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Case Studies on **Innovations** in **Temporary Traffic Control**

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Innovations in Temporary Traffic Control

American Traffic Safety Services Association

Table of Contents

List of Figures

List of Tables

Executive Summary

More than 35,000 fatalities occur on U.S. highways each year. In 2018, 672 fatal crashes occurred in work zones, with 755 resulting work zone fatalities. Several factors contribute to crashes in work zones, including traffic queues, speed, speed variability, worker exposure and driver behavior. Given these statistics and trends shown in the last decade, practitioners are developing new strategies and devices to reduce the impacts and improve safety for all work zone stakeholders.

The American Traffic Safety Services Association (ATSSA) developed this document as part of an effort to provide information on strategies that can improve work zone safety and reduce injuries and fatalities. As representatives of the public and private sectors, ATSSA members play a key role in implementation of innovative practices through research, strategy development, device manufacturing and specification development for experimental and proven work zone strategies. State Departments of Transportation (DOTs) pilot test new devices, techniques and materials to improve work zone safety and standardize practices that yield valuable benefits. Contractors, vendors, universities and consultants research, develop and deploy devices and strategies based on DOT specifications and guidelines. Promotion of innovative applications that have the potential to make a positive impact is a priority for ATSSA.

This document provides case studies of examples of innovation in temporary traffic control, as highlighted in the following list.

- Wisconsin's DOT (WisDOT) installs orange pavement markings at work zone lane shifts to improve visibility, especially in winter-weather conditions.
- Michigan's DOT (MDOT) applies wet reflective optics to enhance traditional pavement markings and uses enhanced preformed tape for splicing to ensure consistency in work zone markings throughout a project. MDOT also uses longer sections of solid white pavement markings at approaches to lane shifts to enhance visibility.
- MDOT deploys Driveway Assistance Devices (DAD) and Automated Flagger Assistance Devices (AFAD) to improve traffic operations as drivers approach construction and maintenance work zones on two-lane highways. MDOT is also using worksite access systems and smart work zone sensors to alert motorists that trucks are entering the highway.
- WisDOT and MDOT also use innovative signing, such as indicating that drivers should use both lanes during backups, for queue management on multi-lane highways.
- The Arkansas DOT (ArDOT) implemented the lane-weave traffic control plan to ensure consistency in merging on high-speed, multi-lane facilities.
- A contractor in Alabama is using an AFAD that captures video for monitoring the approaches to the transition.
- Iowa's DOT tested smart arrow boards on freeway projects to capture data on active lane closures. Iowa DOT required this application for freeways effective October 2020.

- Virginia’s DOT (VDOT) requires the use of Portable Temporary Rumble Strips (PTRS) on all flagging operations greater than three hours in length and less than 72 hours in length, with some exceptions. Montana’s DOT (MDT) also developed specifications for use of PTRS to warn drivers approaching flagging operations.
- The North Carolina DOT (NCDOT) researched and deployed lighting devices for nighttime visibility for several applications, including balloon lights for reduced glare for approaching traffic.
- The city of Austin, Texas, developed innovative traffic control for planned special events such as the South by Southwest (SXSW) festival. These applications include use of water-filled barriers for pedestrian channelization.

The case study devices and strategies outlined in this document have the potential for widespread implementation given the testing and deployment successes outlined by the implementing agencies. Through outreach and by providing greater awareness of these strategies, ATSSA is committed to improving work zone safety and reducing injuries and fatalities. For more information, visit ATSSA.com or call 540-368-1701.

Introduction

The American Traffic Safety Services Association (ATSSA) is committed to reducing work zone injuries and fatalities through the promotion of innovation in work zone traffic control. ATSSA members play a key role in implementing innovative practices through research, strategy development, device manufacturing and specification development for experimental and proven work zone strategies. Transportation agencies, contractors, consultants and product manufacturers all play a key role in applying innovation to make work zones safer.

State departments of transportation (DOTs) pilot test new devices, techniques and materials to improve work zone safety, and standardize those practices that yield valuable benefits. The Manual on Uniform Traffic Control Devices (MUTCD), along with federal regulations such as the Work Zone Safety and Mobility Rule, outline the standards and provide guidance for temporary traffic control. Agencies often supplement these standards and regulations with innovative approaches to meet the intent of the regulations.

Practitioners need information on proven, tested techniques that can improve work zone safety. This need includes documentation on successes, challenges and lessons learned from peers.

The case study examples provided in this document outline some of the innovative techniques implemented by DOTs to meet work zone safety challenges. This document includes six case study examples that outline enhanced application of the concepts from the national standards as well as experimental applications to enhance work zone performance. These case study examples will benefit interested transportation agencies and private-sector representatives.

Case Study Topic	Examples Included
1 – Innovative Pavement Markings	Orange Markings, Wet Reflective Optics, Lane Weave Applications
2 – Advanced Technologies	Smart Arrow Boards, Driveway Assistance Devices, AFADs, Truck Entry Warning Sensors
3 – Lane Merge Strategies	Early/Late Merge, Dynamic Merge, Queue Protection
4 – Portable Temporary Rumble Strips	Requirements and Guidelines from Virginia DOT and Montana DOT
5 – Nighttime Traffic Control: Presence Lighting	Balloon lighting, portable light towers
6 – Traffic Control for Planned Special Events	South by Southwest festival in Austin, Texas

Case Study 1 – Innovative Pavement Marking Applications

Orange Temporary Work Zone Pavement Markings in Wisconsin

Several DOTs have tested or plan to test an innovative technique for enhancing the visibility of temporary pavement markings in work zones. The Wisconsin Department of Transportation (WisDOT) recently installed orange temporary pavement markings on Interstate 94 as part of the $1.7 billion, six-year Zoo Interchange Reconstruction Project on the west side of Milwaukee. This interchange is a major freeway connector for downtown Milwaukee, Chicago, Madison and Fond Du Lac, and carries more than 350,000 vehicles per day at the intersection of I-94 and I-41.

Work Zone Safety Challenges

Traditional white and yellow pavement marking removal methods typically leave scars on the pavement. The scars resemble pavement marking lines and cause driver confusion. The scarring appears as a polished surface on concrete and fractured white aggregate on asphalt surfaces. In addition, chloride treatment in the winter often masks the white pavement markings, making it difficult for drivers to distinguish lane shifts. WisDOT personnel observed close calls (high sideswipe crash risk) with traditional white and yellow markings, as some drivers followed joint lines or judged their location by the proximity to nearby barrier wall. This situation resulted in errant vehicles nearly impacting the vehicles that were able to correctly follow the work zone lane alignments. Drivers needed a contrast in color to the white lane line markings to improve visibility.

Several challenges existed for WisDOT in implementing temporary traffic control on this multi-year project, including:

- visibility of traditional pavement markings for the duration of the project, especially at night;
- service life of temporary pavement markings;
- successful removal of permanent markings without scarring, as well as temporary marking alterations within the frequent project phase changes;
- the need to comply with the MUTCD, including requirements for white and yellow pavement markings, their meanings, and the potential for other colors for contrast;
- seasonal variation, including impacts to traditional markings during summer weather conditions and also during winter maintenance activities; and
- the desire to ensure appropriate levels of safety for the traveling public.

Figure 1. Traditional Temporary White Markings on Lane Shift

WisDOT considered the potential benefits of applying the orange pavement markings, including greater visibility for drivers, especially for lane shifts in winter conditions. However, the DOT also considered several challenges prior to implementation, as shown in the following bulleted list.

- Industry representatives did not have experience painting orange markings on highways.
- Specifications for such materials did not exist and manufacturing representatives needed enough demand for orange marking materials to make it cost effective to develop the material.
- The brighter the material, the easier it would be to see, but it would have more degradation from ultra-violet light as fluorescence increased.

Temporary Traffic Control Device Application

Given these challenges, WisDOT researched the successful application of orange temporary pavement markings in Canada, as well as in several other countries. Since the MUTCD does not mention work zone pavement marking colors other than traditional white and yellow, WisDOT developed a Request to Experiment (RTE) and submitted it for review and approval by the Federal Highway Administration (FHWA). The project request included an 18-month evaluation period, with one direction maintained with traditional pavement marking colors to serve as a control for comparison.

As this was the first implementation of temporary orange pavement markings, WisDOT lacked a specification that detailed the requirements. Potential solutions included paint with standard glass beads, paint with enhanced prismatic beads, Methyl Methacrylate (MMA) and epoxy. The DOT developed a change order for the contractor that included epoxy paint supplied by the DOT (in cooperation with a local vendor) with provisions for the contractor to perform the application.

Figure 2. Orange Temporary Marking on Asphalt Surface

The initial application worked well and WisDOT requested that FHWA allow for orange markings in both directions, which FHWA granted. After the first year of application, WisDOT requested a two-year extension and, given the extremely positive public perception, FHWA also approved this request.

After a number of adjustments to the orange markings, WisDOT determined that using fluorescent orange epoxy from November to April worked well for winter conditions and a non-fluorescent orange latex paint supplemented by orange raised pavement markers (RPM) worked well from May to October for warm-weather conditions.

Additionally, WisDOT procured orange preformed tape for use in locations where small sections of the orange markings required fixes, such as where potholes may form along the painted line. The DOT also determined that a 5-inch-wide pavement marking would provide for enhanced visibility as compared with a traditional 4-inch-wide marking.

All test sections included the advance signing "ORANGE PAVEMENT MARKING TEST SECTION AHEAD."

One challenge in implementation of orange temporary pavement markings in work zones is the meaning of the traditional yellow marking and the separation of traffic flows in opposite directions. WisDOT determined that the orange markings in place of traditional yellow should be used in locations with temporary or permanent barrier wall separating opposite directions of traffic.

Lessons Learned

User surveys from local businesses showed that initial orange markings were not as visible as users expected, especially at night. The addition of the enhanced prismatic beads and higher overall paint fluorescence provided for an 80% favorable rating by surveyed users for the orange temporary pavement markings. Video evidence showed that drivers maintained their lane better and the DOT received 95% fewer complaint calls regarding pavement markings. Law enforcement and project staff also observed better driver navigation at the lane shifts.

WisDOT determined that temporary orange pavement markings in work zones can have a positive effect on driver awareness of the work zone. The DOT created a "Lessons Learned" document for the project, which suggested that the technique be used on complicated projects with multiple stages or at transitions, such as lane shifts and crossovers, for more linear projects. For long stretches of straight work zone sections, the benefits may not outweigh the costs and agencies may choose to apply traditional white and yellow temporary pavement markings in those areas. For locations that experience potholes or pavement condition issues, temporary orange tape provides a solution for maintaining marking continuity in small sections.

Other agencies such as the Kentucky Transportation Cabinet, Texas DOT and the California Department of Transportation (Caltrans) have either tested or plan to test the orange markings as an application to improve visibility as drivers enter the work zone. While the costs are higher compared to traditional white and yellow markings, driver experience is improved. In addition, future applications such as with connected and automated vehicles (CAV) may prove beneficial as well, as CAVs could easily recognize a lane shift by picking up the distinct color of the orange temporary pavement markings.

Layout of Temporary Pavement Markings in Michigan

The Michigan Department of Transportation (MDOT) also identified a need for innovation in temporary pavement markings to address challenges with driver behavior at lane shifts, marking visibility, marking durability and overall safety in traffic pattern modifications.

Work Zone Safety Challenges

MDOT identified several challenges with work zone safety at lane shifts, including:

- Visibility of pavement markings during the presence of sun glare.
- Durability of temporary tape applications, especially with pavement cracks and potholes.
- Feasibility and level of effort in removing temporary tape markings.
- Alerting motorists of the shift as it is introduced.

Temporary Traffic Control Device Application

MDOT evaluated the potential for more prominent pavement markings to delineate lane shifts. Instead of beginning the shift lane with a solid white pattern at the lane line skip marking, MDOT developed a specification for use of white temporary pavement markings in solid color prior to the lane shift and on the lane lines. The application, coined "lead and lag tails," provides a more prominent delineation of the shift using a 6-inch, solid white line 300 feet in advance of the lane shift on freeways, and 150 feet in advance of the lane shift on all other multi-lane roadways. The specification also requires a similar pattern at the end of the lane shift so that drivers are aware that traffic has resumed the normal path.

MDOT also uses enhanced bead cluster markings called wet reflective optics for all work zone markings. These temporary white and yellow pavement markings are applied at a rate of 18 mils instead of the traditional 16-mil application rate. The DOT also plans to widen lane and edge pavement markings to 6 inches from 4-inch wide markings for all work zone applications (effective in 2020 for freeways and in 2021 for all roadways). MDOT initially used 8-inch lines at the shift, but found that 6-inch lines provided better uniformity along with greater visibility compared with the 4-inch markings. MDOT also based implementation decisions on past research of percentage increases in edge line markings for greater visibility (i.e., a 50% increase from a 4-inch marking to a 6-inch marking, versus a 33% increase from a 6-inch marking to an 8-inch marking).

In addition, an enhanced form of temporary tape is decreasing the amount of time MDOT workers spend removing this tape in work zones. The new tape has improved removability due to a stronger internal integrity of the material. The tape includes a thicker interwoven net and is now easier to remove in larger sections. Previous materials would break under a joint or crack whereas the enhanced tape design stays intact when pavement surface conditions change. On a recent project on I-75, the standard tape took an hour to remove and a similar length of enhanced temporary tape took only 15 minutes to remove. MDOT required the improved removable tape on all freeway construction projects during the 2020 construction season for existing contracts (using modifications) and for newly let contracts.

Figure 3. MDOT Comparison of Standard and Enhanced Temporary Tape

Lessons Learned

MDOT identified a need for both enhancing motorist safety at lane shifts and for reducing time and effort in applying and removing temporary tape pavement markings. The lead and lag tails application provides greater visibility for motorists as they enter the lane shift and enhances compliance with the shift pattern. The temporary tape application provides ease of installation and removal and creates a stronger material that has improved durability and easier operator installation and removal as compared with traditional preformed temporary tape. MDOT is also using a detailed evaluation plan for the temporary tape marking applications.

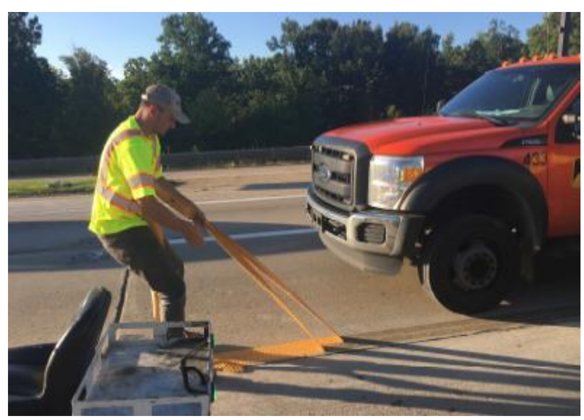

Figure 4. Temporary Tape Removal Example

Application of the Lane Weave on Freeways in Arkansas

While the two previous case study examples included application of innovative temporary pavement markings for traffic control, agencies also use innovative traffic control plans to help improve work zone safety. One example is currently in use in Arkansas and has been for several years. The Arkansas Department of Transportation (ArDOT) realized greater driver consistency in merging at freeway lane closures by requiring a specific merging traffic control plan on all projects.

Work Zone Safety Challenges

Merging on high-speed roads is problematic for drivers in general. Driver behavior is a key factor in merging crashes, and freeway crashes have a much higher crash severity than crashes on lower speed facilities. In addition, driver expectation is changed when the direction of a merge pattern changes from one work zone to another.

Temporary Traffic Control Device Application

ARDOT provides for greater consistency and meets driver expectations through the application of one merge pattern for all freeway projects. The lane weave, called the "Arkansas Shift," is a pattern where drivers always merge from right to left. Even when the left lane is closed, drivers merge right to left and then the traffic control pattern shifts traffic back to the right downstream of the merge. This application is used in several states across the United States and provides several benefits in addition to driver consistency in merging. It is also referenced in National Cooperative Highway Research Program (NCHRP) Report 476 entitled, "Guidelines for Design and Operation of Nighttime Traffic Control for Highway Construction and Maintenance." This application, when used at night, can allow crews to work on both sides of the freeway during the same work shift without requiring the setup of a different lane closure.

For ARDOT, the pattern provides greater consistency in meeting driver expectations. With right-lane closures, the traffic control pattern is a standard stationary lane closure. For left-lane closures, the lane weave merges traffic right to left and then shifts traffic back to the right lane. This approach provides greater consistency in merging and was shown to increase safety and reduce crashes at merge points in Arkansas work zones.

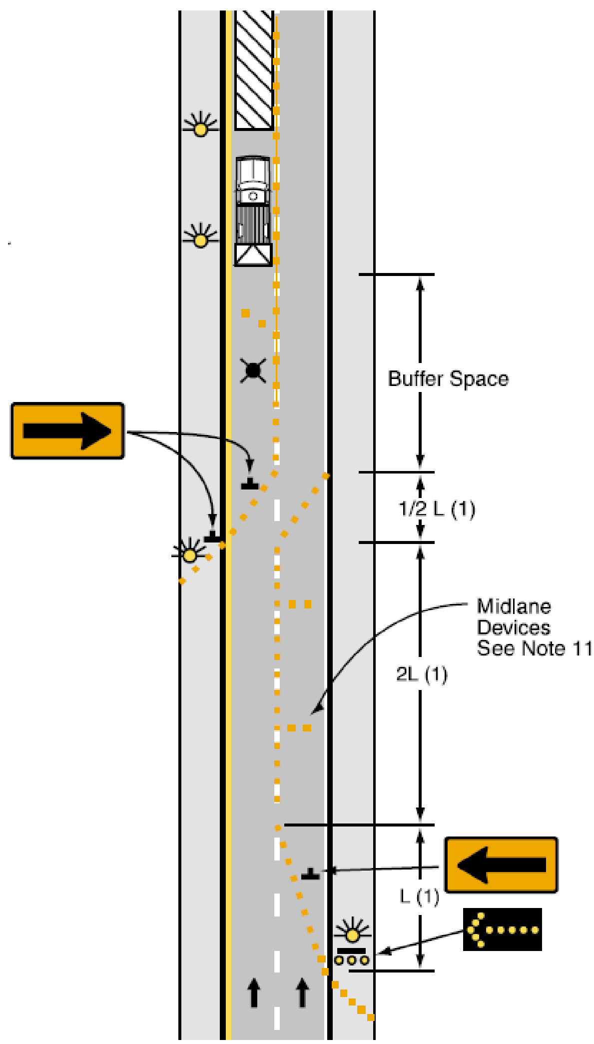

Figure 5. NCHRP 476 Lane Weave Typical Application

This application is used for all freeway closures affecting the left lane of traffic instead of the traditional left-lane closure. Researchers also developed a Crash Modification Factor (CMF) for the application of the left-hand merge and downstream lane shift.

Lessons Learned

ARDOT and several other DOTs have realized the benefits of the application of the lane weave temporary traffic control pattern. There are several constructability benefits to the application (including ease of installation at locations with narrow inside shoulders that prohibit placement of arrow boards), but the primary benefit is the consistency realized by drivers in merge patterns on freeways. These high-speed locations have proven to be safer for drivers when merge patterns are consistent across all work zones on freeways.

Case Study 2 – Innovative Work Zone Technology Applications

Application of Smart Arrow Boards in Iowa

The Iowa Department of Transportation (Iowa DOT) identified a need to expand smart work zone deployments to include devices that capture data and provide information that benefits all stakeholders, including the traveling public. For at least the past two decades, a group of individuals within the DOT met frequently to discuss statewide work zone coordination to improve operations. In early 2020, and with the catalyst of a DOT director that encouraged greater use of technology, Iowa DOT developed a requirement for use of smart arrow boards on all interstate projects beginning with the October 2020 contract letting season.

Work Zone Safety Challenges

Iowa DOT identified several key challenges to improving work zone operations and associated information, including:

- Providing timely and accurate information on active lane closures to both DOT personnel and motorists, as well as other public and private stakeholders managing highway construction and maintenance;
- Developing a standardized technique for disseminating information to connected and automated vehicles (CAVs) in the future to help with work zone navigation;
- Monitoring the performance of Traffic Critical Projects (TCP) that have the potential to significantly impact safety and mobility;
- Supporting the intent of the FHWA Work Zone Rule and Work Zone Data Initiative by collecting information on work zone activity statewide, without undue burden on stakeholders; and
- Applying technology effectively and efficiently to enhance information provided on in-vehicle displays without cumbersome data processing needs.

One of the primary challenges in implementing smart arrow boards involves establishing adequate communication protocols and minimizing the level of effort on the part of the DOT to import data into systems (as occurs with existing permanent monitoring equipment). Each device typically requires individual integration to communicate with servers at a traffic management center (TMC).

Temporary Traffic Control Device Application

Smart arrow boards capture data at the starting point of work zone lane closures. In the future, DOTs could use similar technology to capture data at the ending point. The device is similar to a traditional arrow board, but with the addition of a cellular modem and global positioning system (GPS) antenna.

Figure 6. Traditional Freeway Lane Closure Using an Arrow Board

The Smart Arrow Board includes traditional equipment with the addition of a cellular modem and GPS unit.

As the Manual on Uniform Traffic Control Devices (MUTCD) requires arrow boards on freeway lane closures, contractors and DOT personnel already use the devices to alert motorists of an upstream merging taper. With the addition of technology on the device, the smart arrow board communicates information to a central location for dissemination.

The smart arrow boards report latitude and longitude, GPS-lock status, orientation as a compass heading and information on the display mode (flashing arrow and orientation, sequential chevron and orientation, or caution mode and type). Data reports include a timestamp, GPS information age and whether the arrow board is up or down. Third-party navigation apps such as Waze can also use the information collected to warn drivers of upcoming lane closures on their routes in real time.

Figure 7. Arrow Board Field Location Example

Smart work zone deployments in Iowa include devices that capture real-time information such as video cameras, detectors and dynamic message signs. The DOT routes all smart work zone device information through central traffic management software operated within the TMC. Iowa DOT requires all rented work zone devices to be configured for communication with the existing software, so that one electronic tool can pull data from every device in use.

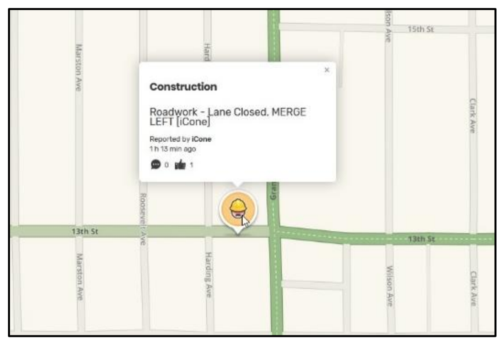

Figure 8. Online Map of Arrow Board Location

The smart arrow boards first communicate with the manufacturer's central server. The DOT then accesses that data from the server. A benefit of this approach is that local agencies can access the information in the same manner without specialized software. Iowa DOT released its communication protocols in the fall of 2019, and the DOT is developing specifications to outline how the smart arrow boards will function in the field.

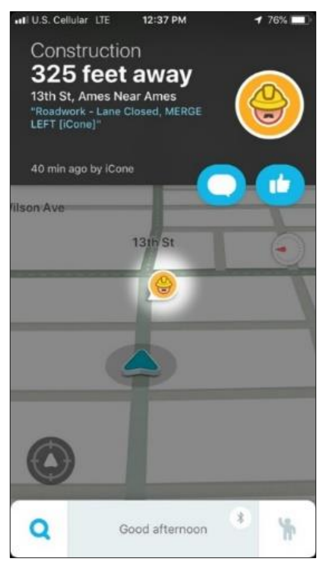

Figure 9. Integration of Data with In-Vehicle App

For example, if the contractor changes the pattern or moves the smart arrow board more than 500 feet, the device provides an update to the data feed within two minutes, along with a health-check message every 30 minutes.

The Iowa DOT is currently testing smart arrow boards from six different manufacturers. Two boards are on DOT vehicles that are performing pavement marking operations, and another is in use by a local contractor on projects.

An additional test of the initial deployment evaluated how the well the communication protocol adds data into the DOT system. Ultimately, the

DOT realizes the benefit of the smart arrow boards with integration and application to work zone operations and performance measurement. If the operational integration works well for the tests of arrow boards, the DOT will expand a similar communication application to a variety of devices, such as portable signals on two-lane roads.

Lessons Learned

Several vendors have smart arrow boards that are ready for use as part of the 2020 lettings in Iowa. The technology application process began in 2017 and included development of a draft specification with input from the industry along with revisions to the requirements. The process began with a vendor showcase and Iowa DOT gathered some of the information used to inform the initiative from recent ATSSA meetings, including the 2020 Traffic Expo. The DOT, the traveling public and other key stakeholders will realize benefits to work zone safety and mobility through the application of smart arrow boards.

Agencies are also using a smart beacon that attaches to vehicle hazard lights and provides information to in-vehicle systems. This device can transmit location, vehicle arrow board status and attenuator status (up/down).

Application of Driveway Assistance Devices in Michigan

The Michigan Department of Transportation (MDOT) identified a need for innovation in temporary traffic control on two-lane highways for projects with lane closures. With several options available for handling traffic on side streets and driveways that approach long stretches of work space, MDOT evaluated the potential for technology to manage traffic entering the traffic space from a driveway.

Work Zone Safety Challenges

MDOT identified several challenges with work zone safety for areas with long expanses of work space on two-lane roadways, including:

- providing clear guidance and safely controlling movements at driveway locations;
- applying an efficient decision-making process for how to optimize resource allocation while maintaining traffic, including the efficiency and safety of traffic regulators (flaggers);
- meeting the requirements of the Manual on Uniform Traffic Control Devices (MUTCD) while also applying experimental technology[1] for controlling traffic; and
- providing for safe entry for traffic from driveways without impeding portable signal timing, including clearance intervals and proper phasing.

[1] MDOT followed the requirements of Part 6 of the MUTCD while also obtaining Request to Experiment (RTE) approval from FHWA. For more information, see MDOT DAD Final Project Evaluation Report.

Temporary Traffic Control Device Application

The Driveway Assistance Device (DAD) is a portable trailer-mounted signal head with signing that is used to control driveway traffic entering a one-lane work zone. For a long stretch of one-way flow on a two-lane road with one lane closed, driveway entry into the traffic space can be confusing for motorists unless they are able to follow a mainline vehicle or platoon of vehicles. In periods of light traffic, turning into the traffic space can be a maneuver that is opposite the flow controlled by portable signals on the mainline. The DAD includes signal heads normally displaying either solid red, flashing left arrow or flashing right arrow indications for motorists entering the mainline from a driveway. The DAD is supplemental and used in conjunction with portable traffic signals on trailers at each end of the work zone that maintain bi-directional traffic.

Figure 10. DAD Installed on M-44 in Michigan

When flaggers control each end of the work zone, flaggers may also control traffic at driveway locations. For long-term projects where temporary traffic control remains throughout the duration, and operations cease at night, agencies use portable signals with long clearance intervals to control alternating traffic in the open and closed lanes. When volumes are light, the situation creates the risk of a motorist turning in conflict with the mainline temporary signal pattern.

Table 1. Observations of Vehicle Compliance with DADs

Project Site[2]	Percentage of Driveway Vehicles Proceeding Correctly[3]
2015 M-44	76%
2016 M-68	79%
2016 US-23	50%
2017 M-66	87%
2018 US-31	71%

Lessons Learned

MDOT collected data at each of five locations from 2015 through 2018 and observed high driver compliance rates for each of the DAD deployments. Compliance rate is directly related to visibility on the project site, meaning that if the device is too close to the mainline signal, vehicles are more likely to turn when the DAD signal is red. If drivers see stopped traffic nearby, then they are more likely to assume it is safe to proceed. In addition, if the driveway is a commercial entry point or a minor side street, the operation may benefit from a right or left turn lane pocket. Driveway volumes less than 400 vehicles per day may be appropriate for this application.

MDOT determined that DADs are a useful and safe device for low-volume driveways due to compliance rates, safe movement observations and the fact that no crashes resulted from use of the device. MDOT

[2] Project sample sizes differ based on number of observations and also daily traffic counts.
[3] Even when vehicles proceeded incorrectly and turned on the solid red indication, they still joined the end of the queue safely (for all sites, 99% of all movements from driveways using the DADs proceeded safely).

did not receive any reports of driver confusion or issues related to the devices. DADs provide flexibility in temporary traffic control by potentially reducing the number of construction stages and providing for safe, efficient traffic movements.

Other Innovative Technologies for Work Zone Applications

Automated Flagger Assistance Devices - Several agencies outline requirements for the use of Automated Flagger Assistance Devices (AFAD) and agencies and contractors have applied such technology for several years. The AFAD provides enhanced safety for flaggers by allowing them to control the devices from a location off the shoulder of the roadway.

Michigan DOT allows use of AFADs for work zones up to 750 feet in length, with low traffic volumes and a good line of sight. The devices also must have a manual intrusion alarm and locked cabinets.

Figure 11. Closed Lane AFAD Application in Michigan

The MUTCD outlines several requirements and recommendations for application of AFADs, including the following condition information:

- AFADs shall be operated only by a flagger who has been trained in proper operation of the AFAD.
- Traffic control shall either include an AFAD at each end of the zone, or an AFAD at one end and a flagger at the opposite end.
- AFADs may be operated by a single flagger if views are unobstructed to the AFADs and for traffic approaching in both directions.
- AFADs may include a stop/slow indication or a red/yellow lens device.

One contractor in Alabama is using a trailer-mounted AFAD with portable camera technology linked to iPads in the field. Flaggers monitor the operation using the iPad and control the devices from a distance. This application has also been used with a pilot car operation, where the pilot vehicle leads traffic through more complicated routes.

Figure 12. AFAD with Video Monitoring in Alabama

Worksite Access Systems - MDOT also uses a system to notify motorists of trucks entering the traffic space from the work space. This system uses a radar sensor on a trailer to detect trucks prior to their entry into the traffic stream and alerts drivers through signs with flashing lights. The sensor in a truck beacon can also map to in-vehicle technology to report information to motorists as they approach. This system reduces issues with close calls and especially improves awareness of speed variability between motorists and trucks entering the traffic stream. The signs can be LED edge-lit for increased visibility. MDOT is currently piloting various sensor types and system components. As pilot projects produced lessons learned, the DOT plans to develop a specification for future implementation and based on product improvements.

Figure 13. Truck Entry Warning System

Smart Work Zone Sensors - In addition to the previously mentioned Smart Arrow Boards, agencies are also experimenting with other devices that report the location of key work zone features. For example, MDOT plans to use “Orange IQ” as part of its smart work zone deployment during the 2020 construction season. This technology can be attached to sign posts to digitally provide a real-time work zone data stream.

Such devices are used to:

- identify the location of a work zone;
- identify who placed the devices or removed the devices and when;
- alert appropriate practitioners if a device needs maintenance;
- document who provided the maintenance activity and when;
- identify the direction the sign is facing;
- document if equipment is stored along the roadside; and
- document the sign type (MUTCD designation).


Figure 14. Orange IQ Sensor Application

The Orange IQ device is a sensor that attaches to the opposite side of a sign post and includes a cellular modem, GPS unit and a digital compass. The sensor includes capacitive touch sensing and has a unique Quick Response (QR) code. The device continuously looks for the appropriate security credentials and realizes if management or movement of the work zone device occurs without proper security credentials (for a sign, for example). To activate the device, users can swipe up or down with a hand motion to make the device active or inactive based on the capacitive touch feature. The process is coupled with Bluetooth wireless security keys through a beacon on trucks or through a smartphone application. If the sign is tipped over or rotated, the technology notifies managers and issues data showing the “standby” mode for the device.

Case Study 3 – Innovative Lane Merge Strategies

Background and Understanding of Traffic Flow

Drivers have an expectation of unencumbered travel and are often impacted by delays due to construction or maintenance. This situation is common with non-recurring congestion caused by freeway and multi-lane highway work zones. Federal, state and local standards identify the requirements for temporary traffic control plans that are based on well-defined design principles. However, driver behavior can have significant impacts on traffic flow at bottlenecks. DOTs and contractors commonly apply various merging strategies for 2-to-1 lane drops, while practitioners may have less information on the benefits of various merging strategies for 3-to-2 or 4-to-3 lane drop configurations. In addition, practitioners continue to desire information on the types of merge conditions that work best for various situations. DOTs have identified ranges of hourly traffic volumes for a stationary lane closure on a four-lane highway of 1,200 to 1,500 vehicles per hour (a 2-to-1 lane drop, for example). Higher volumes result in queues and create potential safety issues on high-speed facilities. Several merge strategies exist for use in traffic control plans, and if queues are unavoidable, agencies also have proven techniques to mitigate the impacts.

Work Zone Safety Challenges

Several challenges exist in adequately accounting for safety at work zone merging tapers, including:

- minimizing queue lengths to the extent practical, and maintaining queues based on defined agency policies (e.g., maximum allowable queue length of 0.75 miles);
- effectively managing speed variability–one of the primary contributing factors to significant crashes (both injury and fatal) at lane closures on high-speed facilities;
- accounting for driver behavior that designers may not have anticipated during the design of the traffic control plan; and
- providing simple, understandable information to drivers on how to merge safely without confusion or other unintended consequences.

Temporary Traffic Control Device Applications

In an effort to better understand the best approach to managing driver behavior at lane closures, agencies have implemented various strategies using static signing, enforcement practices, dynamic indications using technology applications, or a combination of these techniques. If designers expect queuing based on work zone traffic impact analysis results, mitigation strategies can also help manage the impacts if they are unavoidable due to construction or maintenance needs.

Figure 15. Static Early Merge Regulatory Signing Example

Static Early Merge - One example that agencies have implemented for several decades involves the early merge strategy. For a typical 2-to-1 lane closure, the advance warning area may include additional signs that require traffic to merge early into the open lane. The signing includes a simple application of the regulatory “Do Not Pass” sign (or signs) in the location of the expected queue. The early merge strategy is designed to reduce aggressive maneuvers at the merge point where one or more vehicles merge late while others merge early. This situation creates issues with safety and crash risk at the merge point. By using static "Do Not Pass" signs, owner agencies create an enforceable no passing zone at the approach to the merging taper.

Dynamic Early Merge - An enhanced application of the early merge strategy involves a technology application to process data and effectively manage traffic at the lane closure. The dynamic early merge concept creates a dynamic, enforceable no passing zone at the approach to the merging taper. Through the use of trailers with signs, communications equipment and flashing light panels, agencies can control the no passing zone as drivers approach. Michigan DOT used this approach with success on U.S. 131 in Kalamazoo, Mich., where traffic volumes were relatively low on a four-lane limited-access highway. Early merge strategies can create longer queues while attempting to smooth traffic flow and reduce aggressive maneuvers at the merge point.

Figure 16. Dynamic Early Merge Application

Dynamic early merge may include multiple trailers spaced evenly at the work zone approach, with sensors measuring volume, speed and lane occupancy at each location. Amber lights on each side of the "Do Not Pass When Flashing" signs activate when traffic volumes and lane occupancy reach a pre-determined threshold. An example threshold is 10% lane occupancy. One trailer is placed at the merge point, with constantly flashing amber lights at this location. As the detector on each trailer measures occupancy levels above the threshold, communications equipment relays a message to the next upstream trailer, which activates the flashing lights. This data collection and communication continues across multiple trailers (MDOT used a total of five on the Kalamazoo project) and creates the dynamic no passing zone to smooth traffic flow. Enforcement activities can help ensure that drivers comply with the traffic control requirements (agencies may opt for an initial warning period prior to issuing citations).

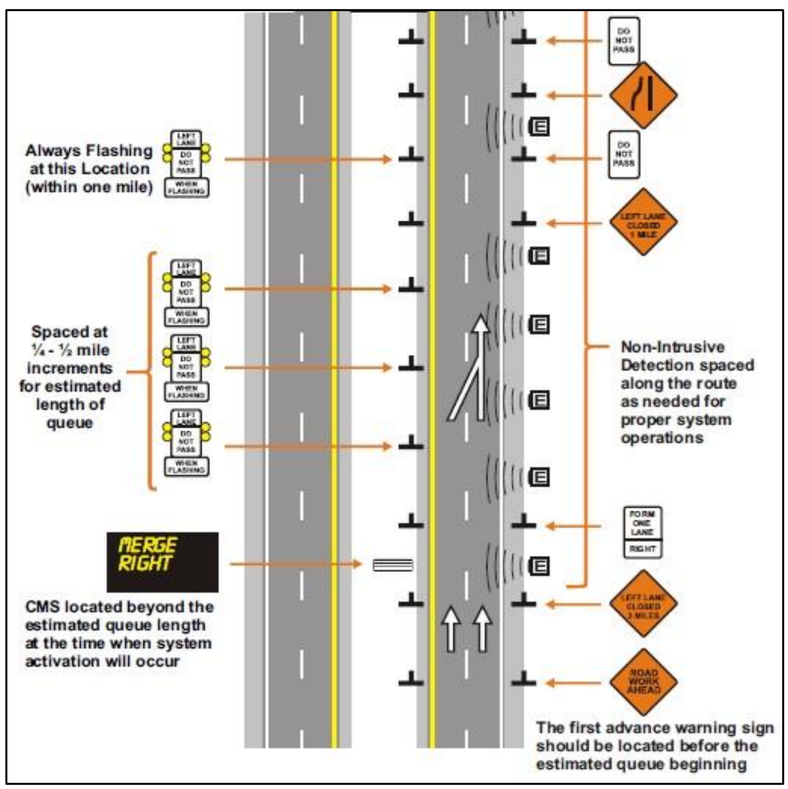

Figure 17. Minnesota DOT Dynamic Early Merge Typical Application

Static Late Merge - Another strategy that has seen more prevalent use in the last decade is the late merge concept. Using this strategy, agencies and contractors manage traffic queues by guiding drivers to use both lanes to the merge point. This concept is also coined the "zipper merge," as traffic merges late and takes turns at the merging taper. Michigan, Minnesota and Virginia are representative states that have typical application examples for the late merge concept. Michigan DOT examples include regulatory signing requiring drivers to use both lanes to the merge point when backups are present. Since drivers are likely to merge early absent any other guidance, the presence of the regulatory signs is especially important in modifying driver behavior to make the merge more efficient and reduce the overall queue length.

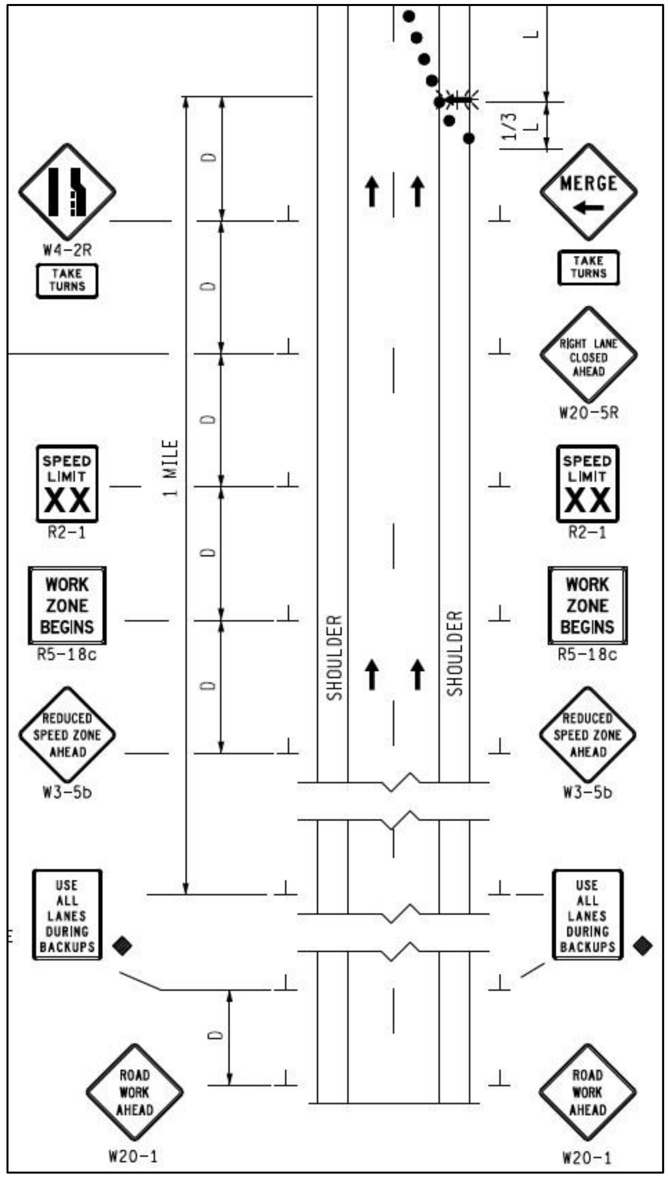

Figure 18. Michigan DOT Static Late Merge Typical Application

Dynamic Merge - Considering the concepts and considerations for early and late merging, agencies have also developed concepts for fully dynamic systems to manage merging patterns. This type of application detects traffic conditions and implements the dynamic early or late merge based on traffic conditions using portable, changeable message signs. For example, if traffic volumes are large enough to create a queue at the merge, but not high enough to produce queues that exceed agency policy levels, then the system initiates an early merge strategy. When traffic volumes are higher and queues would exceed policy limits, the system creates a late merge zone in advance of the taper. This is an advanced application of the merging strategies presented, with a focus on the dynamic nature of traffic volume levels and to optimize the effectiveness of merging strategies based on demand.

Other Innovative Merge Strategies - The Louisiana Department of Transportation and Development (LADOTD) tested an innovative lane merge concept that removes the open lane priority in favor of an alternative merge configuration. This strategy, labeled the "joint merge," simultaneously merges two lanes into one through the use of a two-sided taper. Through an evaluation, researchers determined that the joint merge increased merging efficiency, similar to the effects of the late merge concept (minimizing the queue through the use of the available storage space in both lanes).

To test this merge strategy, LADOTD collected data on Interstate 55 near Hammond, La. LADOTD created the concept by determining that the joint-merge strategy would be a cost-effective traffic control setup that would increase desirable merging maneuvers by combining the benefits of the late merge and the merge followed by a shift (the concept of always closing the right lane). LADOTD designed this concept to create a cooperative environment where motorists share responsibility for merging.

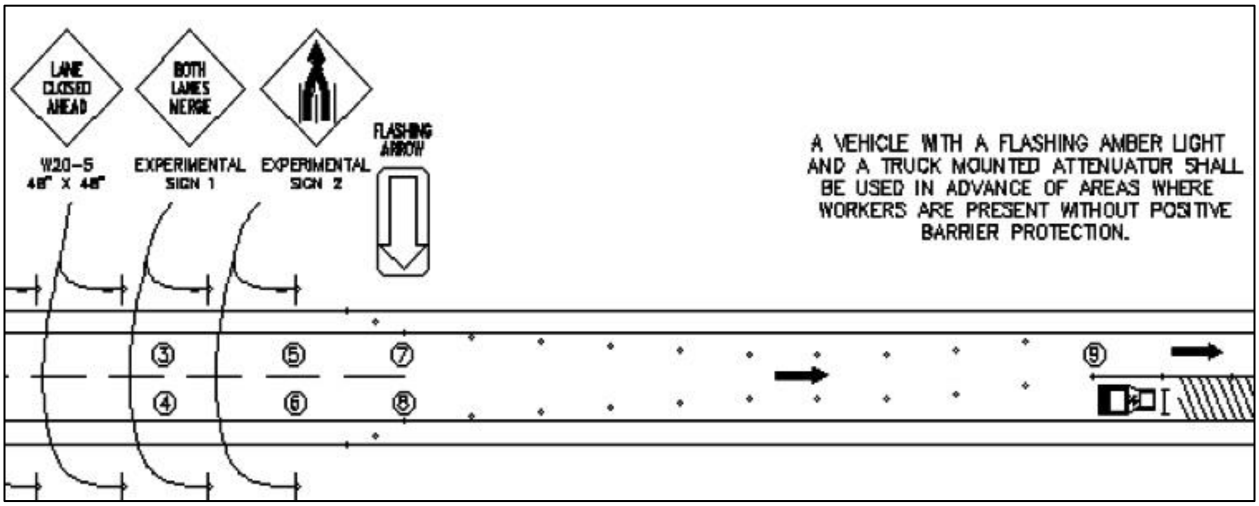

Figure 19. LADOTD Joint Merge Temporary Traffic Control Standard Example

The joint merge evaluation showed lower speeds at certain locations approaching the merging taper, fewer lane changes and more evenly distributed traffic across both lanes as compared with traditional traffic control plans for stationary lane closures. While the agency was not able to evaluate the effects on capacity, drivers easily interpreted and understood the merging requirements based on the altered traffic control configuration.

Protecting the Queue - Several agencies, including the Tennessee Department of Transportation (TDOT) and the South Carolina Department of Transportation (SCDOT), have used contractor pay items to manage the back-of-queue and respective speed variability on freeways. TDOT and SCDOT include such pay items for contractors to maintain presence of advance warning vehicles on freeways when queues are imminent or present. Such advance warning vehicles provide portable changeable message signs mounted on protective vehicles to alert high-speed traffic of slow-moving queues downstream. This application is designed to reduce the risk of back-of-queue crashes and reduce the severity of crashes where speed variability is a contributing factor.

TDOT's special provision for queue protection on limited-access facilities includes the following requirements:

- one queue protection truck for each direction where traffic flow is reduced;
- one additional queue protection truck used as a reserve;
- a truck-mounted attenuator that meets the requirements of National Cooperative Highway Research Program (NCHRP) Test Level 3;
- four rear-facing round yellow strobe lights with auto dimmers;
- one standard cab-mounted light bar;

- a truck-mounted message board on each truck;
- four-hour training for queue truck operators; and
- a truck location of approximately one-half mile upstream from the back of the queue.

Police presence can also help alert drivers to the speed variability conditions caused by work zone queues. Agencies commonly pay contractors to hire off-duty police to provide presence in the work zone or may have an inter-agency agreement with public-safety agencies to provide police presence. For example, the New Jersey State Police has a construction unit dedicated to projects to provide enhancements and improve safety. This unit provides a comprehensive safety approach through specialized training for law enforcement personnel on temporary traffic control to assist with contractor compliance. Agencies use standards to ensure that police officers are protected, including requirements for police vehicle locations such as on the shoulder in advance of the queue or downstream of a protective vehicle with attenuator. Standards vary across agencies for this type of operation.

Lessons Learned

Motorists commonly merge as soon as they see slowed or stopped traffic or warning signs indicating a lane closure ahead. The expectation for merging early is part of the behavior that agencies may try to maintain or change using the techniques outlined in this case study. Agencies have a toolbox of strategies to alleviate traffic impacts caused by work zones and can use the strategies outlined in this document to develop their own typical applications that best fit local needs.

Case Study 4 – Portable Temporary Rumble Strips

Introduction

The installation of temporary rumble strips is a widely accepted traffic control measure at work zones. The installation and removal of temporary rumble strips composed of thermoplastic or marking tapes can take several hours, or even several days in some cases, which limits the use of these materials in short-duration or mobile work zones.

Figure 20. Transport of Portable Temporary Rumble Strips (Photo Credit: Portable Temporary Rumble Strips of Virginia)

The use of portable temporary rumble strips can provide the benefits of temporary rumble strips, while greatly reducing the time and effort required for installation and removal. Portable rumble strips are typically manufactured from polymer or lightweight manufactured plastics and are designed for easy transport, quick installation and removal and deployment at short-term work zones that include both stationary and non-stationary flagging operations.


Figure 22. Installation of Portable Temporary Rumble Strips (Photo Credit: Augusta Free Press)

Effectiveness

Similar to temporary or permanent rumble strips, portable temporary rumble strips alert inattentive drivers to a changing road environment ahead by generating noise and vibration from vehicle tires traveling over the rumble strips. The audible warning also alerts workers to the presence of approaching vehicles. In addition, there is evidence that the installation of temporary rumble strips leads to reduced vehicle speeds and a reduction in rear-end collisions and roadway departures as distracted drivers are alerted to changing roadway conditions.


Figure 21. Installed Portable Temporary Rumble Strips (Photo Credit: Antigo Times)

State Guidelines

Virginia Department of Transportation (VDOT) - The Virginia Department of Transportation (VDOT) has developed guidance for the use of portable temporary rumble strips when entering flagging operations on two-lane roadways and lane closures on multi-lane roadways. The VDOT guidelines state that portable temporary rumble strips shall be used when the following conditions are met:

- Work operations involving flaggers are occurring on a two-lane roadway during daylight hours.
- Work duration of the activity at a location is greater than three hours but less than 72 consecutive hours.
- Existing posted or regulatory speed limit is 35 mph or greater.
- Roadway has a marked centerline.

The guidance further states that portable temporary rumble strips may be considered for use on unmarked two-lane roadways with a width of 18 feet or more. Guidelines also advise that portable temporary rumble strips may be used on roads with posted speeds less than 35 mph under certain conditions, and on a one-lane, two-way application utilizing an Automated Flagger Assistance Device (AFAD) or a portable traffic signal.

The VDOT guidelines state that portable temporary rumble strips shall be installed at the beginning of non-stationary flagging operations. However, repositioning of the rumble strips is not required as the work advances. In addition, portable temporary rumble strips should be located in advance of horizontal curves when possible to enhance visibility for oncoming motorists.

VDOT guidance advises that portable stationary rumble strips shall not be used on loose gravel, bleeding asphalt, heavily rutted pavements or unpaved surfaces, nor shall they be placed through pedestrian crossings or marked bicycle lanes. Furthermore, the guidance states that portable temporary rumble strips are not required if the work is of emergency nature, or if the work zone is in rain, snow or icy weather conditions.

Specifications - The VDOT guidance states that portable temporary rumble strips meet the following specifications:

- They must be used in arrays of three rumble strips.
- Strips should be hinged for rapid deployment and shall be black or orange. The colors shall not be mixed within the work zone.
- They must consist of hinged segments of equal length within the following dimensions:
    - Minimum length: 10 feet 9 inches.
    - Maximum length: 11 feet.
    - Maximum height: 1 foot.
    - Minimum width: 12 inches.
    - Maximum width: 13 inches.
- Strip weight should be from 100 pounds to a maximum of 120 pounds per strip.
- Strips should be able to withstand being run over by an 80,000-pound vehicle and not move more than 6 inches in an eight-hour period.

Installation - VDOT installation guidance states that portable temporary rumble strips shall consist of three rumble strips placed perpendicular to the centerline and parallel to one another in accordance with the following spacing requirements:

Table 2. VDOT PTRS Spacing Requirements by Speed

Posted/Statutory Speed Limit	Less than 40 mph	40-49 mph	Greater than or equal to 50 mph
Spacing (center to center)	10 feet	15 feet	20 feet

When the rumble strip array is installed, the Rumble Strips Ahead (W20-V26) sign shall be utilized. The rumble strip array shall be placed at the same time the advanced warning signs are installed.

The preferred location of the rumble strip array in two-lane operations is adjacent to the Be Prepared to Stop (W3-4) sign but the array can be moved to other locations within the advance warning area based on field conditions and traffic queue. An optional set of rumble strips may be used at the beginning of the buffer space.

When traffic queues prior to the array, the array and rumble strip signs may need to be relocated in advanced of the queue to better serve as a warning device to motorists and removal of PTRS should be accomplished with the removal of the advance warning signs.

Montana Department of Transportation (MDT) - The Montana Department of Transportation (MDT) guidance states that portable temporary rumble strips can be an added safety measure for nighttime flagging operations and projects located on routes with high ADT and roadways likely to experience high probability of distracted drivers (such as roads that are adjacent to national parks or tourist areas). The MDT guidance advises that installation of portable temporary rumble strips be avoided on horizontal curves, steep slopes, fresh seal coats, bleeding asphalt, soft pavement, heavily rutted road or gravel surfaces. The guidance recommends that outreach to residents be conducted to inform them of the noise pollution that can be caused by installation of portable temporary rumble strips.

Specifications - The MDT guidance states that portable temporary rumble strips meet the following specifications:

- provide significant audible and vibratory alerts to drivers;
- dimensions are a minimum of 10 feet long, 1 foot wide and ¾ inch thick;
- maintain position on roadway without the use of adhesives or fasteners;
- maintain rigidity with no curling;
- have a bevel on the leading edge within the range of 11-13 degrees;
- are made of flexible polymer material with a non-slip surface;
- maintain functionality on wet surfaces;
- are capable of being installed and removed without any auxiliary equipment or machinery;
- are deemed safe by the manufacturer for use by motorcycles;
- function at the posted speed limit; and
- meet MUTCD color requirements; if not the same color as the pavement, color can be black, white or orange.

Installation - MDT provides the following guidance on the installation of portable temporary rumble strips.

- All lanes of travel in the same direction receive temporary portable rumble strip coverage.
- Portable temporary rumble strips should be installed so that both front tires of a vehicle will contact the rumble strip at the same time.
- When utilizing the temporary portable rumble strips in advance of flagging stations or signals, place one array of three strips at the “Be Prepared To Stop” (W3-4) or “One Lane Road Ahead” (W20-4) signs. If traffic queues warrant an extended flagging sequence, an additional array can be installed to provide further advance warning.

- If using to alert of a work zone speed change, install an array at the "Reduce Speed Ahead" (W3-5).
- If using to signal a detour, place the array at the "Detour 1000 feet" sign (W20-2).
- If the route experiences high motorcycle traffic, or the presence of the rumble strips causes erratic driver maneuvers, a "Rumble Strip Ahead" sign can be added 200 feet upstream of the rumble strips.
- Portable temporary rumble strips will be removed at the discretion of the Engineering Project Manager (EPM) or when the hazard (i.e., flagging operation) is no longer present.
- Regular inspection of the rumble strips should be conducted to ensure they remain in place and in proper condition. If more than 2 feet of lateral or perpendicular movement occurs, the strips must be reset to original positions.

MDT installation guidance states that portable temporary rumble strips shall parallel each other in accordance with the following spacing requirements:

Table 3. MDT PTRS Spacing Requirements by Speed

Posted/Statutory Speed Limit	Less than 40 mph	41-55 mph	Greater than or equal to 55 mph
Spacing (center to center)	10 feet	15 feet	20 feet

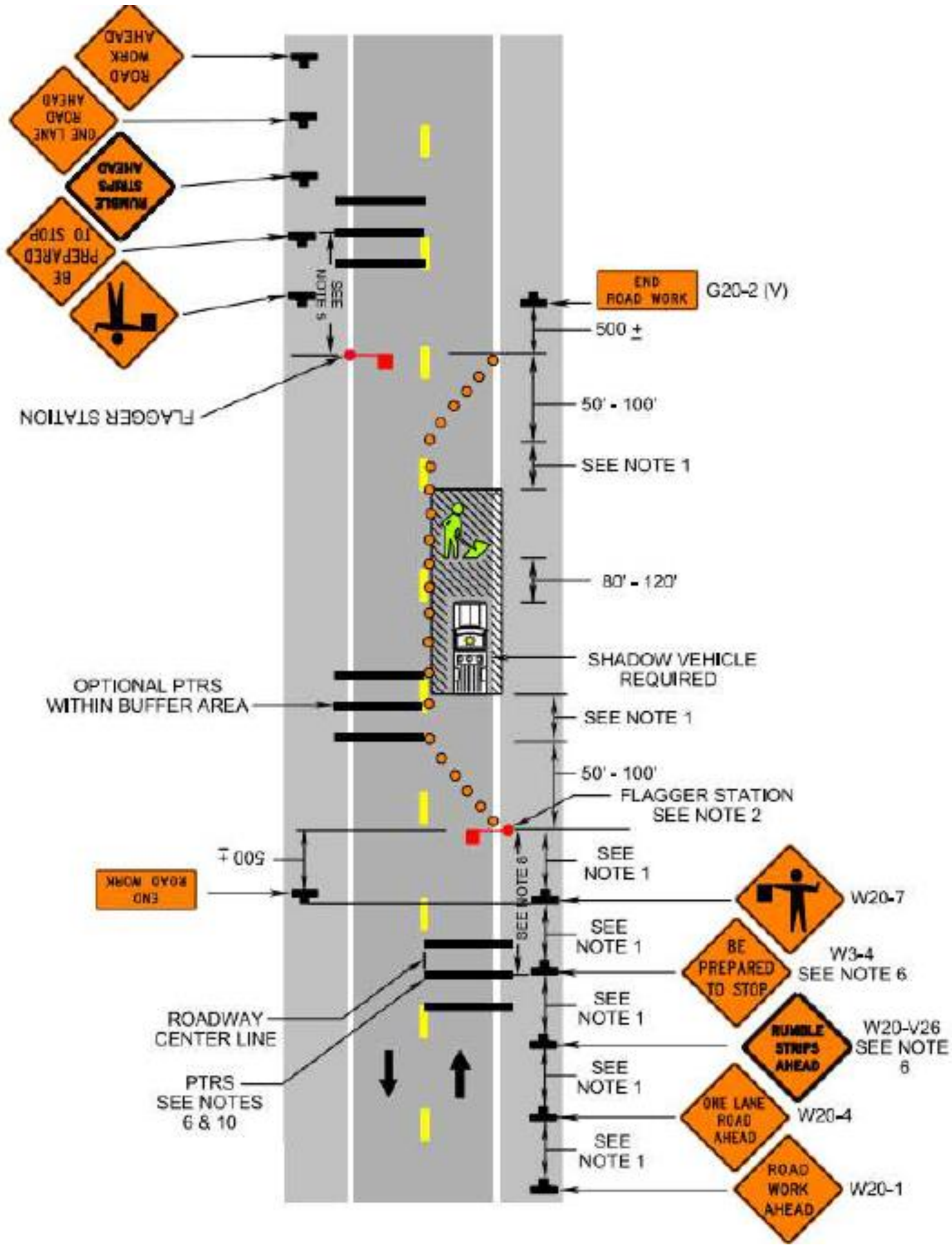

Figure 23. Typical Installation On A Two-Lane Roadway Using Flaggers

Standard:

1. **Tables 6H-2, 6H-3, 6H-4 and 6H-5 shall be used for installing temporary traffic control devices.**

Guidance:

2. *Care should be exercised when establishing the limits of the work zone to ensure maximum possible sight distance in advance of the flagger station and transition, based on the posted speed limit and at least equal to or greater than the values in Table 6H-3. Generally speaking, motorists should have a clear line of sight from the graphic flagger symbol sign to the flagger.*

Standard:

3. **Flagging stations shall be located far enough in advance of the work space to permit approaching traffic to reduce speed and/or stop before passing the work space and allow sufficient distance for departing traffic in the left lane to return to the right lane before reaching opposing traffic. Intersecting roadways in between the work zone's flagger stations shall be controlled by a flagger.**
4. **A shadow vehicle with at least one high intensity amber rotating, flashing, or oscillating light shall be parked 80'-120' in advance of the first work crew.**

Option:

5. A supplemental flagger may be required in this area to give advance warning of the operation ahead by slowing approaching traffic prior to reaching the flagger station or queued traffic.

Guidance:

6. *The location of the PTRS should be adjacent to the BE PREPARED TO STOP (W3-4) sign. If the queue of traffic reaches the BE PREPARED TO STOP (W3-4) sign then the signs and PTRS, should be readjusted at greater distances. The PTRS and the RUMBLE STRIP AHEAD sign can be moved to other locations within the advance warning area based on field conditions.*
7. *When a highway-rail crossing exists within or upstream of the transition area and it is anticipated that queues resulting from the lane closure might extend through the highway-rail grade crossing, the temporary traffic control zone should be extended so that the transition area precedes the highway-rail crossing (see Figure TTC-56 for additional information on highway-rail crossings).*

Standard:

8. **At night, flagger stations shall be illuminated, except in emergencies.**

Option:

9. Cones may be eliminated when using a pilot vehicle operation or when the total roadway width is 20 feet or less.

Standard:

10. **The spacing of the PTRS shall be:**

Posted Speed	< 40 mph	40 – 49 mph	≥ 50 mph
PTRS Spacing (Center to Center)	10 Feet	15 Feet	20 feet

Support:

11. For additional information, see TTC-23 in the 2011 Virginia Work Area Protection manual.

Figure 24. VDOT Work Area Protection Manual Excerpt

Case Study 5 – Nighttime Traffic Control Presence Lighting

Introduction

Nighttime construction provides the benefit of lower traffic levels to manage and cooler temperatures for workers during work activities. But the performance of roadway construction and maintenance activities at night relies upon portable construction and equipment lighting to illuminate the active work area for worker safety.

The Manual on Uniform Traffic Control Devices (MUTCD) does not provide information regarding the appropriate type, quantity or configuration of lighting systems to use for specific work zone activities. Several states have developed guidance to assist in the deployment of lighting equipment within work zones to support work tasks.

The most commonly used temporary lighting systems include:

Portable Light Plant Towers – This lighting consists of numerous luminaires mounted to a mast arm that is capable of holding the luminaires at various mounting heights. The mast arm is attached to a trailer with a generator that can be towed by a vehicle.

Balloon Lighting – This type of lighting consists of a large balloon-type luminaire that provides a fairly large area of evenly distributed light and is relatively glare-free. Balloon lights can be mounted on slow-moving equipment or portable light towers.

Roadway Luminaires Mounted on Temporary Poles – This would consist of any permanent roadway lighting fixture mounted on temporary poles and hard-wired to an electrical system. This type of system would normally be prepared by a lighting design professional.

Factory-Installed Lights on Equipment – Headlights installed on most equipment do not normally provide adequate lighting for most work operations and, as a large component of glare, should not be used when facing any oncoming traffic.

As a supplement to work activity lighting, the deployment of lighting equipment to alert motorists to the presence of a work zone can help drivers see the general direction of the roadway through the work zone and illuminate obstacles along the roadway for motorists to avoid. In addition, the use of presence lighting has proven to be beneficial in reducing average speeds in work zones and therefore may be a beneficial strategy to augment work activity lighting.

North Carolina DOT (NCDOT) Guidance

NCDOT has prepared presence lighting guidance to supplement task equipment lighting during nightly work activities on high-speed (greater than 55 mph) facilities and/or facilities that have significant traffic volumes and impacts. Presence lighting provides lighting to areas of the lane closure without task lighting. If task lighting meets the requirements of NCDOT specifications for the full length of the lane closure, or there is sufficient existing overhead lighting, presence lighting may be eliminated. Presence lighting must not interfere with the task lighting or work operations.

Figure 25. Various Presence Lighting Fixtures

Each light unit shall be capable of providing a minimum of 50,000 lumens illuminating a minimum area of approximately 20,000 square feet. The light shall be capable of being elevated to a height of 14 feet above the pavement.

Each light unit shall be installed along with the lane closure traffic-control devices and moved as necessary to allow for efficient paving operations to take place as well as to not interfere with the contractor's ability to light the work area.

Whenever possible, each light unit shall be placed on the 10-foot paved shoulder according to the above spacing, based on the amount of light output for each unit. Each light unit support structure or mounting stand shall have the capability of being leveled.

The lighting units shall be installed inside the full length of the lane closure and spaced according to the following chart.

Table 4. Presence Spacing Chart

Light Output (Lumens)	Minimum Lighted Fixture Area (Square Feet)	Maximum Spacing (Feet)	Light Units (Per Mile)
50,000 to 65,000	5.5	750	6
66,000 to 80,000	5.5	1,000	5
81,000 to 100,000	36.0	1,250	4

NCDOT conducted a test of work zone presence lighting on U.S. 17. Speed data were first collected one mile downstream from an active work zone without lights. Presence lighting equipment alone was then installed, and speed data were re-collected. Average speed without presence lighting was 57.7 mph and average speed with presence lighting was 51.94 mph, a 5.76-mph average speed reduction. The following table from studies of presence lighting shows similar speed reductions.

Table 5. Speed Studies Conducted at Locations Deploying Presence Lighting

Location	Vehicle Speeds Recorded	Average Speed Without Presence Lights (mph)	Average Speed With Presence Lights (mph)	Average Reduction in Average Speed (mph)
U.S 23 Tawes, Mich.	1,678	56.92	51.27	5.65
I-94WB, Jackson, Mich.	22,145	68.48	62.82	6.95
I-94 EB, Kalamazoo, Mich.	11,191	65.19	57.94	7.25
TN I-40E, Haywood, Tenn.	7,865	68.76	63.82	4.94
TN I-75, McMinn County, Tenn.	12,248	74.76	68.89	5.87

Case Study 6 – Traffic Control for Planned Special Events: South by Southwest Event Austin, Texas

Introduction

South by Southwest (SXSW) is a large special event featuring, music, film and interactive media attended by more than 200,000 registrants each spring in Austin, Texas. The event includes SXSW Music with 2,000-plus acts performing across the city; SXSW Film (with screenings of anticipated movies, panels, and workshops); and SXSW Interactive, which features speakers, panels and also a pitch competition called SXSW Pitch.

SXSW venues are located in the normally congested downtown core of Austin. As a result, city traffic engineers implement eight traffic control plans throughout the duration of the 10-day event to manage the large influx of vehicles and pedestrians accessing SXSW events. These plans detail traffic control equipment requirements and specify road closures, street detours, pedestrian protection strategies and bicycle safety provisions to accommodate the surge in travel demand safely and efficiently. Each year, organizers and planners use the experience gained from prior events to improve travel management as the event grows in popularity.

Traffic Control Measures

Each traffic control plan specifies:

- traffic control device locations;
- device types and amounts;
- setup and pickup times of traffic control devices;
- suggested maximum spacing of devices;
- police officer locations; and
- other additional requirements and notes.

Traffic engineers have developed a great deal of experience managing planned special events as the city is host to more than 130 events each year of various sizes, each requiring a different type and quantity of temporary traffic control devices. Among the policies the city has developed and applied during the SXSW event are the following:

- All closures must maintain access for first responders at all times.
- Enough parking must be provided for the number of participants expected to avoid traffic queuing close to event venues.
- If handicap parking is blocked on a closure, parking must be replaced on an open space or a parking garage.
- Dynamic Message Signs (DMS) are deployed in advance locations displaying event information to alert drivers of closures.
- When possible, access for local residential and business traffic is provided for closed streets.
- A route detour plan is provided for affected main arterials.
- When separating pedestrians and vehicles, 42-inch grabber traffic cones are deployed and a combination of 42-inch and 28-inch cones are spaced at distances dependent on the street speed limit.

- For advance closures on streets with posted speeds above 45 mph, barrels are deployed with a spacing of 50 feet.
- For sidewalk closures, a temporary pathway is maintained with a clear width of 5 feet to accommodate pedestrians in wheelchairs.

Mobility Options

Figure 26 summarizes the various street closures implemented over the duration of SWSX. The 6th street corridor is at the heart of event activities and is designated as one of several pedestrian zones throughout the duration of the event (Figure 27). To support pedestrian travel, the plan also designates the MetroRapid station, bicycle routes, B-cycle bike sharing stations and pedicab staging locations to facilitate no-auto mode use during the event (Figure 28). The plan also incorporates ride-hailing pick-up and drop-off zones located throughout the area to provide registrants another alternative for vehicle access to event venues (Figure 29).

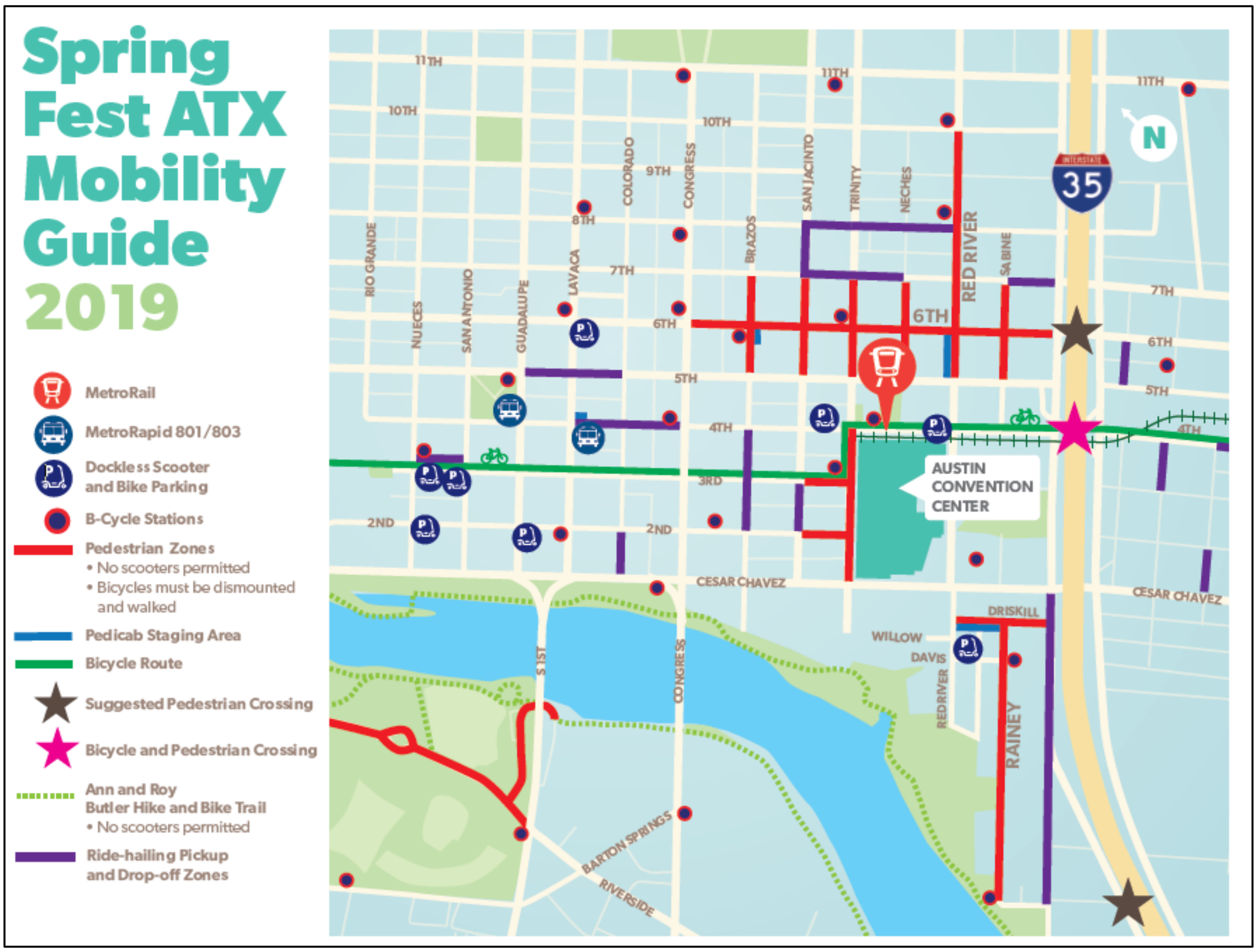

Figure 26. Spring Fest ATX Guide 2019 (Image Credit: City of Austin)

Figure 27. SWSX Pedestrian Nighttime Street Activity on 6th Street (Photo Credit: CNet)

Figure 28. Bike Sharing Station at SWSX (Photo Credit: Curbed Austin)

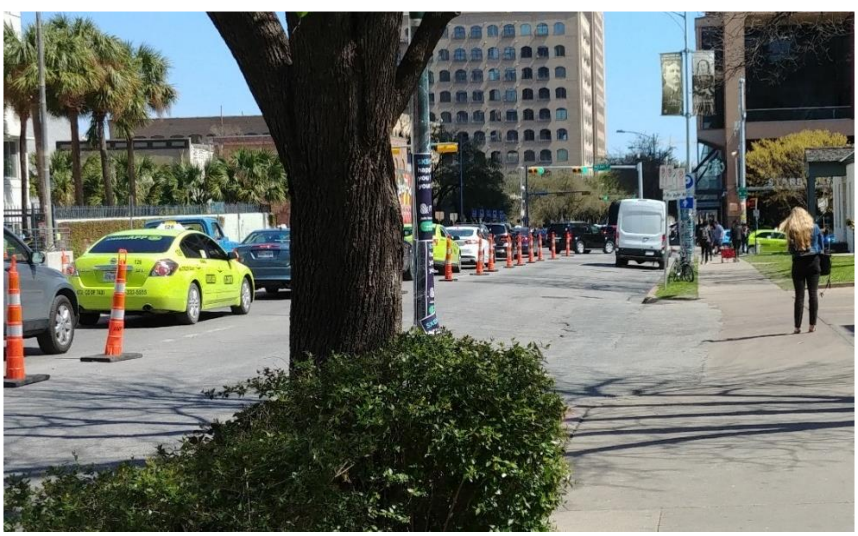

Figure 29. Pick-Up and Drop-Off Location Designated Using 42-Inch Cones (Photo Credit: City of Austin)

Emergency Vehicles and Evacuation

The city fire department requires 25-foot clearance for fire engines when establishing traffic-control plans. The fire department requires that an emergency lane at least 25 feet wide be kept clear with no obstructions at any time. For emergency management purposes, all lane closures are provided with a break between barriers to avoid trapping wheelchair and non-wheelchair users behind barriers in the event of a need for evacuation.

Pedestrian Channelization

Pedestrians are separated from traffic using 42-inch cones as well as water-filled barriers (Figure 30). The 42-inch cones are used to provide pedestrian-vehicle separation because the visibility is much better than smaller 24-inch cones and because shorter cones may lose their locations quickly, causing more trouble for maintaining driving patterns.

Figure 37. Pedestrian Bypass Channelization Using Water-Filled Barriers (Photo Credit: City of Austin)

Lessons Learned

City traffic engineers emphasize that in designing traffic control for special events, it is critical to recognize that drivers can be distracted or confused by new traffic patterns and that sharing information on closures early and often is critical to ensuring safe operations. In addition, traffic engineers learned to appreciate the importance of using larger, brighter devices to attract and hold drivers' attention. For example, the use of 42-inch cones in place of 28-inch cones appears to provide pedestrians with a better feeling of safety. Finally, to increase security, the city police department deploys barricades around the outer perimeter for SXSW and stations two marked patrol vehicles and an officer at each barricade to prevent vehicles from entering festival zones.

Summary and Conclusions

Temporary traffic control for work zones and planned special events requires careful planning and consideration of innovative approaches to minimize impacts. The temporary traffic control approaches highlighted in this document provide work zone safety and mobility benefits when implemented by agencies, contractors and private-sector representatives.

The American Traffic Safety Services Association (ATSSA) is committed to improving work zone safety and reducing injuries and fatalities through outreach on innovative practices. For more information, see ATSSA's website (ATSSA.com) or call 540-368-1701.

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