Guidance on Use of Channelization for Two-Lane Two-Way Work Zone Configurations

Final Report
June 2021

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The preparation of this report was financed in part through funds provided by the Iowa Department of Transportation through its "Second Revised Agreement for the Management of Research Conducted by Iowa State University for the Iowa Department of Transportation" and its amendments.

Technical Report Documentation Page

<table>
<tr><td>1. Report No.
InTrans Project 19-720</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="2" rowspan="2">4. Title and Subtitle
Guidance on Use of Channelization for Two-Lane Two-Way Work Zone Configurations</td><td colspan="2">5. Report Date
June 2021</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="2">7. Author(s)
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InTrans Project 19-720</td></tr>
<tr><td colspan="2" rowspan="2">9. Performing Organization Name and Address
Center for Transportation Research and Education
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664</td><td colspan="2">10. Work Unit No. (TRAIS)</td></tr>
<tr><td colspan="2">11. Contract or Grant No.</td></tr>
<tr><td colspan="2" rowspan="2">12. Sponsoring Organization Name and Address
Iowa Department of Transportation
800 Lincoln Way
Ames, IA 50010</td><td colspan="2">13. Type of Report and Period Covered
Final Report</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code</td></tr>
<tr><td colspan="4">15. Supplementary Notes
Visit https://ctre.iastate.edu for color pdfs of this and other research reports.</td></tr>
<tr><td colspan="4">16. Abstract
Addressing work zone crashes is critical for both the traveling public and highway workers. Two-lane two-way (TLTW) work zone configurations pose a special crash risk because the separation between opposing lanes of high-volume, high-speed, multilane traffic narrows to a head-to-head configuration.

Various traffic control devices (TCDs) are used to separate opposing traffic in TLTW configurations, with each TCD having advantages and disadvantages in terms of cost, safety, and other factors. At the same time, agencies have little guidance as to when and where different configurations should be used.

The objective of this research was to assess the advantages and disadvantages of various types of traffic control devices used to separate opposing lanes of traffic in TLTW work zones and to provide information about their use. The research included identifying the advantages and disadvantages of various types of TCDs, evaluating the effect of different TCDs on truck lane position in Iowa TLTW work zones, and analyzing crashes in Iowa TLTW work zones.

The results of the lane position assessment yielded useful and statistically significant preliminary results. In the analysis of lateral lane position, 20% of large trucks positioned themselves over the right lane line when a portable concrete barrier (PCB) was present, compared to 4% when only tubular markers were present or 3% when curbing with tubular markers was present. Large trucks were most likely to be positioned within their lane when separated from opposing traffic by only tubular markers (73%), compared to 51% when curbing with tubular markers was used or 43% when PCBs were used (43%). The analysis of crashes in TLTW work zones that used tubular markers only or PCBs did not yield useful insights due to the small sample size.

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<tr><td colspan="2">17. Key Words
temporary barrier—traffic control device—two-lane two-way (TLTW) work zone—work zone configuration</td><td colspan="2">18. Distribution Statement
No restrictions.</td></tr>
<tr><td>19. Security Classification (of this report)
Unclassified.</td><td>20. Security Classification (of this page)
Unclassified.</td><td>21. No. of Pages
58</td><td>22. Price
NA</td></tr>
</table>

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

GUIDANCE ON USE OF CHANNELIZATION FOR TWO-LANE TWO-WAY WORK ZONE CONFIGURATIONS

Final Report
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Sponsored by
Iowa Department of Transportation

Preparation of this report was financed in part
through funds provided by the Iowa Department of Transportation
through its Research Management Agreement with the
Institute for Transportation
(InTrans Project 19-720)

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https://ctre.iastate.edu

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ACKNOWLEDGMENTS

The authors would like to thank the Iowa Department of Transportation for sponsoring this project and the project's technical advisory committee for their assistance and insight.

EXECUTIVE SUMMARY

Addressing work zone crashes is critical for both the traveling public and highway workers. Two-lane two-way (TLTW) work zone configurations pose a special crash risk because the separation between opposing lanes of high-volume, high-speed, multilane traffic narrows to a head-to-head configuration.

Various traffic control devices (TCDs) are used to separate opposing traffic in TLTW configurations, with each TCD having advantages and disadvantages in terms of cost, safety, and other factors. At the same time, agencies have little guidance as to when and where different configurations should be used.

The objective of this research was to assess the advantages and disadvantages of various types of traffic control devices used to separate opposing lanes of traffic in TLTW work zones and to provide recommendations for their use. The research included identifying the advantages and disadvantages of various types of TCDs, evaluating the effect of different TCDs on truck lane position in Iowa TLTW work zones, and analyzing crashes in Iowa TLTW work zones.

The results of the lane position assessment yielded useful and statistically significant preliminary results. While no definitive conclusions could be drawn from the crash analysis due to small sample size, some initial patterns did emerge, indicating that evaluation of additional data would be useful.

1. INTRODUCTION

1.1 Background

In 2017, a total of 710 fatal work zone crashes occurred, and these crashes accounted for 1.7% of all roadway fatal crashes in the US (710 of 42,231). Additionally, 94,000 total crashes and 25,000 injury crashes occurred in work zones in 2017, and work zone fatalities on US roads increased by 3.2% from 2016 to 2017 (NWZSIC 2019). Work zone crashes are not only a problem for the traveling public, but they are also a serious concern for highway workers who are injured or killed by errant vehicles. A total of 132 work zone worker fatalities occurred in 2017 (NWZSIC 2019), and 60% of worker fatalities were due to being struck by vehicles in the work zone (NIOSH 2019). Consequently, addressing work zone crashes is critical for both the traveling public and highway workers. Statistics are provided for 2017, since that is the most recent year for which all of the statistics reported above were consistently available.

In particular, two-lane two-way (TLTW) work zone configurations pose a challenging scenario because separated high-volume, high-speed opposing lanes of multilane traffic are narrowed to a head-to-head configuration, resulting in potential conflicts between oncoming lanes.

Traffic control devices (TCDs), including channelizers and temporary barriers (e.g., concrete), are used to separate opposing traffic in TLTW configurations, as shown in Figure 1.

Willie Sorenson, Iowa Department of Transportation

Figure 1. TCDs used in Iowa work zones to separate traffic in TLTW operations

Each device has different advantages/disadvantages in terms of cost, safety, mobility, and ease of application/removal. Channelizers (e.g., tubular markers, cones, barrels) are the most cost effective and easy to place or move in a work zone. However, in high-speed operations, they provide minimal protection from opposing vehicles. Temporary barrier rails (TBRs) provide positive protection from oncoming vehicles but is significantly more expensive and not as easily moved. Additionally, TBRs often have a wider footprint and occupy more of the travel lane, which may restrict traffic flow. Meanwhile, agencies have little guidance as to when and where different configurations should be used.

1.2 Problem Statement and Approach

The objective of this research was to assess the advantages and disadvantages of various types of traffic control devices used to separate opposing lanes of traffic in TLTW work zones and to provide recommendations for their use. The research included an evaluation of the safety and operational impacts as well as an assessment of the tradeoffs in terms of benefit and cost.

1.3 Summary of Results

This report documents the following activities.

1.3.1 Summary of Traffic Control Devices Used to Separate Opposing Lanes of Traffic in TLTW Operations

Several different types of traffic control devices are used to separate opposing traffic in TLTW work zone configurations. These include channelizers (e.g., tubular markers, cones, barrels) as well as various types of temporary barriers (e.g., concrete). The types of devices used to separate opposing traffic and their advantages and disadvantages in terms of their use in TLTW work zones is summarized in Chapter 2.

A literature review was also conducted to determine whether any studies have evaluated the safety impacts of TCDs in TWTL work zones. Three studies were found that evaluated work zone barriers in general, but none were found that evaluated barriers in TLTW work zones.

1.3.2 Summary of State Practices for Use of Channelizers or Barriers in TLTW Operations

Chapter 3 summarizes guidance from 24 states on the use of channelizers or barriers in work zones with TLTW configurations. In most cases, the available guidance is for positive protection devices.

1.3.3 Evaluation of Lane Position in TLTW Operations

Chapter 4 summarizes an evaluation of lateral lane position in TLTW work zones.

Iowa work zones during the 2019 and 2020 construction seasons were reviewed, and those with two-lane two-way configurations were identified. For the 2019 construction season, three different work zones were identified that used curbing with tubular markers. Two locations were found that utilized only tubular markers as the separator between opposing lanes. Only one location was found that used a concrete barrier. No other barrier types were found for TLTW operations.

For the 2020 construction season, three locations were identified that used curbing with tubular markers, and one location was identified that utilized tubular markers. Unfortunately, no locations with portable concrete barriers or other positive protection devices were found.

One measure used to assess the safety impact of a device is lane position. Vertical channelizers and barriers provide both an actual and psychological barrier, which may cause a sense of friction. Objects that present a greater sense of friction (portable concrete barriers [PCBs] versus channelizers) may result in an increased chance that drivers will position themselves away from the object. In particular, there was concern that if large trucks position themselves away from the centerline, there is an increased likelihood of lane departure.

The actual position of a vehicle within its lane (i.e., inches from the center or right lane line) could not be extracted without a significant amount of manual data reduction. As a result, categorical measures were used to evaluate vehicle position within a lane. Lane position was only reduced for large trucks, which included single-unit (SU) trucks and larger. Data reductionists were used to manually reduce vehicle position within the lane. The results are summarized by type of separator and are presented by 2019 or 2020 construction season.

The results for the 2019 construction season indicated that trucks in work zones that used portable concrete barriers were more likely to cross over the edge line (20%) than when either of the other treatments were used (4% for tubular markers only and 3% for curbing with tubular markers).

Large trucks were more likely to be positioned on top of the right lane line when curbing with tubular markers was present (46%) than when other separators were present (37% for PCB and 23% for tubular markers only).

Large trucks were most likely to be positioned within their lane when opposing TLTW traffic was separated by only tubular markers (73%). Only 51% of large trucks were positioned within their lane when curbing with tubular markers was used. Large trucks were least likely to be positioned within their lane when PCB was present (only 43%).

No PCB sites were available for the 2020 construction season. When curbing with tubular markers was present, drivers were slightly more likely to position themselves over the right lane line than when only tubular markers were present (1.6% versus 0.1%). However, drivers were less like to drive on top of the lane line when curbing with tubular markers was present (22% versus 44%). Additionally, 77% of drivers stayed within the lane lines when curbing with tubular markers was present, while 56% of drivers did so when only tubular markers were present (56%).

1.3.4 Evaluation of Crashes

A simplistic crash analysis was conducted as described in Chapter 4. Crash rates could not be established because the study period was short and there were a number of factors that could have impacted crash rate but could not be accounted for (e.g., length of work zone, traffic volume, duration of work zone). As a result, the type of crash and sequence of events were compared for different types of separator.

The begin and end point of each work zone was identified, along with construction dates. Crashes that occurred within these locations/times were extracted. Only work zones for the 2019 construction season were included in the crash analysis because traffic behavior during the COVID-19 pandemic was highly irregular and no work zones with PCB were found.

One work zone used tubular markers, three work zones used curbing with tubular markers, and one work zone used portable concrete barriers. Crashes were combined by type of separator. As noted above, the length of the work zone, work zone duration, and traffic volume varied by site. Additionally, only curbing with tubular markers was present at more than one work zone. As a result, significantly more crashes were available for work zones that used curbing with tubular markers (n = 216) than for work zones that used tubular markers only (n= 28), and only 10 crashes were available for the work zone that used PCB.

Since crash rate could be utilized, the first sequence of events for each crash was evaluated to determine whether there was a pattern (e.g., crossed centerline, run-off-road [ROR] right). For instance, if ROR left crashes were more prevalent when PCB was present, this may suggest that drivers position themselves away from the barrier. The type of crash was also summarized (e.g., rear-end, head-on). Due to the sample size, no pattern or useful insights emerged from the analysis. However, it is likely that with a sufficient number of work zones (particularly those with PCB) a pattern of crash types could be established.

2. TRAFFIC CONTROL DEVICES FOR SEPARATION OF OPPOSING TRAFFIC IN TLTW OPERATIONS

Several different types of traffic control devices are used to separate opposing traffic in TLTW work zone configurations. These include channelizers (e.g., tubular markers, cones, barrels) as well as various types of temporary barriers (e.g., concrete). The following sections provide a summary of the types of devices used to separate opposing traffic and their advantages and disadvantages in terms of their use in TLTW work zones. TBRs and other TCDs are also used to protect workers and shield traffic from other work zone hazards, but this type of traffic control is not the focus of this report.

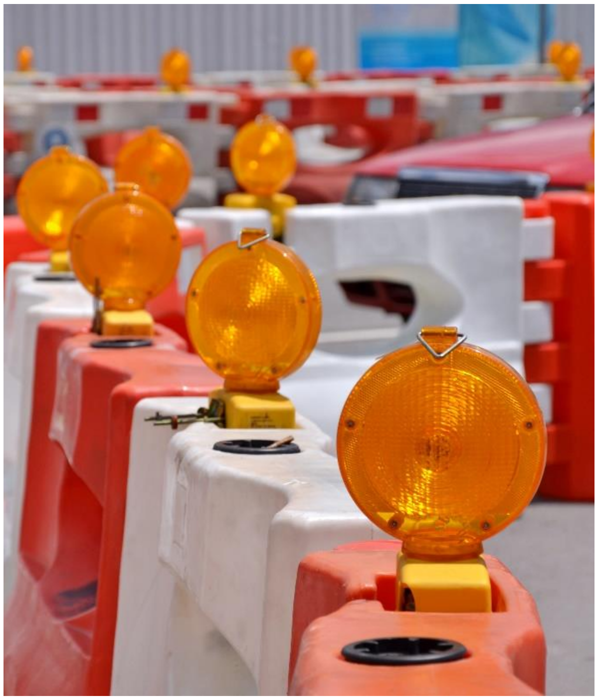
Note: Multiple resources are available for the selection and use of barriers and other positive protection devices (PPDs). The objective of this report was to summarize guidance on the use of devices in TLTW configurations. As a result, this document does not provide a comprehensive overview of the advantages/disadvantages of or methods for selecting, configuring, and applying channelizers or PPDs.

2.1 Type of Channelizers

Channelizers are traffic control devices that provide separation or channelization of traffic. They include barrels, cones, panels, tubular markers, raised channelizers or markers, and non-ballast-filled longitudinal channelizers. Channelizers do not shield or redirect errant traffic. However, they are typically much lower in cost and easier to set up and move than temporary barriers. As a result, various types have been used in TLTW work zone configurations to separate opposing lanes of two-way traffic.

2.1.1 Longitudinal Channelizing Devices

Longitudinal channelizing devices (LCDs) are lightweight and deformable channelizing devices that can be used singly or in a connected system (AASHTO 2011). They are designed to channelize but not redirect errant vehicles (ARTBA 2018). Similar devices are designed to be filled with ballast and are used as temporary barriers; these devices are discussed in Section 2.2.3. Typical dimensions of LCDs are 32 to 36 inches tall and 18 inches wide. Figure 2 shows an example of a longitudinal channelizing device.



sevenke/Shutterstock.com

Figure 2. Longitudinal channelizer

Advantages:

- Compared to other channelizers, they provide the appearance of being a formidable object
- Highly visible
- Lightweight
- Portable but larger than other channelizing devices

Disadvantages:

- Not as easily moved as other channelizing devices such as cones, panels, or drums
- Do not provide positive protection
- Width (18 inches) occupies more of the available lane cross-section than other channelizing devices, though less than most PPDs

2.1.2 Cones and Tubular Markers

Tubular markers are cylindrical devices with a broad base that can be fastened to the pavement to be self-restoring. Cones are conical devices with a wider base that decrease in width at the top of the device. Figures 3 and 4 show examples of tubular markers and cones, respectively.

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Figure 3. Tubular markers

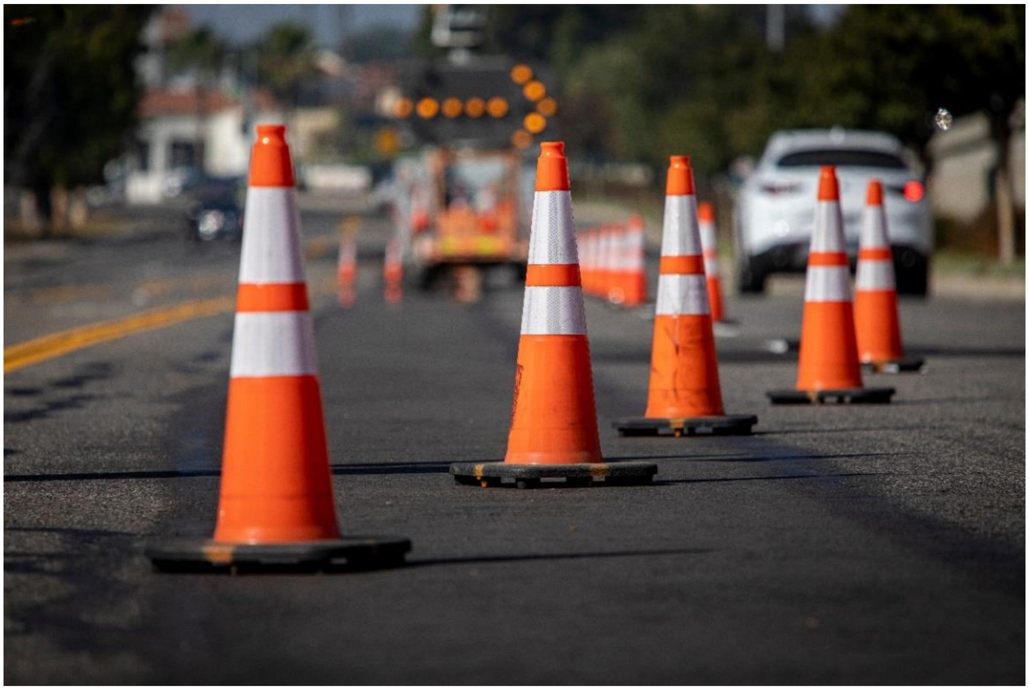

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Figure 4. Cones

Cones and tubular markers are primarily used for delineating or channelizing. Both provide delineation to separate opposing lanes of traffic but provide no positive protection.

Cones are typically 28 to 48 inches tall with a 14- to 15-inch-wide base. Tubular markers are 42 to 49 inches tall with a base that is 8 to 12 inches wide. Tubular markers are used alone (Figure 3, left) or in combination with raised curbing (Figure 3, right).

Advantages

- Lightweight:
- Portable
- Easy to set up or move
- Not likely to damage vehicles when struck
- Lower cost than other devices
- Visible to drivers
- Width (8 to 12 inches) occupies a minimal amount of the available lane cross-section

Disadvantages:

- No redirective capabilities
- Not designed to provide positive protection
- Unanchored devices may need to be continually replaced

2.1.3 Vertical Panels

Vertical panels are post-mounted signs that are striped downward in the direction of traffic flow. They may be designed to be rigid or self-righting when impacted (AASHTO 2011). Typical dimensions are 24 to 44 inches tall with an 8- to 15-inch-wide base. Similar to cones and tubular channelizers, vertical panels provide delineation to separate opposing lanes of traffic but provide no positive protection. Figure 5 shows an example of vertical panels.

val lawless/Shutterstock.com

Figure 5. Vertical panels

Advantages:

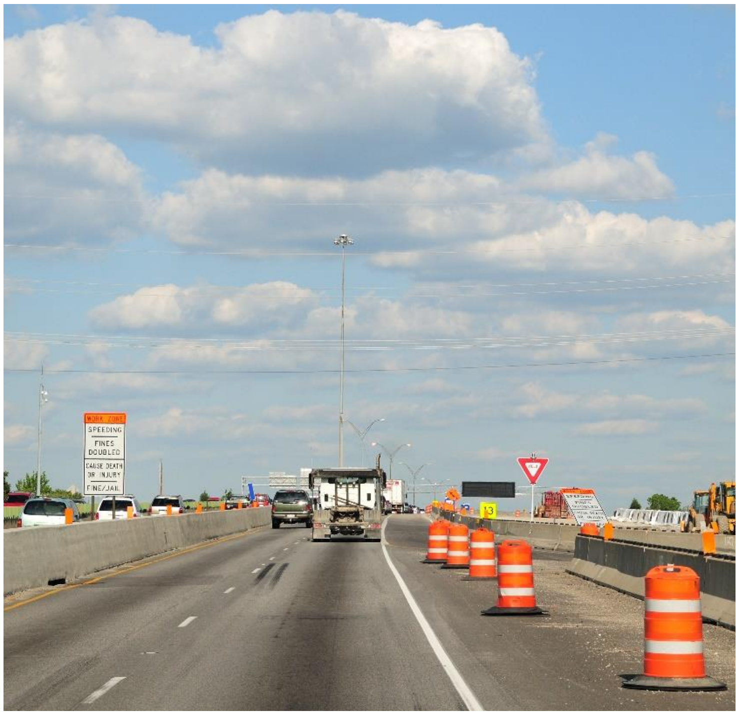
- Lightweight
- Portable
- Easy to set up or move
- Not likely to damage vehicles when struck
- Lower cost than other devices
- Visible to drivers
- Width (8 to 15 inches) occupies a minimal amount of the available lane cross-section

Disadvantages:

- Do not redirect errant vehicles or provide any positive protection
- Unanchored devices may need to be continually replaced

2.1.4 Drums

Drums are made of lightweight, flexible, and deformable material. They provide delineation to separate opposing lanes of traffic but do not provide any positive protection. They are usually cylindrical with a height of 35 to 42 inches and a width of 18 to 24 inches (AASHTO 2011). Figure 6 shows an example of drums.



Anne Kitzman/Shutterstock.com

Figure 6. Drums

Advantages:

- Lightweight
- Portable
- Easy to set up or move
- Lower cost than other devices
- Provide a high level of visibility to drivers due to their size

Disadvantages:

- Does not redirect errant vehicles or provide any positive protection
- Width (18 to 24 inches) occupies a greater amount of the available lane cross-section than other channelizers

2.2 Temporary Barriers for Positive Protection in Work Zones

Barriers are traffic control devices used to shield motorists from natural or human-made objects or from traffic (AASHTO 2011). Barriers do not prevent crashes but may reduce the severity of a crash by redirecting the vehicle or providing a more forgiving surface when an impact occurs. However, the presence of a barrier itself presents an object that can be struck.

Most barriers used in TLTW work zones are PPDs. The Federal Highway Administration (FHWA) defines PPDs as devices that contain and/or redirect vehicles and meet the crashworthiness evaluation criteria contained in National Cooperative Highway Research Program (NCHRP) *Report 350: Recommended Procedures for the Safety Performance Evaluation of Highway Features* (Hoss et al. 1993). Examples of different types of positive protection devices include portable concrete barriers, ballast-filled barriers, steel barriers, moveable concrete barriers, shadow vehicles with attenuators, and vehicle arresting systems.

While the primary function of a PPD is protection, it may also be used to channelize traffic. Markings and other devices may be added to the barrier to enhance its visibility.

The *Roadside Design Guide* (AASHTO 2011) and materials developed by a number of state transportation agencies include guidance on the use of positive protection to protect highway workers or when roadside hazards (e.g., drop-off, unfinished bridge decks) are present. Less guidance is given on the use of PPDs versus other channelizers to separate opposing lanes of traffic.

The *Roadside Design Guide* (AASHTO 2011) indicates that barriers in work zones have several functions, including the following:

- Reduce the likelihood of vehicles entering work areas
- Provide protection for road workers
- Separate two-way traffic
- Protect exposed objects
- Provide protection for pedestrians

The American Traffic Safety Services Association (ATSSA) provides guidance for the selection of appropriate positive protection in work zones, which considers the following criteria (ATSSA 2006):

- Project scope and duration
- Anticipated speed
- Anticipated traffic volume
- Vehicle mix – greater impact of heavy vehicle intrusion
- Type of work
- Presence of escape paths
- Time of day
- Consequences to road users from a roadway departure
- Hazards to workers during barrier installation and removal
- Geometrics and/or work area restrictions
- Access to and from the work area
- Roadway class
- Impact on project cost and duration

2.2.1 Portable Concrete Barriers

PCBs are some of the most widely used longitudinal positive protection devices. They typically consist of segmented units that are attached end to end by a load-bearing connection. This type of barrier is able to redirect errant vehicles from oncoming traffic or the work zone activity area (ARTBA 2018). Anchored PCBs typically have a lateral deflection of less than 1 foot, while unanchored PCBs deflect 2.5 to 6 feet (ARTBA 2018). When used to divide opposing traffic lanes in a TLTW work zone, the impact deflection distance needs to be considered (ATSSA 2015). Concrete barriers are typically 32 to 42 inches tall and 24 to 32 inches at the widest part of the base. Figure 7 shows an example of a concrete barrier.

Kenneth Sponsler/Shutterstock.com

Figure 7. Portable concrete barrier

Advantages:

- Provides both channelization and positive protection
- Can prevent head-on or sideswipe collisions in TLTW work zones
- Can redirect errant vehicles

Disadvantages:

- May be harder for drivers approaching work zones to see during the night and in adverse weather conditions (e.g., rain, fog, haze) (Noel et al. 1989)

- High weight (depending on design, PCBs can vary from 400 to 720 pounds per foot); as Figure 8 shows, for the same number of PCB and steel barrier units, substantially more truckloads would be required to transport the PCB units
- Substantial installation and removal costs (ATSSA 2015)
- Requires adequate space for heavy equipment to install and remove the barrier (ATSSA 2015)
- Width (24 to 32 inches) occupies a greater amount of the available lane cross-section than other channelizers
- The barrier itself can be an obstacle (Bremer et al. 2019)
- Requires lateral space to function appropriately
- Compared to lighter weight devices (panels, cones, drums, etc.), concrete barriers can be difficult to reposition, making it difficult to adapt to changing conditions in the work zone
- Accommodation needs to be made for drainage

MSWZSC 2015

Figure 8. Truckloads with barriers: 750 linear feet of steel barriers (left) versus 100 linear feet of portable concrete barriers (right)

2.2.2 Moveable Concrete Barriers

Moveable concrete barriers (MCBs) have been used in situations where a work zone needs to be reconfigured frequently. MCBs require substantial cost and effort to install, limiting their use to longer duration applications. Reconfiguring MCB barriers (once initial installation is complete) proceeds quickly and with minimal disruption to traffic. This type of barrier is useful in scenarios where directional flow, frequent opening/closing of lanes, and changing work zone widths are needed (Schrock et al. 2013). MCBs have similar dimensions to PCBs, with a typical height of 32 inches and an 18- to 24-inch-wide base.

Advantages:

- Provides both channelization and positive protection
- Can prevent head-on or sideswipe collisions in TLTW work zones
- Can redirect errant vehicles

Disadvantages:

- May be harder for drivers approaching work zones to see during the night and in adverse weather conditions (e.g., rain, fog, haze) (Noel et al. 1989)
- High weight
- Substantial installation and removal costs (ATSSA 2015)
- Requires adequate space for heavy equipment to install and remove the barrier (ATSSA 2015)
- Width (18 to 24 inches) occupies a greater amount of the available lane cross-section than other channelizers, though less than PCBs
- Requires specialized equipment to move the barrier
- The barrier itself can be an obstacle (Bremer et al. 2019)

2.2.3 Ballast-Filled Barriers

Ballast-filled barriers consist of segmented longitudinal barriers with a polyethylene plastic shell and steel framework that are filled with ballast (AASHTO 2011). To function as a barrier, the device needs to meet testing requirements to safely redirect, slow, or stop errant vehicles. Similar looking devices are also used but are "barricades" or "channelizers" and do not serve the same purpose (AASHTO 2011). Figure 9 shows an example of a ballast-filled barrier.

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Figure 9. Ballast-filled barrier

Typical ballasts include water and sand. Water lends itself to short-term or temporary work activities, while sand may be more suitable for longer periods. Water is easier to transport, handle, and dispose of but may not be desirable in cold weather due to freezing. Additionally, the exterior shell of the barrier devices may become brittle due to exposure to cold weather, potentially causing issues with the ballast material.

Anchored water-filled barriers typically have a lateral deflection of 9 feet, while unanchored water-filled barriers deflect 11.2 to 22.6 feet (ARTBA 2018). Common ballast-filled barriers are 32 inches tall and 18 to 21 inches wide.

Ballast-filled barriers are typically used (ATSSA 2015) in the following scenarios:

- Where large deflections are less likely due to lower traffic speeds or low impact angles
- Where large deflections can be accommodated
- Where space is too limited to allow heavy equipment
- Where travel lanes are narrow with low speeds

Advantages:

- Provides both channelization and positive protection
- Can prevent head-on or sideswipe collisions in TLTW work zones
- Can redirect errant vehicles
- Lower cost and lighter weight than PCBs, making ballast-filled barriers easier to install and move
- May be more visible than PCBs
- May be a more forgiving surface if struck than PCBs

Disadvantages:

- Requires equipment to install and remove the barrier (ATSSA 2015)
- Higher installation and removal costs than channelizers
- Width (18 to 21 inches) occupies a greater amount of the available lane cross-section than other channelizers, though less than concrete barriers
- Requires specialized equipment to move the barrier
- The barrier itself can be an obstacle (Bremer et al. 2019)

2.3.4. Steel Barriers

Steel barriers consist of portable longitudinal barriers of galvanized steel with varying lengths that can redirect errant traffic and provide positive protection for roadway workers (AASHTO 2011). They are typically used in short-term work zones where barriers need to be placed and removed regularly (ARTBA 2015). They can be anchored down to minimize deflection. Anchored steel barriers typically have a lateral deflection of 0.4 to 6.3 feet, while unanchored steel barriers deflect 6.3 to 13.1 feet (ARTBA 2018). Steel barriers are typically 32 inches tall and 22 inches wide.

Advantages:

- Provides both channelization and positive protection
- Can prevent head-on or sideswipe collisions in TLTW work zones
- Can redirect errant vehicles
- Lightweight and usually stackable, allowing larger quantities to be loaded onto a single truck compared to PCB (AASHTO 2011) (see Figure 8, which compares a truckload of PCBs to a truckload of steel barriers)
- Relatively easy to install compared to other TBRs
- May be a more forgiving surface if struck than PCBs

Disadvantages:

- High cost
- Requires equipment to install and remove the barrier (ATSSA 2015)
- May not be as visible to drivers as other devices
- Width (22 inches) occupies a greater amount of the available lane cross-section than channelizers, though approximately as much as other PPDs
- The barrier itself can be an obstacle (Bremer et al. 2019)

3. SUMMARY OF STATE PRACTICES FOR USE OF CHANNELIZER OR BARRIERS IN TLTW

The following sections summarize guidance from several state departments of transportation (DOTs) on the use of channelizers or barriers in work zones with TLTW configurations. In most cases, the available guidance is for positive protection devices.

3.1 Alabama

The Alabama DOT (ALDOT) provides guidance for PPDs, including warrants for their use on roadways with speeds greater than 45 mph. The warrants include use of PPDs for separation of opposing traffic on Interstate and high-speed facilities with high truck volumes (ALDOT 2011).

3.2 Arkansas

The Arkansas DOT (ArDOT) uses a document called *Policy for Work Zone Safety and Mobility* (ArDOT 2015). No direct information is provided on the use of channelizers or barriers for TLTW configurations. A survey of state practices on positive protection in work zones found that Arkansas utilizes protection in head-to-head work zones on Interstate rehabilitation projects where one set of lanes is closed on a four-lane divided freeway (CTC & Associates, LLC 2017).

3.3 Colorado

The Colorado DOT (CDOT) has guidance for the use of positive protection devices that includes their use for separation of opposing traffic (CDOT 2010). Specifically, positive separation is considered in situations where multilane divided facilities are temporarily shifted to a two-lane two-way traffic pattern for periods longer than three days. Conditions that influence the decision to use positive protection are high-speed facilities, narrowed lanes, and high traffic volumes (CDOT 2010).

3.4 Delaware

The *Delaware Manual on Uniform Traffic Control Devices* (DelDOT 2011) provides some guidance on use of positive protection in work zones but does not provide guidance for head-to-head configurations. A survey of state practices on positive protection in work zones found that Delaware rarely uses barriers in head-to-head configurations due to space constraints. It is required on limited-access high-speed roadways and is used on a case-by-case basis for other roadways (CTC & Associates, LLC 2017).

3.5 Florida

Florida has guidance on the use of temporary concrete barriers but does not have guidance on the selection of barriers for head-to-head work zone configurations (FDOT 2018)

3.6 Georgia

Georgia has a document called *Work Zone Safety and Mobility Policy* (GDOT n.d.), but the document does not have any guidance on the use of separators in TLTW work zones.

3.7 Idaho

The Idaho Transportation Department (ITD) has a *Work Zone Safety and Mobility Program* document (ITD 2012) that provides guidance on the use of longitudinal or other PPDs in work zones. Their use is considered in situations that include work zones with durations of two weeks or longer and where operating speeds are 45 mph or higher. The need for their use is based on an engineering study.

3.8 Illinois

The Illinois Department of Transportation (IDOT) has a *Safety Engineering Policy Memorandum* (IDOT 2006), but the document does not have any guidance on the use of separators for TLTW work zones.

3.9 Indiana

The Indiana DOT (INDOT) has a *Policies, Processes, and Procedures for Work Zone Safety and Mobility* document that has recommendations on the use of PPDs, which includes the use of PPDs for worker safety (INDOT 2015). The guidance also indicates that positive protection should be considered where it provides the highest potential for increased safety for road users.

3.10 Iowa

The research team was not able to find guidance on the use of temporary barriers or guidance for the separation of traffic in TLTW work zone configurations for Iowa.

3.11 Maryland

Maryland has a policy for the use of temporary barriers in work zones. A screening is suggested to determine the need for temporary traffic barriers. One scenario where barriers may be warranted is when there is a need to separate opposing directions of traffic, such as when two-way traffic is present on one roadway of a normally divided facility. If a temporary barrier is warranted, a traffic engineering study is used to confirm the need for the barrier and to determine the most appropriate type of barrier (MDSHA 2021).

3.12 Massachusetts

Temporary barrier design guidance was not found for Massachusetts. However, a survey of state practices on positive protection in work zones found that Massachusetts requires the space between the barrier face and the roadway's yellow edge line to meet or exceed the tested permanent deflection value of the barrier (CTC & Associates, LLC 2017).

3.13 Michigan

Michigan has guidance on the use of temporary barriers in work zones. The guidance suggests the use of barriers to separate opposing directions of freeway traffic but does not provide specific guidance for their use in head-to-head configurations (MDOT 2020)

3.14 Minnesota

The Minnesota DOT (MnDOT) has a manual that provides guidance on the use of temporary barriers (MnDOT 2018), including guidance on the use of portable concrete barriers. MnDOT does not generally use portably concrete barriers for head-to-head configurations. Typically, tube delineators, temporary raised pavement markers, and striping are used. However, PCBs have been used on specific freeways in the Twin Cities metropolitan area (CTC & Associates, LLC 2017).

3.15 Nebraska

Temporary barrier design guidance was not found for Nebraska. However, a survey of state practices on positive protection in work zones found that Nebraska only uses temporary barriers when there are two or more lanes in each direction (CTC & Associates, LLC 2017).

3.16 New Hampshire

New Hampshire follows the AASHTO *Roadside Design Guide* and the *Manual on Uniform Traffic Control Devices* (MUTCD) for all temporary protection (NHDOT 2010)

3.17 New Mexico

The New Mexico DOT (NMDOT) has a *Design Manual* that addresses temporary traffic control on two-lane two-way operations on one roadway of a normally divided highway. The guidance states that opposing traffic shall be separated with either a temporary traffic barrier (concrete safety shape or an approved alternative), channelizing devices, or a temporary raised island throughout the length of the two-way operation. Markings and complementary signing by themselves are not allowed. A concrete wall barrier must be considered as part of an engineering analysis for crossovers when the speed limit is posted at or above 35 mph (NMDOT 2020).

3.18 New York

New York State DOT (NYSDOT 2020) has guidance on the use of positive protection in work zones. The guidance recommends that positive protection should be used instead of channelizing devices in the following circumstances:

- Daily design hourly volume exceeds 1,300
- Operating speed is 50 mph or greater
- Truck volume is 10% or greater
- On a long, steep grade or on a sharp curve that occurs at the base of a long, steep grade

3.19 North Dakota

Temporary barrier design guidance was not found for North Dakota. A survey of state practices on positive protection in work zones also found that North Dakota does not have a formal policy on the use of temporary barriers (CTC & Associates, LLC 2017).

3.20 Ohio

The Ohio DOT's *Traffic Engineering Manual* provides guidance on the use of temporary traffic barriers (ODOT 2002). No guidance is provided on the use of traffic control devices to separate opposing traffic in head-to-head configurations.

3.21 South Carolina

Temporary barrier design guidance was not found for South Carolina. However, a survey of state practices on positive protection in work zones found that South Carolina uses TBRs at all times when opposing directions of traffic that are normally separated by an earth median are temporarily located in a head-to-head configuration (CTC & Associates, LLC 2017).

3.22 Virginia

Virginia uses the *Virginia Work Area Protection Manual* (VDOT 2011). Guidance for head-to-head traffic configurations allows the use of traffic cones, tubular markers, vertical panels, temporary lane separators, portable barriers, or movable barriers to divide opposing vehicular traffic lanes. Specifically, the manual states that when two-lane two-way work zones are used on normally divided highways, opposing vehicular traffic shall be separated with either a temporary traffic barrier, channelizing devices, or temporary raised islands through the length of the two-way operation. The use of markings and signing alone is prohibited.

3.23 West Virginia

The West Virginia DOT (WVDOT 2014) has guidelines for temporary median crossovers. However, no specifications are provided on the use of channelizers or barriers. The guidelines do specify that traffic barriers can be used to separate two-way traffic.

3.24 Wisconsin

Wisconsin (WisDOT 2019a, WisDOT 2019b) provides guidance on the use of temporary barriers. The guidance specifies that when a TLTW configuration is used, the traffic control plan must include provisions for the separation of opposing lanes of traffic. When a TLTW configuration is used on one roadway of a normally divided highway, centerline striping, raised pavement markings, and complimentary signing are not sufficient. Typically, opposing traffic in TLTW configurations is separated by tubular markers, drums, or concrete barriers.

3.25 Wyoming

Temporary barrier design guidance was not found for Wyoming. Additionally, a survey of state practices on positive protection in work zones found that Wyoming does not have formal guidance on the use of temporary barriers (CTC & Associates, LLC 2017).

4. EFFECTIVENESS OF TRAFFIC CONTROL DEVICES FOR TLTW WORK ZONES

A literature review was conducted to determine the safety impacts of various types of traffic control devices used to separate opposing lanes of traffic in TLTW work zones. However, no studies were found that specifically assessed the safety impacts of these devices. Several studies were found that assessed the impacts of different types of barriers in general, as described in Section 4.1.

An evaluation of the safety impacts of various types of separators used in TLTW work zone configurations in Iowa was conducted. TLTW work zones were identified for the 2019 and 2020 construction seasons. Three types of TCDs were used in Iowa during these two seasons. These include PCBs, tubular markers, and curbing with tubular markers.

A crash analysis is the best indicator of safety, and crash data in TLTW works zones were collected as described in Section 4.3. However, only a few such locations were available in the 2019 and 2020 construction seasons, which did not provide a good sample size. As a result, only a simplistic analysis could be conducted. Other surrogate safety measures are evaluated when a robust crash analysis cannot be conducted. One metric is a comparison of lane position. Vertical channelizers and barriers provide both an actual and psychological barrier, which may cause a sense of friction. As a result, drivers may be more likely to position themselves away from these types of objects. In particular, there was concern that if large trucks place themselves away from the centerline, there is an increased likelihood of lane departure.

An attempt was also made to record strikes on barriers or channelizers. An initial survey was conducted for several work zones that involved the research team driving the work zone and creating a video log. Marks on barriers or damaged devices were recorded. The intent was to regularly drive several work zones and identify new strikes or damage, which would indicate a centerline crossing that may not have resulted in a crash. After several attempts to collect data, it quickly became obvious that it was very difficult to differentiate between new strikes and existing damage. As a result, this method was abandoned early in the project as being unfeasible.

4.1 Summary of Relevant Literature

Three studies were found that evaluated the impact of different types of barriers on lane position and speed. The studies were for work zone barriers in general and were not related to TLTW. In general, speeds were lower and lane deviation higher when concrete barriers were present compared to other separators such as cones or metal barriers.

Banerjee and Jeihani (2019) investigated the impact of different work zone barriers (cone pylons, concrete jersey barriers, and metal barriers) on driver behavior using a medium-fidelity full-scale driving simulator. A freeway work zone was simulated using traffic volumes based on level of service (LOS) C. The study included 65 individual participants. An analysis of variance (ANOVA) indicated that there was a statistically significant difference between mean vehicle speeds across all barrier types as well as mean vehicle speeds in the presence of a metal barrier for drivers aged 35 and above versus other age groups. An interesting observation was that drivers tended to deviate from the center of the lane away from concrete jersey barriers on freeways.

Reyes and Khan (2008) conducted a high-fidelity simulator experiment that evaluated driver behavior in the presence of several different work zone interventions, including different types of barriers used to demarcate a lane closure (speed limit was 55 mph). Three barrier types were evaluated: cone pylons, concrete jersey barriers, and metal barriers. Higher average deviation from the center of the lane was found for concrete jersey barriers compared to cone pylons, and the difference was statistically significant. The average deviation from the center of the lane was 0.65 feet for concrete barriers, 0.60 feet for metal barriers, and 0.5 feet for cone pylons.

Additionally, drivers aged 35 and above drove more slowly in the presence of all barrier types. For instance, drivers aged 35 and above had an average speed of around 55 mph compared to 57 mph for drivers aged 26 to 35 and 58 mph for drivers aged 18 to 25. Reyes and Khan (2008) found that drivers drove the fastest (55.1 mph) and with the least speed variability when concrete barriers were present than when channelizers (52.4 mph) or drums (52.9 mph) were present.

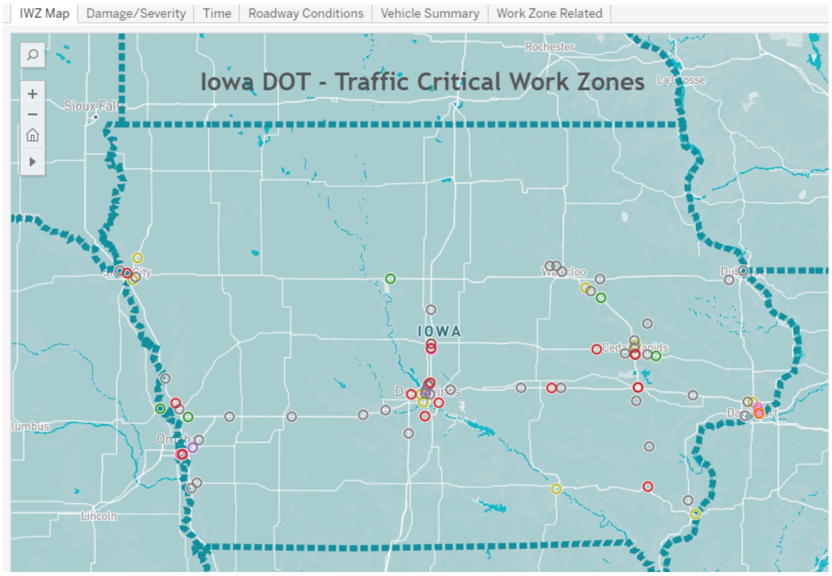
Finley et al. (2008) conducted a survey of drivers at Texas Department of Public Safety offices in four Texas cities. Participants were asked what work zone conditions would cause them to slow down. Respondents were provided an opportunity to respond independently as well as being prompted about particular features. Around 43% of drivers independently noted that they would slow when workers were present. When prompted, about 95% of drivers noted that they would slow when workers were present behind a barrier compared to 95% who indicated that they would slow if workers were in or near the roadway. Seven percent independently responded that they would slow when a concrete barrier was present. It is not known whether they would slow if other types of barriers were present.

4.2 Evaluation of TLTW Sites in Iowa

The research team worked with the project’s technical advisory committee (TAC) to identify work zones in Iowa where TLTW configurations were used for the 2019 and 2020 construction seasons. When feasible, the team visited the work zones to ensure that the characteristics were as stated in the plans and to note any unusual characteristics.

4.2.1 2019 TLTW Locations

Work zones for the 2019 construction season (Figure 10) were identified with input from the TAC and from a review of the traffic camera data hosted at the Real-Time Analytics of Transportation Data (REACTOR) Laboratory at the Institute for Transportation (InTrans).



© 2021 Mapbox. © OpenStreetMap.

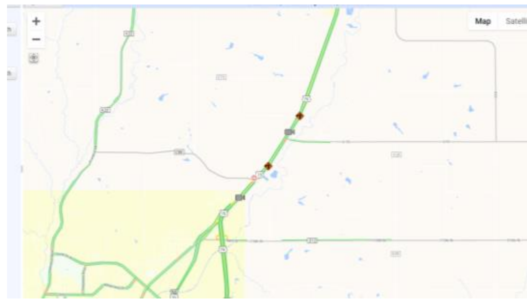
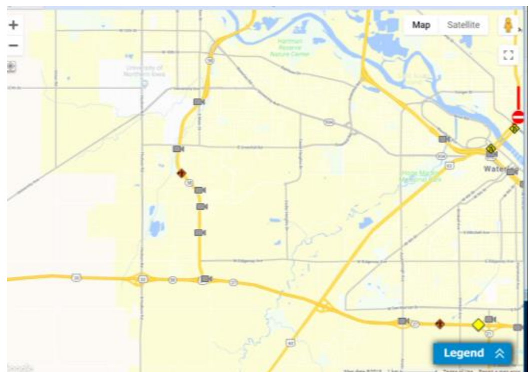
Figure 10. 2019 work zone locations in Iowa

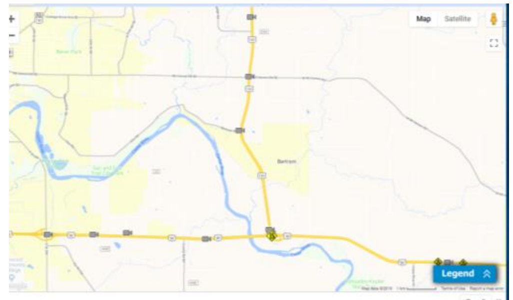
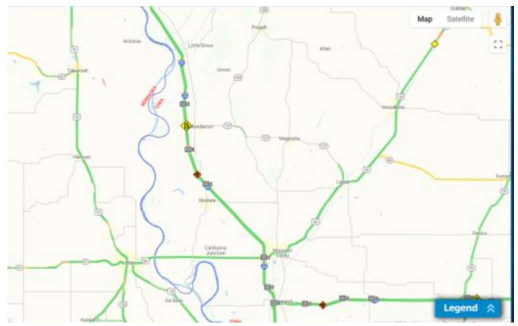
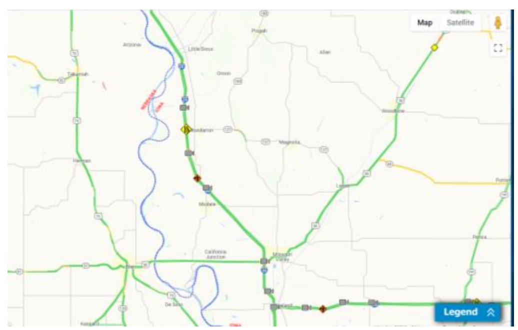
Twenty work zones and their associated traffic camera data were examined in depth, and viable sites were identified. Only work zones with a two-lane two-way traffic control plan were included. Four different work zones were identified that used tubular markers with raised channelizers. One of those was at an intersection. Data were reduced for that location, but ultimately it was decided that the location was not comparable to the other locations and therefore was not included in the analyses. Two locations were found that utilized only tubular markers as the separator between opposing lanes. Only one location was found that used concrete barriers. No other barrier types were found for TLTW operations.

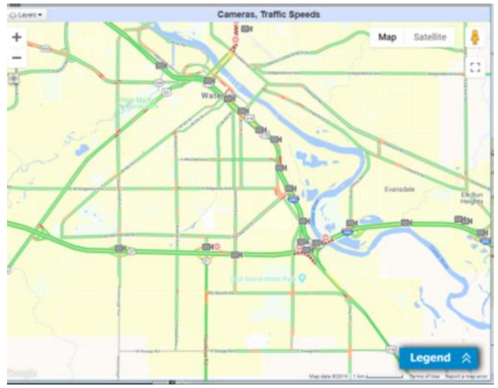
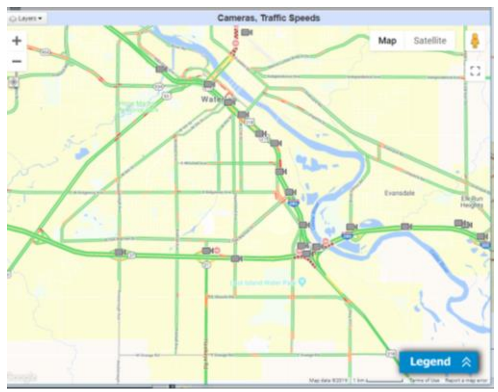
Video data from cameras already present at each work zone were examined, and cameras for which data reduction was possible were identified. In several cases, more than one camera was viable for a particular work zone. For instance, two viable cameras were found for the I-29 work zone, which used tubular markers only. Four different cameras were determined to be viable for the I-35 work zone, which employed PCBs.

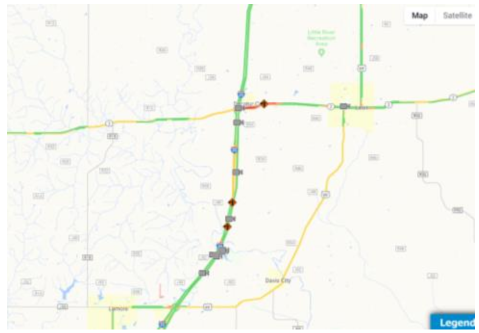
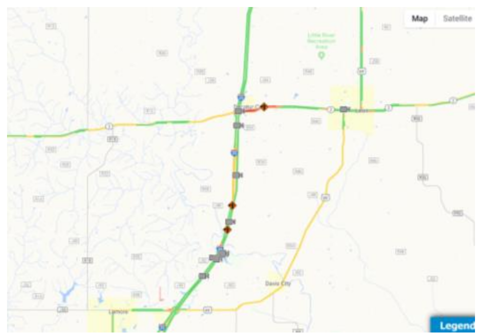
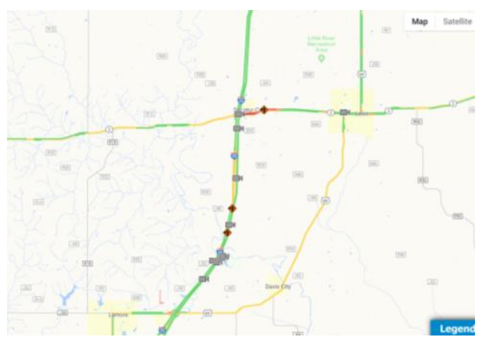
Table 1 shows the TLTW locations for the 2019 construction season. Each row represents one viable camera, so some locations are listed more than once.

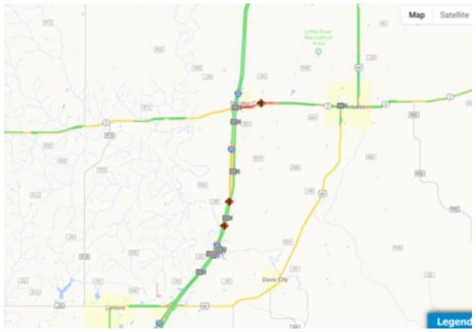
Table 1. TLTW locations for the 2019 construction season

Road	Separator	Camera	Map	Video Image
US 75 (WZ 3P)	Curbing with Tubular Markers	IWZ 3159		
IA 58 (WZ 2P)	Curbing with Tubular Markers	IWZ 3174		

Road	Separator	Camera	Map	Video Image
US 151 (6BX)	Curbing with Tubular Markers	IWZ 3193		
I-29 (WZ 3S)	Tubular Markers	IWZ 3716		
I-29 (WZ 3S)	Tubular Markers	IWZ 3717		

Road	Separator	Camera	Map	Video Image
US 20 (WZ 2Q)	Tubular Markers	WLT VO3		
I-380 (WZ 2Q)	Tubular Markers	WLT VO4		

Road	Separator	Camera	Map	Video Image
I-35 (WZ 5V)	PCB	IWZ 3102		
I-35 (WZ 5V)	PCB	IWZ 3105		
I-35 (WZ 5V)	PCB	IWZ 3189		

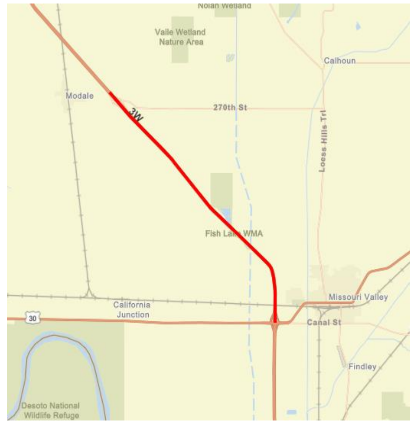
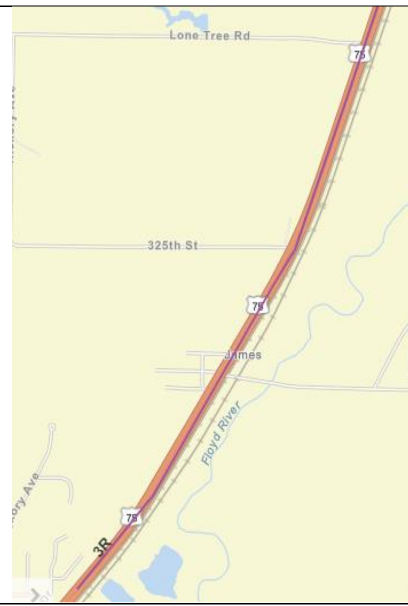
Road	Separator	Camera	Map	Video Image
I-35 (WZ 5V)	PCB	IWZ 3196		

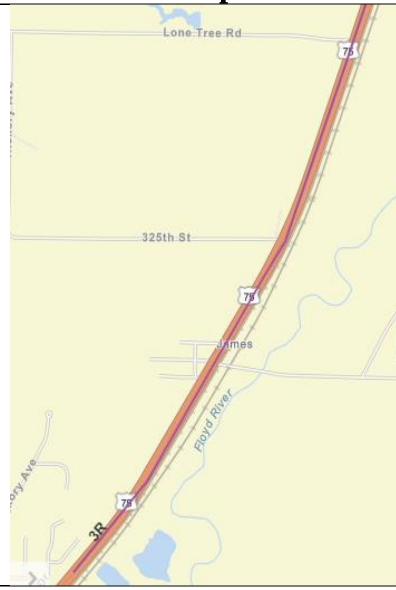
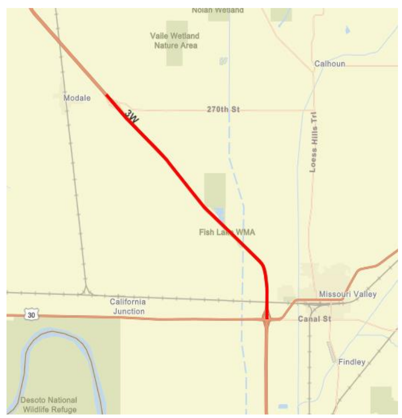
4.2.2 2020 TLTW Locations

TLTW locations were also sought for the 2020 construction season. Locations were identified using the same method described for identifying the 2019 TLTW locations. Three locations were identified that used curbing with tubular markers, and one location was identified that utilized tubular markers. Unfortunately, no locations with portable concrete barriers or other positive protection devices were found.

Table 2 shows the TLTW locations for the 2020 construction season.

Table 2. TLTW locations for the 2020 construction season

<table>
<tr><th>Road</th><th>Separator</th><th>Camera</th><th>Map</th><th>Video Image</th></tr>
<tr><td>I-29 (3W)</td><td>Curbing with Tubular Markers</td><td>IWZ 3714</td><td>
</td><td>
</td></tr>
<tr><td>US-75 (3R)</td><td>Curbing with Tubular Markers</td><td>IWZ 3138</td><td>
</td><td>
</td></tr>
</table>

Road	Separator	Camera	Map	Video Image
US 75 (3R)	Curbing with Tubular Markers	IWZ 3117		
I-29 (3W)	Tubular Markers	IWZ 3159		

4.3 Evaluation of Lane Position

One measure of safety is the evaluation of lane position. Vertical channelizers and barriers provide both an actual and psychological barrier, which may cause a sense of friction for drivers. Objects that present a greater sense of friction (PCBs versus channelizers) may result in an increased chance that drivers will position themselves away from the object. In particular, there was concern that if large trucks position themselves away from the centerline, there is an increased likelihood of lane departure.

The actual position of a vehicle within its lane (i.e., inches from the center or right lane line) could not be extracted without a significant amount of manual data reduction. As a result, categorical measures were used to evaluate vehicle position within a lane. Since passenger vehicles are able to place themselves away from the centerline and therefore are less likely to be close to the edge line, it was more difficult to utilize categorical measures and obtain distinct differences for this type of vehicle. Additionally, the TAC agreed that large trucks were the primary concern, since they were the most likely have a road departure. As a result, lane position was only reduced for large trucks, which included single-unit vehicles and larger.

Data reductionists were used to manually reduce vehicle position within the lane for large trucks. Three categories for vehicle position were used, as shown and described in Figure 11.

Within lane: Truck is positioned normally within the lane so that the right wheels are to the left of the right lane line. They may be close but are not touching the lane line.

On top: Truck is positioned to the right within the lane, and the right truck wheels are touching but are not over the right lane lines.

Over: Truck is positioned to the right within the lane. and the right truck wheels are clearly over the right lane lines.

Figure 11. Examples of truck position within lane

4.3.1 Results for 2019 TLTW Work Zones

As noted in Section 4.2.1, three 2019 TLTW work zones used curbing with tubular markers. Four TLTW locations were found that utilized only tubular markers, and one location was found that used portable concrete barriers. In some cases, several cameras were present at the same work zone. Data were combined for each type of channelizer and the numbers of noted instances for each category of lane position were compared, as shown in Table 3.

Table 3. Observations by type of separator for 2019 sites

	Portable Concrete Barrier	**Tubular Markers**	**Curbing with Tubular Markers**
Within lane	342	845	209
On top of lane line	484	516	288
Over lane line	257	88	17
Total	1,295	2,207	627

The information is shown graphically in Figure 12.

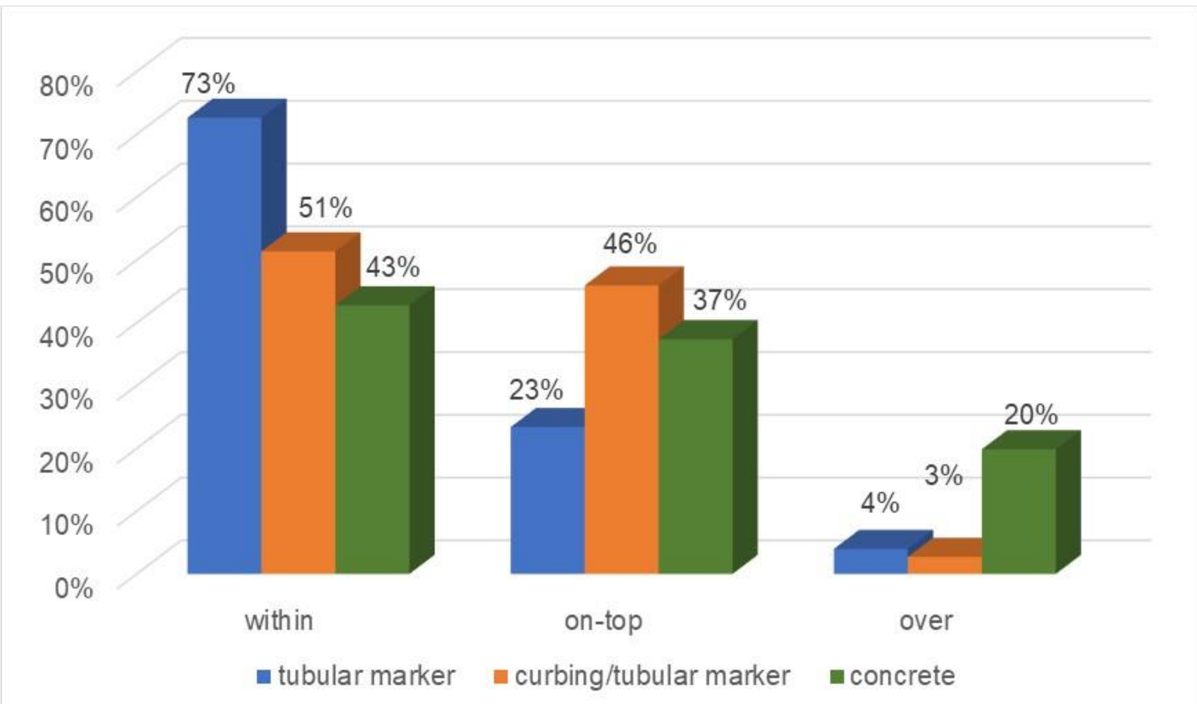


Figure 12. Large truck lane position by type of TLTW separator (2019 construction season)

As noted, trucks in work zones that used portable concrete barriers were more likely to cross over the edge line (20%) than trucks in works zones that used either other treatment (4% for tubular markers only and 3% for curbing with tubular markers). In many cases, trucks were positioned significantly over the lane line for the TLTW work zone that used PCBs, as shown in

Figure 13. Using a test of proportions, the results were statistically significant for PCBs compared to other separators. No statistically significant difference was found for the percentage of vehicles over the lane line in work zones that used tubular markers only versus curbing with tubular markers.

Figure 13. Examples of trucks positioned well over right lane line in the presence of PCBs

Large trucks were more likely to be positioned on top of the right lane line when opposing lanes in the TLTW were separated by curbing with tubular markers (46%) than other separators (37% for PCBs and 23% for tubular markers only). The differences between all types of separators were statistically significant.

Large trucks were most likely to be positioned within their lane when separated from opposing TLTW traffic by only tubular markers (73%). Only 51% of large trucks were positioned within their lane when curbing with tubular markers was used. Large trucks were least likely to be positioned within their lane when PCBs were present (only 43%).

4.3.2 Results for 2020 TLTW Work Zones

The TLTW sites for the 2020 construction season included three locations that used curbing with tubular markers and one location that used only tubular markers. Unfortunately, no locations that used portable concrete barriers or other positive protection devices were found. In some cases, several cameras were present at the same work zone. Data were combined for each type of TCD and the numbers of noted instances for each category of lane position were compared, as shown in Table 4.

Table 4. Observations by type of separator for 2020 sites

	Tubular Markers	**Curbing with Tubular markers**
Close	555	1,650
Normal	257	1,819
On top	634	988
Over	1	71
Total	**1,447**	**4,528**

The information is shown graphically in Figure 14.

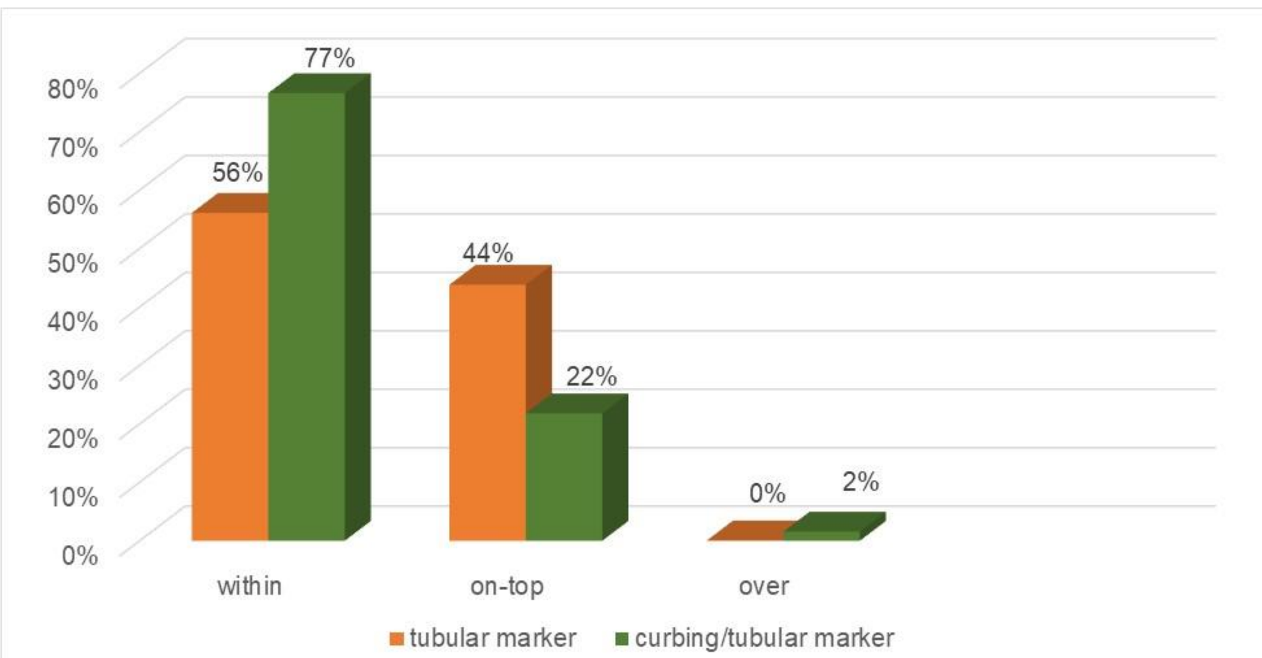


Figure 14. Large truck lane position by type of TLTW separator (2020 construction season)

As shown in the table and figure, when curbing with tubular markers was present, drivers were slightly more likely to position themselves over the right lane line than when only tubular markers were present (1.6% versus 0.1%). However, drivers were less likely to drive on top of the lane line when curbing with tubular markers was present (22% versus 44%). Additionally, 77% of drivers stayed within the lane lines when curbing with tubular markers was present compared to when only tubular markers were present (56%). All results were found to be statistically significant at the 95% level of significance using a test of proportions.

4.4 Evaluation of Crashes

A simplistic crash analysis was conducted. Crash rates could not be established because the study period was short and there were a number of factors that could have impacted crash rate but could not be accounted for (e.g., length of work zone, traffic volume, work zone duration, differences in roadway type). Instead, the type of crash and sequence of events were compared for different types of separator. It was surmised that certain types of crashes may be more likely if vehicles were more likely to position themselves away from the TLTW separator. For instance, trucks were much more likely to position themselves across the right lane line away from the TWTL separator when a PCB was present. As a result, the first event in the crash sequence of events may have provided insight as to whether driver reaction to the TLTW separator was more likely to contribute to a crash.

The begin and end point of each work zone was identified, along with construction dates. Crashes that occurred within these locations/times were extracted. Only work zones for the 2019 construction season were included in the crash analysis because traffic behavior during the COVID-19 pandemic was highly irregular and no work zones with PCBs were found.

Two work zones used tubular markers only: I-29 (WZ 3S) and I-380 (WZ 2Q). Three work zones used curbing with tubular markers: US 75 (WZ 3P), IA 58 (WZ 2P), US 151 (6BX). One work zone used portable concrete barriers: I-35 (WZ 5V). Crashes were combined by type of work zone. As noted above, the length of the work zone, work zone duration, and traffic volume varied by site. Additionally, curbing with tubular markers was used at more work zones than the other types of separators. As a result, significantly more crashes were available for work zones that used curbing with tubular markers (n = 216), while 28 crashes were available for work zones that used tubular markers only and only 10 crashes were available for the work zone that used PCBs.

The first metric analyzed was the first action taken by the driver in the crash. The first event in the sequence of events for each crash was extracted and summarized by type. The results are shown in Figures 15 and 16.

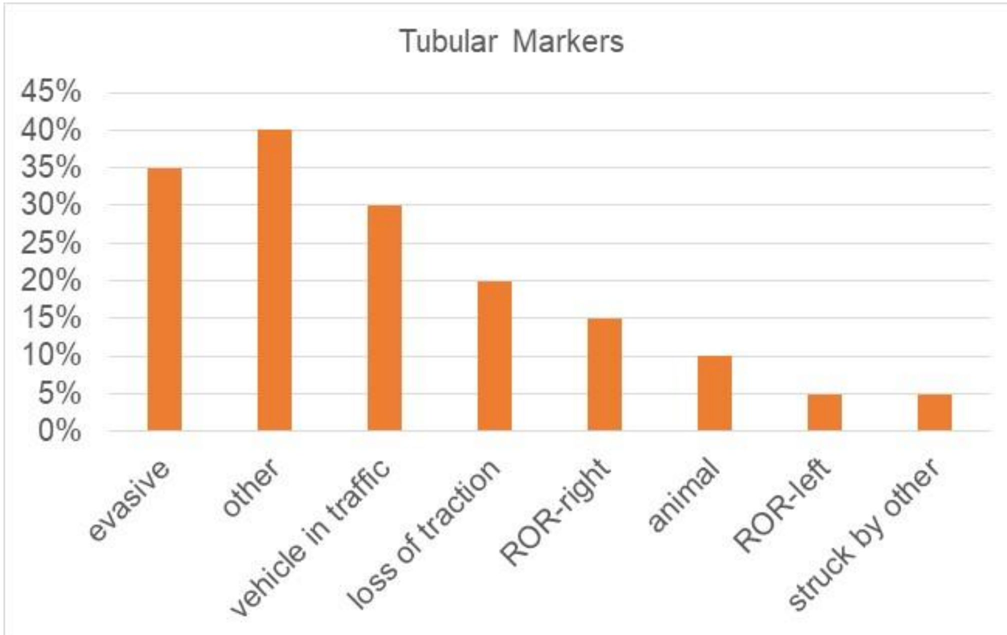


Figure 15. First event for TWTL work zone crashes with tubular marker only as separator

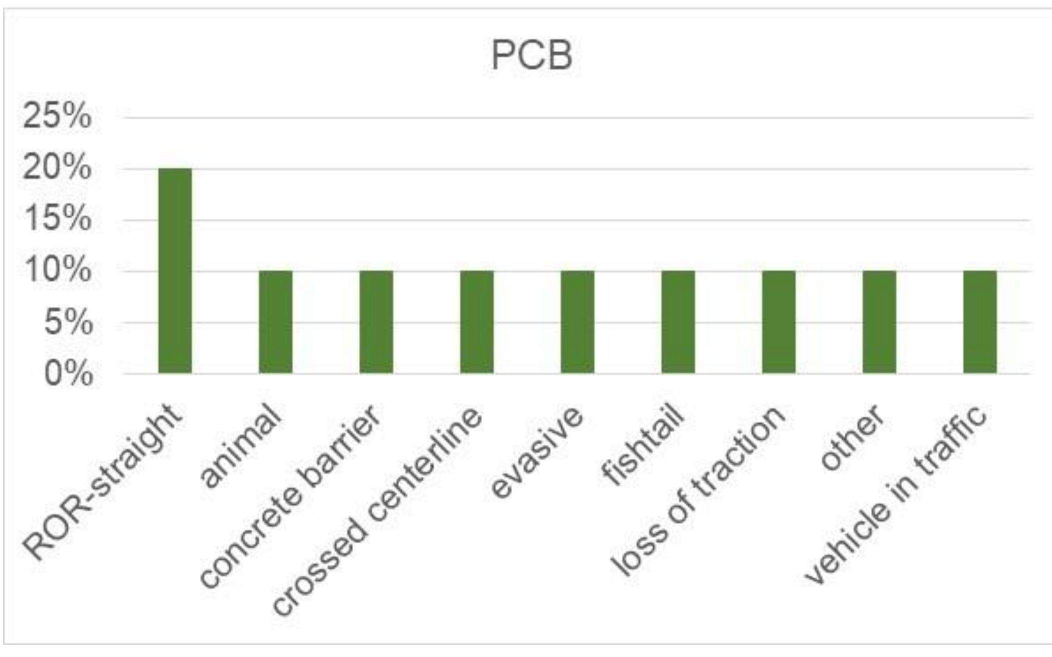


Figure 16. First event for TWTL work zone crashes with PCB as separator

As shown in Figure 15, the most relevant first actions taken by drivers in work zones with tubular markers only were “evasive,” “loss of traction,” “ROR right,” and “ROR left.” Although the sample size was small, 20% of crashes were some type of run-off-road crash.

As shown in Figure 16, the most relevant first actions taken by drivers in work zones where PCBs were present was “ROR straight,” “striking concrete barrier,” and “evasive.” One of the crashes involved the driver striking the median barrier.

The sample sizes of crashes in work zones that used either tubular markers only or PCBs was small. Consequently, the results are not very instructive in terms of understanding the effectiveness of tubular markers or PCBs.

Significantly more crashes were available for work zones that used curbing with tubular markers. Of the 216 crashes in these work zones, 167 involved striking another vehicle in traffic. Since this made up over 77% of the crashes and was not instructive for this analysis, this value is not shown in Figure 17. As shown in the figure, the most common relevant first events were “crossed centerline” (4% of crashes), “evasive” (2% of crashes), and “ROR right” (1% of crashes).

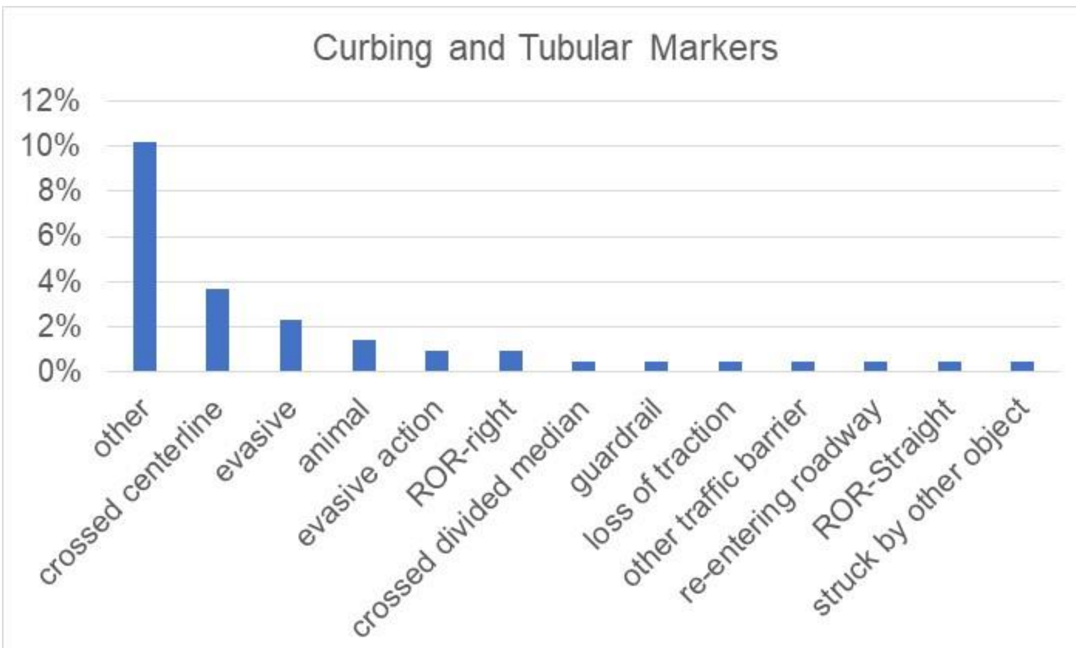


Figure 17. First event for TWTL work zone crashes where curbing with tubular markers was the separator

Crossing the centerline was clearly problematic in work zones that used curbing with tubular markers, with both “crossed centerline” and “crossed divided median” as somewhat frequent first events. This suggests that crossing the center line is problematic, which could potentially be addressed using PCBs.

The second analysis involved the types of crashes observed for each type of barrier used in TWTL configurations. The crash types observed in TWTL work zones that used tubular markers only are provided in Figure 18.

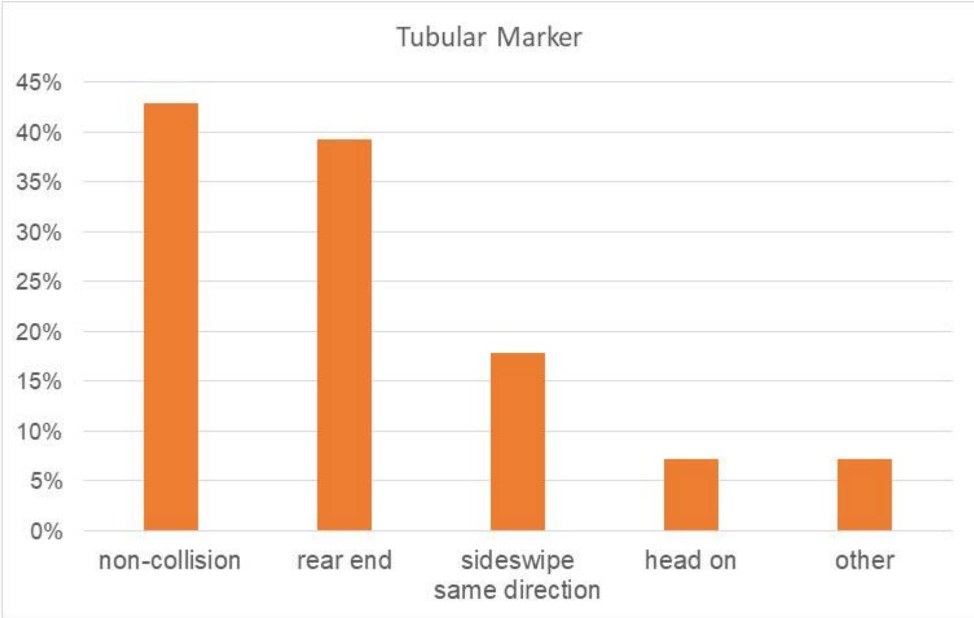


Figure 18. Crash type for TWTL work zones with tubular markers as separator

As the figure shows, noncollision was the predominant crash type, followed by rear-end. Around 25% of crashes were head-on or sideswipe same direction, which suggests vehicles crossed the separator.

As shown in Figure 19, the most prevalent crash type observed in TWTL work zones that used PCBs was primarily noncollision (70%).

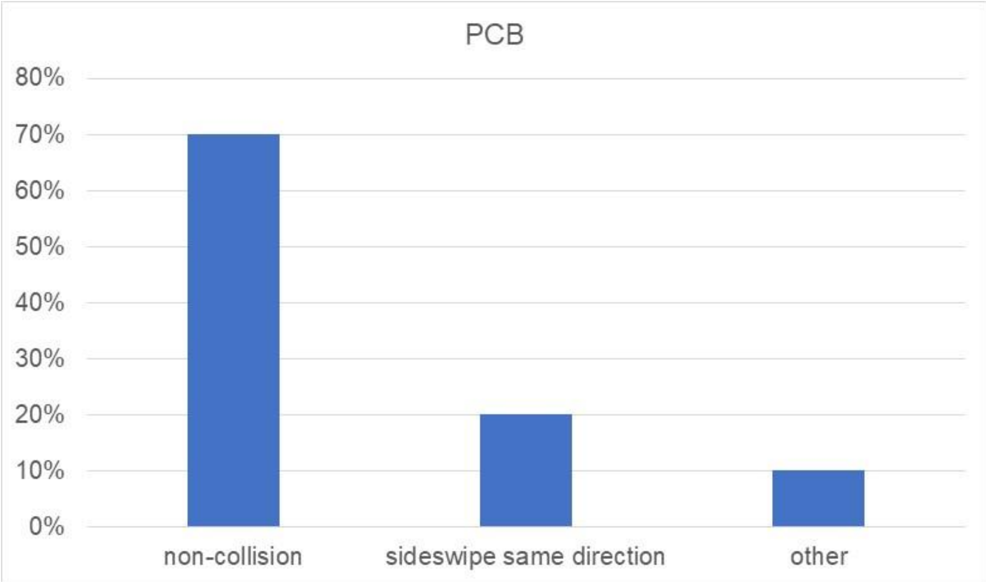


Figure 19. Crash type for TWTL work zones with PCBs as separator

Two crashes were listed as sideswipe same direction, which is puzzling because it would be expected that the portable concrete barrier would have physically prevented conflicts between opposing directions of traffic.

The results for TWTL work zones that used curbing with tubular markers are shown in Figure 20.

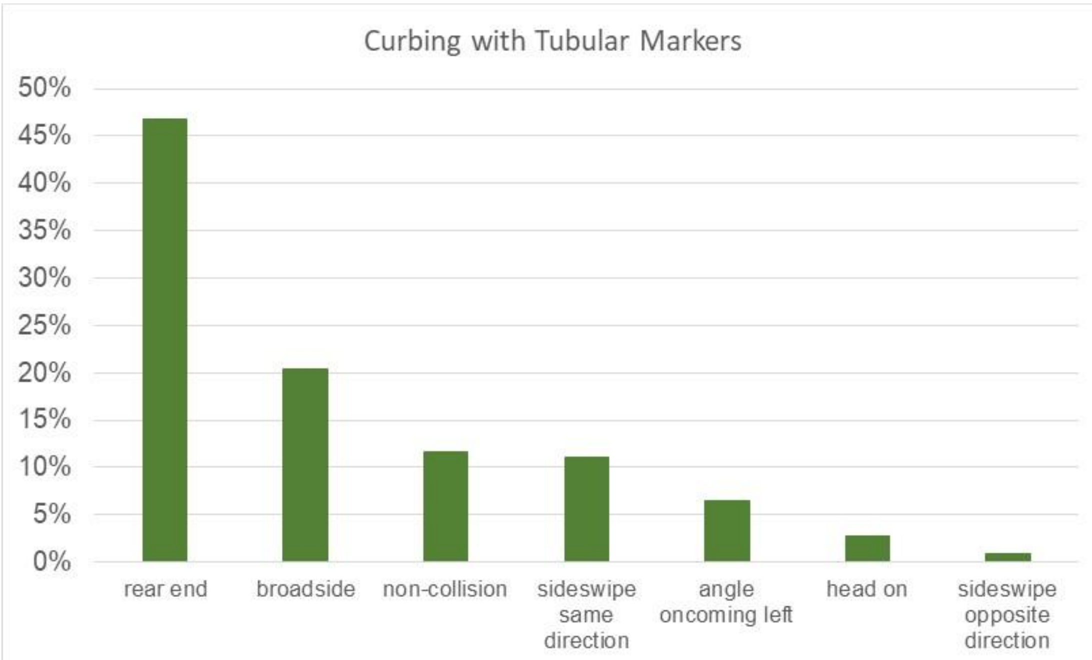


Figure 20. Crash type for TWTL work zones with curbing with tubular markers as separator

As the figure shows, the majority of crashes were rear-end, which is likely due to congestion and traffic volume. The second most common crash type was broadside, which is unusual because this crash type is usually observed at intersections. Around 21% of crashes were crash types where the vehicles involved would have crossed into opposing lanes of traffic (i.e., head-on, angle oncoming left, sideswipe same direction). Consequently, although the results should be used with caution, a primary crash type when channelizers are present appears to involve vehicles crossing into adjacent lanes.

5. SUMMARY

5.1 Summary and Conclusions

This report summarized information about the effectiveness of different traffic control devices used to separate opposing lanes of traffic in two-lane two-way traffic configurations.

Average lane position is the most common metric that has been used to evaluate the impact of separators or barriers in work zones. A simulator study by Reyes and Khan (2008) found that drivers were likely deviate from the center of the lane when concrete barriers were present (0.65 feet) compared to metal barriers (0.6 feet) or cones (0.5 feet).

The research conducted in the present study evaluated how large trucks positioned themselves in TWTL operations during the 2019 and 2020 construction seasons in Iowa. The results showed that when a PCB was present, 20% of drivers positioned themselves over the right lane line, compared to 4% when only tubular markers were present or 3% when curbing with tubular markers was present. Large trucks were most likely to be positioned within their lane when separated from opposing TLTW traffic by only tubular markers (73%). Only 51% of large trucks were positioned within their lane when curbing with tubular markers was used. Large trucks were least likely to be positioned within their lane when a PCB was present (only 43%).

A crash analysis was conducted for the 2019 work zones. Unfortunately, only two work zones were available that used tubular markers, only one was available that used a PCB, and only three were available that used curbing with tubular markers. Only crashes that occurred within the temporal and spatial limits of the work zone were compared. Differences in work zone length and duration, traffic volume, and type of roadway were present, and due to the short duration of the work zones, the sample of crashes was small. As a result, it was not possible to compare crash rates. Therefore, the first action a driver took and the type of crash were compared to assess whether a particular pattern emerged for a type of separator. Due to the sample size, the results were not insightful for tubular markers or PCBs.

More crashes were available when curbing with tubular markers was present than when other separators were present. The majority of crashes were rear-end, which is likely due to congestion and traffic volume. Around 21% of crashes were crash types where the vehicles involved would have crossed into opposing lanes of traffic (i.e., head-on, angle oncoming left, sideswipe same direction). Consequently, although the results should be used with caution, a primary crash type when channelizers are present appears to involve vehicles crossing into adjacent lanes.

5.2 Impact and Future Direction

The results of this project were useful in assessing lane position. Unfortunately, no work zones that used PCBs were available for the 2020 construction season. Additionally, while no definitive conclusions could be drawn from the crash analysis, some early patterns did emerge, indicating that evaluation of additional data would be useful.

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