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EFFECT OF FLAGGERS AND SPOTTERS IN DIRECTING WORK ZONE TRAFFIC FOR ILLINOIS EXPRESSWAYS AND FREEWAYS

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Effects of Flaggers and Spotters in Directing Work Zone Traffic for Illinois Freeways and Expressways

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16. Abstract

This research project focused on assessing the effectiveness and essential role of flaggers and spotters in directing traffic for expressway and freeway work zones in Illinois with a posted speed limit greater than 40 mph. The objectives of this project were to (1) conduct a comprehensive literature review to study the latest standards and research on the use of flaggers and spotters to direct work zone traffic on expressways and freeways; (2) perform site visits and field studies to evaluate flagger practices currently used in work zones in Illinois; (3) collect and fuse the latest data on work zone crashes in Illinois during a 14-year period from 1996 to 2009 from all available sources; (4) analyze the gathered data to study the frequency and severity of traffic-related work zone crashes in Illinois highways, and investigate the probable causes and contributing factors of these work zone crashes; (5) investigate the feasibility and effectiveness of work zone safety measures that can be used to supplement or replace the use of flaggers and/or spotters, such as intrusion alarm systems, portable changeable message signs, and portable speed monitoring displays; (6) conduct an online survey of resident engineers and construction personnel in the Illinois Department of Transportation (IDOT) and other state DOTs to gather their feedback on the essential roles and effectiveness of flaggers and spotters in directing work zone traffic for expressways and freeways; (7) identify the effectiveness and risks of using spotters and/or flaggers in work zones with a posted speed limit greater than 40 mph on Illinois expressways and freeways, and identify effective work zone safety measures that can be used to supplement or replace flaggers in these works zones; and (8) develop recommendations on the use of flaggers, spotters, and other safety measures in work zones with a posted speed limit greater than 40 mph on Illinois expressways and freeways. These recommendations can be used by IDOT to update and/or expand related IDOT policies, specifications, and standards in order to improve work zone safety and mobility.

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EXECUTIVE SUMMARY

This report presents the findings of a research project funded by the Illinois Center for Transportation to assess the effectiveness and essential role of flaggers and spotters in directing traffic for expressway and freeway work zones in Illinois with a posted speed limit greater than 40 mph and to consider alternative means of providing this function.

The objectives of this project were to

1. Conduct a comprehensive literature review to study the latest standards and research on the use of flaggers and spotters to direct work zone traffic on expressways and freeways.
2. Perform site visits and field studies to evaluate flagger practices currently used in work zones in Illinois.
3. Collect and fuse the latest data and reports on work zone crashes in Illinois during a 14-year period from 1996 to 2009 from all available sources.
4. Analyze the gathered data to study the frequency and severity of traffic-related work zone crashes in Illinois highways, and investigate the probable causes and contributing factors of these work zone crashes.
5. Investigate the feasibility and effectiveness of work zone safety measures that can be used to supplement or replace the use of flaggers and/or spotters, such as intrusion alarm systems, portable changeable message signs, and portable speed monitoring displays.
6. Conduct an online survey of resident engineers and construction personnel in the Illinois Department of Transportation (IDOT) and other state DOTs to gather their feedback on the essential roles and effectiveness of flaggers and spotters in directing work zone traffic for expressways and freeways with a posted speed limit greater than 40 mph.
7. Identify the effectiveness and risks of using spotters and/or flaggers in work zones with a posted speed limit greater than 40 mph on Illinois expressways and freeways, and identify effective work zone safety measures that can be used to supplement or replace flaggers in these works zones.
8. Develop recommendations on the use of flaggers, spotters, and other safety measures in work zones with a posted speed limit greater than 40 mph on Illinois expressways and freeways. These recommendations can be used by IDOT to update and/or expand related IDOT policies, specifications, and standards in order to improve work zone safety and mobility. These objectives were accomplished using a rigorous research methodology that organized the research work in this project into eight main tasks, where each task corresponds to one of these objectives.

Based on the findings of the research tasks in this project, a number of recommendations were developed. These recommendations can be used by IDOT to update and/or expand work zone–related measures. The recommendations are as follows:

1. Replace the current IDOT requirement that *“At all times where traffic is restricted to less than the normal number of lanes on a multilane pavement with a posted speed limit greater than 40 mph and the workers are present, but not separated from the traffic by physical barriers, a flagger shall be furnished to support the workers and to warn and direct traffic”* with the requirement that flaggers and/or spotters direct traffic only when necessary during work zone operations that require intermittent and/or additional slowing down of traffic.

2. Allow the use of spotters instead of flaggers and define the role of spotter as "a trained person/flagger whose duty is to monitor traffic and warn workers of errant drivers or other hazards using an effective warning device such as a whistle or air horn, and/or direct traffic when necessary during work zone operations that require intermittent or additional slowing down of traffic."
3. Minimize the exposure of flaggers and/or spotters to traffic hazards by positioning them in safe locations away from traffic when they are not engaged in directing work zone traffic, establishing a predetermined escape route for each spotter or flagger, and limiting their tasks to monitoring the traffic from safe locations away from traffic and guiding traffic only when needed.
4. Supplement the use of spotters in these types of work zones with additional temporary traffic control devices such as police patrol, a work vehicle with warning beacon, truck-mounted attenuators (TMAs), portable speed monitoring displays (PSMDs), and portable changeable message signs (PCMSs).
5. Train flaggers and/or spotters to perform their tasks of monitoring the traffic from safe locations away from traffic and guide traffic only when needed, ensure that they do not reduce traffic speed to an extent that could cause traffic delays and rear-end crashes, and avoid the excessive push of traffic away onto the shoulder, which can cause damage to the shoulder and other traffic hazards.
6. Update IDOT specifications to implement the aforementioned recommendations after conducting trial experiments of these recommendations on Illinois expressway and freeway work zones in order to gather field data that can be used to further verify that these recommendations, including the use of spotters instead of flaggers, do not adversely affect work zone safety and mobility.

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CHAPTER 1 INTRODUCTION

1.1 PROBLEM STATEMENT

The current Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction do not currently have any requirements or guidance on the use of spotters in the work zone but do provide the following guidance on the use of flaggers in multilane highway work zones: “At all times where traffic is restricted to less than the normal number of lanes on a multilane pavement with a posted speed limit greater than 40 mph and the workers are present, but not separated from the traffic by physical barriers, a flagger shall be furnished to support the workers and to warn and direct traffic. One flagger will be required for each separate activity of an operation that requires frequent encroachment in a lane open to traffic” (IDOT 2012). This required use of flaggers introduces inherent risks and varying effectiveness by positioning flaggers next to the active traffic. Alternatively, some contractors believe that spotters can be a more effective means for improving the safety of construction work zones, simply by observing traffic (work zone and motorist) in the operation area and alerting workers to any perceived dangerous conditions.

This research project focuses on (1) investigating the current uses of spotters and flaggers in maintaining work zone safety and mobility, (2) the most effective way to use flaggers and spotters in maintaining work zone safety and mobility, and (3) investigating other devices and techniques for managing and directing traffic through a work zone.

1.2 RESEARCH OBJECTIVES AND METHODOLOGY

The main goal of this study was to assess the effectiveness and essential role of flaggers and spotters in directing work zone traffic on Illinois expressways and freeways with a posted speed limit greater than 40 mph and to consider alternative means of providing this function. The study’s findings on the roles and effectiveness of flaggers versus spotters for directing work zone traffic control can be used to guide decision makers in changing and/or expanding existing policies to improve work zone safety and mobility performance on future road and bridge construction projects. To accomplish this critical goal, the objectives of the research were as follows:

- Conduct a comprehensive literature review to study the latest standards and research on the use and effectiveness of flaggers and spotters in expressway and freeway work zones to direct traffic and/or warn workers.
- Perform site visits and field studies to evaluate flagger practices that are currently used in work zones in Illinois.
- Collect and fuse the latest data and reports on work zone crashes in Illinois during a 14-year period from 1996 to 2009 from all available sources.
- Analyze the gathered data to study the frequency and severity of traffic-related work zone crashes in Illinois highways, and investigate the probable causes and contributing factors of these work zone crashes.
- Investigate the feasibility and effectiveness of work zone safety measures that can be used to supplement or replace the use of flaggers and/or spotters, such as intrusion alarm systems, portable changeable message signs, and portable speed monitoring displays.
- Conduct an online survey of resident engineers and construction personnel in IDOT and other state DOTs to gather their feedback on the essential roles and effectiveness of using flaggers and spotters in expressway and freeway work zones to direct traffic and/or warn workers.

- Identify the effectiveness and risks of using spotters and/or flaggers in work zones with a posted speed limit greater than 40 mph on Illinois expressways and freeways, and identify effective work zone safety measures that can be used to supplement or replace flaggers and/or spotters in these works zones.
- Develop recommendations on the use of flaggers, spotters, and other safety measures in work zones with a posted speed limit greater than 40 mph on Illinois expressways and freeways. These recommendations can be used by IDOT to update and/or expand related IDOT policy, specifications, and standards in order to improve work zone safety and mobility.

These objectives were accomplished using a rigorous research methodology that organized the research work project into eight main tasks. The research tasks and their deliverables are described in more detail in the following chapters, as shown in Figure 1.

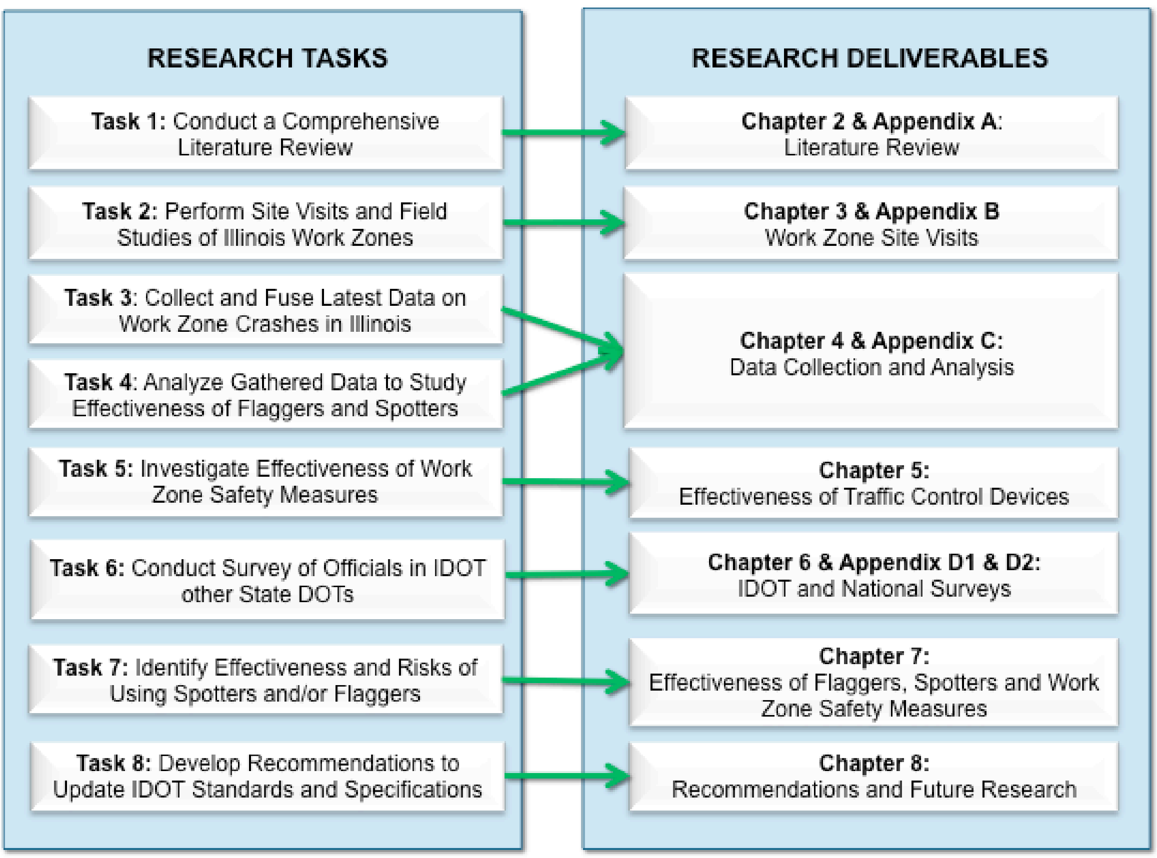


Figure 1. Project tasks and research deliverables.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

This literature review covers current practices and recent research on the effectiveness of flaggers and spotters in directing work zone traffic on Illinois expressways and freeways. A highway work zone is a road section undergoing a construction or maintenance project. In these work zones, a temporary traffic control (TTC) plan must be developed to provide continuity of movement for motor vehicles when the normal function of the highway is suspended around the work zone (Bai and Li 2007).

Flaggers are qualified personnel wearing high-visibility safety apparel who are equipped with handheld devices such as STOP/SLOW paddles, lights, and red flags to control road users through work zones (FHWA 2009). The use of flaggers in highway work zones is described in detail in all state DOT manuals and the Manual on Uniform Traffic Control Devices (MUTCD), including flagger qualifications, apparel, procedures, and stations.

The following sections in this chapter discuss the use of flaggers in MUTCD 2009 and state DOT manuals, related flagger specifications in MUTCD and state DOT manuals, flagger risks and fatalities, effectiveness of flaggers, flagger certification and training, work zone safety devices, and various state DOT specifications regarding use of spotters. Additional literature reviews on work zone strategies, work zone safety and mobility policies, work zone layouts, and mobile work zones are summarized in Appendix A.

2.2 FLAGGER SPECIFICATIONS IN MUTCD 2009 AND STATE DOT MANUALS

2.2.1 Related Flagger Specifications in MUTCD 2009

The MUTCD provides requirements for flagger qualifications, flagger apparel and illumination, flagger hand-signaling devices, flagger procedures, flagger stations, and automated flagger assistance devices. These requirements are described in more detail in the following subsections.

2.2.1.1 Flagger Qualifications

According to the MUTCD, a qualified flagger is able to satisfactorily demonstrate all of the following abilities:

- To receive and communicate specific instructions clearly, firmly, and courteously.
- To move and maneuver quickly in order to avoid danger from errant vehicles.
- To control signaling devices (such as paddles and flags) in order to provide clear and positive guidance to drivers approaching a TTC zone in frequently changing situations.
- To understand and apply safe traffic control practices, sometimes in stressful or emergency situations.
- To recognize dangerous traffic situations and warn workers in sufficient time to avoid injury.

2.2.2 State DOT Flagger Specifications

State DOTs also have specifications regarding the use of flaggers on freeway and expressway work zones. IDOT and some other state DOTs require the use of flaggers on multilane highway work zones with a posted speed limit greater than 40 mph when no physical separation is made between the work zone traffic and construction workers, while other state DOTs, such as Massachusetts (MassDOT) and Washington State (WSDOT) restrict or do not recommend using flaggers in these types of work zones. The following are example specifications from the three DOTs regarding using flaggers in work zones on freeways and expressways with a posted speed limit greater than 40 mph:

IDOT: The current Illinois DOT Standard Specifications for Road and Bridge Construction (IDOT 2012) specify that flaggers shall be provided per the traffic control plan for multilane highways and as follows: At all times where traffic is restricted to less than the normal number of lanes on a multilane pavement with a posted speed limit greater than 40 mph and the workers are present, but not separated from the traffic by physical barriers, a flagger shall be furnished to support the workers and to warn and direct traffic. One flagger will be required for each separate activity of an operation that requires frequent encroachment in a lane open to traffic (IDOT 2012).

MassDOT: MassDOT specifications state that the use of road flaggers shall primarily be restricted to low-speed, low-volume roadways. However, a flagger may also be used on roads with a high-speed designation provided that the traffic volumes are sufficiently low, as determined by the engineer (MassDOT 2011).

WSDOT: WSDOT specifications state that freeway characteristics do not lend themselves to effective flagging. High-speed multiple lanes and normal driver expectancy do not provide an opportunity for the flagger to actually warn or direct traffic; therefore, flagging on freeways and freeway ramps is not normally recommended. However, using a spotter may be helpful to protect the work crew (WSDOT 2009).

2.2.3 Flagger Apparel and Illumination

The MUTCD specifies that for daytime and nighttime activity, flaggers shall wear high-visibility safety apparel that meets the Performance Class 2 or 3 requirements of the ANSI/ISEA 107–2004 publication entitled “American National Standard for High-Visibility Apparel and Headwear” and labeled as meeting the ANSI 107-2004 standard performance for Class 2 or 3 risk exposures. The apparel background (outer) material color shall be fluorescent orange-red, fluorescent yellow-green, or a combination of the two as defined in the ANSI standard. The retro reflective material shall be orange, yellow, white, silver, yellow-green, or a fluorescent version of these colors, and shall be visible at a minimum distance of 1,000 ft. The retroreflective safety apparel shall be designed to clearly identify the wearer as a person.

For nighttime activity, the MUTCD states that “high-visibility safety apparel that meets the Performance Class 3 requirements of the ANSI/ISEA 107–2004 publication entitled “American National Standard for High-Visibility Apparel and Headwear” and labeled as meeting the ANSI 107-2004 standard performance for Class 3 risk exposure should be considered for flagger wear.” The MUTCD also requires that flagger stations be illuminated at night to allow the station and flagger to be seen by approaching traffic.

Several state DOTs, including IDOT, require minimum lighting levels for flagger stations during nighttime activity based on the findings of previous research studies (El-Rayes et al. 2003). This requires a vertical luminance level of at least 10 footcandles (108 lux) for overhead lighting of flagging stations on nighttime projects. Several manufacturers of flagger apparel are equipping high-visibility vests with LEDs to increase the likelihood that drivers will detect and recognize the presence of a flagger at night (See et al. 2009).

Other research studies (NCHRP 475 and 476; Bryden and Mace 2002a, 2002b) provided a number of recommendations for flagger illumination, including (1) to help the flagger stand out against surroundings, temporary illumination should be provided for flaggers at locations that do not have existing light as well as locations that have existing light, (2) illumination should be provided directly overhead rather than from front or back to eliminate glare to the driver and flagger, (3) the flagger should be located on a shoulder or closed lane, and (4) the flagger must be able to be seen from a distance of 1,000 ft.

Gambatese and Rajendran (2011) recommended that lighting should make the flagger as visible as possible whenever a flagger is present in a nighttime work zone. In another study, Benekohal et al. (1995) reported that 63% of the surveyed truck drivers felt that the visibility of flaggers was adequate, while 32% reported that the flaggers were hard to see. Truck drivers who indicated that the flaggers were hard to see had driven more miles than those who disagreed with them. In the same study, 46% of the surveyed drivers reported that the directions given by the flagger were clear, while 49% felt they were confusing, which indicates that the directions are not always clear and need improvements.

2.2.4 Flagger Hand-Signaling Devices

The MUTCD and all state DOTs state that "the STOP/SLOW paddle should be the primary and preferred hand-signaling device because the STOP/SLOW paddle gives road users more positive guidance than red flags and that the use of flags should be limited to emergency situations." The paddle may be modified to improve conspicuity by incorporating either white or red flashing lights on the STOP face, or either white or yellow flashing lights on the SLOW face. The flashing lights may be arranged following the specified patterns and standards in the MUTCD.

2.2.5 Flagger Procedures

The MUTCD describes the flagging procedure as follows: "Flaggers shall use a STOP/SLOW paddle, a flag, or an automated flagger assistance device (AFAD) to control road users approaching a TTC zone. The use of hand movements alone without a paddle, flag, or AFAD to control road users shall be prohibited except for law enforcement personnel or emergency responders at incident scenes." The MUTCD lists three main flagger functions and the specified procedures to implement those using paddles and flags, as shown in Figure 2.

2.2.5.1 Paddle Use

The MUTCD specifies that the following methods of signaling with paddles shall be used:

A. To stop road users, the flagger shall face road users and aim the STOP paddle face toward road users in a stationary position with the arm extended horizontally away from the body. The free arm shall be held with the palm of the hand above shoulder level toward approaching traffic.

B. To direct stopped road users to proceed, the flagger shall face road users with the SLOW paddle face aimed toward road users in a stationary position with the arm extended horizontally away from the body. The flagger shall motion with the free hand for road users to proceed.

C. To alert or slow traffic, the flagger shall face road users with the SLOW paddle face aimed toward road users in a stationary position with the arm extended horizontally away from the body.

2.2.5.2 Flag Use

The MUTCD specifies that the following methods of signaling with a flag shall be used:

A. To stop road users, the flagger shall face road users and extend the flag staff horizontally across the road users' lane in a stationary position so that the full area of the flag is visibly hanging below the staff. The free arm shall be held with the palm of the hand above shoulder level toward approaching traffic.

B. To direct stopped road users to proceed, the flagger shall face road users with the flag and arm lowered from the view of the road users, and shall motion with the free hand for road users to proceed. Flags shall not be used to signal road users to proceed.

C. To alert or slow traffic, the flagger shall face road users and slowly wave the flag in a sweeping motion of the extended arm from shoulder level to straight down without raising the arm above a horizontal position. The flagger shall keep the free hand down.

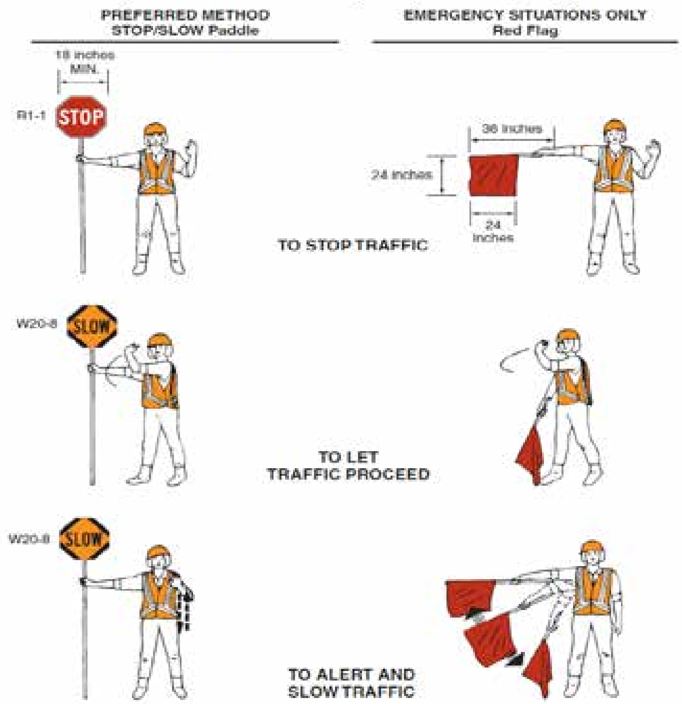


Figure 2. Use of hand-signaling devices by flaggers (FHWA 2009).

2.2.6 Flagger Stations

The MUTCD specifies that flagger stations shall be located such that approaching road users will have sufficient distance to stop at an intended stopping point. The location of a flagger station can be determined based on the stopping sight distances that depend on speed, as shown in Table A.3 in Appendix A. These distances may be increased for downgrades and other conditions that affect stopping distance. Stopping distances vary according to road and weather conditions.

Flagger stations should be located such that an errant vehicle has additional space to stop without entering the workspace. The flagger should identify an escape route that he or she can use to avoid being struck by an errant vehicle. Except in emergency situations, an advance warning sign shall precede flagger stations or signs and shall be illuminated at night (FHWA 2009).

The MUTCD also stated that the flagger should stand either on the shoulder adjacent to the road user being controlled or in the closed lane prior to stopping road users. A flagger should stand in the lane being used by moving road users only after road users have stopped. The flagger should be clearly visible to the first approaching road user at all times. The flagger also should be visible to other road users. The flagger should be stationed sufficiently in advance of the workers to warn them (for example, with audible warning devices such as horns or whistles) of approaching danger by out-of-control vehicles. The flagger should stand alone, away from other workers, work vehicles, or equipment. When a single flagger is used, the flagger should be stationed on the shoulder opposite the spot lane closure or workspace, or in a position where good visibility and traffic control can be maintained at all times.

2.3 FLAGGER RISKS AND FATALITIES

Owing to the nature of their duties, which require them to be in close proximity to open traffic lanes and often without the protection of physical barriers, flaggers are often exposed to hazardous conditions and to the risk of injuries or fatalities (See et al. 2009). Pratt et al. (2001) reported that two-thirds of the injuries to pedestrian workers occurred from vehicles intruding into marked workspaces and striking workers or flaggers. Mohan and Zech (2005 analyzed work zone crashes that caused 36 fatalities and 3,055 severe injuries in New York State from 1990 to 2001. The study found that 86% of these fatalities and 70% of these severe injuries were caused by five types work zone crashes: (1) workspace intrusion, (2) worker struck by vehicle inside workspace, (3) flagger struck by vehicle, (4) worker struck by vehicle entering/exiting workspace, and (5) construction equipment struck by vehicle inside workspace. Another study also reported that construction workers were twice as likely to be killed by a motor vehicle as the average worker and that flaggers account for half of pedestrian accidents (Ore and Fosbroke 1997).

2.4 EFFECTIVENESS OF FLAGGERS

A number of research studies have been conducted to evaluate the effectiveness of using flaggers in work zones. For example, El-Rayes et al. (2010) surveyed IDOT resident engineers and analyzed their assessment of the effectiveness of various TTC devices and methods, including flaggers, in reducing the risk of crash occurrence. The findings of the survey showed that more than 85% of the surveyed IDOT resident engineers reported that using flaggers provides an effectiveness level that ranges from medium to high, as shown in Table 1.

In another study, Li and Bai (2007) evaluated the effectiveness of several commonly used TTC methods using a logistic regression technique and various chi-square statistics. The assessed TTC methods included flagger/officer, stop sign/signal, flasher, no passing zone control, and pavement center/edge lines. The findings of the study indicated that flagger, flasher, and pavement center/edge lines were effective in reducing the probability of fatalities when severe crashes occurred. In addition, using these devices could prevent various common human errors such as “disregarded traffic control,” “inattentive driving,” “followed too closely,” and “exceeded speed limit” from causing severe crashes. Results of the study also indicated that using a flagger/officer in a work zone could reduce the probability of a severe crash being caused by “disregarded traffic control” human errors by 54%.

Table 1. IDOT Resident Engineers Responses on Temporary Traffic Control Effectiveness (El-Rayes et al. 2010)

		Effectiveness of Traffic Control Devices on Reducing Crash Occurrence					
		1 Lowest Effectiveness	2	3 Medium Effectiveness	4	5 Highest Effectiveness	Average
9- Traffic Control Devices	9.1 Message Boards	3.5%	12.8%	28.4%	27.0%	28.4%	3.6
	9.2 Speed Displays	6.4%	11.3%	31.9%	32.6%	17.7%	3.4
	9.3 Flagger	1.4%	10.6%	31.9%	38.3%	17.7%	3.6
	9.4 Truck Mounted Attenuators (TMAs)	2.8%	12.1%	35.5%	32.6%	17.0%	3.5
	9.5 Police Presence	2.8%	0.7%	6.4%	12.1%	78.0%	4.6
	9.6 Automated Photo Enforcement	9.2%	5.7%	27.7%	30.5%	27.0%	3.6
	9.7 Arrow Boards	1.4%	4.3%	32.6%	43.3%	18.4%	3.7
	9.8 Channelization Devices	0.7%	7.1%	29.1%	39.0%	24.1%	3.8

Another study reported that flaggers are most effective on two-lane, two-way rural highways and urban arterials, where they had the least competition for drivers' attention (Richards and Dudek 1986). The same study also reported that flaggers were well suited for short-duration applications (less than one day) and for intermittent use in long-duration work zones. Garber and Woo (1990) conducted another study and reported that the most effective combination of traffic control devices for work zones on multilane highways were cones, arrow boards, and flaggers, while in work zones on urban two-lane highways, cones and flaggers, as well as static signs and flaggers, were the most effective combination.

2.5 FLAGGER CERTIFICATION AND TRAINING

Benekohal et al. (1995) reported that two-thirds of the injuries to pedestrian workers occurred as a result of vehicles intruding into marked workspaces and striking workers or flaggers. To control and minimize these risks, IDOT requires flaggers provided by contractors to receive proper training and be certified by an agency approved by IDOT (Article 701.13 in IDOT 2012). In addition, state DOTs provide flaggers with handbooks and certifications to ensure that they perform well in work zones. The following sections summarize the related sections that are typically included in these handbooks and an example of IDOT sections.

2.5.1 Flagger Duties

The IDOT flagger handbook specifies that (1) the flagger should be able to communicate with each other verbally, by means of signals that cannot be mistaken for flagging signaling or by two-way radios; (2) headsets, cellular phones shall not be used while flagging; (3) each flagger must be stationed at least 100 ft from the work crew and should be visible to oncoming traffic for a minimum of 500 ft.

2.5.2 Flagger Equipment

IDOT specifications require (1) use of paddles or flags that comply with MUTCD 2009 specifications and two-way radios when needed, (2) limiting the use of red flags to daytime emergency situations only, (3) use of a STOP/SLOW paddle with Type A sheeting that is reflective and a minimum of 24 in. wide when directing traffic, (4) that STOP/SLOW paddles be properly maintained and cared for to ensure condition and legibility (must be able to be read from a minimum distance of 400 ft, and (5) for night operations, the use of a red lantern or flashlight with red wand, retroreflective clothing (ANSI Class 3) that highlights the entire range of body movements, and a flagger station fully illuminated by an overhead light source.

2.5.3 Additional IDOT Flagger/Flagging Specifications

IDOT requires that a flagger be on duty, present a neat appearance, and be appropriately dressed for protection from the sun, flying objects, and insects.

IDOT requires that flaggers comply with all current and applicable OSHA, MUTCD, and local standards, which may apply.

In multilane roadway work zones, IDOT specifies that (1) traffic control devices shall be used to control traffic through the work zone, (2) the flagger's responsibility is to protect workers while maintaining traffic speeds at a reasonable level, (3) the flagger must remain on the shoulder or in the closed lane, and (4) the flagger shall be positioned 200 ft in advance of the work operation.

IDOT requires that stopping distances and flagger stations should typically follow those stated in MUTCD 2009.

IDOT specifies that flaggers be trained how to deal with emergency and risk situations and that a flagger should always maintain two escape routes. Flaggers must also be visible to oncoming traffic at all times.

2.6 USE AND DEFINITIONS OF SPOTTERS IN WORK ZONES

A spotter is a trained worker whose sole duty is to monitor traffic and warn workers of errant drivers or other hazards using an effective warning device such as a whistle or air horn (WSDOT 2009). A spotter does not control traffic or use a traffic regulator paddle, but instead uses a warning sounding device. The location of the spotter must be away from unnecessary danger. The following section presents spotter definitions and tasks from some of the states that deploy spotters.

Several state DOTs, such as those in Washington and Oregon, recently began recommending the use of spotters and/or of flaggers to warn workers of errant drivers in multilane highway work zones with speed limits greater than 40 mph (WSDOT 2012; ODOT 2011). The following sections summarize available definitions of spotters and their tasks that are provided by a number of state DOTs.

2.6.1 Virginia DOT

Virginia DOT (VDOT) defines a TTC spotter as a certified flagger whose primary function is to monitor traffic conditions and warn co-workers who are performing tasks such as installing or removing TTC devices and traffic counting devices, and removing debris from the roadway of oncoming traffic. A TTC spotter may stop or slow traffic using a red flag and the correct flagger procedures. Qualifications, clothing requirements, and hand-signaling procedures for TTC spotters shall be the same as for flaggers. The hand-signaling device for a TTC spotter shall be a red flag or a fluorescent orange/red flag a minimum of 24 in. square fastened to a staff that is approximately 36 in. long. The location of the TTC spotter shall be highly visible to oncoming traffic, and the TTC spotter shall stop traffic if necessary when co-workers are installing or removing devices (VDOT 2011).

2.6.2 Michigan

According to Michigan DOT (MDOT), spotters (1) instruct truck drivers when working near other equipment and brief them on procedures for leaving the project area and re-entering the traffic stream and (2) are used solely to alert workers or watch traffic and alert workers of the approach of an errant vehicle. A spotter does not use a traffic regulator paddle, but instead uses a warning sounding device that emits sounds that are different from conventional vehicle horns. The device should be identified to on-site workers so they can take necessary actions whenever they recognize the sound. Michigan DOT recommends using spotters only when the risks to workers exceed those of the spotter. It is also recommended that spotter locations be shown on the temporary traffic control plan (MDOT 2010).

2.6.3 Oregon

Oregon DOT (ODOT) defines a spotter in its TTC handbook for operations of three days or less as "an employee whose sole duty is to provide immediate warning of approaching vehicles, equipment, or other hazards to co-workers" (ODOT 2011). ODOT specifies spotter roles and responsibilities and requires a spotter to (1) focus only on the spotter duties; (2) be within sight or sound of the employee(s) being protected; (3) choose a location that provides optimum sight distance and safety; (4) know the "Alert Call" or communication plan; (5) be on alert to sound the alarm; (6) be in place before the operation begins; and (7) confirm that all affected parties understand the action plan.

ODOT also specifies the following key components in developing and implementing an effective spotter training and performance program:

1. Action Plan—A site or task specific plan along with a hazard assessment for using a spotter must be completed before a spotter can be used. All affected parties must understand the action plan before starting work.

2. When to Use—The need for spotters can be dictated by one or more factors for a given operation or task, including location of task, type of highway, vertical or horizontal alignment, traffic volume

or speed, construction or maintenance activity, traffic controls used, added safety control, and vegetation, trees, roadway geometrics or other conditions that might restrict sight distance or safety of an employee.

3. Location of Spotter—A spotter shall be within visual and verbal contact of employee(s) that are being protected. If visual contact cannot be made with workers, use an air horn, two-way radio, or other warning device to alert workers of an eminent unsafe condition.

4. “Alert Call” and Escape Route—The “Alert Call” (made by voice or mechanical means) needs to be clearly heard above all surrounding noise levels when it appears an unplanned safety problem, errant motorist, equipment or other hazard is intruding into the zone of protection. The “Alert Call” shall be understood and agreed upon by all work party members prior to beginning work. A predetermined escape route for both the spotter and the protected employee(s) shall be established prior to beginning work and agreed upon by all affected parties.

5. Commencement of Work—The spotter shall be in place and prepared to issue alerts before work begins.

6. Training—All affected employees shall understand the roles and responsibilities of a spotter.

ODOT also recommends considering the use of a spotter when:

- Workers have their backs to traffic or other hazards.
- Workers and heavy equipment are working in the same area concurrently.
- Performing work where adequate gaps in traffic allow work to be done in a live travel lane.
- Work encroaches into the roadway, but maintains a minimum 10 ft travel lane.
- Sight distances are limited by vegetation or other conditions.
- Posted speeds are 45 mph or higher.

2.6.4 Wisconsin

Wisconsin DOT (WISDOT) defines the spotter as an emergency personnel assigned to monitor approaching traffic and activate an emergency signal if the actions of a motorist do not conform to established traffic control measures in place at the incident scene (WISDOT 2008).

2.6.5 Washington

Washington DOT (WSDOT 2012) requires the use of a spotter or a very short-duration lane closure to provide advance warning to traffic approaching very short-duration work zones on freeways and high-speed multilane highways as shown on TCP 19A when working in a live lane (Figure 3). TCP 19a classifies the use of spotters as (1) allowed, (2) required, or (3) not recommended (Figure 3) depending on traffic and hazard conditions:

- Using a spotter is allowed in work zones with low impact levels (i.e., low traffic speed and volume and minimum levels of warning, protection, and hazards). In these work zones, a work vehicle with warning beacon and personal protective equipment may be adequate.
- Using a spotter is required in work zones with moderate impact levels (i.e., low or high traffic speed with low to moderate volumes). A moderate level of warning and protection should be considered in these types of work zones, such as spotters, cones, or portable changeable message signs (PCMSs), in addition to the devices mentioned in the low impact scenario.

- Using a spotter is not recommended in work zones with high impact levels (i.e., high traffic speed and volume). All traffic control and safety devices should be considered in these types of work zones, such as PCMSs, TMAs, and signs.

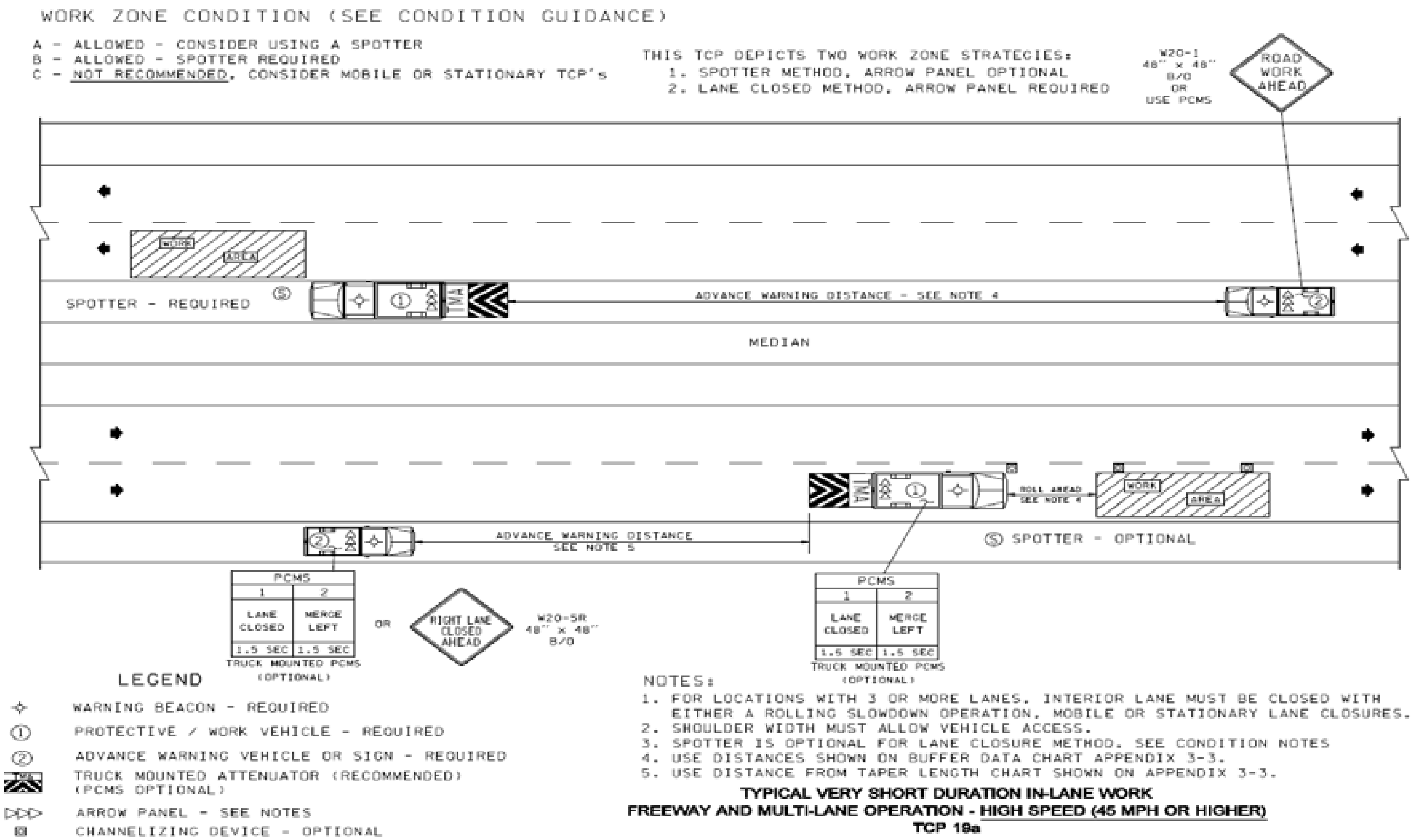


Figure 3. Typical very short-duration in-lane work freeway and multilane operation at speeds of 45 mph or higher (WSDOT 2012).

CHAPTER 3 WORK ZONE SITE VISITS

3.1 INTRODUCTION

In order to evaluate current Illinois flagger and spotter practices, seven highway construction work zones were visited and studied in May through July of 2012 and in July 2013. During these site visits, data were gathered on (1) the type of construction operations performed in the work zone, (2) layout of the work zone and the location of the flaggers, if any, and (3) temporary traffic control measures used in the work zone. The following sections present a brief description of the data gathered during five of these site visits. The findings of the remaining site visits are summarized in Appendix B.

3.2 INTERSTATE HIGHWAY 57, CHAMPAIGN, ILLINOIS

This construction project, located on the southbound of Interstate Highway 57 between Olympian Drive in Champaign and 2 miles south of Thomasboro, Illinois, was visited on May 18, 2012. The operations observed in the highway construction project included removing existing pavement, paving, and rolling operations, as shown in Figures 4, 5, 6, and 7, respectively. The flagger was holding a STOP/SLOW paddle to control the traffic, as shown in Figure 7 and Figure 8. The work zone also had a flagger warning sign located ahead of the flagger to warn oncoming traffic, as shown in Figure 9. In addition, other temporary traffic control devices were used, including (1) direction indicator barricades, as shown in Figure 10, (2) arrow boards, as shown in Figure 10, and (3) drums, as shown in Figure 11, Figure 12, Figure 13, and Figure 14. Furthermore, the research team discussed the use and effectiveness of flaggers in this type of work zone with the project's flaggers and resident engineer.

Figure 4. Pavement removal operations on I-57.

Figure 5. Paving operations on I-57.

Figure 6. Roller operations and flagger to control the traffic.

Figure 7. Flagger location.

Figure 8. Flagger holding a SLOW paddle.

Figure 9. Flagger warning sign.


Figure 10. Direction indicator barricades and arrow board.


Figure 11. Lane closure using drums.

Figure 12. Speed limit sign at the beginning of the work zone.

Figure 13. Drums and opening for exit ramp.

Figure 14. Speed limit sign, direction indicator barricades, and drums.

3.3 INTERSTATE 155, MORTON, ILLINOIS

This construction project, located on Interstate 155 in Morton, Illinois, was visited on July 11, 2012. The research team observed milling operations for the replacement of the drainage system underneath the road shoulder, as shown in Figure 15 and Figure 16. The main types of traffic control measures that were used on the construction site were direction indicator barricades, drums, speed indicators, arrow boards, flagger warning signs, and flaggers, as shown in Figure 17 through Figure 21.

In this work zone, a flagger was deployed at the edge of the live lane to control traffic, as shown in Figure 20. The research team used a speed gun to measure traffic speeds (Figure 22). The vehicles monitored were traveling at or below the posted speed limit of 45 mph.

Figure 15. Milling operations using trench cutter.

Figure 16. Horizontal milling operations using trench cutter.

Figure 17. Speed indicator and traffic drums.

Figure 18. Direction indicator barricades and arrow board.

Figure 19. Traffic drums.

Figure 20. Traffic control using traffic drums and flagger.

Figure 21. Flagger warning sign ahead of flagger location.

Figure 22. Research team using speed gun to measure traffic speed.

3.4 INTERSTATE HIGHWAY 57, NEAR EFFINGHAM, ILLINOIS

This construction site, located on Interstate 57 near Effingham and Neoga, Illinois, was visited on July 13, 2012. The construction included resurfacing and paving of the highway road. The traffic control devices used on this site included direction indicator barricades, cones, drums, flagger and flagger signs, as shown in Figure 23 through Figure 28.

Figure 23. Live and work zone lanes.

Figure 24. Work zone rolling operation and lane closure using cones.

Figure 25. Rolling operation, traffic drums and cones.

Figure 26. Flagger controlling traffic at the edge of live lane.

Figure 27. Rolling operation in work zone and flagger controlling speed on live lane.

3.5 INTERSTATE HIGHWAY 255, NEAR EAST ST. LOUIS, ILLINOIS

This construction project, located on the southbound lanes of Interstate 255 near I-64 in East St. Louis, Illinois, was visited on July 16, 2012. The project involved constructing a large bridge across the Mississippi River and repaving parts of the highway in the nearby interchanges and highway segments. The general project, including several work zones for repairing and reconstructing existing highways, ramps, and bridges. A flagger was deployed to control traffic and guide the trucks entering and exiting the work zone, as shown in Figure 28 and Figure 29.

Figure 28. Flagger controlling traffic at the edge of live lane.

Figure 29. Two-lane closure using cones and flagger to slow the traffic.

3.6 INTERSTATE HIGHWAY 57, CHAMPAIGN, ILLINOIS

This construction project, located in the southbound lane of Interstate 57 near West Olympian Drive in Champaign, Illinois, was visited on July 8, 2013. The observed construction operations included (1) the installation of temporary concrete barriers for the work zone and (2) cutting concrete pavement using diamond-blade saw. The following TTC measures were used: (1) a flagger, (2) TTC signs such as lane closure, flagger ahead, and speed limit, and (3) drums, cones, direction indicator barricades, and arrow board, as shown in Figure 30 and Figure 32. A flagger was deployed during the installation of the temporary concrete barriers to slow down traffic and protect workers. A predetermined escape route, allowing the flagger to jump over the barrier and use it as physical protection against errant drivers or other traffic hazards, was established, as shown in Figure 31. During the site visit, the research team collected field data about (1) the average time required for the flagger to escape from the live traffic lane, which ranged between 3 and 5 seconds, (2) traffic speed, which ranged between an average of 30 mph at the location of the flagger and 38 mph at the start of the work zone lane closure; therefore indicating that traffic speed was excessively reduced below the 45 mph speed limit because of the flagger, and (3) noise levels generated by construction equipment and an intrusion alarm device that was tested by the research team, as shown in Table 2. The intrusion alarm was manually activated 60 ft and 120 ft away from two types of construction equipment (concrete saw and a truck-mounted generator). The sound level was recorded at the location of the two pieces of equipment using a sound meter. The intrusion alarm could be heard when it was activated from a distance of 60 ft and 120 ft away from the truck-mounted generator, but was barely audible when activated from a distance of 60 ft and could not heard at all at a distance of 120 ft away from the concrete saw.

Table 2. Summary of Sound Measurements in dB in Experiment 1

Distance	Truck-Mounted Generator	Concrete Saw
Noise Before Alarm	85	100-105
Alarm at 60 ft	105	105
Alarm at 120 ft	92	105

Figure 30. TTC devices including speed limit signs, direction indicator barricades, and drums.

Figure 31. Installing temporary concrete barriers while flagger slows down the traffic.

Figure 32. Flagger signs and direction indicator barricades.

3.7 ILLINOIS TOLLWAY (I-90) BETWEEN ELGIN AND ROCKFORD, ILLINOIS

This construction project, extending 37 miles on Jane Addams Memorial Illinois Tollway (I-90) between Elgin and Rockford, Illinois, was visited on July 24, 2013. During the site visit, the research team observed and studied several flagger operations and construction activities, including the removal of existing pavement and paving operations. The layout of the work zone and its TTC signs followed the MUTCD, including flagger signs, speed limit signs, and drums. A flagger holding a STOP/SLOW paddle was located at the work zone entrance/exit, 2 to 3 ft away from the edge of the highway ramp, as shown in Figure 35. The flagger monitored traffic, guided trucks entering and exiting the work zone, and alerted workers using hand signals and slowed traffic with the SLOW paddle and used hand signals to alert the workers of trucks exiting the work zone, as shown in Figure 33 and Figure 34 . Flagger operations at the access and egress of the work zone were videotaped, and traffic speed was measured to study the effect of flagger operations on traffic mobility. Analysis of the recorded videotapes and traffic speed showed that trucks entering the work zone slowed down the traffic. However, trucks were allowed to exit the work zone only when there was light or no traffic and, accordingly, they did not cause traffic delays, as shown in Figure 35.

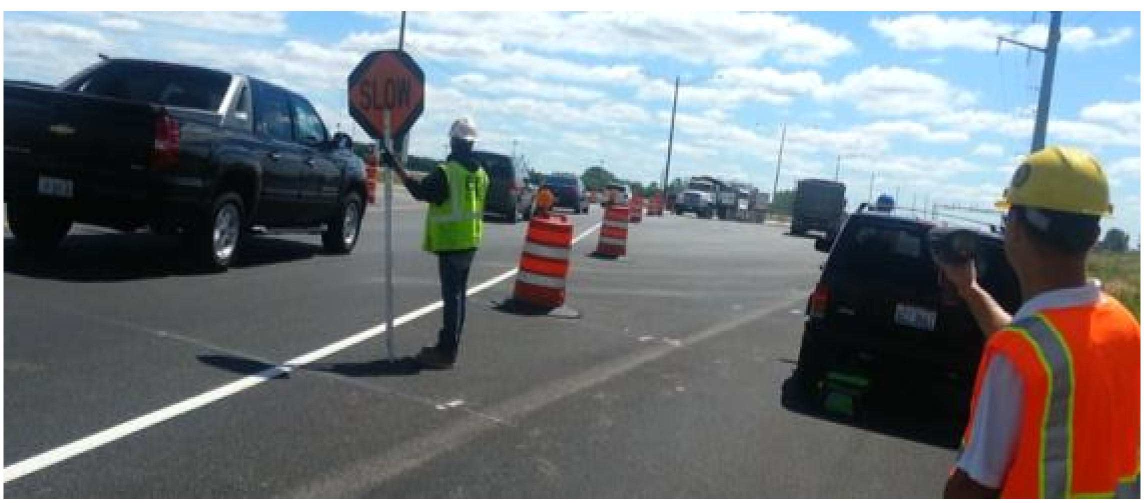


Figure 33. Flagger standing at the edge of live lane monitors traffic to allow the truck to exit.

Figure 34. Truck exits from work zone.


Figure 35. Flagger slows down traffic and guides trucks to enter work zone.

3.8 MEETINGS WITH RESIDENT ENGINEERS

Two meetings were conducted during the site visits: (1) a meeting with IDOT engineers in District 7, Effingham, Illinois, and (2) a meeting with IDOT engineers in District 8, East St. Louis, Illinois. The purpose of these meetings was to gather feedback from IDOT resident engineers on the effectiveness, safety, and risks of using flaggers and spotters in these types of work zones and to discuss alternative means. The meetings included guided questions and open discussions aimed at building consensus and obtaining additional comments that were not part of the structured surveys that are listed in Appendix D.

3.8.1 Meeting with Engineers, District 7, Effingham, Illinois

The research team held meetings with IDOT resident engineers and other engineers in District 7 to gather feedback on the following topics: (1) the safety, need, effectiveness, and limitations of flaggers and (2) the feasibility of replacing flaggers with spotters and/or other measures that can support flaggers and work zones.

3.8.2 Meeting with Engineers, District 8, East St. Louis, Illinois

In this meeting, the research team discussed with District 8 engineers and managers the Mississippi River Bridge Project that connects Illinois and Missouri across the Mississippi River. The research team gathered feedback and comments from participating engineers on the need for flaggers, limitations of flaggers, nighttime work, spotters, radar drones, and automated flaggers to increase work zone safety, as shown in Figure 36.

Figure 36. Meeting with IDOT engineers in District 8.

CHAPTER 4 WORK ZONE CRASH DATA ANALYSIS

4.1 INTRODUCTION

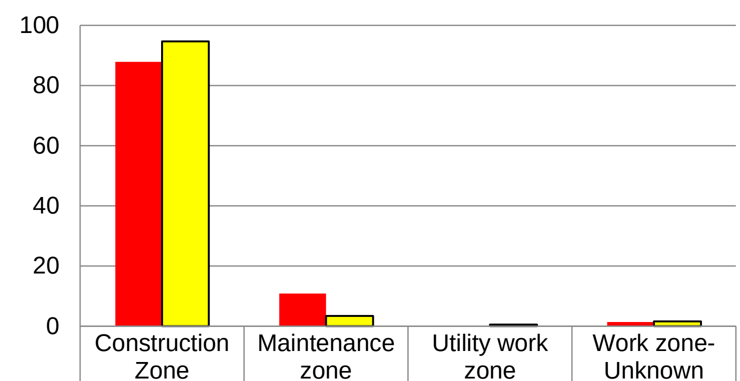
This chapter presents the findings of a comprehensive analysis of work zone crashes in Illinois during a fourteen-year period, from 1996 to 2009. The objectives of this analysis were (1) to study the frequency and severity of work zone crashes on Illinois expressways and freeways and (2) to investigate the probable causes and factors contributing to work zone crashes. Two main research tasks were performed to accomplish these objectives: (1) data and reports on work zone crashes on Illinois multilane highways were collected from available resources and (2) a comprehensive statistical analysis was conducted to study the frequency, severity, and other characteristics of injury and fatal work zone crashes in Illinois. The collection and aggregation of work zone crash data are presented in Appendix C; the findings of the data analysis are described in the following sections.

4.2 DATA ANALYSIS

The following sections summarize the findings of a statistical analysis that was conducted to study the impact of the identified variables listed in Table C.6 in Appendix C on the frequency of fatal and injury work zone crashes.

4.2.1 Road Data Road Condition (RD_CON1)

The impact of the type of work zone on the frequency of fatal and injury crashes in Illinois highways is shown in Figure 37. The work zone variable in this analysis is classified into four types: construction zone, maintenance zone, utility work zone, and unknown work zone. The results show clearly that construction zones were the most dominant type of work zone crashes because they accounted for 88% of fatal crashes and 95% of injury crashes.

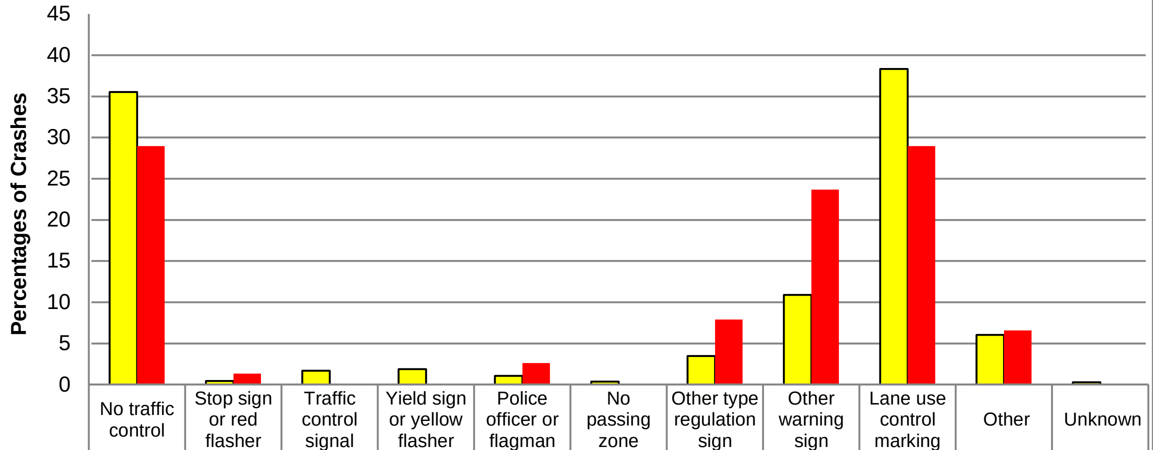


	Construction Zone	Maintenance zone	Utility work zone	Work zone-Unknown
Fatal%	87.8	10.8	0.0	1.4
Injury%	94.6	3.3	0.5	1.6

Figure 37. Impact of the type of work zone on the frequency of fatal and injury crashes.

4.2.2 Road Data Traffic Control (TRA_CON1)

Figure 40 shows the impact of utilizing various traffic control devices on the frequency of fatal and injury work zone crashes on Illinois highways. The results show that 29% of fatal work zone crashes and 35.6% of injury work zone crashes had no traffic control. The results also indicate that the presence of a police officer or flagger in a work zone is an effective traffic control measure because only 2.6% of the fatal crashes and 1.1% of the injury crashes were reported in the presence of a police officer or flagger, as shown in Figure 38.

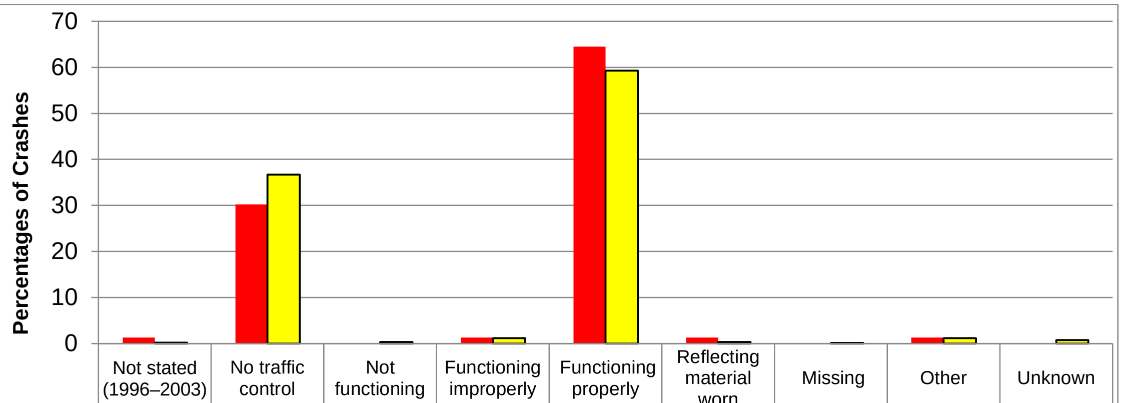


	No traffic control	Stop sign or red flasher	Traffic control signal	Yield sign or yellow flasher	Police officer or flagman	No passing zone	Other type regulation sign	Other warning sign	Lane use control marking	Other	Unknown
Injury	35.54	0.44	1.7	1.88	1.06	0.36	3.48	10.89	38.31	6.03	0.28
fatal	28.95	1.32	0	0	2.63	0	7.89	23.68	28.95	6.58	0

Figure 38. Impact of traffic control on the frequency of fatal and injury crashes.

4.2.3 Road Data Traffic Function (TRA_FUN1)

Figure 39 shows the impact of traffic control functionality on the frequency of fatal and injury crashes in Illinois highways. The results show that 64.5% of fatal crashes and 59.3% of injury crashes occurred in work zones with properly functioning traffic control devices.

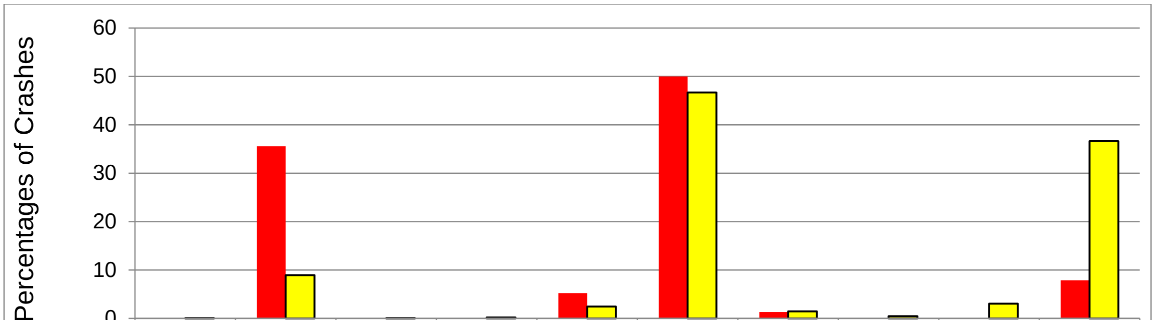


	Not stated (1996–2003)	No traffic control	Not functioning	Functioning improperly	Functioning properly	Reflecting material worn	Missing	Other	Unknown
Fatal%	1.3	30.3	0.0	1.3	64.5	1.3	0.0	1.3	0.0
Injury%	0.2	36.7	0.3	1.2	59.3	0.4	0.1	1.2	0.7

Figure 39. Impact of traffic control functionality on the frequency of crashes.

4.2.4 Road Data: Road Class (RD_CLASS)

Figure 40 shows the impact of the class of traffic way on the frequency of fatal and injury crashes in Illinois highways. The results indicate that urban—controlled access highways had the highest percentage of fatal and injury crashes, while rural—controlled access highways accounted for the second highest percentage of fatal crashes and urban—toll roads accounted for the second highest percentage of injury crashes.

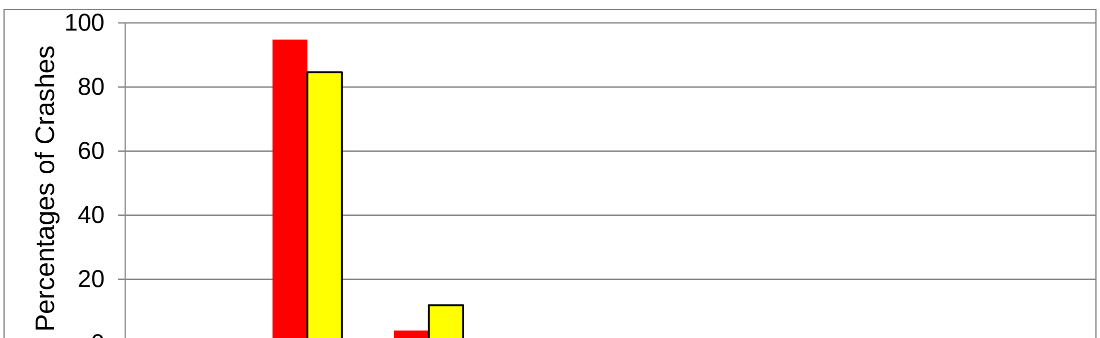


	Rural—unmarked state highway	Rural—controlled access highway	Rural—other marked state highway	Rural—county/local road	Rural—toll road	Urban—controlled access highway	Urban—other marked state highway	Urban—unmarked state highway	Urban—city street	Urban—toll road
Fatal%	0	35.53	0	0	5.26	50	1.32	0	0	7.89
Injury%	0.1	8.94	0.01	0.2	2.47	46.65	1.45	0.49	3.05	36.64

Figure 40. Impact of traffic way class on the frequency of fatal and injury crashes.

4.2.5 Road Data (Road Surface Condition)

Figure 41 shows the impact of the road surface condition on the frequency of fatal and injury crashes in Illinois. The results show that the majority of work zone crashes occur on dry roadway surfaces and only 3.9% and 11.9% of total fatal and injury crashes, respectively, occur on wet roadway surfaces. This indicates that the wet road surface condition is not one of the significant causes of work zone crashes on highways in Illinois.

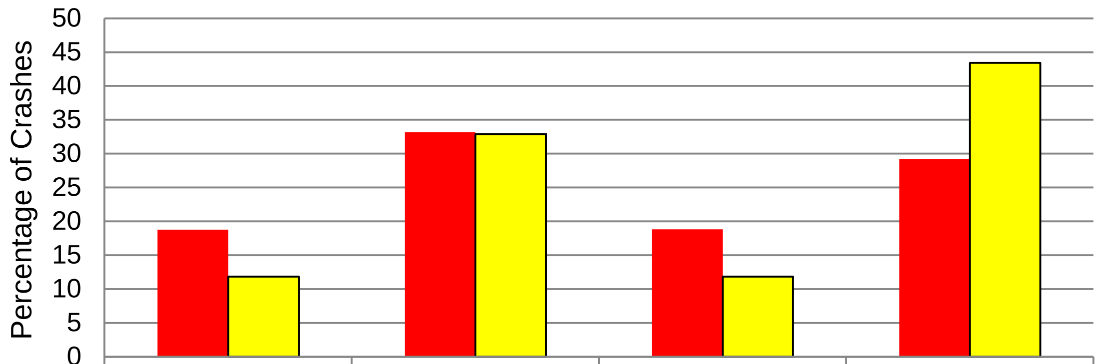


	Not Stated (96-2003)	Dry	Wet	Snow/slush	ice	Sand/mud/dirt/etc.	Other	Unknown
Fatal%	0	94.74	3.95	0	0	0	1.32	0
Injury%	0.61	84.55	11.92	1.13	0.6	0.18	0.6	0.41

Figure 41. Impact of road surface condition on the frequency of fatal and injury crashes.

4.2.6 Time Data (Time of Accident)

Figure 42 shows the impact of the time of day on the frequency of fatal and injury crashes in Illinois. The results indicate that 29.2% and 43.4% of fatal crashes and injury crashes, respectively, occurred at nighttime hours (20:00 to 6:00). These findings suggest that nighttime work zones create safety risks for traffic and cause a significant number of fatal and injury crashes. The increasing nighttime risks must be carefully considered and the visibility of traffic control and lighting designs for nighttime work zones must be improved to increase alertness of nighttime drivers. The results also show that 32.1% and 33.9% of fatal and injury crashes, respectively, occur in daytime.

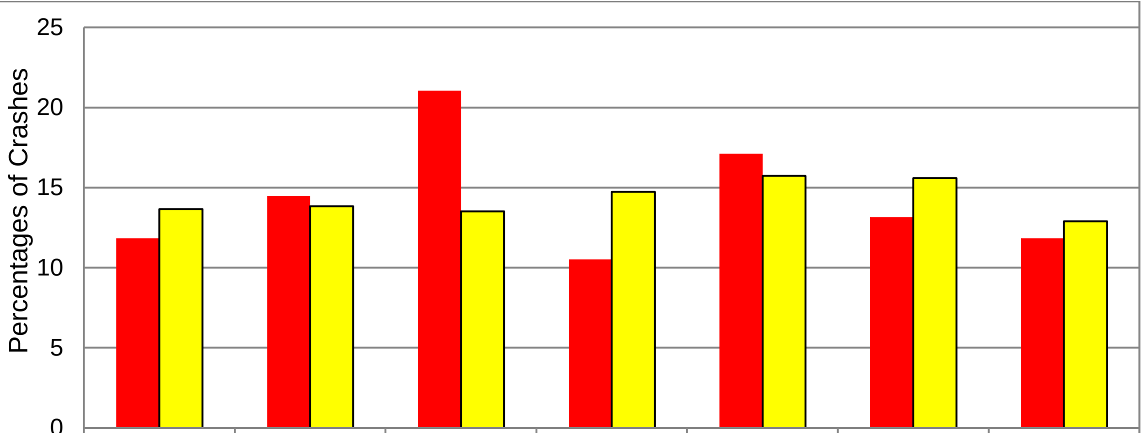


	6:00 – 10:00	10:00– 16:00	16:00 – 20:00	20:00 – 6:00
Fatal%	18.79	33.16	18.82	29.23
Injury%	11.84	32.89	11.84	43.42

Figure 42. Impact of the time of day on the frequency of fatal and injury crashes.

4.2.7 Time Data (Day of the Week)

Figure 43 shows the impact of the day of the week on the frequency of fatal and injury crashes. The results show that there is no significant difference between the types of work zone crashes and their distribution over the days of the week. For example, the largest difference in fatal work zone crashes was equivalent to 10.5%, which represented the difference between crashes occurring on Wednesday, 21.1%, and those occurring on Thursday, 10.5%, and Sunday, 11.8%. The results also show that the lowest percentage of fatal and injury work zone crashes occur on Sunday, which can be attributed to the reduced work zone operations on that day of the week.



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Fatal%	11.84	14.47	21.05	10.53	17.11	13.16	11.84
Injury%	13.66	13.84	13.52	14.74	15.73	15.6	12.91

Figure 43. Impact of the weekday on the frequency of fatal and injury crashes.

4.2.8 Crash Data (Type of Collision)

This section analyzes the types of collisions caused by fatal and injury crashes, as shown in Figure 44. The results of this analysis show that the most frequent type of collision was rear-end for both types of crashes, 38.2% fatal crashes and 54.6% injury crashes, followed by fixed- object collision crashes, 21%, fatal crashes and 15.2 injury crashes. The results indicate that rear-end and fixed-object are the leading types of collisions for fatal and injury work zone crashes in Illinois.

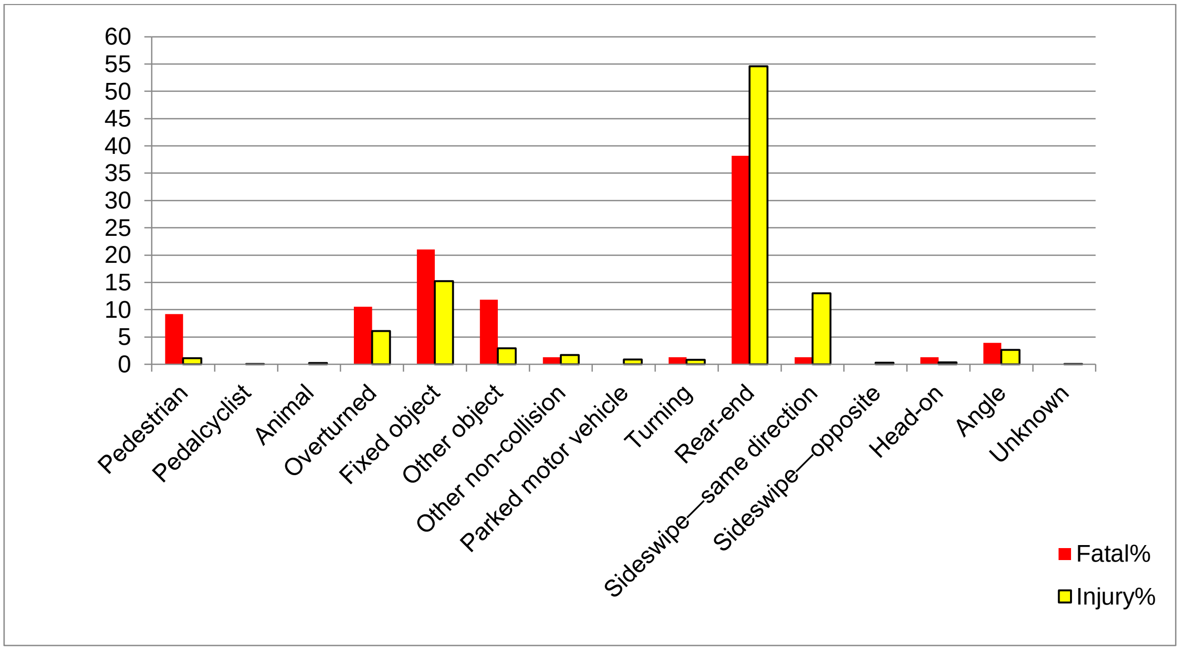
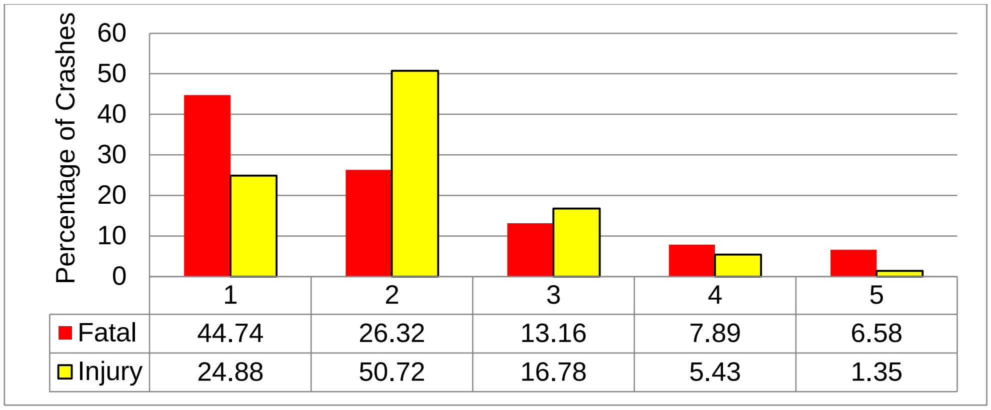


Figure 44. Type of collision caused by fatal and injury crashes.

4.2.9 Crash Data (Number of Vehicles Involved)

In this analysis, the severity of various types of crashes was analyzed using a second metric that represents the total number of vehicles involved in the crash. The results of this severity analysis are shown in Figure 45. The results show that almost half of fatal work zone crashes (44.7%) involved one vehicle only, while a small percentage (8%) of these crashes involved four or more vehicles. On the other hand, 24.9% of injury work zone crashes involved one vehicle only, while 50.7% of this type of crash was caused by two vehicles. This indicates that (1) fatal crashes are more likely to involve one vehicle compared with injury crashes, (2) a significant majority of all types of crashes involves one or two vehicles, and (3) injury crashes are more likely to involve two vehicles.

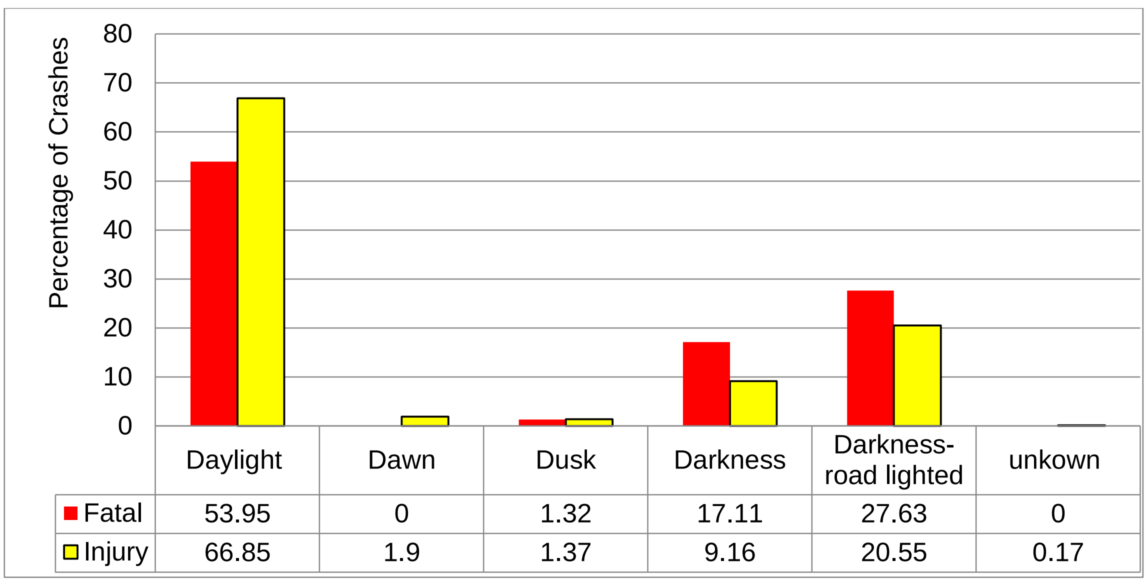


	1	2	3	4	5
Fatal	44.74	26.32	13.16	7.89	6.58
Injury	24.88	50.72	16.78	5.43	1.35

Figure 45. Total number of vehicles involved in fatal and injury crashes.

4.2.10 Light and Weather Data (Light Conditions)

The impact of light conditions on the frequency of fatal and injury crashes in Illinois is shown in Figure 46. The results show that 54% of fatal crashes and 67% of injury crashes occurred in daylight, while the remaining crashes (34% fatal crashes and 29% injury crashes) occurred on dark roads or lighted roads in nighttime, as shown in Figure 48. The results also show that 17% of fatal crashes occurred at night on unlighted roads compared with 9% of total injury crashes that occurred in similar lighting conditions.

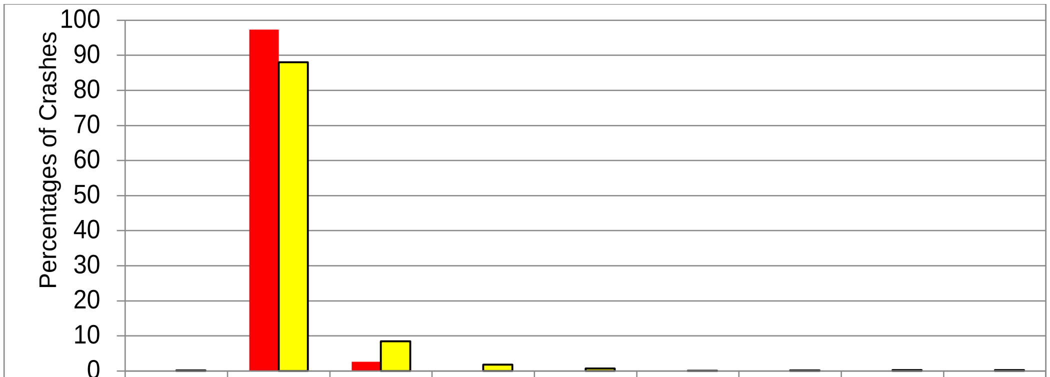


	Daylight	Dawn	Dusk	Darkness	Darkness-road lighted	unkown
Fatal	53.95	0	1.32	17.11	27.63	0
Injury	66.85	1.9	1.37	9.16	20.55	0.17

Figure 46. Impact of light conditions on the frequency of crashes.

4.2.11 Weather Data (Weather)

The impact of weather conditions on the frequency of fatal and injury crashes in Illinois is shown in Figure 47. Results show that the majority of work zone crashes occurred during clear weather conditions. Only 2.6% of fatal crashes and 8.4% of injury crashes occurred in rainy conditions, which reflects that weather is not a major cause of work zone crashes on Illinois highways.

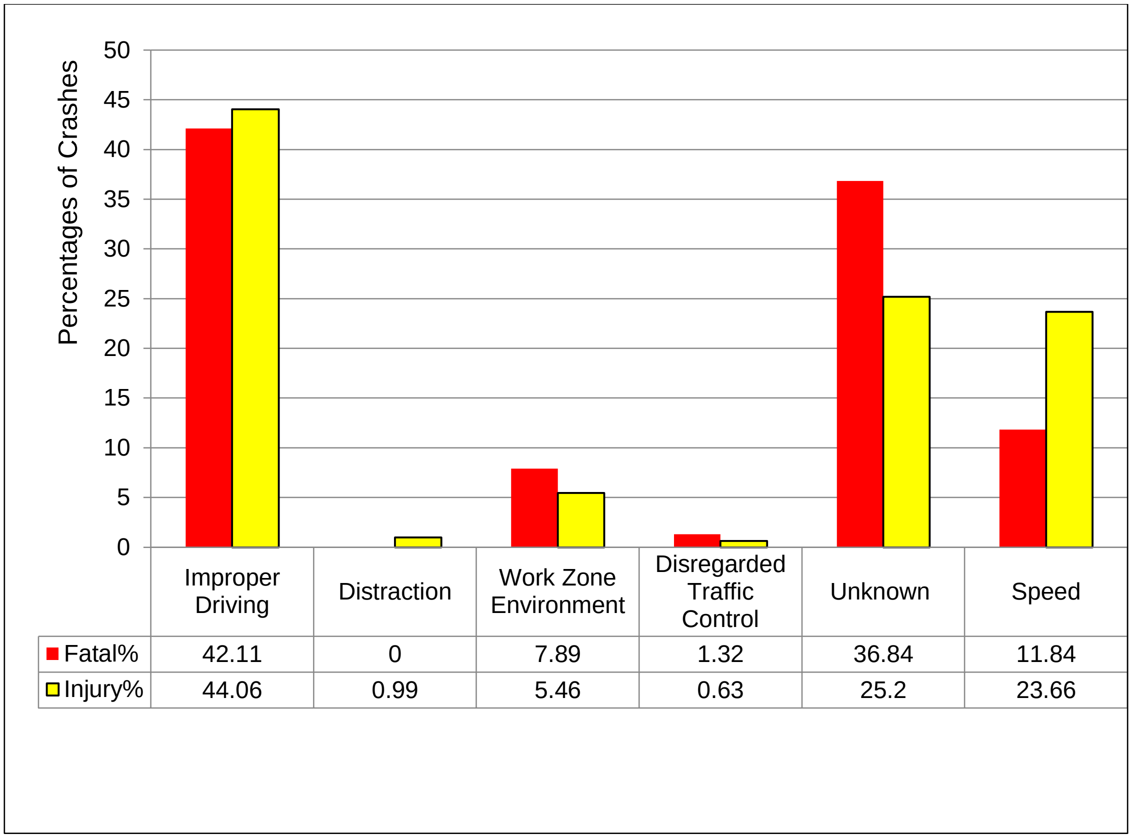


	Not stated	Clear	rain	snow	Fog/smoke /haze	sleet/hail	severe crosswind	other	unknown
Fatal%	0	97.37	2.63	0	0	0	0	0	0
Injury%	0.15	88	8.44	1.8	0.74	0.11	0.2	0.28	0.28

Figure 47. Impact of weather conditions on the frequency of crashes.

4.2.12 Contributing Causes

The contributing cause variable represents various drivers' actions that contributed to crashes. In the National Highway Traffic Safety Administration (NHTSA) data files, this variable has 35 possible values representing potential contributing causes that are related to drivers' actions. In this analysis, the 35 possible values are regrouped and divided into six major contributing causes: (1) improper driving, (2) distraction, (3) work zone environment, (4) disregarding traffic control, (5) speed, and (6) an unknown cause. The impact of these contributing causes on the frequency of fatal and injury crashes in Illinois is shown in Figure 48. The results show that improper driving was the main contributing cause, accounting for 42% and 44% of fatal and injury work zone crashes, respectively, followed by speed and work zone environment causes. In addition, it is observed that improper driving covers a number of driver actions such as following too closely, wrong side/way, improper turn, and right turn on red, as shown in Appendix C. Speed also covers several speed-related actions, and the work zone environment covers a number of subcategories such as: road engineering, surface, markings, and defects, road construction, obscured vision, and improper lane usage. Therefore, it is important to attract the attention of drivers and increase awareness of work zones in order to minimize potential crash causes and, consequently, reduce the risks of fatal and injury crashes and improve traffic safety. Results also show that "Unknown" was the second highest category due to its selection in the crash report by police officers when they cannot identify the specific cause of crash.



	Improper Driving	Distraction	Work Zone Environment	Disregarded Traffic Control	Unknown	Speed
Fatal%	42.11	0	7.89	1.32	36.84	11.84
Injury%	44.06	0.99	5.46	0.63	25.2	23.66

Figure 48. Impact of contributing causes on the frequency of fatal and injury crashes.

CHAPTER 5 EFFECTIVENESS OF TRAFFIC CONTROL DEVICES

5.1 INTRODUCTION

This chapter analyzes the feasibility and effectiveness of new and existing work zone safety measures that can supplement or replace the use of flaggers and/or spotters on freeways and expressways with speed limits greater than 40 mph. The analyzed measures included intrusion alarms alert systems, portable changeable message signs (PCMSs), portable speed monitoring displays (PSMDs), temporary rumble strips, radar drones, truck-mounted attenuators (TMAs), mobile barriers, and automated flagger assistance devices (AFADs). The following sections summarize the main features of each measure and their reported effectiveness in recent research studies.

5.2 INTRUSION ALARMS

5.2.1 Features

Intrusion alarms, such as the SonoBlaster®, are impact-activated safety devices that warn construction workers and errant vehicle drivers simultaneously to help prevent crashes and injuries in work zones, as shown in Figure 49. SonoBlaster can be mounted on typical work zone barricades, cones, drums, delineators, A-frames and other barriers. Upon impact of an errant vehicle, the SonoBlaster's built-in CO_2-powered horn blasts at 125 dB to alert workers that their protective zone has been violated, giving them critical reaction time to move out of harm way (SonoBlaster 2011).The system also warns errant drivers in case of an intrusion into a work zone.

Figure 49. Intrusion alarm (SonoBlaster® 2011).

5.2.2 Effectiveness Reported in Recent Studies

In a recent study sponsored by NJDOT, Krupa (2010) evaluated the effectiveness of a "SonoBlaster Work Zone Intrusion Alarm." The study concluded that the alarm's sound is satisfactory during normal traffic conditions and for a distance of 200 ft even if ear protection is worn. In addition, the effectiveness of the alarm system and its sound levels were tested when a roller and other high-noise mechanical equipment, such as jackhammers, were in use. Based on the results of these tests, the study concluded that the roller operator was able to hear the alarm during equipment operations. However, the study did not reach the same conclusion for operators of other high-noise mechanical equipment such as jackhammers. The study also reported that the setup procedures could be confusing and that the units were very sensitive and therefore had to be carefully handled, which might cause delays for the setup crews and expose them to traffic hazards. In order to improve effectiveness of the alarm system, the study recommended (1) increasing the alarm's sound, volume, and duration, (2) making the docking easier, and (3) modifying alarms attachment to the cones to allow for cones stacking. The study concluded that SonoBlaster equipped cones could be more useful for smaller roads with lower speeds and less traffic. Based on the findings of this study, NJDOT decided not to deploy the tested alarm system because of reported quality control, reliability, and cost issues.

In another recent study, Wang et al. (2011) evaluated the effectiveness of this alarm system using a nationwide survey of DOTs. In this survey, three states reported that they were using or testing the alarm system and six other states reported that they had used or tested them in the past. The survey results also show that 44% of these nine states reported that the alarm system was ineffective, while the remaining 56% did not provide their opinion regarding the effectiveness of the alarm system. In addition, survey respondents reported other operational problems associated with false alarms, maintenance, and installation time.

Kuta (2009) conducted another study to evaluate the feasibility and effectiveness of the intrusion alarm system. Forty-eight sets of the system (1,175 units) were distributed to and evaluated by various agencies across the nation, as shown in Figure 50 and Figure 51. The study found the following operational problems to be associated with the SonoBlaster system: (1) difficulty of storing cones with SonoBlaster units, (2) length of the system setup and dismantling time, (3) difficulty of arming the unit, (4) difficulty of verifying that the unit was armed, and (5) failure of the alarm sound to alert workers in noisy work zones. The study also provided the following suggestions to improve the system: (1) increase system volume and duration, (2) make system units stackable to facilitate and speed up setup and storage, (3) shorten and clarify setup directions, and (4) make system indicator more visible so that workers can verify that the system is active from a far distance.

Other studies were also conducted by New York and Washington DOTs to evaluate the effectiveness of intrusion alarm systems (Hibbs 1997). Based on the findings of Washington DOT evaluation, the alarm systems were proven user-friendly and easy to set up. On the other hand, the study reported that the devices did not produce a warning loud enough to be heard by workers over existing traffic and construction sounds. New York DOT study reported that 88% of work crews favored the intrusion alarm system and were interested in purchasing it. During field evaluation of that study, errant vehicles set off the intrusion alarms several times, but none of the vehicles entered the work area.

Figure 50. Intrusion alarms demonstration (Kuta 2009).

Figure 51. Intrusion alarms ready to be distributed for demonstration (Kuta 2009).

5.3 TEMPORARY RUMBLE STRIPS

5.3.1 Features

Temporary rumble strips are devices that generate sounds and vibrations as vehicles pass over them to draw drivers' attention to roadway/work zone conditions. Temporary rumble strips are used over short distances in different patterns for the purpose of providing motorists with increased perception of speed (Fontaine and Carlson 2001). The rumble strips consist of intermittent, narrow, and transverse areas of rough-textured or slightly raised road surface extending across travel lanes to alert drivers of uncommon vehicular conditions (Miles and Finley 2007). Rumble strips patterns vary according to several factors, including pavement materials, types of rumble strips, locations of wheel paths relative to rumble strips, and duration of temporary arrangement (Meyer 2000).

5.3.2 Effectiveness Reported in Recent Studies

Several recent studies evaluated the effectiveness of various types of rumble strips with different configurations. In a recent IDOT sponsored study, El-Rayes et al. (2010) performed field experiments to study the efficiency and effectiveness of using temporary rumble strips prior to and at the edge of work zones, as shown in Figure 52. Field experiments were conducted on different patterns of three types of temporary rumble strips using three testing vehicles: sedan, cargo van, and 26-foot truck. Sound levels of 189 test configurations were continuously collected as testing vehicles traversed different patterns of the rumble strips. The findings of the experiments confirmed that (1) the three tested types of temporary rumble strips were efficient in terms of installation and removal while the total installation efficiency varied according rumble strips type and the number of strips per set; and (2) the temporary rumble strips were effective in terms of generating auditory stimulus capable of alerting motorists of the approaching work zone.

Figure 52. Site of field experiments showing tested sets of temporary rumble strips (El-Rayes et al. 2010).

Other research studies evaluated the effectiveness of temporary rumble strips in reducing vehicles speed in enforced work zone areas. These studies proved that temporary rumble strips are effective temporary traffic control device for alerting motorists to reduce their speed (Meyer 2000; Fontaine and Carlson 2001). Meyer (2000) evaluated the effectiveness of 1/8 in. thick temporary rumble strips versus standardized 1/2- to 3/4-in. asphalt rumble strips at a bridge repair site in Kansas. The reduction in vehicle speeds caused by the temporary rumble strips was then quantified and compared with the speed reduction caused by standard asphalt rumble strips. The study reported that the 1/8 in. thick strips were not sufficient to be reliably detected by drivers; however, there was a statistically significant reduction in vehicle speeds after the installation of the strips. In a similar study, Fontaine and Carlson (2001) reported that the percentage of passenger cars that exceeded the speed limit in work zones was significantly reduced after the implementation of temporary rumble strips. In another recent study, Wang et al. (2011) evaluated the effectiveness of temporary rumble strips using a nationwide DOTs survey. In this survey, seven states reported that they were using or testing temporary rumble strips and four other states reported that they had used or tested them in the past. The survey results also show that four of these eleven states (36%) reported that temporary rumble strips were ineffective while the remaining seven did not provide their opinion regarding the effectiveness of temporary rumble strips.

5.3.3 Effectiveness Reported in Survey Results:

In the recently completed survey in this study, the effectiveness of temporary rumble strips in increasing the safety and mobility of work zones received an average effectiveness score of 0.557, where "0" represents least effective and "1" represents most effective.

5.4 PORTABLE CHANGEABLE MESSAGE SIGNS

5.4.1 Features

Portable changeable message signs (PCMSs) are movable traffic control devices that can display a variety of messages to inform motorists about work zone conditions, as shown in Figure 53. Displayed messages are limited to the size of the sign, which usually consist of three rows of eight characters each. PCMS announcements are used to alert drivers and provide advanced warnings of detours, ramp closures, reduced speed limits, and unexpected traffic queues. PCMSs can be mounted on either a trailer or work vehicle and are capable of displaying two or three lines of text, depending on the PCMS size. A PCMS message can use one, two, or, when absolutely necessary, three phases in which to relay its message (ODOT 2013). PCMSs are commonly used to encourage and direct traffic to transition out of one or more closed lanes before the work zone (Wang et al. 2011).

5.4.2 Effectiveness Reported in Recent Studies

In a recent study, Zech et al. (2008) evaluated the effectiveness of PCMS messages. The study reported that the message "WORK ZONE MAX SPEED 45" led to a reduction in vehicles speed by 3.3 to 6.7 mph. Therefore, it was concluded that properly selected PCMS messages could be effective in reducing the speed of vehicles in the vicinity of highway work zones. Another study (Garber and Patel 1995) recommended using PCMSs in short-term work zones and suggested further research for its use in long-term work zones. Garber and Srinivasan (1998) tested the effectiveness of using PCMSs with speed radar to automatically display warning messages to speeding drivers. The study reported that the PCMS and radar combination was more effective than traditional work zone traffic control devices in reducing traffic speed. In a recent nationwide survey, 100% of the responding states that used or tested PCMSs (26 states) reported that the device was effective in short-term work zones (Wang et al. 2011).

Figure 53. Portable changeable message sign (PCMS).

5.5 PORTABLE SPEED MONITORING DISPLAYS

5.5.1 Features

Portable speed monitoring displays (PMSDs) are electronic signs activated by radar to display vehicles speed, as shown in Figure 54. PSMDs are used to raise drivers' awareness of their speed and remind them to comply with the posted speed limit. PSMDs are also known as "driver feedback signs," "radar signs," and "speed signs."

Figure 54. Portable speed monitoring display (PSMD).

5.5.2 Effectiveness Reported in Recent Studies

Pesti and McCoy (2001) evaluated the long-term effectiveness of PSMDs by studying the impact of deploying three PSMDs along a 2.7-mile roadway section for a period of five weeks. Based on the findings of these tests, PSMDs were proven effective in lowering speeds, improving uniformity of speeds, and increasing compliance with speed limits. Furthermore, the study reported that significant speed reductions and speed limit compliance were noticed for one week after the removal of the PSMDs. In another study, Fontaine and Carlson (2001) evaluated the effectiveness of PSMDs in a short-term highway work zone and reported that the use of PSMDs was effective in lowering vehicle speeds. In addition, McCoy et al. (1995) tested the impact of using PSMDs and reported that their use caused a reduction in the average traffic speed by 4 to 5 mph

5.5.3 Effectiveness Reported in Survey Results

In the survey recently completed for this study, the effectiveness of PSMDs in increasing work zone safety received a weighted effectiveness score of 0.731, where "0" represents least effective and "1" represents most effective. Furthermore, a number of IDOT resident engineers who were interviewed in this project suggested that PSMDs would be more effective if they could capture photos of speeding drivers and/or license numbers of speeding vehicles and display them on PSMDs.

5.6 RADAR DRONES

5.6.1 Features

Radar Drones are small, lightweight, and weatherproof electronic devices that emit radio signals similar to police radar systems. Radar drones can be mounted on work zone vehicles or signs to reduce traffic speed, as shown in Figure 55. This device is used in work zones to activate the radar detectors used by drivers in order to reduce their speed and avoid speeding tickets. Radar drones can be effective in reducing work zone traffic speed because (1) many drivers have radar detectors; and/or (2) drivers with radar detectors may travel faster than other drivers (Teed and Williams 1990; Carlson et al. 2000).

Figure 55. Radar drones.

5.6.2 Effectiveness Reported in Recent Studies

Several studies were conducted to analyze the effectiveness of radar drones in reducing vehicle speeds. Eckenrode et al. (2007) analyzed the findings of similar studies conducted between 1986 and 2007. The analysis concluded that radar drones caused a reduction of 5 to 8 mph in the speed of vehicles equipped with radar detectors and a reduction of 2 mph in the mean speed of all vehicles. Ryan et al. (2006) reported that the effectiveness of radar drones is highly dependent on the percentage of drivers having radar detectors. Benekohal et al. (1992) studied the effectiveness of radar drones in Illinois in rural Interstate work zones. The study reported that radar drones were effective in reducing vehicle speeds by 3 to 6 mph for trucks and 3 mph for cars. In a recent national survey of state DOTs (Wang et al. 2011), eight of the 26 participating state DOTs reported that they were using or had previously used radar drones. Four of these eight states reported that they discontinued using radar drones because of their perceived ineffectiveness. On the other hand, Indiana DOT reported that radar drones were effective in getting the attention of drivers with radar detectors.

5.7 TRUCK-MOUNTED ATTENUATORS

5.7.2 Features

Truck-mounted attenuators (TMAs) are energy-absorbing devices attached to the rear of a shadow trailer or truck to dissipate the energy of a rear-end collision. Shadow vehicles equipped with TMAs should be located ahead of work zones, workers, or equipment to reduce the severity of rear-end crashes caused by errant vehicles. Shadow vehicles are usually equipped with arrow boards, changeable message signs, and/ or high-intensity rotating, flashing, oscillating, or strobe lights located properly ahead of the workers and/or equipment being protected (MUTCD).

5.7.3 Effectiveness Reported in Recent Studies

In a recent nationwide survey, 100% of the responding states that used or tested TMAs (23 states) reported effectiveness of the device in short-term work zones (Wang et al. 2011). In another study, Humphreys and Sullivan (1991) evaluated the effectiveness of TMAs and reported that using TMAs saved about $23,000 per accident and reduced damage to the maintenance truck, and that injury rates were higher in maintenance vehicles that were not equipped with TMAs. Other studies investigated the impact of the striping patterns and color at the rear of TMAs on the visibility of TMAs and the ability of drivers to recognize them from safe distances Kamyab and Storm (2010) found that the yellow-green color improved contrast between the orange color of the sign and the orange color of the DOT truck. Hawkins et al. (2000) concluded that fluorescent colors have higher color perception accuracy and recognition distances during daylight hours but not during the night. Bham et al. (2009) indicated that a yellow and black inverted-V pattern and an orange and white vertical striped pattern were more effective than a fluorescent yellow-green and black inverted-V pattern or a red and white checkerboard pattern.

5.8 MOBILE BARRIERS

5.8.1 Features

A mobile barrier is an integrated rigid wall or semi-trailer used in conjunction with a standard tractor to provide safe and mobile work environments for workers in work and maintenance zones, as shown in Figure 56 and Figure 57. It functions as an extended longitudinal barrier that provides physical and visual barrier between traffic and work zone crews (Wang et al. 2011).

Figure 56. Mobile barrier trailer (MBT-1) system (Mobile Barriers LLC 2009).

Figure 57. Balsi Beam mobile barrier system (Wang et al. 2011).

5.8.2 Effectiveness Reported in Recent Studies

In a recent study, Kamga and Washington (2009) analyzed the effectiveness of the mobile barrier system, MBT-1. It was reported that the system exceeded expectations on the protection of workers from physical injuries caused by errant vehicles because of its ability to absorb crash energy by crushing upon impact and because of its integrated TMAs. In another study, Hallowell et al. (2009) investigated the effectiveness of the mobile barrier system, MBT-1, in work zones in Colorado. The study reported that the MBT-1 system was capable of improving the safety of highway construction and maintenance work zones. Based on the findings of a national survey of state DOTs, Wang et al. (2011) reported that none of the responding states had used the mobile barrier systems because of their high cost, but that they would be interested in using them in the future if they became less costly.

5.9 AUTOMATED FLAGGER ASSISTANCE DEVICES

5.9.1 Features

Automated flagger assistance devices (AFADs) allow flaggers to be positioned out of the traffic lane and are used to control road users in temporary traffic control zones. These devices are designed to be remotely operated by a single flagger located at one end of the TTC zone or at a central location or by separate flaggers located near each device, as shown in Figure 58. AFADs are appropriate for short-term and intermediate-term activities, but may not be used for long-term activities (MUTCD).

Figure 58. Automated flagger assistance device (AFAD).

5.9.2 Effectiveness Reported in Recent Studies

A recent study evaluated the effectiveness of automated flagger assistance devices in Virginia. The study reported that AFADs were successfully deployed by two VDOT area headquarters and were useful in reducing the need for flaggers and minimizing their exposure to hazards (Cottrell 2006).

5.10 RADAR-ACTIVATED FLAGGER PADDLE

Radar-activated flagger paddles consist of a flashing LED flagger paddle that can be activated when the radar detects vehicles exceeding the speed limits. The paddle's red and white LEDs blink alternatively when the radar detects a speeding vehicle. The radar can function only when the stop legend is facing the traffic. The researchers who developed this prototype device recommended further testing to evaluate its effectiveness (Fontaine et al. 2001).

CHAPTER 6 IDOT AND NATIONAL SURVEYS

6.1 INTRODUCTION

Two identical online surveys were conducted to gather and analyze feedback from engineers and construction personnel in IDOT and other state DOTs on the effectiveness of flaggers and spotters in directing work zone traffic on freeways and expressways with a posted speed limit greater than 40 mph. The Technical Review Panel (TRP) distributed the survey to IDOT resident engineers, managers, supervisors, maintenance personnel, contractors, and consultants. Another version of the survey was also distributed to other state DOTs. The survey was developed following the guidelines of the American Association for Public Opinion Research (AAPOR, no date). This chapter presents the results of analyzing and comparing the findings of the two surveys of IDOT and other state DOTs. Both surveys are identical and consist of three main sections, as shown in Appendix D. The first section asks respondents to identify the need, benefits, and risks of using flaggers in and around work zones. The second section requires respondents to evaluate spotter functions, benefits, and risks. The third section aims at collecting feedback from survey respondents on the effectiveness, need, and risks of using spotters instead of flaggers in work zones. In addition, the impact of using spotters instead of flaggers in different types of work zones and the effectiveness of using various safety measures were evaluated. Respondents were also asked to evaluate the effectiveness of various safety measures in improving the safety of work zone access and egress points.

6.1.1 Analysis of Survey Respondents

Eighty complete responses were received from the survey that targeted IDOT engineers, personnel, and contractors. The respondents were classified based on their reported title, as shown in Figure 59. Twenty complete responses were received from 14 state DOTs in the national survey; three responses were received from Iowa and Alabama DOTs, two responses were received from Texas, Kansas, and Minnesota DOTs, and one response was received from Arizona, Florida, Connecticut, Michigan, Mississippi, Missouri, Montana, Virginia, and Washington DOTs. Figure 60 shows the distribution of respondent titles in the national survey and Table 3 summarizes the number of responses received from each participating state DOT.

Table 3. Number of Complete Responses Received from State DOTs

State	Number of Responses	Percent
Alabama	2	10%
Arizona	1	5%
Connecticut	1	5%
Florida	1	5%
Iowa	3	15%
Kansas	2	5%
Michigan	1	5%
Minnesota	2	10%
Mississippi	1	5%
Missouri	1	5%
Montana	1	5%
Texas	2	10%
Virginia	1	5%
Washington	1	5%

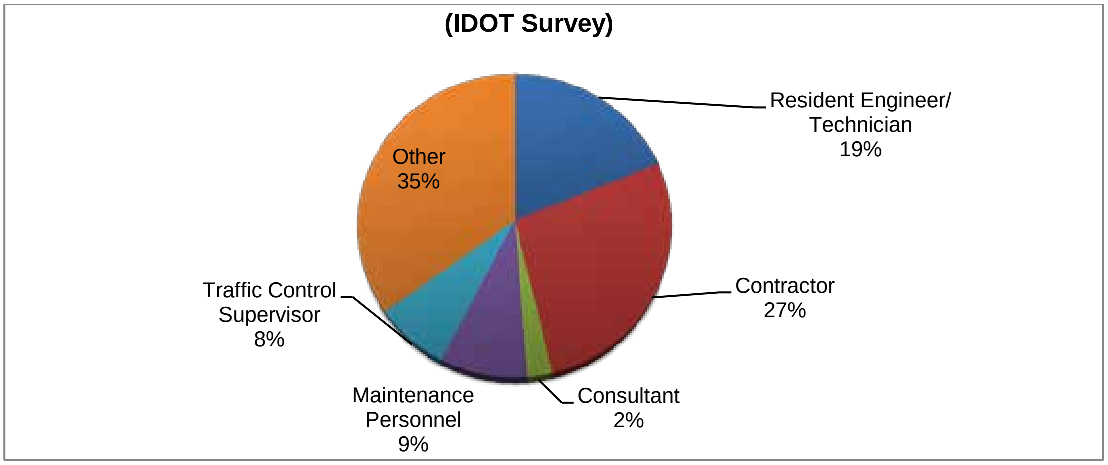


Figure 59. Distribution of IDOT survey respondents according to reported titles.

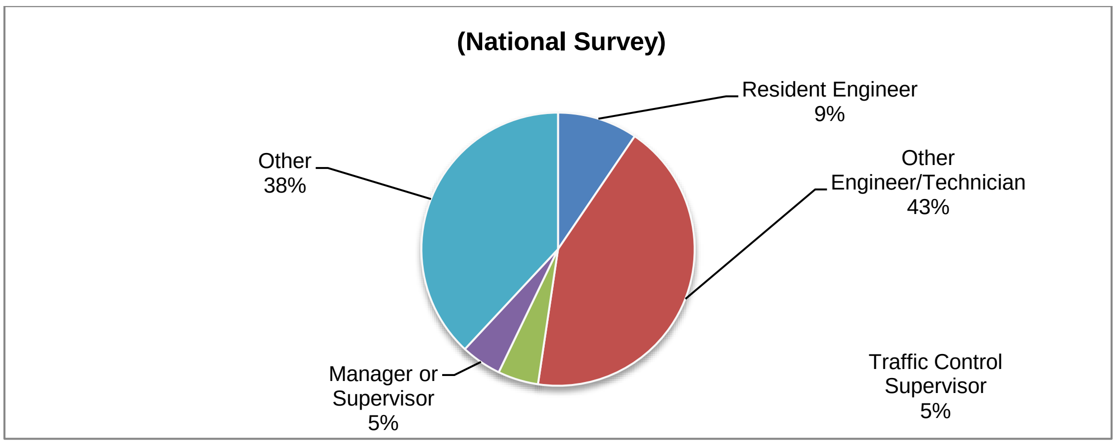


Figure 60. Distribution of national survey respondents according to reported titles.

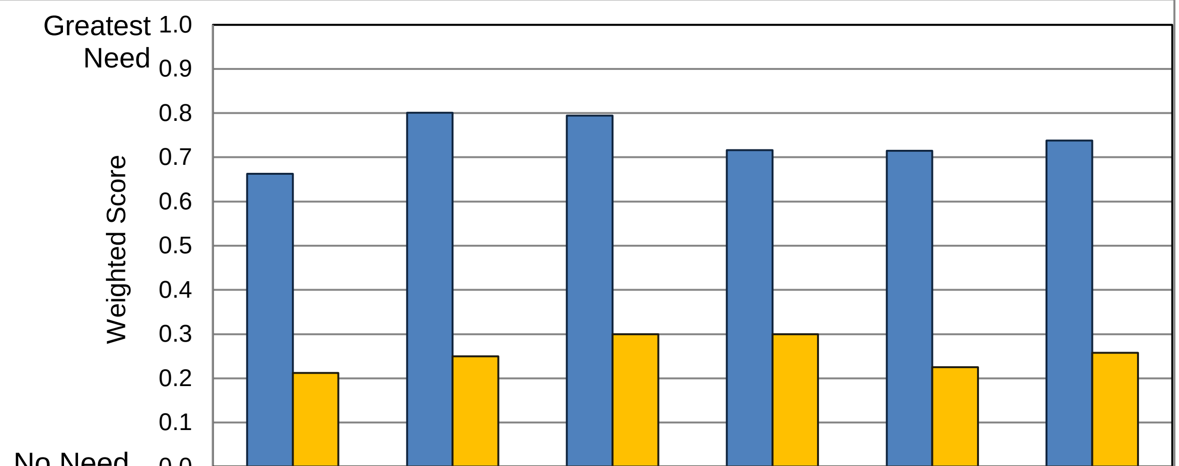
6.2 BENEFITS AND RISKS OF USING FLAGGERS

In DOT and national surveys, respondents were asked to assess the level of need, effectiveness, benefit, or risk of using flaggers on freeway/expressway work zones. Each respondent needs to select one category from five available alternatives that represent the level of need, effectiveness, benefit, or risk. For example, the level of need in the survey can be selected as "no need" that is represented numerically by "0.0", "low need" represented by "0.25", "moderate need" represented by "0.5", "high need" represented by "0.75", and "greatest need" represented by "1.0". Similarly, a level of risk/hazard equivalent to "0.0" indicates "lowest risk" while "1.0" indicates "highest risk." Weighted scores were calculated for each question in the survey to compare the average scores obtained from both surveys.

6.2.1 Need for Flagger Functions

Survey respondents were asked to identify the level of need for a flagger to perform a set of functions, including slowing down traffic, alerting road users approaching the work zone, warning workers of errant drivers, and directing traffic when construction trucks enter and exit the work zone. The results of the weighted scores for each function in IDOT and national surveys are shown in Figure 63. In the IDOT survey, the two functions that received the highest weighted score were "slow the speed of oncoming traffic" and "warn workers of errant drivers and vehicle intrusion into work zone," which received weighted scores of 0.801 and 0.794, respectively. In the national survey, the two functions that received the highest weighted score were “warn workers of errant drivers and vehicle intrusion into work zone” and “direct traffic when construction trucks enter the work zone,” which received a score of 0.30 each.

The average score for the need of flaggers to perform various safety and mobility functions on freeway and expressway work zones was 0.738 in the IDOT survey and 0.258 in the national survey, as shown in Figure 63. This indicates that other state DOTs considered that the level of need for flaggers in these types of work zones ranges from “no need” to “moderate need,” as shown in Figure 61. In addition, a number of state DOTs, including Florida, Minnesota, Michigan, and Virginia DOTs, stated that they no longer use flaggers in these types of work zones.

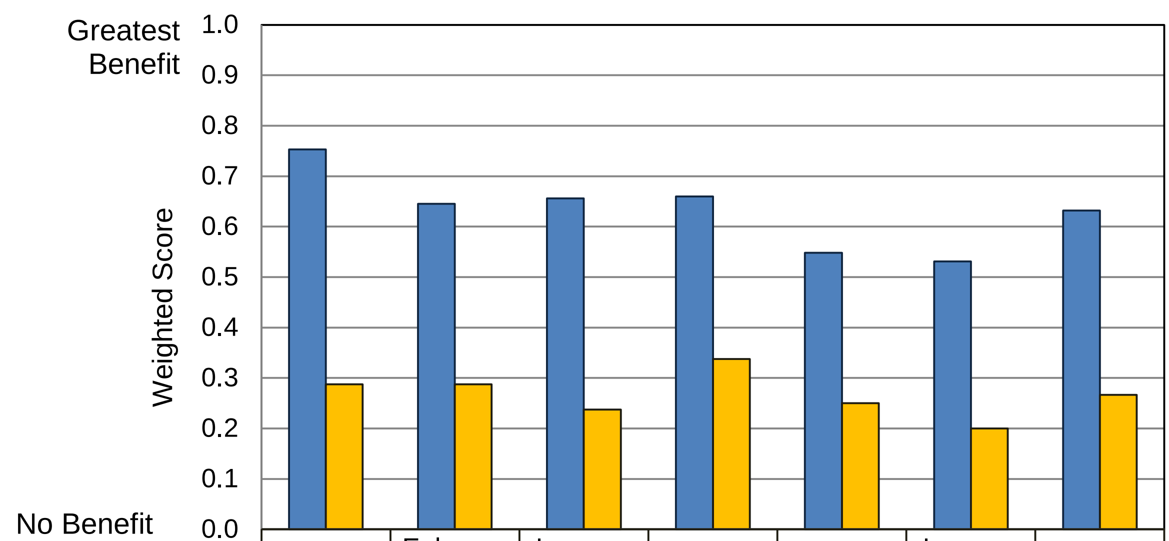


	Alert road users approaching the work zone	Slow the speed of oncoming traffic	Warn workers of errant drivers and vehicle intrusion into work zone	Direct traffic when construction trucks enter the work zone	Direct traffic when construction trucks exit the work zone	Average
IDOT Survey	0.663	0.801	0.794	0.716	0.715	0.738
National Survey	0.213	0.250	0.300	0.300	0.225	0.258

Figure 61. Weighted scores for need of flagger functions from IDOT and national surveys.

6.2.2 Benefit of Flagger Functions

In the national survey, the level of benefits that can be gained from using flaggers in freeway/expressway workzones received very low weighted scores ranging from 0.20 to 0.338, where a score of “0.0” represents “no benefit” and a score of “1.0” indicates “greatest benefit,” as shown in Figure 62. IDOT survey respondents gave relatively higher weighted scores for flagger benefits, ranging from 0.531 to 0.753.The flagger benefit that received the highest weighted score in national and IDOT surveys was “enhance road users safety” and “improve workers safety,” which scored 0.338 and 0.753, respectively. The flagger benefit with the lowest weighted score was “improve compliance with traffic speed limit,” which scored 0.20 in the national survey and 0.531 in the IDOT survey. The average score for the benefits that can be gained from using flaggers on freeway and expressway work zones was 0.632 in the IDOT survey and 0.267 in the national survey, as shown in Figure 62. This indicates that other state DOTs considered that there was “no benefit” or only a “moderate benefit” gained from using flaggers in these types of work zones.



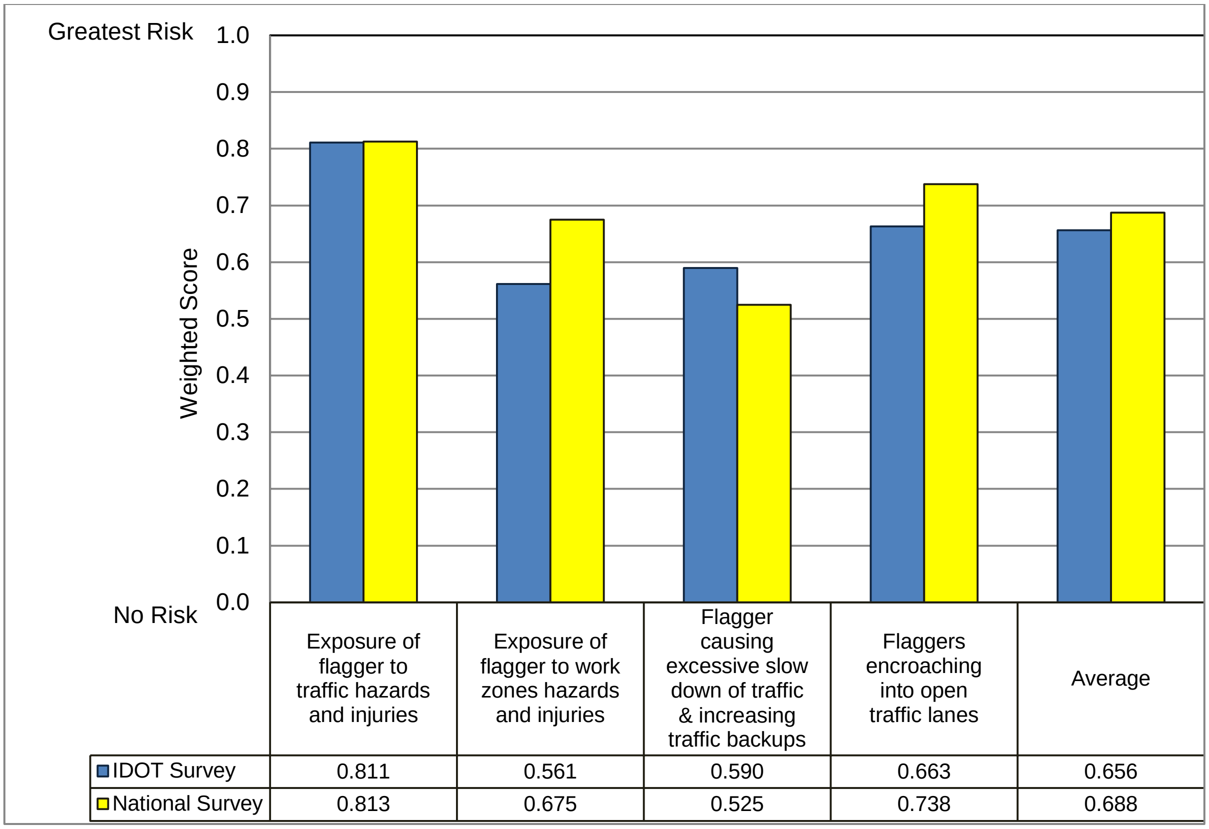
	Improve workers safety	Enhance safety of trucks entering work zone	Improve safety of trucks exiting work zone	Enhance road users safety	Improve traffic mobility	Improve complian ce with traffic speed limit	Average
IDOT Survey	0.753	0.645	0.656	0.660	0.548	0.531	0.632
National Survey	0.288	0.288	0.238	0.338	0.250	0.200	0.267

Figure 62. Weighted scores for level of benefit of flagger functions from IDOT and national surveys.

6.2.3 Risk/Hazard Caused by Using Flaggers

In this question, survey respondents were asked to report the level of risks that might result from using flaggers in freeway/expressway work zones. The weighted scores for the listed risks were similar in IDOT and national surveys. Both scores were above 0.5, where a score of “0.0” represents “no risk” and a score of “1.0” indicates “greatest risk,” as shown in Figure 63. The risk that had the highest score was “exposure of flaggers to traffic hazards and injuries” with scores of 0.813 and 0.811 in IDOT and national surveys, respectively. This highlights the high level of exposure to hazards that flaggers experience in this type of work zone. The risk that had the second highest score was “flaggers encroaching into open traffic lanes,” with a score of 0.738 in the national survey and 0.663 in the IDOT survey.

The average score for the risks and hazards that can be caused by using flaggers on freeway and expressway work zones was 0.656 in the IDOT survey and 0.688 in the national survey, as shown in Figure 63. This indicates that both IDOT respondents and other state DOTs respondents identified the level of risks caused by using flaggers in these types of work zones to be between “moderate risk” and “greatest risk.”

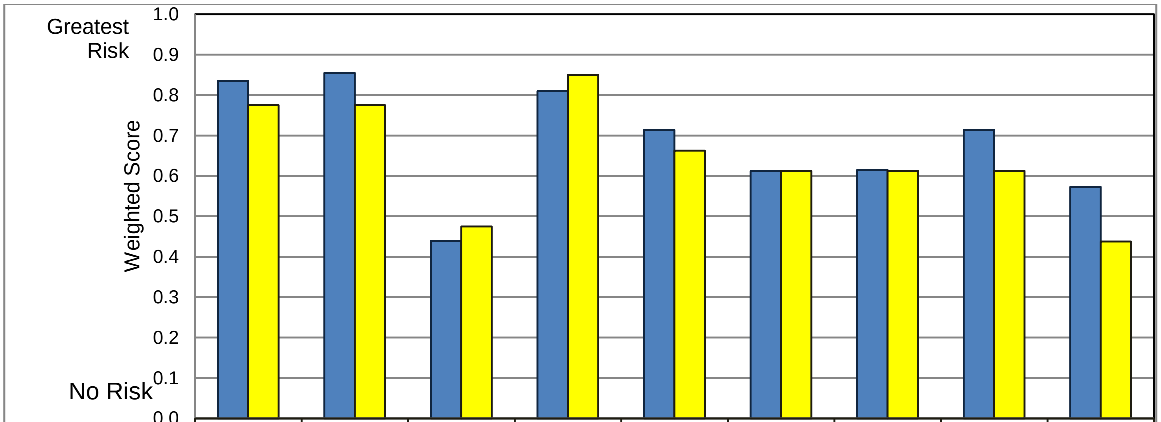


	Exposure of flagger to traffic hazards and injuries	Exposure of flagger to work zones hazards and injuries	Flagger causing excessive slow down of traffic & increasing traffic backups	Flaggers encroaching into open traffic lanes	Average
IDOT Survey	0.811	0.561	0.590	0.663	0.656
National Survey	0.813	0.675	0.525	0.738	0.688

Figure 63. Weighted scores for level of risk/hazard caused by using flaggers from IDOT and national surveys.

6.2.4 Risk/Hazard to Flaggers in Different Work Zone Conditions

In this question, respondents were asked to identify the level of risk to flaggers in different work zone conditions. The weighted scores of the received responses in both surveys are shown in Figure 64. Results from both surveys were similar in most work zone conditions. Daytime work zones received the lowest weighted scores of 0.475 and 0.439 in the national and IDOT surveys, respectively. Work zones with nighttime activities, curves, and hills received the highest weighted scores of 0.850/0.810, 0.775/0.835, and 0.775/0.855 in the national and IDOT surveys, respectively. This highlights the increased level of risk in these conditions and the need to find alternative and safer solutions to control and minimize risks/hazards to flaggers.



	Curves	Hills	Daytime work zones	Nighttime work zones	Glare from sun	Glare from vehicle headlights	Glare from nighttime work zone lighting	Adverse weather conditions	Lack of visibility due to construction-related dust or temporary structures
IDOT Survey	0.835	0.855	0.439	0.810	0.714	0.612	0.615	0.714	0.573
National Survey	0.775	0.775	0.475	0.850	0.663	0.613	0.613	0.613	0.438

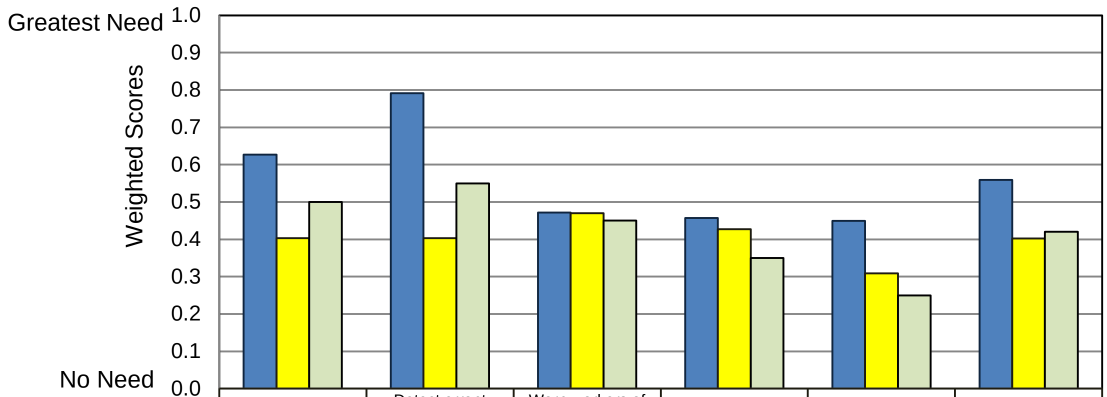
Figure 64. Weighted scores for the level of risk/hazard to flaggers in work zone conditions from national and IDOT surveys.

6.3 BENEFITS AND RISKS OF USING SPOTTERS

The second section in both surveys was designed to evaluate the benefits and risks of using spotters in freeway/expressway work zones to warn workers of errant drivers. A spotter was defined as a trained person whose sole duty is to monitor traffic and warn workers of errant drivers or other hazards using an effective warning device, such as a whistle or an air horn. National survey respondents were asked if their organizations allow or recommend the use of spotters to warn workers of errant drivers in freeway and expressway work zones with speed limits greater than 40 mph; five respondents answered "yes" while ten respondents answered "no." The following section compares the average scores provided by IDOT responses, state DOT responses, and the state DOT responses that reported prior use of spotters in the national survey.

6.3.1 Need for Potential Spotter Functions

In this question, respondents were asked to evaluate the level of need for various potential spotter functions such as "Warn workers of oncoming traffic." Figure 65 shows the calculated weighted scores for each potential spotter function for the IDOT and national surveys. In the IDOT survey, the two spotter functions that received the highest weighted scores were "Detect errant drivers and warn workers using effective warning devices" and "Warn workers of oncoming traffic," which received scores of 0.792 and 0.627, respectively, while other functions received scores ranging from 0.449 to 0.471. The average score for the need of spotters to perform various safety and mobility functions on freeway and expressway work zones was 0.559, 0.402, and 0.420 from IDOT respondents, state DOTs participating in the national survey, and state DOTs with prior experience in using spotters, respectively, as shown in Figure 65. This indicates that IDOT and other state DOTs considered the level of need for spotters in these types of work zones as "moderate need."

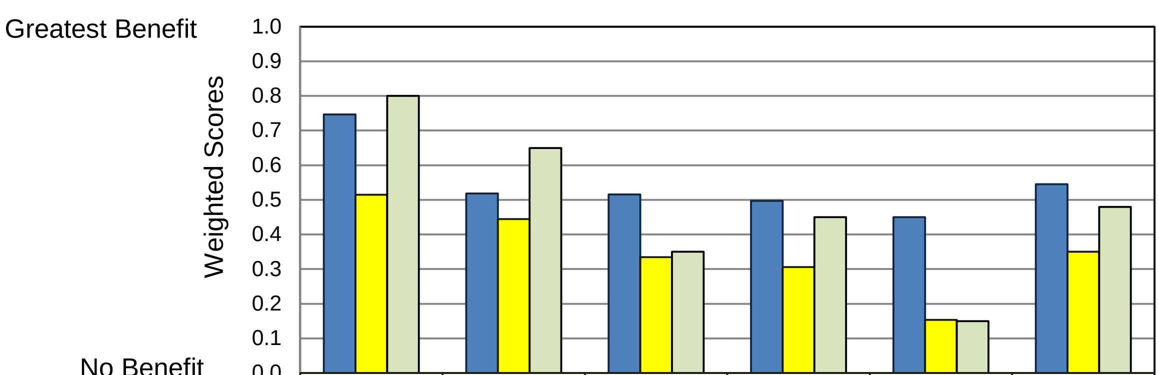


	Warn workers of oncoming traffic	Detect errant drivers and warn workers using effective warning devices	Warn workers of construction equipment hazards in the work zone	Guide trucks/equipment entering the work zone	Guide trucks/equipment exiting the work zone	Average
IDOT Survey	0.627	0.792	0.472	0.457	0.450	0.559
All Participating DOTs	0.403	0.403	0.470	0.427	0.309	0.402
DOTs Deploying Spotters	0.5	0.55	0.45	0.35	0.25	0.42

Figure 65. Weighted scores for the level of need for potential spotter functions.

6.3.2 Benefits of Potential Spotter Functions

In this question, survey respondents were asked to evaluate the level of potential benefits that can be gained by deploying spotters in freeway/expressway work zones. Weighted scores were calculated from survey responses for each spotter function. Figure 66 shows the weighted scores received from the IDOT survey and national survey. The greatest benefit of using spotters was “Improve workers safety” which received 0.747, 0.514, and 0.80 from IDOT respondents, all state DOTs, and state DOTs with prior experience in using spotters, respectively, as shown in Figure 66. The function “Enhance trucks entering the work zone” received a weighted score of 0.650 from state DOTs with prior experience in using spotters.

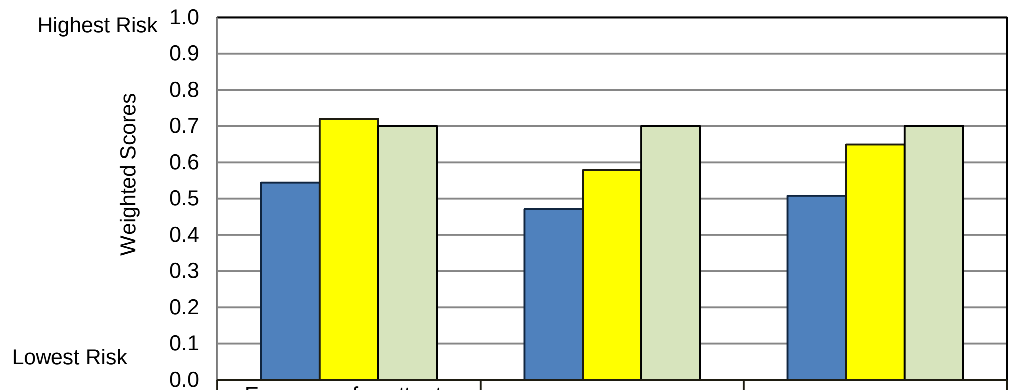


	Improve workers safety	Enhance safety of trucks entering work zone	Improve safety of trucks exiting work zone	Enhance road users safety	Improve traffic mobility	Average
IDOT Survey	0.747	0.519	0.516	0.497	0.450	0.546
All Participating DOTs	0.514	0.445	0.334	0.306	0.153	0.350
DOTs Deploying Spotters	0.800	0.650	0.350	0.450	0.150	0.480

Figure 66. Weighted scores for the level of benefits for potential spotter functions.

6.3.3 Potential Risks Caused by Using Spotters

In this question, survey respondents were asked to identify the level of risk of two potential hazards that can be caused by using spotters in freeway/expressway work zones. Figure 67 shows the weighted scores for both hazards in the national and IDOT surveys. The hazard of "exposure of spotter to traffic hazards and injuries" received the highest weighted score of 0.544, 0.720, and 0.70 from IDOT respondents, all state DOTs, and state DOTs with prior experience in using spotters, respectively.



	Exposure of spotter to traffic hazards and injuries	Exposure of workers to traffic hazards	Average
IDOT Survey	0.544	0.471	0.508
All Participating DOTs"	0.720	0.579	0.650
DOTs Drploying Spotters	0.700	0.700	0.700

Figure 67. Weighted scores for the level of risk that can be caused by spotters on freeway/expressway work zones.

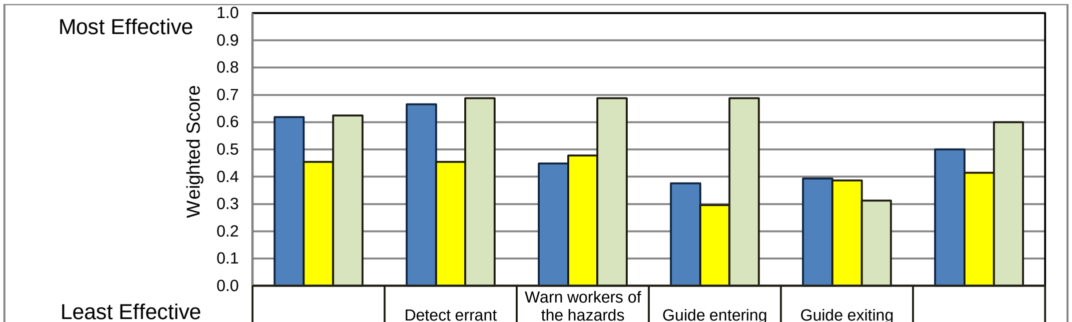
6.4 USING SPOTTERS INSTEAD OF FLAGGERS

This section of the survey gathered respondents' feedback on the effectiveness of using spotters instead of flaggers in freeway and expressway work zones with speed limits greater than 40 mph.

In this section, respondents were asked to identify (1) the level of effectiveness if spotters are used instead of flaggers to perform a set of functions; (2) the level of effectiveness achieved by replacing flaggers with spotters to accomplish various safety and mobility goals, (3) the potential impact of using spotters instead of flaggers in different work zone layouts, (4) the level of effectiveness of various measures that can be used to maximize work zone safety and mobility, (5) the level of effectiveness of various measures that can be used to improve the safety of access and egress points in freeway and expressway work zones, and (6) the effectiveness of various temporary traffic control (TTC) devices.

6.4.1 Effectiveness of Spotters in Performing Flagger Functions

In this question, survey respondents were asked to identify the level of effectiveness that might be achieved by replacing flaggers with spotters in performing flagger functions using a five-point scale that ranges from least effective "0.0" to most effective "1.0". The main evaluated functions include (1) warn workers of oncoming traffic, (2) detect errant drivers and warn workers, (3) warn workers of the hazards, (4) guide entering trucks and other construction equipment to work zone, and (5) guide exiting trucks and other construction equipment from work zone. A weighted score was calculated for all functions in both surveys, as shown in Figure 68. In the IDOT survey, the top two functions that received the greatest weighted scores were "warn workers of oncoming traffic" and "detect errant drivers and warn workers using effective warning devices," which received a score of 0.619 and 0.666, respectively. In the national survey, the top three functions that received the greatest weighted scores from state DOTs with prior experience in using spotters were “detect errant drivers and warn workers,” “guide entering equipment/trucks to work zone,” and “warn workers of the hazards posed by construction equipment in the work zone,” which received a score of 0.688 each.

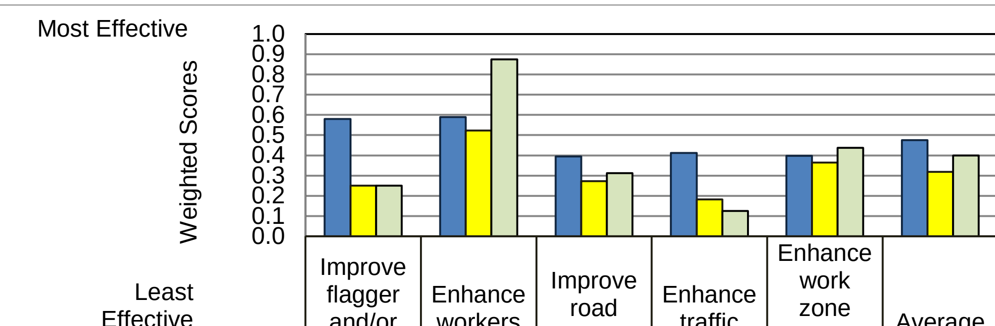


	Warn workers of oncoming traffic	Detect errant drivers and warn workers using effective warning devices	Warn workers of the hazards posed by construction equipment/ trucks in the work zone	Guide entering trucks and other construction equipment to work zone	Guide exiting trucks and other construction equipment from workzone	Average
IDOT Survey	0.619	0.666	0.449	0.376	0.394	0.501
All Participating DOTs	0.455	0.455	0.478	0.296	0.387	0.414
DOTs Deploying Spotters	0.625	0.688	0.688	0.688	0.313	0.600

Figure 68. Weighted scores for effectiveness of using spotters instead of flaggers to perform flagger functions.

6.4.2 Impact of Using Spotter on Safety and Mobility Goals

In this question, survey respondents were asked to identify the level of effectiveness achieved by using spotters instead of flaggers to accomplish a set of safety and mobility goals using a five-point scale that ranges from least effective “0.0” to most effective “1.0”. The goal “enhance workers safety” received the greatest weighted score of 0.590, 0.523, and 0.875 from IDOT respondents, all state DOTs, and state DOTs with prior experience in using spotters, respectively, as shown in Figure 69. This highlights that state DOTs with prior experience in using spotters instead of flaggers reported a high level of effectiveness for this practice.

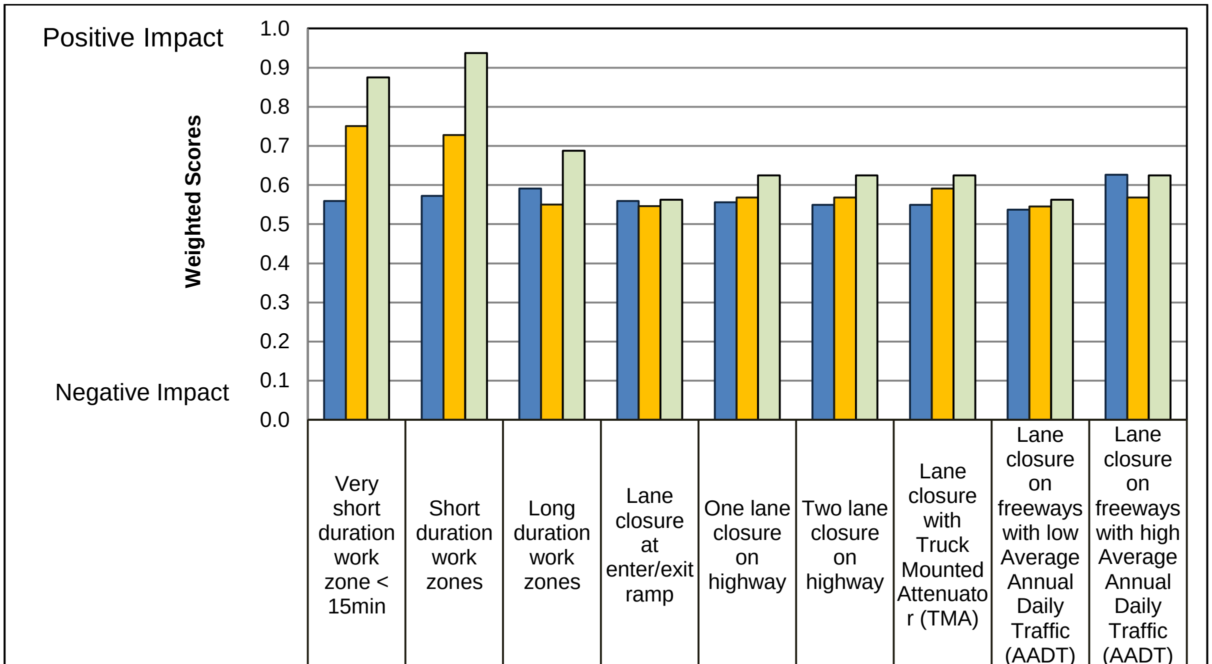


	Improve flagger and/or spotter safety	Enhance workers safety	Improve road users safety	Enhance traffic mobility	Enhance work zone access and egress	Average
IDOT Survey	0.580	0.590	0.394	0.412	0.399	0.475
All Participating DOTs	0.250	0.523	0.273	0.182	0.364	0.319
DOTs Deploying Spotters	0.250	0.875	0.313	0.125	0.438	0.400

Figure 69. Weighted scores for level of effectiveness of using spotters Instead of flaggers to accomplish safety and mobility goals.

6.4.3 Impact of Using Spotters in Different Work Zone Layouts

In this question, survey respondents were asked to identify the level of impact of using spotters instead of flaggers in various work zone layouts based on a five-point scale that ranges from negative impact “0.0” to positive impact “1.0”. In the IDOT survey, work zones that have “lane closure on freeways with high AADT” scored the highest weighted score of 0.62, where “0.5” indicates no impact and “1.0” indicates positive impact. The weighted scores for all other work zone types ranged from 0.538 to 0.592, as shown in Figure 70. The top three work zone layouts that received the greatest weighted scores were “short-duration work zone,” “very short-duration work zone,” and “long-duration work zone,” which received a score ranging from 0.550 to 0.938 from IDOT respondents, all state DOTs, and state DOTs with prior experience in using spotters, as shown in Figure 70.

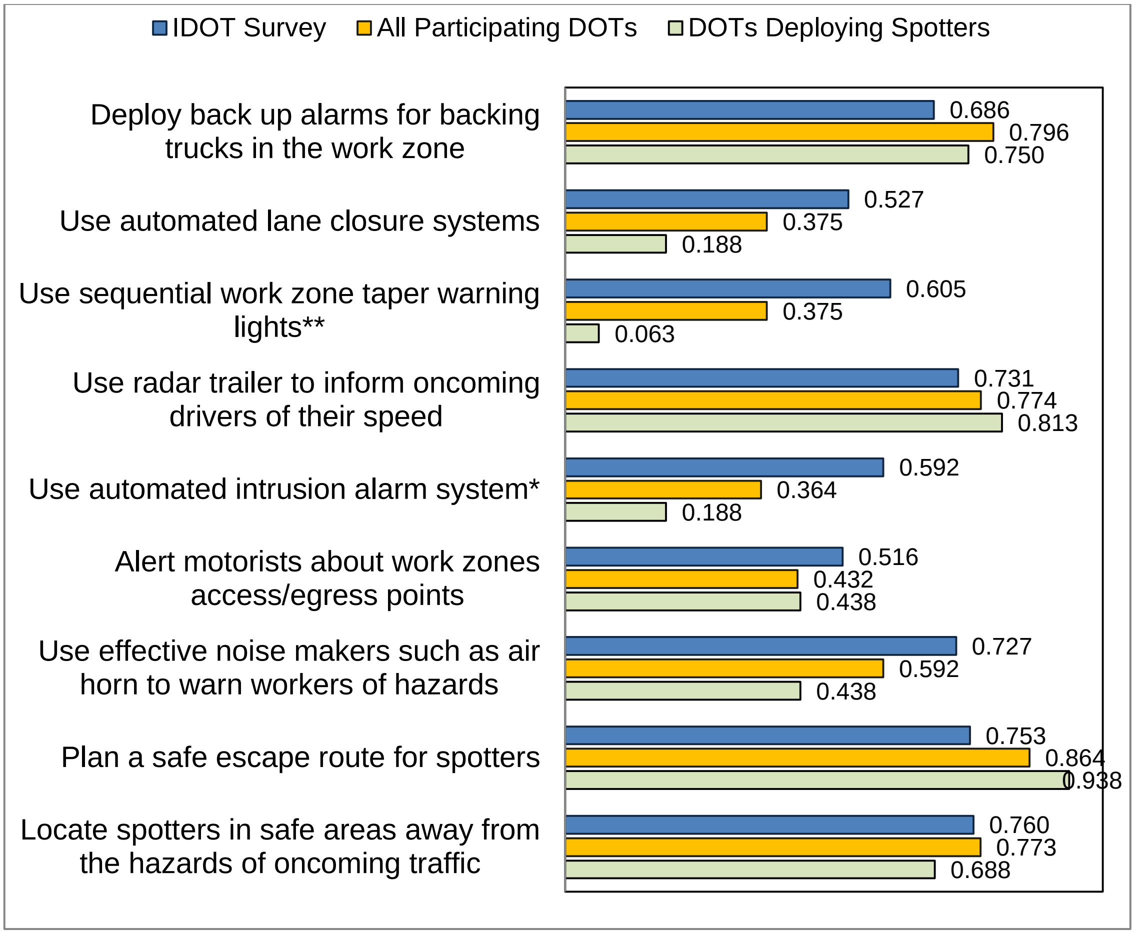


	Very short duration work zone < 15min	Short duration work zones	Long duration work zones	Lane closure at enter/exit ramp	One lane closure on highway	Two lane closure on highway	Lane closure with Truck Mounted Attenuator (TMA)	Lane closure on freeways with low Average Annual Daily Traffic (AADT)	Lane closure on freeways with high Average Annual Daily Traffic (AADT)
IDOT Survey	0.559	0.572	0.592	0.560	0.556	0.550	0.549	0.538	0.626
All Participating DOTs	0.751	0.728	0.550	0.546	0.568	0.568	0.591	0.546	0.568
DOTs Deploying Spotters	0.875	0.938	0.688	0.563	0.625	0.625	0.625	0.563	0.625

Figure 70. Weighted scores for impact of using spotters instead of flaggers in different work zone layouts.

6.4.4 Measures to Maximize Work Zone Safety and Mobility

In this question, survey respondents were asked to identify the level of effectiveness of a set of measures used to maximize work zone safety and mobility if flaggers are replaced with spotters based on a five-point scale that ranges from least effective “0.0” to most effective “1.0”. In the national survey, the top four measures that were reported to have the greatest effectiveness were “plan a safe escape route for spotters,” “deploy back-up alarms for backing trucks in the work zone,” “use radar trailer to inform oncoming drivers of their speed,” and “locate spotter in safe areas away from hazards of oncoming traffic,” which scored 0.864, 0.796, 0.773, and 0.773, respectively, as shown in Figure 71. In the IDOT survey, the measures that received the highest weighted score were “plan a safe escape route for spotters,” and “locate spotter in safe areas away from hazards,” which scored 0.753 and 0.760, respectively. State DOTs with prior experience in using spotters gave the highest weighted score of 0.938 to the measure "plan an escape route for spotters," which was very close to the level of greatest effectiveness.



* Automated intrusion alarm system: An automated system that detects the intrusion of errant vehicles into the workspace and produces an audible, visual, and/or tactile alarm to notify downstream workers of the intrusion.

** Sequential work zone taper warning lights: A series of sequential flashing warning lights that can be placed on channelizing devices that form a merging taper in order to increase driver detection and recognition of the merging taper.

Figure 71. Level of effectiveness of safety measures to maximize work zone safety and mobility when replacing flaggers with spotters.

6.5 SAFETY MEASURES TO MAXIMIZE WORK ZONE SAFETY

In this section of IDOT and national surveys, respondents were asked to evaluate the effectiveness of new and existing temporary traffic control devices and various measures to improve the safety of access and egress points.

6.5.1 Effectiveness of Temporary Traffic Control (TTC) Devices

In this question, respondents of both surveys were asked to identify the level of effectiveness of various temporary traffic control (TTC) devices such as intrusion alarms, portable changeable message signs (PCMSs), temporary rumble strips, speed displays, truck-mounted attenuators (TMAs), and police patrols. In addition, respondents in the national survey were asked to identify the level of effectiveness of radar drones, automated flagger assistance devices (AFADs), and mobile barriers, as shown in Figure 72.

In the IDOT survey, the top four effective measures were police patrols, portable speed monitoring displays, TMAs, and PCMSs, which received a weighted score ranging between 0.693 and 0.934, as shown in Figure 72. In the national survey, the top four effective measures were TMAs, PCMSs, police patrols, and mobile barriers, which received a weighted score ranging between 0.891 and 0.796, respectively, as shown in Figure 72.

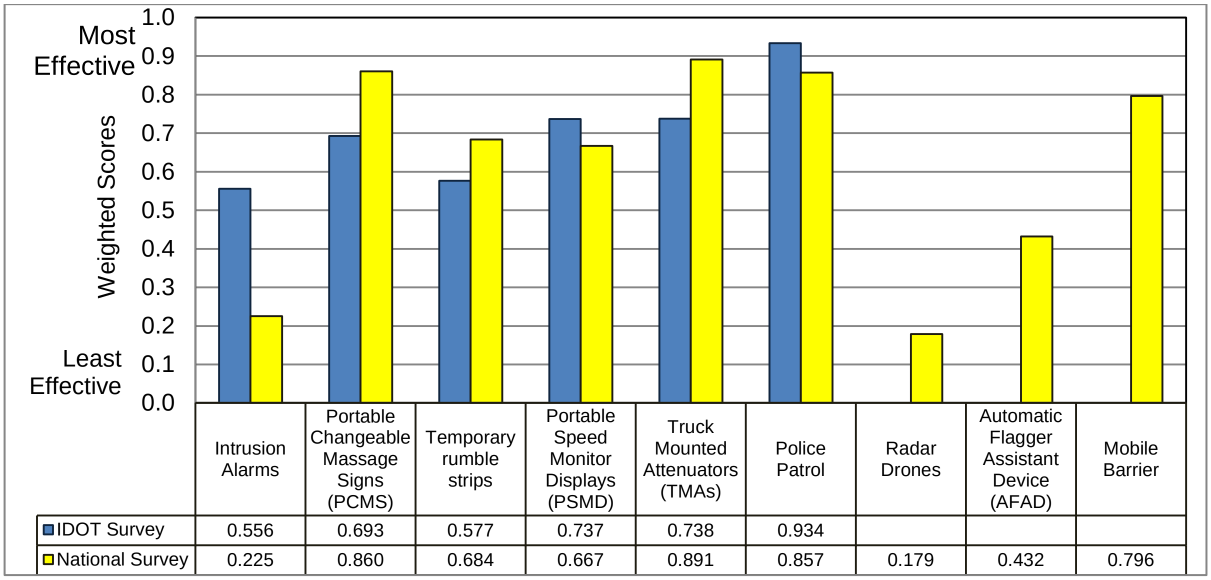


Figure 72. Effectiveness of TTC devices.

National survey respondents were also asked to report if their state DOT recommended the deployment of the listed TTC devices. The percentages of states that recommended or deployed TTC devices are listed in Figure 73. All responding states reported that they recommended the deployment of speed monitor displays. The results also show that 92.9% of the responding states recommended the use of PCMSs, TMAs, and temporary rumble strips, while 78.6% of the respondents recommended the use of police patrols, as shown in Figure 73.

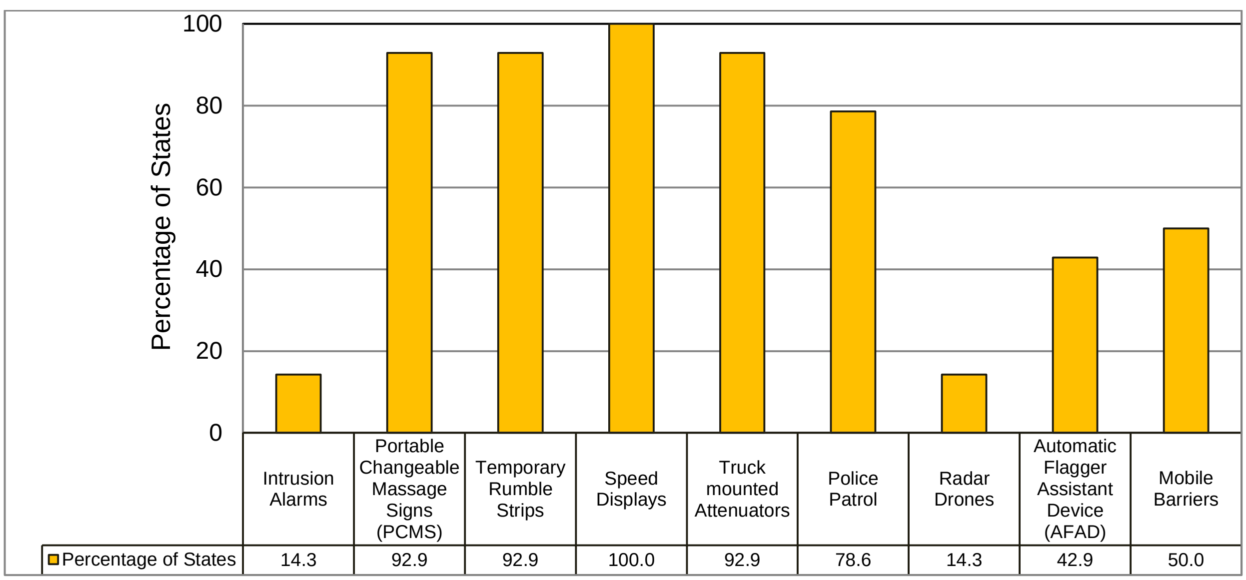


Figure 73. Percentage of responding states that recommend or use TTC devices.

6.5.2 Improving Safety of Access and Egress Points

In this question, the respondents were asked to identify the level of effectiveness of various measures to improve the safety of access and egress points in freeway and expressway work zones based on a five-point scale that ranges from 0.0 to 1.0. In the national survey, the top four effective measures were "incorporate access/egress into internal traffic control plan," "build temporary ramp to provide median access from street overpass," "improve lighting and visibility of access/egress points during nighttime work zone," and "use ITS technology to improve access/egress safety," which received weighted score of 0.841, 0.80, 0.729 and 0.667, respectively. In the IDOT survey, the top five measures were: "improve lighting and visibility of access and egress points during nighttime work zone," "incorporate access/egress into internal traffic control plans," "equip the rear of construction vehicles entering the work zone with a warning sign," and "deploy flagger to assist vehicles in entering and exiting work zone," which received weighted scores of 0.793, 0.685, 0.637, 0.615, and 0.616, respectively, as shown in Figure 74. State DOTs that reported previous experience in using spotters in the national survey gave the measure "deploy spotter to assist vehicles entering and exiting work zone" a score of 0.750.

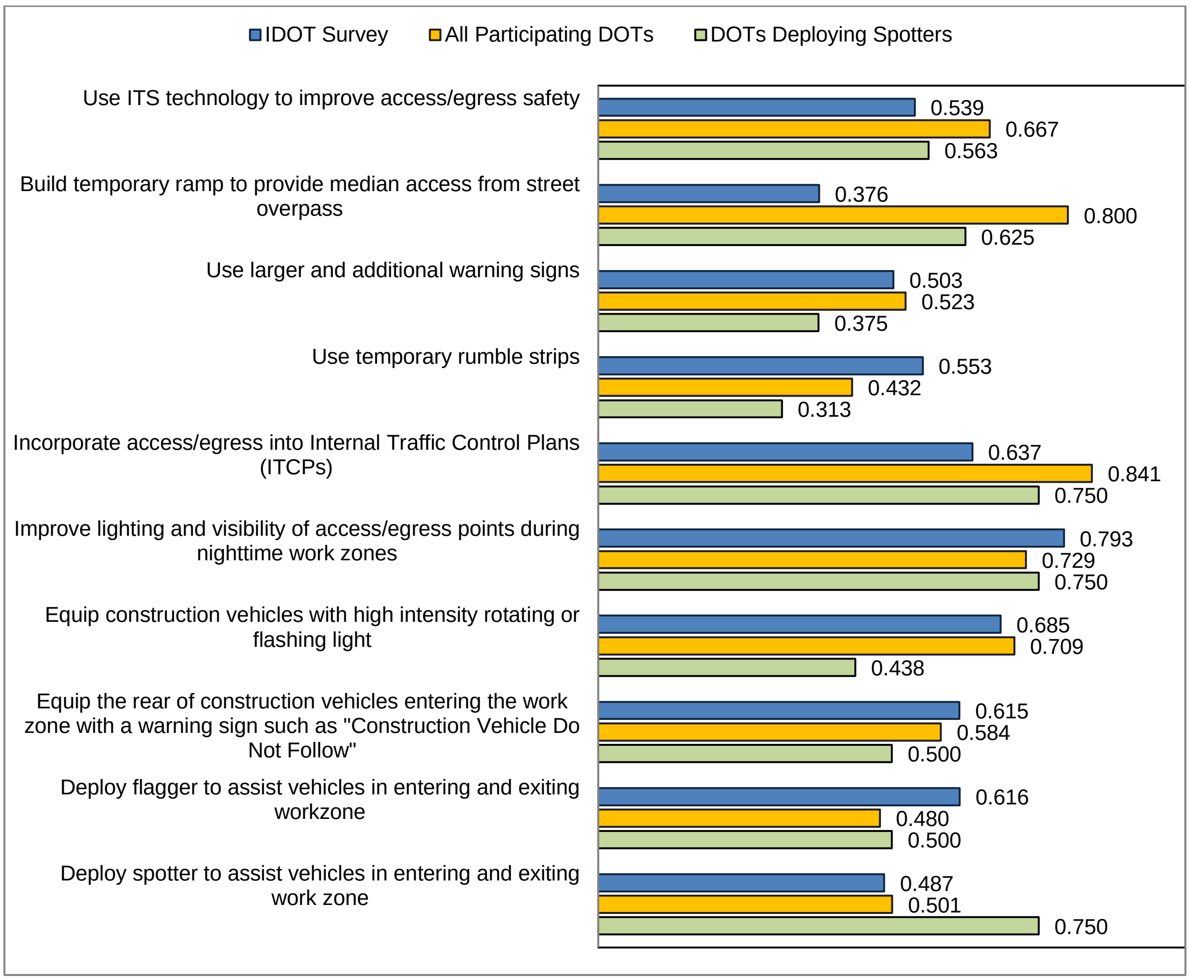


Figure 74. Weighted scores for level of effectiveness of measures to improve safety of access and egress points.

6.6 ANALYSIS OF COMMENTS AND FEEDBACK FROM INTERVIEWS AND SURVEYS

This section provides a comprehensive analysis of feedback and comments collected from the following sources: (1) interviews with flaggers and resident engineers during site visits and meetings with district engineers, (2) comments and feedback collected from the IDOT survey, and (3) comments and feedback collected from the national survey. The collected feedback is categorized into five sections:

1. Needs and benefits of flaggers in freeway/expressway work zones.
2. Limitations of using flaggers to perform required functions in freeway/expressway work zones.
3. Risks caused by using flaggers in freeway and expressway work zones.
4. Needs, benefits, and risks of using spotters.
5. Recommendations for TTC devices and new safety measures that support or replace flaggers in freeway and expressway work zones.

6.6.1 Need for Flaggers in Freeway and Expressway Work Zones

In the following sections, comments and feedback on the benefits and need for flaggers are classified into two main functions: slowing down traffic speed and attracting drivers' attention to work zone conditions.

6.6.1.1 Slow Down Traffic Speed

The following paragraphs summarize feedback and comments collected from each source on the need for flaggers to slow down traffic speed.

6.6.1.1.1 Site Visit Interviews and District Engineer Meetings

Interviewed engineers and flaggers reported that flaggers are needed to slow down traffic speed and ensure compliance with work zone speed limits. The interviewees maintained that the physical presence of a person who is capable of alerting drivers to work zone conditions is effective. Resident and district engineers reported that a flagger represents an effective measure to slow down traffic speed and that flaggers are needed to facilitate the entrance and exit of construction equipment in work zones.

6.6.1.1.2 IDOT Survey Comments and Feedback

Some of IDOT survey respondents reported that flaggers are needed to slow down traffic when trucks are entering and exiting the work zone, but that flaggers are not needed to direct traffic. Other respondents commented that flaggers are supposed to protect workers by reducing traffic speed. However, some IDOT survey respondents stated that flaggers are sometimes too aggressive in reducing traffic speed to a level much lower than the speed limit, thereby creating significant traffic back-up risks and hazards.

6.6.1.1.3 National Survey Comments and Feedback

Florida, Minnesota, Michigan, and Virginia DOT respondents reported that they do not use flaggers or spotters in their freeways and expressway work zones to slow down traffic. For instance, Virginia DOT respondents reported that flaggers are only used under or above interstate highway ramps only, and that they are not used on hazardous Interstates. Michigan DOT respondents stated that flaggers can provide a safe flow of traffic in work zones, provided that they are properly used, and that seeking the assistance of flaggers is better and cheaper than using temporary signals. Minnesota DOT respondents commented that they prefer not to use flaggers to slow down traffic on freeways/expressways work zones. They deploy flaggers only when they are needed to control traffic.

6.6.1.2 Attract Drivers' Attention to Work Zone Conditions

The following paragraphs summarize feedback and comments collected from each source on the need for flaggers to attract the attention of drivers to work zone conditions and enhance compliance with traffic control plan.

6.6.1.2.1 Site Visit Interviews and District Engineer Meetings

During the site visits, flaggers and resident engineers reported that flaggers are more effective in attracting the attention of drivers when they are closer to the live lane. According to the flaggers and resident engineers, drivers slow down immediately when they see a person standing very close to the traffic and steer away to avoid hitting the flagger. A number of Illinois resident engineers recommended using a flagger in all work zone active operations because the presence of a flagger makes drivers more alert to workers and work zones.

6.6.1.2.2 IDOT Survey Comments and Feedback

IDOT survey respondents stated that a waving flagger can help attract the attention of drivers, especially careless motorists. The respondents added that flaggers also help alert traffic to temporary job site hazards.

6.6.1.2.3 National Survey

Minnesota DOT respondents stated that they prefer not to use flaggers except for controlling traffic.

6.6.2 Limitations of Using Flaggers to Perform Required Functions in Freeway/Expressway Work Zones

The following sections summarize and group the comments and feedback collected on the limitations of using flaggers into three main sections: inability to warn workers effectively, lack of or inconsistent training, and ineffectiveness of flaggers in performing expected functions.

6.6.2.1 Inability to Warn Workers Effectively

The inability of flaggers to warn workers of errant drivers is considered one of the most significant limitations of using flaggers according to the collected comments and feedback. Resident engineers stated that flaggers are unable to warn workers effectively of vehicles intruding into the work zone because they will be focusing on their own escape from the path of errant vehicle. The interviewed flaggers also doubted that they would be able to warn workers at the same time while escaping from the path of an errant vehicle. In addition, it was reported that traditional warning methods, such as yelling and horns, are not loud enough to be heard due to the noise levels in the work zone.

6.6.2.2 Inconsistent Flaggers Training

The inconsistent training received by flaggers and/or flaggers behavior are another limitation reported in the collected comments and feedback. The following work zone safety issues are attributed to flaggers' behavior: (1) flaggers can be too aggressive in pushing traffic away from the work zone and onto the shoulder, thereby creating hazardous traffic conditions, (2) inconsistent flagger distance from the live traffic lane that has an impact on their effectiveness, and (3) flaggers can be too aggressive in slowing down traffic well below the speed limit, which creates safety and mobility issues.

6.6.2.3 Ineffectiveness of Flaggers in Performing Required Functions

The collected comments and feedback report that flaggers are not effective in controlling and slowing down traffic and warning and protecting workers. Resident engineers and flaggers maintained that flaggers are unable to escape from the path of errant vehicles and warn workers simultaneously. For example, a resident engineer stated: “To escape from errant vehicles is not easy and, accordingly, flaggers often do not have enough response time to warn their colleagues in case of intruding vehicles and will focus mainly on their own escape and survival." In addition, flaggers' ability to warn other workers is limited by the ineffectiveness of traditional warning methods, such as yelling or blowing a horn, in noisy work zones. Almost all interviewed flaggers recalled close calls from their past work experience. They reported that drivers were blinded by morning sun or distracted by their cell phones or other distractions. Other IDOT survey respondents reported that flaggers are not effective on speedy highways and recommended using other safety measures, such as police patrols or TMAs. Other state DOTs reported in the national survey that they do not use flaggers on freeways or expressways.

6.6.3 Risks and Hazards Caused by Flaggers

The following sections summarize and group the comments and feedback collected on the risks and hazards caused by flaggers into two sections: risks to flaggers and risks caused by flaggers.

6.6.3.1 Risks to Flaggers

Flaggers' proximity to traffic exposes them to serious risks. Most collected feedback reported that flaggers must stand close to the live lane of traffic in order to attract drivers' attention and slow down traffic, but this proximity exposes flaggers to injuries from oncoming traffic and makes their job very risky. For example, an IDOT survey respondent stated that "it is too unsafe to have a flagger standing out there at high speeds!" Other IDOT survey respondents recommended the use of TMAs to protect work zones instead of using spotters or flaggers on high-speed freeways and expressways.

6.6.3.2 Risks Caused by Flaggers

<u>6.6.3.2.1 Back-Up and Rear-End Crashes</u>

Some flaggers slow down the traffic far below work zone speed limits, which increases the risks of back-up accidents and rear-end crashes. This is often caused by the flagger's inability to accurately estimate the speed of traffic. During the site visits, the research team observed that the proximity of flaggers to traffic often causes them to overestimate the speed of vehicles. IDOT survey respondents reported that risks caused by aggressive flaggers can negatively affect traffic mobility and cause rear-ends crashes. Other respondents mentioned excessive slowing down increases traffic delays and backups. For example, a resident engineer stated that "there is an increased level of traffic accidents when flaggers try to slow down traffic too much on freeways." Another stated that it "could be a major cause of preventable accidents that often result in multiple fatalities for a function that provides zero benefit."

<u>6.6.3.2.2 Pushing the Traffic to Shoulder</u>

An IDOT survey respondent stated that "some flaggers disrupt traffic flow on freeways causing unsafe conditions for motorists. This can lead to unsafe conditions for flaggers and workers. Flaggers can also be hard to see in lane closures that require drums or barricades." A Michigan DOT respondent stated in the national survey that "contractors have become accustomed to using flaggers in an aggressive stance, pushing traffic onto the shoulder and slowing traffic - all at great risk to the flagger and traffic." Another risk that can be caused by aggressive flaggers is pushing traffic onto the shoulder, causing hazardous driving conditions and potential damages to the shoulder. This risk was observed during work zone site visits and was mentioned as a serious risk in the meetings with resident engineers. They were concerned about aggressive flaggers who push the traffic to an excessively slow speed and about drivers heading onto the shoulder in an attempt to avoid the flaggers standing too close to traffic. Several respondents mentioned that "flaggers may cause accidents by pushing the traffic too much to the shoulder" and "flaggers can be too aggressive and exposed to additional hazards when they notice that some drivers do not follow their instructions to slow down." It was also mentioned that the negative effect on the shoulder occurs because "aggressive flaggers sometimes push the traffic too much to the shoulder which increases the risks of crashes or potential damage of shoulders."

6.6.4 Using Spotters in Work Zones

A spotter was defined in the conducted survey and interviews as “a trained person whose sole duty is to monitor traffic and warn workers of errant drivers or other hazards using an effective warning device such as a whistle or air horn.” It was also stated that “a spotter does not control traffic or use a traffic regulator paddle, but uses a warning sounding device,” and that “spotters must be positioned away from unnecessary danger.” Spotters are used primarily to warn workers of errant traffic with the help of a warning device. The following sections summarize the comments and feedback collected on the potential benefits of using spotters.

6.6.4.1 Site Visit Interviews and District Engineer Meeting

A number of IDOT resident engineers reported that replacing flaggers with spotters might create challenges, including (1) spotters can get bored and be less vigilant than flaggers are, (2) spotters will be located away from live traffic and will not slow down traffic, and (3) replacing flaggers may cause union issues. The resident engineers also expressed doubts about the effectiveness of soundmaker devices, such as whistles and air horns, and whether such devices can be heard above the noise of the work zone.

6.6.4.2 IDOT Survey Comments and Feedback

A number of IDOT survey respondents doubted that spotters could be effective in warning workers using audible devices, such as whistles and air horns. Other IDOT respondents reported that the idea of having someone who is always looking for danger and ready to warn workers is a great idea, but spotters are rarely used in Illinois work zones.

6.6.4.3 National Survey Comments and Feedback

Respondents from Washington DOT stated in the national survey that a spotter is most effective in operations that are next to the live lane, such as pavement and marking operations, and that spotters should never be used except as a last resort and only for short-duration work zones. Washington DOT recommends or allows the use of spotters on freeways/expressways on a case-by-case basis. Missouri DOT respondents reported that neither spotters nor flaggers are allowed in freeway and expressway work zones. Michigan DOT respondent wondered how spotters or flaggers could determine whether drivers are traveling over the speed limit or not. Respondents from Virginia and Florida DOTs reported that they do not use spotters or flaggers in operations on freeway/expressway work zones. Florida DOT allows contractors to decide if they need spotters or not.

6.6.5 TTC Devices and Safety Measures

The following sections summarize and group the comments and feedback collected on the effectiveness of safety measures that can be used to replace or enhance flaggers’ functions.

6.6.5.1 Site Visit Interviews and District Engineers Meetings

Resident engineers reported that police patrols are the most effective safety measure that can support flaggers because drivers slow down in the presence of a police patrol to avoid violation of the law and payment of tickets. Other respondents reported that radars and speed display tools are effective to reduce drivers’ speed and can be used to replace flaggers. In addition, some engineers expressed doubts about the effectiveness of intrusion alarms because of the high level of noise in the work zone environment; however, when asked about intrusions alarms, a resident engineer maintained that “we need to practically try it to see if it can be an efficient tool.” PCMSs were also reported as an effective tool to communicate with traffic depending on work zone conditions.

6.6.5.2 IDOT Safety Measures Recommended by IDOT Survey Respondents

- Tall grabber cones that are easy to see through and have small footprints, unlike regular cones that occupy larger areas of the road and cause traffic to move to the shoulder.
- Flashing LED lights on the STOP/SLOW paddles to improve visibility.
- Intelligent traffic system (ITS) components, such as smart cones, that provide real-time data on traffic and are connected to a PCMS to minimize rear-end crashes.
- Cell phone blockers to reduce driver distraction in the work zone area.
- Increase the use of other successful devices such as TMAs, speed displays, and message boards.

6.6.5.3 Comments and Feedback from National Survey

National survey respondents also recommended new and existing technology that could enhance and/or replace flagger tasks, including:

- Web-based speed monitoring devices such as smart cones.
- Traffic advisory systems that provide real-time back-up alerts and messages and other ITS components such as queue detection.
- Sequential lighting for nighttime work zones that was recommended by Missouri DOT that stated "These lights have shown a larger amount of the traveling public will merge sooner during nighttime projects."

CHAPTER 7 EFFECTIVENESS OF FLAGGERS, SPOTTERS AND WORK ZONE SAFETY MEASURES

This chapter summarizes the main findings of the research project on the effectiveness of (1) using flaggers and/or spotters in work zones with a speed limit greater than 40 mph on Illinois expressways and freeways and (2) work zone safety measures that can be used to supplement or replace flaggers in these works zones. The findings are based on the collective results of project tasks, including survey results of IDOT resident engineers, traffic personnel and highway contractors, national survey results of others state DOTs, field observations from site visits to IDOT work zones, feedback from interviews and meetings with resident engineers during the site visits, and statistical analysis of work zone crash data gathered in Illinois.

7.1 EFFECTIVENESS OF FLAGGERS AND/OR SPOTTERS

The main findings of this research project on the effectiveness of using flaggers and/or spotters in work zones with a speed limit greater than 40 mph on Illinois expressways and freeways can be summarized as follows:

1. Need for flaggers in national survey: The results indicate that the average score for the need of flaggers to perform various safety and mobility functions in freeway and expressway work zones is 0.256, which highlights that other state DOTs reported the level of need for flaggers in these types of work zones ranges between “no need” and “moderate need.” In addition, several respondents from Florida, Michigan, Minnesota, and Virginia state DOTs reported that they do not allow/use flaggers in these types of work zones.
2. Need for flaggers in IDOT survey: The results indicate that the average score for the need of flaggers to perform various safety and mobility functions in freeway and expressway work zones is 0.738. The highest weighted score for the need of flagger functions was scored by the functions “warn workers of errant drivers and vehicle intrusion into work zone” and “slow the speed of oncoming traffic,” which received of 0.801 and 0.794, respectively. The same flagger functions received a weighted score of 0.25 and 0.3, respectively, in the national survey.
3. Benefits of flaggers in national survey: The results indicate that the average score for the benefits that can be gained from using flaggers in freeway and expressway work zones is 0.267, which indicate that other state DOTs reported the level of benefits from using flaggers in these types of work zones ranges between “no benefit” and “moderate benefit.”
4. Benefits of flaggers in IDOT survey: The results indicate that the average score for the benefits that can be gained from using flaggers in freeway/expressway work zones is 0.632, which indicates that IDOT engineers and work zone personnel identified the level of benefits that can be achieved by using flaggers in these types of work zones to be slightly higher than “moderate benefit.”
5. Risks of using flaggers in IDOT and national survey: The results indicate that the average score for the risks and hazards that can be caused by using flaggers in freeway and expressway work zones is 0.656 in the IDOT survey and 0.688 in the national survey. This highlights that IDOT and other state DOTs identified the level of risks caused by using flaggers in these types of work zones to be between “moderate risk” and “greatest risk.”
6. Highest risk caused by using flaggers: “Exposure of flaggers to traffic hazards and injuries” received the highest weighted score in the IDOT survey, 0.811, and 0.813 in the national surveys, which highlights the significance of this type of hazard and the need to address it.

7. Most hazardous work zones for flaggers: The work zones that had nighttime work, curves and hills received the highest weighted scores of 0.810/0.85, 0.835/0.775, and 0.855/0.775 in IDOT and national surveys, respectively. This highlights the increased level of risks in these types of work zones and the need to find alternative and safer solutions to control and minimize this risk/hazard to flaggers.
8. Least hazardous work zones for flaggers: Daytime work zones received the lowest weighted scores of 0.435 and 0.475 in the IDOT and national surveys, respectively.
9. Use of spotters in other state DOT standards: The literature review indicates that a number of state DOT standards define spotters and their tasks, including Virginia, Michigan, Oregon, Wisconsin, and Washington DOTs. For example, Oregon DOT defines a spotter in its TTC handbook for operations of three days or less as "an employee whose sole duty is to provide immediate warning of approaching vehicles, equipment, or other hazards to co-workers." Washington state DOT standards specify that spotters can be used in very short-term freeway and highway work zones. Wisconsin DOT standards specify that spotters can be used at incident scenes to monitor approaching traffic and activate an emergency signal if the actions of a motorist do not conform to established traffic control measures.
10. Need for spotters in IDOT and national surveys: The results indicate that the need of spotters to perform various safety and mobility functions in freeway and expressway work zones received an average score of 0.559, 0.402, and 0.420 from IDOT respondents, state DOTs, and state DOTs with prior experience in using spotters, respectively. This indicates that IDOT and other state DOTs reported the level of need for spotters in these types of work zones to be approximately "moderate need." IDOT survey respondents gave the highest score of 0.792 to the function "detect errant drivers and warn workers using effective warning devices" which highlights the high need for this function.
11. Benefits of spotters in IDOT and national surveys: The results indicate that the benefits of using spotters in freeway and expressway work zones received an average score of 0.546, 0.350, and 0.480 from IDOT respondents, state DOTs, and state DOTs with prior experience in using spotters, respectively. The greatest benefit of using spotters was "Improve workers safety," which received a weighted score of 0.747, 0.514, and 0.80 from IDOT respondents, state DOTs, and state DOTs with prior experience in using spotters, respectively.
12. Risks of using spotters in IDOT and national survey: The average risk of using spotters was 0.508 in the IDOT survey and 0.650 in the national survey, which indicates moderate to high risk. The hazard of "Exposure of spotter to traffic hazards and injuries" received a moderate risk score of 0.544 in the IDOT survey, a high weighted score of 0.720 from all state DOTs, and 0.70 from state DOTs with prior experience in using spotters.
13. Effectiveness of using spotters instead of flaggers: In the IDOT survey, the two functions "Warn workers of oncoming traffic" and "Detect errant drivers and warn workers using effective warning devices" received the greatest weighted scores of 0.619 and 0.666, respectively, in case of using spotters instead of flaggers. The top three functions that received the highest weighted score from state DOTs with prior experience in using spotters were "Detect errant drivers and warn workers," "Guide entering trucks to work zone," and "Warn workers of the hazards posed by construction equipment in the work zone," which received an equal weighted score of 0.688.
14. Impact of using spotters instead of flaggers on safety and mobility: Survey respondents were asked to identify the level of effectiveness of using spotters instead of flaggers to accomplish a set of safety and mobility goals based on a five-point scale that ranges from

least effective (0.0) to most effective (1.0). The goal “Enhance worker safety” received the greatest weighted score of 0.590, 0.523, and 0.875 from IDOT respondents, state DOTs, and state DOTs with prior experience in using spotters, respectively.

15. Impact of using spotters in different work zone layouts: Survey respondents were asked to identify the level of impact of using spotters instead of flaggers on various work zone layouts based on a five-point scale that ranges from negative impact (0.0) to positive impact (1.0). In the IDOT survey, the highest weighted score of 0.620 was scored by work zones that have “lane closure on freeways with high AADT,” where a weighted score of 0.5 indicates no impact and 1.0 indicates positive impact, while the weighted scores for all the remaining work zone types ranged from 0.53 to 0.59. In the national survey, the work zones that received the highest weighted score were “short-term work zones” and “very short-term work zones” that received weighted scores of 0.728/0.938 and 0.751/0.875 from all state DOTs and state DOTs with prior experience in using spotters, respectively.
16. Effective measures for work zone safety: The IDOT survey results indicate that the top four measures that can best maximize work zone safety and mobility are “Plan a safe escape route for spotters,” “Deploy back-up alarms for backing trucks in the work zone,” “Use radar trailer to inform oncoming drivers of their speed,” and “Locate spotter in safe areas away from hazards,” which received scores of 0.864, 0.796, 0.774, and 0.773, respectively. Furthermore, the national survey results showed that state DOTs with prior experience in using spotters reported a weighted score of 0.938 for the effectiveness of “Planning an escape route for spotters” to maximize work zone safety, which highlights the high level of effectiveness of this measure.
17. Effective measures for work zone access and egress: The National survey results show that “incorporating access/egress into internal traffic control plans (ITCPs)” received a high weighted score of 0.841 from all DOTs participating in the survey, which indicates that this measure is considered to be close to “most effective” in improving the safety of access and egress points.
18. Impact of improper driving on work zone crashes: The analysis of Illinois crash data from 1996 to 2009 indicates that “improper driving” was a major cause of 42.1% of the fatal crashes and 44.0% of injury crashes in work zones on Illinois freeways/expressways.
19. Impact of speed on work zone crashes: The analysis of Illinois crash data from 1996 to 2009 indicates that “speed” was a major cause of 11.8% of fatal crashes and 23.7% of injury crashes in work zones on Illinois freeways/expressways. This highlights the need to increase the enforcement of speed limits in these types of work zones.
20. Types of work zone crashes: The analysis of Illinois crash data from 1996 to 2009 indicates “rear-end crashes” was responsible for 38.2% of fatal crashes and 54.6% of injury crashes in work zones on Illinois freeways/expressways. This highlights the need to improve existing work zone safety measures to control and minimize this type of crash.

7.2 EFFECTIVENESS OF WORK ZONE SAFETY MEASURES

This section identifies a number of effective work zone safety measures that can be used to supplement or replace flaggers in freeway and expressway work zones with speed limits over 40 mph. The safety measures were identified based on the collective findings of IDOT and national surveys, feedback and observations from interviews and meetings with resident engineers during site visits to IDOT work zones, and a comprehensive literature review. The main findings are summarized as follows:

1. Effectiveness of safety measures in IDOT survey: The results of this survey indicate that the relative ranking of the effectiveness of work zone safety measures in descending order

is (1) police patrols, (2) truck-mounted attenuators (TMAs), (3) portable speed monitoring displays (PSMDs), (4) portable changeable message signs (PCMSs), (5) temporary rumble strips, and (6) intrusion alarms.

2. Effectiveness of safety measures in national survey: The results of this survey indicate that the relative ranking of the effectiveness of safety measures in descending order is (1) truck-mounted attenuators (TMAs), (2) portable changeable message signs (PCMSs), (3) police patrols, (4) mobile barriers, (5) temporary rumble strips, (6) portable speed monitor displays (PSMDs), (7) automated flagger assistance devices (AFADs), (8) intrusion alarms, and (9) radar drones.
3. Use of safety measures in national survey: More than 78% of participating state DOTs reported their use of the following work zone safety measures that are ranked in descending order based on their use: portable speed monitor displays (PSMDs), portable changeable message signs (PCMSs), temporary rumble strips, truck-mounted attenuators (TMAs), and police patrols.
4. Recommended use of ITS in national survey: Four state DOT survey respondents (from Arizona, Texas, Washington, and Virginia) reported their successful use of ITS components such as smart cones, queue detection, and PCMSs to enhance work zone safety and mobility.
5. Use of sequential lighting: Missouri DOT recommended using sequential lighting as an effective safety measure to improve the merging of traffic in nighttime work zones.

CHAPTER 8 RECOMMENDATIONS AND FUTURE RESEARCH

8.1 RECOMMENDATIONS

This section provides a list of recommendations on the use of flaggers, spotters, and other safety measures in work zones with a speed limit greater than 40 mph on Illinois expressways and freeways. The recommendations can be used by IDOT to update and/or expand related IDOT policies, specifications, and standards in order to improve work zone safety and mobility. The recommendations are based on the collective findings of all the completed tasks in the project, including (1) literature review, (2) survey results of IDOT resident engineers, traffic personnel and highway contractors, (3) survey results from other state DOT personnel, (4) field observations from site visits to IDOT work zones and feedback from interviews and meetings with resident engineers, and (5) statistical analysis of work zone crash data gathered in Illinois. The following section highlights a list of recommendations and the basis for their development. It should be noted that the following recommendations are limited only to work zones with a speed limit greater than 40 mph on Illinois expressways and freeways.

8.1.1 Recommendation 1

IDOT Standard Specifications for Road and Bridge Construction should be revised to replace the requirement of using flaggers in multilane highway work zones that states: “At all times where traffic is restricted to less than the normal number of lanes on a multilane pavement with a posted speed limit greater than 40 mph and the workers are present, but not separated from the traffic by physical barriers, a flagger shall be furnished to support the workers and to warn and direct traffic. One flagger will be required for each separate activity of an operation that requires frequent encroachment in a lane open to traffic” with the condition that “flaggers and/or spotters direct traffic only when necessary during work zone operations that require intermittent and/or additional slowing down of traffic such as (1) trucks entering or exiting the work zone, (2) installing or removing temporary traffic control devices, (3) removing roadway debris, and/or (4) emergency situations.”

8.1.1.1 Basis for Recommendation 1

Virginia, Michigan, Oregon, Wisconsin, and Washington DOTs have recently updated their standard specifications to add a requirement for using spotters instead of flaggers and for limiting the role of flaggers in directing traffic to necessary work zone operations.

Florida, Michigan, Minnesota, and Virginia state DOTs respondents stated that they no longer allow/use flaggers in these types of work zones.

National survey results indicate that the average score for the need for flaggers in these types of work zones is 0.256, which represents a level of need ranging between “no need” and “moderate need.”

The average score of benefits that can be gained from using flaggers in these work zones is 0.26 in the national survey and 0.63 in the IDOT survey, which indicates that the level of benefits ranges between “no benefit” and “moderate benefit” in the national survey and is slightly higher than “moderate benefit” in the IDOT survey.

The average score for the risks and hazards that can be caused by using flaggers on freeway and expressway work zones is 0.66 in the IDOT survey and 0.68 in the national survey, which represents a level of risk ranging between “moderate risks” and “greatest risks.”

Results of the field observations that were collected during the conducted site visits of seven expressway and freeway wok zones in Illinois show that flaggers were used only whenever trucks enter or exit the work zone and whenever workers are located close to the live lane for the installation of temporary traffic control devices.

8.1.2 Recommendation 2

IDOT Standard Specifications for Road and Bridge Construction should be updated to allow the use of spotters instead of flaggers in these types of work zones and to adopt the following definition of a spotter, "a trained person/flagger who (1) monitors traffic and warns workers of errant drivers or other hazards using an effective warning device such as a whistle or air horn and/or (2) directs traffic when necessary during work zone operations that require intermittent or additional slowing down of traffic such as trucks entering or exiting the work zone, installing or removing temporary traffic control devices, removing roadway debris, or during emergency situations."

8.1.2.1 Basis for Recommendation 2

Virginia, Michigan, Oregon, Wisconsin, and Washington state DOTs have recently updated their standard specifications to require the use of spotters instead of flaggers in these types of work zones.

National survey results show that state DOTs with prior experience in using spotters reported a weighted score of 0.875 for the effectiveness of using spotters instead of flaggers to "enhance workers safety" on a scale ranging from "0.0" for least effective to "1.0" for most effective, which highlights the high level of effectiveness of this practice in enhancing workers safety.

Florida, Michigan, Minnesota, and Virginia state DOTs respondents reported that they no longer allow/use flaggers in these types of work zones.

Survey results indicate that flaggers are subject to a high level of risks and hazards in these types of work zones. The average weighted scores for risks of flaggers is 0.656 in the IDOT survey and 0.688 in the national survey, which represents a level of risk ranging between "moderate" and "greatest" risks.

The research team observed, during a number of the site visits, that flaggers did not direct work zone traffic at all times, but rather focused on monitoring traffic and guiding truck drivers entering or exiting the work zone.

There is a need to replace the current requirement that flaggers be "*furnished at all times to direct work zone traffic*" with another requirement that specifies the use of spotters to direct traffic when necessary. This requires updating the specifications to allow the use of spotters and to differentiate between the role of spotters in these types of work zones and the role of flaggers in other types of work zones.

8.1.3 Recommendation 3

The IDOT flagger handbook and/or IDOT Standard Specifications for Road and Bridge Construction should be updated to minimize the exposure of flaggers and/or spotters to traffic hazards in these types of work zones by (1) positioning flaggers and/or spotters in safe locations away from traffic when they are not engaged in directing work zone traffic, (2) establishing a predetermined escape route for flaggers and/or spotters to protect them from errant drivers, and (3) limiting the time of flaggers and/or spotters exposure to traffic by limiting their tasks to monitoring traffic from safe locations away from traffic and guiding traffic only when needed.

8.1.3.1 Basis for Recommendation 3

The work zone hazard of "Exposure of flaggers to traffic hazards and injuries" received the highest weighted score of 0.811 in both IDOT and national surveys. This highlights the significance of this type of hazard and the need to address it.

National survey results show that state DOTs with prior experience in using spotters reported a weighted score of 0.938 for the effectiveness of "Planning an escape route for spotters" to maximize work zone safety on a scale ranging from (0.0) for least effective to (1.0) for most effective, which highlights the high level of effectiveness of this measure in enhancing work zone safety.

National survey results also showed that the average risks for flagger functions reported by other state DOTs is 0.688, which represents a level of risk ranging between “moderate risk” and “greatest risk.”

During the site visits, the research team observed the high level of hazards that flaggers are exposed to because of their proximity to traffic and the lack of physical barriers. This was also confirmed by most of the flaggers who were interviewed during these site visits.

Survey respondents were asked to identify the level of effectiveness of a set of measures to maximize work zone safety and mobility if spotters are used instead of flaggers based on a five-point scale that ranges from least effective (0.0) to most effective (1.0). The measures of “Locate spotters in safe areas away from the hazards of oncoming traffic” received a score of 0.773 in the national survey and 0.760 in the IDOT survey. The measure of “Plan a safe escape route for spotters” received a weighted score of 0.753, 0.864, and 0.938 from IDOT respondents, all state DOTs, and state DOTs with prior experience in using spotters, respectively.

8.1.4 Recommendation 4

IDOT Standard Specifications for Road and Bridge Construction should be updated to supplement the use of spotters with additional temporary traffic control devices such as a work vehicle with high-intensity rotating or flashing light, truck-mounted attenuators (TMAs), portable speed monitoring displays (PSMDs), and/or portable changeable message signs (PCMSs).

8.1.4.1 Basis for Recommendation 4

The results of the completed IDOT survey indicate that the temporary traffic control devices that received the highest level of effectiveness were police patrols, truck-mounted attenuators (TMAs), portable speed monitoring displays (PSMDs), and portable changeable message signs (PCMSs).

The results of the national survey indicate that the temporary traffic control devices that received the highest level of effectiveness were truck-mounted attenuators (TMAs), portable changeable message signs (PCMSs), police patrols, and mobile barriers.

A number of state DOTs, such as Washington DOT (1) allows using a spotter supplemented with a work vehicle, warning beacon, and personal protective equipment in work zones with the lowest level of impacts that have low traffic speed and volumes; and (2) requires the use of a spotter supplemented with cones or PCMSs in work zones with moderate impacts that have low or high traffic speed with low to moderate volumes.

8.1.5 Recommendation 5

The training of spotters and/or flaggers deployed in these types of work zones should be updated and expanded to (1) adopt Recommendations 1 and 2, which limit their tasks to monitoring traffic from safe locations away from traffic and guiding traffic only when needed, (2) ensure that they do not overly reduce traffic speed which often causes traffic delays and increases the risks of rear-end crashes, and (3) avoid the excessive push of traffic to the shoulder, which may cause damages to the shoulder and other traffic hazards.

8.1.5.1 Basis for Recommendation 5

During the site visits, the research team measured traffic speed using radar guns and observed that they were well below the speed limits. This was caused by flaggers who overly reduced traffic speed based on subjective and inaccurate estimates of the vehicles speed.

The research team observed during the site visits a number of flaggers who excessively pushed traffic to the shoulder, thereby potentially causing shoulder damage and creating hazardous driving conditions.

A number of the interviewed resident and district engineers recommended the expansion and improvement of flagger training to minimize excessive reduction in traffic speed and avoid pushing traffic to the shoulders.

The conducted analysis of work zone crashes in Illinois revealed that rear-end crashes were responsible for 38.2% of fatal crashes and 54.6% of injury crashes in these types of work zones. This highlights the need to minimize the causes of rear-end crashes, including the excessive reduction of speed limits in and around work zones.

8.1.6 Recommendation 6

The aforementioned recommendations to update IDOT specifications can be implemented after conducting field experiments of these recommendations on a trial basis in work zones on Illinois expressways and freeways. The primary objective of the field experiments is to gather and analyze field data to verify that the replacement of flaggers with spotters will not have a negative impact on work zone safety and mobility. Field data must be collected from multiple work zones using flaggers and an equal number of work zones using spotters instead of flaggers as per the above recommendations. The field data can be collected using video streams captured with fixed cameras that continuously monitor and record traffic safety and mobility conditions in and around the work zone for an extended period of 6 to 12 months. The field data must be analyzed and compared to verify that using spotters instead of flaggers has no negative impact on work zone safety and mobility. This verification should be required before updating IDOT specifications to implement the aforementioned recommendations.

8.1.6.1 Basis for Recommendation 6

The aforementioned recommendations were developed based on the collective findings of a comprehensive literature review, two surveys targeting officials in IDOT and other state DOTs, field observations and interviews during the conducted site visits, and a detailed data analysis of work zone crashes in Illinois. The basis for these recommendations, however, can be more statistically significant if there were any field data comparing the safety and mobility of work zones using traditional flaggers with those using spotters. The collection and analysis of this data can confirm whether the use of spotters instead of flaggers has a positive, negative or no impact on the safety and mobility of freeway and expressway work zones in Illinois.

8.2 FUTURE RESEARCH

During the course of this study, the research team identified a number of promising research areas that need further in-depth analysis and investigation in a follow-up phase. Building on the accomplishments in this project, the research team foresees an opportunity to continue studying and improving work zone safety and mobility in a second phase of the project by focusing on one or more of the following research areas.

8.2.1 Research Area 1: Collect and Analyze Field Data on the Impact of Using Spotters Instead of Flaggers on Work Zone Safety and Mobility

8.2.1.1 Problem Statement

The developed recommendations in the completed project were based on the collective findings of a comprehensive literature review, two surveys of IDOT and other state DOTs, field observations and interviews, and a detailed data analysis of work zone crashes in Illinois. Despite the wide range of findings used in developing these recommendations, there is a lack of field data and knowledge on the real impact of using spotters instead flaggers on the safety and mobility of these types of work zones. Accordingly, there is a pressing need to conduct field experiments on a trial basis to collect reliable field data that can be used to verify that using spotters instead of flaggers does not adversely affect work zone safety and mobility.

8.2.1.2 Objective and Scope of Proposed Research

The main objective of this proposed research is to collect and analyze field data to study and confirm whether replacing flaggers with spotters has a positive, negative, or no impact on the safety and mobility of freeway and expressway work zones in Illinois. To accomplish this objective, the following proposed research tasks must be fulfilled:

1. Collect field data from a representative and adequate number of work zones on Illinois expressways and freeways that deploy traditional flaggers using fixed cameras and speed monitoring devices to continuously monitor and record traffic speed, safety, and mobility conditions in and around the work zone for an extended period of 6 to 12 months.
2. Gather field data from an equal number of work zones that adopts the aforementioned recommendations to deploy spotters instead of flaggers using the same data collection methods and study periods.
3. Compare the impact of using spotters and flaggers on work zone safety by analyzing the captured video streams, recorded traffic speed, and/or crash records to identify the frequency and severity of crashes and other safety conditions in and around the targeted work zones.
4. Compare the impact of using spotters and flaggers on work zone mobility by analyzing the captured length and duration of traffic queues, if any, and the recorded traffic speed and delays.
5. Analyze whether the use of spotters instead of flaggers has a positive, negative, or no impact on the safety and mobility of expressway and freeway work zones in Illinois.
6. Update the recommendations on using spotters and/or flaggers based on the findings of this research in order to maximize the safety and mobility of work zones on Illinois expressways and freeways.

8.2.1.3 Expected Outcome

The expected outcomes of this research include (1) field data and new knowledge on the impact of replacing traditional flaggers with spotters on the safety and mobility of Illinois expressway and freeway work zones and (2) recommendations to update and/or expand related IDOT policy, specifications, and standards to specify the use of spotters and/or flaggers in Illinois expressway and freeway work zones.

8.2.2 Research Area 2: Study and Improve the Effectiveness of Warning Devices to Alert Workers

8.2.2.1 Problem Statement

The completed project recommended updating IDOT specifications to allow the use of spotters to monitor traffic and warn workers of errant drivers or other hazards using an effective warning device such as a whistle or air horn. These warning devices must be effective in alerting workers who are subject to high levels of noise from various construction operations and equipment. During the site visits, the research team conducted initial experiments and concluded that the tested warning device was barely audible by workers who were located near high-noise equipment, such as a concrete saw. In addition, the inability of workers involved in noise-generating operations to hear the warning devices was confirmed by a number of literature studies and survey respondents. Furthermore, there is a lack of reliable and scientific studies that analyze the effectiveness of noise levels generated by warning devices. Accordingly, there is a need to conduct field experiments to study and improve the effectiveness of various warning devices to ensure that workers can be effectively warned in case of errant drivers or other hazards.

8.2.2.2 Objective and Scope of Proposed Research

The main objective of this proposed research is to conduct field experiments to study and improve the effectiveness of various warning devices in order to ensure that workers can be effectively warned in case of errant drivers or other hazards. To accomplish this objective, the following proposed research tasks must be fulfilled:

1. Collect data on the latest devices that can be used to warn workers in work zone.
2. Conduct field studies to measure the levels of noise generated by different types of equipment and operations in the work zone using sound meters.
3. Study workers perception of alarms and identify the required level of alarm noise to provide timely alert that enables them to safely evacuate and escape from errant vehicles or other hazards in the work zone.
4. Provide recommendations on the required noise level that should be generated by warning devices in the work zone.
5. Investigate additional measures to improve the effectiveness of work zone warning devices such as synchronized alarms and vibrating devices that can be activated to warn workers.
6. Update the recommendations on spotters using warning devices based on the findings of this research in order to maximize the safety of work zones in Illinois.

8.2.2.3 Expected Outcome

The expected outcomes of this research include (1) field data and new knowledge on the effectiveness of existing warning devices and (2) recommendations to update and/or expand related IDOT policy, specifications, and standards to specify the use of warning devices in Illinois work zones.

8.2.3 Research Area 3: Conduct Field Experiments to Study the Effectiveness of Sequential Lighting

8.2.3.1 Problem Statement

Sequential lighting is an innovative method for improving driver recognition of lane closures and work zone tapers using wireless warning lights that flash in a sequence to clearly delineate the taper at work zones. Several studies reported that using sequential lighting in nighttime work zones results in reducing traffic speed, increasing drivers' compliance with work zone requirements, and improving traffic merging in lane closure work zones. Furthermore, Missouri DOT respondents recommended the use of sequential lighting as an effective safety measure to improve traffic merging in nighttime work zones. Accordingly, there is a need to conduct field experiments to study the effectiveness of sequential lighting and its impact on work zone safety and mobility.

8.2.3.2 Objective and Scope of Proposed Research

The main objective of this proposed research is to conduct field experiments to study the effectiveness of sequential lighting and improve its impact on work zone safety and mobility. To accomplish this objective, the following proposed tasks must be fulfilled:

1. Identify various types of available sequential lighting equipment and their relative costs.
2. Identify and study the performance of a number of trial case studies of work zones that will be equipped with sequential lighting.

3. Identify and study the performance of an equal number of work zone case studies with similar conditions that lack sequential lighting to enable a comparison between the two types of case studies.
4. Install cameras at varying distances from the start of the taper of the two types of case studies to monitor and record the location where vehicles merge into open lane from the closed lane.
5. Measure and record traffic speed at the beginning of the lane closure in both types of case studies.
6. Analyze and compare traffic merging and speed data that are collected from both types of case studies at the same time of the day and the same traffic conditions.
7. Compare the impact of using sequential lighting on work zone safety by analyzing the captured video streams, recorded traffic speed, and/or crash records to identify the frequency and severity of crashes and other safety conditions in and around the work zone.
8. Compare the impact of using sequential lighting on work zone mobility by analyzing the captured length and duration of traffic queues, if any, and the recorded traffic merging, speed and delays.
9. Develop recommendations on the use of sequential lighting based on the findings of this research to maximize work zone safety and mobility.

8.2.3.3 Expected Outcome

The expected outcomes of this research include (1) field data and new knowledge on the effectiveness of sequential lights in expressways/freeways nighttime work zones and (2) recommendations to update and/or expand related IDOT policy, specifications, and standards.

8.2.4 Research Area 4: Study and Recommend Effective Measures to Improve Safety and Mobility at Work Zone Access and Egress Points

8.2.4.1 Problem Statement

Survey respondents reported the effectiveness of a number of measures and/or layouts in improving the safety and mobility of work zone access and egress points such as “Incorporate access/egress into internal traffic control plan,” “Build temporary ramp to provide median access from street overpass,” Improve lighting condition and visibility of access and egress points during nighttime work zone,” and “Equip the rear of construction vehicles entering the work zone with a warning sign.” There are many benefits and opportunities to conduct case studies to analyze the effectiveness of these measures and/or layouts in improving work zone safety and mobility.

8.2.4.2 Objective and Scope of Proposed Research

The main objective of this proposed research is to study and recommend effective measures to improve safety and mobility at work zone access and egress points. To accomplish this objective, the following proposed research tasks must be fulfilled:

1. Conduct case studies to analyze the performance of a set of identified work zones that utilize various measures and/or layouts for controlling the entrance and exit of trucks.
2. Collect field data from the identified case studies using fixed cameras and speed monitoring devices to continuously monitor and record traffic speed, safety, and mobility conditions as well as specific traffic operations at the work zone access and egress points for an extended period of 6 to 12 months.

3. Collect and record field data on traffic queues and the traffic operations at work zone access and egress points to analyze and measure work zone mobility.
4. Analyze collected data to evaluate the effectiveness of various measures and/or layouts for controlling the entrance and exit of trucks and identify their impact on work zone safety and mobility.
5. Develop recommendations to improve safety and mobility at work zone access and egress points.

8.2.4.3 Expected Outcome

The expected outcomes of this research include (1) field data and new knowledge on the effectiveness of the studied safety measures and/or layouts in enhancing the safety and mobility of access and egress of work zones, (2) a list of effective measures and/or layouts to improve work zone access and egress points, and (3) recommendations to update and/or expand related IDOT policies, specifications, and standards.

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APPENDIX A ADDITIONAL LITERATURE REVIEW

A.1 WORK ZONE LAYOUTS

The layout of a work zone must provide a clear separation between the travel and work activity spaces and provide buffer spaces for protecting motorists and workers (Bryden and Mace 2002a, 2002b). The work zone is divided into four areas: (1) advance warning; (2) transition; (3) activity; and (4) termination, as shown in Figure A.1 (FHWA 2009).

A.1.1 Advance Warning Area

The advance warning area is the section of roadway where road users are informed about the upcoming work zone. Since two or more advance warning signs are regularly used, the advance warning area should extend 1,500 ft (450 m) or more for open highway conditions and it may extend on freeways and expressways as far as 0.5 mile (800 m) or more (FHWA 2009). The effective placement of the first warning sign in advance of the taper in feet (meters) should be substantially long from 8 to 12 times the speed limit in mph (1.5 to 2.25 times the speed limit in km/h) (FHWA 2009). The advance warning signs may vary from a single sign or high-intensity rotating, flashing, oscillating, or strobe lights on a vehicle to a series of signs in advance of the temporary traffic control (TTC) zone, as shown in Figure A.2.

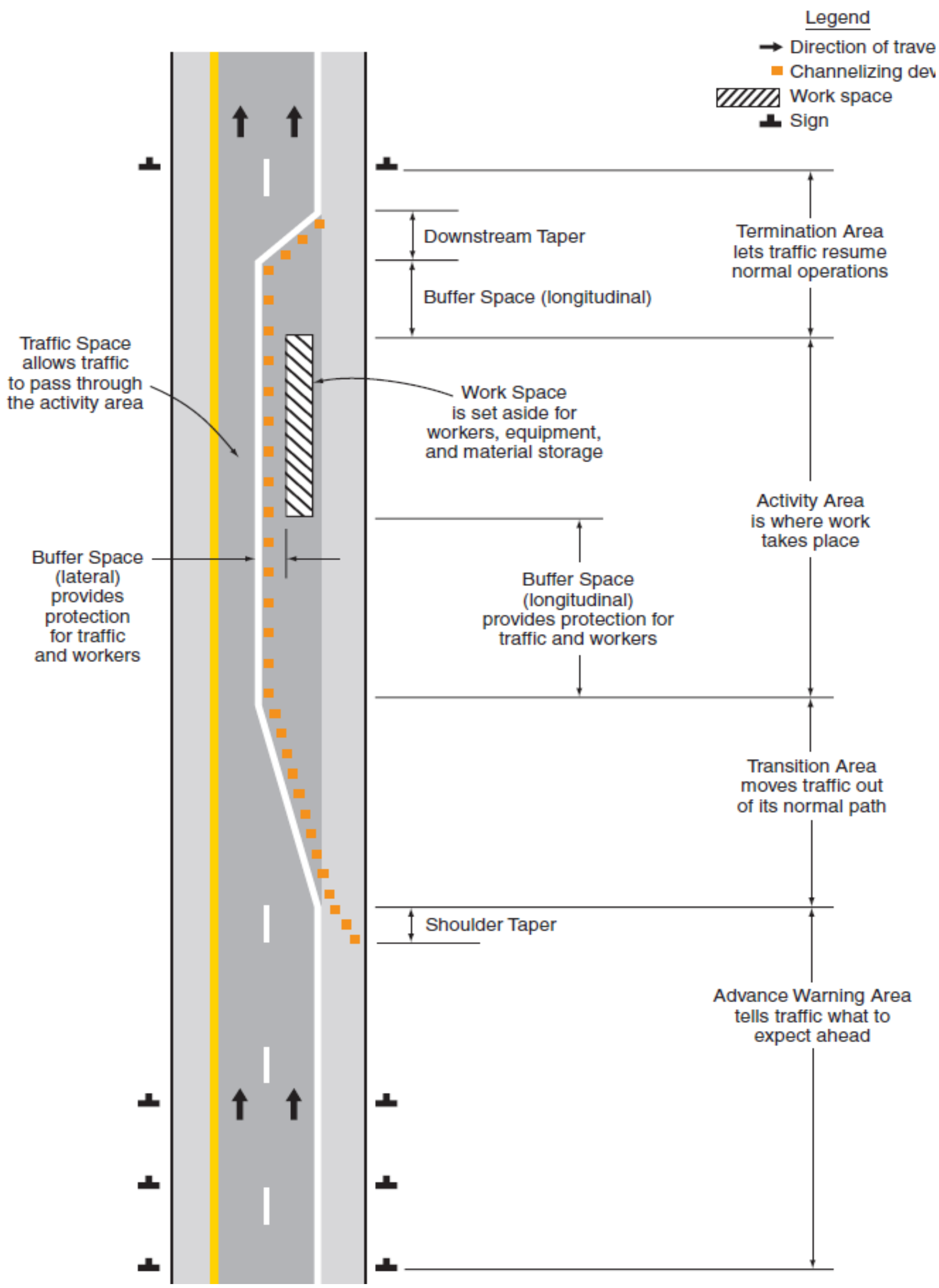

Figure A.1. Major components of a temporary traffic control zone (FHWA 2009).

A.1.2 Transition Area and Tapers

The transition area is the section of roadway where road users are redirected outside their normal path. Transition areas usually involve strategic use of tapers that are created by using a series of channelizing devices and in some cases pavement markings to move traffic from the normal path, as shown in the different types of tapers in Figure A.3. Tapers may be used in both the transition and termination areas. The appropriate taper length (L) is determined using Tables A.1 and A.2, and the maximum distance in feet (meters) between devices in a taper should not exceed 1.0 times the speed limit in mph (0.2 times the speed limit in km/h) (FHWA 2009). Whenever tapers are to be used in close proximity to an interchange ramp, crossroads, curves, or other influencing factors, the length of the tapers may be adjusted.

Table A.1. Formulas for Determining Taper Length (FHWA 2009)

Speed Limit (S)	Taper Length (L) Meters
60 Km/h or less	L= $\frac{WS^2}{155}$
70 km/h or more	L = $\frac{WS}{1.6}$

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

Where: L = taper length; S = posted speed limit; W = width of offset

Table A.2. Taper Length Criteria for Temporary Traffic Control Zone (FHWA 2009)

Type of Taper	Taper length (L)
Merging Taper	At least L
Shifting Taper	At least 0.5L
Shoulder Taper	At least 0.33L
One-Lane, Two-Way Traffic Taper	100 ft (30 m) maximum
Downstream Taper	100 ft (30 m) per lane

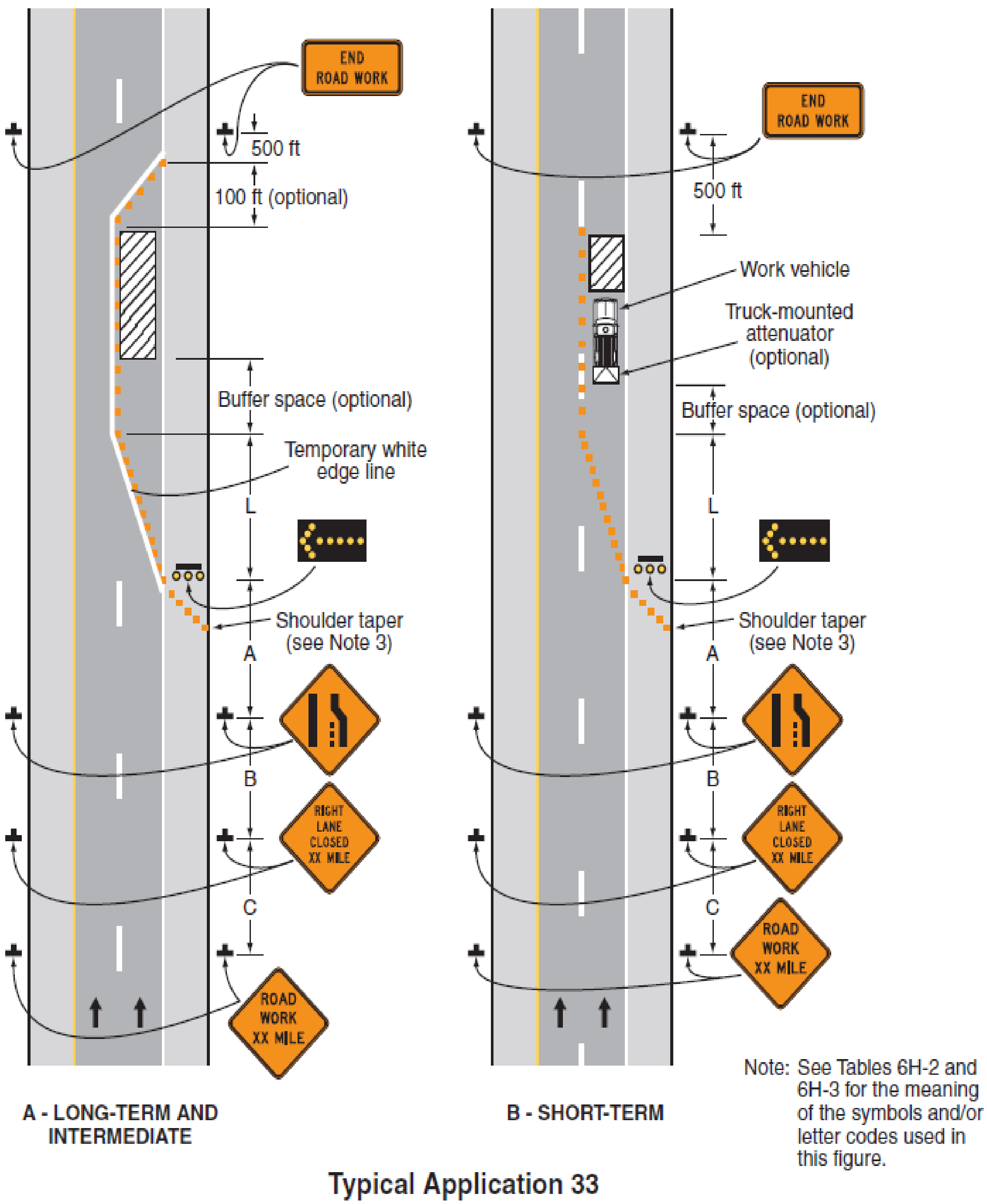

Figure A.2. Stationary lane closure on a divided highway (FHWA 2009).

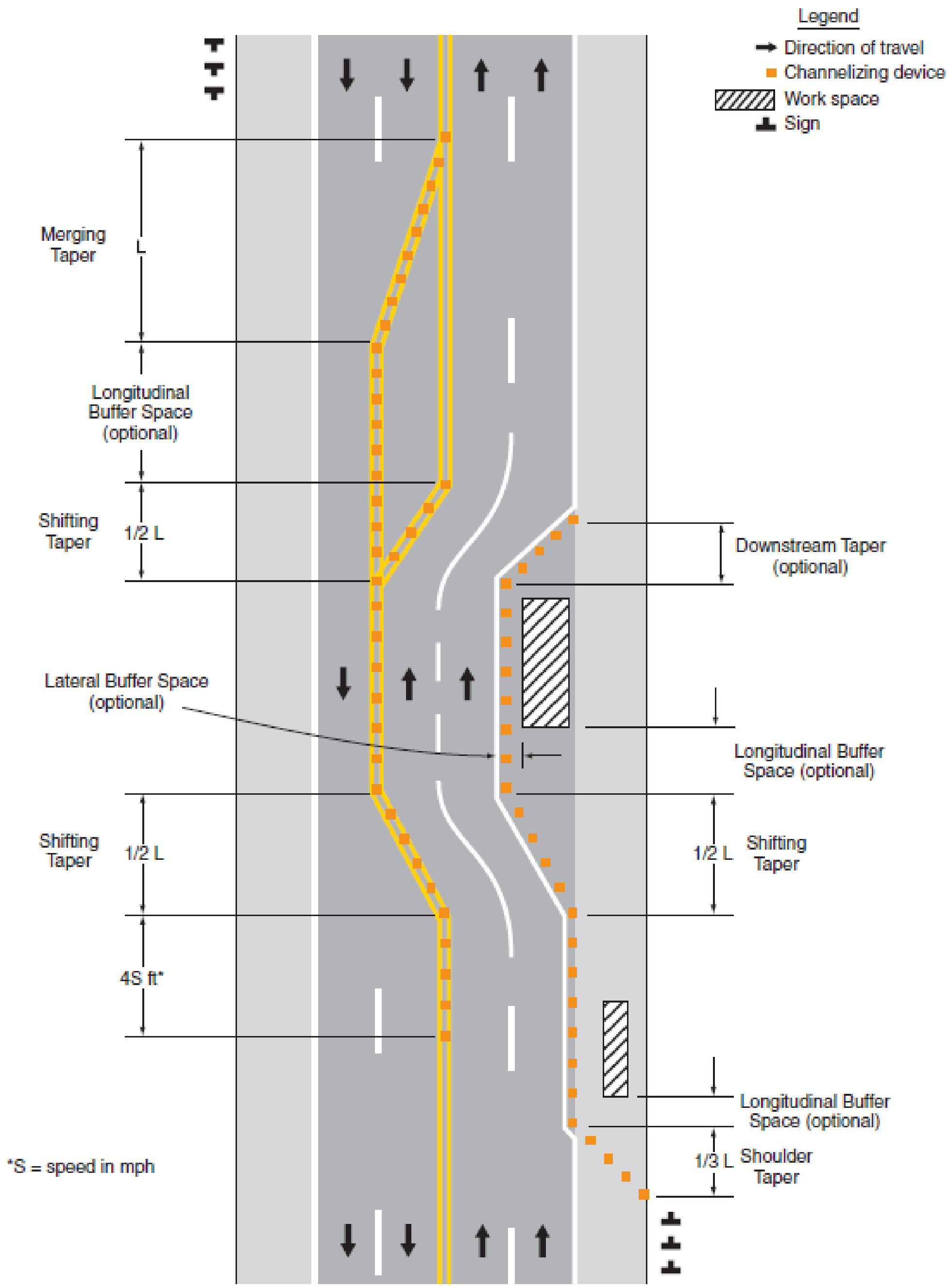

Figure A.3. Types of tapers and buffer spaces (FHWA 2009).

A.1.3 Activity Area

The activity area is the section of the roadway where the work activities take place. It comprises of the workspace, the traffic space, and the buffer space, as shown in Figure A.1. The workspace could be stationary or mobile depending on the progress of work. The traffic space allows traffic to pass through the activity area. The buffer space is a lateral and/or longitudinal area that separates road user flow from the workspace and it provides recovery space for an errant vehicle, as shown in Figure A.1. The allowable length of the longitudinal buffer is determined based on the allowable stopping sight distance, which varies according to the design speed (FHWA 2009).

A.1.4 Termination Area

The termination area is the section of the roadway that returns road users to their normal driving path. It extends from the downstream end of the work area to the last temporary traffic control (TTC) device. An “END ROAD WORK” sign, a “Speed Limit” sign, or other signs may be used to inform road users that they can resume normal operations and a longitudinal buffer space may be used between the workspace and the beginning of the downstream taper.

A.2 MOBILE WORK ZONES

Mobile work zones are used when work activities typically move along the road either intermittently or continuously. They include activities that require (1) slow-moving operations where workers and equipment move along the road without stopping, such as lane marking and striping operations; and (2) frequent short stops such as pothole patching, litter pickup, and herbicide spraying. These operations may require the use of channelizing devices, truck-mounted signs, portable changeable message signs (PCMSs), truck-mounted attenuators (TMAs), warning lights, and/or flaggers (WSDOT 2009). Messages for truck-mounted PCMSs should conform to standard work messages whenever possible (WSDOT 2009). Example warning signs and plaques in temporary traffic control zones (FHWA 2009) are shown in Figure A.4.

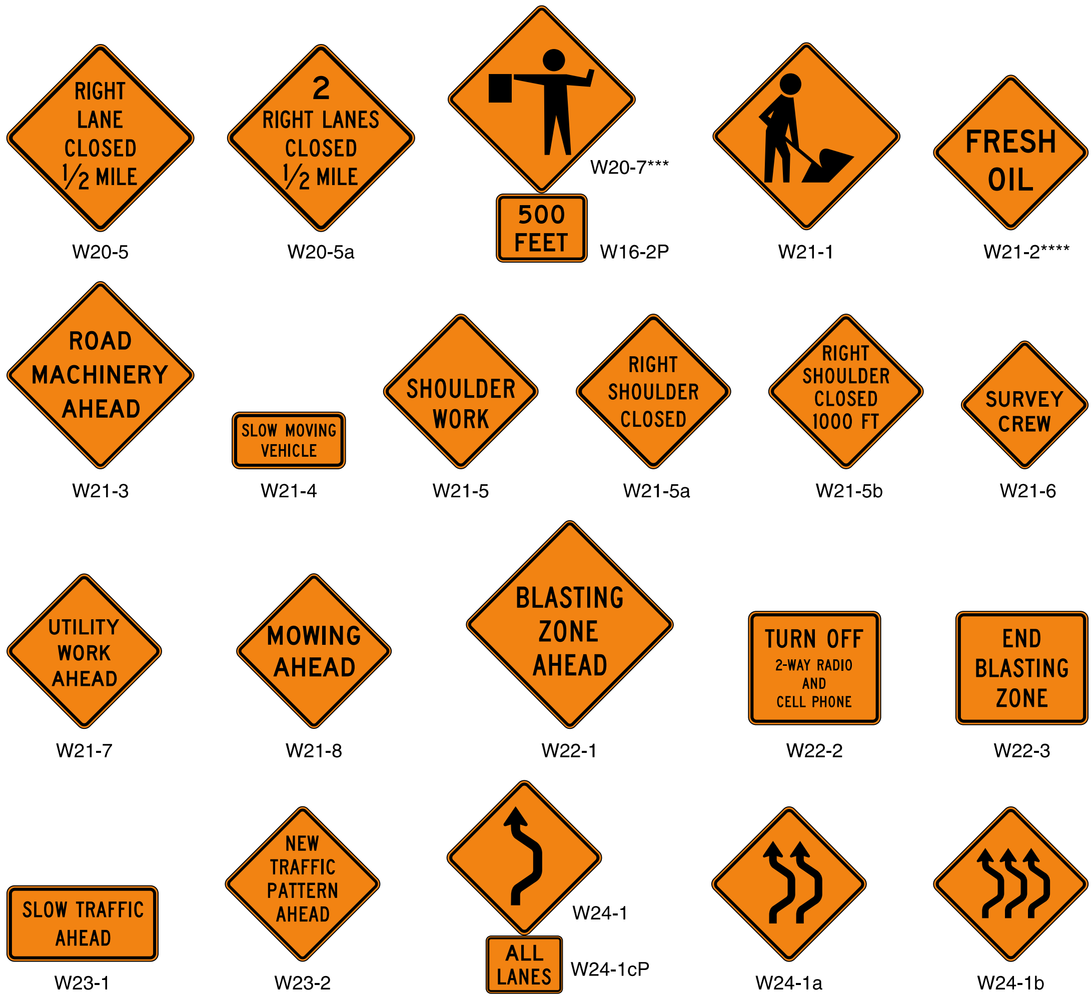

Figure A.4. Example warning signs and plaques in temporary traffic control zones (FHWA 2009).

A.3 FLAGGER STATIONS

MUTCD (FHWA 2009) states that “flagger stations shall be located such that approaching road users will have sufficient distance to stop at an intended stopping point.” The distances shown in Table A.3, which provides stopping sight distance as a function of speed, may be used for the location of a flagger station. These distances may be increased for downgrades and other conditions that affect stopping distance. Flagger stations should be located such that an errant vehicle has additional space to stop without entering the workspace.

Table A.3. Stopping Sight Distance as a Function of Speed (FHWA 2009)

Speed	Distance
20 mph	115 feet
25 mph	155 feet
30 mph	200 feet
35 mph	250 feet
40 mph	305 feet
45 mph	360 feet
50 mph	425 feet
55 mph	495 feet
60 mph	570 feet
65 mph	645 feet
70 mph	730 feet
75 mph	820 feet

A.4 WORK ZONE STRATEGIES

A work zone strategy is developed to carry traffic through or around the facility under construction via a system of infrastructure and a set of temporary traffic controls (Mahoney et al. 2007). Nine strategies are widely employed for construction work zones on highways, and are outlined in the transportation management plans (TMP) for specific projects (IDOT 2002; Mahoney et al. 2007). These strategies include (1) alternating one-way operation; (2) detour; (3) diversion; (4) full road closure; (5) intermittent closure; (6) lane closure; (7) lane constriction; (8) median crossover; and (9) use of shoulder. Each of these nine strategies has its own basic characteristics and offers a unique set of advantages and disadvantages as summarized in A.4 (Mahoney et al. 2007). The selection process of a work zone strategy is governed by many factors such as the number of lanes, geometric and structure design, highway and worker safety, accessibility, capacity and queues, constructability, and cost consequences (Mahoney et al. 2007).

Table A.4. Advantages and Disadvantages of Work Zone Strategies (Mahoney et al. 2007)

Strategy	**Summary**	**Advantages**	**Disadvantages**
Alternating one-way operation	Mitigates for full or intermittent closure of lanes. Used primarily with two-lane facilities.	Low agency cost and low non-transportation impacts; flexible, several variations available.	Requires stopping of traffic; reduces capacity.
Detour	Reroutes traffic onto other existing facilities.	Flexible: cost varies depending on detour route improvements; in some cases, only TTC needed.	Usually reduces capacity; service and infrastructure on existing roads may be degraded; may need agreement of another agency.
Diversion	Provides a temporary roadway adjacent to construction.	Separates traffic from construction: reduced impact on traffic.	Cost may be substantial, especially if temporary grade separation of hydraulic structure involved; right-of-way often required.
Full road closure	Closes the facility to traffic a specified (limited) duration.	Generally also involves expedited construction; separates traffic from construction	Some form of mitigation is needed (detour, diversion, etc.); potentially significant traffic impacts.
Intermittent closure	Stops traffic for a short period.	Flexible and low agency cost.	Useful only for activities that can be completed in short time; requires stopping traffic.
Lane closure	Closes one or more travel lanes.	Maintains service; fairly low agency cost if temporary barriers are omitted.	Reduces capacity; may involve traffic close to active work.
Lane construction	Reduces traveled way width.	Maximizes number of travel lanes.	Traveled way width is less than desirable; may involve traffic close to active work.
Median crossover	Maintains two-way traffic on one roadway of a normally divided highway.	Separates traffic from construction; right-of-way not required.	Reduced capacity; not consistent with approach roadway; relatively costly; interchanges need special attention.
Use of shoulder	Uses shoulder as a travel lane.	Fairly low cost, depending on shoulder preparation.	Displaces traditional refuge for disabled vehicles; debilitates shoulder pavement structure; cross slopes may be problematic.

A.5 WORK ZONE SAFETY AND MOBILITY POLICIES

Work zones have been recognized as hazardous locations for workers. An analysis of serious and fatal injuries to highway workers in New York (Bryden and Andrew 1999) found that 22% of all serious worker injuries and 43% of fatal worker injuries resulted from traffic crashes. It was also observed that two-thirds of the injuries to pedestrian workers occurred from vehicles intruding into marked workspaces and striking workers or flaggers. The proximity of workers and traffic is another concern that makes safety a high priority in highway work zones.

The FHWA is actively improving work zone safety and mobility through new regulations, better engineering, education, enforcement, and communication with concerned public safety agencies (FHWA Work Zone Safety, no date). On September 9, 2004, the FHWA updated the work zone regulations at 23 CFR 630 Subpart J under the "Work Zone Safety and Mobility Rule" that affect all state projects as well as federal aid funded local highway projects starting on October 12, 2007 (Scriba et al. 2005). The main goal of the updated rule is to reduce work zone crashes and congestion at three main implementation levels: (1) policy-level by developing general work zone policies that suit state transportation agencies; (2) process-level by developing agency's work zone processes and procedures; and (3) project-level by identifying significant project requirements and developing appropriate transportation management plans (TMPs) to manage these requirements (Scriba et al. 2005).

The FHWA has also developed the National Highway Work Zone Safety Program (NHWZSP) to reduce fatal and injury crashes in work zones in order to enhance traffic mobility and safety within work zones (FHWA Facts and Statistics, no date). This program is designed to review the standards of traffic control devices, operational features, traffic control plans, and contract specifications to identify and improve work zone management practices. The program consists of four main components: (1) standardization; (2) compliance; (3) evaluation; and (4) implementation (FHWA Work Zone Safety, no date). The National Work Zone Safety Information Clearinghouse (NWZSIC) can also be used to retrieve and analyze data on work zone crashes, statistics, laws and regulations, news and events, research, safety products, standards and practices, and training programs (FHWA Facts and Statistics, no date).

The Illinois Department of Transportation (IDOT) has developed the Illinois Strategic Highway Safety Plan, which identified work zone safety as a priority area and it seeks to provide a high level of safety for both motorists and construction workers. The plan outlines IDOT guidelines to comply with the FHWA Work Zone Safety and Mobility Rule. The main safety goal of this plan is to achieve a new goal of "Zero Fatalities," which envisions reducing fatalities on Illinois roads to zero in the long term. In order to achieve this goal, IDOT has developed (1) significant route location maps; and (2) work zone safety and mobility process flow charts, as shown in Figure A.5. First, the work zone significance is determined using the significant route location maps that classify routes into three categories: (1) non-significant; (2) significant, short term (less than 3 days); and (3) significant, long term. The work zone safety and mobility process flow chart, as shown in Figure A.5, is used to guide the necessary steps to implement the federal work zone safety and mobility rule.

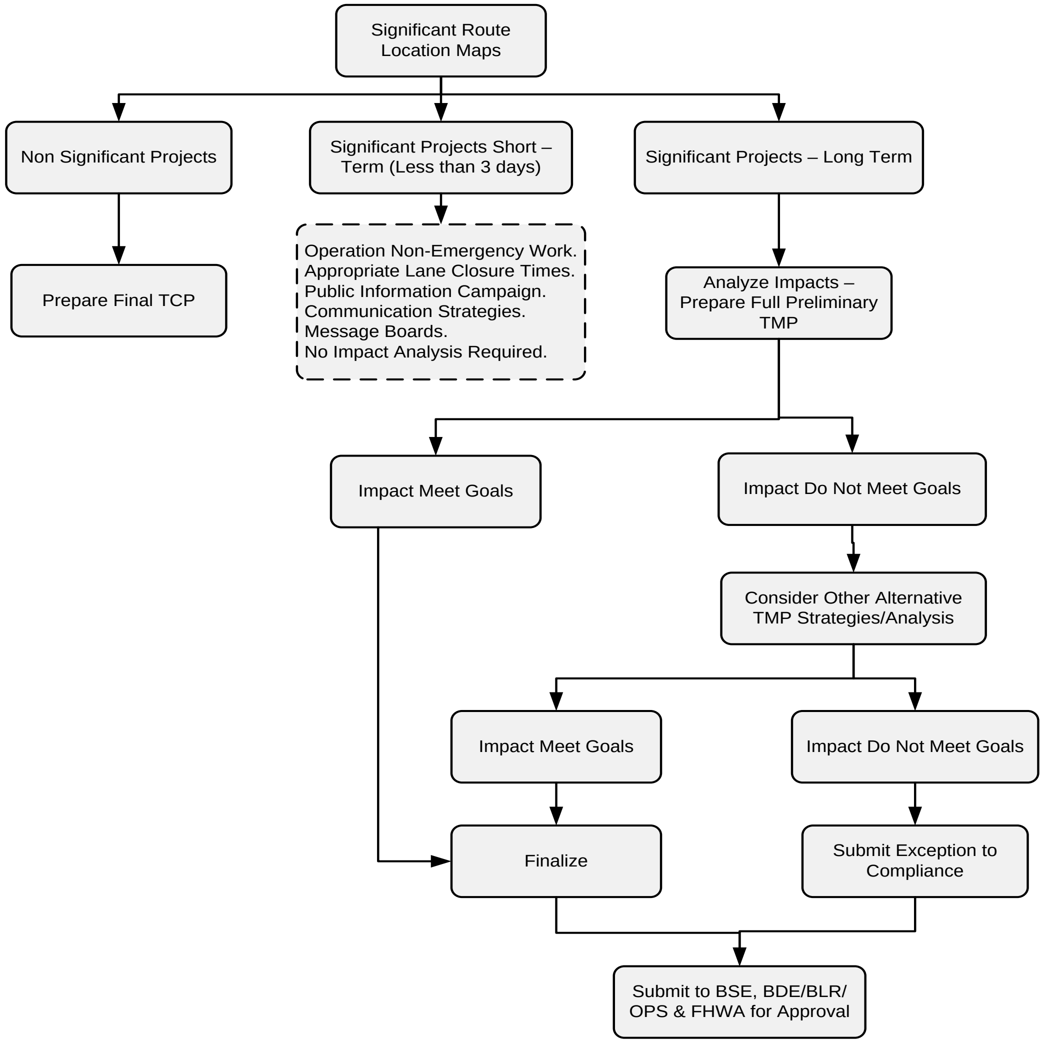

Figure A.5. Work zone safety and mobility process flow chart (ICHSP 2005).

For significant long-term projects, impact analysis is required to determine the greater impact that work zones may cause to traffic (FHWA Work Zone Safety, no date). The impact analysis should involve the safety and mobility impacts of the construction/maintenance project utilizing hourly volume maps, district knowledge and experience, site reviews, computer simulation programs such as QUEWZ, TSIS-CORSIM, and QuickZone by University of Florida (IDOT 2007). To address the expected impacts, various Transportation Management Plan (TMP) strategies are developed and the resulting impacts of delays and queuing are evaluated.

The Illinois Strategic Highway Safety Program (ISHSP 2008) also seeks to assess and improve the safety of work zones by requiring the submission of a detailed work zone crash summary report for any fatal work zone crash within 10 days to the Bureau of Safety Engineering. This report analyzes the crash data and includes the following information: (1) summary of the type of construction; (2) description of the traffic control in place at the time of crash; (3) description of the traffic conditions at the time of the crash; (4) description of the contractor's operations at the time of the crash; (5) description of the weather conditions; (6) pavement conditions, and time of day; (7) description of changes made to the traffic control as a result of the crash; (8) recommendations for change to IDOT standards, and (9) photos of the traffic control throughout the project before and after the crash (Illinois SCHSP 2008).

APPENDIX B ADDITIONAL SITE VISITS

B.1 INTERSTATE HIGHWAY I-74, PEORIA, ILLINOIS

This construction project, located on I-74 between Sterling Avenue and Route 6 in Peoria, Illinois, was visited on May 18, 2012. The observed construction operations included bridge beams rehabilitation and welding, and earthwork on the bridge entrance and exit ramps, as shown in Figures B.1 and B.2, respectively. The layout of the project and temporary traffic control redirected the original traffic direction on the repaired bridge to the other side of the expressway that was kept open for both sides of traffic (crossover), as shown in Figure B.1. This work zone layout was able to provide complete separation between the open traffic lanes on the other side of the bridge and the work zone and its workers. Accordingly, this work zone did not deploy any flaggers at the time of visit in May since there was no direct interaction between the work area and traffic, although flaggers were deployed earlier when the crossover lane change occurred.

Figure B.1. Bridge steel beams and separation between work zone and redirected traffic on the other side of the bridge.

Figure B.2. Earthwork on the entrance and exit ramps for the bridge.

B.2 INTERSTATE HIGHWAY 474 OVER THE ILLINOIS RIVER, ILLINOIS

This bridge construction project, located on highway I-474 over the Illinois River in Peoria, Illinois, was visited on May 18, 2012. The observed construction operations on this bridge repair project included installation of new joints for the steel bridge and steel repair. The layout of the work zone and its temporary traffic control (TTC) plan redirected the traffic away from the side the highway of the bridge under repair to the other side of the highway (crossover) using temporary concrete barriers between the two directions on the other bridge as shown in Figure B.3. This work zone layout was also able to provide complete separation between the work zone and the open traffic on the other side of the highway. Accordingly, this work zone did not deploy flaggers at the current stage of construction since there was no contact between the work zone and the direct traffic.

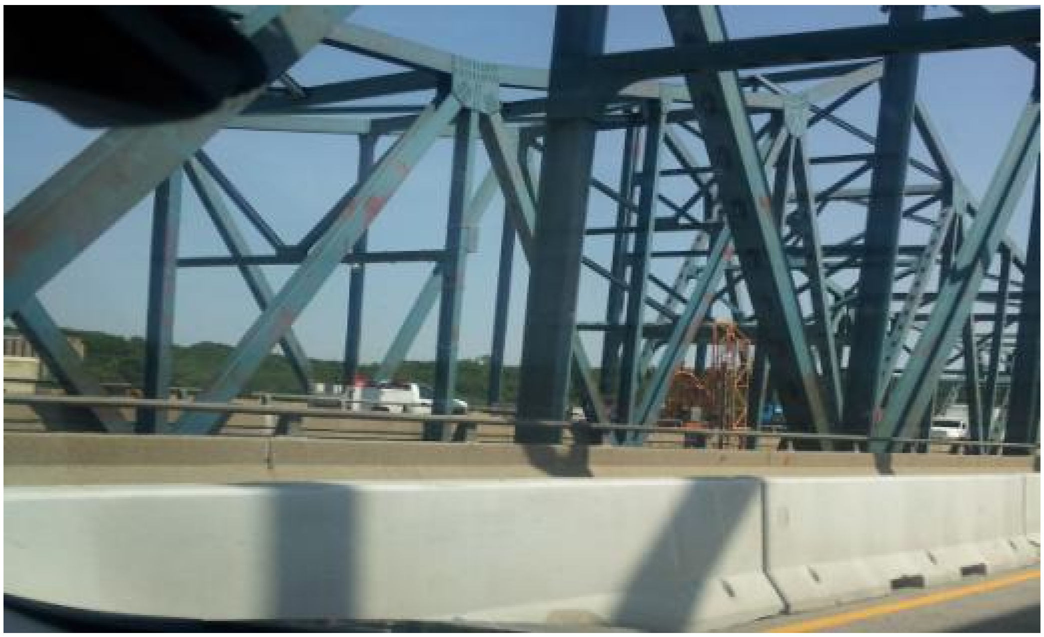

Figure B.3. Temporary concrete barriers between the open traffic lanes on one side of the bridge and the work zone on the other side.

APPENDIX C WORK ZONE CRASH DATA COLLECTION AND ANALYSIS

C.1 DATA COLLECTION

This research task focused on gathering and fusing the latest data and reports on work zone crashes from all available sources and all types of roads and highways in Illinois for a 14-year period (1996 to 2009). The sources of collected data include (1) the National Highway Traffic Safety Administration (NHTSA) that contains data on approximately 400,000 records of all types of Illinois crashes per year and provides a wide range of data for each recorded crash, including crash severity, number of fatalities and injuries, work zone type, traffic volume (AADT), road classification, used traffic control measure, time and day, light conditions, and weather data, as shown in Table C.21; and (2) police reports that provide additional data on work zone configuration, flagger and spotter usage, work zone delays and queues, and major delay/queue contributing factors.

C.1.1 NHTSA Data

The latest available data from the NHTSA contained 28,852 crashes on expressway and freeway work zones that caused 148 fatal crashes, 7,087 injury crashes, and 21,617 property damage crashes during a 14-year period from 1996 to 2009, as shown in Table C.1. The composition of Illinois work zone crashes for the years 1996–2009 is presented in Figure C.1. It illustrates that the property damage only (PDO) crashes are 21,617 crashes and represent 75% of the total number of crashes. The annual number of fatal and injury work zone crashes over the 14-year period (1996–2009) is presented in Figure C.2 and Figure C.3, respectively. It clearly shows an increasing trend starting at (2000) reaching a peak in (2004), then the annual number of work zone crashes slightly decreases and fluctuated over the following five years (2005–2009). The total number of injury crashes has fluctuated from 350 to less than 700 annual crashes over the analyzed period as shown in C.3.

Table C.1. Work Zone Crashes on Illinois Expressways and Freeways (1996–2009)

Year	Fatal Crashes	Injury Crashes	Property Damage	Total number of crashes	Number of Fatalities	Number of Injuries
1996	*5*	*492*	*700*	*1197*	*7*	*780*
1997	*7*	*363*	*612*	*982*	*8*	*555*
1998	*6*	*548*	*960*	*1514*	*6*	*886*
1999	*5*	*676*	*1203*	*1884*	*5*	*1012*
2000	*10*	*446*	*899*	*1355*	*13*	*648*
2001	*12*	*511*	*1021*	*1544*	*14*	*704*
2002	*15*	*453*	*872*	*1340*	*16*	*728*
2003	*16*	*449*	*847*	*1312*	*25*	*737*
2004	*17*	*349*	*880*	*1246*	*24*	*553*
2005	*13*	*563*	*2429*	*3005*	*16*	*831*
2006	*14*	*677*	*3359*	*4050*	*20*	*982*
2007	*6*	*492*	*2668*	*3166*	*7*	*670*
2008	*13*	*515*	*2879*	*3407*	*13*	*742*
2009	*9*	*553*	*2288*	*2850*	*9*	*806*
Total	***148***	***7,087***	***21,617***	***28,852***	***183***	***10,634***

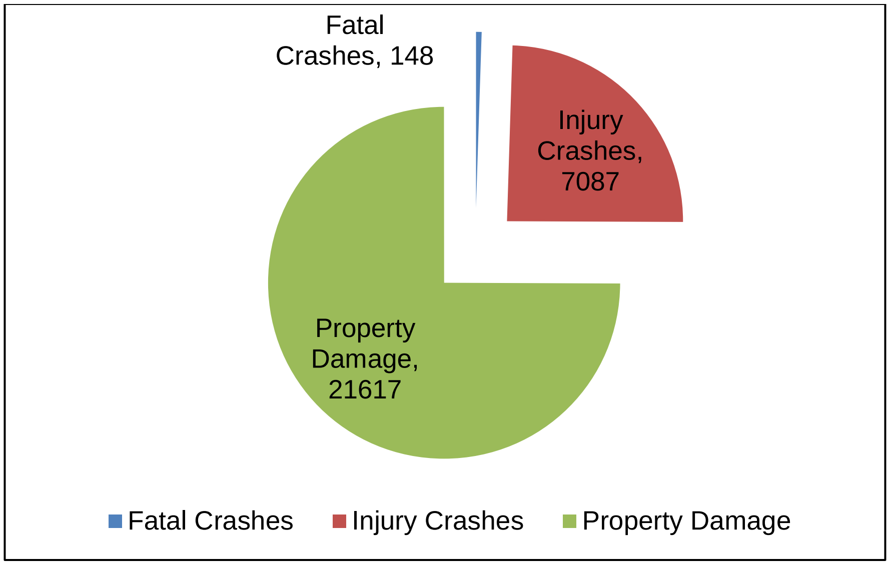

Figure C.1. Overall composition of work zone crashes on Illinois expressways and freeways (1996–2009).

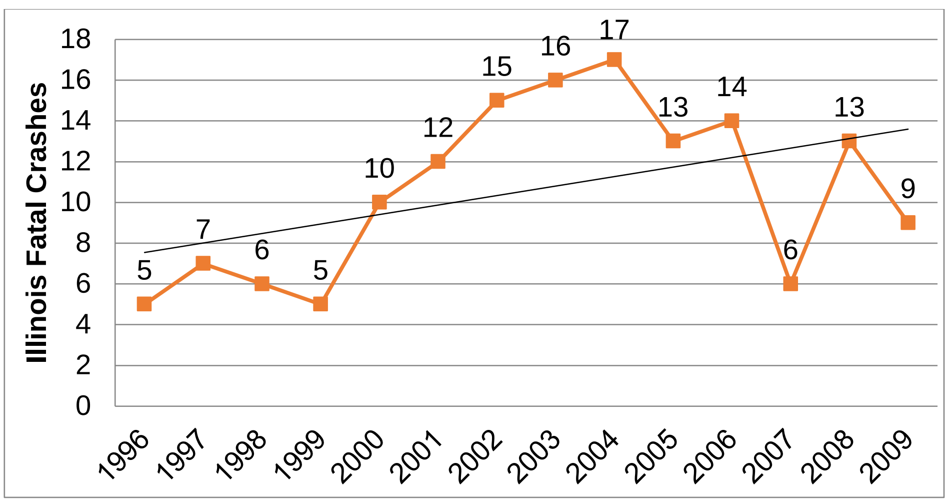

Figure C.2. Fatal work zone crashes on Illinois expressways and freeways (1996–2009).

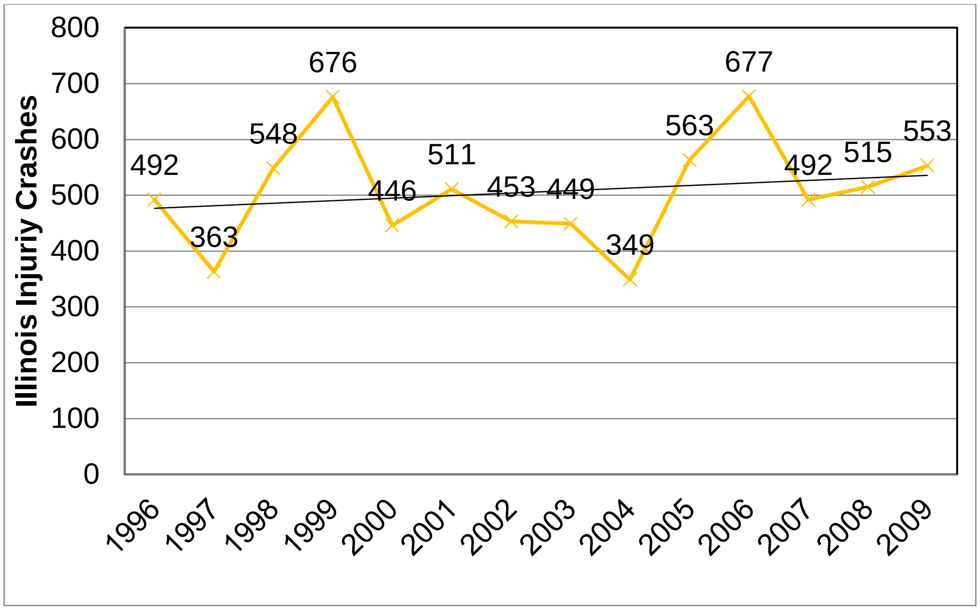

Figure C.3. Injury work zone crashes on Illinois expressways and freeways (1996–2009).

C.1.2 Police Reports on Fatal Crashes

The second source of data in this study was Illinois police reports on fatal work zone crash flagger/policeman related crashes. These police reports were collected from IDOT and were analyzed to identify and incorporate any additional information on crash circumstances that are not available in NHTSA files. A sample police crash report is shown in Figure C.4.

C.2 ANALYSIS OF WORK ZONE CRASH DATA

Work zone crashes are defined as crashes that occur in the terrain of a work zone, whether it is a construction, maintenance, or utility work zone (FHWA 2009). This section summarizes the frequency and severity as well as other characteristics of injury and fatal work zone crashes in Illinois.

C.2.1 Data Fusion

The crash data in the collected datasets were organized and grouped in five main steps.

1. Filter the data to include only multilane highways.
2. Filter the data to include only work zone–related crashes.
3. Exclude PDO crashes.
4. Gather the filtered data for each year in one large file.
5. Categorize some variables to match different description for each year.

The first step is extracting crashes on multilane highway from all the available NHTSA data records for each year. The class of roads were identified as a subset of entire crash data set using the variable "FD_CLASS" in the crash file that indicates the federal classification of the road where the crash occurred and has 14 possible values for the data from year (1994 to 2003) as shown in Table C.2 and 11 possible values from year (2004 to present) as shown in Table C.3. The values 01, 02, 11, and 12 for the years (1996 to 2003) represents Interstate (not on National Highway System), Freeway/expressway (not on National Highway System), Interstate (on National Highway System), and freeway/ expressway (on

National Highway System) respectively as same as the values 10 and 20 represents Interstate, and freeway and expressway respectively for the years (2004 to present).

Table C.2. Federal Classification of Highways (1994–2003)

Value (2004–present)	Meaning
0	Not available (when a code was not entered, in which case it defaulted to zero)
10	Interstate
20	Freeway and expressway
30	Other principal arterial
40	Minor arterial (non-urban)
50	Major collector (non-urban)
55	Minor collector (non-urban)
60	Local road or street (non-urban)
70	Minor arterial (urban)
80	Collector (urban)
90	Local road or street (urban)

Table C.3. Federal Classification of Highways (2004–present)

(FD_CLASS)	Federal Classification of Highways Indicates the federal classification of the road where the crash occurred
Value (1994–2003)	**Meaning**
01	Interstate (not on National Highway System)
02	Freeway/expressway (not on National Highway System)
03	Major principal arterial (not on National Highway System)
04	Minor arterial (not on National Highway System)
05	Major collector (not on National Highway System)
06	Minor collector (not on National Highway System)
07	Local road (not on National Highway System)
11	Interstate (on National Highway System)
12	Freeway/expressway (on National Highway System)
13	Major principal arterial (on National Highway System)
14	Minor arterial (on National Highway System)
15	Major collector (on National Highway System)
16	Minor collector (on National Highway System)
17	Local road (on National Highway System)

The second step was extracting the work zone crashes from all filtered data. These work zone crashes were identified as a subset of the entire crash data set using the variable “RD_CON1” in the crash file that represents roadway condition and has 12 possible values, as shown in C.4. Values of 2, 3, 4, and 5 for this variable represent construction zone, maintenance zone, utility work zone, and work zone unknown, respectively. All crashes that had these values were extracted and listed under a new variable named “Road Condition” and were combined in a single spreadsheet. An advanced statistics program was used to import the collected data to be ready for statistical analysis.

Table C.4. NHTSA Road Condition Variable (RD_CON1)

Variable	Possible Values	Road Condition (RD_CON1)
Indicates a deficiency in the road where the crash occurred. In 2004, leading zeroes were dropped from this variable.	0	Not stated
	1	No defects
	2	Construction zone
	3	Maintenance zone
	4	Utility work zone
	5	Work zone-unknown
	6	shoulders
	7	Ruts/holes
	8	Worn surface
	9	Debris on roadway
	10	Other
	99	unknown

The third step involved extracting work zone injury and fatal crash records after excluding property damage only (PDO) work zone crashes for each year. Identifying injury and fatal crashes was performed using the variable “SEVERITY” in the crash file. The data files from 1996 to 2003 used the numerical values of 1 and 2 to represent fatal and injury crashes, while the data files from 2004 to 2009 used the alphabetical values of F and I to represent fatal and injury crashes, respectively as shown in C.5.

Table C.5. NHTSA Accident Severity Variable

Variable	Possible Values	Description
Accident Severity: Indicates the most severe injury sustained by any occupant or non-occupant involved in the crash.	1,F	Fatal
	2,I	Injury
	3,P	Property Damage Only (PDO)

The fourth step involved joining the crash, vehicle, and person files using the “CASE Number” and collecting all the filtered data for all the analysis years in one large spreadsheet/SAS data file. A sample of the spreadsheet that includes the first dataset of fatal work zone crashes is presented in Table C.21. This spreadsheet is designed to include all the available data in the data files obtained from the National Highway Traffic Safety Administration (NHTSA).

The fifth step was to categorize some variables for the purpose of the analysis. The cause variable was categorized into six groups and the hour of the accidents categorized into four times as described in the next section.

C.2.2 Categories of Crash Variables

For each of the listed fifteen variables in C.6, a comprehensive analysis was conducted to investigate and compare its individual impact on the frequency of (1) fatal work zone crashes; and (2) all injury work zone crashes involving one or more vehicles. These fifteen variables were grouped into six main categories: (1) control variables; (2) road data; (3) time data; (4) crash severity data; (5) environmental conditions; and (6) causes of crash. The following sections provide list and describe the variables included in each of these six categories, as shown in C.6.

I. Control Variables

This category has two variables that represent the identity of the crash: (1) year of the accident; and (2) case number, which lists the police case number. These two variables were used to identify each crash and to match it with police reports, if needed.

II. Road Data

This category includes the basic road characteristics of each work zone injury and fatal crash and is represented by six variables: (1) federal classification of highway; (2) road condition; (3) road surface condition; (4) route prefix; (5) traffic control; and (6) traffic control functionality. Road data variables are presented in Table C.10.

III. Time Data

This category includes two variables that represent (1) the time of the crash; and (2) the day of the week. Similar to previous traffic-related crash studies, the time of the crash has been divided into four periods: (1) 6:01–10:00 representing the peak morning hours; (2) 10:01–16:00 representing the daytime non-peak hours; (3) 16:01–20:00 representing the afternoon/evening peak hours; and (4) 20:01–6:00 representing the nighttime hours. Time data variables and their data are listed in C.7.

IV. Severity Data

This category includes the main characteristics of injury and fatal crashes represented by five variables: (1) total number of fatalities; (2) total number of injuries; (3) number of vehicles involved; (4) accident severity; and (4) type of collision. Crash data variables are listed in C.6

V. Environmental Condition

This category represents two variables: (1) light condition; and (2) weather condition. These two variables are presented in C.19 and Table C.20.

VI. Contributing Causes Data

This category is represented by two variables: (1) contributing cause1; and (2) contributing cause 2. Both variables indicate any action the driver did to contribute to the crash according to police reports. The driver contributing causes include 35 categories (for the data sets from 1996 to 2001) representing all possible contributing causes of a crash such as: failed to yield, disregarded control devices, too fast for conditions, wrong way/side, and followed too closely. (From the year 2002 to present) the contributing cause expanded to be 38 causes including more distraction causes like Distraction-from outside vehicle, Distraction-from inside vehicle, and Distraction-operating a wireless phone. These 31/38 different contributing causes were grouped and divided into six major contributing causes: (1) improper driving; (2) distraction; (3) work zone environment; (4) disregarding traffic control; (5) speed; and (6) unknown. Contributing cause variables are listed in C.17a and C17b.

Table C.6. Summary of Analysis Variables

	Variable Name	Meaning	Observations
Control Variables	Year	Year of the accident	Actual Number
	CASENO	*Case No.*	Actual Number
Road Data	RTE_PREF	*Route Prefix*	See Table C.14.
	RD_CON1	*Road Condition*	See Table C.12.
	TRA_CON1	*Traffic Control*	See Table C.15.
	TRA_FUN1	*Traffic Function*	See Table C.16.
	RD_CLASS	*Road Class*	See Table C.10.
	Road Surface	*Road Surface*	See Table C.13.
Time Data	Time	*Time of the accident (Hour)*	See Table C.7.
	WEEKDAY	*Day of the week*	See Table C.8.
Crash Severity Data	Collision	*Type of collision*	See Table C.9.
	SEVERITY	*Accident Severity*	See Table C.5.
	NUM_VEH	*Number of Vehicle involved in the accident*	Using Actual Number
	NUM_FAT	*Number of fatalities in the accident*	Using Actual Number
	NUM_INJ	*Number of injuries the accident*	Using Actual Number
Environmental Condition	LIGHT	*Lightning Condition*	See Table C.19.
	WEATHER	*Weather Type*	See Table C.20
Causes	Cause 1	*1st Cause of the Accident*	See Table C.17a &C.17b.
	Cause 2	*2nd Cause of Accident*	See Table C.17a &C.17b.

Table C.7. Observations for Time Data (Time of the Accident)/(AccHour)

Variable	Number	Description
Time of the accident: Indicates the time period in which an accident occurred.	1	06:01:10:00 (Morning peak hours)
	2	10:01:16:00 (Daytime non-peak hours)
	3	16:01:20:00 (Afternoon peak hours)
	4	20:01:06:00 (Nighttime hours)

Table C.8. Observations for Time Data (Day of the Week)

Variable	Number	Description
Day of week: Indicates the day of the week on which the crash occurred.	1	Monday
	2	Tuesday
	3	Wednesday
	4	Thursday
	5	Friday
	6	Saturday
	7	Sunday

Table C.9. Observations for Crash Data (Type of Collision)

Variable	Number	Description
Type of Collision: Indicates the type of crash.	00, 99	Not stated, Unknown
	1	Pedestrian
	2	Pedalcyclists
	3	Train
	4	Animal
	5	Overturned
	6	Fixed object
	7	Other object
	8	Other non-collision
	9	Parked motor vehicle
	10	Turning
	11	Rear-end
	12	Sideswipe—same direction
	13	Sideswipe—opposite direction
	14	Head-on
	15	Angle

Table C.10. Observations for Road Data (Class of Traffic Way)

Variable	Number	Description
Class of traffic way : Indicates the classification of the road where the crash occurred.	0	Rural—unmarked state highway
	1	Rural—controlled access highway
	2	Rural—other marked state highway
	3	Rural—county/local road
	4	Rural—toll road
	5	Urban—controlled access highway
	6	Urban—other marked state highway
	7	Urban—unmarked state highway
	8	Urban—city street
	9	Urban—toll road

Table C.11. Observations for Road Data (Federal Classification of Highway)

Variable	Number	Description
Federal Classification of Highway: Indicates the federal classification of the roadway where the crash occurred.	01,10	Interstate (not on National Highway System)
	02,20	Freeway/expressway (not on National Highway
	03,30	Major principal arterial (not on National Highway
	04,40	Minor arterial (not on National Highway System)
	05,50	Major collector (not on National Highway System)
	06,60	Minor collector (not on National Highway System)
	07	Local road (not on National Highway System)
	11	Interstate (on National Highway System)
	12	Freeway/expressway (on National Highway System)
	13	Major principal arterial (on National Highway
	14, 70	Minor arterial (on National Highway System)
	15	Major collector (on National Highway System)
	16	Minor collector (on National Highway System)
	17, 90	Local road (on National Highway System)

Table C.12. Observations for Road Data (Road Condition)/(Type Construction)

Variable	Number	Description
Road Condition: Indicates a deficiency in the road where the crash occurred.	0	Not stated
	1	No defects
	2	Construction zone
	3	Maintenance zone
	4	Utility work zone
	5	Work zone—unknown
	6	Shoulders
	7	Ruts/holes
	8	Worn surface
	9	Debris on roadway
	10	Other
	99	Unknown

Table C.13. Observations for Road Data (Road Surface)/(Road Surface Condition)

Variable	Number	Description
Road surface: Indicates the road surface condition at the scene of the crash.	0	Not stated
	1	Dry
	2	Wet
	3	Snow/slush
	4	Ice
	5	Sand/mud/dirt/etc.
	6	Other
	9	Unknown

Table C.14. Observations for Road Data (Route Prefix)

Variable	Number	Description
Route Prefix: Indicates the route where the crash occurred.	0	Not applicable
	1	U.S. route
	2	Interstate business loop
	3	U.S. business route
	4	Bypass (in 1996, also means U.S. one-way couple)
	5	Illinois route
	6	Illinois alternate route (in 1996 also means Illinois one-way couple)
	7	Illinois business route (in 1996 also means interstate business loop one-way couple)
	8	Non-marked route
	9	Interstate

Table C.15. Observations for Road Data (Traffic Control)

Variable	Number	Description
Traffic Control: Indicates the type of traffic signals or restrictions at the scene of the crash.	0	Not stated
	1	No traffic control
	2	Stop sign or red flasher
	3	Traffic control signal
	4	Yield sign or yellow flasher
	5	Police officer or flagman
	6	Railroad crossing gate
	7	Other railroad crossing device
	8	School speed zone
	9	No passing zone
	10	Other type regulation sign
	11	Other warning sign
	12	Lane use control marking
	13,99	Other, Unknown

Table C.16. Observations for Road Data (Traffic Control Functionality)

Variable	Number	Description
Traffic Control Functioning: Indicates the type of traffic control functioning at the scene of the crash.	0	Not stated
	1	No traffic control
	2	Not functioning
	3	Functioning improperly
	4	Functioning properly
	5	Reflecting material worn
	6	Missing
	7	Other
	8	Unknown

Table C.17a. Observations for Contributing Causes (1 & 2)

Variable	Observation	Description
Contributing cause: *Indicate the actions of the driver that contributed to the crash.*	0	Not stated
	1	Exceeded authorized speed limit
	2	Right-of-way
	3	Following too closely
	4	Overtaking/passing
	5	Wrong side/way
	6	Improper turn/no turn signal
	7	Right turn on red
	8	Under the influence of alcohol/drugs (used when arrest is effected)
	9	Operated vehicle in erratic, reckless, careless, negligent or aggressive manner
	10	Equipment—vehicle condition
	11	Weather
	12	Road engineering/surface/markings/defects
	13	Road construction
	14	Vision obscured (signs, tree limbs, buildings, etc.)
	15	Driving skills, knowledge, experience
	16	Driver distraction/inattention
	17	Physical condition of driver
	18	Unable to determine
	19	Had been drinking (used when arrest is not made)
	20	Improper lane usage
	21	Swerved due to animal, object, non-motorist
	22	Disregarded yield sign

table continues next page

Table C.17a (continued). Observations for Contributing Causes (1 & 2)

	23	Disregarded stop sign
	24	Disregarded other traffic signs
	25	Disregarded traffic signals
	26	Disregarded road markings
	27	Exceeded safe speed for conditions
	28	Failure to reduce speed to avoid crash
	29	Passed stopped school bus
	30	Improper backing
	31	Electronic equipment, i.e. cellular phone, Observations for Contributing Causes (Cause 1 &2) added after 2004

Table C.17b. Observations for Contributing Causes (1 & 2) Added 2002–Present

Variable	Observation	Description
Contributing cause: Indicate the actions of the driver that contributed to the crash.	32	Evasive action due to animal, object, non- motorist
	40	Distraction—from outside vehicle
	41	Distraction—from inside vehicle
	42	Distraction—operating a wireless phone
	50	Operated vehicle in erratic, reckless, careless, negligent or aggressive manner
	51	Not applicable (2002–2003)
	99	Not applicable

Table C.18. Observations for Contributing Causes (Categorized Contributing Causes)

Categorized Contributing Causes	Number	Description (See Table 17-A & 17-B)
Improper Driving	1	2,3,4,5,6,7,8,9,10,15,16,17,19,29,30
Distraction	2	31
Work Zone Environment	3	11,12,13,14,20,21
Disregarded Traffic Control	4	22,23,24,25,26
Unknown	5	0,18
Speed	6	1,27,28

Table C.19. Observations for Light Condition

Variable	Number	Description
Light Condition: Indicates the general light conditions prevailing at the time of the crash.	0, 9	Not stated
	1	Daylight
	2	Dawn
	3	Dusk
	4	Darkness
	5	Darkness—road lighted

Table C.20. Observations for Weather

Variable	Number	Description
Weather: Indicates the weather conditions at the time of the crash.	0	Not stated, Unknown
	1	Clear
	2	Rain
	3	Snow
	4	Fog/smoke/haze
	5	Sleet/hail
	6	Severe crosswind
	7	Other

Table C.21. Sample NHTSA Dataset of Fatal Illinois Work Zone Crashes in 2005

Crash	Time Information			Accident Severity			Crash Information					
Number	Date of Accident	Time of Accident	Day of Week	Number of Fatalities	Number of Injuries	Total number Inj & Fat	County	Population Group	Enforcement Agency	Intersection Related	Number of Vehicles	Type of Collision
50000645	1172005	4	1	1	0	1	16	3	3	2	1	8
50056209	2272005	4	7	1	0	1	16	3	3	2	1	6
50075837	2272005	4	7	1	5	6	16	3	3	2	2	7
50150994	3022005	4	3	1	1	2	69	0	3	2	2	14
50199199	2282005	1	1	1	1	2	49	6	1	1	2	10
50301647	3072005	3	1	1	4	5	84	9	1	1	4	15
50349786	5072005	3	6	1	0	1	82	0	3	2	1	7
50442409	5182005	2	3	1	1	2	16	5	3	2	6	11
50514694	5182005	2	3	1	0	1	99	0	3	2	2	11
50780139	6242005	2	5	3	0	3	101	7	3	2	4	11
50808955	6122005	2	7	1	3	4	11	0	3	2	3	14
51648947	8052005	4	5	1	0	1	16	3	3	2	1	1
51653186	8292005	1	1	1	0	1	16	7	3	2	2	7
51685154	8312005	1	3	1	0	1	75	0	3	2	1	6
51731727	8312005	4	3	1	2	3	16	7	3	2	3	11
52009198	9052005	1	1	1	0	1	84	9	1	2	1	5
52154507	9272005	2	2	1	1	2	22	8	1	2	3	15
52155181	9262005	4	1	2	0	2	16	3	3	2	2	11
52376985	10142005	1	5	1	0	1	16	8	1	2	1	2
52807021	11162005	4	3	1	1	2	16	3	3	2	2	11
52807385	11192005	4	6	1	0	1	50	6	3	2	2	6

Table continues next page

Table C.21 (continued). Sample NHTSA Dataset of Fatal Illinois Work Zone Crashes in 2005

Crash Number	Roadway Information							Contributing Causes		Climatic Information	
	Class of Trafficway	Federal Classification of Highways	Road Condition	Road Surface	Route Prefix	Traffic Control	Traffic Cont Functionality	Contributing Cause1	Contributing Cause2	Light Condition	Weather Condition
50000645	5	1	2	1	9	12	4	15	0	5	1
50056209	5	1	2	1	9	11	4	1	20	5	1
50075837	5	1	2	1	9	12	4	8	27	5	1
50150994	2	3	2	1	1	12	4	19	20	4	1
50199199	6	3	2	2	5	3	4	25	99	1	3
50301647	6	3	2	1	5	3	4	2	99	5	1
50349786	5	1	2	1	9	99	2	19	20	1	1
50442409	8	1	2	1	9	12	4	28	27	1	1
50514694	1	1	2	1	9	12	4	28	27	1	1
50780139	5	1	2	1	9	1	1	28	18	1	1
50808955	2	4	2	2	5	1	1	20	15	1	2
51648947	5	1	2	1	9	12	4	24	99	5	1
51653186	8	1	2	1		4	1	15	15	1	1
51685154	2	5	3	1	5	10	4	18	0	1	1
51731727	8	1	2	1	9	11	4	28	3	5	1
52009198	7	14	2	1	8	1	1	0	0	1	1
52154507	6	3	2	1	5	11	4	18	99	1	1
52155181	5	1	2	1	9	12	4	1	2	5	1
52376985	8	17	2	1		1	1	0	0	1	1
52807021	5	1	2	1	9	11	4	1	99	5	1
52807385	8	17	2	1		11	4	24	50	4	1

200901071421
PoliceReport

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ILLINOIS TRAFFIC CRASH REPORT

Sheet 1 of 1 Sheets

ISP-4643-20090425-143829

04412927

DRAC	DRAC	PEDV	PEDV	TRFD	TRFC	WEAT	DRVA	DRVA	VIS	VIS	VEHD	VEHD	LGHT	COLL	MANV	MANV	PPA	PPA	PPL	PPL
09	01	09	09	12	04	01	08	01	99	01	99	01	01	13	01	01	99	99	09	09

INVESTIGATING AGENCY: ILLINOIS STATE POLICE
DAMAGE TO ANY ONE PERSON'S VEHICLE / PROPERTY: ☐ $500 OR LESS ☐ $501 - $1,500 ☒ OVER $1,500
TYPE OF REPORT: 1 On-scene
TYPE OF CRASH: B Injury
AGENCY CRASH REPORT NO.: 11-09-00870
ADDRESS NO.:
HIGHWAY or STREET NAME: INTERSTATE 55 SB
☐ City Township ☒ HAMEL TWP
INTERSECTION RELATED: ☐ Yes ☒ No
PRIVATE PROPERTY: ☐ Yes ☒ No
HIT & RUN: ☐ Yes ☒ No
DATE OF CRASH: 04/25/2009 (mo day yr)
TIME OF CRASH: 12:46PM ☐ AM ☐ PM
LARS CODE:
0.35 (CIRCLE) FT / MI (CIRCLE) N E S W MILE POST 27 (NAME OF INTERSECTION OR ROAD FEATURE)
☐ AT INTERSECTION WITH
COUNTY: MADISON
CIRCLE DAY OF WEEK: SU MO TU WE TH FR SA
NUMBER MOTOR VEHICLES INVLD: 2
LARS CODE:

TRFW 02 | VEHT 03 | VEHT 07 | # LANES 04 | ALGN 01 | RSUR 01 | VEHU 02 | VEHU 20 | RDEF 01 | BAC 96 | BAC 96 | # OCCS 1 | # OCCS 1 | DIRP 05 | DIRP 01

Unit 1

NAME: ☒ DRIVER ☐ PARKED-NO DRIVER ☐ PED ☐ PEDAL ☐ EQUES ☐ NMV ☐ NCV — CROWSON, ERNEST B
DATE OF BIRTH: 04/13/1939
MAKE: CHEVROLET | MODEL: APV-VENTURE | YEAR: 1999
STREET ADDRESS: 5504 HAMILTON
SEX: M | SAFT: 02 | AIR: 09
PLATE NO.: FB8P2X | STATE: MO | YEAR: 2011
CITY: SAINT LOUIS | STATE: MO | ZIP: 63136
INJURY: K | EJECT: 01
VIN: 1GNDX03E3XD189239
TELEPHONE: (314) 381-3417
DRIVER LICENSE NO.: S137094004
STATE: MO | CLASS: F
VEHICLE OWNER (LAST, FIRST, M): CROWSON, ERNEST B
TAKEN TO: Anderson Hospital-Maryville
EMS AGENCY: Madison Co Coroner
OWNER ADDRESS (STREET, CITY, STATE, ZIP): 5504 HAMILTON SAINT LOUIS, MO 63136
DAMAGED AREA(S): 00 - NONE; 10 - UNDER CARRIAGE; ☒ - TOTAL (ALL AREAS); 12 - OTHER; 99 - UNKNOWN
POINT OF FIRST CONTACT: 01
TOWED: Y ☒ N ☐ | FIRE: Y ☒ N ☐ | HAZMAT SPILL: Y ☐ N ☒ | CONVEH: Y ☐ N ☒
INSURANCE CO.: GEICO Casualty Company
TELEPHONE: (314) 381-3417
POLICY NO.: 4011-26-65-35

Unit 2

NAME: ☒ DRIVER ☐ PARKED-NO DRIVER ☐ PED ☐ PEDAL ☐ EQUES ☐ NMV ☐ NCV — BOLINE, GEORGIA A
DATE OF BIRTH: 12/12/1949
MAKE: MACK TRUCKS, IN | MODEL: TRUCK | YEAR: 9
STREET ADDRESS: 1935 N 32ND ST
SEX: F | SAFT: 02 | AIR: 04
PLATE NO.: P365328 | STATE: IL | YEAR: 2009
CITY: DECATUR | STATE: IL | ZIP: 62526
INJURY: C | EJECT: 01
VIN: 1M1AW02Y49N009158
TELEPHONE: UNK
DRIVER LICENSE NO.: B450-2814-9953
STATE: IL | CLASS: A*
VEHICLE OWNER (LAST, FIRST, M): ADM, TRUCKING INC
TAKEN TO: Anderson Hospital-Maryville
EMS AGENCY: Edwardsville Ambulance
OWNER ADDRESS (STREET, CITY, STATE, ZIP): 4666 FARIES PARKWAY DECATUR, IL 62525
DAMAGED AREA(S): 00 - NONE; 10 - UNDER CARRIAGE; 11 - TOTAL (ALL AREAS); 12 - OTHER; 99 - UNKNOWN
POINT OF FIRST CONTACT: 02
TOWED: Y ☒ N ☐ | FIRE: Y ☐ N ☒ | HAZMAT SPILL: Y ☐ N ☒ | CONVEH: Y ☒ N ☐
INSURANCE CO.: Gallant Insurance Company
TELEPHONE: UK
POLICY NO.: UNK

UNIT	SEAT	DOB	SEX	SAFT	AIR	INJ	EJCT	PASSENGERS & WITNESSES ONLY (NAME, ADDR, TEL)	HOSP	EMS
W		09/20/1958	M					SMITH, DALE D 10928 AVENAL ST HESPERIA, CA 92344 (760) 694-2368		
W		12/31/1948	M					BARRIE, FRED R 1301 PEACHTREE DR VALPARAISO, IN 46383 (219) 462-1039		
W		02/13/1984	F					DICKERSON, DESREE N 1109 EKSTAM DR APT 101 BLOOMINGTON, IL 61704 (314) 381-3417		
W		03/23/1961	M					WISDOM, ANDREW M 1909 S ASHLAND CHICAGO, IL 60608 (312) 401-0683		
W		04/04/1955	M					NOVARIO, MICHAEL D 505 WELLESLEY NORMAL, IL 61761 (309) 452-3166		

Unit	EVNO	MOST	EVNT	LOC
1	1	☐	1	2
1	2	☒	11	1
1	3	☐		
2	1	☒	11	1
2	2	☐		
2	3	☐		

DAMAGE PROPERTY OWNER NAME:
DAMAGED PROPERTY:
PROPERTY OWNER ADDRESS (STREET, CITY, STATE, ZIP):
ARREST NAME: | SECTION: | CITATION NO.:
ARREST NAME: | SECTION: | CITATION NO.:
CONTRIBUTORY CAUSE(S): PRIMARY: 20 Improper lane usage; SECONDARY: 18 Unable to determine
POSTED SPEED LIMIT:
DATE NOTIFIED: 04/25/2009 | TIME NOTIFIED: 12:49PM ☐ AM ☐ PM
OFFICER ID: 4643 | SIGNATURE: | BEAT / DIST: 11 | SUPERVISOR ID:
COURT DATE: | COURT TIME: ☐ AM ☐ PM

SR 1050 JANUARY 2009 (MCR)

Figure C.4. Sample of collected police reports (figure continues next page).

200901071421
PoliceReport

04412927

DIAGRAM

NO DIAGRAM

NARRATIVE (Refer to vehicle by Unit No.)

Unit #1 was southbound on Interstate 55. Unit #2 was northbound on Interstate 55 in the right lane. For an unknown reason unit #1 crossed the grass median and entered the northbound lanes. There were only two tire marks in the grass median indicating unit #1 was not rotating as the vehicle traveled through the median. Driver #2 steered to the left in an attempt to avoid unit #1. The right side of unit #1 struck the right side of unit #2. The two vehicle continued side swiping until unit #1 reached the axles of the semi trailer unit #2 was pulling. The front of unit #1 then struck the axles on the semi trailer (IL Reg. T55880). Unit #1 rotated about 90 degrees clockwise and came to rest with the front tires on the east shoulder of the northbound lane and the rear tires in the grass on the east side of the interstate. Unit #1 caught on fire. Driver #1 remained in the vehicle. Unit #2 came to rest in the left northbound lane of Interstate 55.

LOCAL USE ONLY

U1 Color: Unknown	U1 Towed By / To: ADR Inc-Troy / ADR Inc-Troy
U2 Color: White	U2 Towed By / To: ADR Inc-Troy / ADR Inc-Troy

COMMERCIAL VEHICLE — Unit 1

CARRIER NAME
ADDRESS
CITY STATE ZIP

SOURCE: SIDE OF TRUCK / PAPERS / DRIVER / LOG BOOK

ID Number:
USDOT ICCMC
OR State No. State Name None
GVWR

HAZARDOUS MATERIALS — PLACARDED ?
IF YES: 4 DIGITS 1 DIGIT Name

HAZARDOUS CARGO RELEASED FROM TRUCK? N
VIOLATION OF HAZMAT REGS. CONTRIBUTE TO CRASH?
VIOLATION OF MCS REGS CONTRIBUTE TO CRASH?
INSPECTION FROM COMPLETED?
HAZMAT OUT OF SERVICE?
MCS OUT OF SERVICE?
FORM NO.

IDOT PERMIT# | WideLoad

TRAILER WIDTH(S)	TRAILER LENGTH(S)	Vehicle Length
TRAILER 1	TRAILER 1	Total - Ft
TRAILER 2	TRAILER 2	No Of Axles
Vehicle Configuration	Cargo Body Type	LoadType

COMMERCIAL VEHICLE — Unit 2

CARRIER NAME: ADM TRUCKING INC
ADDRESS: 4666 FARIES PARKWAY
CITY STATE ZIP: DECATUR IL 62525

SOURCE: X SIDE OF TRUCK / PAPERS / DRIVER / LOG BOOK

ID Number:
USDOT 238954 ICCMC
OR State No. State Name IL
GVWR 80000

HAZARDOUS MATERIALS — PLACARDED ? Y
IF YES: 4 DIGITS 19 1 DIGIT 03 Name ETHONOL

HAZARDOUS CARGO RELEASED FROM TRUCK? N
VIOLATION OF HAZMAT REGS. CONTRIBUTE TO CRASH? N
VIOLATION OF MCS REGS CONTRIBUTE TO CRASH? N
INSPECTION FROM COMPLETED?
HAZMAT N OUT OF SERVICE? N
MCS N OUT OF SERVICE? N
FORM NO. IL3551003808

IDOT PERMIT# | WideLoad N

TRAILER WIDTH(S)	TRAILER LENGTH(S)	Vehicle Length
TRAILER 1 0-98"	TRAILER 1 53	Total - Ft 70
TRAILER 2	TRAILER 2	No Of Axles 5
Vehicle Configuration 08	Cargo Body Type 03	LoadType 05

** This is a copy of a scanned document. The original was filed with the Illinois Department of Transportation, Division of Traffic Safety. **

Figure C.4 (continued). Sample of collected police reports.

APPENDIX D NATIONAL AND IDOT SURVEY QUESTIONS AND RESPONSES

D.1 NATIONAL SURVEY QUESTIONS AND RESPONSES

1. Please indicate the level of need for using flaggers in freeway and expressway work zones.

	No Need 0.0	0.25	Moderate Need 0.5	0.75	Greatest Need 1.0	Responses
Alert road users approaching the work zone	60.0% 12	20.0% 4	5.0% 1	5.0% 1	10.0% 2	20
Slow the speed of oncoming traffic	50.0% 10	25.0% 5	10.0% 2	5.0% 1	10.0% 2	20
Warn workers of errant drivers and vehicle intrusion into work zone	45.0% 9	30.0% 6	0.0% 0	10.0% 2	15.0% 3	20
Direct traffic when construction trucks enter the work zone	30.0% 6	25.0% 5	40.0% 8	5.0% 1	0.0% 0	20
Direct traffic when construction trucks exit the work zone	40.0% 8	35.0% 7	20.0% 4	5.0% 1	0.0% 0	20

Other flagger functions: Please specify the type and level of need for any other flagger functions that are not listed in the table.

State	Response
Florida	FDOT does not allow the use of flaggers on freeways and expressways.
Minnesota	We don't usually use flaggers on expressways or freeways. Rarely they will wave a SLOW paddle when a truck exits. State patrol is used when a roadway is closed but haul trucks need to enter.
Michigan	We don't allow traffic regulators on the interstate in Michigan. We do have non-freeway that is posted at 55 mph.
Virginia	We only flag on ramps or the roads under/above an Interstate. We do not flag on Interstates with the possible exception for incident management.

2. Please indicate the level of benefit gained from using flaggers in freeway and expressway work zones with speed limits greater than 40 mph.

	No Benefit 0.0	0.25	Moderate Benefit 0.5	0.75	Greatest Benefit 1.0	Responses
Improve workers safety	45.0% 9	20.0% 4	20.0% 4	5.0% 1	10.0% 2	20
Enhance safety of trucks entering work zone	35.0% 7	25.0% 5	35.0% 7	0.0% 0	5.0% 1	20
Improve safety of trucks exiting work zone	40.0% 8	35.0% 7	20.0% 4	0.0% 0	5.0% 1	20
Enhance road users safety	35.0% 7	15.0% 3	35.0% 7	10.0% 2	5.0% 1	20
Improve traffic mobility	55.0% 11	5.0% 1	30.0% 6	5.0% 1	5.0% 1	20
Improve compliance with traffic speed limit	60.0% 12	10.0% 2	20.0% 4	10.0% 2	0.0% 0	20

Other benefits: Please specify the type and level of any other flagger benefits that are not listed in the table.

State	Response
Virginia	We do not flag on Interstates.
Florida	FDOT does not allow the use of flaggers on freeways and expressways.
Minnesota	We would prefer an intelligent work zone solution to using a human. “Trucks entering/exiting when flashing” has been used with sensors to activate the flashing lights with some success.
Michigan	When used correctly they provide a safe flow of traffic around the work zone. Better and cheaper than a Temp signal.

3. Please indicate the level of risk/hazard caused by using flaggers in freeway and expressway work zones with speed limits greater than 40 mph.

	Lowest Risk 0.0	0.25	Moderate 0.5	0.75	Highest Risk 1.0	Responses
Exposure of flagger to traffic hazards and injuries	5.0% 1	5.0% 1	15.0% 3	10.0% 2	65.0% 13	20
Exposure of flagger to work zones hazards and injuries	5.0% 1	20.0% 4	20.0% 4	10.0% 2	45.0% 9	20
Flagger causing excessive slowdown of traffic & increasing traffic backups	20.0% 4	10.0% 2	35.0% 7	10.0% 2	25.0% 5	20
Flaggers encroaching into open traffic lanes	10.0% 2	5.0% 1	5.0% 1	40.0% 8	40.0% 8	20

Other risks: Please specify the type and level of flagger risks that are not listed in the table.

State	Response
Florida	FDOT does not allow the use of flaggers on freeways and expressways.
Mississippi	Pedestrians struck by vehicles traveling in excess of 40mph are injured 15% of the time and killed 85% of the time, statistically speaking.
Minnesota	We would prefer not to use a flagger unless they are actually controlling traffic, not just to slow traffic which can be done with static or dynamic signs.

4. Please indicate the level of risk/hazard to flaggers in the following work zone conditions.

	Lowest Risk 0.0	0.25	Medium Risk 0.5	0.75	Highest Risk 1.0	Responses
Curves	0.0% 0	0.0% 0	20.0% 4	50.0% 10	30.0% 6	20
Hills	0.0% 0	0.0% 0	20.0% 4	50.0% 10	30.0% 6	20
Daytime work zones	10.0% 2	15.0% 3	55.0% 11	15.0% 3	5.0% 1	20
Nighttime work zones	0.0% 0	0.0% 0	15.0% 3	30.0% 6	55.0% 11	20
Glare from sun	0.0% 0	5.0% 1	35.0% 7	50.0% 10	10.0% 2	20
Glare from vehicle headlights	0.0% 0	15.0% 3	40.0% 8	30.0% 6	15.0% 3	20
Glare from nighttime work zone lighting	0.0% 0	15.0% 3	45.0% 9	20.0% 4	20.0% 4	20
Adverse weather conditions	5.0% 1	15.0% 3	25.0% 5	40.0% 8	15.0% 3	20
Lack of visibility due to construction-related dust or temporary structures	10.0% 2	35.0% 7	30.0% 6	20.0% 4	5.0% 1	20

5. Please indicate the level of need for the following potential spotter functions in freeway and expressway work zones with speed limits greater than 40 mph.

	No Need 0.0	0.25	Moderate Need 0.5	0.75	Greatest Need 1.0	Responses
Warn workers of oncoming traffic	27.8% 5	22.2% 4	22.2% 4	16.7% 3	11.1% 2	18
Detect errant drivers and warn workers using effective warning devices	27.8% 5	22.2% 4	22.2% 4	16.7% 3	11.1% 2	18
Warn workers of construction equipment hazards in the work zone	11.8% 2	35.3% 6	23.5% 4	11.8% 2	17.6% 3	17
Guide trucks/equipment entering the work zone	17.6% 3	35.3% 6	11.8% 2	29.4% 5	5.9% 1	17
Guide trucks/equipment exiting the work zone	29.4% 5	41.2% 7	5.9% 1	23.5% 4	0.0% 0	17

Other spotter functions: Please specify the type and level of need for any other potential spotter functions that are not listed in the table.

State	Response
Florida	FDOT Standards does not require a spotter, but contractors elect to use one as needed.
Virginia	I have no knowledge of the construction activities noted in the last three questions in this section. This is typically the responsibility of the contractor.
Minnesota	Our workers are in marked work zones so spotters are not usually used. They are used for backing up trucks such as haul trucks backing up to the paver.

6. Please indicate the level of potential benefits that can be gained from using spotters in expressway and freeway work zones with speed limits greater than 40 mph.

	No Benefit 0.0	0.25	Moderate Benefit 0.5	0.75	Greatest Benefit 1.0	Responses
Improve workers safety	11.1% 2	22.2% 4	33.3% 6	16.7% 3	16.7% 3	18
Enhance safety of trucks entering work zone	22.2% 4	33.3% 6	5.6% 1	22.2% 4	16.7% 3	18
Improve safety of trucks exiting work zone	33.3% 6	27.8% 5	16.7% 3	16.7% 3	5.6% 1	18
Enhance road users safety	50.0% 9	16.7% 3	5.6% 1	16.7% 3	11.1% 2	18
Improve traffic mobility	66.7% 12	16.7% 3	5.6% 1	11.1% 2	0.0% 0	18

Other benefits: Please specify the type and level of any spotter benefits that are not listed in the table.

	Response
Minnesota	At high speeds, bad things can happen to quickly for a spotter to make a difference. They may have some benefit in spotting gaps for trucks to enter when leaving the WZ.

7. Please indicate the level of potential risks that can be caused by using spotters in freeway and expressway work zones with speed limits greater than 40 mph.

	Lowest Risk 0.0	0.25	Moderate 0.5	0.75	Highest Risk 1.0	Responses
Exposure of spotter to traffic hazards and injuries	0.0% 0	18.8% 3	18.8% 3	18.8% 3	43.8% 7	16
Exposure of workers to traffic hazards	6.3% 1	18.8% 3	31.3% 5	25.0% 4	18.8% 3	16

Other Risks: Please specify the type and level of any other spotter risks that are not listed in the table.

State	Response
Mississippi	Pedestrians struck by vehicles traveling in excess of 40mph are injured 15% of the time and killed 85% of the time, statistically speaking.
Minnesota	Again, we would prefer to use static or portable changeable warning signs to alert the drivers to potential hazards.

8. Does your DOT allow or recommend using of spotters to warn workers from errant drivers in freeway and expressway work zones with speed limits greater than 40 mph.

Answer	Survey Responses	Percent of Responses
Yes	5	33.3%
No	10	66.7%

Additional comments:

Response
We allow/recommend traffic spotters on freeway/expressway/Interstates on a case-by-case basis.
We would rather try to communicate with drivers by static or portable changeable message signs.
I will ask someone from the maintenance perspective (I am construction) to take the survey too. You may get different answers.
FDOT Standards does not require the use of spotters, but contractors are allowed to use them if needed.

9. Based on the collective experience in your DOT, please indicate the level of effectiveness of using spotters to perform the following functions instead of flaggers in the following work zone layouts in freeway and expressway work zones with speed limits greater than 40 mph.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective 1.0	Responses
Alert oncoming traffic & reduce its speed	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Warn workers of oncoming traffic	27.3% 3	9.1% 1	36.4% 4	9.1% 1	18.2% 2	11
Detect errant drivers and warn workers using effective warning devices	18.2% 2	27.3% 3	18.2% 2	27.3% 3	9.1% 1	11
Warn workers of the hazards posed by construction equipment/ trucks in the work zone	9.1% 1	27.3% 3	36.4% 4	18.2% 2	9.1% 1	11
Guide entering trucks and other construction equipment to work zone	36.4% 4	36.4% 4	9.1% 1	9.1% 1	9.1% 1	11
Guide exiting trucks and other construction equipment from work zone	27.3% 3	36.4% 4	9.1% 1	9.1% 1	18.2% 2	11

10. Based on the collective experience in your DOT, please indicate the level of effectiveness of using spotters instead of flaggers to accomplish the following safety and mobility goals in freeway and expressway work zones with speed limits greater than 40 mph.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective1.0	Responses
Improve flagger and/or spotter safety	45.5% 5	18.2% 2	27.3% 3	9.1% 1	0.0% 0	11
Enhance workers safety	18.2% 2	18.2% 2	27.3% 3	9.1% 1	27.3% 3	11
Improve road users safety	45.5% 5	18.2% 2	18.2% 2	18.2% 2	0.0% 0	11
Enhance traffic mobility	54.5% 6	27.3% 3	9.1% 1	9.1% 1	0.0% 0	11
Enhance work zone access and egress	36.4% 4	18.2% 2	18.2% 2	18.2% 2	9.1% 1	11

11. Based on the collective experience in your DOT, please indicate the impact of using spotters instead of flaggers in the following work zone layouts in freeways and expressways with speed limits greater than 40 mph.

	Negative Impact 0.0	0.25	No Impact	0.75	Positive Impact 1.0	Responses
Very short-duration work zone < 15min	0.0% 0	0.0% 0	45.5% 5	9.1% 1	45.5% 5	11
Short-duration work zones	0.0% 0	0.0% 0	45.5% 5	18.2% 2	36.4% 4	11
Long-duration work zones	0.0% 0	20.0% 2	40.0% 4	40.0% 4	0.0% 0	10
Lane closure at enter/exit ramp	0.0% 0	18.2% 2	45.5% 5	36.4% 4	0.0% 0	11
One-lane closure on highway	0.0% 0	9.1% 1	54.5% 6	36.4% 4	0.0% 0	11
Two-lane closure on highway	0.0% 0	9.1% 1	54.5% 6	36.4% 4	0.0% 0	11
Median crossover	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Use of shoulder	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Ramps	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Lane closure with truck-mounted attenuator (TMA)	0.0% 0	0.0% 0	63.6% 7	36.4% 4	0.0% 0	11
Lane closure on freeways with low average annual daily traffic (AADT)	0.0% 0	9.1% 1	63.6% 7	27.3% 3	0.0% 0	11
Lane closure on freeways with high average annual daily traffic (AADT)	0.0% 0	9.1% 1	54.5% 6	36.4% 4	0.0% 0	11

12. When spotters are used instead of flaggers in freeway and expressway work zones with speed limits greater than 40 mph, please indicate the level of effectiveness of the following measures to maximize work zone safety and mobility.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective 1.0	Responses
Locate spotters in safe areas away from the hazards of oncoming traffic	0.0% 0	9.1% 1	27.3% 3	9.1% 1	54.5% 6	11
Plan a safe escape route for spotters	0.0% 0	0.0% 0	18.2% 2	18.2% 2	63.6% 7	11
Use effective noise makers such as air horn to warn workers of hazards	0.0% 0	36.4% 4	18.2% 2	18.2% 2	27.3% 3	11
Alert motorists about work zones access/egress points	18.2% 2	36.4% 4	18.2% 2	9.1% 1	18.2% 2	11
Use automated intrusion alarm system	18.2% 2	45.5% 5	18.2% 2	9.1% 1	9.1% 1	11
Use radar trailer to inform oncoming drivers of their speed	0.0% 0	9.1% 1	18.2% 2	27.3% 3	45.5% 5	11
Use sequential work zone taper warning lights	20.0% 2	30.0% 3	30.0% 3	20.0% 2	0.0% 0	10
Use automated lane closure systems	10.0% 1	40.0% 4	40.0% 4	10.0% 1	0.0% 0	10
Use Automated Flagger Assistance Devices (AFADs)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Deploy back-up alarms for backing trucks in the work zone	0.0% 0	9.1% 1	9.1% 1	36.4% 4	45.5% 5	11

13. Please indicate the level of effectiveness of the following measures to improve the safety of access and egress points in a freeway and expressway work zones with speed limits greater than 40 mph.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective	Responses
Deploy spotter to assist vehicles in entering and exiting work zone	9.1% 1	36.4% 4	18.2% 2	18.2% 2	18.2% 2	11
Deploy flagger to assist vehicles in entering and exiting work zone	16.7% 2	25.0% 3	25.0% 3	16.7% 2	16.7% 2	12
Equip the rear of construction vehicles entering the work zone with a warning sign such as “Construction Vehicle Do Not Follow”	8.3% 1	25.0% 3	16.7% 2	25.0% 3	25.0% 3	12
Equip construction vehicles with high-intensity rotating or flashing light	8.3% 1	0.0% 0	16.7% 2	50.0% 6	25.0% 3	12
Improve lighting and visibility of access/egress points during nighttime work zones	0.0% 0	8.3% 1	25.0% 3	33.3% 4	33.3% 4	12
Incorporate access/egress into Internal Traffic Control Plans (ITCPs)	0.0% 0	9.1% 1	0.0% 0	36.4% 4	54.5% 6	11
Use temporary rumble strips	18.2% 2	27.3% 3	27.3% 3	18.2% 2	9.1% 1	11
Use larger and additional warning signs	9.1% 1	18.2% 2	45.5% 5	9.1% 1	18.2% 2	11
Build temporary ramp to provide median access from street overpass	0.0% 0	10.0% 1	0.0% 0	50.0% 5	40.0% 4	10
Use ITS technology to improve access/egress safety	0.0% 0	16.7% 2	25.0% 3	33.3% 4	25.0% 3	12

14. Please indicate which of the following temporary traffic control measures has been deployed or recommended in your DOT for work zones on freeway and expressway with speed limits greater than 40 mph.

Device	Responses
Intrusion Alarms	2
Portable Changeable Message Signs (PCMSs)	16
Temporary Rumble Strips	13
Speed Displays	14
Truck-Mounted Attenuators (TMAs)	14
Police Patrols	14
Radar Drones	2
Automatic Flagger Assistance Devices (AFADs)	6
Mobile Barriers	8

15. Please indicate the level of effectiveness of the following Temporary Traffic Control (TTC) devices to improve safety in freeway and expressway work zones with speed limits greater than 40 mph.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective 1.0	Responses
Intrusion Alarms	60.0% 6	10.0% 1	20.0% 2	0.0% 0	10.0% 1	10
Portable Changeable Message Signs (PCMSs)	0.0% 0	0.0% 0	0.0% 0	56.3% 9	43.8% 7	16
Dynamic Message Boards	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Temporary Rumble Strips	6.7% 1	0.0% 0	26.7% 4	46.7% 7	20.0% 3	15
Portable Speed Monitor Displays (PSMDs)	0.0% 0	0.0% 0	60.0% 9	13.3% 2	26.7% 4	15
Truck-Mounted Attenuators (TMAs)	0.0% 0	0.0% 0	6.3% 1	31.3% 5	62.5% 10	16
Police Patrols	0.0% 0	7.1% 1	7.1% 1	21.4% 3	64.3% 9	14
Automated Flagger Assistance Devices (AFADs)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Radar Drones	42.9% 3	42.9% 3	14.3% 1	0.0% 0	0.0% 0	7
Automatic Flagger Assistance Devices (AFADs)	27.3% 3	27.3% 3	9.1% 1	18.2% 2	18.2% 2	11
Mobile Barriers	0.0% 0	0.0% 0	27.3% 3	27.3% 3	45.5% 5	11

16. Please list any new traffic control devices or technologies that can be used to improve work zone safety and mobility in freeway and expressway work zones with speed limits greater than 40 mph.

Response
Stopped traffic advisory systems. Provide real-time back-up alerts and messages.
We have been utilizing iCone on a few projects to track queuing.
Web-based speed monitoring devices (iCone, SmartCone, etc.)
mobile barrier & work zone ITS such as queue detection
We have implemented sequential lighting for nighttime work. These lights have shown a larger amount of the traveling public will merge sooner during nighttime projects.
Our metro district often closes a section of freeway on weekends for paving and related work. Other freeways are the detour and with lower weekend traffic volumes, backups are not too bad, there is a lot of media publicity, and the public seems to accept it as the work gets done quicker.

17. Please feel free to add any other comments on the use of spotter and/or flagger to improve freeway and expressway work zones safety and mobility with speed limits greater than 40 mph.

Response
Don't.
Spotters should only be used as a last resort or for short-duration work zones. Flaggers should not be used as a traffic control method under the above-mentioned application.
In Missouri, we do not use spotters or flaggers on freeway/expressway work zones. We will allow contractors to use them on some projects, upon request. The major concerns is usually a lone person in the work zone area and many will stand very close to the open lane to try to slow people down. This may cause the traveling public to slow down excessively and then you may have a queuing concern and potential of rear-end accidents. How does the spotter or flagger know the traveling public is going over the speed limit? Several times the flagger will motion to slow down even though the public is traveling the speed limit or slower.
The spotter is most effective when working next to or in the barrel line. Pavement marking operations that tend to be closer to the traffic than other operations has the largest benefit.
Questions 9 through 13 were not answered because we do not conduct flagging operations on freeway/expressway/Interstates roadways.

D.2 IDOT SURVEY QUESTIONS AND RESPONSES

1. Please indicate the level of need for the following flagger functions in freeway and expressway work zones with speed limits greater than 40 mph.

	No Need 0.0	0.25	Moderate Need 0.5	0.75	Greatest Need 1.0	Responses
Alert road users approaching the work zone	17.5% 14	6.3% 5	17.5% 14	11.3% 9	47.5% 38	80
Slow the speed of oncoming traffic	5.0% 4	8.8% 7	10.0% 8	13.8% 11	62.5% 50	80
Warn workers of errant drivers and vehicle intrusion into work zone	8.8% 7	2.5% 2	11.3% 9	17.5% 14	60.0% 48	80
Direct traffic when construction trucks enter the work zone	7.5% 6	10.0% 8	16.3% 13	21.3% 17	45.0% 36	80
Direct traffic when construction trucks exit the work zone	6.3% 5	8.9% 7	20.3% 16	21.5% 17	43.0% 34	79

Other flagger functions: Please specify the type and level of need for any other flagger functions that are not listed in the table.

Response
Loud noise, excessive dirt
Protect other passing motorists from excessive speed
It is too unsafe to have a flagger standing out there at high speeds!
Stopping traffic for equipment movement & materials thru out projects. Alert traffic to temporary job site hazards.
What does direct traffic mean? The main job for a flagger is to slow traffic when trucks are leaving or entering work zone. Not to redirect traffic.
1) To alert motorist and protect workers WITHIN the work zone when the work operations are spread out, i.e. patching, HMA placement.
Give a presence to the traveling public, especially motorists who don't shy from the edge of the closed lane and work is along or beyond that edge of the work lane, the flagger can give a waving motion to push traffic over. Need 1.0.
Spotters needed for directing construction trucks. (Flaggers are not needed to direct interstate traffic.) All answers assume the work area is not behind temporary barrier.

2. Please indicate the level of benefit gained from using flaggers in freeway and expressway work zones with speed limits greater than 40 mph.

	No Benefit 0.0	0.25	Moderate Benefit 0.5	0.75	Greatest Benefit 1.0	Responses
Improve workers safety	6.3% 5	8.8% 7	15.0% 12	17.5% 14	52.5% 42	80
Enhance safety of trucks entering work zone	8.9% 7	10.1% 8	30.4% 24	15.2% 12	35.4% 28	79
Improve safety of trucks exiting work zone	5.0% 4	12.5% 10	32.5% 26	15.0% 12	35.0% 28	80
Enhance road users safety	7.5% 6	13.8% 11	23.8% 19	17.5% 14	37.5% 30	80
Improve traffic mobility	21.3% 17	12.5% 10	23.8% 19	11.3% 9	31.3% 25	80
Improve compliance with traffic speed limit	21.5% 17	13.9% 11	22.8% 18	13.9% 11	27.8% 22	79
Flaggers encroaching open traffic lanes	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Compliance with traffic speed limit	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0

Other benefits: Please specify the type and level of any other flagger benefits that are not listed in the table.

Response
All answers assume the work area is not behind temporary barrier.
They provide the eyes that other people may not be able to do as they are busy performing tasks.
it’s just another body put at unneeded risk
1) Flaggers are often used to shift traffic over in moving operations, but the motorists are not informed by signing this is the situation. When this happens, traffic mobility is substantially impacted in a negative way because of traffic suddenly slowing to accommodate the situation. 2) Flaggers are ignored by the motoring public with respect to slowing traffic unless they physically stand in the live lane. The only thing that seems to help slow traffic down and keep the flagger out of harm’s way is a very visible police presence. Photo enforcement doesn't slow down traffic; just more speeding tickets are issued.
Flaggers tend to defeat mobility and work zone speed limits by over-aggressive actions; pushing traffic into the shoulder, demanding speeds much less than the work zone speed limit.
Flaggers do not seem to have an effect on the motorists' perception of need to comply with work zone speed limits. More enforcement is needed and should be a part of the project plan.

3. Please indicate the level of risk/hazard caused by using flaggers in freeway and expressway work zones with speed limits greater than 40 mph.

	Lowest Risk 0.0	0.25	Moderate 0.5	0.75	Highest Risk 1.0	Responses
Exposure of flagger to traffic hazards and injuries	2.6% 2	6.4% 5	14.1% 11	17.9% 14	59.0% 46	78
Exposure of flagger to work zones hazards and injuries	11.5% 9	14.1% 11	35.9% 28	15.4% 12	23.1% 18	78
Flagger causing excessive slow down of traffic & increasing traffic backups	16.7% 13	15.4% 12	12.8% 10	25.6% 20	29.5% 23	78
Flaggers encroaching into open traffic lanes	11.5% 9	14.1% 11	12.8% 10	20.5% 16	41.0% 32	78

Other risks: Please specify the type and level of flagger risks that are not listed in the table.

Response
All answers assume the work area is not behind temporary barrier.
1) Contractors use flaggers improperly by having them stop traffic in non-emergency situations for contractor convenience to move material or equipment within the work zone which generally causes incidents as this is unexpected by the motoring public. When they see speed signs up stating a speed limit, they expect to be able to go through the work zone at that speed. 2) Flaggers are often used to solve all of the contractors' errors in planning to handle traffic issues, many times with too few of them strictly because of cost. Our only recourse is to issue TC Deficiencies, but it doesn't address the issues at hand, it just fines the contractor.
this stuff sounds good on paper but the people standing out there would disagree please don't put me at unneeded risk I have kids
Aggressive flaggers are pushing well into the traveled lane, risking themselves and interrupting traffic flow - which can lead to rear-end crashes.
Flaggers propose zero risks. Traffic is slower when a flagger is present when compared to not being present.
There is an increase level of traffic accidents when flaggers try to slow down traffic too much on freeways.

4. Please indicate the level of risk/hazard to flaggers in the following work zone conditions.

	Lowest Risk 0.0	0.25	Medium Risk 0.5	0.75	Highest Risk1.0	Responses
Curves	1.3% 1	1.3% 1	8.8% 7	40.0% 32	48.8% 39	80
Hills	1.3% 1	1.3% 1	5.1% 4	39.2% 31	53.2% 42	79
Daytime work zones	14.1% 11	24.4% 19	39.7% 31	15.4% 12	6.4% 5	78
Nighttime work zones	1.3% 1	5.1% 4	13.9% 11	27.8% 22	51.9% 41	79
Glare from sun	5.0% 4	8.8% 7	18.8% 15	31.3% 25	36.3% 29	80
Glare from vehicle headlights	5.1% 4	16.5% 13	31.6% 25	19.0% 15	27.8% 22	79
Glare from nighttime work zone lighting	7.7% 6	12.8% 10	30.8% 24	23.1% 18	25.6% 20	78
Adverse weather conditions	5.1% 4	10.1% 8	15.2% 12	34.2% 27	35.4% 28	79
Lack of visibility due to construction-related dust or temporary structures	8.9% 7	24.1% 19	21.5% 17	20.3% 16	25.3% 20	79

5. Please indicate the level of need for the following potential spotter functions in freeway and expressway work zones with speed limits greater than 40 mph.

	No Need 0.0	0.25	Moderate Need 0.5	0.75	Greatest Need 1.0	Responses
Warn workers of oncoming traffic	13.9% 11	19.0% 15	11.4% 9	13.9% 11	41.8% 33	79
Detect errant drivers and warn workers using effective warning devices	7.6% 6	7.6% 6	8.9% 7	12.7% 10	63.3% 50	79
Warn workers of construction equipment hazards in the work zone	20.3% 16	26.6% 21	20.3% 16	10.1% 8	22.8% 18	79
Guide trucks/equipment entering the work zone	27.8% 22	19.0% 15	20.3% 16	8.9% 7	24.1% 19	79
Guide trucks/equipment exiting the work zone	25.3% 20	22.8% 18	21.5% 17	7.6% 6	22.8% 18	79

Other spotter functions: Please specify the type and level of need for any other potential spotter functions that are not listed in the table.

Response
All answers assume the work area is not behind temporary barrier.
Spotters serve no function, they can be as effective as a flagger on-site
never observed a spotter in action
someone watching your back would be great
1) Spotters may be helpful in guiding trucks into and out of work zones if there is no real clear path the trucks are to be taking in doing so. Otherwise they will be just one more person 'in the way for a potential incident' 2) For the work crew to actually hear an audible warning from a spotter, is unrealistic because of the noise level in a construction zone. I don't know of any horn or whistle that is loud enough to overcome the noise from driving pile, to scrappers, dozers, and other earth moving equipment operating in the work zone.
I would think spotter is either watching traffic or construction equipment and not both. We have not used one in D3 to my knowledge.

6. Please indicate the level of potential benefits that can be gained from using spotters in expressway and freeway work zones with speed limits greater than 40 mph.

	No Benefit 0.0	0.25	Moderate Benefit 0.5	0.75	Greatest Benefit 1.0	Responses
Improve workers safety	9.0% 7	6.4% 5	19.2% 15	7.7% 6	57.7% 45	78
Enhance safety of trucks entering work zone	20.3% 16	12.7% 10	27.8% 22	17.7% 14	21.5% 17	79
Improve safety of trucks exiting work zone	19.2% 15	12.8% 10	29.5% 23	19.2% 15	19.2% 15	78
Enhance road users safety	24.1% 19	16.5% 13	21.5% 17	12.7% 10	25.3% 20	79
Improve traffic mobility	26.6% 21	20.3% 16	22.8% 18	7.6% 6	22.8% 18	79

7. Please indicate the level of potential risks that can be caused by using spotters in freeway and expressway work zones with speed limits greater than 40 mph.

	Lowest Risk 0.0	0.25	Moderate 0.5	0.75	Highest Risk 1.0	Responses
Exposure of spotter to traffic hazards and injuries	15.2% 12	13.9% 11	30.4% 24	19.0% 15	21.5% 17	79
Exposure of workers to traffic hazards	23.1% 18	16.7% 13	25.6% 20	17.9% 14	16.7% 13	78

8. Please indicate what you believe the level of effectiveness would be if spotters are used to perform the following functions instead of flaggers in freeway and expressway work zones with speed limits greater than 40 mph.

	Least Effective 0.0	0.25	Medium Effectiveness 0.5	0.75	Most Effective 1.0	Responses
Alert oncoming traffic & reduce its speed	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Warn workers of oncoming traffic	12.8% 10	12.8% 10	24.4% 19	14.1% 11	35.9% 28	78
Detect errant drivers and warn workers using effective warning devices	12.8% 10	7.7% 6	20.5% 16	17.9% 14	41.0% 32	78
Warn workers of the hazards posed by construction equipment/ trucks in the work zone	16.7% 13	23.1% 18	37.2% 29	10.3% 8	12.8% 10	78
Guide entering trucks and other construction equipment to work zone	26.9% 21	25.6% 20	28.2% 22	9.0% 7	10.3% 8	78
Guide exiting trucks and other construction equipment from work zone	23.1% 18	28.2% 22	28.2% 22	9.0% 7	11.5% 9	78

9. Please indicate the potential level of effectiveness of using spotters instead of flaggers to accomplish the following safety and mobility goals in freeway and expressway work zones with speed limits greater than 40 mph.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective 1.0	Responses
Improve flagger and/or spotter safety	17.7% 14	17.7% 14	13.9% 11	16.5% 13	34.2% 27	79
Enhance workers safety	12.8% 10	16.7% 13	21.8% 17	19.2% 15	29.5% 23	78
Improve road users safety	30.8% 24	20.5% 16	21.8% 17	14.1% 11	12.8% 10	78
Enhance traffic mobility	31.6% 25	16.5% 13	22.8% 18	13.9% 11	15.2% 12	79
Enhance work zone access and egress	27.8% 22	21.5% 17	25.3% 20	13.9% 11	11.4% 9	79

10. Please indicate the potential impact of using spotters instead of flaggers in the following work zone layouts in freeways and expressways with speed greater than 40 mph.

	Negative Impact 0.0	0.25	No Impact	0.75	Positive Impact 1.0	Responses
Very short-duration work zone < 15min	11.7% 9	9.1% 7	45.5% 35	11.7% 9	22.1% 17	77
Short-duration work zones	11.7% 9	11.7% 9	29.9% 23	29.9% 23	16.9% 13	77
Long-duration work zones	15.6% 12	11.7% 9	23.4% 18	19.5% 15	29.9% 23	77
Lane closure at enter/exit ramp	18.4% 14	10.5% 8	25.0% 19	21.1% 16	25.0% 19	76
One-lane closure on highway	19.5% 15	10.4% 8	20.8% 16	27.3% 21	22.1% 17	77
Two-lane closure on highway	21.1% 16	6.6% 5	26.3% 20	23.7% 18	22.4% 17	76
Median crossover	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Use of shoulder	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Ramps	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Lane closure with truck-mounted attenuator (TMA)	14.5% 11	11.8% 9	31.6% 24	23.7% 18	18.4% 14	76
Lane closure on freeways with low average annual daily traffic (AADT)	13.5% 10	10.8% 8	35.1% 26	28.4% 21	12.2% 9	74
Lane closure on freeways with high average annual daily traffic (AADT)	16.9% 12	5.6% 4	21.1% 15	22.5% 16	33.8% 24	71

11. If spotters are used instead of flaggers in freeway and expressway work zones with speed **limit more than 40 mph, please indicate which of the following measures can be used to maximize work zone safety and mobility.**

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective 1.0	Responses
Locate spotters in safe areas away from the hazards of oncoming traffic	6.5% 5	5.2% 4	18.2% 14	18.2% 14	51.9% 40	77
Plan a safe escape route for spotters	5.1% 4	2.5% 2	25.3% 20	20.3% 16	46.8% 37	79
Use effective noise makers such as air horn to warn workers of hazards	10.3% 8	6.4% 5	15.4% 12	17.9% 14	50.0% 39	78
Alert motorists about work zones access/egress points	10.3% 8	21.8% 17	34.6% 27	17.9% 14	15.4% 12	78
Use automated intrusion alarm system	7.9% 6	13.2% 10	32.9% 25	26.3% 20	19.7% 15	76
Use radar trailer to inform oncoming drivers of their speed	3.8% 3	5.1% 4	23.1% 18	30.8% 24	37.2% 29	78
Use sequential work zone taper warning lights	8.9% 7	10.1% 8	31.6% 25	29.1% 23	20.3% 16	79
Use automated lane closure systems	14.3% 11	16.9% 13	28.6% 22	24.7% 19	15.6% 12	77
Use automated flagger assistance devices (AFADs)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0
Deploy back-up alarms for backing trucks in the work zone	9.1% 7	7.8% 6	19.5% 15	27.3% 21	36.4% 28	77

12. Please indicate the level of effectiveness of the following measures to improve the safety of access and egress points in a freeway and expressway work zones with speed limits greater than 40 mph.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective	Responses
Deploy spotter to assist vehicles in entering and exiting work zone	20.5% 16	15.4% 12	32.1% 25	12.8% 10	19.2% 15	78
Deploy flagger to assist vehicles in entering and exiting work zone	10.3% 8	9.0% 7	30.8% 24	24.4% 19	25.6% 20	78
Equip the rear of construction vehicles entering the work zone with a warning sign such as “Construction Vehicle Do Not Follow”	3.8% 3	14.1% 11	34.6% 27	26.9% 21	20.5% 16	78
Equip construction vehicles with high-intensity rotating or flashing light	5.1% 4	7.7% 6	20.5% 16	41.0% 32	25.6% 20	78
Improve lighting and visibility of access/egress points during nighttime work zones	3.9% 3	2.6% 2	13.0% 10	33.8% 26	46.8% 36	77
Incorporate access/egress into Internal Traffic Control Plans (ITCPs)	10.4% 8	2.6% 2	31.2% 24	33.8% 26	22.1% 17	77
Use temporary rumble strips	13.0% 10	10.4% 8	32.5% 25	31.2% 24	13.0% 10	77
Use larger and additional warning signs	14.1% 11	19.2% 15	33.3% 26	17.9% 14	15.4% 12	78
Build temporary ramp to provide median access from street overpass	13.2% 10	22.4% 17	36.8% 28	18.4% 14	9.2% 7	76
Use ITS technology to improve access/egress safety	9.2% 7	19.7% 15	28.9% 22	30.3% 23	11.8% 9	76

13. Please indicate the level of effectiveness of the following Temporary Traffic Control (TTC) devices in freeway and expressway work zones with speed greater than 40 mph.

	Least Effective 0.0	0.25	Moderate Effectiveness 0.5	0.75	Most Effective 1.0	Responses
Intrusion Alarms	10.4% 8	18.2% 14	27.3% 21	27.3% 21	16.9% 13	77
Portable Changeable Message Signs (PCMSs)	0.0% 0	8.9% 7	35.4% 28	25.3% 20	30.4% 24	79
Temporary Rumble Strips	7.7% 6	10.3% 8	39.7% 31	28.2% 22	14.1% 11	78
Speed Displays	3.8% 3	5.1% 4	19.2% 15	35.9% 28	35.9% 28	78
Truck-Mounted Attenuators (TMAs)	1.3% 1	7.7% 6	16.7% 13	43.6% 34	30.8% 24	78
Police Patrols	0.0% 0	1.3% 1	6.3% 5	10.1% 8	82.3% 65	79
Automated Flagger Assistance Devices (AFADs)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0

Other devices:

Response
Message Signs or Message Signs?
PERMANENT POLICE PATROL
Police patrol is the most effective and needs to be used more often.

14. Please list any new traffic control devices or technologies that can be used to improve work zone safety and mobility in freeway and expressway work zones with speed greater than 40 mph.

Response
Give the flagger the ability to control drivers or something similar to warn workers
ISP Photo Enforcement Vans deployed within work zones. Trooper in a truck.
Mobile Barrier
SPEED BUMPS
1) Public education in Illinois: work zone speeds are not just when worker are present. 2) Require speed displays in the TCP. 3) Require some level of enforcement/police presence in the TCP. 4) Develop and enforce penalties for leaving signs up on inactive work zones that should not be there unless work is being performed
Not a device: but I think earlier warning of which lane is being closed would be helpful in high traffic areas
Start notifying traffic to merge up to 3 miles out. We have successfully used a truck-mounted message board to travel backwards on shoulder and notify oncoming traffic of delays, stopped traffic, detours, etc.
The best way and probably the only way to slow traffic down is police patrol. The safest work zone is a slow-moving one.
Make a device that blocks all cell phone service (in the work zone) in order to cut down on distracted drivers.
Remote controlled flagger stations. Increased use of TMAs - going two wide with one on the shoulder to prevent run-around accidents.
Reflectors on barrels in lieu of lights for overnight closures. Lights burn out, reflectors do not.
Install flashing LED lights on stop/go paddles for better visibility. Batteries could be mounted in handle.
Tall grabber cones, as used in other states, they are easier to see thru when used to delineate exit/entrance ramps. Also, have a smaller foot print, take up less roadway space. Especially when you have to put them in the live lane for HMA paving operations. With drums it forces people to drive on rumble strips and they don't like that.
There are ITS components available, such as barrels, which can relay real-time travel info to motorists on an advanced message board and even GPS units. I think this would be a huge benefit to prevent rear-end collisions from queues.

15. Please feel free to add any other comments on the use of spotter and/or flagger to improve freeway and expressway work zones safety and mobility with speed greater than 40 mph.

Response
Don’t have a person standing out on the highway trying to direct traffic.
Enforce Scott’s law with law enforcement get out there and start writing tickets.
Neither should be used at those speeds it is for the TMA to protect the work site.
Flaggers are the safest way to keep workers safe on the roads. They are a crucial piece in working on the highways. They are used more than what people realize and they are trained to do their job.
It is our experience that there are enough warnings/signs/flaggers, the problem is poor/rude/distracted drivers who do not pay attention or are mad/upset and in a hurry and do not think any of the speed limit signs apply to them.
Some flaggers disrupt traffic flow on freeways causing unsafe conditions for motorist. This also can lead to unsafe conditions for the flaggers & workers. Flaggers can also be hard to see in lane closures that require drums or barricades. Mobile message boards relaying messages about construction ahead or trucks entering and leaving may be safer for both the flaggers and the motorist. Speed indicator signs also seem very effective in slowing down traffic.
Police are the best. Flaggers do have a place but offer little in the way of actually alerting workers of hazards. One obstacle is the high noise level and distance of flagger from the workers. I understand the distance but the key component is how to effectively warn the workers where a spotter may be better suited.
Converting flaggers to spotters will require great effort by IDOT. Contractors have become accustomed to using the flagger in an aggressive stance, pushing traffic into the shoulder and slowing traffic - all at great risk to the flagger and traffic.
The spotter is a dumb idea. If a work zone has multiple crews how many spotter do you need? If someone comes through a work zone an alarm goes off, ok then what the crews still have to find the danger and react. My opinion through 25 years + in work zones is it is probably too late.
1) From previous definition, spotters don't have any authority to direct or control traffic. How are they in any way going to guide traffic through a work zone? There only purpose would be to direct the contractors operations inside the work zone, which we already have a project foremen doing this, in theory anyway.
I was unsure what was meant by “replace” flagger with spotter. Does this mean there would be not flagger? In some instances cited this is not even feasible.
I believe there is a great safety benefit for using either in a work zone. Many situations both would be needed at the same time. I feel they provide some of the same as well as different jobs. Flaggers help slow down and control traffic and when a vehicle intrudes the work zone the flagger is concerned with their own safety first which delays them from warning other workers where spotters primary concern is warning workers of pending danger.
A major concern I have is the (mis)use of flaggers for a lane closure on multilane facilities. They are only supposed to be there to help the trucks get in and out of the work zone. In reality, all they do is stand in the open lane of traffic, unnecessarily forcing traffic onto the shoulder and slowing it far below the work zone speed limit (as well as exposing the flaggers themselves to oncoming traffic). The result is greatly increased user delays and often the back-up extends beyond the traffic control. This is a major cause of totally preventable accidents that often result in multiple fatalities for a function that provides zero benefit.

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A flagger is valuable to motorists to alert them of the presence of workers and equipment in high-speed work zones. The flagger can also serve as a spotter if they are positioned correctly, which is valuable to workers to alert them of intrusion into the work zone. Flagger equipped with immediate access to air horns or equivalent warning devices can serve as a flagger/spotter and warn both motorists and workers.
Drivers are like sheep. They follow each other. That means they follow the construction vehicle in front of them.
These are all great ideas, but until you start hammering people for breaking the law in work zones, most attempts of safety is worthless.
I would never like to see only a spotter at the workers feel advance warning of flagger is needed also.
Flaggers are very good at getting drivers attention especially when working on centerline and drivers must squeeze the shoulder. A good flagger will command the attention of drivers, even on a busy interstate and thereby the most effective. On the other hand, some flaggers seem to blend into the background and are not effective. Boldness should be a trait of flaggers. I believe a flagger should be equipped with an air horn hanging from their belt to notify workers of an errant driver.

Illinois Department of Transportation

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