Implementing the Proven Safety Countermeasures in Work Zones

U.S. Department of Transportation
Federal Highway Administration

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

FHWA-SA-24-014

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Technical Documentation Page

<table>
<tr><td>1. Report No.
FHWA-SA-24-014</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
Implementing the Proven Safety Countermeasures in Work Zones</td><td colspan="2">5. Report Date
October 2024</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="2">7.Author(s)</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="2" rowspan="2">9. Performing Organization Name and Address
Vanasse Hangen Brustlin, Inc (VHB)
940 Main Campus Drive, Suite 500
Raleigh, NC 27606</td><td colspan="2">10. Work Unit No.</td></tr>
<tr><td colspan="2">11. Contract or Grant No.
DTFH61-05-D-00024 (VHB)</td></tr>
<tr><td colspan="2" rowspan="2">12. Sponsoring Agency Name and Address
Federal Highway Administration Office of Safety
1200 New Jersey Ave., SE
Washington, DC 20590</td><td colspan="2">13. Type of Report and Period
Final Report October 2024</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code
FHWA</td></tr>
<tr><td colspan="4">15. Supplementary Notes
The contract manager for this report was Phil Bobitz, with the FHWA Office of Safety.</td></tr>
<tr><td colspan="4">16. Abstract
The purpose of this guide is to provide information to State and local agencies on work zone fatalities in the U.S. and the application of Safe System Approach principles to work zone planning, design, operations, and management. This includes describing work zone applications of FHWA’s Proven Safety Countermeasures (PSCs), a collection of countermeasures and strategies effective in reducing roadway fatalities and serious injuries on U.S. highways and streets. Each of the PSCs can be implemented in work zones, depending on the individual work zone characteristics and the safety-related needs. The PSCs are generally associated with well-documented crash reductions under non-work zone conditions. The extent of examples of applications in work zones varied. There are opportunities to increase awareness of work zone applications through performing work zone specific safety performance studies, producing case studies, or otherwise documenting benefits and considerations.</td></tr>
<tr><td>17. Key Words:
Proven safety countermeasures, work zones, Safe System approach</td><td colspan="3">18. Distribution Statement
No restrictions.</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td>20. Security Classif. (of this page) Unclassified</td><td>21. No. of Pages 50</td><td>22. Price</td></tr>
</table>

Form DOT F 1700.7 (8-72) Reproduction of completed pages authorized.

Table of Contents

List of Figures

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ATSSA	American Traffic Safety Services Association
CMF	Crash Modification Factor
CMF ID	CMF Clearinghouse ID
DOT	Department of Transportation
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
FIRST	Fatality and Injury Reporting System Tool
HFST	High Friction Surface Treatment
LPI	leading pedestrian interval
LRSP	local road safety plan
mph	miles per hour
MUT	median U-turn
MUTCD	Manual on Uniform Traffic Control Devices
NHTSA	National Highway Traffic Safety Administration
NIOSH	National Institute for Occupational Safety and Health
NRSS	National Roadway Safety Strategy
P2P	Point-to-Point
PHB	pedestrian hybrid beacon
PSC	Proven Safety Countermeasure
RCI	reduced conflict intersection
RCUT	restricted crossing U-turn
RRFB	rectangular rapid flashing beacon
RSA	Road Safety Audit
SHSP	Strategic Highway Safety Plan
SSA	Safe System Approach
SSC	speed safety camera
TMA	truck mounted attenuators
TPAR	temporary pedestrian accessible route
TTC	temporary traffic control
TO	Transportation Operations
TWLTL	two-way left-turn lane

USDOT	United States Department of Transportation
VSL	variable speed limit

Chapter 1. Introduction

Purpose of the Guide

Work zone safety is a high priority for transportation agencies, the construction industry, and the travelling public. Work zones are necessary to maintain, rehabilitate, enhance, and reconstruct this nation's roadway network, but they are also the location where a significant number of traffic fatalities occur each year. According to the National Highway Traffic Safety Administration's (NHTSA's) Fatality and Injury Reporting System Tool (FIRST), 4319 people were killed in work zone crashes in the U.S. between 2018 and 2022 (NHTSA, 2024). Figure 1 summarizes work zone fatalities by year and as a percentage of total traffic fatalities. The number of work zone fatalities has grown from 757 fatalities in 2018 to 891 in 2022, an 18 percent increase. Information on the best use of resources to improve work zone safety is limited.

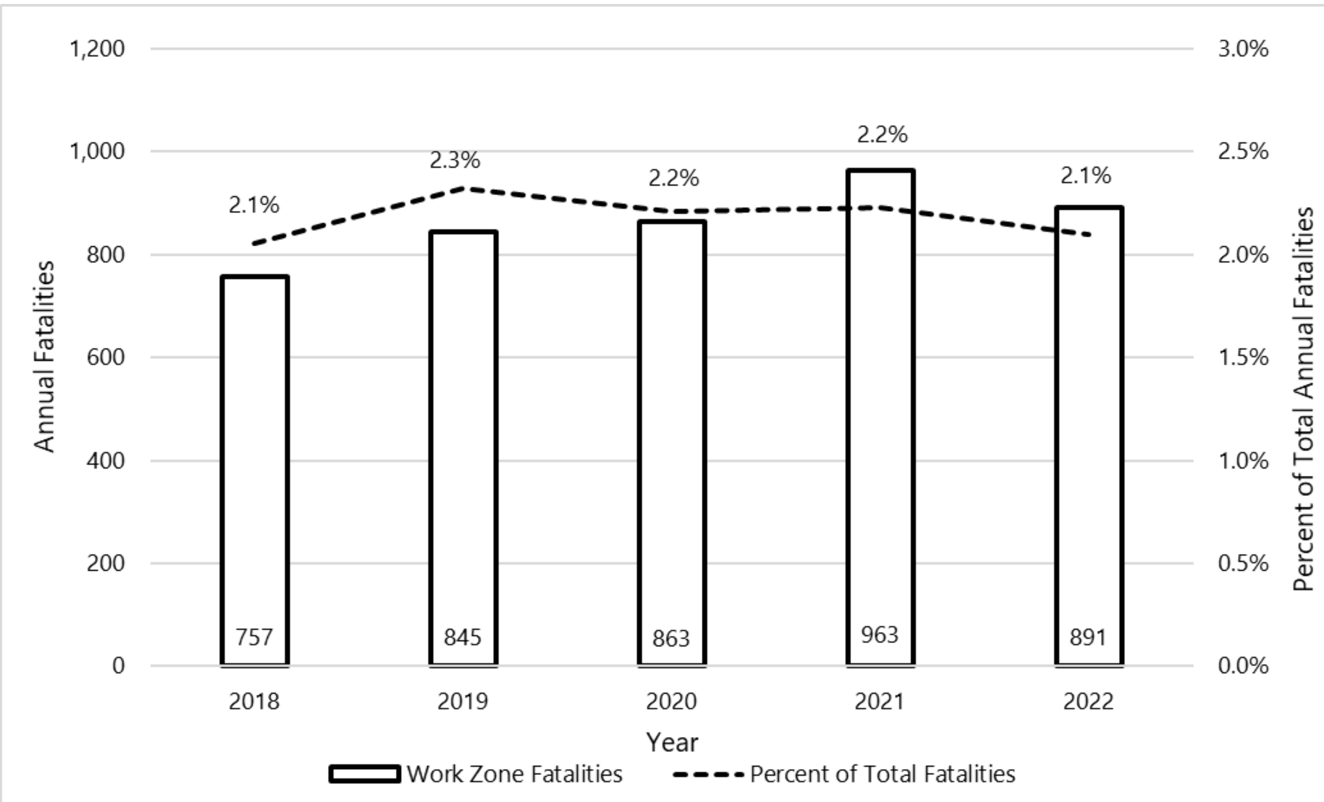


Figure 1. Annual work zone fatalities. Source: FARS

Accordingly, the United States Department of Transportation's (USDOT's) 2023 Progress Report on the National Roadway Safety Strategy (NRSS) highlights a need to "Advance strategies and practices for safe and reliable travel through work zones for all road users, including highway workers, through training and knowledge transfer to State and local agencies." In the NRSS, "USDOT adopts the Safe System Approach as the guiding paradigm to address roadway safety (p. 6; USDOT, 2022)." The Safe System Approach represents a paradigm shift in managing safety to achieve a goal of zero fatalities.

The purpose of this guide is to provide information to State, local, Federal Land Management, and Tribal agencies on the application of Safe System Approach principles to work zone planning, design, management, and operations, as well as program evaluation. This includes describing work zone applications of the Federal Highway Administration's (FHWA's) Proven Safety Countermeasures (PSCs)—a collection of countermeasures and strategies effective in reducing roadway fatalities and serious injuries on our Nation's roads.

Chapter 2 of the guide provides an overview of work zone fatalities in the U.S.

Chapter 3 describes a Safe System Approach to work zone management.

Chapter 4 presents general principles for implementing PSCs in work zones, including information about their use and effectiveness in general and in work zone contexts.

Chapter 5 provides a summary, conclusions, and future information needs.

Chapter 2. Work Zone Fatalities in the U.S.

4,319 people were killed in work zone crashes in the U.S. between 2018 and 2022 (NHTSA, 2024). This section provides a summary of selected crash characteristics associated with work zone fatalities based on queries with NHTSA's FIRST. The National Work Zone Safety Information Clearinghouse provides additional analyses of work zone data and crashes.

When analyzing work zone fatalities by work zone type, the majority (57 percent) of fatalities occurred in construction zones, while the second largest proportion (36 percent) occurred where the work zone type was unknown. Maintenance and utility work areas accounted for a smaller proportion (7 percent) of work zone fatalities. Looking at the distribution of work zone fatalities by manner of collision for 2018 through 2022, more than half of work zone fatalities (53 percent) occurred as a result of "Not a Collision with Motor Vehicle in Transport," which FARS (Fatality Analysis Reporting System) defines as "when the first harmful event is not an impact between two in-transport motor vehicles (NHTSA, 2023)." Rear-end crashes accounted for the next highest proportion (23 percent), followed by angle crashes (11 percent).

The First Harmful Event data element provides additional insight into the 53 percent of work zone fatalities resulting from collisions labelled "Not a Collision with Motor Vehicle in Transport." Of those fatalities, the first harmful event accounting for the largest proportion was Pedestrian (26 percent), followed by Rollover/Overturn (12 percent), and Concrete Traffic Barrier (8 percent). The pedestrian proportion is notably high and includes both pedestrian facility users and workers who are on foot working within a work zone. In addition, the total number of pedestrians killed in work zones has grown each year from 2018 to 2021 (driven by annual increases in non-workers), increasing by a total of 35 percent between 2018 and 2021, as shown in Figure 2. Over this same time period, the number of pedestrians killed in non-work zones increased from 6,252 pedestrians in 2018 to 7,307 pedestrians in 2021: a 17 percent increase. In other words, the increased rate in pedestrian fatalities in work zones is double the increase in non-work zone pedestrian fatalities, further emphasizing the need to plan and design work zones for safe access and use by both workers and non-workers. Pedestrians killed in work zones then decreased from 2021 to 2022 by 18 percent (NHTSA FARS).

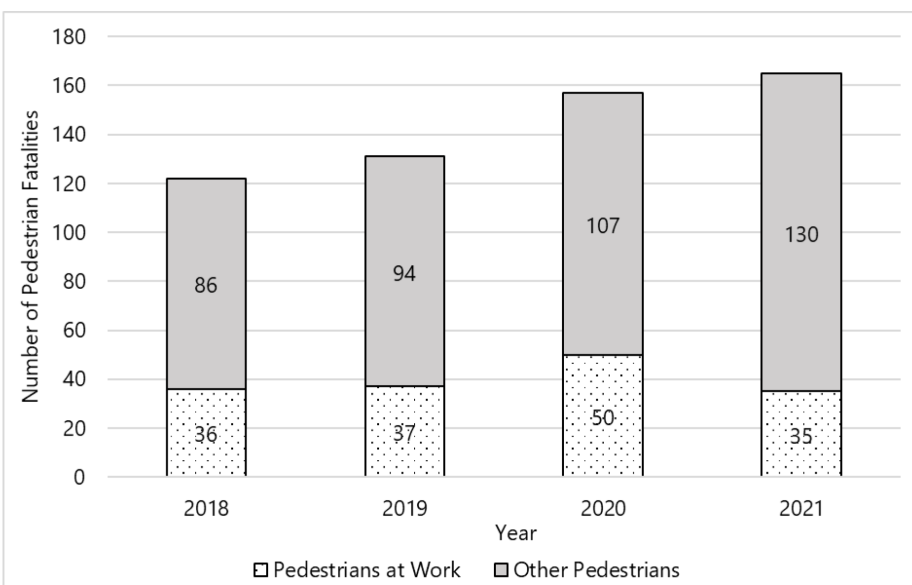


Figure 2. Graphic. Pedestrian Fatalities in Work Zones (NHTSA FARS).

FARS includes several flags for crashes to indicate whether a fatal crash involves a certain type of user, behavior, or facility. When comparing the number and proportion of work zone fatalities to those which occurred outside of work zones for 2018-2022, notably, 31 percent of work zone fatalities involved a large truck, compared to only 13 percent of non-work zone fatalities (NHTSA, 2024). This is a significant overrepresentation in work zones, which should inform work zone planning and design. Work zone fatalities involving distracted drivers and speeding are also both overrepresented compared to non-work zone fatalities. One quarter of work zone fatalities occurred on urban interstates (28 percent); the second most common contexts being rural interstates (16 percent) and other urban principal arterials (14 percent).

These trends point to several pressing needs and opportunities to reduce work zone fatalities through implementation of the Safe System Approach.

Chapter 3. Safe System Approach to Work Zone Management

The USDOT's NRSS adopts the Safe System Approach to guide policies and actions in the U.S. based around the pursuit of five SSA elements: Safe Road Users, Safe Roads, Safe Vehicles, Safe Speeds, and Post-Crash Care. Six principles characterize the Safe System Approach, including death or serious injury is unacceptable, humans make mistakes, humans are vulnerable, safety is proactive, responsibility is shared, and redundancy is crucial. Figure 3 illustrates the Safe System approach in the U.S.

Figure 3. Graphic. Overview of the Safe System approach in the U.S. (FHWA, 2020).

A Safe System Approach to work zone planning, design, management, and operations decisions aims to anticipate human mistakes and keep impact forces that humans experience in work zone crashes below those that cause death or serious injury. This can be achieved in two ways:

1. Eliminate potential conflicts and specific high-risk conditions between users of the transportation system. This involves separating users in space and time to reduce the risk of work zone crashes.
2. Reduce the impact forces to tolerable levels if a work zone crash does occur. This involves implementing design features and speed management strategies to manage speeds and impact angles to minimize chances of death or serious injury in a work zone crash should it occur.

In addition to these two approaches to achieving a Safe System, there are a number of other measures and strategies aimed at increasing user awareness and improving behavior in work zones. These strategies focus on communicating and guiding users through work zones with clear work zone regulations, traffic control devices, and other design and operational strategies. These strategies and devices are part of a comprehensive and redundant work zone safety management approach.

FHWA has developed a *Safe System Roadway Design Hierarchy* to characterize countermeasures and strategies relative to their alignment with the Safe System Approach, toward the goal of eliminating fatalities and serious injuries[1]. The purpose of the hierarchy is to help transportation agencies and practitioners identify and prioritize countermeasures and strategies based on their alignment with Safe System Approach when developing policies as well as when planning and designing transportation projects. The hierarchy concept is modeled after the hierarchy of controls for workplace safety (NIOSH, 2023) and previous work by Austroads (Woolley et al., 2018). It includes four tiers that are arranged from most to least aligned with the Safe System Approach principles (see Figure 4):

[1] https://highways.dot.gov/sites/fhwa.dot.gov/files/2024-01/Safe_System_Roadway_Design_Hierarchy.pdf

- **Tier 1 – Remove Severe Conflicts**. Strategies in Tier 1 involve the elimination of specific high-risk conditions, and therefore the possibility of fatality or serious injury from certain conflicts. This includes 1) separating users of the transportation system moving at different speeds or different directions in space to minimize conflicts between users, 2) providing physical separation or varying degrees of buffered separation between users and other severe conflict opportunities (e.g., fixed objects, construction equipment, significant pavement edge drop offs), or 3) some combination of these actions. For example, pedestrians in a work zone can be separated from traffic moving faster than 20 mph with a barrier to remove severe vehicle-pedestrian conflicts.
- **Tier 2 – Reduce Vehicle Speeds**. Strategies in Tier 2 involve the implementation of design features and speed management strategies to effectively reduce vehicle speeds and therefore reduce the kinetic energy involved in a crash should it occur. This includes setting appropriate work zone speed limits for all road users and implementing self-enforcing roadways and traffic calming measures that use roadway and roadside design elements (e.g., lane narrowing, intersection channelization, horizontal and vertical deflection) to prompt reduced vehicle speeds. Other Tier 2 strategies reduce speeds through regulation, warning, and feedback (e.g., speed safety cameras, dynamic speed feedback signs, pilot car operations).
- **Tier 3 – Manage Conflicts in Time**. Strategies in Tier 3 assume that users will need to occupy the same physical space on the roadway and therefore focus on creating a safer environment by separating the users in time using traffic control devices. These strategies include traffic signals, pedestrian hybrid beacons, flagging operations, and other traffic control devices that assign movement priority.
- **Tier 4 – Increase Attentiveness and Awareness**. Strategies in Tier 4 involve alerting road users of potential conflicts, providing information that guide user navigation through a location, and raising conspicuity of such cues. Examples include rumble strips and stripes, visibility enhancements, signing, markings, and lighting. These types of Tier 4 strategies focus on reducing crash likelihood, but crashes that occur could still produce higher amounts of energy transfer if these were the only strategies in place.

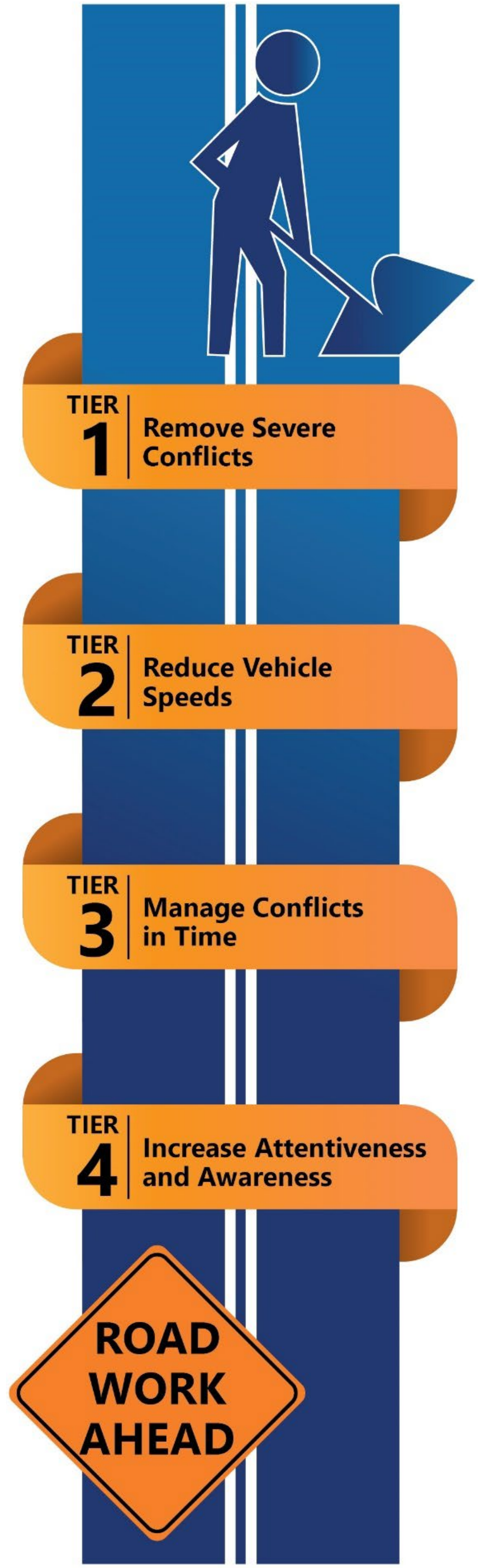


Figure 4. Safe System Design Hierarchy
Source: FHWA

At the policy, program, process, and individual project (i.e., work zone) levels, agencies can use the *Safe System Roadway Design Hierarchy* as a framework to assess where their work zone management approaches fall within or align with the Safe System Approach. This is one set of the many factors practitioners and agencies can use to identify and prioritize countermeasures and strategies and is intended as a supplement to other factors. Some other factors include feasibility, cost, and community input. When using the hierarchy, agencies and practitioners should consider countermeasures and strategies from Tier 1 first, as physical or buffered separation can permanently eliminate conflicts that lead to severe crashes. If strategies from Tier 1 are not feasible, agencies and practitioners should consider strategies from Tier 2 and subsequent tiers. Typically, strategies from multiple tiers are used in combination, as redundancy is crucial in the Safe System Approach. Figure 5 provides an illustration of a work zone on an undivided, four-lane road with safety countermeasures that align with the *Safe System Roadway Design Hierarchy*.

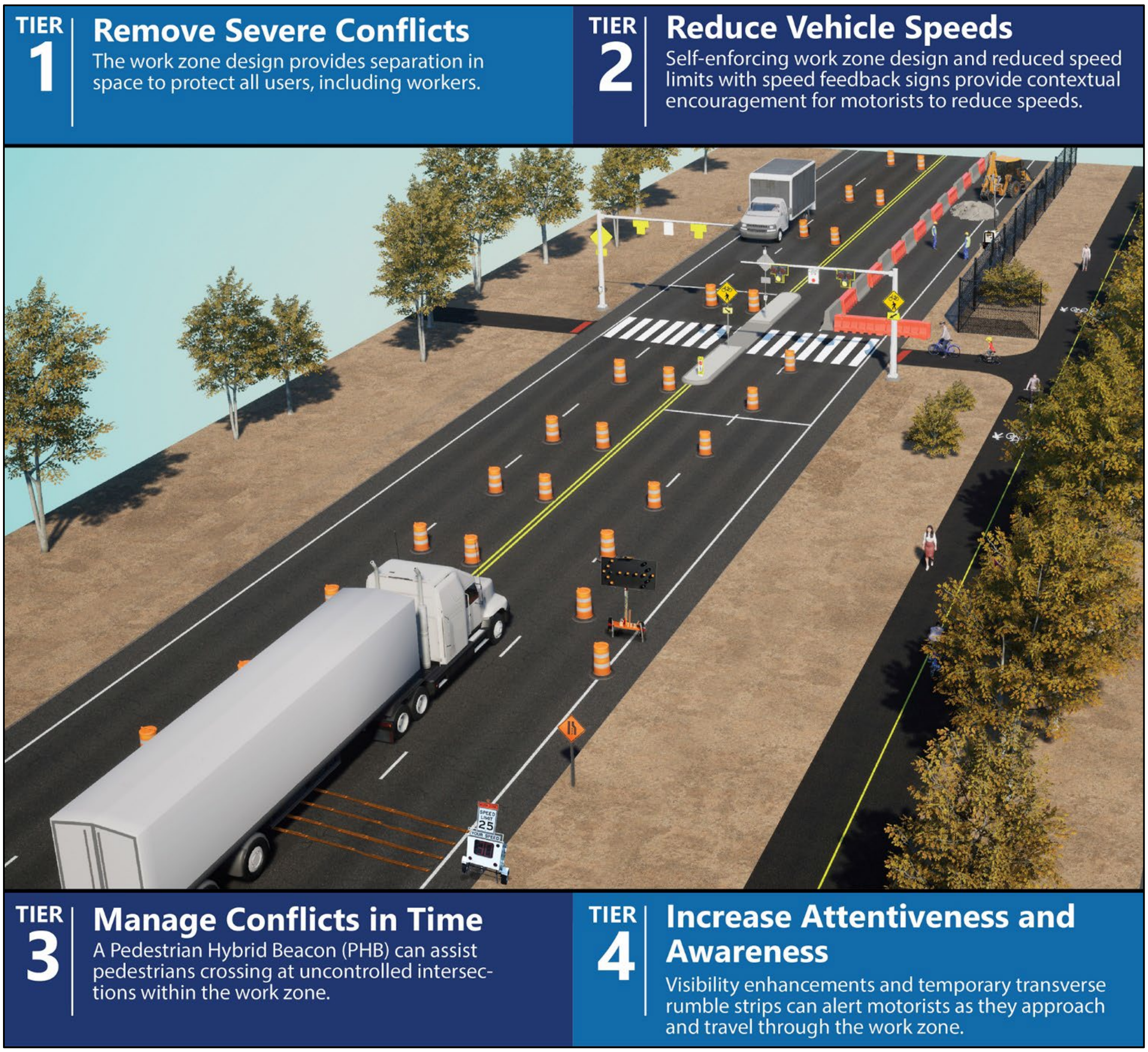


Figure 5. Example work zone layout with safety countermeasures that align with the Safe System Roadway Design Hierarchy. Source: FHWA

Chapter 4. PSCs and Work Zones

FHWA's PSCs[2] are a collection of countermeasures and strategies effective at reducing roadway fatalities and serious injuries on our Nation's roads. Transportation agencies are encouraged to consider widespread implementation of PSCs to accelerate the achievement of their local and State safety goals. The PSCs address safety for all users and their potential applications span different area types (e.g., from rural to urban), facility types (e.g., freeways, arterials, local roads), and site types (e.g., horizontal curves, intersections). FHWA's PSC website hosts resources that provide more information on PSCs, including descriptions, safety effectiveness, context, application, and considerations for implementation.

Like locations outside of work zones, roadway departure, intersection, pedestrian, and motorcyclist crashes make up a significant proportion of work zone fatalities. In addition, speeding is overrepresented in work zone fatal crashes. Efforts to manage these crash types in work zones can leverage efforts and lessons learned outside of work zones. Each PSC addresses at least one of FHWA's safety focus areas—speed management, intersections, roadway departures, or pedestrians/bicyclists—while others are crosscutting strategies that address multiple safety focus areas. The PSCs have proven effective because they align with Safe System Approach principles, and span Safe System Approach elements, to various levels. The *Safe System Roadway Design Hierarchy* maps the PSCs to each tier of the hierarchy described in the previous section of this guide.

Implementing PSCs in work zones is a step towards a Safe System Approach to work zone planning, design, deployment, management, and operations. The remainder of this guide provides agencies with information on using FHWA's PSCs as part of their work zone safety management efforts (see Appendix A for this information summarized in a desktop reference). Implementing a Safe System Approach requires collaborative engagement among a diverse group of stakeholders to increase safety for all road users. The PSCs and the National Highway Traffic Safety Administration's (NHTSA) Countermeasures that Work[3] can create a system with redundancies in place to protect all road users. Agencies can implement PSCs and other effective countermeasures through their work zone policies and program-level processes, or by proactively implementing these countermeasures as part of individual TTC (Temporary Traffic Control) plans and TO (Transportation Operations) components. The National Work Zone Safety Information Clearinghouse provides additional information about safety in work zones, including work zone safety countermeasures[4].

Policy-Level Implementation

Transportation agencies develop policies and guidelines for the planning, design, management, and operations of work zones. In developing such policies and guidelines, agencies can inform their decisions with analyses of work zone crash data and tying work zone safety priorities to other safety priorities. Agencies can use work zone process reviews, which are periodic evaluations of work zone policies, processes, and procedures, to evaluate the effectiveness of work zone decisions, and ultimately, work zone safety performance.

Agencies can begin by reviewing their State's Strategic Highway Safety Plan (SHSP) to determine what the primary safety issues are in the State (e.g., lane departure crashes, impaired driving crashes, aggressive driving crashes) and how those priorities should translate to their work zone safety priorities. For instance, if the State has identified motorcycles as an SHSP emphasis area, agencies can consider methods for addressing motorcycles in their work zones. PSCs and other countermeasures applicable to these crash types can be emphasized in work zone policies and processes.

[2] https://highways.dot.gov/safety/proven-safety-countermeasures
[3] https://www.nhtsa.gov/book/countermeasures/countermeasures-that-work
[4] https://workzonesafety.org/

Agencies can also review work zone-specific crash data to identify the most common crash types and scenarios that account for fatalities and injuries in their work zones. This can include comparing work zone crash characteristics to non-work zone crash characteristics to identify characteristics that are overrepresented in work zone crashes. Such analyses can be performed, for example, with fatal and suspected serious injury crashes; fatal and all injury crashes; and all crashes. The analysis can also identify work zone types and other contributing factors associated with the most frequent crash types. Findings can then support policy and process development that guides work zone managers to implement the applicable PSCs for given work zone types or to address specific contributing factors that are present.

Ultimately, decisions about work zone safety policy should be guided by the Safe System Approach, acknowledging that crashes are inevitable and therefore focused on ways to reduce the potential severity of the crashes by providing redundancy, designing for all users of the transportation system, focusing on reducing kinetic energy in collisions, and protecting the most vulnerable users of a work zone (e.g., pedestrians, bicyclists, and workers). Policy-level implementation could include a menu of countermeasures, including FHWA's PSCs, along with guidance for where and how the PSCs can be implemented.

Project-Level Implementation

With or without a broader work zone policy that includes PSCs, agencies can implement PSCs at the individual work zone level. The following pages provide PSC briefing sheets, based on the original FHWA PSC flyers but with additional information and resources, when available, on work zone applications.

Work zone planners, designers, and managers can initiate project-specific implementations by performing a Road Safety Audit (RSA) at any phase of work zone planning, design, and deployment, including during active work zones. A work zone RSA is the formal safety performance examination of a work zone by an independent, multidisciplinary team. Figure 6 displays the RSA process and responsibilities of an RSA team. A work zone RSA qualitatively estimates and reports on potential work zone safety issues and identifies opportunities for improvements in safety for all road users.

Figure 6. RSA Process and Responsibilities (FHWA, 2021i).

During the work zone planning and design stage, agencies can use RSAs to evaluate the proposed TTC plan and (if applicable) TO component to identify:

- Potential safety issues and risk factors that align with an agency's priorities, as described by the agency's work zone policies and processes, as well as the SHSP.
- The expected user experience for all users in the work zone, including motorists, workers, pedestrians, and cyclists, and potential risk factors that may be unique to one or more types of users.
- Additional risk factors that may contribute to the frequency and severity of work zone crashes.

FHWA's *Road Safety Audit Guidelines* provides the following recommendations for performing a work zone design RSA (FHWA, 2006):

[The RSA team] must evaluate the safety of all temporary roadways and transition areas. They should consider the appropriateness of all traffic control devices and be cognizant of any conflicting information given to the road users by the permanent and/or the temporary traffic controls. Further, they need to think about the other road users besides passenger automobile operators (e.g., pedestrians, including the disabled; bicyclists; large trucks; school buses) because work areas often fail to properly accommodate users from these other groups (FHWA, 2006; Page 22).

The American Traffic Safety Services Association's (ATSSA's) *Work Zone Road Safety Audit Guidelines and Prompts List* (Atkinson et al., 2013) also provides guidance for performing RSAs in work zones. The outcome of the RSA is a list of findings, describing the factors that are expected to influence safety outcomes in the work zone, and strategies to mitigate these factors. RSAs help identify where drivers make mistakes and identify opportunities to build redundancy into the system to reduce the risk of mistakes resulting in a fatal or serious injury crash. Planners, designers, and managers can review the PSCs included in this guide and incorporate them into the work zone design or operation to address safety needs from the RSA. This serves as a proactive approach to reducing crash frequency and severity.

Many other strategies can be used to identify opportunities to implement PSCs in work zones (Atkinson et al., 2013):

- Work Zone Inspections – review of TTC devices and safety and mobility strategies that have been deployed per the approved TTC plan, standards, and specifications in an active work zone.
- Coordination and Collaboration among Stakeholders, Safety Partners, and Project Staff – includes coordination within a single project or among multiple projects within a corridor, network, or region, and possibly across agency jurisdictions with a focus on minimizing work zone safety and mobility impacts.
- Work Zone Impacts Assessment – systematically assessing work zone impacts through the project development stages and by looking at work zone impacts mitigation from a transportation management perspective rather than just a traffic control perspective.

PSCs in Work Zones

The following pages describe each PSC and how it can be implemented or considered in a work zone context. Each description includes the countermeasure name; a photo (if available); a "General Principles" section; and an "Application in Work Zones" section. Appendix A summarizes this information as a desktop reference, which includes the applicable Safe System Design Hierarchy Alignment, crash reduction/safety benefit, relative cost, and use in work zones.

Agencies can familiarize themselves with the information contained in this resource and reference FHWA's PSC website to inform their practices for incorporating PSCs into their work zone management activities. The PSC webpage includes additional information on each PSC, and a search and filter function.[5] Users answer questions regarding area type, functional classification, traffic volumes, safety problem(s) to be addressed, targeted crash types, and other information to receive a list of PSCs meeting the criteria. The search function allows users to

[5] https://highways.dot.gov/safety/proven-safety-countermeasures/search

obtain a tailored list of potential PSCs and assists practitioners with identifying the most appropriate PSC(s) for their location of interest.

This resource shows that each of the PSCs can be implemented in work zones, depending on the individual work zone characteristics and context. When using the PSCs in work zones, agencies should perform public outreach to provide information to users about what to expect and how to behave when they encounter the PSCs. The PSCs are generally associated with well-documented crash reductions under non-work zone conditions. This crash reduction information draws from the Crash Modification Factors (CMF) Clearinghouse,[6] which provides a searchable database of CMFs along with guidance and resources on using CMFs in road safety practice. The CMF Clearinghouse ID (CMF ID) number is listed for safety benefits when applicable and available. The extent of PSC applications in work zones varies. Transportation agencies have significant experience using some PSCs in work zones, and those PSCs appear in work zone-specific guidance documents, safety studies, and/or case study examples. For other PSCs, there is limited research or information available regarding the effectiveness in work zone applications. This does not suggest that the PSCs are not effective in work zones, but rather there is an opportunity to build on these experiences by performing work zone specific safety performance studies, producing case studies, or otherwise documenting benefits and considerations. Finally, some PSCs have not been regularly used in work zones. For these PSCs, there are opportunities for increased work zone implementation and pilot/demonstration projects.

[6] https://www.cmfclearinghouse.org/

Appropriate Speed Limits

Speed control is one method agencies can use to help reduce fatal and serious injury crashes, especially crashes that involve vulnerable road users.

General Principles

Setting speed limits that are consistent and reasonable for work zone conditions is critical for effectively managing vehicle speeds and reducing crash severity. When setting speed limits, agencies should consider non-vehicular activities, types of road users present, crash history, land use context, traffic volumes, and observed speeds, among other factors.

Application in Work Zones

Traffic control in work zones is designed on the assumption that drivers will only reduce their speeds if they clearly perceive a need to do so. Agencies can consider reducing speed limits under restrictive conditions (e.g., narrow lanes) or when workers and other road users are next to moving traffic without positive protection.

Source: FHWA (2016)

Work Zone Safety Benefits

Appropriately reduced work zone speed limits can reduce operating speeds and improve speed limit compliance though work zones (Sharma et al., 2017).

Resources

- Guidelines on Managing Speeds in Work Zones.
- MUTCD Section 6B.01.

Variable Speed Limits

Variable speed limits (VSLs) are speed limits that adapt and change automatically based on prevailing traffic conditions, such as traffic speed, traffic volumes, or road surface conditions.

General Principles

VSLs adjust and display the speed limit in real-time to harmonize operating speeds during various conditions. This can help to alleviate stop-and-go conditions, reduce the chance of collisions, and improve driver expectancy. Typical applications of VSLs include reduced speed limits during congestion, incidents, inclement weather, and work zones.

Application in Work Zones

VSLs in work zones, including portable VSLs, could have similar effects to their use in permanent locations. VSLs can improve driver expectation by providing information in advance of slowdowns and potential lane closures, which could reduce the probability for primary and secondary crashes. They can be particularly effective on high-volume urban and rural freeways and high-speed arterials with posted speed limits greater than 40 mph. An evaluation of VSLs in work zones in Minnesota found a 7 percent increase in throughput and a 25 to 35 percent decrease in speed variance (Kwon et al., 2007).

Source: FHWA (2013)

Work Zone Safety Benefits

VSLs can:

- Reduce speeding and improve speed harmonization through work zones (Chowdhury and Abaza, 2017).
- Reduce fatal and injury crashes on freeways up to 51 percent (CMF ID: 11003).

Resources

- Work Zone Variable Speed Limit Systems: Effectiveness and System Design Issues.
- Development and Field Evaluation of Variable Advisory Speed Limit System for Work Zones.

Speed Safety Cameras

Speed safety cameras (SSCs) use speed measurement devices to detect speeding and capture photographic or video evidence of vehicles that are violating a set speed threshold.

General Principles

When implemented appropriately as part of a speed management program, SSCs can reduce operating speeds and crashes. SSCs can either be fixed units, point-to-point (P2P) units, or mobile units. State and local regulations determine the types of areas where agencies can implement SSCs.

Application in Work Zones

Vehicle speed and speed variability tend to be primary contributors to crashes in work zones. Construction workers in work zones may not have positive protection, thus exposing them to these vehicle speeds. Enforcement can be an effective strategy to reduce vehicle operating speeds through work zones. However, human law enforcement may not be feasible due to restrictive geometry and limited space for traffic stops. States have deployed SSCs in work zones to improve safety and reduce operating speeds. SSCs in work zones typically utilize highly visible, mobile units. Agencies should conduct engineering studies, including speed limit and safety analyses for work zones, to determine if speed limits are appropriately set, limits are properly posted, and to review other safety factors.

Source: Maryland SafeZones (n.d.)

Work Zone Safety Benefits

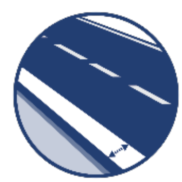
SSCs can:

- Reduce work zone fatal crashes by 25 percent and traffic speeds by 17 percent (PennDOT, 2022a and 2023).
- Decrease the occurrence of speeds traveling over the citation threshold (11 mph over the posted speed limit) by 90 percent (Maryland DOT, 2019).

Resources

- Automated Speed Enforcement in Work Zones.
- Pennsylvania's Automated Work Zone Speed Enforcement.
- Speed Safety Camera Program Planning and Operations Guide.

Wider Edge Lines



Edge lines are considered "wider" if the width is increased from the minimum normal line width of 4 inches to a width of 6 inches.

General Principles

Wider edge lines provide a safety benefit across different facility types and area types. Wider edge lines increase the visibility of the travel lane and the driver's perception of the pavement edge.

Application in Work Zones

Drivers may have difficulty comprehending and navigating the travel path in work zones. Similar to permanent installations of wider edge lines, temporary wider edge lines can be used in work zones to improve visibility of the travel lane and edge line. Wider edge lines in work zones have the potential to provide similar impacts as they do in permanent applications (Roadway Safety Consortium, 2011a). The Iowa Department of Transportation has used 8-inch markings for shift and merge areas but have not performed a formal safety performance evaluation (National Work Zone Safety Information Clearinghouse, 2023a).

Source: MDOT (2020)

Safety Benefits

Wider edge lines can:

- Reduce non-intersection, fatal and injury crashes on rural, two-lane roads by 37 percent (CMF ID: 4737).
- Reduce fatal and injury crashes on rural freeways by 22 percent (CMF ID: 4792).

Resources

- Guidelines on Ensuring Positive Guidance in Work Zones.
- Practice: Lane Lines in Work Zones.
- Safety Effects of Wider Edge Lines on Rural, Two-Lane Highways.

Median Barriers

Median barriers are longitudinal barriers that separate road users moving at different speeds or different directions in space and aim to redirect vehicles to the roadway if they hit the barrier.

General Principles

Types of median barrier include cable barriers, metal-beam guardrails, and concrete barriers. Cable barriers consist of steel cables mounted on weak posts in high or low tension. Metal-beam guardrails can consist of either a box-beam or W-beam system. Concrete barriers are rigid barriers and more-commonly used than other rigid median barriers for work zones.

Application in Work Zones

Various types of barriers can be used for positive protection depending on the work zone scenario, including portable concrete barriers, ballast-filled barriers typically filled with sand or water, portable steel barriers, mobile barrier trailers or moveable barrier systems, and truck mounted attenuators (TMAs). These barriers may have several functions in work zones, including reducing the likelihood of traffic entering work areas such as excavations or material storage sites; providing positive protection for workers, pedestrians, bicyclists, and other vulnerable road users; separating pedestrians, bicyclists, and other users from vehicular traffic; separating two-way traffic; and protecting construction equipment and materials such as falsework for bridges and other exposed objects.

Source: Lochrane et al. (2013)

Safety Benefits

Median barriers can reduce cross-median crashes on rural four-lane freeways by 97 percent (CMF ID: 7040).

Resources

- Work Zone Positive Protection Toolbox.
- Work Zone Devices.
- Installing and Maintaining Crashworthy Work Zone Traffic Control Devices.

Lighting

Roadway lighting can be installed to improve road user visibility in dark conditions.

General Principles

Lighting that meets or exceeds illuminance standards can have safety benefits for all road users and can also improve personal security for nonmotorized road users. Lighting can be applied in a linear fashion along road segments or at spot locations such as intersections and pedestrian crossings.

Application in Work Zones

Agencies may implement active work zones during nighttime or dark conditions to perform work when traffic volumes are lowest. Travel speeds are generally higher and visibility is lower at night, leading to potentially higher risks for road users and workers. Workers need light to conduct work activities and lighting increases the visibility of workers. Lighting also improves drivers' abilities to see closed lanes, shifted lane markings, construction equipment, and other work zone features. Various types of lighting can be used in work zones (e.g., portable light plant towers, conventional roadway luminaires on temporary poles, factory-installed lighting on work equipment, and balloon portable light towers) which are designed to minimize glare for motorists and workers. Different construction activities may require different levels of illumination (Shane et al., 2012).

Source: Roads and Bridges (2021)

Safety Benefits

Lighting can:

- Reduce nighttime injury crashes by up to 28 percent on rural and urban highways (CMF ID: 192).
- Reduce nighttime pedestrian injury crashes by up to 42 percent at intersections (CMF ID: 436).

Resources

- FHWA Lighting Handbook.
- Nighttime Lighting Guidelines for Work Zones.

Crosswalk Visibility Enhancements

Crosswalk visibility enhancements include several treatments that make crosswalks (and the pedestrians, bicyclists, and other road users who use them) more visible to drivers and can also assist crosswalk users in locating the appropriate crossing locations.

General Principles

Three main crosswalk visibility enhancement treatments are high-visibility crosswalk markings, lighting, and signing and pavement markings. These treatments can be implemented individually or in combination depending on characteristics of the crossing location.

Application in Work Zones

Crosswalk visibility enhancements can be applied in work zones, on both pre-existing crosswalks and temporary crosswalks implemented as part of the work zone phasing. If work zones intrude into pedestrian pathways, TTC measures should be in place to accommodate pedestrians (MUTCD Section 6C.02; FHWA, 2023). The MUTCD states that all temporary crosswalks must be accessible to pedestrians with disabilities (MUTCD Section 6G.09; FHWA, 2023).

Source: FHWA (2021a)

Safety Benefits

- High-visibility crosswalks can reduce pedestrian injury crashes by up to 40 percent (CMF ID: 4123).
- Intersection lighting can reduce pedestrian crashes by up to 42 percent (CMF ID: 436).
- Advance yield or stop markings and signs can reduce pedestrian crashes by up to 25 percent (CMD ID: 9017).

Resources

- Accommodating Pedestrians in Work Zones.
- Work Zones – Pedestrian Detours.

Walkways

A walkway is a defined path for use by a pedestrian traveling on foot or using a wheelchair. Walkways may include sidewalks, pedestrian paths, shared-use paths, or other pedestrian-oriented facilities.

General Principles

Walkways, when designed well and integrated into a pedestrian network, improve pedestrian safety by minimizing pedestrian exposure to motor vehicle traffic.

Application in Work Zones

When an existing walkway is disrupted due to a work zone, a temporary facility and TTC should be implemented to accommodate pedestrians. The MUTCD states that the temporary facility must include accessibility features consistent with the original facility, as required by Americans with Disabilities Act (ADA) (MUTCD Section 6C.03, 2023). Properly designed, implemented, and maintained walkways in and adjacent to work zones keep pedestrians safe from construction activities while maintaining accessibility and minimizing the effects on pedestrians. The temporary facility should provide a convenient and accessible path and avoid conflicts with obstacles related to the work zone (e.g., signing, fencing, construction equipment) (MUTCD Section 6C.03, 2023).

Source: FHWA (2017)

Safety Benefits

Sidewalks can reduce crashes with pedestrians walking along roadways by 65 to 89 percent (CMF ID: 1333-1337).

Resources

- Pedestrian Accommodation in Work Zones: A Field Guide.
- Applying the Americans with Disabilities Act in Work Zones: A Practitioner Guide.
- Guidelines for Work Zone Designers – Pedestrian and Bicycle Accommodation.

Leading Pedestrian Interval

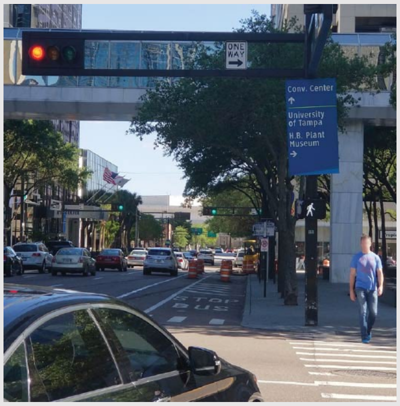
A leading pedestrian interval (LPI) is a traffic signal timing treatment that begins the pedestrian WALK phase 3-7 seconds before the parallel motor vehicle movement is given a green indication.

General Principles

LPIs give pedestrians a “head start” and an opportunity to enter the crosswalk before vehicles begin to move, improving pedestrian visibility to drivers. Agencies should ensure that pedestrian signals are accessible for all users (MUTCD Section 4I.06, 2023).

Application in Work Zones

LPIs can be particularly beneficial at signalized intersections with high turning vehicle volumes (Brewer et al., 2014). If a work zone uses a temporary detour for motor vehicles that results in increased turning volumes, an LPI may be an effective countermeasure to improve pedestrian crossing safety. LPIs may also be beneficial at signalized intersection crossing locations where construction vehicles or other heavy trucks are frequently turning.



Source: FHWA (2021b)

Safety Benefits

LPIs can reduce pedestrian crashes by 13 percent (CMF ID: 9918).

Resources

- Safety Evaluation of Protected Left-Turn Phasing and Leading Pedestrian Intervals on Pedestrian Safety.

Pedestrian Refuge Islands

A pedestrian refuge island (also known as a crossing island) is a median that is intended to help protect pedestrians who are crossing a multilane road.

General Principles

A median or pedestrian refuge island allows pedestrians to focus on one direction of traffic at a time as they cross. It also gives them a place to wait for an adequate gap in oncoming traffic before finishing the second phase of a crossing. Pedestrian refuge islands can also enhance the visibility of the crossing and reduce motor vehicle speeds.

Application in Work Zones

The reduction in user workload and crossing movement complexity that refuge islands afford can be beneficial when applied in the context of a work zone. This is especially true when other work zone features, such as TTC devices, barriers, and construction equipment may increase the visual clutter of the roadway and thus increase the crossing movement complexity. The MUTCD states that temporary raised islands that are located at pedestrian crossing locations must have an opening to provide a pathway for crossing pedestrians (Section 6M.03; FHWA, 2023). Temporary pedestrian refuge islands in work zones could be delineated using flex posts, plastic longitudinal barriers, or other devices (City of Orlando, 2023).

Source: MnDOT (2023)

Safety Benefits

Pedestrian refuge islands can reduce pedestrian crashes by up to 46 percent (CMF ID: 175).

Resources

- Median or Pedestrian/Bicycle Refuge Island.
- Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations.

Rectangular Rapid Flashing Beacons

A Rectangular Rapid Flashing Beacon (RRFB) is a pedestrian-actuated device that flashes in an alternating high-frequency pattern to alert drivers to a pedestrian using an uncontrolled, marked crosswalk.

General Principles

RRFBs are used with pedestrian, school, or trail crossing warning signs at uncontrolled, marked crosswalks. RRFBs improve the conspicuity of the crosswalk and alert drivers to the presence of a pedestrian in or approaching the crosswalk. Motorist yielding rates depend on the traffic volume, number of lanes, and speed limit, among other factors, but they are generally effective at multilane crossings with speed limits less than 40 miles per hour.

Application in Work Zones

RRFBs can be implemented at uncontrolled marked crosswalks in work zones, on both pre-existing crosswalks and temporary crosswalks. They can be used in work zone locations with TTC devices, such as sidewalk closed and detour signs, temporary curb ramps, and pedestrian channelizing devices (Oregon DOT, 2021). RRFBs can use solar power, eliminating the need for a power source.

Source: ITE (n.d.)

Safety Benefits

RRFBs can:

- Reduce pedestrian crashes by up to 47 percent (CMF ID: 9024).
- Increase driver yielding by up to 98 percent (Fitzpatrick et al., 2016).

Resources

- Temporary Pedestrian Accessible Route (TPAR): Temporary Midblock Crossing.
- Rectangular Rapid-Flashing Beacon (RRFB).

Pedestrian Hybrid Beacons

A pedestrian hybrid beacon (PHB) is a traffic control device designed to help pedestrians safely cross higher-speed roadways at midblock crossings and other uncontrolled crossing locations.

General Principles

The beacon head consists of two red lenses above a single yellow lens. The lenses remain dark until a pedestrian pushes the call button to activate the beacon, which then initiates a sequence consisting of flashing and then steady lights that directs motorists to slow and come to a stop, providing the right-of-way to the pedestrian to cross the roadway. In general, PHBs are most effective at multilane crossings with speed limits greater than 35 miles per hour and/or daily traffic volumes exceeding 9,000 vehicles (Blackburn et al., 2018).

Application in Work Zones

PHBs can be implemented at uncontrolled marked crosswalks in work zones, on both pre-existing crosswalks and temporary crosswalks, especially when longer work zone durations or other factors are present. Improving the conspicuity of crosswalks can be helpful when additional work zone signing, construction equipment, and other features may distract road users from recognizing a crosswalk. Temporary mobile PHB systems are available for work zone applications.

Source: FHWA (2014)

Safety Benefits

PHBs can:

- Reduce total crashes by up to 29 percent (CMF ID: 2911).
- Reduce pedestrian crashes by up to 55 percent (CMF ID: 9020).

Resources

- Safety Effectiveness of the HAWK Pedestrian Crossing Treatment.
- Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments.

Road Diets

A Road Diet, also called a roadway reconfiguration, typically involves reducing a four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL).

General Principles

A Road Diet improves safety by including a protected left-turn lane for mid-block left-turning motorists, reducing crossing distance for pedestrians, and reducing travel speeds that decrease crash severity. Additionally, the Road Diet provides an opportunity to allocate excess roadway width to other purposes, including bicycle lanes, on-street parking, or transit stops.

Application in Work Zones

Work zones frequently incorporate temporary reductions in the number of lanes or roadway width. Common features associated with permanent road diets (e.g. pedestrian refuge, crosswalk enhancements, on-street parking, transit accommodations, shorted pedestrian crossings, bicycle lanes) can be applied to work zones to reduce motor vehicle speeds, reduce road user exposure, and improve access and comfortability for all road users. Applying road diet principles in work zones can create a more community-focused environment that accommodates all road users.

Source: Oregon DOT (2016)

Safety Benefit

Road Diets can reduce crashes by 19 to 47 percent (CMF ID: 5554, 2841).

Resources

- Road Diet Informational Guide.

Bicycle Lanes

Bicycle lanes designate a preferential or exclusive space of the roadway for bicyclists through the use of signs, markings, and other vertical elements.

General Principles

Providing bicycle facilities can mitigate or prevent interactions, conflicts, and crashes between bicyclists and motor vehicles, and create a network of safer roadways for bicycling. Bicycle lane design should vary according to roadway characteristics (number of lanes, motor vehicle and truck volumes, speed, presence of transit), user needs (current and forecasted ridership, types of bicycles and micromobility devices in use within the community, role within the bicycling network), and land-use context (adjacent land uses, types and intensity of conflicting uses, demands from other users for curbside access). Separated bicycle lanes are recommended on roadways with higher vehicle volumes and speeds, such as arterials.

Application in Work Zones

When a bicycle facility passes adjacent to work zones, or construction activities affect the path of a bicycle facility, the continuity of a bikeway should be maintained through the work zone if practical. If a bikeway detour is unavoidable, it should be as short and direct as practical (MUTCD Section 6N.04, 2023). The MUTCD provides guidance on signing and TTC that can be used to close, shift, or detour a bicycle lane.

Source: NYCDOT (2019)

Safety Benefits

Separated bicycle lanes with flexible delineators can:

- Reduce bicycle vehicle crashes up to 53 percent (CMF ID: 11296).

Bicycle lane additions can:

- Reduce crashes up to 49 percent on urban four-lane undivided collectors and local roads (CMF ID: 10738).
- Reduce crashes up to 30 percent on urban two-lane undivided collectors and local roads (CMF ID: 10742).

Resources

- Accommodating People on Bicycles Through Work Zones.
- Bikeway Selection Guide.
- Guidelines for Work Zone Designers – Pedestrian and Bicycle Accommodation.

Rumble Strips

Rumble strips consist of raised or milled elements that produce noise or vibration to alert drivers that their vehicle has left the travel lane or that an unexpected condition that may require slowing or stopping is ahead.

General Principles

Longitudinal rumble strips run along the shoulder, edge line, or at the center of the roadway to alert drivers that their vehicle has left the travel lane if they are distracted, drowsy, or inattentive. Transverse rumble strips are installed perpendicular to the direction of travel and alert drivers to slow down or stop due to specific conditions ahead (e.g., intersections, curves, work zones).

Application in Work Zones

Similar to permanent installations of transverse rumble strips, temporary transverse rumble strips used in work zones alert drivers, but use a temporary raised surface placed on or adhered to the pavement surface (ATSSA, 2013). Temporary transverse rumble strips can alert drivers approaching a work zone to the need to slow down or stop. These types of rumble strips are typically quick to install and remove and perform similarly to permanent installations. Temporary or portable rumble strips can be implemented when work zones are stationary or slow-moving and last longer than one hour (MSU, 2021).

Source: Fontaine (2017)

Work Zone Safety Benefits

Temporary portable rumble strips can:

- Reduce mean operating speed by 10 to 13 percent (Yang et al., 2015).
- Reduce crashes in queued conditions by 60 percent (Brown et al., 2022).

Resources

- Guidance for the Use of Temporary Rumble Strips in Work Zones.
- Effectiveness of Temporary Rumble Strips in Work Zones.

Enhanced Delineation for Horizontal Curves

Enhanced delineation for horizontal curves includes various treatments or combinations of treatments approaching and/or within a horizontal curve to alert drivers of an approaching curve, specific sharpness or direction of a curve, or a recommended advisory speed.

General Principles

Potential strategies to enhance delineation of a horizontal curve include in-lane warning pavement markings, retroreflective strips on sign posts, delineators, chevron signs, enhanced conspicuity of signs, dynamic curve warning signs, and sequential dynamic chevrons.

Application in Work Zones

Enhanced delineation of curves in work zones can improve visibility to drivers approaching and navigating the curve. Enhanced pavement marking and signing strategies can have similar safety effects as those for horizontal curves outside of work zones. Warning devices, such as warning signs, arrow boards, or taper devices should be placed in the tangent section in advance of the curve to improve visibility (VDOT, 2019), so some taper lengths and buffer spaces should be lengthened to occur before horizontal curves (TEXX, 2011).

Source: FHWA (2009)

Safety Benefits

Chevron signs can:

- Reduce nighttime crashes by 25 percent (CMF ID: 2439).
- Reduce non-intersection fatal and injury crashes by 16 percent (CMF ID: 2438).

Oversized Chevron signs can:

- Reduce fatal and injury crashes by 15 percent (CMF ID: 8978).

Sequential dynamic chevrons can:

- Reduce fatal and injury crashes by 60 percent (CMF ID: 10362).

Resources

- Reference Guide to Work Zone Traffic Control.
- Work Zone Safety: Guidelines for Temporary Traffic Control.

Roadside Design Improvements at Curves

Roadside design improvements at curves include strategies applied to the outside of horizontal curves to improve roadside environments where vehicles have a higher risk for roadway departures.

General Principles

Improvements such as clear zone widening, slope flattening, and adding or widening shoulders can help drivers recover if they depart the roadway. Other improvements can help reduce crash severity if roadside hazards cannot be relocated, redesigned, or removed, such as cable barriers, metal-beam guardrail, and concrete barriers.

Application in Work Zones

Roadside design improvement strategies at horizontal curves can be applied temporarily in work zones. The American Association of State Highway and Transportation Officials' (AASHTO's) *Roadside Design Guide* (AASHTO, 2011) specifically discusses traffic barriers, traffic control devices, and other roadside safety features in work zones. The *Roadside Design Guide* includes common clear zone widths for work zones, and greater clear zone width may be required depending on equipment and material storage needs. The recommended clear zone widths do not change based on presence of horizontal curves, but designers should be aware of site restrictions to accommodate traffic.

Source: PennDOT (2022b)

Safety Benefits

- Flattening sideslopes from 1V:3H to 1V:4H can reduce single-vehicle crashes by 8 percent (CMF ID: 4627).
- Increasing the distance to roadside features can also reduce crashes. For example, Elvik and Vaa (2004) reported increasing the distance to roadside features from 3.3 ft to 16.7 ft can reduce total crashes by 22 percent (CMF ID: 35).

Resources

- Roadside Design Guide.
- Guidance Use of Work Zone Clear Zones, Buffer Spaces, and Positive Protection Deflection Distances.

SafetyEdge℠

SafetyEdge℠ shapes the edge of pavement at approximately 30-degrees from the pavement cross slope to eliminate vertical drop-offs at the pavement edge.

General Principles

SafetyEdge℠ can help drivers return to the roadway if they start to depart while maintaining control of their vehicle. It can also improve the durability of the pavement by reducing raveling of the pavement edge.

Application in Work Zones

Pavement edge drop-offs may occur in work zones due to construction activities such as staged construction, pavement repairs, resurfacing, overlays, or shoulder work. Similar to permanent applications, SafetyEdge℠ can be installed temporarily in work zone applications to help drivers return to the road if they leave the pavement. It may be applicable to situations where temporary pavement is applied or when there are temporary pavement edge drop-offs greater than 2 inches that are not shielded by barrier. Temporary applications of SafetyEdge℠ in work zones have the potential to have similar safety benefits as permanent installations.

Source: FHWA

Safety Benefits

Safety Edge℠ can:

- Reduce fatal and injury crashes by 11 percent (CMF ID: 9205).
- Reduce run-off-road crashes by 21 percent (CMF ID: 9211).
- Reduce head-on crashes by 19 percent (CMF ID: 9217).

Resources

- Safety Effects of the SafetyEdge: Technical Summary of Crash Modification Factors.
- Traffic Control Strategies in Work Zones with Edge Drop-Offs.

Backplates with Retroreflective Borders

Backplates added to a traffic signal head improve the visibility of the illuminated face of the signal by introducing a controlled-contrast background.

General Principles

Backplates with a 1- to 3-inch yellow retroreflective border can improve the visibility, conspicuity, and orientation of the signal face in day and night conditions, especially for older drivers or drivers with color vision deficiencies.

Application in Work Zones

Backplates with retroreflective borders can be installed on either permanent traffic signals in work zones or temporary (or portable) traffic signals in work zones. Portable traffic signals in work zones typically replace either existing traffic signals or flaggers for alternating one-way flow of traffic. These borders in work zone conditions could have similar safety effects as permanent installations in non-work zone situations since they improve visibility and conspicuity of the signals.

Source: Village of Canastota (2023)

Safety Benefits

Backplates with retroreflective borders can reduce total crashes by 15 percent (CMF ID: 1410).

Resources

- Toolbox for Low-Cost Work Zone Management Strategies.

Access Management

Corridor access management involves controlling entry and exit points (i.e., access points) along a stretch of roadway to improve safety, encourage walking or biking, and improve traffic conditions.

General Principles

Access management may include limiting the number of access points allowed on a roadway; consolidating, removing, or relocating driveways; limiting specific movements (e.g., allowing right-in/right-out only); or installing raised medians to prevent access or limit movements.

Application in Work Zones

Elements of permanent corridor access management can be applied to work zones to improve traffic management and are typically included in transportation management plans. This could include access management of construction sites and/or permanent entry and exit points along roadways, both having similar safety benefits. Strategically placing entry and exit points to/from the activity area in a work zone can help limit the number of conflict points between construction vehicles and other road users. Similarly, strategically consolidating, limiting, or removing permanent driveway access points or limiting movements at these driveways while work zones are in place can help reduce the number of conflict points in a work zone.

Source: Roadway Safety Consortium (2011b)

Safety Benefits

Corridor access management can:

- Reduce total crashes along two-lane rural roads by 5 to 23 percent (Harwood et al., 2000).
- Reduce fatal and injury crashes along urban/ suburban arterials by 25 to 31 percent (CMF ID: 179, 178).

Resources

- Guidelines on Work Zone Access and Egress.
- Improved Business Driveway Delineation in Urban Work Zones.

Dedicated Turn Lanes

Turn lanes, for both left- and right-turn movements, separate turning traffic that is slowing or stopped from through-moving traffic at intersections.

General Principles

Turn lanes have been shown to provide both safety and operational benefits. Turn lanes can be designed to provide for deceleration prior to a turn, as well as for storage of vehicles that are stopped and waiting for the opportunity to complete a turn. Providing offset of left- and right-turn lanes to increase visibility can provide added safety benefits, and is preferable in many situations, particularly at locations with higher speeds, or where free-flow or permissive movements are possible.

Application in Work Zones

Turn lanes often exist in work zones. These may include existing turn lanes that are in the work zone or turn lanes created as part of the work zone traffic control plan. Offset left-turn lanes can improve visibility and sight distance when work zone activities, barriers, or other traffic control devices are present. Warning signs and other strategies can be used when work zone activities require lane closures that affect left- or right-turn lanes.

Source: FHWA (2021e)

Safety Benefits

- Left-turn lanes can reduce total crashes by 28 to 48 percent (CMF ID: 260, 268).
- Right-turn lanes can reduce total crashes by 14 to 26 percent (CMF ID: 285, 289).
- Positive offset left-turn lanes can reduce fatal and injury crashes by 36 percent (CMF ID: 6096).

Resources

- Safety Effectiveness of Intersection Left- and Right-Turn Lanes.

Roundabouts

A roundabout is a circular intersection in which traffic travels counterclockwise around the center island and entering traffic must yield to circulating traffic.

General Principles

Roundabouts encourage slower speeds (15-25 mph) and reduce the number and severity of conflict points at an intersection. They are also operationally beneficial, as the yield-control reduces intersection delay and queuing. Roundabouts are an effective option for managing speed and transitioning traffic from high-speed to low-speed environments.

Application in Work Zones

Temporary roundabouts are an increasingly common and effective solution for temporary traffic control, especially in cases where work zone activities affect existing traffic signals. Additionally, temporary roundabouts can be deployed as a traffic management strategy for major power outages and infrastructure damage resulting from severe storms (Schroeder, n.d.). Temporary roundabouts can be implemented using traffic cones, drums, vertical delineators, or portable curbing, along with proper traffic control devices such as yield signs and one-way signs.

Source: MoDOT (2024)

Safety Benefits

- Converting a two-way stop-controlled intersection to a roundabout can reduce fatal and injury crashes by 82 percent (CMF ID: 211).
- Converting a signalized intersection to a roundabout can reduce fatal and injury crashes by 78 percent (CMF ID: 226).

Resources

- Rapid Response Techniques for Disasters Near Roadway Work Zones: Temporary Roundabouts.

Reduced Left-Turn Conflict Intersections

Reduced left-turn conflict intersections feature geometric designs that change how and where left-turn movements occur. Two types include the Restricted Crossing U-turn (RCUT) and the Median U-turn (MUT).

General Principles

RCUT intersections—also known as Superstreets, J-Turns, or Reduced Conflict Intersections (RCIs)—modify minor road left-turns by directing traffic to make a right-turn and then a U-turn at a downstream U-turn crossover intersection. MUT intersections modify the left-turns from the major approaches, requiring those drivers to proceed through the intersection and make a U-turn at a crossover intersection downstream and then a right-turn at the main intersection.

Application in Work Zones

The principles of both RCUT and MUT intersection designs can be applied in work zones to prohibit left or through movements from some intersection approaches. The availability of locations to make U-turns is a key consideration in applying reduced left-turn conflict intersections in work zones.

Source: FHWA (2009)

Safety Benefits

RCUTs can reduce fatal and injury crashes by 22 to 63 percent (CMF ID: 5556, 9985, 4884).

Resources

- A Guide to Work Zone Temporary Traffic Control Near Signalized/Unsignalized Intersections.

Systemic Application of Low-Cost Countermeasures at Stop-Controlled Intersections

The systemic approach to safety involves deploying low-cost countermeasures at many sites to maximize resources and cost-effectiveness.

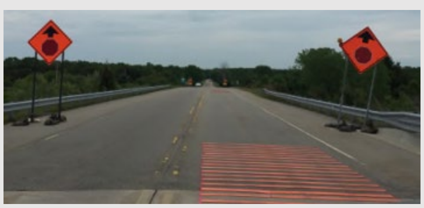
General Principles

Common treatments deployed systemically at stop-controlled intersections include:

- Retroreflective sheeting on sign posts.
- Enhanced pavement markings.
- Double, oversized advance "Stop Ahead" or advance intersection warning signs (often with flashing beacons) and/or Stop signs.
- Properly placed stop bars.
- Removal of vegetation, parking, or other sightline obstructions.

Application in Work Zones

Low-cost, systemic countermeasures at stop-controlled intersections can be especially helpful in work zones, where work zone activities may affect several intersections and changes to the intersections may be temporary. Enhancing the signing and markings in work zones (for example, using oversized or double signs, beacons, or high-visibility pavement markings) can help alert drivers to important information, like an upcoming intersection, amidst the added visual clutter and distraction of work zone activities.



Source: MDOT (2024)

Safety Benefits

Systemic treatments at stop-controlled intersection can:

- Reduce fatal and injury crashes by 10 percent (CMF ID: 8867).
- Reduce nighttime crashes by 15 percent (CMF ID: 8870).
- Reduce fatal and injury crashes at rural intersections by 27 percent (CMF ID: 8874).

Resources

- Proven Safety Countermeasures: Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections.

Yellow Change Intervals

A yellow signal indication occurs on a traffic signal before the red indication and after the green indication ends. The yellow change interval refers to the amount of time that the yellow signal indication is displayed on the traffic signal.

General Principles

Yellow change intervals should be properly timed so drivers can safely stop. A properly timed yellow change interval reduces the potential for red-light running. Factors that are part of the timing calculation include approach speed, perception-reaction time, vehicle deceleration, and the geometry of the intersection.

Application in Work Zones

Appropriately timed yellow change intervals can be applied in work zones for TTC at both permanent traffic signals and portable temporary traffic signals. Appropriately timed yellow change intervals in work zones may show similar benefits as permanent applications, including reductions in red-light running and related crashes. Yellow change intervals can be regularly monitored and adjusted, if needed, to improve performance.

Source: FHWA (2021f)

Safety Benefits

Appropriately timed yellow change intervals can:

- Reduce red-light running by 36 to 50 percent (McGee et al., 2012).
- Reduce total crashes at intersections by 8 to 14 percent (McGee et al., 2012).
- Reduce injury crashes at intersections by 12 percent (CMF ID: 384).

Resources

- Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections.

Pavement Friction Management

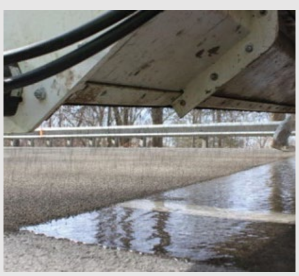
Pavement friction is an important characteristic of the roadway that impacts a vehicle's ability to stay in the lane and on the roadway.

General Principles

Measuring, monitoring, and maintaining pavement friction at locations where vehicles frequently turn, slow, or stop can improve performance and reduce roadway departure, intersection-related, wet-road, and pedestrian crashes. Where increased friction is desired, agencies can install a High Friction Surface Treatment (HFST) on the pavement to enhance friction and skid resistance.

Application in Work Zones

HFST can be applied in work zones to improve pavement friction for temporary and permanent pavements. Conditions that require increased friction may be similar to those in permanent conditions, such as along horizontal curves; approaching intersections or pedestrian crossings; approaching a work zone; where there are temporary changes in road geometry; and locations that have a risk of increased crashes that could be helped by increasing friction demand. Another situation that may require increased friction in work zones are steel plate trench covers commonly used during construction. These plates can be slick, especially when wet; applying HFST resin binder materials to the surface of plates can improve friction (Merritt et al., 2021).



Source: FHWA (2021g)

Safety Benefits

HFST can:

- Reduces injury crashes at ramps by 63 percent (CMF ID: 10342).
- Reduces injury crashes at horizontal curves by 48 percent (CMF ID: 10333).
- Reduces total crashes at intersections by 20 percent (CMF ID: 2259).

Resources

- High Friction Surface Treatments (HFST).
- Safety Effects of a Targeted Skid Resistance Improvement Program.

Source: FHWA (2021h)

Safety Benefits

LRSP implementation has been associated with the following safety benefits (FHWA, 2021h):

- Reductions in fatalities on county roads by 25 percent.
- Reductions in serious injury crashes on county-owned roads by 17 percent.
- Reductions in severe curve crashes by 35 percent.

Resources

- Work Zone Management Capability Maturity Framework.
- Guidance for Conducting Effective Work Zone Process Reviews.

Local Road Safety Plans

Local Road Safety Plans (LRSPs), or Safety Action Plans, are a framework to identify, analyze, and prioritize safety improvements based on community needs.

General Principles

The successful development of an LRSP engages multiple stakeholders, uses a data-driven approach, and results in a list of issues, risks, actions, and improvements that are tailored and prioritized based on local needs to aid agencies in reducing fatalities and serious injuries on their road network.

Application in Work Zones

LRSPs can be incorporated into processes for designing work zones. Agencies can review LRSPs to identify any safety issues in the area of work zones which should be considered when designing the work zone and TTC. This could include specific crash types that are overrepresented in the area or specific geometric features that may result in a greater risk for total or severe injury crashes. In addition, the principles of LRSPs can be applied to making programmatic improvements in work zone safety management.

Source: Atkinson et al. (2013)

Safety Benefits

RSAs can reduce total crashes by 10 to 60 percent (Nabors et al., 2012; FHWA, 2006).

Resources

- Work Zone Road Safety Audit Guidelines and Prompt Lists.
- Work Zone Road Safety Audits: What to Look for.

Road Safety Audit

A Road Safety Audit (RSA) is an assessment of a roadway or intersection by a multidisciplinary team.

General Principles

RSAs identify safety issues, provide recommendations for countermeasures, and formally document findings and recommendations in a report. RSAs consist of the following eight steps: 1) identify projects; 2) select RSA team; 3) conduct start-up meeting; 4) perform field reviews; 5) analyze and report on findings; 6) present findings to owner; 7) prepare formal response; 8) incorporate findings.

Application in Work Zones

RSAs can be performed during the planning or design phase of work zones or during an active work zone to identify opportunities to improve safety. When performing an RSA during planning or design of work zones, the RSA team should identify potential safety issues and risk factors that align with State priorities, identify expected user experience for all road users, and identify any other risk factors. The RSA should be performed on all temporary roadways and transition areas of work zones (FHWA, 2006).

Chapter 5. Summary, Conclusions, and Future Needs

Work zone safety is a high priority for transportation agencies, the construction industry, and the travelling public. Work zones are necessary to maintain, rehabilitate, enhance, and reconstruct this nation's roadway network, but they are also the location where a significant number of traffic fatalities occur each year. There is no single solution to creating safer work zones. However, agencies can apply the Safe System Approach to work zone planning, design, management, and operations. This guide provides information to assist transportation agencies with taking a Safe System Approach to work zone management through implementation of PSCs and other effective countermeasures in work zones.

The *Safe System Roadway Design Hierarchy* can help transportation agencies and practitioners identify and prioritize countermeasures and strategies based on their alignment with Safe System Approach principles when developing policies as well as when planning and designing specific projects. At the policy, program, process, and individual project (i.e., work zone) levels, agencies can use the hierarchy as a framework to assess where their work zone management approaches fall within and align with the Safe System Approach.

FHWA has identified 28 PSCs to reduce fatal and serious injury crashes on roads nationwide. These PSCs are applicable for a range of contexts, road types, and governing agencies across the country. The PSCs can offer significant and measurable impacts across an agency's road network as part of their approach to improving safety. The PSCs can support agencies with implementation of the Safe System Approach, which seeks to build and reinforce multiple layers of protection to both prevent crashes from happening and minimize the harm caused to those involved when crashes do occur.

This guide presented 28 PSCs with descriptions about how to apply them in work zones. These descriptions included a definition of the countermeasure, general notes about its application, a summary of documented safety performance effectiveness, and information on how or why the countermeasure is applicable to work zones. The PSC summaries also presented countermeasure-specific resources that readers can refer to for more information. More implementation and studies are necessary for applying PSCs in work zone contexts to better understand and quantify their effectiveness. However, PSCs present significant potential for reducing work zone fatalities and serious injuries in the U.S. Incorporating them at both the policy- and project-levels represents a step towards a Safe System Approach to work zone safety management and a goal of zero fatalities and serious injuries.

Appendix A: PSCs in Work Zones Desktop Reference

Federal Highway Administration

Proven Safety Countermeasures in **Work Zones**

Desktop Reference

U.S. Department of Transportation
Federal Highway Administration

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

FHWA-SA-24-033

Introduction

Work zones are necessary to maintain, rehabilitate, enhance, and reconstruct this nation's roadway network, but they are also where a significant number of traffic fatalities occur each year. According to the National Highway Traffic Safety Administration's (NHTSA's) Fatality and Injury Reporting System Tool (FIRST), 4,319 people were killed in work-zone crashes in the U.S. between 2018 and 2022. The number of work-zone fatalities has grown from 757 fatalities in 2018 to 891 in 2022, a 17.7 percent increase.

The Federal Highway Administration (FHWA) has identified 28 Proven Safety Countermeasures (PSCs) to reduce fatal and serious injury crashes on roads nationwide (see Figure 1). These PSCs are applicable for a range of contexts, road types, and governing agencies across the country. Efforts to reduce fatal and serious injury crashes in work zones can leverage efforts and lessons learned outside of work zones, including the effectiveness of PSCs. Implementing PSCs in work zones is a step towards a Safe System Approach to work zone planning, design, deployment, management, and operations.

Agencies can implement the PSCs in this desktop reference through their work zone policies and program-level processes, or by proactively implementing these countermeasures as part of individual temporary traffic control (TTC) plans and transportation operations (TO) components. The National Work Zone Safety Information Clearinghouse provides additional information about safety in work zones, including potential work zone safety countermeasures.[1]

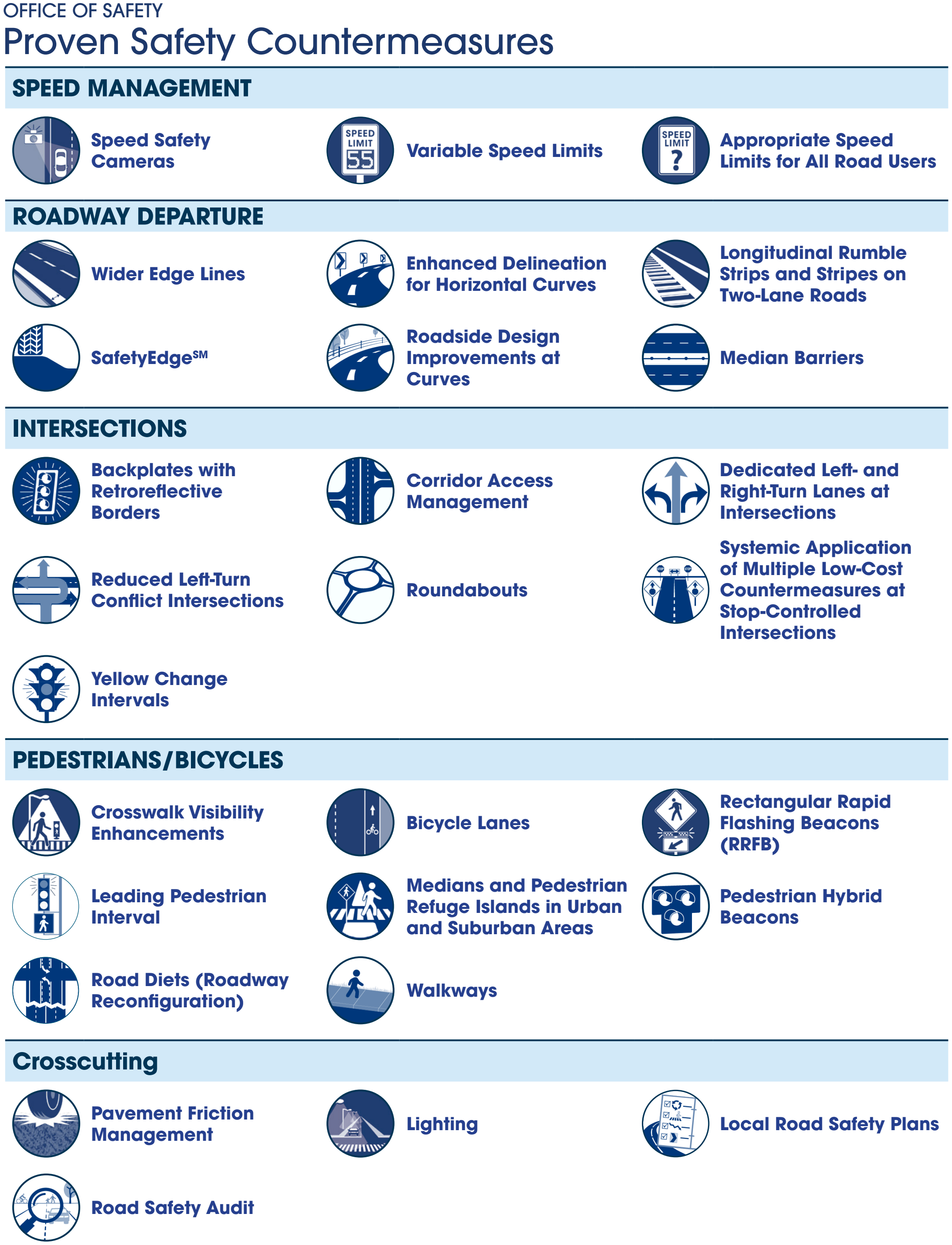


Figure 1. FHWA's 28 Proven Safety Countermeasures. Source: FHWA.

1 https://workzonesafety.org/

Desktop Reference

The Proven Safety Countermeasures (PSCs) in Work Zones Desktop Reference is a quick reference summary of PSC applications in work zones. It addresses four key characteristics of each PSC: 1) how the countermeasure addresses the Safe System Roadway Design Hierarchy, 2) crash reduction ranges or general safety benefits, 3) relative cost for installation, and 4) use or applicability of the PSC in work zones.

1 – Safe System Roadway Design Hierarchy Alignment

- **Tier 1: Remove Severe Conflicts** - eliminating specific high-risk conditions, such as separating road users moving at different speeds or different directions, in space to minimize conflicts.
- **Tier 2: Reduce Vehicle Speeds** - implementing design features and speed management strategies to reduce vehicle speeds; effectively reduces the kinetic energy involved in a crash should it occur.
- **Tier 3: Manage Conflicts in Time** - separating the users in time using traffic control devices, such as traffic signals or hybrid beacons, to minimize vehicle conflicts with vulnerable road users.
- **Tier 4: Increase Attentiveness and Awareness** - alerting roadway users to certain types of conflicts so that appropriate action can be taken.
- Find more information on the Safe System Roadway Design Hierarchy at https://highways.dot.gov/sites/fhwa.dot.gov/files/2024-01/Safe_System_Roadway_Design_Hierarchy.pdf.

2 – Crash Reduction or Safety Benefit[2]

- **Low (L)** - less than or equal to 24% reduction (≤ 24%).
- **Medium (M)** - greater than or equal to 25% and less than or equal to 49% reduction (25-49%).
- **High (H)** - greater than or equal to 50% reduction (≥ 50%).
- The crash types for which the estimated crash reduction benefits apply are provided in parentheses.

3 – Relative Cost

- **Low-cost (L):** up to $5,000 per mile or location.
- **Medium-cost (M):** $5,000 to $50,000 per mile or location.
- **High-cost (H):** more than $50,000 per mile or location.
- Note costs can vary considerably due to local conditions.

4 – Use in Work Zones

- This includes information about the use or applicability of the PSCs in work zone contexts. It is consistent with information in the PSC summaries in *Implementing the Proven Safety Countermeasures in Work Zones.*

Table 1. The Work Zone PSC Desktop Reference

Safety Focus Area	Proven Safety Countermeasure	1 Safe System Design Hierarchy Alignment				2 Crash Reduction or Safety Benefit L-M-H	3 Relative Cost L-M-H	4 Use in Work Zones
		Tier 1: Remove Severe Conflicts	Tier 2: Reduce Vehicle Speeds	Tier 3: Manage Conflicts in Time	Tier 4: Increase Attentiveness and Awareness			
	Appropriate Speed Limits for All Road Users	-	Yes	-	-	Reduce operating speeds and improve speed limit compliance through work	L	• When setting speed limits, agencies should consider non-vehicular activities, types of users present, crash history, land use context, traffic volumes, and observed speeds, among other factors. • Agencies can consider reducing speed limits under

Figure 2. Excerpt of the Work Zone PSC Desktop Reference table columns.

2 All cited crash reductions or safety benefits are consistent with the PSC summaries in *Implementing the Proven Safety Countermeasures in Work Zones*. If information about crash reductions was not available, the reference includes information about other general safety benefits (e.g., speed reduction).

Table 1. The Work Zone PSC Desktop Reference

Safety Focus Area	Proven Safety Countermeasure	Safe System Design Hierarchy Alignment				Crash Reduction or Safety Benefit L-M-H	Relative Cost L-M-H	Use in Work Zones
		Tier 1: Remove Severe Conflicts	Tier 2: Reduce Vehicle Speeds	Tier 3: Manage Conflicts in Time	Tier 4: Increase Attentiveness and Awareness			
Speed Management	Appropriate Speed Limits for All Road Users	-	Yes	-	-	Reduce operating speeds and improve speed limit compliance through work zones	L	• When setting speed limits, agencies should consider non-vehicular activities, types of users present, crash history, land use context, traffic volumes, and observed speeds, among other factors. • Agencies can consider reducing speed limits under restrictive conditions or when workers are next to moving traffic without positive protection.
	Speed Safety Cameras (SSCs)	-	Yes	-	-	M (work zone fatal crashes) L (work zone speeds) H (occurrence of speeds over the citation threshold)	M-H	• Traditional speed enforcement may not be feasible in work zones due to restrictive geometry or limited space, so states and municipalities have passed legislation to allow SSCs in work zones to improve safety. • Engineering studies, including speed limit and safety assessments, should also be conducted for each work zone to determine if speed limits are appropriately set, limits are properly posted, and to review other safety factors.
	Variable Speed Limits (VSLs)	-	Yes	-	Yes	H (fatal and injury crashes on freeways) Reduce speeding and improve speed harmonization through work zones	L-H	• Portable VSLs can be used in work zones. • VSLs can improve driver expectation by providing information in advance of slowdowns and potential lane closures.
Pedestrian/ Bicyclist	Bicycle Lanes	Yes	-	-	-	H (bicycle/vehicle crashes) M (total crashes)	L-M	• When a bicycle facility passes adjacent to work zones or construction activities affect the path of a bicycle facility, the continuity of a bikeway should be maintained through the work zone if practical (MUTCD Section 6N.04, 2023). • If a bikeway detour is unavoidable, it should be as short and direct as practical (MUTCD Section 6N.04, 2023).
	Crosswalk Visibility Enhancements	-	-	-	Yes	M (pedestrian injury and pedestrian crashes)	L-M	• Crosswalk visibility enhancements can be applied in work zones on pre-existing crosswalks and temporary crosswalks. • If work zones intrude into pedestrian pathways, TTC measures should be in place to accommodate pedestrians (MUTCD Section 6C.02; FHWA, 2023).

Safety Focus Area	Proven Safety Countermeasure	Safe System Design Hierarchy Alignment				Crash Reduction or Safety Benefit L-M-H	Relative Cost L-M-H	Use in Work Zones
		Tier 1: Remove Severe Conflicts	Tier 2: Reduce Vehicle Speeds	Tier 3: Manage Conflicts in Time	Tier 4: Increase Attentiveness and Awareness			
Pedestrian/ Bicyclist	Leading Pedestrian Interval (LPI)	-	-	Yes	-	L (pedestrian crashes)	L	• LPIs may be beneficial in work zones at signalized intersections with high turning vehicle volumes. • They can also be beneficial at signalized intersection crossing locations where construction vehicles or other heavy trucks are frequently turning.
	Pedestrian Refuge Islands	Yes	Yes	-	-	M (pedestrian crashes)	L-M	• Pedestrian refuge islands may be useful in work zones when work zone features, such as temporary traffic control devices, barriers, and construction equipment, may increase the visual clutter of the roadway and increase the crossing movement complexity. • Temporary pedestrian refuge islands in work zones can be delineated using flex posts, longitudinal plastic barriers or channelizing devices, or other elements.
	Pedestrian Hybrid Beacons (PHBs)	-	-	Yes	-	M-H (total and pedestrian crashes)	M	• PHBs can be implemented at uncontrolled marked crosswalks in work zones on pre-existing and temporary crosswalks. • Temporary mobile PHB systems are available for work zone applications.
	Rectangular Rapid Flashing Beacons (RRFBs)	-	-	-	Yes	M (pedestrian crashes) H (driver yielding rates)	L	• RRFBs can be implemented at uncontrolled marked crosswalks in work zones on pre-existing crosswalks and temporary crosswalks. •RRFBs can use solar power, which eliminates the need for a power source.
	Road Diets (Roadway Reconfiguration)	Yes	Yes	-	-	L-M (total crashes)	L-H	• Work zones frequently incorporate temporary reductions in the number of lanes to facilitate construction activities in or adjacent to the roadway. • Common features associated with permanent road diets can be applied to work zones to reduce motor vehicle speeds, reduce road user exposure, and improve access and comfortability for all users.
	Walkways	Yes	-	-	-	H (pedestrian crashes)	L-H	• When an existing walkway is disrupted due to a work zone, a temporary facility with temporary traffic control should be implemented in its place to provide safe, accessible accommodations for pedestrians and other users. (MUTCD Section 6C.03, 2023) • The temporary facility should provide a convenient and accessible path and avoid conflicts with obstacles related to the work zone (e.g., signing, fencing, construction equipment) (MUTCD Section 6C.03, 2023).

Safety Focus Area	Proven Safety Countermeasure	Safe System Design Hierarchy Alignment				Crash Reduction or Safety Benefit L-M-H	Relative Cost L-M-H	Use in Work Zones
		Tier 1: Remove Severe Conflicts	Tier 2: Reduce Vehicle Speeds	Tier 3: Manage Conflicts in Time	Tier 4: Increase Attentiveness and Awareness			
Roadway Departure	Enhanced Delineation for Horizontal Curves	-	-	-	Yes	M (nighttime crashes) L-H (fatal and injury crashes)	L	• When work zones have horizontal curves, including on temporary roadways, enhanced delineation of the curve can improve visibility to drivers approaching and navigating the work zone. • Warning devices can be used on tangents approaching the curve to improve visibility, such as warning signs, arrow boards, or taper devices.
	Rumble Strips	-	-	-	Yes	H (queued condition crashes) L (mean operating speed reduction in work zones)	L	• Temporary transverse rumble strips can alert drivers approaching a work zone to the need to slow down or stop. • Temporary transverse rumble strips in work zones use a temporary raised surface placed on or adhered to the pavement surface.
	Median Barriers	Yes	-	-	-	H (cross-median crashes)	M-H	• Barriers can help reduce likelihood of traffic entering work areas such as excavations or material storage sites and provide positive protection for workers, pedestrians, bicyclists, and other vulnerable road users. • Different barrier types can be used for positive protection depending on the work zone conditions (e.g., portable concrete barriers, ballast-filled barriers typically filled with sand or water, portable steel barriers, mobile barrier trailers or movable barrier systems, and truck mounted attenuators).
	Roadside Design Improvements at Curves	Yes	-	-	-	L (total crashes)	L-H	• Roadside design improvement strategies at curves can be applied temporarily in work zones using devices such as traffic barriers, traffic control devices, and other roadside safety features. • Clear zone widths in work zones may vary depending on equipment and material storage needs.
	SafetyEdge℠	Yes	-	-	-	L (fatal and injury, run-off road, and head-on crashes)	L	• Pavement edge drop-offs may occur in work zones due to construction activities such as pavement replacement or overlays. • SafetyEdge℠ may be applicable to situations where temporary pavement is applied or when there are temporary pavement edge drop-offs that are not shielded by a barrier.
	Wider Edge Lines	-	-	-	Yes	M (fatal and injury crashes on rural two-lane roads) L (fatal and injury crashes on rural freeways)	L	• Road users may have difficulty comprehending and navigating the travel path in work zones. • Temporary wider edge lines can be used in work zones to improve visibility of the travel lane and edge line.

Safety Focus Area	Proven Safety Countermeasure	Safe System Design Hierarchy Alignment				Crash Reduction or Safety Benefit L-M-H	Relative Cost L-M-H	Use in Work Zones
		Tier 1: Remove Severe Conflicts	Tier 2: Reduce Vehicle Speeds	Tier 3: Manage Conflicts in Time	Tier 4: Increase Attentiveness and Awareness			
Intersections	Backplates with Retroreflective Borders	-	-	-	Yes	L (total crashes)	L	• Backplates with retroreflective borders can be installed on either permanent traffic signals or temporary (or portable) traffic signals in work zones. • These borders can improve visibility and conspicuity of the signals.
	Access Management	Yes	-	-	-	L-M (total crashes on two-lane rural roads or fatal and injury crashes on urban/suburban arterials)	L-M	• Corridor access management can be applied in work zones to improve access to construction sites and/or permanent entry and exit points along roadways with work zones. • Strategically placing entry and exit points in a work zone can help limit the number of conflict points between construction vehicles and other users.
	Dedicated Turn Lanes	Yes	-	-	-	L-M (total or fatal and injury crashes)	M	• Work zones can utilize existing turn lanes or new turn lanes can be created as a part of the temporary traffic control plan. • Warning signs and other strategies can be used when work zone activities require lane closures that affect left- or right-turn lanes.
	Reduced Left-Turn Conflict Intersections	Yes	-	-	-	L-H (fatal and injury crashes)	H	• Temporary or permanent Restricted Crossing U-turns (RCUTs) or Median U-turns (MUTs) can be used in work zones to reduce conflicts at intersections. • A key consideration in applying RCUTs and MUTs in work zones is the availability of locations for U-turns.
	Roundabouts	Yes	Yes	-	-	H (fatal and injury crashes)	L-H	• Temporary roundabouts can be an effective solution in work zones, especially in cases where work zone activities affect existing traffic signals or during adverse events, such as severe storms. • Temporary roundabouts can be constructed using traffic cones, drums, vertical panels, and parking curbs.
	Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections	-	-	-	Yes	L (fatal and injury and nighttime crashes) M (fatal and injury crashes at rural intersections)	L	• Enhancing the signing and markings in work zones (for example, using oversized or double signs, beacons, or high-visibility pavement markings) can help alert drivers to important information, like an upcoming intersection amidst the added visual clutter and distraction of work zone activities.
	Yellow Change Intervals	-	-	Yes	-	L (total and injury crashes at intersections) M-H (red-light running)	L	• Appropriately timed yellow change intervals can be applied in work zones for temporary traffic control at permanent and portable traffic signals.

Safety Focus Area	Proven Safety Countermeasure	Safe System Design Hierarchy Alignment				Crash Reduction or Safety Benefit L-M-H	Relative Cost L-M-H	Use in Work Zones
		Tier 1: Remove Severe Conflicts	Tier 2: Reduce Vehicle Speeds	Tier 3: Manage Conflicts in Time	Tier 4: Increase Attentiveness and Awareness			
Crosscutting	Lighting	-	-	-	Yes	M (nighttime injury and pedestrian injury crashes)	L-H	• Lighting can improve visibility of closed lanes, lane shift markings, construction equipment, other unexpected features, and workers. • Lighting in work zones may include portable light plant towers, conventional roadway luminaires on temporary poles, factory-installed lighting on work equipment, and balloon portable light towers.
	Local Road Safety Plans (LRSPs)	Yes	Yes	Yes	Yes	L-M (total crashes)	L-H	• LRSPs can be incorporated into work zone planning and design processes. • Agencies can review LSRPs to identify safety issues in the area of work zones which should be considered when designing the work zone and temporary traffic control (e.g., overrepresentation of certain crash types).
	Pavement Friction Management	Yes	Yes	-	-	H (injury crashes at ramps) M (injury crashes at horizontal curves) L (total crashes at intersections)	L-M	• High Friction Surface Treatments (HFST) can be applied to temporary or permanent pavement in work zones. • Work zone conditions that may require increased friction demand include along horizontal curves, approaching intersections or pedestrian crossings, approaching a work zone, where there are temporary changes in road geometry, steel plate trench covers, and at locations with a risk of increased crashes where increasing friction demand could help.
	Road Safety Audit (RSA)	Yes	Yes	Yes	Yes	L-H (total crashes)	L-M	• Work zone RSAs can occur during planning and design of work zones or during an active work zone. • Work zone RSAs can help mitigate potential safety impacts or identify unforeseen safety issues.

U.S. Department of Transportation
Federal Highway Administration

Office of Safety

Proven Safety Countermeasures

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