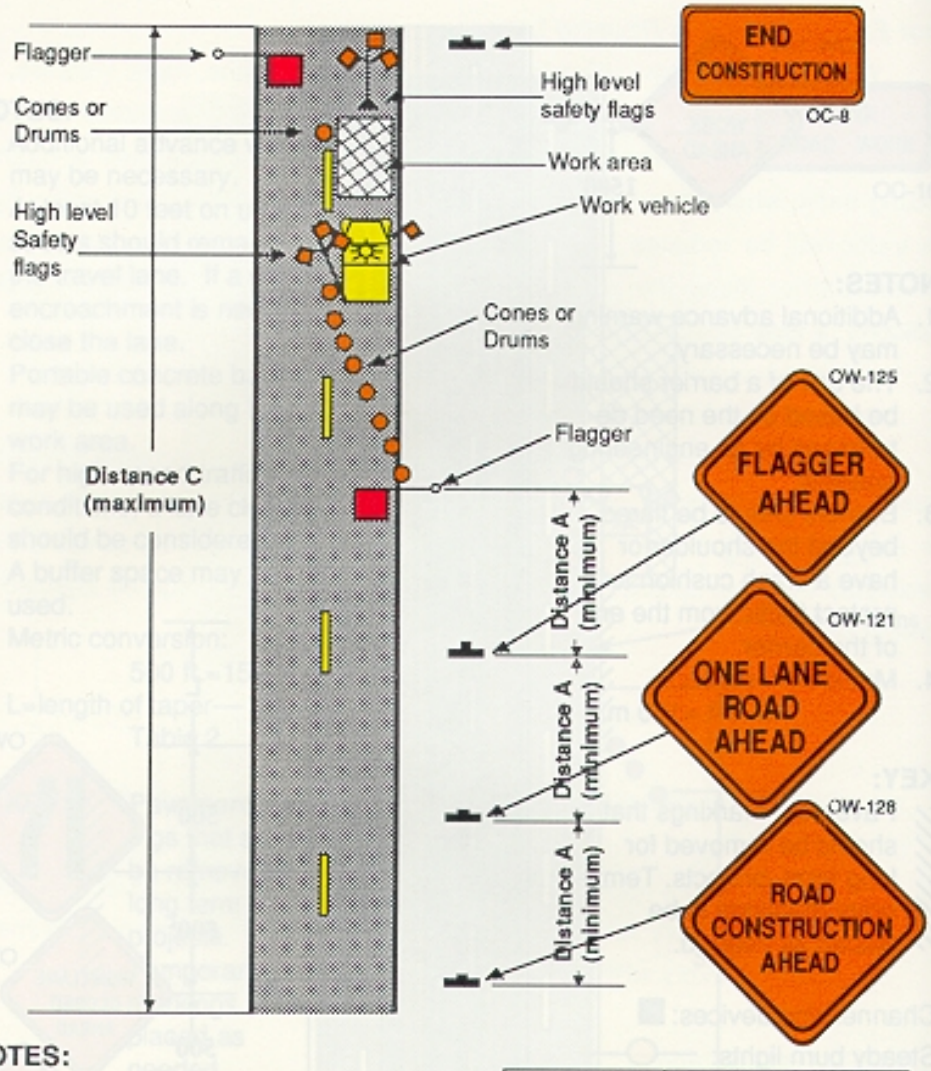
Barrier: ▭

Arrow panel: ●●●

Crash cushion: ▼

Figure 12

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR STATIONARY OPERATIONS IN ONE LANE



NOTES:

1. See Table 2 for taper lengths.
2. Use the same warning signs on the opposite approach.

TYPE OF ROADWAY	DISTANCES	
	A - ft.	C-mi
Urban	200	0.5
Standard	500	1.0

Figure 13

Curved Roadway and Hill

If the work area ends near the curve or hill, a flagger should be adjusted so that the flagger and the entire taper will be visible before the curve or hill for an adequate stopping sight distance. Figures 14 and 15 illustrate typical short-term flagging operations.

4. Work on Four-Lane, Two-Way Roadway (Undivided)

Right Lane Closed

Traffic controls similar to Figure 16 may be used for four-lane roads, either undivided or divided. If traffic volumes are high, traffic may back up as a result. If morning and evening peak hourly traffic volumes in the two directions are uneven and the greater volume is on the side where the work is being done, the inside lane for opposing traffic may be closed and made available to the side with heavier traffic. A volume check in both directions should be made before this method is used.

If the heavier traffic changes to the opposite direction, the traffic control can be changed to allow two lanes for opposing traffic by moving the devices from the opposing lane back to the centerline. (If these changes occur frequently, cones or tubes should be used at close spacing to emphasize lane lines and the centerline.)

Left Lane Closed

If the work activity can be contained entirely within the left (or inside) lane, it may be appropriate to close only that lane. Channelizing devices should be placed along the centerline and outside of the work activity to give advance warning to the opposing traffic. An alternative is to close the two center lanes, as shown in Figure 17, to give traffic and workers additional protection and to provide easier access to the work area. Overall safety, considered with existing traffic volumes in each direction, are the main factors for determining alternates.

Two Lanes Closed

When the work occupies both lanes for one direction of traffic, the number of lanes remaining open may be reduced to one for each direction as shown in Figure 18. A capacity analysis is necessary before this method is initiated. Traffic should be moved over one lane at a time and the tapers should be separate by a distance of 2L. When both center lanes are closed, traffic controls may be used as indicated in Figure 17.

TYPICAL APPLICATION:

DAYTIME MAINTENANCE OPERATIONS OF SHORT DURATION ON A TWO-LANE ROADWAY—FLAGGING IS PROVIDED

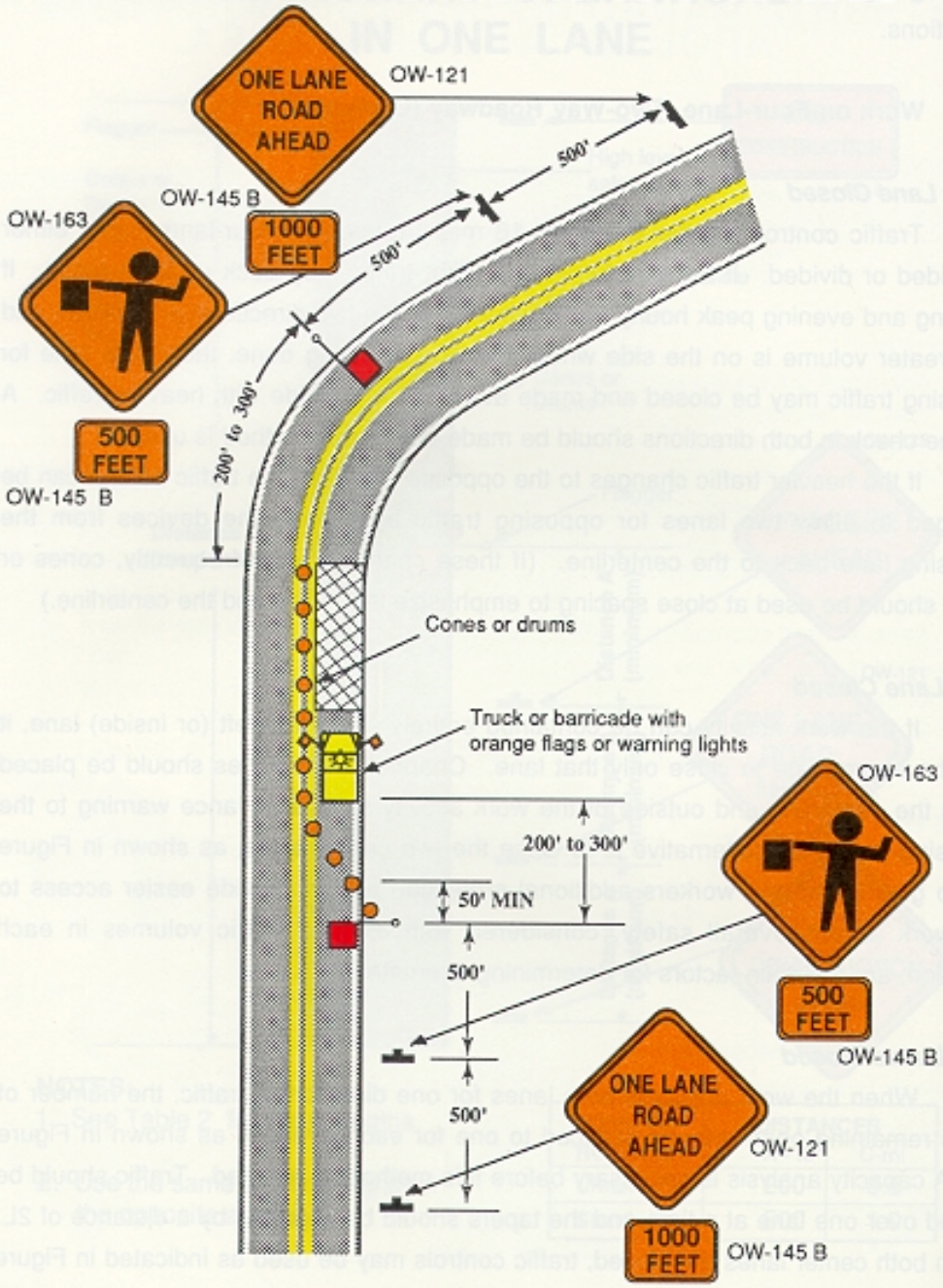
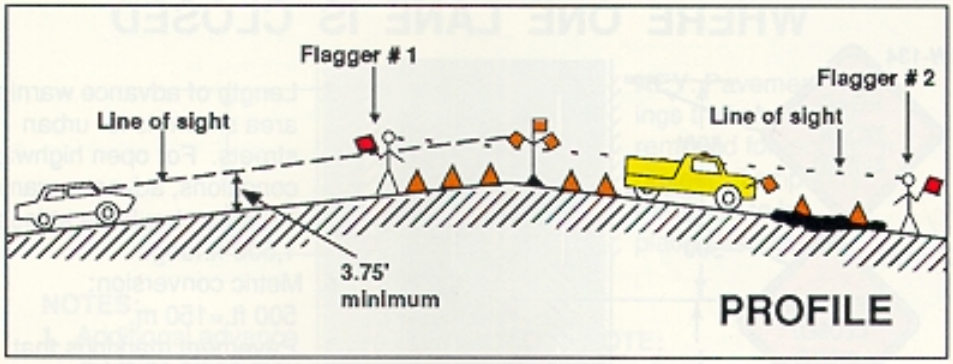
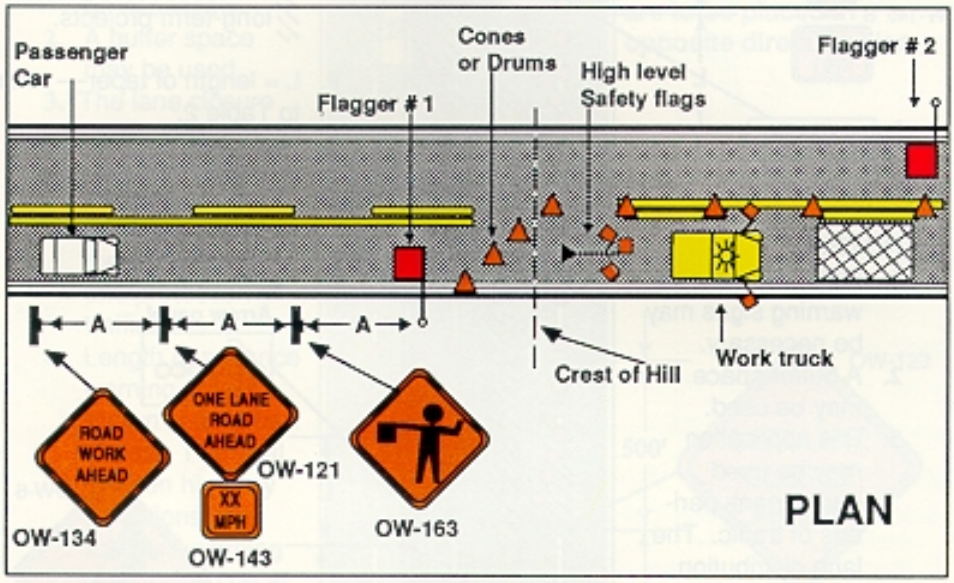


Figure 14

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR OPERATIONS NEAR THE CREST OF A HILL





A = 200' Urban
500' Std.

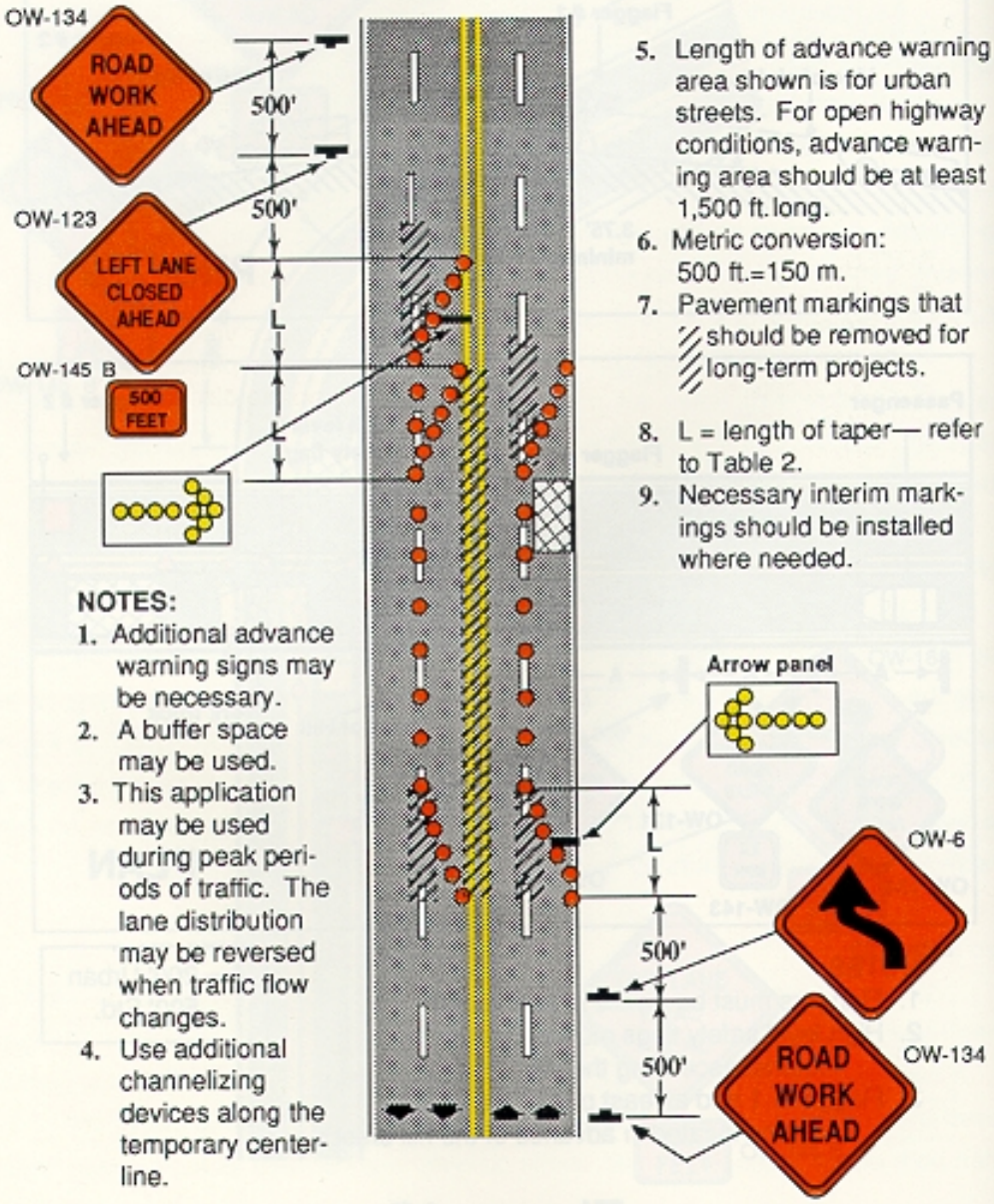
NOTES:

1. Flaggers must be visible to each other.
2. High level safety flags must be visible to motorist ascending the hill.
3. Flagger # 1 and at least part of the taper must be located in advance of the hill crest.

Figure 15

TYPICAL APPLICATION OF
TRAFFIC CONTROL DEVICES FOR

DAYTIME MAINTENANCE OPERATIONS OF SHORT DURATION ON A FOUR-LANE UNDIVIDED ROADWAY WHERE ONE LANE IS CLOSED



NOTES:

1. Additional advance warning signs may be necessary.
2. A buffer space may be used.
3. This application may be used during peak periods of traffic. The lane distribution may be reversed when traffic flow changes.
4. Use additional channelizing devices along the temporary centerline.
5. Length of advance warning area shown is for urban streets. For open highway conditions, advance warning area should be at least 1,500 ft. long.
6. Metric conversion: 500 ft.=150 m.
7. Pavement markings that should be removed for long-term projects.
8. L = length of taper— refer to Table 2.
9. Necessary interim markings should be installed where needed.

Figure 16

5. Work on a One-Way or Divided Roadway

One Lane Closed

An example of a right lane closure is shown in Figure 16 (page 70) for a four-lane divided roadway.

Two Lanes Closed on a Four-Lane Roadway

Two lanes of a multiple lane roadway can be closed by using two separate tapers and separating them by a distance of 2L where L is the minimum length of taper. The right lane is closed first, and after a distance of 2L, the taper closing the inside lane is begun. Careful analysis of roadway capacity should be made first. This type of closure is usually limited to non-peak hours of traffic.

Center Lane Closed on a Three-Lane Roadway

To close the center lane traffic must first be channelized out of the left lane (or right lane) and into the center lane. Then, traffic in the center lane can be directed around the work area by a second taper.

6. Mobile Operations

Mobile operations are work activities that make frequent short stops, up to a15-minute period, such as litter cleanup or pothole patching, and are similar to stationary operations. Warning signs, flashing vehicle lights, flags, and/or channelizing devices should be used.

Safety should not be compromised by using fewer devices simply because the operation will change its location frequently. Portable devices should be used. Flaggers may be used but caution must be taken so they are not exposed to unnecessary hazards. The control devices should be moved periodically to keep them near the work area. If mobile operations are in effect on a high speed travel lane, flashing arrow panels should be used.

7. Moving Operations

Moving operations are work activities where workers and equipment move along the road without stopping, usually at slow speeds. The advance warning area moves with the work area. Traffic should be directed to pass safely. Parking may be prohibited and work should be scheduled during off-peak hours. For some moving

operations, such as street sweeping, if volumes are light and sight distances are good, a well marked and signed vehicle may suffice. If volumes and/or speeds are higher, a shadow or backup vehicle equipped as a sign truck, preferably equipped with a flashing arrow panel, should follow the work vehicle. Where feasible, warning signs should be placed along the road and periodically moved as the work progresses. In addition, vehicles may be equipped with flags, flashing vehicle lights, and appropriate signs. See Figure 19 (page 75) for one example of using a shadow vehicle for a moving operation. Actual conditions may change the signs and devices needed.

8. Short-Term Utility Operations

Despite the shortness of "short-term"operations, certain traffic controls are necessary.

In urban areas, the work vehicle may be used for warning if it is equipped with flashing lights, rotating beacons, or flags.

Figures 20, 21, 22, and 23 are specifically included as typical applications for utility operations. Other typical applications may apply as well.

When entering or leaving a manhole, workers should always face oncoming traffic, so that they can get out of the way if necessary. Materials or equipment should be stored away from the manhole opening.

9. Urban Areas

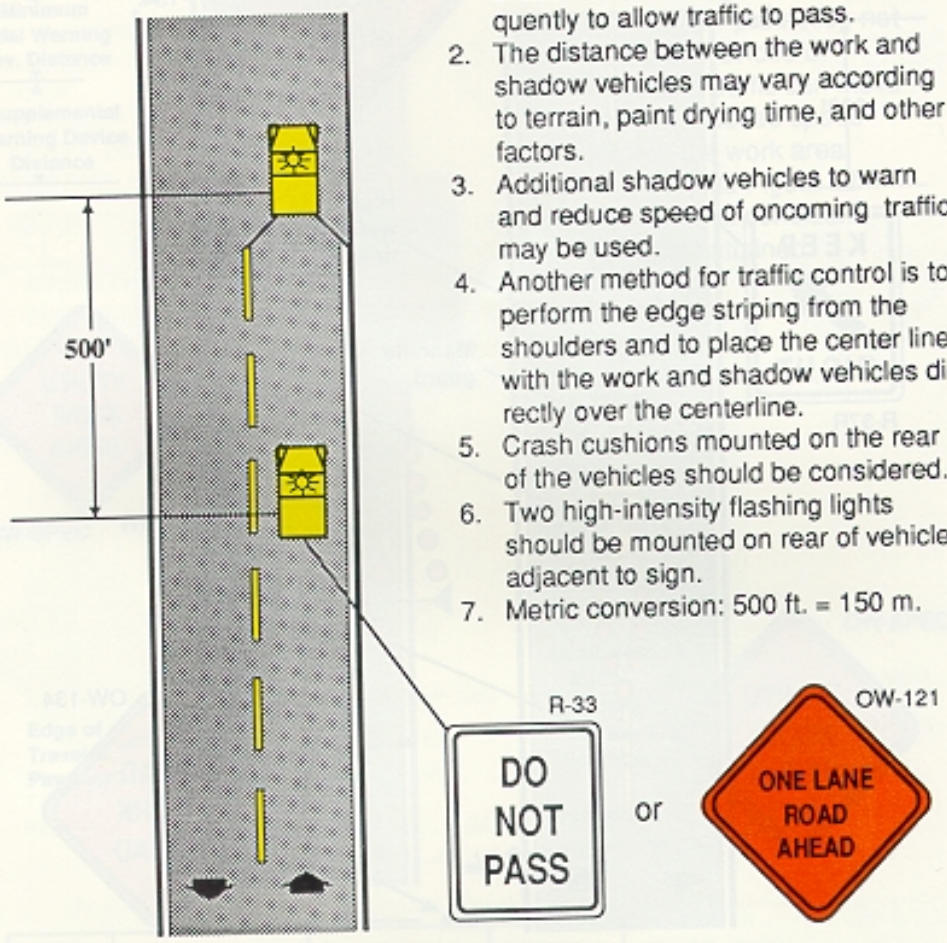
Urban traffic control zones may be subdivided into segments. Decisions must be reached as to how to control vehicular traffic; how many lanes are required; or whether any turns should be prohibited at intersections. Pedestrian traffic must be considered. If work will be done on the sidewalk, will it be necessary to close the sidewalk and assign the pedestrians to another path? (See Figure 24, page 80, for an example.) Next, decisions must be reached as to how to maintain access to business, industrial and residential areas. Even if the road is closed to vehicles, pedestrian access and walkways should be provided.

TYPICAL APPLICATION OF
TRAFFIC CONTROL DEVICES
FOR

USING A SHADOW VEHICLE FOR ADVANCE WARNING

NOTES:

1. With this type of control, the work and shadow vehicles should pull over frequently to allow traffic to pass.
2. The distance between the work and shadow vehicles may vary according to terrain, paint drying time, and other factors.
3. Additional shadow vehicles to warn and reduce speed of oncoming traffic may be used.
4. Another method for traffic control is to perform the edge striping from the shoulders and to place the center line with the work and shadow vehicles directly over the centerline.
5. Crash cushions mounted on the rear of the vehicles should be considered.
6. Two high-intensity flashing lights should be mounted on rear of vehicles adjacent to sign.
7. Metric conversion: 500 ft. = 150 m.

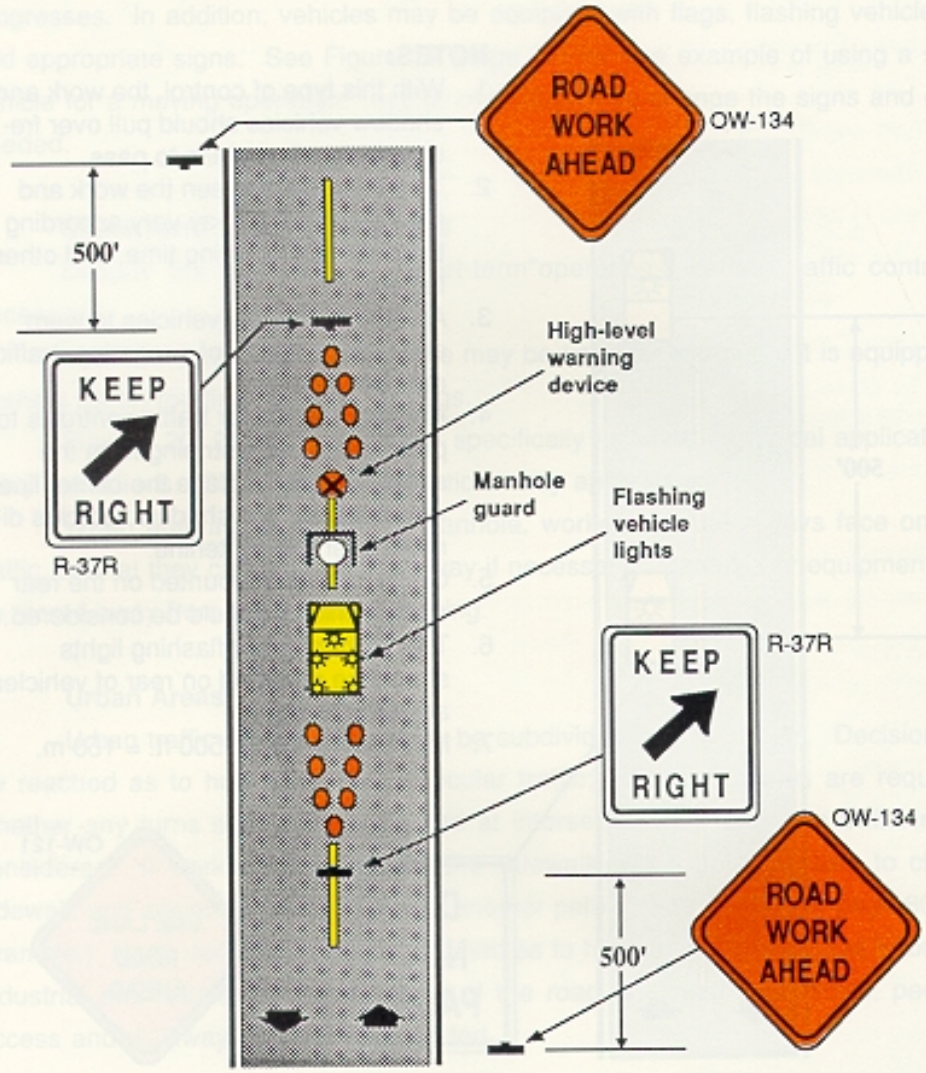


KEY: Flashing vehicle light

Figure 19

TYPICAL APPLICATION OF
TRAFFIC CONTROL DEVICES
FOR A

SHORT TERM UTILITY OPERATION IN AN URBAN LOCATION

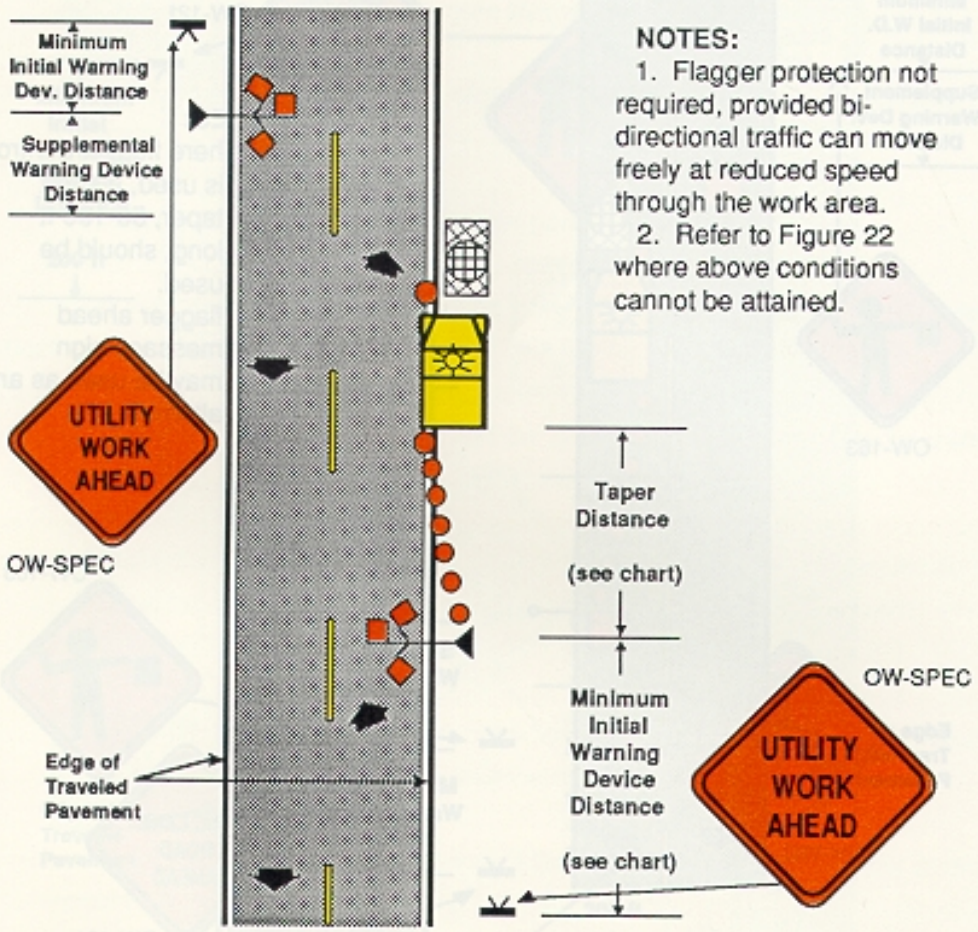


NOTES:

1. Additional advance warning may be used.
2. Metric conversion: 500 ft. = 150 m.

Figure 20

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR A UTILITY WORK ZONE ON A TWO-LANE ROADWAY WITH LOW TRAFFIC VOLUME



NOTES:

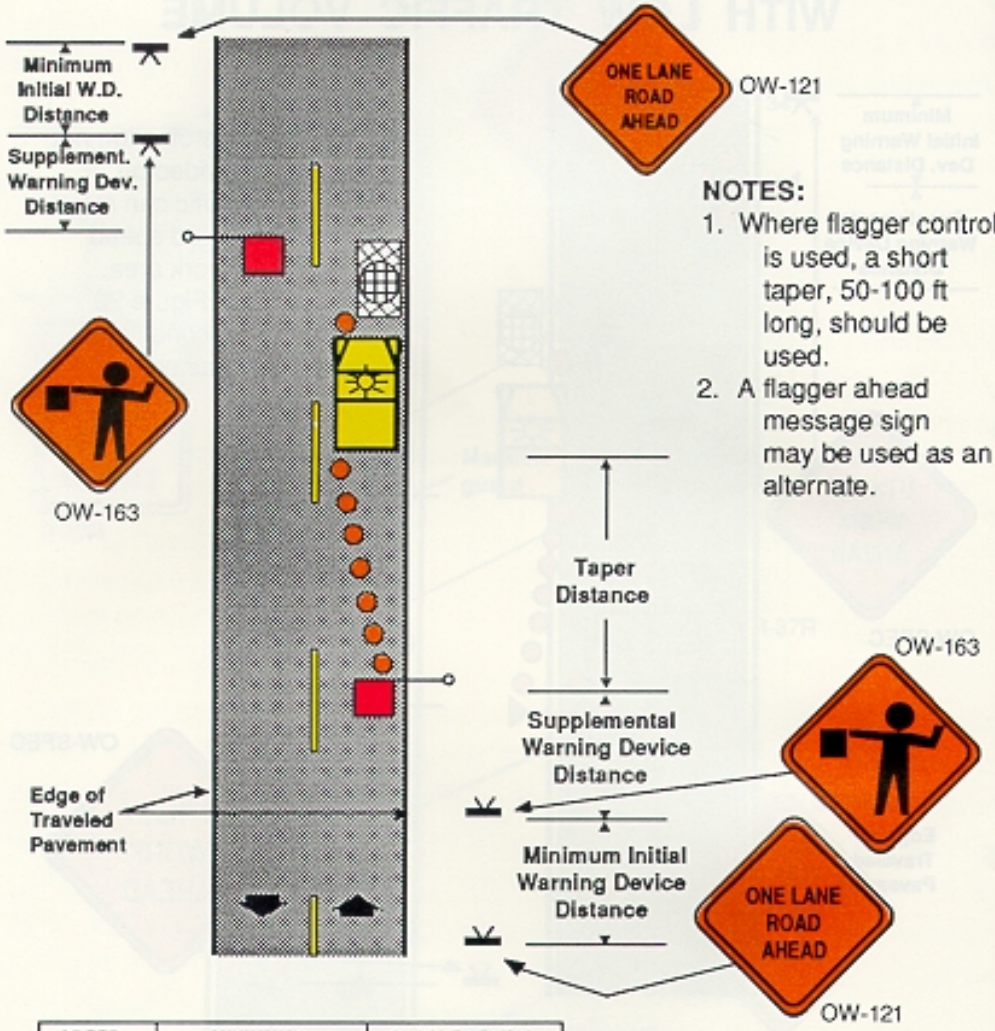
1. Flagger protection not required, provided bi-directional traffic can move freely at reduced speed through the work area.
2. Refer to Figure 22 where above conditions cannot be attained.

SPEED LIMIT	MINIMUM * INITIAL WARNING	SUPPLEMENTAL WARNING	TAPER DISTANCE
0 - 25	200 ft	200 ft.	125 ft.
26 - 35	300 ft.	300 ft.	250 ft.
36 - 50	500 ft.	400 ft.	600 ft.
over 50	1,000 ft.	500 ft.	660 ft.

*MUTCD requires an advance warning distance of 1,500 ft. on rural or open highway conditions.

Figure 21

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR A UTILITY WORK ZONE ON A TWO-LANE ROADWAY



NOTES:

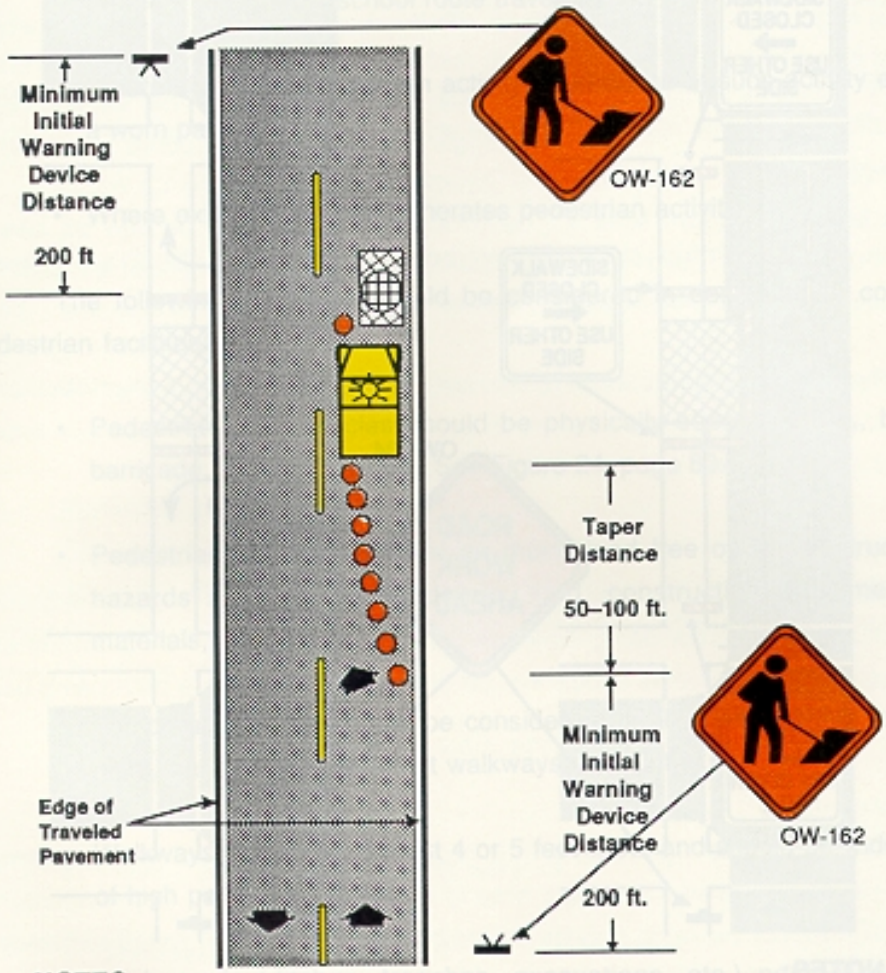
1. Where flagger control is used, a short taper, 50-100 ft long, should be used.
2. A flagger ahead message sign may be used as an alternate.

SPEED LIMIT M.P.H.	MINIMUM * INITIAL WARNING DEVICE DISTANCE	SUPPLEMENTAL WARNING DEVICE DISTANCE
0 - 25	200 ft	200 ft.
26 - 35	300 ft.	300 ft.
36 - 50	500 ft.	400 ft.
over 50	1,000 ft.	500 ft.

*MUTCD requires an advance warning distance of 1,500 ft. on rural or open highway conditions.

Figure 22

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES FOR A UTILITY WORK ZONE ON A TWO-LANE RESIDENTIAL STREET (LOW TRAFFIC VOLUME)



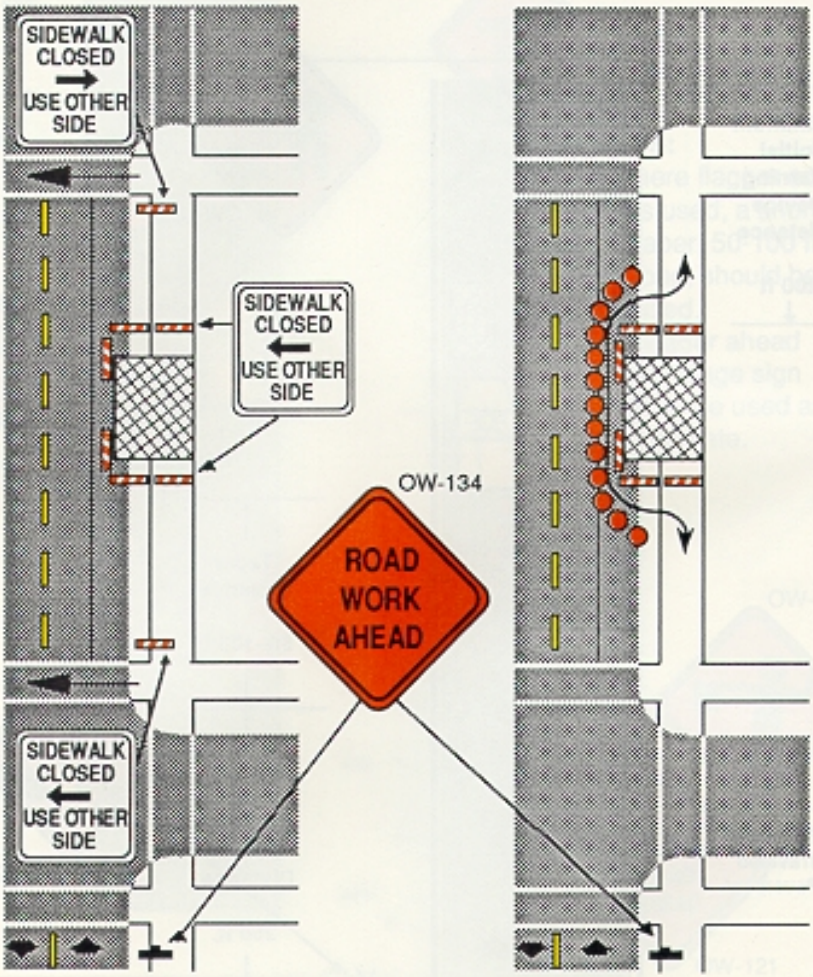
NOTES:

1. Where flagger is required because of traffic volume or visibility, refer to Figure 22 for set-up.
2. With very few exceptions, this control device set-up is not to be used in rural areas. Typical applications of traffic control devices on other roadways are shown on Figures 21 and 22.

Figure 23

TYPICAL APPLICATION OF
TRAFFIC CONTROL DEVICES.
TWO METHODS FOR CONTROLLING PEDESTRIAN TRAFFIC:

DIRECTING PEDESTRIANS TO ANOTHER ROUTE OR PROVIDING A WALKWAY



NOTES:

1. Additional advance warning may be necessary.
2. Controls for pedestrians only are shown; vehicular traffic should also be considered.
3. Street lighting should be considered.
4. Use warning lights on barricades.

KEY:
barricades

Figure 24

10. Pedestrians

When there is pedestrian traffic in the area, walkways should be provided. (Figure 24, page 80) The following situations would normally warrant including walkways in the TCP:

- Where sidewalks traverse the work zone,
- Where a designated school route traverses the work zone,
- Where significant pedestrian activity or evidence of such activity exists (i.e., a worn path), and
- Where existing land use generates pedestrian activity.

The following principles should be considered in designing or constructing pedestrian facilities:

- Pedestrian and vehicles should be physically separated (i.e., by barrier, barricade, or similar items). See Figure 24, page 80.
- Pedestrian walkways should be maintained free of any obstructions and hazards such as holes, debris, mud, construction equipment, stored materials, etc.
- Temporary lighting should be considered by all walkways that are used at night, particularly if adjacent walkways are lighted.
- Walkways should be at least 4 or 5 feet wide, and should be wider in areas of high pedestrian activity.
- All hazards (ditches, trenches, excavations, etc.) near or adjacent to walkways should be clearly delineated.
- Walkways under or adjacent to elevated work activities such as bridges or retaining walls may require covered walkways.

- Where safe pedestrian passage cannot be provided, pedestrians should be directed to the other side of the street by appropriate traffic control devices. See Figure 24, page 80.

- Signs and traffic control devices should not be a hazard to pedestrians.

- Signs located near or adjacent to a sidewalk should have a 7-foot clearance.

- Where construction activities involve sidewalks on both sides of the street efforts should be made to stage the work so that both sidewalks are not out of service at the same time.

- In the event that sidewalks on both sides of the street are closed, pedestrians should be guided around the construction site.

- Reflectorized traffic control devices are of little value to pedestrians. Warning lights should be used to delineate the pedestrians pathway and to mark hazards as appropriate.

11. Bicycles

Bicycles also need protection and access to the roadway. If a bicycle path is closed because of the work being done, an alternate route should be provided and signed if appropriate. Bicycles should not be directed into the same path being used by pedestrians.

12. Interchanges

On limited access highways, with interchange ramps, access to these ramps should be maintained even if the work area is in the lane adjacent to the ramps. If access is not possible the ramp may be closed by using signs and Type III barricades. Early coordination with officials having jurisdiction over the affected cross streets is needed prior to ramp closures.

The access to the exit ramp should be clearly marked and outlined with channelizing devices. For long-term projects, old markings should be removed and new markings placed. As the work area changes, the access area may be changed.

13. Intersections

Use advance warning signs, devices, and markings as appropriate on all cross streets. The effect of the work upon signal operation should be considered such as signal phasing for adequate capacity and for maintaining or adjusting detectors in the pavement.

14. Detours

Detour signing is usually handled by the traffic engineer with authority over the roadway because it is considered a traffic routing problem. Detour signs are used to direct traffic onto another roadway. When the detour is long, signs should be installed to periodically remind and reassure drivers that they are still on a detour. This is done by using the Detour Marker or Detour signs.

When an entire roadway is closed, a detour should be provided and traffic should be warned of the closure in advance. If local traffic is allowed to use the roadway up to the closure, the ROAD CLOSED TO THRU TRAFFIC sign should be used. The portion of the road open to local traffic should have adequate signing, marking, and protection.

Detours should be signed so that traffic will be able to get through the entire area and back to the original roadway.

15. Portable Concrete Barrier

Figure 12, page 65, illustrates the use of a portable concrete barrier around a work area which also includes a lane closure. When determined necessary by an engineering analysis, barriers should be used for added safety. There are four primary functions of barriers:

- Keep traffic from entering work areas, such as excavations or material storage sites;
- Provide positive protection for workers;
- Separate two-way traffic; and
- Protect construction such as false work for bridges and other exposed objects.

CHAPTER 3

INSTALLATION, MAINTENANCE AND INSPECTION

Before the work is scheduled to begin, the foreman and/or inspector should check all signs, pavement marking material, and channelizing devices that are to be used. All devices should be:

- Standard in size, shape, color, or message;
- In good condition, not needing repair; and
- Reflectorized.

If a particular device does not meet all of the above requirements it should be replaced with one that does. Additional devices should be available to replace any that may be damaged while the work is in progress. On construction, the inspector and foreman should be in agreement that the devices are satisfactory before they are placed on the roadway.

Reflectorized devices need extra care when handling and transporting to ensure that the reflectorizing elements are not damaged.

Existing signs that do not apply during construction, maintenance, or utility work should be removed or completely covered. Burlap or other materials that are not opaque are not acceptable. At night, non-opaque materials let the messages be seen because headlights reflect the message through the material.

Work area signs that are installed before traffic patterns are changed should be covered, rotated, or folded in half so drivers cannot read the message.

Since many maintenance, utility, and emergency operations require the same devices for each job, vehicles should be equipped with an adequate supply of commonly used portable devices.

A. Installation and Removal

1. Order of Placement

Traffic control devices should be placed in the order that drivers will see them, starting with the sign or device that is farthest from the work area and placing the others as the work area is approached. If traffic in both directions will be affected, such as with work in the center lanes, the devices can be placed in both directions at the same time, starting at each end farthest from the work area.

When one direction of traffic will be directed into opposing traffic lanes, such as shown in Figures 16 and 18 (pages 70 and 72), the signs, devices, and pavement markings for the opposing traffic should be placed first. When the signs and devices are across from or at the work area, the devices for the oncoming direction can then be set up. (It is essential to channelize opposing traffic out of its lane before moving the oncoming traffic into the lane.)

When signs or channelizing devices are to be installed and removed several times during the work operation, a spot should be painted where the devices are located so the installation can be repeated quickly and so that proper placement is assured. The devices should be stored off the roadway, out of sight, or transported to another location.

Motorists do not expect to encounter workers in the roadway setting up a traffic control zone. Since the goal is to make the entire operation safe, high-level warning devices, flaggers, or flashing vehicle lights should be used to warn the drivers of the presence of workers. Flashing arrow panels are valuable to assist the workers during placement or removal of channelizing devices for lane closures.

2. Removal of Devices

As soon as the work is completed and the devices are no longer needed, they should be removed. Devices should be removed in the opposite order of installation by starting with the devices closest to the work area and continuing away from the area. Flashing arrow panels, high-level warning devices, flaggers, and/or flashing vehicle lights should be used for the removal process.

3. Pavement Marking Removal

Motorists use pavement markings as a primary source of guidance. Temporary pavement markings, such as pressure-sensitive traffic tape or raised pavement markings, can be used with other devices in a traffic control zone. Any pavement markings that are no longer applicable or that may confuse drivers should be removed as soon as practicable.

Traditionally, methods of removal include grinding, burning, chemical treatment, sandblasting, hydroblastic, and high pressure water jetting (List of References #5). Over-painting markings that are no longer appropriate with black paint and bituminous solutions is specifically disallowed by the MUTCD. This treatment has proved unsatisfactory since the original lines eventually reappear as the overlying material wears away under traffic. In addition, lines which are covered in this way are still visible under certain conditions (low angles of illumination).

B. Inspection and Maintenance Program

1. Purpose

Once the traffic control zone is established, it is important to ensure that it continues to function as it was intended; installed and perhaps subsequently modified as a result of the evaluation process.

Maintenance is needed to service the equipment and make corrections which may be required due to any combination of the following factors.

On highway construction projects, this is normally the responsibility of the contractor.

- Traffic accidents;
- Device displacement:
  - vehicular contact,
  - slip stream from trucks,
  - workers,
  - wind;
- Damage caused by construction activities;
- Weather created damage;

- Malfunctions and burn outs;

- Consumption of energy:
  - battery-operated lights,
  - gasoline generators;

- Physical deterioration;

- Dust and grime:
  - on sign faces,
  - on reflectorized rails;

- Dirt and debris:
  - on roadways; and

- Vandalism.

2. Elements of an Inspection Program

A comprehensive inspection and maintenance program should include the following elements:

- A formalized plan;

- Defined inspection procedures;

- A form on which the findings of the field inspection are recorded;

- A repair program;

- Assurance of an adequate inventory of devices for emergency replacement or repairs;

- Check procedures to assure that specified repairs are made;

- Identify possible causes of accidents or skid marks;

- A review to insure that the travel path is clearly marked through the entire work zone, both day and night; and

- Formal documentation of inspections and repairs made.

The inspector will be faced with the need to make decisions during the inspection and must exercise judgment in establishing appropriate practices.

A key element of the program is the procedure which insures that the required maintenance is performed. When the corrective action is taken, it should be so noted in order that documentation is complete.

3. Responsibility

For each project, an individual should be assigned the responsibility for traffic control. On construction projects, the contractor should designate a specific person by name and telephone number. In addition, on large projects, the traffic control responsibility should be assigned to an employee in the agency's organization. Routine inspections of the traffic control installation should be carried out by these individuals.

Less frequent but periodic inspections should be performed by senior staff of the contractor (typically the superintendent) and the agency (the resident engineer and/or the traffic engineer).

Lines of communication and responsibility should be clearly established between individuals in control of routine maintenance activities and those with greater authority, so that urgent problems that arise from time to time can be brought promptly to the attention of officials who are in a position to respond immediately.

4. Frequency

To determine the frequency with which inspections should be performed, the following factors should be considered:

- Project size and duration;

- Nature of work activity;

- Complexity of traffic control;

- Frequency at which damage is occurring; and

- Number of deficiencies observed during previous inspections.

Traffic controls that are left in place overnight should be inspected during hours of darkness at the same frequency as during the daylight hours. Holiday and weekend inspections should be made as needed.

5. Record Keeping

Good record keeping procedures suggest that the time and location of the installation and removal of traffic control devices be noted. Although this can be time consuming for a moving maintenance operation, it is important to record significant traffic control actions taken by the field crew. It is desirable that this include:

- Starting and ending time of work;
- Location of work;
- Type, condition and position of traffic control devices;
- Names of personnel;
- Type of equipment used; and
- Any change in temporary or permanent regulatory devices.

Major projects will require more detailed record keeping, since they may involve greater amounts of funds, outside (Federal or State aid) funding sources, and longer distances and times of physical exposure to the workers, motorists, or pedestrians.

Several methods of recording traffic controls are available. These include:

- Use of photo logging;
- Photographs either keyed to a diary or containing a brief description of:
  - time,
  - location,
  - direction,
  - photographer's name;

- Special notes on construction plans (preferably the traffic control plan sheet); and

- Daily diary entries of times, location, and names of individuals (when known) involved in the:
  - installation,
  - change, and
  - removal of traffic control devices.

Change orders or work orders also serve as a reference, and should be keyed to the diary when used.

When the inspection process reveals a condition that requires correction, the documentation should include:

- Description of the correction needed, when it was noted, and by whom;

- Corrections made or deferred and why;

- Replacements made or deferred and why; and

- Any other needed actions.

C. Legal Liability

Highway personnel should anticipate the likelihood of lawsuits in the event of an accident or other grievance suffered by an injured citizen. To prevent or minimize such litigation, and to help defend lawsuits, the following steps are recommended:

- Know and comply with the traffic control for street and highway construction and maintenance operations set forth in the Ohio MUTCD, this Handbook and other nationally accepted engineering standards and practices.

- Provide properly working devices at the site, particularly when unattended (nights, weekends, etc.).

- Document all actions taken on or related to traffic controls that are placed in effect at the work site.

- Inspect the work site at frequent intervals with a view to detecting and immediately correcting deficiencies in traffic control.

- Remove all material and equipment not needed at the site as soon as possible. (This applies also to traffic control devices that cease to be needed.)

- Provide warning and protection to motorists, pedestrians, and workers for potential conflicts and hazards that may result from the work being done at the site or from a vehicle striking a device.

D. Documentation for Protection

Since it is not known when an accident will occur, the key to defending cases in courts of law is advanced preparation. Highway personnel and contractors should maintain a careful record of job related activities so they may document their efforts to provide good traffic control at the work site. The record system should reflect priorities and a planned safety program.

The following steps are recommended as a means of establishing effective project documentation:

- Maintain up-to-date engineering drawings.

- File all pertinent memoranda and correspondence.

- Reference standards and specifications.

- Keep daily project diary.

- Perform and document routine inspections.

- Follow all safety regulations.

- Conduct personnel safety training.

- Document all instructions to contractors or subcontractors.

- Take photographs at key project stages and for unusual situations.

In case of an accident, project personnel should promptly record and document the circumstances and pertinent factors. Photographs are recommended.

REFERENCES

1. Federal Highway Administration (FHWA), Standard Highway Signs, Washington, D. C.. U. S. Department of Transportation, 1979; vp.

2. Federal Highway Administration (FHWA), Standard Alphabets for Highway Signs and Pavement Markings, Washington, D. C., U. S. Department of Transportation, 1979; 56 p.

3. American Association of State Highway and Transportation Officials (AASHTO), Guide for Selecting, Locating, and Designing Traffic Barriers, Washington, D. C.. 1977; 322 p.

4. Federal Highway Administration (FHWA), Federal Aid Highway Program Manual Volume 6, Chapter 4, Section 2, Subsection 12, Washington, D. C., U. S. Department of Transportation.

5. Niessner, Charles W., Traffic Stripe Removal, Washington, D. C., Federal Highway Administration, July 1979; 60 p.

City of Cincinnati

TRAFFIC SAFETY HANDBOOK

Prepared By:

Pflum, Klausmeier & Gehrum Consultants
For
Employee Safety/Risk Management Division
Office of the City Manager

For the purpose of improving work site protection, this document has been prepared as a training handbook for the City of Cincinnati. It has been developed from two publications: the Traffic Control Devices Handbook of the Federal Highway Administration, U. S. Department of Transportation; and the Ohio Manual of Uniform Traffic Control Devices (Ohio MUTCD), prepared and maintained by the Ohio Department of Transportation. The Ohio MUTCD and other accepted standards and guidelines must be followed in the planning and implementation of work site protection on public roads and streets.

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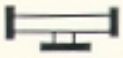
APPENDIX

KEY TO SYMBOLS


Sign on a post support


Sign on a portable sign support.


Sign on a portable barricade


Sign on a fixed barricade


Work vehicle with flashing light


Cone

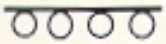

Drum


Road edge delineator


High level safety flags


Flagger


Workman


Guardrail


Work area


Flashing arrow panel


Vertical panel