Advanced Work Zone Training

Contents

Introduction

On any given day, the Missouri Department of Transportation (MoDOT) has at least 100 work zones on the highway system. This number increases threefold in the summer months. MoDOT is committed to providing safe and efficient movement of both motorized and non-motorized traffic through or around temporary traffic control work zones and providing protection for workers and equipment located within those work zones. MoDOT focuses its resources to emphasize roadway visibility in temporary traffic control work zones and traffic flow through those work zones.

While work zone traffic accident statistics have been on a steady decline since 2002, there is still a need to reduce the number of accidents in work zone. In 2005 Missouri experienced:

- 3,140 work zone crashes
- 988 work zone injuries
- 15 work zone fatalities

The desired end-results of MoDOT's efforts is to reduce work zone incidents and travel time while providing safer work zones with minimal impact on the traveling public. MoDOT has continued to see a steady decline in the amount of work zone fatalities, injuries, and crashes every year since 2002.

To better educate those responsible for designing and managing temporary traffic control in work zone safety considerations, MoDOT has created this course, "Advance Work Zone Training" (AWZT). The course is the third part of a curriculum pertaining to work zones. Upon completion of the course, the participants will be certified as a "Work Zone Specialist" (WZS). MoDOT will have a WZS involved in every aspect of the traffic control plan from preliminary to post-construction work.

The WZS' actions directly impact the mobility and safety of a work zone. The WZS is responsible for knowing applicable standards, guidelines, interpreting plans, specifications, coordinating temporary traffic control requirements, meeting the requirements of the contract or field operation guidelines, and supervising traffic control personnel.

The WZS' action or inaction can have a dramatic impact on the safety of the traveling public and the workers. Making safety a high priority will minimize crashes. Thereby, reducing property damage, injuries, and fatalities within MoDOT's work zones.

The AWZT consists of four parts including three learning sessions and a project. The subjects will range from reviewing MoDOT's work zone policies, traffic control devices, basic plan reading, work zone inspections, tort liability, etc. The class will be broken into groups which will work on a three-phase project ending in a presentation. Each portion of the project will be utilized upon the tools the participants will learn through the class. Each participants comprehension of the course material will be tested at the end of class.

Module 1: MoDOT's Work Zone Policy

MoDOT is committed to providing for the safe and efficient movement of both motorized and non-motorized traffic through or around temporary traffic control work zones and in providing protection for workers and equipment located within those work zones. It is essential that the Work Zone Specialist actively monitor the work zone and its operations as well as make appropriate adjustments to the plans.

The department has developed fundamental principles, established responsibilities, and implemented measurements to improve the design, management, and operation of work zones located on the state highway system. Examples of these guidelines follow.

Fundamental Principles

Traffic and worker safety is an integral and high-priority element of every incident management, maintenance, permit, and utility operation. Consideration of the following principles will ensure a safe temporary traffic control zone.

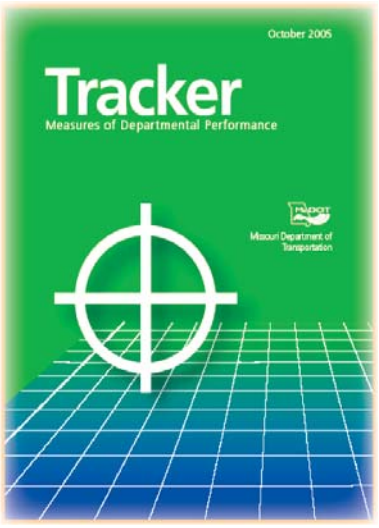
- Prepare a temporary traffic control plan and communicate it to all responsible parties prior to occupying the site.
- Provide those whose actions affect the temporary traffic control zone with training appropriate to their level of responsibility.
- Employ the same basic safety principles used to design permanent roadways.
- Avoid frequent or abrupt geometric changes.
- Minimize delay and disruption.
- Schedule and coordinate operations according to MoDOT's Work Zone Guidelines.
- Provide adequate warning, delineation, and channelization in advance of and through the area affected.
- Provide positive guidance.
- Provide for safe operation of work.
- Encourage use of alternative routes.
- Assume drivers will only reduce their speeds if they clearly perceive a need to do so.
- Provide for reasonably safe passage of bicyclists and pedestrians.
- Provide recovery areas where practical.
- Coordinate operations with those having jurisdiction over any affected cross streets, railroads, or transit facilities.
- Ensure continuation of emergency services.
- Communicate with and provide reasonable accommodations for adjoining property owners.
- Ensure temporary traffic control devices used are in good working order, reasonably consistent with the temporary traffic control plan, and effective.

- Monitor performance of the temporary traffic control and modify as needed.
- Inspect and maintain temporary traffic control devices.
- Remove, cover, or turn; and turn off all unnecessary temporary traffic control devices.
- Maintain a record of any crashes or incidents.
- Store unused equipment and material in such a manner to reduce the probability of being hit.
- Involve the media to assist in information dissemination.

Responsibilities

MoDOT employee's, (field operation forces, construction inspectors, design personnel, district and Central Office staff); contractors; permittees; law enforcement personnel; and product vendors, manufacturers, and suppliers play a vital role in ensuring work zones are safe and efficient. Examples of these responsibilities include:

- Conduct analyses to identify work zone impacts to traffic flow and safety.
- Identify strategies to minimize impact and maximize awareness of work zones.
- Use innovative contracting and bidding options to reduce construction time.
- Set appropriate work zone speed limits.
- Incorporate innovative technologies to improve traffic flow through work zones.
- Coordinate lane closures to maximize traffic capacity and minimize disruption.
- Designate a trained person at the project/work level who has the primary responsibility, and sufficient authority, to implement the transportation management plan (TMP) and other safety and mobility aspects of the project/work.
- Verify all personnel are trained in traffic control to a level commensurate with their responsibilities.
- Ensure work zones are maintained in a neat, orderly, and effective manner.
- Improve traffic control measures, as needed, to address field conditions pertaining to traffic flow, visibility and workers and motorist safety.
- Perform quality assurance reviews of work zones to promote consistency and ensure compliance with policies and guidelines.
- Identify successes and areas of improvement and share that information with appropriate personnel.



Measurements

An important factor in evaluating the department's performance in temporary traffic control design, deployment, operation, and maintenance are the measurements of our work zones affect on mobility and safety. These measures track how well the department meets its customer expectations of work zones on state highways.

MoDOT reports quarterly on its ability to provide safe, effective, and efficient work zones via three Tracker measures. These measures, which relate to the department's tangible results of Uninterrupted Traffic Flow, Roadway Visibility, and Safe Transportation System are:

- "Percent of Work Zones Meeting Expectations for Traffic Flow"
- "Percent of Work Zones Meeting Expectations for Visibility," and
- "Number of Fatalities and Injuries in Work Zones."

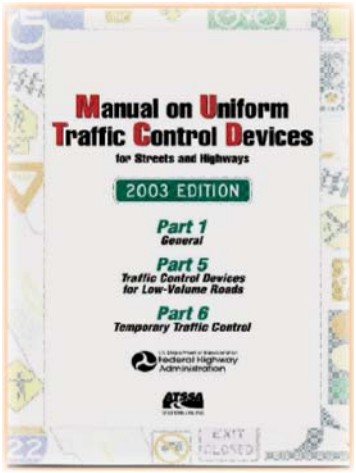
NOTE: For additional guidance on work zones, refer to MoDOT's Work Zone Safety and Mobility Policy.

Module 2: Work Zone Standards

There are three sources of information regarding temporary traffic control requirements for work on Missouri's state highway system. They include: Federal Highway Administration's Manual on Uniform Traffic Control Devices (MUTCD); MoDOT's Traffic Control for Field Operations manual; and our project design and construction documents.

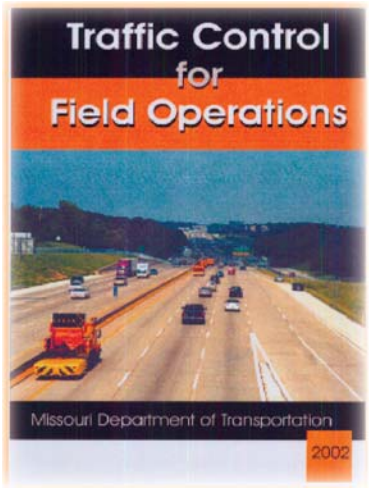
Because of variations in temporary traffic control requirements afforded by these documents, it is important to realize the differences and their applicability to activities performed on the state highway system.

Manual on Uniform Traffic Control Devices (MUTCD)



Part 6 of the MUTCD sets forth minimum temporary traffic control standards to be implemented on the nation's highways. MoDOT elects to use this document as the standard for all permit or utility work on our state highways to provide an easy reference manual to those performing this type of work in multiple states. This allows these parties some flexibility in choosing to use certain devices and equipment in their work zones and the physical and design aspects of those items as long as they comply with the MUTCD, including crashworthiness requirements, and the fundamental principles and responsibilities noted in Module 1.

MoDOT Traffic Control for Field Operations Manual



MoDOT's Traffic Control for Field Operations manual provides guidance on the implementation of temporary traffic control measures by MoDOT's field personnel. The guidelines are based on the standards provided in Part 6 of the MUTCD, but incorporate certain MUTCD allowances and department recommendations to improve work zone safety and mobility. The temporary traffic control set-ups shown in the manual are typical and may, as field conditions require, be adjusted per those guidelines. This manual applies to all operations performed by MoDOT staff on the state highway system. Link: wwwi/intranet/tr/ttc/opt_fo_manual.htm

Project Design and Construction Documents

MoDOT maintains several other publications specifically used in development of contract documents and the administration of those contracts for construction purposes. These publications include the Construction Manual, Project Development Manual, Standard Plans, Standard Specifications, and Job Special Provisions. The guidance provided in these documents, like those contained in the Traffic Control for Field Operations manual, is based on the standards provided in Part 6 of the MUTCD and incorporate certain MUTCD allowances and department recommendations to improve work zone safety and mobility. However, some requirements are different due to worker liability concerns and the complexity and longevity of construction-type work.

The Missouri Highways & Transportation Commission (MHTC) has adopted the MUTCD as the basis for the creation of MoDOT's traffic policies, including its work zone standards. It may be referred to when MoDOT publications do not adequately address a topic or if additional information on a subject is needed.

Module 3: Work Zone Basics

The purpose of temporary traffic control is twofold. First, to provide for the safe and efficient movement of both motorized and non-motorized traffic through or around a temporary traffic control zone. Second, to provide protection for workers and equipment in the work space.

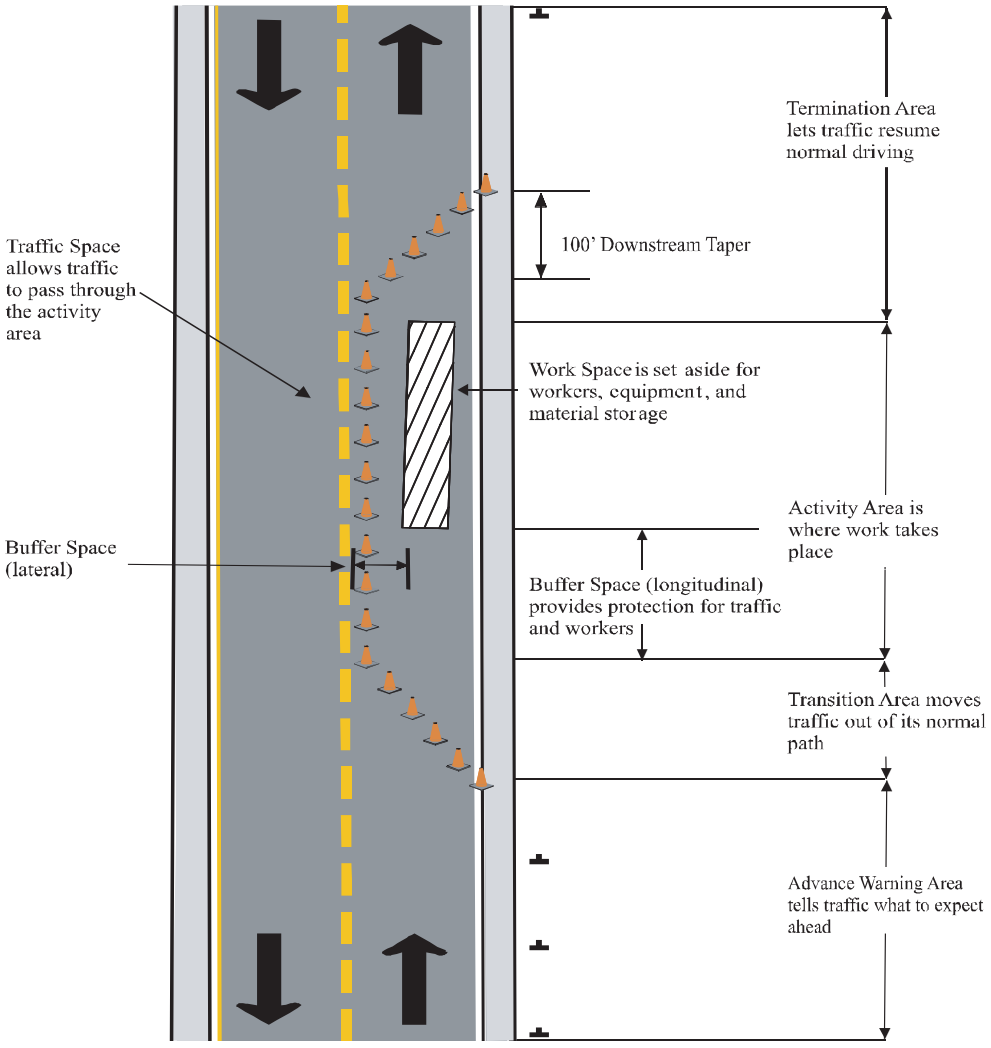
The presence of temporary traffic control devices violates driver expectation and, because highway-related work is performed in vulnerable conditions, it is imperative that temporary traffic control be properly planned and executed to achieve these objectives successfully.

Work Zone Components

A temporary traffic control zone is a section of highway where traffic conditions are changed due to a work zone or an incident area through the use of temporary traffic control devices, law enforcement or other authorized officials. It extends from the first warning sign or rotating/strobe lights on a vehicle to the last temporary traffic control device. The zone may either be stationary or move as work progresses.

A temporary traffic control zone consists of four areas - advance warning, transition, activity, and termination.

These areas are illustrated in the following figure.

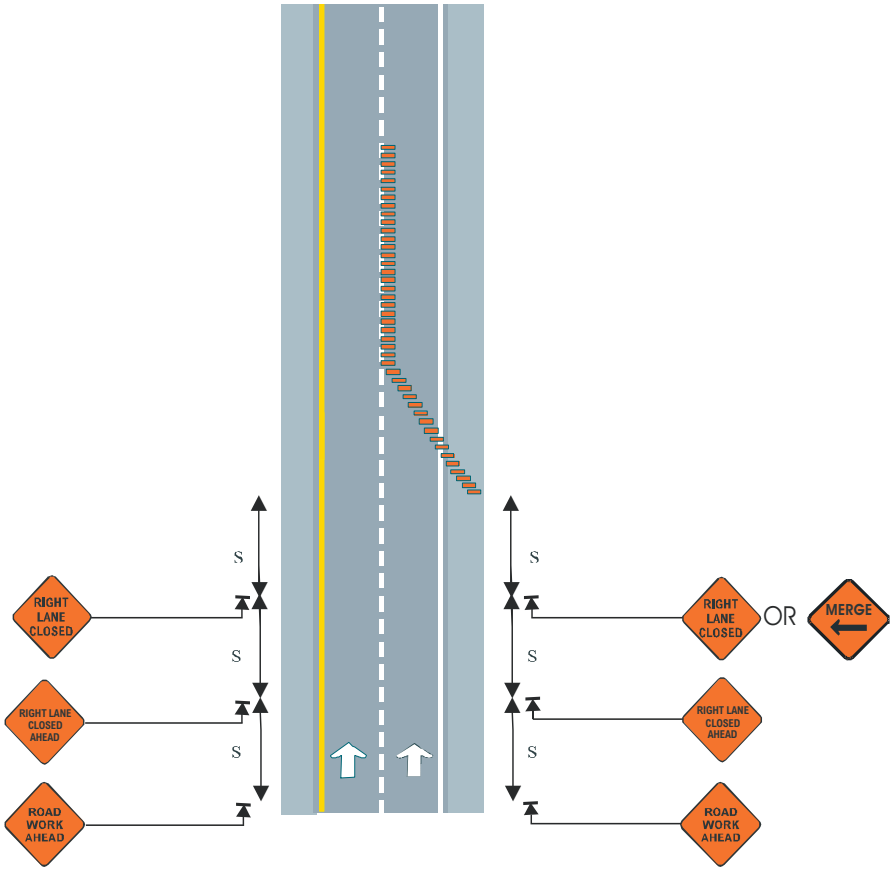


Advance Warning Area

The advance warning area is where traffic is informed of an upcoming temporary traffic control zone. It may vary from a single sign or rotating/strobe lights on a vehicle to a series of signs depending on the duration, location, and type of work.

Recommended sign spacing in this area is shown in the following table.

Speed Limit (mph)	Spacing[1] (ft.)	
	Undivided Highway	Divided Highway
0-35	200	200
40-45	350	500
50-55	500	1000
60-70	1000	1000
[1]Sign spacing may be adjusted, normally by increasing it, to accommodate field conditions and visibility.		



Transition Area

The transition area is where traffic is redirected out of its normal path and into the traffic space. This is usually accomplished through the use of a series of channelizers placed in a taper across the portion of roadway to be closed. There are three types of tapers: shoulder; lane; and one-lane, two-way.

- The *shoulder taper* is used to close the shoulder where it is part of the activity area or when improved shoulders might be mistaken for a driving lane.
- The *lane taper* is used to close a driving lane by forcing traffic to merge.

Recommended taper length and channelizer spacing for shoulder and lane tapers in the transition area are shown in the following table.

Taper Spacing Chart

Speed Limit (mph)	Taper Length[1] (ft.)		Channelizer Spacing [4] (ft.)
	Shoulder[2] (T1)	Lane[3] (T2)	
0-35	70	245	35[5]
40-45	150	540	40[5]
50-55	185	660	50[6]
60-70	235	840	60[6]

[1] Taper lengths may be adjusted to accommodate crossroads, curves, intersections, ramps, or other geo metric features.
[2] Based on 10 ft. shoulder width.
[3] Based on 12 ft. lane width
[4] Channelizer spacing may be reduced to discourage traffic encroachment.
[5] Spacing reduced to $^1/_2$ at intersections.
[6] Spacing may be reduced to $^1/_2$ at intersections.

The **one-lane, two-way taper** is used to close one lane of a two-lane, undivided highway where the remaining lane is used alternately by traffic in each direction. The taper should have a length of 100 feet (5 channelizers @ 20 foot spacing). In addition to the channelizers, a flagger, STOP or YIELD sign, pilot car or temporary traffic signal controls traffic through this section.

Note: Taper lengths may be adjusted whenever they are located in close proximity to a crossroad, curve, intersection, ramp, or other geometric feature.

Whenever tapers are used near interchange ramps, crossroads, curves, or other influencing factors, it may be desirable to adjust the length of tapers. Longer tapers are not necessarily better than shorter tapers (particularly in urban areas characterized by short block lengths, driveways, etc.), because extended tapers may encourage motorists to delay lane changing. The real test of taper length involves observing motorists' after the traffic control plan has been implemented.

Activity Area

The activity area is where work activity takes place. It is comprised of three spaces - work, traffic, and buffer.

- The *work space* is the area closed to traffic and set aside for workers, equipment, materials, and a protective vehicle, if one is used upstream. They are usually delineated by channelizer or temporary barriers to exclude vehicles and pedestrians.
- The *traffic space* is the area in which traffic is routed through the activity area.
- The *buffer space* is the area separating traffic from the work space or an unsafe area. Since this area provides some recovery space for an errant vehicle, it should be kept free of any work activity, equipment, vehicles, and material storage. There are two types of buffer spaces - longitudinal and lateral.
    - A longitudinal buffer space may be used in advance of the work space or to separate opposing traffic flows using portions of the same traffic lane. When an item such as a protective vehicle is located in this space, only the area upstream of the item functions as the buffer space.
    - A lateral buffer space may be used adjacent to the work space, an unsafe condition, or between two lanes, especially those carrying traffic in opposite directions. The minimum width of this space is not set but should be determined based on the type of facility, work activity, condition for which the space is being provided, and space available.

Recommended longitudinal buffer length and channelizer spacing in the activity area are shown in the following table.

Buffer Chart

Speed Limit (mph)	Buffer Length (ft.)	Channelizer Spacing[1] (ft.)
0-35	120	50[2]
40-45	220	100[2]
50-55	335	100[3]
60-70	550	100[3]

[1] Channelizer spacing may be reduced to discourage traffic encroachment.
[2] Spacing reduced to 1/2 at intersections.
[3] Spacing may be reduced to 1/2 at intersections.

Termination Area

The termination area is where traffic is returned to its normal path. This area extends from the downstream end of the activity area to the last temporary traffic control device. This area may include a downstream taper or a sign informing traffic they may return to normal operations (e.g. END ROAD WORK or Speed Limit). When a downstream taper is used, the recommended length is 100 feet (5 channelizers @ 20 foot spacing) per lane.

Flagger Control

The role of the flagger in temporary traffic control is an important one. It is the flagger's responsibility to assess the safety and efficiency of traffic operations within the temporary traffic control zone and manage the movement of traffic through the proper assignment of right of way and/or by controlling speed. Guidelines for performing this vital function are set forth in the *Flagger Training* course materials. It is good practice for flaggers to review these guidelines on a regular basis to ensure they perform their duties effectively.

Except when performed under emergency conditions, workers engaged in flagging operations on the state highway system shall have successfully completed a recognized flagger training course. For MoDOT employees, this requires the successful completion of the *Flagger Training* course or an approved substitute.

Duration of Work

Work duration is a major factor in determining the number and types of devices used in temporary traffic control zones. The duration of a temporary traffic control zone is defined relative to the length of time an operation occupies a location. The six categories of work duration are:

- ***Long-Term Stationary*** - planned work occupying a location more than three days.
- ***Intermediate-Term Stationary*** - planned work occupying a location more than one daylight period up to three days, or nighttime work lasting more than 30 minutes.
- ***Short-Term Stationary*** - planned daytime work occupying a location for more than 30 minutes, but less than twelve hours.
- ***Short Duration*** - planned daytime or nighttime work occupying a location up to 30 minutes.
- ***Mobile*** - planned work moving intermittently or continuously.
- ***Emergency*** - work involving the initial response to and repair/removal of Response Priority 1 items according to the *MoDOT's Incident Response Plan Manual or District Incident Response Manual*.

Long-term stationary operations include planned work occupying a location more than three days. Post-mounted signs, larger channelizers and barricades, temporary traffic barriers, temporary pavement markings, work lighting, area lighting, warning lighting, and temporary traffic signals are devices generally incorporated into the temporary traffic control plan for these operations. In addition to providing a greater margin of safety, these types of devices provide superior operational characteristics - an important consideration during nighttime hours and periods when workers are not present.

Intermediate-term stationary operations include planned daytime work occupying a location from more than one daylight period up to three days or planned nighttime work occupying a location more than 30 minutes.

In these operations the same procedures and devices used in long-term stationary operations may be desirable. However, their use should be carefully considered, as they may not be feasible or practical to deploy. The increased time to place and remove these devices in some cases could significantly lengthen the project, thus increasing exposure time.

Short-term stationary operations include planned daytime work occupying a location for more than 30 minutes, but less than twelve hours. This category describes the majority of work zone activities undertaken on the state highway system.

In these operations, procedures and devices are usually simplified when compared to intermediate- and long-term stationary operations because workers are present to maintain and monitor the temporary traffic control zone, the zone is only set up during daylight hours, and it is only in place for a relatively short period of time. Portable signs, flashing arrow panels, channelizers, fleet lighting, protective vehicles, and truck-mounted attenuators are devices generally incorporated into the temporary traffic control plan for these operations.

Short duration operations include planned daytime or nighttime work occupying a location up to 30 minutes.

These operations might involve different types of temporary traffic control devices since it often takes longer to set up and remove the temporary traffic control than it does to perform the actual work. Vehicle-mounted signs, truck-mounted flashing arrow panels, fleet lighting, protective vehicles, channelizer cones, and truck-mounted attenuators are typical devices considered for use in these types of operations.

Mobile operations include planned work that moves intermittently or continuously.

These operations often involve frequent, short stops for activities where workers are on foot. These **stops can last up to 15 minutes in duration**. Typical work activities include litter cleanup and pothole patching.

Due to the similarity of these activities to short duration operations, the same procedures and devices considered for use in short duration operations are also desirable for use in these types of mobile operations. When non-mobile devices like portable signs are used, they should be moved periodically to keep them near the operation.

Mobile operations also include work activities in which workers and equipment move along the roadway without stopping. Typical work activities include mowing, snow removal, spraying, sweeping, and long-line striping.

In these types of activities the advance warning area moves with the operation. Therefore, total mobility of the temporary traffic control zone is important and devices should be chosen accordingly. In some continuously moving operations, a work vehicle equipped with fleet lighting may be sufficient. In others, a protective vehicle equipped with fleet lighting, a truck-mounted attenuator, a flashing arrow panel, and a sign may be needed. Where work proceeds at unusually slow speeds, less than five miles per hour, it may be desirable to place warning signs along the roadway and move them periodically as work progresses.

Emergency operations include unplanned work occupying a location up to 15 minutes. Within MoDOT, these operations consist of the initial response to and repair/removal of safety concerns as defined by Response Priority 1 items (refer to the *MoDOT's Incident Response Plan Manual*).

In these operations, it is usually more advantageous, from a safety standpoint, to remove or provide warning of the risk in a timely manner with limited temporary traffic control than it is to set up a temporary traffic control zone for short duration operations. The decision to reduce the temporary traffic control shall be at the discretion of the supervisor. However, work activities shall still be performed with the safety of the motorist and worker in mind. A vehicle-mounted sign, truck-mounted flashing arrow panel, and fleet lighting are devices generally incorporated into the temporary traffic control plan for these operations. A protective vehicle and truck-mounted attenuator should be considered as additional safety measures.

Location of Work

In addition to work duration, work location is also a major factor in determining the temporary traffic control needed for a temporary traffic control zone. As a general rule, the closer the work activity is to traffic, the greater the need for and number of temporary traffic control devices. Typically, the degree of temporary traffic control is based on three locations - work beyond shoulder, work on shoulder, and work within the traveled way.

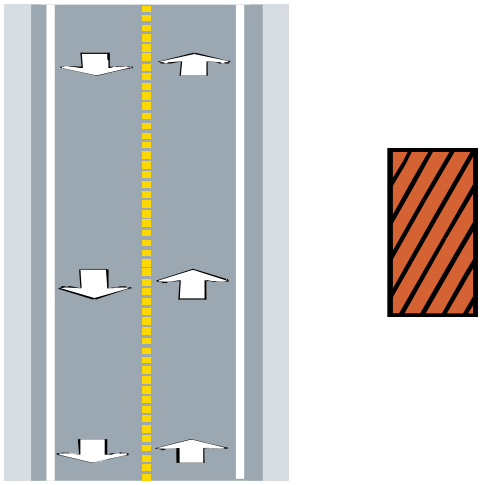
Work beyond shoulder includes any work performed between the edge of the shoulder, the edge of the traveled way where no shoulder exists, to the right-of-way line or within any unimproved median.

Work performed in this area typically requires a minimal amount of temporary traffic control, such as signs and fleet lighting, or even none at all. The amount and type of temporary traffic control depends on the lateral displacement of the work activity and the location and movement of any work vehicle or equipment relative to the edge of the shoulder, or traveled way where no shoulder exists.

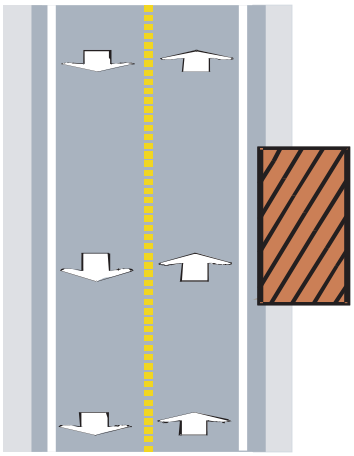
Work on shoulder includes any work performed on the shoulder that does not significantly encroach upon the adjacent driving lane. Where no shoulder exists, this also includes any work performed adjacent to the roadway that encroaches, but not significantly, upon the adjacent driving lane. A significant encroachment means ten feet of driving surface cannot be maintained for traffic.

Work within the traveled way includes any operation requiring a lane closure. Due to the location of the operation, more temporary traffic control devices are required to ensure the safety of both the motorist and the worker. Mobile operations typically require a vehicle-mounted sign, flashing arrow panel, fleet lighting, protective vehicle, and truck-mounted attenuator. Stationary operations usually require the substitution of multiple stationary signs for the single vehicle-mounted sign and the addition of channelizers and flaggers.

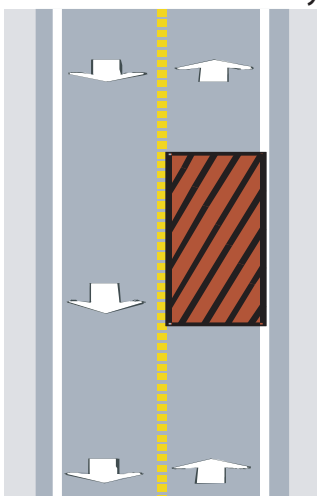
Outside the shoulder



On the shoulder with no encrochment



Within the travel way



Module 4: Transportation Management Plan

The Transportation Management Plan (TMP) consists of strategies to manage the work zone impacts of a project. The TMP may include only a Traffic Control Plan (TCP) on non-significant projects. For projects that have been determined to have a significant impact on the driving public the TMP should include TCP, Transportation Operations (TO), and Public Information (PI) components.

Traffic Control Plan (TCP)

A TCP describes measures to be used to direct road users through a work zone and to provide highway work safety within that work zone. The TCP plan needs to be consistent with MoDOT policies, guidelines and standards, and at minimum shall meet the provisions of Chapter 6 of the Manual on Uniform Traffic Control Devices (MUTCD). The TCP plan shall maintain pre-existing roadside safety hardware at an equivalent or better level of condition than existed prior to project implementation.

Transportation Operations (TO)

The TO component of the TMP identifies strategies that will be used to mitigate impacts of the work zone on the operation and management of the transportation system within the work zone impact area. Typical TO strategies may include, but are not limited to, demand management, corridor/network management, safety management and enforcement, and work zone traffic management. The scope of the TO component will be determined by the project characteristics and the transportation operations and safety strategies. Some examples of TO are capacity, detours, ingress/egress, emergency vehicles, traffic generators, law enforcement, and motorist assist.

Public Information (PI)

The PI component of the TMP communicates strategies to inform affected road users (e.g., the general public, area residents, businesses, and appropriate public and transportation association entities) about the project, the expected work zone impacts of and the changing conditions on the project. The scope of the PI component is determined by the project characteristics and the public information and outreach strategies identified through the use of the traffic management strategy matrix. Public information should be provided through methods best suited for the project and may include, but are not limited to, information on the project characteristics, expected impacts, closure details, commuter alternatives and other traveler information strategies. Some examples of PI are direct mailing, radio, web site, public discussions, news releases, and Portable Changeable Message Signs.

The TMP should be developed and implemented in sustained consultation with all stakeholders (e.g., other transportation agencies, railroad agencies/operators, transit providers, freight movers, utility suppliers, police, fire, emergency medical services, schools, business communities and regional transportation management centers, etc.).

Traffic Management Strategy Matrix

To facilitate the development and continual improvement of the TMP, a traffic management strategy matrix has been developed and should be used throughout all phases of a project, from the preliminary development stage to final construction of a project. The traffic management strategy matrix addresses key components and identifies corresponding strategies to manage the work zone impacts of a project. Thereby assisting in developing the TMP components. Link to the strategy matrix

http://wwwi/intranet/tr/ttc/programs.htm

General Public Information

In addition to the work zone specific Public Information activities, MoDOT provides general work zone information to the public through various outlets including publication of a statewide work zone map and work zone driving safety tips, posting of current work zone locations and conditions to the Internet, promotion of Work Zone Safety Awareness Week, and advertisement of work zone safety-related messages via radio, television, and billboards. Through these efforts, MoDOT positively influences work zone safety and mobility, by helping motorists access information they need to plan their trips and become more work zone conscious.

Module 5: Law Enforcement

The use of law enforcement in an active or passive capacity will be identified initially at the planning stage, but needs to be continually re-evaluated throughout the duration of the maintenance or construction project. Typical situations where law enforcement may be beneficial are speed enforcement, temporary flagging situations, incident management, complex traffic control setups, mobile operations, and changes in traffic control setups.

The presence of law enforcement within the work zone may have a positive or negative impact on traffic flow and safety within a work zone, depending on the placement of the law enforcement officials and how law enforcement officials ticket violators. Law enforcement officials and their vehicles should be located as not to be a hazard to the driving public nor themselves. They should be asked to pull violators over at a pre-designated area, such as beyond the end of the work zone, at a location that will have minimal impact.

When law enforcement is present, you need to continually evaluate the effectiveness of their presence. For example, if their presence starts backing up traffic to where motorist may be placed in an unsafe situation, such as just over a hill or around a curve where inadequate sight distance is provided for approaching vehicles to stop, the law enforcement official should be asked to move to another location where they are not restricting traffic flow or to leave the area when such conditions develop.

Module 6: Traffic Capacity (Hourly Volume Restrictions)

In planning work on highways, it's important to consider traffic volume. Traffic volumes help determine time of work with minimum disruption to traffic and allows you to gage the measures necessary to inform the traveling public or midigate traffic backups when that work can't be done in those specifice time frames. The following are traffic capacities for typical highways.

Interstates and Freeways

Interstates and freeways are high-volume multiple-lane routes divided by medians. These routes carry the largest volumes of traffic, and depending on the number of lanes, can affect thousands of vehicles per hour. By using the appropriate work zone guidelines on these roadways, the biggest work zone improvements can be made. The Highway Capacity Manual provides traffic-capacity information for urban freeway work zones. This information may also be used for rural freeways and interstates.

The most common interstate and freeway work zone situation in Missouri is where one of two lanes are closed in a direction. This condition results in a maximum traffic capacity of 1,240 vehicles per hour per lane. Strategies to reduce effects on the motoring public should be considered when traffic volumes approach 1,000 vehicles per hour per lane.

Where there are three lanes in one direction and one is closed, or where there are four lanes with one or two lanes closed, the open-lane capacity is approximately 1,450 vehicles per hour per lane. Strategies to reduce effects on the motoring public should be considered when traffic volumes approach 75 percent of the restricted capacity, or 1,100 vehicles per hour per open-lane.

Where there are three lanes in one direction and two are closed, the maximum capacity is approximately 960 vehicles per hour per lane and strategies should be considered when traffic volumes approach 750 vehicles per hour per lane.

The greatest traffic reductions per lane occur when the situation is most restricted. For instance, if there are five lanes in one direction and three are closed, the capacity of the two open lanes is 1,320 vehicles per hour per lane. Strategies to reduce effects on the motoring public should be considered when volumes approach 75 percent of the restricted capacity, or 1,000 vehicles per hour per open lane.

Multi-Lane Roadways

Undivided multi-lane roadways also have more than one lane per direction. However, because most do not have medians, they must be treated differently than interstates and freeways. The work-zone capacity of multi-lane roadways is approximately 1,000 vehicles per hour per open lane. Strategies to reduce effects on the motoring public should be considered when volumes approach 80 percent, or 800 vehicles per hour per open lane.

Divided multi-lane roadways that are in rural settings with limited access points should be treated like interstates, while such facilities in urban settings with numerous access points should be treated like undivided multi-lane roadways.

Two-Lane Roadways

Work zones for two-lane roadways need to be reviewed on a case-by-case basis. Although these routes have the lowest traffic volumes, they do not have medians and may have narrower shoulders and more curves than higher-volume routes. Strategies to reduce effects on the motoring public should be considered when volumes from both directions approach 600 vehicles per hour.

The capacities provided above are estimates and may be adjusted based on past experience, lane widths, truck volume, geometrics, lane usage, etc..

Module 7: Travel Time Information

To help alleviate driver frustration with delays through maintenance and construction work zones, Portable Changeable Message Signs (PCMS) or Dynamic Message Signs (DMS) are to be used to inform motorists of travel times. The following provides guidance on their usage.

- On interstate and other major roadway or bridge projects, near real-time travel time will be provided for work zones subject to traffic delays of five (5) minutes or more due to work activity. Delay time will be calculated by the following equation:

Delay Time = T_{wz} - T_p
Where T_{wz} = Time to travel through WZ
T_p = Time to travel through area at posted WZ speed limit

- Travel times will be determined and messages update, as needed, at regular intervals and as conditions change. Possible methods to estimate travel times include: 1) driving the limits of the work zone, 2) establishing times based on predetermined queuing lengths, 3) monitoring travel times of vehicles traveling through the work zone, or 4) automated means.
- Distance to end of work zone, in miles, with estimated travel times, in five-minute increments, will be displayed on a properly delineated PCMS or DMS board. These boards will be located in advance of any potential traffic queue. Additional boards may be used as needed. The recommended display for these messages is:

Work Zone Ends 10 Miles	15-20 Minutes Travel

- Unless travel time is provided through automated means, PCMS and DMS units will display the following recommended messages when workers are not present and traffic delay can be expected.

Work Zone Ends 10 Miles	Expect Delays

- PCMS and DMS units may display meaningful messages when workers are not present, no traffic delay can be expected, and travel time is not provided through automated means.
- It is recommended that the units be capable of being remotely updated via cell phone or other means to make the information more time relevant.

Module 8: Designing for the Driver

There are three basic factors that affect temporary traffic control zones.

- Roadways
- Vehicles
- The driver

Of all three factors, the driver is by far the largest contributor to accidents in temporary traffic control zones. An estimated 85% of all accidents can be attributed to "human error". There are many different factors that can be attributed to "human error". Drivers may be angry, inattentive, in a hurry, careless, under the influence, or even downright nasty. Although we can not control these behaviors, we should anticipate "human error" and prepare for it.

To help reduce some of the problems associated with "human error" an effective temporary traffic control plan addresses the following:

The keys to designing a good plan are as follows:

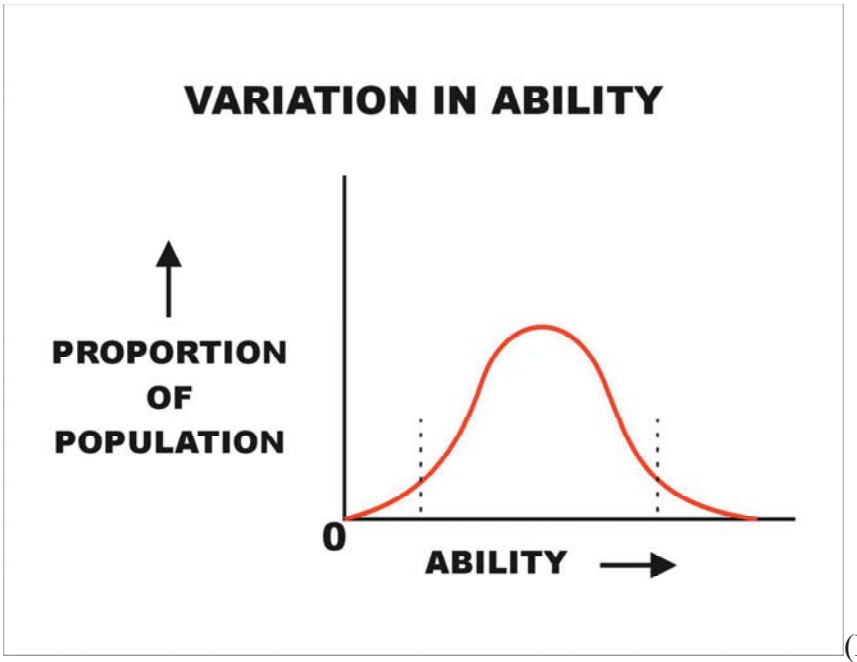
- Consider the users' needs and desires
- Allow adequate time for decisions and response
- Provide "positive guidance"
- Minimize congestion and delays

Consider Users Needs

A temporary traffic control design must anticipate what a driver will do and prepare for it. The design must consider the driver's actions and reactions. The design should meet the driver's expectations, meaning they should readily recognize what they are supposed to do in relation to the temporary traffic control zone. The design should take into consideration the actual user population including age, driving experience, and the users' perceptual ability.

Anticipating the driver's actions is difficult; but, the design should eliminate as much decision making as possible for the driver. Decision making takes time and slows reaction time. In some cases the driver may not know what to do, thereby causing more problems.

So, which driver are we designing for average, typical, or worst? It is best to design for the majority.

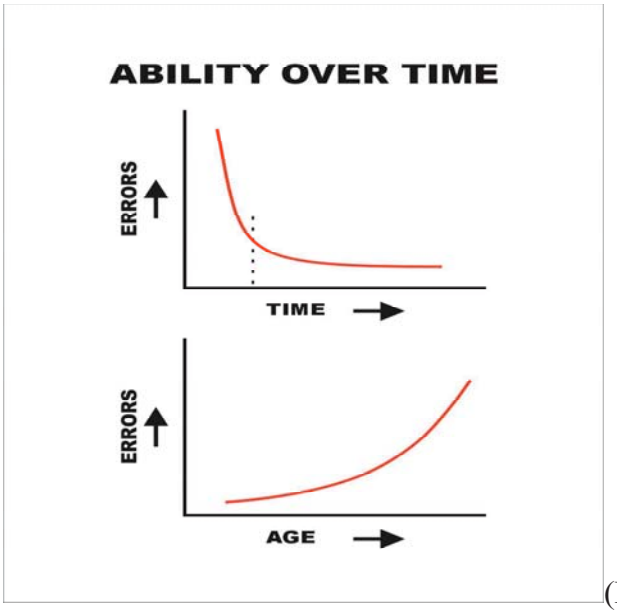


(Fig. A)

This curve is commonly called the "Normal Distribution" curve, or "Bell" curve. It also shows that an approximately same number of drivers have high abilities as do those with low abilities. 68% of the sample lies in the middle part, and represents those with "average" abilities. The percentage of persons in each of the two "tails" amounts to 16% each. So, with the 68% in the "middle" and 16% in the "lower" tail, we design for 84% of the drivers. We round up to 85th percentile.

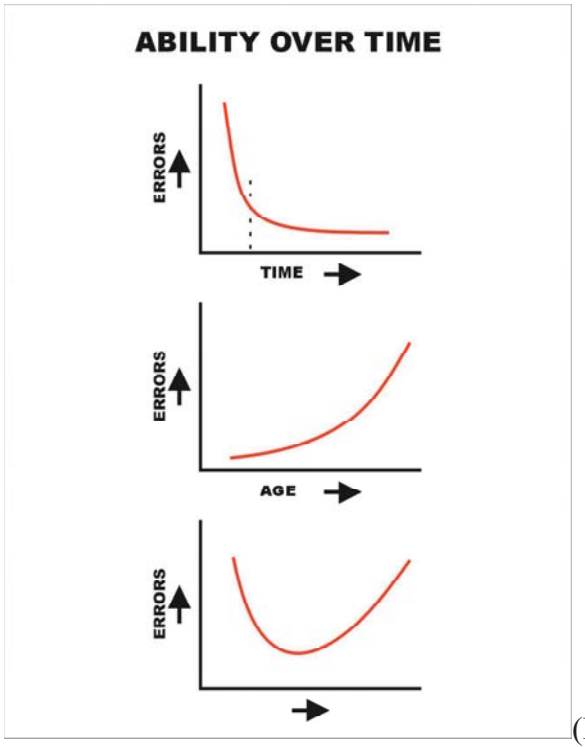
(Fig B)

The left-most point represents the errors committed by inexperienced drivers, including teens. As more experience is gained, the number rapidly decreases. By the age of 31 (15 years of experience) the gaining of experience sharply drops off. After a longer time driving, there seems to be little that the aging driver gains.



(Fig. C)

As a person gets older, their physical and mental faculties start to deteriorate. They are prone to more errors!



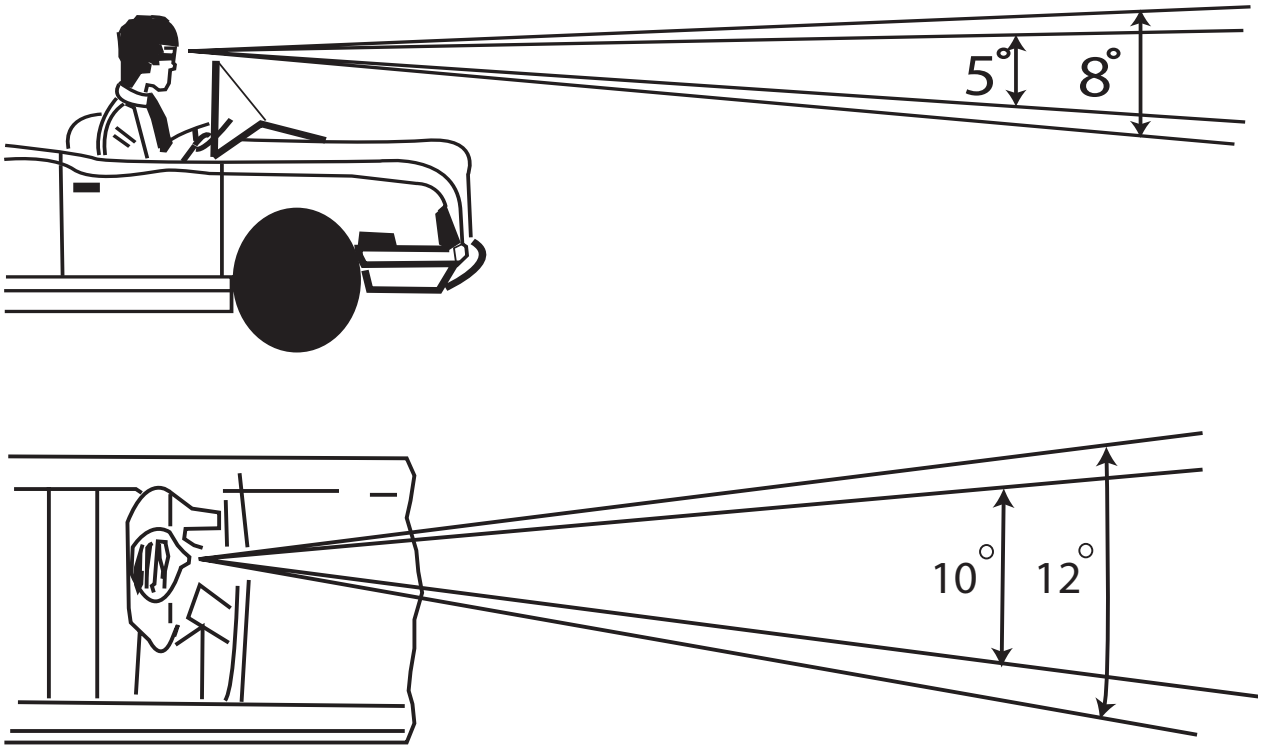
(Fig. D)

Putting the two curves together into a composite reveals special consideration must be given in traffic control for both the young, inexperienced driver, as well as the aging driver. The low point on this curve is our peak ability, when we have enough driving experience and are able to react quickly. That age is around 32-33 years old.

A driver's perceptual ability is the ability to understand what is wanted of them and the ability to react. Drivers acquire most of their information by sight. Therefore, good vision is necessary in order to read signs, markings, and other devices at a long distance. Proper placement of signs and devices are critical. If a sign is too low or too high, most drivers will miss it.

Sight and the cones of vision must be considered when designing a temporary traffic control plan.

Cones of vision



- Peripheral vision = 120-160 degrees
- Satisfactory vision = 20 degrees
- Clear vision = 10 degrees
- Best vision = 3 degrees

This is how people see and take in visual information. As we age, people need more light and time to see things with the same clarity as when they were younger. A 20 year old may identify a sign at 575 feet while a 60 year old may identify the same sign at 280 feet. These distances are regardless of how sharp the vision is. They relate to the amount on light needed to see with the same clarity.

This data clearly shows that as people age their vision deteriorates. After age 20, the amount of light needed to see the same doubles every 13 years.

While vision is one of the most important factors, there are other factors that can affect a driver's abilities: alertness, concentration ability, driving distractions, day or night driving, familiarity with area, general health, age, and experience. These factors, or their combination, can lead to crashes. It is important to recognize them and plan for them when designing the work zone.

Expectations of the driver must also be considered in the temporary traffic control design. Each of us, depending on our driving experience, has developed expectations in driving. violation of these expectations may lead to a mistake with dangerous consequences.

Presentation of something that is familiar to a person can "condition" a person to come to an erroneous conclusion. Where do you expect to find the light switch when you enter a dark room? That is called "conditioning", or training the mind to expect to find the light switch in certain place.

Different people see different things when presented with the same information. Do you see an old woman or a young woman?

Allow Adequate Time for Decision and Response

An effective temporary traffic control plan must be designed with drivers' needs in mind. Decisions require time, so drivers must be warned early enough in advance of the work zone to take proper action.

In order to better design for the driver, it is essential that we understand the driver and how the driver reacts to a situation. We need to look at how the motorist (a human being) perceives, analyzes, makes decisions, and reacts to situations on the roadway; and the time this takes. We call this time the perception-reaction time (PRT).

The PRT in work zones is twice as much as in normal, everyday conditions, between 5 and 7 seconds. Why? Because we are not use to these new conditions, it takes longer to analyze the situation. We are not "conditioned" to these "new" sets of variables.

To estimate the number of feet traveled in one second, multiply the speed in miles per hour by one and a half. So if the speed limit is 60 mph and you add it's half, which is 30, you get approximately 90 feet per second. Keep in mind this a minimum and a best case scenario.

Example: 60 mph = 60 + 30 = 90 fps

At 60 mph a vehicle travels 88 feet in one second. Multiply the speed in miles per hour by 1.47 to obtain the number of feet a vehicle travels in on second.

Example: 60 mph = (60) (1.47) = 88 fps

At 60 mph, assuming a PRT of 5 seconds, a driver will need 440 feet to go through the PRT cycle.

Provide "Positive Guidance"

When designing a temporary traffic control plan, minimize the decisions for the driver and eliminate doubt in the driver's mind. This is accomplished by using standardized traffic control devices, clearly indicating the desired path, and providing clear directions by the proper use and setting of said devices. The visibility should also be considered for day or nighttime operations.

Feet Traveled During the PRT

Speed (mph)	Feet traveled in 2.5 sec.	Feet traveled in 5.0 sec.
25	92	183
35	129	257
45	165	331
55	202	404
60	220	440
65	239	478
75	276	551

The path through the temporary traffic control zone should be obvious. This can be accomplished by using proper signage, quality tapers, and good channelization and delineation.

Minimize Congestion and Delays

What affect does congestion and delays have on the motorist? Generally, they may experience more stress because their trip takes more time. An unstressed driver makes better decisions. Remember the fundamental principles of a temporary traffic control plan. You should make every attempt to minimize congestion and delays.

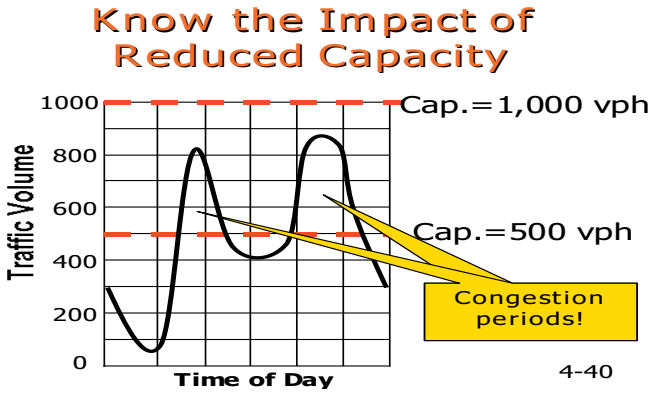
Understanding the characteristics of the roadway will help you determine the optional condition to be created. "Capacity" refers to the amount of vehicles per hour that a roadway can handle. The plan should take into consideration any particular traffic volumes such as vehicles per hour and the average daily traffic. The plan should also take into account any particular traffic movement considerations and hourly variations.

If congestion is highly anticipated, it's a good idea to utilized local media and/or newspapers to notify the public ahead of time and recommend alternate routes.

In this example, capacity of the roadway was 1,000 vehicles per hour before a closure, resulting in no congestion. With the closure, the capacity decreased to 500 vehicles per hour, resulting in two congestion periods.

When designing a temporary traffic control plan always remember to:

1. Be sensitive to the users' needs and desires



2. Allow adequate time for decisions and responses
3. Provide "positive guidance"
4. Minimize congestion and delays

Understanding and considering these factors will result in a more effective temporary traffic control design.

Module 9: Pedestrian/Bicyclist Consideration

Work zones should continue to accommodate the road users who were using a roadway before construction began. Work zones present additional workload not only to drivers of passenger vehicles and heavy trucks, but also to pedestrians, bicyclists, and motorcyclists. In addition to providing well-designed facilities for these other road users, agencies should notify drivers of the presence of these people and vehicles and design the work zone so drivers can see and avoid these users. Accommodation of pedestrians, bicyclists, motorcyclists, and heavy-truck drivers should be planned before work begins. In addition, regular inspection of conditions for these road users should be performed in order to ensure that these users are being accommodated safely.

Roadway sections in work zones open to public travel should be free from surface irregularities and construction debris. Uneven and cluttered surfaces can cause motorcyclists or bicyclists to fall and may present tripping hazards to pedestrians. Hazards include pavement edges, large or deep ruts, metal plates, drainage grates, expansion joints, and pavement or other surfaces with low skid resistance. The travel path should be continuous and hard. Vehicle detectors and pedestrian push buttons on existing roadways should continue to be accessible, or other options provided, during the project.

Additional strategies beyond those briefly discussed in this section are covered in other volumes of the NCHRP Report 500 series:

- Pedestrians (Volume 10)
- Bicycles (forthcoming)
- Motorcycles (Volume 18)
- Disabled (Volume 13)

Pedestrians

The MUTCD should be consulted for information on accommodating pedestrians in work zones and on reducing pedestrian-vehicle conflicts.

Careful consideration should also be given to the needs of pedestrians with disabilities, especially when there is evidence that the regular users of this area include pedestrians with special needs. The level of accessibility of existing pedestrian facilities should be maintained during the work period to the extent practical.

The MUTCD provides guidance on providing accessible facilities in work zones, including consideration of pedestrians with either visual or mobility disabilities. The changes made to a pedestrian's path, due to work zones,

will interrupt the routine of a person with visual disabilities whose route goes through the affected area. Visually impaired pedestrians need clear guidance though the work zone, and this can be provided through detectable barriers and edges on channelizing devices, guide rails, audible warning devices, or even audible spoken messages activated by push buttons.

Pedestrian accommodations include:

- **Pedestrian Paths**: Pedestrian paths should be continuous, smooth, hard, and located out of hazardous areas. Maintaining pedestrian access to adjacent properties throughout construction may be required. While undesirable, it may be necessary for practical reasons to allow for pedestrian travel through the work zone.

If pedestrian travel paths will be obstructed or made more hazardous by ongoing work, the traffic control plan should provide an alternate, safer route. This may be accomplished with:

- ***Existing pathways*:** pedestrians can be directed to use alternate pathways already existing in the work zone. This may include sidewalks on the other side of the street.
- ***Bypasses***: temporary bypass routes can be provided where unobstructed and non-hazardous space is available in the right-of-way. Bypasses may be established in parking lanes or grass buffers in the work zone.
- ***Detours*:** pedestrians can be instructed to use a detour route when it is not possible to use other existing pathways.
- ***Traffic Plans***: When establishing pedestrian traffic plans, the origins and destinations of the pedestrians should be considered, as well as the ideal (typically shortest) routes through the work zone. Access to bus stops and cross walks should be maintained, or temporary relocation of both should be considered. Pedestrians will be using the paths during all lighting and weather conditions; therefore, messages (both visual and audible) should be clear at all times.
- ***Channelization***: Pedestrians should be encouraged to use the safest path and to cross roadways in the appropriate location. One way to accomplish this is through channelization, which can help reduce conflicts with work activities and vehicular traffic. Any devices or barriers used to channelize pedestrian movements should not obstruct the sight distance for motorists. Barriers can also serve as protection from vehicular traffic when the two travel paths are close.
- ***Public education***: Educating pedestrians on appropriate behaviors when walking through work zones, as well as on the meanings of traffic control devices, can contribute to their safe use of pedestrian facilities in work zones.

Bicyclists

Consideration should be given to the needs of bicyclists as work zones are being designed, set up, and as work is being performed. Pavement edge drop-offs or longitudinal joints can present hazards to bicyclists, as can surface debris and low-traction areas.

Warning signs increase driver awareness of bicycles in work zones. Standard MUTCD bicycle warning signs should be used to alert drivers to the presence of bicyclists.

Module 10: Nighttime Work Zones

With increased volumes of traffic on the highway system, nighttime road construction has become a strategy that MoDOT uses to minimize traffic delays. When working at night there are several challenges that require attention. First, nighttime work brings a reduction in visibility for workers and drivers. Second, nighttime work may negatively impact the surrounding community with excessive noise and light. Third, construction personnel and the drivers are more likely to suffer fatigue during the night rather than during the day. These challenges make it imperative that a safe work zone and lighting plan is designed to address nighttime challenges.

The decision to work at night should be based on several factors including:

1. Traffic Characteristics
2. Construction Schedule
3. Impact to Communities and Businesses
4. Other Items

Advantages and Disadvantages of Nighttime Work Zones Include:

Typical Advantages

- Reduced traffic congestion due to low volumes
- Less involvement with business activity
- Allows for restoration of normal traffic patterns during the day
- Less traffic is exposed to hazards related to driving through the work zone
- Workers are exposed to fewer passing vehicles
- Road user costs may be lower
- Work periods may be longer
- Traffic control options may be more feasible
- Nighttime work may allow for better productivity, easier material delivery, and reduced equipment costs
- Air pollution and fuel consumption is reduced
- Lower nighttime temperatures, during the normal construction season, improves working conditions and makes for better material handling

Typical Disadvantages

- Reduced visibility
- Greater probability for fatigued and impaired drivers
- Impact to surrounding communities
- Unit construction costs are generally higher
- Nighttime traffic speeds will tend to be higher because drivers are less likely to expect to encounter work zones
- A greater proportion of the vehicles encountered at night will include alcohol or drug - impaired drivers
- Local residents may experience noise and light pollution, as well as vibration disturbances, during night construction
- Reduced construction season

Below is a list of factors to take into consideration when designing and operating nighttime work zone.

Apparel

- For nighttime activity, safety apparel meeting the requirements of ANSI/ISEA 107-2004 Standard Performance for Class 3 Risk Exposure shall be worn by all MoDOT personnel and should be considered by all other entities. MoDOT Consists of class 2 shirts/vests and class E pants.
- The background material shall be either fluorescent orange-red or fluorescent yellow-green with retroreflective accents of either orange, yellow, white, silver, yellow-green, or fluorescent version of these colors which are visible at a minimum distance of 1000 ft.

Lighting

When nighttime work is being performed, lighting should be used to illuminate the work area, equipment crossings, and other areas. The amount and location of light provided is base on the type and detail of work being performed and the degree of difficulty in navigating the work zone.

Recommended illumination levels are as follows:

- ***Category 1*** - 5 foot-candles – e.g. excavation, sweeping, movement.
  - Low Accuracy
  - Slow-Moving Equipment
  - Large Objects
  - Setup and Removal of Traffic Control Devices
  - Flagger Stations (required)

- ***Category 2*** - 10 foot-candles – e.g. paving, milling, concrete work.
  - Work around Construction Equipment
  - Higher Accuracy
  - Safety Concerns
- ***Category 3*** - 20 foot-candles – e.g. crack filling, pothole filling, signalization.
  - Pavement Crack/Filling
  - Patching
  - Electrical Work

This lighting shall not produce a disabling glare condition for approaching road users, flaggers, or workers.

- Factors impacting glare:
  - Distance between driver and luminaires
  - Height of luminaires
  - Direction the luminaires are aimed
- To minimize glare:
  - Locate luminaires so that axis of candlepower is located away from the line of sight of motorists
  - Luminaires should be aimed so the center of the beam axis is no greater than 60 degrees above vertical plane.
  - Tower-mounted luminaires should be aimed either perpendicular or parallel to the roadway.

Traffic Control

Nighttime work does not require changes in traffic control setup or in the design of the devices. However, enhancements to traffic control may be considered and flashing arrow panels and changeable message signs shall be dimmed when working at night. Traffic control enhancements include tighter channelizer spacing, larger devices, addition of warning lights, longer transition areas, etc.

Module 11: Work Zone Speed Limits

MoDOT's goal is to assure appropriate temporary speed limits or advisory speed placards as applicable, are set for conditions within the temporary traffic control zone and ensure that temporary or advisory speeds are in affect only for the time and vicinity of the condition.

Reduced speed zoning (lowering the regulatory speed limit) should be avoided as much as practical because drivers will reduce their speeds only if they clearly perceive a need to do so. Research has demonstrated that large reductions in the speed limit increase speed variance and the potential for crashes. Smaller reductions in the speed limit of up to 10 mph cause smaller changes in speed variance and lessen the potential for increased crashes.

Factors to consider when posting a reduced speed limit in a work zone include:

- Protected or Unprotected work area (Shielded by a crashworthy device such as traffic barrier, guard rail, impact attenuators, etc.)
- Posted speed limit prior to beginning the work activity
- Location of workers, equipment, and material (distance from edge of thru pavement)
- Type of facility e.g. multi-lane or two-lane/two-way
- Flagging operations

The primary tool used in establishing temporary speed limits is the Work Zone Speed Limit Chart, Standard Drawing 606.10.

Location of Activity (i.e. workers, equipment, material) or Type of Operation	**Posted Speed Greater than 55 MPH**		**Posted Speed Less than or Equal to 55 MPH**	
	Protected	**unprotected**	**Protected**	**Unprotected**
Multilane Facility				
Beyond 30' of Eqtp	Posted	Posted	Posted	Posted
10' to 30' of Eqtp	Posted	Posted-10	Posted	Posted
Within 10' of Eqtp	Posted	Posted-10	Posted	Posted-10
In Traffic Lane	Posted-10	Posted-20 (min. 45 mph.)	Posted-10	Posted-10
Head-to-Head	Posted-10	Posted-10	Posted-10	Posted-10
2-Lane / 2-Way Operation				
Beyond 30' of Eqtp	Posted	Posted	Posted	Posted
10' to 30' of Eqtp	Posted	Posted-10 (min. 45 mph.)	Posted	Posted
Within 10' of Eqtp	Posted	Posted-20 (min. 45 mph.)	Posted	Posted-10
1 Lane / 2 Way Operation	35 mph *			
Temporary Closure within Flagger	35 mph *			

The purpose of the chart is to promote uniformity of temporary speed limits and to assure temporary speed limits are based on current conditions.

Note: The values noted in the drawing are the maximum allowed speed reductions.

To minimize the length of the reduced speed area, the speed limit will be posted as follows:

1. Install speed limit signs required for physical restrictions in the advance warning area.
2. Install advisory speed plaques as necessary on the advance warning signs.
3. Install the speed limit signs required for work being performed immediately prior to the area where work is being performed.
4. Install another speed limit sign reflecting the normal speed limit immediately beyond where work is being performed.
5. Move the signs noted in 3 and 4 as the work progresses down the road.

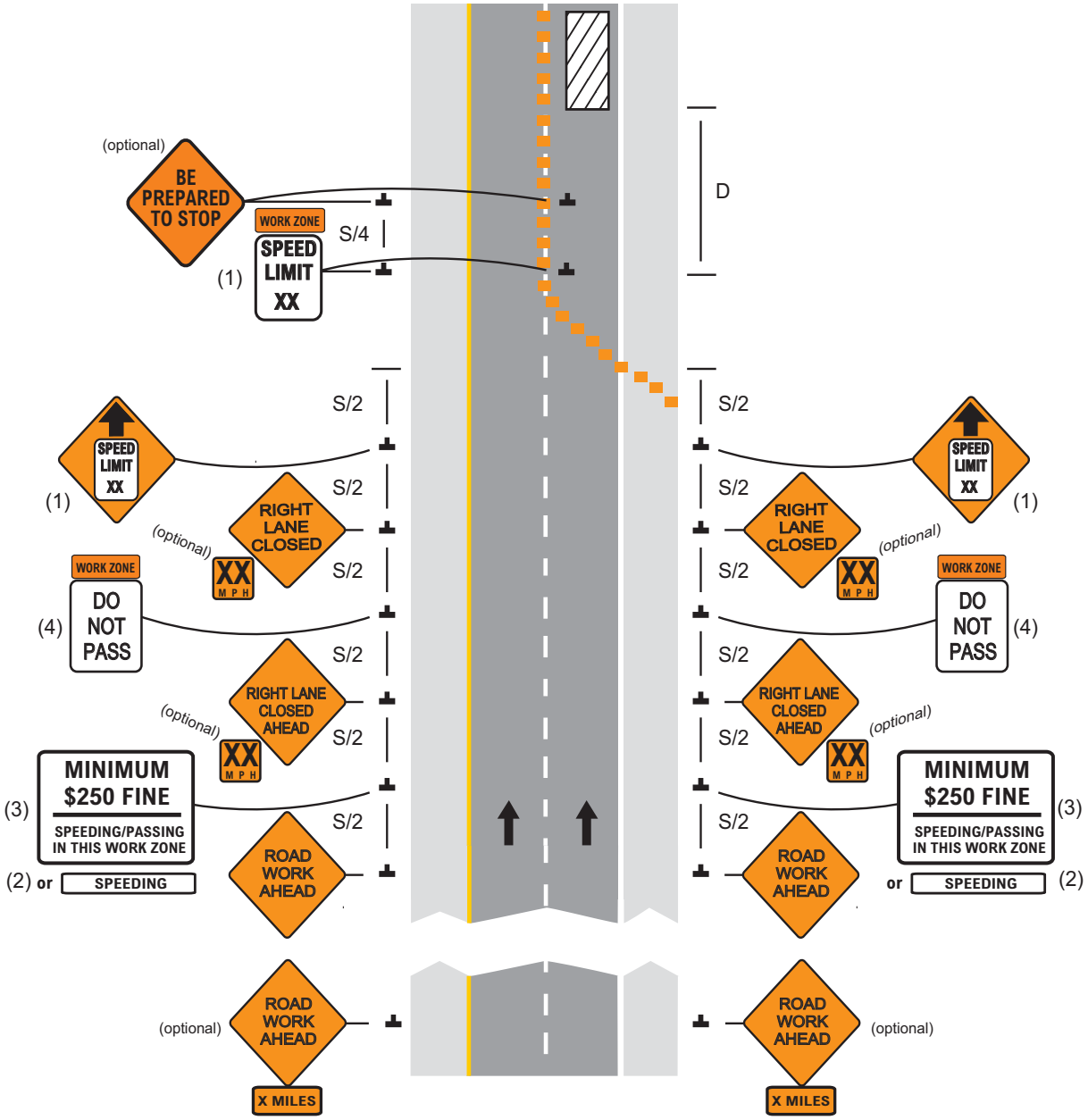
Speed Limits on Divided Highway

Notes:

Work Zone Speed Limit signs posted at S/2 $\leq$ D $\leq$ 1/2 mile for work areas and conditions less than 1/2 mile in length and work areas and/or conditions separated by more than 1/2 mile.

Work Zone Speed Limit signs posted at 1/2 mile intervals for work areas and conditions greater than 1/2 mile in length and work areas or condition separated by less than 1/2 mile.

Work Zone Speed Limit and BE PREPARED TO STOP signs **shall** not be located in advance warning of transition areas. Signs to be removed when workers or condition is no longer present.



(1) Signs used with work zone speed limit reduction.

(1), (2), (3) Signs used with work zone speed limit reduction and speeding fine provision.

(1), (3), (4) Signs used with work zone speed limit reduction and speeding and passing fine provisions.

11/01/05

Module 12: Temporary Traffic Control Devices

All temporary traffic control devices (TTCD) shall be certified, constructed, and installed in accordance with standard specifications, standard plans, the traffic control plan, manufacturers' recommendations, and NCHRP 350 crash test requirements, as applicable. Devices not meeting the above referenced requirements shall be replaced, repaired, or removed.

Due to natural or vehicle-induced-wind, ballasting may be required to keep the TTCD in the proper locations. Ballasts shall be selected and installed so the ballast itself does not become a hazard if impacted by a vehicle. Many TTCD have manufacturer's recommendations for ballasting.

Signs

Typical work zone signage includes warning, regulatory, guide, "Drive Smart", "Point of Presence", and "Work Zone Fine" signs.

Regulatory signs give notice of traffic laws or regulations and indicate applicability of legal requirements that would not be readily apparent. These signs are generally rectangular in shape and black on white in color. A noteworthy exception to this rule is STOP, YIELD, DO NOT ENTER, and WRONG WAY signs.

Warning signs give notice to situations or conditions that might not be readily apparent. These signs are generally 48" x 48" diamond-shaped signs and, when used in a temporary traffic control zone, black on fluorescent orange in color.

Guide signs indicate route designations, destinations, directions, distances, services, points of interest, or other geographical, recreational, or cultural information. These signs come in different shapes and colors depending upon type and purpose of the signing. However, special guide signs relating to the conditions of the temporary traffic control zone (e.g. RAMP OPEN, DETOUR, ROAD WORK NEXT XX MILES, etc.) are typically rectangular in shape and black on fluorescent orange in color.

Note: Different sign sizes and types of retroreflective sheeting may be used by entities other than MoDOT or its contractors.

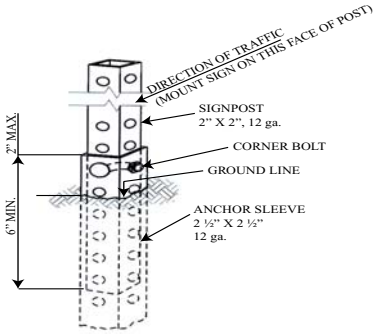
Signs may be installed per the following table:

Drawing 616.10

Type	Sign Support	Sign Substrate	Minimum Mounting Height (3)	Usage Liminations	Comments
Post	Perforated Square Steel Tube U-Channel Wood	Rigid	5' Rural Undivided Highways 7' Rural Divided Highways 7' Urban Highways	None	Posts shall be free of any bracing and extend no further above the sign except as needed for warning light attachment. See standard plan 903.03 for post installation details. Galvanization of posts will not be required.
Type 1 Portable	Skid Fold-up Stand	Rigid	5' Rural Undivided Highways 7' Rural Divided Highways 7' Urban Highways	Permitted only where post mounting is not feasible	Systems shall comply with crash test requirements of NCHRP 350 Test Level 3 and may be placed adjacent to or within the roadway provided a minimum lateal clearance of 3 feet. Measured horizontally from the edge of the sign to the edge of designated traveled way, is maintained.
Type 2 Portable	Easel Fold-up Stand Self-driving Post Type III Moveable Barricade Skid	Flexible Rigid	12" (4)	Permitted only for installation up to 3 days (5). Where signs are obscured by other objects (i.e. traffic control devices. Parked vehicles, barrier, vegetation, etc.) or installed on multiland undivided facilities or multiland divided facilities with 3 or more lanes in one direction. Mounting heights shall be as specified for post-mounted signs	Systems shall comply with crash test requirements of NCHRP 350 Test Level 3 and may be placed adjacent to or within roadway provided a minimum lateral clearance of 3 feet. Measured horizontally from the edge of the sign to the edge of the designated traveled way, is maintained.
Barrier	Concrete Traffic Barrier Guardrail	Flexible Rigid	5' Rural Undivided Highways 7' Rural Divided Highways 7' Urban Highways	Permitted only where longitudinal barrier is present.	System shall provide positive connection to the barrier and minimize potential for vehicle snagging.
Vehicle	Pavement Marking Equipment Pilot Car Protective Vehicle	Flexible Rigid	48"	Permitted only in pilot car or moving operations.	
(3)	Measured from the bottom of the sign to the near edge of the pavement.				
(4)	Mounting heights for critical regulatory and guide signs (e.g., stop, yield, do not enter, wrong way, one way, and gore exit) shall be as specified for post-mounted signs.				
(5)	Signs mounted on Type III barricades, gore exit sign, and signs for crosswalk/sidewalk closures may be left in place for more than 3 days.				

All sign support systems shall comply with crash test requirements of NCHRP 350 test level 3 except for those mounted on barriers or vehicles. When post mounting signs, the appropriate number of posts for the corresponding sign area is critical. Post splices shall be positioned entirely below or above 18-inches, not to exceed 60-inches, above the ground line.

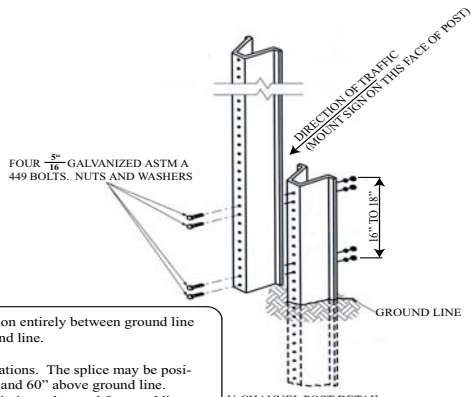
Splice Drawing 903.03



PERFORATED SQUARE STEEL TUBE POST DETAIL

The signpost is attached to the anchor sleve with the corner bolt per manufacturer's specification.

In temporary installations, a splice may be positioned entirely between 18" and 60" above ground line to accommodate readily available stock. The splice shall consist of a 12 inch piece of 1 ¾ inch tube, inserted 6" into both the upper and lower signpost sections and corner-bolted at both ends.



U-CHANNEL POST DETAIL

Spice shall be position entirely between ground line and 18" above ground line.

In temporary installations. The splice may be positioned between 18" and 60" above ground line. Placed to entirely eliminate the need for an additional splice when reaily available stock is used.

Only one splice will be allowed per post.

Use of splice is optional.

Drivers are not use to a change in their daily driving patterns, so care must be taken when changing traffic patterns. Signs should be located as to provide the drivers enough reaction time to read, comprehend, and respond accordingly. Signs should be located so they aren't obscured by other signs, trees, grass, vehicles, etc.

Warning lights may be used to enhance signs, but the light shall not obscure the sign face and the battery pack, if separate from the light unit, shall be positioned no higher than 18-inches above the ground line.

Barricades

Barricades consist of one, two, or three horizontal panels with appropriate markings mounted on a portable support system used to control traffic by closing, restricting, or delineating all or a portion of the right of way.

Only Type 3 barricades (three panel) are used in MoDOT applications. One Type 3 barricade is required for each 8 feet of closed pavement, including shoulders. For example, a typical roadway width of two, 12-foot lanes with no shoulders requires 3 barricades.

Signs and/or lights may be attached or mounted to the barricade provided they are lightweight in design (3.3 or less). Signs or lights not meeting this criteria shall be installed on a separate crashworthy mounting located 7-10 feet behind the barricade.

Barricades shall be marked appropriately with right or left markings reflecting the intended direction of travel. Where traffic is to pass to the left, the marking shall be down and to the left. Where traffic is to pass to the right, the marking shall be down and to the right. Where traffic may pass either to the left or right, the marking shall be down and to the sides of the barricade array. Where traffic may not pass either to the left or right, the marking shall be down and to the middle of the barricade array.

Channelizing Devices

Channelizing devices are commonly used to delineate the traffic path through a work zone. Channelizers typically used in MoDOT applications include the following:

- ***Trim-line*** – 42" tall, conical shaped orange devices with orange and white retroreflective bands used in all types of operations.
- ***Direction Indicator Barricades*** – 36" tall x 24" wide device with two panels. The 12" tall top panel consists of a black on retroreflective orange arrow. The 8" tall bottom panel consists of alternating retroreflective orange and white stripes at a 45 degree angle. They may be used to provide better guidance through merge tapers.
- ***Vertical Panels*** - 36" tall x 12" wide device with orange and white retroreflective stripes at a 45 degree angle. They may be used to provide better guidance through longitudinal sections.
- ***Drum-like*** – 36" tall, cylindrical shaped orange devices with orange and white retroreflective bands used in merge tapers and longitudinal sections where greater target area is needed and their size is not a hindrance to traffic (e.g., intersections and ramp areas).
- ***Cones*** – 28" tall, conical shaped orange devices used in short duration and moving operations. bands used in merge tapers and longitudinal sections where greater target area is needed and their size is not a hindrance to traffic (e.g., intersections and ramp areas).
- ***Cones*** – 28" tall, conical shaped orange devices used in short duration and moving operations.
- ***Tubular Markers*** - 24" tall orange tubes with white retroreflective bands used to divide traffic in temporary two-lane, two-way traffic situations.

Note : Type I and Type II barricades may be used for channelizing purposes by entities other than MoDOT or its contractors.

Warning Lights

In certain situations it may be desirable or necessary to supplement traffic control devices with warning lights. These devices consist of a self contained unit that emits a yellow light in either a steady burn or flashing mode. A description of the types of warning lights is as follows:

- ***Type A*** - Low intensity flashing lights capable of being visible from a distance of 3,000 ft. on a clear night. These units may be used on channelizers to warn of an unexpected, isolated hazard. This device should not be used in shifts, tapers or long runs of channelizing devices.
- ***Type B*** - High intensity flashing lights capable of being visible from a distance of 1,000 ft. on a sunny day with the sun directly on or behind the device. These units may be used on advance warning signs or other devices when geometrics, traffic volumes or other conditions warrant increased motorist attention.
- ***Type C*** - Steady-burn lights capable of being visible from a distance of 3,000 ft. on a clear night. These units may be used on channelizers to delineate traffic in shifts, tapers, diversions, curves, etc. in the work area at night. When used on curves, these units shall only be placed on the channelizers delineating the outside of the curve.

Temporary Concrete Traffic Barrier

Temporary concrete traffic barrier is a physical device used to prevent vehicles from entering the work area or to separate temporary two-lane, two-way traffic situations on normally divided highways. The use of temporary concrete traffic barrier in lieu of standard temporary traffic control measures is based on engineering judgment. However, temporary concrete traffic barrier is required on bridge rehabilitation jobs with bridge rail replacement and/or bridge deck replacement, and should be considered for any other type of long-term bridge repair work.

In general, the preferred installation method for temporary concrete traffic barrier is free-standing, which requires a minimum buffer area of 2 feet behind the barrier to allow for lateral deflection in both work areas and lane separation situations. When free-standing installations are used on bridge decks, a buffer area of 4 feet is required. Concrete traffic barrier may be placed 6 inches from the edge of bridge decks if tie-down straps are used, however, a buffer area of 3 feet must be maintained. On bridge decks where lateral deflection cannot be tolerated, the barriers shall be bolted through the bridge deck. A proper transition from free-standing barrier to barrier with anchor bolts shall be installed on bridge decks. The method of installation on bridge decks is determined by MoDOT's Bridge Division and shown on the bridge plans.

When a temporary concrete traffic barrier has been displaced from its original location due to vehicle impact or other incidents the barrier shall be returned to its original position and pinned together, as originally designed. When the barrier cannot be realigned, sections must be added to provide a 75 foot overlap or the barrier must be anchored. Anchoring is achieved by pinning the barrier into the pavement or by drilling the overlapping barrier sections together with steel rods. Anchoring the barrier into the pavement is not recommended unless that segment of pavement is planned to be replaced or will not be part of the final traveled way. Care must be taken when drilling barrier to prevent damaging reinforcement steel. If any reinforcement steel is damaged by drilling, the barrier cannot be used except when barrier sections are overlapped and secured together.

Appropriate channelizing devices and pavement marking are always used in front of barrier tapers for lane closures, shoulder closures, and transition areas for temporary bypasses or connections. Wherever practical, a lateral buffer space should be provided between the edge of the driving lane and the barrier, and a longitudinal buffer space should be provided between the channelizer taper and the barrier taper.

Temporary Concrete Traffic Barrier End Treatments

Exposed temporary concrete traffic barrier ends present a safety concern and should be treated in one of the following methods:

- ***Barrier Flare*** - The barrier run is flared at an 8:1 ratio from the shoulder point to the limits of the clear zone. Where the existing shoulder slope or median slope is steeper than 6:1, temporary grading is provided or other end treatments are needed. The Roadside Design Guide contains recommended barrier placement in non-level medians. These guidelines also apply to outside shoulders.
- ***Barrier Height Transition*** - A barrier height transition is designed to redirect traffic away from the blunt end of the barrier. A barrier height transition may be installed, in lieu of barrier flare, on the exposed end of the barrier where the normal posted speed on an existing facility, or the design speed of a temporary facility, is 35 mph or less.
- ***Crash Cushion*** - Crash cushions are designed to absorb energy of an impacting vehicle and reduce the force on a passenger to an acceptable level. An approved crash cushion is installed on the exposed end of the barrier when the normal posted speed on an existing facility, or the design speed of a temporary facility, is greater than 35 mph. A crash cushion is required on the upstream end for divided facilities, and on both ends for all two-way facilities.

Crash cushions consist of the following devices:

- ***Impact Attenuators (Sand Barrels)*** - This system consists of a group of freestanding sand barrels. Each barrel is designed with a specific weight of sand to absorb the energy of an errant vehicle. Sand barrels are used when sufficient length and width is available for their placement. Care should be taken to ensure the barrel array is properly installed with the proper number of barrels, weights, spacing and alignment to perform properly. The barrel array shall be placed 2 feet from the obstruction and flared at 5 degrees towards oncoming traffic with individual units and separated from each other by 6 inches.
- ***Proprietary Crash Cushions*** - Units, such as the Quadguard-CZ and the ADIEM II, may be used when sufficient length or width is not available for sand barrels, in high impact areas, or where numerous deployments are required. These types of crash cushions require a paved surface matching the horizontal and vertical slopes on which the barriers are placed, and are installed parallel to the direction of traffic. Design details, recommended uses and drawings of these devices can be obtained from the MoDOT web site.

Truck-Mounted Attenuators

MoDOT is actively working to have all new NCHRP 350 TMAs on high-volume routes prior to 2008. NCHRP 230 TMAs may continue to be used on lower volume and lower speed routes.

The TMA should be positioned at least 150 feet in the advance warning area of the workplace and observant to all surrounding conditions. The wheels should be aligned with the traffic the wheels should be aligned with traffic.

Seat belt usage is mandatory in a MoDOT owned or leased vehicles. It is extremely important that the driver of a TMA not only wears his/her seat belt, but also must have it adjusted properly.

Highway Type	Operation Location and Duration		
	In Lane		On Shoulders and Ramps and at Intersections
	Mobile	Stationary	
Two-Lane Undivided	Recommended	Recommended	Recommended
Multi-lane Undivided	Required	Recommended	Recommended
Multi-lane Divided	Required	Required	Recommended

Work Zone Lighting

Work zone lighting provides illumination portion of the roadway so work activities can be safely and effectively performed or to highlight areas requiring increased driver attention at night. This is accomplished through work area lighting and overhead lighting respectively.

Work area lighting enhances workers' safety and quality of work performed during nighttime operations by illuminating the work area to a level at which workers can adequately see what they are doing. A minimum of 5 foot-candles is recommended for this type of lighting. This type of lighting may be provided by portable light towers, balloon lighting, or lights attached to equipment. Refer to Module 10 for additional information on lighting levels and installation recommendations.

Overhead lighting illuminates specific areas significant to traffic guidance within the work zone during nighttime hours. This type of lighting is required at flagger stations in operation at night and may be considered at gore areas, transitions, ingress and egress areas, equipment crossings, intersections, and temporary signals. A minimum of 0.6 foot-candles is required for this type of lighting. This type of lighting may be provided by a portable light tower or post-mounted light. Refer to Module 10 for installation recommendations.

Note: When a project involves stationary operations exceeding 15 continuous days, such as a bridge replacement, interchange, or intersection work that occurs at night, temporary fixed lighting should be considered in lieu of work zone lighting. Temporary fixed lighting should also be considered for islands; temporary bypasses; crossovers and connections; and areas of potential conflict, such as temporary ramps, intersections, and one-lane, two-way traffic operations that are in place for more than 15 continuous days. These conditions may require lighting even though the work may not be conducted at night. This type of lighting, while more difficult to design and install, provides more uniform light distribution; thereby, enabling motorists to better navigate the work zone at night.

Flagger Control

Flagger control should be used to control traffic during one-lane, two-way operations when two-lane, two-way operations will be restored during non-working hours and at equipment crossings. Flagger control should be limited to the shortest distance possible, keeping in mind that flaggers should never be more than one mile from the flagger symbol sign.

On routes with AADTs of 500 or less, a single flagger may be used provided the work zone is less than 500 feet in length, the flagger can see 1,000 feet in each direction, and there is an adequate escape route available.

Flaggers shall be outfitted in proper PPEs, positioned to be visible to oncoming traffic, follow appropriate procedures, and for nighttime work, be provided with overhead lighting.

Pilot vehicles may be used to supplement flaggers. Consideration for use should be based on traffic volume, length of lane closure, geometrics, number of intersecting roads, and availability of turn around locations.

Automated Flagging Assistance Devices (AFAD) may be used in lieu of human flaggers in some situations. The deployment needs to be evaluated on a case by case basis. Some factors to consider include the length, duration and type of operation, traffic volumes, and geometrics. Note: Use of this device requires additional signage specific to the type of AFAD deployed.

Traffic Signal Control

Traffic signal control is accomplished through the deployment of portable traffic signals or the installation of temporary traffic signals. Either method may be used for work on two-lane roadways when two-lane, two-way operations will not be restored during non-working hours.

For locations requiring three or more phase signal operation, temporary traffic signals should be used and designed to meet the traffic control needs at the location. These are typically pre-timed, wood pole span, wire installations; however, semi-actuated or fully-actuated control may be considered based on conditions. The traffic control plan should include proposed pole and signal controller locations, type of signal heads, signal phasing, signing, and necessary pavement marking revisions.

Lighting is provided for any portable traffic signal deployment or temporary traffic signal installation. At each portable traffic signal location, approved overhead lighting providing an average maintained intensity of 0.6 foot-candles is required. A 150-watt luminaire mounted at 30 feet is required on each approach for temporary traffic signals.

Flashing Arrow Panel

Flashing arrow panels are intended to provide additional warning and directional information to assist in traffic movement through or around a work zone. These truck or trailer-mounted units are operated in one of three modes - arrow, double arrow, or four-corner caution.

The arrow and double arrow modes are used for stationary or moving lane closures on multilane roads where traffic may pass to one side or both sides, respectively. In stationary operations, the flashing arrow panel should be placed on the shoulder at the start of the lane closure taper or, where space does not allow, within the closed lane behind the taper. In moving operations the unit is placed within the closed lane.

Note: In channelized operations, additional units located downstream of the taper area shall display the caution mode.

The caution mode is used for shoulder work, blocking the shoulder, work within the lane where the lane is not closed, and lane closures on two-lane undivided highways.

Flashing arrow panels should maintain a 7-foot mounting height and a 3-foot offset from the traveled way. Care should be taken to ensure the units are sighted and aligned with approaching traffic and dimmed at night to provide maximum visibility.

Portable Changeable Message Signs

A Portable Changeable Message Sign (PCMS) is a traffic control device that is capable of displaying a variety of messages to inform motorists of unusual driving conditions. Every phase of the message is usually limited to three lines with eight characters per line. A PCMS is housed on a trailer or truck bed and can be deployed quickly to meet the temporary requirements frequently found in work zones or incident areas.

The primary purpose of a PCMS is to advise motorists of unexpected conditions. Some typical applications include the following:

- When the speed of vehicular traffic is expected to drop substantially;
- When significant queuing and delays are expected;
- When adverse environmental conditions are present;
- When there are changes in alignment or surface conditions;
- When advance notice of ramp, lane, or roadway closures is needed;

- When crash or incident management is needed; and/or;
- When changes in the road user pattern occur (this includes expected reopening of existing closed lanes).

They can also be used for special events and to notify motorists of future construction or events. MoDOT's policy for PCMS indicates the priority of types of messages.

A PCMS can be an effective temporary traffic control device when used appropriately. By its very nature, it draws the attention of the motorist; however, this effect can be diminished if this device is overused. The PCMS should not replace standard signing and should not be used if standard traffic control devices adequately provide the information the motorist needs to travel safely.

PCMS's should be placed in advance of the advance warning area and should be positioned and aligned to provide maximum legibility and safety. The PCMS should be visible from at least ½ mile and legible from a minimum of 650 feet. The bottom of the sign shall be a minimum of 7 feet above the roadway. The PCMS should be located off to the right of any usable portion of the roadway. Where field conditions do not allow this position, the sign may be located on the outside shoulder of the roadway; or, within the median where field conditions do not allow for deployment on the outside shoulder. A minimum lateral clearance of 3 feet, measured horizontally from the edge of the sign to the edge of the traveled way, is recommended. The PCMS should be placed on level ground and aligned three degrees toward the roadway from the perpendicular edge of the roadway to reduce glare. Care should be taken to not place the PCMS so far off the roadway that the PCMS is not in the motorist's cone of vision long enough to read the message.

Factors that change the motorist's cone of vision include:

- Distance the PCMS is placed from the side of the road
- Number of lanes
- Roadway curvature

A minimum of 5 channelizers with a spacing of 20 feet should be used if the PCMS cannot be protected by a physical barrier.

When a PCMS is not being used to display a work zone related message, the board should be turned parallel to traffic or removed.

The brightness of PCMS's should be adjusted to under varying light conditions to maintain legibility. PCMS are virtually unreadable at night if they are not dimmed.

Messages displayed shall convey pertinent information that assists motorists in their driving decisions. Messages shall be conveyed in a standard, non-confusing manner that allows drivers to both perceive and react to the information given in a timely fashion. PCMS shall not be used to convey the same message for an extended period of time when that message could be conveyed with a conventional guide sign, regulatory sign, or warning sign. Each message shall consist of either one or two phases. A phase shall consist of up to three lines of eight characters per line. Techniques such as fading, exploding, dissolving, moving, or scrolling text or symbols should not be used. The entire message cycle should be readable to traffic at least twice while traveling at the posted speed.

Messages should take the following into consideration:

- Each phase should convey a single thought
- If the message can be displayed in one phase, the top line should present the problem, the center line should present the location or distance ahead, and the bottom line should present the recommended driver action.
- The message should be as brief as possible.
- When a message is longer than two phases, additional PCMS's should be used.
- When abbreviations are used, they should be easily understood.

The following are examples of pertinent messages which may be displayed on PCMS:

1. Road paving ahead
2. Road under repair
3. Concrete repairs ahead
4. Bridge under repair
5. Drainage work ahead
6. Workers on roadway
7. Use left/right lane
8. Work zone ends xx miles
9. xx minutes travel
10. Expect delays
11. Crash ahead
12. All lanes blocked
13. Crash at xxx mm
14. Delay of xx hour(s) possible

The following table contains the most common abbreviations used in PCMS messages:

Word	Abbreviation	Word	Abbreviation
Alternate	ALT	Minor	MNR
Avenue	AVE	Normal	NORM
Boulevard	BLVD	North	N
Cannot	CANT	Northbound	NB
Center	CNTR	Parking	PKING
Do Not	DON'T	Right	RHT
East	E	Road	RD
Eastbound	EB	Service	SERV
Emergency	EMER	Shoulder	SHLDR
Entrance	ENT	Slippery	SLIP
Enter	ENT	South	S
Expressway	EXPWY	Southbound	SB
Freeway	FRWY	Speed	SPD

Hazardous Material	HAZMAT	Street	ST
High-Occupancy Vehicle	HOV	Temporary	TEMP
Hour(s)	HR	Traffic	TRAF
Information	INFO	Vehicle	VEH
It Is	ITS	Warning	WARN
Junction	JCT	West	W
Lane	LN	Westbound	WB
Left	LFT	Will Not	WONT
Maintenance	MAINT	Miles	MI
Major	MAJ		

Abbreviations in the following table may be used only when the prompt word either precedes or follows the abbreviation.

Word	Abbreviation	Prompt
Access	ACCS	Road
Ahead	AHD	Fog*
Blocked	BLKD	Lane*
Bridge	BRDG	(name)*
Condition	COND	Traffic*
Congestion	CONG	Traffic*
Construction	CONST	Ahead
Downtown	DWNTWN	Traffic*
Exit	EX, EXT	Next*
Express	EXP	Lane
Hazardous	HAZ	Driving
Interstate	I	(route number)
Local	LOC	Traffic
Lower	LWR	Level
Major	MAJ	Crash
Oversized	OVRSZ	Load
Prepare	PREP	To Stop
Pavement	PVMT	Wet*
Roadwork	RD WK	Ahead
Route	RT	Best*
Turnpike	TRNPK	(name)*
Township	TWNSHP	Limits
Upper	UPR	Level
*Prompt word goes before abbreviation		

Abbreviations in the following table should <u>not</u> be used as they may cause confusion.

Abbreviations	Intended Word	Common Misinterpretation
ACC	Accident	Access (Road)
B4	Before	None
CLRS	Clears	Color
DLY	Delay	Daily
FDR	Feeder	Federal
L	Left	Lane (Merge)
LT	Light (Traffic)	Left
PARK	Parking	Park
POLL	Pollution (Index)	Poll
RED	Reduce	Red
STAD	Stadium	Standard
WRNG	Warning	Wrong

A complete list of acceptable abbreviation can be found in Part 1 of the MUTCD.

Temporary Pavement Markings

Pavement markings are the primary means of channelizing and providing guidance to traffic. However, when temporary traffic control activities impact the use of a roadway, or when operations eliminate permanent pavement markings, existing pavement markings, or lack thereof, can confuse the motorist.

Changes in roadway use caused by long-term operations should be accompanied by pavement marking revisions (i.e., the removal or obliteration of any pavement markings that are not applicable to current roadway use and the installation of temporary pavement markings). For operations of shorter duration, the other temporary traffic control devices (e.g. channelizers, signs, etc.) deployed will be relied on to provide traffic with the needed channelization and guidance cues. Pavement marking revisions for shorter duration operations could be a possibility; but, should be considered on a case-by-case basis.

Elimination of permanent pavement markings for a distance of 200 linear feet or more caused by operations such as leveling course, patching, seal coat, spot sealing, crack pouring, milling, and scrub sealing shall be accompanied by the installation of temporary centerline and lane line pavement markings and NO CENTER STRIPE signs, as specified.

There are four means typically used to provide temporary pavement marking – *preformed short-term pavement marking tape*, Type 1 temporary raised pavement markers, Type 2 temporary raised pavement markers, and pavement marking paint.

Preformed short-term pavement marking tape consists of a four-inch wide retroreflectorized tape with a pressure-sensitive adhesive on the back. The tape, available in white and yellow, may be used to provide a surrogate permanent pavement marking or it may be cut into four-foot long sections and applied to the road surface at 40-foot intervals as a temporary pavement marking. The length and spacing of the latter pavement marking may be reduced to one-half when marking intersections, ramp gores, and other transition areas. This material is typically used to temporarily

mark changes in normal roadway use and to provide temporary marking of centerlines and lane lines when permanent pavement markings are eliminated. It is not recommended for locations where the material will be subjected to heavy traffic, in areas of heavy turning movements, on short radius curves, or on roadways having loose aggregate on the surface, as the material will not adhere well under these conditions. These markings do not have to be removed when placed on intermediate lifts.

Type 1 - Temporary Raised Pavement Markers consist of an L- or T-shaped flexible tab with a retroreflective sheeting on both faces of the vertical section and a pressure-sensitive adhesive on the base. These markers, available in white and yellow, are typically used to temporarily mark centerlines and lane lines by applying them to the road surface at 40-foot intervals and shoulder areas at 200 ft. intervals. Except for hot/cold mix asphalt applications and diamond grinding operations, the markers are installed prior to an operation, with the removal of the protective film covering the retroreflective sheeting occurring upon completion of the operation. This spacing may be reduced to one-half when marking intersections, ramp gores, and other transition areas. Type 1 markers are the preferred means of providing temporary marking on rough surfaces. These markings must be removed prior to placement of subsequent lifts.

Type 2 - Temporary Raised Pavement Markers consist of a plastic dome with reflectors on the sides and a pressure-sensitive adhesive on the base. These markers, available in white and yellow, are typically used to temporarily mark changes in normal roadway use or temporarily mark centerlines and lane lines by applying them to the road surface at 40-foot intervals. This spacing may be reduced to one-half when marking intersections, ramp gores, and other transition areas. Type 2 markers work well on concrete and smooth asphaltic surfaces. These markings must be removed prior to placement of subsequent lifts.

Note: A combination of Type 1 and Type 2 temporary raised pavement markers may be used to temporarily mark centerline and lane lines for enhanced daytime visibility and nighttime reflectivity.

Pavement Marking Paint consists of applying a four-inch wide strip of acrylic waterborne paint with drop-on glass beads for retroreflectivity. The paint, available in white and yellow, may be used to provide a surrogate permanent pavement marking or it may be applied in four-foot long sections at 40-foot intervals as a temporary pavement marking. The length and spacing of the latter pavement marking may be reduced to one-half when marking intersections, ramp gores, and other transition areas. This material is typically used to temporarily mark changes in normal roadway use and to provide temporary marking of centerlines and lane lines when permanent pavement markings are eliminated. These markings do not have to be removed when placed on intermediate lifts.

In addition to providing temporary pavement markings, ***NO CENTER STRIPE signs*** may also be warranted. NO CENTER STRIPE signs are black-on-orange warning signs used on two-lane and two-lane with auxiliary lane facilities where no-passing zone centerline marking is eliminated for 200 linear feet or more. These signs are placed in advance of the missing no-passing zone centerline marking area at the recommended sign spacing. For extended areas continuously or intermittently missing no-passing centerline marking, NO CENTER STRIPE signs should also be installed within 150 feet after the intersection of a state highway and at one-mile spacing throughout the affected area. Upon the discretion of the supervisor, additional NO CENTER STRIPE signs may be installed within 150 feet after other intersections. When a sign placed at the

one-mile interval and one placed after an intersection fall within one-eighth mile of each other, the sign placed at the one-mile interval may be eliminated.

When temporary pavement markings and/or NO CENTER STRIPE signs are necessitated by either a change in roadway use or the elimination of permanent pavement markings, the following provisions shall be incorporated into the operation by:

- Those performing the operation shall be responsible for coordinating the procurement, installation, maintenance, and removal, as applicable, of pavement markings, temporary or permanent, and any NO CENTER STRIPE signs.
- Temporary pavement markings and any NO CENTER STRIPE signs shall be in place prior to opening a roadway to traffic. On two-lane highways with AADTs less than 1000, however, installation of pavement markings may be delayed up to 5 working days, initiated by the elimination of the permanent pavement markings, provided the required NO CENTER STRIPE signs are in place prior to opening the facility to traffic.
- Temporary centerline and lane line pavement markings and any NO CENTER STRIPE ***signs*** shall be in accordance with Standard Plan 620.10. Note: Temporary marking of edgelines is not required for work performed by maintenance forces.
- For maintenance forces, permanent pavement markings shall be installed no later than 15 calendar days after an operation has been completed. For construction projects, permanent pavement markings shall be installed no later than 5 calendar days after an operation has been completed. Every effort shall be expended to minimize installation time.
- Removal or obliteration of all pavement markings are to be complete and leave minimal pavement scarring. Concealing any pavement marking with black paint or liquid asphalt is not acceptable. Installation of temporary pavement marking are to be aligned to the same standards as permanent pavement marking.
- Temporary pavement markings will provide adequate retroreflectivity for positive guidance to motorists. Temporary pavement markings are to be periodically checked to ensure effectiveness until permanent pavement markings can be applied.

Module 13: Crashworthiness of Traffic Control Devices

To provide safer driving environments, many states, including Missouri, began testing roadside hardware in the 1930's on their own. In the early 1960's, FHWA, state DOT's, and research agencies conspired to bring uniformity to the different tests being performed around the country. As a result, the first comprehensive report, National Cooperative Highway Research Program (NCHRP) 230, was published in 1980. This report provided crash-testing procedures for roadside hardware, including criteria for temporary traffic control devices. Theses tests were performed using the typical vehicle of the time, a full-sized car. Soon after the publication, however, vehicle design and sales began changing drastically.

To address these changes, the NCHRP 350 report titled "Recommended Procedures for the Safety Performance Evaluation of Highway Features," was published in 1993. This report took into consideration the most prevalent vehicle types found on the nation's highways (i.e., the mini-compact car, ¾-ton pick-up truck, single-unit cargo trucks, and tractor-trailer) in its crash testing of roadside hardware and recommended performance standards for the use of these devices. These performance standards, or test levels, are dependent on speed (31-mph to 62-mph), size of the vehicles (compact car to tractor-trailer), and impact angles (0 to 90 degrees). The higher the test level the more intense the testing.

In 1998, MoDOT adopted and implemented Test Level 3 criteria for temporary traffic control devices used on Missouri State Highway system.

NCHRP 350 prescribes four categories of temporary traffic control devices. These categories, defined as 1 through 4, are discussed below.

- ***Category 1*** – Lightweight devices, including cones, trim-line and drum-like channelizers, and tubular markers, with or without fixed lights. Past testing and performance indicate these devices did not cause an appreciable change in speed or intrude into the passenger compartment of the impacting vehicle. FHWA suggests states accept Category 1 devices based on self-certification by the contractor, manufacturer, and vendor. Hence, MoDOT specifications require the contractor, manufacturer or vendor to furnish a manufacturer's certification of crashworthiness, per NCHRP 350 Evaluation Criteria, for these devices.
- ***Category 2*** – Traffic control devices, including, Types I, II, and III barricades, vertical panels, directional indicator barricades, and portable sign supports, with or without lights. These devices must be successfully crash tested to at least NCHRP 350, Test Level 3. For Category 2 devices, this requires crashing a compact vehicle traveling at 62 mph into the device at 0 and 90 degrees. MoDOT specifications require the contractor, manufacturer, or vendor to furnish the FHWA acceptance letter and a certification letter stating the device being furnished is of the same physical and chemical properties of that tested. The FHWA acceptance letter shall indicate the device and appurtenances comply with the crash test requirements of NCRHP 350, Test Level 3 (TL-3).

- ***Category 3*** – Rigid devices, including truck-mounted attenuators, barriers (temporary and permanent), impact attenuators, crashworthy end terminals, and breakaway sign supports. These devices must be successfully crash tested to at least NCHRP 350, Test Level 3. For Category 3 devices, this requires crashing a 3/4 ton pick-up truck at 62 mph into the device at 0 degrees (20 degrees for longitudinal barriers). Portable 3-loop concrete barriers and post-mounted sign support assemblies do not require certification of crashworthiness as MoDOT prescribes the design of these devices in its specifications. For other Category 3 devices, MoDOT specifications require the contractor, manufacturer, or vendor to furnish the FHWA acceptance letter indicating the device and appurtenances comply with the crash test requirements of NCRHP 350, Test Level 3.
- ***Category 4*** – Trailer-mounted equipment including lighting units, arrow panels, temporary traffic signals, and changeable messages signs. Currently, Category 4 devices do not need to meet any crashworthy requirements. However, these devices shall be properly located and delineated or shielded from traffic, where feasible. In addition, it is important to remove these devices when not needed as they do pose a safety concern.

Note: In addition to the certification requirements noted above, the contractor, manufacturer, or vendor must certify the devices are constructed and installed according to MoDOT standard specifications and plans. Modifications may make devices non-compliant. Modifications must be approved by appropriate MoDOT staff prior to being implemented.

Module 14: Creating A Safe Driving And Work Environment

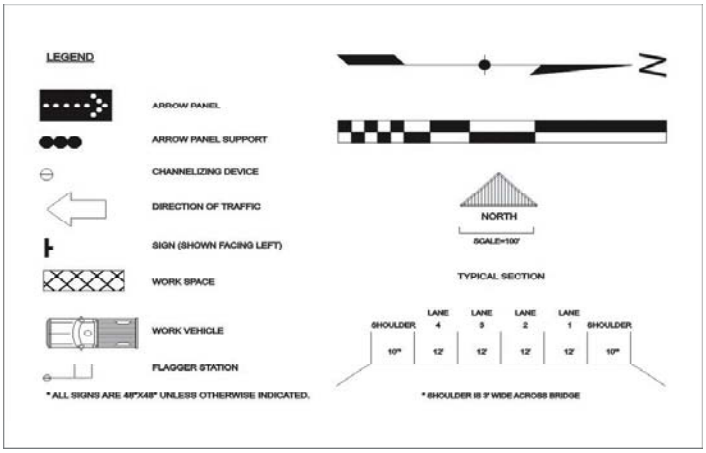
Work zones can present motorists with atypical driving conditions. These conditions may increase the potential for vehicle on object, vehicle on vehicle, and vehicle on worker incidents. Therefore, it is essential that the WZS review the setup and operation of the work zone and make field adjustments to minimize risk.

- ***Equipment and Material*** – Only equipment and materials necessary to perform the work are to be located within the work zone. Unnecessary or non-essential items shall be removed from the roadway or stored in an acceptable staging area. This includes personal vehicles, hauling equipment, idle traffic control devices, machinery, etc.
- ***Traffic Control Devices*** - Devices must fulfill a need, provide appropriate and pertinent information, be properly located, and meet quality standards. Devices failing to do so are to be adjusted, replaced, or removed, as appropriate, from the roadway. Unused devices are either stored off site at an acceptable staging area or in a safe manner along the roadside. Care is to be taken to ensure devices are installed and operated in accordance with crashworthiness requirements. This is particularly true for crash cushions, portable concrete traffic barrier, and TMAs where energy absorption, device deflection, vehicle redirection, and roll ahead dynamics are critical to the safe performance of the devices.
- ***Workers*** - Personnel should be limited to those necessary to perform the work. Persons not performing actual work on the road should remain in a vehicle until their services are required. All personnel should be attired in proper PPEs. Workers performing traffic control functions, such as flagging, shall make themselves readily visible to oncoming traffic.
- ***Conditions*** - Care should be taken to avoid or minimize conditions which may impose safety concerns to traffic. For example: dirt, debris, dust, etc., resulting from work activity should be removed or abated; severe geometrics, blunt ends, open excavations, etc. should be avoided, delineated, or shielded, as appropriate; and driving opposed to traffic, should be restricted to areas where the traffic and work spaces are separated by a physical barrier.
- ***Traffic*** - The WZS should actively monitor traffic operations in advance of and through the work zone and make appropriate corrections to the temporary traffic control to improve movement throughout the operation. Evidence of accidents, hard braking, displaced devices, traffic backups, and displeased motorists are indicators of a poor performing work zone that needs modifying.

Module 15: Basic Plan Reading

A Traffic Control Plan (TCP) is a set of drawings and notes detailing the temporary signing, striping, and other traffic control devices to be set up on a specific project. These plans are consistent with the complexity of the project. A TCP can be very simple or very complex, depending on how much a particular job might impact the road user. It is the WZS responsibility to interpret the TCP, implement it in the field and adjust it for field conditions by the safest possible manner.

Parts of a Typical Traffic Control Plan



Title Sheet – This the very first sheet in a set of plans. The title sheet contains the legend of symbols used in that set of plans. The title sheet also contains an index of the plan sheets. The index is important for finding the appropriate information whether it be traffic control, drainage, bridges, etc. The title sheet is also where you will find the name and signature of the engineer of record.

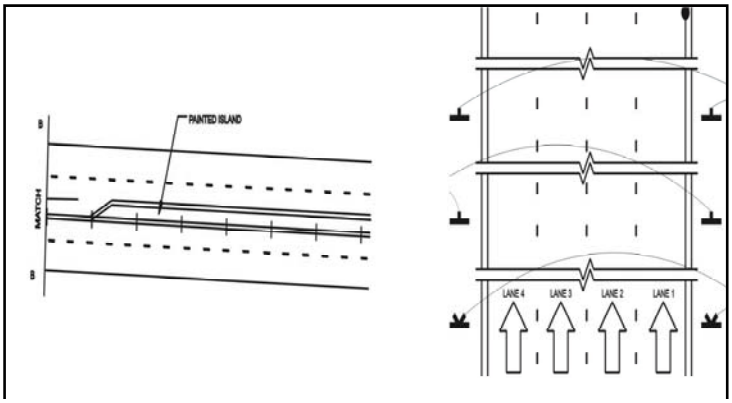
Title Block- This is where you find project-specific information including the route, county, project number, and the contract number.

North Arrow- There is a North arrow on every plan sheet. The North arrow helps you orient the plan by identifying which way the plan lies in relation to the direction, North.

Legend- The legend is where you'll find the symbols used on the plan sheets and their meaning.

Match Lines- Match lines identify where separate drawings may be connected to form a single drawing when the drawing extends over multiple pages.

Break Lines- Break lines are used to indicate an area where geometric conditions do not change or areas of insignificance.



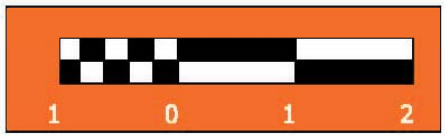
Station- Stationing is the conventional way of identifying distances along the roadway, (usually along the centerline) marking each 100' interval in a 0 + 00 format. Look for equations, which are used occasionally to call out breaks in the stationing, which will need to be accounted for when determining the correct distance between two points (stations) along the roadway. Permanent field markings may be in place on some roadways.

Graphic Scale- Because plan sizes often change, a graphic scale is provided to estimate distances.

Golden Rules of Plan Reading: ***"READ THE NOTES"***

When reading a plan, it is important to read the notes. They may contain important information, details, exceptions and clarifications. Designers use notes to be specific about a particular item.

Graphic Scale



Scale in feet

Module 16: Work Zone Inspections

The act of designing a work zone or putting that plan into action does not guarantee satisfactory performance in the field. For that reason, it is vitally important that work zone inspections be performed to assess compliance with temporary traffic control requirements and the safety of both the motorist and the worker. By identifying any concerns and addressing them as soon as practical, we can avoid situations that may reduce the effectiveness of the temporary traffic control measures deployed and potentially improve the overall performance of future work zones.

Work zone inspections, similar to other inspection processes, have a quality control and a quality assurance component. These two inspection categories are discussed in more detail below.

Quality Control Inspections

Quality control inspections are normally performed by the contractor, subcontractor, field operation and inspection personnel responsible for installing, operating, maintaining, and removing the work zone. Inspections performed at different times throughout the life of the operation or project to ensure the temporary traffic control devices are in good condition, function properly, meet requirements, and provide adequate guidance to the motorists. While the results of such inspections may not be documented, the performance of them is important to the overall quality and operation of the work zone and should not be dismissed.

There are four different types of work zone quality control inspections – Pre-Installation, Post-Installation, Routine, and Removal. A description of each type of these inspections follows.

Pre-Installation Inspections are performed at a staging area or maintenance facility prior to deploying temporary traffic control devices in the field. The purpose of this inspection is to ensure the proper devices are available, in good condition, and working properly before they are put into service. Inspection of the work zone location should not be overlooked during pre-installation inspections because modifications to the temporary traffic control plan may be necessary to accommodate field conditions. As with the devices, it is better to identify and address problems before installing the devices.

Post-Installation Inspections are performed after the temporary traffic control devices have been deployed and after any modifications or phase changes. The purpose of this inspection is to ensure the work zone is set up correctly, the devices are working properly, and traffic responds appropriately to the guidance provided to them.

Routine Inspections are performed at regular intervals throughout the life of the work zone. The purpose of this inspection is to identify any concerns with the quality, performance, and placement of the temporary traffic control devices or motorists' response so they may be remedied.

Removal Inspections are performed during the removal of the temporary traffic control devices from the work zone or when they are returned to the staging area or maintenance facility. The purpose of this inspection is to identify and complete any needed repairs and replacements to the devices before they are put back into inventory.

Work Zone Checklist

Advance Warning Area

Message Sign

- ☐ Placement/height - 7' above pavement
- ☐ Is sign visible by motorist from 1/2 mile and message legible at 650 feet?
- ☐ Message appropriate
- ☐ Limit of two messages per sequence - no duplications of standard signs
- ☐ Is message brief ? Is message simple and easy to understand?
- ☐ If motorized, tank full of fuel?
- ☐ Is panel locked?
- ☐ Is board locked in an upright position?
- ☐ Is message board in a location that will be least likely to get hit by motorist?

Signs

- ☐ Proper signs/number of signs present
- ☐ Is spacing correct according to the *Traffic Control for Field Operations Manual*?
- ☐ Proper height for duration and location
- ☐ Accessories (cones/flags) if required by district
- ☐ Visibility by motorist
- ☐ Condition/reflective/retroreflective

Flagger

- ☐ On site (if required)
- ☐ Location of flagger station - can be seen by motorist
- ☐ Communication between flaggers (two-way hand held radio and/or clear sight distance)
- ☐ Equipment (paddle, vest, and hat)
- ☐ Proper techniques (hand signals and paddle)

Transition Area

Taper(s)

- ☐ Distance from advance warning area
- ☐ Quality of devices
- ☐ Proper type, spacing, alignment, and number of devices
- ☐ Retroreflectivity if nighttime work
- ☐ Room for motorist to merge?
- ☐ Are channelizers present?

Arrow Panel

- ☐ Placement and visible by motorist
- ☐ Type appropriate for job (moving operation or stationary)
- ☐ Operating (bulbs work, oil, and fuel)
- ☐ Proper setting (day/night, left/right, caution/ double arrow)

Activity Area

Channelizer

- ☐ Proper type and spacing
- ☐ Quality/quantity appropriate for job

TMA

- ☐ Protective Vehicle (front wheels alignedwith the traffic and brake set)
- ☐ Warning lights, safety alarms, arrow panel is operational, and arrow flashing the correct way
- ☐ Proper location

Buffer Space

- ☐ Proper spacing if used (see buffer chart)
- ☐ Free of equipment, vehicles, and people Work Space
- ☐ Adequate room to accomplish work
- ☐ Stays within range of advance warning area
- ☐ Workers adequately protected from motorist
- ☐ Are additional traffic control devices needed?
- ☐ Does work space encroach on motorist space?
- ☐ Are motorist traveling through work zone in a reasonable manner?
- ☐ Do motorist seem to comprehend messages conveyed by signs, flaggers, and other traffic control devices?

Termination Area

- ☐ Proper spacing
- ☐ Proper number of devices
- ☐ Speed limit change (if needed)
- ☐ Is "End Road Work" sign needed?
- ☐ Are routine inspections of traffic control elements being performed?

Quality Assurance Inspections

Quality assurance inspections provide project- and operation-related staff with input on the performance of their work zones from a district or statewide perspective and assist those who perform them in identifying areas of program improvement. These inspections are typically performed by district and Central Office engineering and management staff, but can also be conducted by lead field operation and inspection personnel. They are more formal than the quality control inspections because the inspection results are documented and shared with responsible parties.

Quality assurance inspections can be separated into two different types based on the focus of the inspection. **Technical Inspections** focus on the more physical aspects of the work zone. They consist of identifying the temporary traffic control devices and measures present in a work zone and providing an objective evaluation of how well they comply with MoDOT standards and specifications. In contrast, **Operational Inspections** focus on the more cognitive aspects of the work zone. They strive to evaluate how a work zone might be perceived from a motorist's point of view.

MoDOT's Temporary Traffic Control Inspection Worksheet and Temporary Traffic Control Visibility and Mobility Inspection Worksheet are examples inspectors use to perform technical and operational work zone inspections, respectively.

MoDOT
Temporary Traffic Control
Visibility and Mobility Inspection Worksheet

District: _____ County: _____ Route: _____

Project No.: _____ Location: _____

Date/Time: _____ Weather: _____ Reviewer: _____

I. VISIBILITY				
A. General				
1.	Devices installed and maintained at locations and in orientations that maximize safety and minimize disruption to traffic flow.	Pass	Fail	N/A
2.	Devices aligned with the road user's line of vision.	Pass	Fail	N/A
3.	Devices positioned as to not obstruct other applicable traffic control devices	Pass	Fail	N/A
4.	Devices free of any appreciable dents, holes, deformations, abrasions, tears, marks, stains, residues, fading or other deficiencies that affect the operational performance of a device.	Pass	Fail	N/A
5.	Devices properly covered, turned, stowed, or removed when not in use.	Pass	Fail	N/A
B. Barricades, Channelizing Devices, and Signs				
1.	Signs convey proper messages	Pass	Fail	N/A
2.	Reasonably plumb to the pavement.	Pass	Fail	N/A
3.	Safely and neatly ballasted, as needed.	Pass	Fail	N/A
4.	Clearly visible and legible/distinguishable to approaching traffic during the day and, if applicable, at night.	Pass	Fail	N/A
C. flashing Arrow Panels				
1.	Functioning in the appropriate mode.	Pass	Fail	N/A
2.	No more than one lamp, of those to be energized, out in stem and no lamps out in the arrow head(s) when in the arrow (single or double headed) mode and no lamps out when in the caution (four corners) modes.	Pass	Fail	N/A
3.	Appropriate light intensity level during day or nighttime.	Pass	Fail	N/A
D. Changeable Message Signs				
1.	Displaying a pertinent message at an appropriate cycle.	Pass	Fail	N/A
2.	Clearly legible to approaching traffic with minimal display abnormalities.	Pass	Fail	N/A
3.	Clearly legible to approaching traffic with minimal display abnormalities.	Pass	Fail	N/A
E. Temporary Pavement Markings				
1.	In place at applicable times.	Pass	Fail	N/A
2.	Reasonably aligned longitudinally.	Pass	Fail	N/A
3.	Clearly visible to approaching traffic during the day and night.	Pass	Fail	N/A
4.	Completely removed when no longer applicable.	Pass	Fail	N/A

II. TRAFFIC FLOW				
A. Traffic Management				
1.	Traffic moves at an acceptable pace.	Pass	Fail	N/A
2.	Appropriate speed limit set.	Pass	Fail	N/A
3.	No unnecessary excessive queues.	Pass	Fail	N/A
4.	No unnecessary excessive detour lengths	Pass	Fail	N/A
B. Physical Conditions				
1.	Physical restrictions limited to areas of work and need.	Pass	Fail	N/A
2.	Appropriate length transitions.	Pass	Fail	N/A
3.	Adequately designed intersections and entrance/exit ramps.	Pass	Fail	N/A
4.	No unnecessary adverse pavement conditions (e.g., ruts, pot holes, bumps, debris, etc.)	Pass	Fail	N/A
5.	No adverse roadway alignments	Pass	Fail	N/A
6.	Acceptable edge drop-off treatment.	Pass	Fail	N/A
PERCEPTION RATING				

COMMENTS

NOTES

- For maintenance work, in the block labeled job number in the header, insert "Maint." and the type of work being performed, such as mowing, patching pot holes, sealing cracks, etc.
- Individuals ratings are based on the condition of the listed work zone components.
- Perception ratings will reflect public perception of the work zone. A favorable impression of the visibility or traffic flow attributes of the work zone is reflected in a 'Pass' rating. A negative impression, or the presence of an unsafe condition, is reflected in a 'Fail' rating.
- The inspector shall provide comment on all individual and overall 'Fail' ratings.
- Serious safety infractions noted during the inspection shall be immediately brought to the attention of the appropriate district personnel.
- Enter the inspection work sheet results into the Work Zone database (located on MoDOT's web site, www.modot.mo.gov/workzones/WorkZoneMapIntro.htm) within three working days of the inspection.

Module 17: Addressing Work Zone Deficiencies

Once you have identified a deficiency or it has been brought to your attention, the time frame for correcting it is based on an evaluation of the exposure. Exposure is determined by the combination of the number of people affected and the severity of the deficiencies. These two factors give an indication of the danger faced by both the motorists and workers. Good judgment must be used to determine the severity of the exposure.

To help determine the severity of the exposure the following categories should be used:

- ***Priority 1***

  Deficiency presents an immediate hazard to motorists or workers (e.g. improperly positioned flaggers, failure to wear PPE, incorrectly installed crash attenuators, blunt ends, missing devices, malfunctioning devices, disabling light glare, short tapers). Corrective actions should be taken as soon as possible (day or night, weekends, or holidays) suspending other work if necessary.

Note: Failure to immediately address the problem can cause the operation to be shut down.

- ***Priority 2***

  Deficiency does not pose an immediate threat to either the motorists or the workers, but can impact the proper functioning of the work zone (e.g. missing pavement markings, improper channelizer spacing, traffic congestion, inappropriate speed limits, displaced/damaged devices, improper barricade marking, sign height). Corrective actions should be accomplished as soon as practical. Depending on the severity the deficiency, corrections should be completed within 12 to 48 hours of notification.

- ***Priority 3***

  Deficiency doesn't impact the functioning of the work zone but is more of a maintenance or aesthetic issue (e.g. leaning signs, dirty devices, bad sign covering, improper storage of devices, CMS messaging, intermixing of channelizers). Corrective actions should be accomplished within 96 hours of notification.

Regardless of the severity of the deficiency, corrections should be made as soon as possible to maintain a quality work zone. Failure to address problems according to the above guidelines may be grounds to suspend work.

	PRIORITY 1	PRIORITY 2	PRIORITY 3	PRIORITY 4
PRIORITIES ARE GUIDELINES AND MAY BE UPGRADED IF PRIMARY CONTACT DEEMS NECESSARY	Urgent. Respond as soon as possible (day or night, weekends, or holidays) suspending other lower priority work if necessary. May represent immediate hazard to the public.	Repair should be accomplished as soon as practical during normal working hours, but only after Priority 1 repairs are completed.	Repair should be accomplished with higher urgency than routine maintenance.	Not urgent. Normally considered routine maintenance.
TRAFFIC CONTROL IN WORK ZONES				
SAFETY DEFICIENCIES(e.g., Improper flagging position and procedure; missing PPEs and devices; faulty devices and safety appurtenances; hazards; glare; improper tapers; etc.)	X			
PERFORMANCE DEFICIENCIES(e.g., missing pavement markings; improper device spacing, marking, and dimension; traffic congestion; inappropriate speed limits; displaced and damaged devices; etc.)	X	X		
AESTHETIC DEFICIENCIES(e.g., Leaning signs; dirty devices; bad sign covering; improper storage; CMS messaging, etc.)	X		X	

Module 18: Tort Liability and Risk Management

This section provides an overview of risk management principles, tort liability, and techniques for monitoring and evaluating existing facilities and programs.

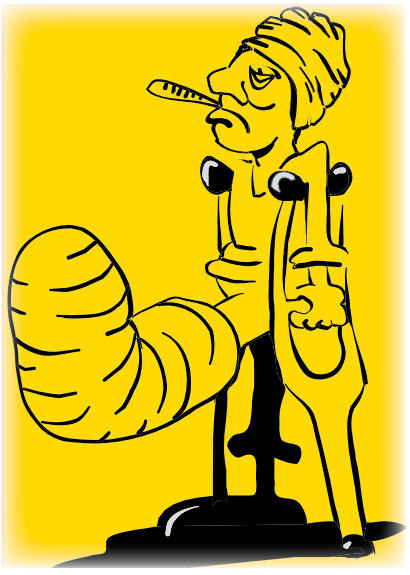
Issues of risk management and tort liability are becoming major determinants of planning, engineering, and implementation programs for motorists. Agency concerns about potential liability can either lead to innovation and substantially improved facilities and programs or they can lead to a "do nothing" approach. Ignoring risks does not make them go away. Taking systematic steps to identify and evaluate risks and to develop an effective risk management program are essential measures, even if you cannot afford to remedy all problems immediately.

Basic Definitions

Tort: A wrongful act that results in injury to another person's or property and for which the injured party is entitled to compensation.

When an individual is harmed by another party without criminal intent, he or she may be able to file a tort claim. The tort claim must be based on establishing that the party had a duty to perform relative to the injured individual and that this duty was not performed with ordinary care, in a reasonable and prudent manner. An injury resulting from a breach of contract or trust does not fall within the definition of a tort. Torts are generally divided into two categories: intentional torts and non-intentional torts.

- Intentional torts include those actions that are intentional and voluntary and that are made with knowledge by the tortfeasor (the person who committed the tort) upon the plaintiff (the one who brings the complaint seeking relief). Intentional torts include: battery, assault, false imprisonment, invasion of privacy, fraud, defamation of character, and the real property tort of trespass to land.
- Unintentional tort claims, negligence, is the most common source of litigation in most American courts. It is a form of extra-contractual liability that is based upon a duty of care of a reasonable person, who, being the proximate cause of damages, and but for the tortfeasor's act, is the cause of damages to the plaintiff. Other non-intentional torts include negligent infliction of emotional harm (not recognized in all states), malpractice (professional negligence), and product liability (liability of manufacturers, wholesalers and retailers for unreasonably dangerous products). The majority of temporary traffic control law suits filed fall into this category.



Negligence: An act or omission within the scope of the duties of an individual, agency, or organization that leads to the harm of a person or of the public; the failure to use reasonable care in one's actions.

To prove negligence, the plaintiff's attorney must prove each of these conditions:

- ***The defendant has a duty to use reasonable care***: Do the defendant's duties include responsibility for some element of the accident (site, vehicle, etc.)?

- ***The defendant did not responsibly carry out that duty (was negligent)***: Did the defendant exercise ordinary care performing his or her duty in a reasonable and prudent way?
- The defendant's failure to carry out that duty (negligence) was directly responsible for the injury ("proximate cause").
- The plaintiff was not guilty of contributing to the cause of the accident through comparative negligence.
- The plaintiff incurred damages resulting from the incident.

Immunity

Entities with full sovereign immunity are not required to pay settlements, while those with partial immunity have limits on how much can be awarded or limits on their exposure in certain areas, such as maintenance and operations.

Very few states still have full sovereign immunity. Many governments, including the state of Missouri, have partial immunity.

Certain actions have full or partial immunity from legal action. As a general rule, governments still enjoy some immunity in the area of design, although this, too, is eroding. There is little immunity for actions related to operations or maintenance. Lawsuits relating to signing, warnings, surface conditions, poor maintenance, and similar factors are among the most difficult cases to defend.

Planning, Engineering, and Public Perception

Building and maintaining the public's confidence in the work of government is a constant struggle. When an incident occurs on a roadway, the public generally looks beyond themselves for someone to blame. It is tempting to pin responsibility on the faceless public agency most directly involved in design, maintenance, regulation, or operation of the facility.

Implementing an aggressive and well-publicized risk management program can help head off these problems. An effective first line of defense is to build and maintain public confidence; to protect budget allocations for needed public works projects; and to foster a spirit of cooperation, not confrontation, between public and private sector parties.

Today, the newspapers and electronic news media frequently headline court settlements against public agencies that have allegedly failed to use good judgment or carry out their professional responsibility on behalf of public health, safety, and welfare. Some settlements may soar as high as $10 to $14 million for a single injury. Even minor lawsuits, which may be settled for as little as $5,000, may cost $10,000 to defend.

Trends in Tort Settlements

America is experiencing an increase in tort liability claims. The public and its officials can and should demand fairness in settlements; however, it is unlikely that we will see a dramatic reduction in charges and complaints. Trends indicate just the opposite:

- More lawsuits are being filed.
- ***Legal action is becoming broader in its scope*** - suing non-profits, families of those affected, as well as agencies and individuals.

- Government agencies, well-insured corporations, and professionals continue to be favored targets due, in part, to their perceived "deep pockets" and ability to pay.
- There is a tendency toward increased liability in areas that once had some degree of immunity.
- There is a continuing rise in the size of claims.
- ***Insurance companies often settle rather than defend.*** People who are looking to sue are encouraged by the knowledge that insurance companies often settle quickly rather than bear the time and cost of defending themselves against relatively low-dollar claims. The courts are, in this way, taken out of the process. It is important that agencies and organizations understand it and structure their actions accordingly.

The Impact of these Trends

The issue of risk management is becoming a major factor in decisions about implementation of projects and programs. The high costs associated with claims have, in some cases, meant that things just don't get built or programs don't get funded. Decision-makers are getting gun-shy. Ignoring the problem, however, won't make it go away. Governments are just as often sued for what they don't do as for the actions they do take.

The best approach is to develop a strong, pro-active program to plan, design, build, maintain, and operate a fully balanced transportation system that responds to the needs of all potential users. An agency's ability to demonstrate that it is aware of potential problems and is taking systematic steps to address them is very important.

Is Ignorance REALLY Bliss?

The comment is sometimes heard that if all these potential hazards are identified, then the agency's liability may increase since the agency can be shown to have been aware of the hazards without correcting them. Are you really less vulnerable if you don't know what the problems are?

In a word, the answer is "NO." It's not quite as simple as that, but here is a summary:

- What if you don't know about a potentially hazardous condition and an injury occurs?
- The success of your defense may, in part, depend on how discoverable or readily apparent the condition was.

If It's Broken - Fix It

What if you have been made aware of a potentially hazardous condition and an injury occurs before you have taken steps to correct the condition?

Agencies have a responsibility to fix problems, but the courts tend to favor good will and intent to find solutions, even if some conditions are too expensive to fix immediately.

Again, a great deal will depend on the length of time that has passed between identifying the condition and the injury. If it can be shown that a reasonably short period has elapsed and that the agency or other party is taking positive steps toward correcting the condition, the defense position will be improved.

If it had not identified potential risks and taken steps toward risk reduction, the defense will be substantially weakened.

Signing a hazardous condition has long been recognized as an important interim treatment for many conditions. Failing to sign a known condition is difficult to defend.

Signing and warning offers two types of benefits: (1) People are more cautious, so the number of incidents and injuries are reduced; and (2) The attempt to alert the public about a potentially hazardous condition generates good will and makes it more difficult for a plaintiff's attorney to argue that the plaintiff was surprised by the condition. Signing should follow standard signing and marking practices.

What if you have identified a potentially hazardous condition and have taken steps to correct it?

Assuming the responsible agency has carried out its duties using ordinary care in a responsible way, it will be more difficult to prove negligence. The burden of responsibility may well shift to the injured party whose contributory negligence may have led to the incident.

Components of a negligence cause of action

When considering a negligence cause of action there are four primary elements which need to be viewed and covered thoroughly: (1) duty, (2) breach of duty, (3) causation, and (4) damages.

(1) The duty element is the legal requirement that the person being sued for negligence must adhere to a standard of conduct in protecting others from unreasonable risk of harm.

Different duties apply to different people.

- Parents have a duty to care for their children.
- A landlord has a duty to keep a residence habitable for tenants.
- Each duty is applicable to the pertinent responsibility at hand.
- Professionals are held to a higher standard of care than the average person in society. Professionals, like lawyers, take oaths in their professions and need to maintain that level of duty when they perform their professional activities.
- As an entity performing work on a public right-of-way, it is our duty to provide for a safe driving and work environment through application of appropriate temporary traffic control.

(2) Breaching that duty is the second element to a negligence lawsuit. The question to be asked or answered is:

- Would a reasonable person, in a similar situation, have done the same thing as the person being sued? To come to that conclusion both objective and subjective standards need to be considered.

- The objective standard of breach of duty only considers a hypothetical person and what her or his reasonable behavior might be.
- The subjective standard considers the actual person being sued and if she or he thinks they acted reasonably in the matter at hand.

(3) The causation of negligence is the third critical element of the lawsuit. Both actual cause and proximate cause are considered. Actual cause asks the question of whether the person being sued, the defendant, was the actual cause of injuries sustained by the person initiating the lawsuit, the plaintiff. Proximate cause looks at the issue of foreseeability. When considering the event that has happened, it is asked whether or not the injuries sustained were foreseeable or too remotely connected to the incident to even consider.

(4) The final element of a negligence lawsuit is the damages being sought. Damages are what the plaintiff is seeking in recovering for the incident resulting from the negligent act.

- Compensatory damages are designed to compensate the plaintiff for actual costs incurred. Of those, there are general and special damages.
- General damages such as monetary compensation for the injury sustained.
- Special damages involve extra items such as loss of material possessions resulting from the negligent act.
- Nominal damages can also be awarded when negligence can be proven without resulting in a quantifiable loss.
- Punitive damages are those with the intent to punish the defendant. The hope is that awarding punitive damages will deter similar actions in the future both by the defendant and others similarly situated.

Plaintiff or claimant refers to the party initiating the lawsuit and claiming damages for injury or loss. In some jurisdictions, the commencement of a lawsuit is done by filing a summons and/or a complaint -- these documents are known as pleadings -- that describe the alleged wrongs committed by the defendant with a demand for relief. In other jurisdictions, the action is commenced by service of legal process by delivery of these documents on the defendant by a process server; they are only filed with the court subsequently with an affidavit from the process server that they had been given to the defendant(s) according to the rules of civil procedure.