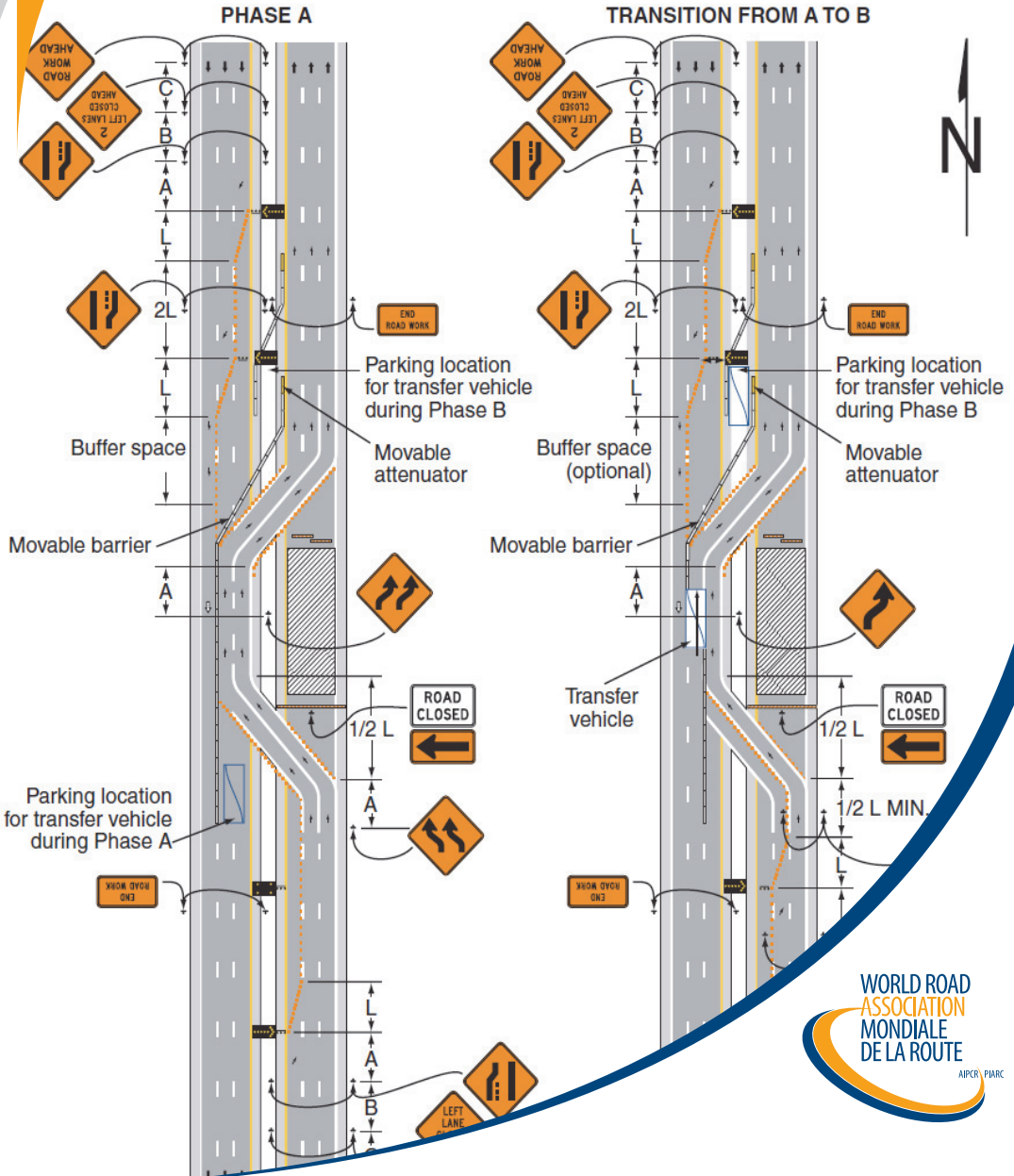


IMPROVEMENTS IN SAFE WORKING ON ROADS

Technical Committee C.1 Safer Road Infrastructure



The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

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Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organizations or agencies.

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*World Road Association (PIARC)
La Grande Arche, Paroi nord, Niveau 2
92055 La Défense cedex, FRANCE*

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This report was produced by the technical Committee C.1 Safer Road Infrastructure.

The contributors to this report are:

Mike Greenhalgh (United Kingdom), Working group leader;

Elizabeth Alicandri (United States);

Aditya Bahadur (India);

Uros Brumec (Slovenia);

Jaakko Klang (Finland);

Åke Larsson (Sweden);

Bernhard Lautner (Austria).

The Technical Committee was chaired by Hans-Joachim Vollpracht (Germany), John Douglas (Australia) was the English-speaking secretary. French-speaking secretary was Lise Fournier (Canada-Québec) and Spanish-speaking secretary Roberto Llamas Rubio (Spain).

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EXECUTIVE SUMMARY

Many road safety engineers and planners are familiar with the 4 (sometimes 5) E's for safety 'Engineering', 'Evaluation', 'Education' and 'Enforcement' and, sometimes, 'Emergency services'.

For the safe, efficient and effective management of work zones, it is proposed that a 4 C's principle be adopted. Work zones should be designed, operated and maintained such that the works are: *conspicuous, clear, consistent and credible*.

The focus of this guide is on safety of both workers and road users in construction zones, with an emphasis on basic principles and low-cost solutions that can be implemented in developed and developing countries

The number of work zones is increasing – in developed countries to replace ageing infrastructure and in developing and transitional countries as their network matures. With an increase in traffic volumes, the demands to improve the networks and provide additional capacity increases. Further, the positive effects of countermeasures to improve the safety of road works are proven.

For road workers, the safety issues of the work zone are obvious – their workplace is surrounded by many rapidly moving vehicles. For the driver travelling in a work zone, the hazards, although less noticeable, are still important. In the frequently changing environment that occurs during road work, the driver is often surprised and may not have the necessary information or space to make safe and sound decisions.

Given the need to build, improve and maintain roads while they are open to traffic, the vulnerabilities of the road worker must be considered. The risks to workers from the travelling public, as well as the risks to the travelling public because of the work zone, can be minimized. However, protecting the driving public, as well as these vulnerable road workers, requires cooperation and collaboration from many sectors.

INTRODUCTION

Adequate transportation is a requirement for all economies, but particularly for developing and transitional ones. Improving and expanding the roadway network is critical to quality of life as well as economic success. There is very little reliable international data on how fatalities in work zones contribute to the overall roadway fatality problem.

According to Advanced Research on Road Work Zone Safety Standards in Europe (ARROWS)[2]. *“It seems rather well substantiated that work zones are relatively unsafe places to be. However, the estimates regarding how large the relative increase in the accident risk is in a work zone vary from a few to a several hundred percent. The sources of these enormous differences are unclear, etc. However, one would suspect that the former number (of a few percent) is more likely than the latter.”*

Even if the number of crashes and injuries occurring at work zones is still relatively small in relation to crashes on the open road, improving work zone safety is a crucial part of a wider plan to reduce the death toll on our world’s highways.

1. AN INTRODUCTION TO SAFETY AND WORK ZONES

1.1. PROBLEM STATEMENT AND BACKGROUND

Traffic fatalities are an international health concern. The World Health Organization [1] estimates that road traffic crashes kill 1.2 million people annually and injure or disable between 20 and 50 million. Outside of the tragic human costs, the economic burden of these preventable deaths and injuries is staggering – USD 518 billion. The fatality rate per population is significantly higher in low and middle-income countries than in high income countries, creating, arguably, an even greater burden on their economies.

Adequate transportation is a requirement for all economies, but particularly for developing and transitional ones. Improving and expanding the roadway network is critical to quality of life as well as economic success. There is very little reliable international data on how fatalities in work zones contribute to the overall roadway fatality problem. According to Advanced Research on Road Work Zone Safety Standards in Europe (ARROWS) [2] *“It seems rather well substantiated that work zones are relatively unsafe places to be. However, the estimates regarding how large the relative increase in the accident risk is in a work zone vary from a few to a several hundred percent. The sources of these enormous differences are unclear... However, one would suspect that the former number (of a few percent) is more likely than the latter.”* United States figures [3] indicate that work zone fatalities make up about 2 percent of the overall fatalities, and of that figure, most of the fatalities are drivers travelling through the work zone (approximately 80%). In Austria in 2008, work zone fatalities on motorways represented 2.5% of all fatalities and none of these were workers. In the Netherlands, traffic crash statistics show an annual average of about 20 fatalities in work zones, with less than one (on average) worker fatality. Even if the number of crashes and injuries occurring at work zones is still relatively small in relation to crashes on the open road, improving work zone safety is a crucial part of a wider plan to reduce the death toll on our world’s highways. Furthermore, anything we can do to prevent even a single work zone fatality, given not only the financial costs, but the cost of a human life to society, is worthwhile and necessary.

The number of work zones is increasing – in developed countries to replace ageing infrastructure and in developing and transitional countries as their networks mature. With an increase in traffic volumes, the demands to improve the networks and provide additional capacity increases. Further, the positive effects of countermeasures to improve the safety of work zones is proven – Austria instituted a work zone safety program on motorways in 2004 that has led to a reduction of more than 60% in the number of injury crashes [4]. Now the risk of an injury accident in a work zone is the same as on the rest of the network. The UK reports [5] similar findings for minor

works on trunk roads and motorways: *“There is not a statistically significant increase in accidents due to the works”*.

For road workers, the safety issues of the work zone are obvious – their workplace is surrounded by many rapidly moving vehicles. For the driver traveling in a work zone the hazards, although less noticeable, are still important. In the frequently changing environment that occurs during road work, the driver is often surprised and may not have the necessary information or space to make safe and sound decisions or maneuvers.

Some countries use a *“Safe System”* approach in work zones to ensure that in the event of a crash, the impact energies remain below the threshold likely to produce either death or serious injury. This threshold will vary from crash scenario to crash scenario, depending upon the level of protection offered to the road users involved. For example, the chances of survival for an unprotected pedestrian hit by a vehicle diminish rapidly at speeds greater than 30 km/h, whereas for a properly restrained motor vehicle occupant the critical impact speed is 50 km/h (for side impact crashes) and 70 km/h (for head-on crashes).

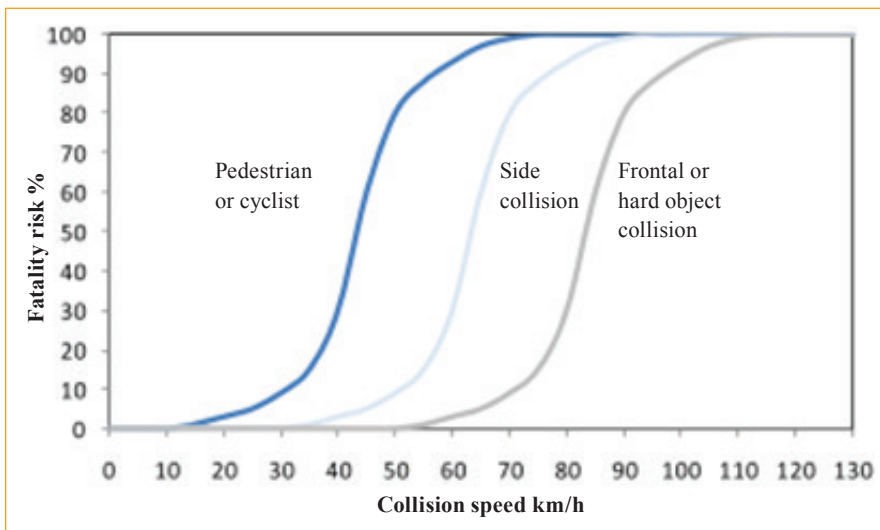


FIGURE 1 – COLLISION SPEED – FATALITY RELATIONSHIP (WRAMBORG, 2005) [6]

Clearly, complete separation of drivers from the work area is the most comprehensive approach to improving work zone safety, and full road closures are used in some circumstances. However, maintaining mobility while ensuring safety is the balance that most agencies face when designing and implementing a work zone. Certain principles, such as minimizing the duration of work, actively communicating information to the driving public, and positively separating the workers from the traffic are commonly used to strike this critical balance.

Given the need to build, improve and maintain roads while they are open to traffic, the vulnerabilities of the road worker must be considered. The risks to workers from the traveling public, as well as the risks to the traveling public because of the work zone, can be minimized. However, protecting the driving public, as well as these vulnerable road workers, requires cooperation and collaboration from many sectors. At a minimum:

- politicians must take an active interest in road safety;
- highway and road authorities must develop and implement safety standards for work zones;
- designers must consider safety issues as they develop roadway plans;
- contractors must ensure their personnel are appropriately trained and equipped;
- road workers must actively follow safety procedures;
- drivers must behave responsibly;
- police must actively participate in speed management and work zone safety.

1.2. RESULTS OF AN INTERNATIONAL SURVEY ON IMPROVEMENTS IN SAFE WORKING ON ROADS

In July 2008, the World Road Association team addressing work zone safety under Technical Committee 1.4 *Safer Road Infrastructure* prepared and distributed a survey to all committee members. The summarized findings, based on the responses of 17 member organizations, are presented here.



FIGURE 2 – WORK ZONES AND OTHER ROAD TRAFFIC INCIDENTS CAUSE ADDITIONAL COSTS AND INCONVENIENCE TO ROAD USERS AND SOCIETY IN GENERAL

(photo courtesy J. Klang)

1.2.1. Guidelines and Standards

The first major section of the survey assessed the use of guidelines and standards for work zones, including specifically addressing issues of conspicuity and the use of advance warning signs. All respondents have guidance or standards that include basic safety information for work zones. Only about half include additional information regarding best practices. Conspicuity, particularly for signs and markings and for worker clothing is addressed in most standards. Advance signing is frequently used, with an emphasis on telling drivers what is coming up and what action they should take, but end of work zone signing is less common.

1.2.2. Legal Aspects

The second major section of the survey assessed legal aspects regarding the control of work zones, including how standards are enforced and how speed in work zones is managed. In most cases, guidelines/standards for work zones are legally binding. In over half the cases, the initial drawings/documents for work zones are prepared by contractors or consultants, but are approved by a government entity, and the government became the liable party. A wide range of requirements for speed management in work zones are common, but additional sanctions for drivers who exceed the work zone speed limit are not.

1.2.3. Surveillance of the Work Zone

Work zones are regularly inspected in most countries, but the responsible party (government entities to police to independent external auditors), the tools used for inspection, the amount of documentation of the inspection and the frequency of inspection (twice a day to weekly) are all highly variable.

1.2.4. Training and Accreditation of Workers

Although a slight majority of respondents require regular formal training for workers, a slight minority required regular retraining. There is wide variance in terms of the requirements, frequency and type of accrediting organization (the road authority, the employer/contractor, or independent agencies).

1.2.5. Communication

Most respondents communicate with road users through signs (changeable or variable) message signs and static signs) and the media (press releases, radio, and internet). Formal communication with workers seems minimal.

1.2.6. Urgent Interventions

A wide range of approaches are taken for urgent interventions with arrow panels and trucks or vans with lights being the most common. Positive protection (crash cushions) was rarely mentioned. Standards and guidelines tend to dictate the positions of devices, with different requirements for different speed and situations. Standard signing for lane closures is almost universal as is some form of materials approval – in about half the cases a national body or transportation ministry. The risk of a device being dangerous is considered by most countries before it is used.

1.2.7. Crash Statistics in Work Zones

About half the respondents indicated that crash statistics were available for work zones. The type and level of detail of data collected on work zones fatalities and injuries varies dramatically. For example, Canada, Finland and Austria were able to provide data on work zone injuries and only Canada and United States could differentiate worker fatalities from motorist fatalities. Summarizing the data across countries is difficult given these dramatic differences, so a summary is provided for each country that replied.

Australia (Queensland): Queensland represents about 20% of Australia's population. From 1992 – 2008 there were 3 work zone fatalities in Queensland and 108 injuries (22 that required hospitalization). "*Adjusting*" with an increase to account for the total population of Australia, this yields, approximately, less than one fatality per year and 32 injuries annually.

Austria: For 2008, on the highway network, there were 2 fatalities and 143 motorists injured in work zones, representing about 2.5% of all fatalities and 4% of all injuries. It appears that no workers were killed on the highway network in that year.

Canada: In 2006, there were 164 collisions in which a worker was killed (6) or injured (158). In these collisions, 1 driver was killed and 4 were injured. These data do not include the province of Alberta, which normally makes up about 13% of casualty producing collisions in Canada. "*Adjusting*" with an increase of 13% to account for the total picture in Canada, this yields, approximately, 8 fatalities (86% were workers) and 183 injuries (97% were workers).

Finland: From 2003 – 2007, there were 17 fatalities and 442 injuries in work zones in Finland. This yields an average of 3 fatalities and 88 injuries in work zones annually. The crashes predominantly occurred on clear or partly cloudy days, peak in summer months and represent about 1.8% of accidents involving personal injuries.

Netherlands: Traffic crash statistics show that annually there are 20 fatalities and 165 serious injuries in work zones annually. From a different data base, and using different years it appears that annually there are approximately 2 crashes per year involving road workers, and a quarter of these involve fatalities. Of these crashes where a worker was injured or killed, 12% involved other traffic – the preponderance involved a construction vehicle. The accident information may be underreported by as much as one half for occupational hazards, but the fatality information is considered good. The fatality rate for road construction workers is higher than for other construction workers.

United States: In 2007, 835 fatalities were reported in work zones. Approximately 85% of the fatalities were motorists and 15% were road workers. To determine if worker fatalities are caused by motorists or construction vehicles, different databases must be used, and it appears that approximately 80% of the fatalities do not include other motorists.

1.2.8. Miscellaneous Issues

The last section of the survey gathered broad information on work zone safety and issues. The majority of respondents identify driver behavior (inattention, speeding) as a current work zone problem. Almost half the respondents mentioned an issue related to standards, either they were insufficient, or not being followed properly. Less frequently mentioned problems included: the overall crash problem and short duration work zones.

1.3. ROAD SAFETY-HUMAN FACTORS BASICS

The highway system consists of three major elements: the driver, the roadway and the vehicle. Environmental factors, including weather issues, can be overlaid on these three major elements. As seen in figures two and three, the overwhelming majority of crashes include driver factors. US data [7] show over half of the causative factors attributed strictly to the driver and over a quarter attributed to driver-roadway interactions. Finnish data[8] provide a different picture, with about 11% of crashes attributed only to the driver, and almost 60% attributed to a combination of driver, roadway and vehicle interactions.

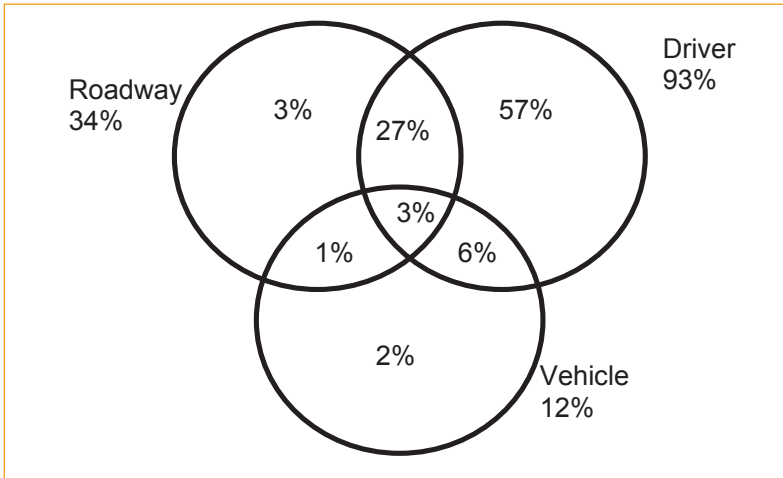


FIGURE 3 – CAUSES OF CRASHES IN THE UNITED STATES [7]

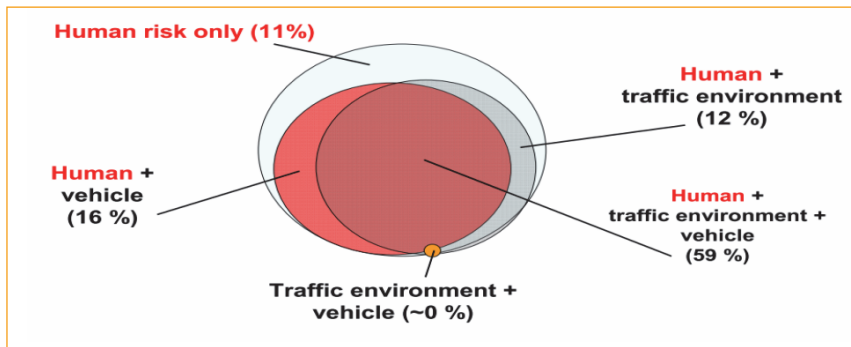


FIGURE 4 – CAUSES OF CRASHES IN FINLAND 2009 [8]

Regardless of the details, it is clear that the driver element must be appropriately considered in the design, operations and control decisions made by traffic engineers. Vehicle and highways have improved over the years with the advent of crumple zones, air bags and seat belts and the implementation of better pavements, improved traffic control device materials, and safer roadway and roadside designs. The driver, however, has not changed dramatically since the advent of the automobile, and we do not anticipate any significant improvements in the basic skills that are needed to operate a motor vehicle. To continue to improve the safety of our highways, we must design and develop a system that meets the needs of the weakest element in the system and the one least amenable to change: the driver.

Human factors focuses on designing systems that meet user needs. By better understanding the human component, we can make choices about the roadway component that ensure that our design decisions are not contrary to drivers' needs

and capabilities. The system model presented above seems simple enough – there are only three components, but of course, the reality is far more complicated. “*Accommodating the driver*” is not a simple task, but because incorporating driver needs in highway design has such great potential to improve the safety and efficiency of our roadways; we must include human factors information in our traffic engineering processes.

The driving process can be divided into three basic phases: Drivers need to gather and process information, make decisions, and execute actions. Roadway elements, particularly in complex situations like work zones, significantly affect how efficiently drivers perform these actions and therefore how safely they operate.

1.4. DRIVERS’ ACTIONS AND ENGINEERING ELEMENTS IN WORK ZONES

Linking driver needs to design and engineering decisions allows us to adequately consider their needs in laying out a work zone. Characteristics of roadway elements can be manipulated in to make them better affect drivers’ abilities to safely perform those actions. The principles discussed in the next chapter of ensuring that works are *conspicuous, clear, consistent and credible*.

In order to minimize risks to drivers and workers and improve safety, engineers must consider the safety implications of every decision. For instance, if you design a six-lane facility, how will you provide appropriate signing to maintain safe operations for a lane closure during later repaving operations? If you decide to minimize the size of the hard shoulder, how will guardrail repair personnel maintain an adequate distance from the travel lane? Is the need for later road works taken into consideration when pavement life-cycle is addressed? Has the need for maintenance on bridges and in tunnels been considered in their cross section design? Safety issues must be considered not only for the immediate work zone you might be creating today, but for the roadway you are leaving for tomorrow for others to work on. Just as lifecycle costs are considered in a pavement decision, so too must the safety implications be considered throughout the lifecycle of a roadway.

1.5. OVERVIEW OF THIS GUIDE

This document provides guidance and examples of best practice to improve the safety for all those who could be affected by work zones either as operatives who necessarily have to work on our highways or road users.

Chapter 2, *Principles of Safe Work Zones* addresses “*what we should think about*” in work zone design, implementation and operations. It is general in nature.

Chapter 3, *Definitions*, covers language conventions used in the guide.

Chapter 4, *Roles and Responsibilities in Work Zones*, takes a broad view, as the roles and responsibilities of parties differ in every country. However, this provides a structure for understanding how the important players can work together.

Chapter 5, *Planning and Design of Work Zones*, is a technical chapter that includes information on achieving a balance between safety and mobility throughout the work zone planning and design process.

Chapter 6, *Safe and Efficient Operations of Work Zones*, is also a technical chapter that includes detailed information on signs and traffic management techniques for setting up and operating work zones.

Chapter 7, *Personnel in Work Zones*, provides an overview of appropriate training and equipment for workers. Given the wide range of occupational health rules and regulations, it is very general in nature.

Chapter 8, *Typical Layouts for Work Zones*, is a technical chapter that provides specific examples of methods of designing and operating a variety of work zones types on a variety of road types.

Chapter 9, *Checklist for Work Zone Safety*, provides straightforward information to use in determining if the safety issues for your work zone have been appropriately considered.

1.6. RESOURCES

ARROWS (Advanced Research on ROad Work Zone Safety Standards in Europe) (<http://www.ntua.gr/arrows/D1.html>) is funded by the European Commission under the Transport RTD Programme of the 4th Framework Programme.

Nova Scotia Temporary Workplace Temporary Traffic Control Manual (<http://www.gov.ns.ca/tran/tcm/2007Manual-20070330-Distribution.pdf>) The purpose of the manual is to provide a traffic control standard for construction, maintenance and utility operations on highways and streets in Nova Scotia.

European program “PREVENT” (<http://www.prevent-ip.org/>) The integrated project PREVENT is a European automotive industry activity co-funded by the European Commission to contribute to road safety by developing and demonstrating preventive safety application and technologies.

OECD 1989 Traffic Management and Safety at Highway Work Zones, Chaired by C. Caubet (France) (report is not available on line)

(http://www.oecd.org/document/15/0,3343,en_2649_34351_1882895_1_1_1_1,00.html).

National Work Zone Safety Information Clearinghouse (<http://www.workzonesafety.org>). An extensive clearinghouse of information, mostly from the US, on work zone safety. The National Work Zone Safety Information Clearinghouse is dedicated to providing the transportation construction industry and the general public with comprehensive information to improve motorist, worker and pedestrian safety in roadway work zones.

Manual on Uniform Traffic Control Devices (MUTCD) http://mutcd.fhwa.dot.gov/pdfs/2009/pdf_index.htm (see Part 6 - Temporary Traffic Control) This document defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public traffic in the United States.

Traffic Signs Manual <http://www.dft.gov.uk/pgr/roads/tss/tsmanual/> (see part 8 Road works and temporary situations). This document provides guidance for traffic authorities on the use of traffic signs and road markings in the United Kingdom.

Increased penalties for drivers in work zones In some cases, the penalties or fines for drivers who disobey the law are higher in a work zone. This link provides information on such approaches across the United States. http://www.workzonesafety.org/laws/state_laws/fine_legislation

Slovenia: Signs for Road Works Written in Slovenian, but the signing diagrams and typical layouts are useful regardless of language <http://www.uradni-list.si/1/content?id=76399> & (completion) <http://www.uradni-list.si/1/content?id=88352&part=&highlight=Pravilnik+o+na%C4%8Dinu+ozna%C4%8DDevanja+in+zavarovanja+del+na+javnih+cestah>

‘Know your Traffic Signs’ This UK document provides basic information on traffic signs for the general reader <http://www.dft.gov.uk/pgr/roads/tss/gpg/trafficsigns.pdf>

Public Outreach Campaigns

<http://www.highways.gov.uk/knowledge/20631.aspx>

<http://www.highways.gov.uk/knowledge/11349.aspx>

<http://www.highways.gov.uk/knowledge/20639.aspx>

<http://www.roadsafe.com/news/article.aspx?article=806>

2. PRINCIPLES OF SAFE WORK ZONES

2.1. INTRODUCTION

The economic well-being of a country is, to a greater or lesser extent, inexorably linked to the effectiveness of infrastructure transportation links; highways, railways, air transport and water borne traffic. The vibrancy, or otherwise of a country's economy is directly affected by the efficiency, effectiveness and, crucially, the safety of those transport links.

For the successful operation and maintenance of a highway system, it is often necessary, once the asset has been put into use, to put in place temporary traffic management (TTM) to enable safe work zones or other temporary closures. In this regard it is particularly important, therefore that all work zones and temporary closures are carefully planned to ensure that whilst safety is crucial and throughput and maintenance of traffic flow an important aspect, the final solution provides the best balance between these potentially competing elements and that in particular the safety of those who necessarily have to work on the highway is not compromised in favor of either cost, vehicle throughputs or driver convenience.

A fundamental aspect of temporary traffic management design, operation and maintenance must therefore be ensure so far as reasonably practicable the safe, efficient and effective movement of all road users (drivers, pedestrians, bicyclists, other vulnerable road users, etc.) and the safety of all those working on or in the work zone.

Many countries recognize the following as 'vulnerable road users' (i.e. those without a protective 'shell' around them) and would often give special consideration to their needs:

- pedestrians,
- bike riders
- motorcyclists, and
- equestrians (in some countries).

Nowhere, however, are road workers yet regarded as 'vulnerable' in this sense. It is the contention of this guide, therefore, that they should be thus classified. Road workers are most certainly 'vulnerable' in as much as they often have no protection other than safety clothing and footwear and they are 'road users' in as much as they use the roadway as their place of work. Considering road workers as vulnerable road users will encourage a mind set and attitude to their safety and welfare that is not always present currently.

2.2. CONSIDERATIONS

Many road safety engineers and planners are familiar with the 4 (sometimes 5) E's for safety 'Engineering', 'Evaluation', 'Education' and 'Enforcement' and, sometimes, 'Emergency services'.

For the safe, efficient and effective management of work zones it is proposed that a 4 C's principle be adopted i.e., work zones should be designed, operated and maintained such that they are: *Conspicuous, Clear, Consistent, and Credible*.

2.2.1. Conspicuous

The first principle is that the driver must notice the work zone – it must be conspicuous. They must be physically able to see what is coming up. The work zone must be obvious, noticeable and eye-catching to attract the attention of the driver and to start the process of encouraging them to act in the desired way with regard to speed, position of vehicle and heightened attention. The objective is to provide noticeable early warning of the need for drivers to be alert to obstructions and/or deviations in the road.

A number of countries use different colored signing for work zones to differentiate them from normal road conditions. For example, USA, Canada, parts of Australia and New Zealand use orange signs for work zones.

Many use retro-reflective signing and additional lighting in and around work zones to assist in increasing the conspicuity of the site.

2.2.2. Clear

In order for drivers to make the correct decisions about how to safely approach and pass through work zones all signing, guiding and other instructions must be clear. The driver needs to be absolutely certain about what is required. Signs must be visible from far enough in advance, given the likely approach speed, for the driver to be able to understand what is required and be able to carry out those instructions in a timely fashion.

In the UK's "*Safety at Street Works and Road Works*" there is a simple 'Key Question' which managers and supervisors should ask themselves:

"Will someone coming along the road or footway from any direction understand exactly what is happening and what is expected of them?"

It is vital that when work zones are being planned and executed that this simple question is borne in mind at all times. Safety is often adversely affected by the

presence of work zones and in many situations work zones present a higher accident rate than non work zones. But this does not have to be the case.

Human beings are only able to process a limited amount of information at any one time. So whilst it may seem prudent to provide drivers with many signs, guides, speed limits and other information care must be taken not to overload the drivers. The design of the work zones must include sufficient information to allow the correct actions to be taken without giving extraneous information. Too many signs and too many other instructions will produce a form of ‘sign blindness’ where the driver sees all the information but is unable to process that and turn it into safe actions.

However, care must also be taken to ensure that there is sufficient guidance and instruction to the driver. They need to know what speed to drive at, where to position their vehicle, which lanes are closed, which path to take through the work zone, what the expectations are of them and so on. Not too much information but certainly not too little.

2.2.3. Consistent

Drivers can be conditioned to behave and act in a certain way by the consistent design and operation of work zones. But if drivers encounter differing standards, layouts and arrangements in different areas they become confused and uncertain how to proceed. This in turn can lead to poor driving and a failure to act in the required way. All this is potentially detrimental to the safety performance of the work zone.

The basic rationale of having consistency is to provide the user with the correct expectation of what will occur ahead. By using consistent designs and controls for all work zones, we can set up a set of expectations for drivers that can assist them in making appropriate and safe decisions.

2.2.4. Credible

The final principle involves the credibility or ‘believability’ of the instructions. Drivers must believe that what they are told (e.g. the need to slow down) and that the messages they are given are a true representation of what will occur ahead.

Take a situation where warnings may be given for say, “*active work zone ahead*” but in fact here is no work going on. If drivers frequently see such a warning followed by no work occurring, they may become conditioned not to believe the information.

When, at another time, he/she might be given similar warnings, the driver may not necessarily believe they are likely to encounter a hazard and drive without the care necessary. It is vitally important that the actual scene encountered matches the

instructions and guidance. Without this, drivers will not accept the instructions and will not take the correct safe actions.

2.3. HARMONIZATION

At all times the objectives should be for as much uniformity and harmonization as is possible not just throughout a country but across national boundaries, where this is practicable. Harmonization and standardization of work zone layouts, signing, guarding, lighting, etc. will have benefits for road users in that they will encounter similar situations, similar layouts and would therefore be better able to react accordingly and adjust their driving patterns, speed and behavior to match the situation they find themselves in. Clearly if drivers are more aware of what they need to do, when they need to do it, how they need to react and actually follow these instructions, their safety will be improved and this will have a direct benefit in safety terms to the road worker.

A key axiom of planning and designing the road works must be *'Never surprise the driver'*. Help them to make the right decision in the right time and take the right action.

2.4. ADVANCE NOTIFICATIONS

In accordance with the principle of a *'hierarchy of controls'* (i.e. first try to eliminate the hazard before trying mitigate or manage) research has shown that a significant amount of traffic can be *'removed'* from the work zone areas by adequate early warning of road works e.g. publicity a few weeks before major road works can facilitate drivers the chance to re-plan their routes.

2.5. SEGREGATION

As far as is possible the work zones should be planned and executed to physically separate the road user from the road worker. This may seem obvious, but it is a key principle.

For long term work zones, it is possible to use physical (steel or concrete, etc.) barriers. These are not always feasible for short term (less than 24 hour duration) due to the time taken and consequential risk exposure, in deploying and then removing the barriers. Where physical barriers are not feasible, other safety measures such as further reductions in speed and increases in the segregation between road user and road workers should be considered.

2.6. SIGNING

The fundamental principle of signing work zones is to give sufficient information to drivers to enable them to take the correct action at the correct time and to do this

safely. However, it is important not to overload the driver with either too much or conflicting information. In other words, the signing needs to be appropriate to the situation. At all times, drivers need to be given adequate sight lines to facilitate their correct actions.

Mistakes are often made in having temporary signs which conflict with permanent signs e.g. a temporary speed limit of X which conflicts with an uncovered permanent speed of Y. Also, signs can often be obscured when put out due to insufficient thought given to location/surroundings/flora and fauna etc.

It is important to use correct lettering/number heights such that signs can be read early enough at the approach speed of the vehicles to facilitate drivers taking the desired action.

“A fundamental principle is to use ‘as few signs as possible but as many as necessary’”. (Source ‘ARROWS Advanced Research on Road Work Zone Safety Standards in Europe’) Try to avoid sign/information overload.

2.7. SPEED CONTROL

Work zones often present to the driver a reduced standard of road in terms of layout, lane width, surface texture etc. It is vital, therefore that drivers use these sections of road at an appropriate speed. This is often a lower speed than in the non work situation.

In addition, when it is not possible to physically separate drivers from road workers and other vulnerable road users, speed control is necessary to reduce the risks of serious accidents with potentially fatal consequences.

It is also necessary to consider a gradual reduction in allowable speeds on the approach to work zones in case the work zone has resulted in queuing traffic. Bringing speeds down on the approach to work zones will reduce the potential for rear end shunt accidents. However, whatever speed limit is chosen and implemented; it is absolutely imperative that these are enforced.

Speed control can either be advisory or mandatory limits. The effectiveness of advisory limits may well vary from culture to culture but it should be borne in mind that in certain countries (UK for one) their use has very limited effectiveness as they tend to be ignored.

A more reliable way to ensure the correct speed is used is to employ mandatory limits. However, experience has shown that to be effective and to ensure they do not lose credibility with drivers there must be a programmed of enforcement.

Enforcement can be via physical police presence – this is potentially both costly and resource hungry, or by speed cameras. Point to point or *average* speed cameras are increasingly being used and appear to be very effective as they give drivers the opportunity to modify their behavior even if they speed past the first camera.

The key consideration is to have, at all times, the appropriate speed for the prevailing conditions and to ensure, so far as is reasonably practicable, that this is adhered to.

2.8. MAINTENANCE OF WORK ZONES

Following successful design and implementation of temporary traffic management arrangements, it is important that the work zone layouts and standards are maintained. This should be facilitated by regular inspections of both the layouts and cleanliness/condition of the work zone. The frequency and depth of inspection should be governed factors such as the importance in functional terms of the road, the duration of the road works, and the standards which have been set for drivers (speed, road layout and curvatures, etc.).

Inspections should be carried out by suitably qualified personnel and can take the form of either a walk through inspection/audit or a drive through. Driving through road works is an excellent way to check design assumptions as it gives the inspector the opportunity to observe the work zone from a drivers' perspective.

2.9. CONCLUSIONS

In developing, emerging and countries in transition where resources and experience of safe roadwork design, implementation and management might be limited, the focus should be on:

- providing adequate signing as in advance of the work zone to facilitate the correct action by drivers;
- providing as much separation between road users and road workers as possible;
- training road workers to an agreed minimum standard;
- making the road workers as visible as possible;
- controlling traffic speed – enforcement is vital;
- guiding traffic through the work zone;
- maintain the standard of the work zone throughout its use.

3. DEFINITIONS

3.1. GENERAL

“*Road Works*” includes all measures for improving, maintaining or expanding the road network that may influence the safety of road users and/or road workers. Road Works also encompasses any roadway related measures that are needed to permit works alongside the roadway. Most Road Works need temporary traffic control devices applied in accordance with traffic laws and basic safety principles.

Road Works can be the result of a regular planning procedure or a performed due to more urgent needs.

“*Road Workers*” includes all workers who are present in or in the vicinity of the work zones. Construction management and any kind of surveying are included. Due to a road worker’s close proximity to rapidly moving traffic in their workplace, they are vulnerable road users.

“*Work Zone*” means an area of a road with construction, maintenance or utility work activities. Signs, channelizing devices, barriers, pavement markings, and/or work vehicles typically mark a work zone. A work zone extends from the first warning sign or flashing lights on a vehicle to the end of road work sign or the last traffic control device.

“*Temporary Traffic Management*” includes the placing, removing and maintaining of temporary traffic control devices for work zones.

“*Traffic Control Devices*” means all signs, signals, markings, channelizing and other devices used to regulate, warn or guide traffic, placed on, over, or adjacent to a street, highway, roadway, pedestrian facility, or bicycle path by authority of a public body or official having jurisdiction.

3.2. TYPES OF WORK ZONES

“*Long term work zones*” are stationary work zones with construction site traffic control devices in place for more than 24 hours.

“*Short term work zones*” are stationary work zones with construction site traffic control devices less than 24 hours. If short term road works are performed at night, or in poor visibility conditions, particular attention must be paid to maintain safety.

“*Mobile work zones*” are work zones with continuously moving construction site traffic control devices and safety equipment.

3.3. ROADS AND ROAD EQUIPMENT

3.3.1. Road design and cross section elements

“*Vertical alignment*” is one of the basic elements in road design and includes the longitudinal grades or inclination of the road (vertical curves). Most design guidelines have regulations covering parameters and limits for vertical alignment.

“*Horizontal alignment*” covers the elements of road design of tangents (segments of straight lines), circular curves and, in some cases, spiral transition curves. Horizontal alignment defines roads location and orientation in plan view. Most design guidelines have regulations covering parameters and limits for horizontal alignment.

“*Hard shoulder*” is a surfaced area running along the edge of a motorway/freeway for emergency stops and a typical element of a motorway cross section.

“*Wearing course*” means the upper layer of an asphalt or bitumen roadway.

The “*Roadside recovery area*” includes all structural measures that give drivers a location to stop safely case of an emergency. This area may consist of emergency lanes, shoulders, breakdown lay-bys, emergency exits, recoverable slope, non-recoverable slope or a clear run-out area (clear zone).

“*Channelization*” is a method of moving a traffic stream out of one lane (or road) onto another lane (or road) through the gradual reduction of the lane (or road).

3.3.2. Road and Safety Equipment

“*Advance signing*” refers to signs placed well in advance of where a work zone begins to alert drivers to changing situations. Advance signing can include information on distance, time and the scope of work zone.

“*Changeable message signs*” (CMS) or “*Variable message signs*” (VMS) are portable signs capable of displaying several messages in a sequence including pertinent traffic operational and guidance information. They are often used to advise drivers of unexpected work zone traffic and routing situations. Messages can be changed manually, by remote control, or by automatic controls. Changeable message signs should not display advertising.

“*Temporary signs*” are all road signs used for traffic control in work zones.

“*Safety equipment*” means all supporting tools and materials to decrease risk for workers and drivers. They might improve the visibility, the conspicuity, or the crashworthiness of the situation or reduce the impact energy.

“*Barriers*” are all kinds guardrails, concrete or steel walls or similar devices used to keep vehicles within their lane and prevent vehicles from colliding with dangerous obstacles or workers.

“*Modular lane separators*” are guiding barriers, often combined with beacons.

“*Positive separation*” refers to the principle of keeping workers physically separated from travelling vehicle by way of a physical barrier.

“*Crash cushions*” (or impact attenuators) are absorbing constructions used to reduce kinetic energy and/or redirect the vehicle away from a hazard. For greater mobility they are often mounted on trucks. There are defined in several performance classes and mostly have technical approvals in national or international standards.

“*Traffic cones*” (also called traffic pylons, road cones, highway cones, cones, safety cones, construction cones or (colloquially) witches’ hats) are cone-shaped markers that are placed on roads or footpaths to temporarily redirect traffic in a safe manner. They are often used to create separation or merge lanes in work zones. Traffic cones should be highly visible and easily movable (but not too light such that they are easily disturbed in windy conditions). Various sizes are used, commonly ranging from around 30 cm to over 1 m.

“*Delineators*” (also called posts or beacons) are all kind of tall pylons mounted on the road surface, or along the edge of a road, and are used to channelize traffic in a taper. (Note, in some countries e.g. UK traffic cones are used extensively in tapers) They usually contain one or more reflective strips. They can be round and open in the center or curved (45 degree sections) of plastic with a reflective strip.

“*Retroreflectivity*” describes the ability of a surface to return light back to its source and should be used for signs and pavement markings when lighting is insufficient.

“*Scrolling chevron panel*” are traffic control devices used for additional advance warning where a lane is closed and traffic must merge with traffic in an adjacent lane. They mostly consist of a set of lights creating a picture in the shape of an arrow, chevron or cross and can be used with flashing or running lights to increase attention.

“*Shadow vehicles*” (or security vehicles, service vehicles) are moving trucks with attenuators spaced a short distance from a moving operation, giving physical protection to workers from traffic approaching from the rear. Similar to truck-mounted

devices, trailer-mounted attenuators may also be used on the shadow vehicle on a project-specific basis to protect workers. In a broad view it covers all vehicles or trailers in front of the workers to give them a physical barrier or/and give traffic devices and information.

“*Crashworthiness*” is the ability of a structure to protect humans during an impact. Depending on the nature of the impact and the vehicle involved, different criteria are used to determine the crashworthiness of the structure.

3.4. PARTIES TO ROAD WORKS

The “*Authority*” (Road Authority, Road Administration, Transport Authority) is/are the legal responsible body for traffic and roads. There could be different authorities depending on road categories and responsibilities.

A “*Road Operator*” is responsible for building, maintaining and operating a road network by law, legal act or contract. A Road Operator could be a department, agency, community or company and is the primary client or ordering body for the road works.

A “*Designer*” is an expert in road, traffic and/or transportation planning and responsible for the safe and economic design of a work zone. The designer has to consider technical standards and regulations.

The “*Contractor*” is the company responsible for installing, operating and removing the work zone. The Contractor may be responsible for traffic control devices; otherwise the road operator or traffic police have to provide the devices.

“*Supervision*” means all investigations, audits or inspections done by an expert to improve the quality and safety of a work zone.

“*Road Users*” are all parties of the public traffic within the work zone. Special care is to be given on vulnerable road users.

The “*General Public and Communities*” refers to the neighbors and population who are impacted by road works.

4. ROLES AND RESPONSIBILITIES IN WORK ZONES

4.1. INTRODUCTION

Many parties are involved in the safety of a work zone. To reduce confusion over responsibilities and maximize effectiveness and communications, it is helpful to

clearly define the roles and responsibilities of these parties. Roles describe the proper and customary functions of each participant, while responsibilities are tied to the burden of obligation of that party. There may be modification in terms of roles, through sharing or modification of roles by different parties, but all the necessary responsibilities must be assigned and completed, or the safety of the work zone will be compromised.

Clearly defining roles and responsibilities addresses the critical issues of who must do what and when! Furthermore, these concepts allow us to clearly define where a responsibility resides, and assists in ensuring that as responsibilities transfer from party to party, important safety issues are not overlooked.

Specific legal responsibilities will differ between nations, so the first principle is to understand and align with existing national legal requirements and provisions. If legal requirements (existing laws) are not sufficient to protect the workers or the travelling public then consideration should be given to improving and upgrading those laws. But even in the absence of sufficient safety legislation, the responsibilities outlined here should be heeded.

This chapter defines the roles and responsibilities of seven critical parties:

- Authority
- Road Operator
- Designer
- Contractor
- Supervisor
- Road User
- General Public/Communities

The relationship between these parties is diagrammed at the end of this chapter in *figure 5, page 31*.

4.2. AUTHORITY

First of all, authorities (politicians/decision/policy makers, e.g.: <http://www.highways.gov.uk/knowledge/20631.aspx>) must support and demand:

- responsible work zone planning and design from transportation professionals;
- safe behavior within the work zone from the workers; and
- safe driving through the work zone from the travelling public.

Furthermore, politicians must support the supervision and enforcement of standards in road works. Without the support of such authorities, even the best designs and plans cannot adequately provide for the safety of road users and workers.

Authorities should support adequate legal and safety requirements, standards and regulations for work zones and clearly establish the responsibilities of parties involved. The authority is also responsible for educating and informing the public about road work safety and responsible driving, through outreach and information campaigns. Finally, the authorities are responsible, in the long run, for ensuring that sufficient funding is provided not only for safety in work zones, but for overall road safety.

4.3. ROAD OPERATOR

The road operator must insist that the legal and safety requirements, standards and regulations for work zone safety that have been established by the authorities are used. If necessary, the road operator may demand additional requirements that should be in writing and publically available. These additional demands regarding safety and traffic flow issues include:

- requiring additional safety equipment such as barriers for worker safety, channelizing traffic flow, traffic guidance, and additional signs (with clearly defined sizes and colors based on the traffic environment);
- defining set working hours, like 24 hours or 12 hours on busy roads (depending on technological process of work);
- determining maximum length of detours and minimum requirements for a bypass; and
- specifying requirements for roadways that will be used for detours (including design and pavement standards and capacity requirements to ensure safety is not compromised).

Before beginning the road works the road operator, in coordination with the contractor, must inform the public and residents of the location, duration and possible deviation and time of road closures. Police and emergency services should be fully engaged in understanding where and how a work zone is being implemented, along with the type of work being done and any detours that are planned.

The road operator can demand that the contractor (or whoever requires a work zone to implement their work, such as the laying of cables, pipes, utilities, etc.) design and implement a safe work zone and use all necessary means to ensure safety for workers and road users, as well as sufficient traffic flow. The operator may ask the contractor to take on the responsibility for informing the general public and surrounding community of important information such as the work zone location and duration, access issues, possible detours and other means of travelling through the area.

A variety of methods should be considered to inform the general public and surrounding community, including media outlets (radio, TV, newspaper, websites) or through public gatherings or hearings. The permission of the road operator must be gained for any intervention in or alongside the roadway, including issues related to access management. The road operator will require the contractor to design and implement a safe work zone. The road operator can request that the contractor's supervisor pay additional attention to a work zone that is particularly complex, demonstrates clear risks, or has a history of accidents or incidents.

4.4. DESIGNER

The designer should be a company (or individual) that has significant knowledge of (and, if appropriate, certification in) work zone design and safety issues. The designer's primary responsibility is to ensure traffic safety for road users and workers. The designer should alert the road operator to key issues with regard to safety.

The designer will be responsible for ensuring that all technical solutions are described and can be implemented in accordance with the appropriate laws and standards. The designer will be the legally responsible party for the work zone layouts. The designer must:

- gather all necessary information on traffic density and types of road users and traffic that are expected;
- understand technical elements of the site of the work zone, as well as roads that might be used for detours/diversions/bypasses;
- coordinate and manage detours;
- consider road signs and markings, including existing permanent signs that might need to be removed or covered as well as necessary work zone signs;
- harmonize the technical and scheduling aspects of the work zone with regard to implementing, managing and removing the work zone; and
- identify the necessary lighting of the work zone if night works are being considered.

If possible the designer should develop a work zone that allows emergency vehicles sufficient access and travel. If a road is closed and emergency vehicles must use a detour, the designer should provide that information in writing to the emergency services providers. Furthermore, transit agencies should be informed before detours are established so they can plan their journey and stops. The designer is likely to take on the responsibility of participating in public hearings or community outreach meetings to explain the work zone to the community.

4.5. CONTRACTOR

Contractor has a contract with the road operator to execute the work zone and conduct the work. They are responsible for coordinating with the designer to ensure they understand how the work zone should be set up and operated over the course of the work. If the contractor is not qualified to install, operate, maintain and remove the work zone, then they must hire a special contractor which is qualified for these critical activities.

A particular person from a qualified company should be named to implement the work zone, including installing, operating, maintaining and removing the work zone. The work zone must be checked daily (or more frequently, if necessary) to ensure it meets the designer's scheme. Daily meetings should take place to ensure that all workers and staff are knowledgeable on the work zone activities and safety requirements.

It is the contractor's responsibility to qualify and train the workers and ensure they have the necessary safety equipment (see chapter 7). Those working on roads under traffic should have proper knowledge and training and should wear high visibility clothing with light reflecting material. Those managing the traffic flow (flaggers) should have knowledge on guiding of traffic and (if appropriate, based on national standards) be certified. In general all workers should have proper knowledge and be educated about how to avoid risks and work safely, and the contractor is responsible for insuring that the workers have that knowledge.

4.6. SUPERVISOR

The supervisor must be a highly trained road safety expert or auditor. It is strongly recommended that official road inspectors, trained police personnel or certified independent third party consultants be used. They must be officially approved and certified through the county's relevant institute or agency.

Supervisors are responsible to whoever hires them (the authority, the road operator or the contractor) for checking the work zone design and ensuring that it is safely, effectively and appropriately implemented.

The supervisor will check the work zone design to ensure that:

- it is consistent with legal requirements; and
- it provides safety for road users and workers;

The supervisor will check the actual work zone to ensure it is set up (signs and other equipment) consistent with the approved design.

If the supervisor finds that the design is deficient, he or she should require the designer to make the necessary design improvements. If the actual work zone is not set up consistent with the design, the supervisor should require the contractor to make the necessary changes.

The supervisor should coordinate with police to pay extra attention in work zones, with particular emphasis on vehicle speeds. The control for speeding and careless driving in work zones should be strictly enforced. It must be clear to all: if you violate the law you will be prosecuted!

4.7. ROAD USER

All road users need to pay particular attention while travelling in work zones. Drivers need to appreciate and respect that workers often have very little physical protection from fast moving vehicles that are travelling past their place of work. They should drive so that they do not pose a threat other participants in traffic or to workers. Drivers should be educated about the risks of travelling in work zones and be fully informed that safe driving behaviors will be strictly enforced by the police.

4.8. GENERAL PUBLIC/COMMUNITY

The community has a responsibility to participate in public hearings and be informed about work zones, detours, and possible transportation options. As they have the best knowledge of their environment, they can contribute to improved work zones by providing information about the situation, especially with regard to detours.

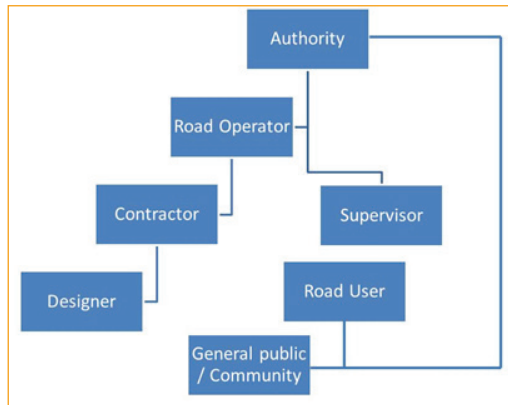


FIGURE 4 – RELATIONSHIPS BETWEEN VARIOUS PARTIES TO WORK ZONE SAFETY

5. PLANNING AND DESIGN OF WORK ZONES

5.1. BACKGROUND

Highway maintenance is an essential part of asset management. The efficient operation of a nation's roadway system is essential to the prosperity of the nation through the safe and efficient movement of people and goods. For a highway asset to be properly maintained, it will be necessary from time to time to put road works in place. Road work activities cause discontinuity in the road layout, which may result in unsafe situations for road users and workers. A well designed work zone plan can help alleviate these problems.

The planning and design for work zones should ideally start as soon as the improvements to the facility and need for road works are identified. Prior to the commencement of the actual construction and/or maintenance activities, a detailed plan, that considers both technical and traffic needs, should be drawn up and discussed between the contractor and the road operator, including input from the community and the police. The involvement of the local government and police is crucial, especially in urban situations which poses challenges in terms of restriction on available work area, access, high traffic volumes during peak hours and access for the abutting properties.

The level of planning and design activities that need to be undertaken for a work zone depends, to some extent, on the type and duration of the work to be performed. Long term works, or works that make a dramatic change to the driving environment need to be more carefully planned than very short term or minor works. Long term and/or complex works can sometimes benefit from a formal Road Safety Audit.

Careful planning and design lead to safer and more efficient work zones. Work should be organized to take the minimum amount of time possible and to minimize the exposure of workers and travelers to potentially hazardous situations. This chapter touches upon basic principles for work zone planning, as well as some strategies to consider when designing a work zone.

5.2. BASIC WORK ZONE PLANNING PRINCIPLES

Several basic principles should be considered in planning work zones.

5.2.1. Provide safety for road users and workers

Safety provisions governing the design of road works should be followed, and a detailed traffic control and management plan should be developed in consultation with partners. It is important to maintain a continuous, safe working environment

and to maintain the work zone devices in every phase of the work. This should include using basic safety principles governing the design of permanent roadways, and should consider the needs of all road users (pedestrians, bicyclists, trucks, etc.). In urban areas, particular consideration is necessary for vulnerable road users, as well as the needs of public transit vehicle and users.

5.2.2. Minimize hindrance or delay to road users

The traffic control and management plan must assume that drivers will reduce speeds if they perceive a clear need to do so. Abrupt, unrecognizable changes to lane position should be avoided, and work should be scheduled to minimize the need for alternate routing and to avoid peak periods – night work, if carefully managed, can be a good way to accomplish this. Road users should be encouraged, as much as possible, to use other routes for the duration of the road works, and on high volume roads, consideration should be given for the closure of entrance ramps as appropriate. Pedestrian and bicyclist movements must be accommodated.

5.2.3. Provide clear and positive guidance to road users

Adequate warning, delineation, and channelization will ensure that road users have a good understanding of what is happening and what is expected of them – minimizing the chance of errors.

5.2.4. Ensure roadside safety maintenance is given due attention

Making sure there is a roadside recovery area (clear zone), although difficult to manage in some work zones, is important, particularly for disabled vehicle and emergency situations. Road worker's vehicles and equipment should NOT be parked in this area, and it should not be used for storing material or debris from the work site.

5.2.5. Ensure that planners and decision makers have the necessary knowledge

Only those individuals who are trained in proper safe practices and have an understanding of safe work zone principles should be permitted to plan and design the work zone.

5.2.6. Provide good public relations

Providing the public with appropriate information about an upcoming work zone, possible alternate transportation means and routes, and expected delays and duration will assist in ensuring that they are engaged in the successful completion of the works. Traffic enforcement should be considered as part of the planning process, and

emergency service providers should be consulted when developing the plan. News media can be of great assistance in these tasks.

5.3. WORK ZONE DESIGN STRATEGIES

To accommodate the need to safely move traffic around the work area, a number of strategies are available. Ten common strategies are described below, and table one describes the advantages and disadvantages of each. Selecting the appropriate strategy is crucial to planning a safe and successful work zone.

5.3.1. Alternate One Way Operations

Generally used on a 2-lane single carriageway road, this approach is suitable for very low volume roads. While one lane of travel is taken up with construction activities, the remaining lane is alternately used to accommodate traffic travelling in opposite directions. This strategy is generally limited to low volume roads, and requires at least two flaggers, or temporary traffic lights, to safety stop and start traffic.

5.3.2. Detours

In this strategy, traffic is rerouted onto an alternate road and the traffic totally avoids the work zone. When traffic is directed from a facility under construction to an alternative traffic route, construction operations can proceed rapidly. This can improve construction efficiency (i.e., reduce cost) and quality and ensure safety for the workers from passing vehicles. The detour can be applied for all categories of vehicles or to certain vehicle types. Detouring traffic imposes additional capacity and load demands on the alternative route. Safety considerations on the detour route should be considered, particularly if the detour route goes through areas with a large volume of vulnerable road users (residential areas, school zones, etc.). Detours should be carefully evaluated to ensure that they are capable of safely accommodating the volume and types (configuration, size, and weight) of expected traffic.

5.3.3. Diversions

The traffic in one or both directions is routed onto a temporary road constructed around the work zone and reconnected with the permanent infrastructure of the designated route. This provides positive separation between traffic and the work zone. Diversions can carry one way or two-way traffic.

5.3.4. Full Road Closures

Although dramatic, this strategy, if properly executed, leads to safe work zones, and reductions in work time such that the full closure is actually better in terms of overall

delay. This can be effective and successful on roads with low, medium or high volume traffic. If a full road closure is chosen, whether it be short term or long term, the need for detours, as discussed above, must be weighed against the safety and operational benefits of the full road closure.

5.3.5. Intermittent Closures

With this strategy, traffic in one or both direction is stopped for relatively short period to allow for construction. This work zone strategy, alone, is generally not adequate for an entire construction project. It is more suitable for specific operations such as setting bridge beams or moving construction machinery. Intermittent closure should be used for short duration (less than thirty minutes), outside peak periods and only during good weather conditions to minimize traffic disruptions and maximize safety.

5.3.6. Lane Closures

In this strategy one or more traffic lanes and any adjacent shoulders are closed to traffic on one lane of a multi-lane highway. When lane closures are used for long term projects, use of barriers should be considered, which can increase implementation costs. The strategy can be adopted for a short period (hours) if barriers are not provided.

5.3.7. Lane Constrictions

This strategy entails reducing the width of one or more travel lanes. This strategy should be adopted when maintaining traffic with less than desirable travel lane width is preferable to other alternatives. This can raise safety concerns, so reduced speeds are critical for this strategy to be successfully implemented.

5.3.8. Median Crossovers

This strategy is most suitable on expressway whereby two-way traffic on a normally divided facility is allowed. A number of steps are necessary to implement this strategy including:

- reducing the number of lanes in both directions of travel (lane closure);
- routing traffic in one direction across the median to the opposite carriageway; and
- maintaining two-way traffic on one carriageway while the opposite direction carriageway is closed.

Substantial separation of traffic from the work zone is provided by this strategy and construction of an entire one-way carriageway (e.g., travel lanes, shoulders, structures, and appurtenances) is facilitated with little conflict between main highway traffic and equipment, workers, or onsite material movement. Traffic

impacts in terms of speeds, queue formation, and delay should be assessed, and overall median crossover length should be carefully considered. Clearly this strategy is only used for long term road works.

5.3.9. Use of Shoulder as a Travel Lane

In this strategy, the outside or inside (median) shoulder is used as a temporary traffic lane. This strategy may require constructing or upgrading shoulder pavement structures to adequately support expected traffic loads. This strategy uses existing roadway width to compensate for the capacity lost by closing a permanent travel lane and can be adopted on a variety of facility types, including multilane (divided or un-divided) or two-lane highways. The existence, proximity, and nature of roadside features (e.g., bridge piers) should be considered in assessing this strategy.

5.3.10. Night Construction

In many situations night construction may be preferred as the volume of traffic is generally lower and conflicts are minimized. Consideration must be given to the effect of night operations on the surrounding environment as well as the workers. Further, even if the work occurs at night, a lane or lanes may need to remain closed during higher traffic times.

TABLE 1 – ADVANTAGES AND DISADVANTAGES OF WORK ZONE DESIGN STRATEGIES

Strategy	Summary	Advantages	Disadvantages
Alternate one-way operations	Mitigates for full or intermittent lane closure. Used on 2-lane facility.	Low agency cost; flexible; several variations available.	Requires stopping of traffic; reduces capacity.
Detours	Reroutes traffic onto other existing facilities.	Flexible; cost depends on improvements to detour route.	Reduces capacity; detoured route may require improvement.
Diversions	Provide temporary roadway adjacent to work area	Separates traffic from construction; reduced impact on traffic.	Cost may be substantial.
Full road closures	Closes the facility to all traffic for a specified duration.	Generally involves expedited construction; separates traffic from work zone.	Potentially significant traffic impacts.
Intermittent closures	Stop traffic for a short period	Flexible; low agency cost.	Only useful for short term activities

TABLE 1 – ADVANTAGES AND DISADVANTAGES OF WORK ZONE DESIGN STRATEGIES (follow)

Strategy	Summary	Advantages	Disadvantages
Lane closures	Closes one or more travel lanes.	Maintains service at fairly low agency cost	Reduces capacity: may involve traffic close to active work.
Lane constrictions	Reduces width of travelled way.	Maximizes number of travel lanes.	Travelled way width is less than desirable: may involve traffic close to active work.
Median crossovers	Maintains two-way traffic on one carriageway of a divided highway.	Separates traffic from construction; right of way not required.	Relatively costly; interchanges need special attention.
Use of shoulder as a travel lane	Uses shoulder as a travel lane.	Fairly low cost depending on shoulder preparation.	Displaces traditional refuge for disabled and emergency vehicles: cross slopes may be problematic.
Night Construction	Move work activities to night time hours.	Lower traffic volume or lower traffic impacts.	Higher agency cost; disruption of social pattern of workers.

5.4. SUMMARY

Work zones are a necessary part of maintaining the critical transportation infrastructure in a nation. However, careful consideration of how to reduce the safety and throughput impacts of work zones will ensure that they do not present additional hazards to workers or travelers. A well thought out and carefully planned work zone can significantly reduce the risk of work zone crashes and selection of appropriate design strategies can ensure smooth and safe operations during work.

6. SAFE AND EFFICIENT OPERATION OF WORK ZONES

6.1. BACKGROUND

The recommendations in this chapter are aimed specifically at those who are responsible for implementing the operational measures on road works. This includes a wide range of personnel, from road operators or their subcontractors to roadwork companies or their subcontractors. However, these guidelines should also be considered by road designers who must consider operational constraints in designing the phasing and construction plans for a work zone which will impact the costs which may be important in the case of work under traffic. This chapter draws heavily on existing guidelines or manuals from different countries.

Although there are many possible procedures for operating a work zone, the recommendations in this section provide a general approach to work zone operations that focus on providing safety for travelers and workers. Clearly individual circumstances, for either a country or a particular combination of traffic, geometry, materials, and human resources must be taken into account.

All users of a work zone, whether construction workers or travelers must be provided with a safe and coherent environment - ensuring worker and traveler safety is paramount. Specific issues related to personnel in work zones are addressed in *chapter 7*, but some operational issues are critical to ensure road worker safety. As individual workers cannot continually monitor traffic, a “lookout” should be assigned to warn workers of possible encroaching vehicle. Use of a “shadow vehicle” with appropriate impact attenuators is recommended where it is not feasible to positively separate workers from through traffic. Finally, limiting the exposure time of workers to active traffic is clearly one of the best methods of keeping workers safe.

The chapter focuses on getting the work zone “*up and running*”, whether in or alongside traffic. It covers three related areas: safety equipment, lane closure management, and phases of work zone operations.

6.2. SAFETY EQUIPMENT

6.2.1. Mobile Road Equipment

Construction vehicles are an obstacle that must be particularly noticeable. Construction vehicles should be painted orange or another conspicuous color. Operation and construction vehicles that are stopped or moving slowly in the road or on the hard shoulder should also be equipped with special hazard warning lights and additional signs, including, as needed, variable message signs and/or flashing arrows.



The special hazard warning lights on a vehicle should be revolving or flashing yellow or orange lights. They should be placed in the upper part of the vehicle, as high as possible above the highest turn signal and should be visible to an observer from the minimum stopping distance based on the speed, but not less than 50 meters.

The lights should operate simultaneously from a single switch, with an indicator light in the cab that shows the user they are in service. To maintain credibility the special lights should only be used when conditions make them necessary. So, for example, if a work site is positively separated from the travel lanes, using special lights within the neutralized zone is not recommended and may in fact be a visual nuisance for the workers and drivers. However, if the work area is not positively separated, using special lights is highly recommended.

Temporary signing should be used on vehicles in an active work zone. The signs should be retro reflective and use red and white biased tape to increase the conspicuity of the vehicles, as shown in *figure 6*.



FIGURE 6 – VEHICLE CONSPICUITY

One of these two signs  or  should be used on the vehicle, along with synchronized warning lights whose use is independent of the special lights. When the construction vehicles are not in operation on a work site, the signs are folded, removed or dismantled. Variable message devices can also be used on vehicles, to indicate warnings or guidance. Text should be yellow, and yellow flashing fixed chevrons should alternate with text providing guidance to the traveler.

6.2.2. Work Zone Signing and Equipment

This section addresses various aspects of work zone signing, including sign and other equipment design and size. Specific information about the location and placement of signs is covered in chapter 8, Typical Workzone Layouts.

Temporary traffic sign colors are the source of much debate. In North America, Australia and New Zealand all signs in work zones (including normally yellow standard warning signs) use an orange background, providing an immediate indication to the drivers that they should take additional care because they are in a work zone. In Australia, only work zone signs associated with works personnel use a fluorescent orange background. Under the Vienna Convention temporary signs MAY have an orange or yellow background [*“Signs indicating temporary conditions such as road works, diversions or detours may have orange or yellow ground with black symbols and inscriptions.”*]. However in some countries sign background colors must be consistent with how that sign type is colored for permanent conditions. The Vienna Convention, in Article 31 also states: *“Where the extent of the road works and the volume of traffic justify it, the limits of the works shall be marked by setting up continuous or discontinuous barriers painted with alternate red and white, red and yellow, black and white, or black and yellow stripes”*. However, in Europe a supplementary agreement of 1971 has restricted the color for barriers to black and white or black and yellow.

The emphasis here is on addressing the legibility and comprehensibility of the signs. The approach speed of the oncoming vehicles will dictate the placement of signs and size of legends. Using standard signs in all work zones will address the critical comprehension issue. Drivers must be able to read and understand the signs leading into and through the work zone.

Further, the signs themselves should not pose a danger. This is addressed by ensuring the mechanical stability of the signal (suitable ballast for weather conditions and speeds) as well as the crashworthiness of posts.

Sign Design: Many different sign types are needed for safe operations of work zones. Shape and color standards vary by country and that is reflected in the figures that follow. In general, however, it is useful to have a particular sign type have a particular color and shape coding. The five broad categories of signs that are indicated below are considered the minimum necessary for safe work zones.

- Hazard and/or Warning Signs (*figure 7*) to draw attention to critical information;
- Position Signs (*figure 8*) to assist road users in maintaining the correct lane;
- Regulatory Signs (*figure 9*) to inform road users of the laws in place;
- Directional and Guidance Signs (*figure 10*) to demonstrate the upcoming road layout or detour information; and
- Indication Signs and Additional Panels (*figure 11*) to provide additional information.

The pictures that follow do not provide an exhaustive inventory of work zone signing, but illustrates these different categories. Of course, country specific requirements and regulations must be followed.

FIGURE 7 – HAZARD AND/OR WARNING SIGNS


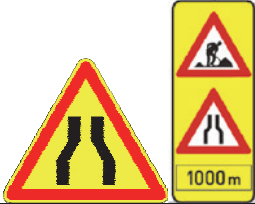





Sign	Meaning and Usage
	<p>Road Works. Requires users to respect a fundamental rule of prudence and to adjust their speed to ensure their own safety and that of other road users and workers (France, Austria, Finland - yellow; USA – orange)</p>
	<p>Narrow Carriageway. Traversable area narrowing (France, Finland – left; Austria - right)</p>
	<p>Other Hazards. The nature of the danger cannot be specified. An additional plaque may be required to explain the nature of the danger (Slovenia – white or yellow; Finland - yellow)</p> <p>Additional plaque: </p>
	<p>Temporary Lane Closure. Indicates lane closed ahead (UK)</p>
	<p>Flagger Ahead. Indicates the presence of a worker directing traffic (USA - orange; Slovenia - yellow)</p>
	<p>Flagging Devices: Manipulated by flaggers to direct traffic. Slovenia – red and green; USA – red and orange)</p>

FIGURE 8 – POSITION SIGNS

Sign	Meaning and Usage
	<p>Traffic Cone. Often used in a series to mark off the work area or close a lane (France – red and white; USA – orange and white; Finland – yellow and orange). In the UK they are often used to form tapers</p>
 <p>Direction of travel / Direction de Voyage</p> <p>or / ou</p>	<p>Alignment Post. Provide direction to drivers on changes in lane direction (France and Slovenia red and white; Arrows – red and yellow)</p>
	<p>Guidance Post. Often used in a series to mark off the work area or close a lane (like cones) (USA – orange and white; France – yellow and white; Finland – yellow and orange)</p>
	<p>Chevron. Identify a traffic diversion or a temporary narrowing of carriageway (France – red and white; Finland – red and yellow)</p>
	<p>Modular Lane Separator. Used as a continuous separation or delineation device (France)</p>
 <p>FIN DE CHANTIER</p> <p>FIN DE CHANTIER</p>	<p>Road Closed. Road is not open to traffic (Finland – red and yellow; France – red and white)</p>

FIGURE 9 – REGULATORY SIGNS


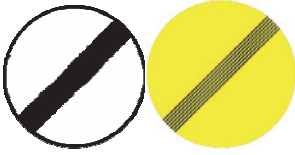
Sign	Meaning and Usage
	<p>Speed Limit. Describes the maximum speed allowed (France - red and white; USA - black and white; Finland – yellow and red)</p>
	<p>Keep Left (or Right). Directs drivers' lane choice (France and Slovenia) (photo: U Brumec)</p>
	<p>End of Local Prohibitions. Moving vehicles can go back to "standard" regulations (France – white and black; Slovenia - yellow and black)</p>

FIGURE 10 – DIRECTIONAL AND/OR GUIDANCE SIGNS

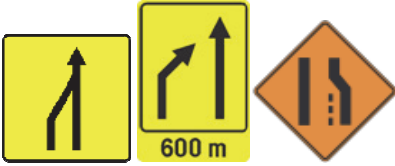
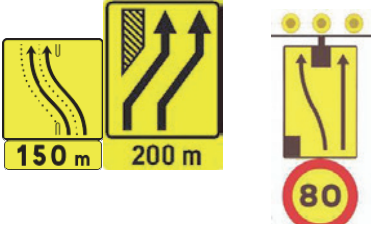

Sign	Meaning and Usage
	<p>Lane Closed. Indicates the closure of one lane (France, Spain, Slovenia and Finland - yellow; USA – orange)</p>
	<p>Crossover. Advance warning for carriageway crossover (FRANCE – left; Slovenia –middle; Spain - right)</p>
	<p>Lane Restriction. Traffic lanes for different size or type of vehicles (Slovenia)</p>

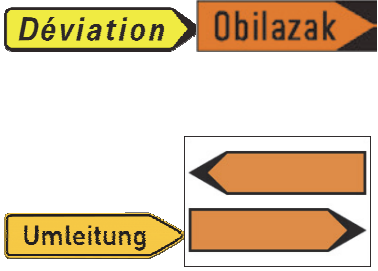

FIGURE 10 – DIRECTIONAL AND/OR GUIDANCE SIGNS (follow)	
Sign	Meaning and Usage
	<p>Direction of Diversion. Indicates the route drivers should take to follow a detour (France – yellow; Croatia – Orange, Germany – yellow or orange)</p>
	<p>Road User Specific Detour. Detour/direction for different types of road users (USA – orange, Germany – white and yellow)</p>

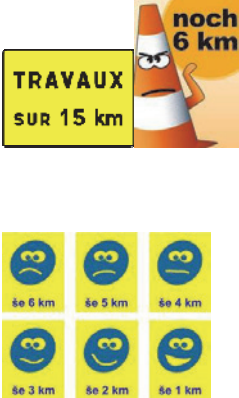





FIGURE 11 – INDICATION SIGNS AND ADDITIONAL PANELS	
Sign	Meaning and Usage
	<p>Construction Project. Indicates upcoming major project and length of works (France – yellow; Austria – orange “cone”; Slovenia – yellow “smiley”)</p>

FIGURE 11 – INDICATION SIGNS AND ADDITIONAL PANELS (follow)

Sign	Meaning and Usage
	<p>Additional Information, Provides location or activity specific information (USA – slippery for bikes when wet; Austria – grass cutting, Slovenia – safety distance). Photo: U. Brumec</p>
	<p>Additional Signs (USA)</p>

Sign Size: The size of a work zone sign is selected based on the approach speed of oncoming traffic.

TABLE 2 – EXAMPLE OF SIZE RANGES AND THEIR FIELD OF USE IN FRANCE AND SLOVENIA

Range	Small (mm)	Normal (mm)	Wide (mm)	Oversized (mm)
	600 - 750	900 – 1,000	1,200 – 1,250	1,500
	400 -650	600 – 850	900 – 1,050	1,250
	400 – 600	600 – 900	900 – 1,350	1,050
Urban roads	Narrow street	YES	YES	NO
Two-way carriageway	NO	YES	Possible	NO
Divided carriageway	NO	Possible on median	Yes	Possible

A single size range is recommended for the entire site, so as not to give too much or too little emphasis to any particular message. On divided carriageway roads, signs repeated on the median may be smaller than the main signs, if the median width does not support the full sized sign.

Sign Retroreflectivity: Retro reflective sign materials assist drivers in seeing the signs in a timely fashion. At night, signs and lighting are among the few clues drivers have at their disposal. They must be clearly visible and show substantially the same appearance as they do in the daytime. The visibility at night of temporary signage is ensured by the use of reflective devices or material, whether the sections are lit or not. The performance of retro reflective sheeting should be certified by an appropriate body. The retro reflective material should cover the entire sign panel with the exception of the black areas. For cones, the retro reflective surface must be flexible and adapted to the shape of the cone, and may be limited to the white striping. Uniformity and consistency in all aspects of signing are critical in work zones, including day and night appearance.

Because retro reflectivity relates to the conspicuity and legibility of a sign, the coefficient of retro reflectivity will need to be higher on a major road or urban road because of traffic or environmental constraints, than on a rural road with minimal traffic and few visual conflicts.

Mobile Sign Supports: Sign supports used in work zones need to provide sufficient height, stability and wind resistance, but must also be sufficiently mobile and agile to be useful. Mobile supports have many benefits, particularly for short term road works, but a few precautions should be considered. For example, supports should

have sufficient ballast that they do not overturn, but care should be taken to ensure that the ballast does not pose a danger. Furthermore, wide and oversized signs (as listed in *table 2*) cannot be used on inclined supports.

Sign Height: Temporary signs are generally 1 meter in height and can be up to 2.30 meters. On restraint systems the height is typically 1 meter. These heights can be reduced to 0.50 meter when the panels are attached to ground-based supports, or even less for signs from the normal range and small range. The additional panels can be placed below this height.

6.3. LANE CLOSURE MANAGEMENT

6.3.1. Work Zone Markings

Frequently when performing road works, traffic lanes are modified. When the position, width, or direction of the lanes differ from those indicated by the permanent marking, it is crucial that drivers clearly understand where they should be. Although some of this information is conveyed by signing as described above, the use of temporary lane markings is also necessary. This is particularly relevant on divided roads, to keep vehicles travelling in the same direction on a safe path and to clearly indicate the appropriate location for vehicle travelling in opposite directions. It is important to avoid providing conflicting information to drivers, so permanent markings that do not agree with the necessary travel paths for the work zone operations must be removed or obscured.



FIGURE 12 – CORRECT (OLD MARKINGS GONE) INCORRECT (OLD MARKINGS STILL VISIBLE)

Photos: ARROWS; U. Brumec

Temporary marking should follow necessary country conventions, but are normally yellow, orange or red and should be retro reflective, using yellow raised pavement markers as necessary. Except for the color, the general characteristics (pattern and width) of temporary marking are the same as for permanent markings. The line separating opposing traffic streams is always continuous. The border lines are always continuous, unless there is an emergency stopping lane or a shoulder wide enough for stopping, in which case it may be discontinuous.

If the wearing course is not rebuilt during the road works, or the project is conducted in stages, temporary markings must be removed without leaving residual traces that may provide inaccurate information to drivers. This need may influence what product is used for temporary markings.

6.3.2. Guidance equipment and lane separators

Positive separation between workers and the travelling public helps ensure the safety of both users. It is often necessary to isolate the approach as well as the work area and to separate traffic flows by modular lane separators. This separation is particularly necessary on divided roads, which pose significant risks to users and workers due to traffic conditions, duration of works and high potential risks to the workers.

To clearly indicate the boundary between a construction zone and traffic lanes, or to separate traffic flows at carriageway crossovers either discontinuous (cones or posts) or continuous (modular lane separators) can be used.

Cones and posts: Cones and posts are relatively inexpensive, lightweight, and can be rapidly placed and removed. However, these discontinuous markers may be less visible to drivers and convey an inadequate sense of hazard. Further, these devices require significantly more regular maintenance, as they are easily overturned and thrown by vehicles. Clearly they provide no physical protection to workers from traffic. Cones and posts should ideally be reserved for short term works or works that require frequent movement of the markers.

Modular lane separators: Modular lane separators (MLS) consist of a set of elementary modules made integral to each other by a link system to create a physical linear and continuous separation between two lanes of traffic or between a roadway and a work zone.



FIGURE 13 – TRANSPORTABLE STEEL CRASH BARRIER STGW QUADRO T3/W3

(Photo: J. Klang)

Typically there are two classes of MLS. Class A devices (mainly plastic) provide guidance and separation. Because they are continuous, they allow provide excellent guidance to drivers about their lanes, and they are relatively lightweight and easily handled. However, they do not prevent incursion of the vehicle into the other lane or the work area, and may give a false sense of safety. Like posts and cones, Class A MLS should be reserved for short term works or works that require frequent movement of the marker.

Class B MLS devices (mainly concrete or metal) add a restraint function. Class B devices are divided into several levels based on crash tests that address mass, velocity and impact angle of the vehicle. These devices provided the highest level of protection, but require significant handling to install and remove. These devices are preferred where user safety is degraded or when the exposure of site personnel presents high risks. Situations appropriate for Class B MLS include: long term construction; works where a permanent restraint devices is being removed or earthworks are being conducted or where obstacle or heavy traffic of vehicles on the site are closely adjacent to the travel lanes.

6.4. PHASES OF WORK ZONE OPERATIONS

Work Zone operations can be divided into four distinct phases: preparing for the work zone, installing signs and markings, monitoring and maintaining the work zone, and removing the work zone devices.

6.4.1. Phase 1 – Preparing for the Work Zone

Preliminary information gathering: Correct preparation before the work zone is implemented makes the task safer and more efficient. Getting acquainted with the work zone layout/design and identifying certain features of the work zone area allows for better final decision making. In particular, take note of:

- critical areas where the works and signing will be difficult to establish (narrow median, narrow hard shoulder, heavy traffic volumes, high speeds, dangerous or blind curves);
- existing permanent signing and markings in comparison to those needed for the road work. If the road work signing plan does not meet the needs of the site, and is not safe for all users, it should be returned to the designer for revisions (if it is a major change) or the designer should be on site (if it is a minor change). All changes to the work zone signing plan should be initialed by the designer;
- materials needed for work zone implementation (signs, posts, cones, marking material, barriers etc.). Identification marks (for new signs or where existing signs will be removed) can be made through small paint marks on the pavement or colored stakes in the ground. This up-front work when the work zone is being prepared will facilitate the subsequent positioning of temporary signs.

Human Resources: In the preparation phase estimates of the human resources needed to set up and perform the works must be determined. The sequence of work should be clearly delineated to ensure that the workforce is sufficient for the whole duration of the intervention and that traffic disruption is minimized. If night works are anticipated, a schedule showing the times of action and rest cycles of staff is indispensable for determining necessary human resources.

Inclusion of partners: In the preparation stage, other partners involved in this section of the road network should be included. This includes contractors, police, emergency services, utility companies, the general public and transport operators. For larger interventions, the road operator and designer should be involved to explain the work zone design and get acquainted with partners' concerns and ideas so that if appropriate, improvements can be made. Early coordination with these partners will help ensure a safe, secure and smooth running work zone.

Timing of road works: The time for road works is typically determined with an objective of minimizing the inconvenience to road users. It includes the installation period, the construction period and the removal period. Optimizing the duration for installing and removing signs on roads with heavy traffic volume in particular can be ensured by a number of actions:

- setting/installing temporary signage after rush hour or the day before road work will begin (e.g. at night when traffic volume is at lowest);
- when a detour must be established, detour signs should be prepared and positioned so that they can be used immediately after road is closed and the detour becomes active (before the detour is active, the signs should be covered to avoid confusing drivers). Detour roads that will bear more traffic should be checked before opening the detour to ensure safe traffic flow;
- using vehicles equipped with warning light (flashing lights, arrows etc.) to protect workers during installation and removal of the work zone. Also places for safe vehicle stopping should be pre-checked.

Equipment: Selecting and checking equipment before beginning the works is clearly important. The signing "*workshop*" is composed, generally, of a van and a trailer for the equipment. The van should be equipped with the signs and lights defined above in "*mobile road equipment*". On divided roads, where the repetition of signs on the median is needed, one of the most important operational matters is to know if the equipment is sufficient to ensure worker safety, or if they should be provided by additional protection by vehicles with warning light arrows or Truck Mounted Attenuator/Crash Cushion.

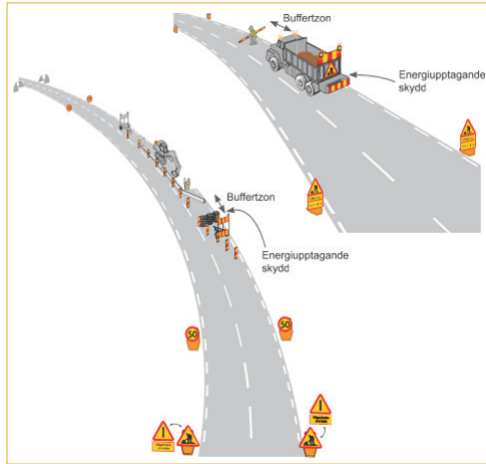


FIGURE 14 – WORKER PROTECTION WITH CRASH CUSHIONS AND TRUCK MOUNTED ATTENUATOR

During implementation of the taper, it may be useful to provide a scrolling or flashing chevron or arrow panel on the van to indicate to approaching drivers to change lanes. The proper operation of vehicle lighting devices must be verified.

Materials: The signing and affiliated support materials in the trailer should be loaded such they are easily accessible in order of the installation. If the trailer is going to stay on the site, it must have specific signing and lighting, to ensure that it does not become a hazard. After the approach signing is installed, the trailer has outlived its usefulness and may even constitute a nuisance during the installation of the taper. It is therefore useful to uncouple the trailer and position it on the hard shoulder. Wherever possible, it is desirable to perform the coupling and uncoupling in unexposed areas (service areas, shelters, service access).

6.4.2. Phase 2 - Installing Signs and Markings

Signing and marking installation must consider three major functions: installing the approach signing, installing the taper, and delineating the work area.

Installing Approach Signing: Initial advance signing should be on the side of the traffic lane in the direction of travel. All personnel must be transported in the van (not on the trailer) and they should exit and enter the van on the “safe” side of the road (not adjacent to the traffic lane). Whenever possible, signs should be removed from the trailer on this “safe” side. Signs and supports should be carried, not pushed. Signs can be fitted with handles to facilitate handling.

Before stopping the van, the driver must (when starting to slow down) give proper signal to other drivers of his attention to stop by turning on flashing lights and/or all

four indicators/blinders. The vehicle must be stopped in safe side, so that overtaking by others is safe. If work must occur in a curve, the van should be stopped before the curve in a location where it is readily visible to oncoming traffic.

The sign panels can be pre-sent at an optimal time and then picked up. The preliminary identification of the sign locations should have been marked in the preparation phase as described above. On divided roads, the signs are, as appropriate, repeated on the median but personnel should be discouraged from crossing the travel lane on foot. If the carriageway **MUST** be crossed on foot, personnel must be very careful, moving quickly and purposefully. It is important to bear in mind that a car travelling at 130 km/h runs 280 meters while an operative crosses a two-lane carriageway. For additional safety (if needed) police can be present.

Nevertheless when crossing the road or walking alongside a travel lane, workers must pay extra attention to traffic – with particular attention being given to seeing and being seen. Workers must be trained to give clear signals of their intention to drivers and to behave in a predictable manner when working in or near traffic. The initial traffic signs for the work zone should be installed at the same time that the existing permanent signs that are not relevant are being removed or covered. Once this “alert” to the drivers is completed, then other devices (road markings, barriers, traffic cones etc.) are installed. The order of sign and other device installation is diagrammed in *figure 15*.

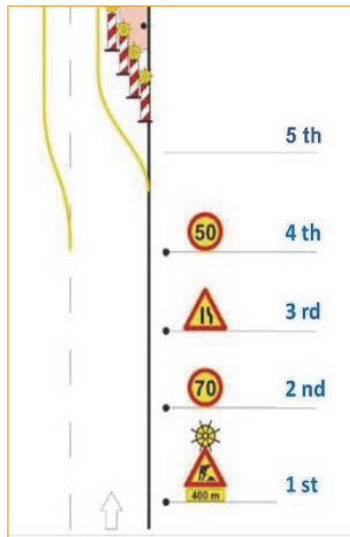


FIGURE 15 – ORDER OF SIGN AND DEVICE INSTALLATION

Installing the taper: A taper provides the instruction and opportunity for oncoming traffic to change their travel lane safely and efficiently. As shown in the typical layouts section (chapter 8), the taper often consists of cones or panels with spacing depending on vehicle approach speed.

When setting up traffic cones the first cone to be installed is the one closest to the oncoming traffic. The order of taper cone installation is diagrammed in *figure 16*. When setting traffic cones workers must be focused on traffic and if necessary give signals to drivers as to where and how to pass. Drivers must be clearly directed through the work zone. Workers must also understand that these situations are complex for drivers, so the need to see, be seen, and communicate clearly with a driver who is possibly confused, distracted, or surprised must be emphasized.

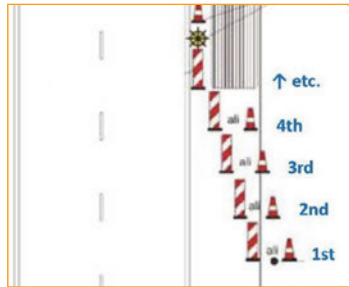


FIGURE 16 – ORDER OF LAYING OUT DEVICES FOR A TAPER

The taper should not be placed on curves or where the vertical alignment could mislead the driver or cause excessive workload. The taper must be placed in such a way that signs and traffic equipment are seen from far enough that drivers will have enough time to take appropriate action. As shown in the typical layouts section (chapter 8) if multiple lanes must be closed, a separate taper for each lane, separate by a straight section of 400 m should be used. The taper is followed by a buffer zone of at least 50 m before the work area. When installing (or removing) the taper or cones worker(s) must be within the closed “safe” area at all times.

Delineating the work area: The area where the work is occurring may be separated from the travel lane by cones, posts or barriers. The devices are placed on the closed lane and side distance must be considered (min. 0.25 m for speed limit 50 km/h – otherwise depending on speed) to limit the wall effect for the drivers and avoid vehicles colliding with the devices. Delineation must be clearly visible at night and must define driving and working spaces.

The installation of cones is done by foot or by vehicles with a special device or stand from which worker puts down cones (while vehicle is moving at a very low speed).

When installing pavement markings, barriers or other specific traffic equipment on the road (where there is active traffic), there should be adequate traffic signs and sufficient workers available so the work is completed in the minimum time needed. A well trained flagger or police officer should manage traffic flow, or even for a short time stop traffic to ensure safe installation.

6.4.3. Phase 3 - Monitoring and Maintaining Safe Operations in Work Zones

Temporary signs and markings in a work zone must be carefully maintained to ensure they retain their safety effectiveness. Such maintenance clearly needs to consider the country's regulatory environment. Regardless of statute, however, well maintained devices communicate to the drivers what is expected of them – improving safety for travelers and workers. So the signs and traffic equipment must meet the 4C's: being conspicuous, clear, consistent and credible.

When devices (marker posts and cones in particular) are so severely degraded that their condition prevents an immediate restoration, maintenance procedure involves implementing immediate safety measures on the site. The contractor responsible for establishing/setting up and maintaining traffic signs and equipment must have sufficient equipment in stock to replace damaged equipment.

Different patterns of organization are possible, and vary according to legal contexts, the nature of work contracts and the length of the construction site. In all cases, the proper functioning of temporary signs, markings and equipment means that tasks of the various partners are clearly identified and known to everyone, internally and externally. Procedure sheets are an excellent way to identify the various protagonists, further clarifying their roles in the maintenance process, communication procedures and intervention times.

Immediately after the installation, dated photos of the various areas that include all the recommended signing and marking make an excellent quick reference sheet. For quality control purposes, an external inspection carried out by the department in charge of operating the road network is suggested if possible. This visit should be formalized in a report forwarded to the construction supervisor who would then use the document to correct any discrepancies from the approved plans.

Periodic inspections are essential to ensure the continuing fitness for purpose of the workzone layout. Furthermore, interventions to restore, repair or replace damaged or defective equipment should be documented in the site diary or a dated and signed intervention record.

6.4.4. Phase 4 - Removing Work Zone Devices

The devices delineating the work area, the taper and the approach are generally removed in reverse order of how they were placed. To avoid reversing with a trailer, the devices can be removed starting from the approach site, under condition that the van is equipped with a panel and flashing lights and the van must be visible all the time so that drivers are not surprised.

7. PERSONNEL GUIDANCE IN WORK ZONES

7.1. GENERAL

The safety of work zone personnel needs to be addressed as an occupational health issues as well as a road safety issue. Occupational health rules and regulations differ dramatically from country to country, and address such activities as how to interact with heavy machinery, how to lift loads, etc. Because of their country specific legal requirements, these issues are addressed only tangentially in this chapter.

Road safety issues for work zone personnel are related to how the workers interact with the traffic traveling past the work area and how they can reduce their risk of injury from passing traffic. Because these issues are broader in nature than the occupational health issues, and general guidance is available, this chapter focuses on road safety items.

When planning for personnel safety at a road work zone it is important to create a situation where both those who work on the road and the road users can be safe and secure and a balance between their respective safety requirements can be achieved.

7.2. HEALTH/FITNESS FOR WORK

Working on a road with significant traffic flows is, despite the potential use of barriers and detailed signing, very stressful. It is important that the personnel are in good health, both physically and mentally. Workers' mobility, vision, hearing and reaction times should be within normal limits. Standards are not defined here for fitness to work. However, it is important to keep in mind that the very nature of the activities occurring in a work zone requires the worker to be reasonably fit. Furthermore, given the proximity to rapidly moving vehicles, it is important that workers be able to gather all necessary information from their environment (requiring good vision and hearing) and react quickly and appropriately (requiring good reaction time and mobility).

An individual in a work zone should be able to perform the tasks assigned to them competently and in a manner which does not compromise the safety of themselves or others. Beyond regular fitness issues, an individual's state may be impaired by a

variety of factors and these factors must be considered in determining the individual's true fitness to work. Such issues include medical conditions, fatigue, stress, or the use of alcohol and other drugs. Where it is believed that an individual may not be fit for work then intervention is required to ensure that the individual is not putting himself or his co-workers at risk.

7.3. TRAINING

Any personnel in a work zone adjacent or near to active traffic must have at least a minimum level of training to keep them safe. The knowledge necessary can be transmitted through formal training, on-the-job training or daily briefings at the work site. Although the training will include occupational issues, the interest here is ensuring that the training also addresses critical road safety issues.

A one day course for road safety issues for workers zones should cover the following items:

- modern road safety principles;
- road safety basics;
- the importance of personal behavior and its impact on safety;
- the behavior of the road users and its impact on safety;
- their own and others responsibility for safety measures;
- the basic rules for signing and safety equipment.

Specific training courses and materials are available. Two sources include the US National Work Zone Safety Information Clearinghouse <http://www.workzonesafety.org/training/> and the UK, National Highway Sector Schemes. http://www.ukas.com/library/Technical-Information/Pubs-Technical-Articles/Pubs-List/NHSSI2D_%20Dec_2009.pdf

For personnel responsible for special items at the work zone (flaggers, installing and removing tapers, checking signs and other devices) additional training courses might be necessary.

7.4. BEHAVIOR

A worker who is focused on getting a particular task completed may neglect to attend to the traffic near their workplace. It is important that workers are regularly reminded that their own behavior is a critical element in maintaining their safety. For example, workers should not cross over live traffic lanes unless there are suitable gaps in the traffic or, preferably, traffic has been stopped. It may seem simple to get across three lanes of traffic to a median strip, but safely judging rapid oncoming vehicle speeds is very difficult. Some guidance can be obtained from the Health and Safety Executive

in the UK; (<http://www.hse.gov.uk/pubns/cis53.pdf>). Furthermore, oncoming traffic should always be considered as a potential hazard even if the work zone is behind barriers. It is also important for workers to stay calm and not let themselves be provoked by rude or aggressive drivers.

7.5. GENERAL CLOTHING

Everyone at a work zone on a road with traffic, even temporary visitors, must wear high-visibility warning clothing equipped with reflectors. The reflectors shall be placed in such a way that a driver can observe a person by the dipped headlight during darkness or bad weather conditions. It is therefore recommended that road workers wear trousers with the reflectors placed in a low position.

High-visibility clothing is a simple, cost-effective way to improve the visibility of people 24 hours a day. The fluorescent background material of a high visibility garment provides daytime visibility while the reflective material around the chest, arms or legs of garments provides night-time reflectivity. This will significantly increase the conspicuity of personnel with a consequential dramatic reduction in the risk of personnel being struck by a moving vehicle in any working environment.

High-visibility clothing should be used in conjunction with other complimentary safety measures. In order to ensure that appropriate clothing is worn, it is recommended that high visibility clothing and other protective articles, such as safety helmets, safety boots, gloves and goggles be provided for free to workers, and that all items be regularly inspected, and cleaned or replaced when they become dirty or worn. Particularly in warm climates, personnel may need to be reminded on a regular basis as to the protective elements of high-visibility clothing.

7.6. PERSONAL PROTECTIVE EQUIPMENT

Everyone within a work zone area should always wear a helmet, not only to protect the head but also to increase their visibility. For every type of work being done the need of relevant safety equipment such as boots, gloves, ear protectors, goggles, etc. should be considered in order to eliminate the risks connected to the work. When using such safety equipment it is important that they are complying with the country specific occupational health requirements.

High visibility clothing must be correctly fastened and should be maintained in a clean and usable condition.



FIGURE 17 – EXAMPLE OF GOOD HIGH-VISIBILITY WARNING CLOTHING



FIGURE 18 – EXAMPLE OF GOOD HIGH-VISIBILITY WARNING CLOTHING (SUMMER)



FIGURE 19 – EXAMPLE OF GOOD HIGH-VISIBILITY VEST AND HELMET (PHOTO COURTESY OF THE AMERICAN ROAD & TRANSPORTATION BUILDERS ASSOCIATION.)



FIGURE 20 – EXAMPLE OF DIFFERENT DESIGN OF HIGH-VISIBILITY WARNING CLOTHING (PHOTO COURTESY OF THE AMERICAN ROAD & TRANSPORTATION BUILDERS ASSOCIATION.)



FIGURE 21 – ALL WORKERS WEAR SIMILAR HIGH-VISIBLE CLOTHES (PHOTO COURTESY OF THE AMERICAN ROAD & TRANSPORTATION BUILDERS ASSOCIATION.)

8. TYPICAL WORK ZONE LAYOUTS

8.1. INTRODUCTION

Road works almost always involve a compromise between completing the required work as quickly and safely as possible and keeping the traffic flowing freely, thereby minimizing delays and cost to the transportation of goods and materials.

This chapter contains a series of typical layouts for different classifications of roads and is intended to supplement the guidance contained earlier such that a consistent and harmonized message is given to road users.

The typical layouts are given for:

- single carriageway (2 way roads), including urban situations;
- short Duration and Mobile works, and
- high speed distributor (motorway/freeway) dual carriageway roads.

The examples given are not intended to be exhaustive. It is not possible to cover every eventuality the designer/operator might encounter but following the guidance contained here will enable the Conspicuous, Clear, Consistent and Credible principles established in Chapter 2 to be achieved.

This guideline is intended to be used worldwide and consequently typical layouts for both driving on the left hand side (LHS) of the road and the right hand side (RHS) have been given.

Each layout is therefore annotated with either LHS or RHS as appropriate.

Note also, some speeds are given in miles per hour (mph) and some in kilometers per hour (kph). Approximate conversions have also been given where appropriate.

General Issues

1. In order to prepare a design which is fit for purpose, a detailed knowledge of the site is required. This will entail obtaining knowledge of lane widths, traffic counts, speed and composition of traffic types, presence of pedestrians and other vulnerable road users, seasonal variations, etc.
2. In normal circumstances, maintenance of the maximum throughput of traffic past or through the works site will be a high priority. Where a hard shoulder exists, consideration should always be given to the use of the hard shoulder as a temporary running lane to maintain capacity; but never at the expense of safety.
3. The use of narrow lanes can also assist in maintaining throughput of traffic but it should be noted that narrow lanes require a raised level of driver concentration and control and this should be taken into account when planning the scheme and determining temporary speed control and scheme length.
4. Another widely used technique on dual carriageway roads to facilitate road works is the use of contra-flow (bi-directional flow). A contra-flow operation is one where one carriageway is used temporarily to carry two-way traffic with the opposing streams of traffic separated by physical barriers, safety zones or a full lane.

8.2. BASIC LAYOUTS

Acknowledgements:

Layouts are based on standard drawings contained in the:

- UK's 'Traffic signs manual – Chapter 8 'Traffic Safety Measures and Signs for Road Works and Temporary Situations' <http://www2.dft.gov.uk/pgr/roads/tss/tsmanual/>
- The USA Manual of Uniform Traffic Control Devices (MUTCD) http://mutcd.fhwa.dot.gov/kno_2009.htm
- The UK Department for Transport Draft 'Red Book' Safety at Street Works and Road Works. <http://www2.dft.gov.uk/pgr/roads/network/local/streetworks/cop/safetyatstreetworksandroadworks.html>

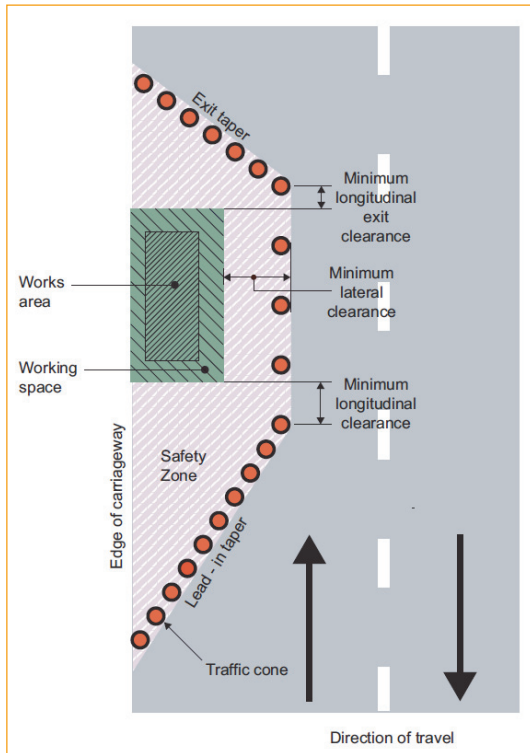


FIGURE 22 – BASIC WORK ZONE LAYOUT SHOWING TAPERS AND SAFETY ZONES (LHS)

Note: The safety zone extends to the outside edge of the cones of the traffic edge of any road markings or studs that are present separating the live traffic lanes from the work area.

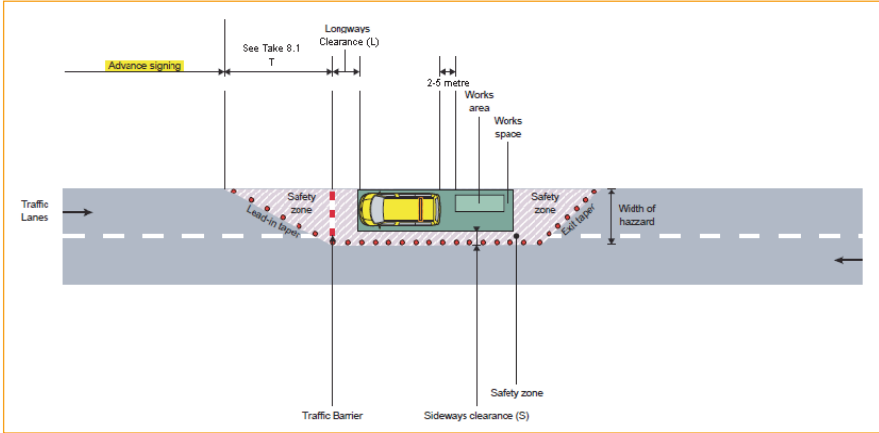


FIGURE 23 – BASIC WORK ZONE LAYOUT WITH WORKS VEHICLES

TABLE 3 – MINIMUM CARRIAGEWAY WIDTHS FOR TWO-WAY WORKING AND SHUTTLE WORKING WITH TRAFFIC CONTROL		
	Normal Traffic including buses and lorries	Cars and light vehicles only
Two-way working	6.75 m minimum	5.5 m minimum
Shuttle working with traffic control	3.7 m maximum 3.25 m desirable minimum 3.0 m absolute minimum	3.7 m maximum 2.75 m desirable minimum 2.5 m absolute minimum

TABLE 4 – SIGN AND TAPER DETAILS BY ROADWAY TYPE (FOR SPEEDS 50 MPH AND BELOW)

Type of Road	Minimum and normal maximum siting distance (D) of first sign in advance of lead-in taper (metres)	Minimum clear visibility to first sign (metres)	Minimum size of signs (mm)	Sideways Safety Zones (S)	Distance (E) from end of works to "End of Road Works" sign (metres)	Details of lead-in tapers (but see Notes below) Recommended lengths	Width of Hazard (metres) including Safety Zone (S)						
							1	2	3	4	5	6	7
Single Carriageway road, restricted to 30mph or less	20 to 45	60	600	0.5m	10-30	Length of taper (T) in metres	13	26	39	52	65	78	91
						Minimum No. of cones	4	4	6	7	9	10	12
						Minimum No. of road warning lights at night	3	3	5	6	8	9	11
Single Carriageway road, restricted to speeds of 31mph to 40mph inclusive	45 to 110	60	750	0.5m	30-45	Length of taper (T) in metres	20	40	60	80	100	120	140
						Minimum No. of cones	4	6	8	10	13	15	17
						Minimum No. of road warning lights at night	3	5	7	9	12	14	16
All purpose dual carriageway road restricted to 40mph or less	110 to 275	60	750	0.5m	45	Length of taper (T) in metres	25	50	75	100	125	150	175
						Minimum No. of cones	4	7	10	13	15	18	21
						Minimum No. of road warning lights at night	3	6	9	12	14	17	20
Single Carriageway road, with speed limit of 50mph or more	275 to 450	75	750	1.2m	30-45	Length of taper (T) in metres	25	50	75	100	125	150	175
						Minimum No. of cones	4	7	10	13	15	18	21
						Minimum No. of road warning lights at night	3	6	9	12	14	17	20
Speed limit (mph)	30 or less	40	50	60	70	NOTES:							
Minimum longways clearance (L) metres	1/2	15	30	60	100	<ol style="list-style-type: none"> Lead-in tapers used with traffic control, and all exit tapers, shall be at about 45° to the kerb line with cones spaced 1.2 metres apart. The maximum spacing distance of cones in longitudinal lengths of coning shall be 9 metres, but no fewer than 2 cones shall be used in any length between tapers. In certain circumstances on congested roads with speed limits of 30mph or under, the taper may also be reduced to 45°. Minimum height of all cones is 450mm. 							

8.3. SINGLE CARRIAGEWAY ROADS

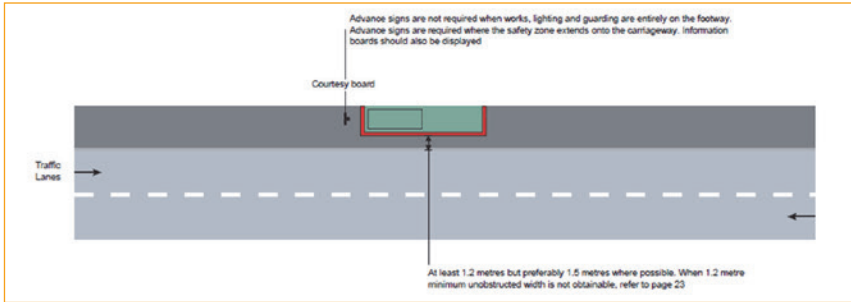


FIGURE 24 – WORK ON FOOTWAYS (LHS)

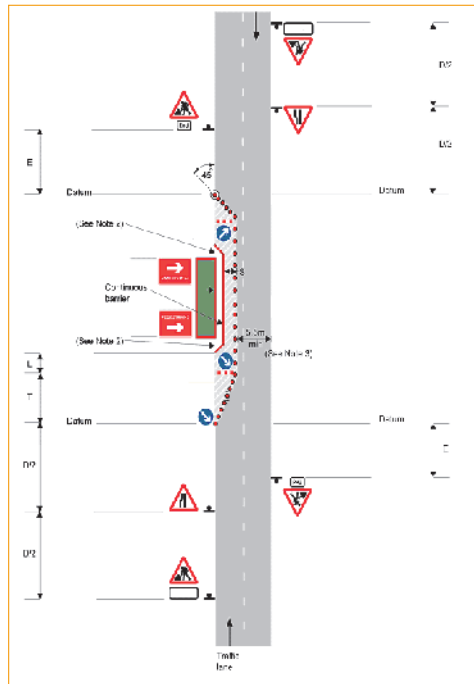


FIGURE 25 – TWO-WAY TRAFFIC ON A SINGLE CARRIAGEWAY ROAD, FOOTWAY DIVERSION (LHS)

Notes:

1. Cone spacing will depend on the type of road – generally 3 m in tapers and 9 m in longitudinal runs.
2. A ramp for wheelchairs, prams, etc. should be provided at the transition between the footway and carriageway.
3. See *table 3* for guidance on lane widths past the works.
4. See *table 5* for D and E distances

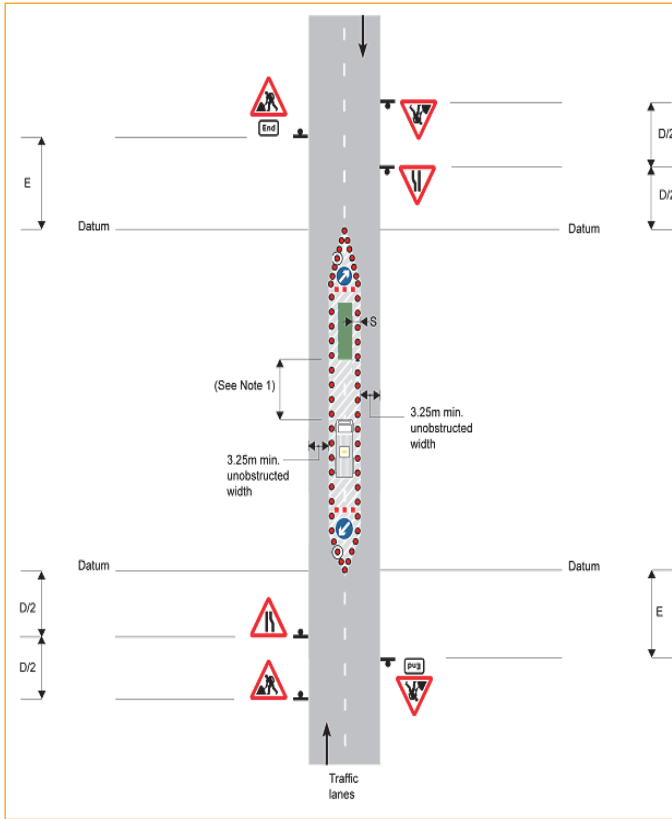


FIGURE 26 – TWO-WAY TRAFFIC ON A SINGLE CARRIAGEWAY ROAD, WORKS IN THE CENTRE OF THE ROAD (LHS)

Note: If the permanent speed limit is 30 mph (50 kph) or less, minimum clearance is 2.0 m. If the permanent speed limit is 40 mph (65 kph) or more, minimum clearance is 5.0 M.

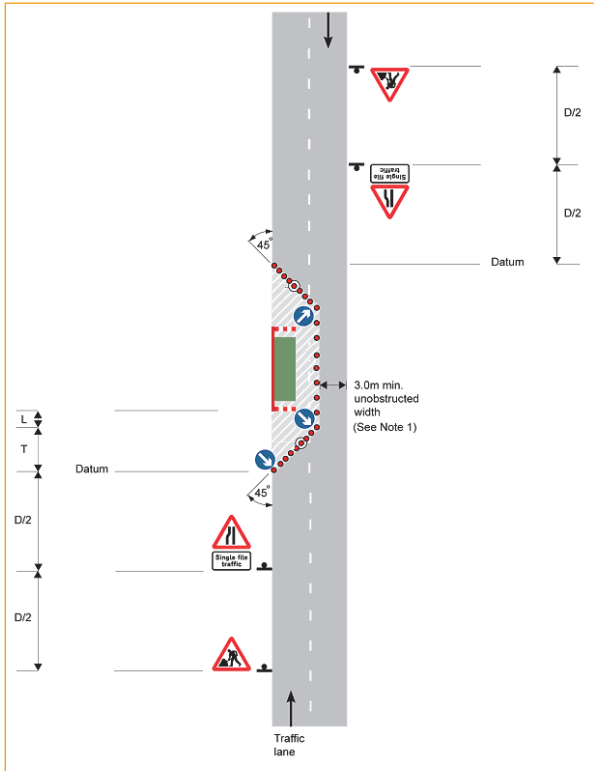


FIGURE 27 – “GIVE AND TAKE” SYSTEM ON A SINGLE CARRIAGEWAY ROAD WITH A PERMANENT SPEED LIMIT OF 30 MPH (50 KPH) OR LESS (LHS)

Note: See [table 3](#) for guidance on lane widths past the works.

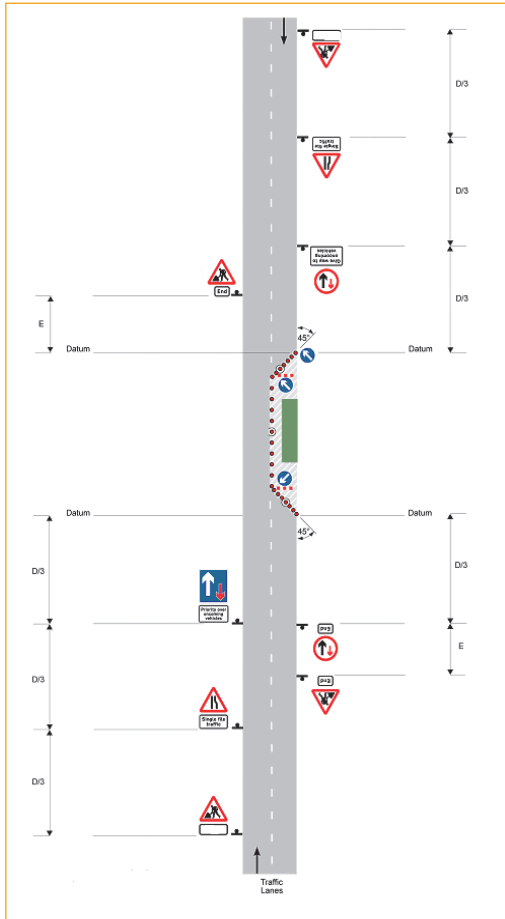


FIGURE 28 – PRIORITY SIGNS ON A TWO-LANE SINGLE CARRIAGEWAY (LHS)

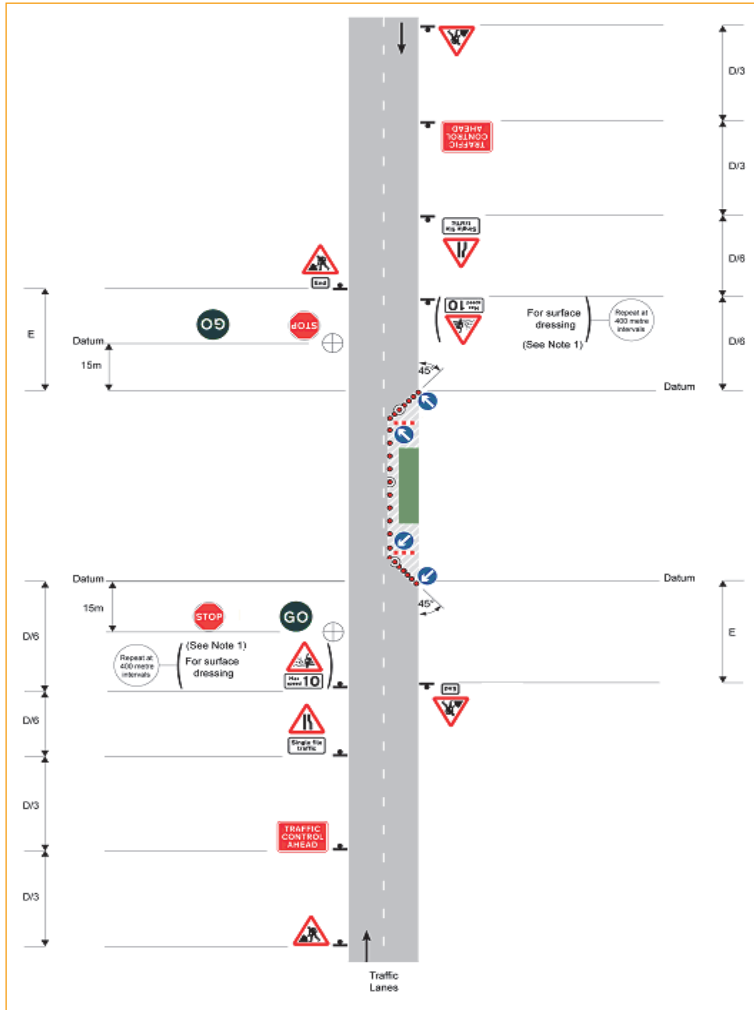


FIGURE 29 – “STOP/GO” SIGNS ON A TWO-LANE SINGLE CARRIAGEWAY ROAD (LHS)

Notes:

1. The same principles apply in circumstances where the near side is a broken white line.
2. Where drivers would be required to cross continuous white lines in the lane changeover positions these should be masked or removed.
3. Refer to [table 5](#) for the recommended range of distances “D” and “E”.

TABLE 5 – DISTANCES ‘D’, ‘E’ AND ‘L’ SHOWN IN PLANS

Single Carriageway road: Permanent speed limit				
	30 mph (50 kph) or less	40 mph (65 kph) or less	50 mph (80 kph) or less	Unrestricted 60 mph (100 kph)
Minimum and normal maximum siting distance D of first sign in advance of lead-in taper in meters	20-45	45-110	275-450	275-450
Minimum longitudinal clearance L in meters	0.5	15	30	60
Length of taper in meters: 1	13	20	25	25
Width of hazard 2	26	40	50	50
(meters) 3	39	60	75	75
Including 4	52	80	100	100
safety zone S 5	65	100	125	125
Minimum lateral safety zone clearance	0.5	0.5	1.2	1.2
Distance E to ‘ <i>end of road works</i> ’ sign	10-30	10-30	30-45	30-45

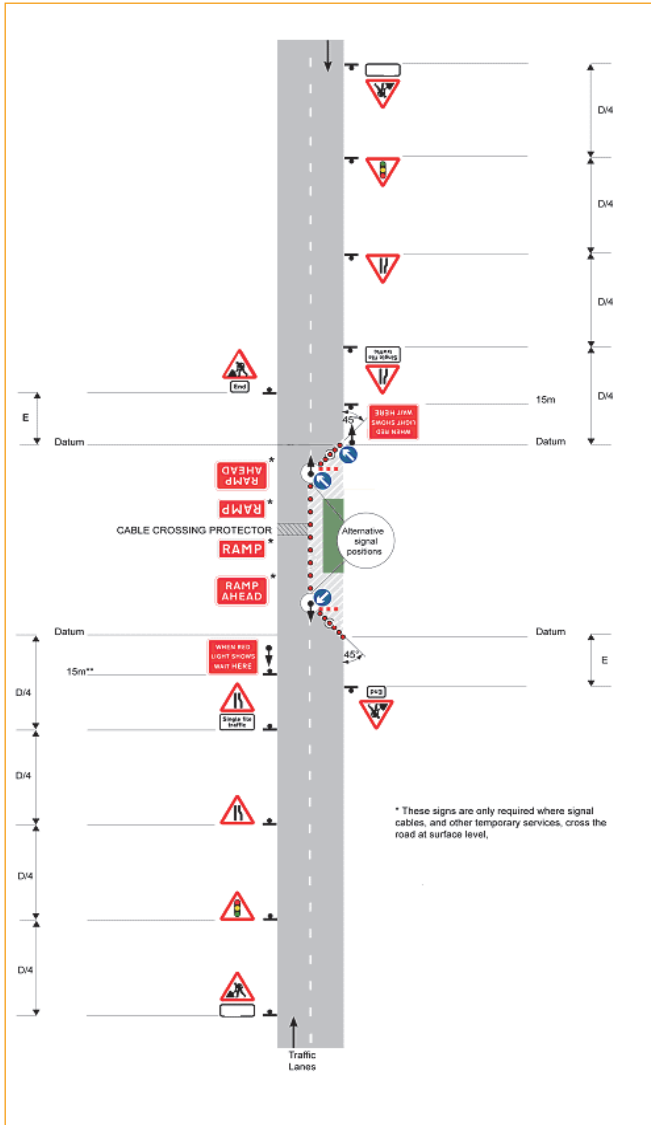


FIGURE 30 – PORTABLE TRAFFIC SIGNALS ON A TWO-LANE SINGLE CARRIAGEWAY ROAD (LHS)

Note: Refer to *table 5* for recommended range of distances for dimensions "D" and "E".

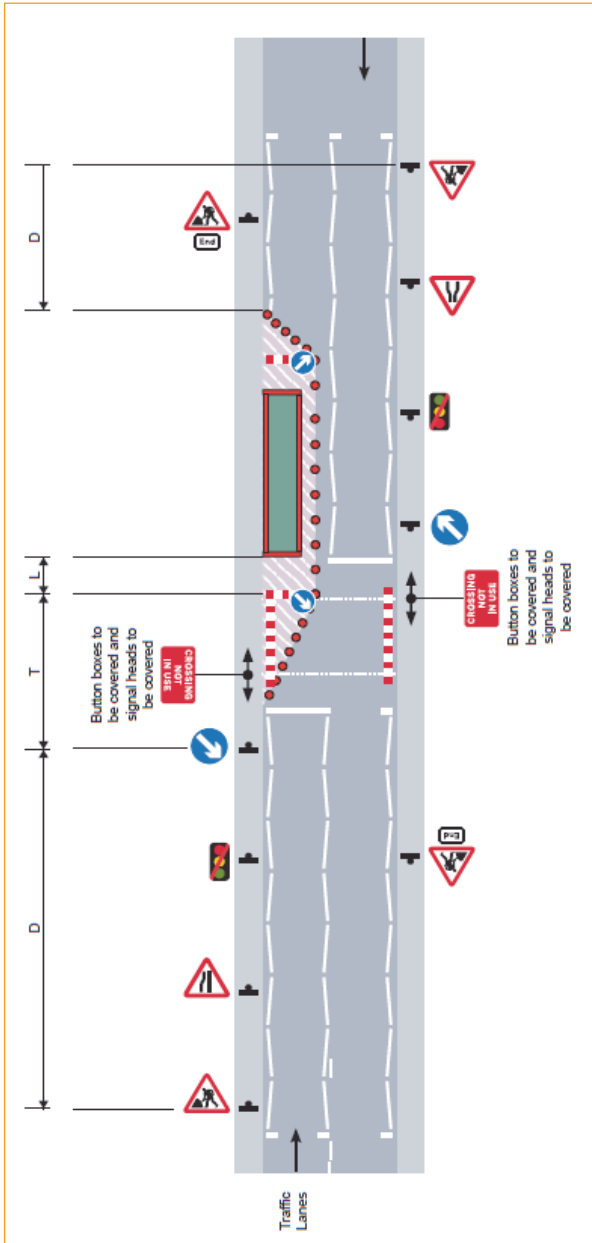


FIGURE 31 – WORKS AT LIGHT CONTROLLED PEDESTRIAN CROSSINGS (LHS)

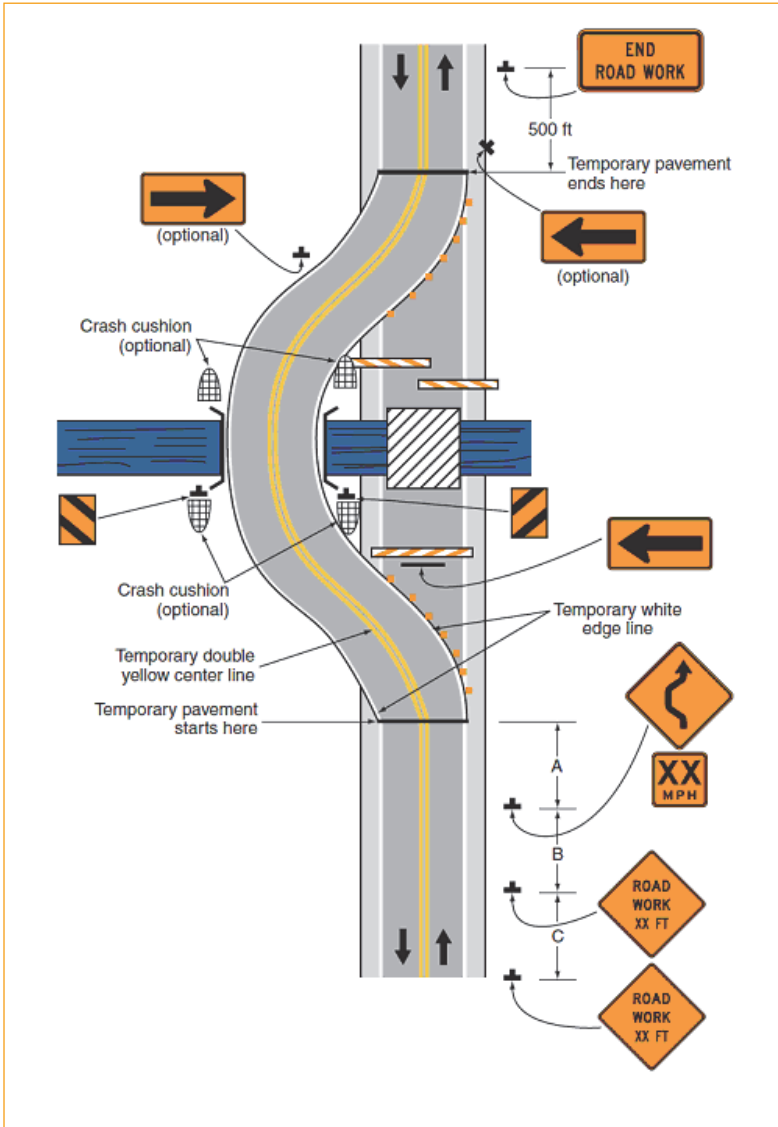


FIGURE 32 – ROAD CLOSURE WITH DIVERSION (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

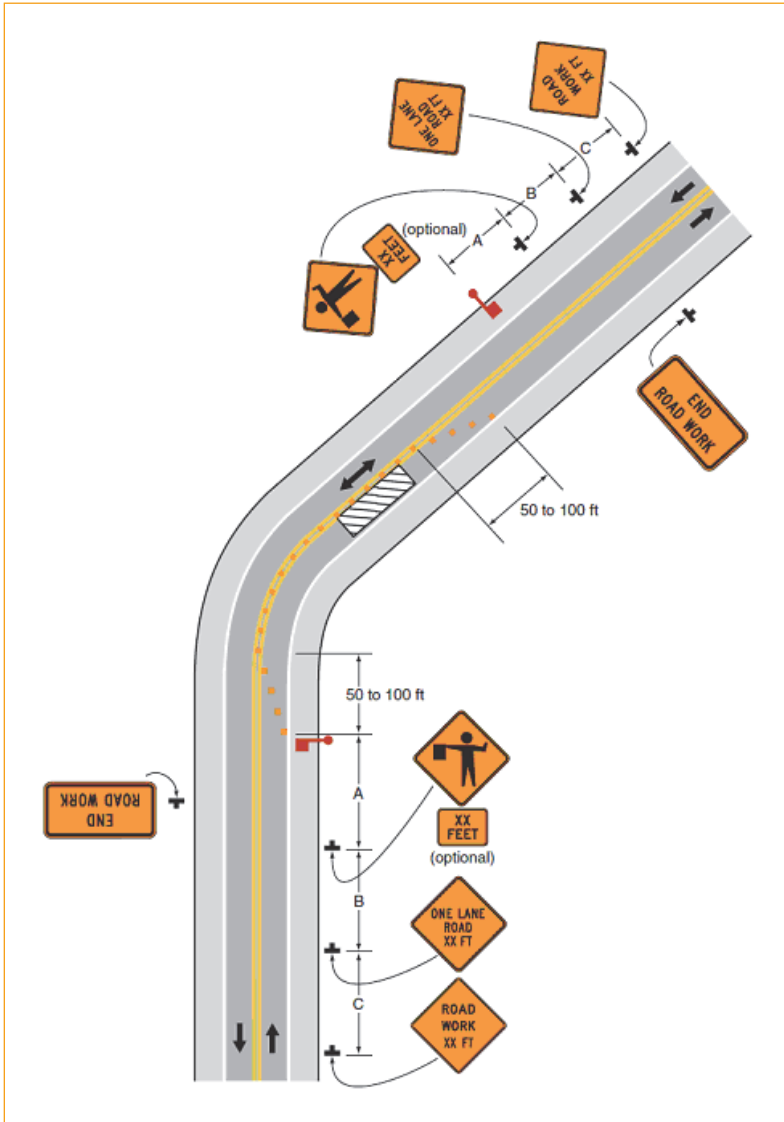


FIGURE 33 – LANE CLOSURE ON A TWO-LANE ROAD USING FLAGGERS (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

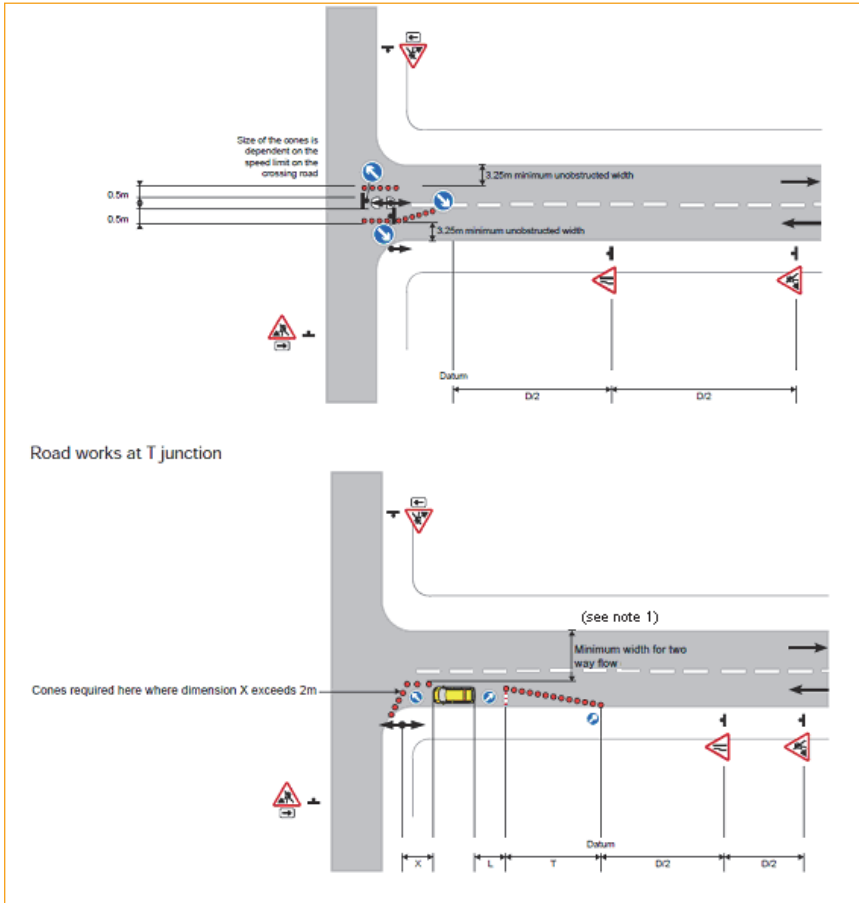


FIGURE 34 – ROAD WORKS AT T JUNCTION (LHS)

	Carriageway width
Two-way working	6.75 m minimum
Shuttle working with traffic control	3.25 m to 3.5 m
Shuttle working with convoy working	3.00 m to 3.75 m

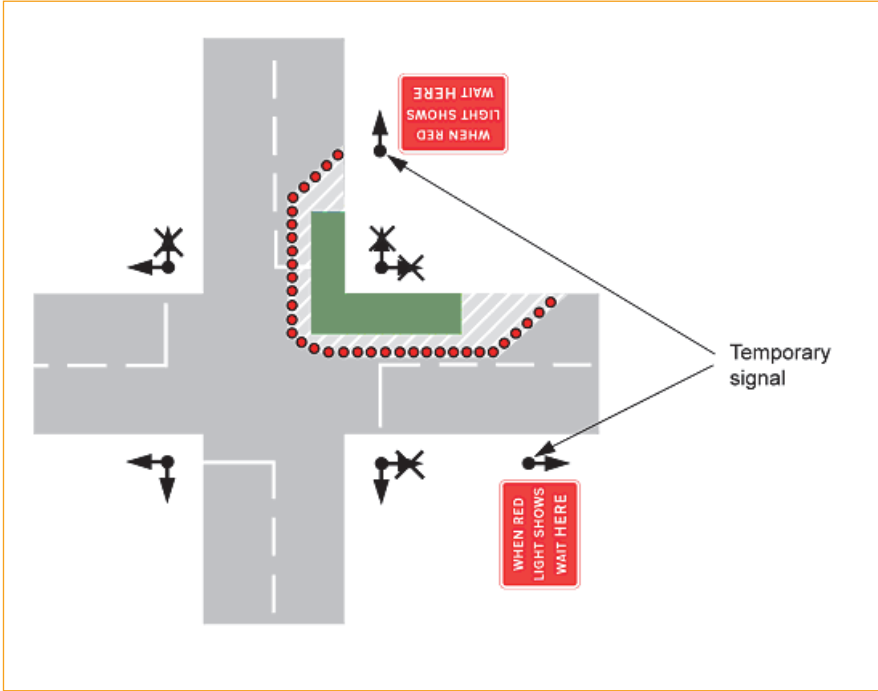


FIGURE 35 – ROAD WORKS AT A CROSSROADS JUNCTION WITH TRAFFIC SIGNALS (LHS)

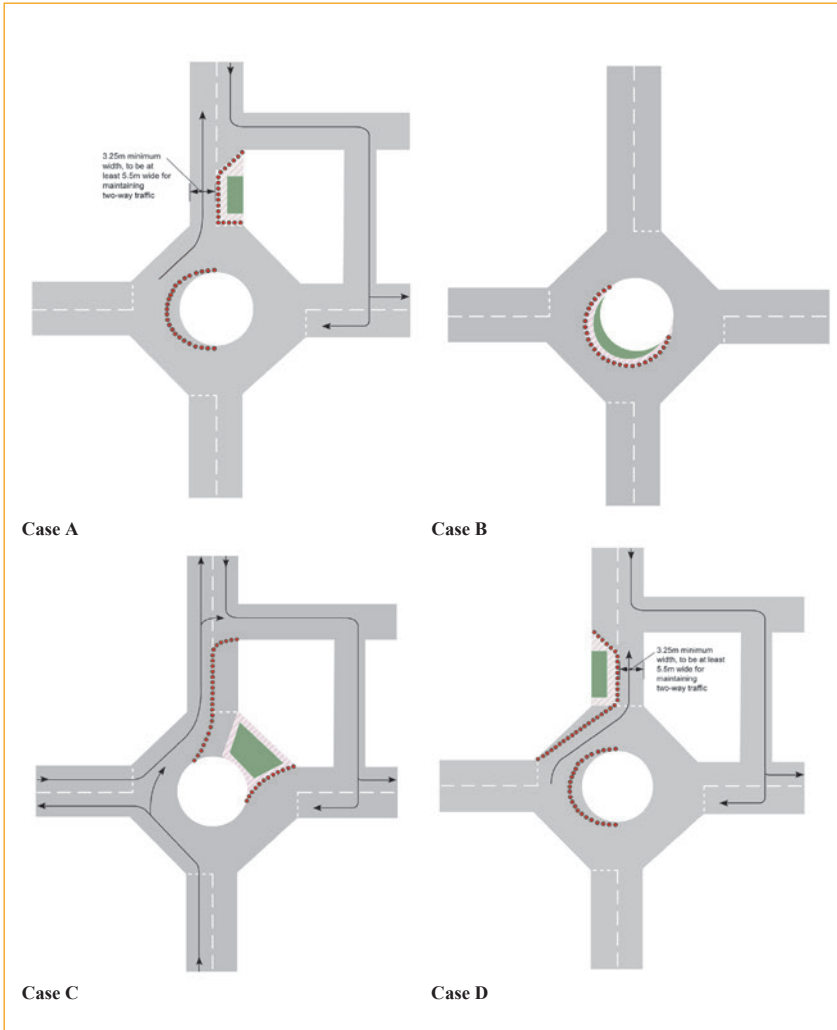


FIGURE 36 – ROAD WORKS AT A ROUNDABOUT (LHS)

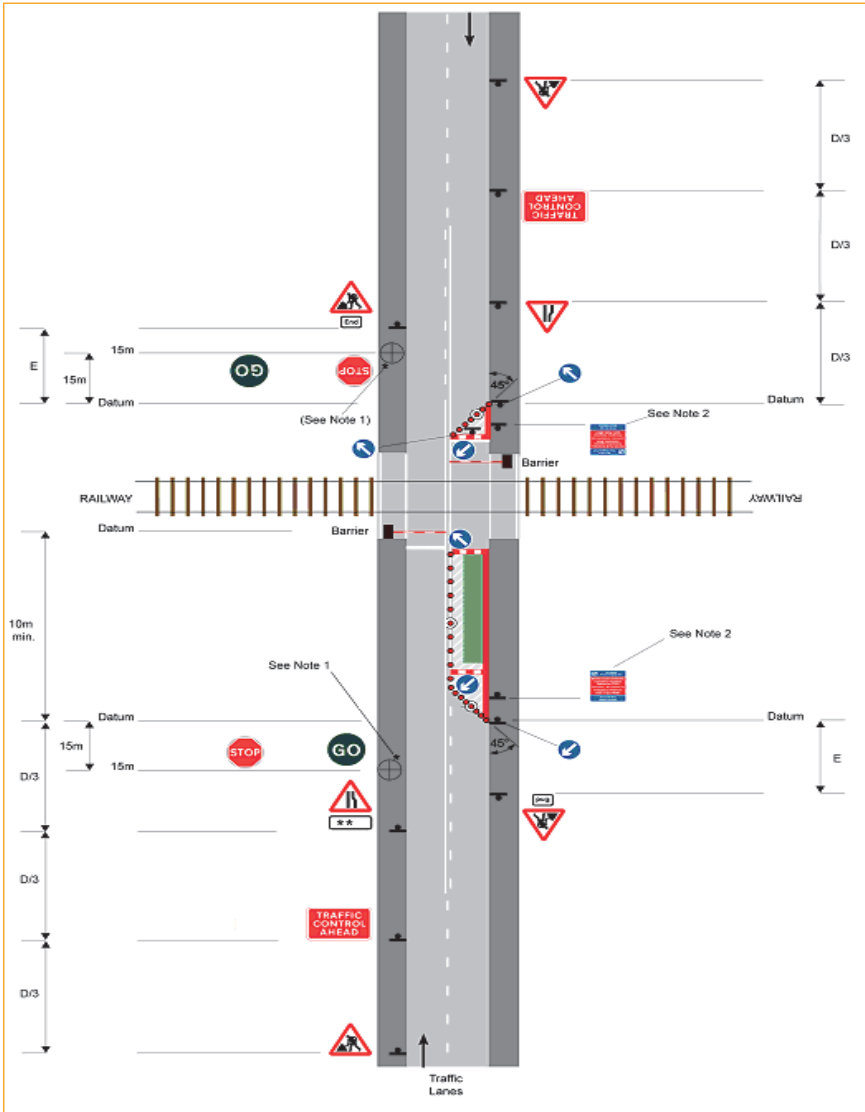


FIGURE 37 – WORKS NEAR A LEVEL CROSSING ON A SINGLE CARRIAGEWAY ROAD WITH FOOTWAY NOT OBSTRUCTED (LHS)

Notes:

1. The “STOP/GO” sign should be placed where it will be in full view of approaching drivers and may be located on either side of the carriageway.
2. These signs are additional to the road works signing and are provided by the statutory undertakers for pedestrians’ information.

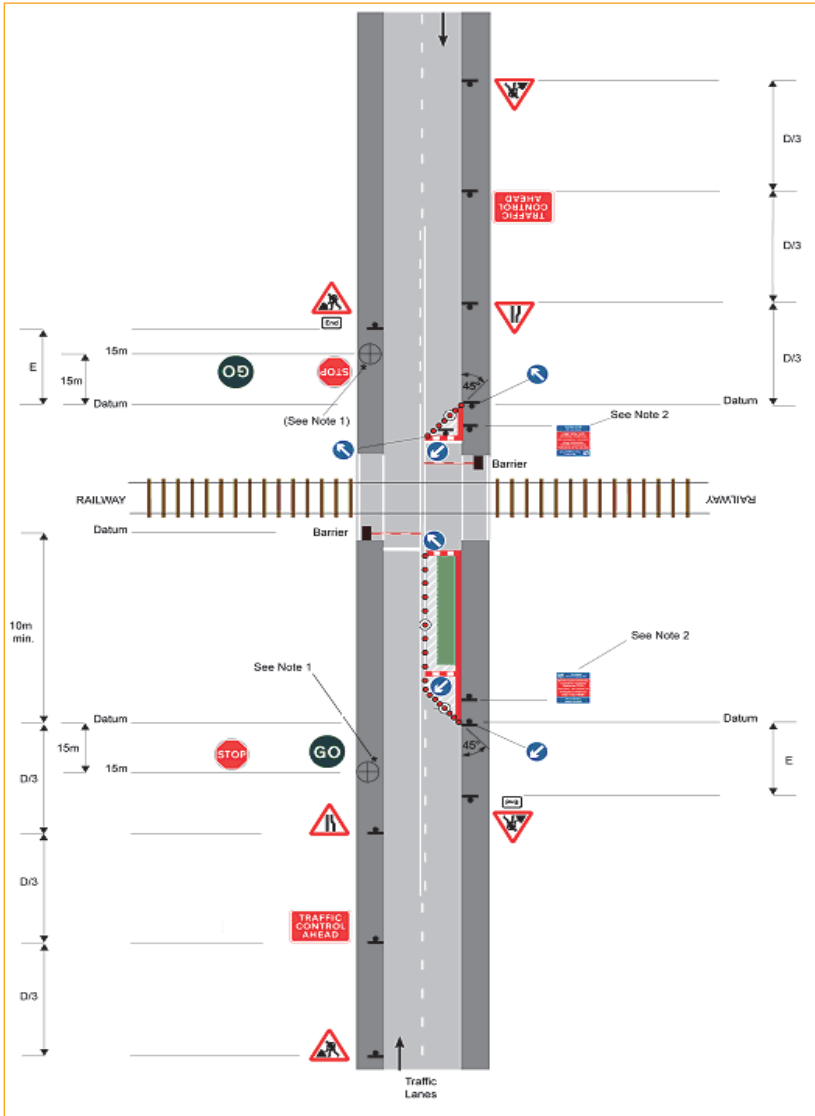


FIGURE 38 – ROAD WORKS NEAR A LEVEL CROSSING ON A SINGLE CARRIAGEWAY ROAD WITH FOOTWAY OBSTRUCTED (LHS)

Notes:

1. The “STOP/GO” sign should be placed where it will be in full view of approaching drivers and may be located on either side of the carriageway.
2. These signs are additional to the road works signing and are provided by the statutory undertakers for pedestrians’ information.

8.4. SHORT DURATION AND MOBILE WORKS

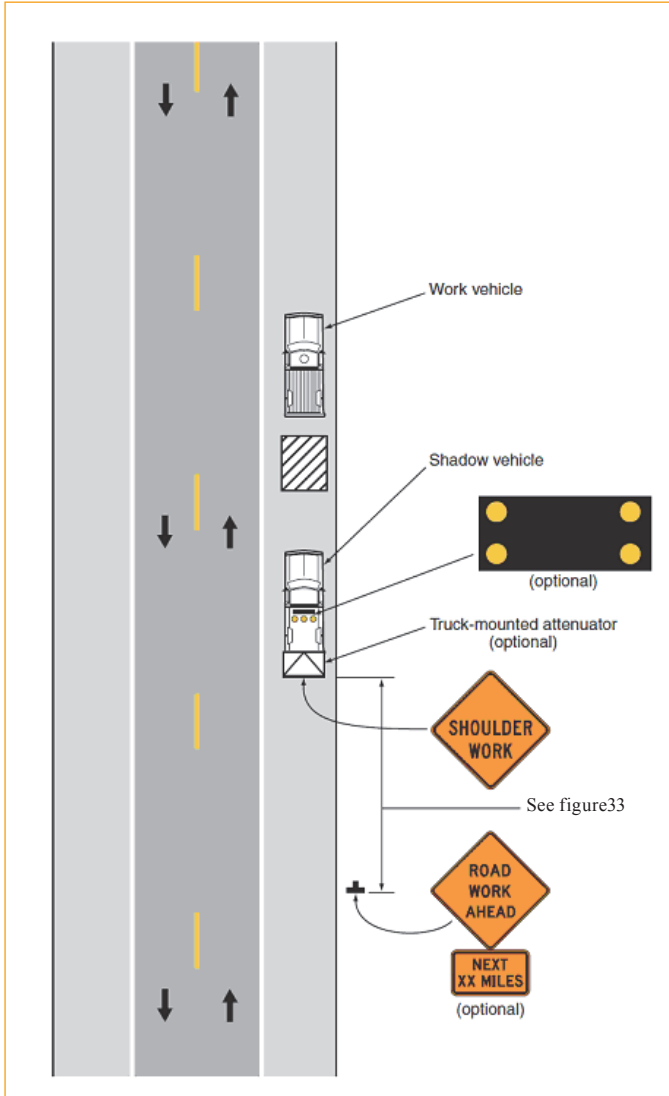


FIGURE 39 – SHORT-DURATION OR MOBILE OPERATION ON A SHOULDER (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

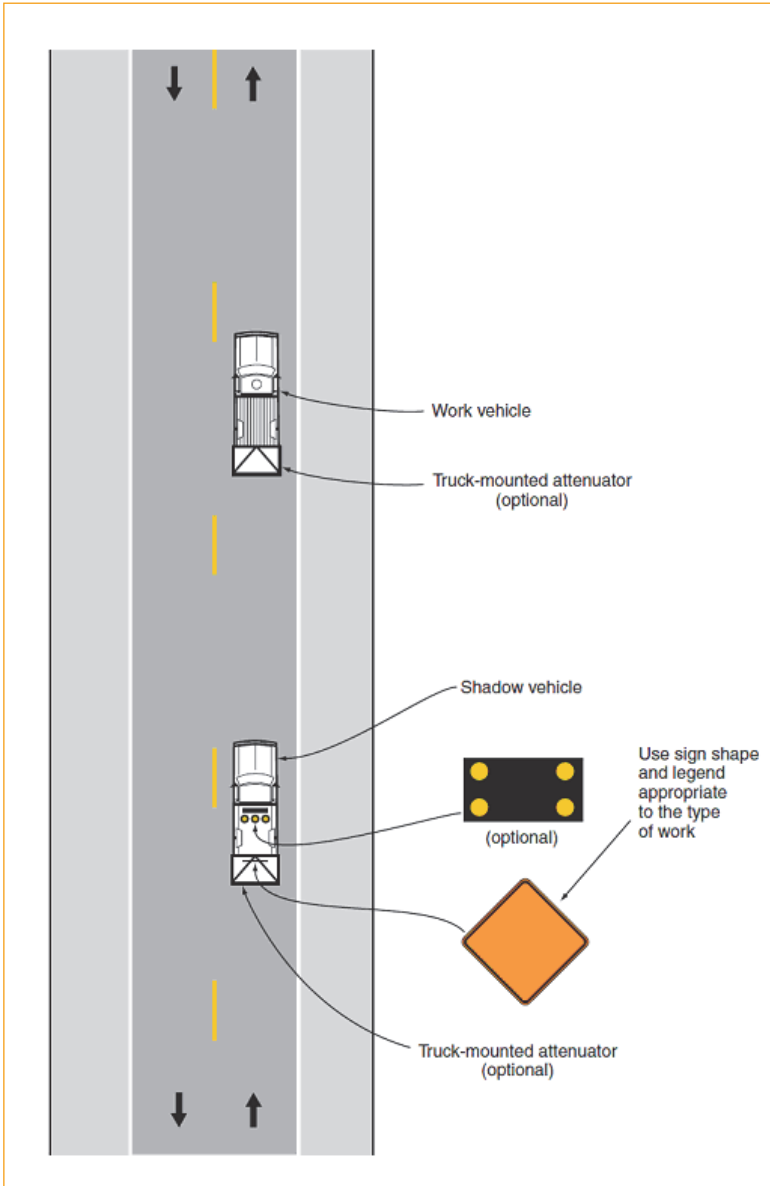


FIGURE 40 – MOBILE OPERATIONS ON A TWO-LANE ROAD (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

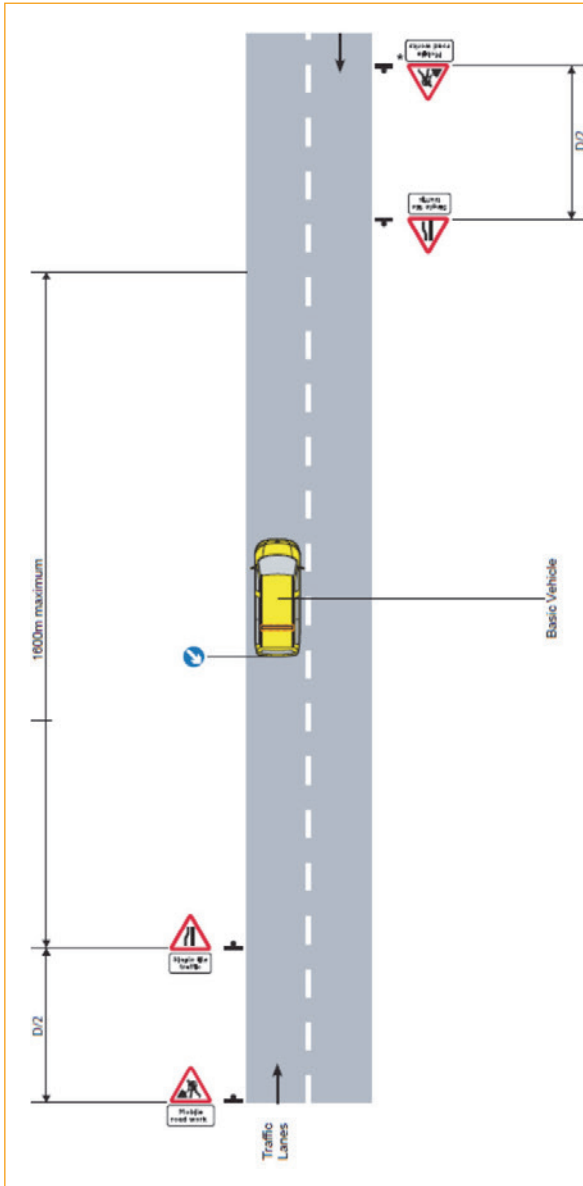


FIGURE 41 – BASIC SITE LAYOUT – MOBILE WORKING ON A SINGLE CARRIAGEWAY ROAD WITH A SPEED LIMIT OF 30 MPH (50 KM/H) OR LESS AND INTERMITTENT STOPS OF UP TO 15 MINUTES (LHS)

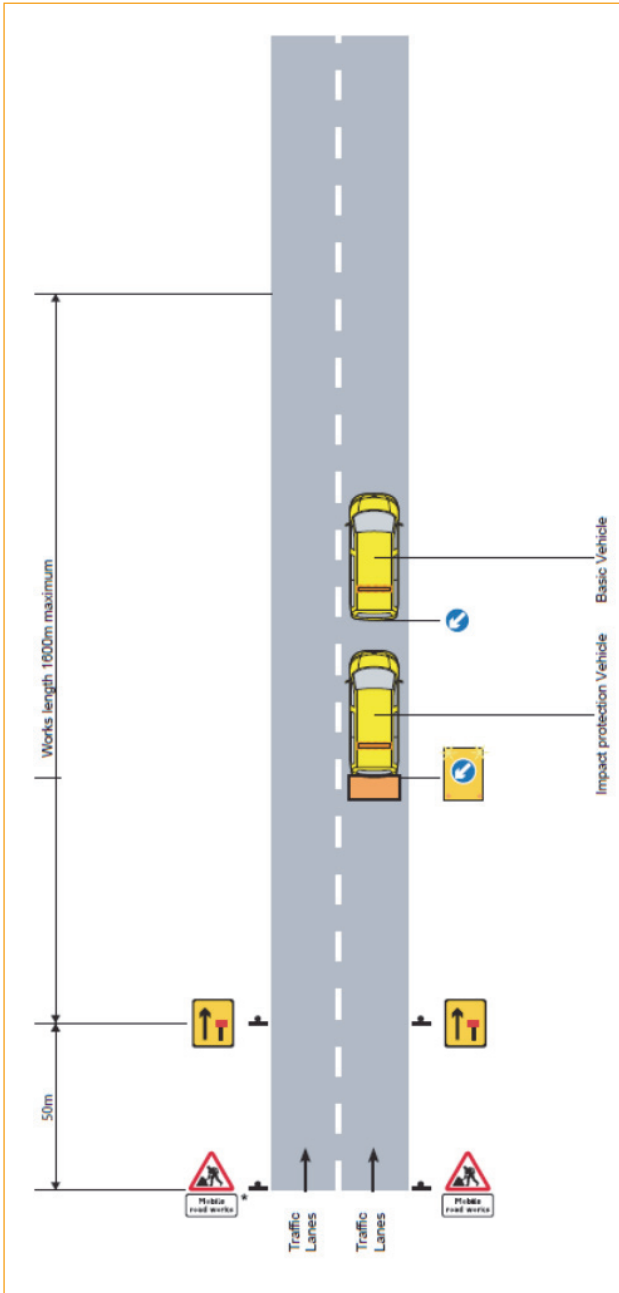


FIGURE 42 – MOBILE WORKING ON A DUAL CARRIAGEWAY ROAD WITH A SPEED LIMIT OF 40 MPH (65 KM/H) OR LESS AND INTERMITTENT STOPS OF UP TO 15 MINUTES (LHS)

8.5. HIGH SPEED DISTRIBUTOR (MOTORWAY/FREEWAY) DUAL CARRIAGEWAY ROADS

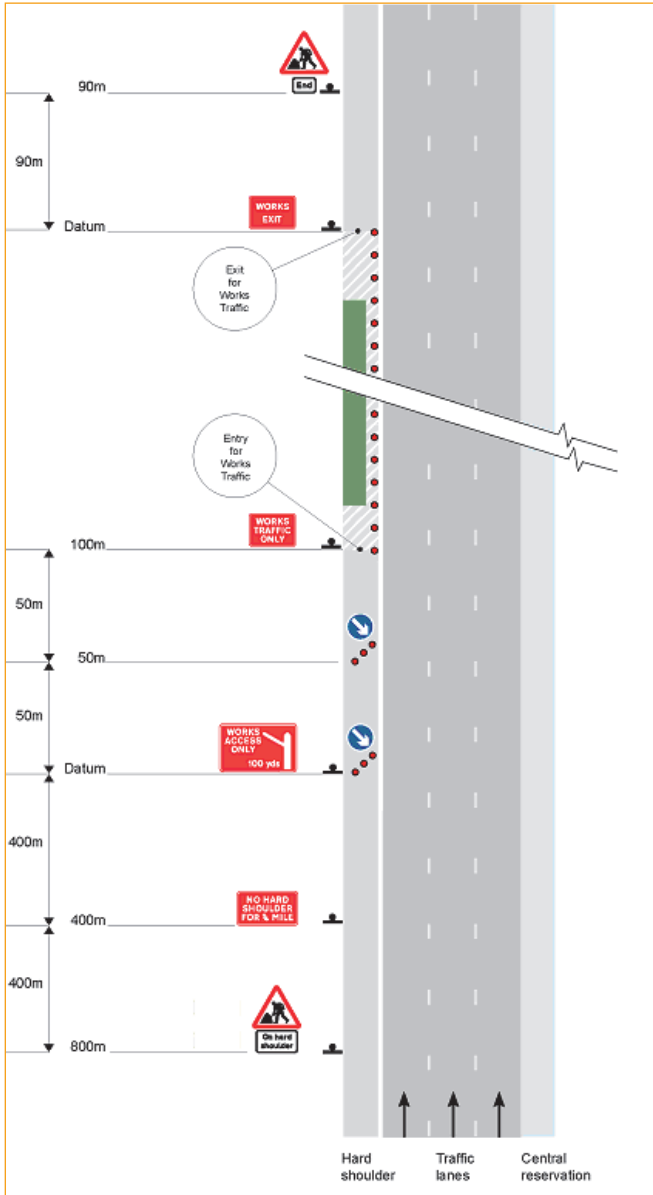


FIGURE 43 – DUAL CARRIAGEWAY ROAD, HARD SHOULDER CLOSURE ONLY (LHS)

TABLE 6 – MEANING OF SYMBOLS ON TYPICAL APPLICATIONS DIAGRAMS


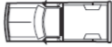





















	Arrow board		Shadow vehicle
	Arrow board support or trailer (shown facing down)		Sign (shown facing left)
	Changeable message sign or support trailer		Surveyor
	Channelizing device		Temporary barrier
	Crash cushion		Temporary barrier with warning light
	Direction of temporary traffic detour		Traffic or pedestrian signal
	Direction of traffic		Truck-mounted attenuator
	Flagger		Type 3 barricade
	High-level warning device (Flag tree)		Warning light
	Longitudinal channelizing device		Work space
	Luminaire		Work vehicle
	Pavement markings that should be removed for a long-term project		

TABLE 7 – MEANING OF LETTER CODES ON TYPICAL APPLICATION DIAGRAMS

Road Type	Distance between signs**		
	A	B	C
Urban (low speed)*	100 feet (30 meters)	100 feet (30 meters)	100 feet (30 meters)
Urban (high speed)*	350 feet (100 meters)	350 feet (100 meters)	350 feet (100 meters)
Rural	500 feet (150 meters)	500 feet (150 meters)	500 feet (150 meters)
Expressway/Freeway	1000 feet (300 meters)	1500 feet (450 meters)	2640 feet (800 meters)

* Speed category to be determined by Highway Authority

** The A dimension is the distance from the transition or point of restriction to the first sign.

The B dimension is the distance between the first and second signs. The C dimension is the distance between the second and third signs. (The “*first sign*” is the sign in three-sign series that is closest to the TTC zone. The “*third sign*” is the sign that is furthest upstream from the TTC zone.)

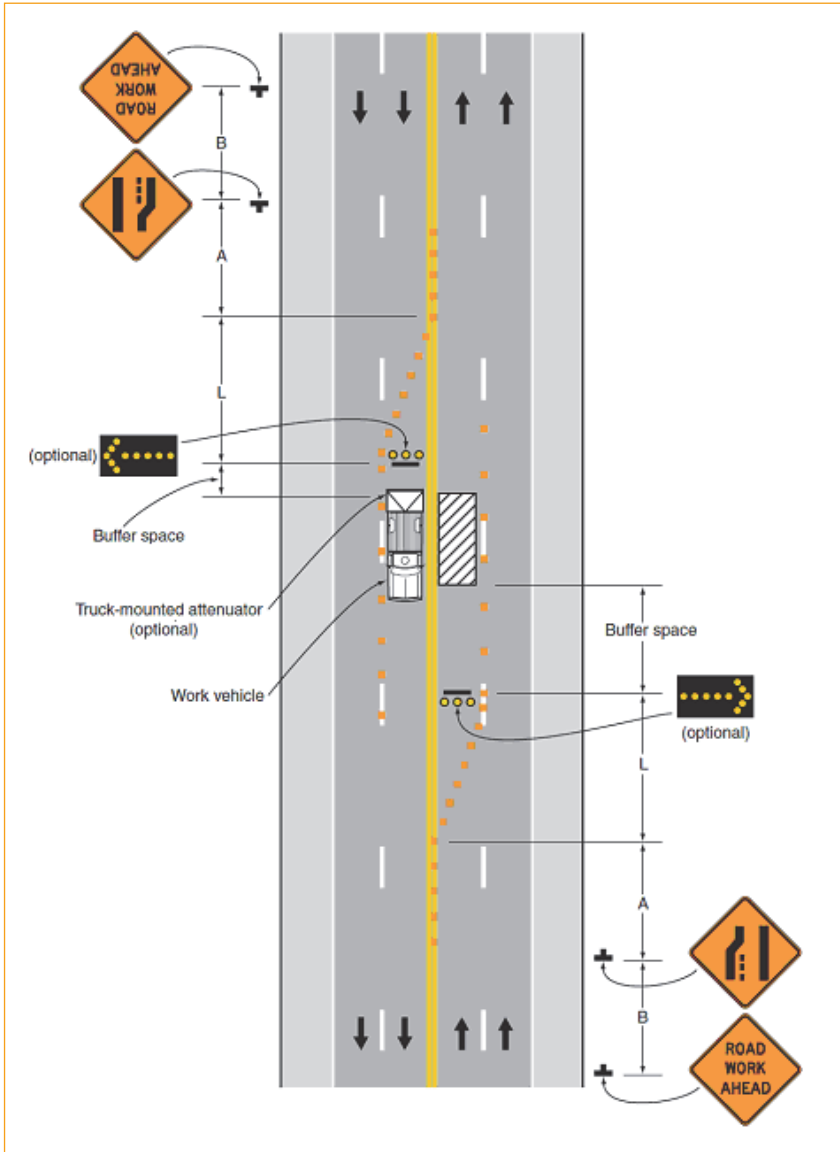


FIGURE 44 – INTERIOR LANE CLOSURE ON A MULTI-LANE STREET (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

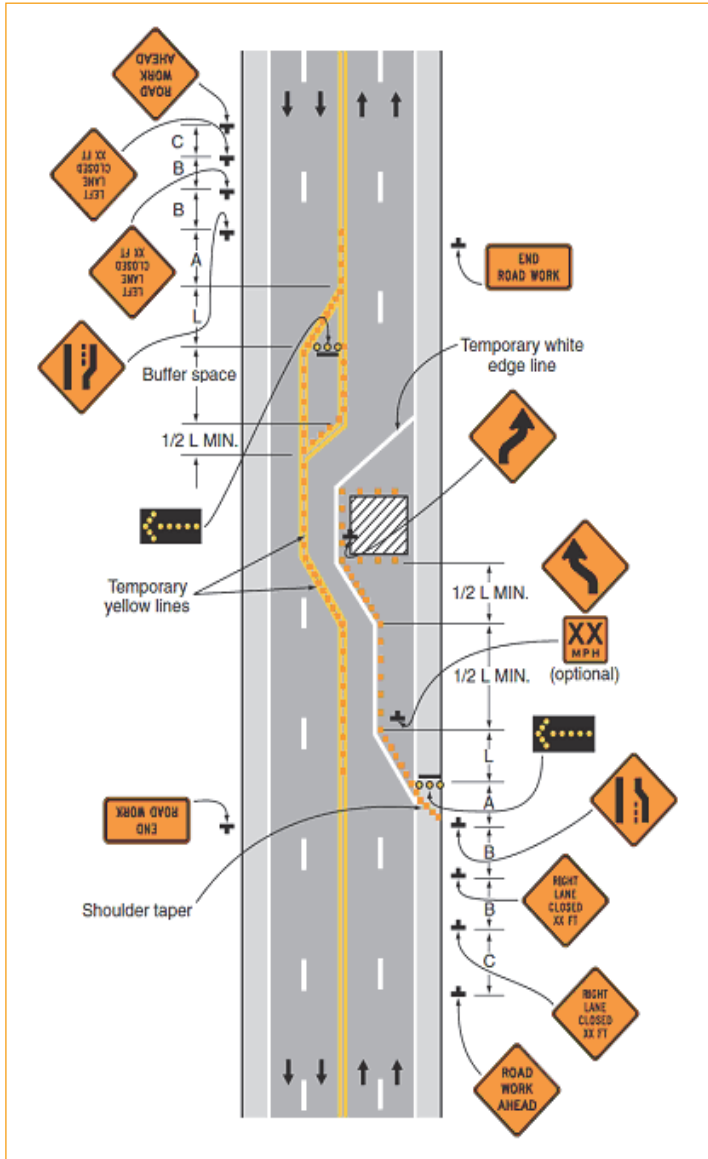


FIGURE 45 – HALF ROAD CLOSURE ON A MULTI-LANE HIGH-SPEED HIGHWAY (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

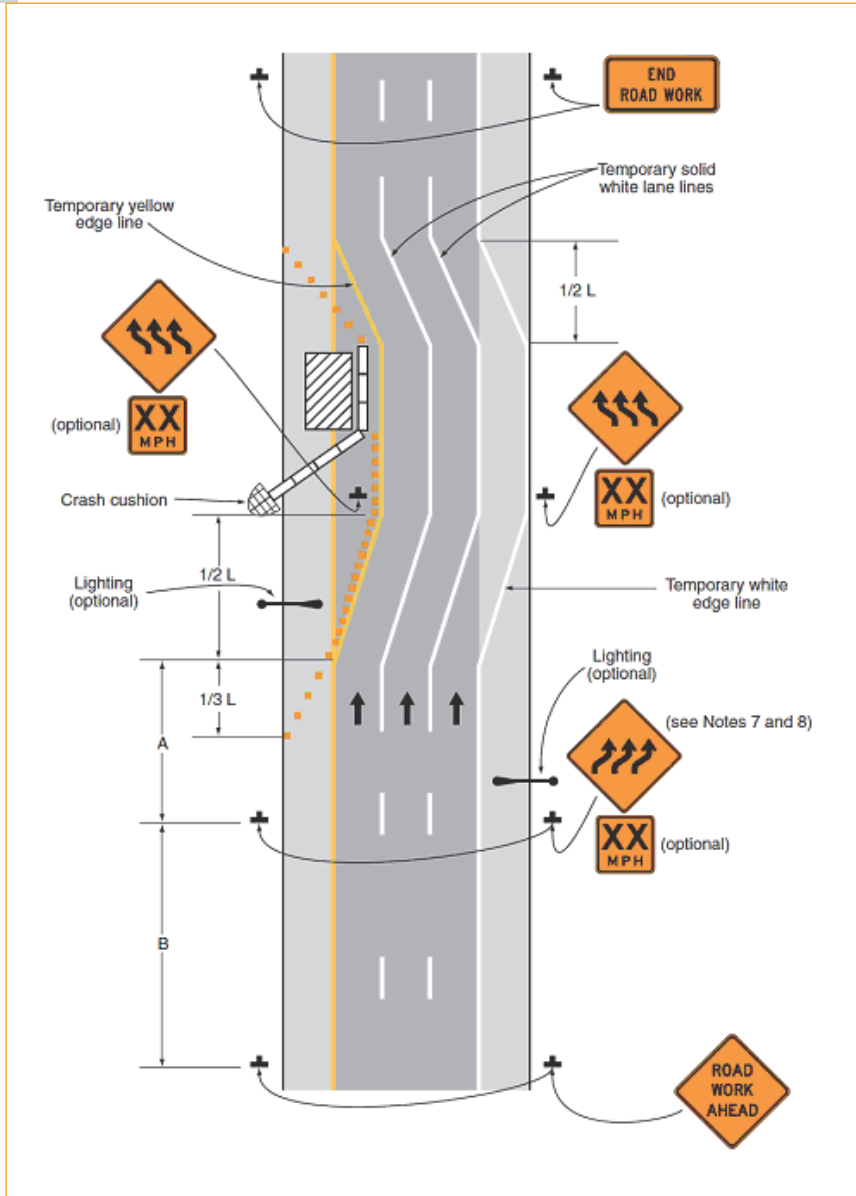


FIGURE 46 – LANE SHIFT ON A FREEWAY WITH CRASH CUSHION (RHS)

Note: See tables 6 and 7 for the meaning of the symbols and/or letter codes used in this figure.

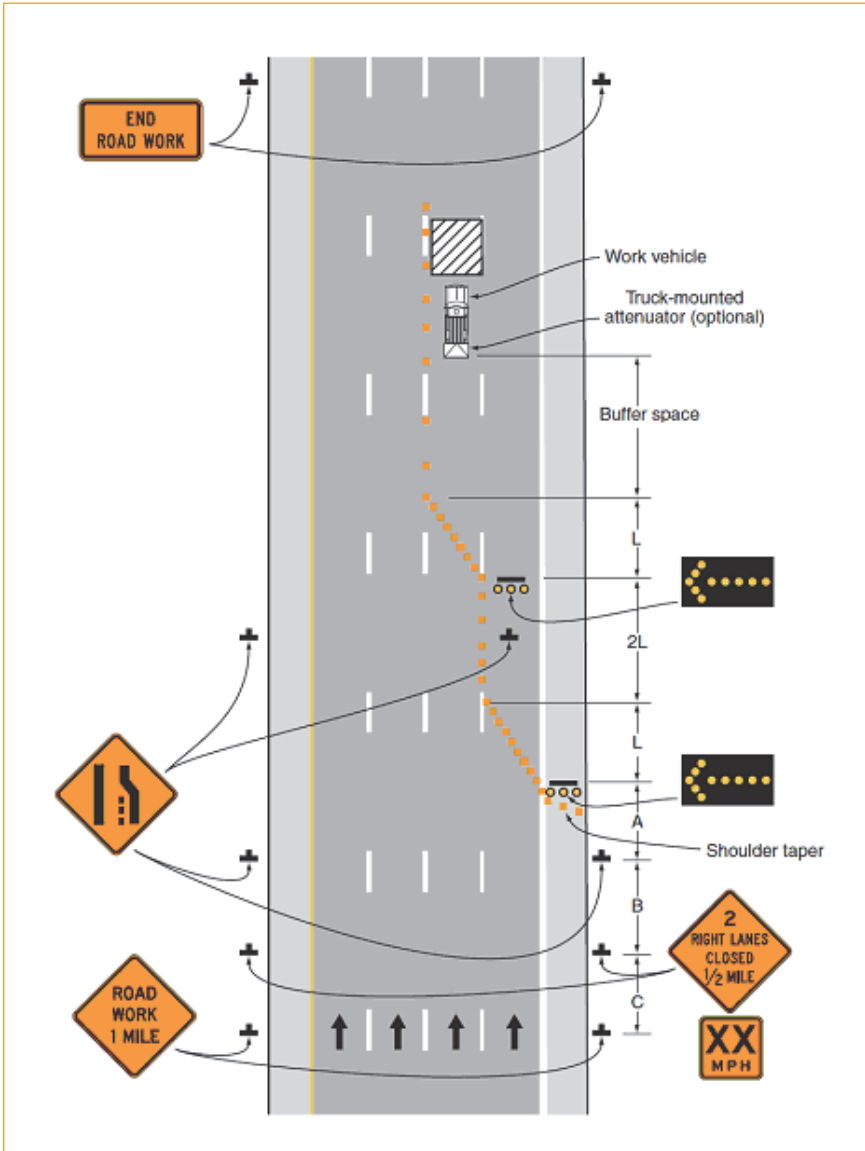


FIGURE 47 – DOUBLE LANE CLOSURE ON A FREEWAY (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

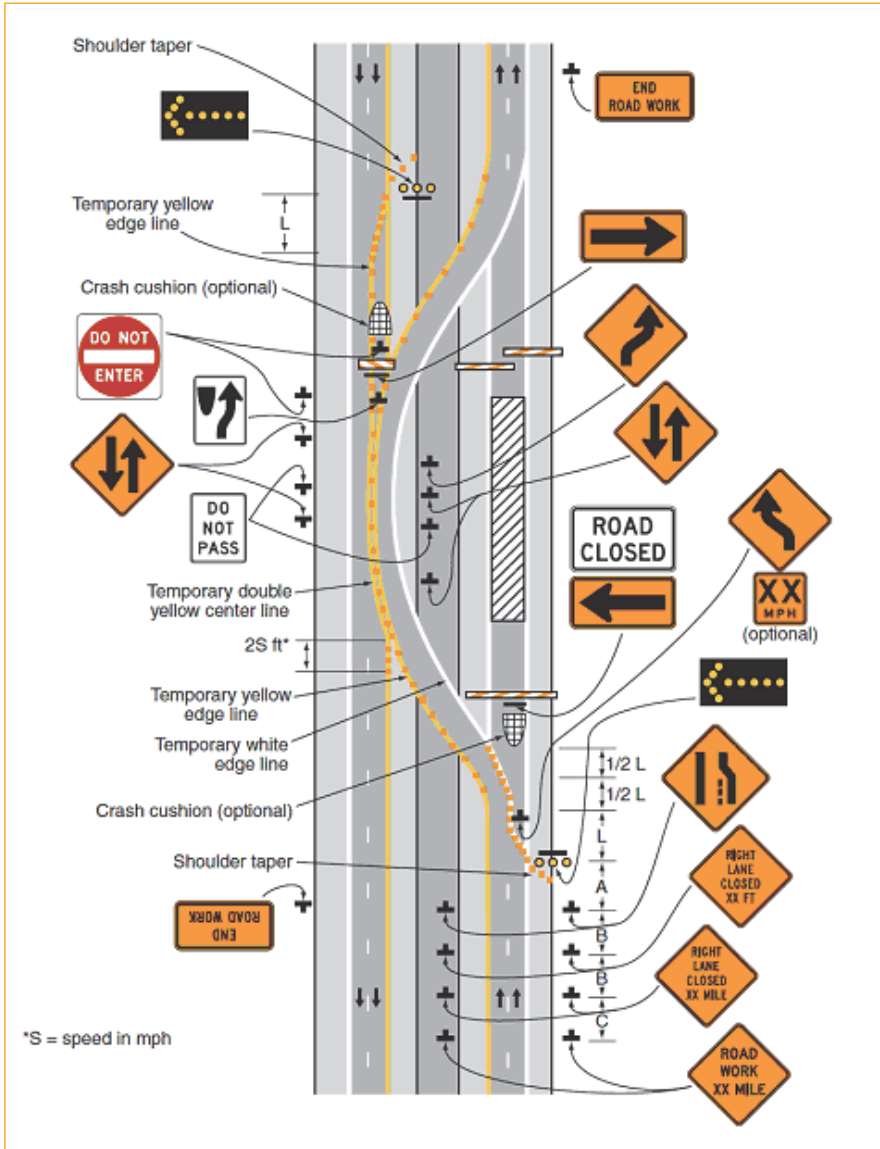


FIGURE 48 – MEDIAN CROSSOVER ON A FREEWAY (RHS)

Note: See tables 6 and 7 for the meaning of the symbols and/or letter codes used in this figure.

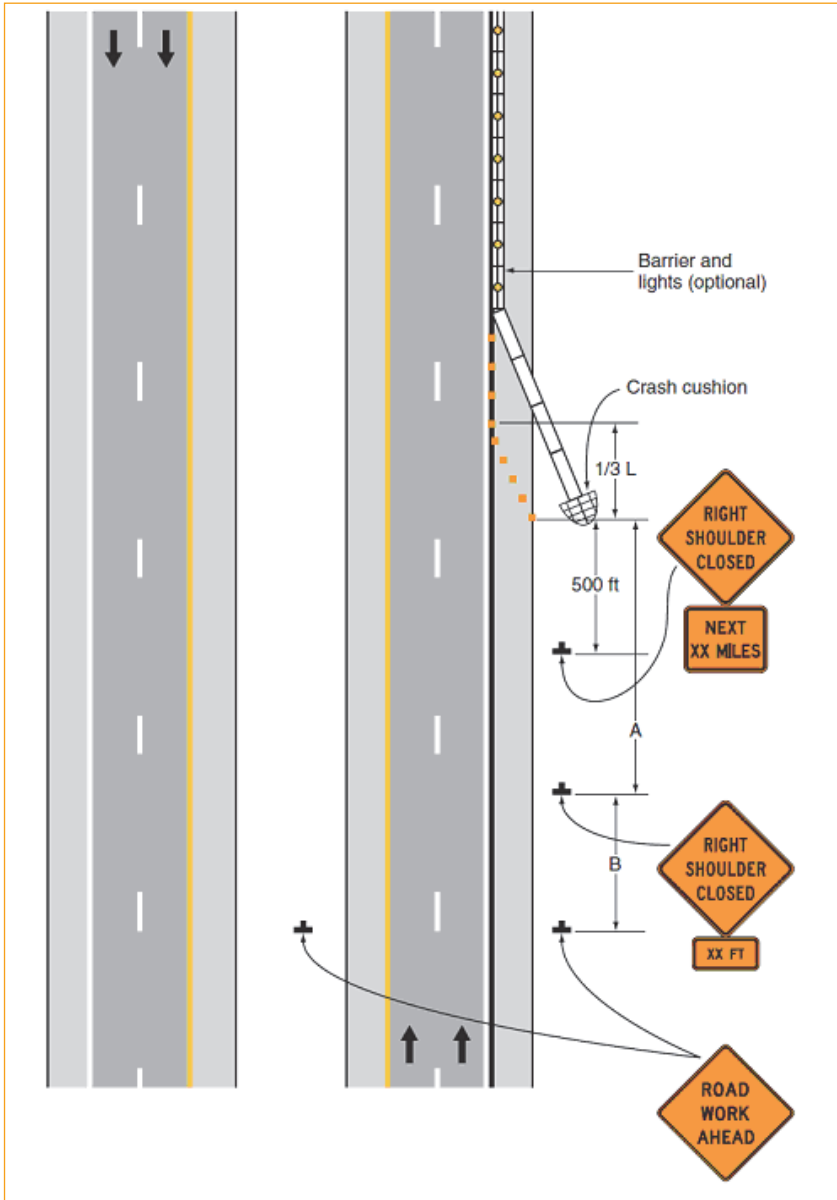


FIGURE 49 – SHOULDER CLOSURE ON FREEWAY (RHS)

Note: See *tables 6 and 7* for the meaning of the symbols and/or letter codes used in this figure.

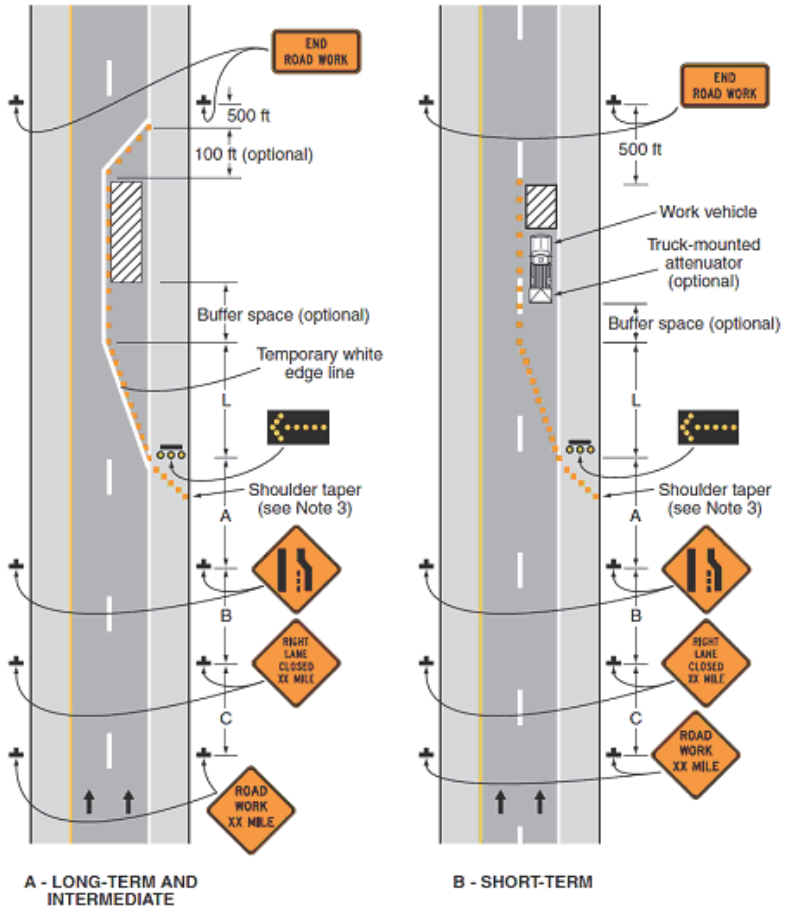


FIGURE 50 – STATIONARY LANE CLOSURE ON DIVIDED HIGHWAY (RHS)

Note: See tables 6 and 7 for the meaning of the symbols and/or letter codes used in this figure.

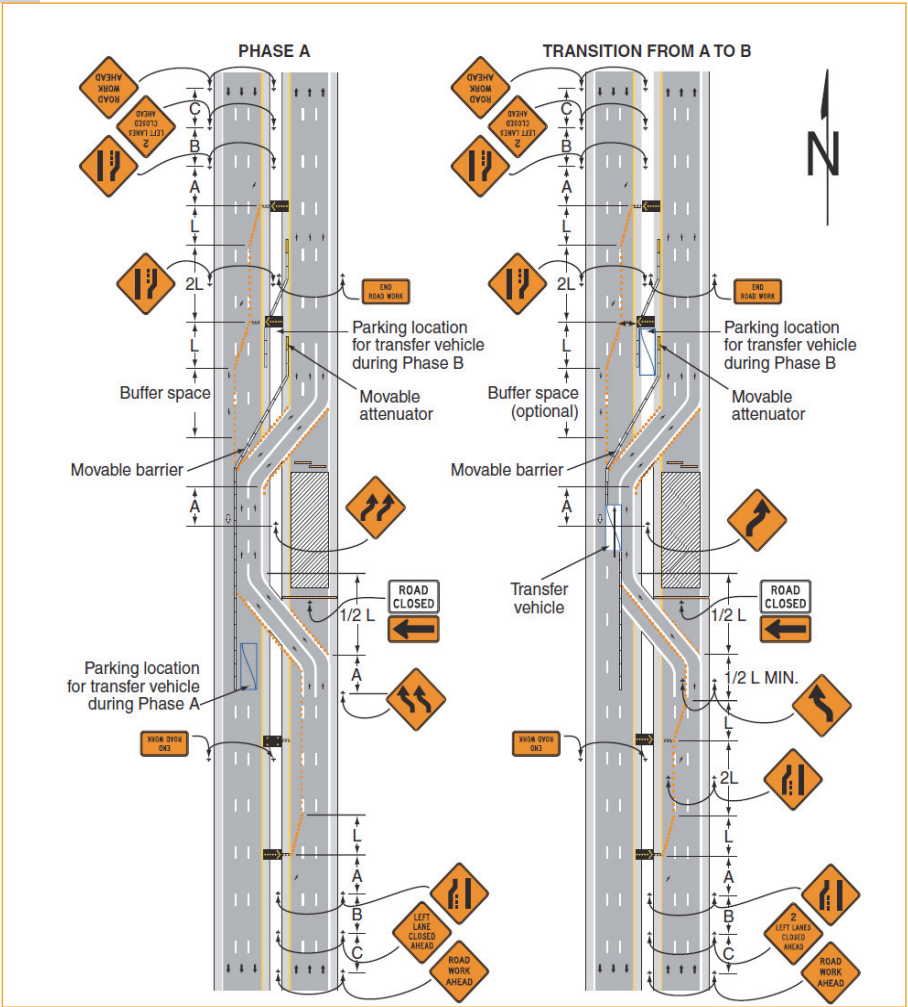


FIGURE 51 – TEMPORARY REVERSIBLE LANE USING MOVABLE BARRIERS (RHS)

Note: See tables 6 and 7 for the meaning of the symbols and/or letter codes used in this figure.

Although leader lines point to the signs on the right-hand side of the roadway, most of these signs should be installed on both sides of the roadway.

9. CHECKLIST FOR WORK ZONE SAFETY

9.1. INTRODUCTION

This checklist (and its affiliated instructions) can be used to assess the status of the work zone, with an emphasis on critical safety features. Such a checklist can be incorporated into a standard inspection of work zones, immediately after set up or during operations. Further, particularly when supported by photo documentation, it can serve as evidence of how the work zone was operating at any given time.

INSTRUCTIONS FOR THE WORK ZONE CHECKLIST

Please mark **YES**, **NO** or **N/A** (NOT APPLICABLE) on each row in the checklist. Please write a note for each NO answer and the date when corrected.

If the work zone is moved or changed during the work, the temporary traffic arrangements should be checked at least once a day.

	DESCRIPTION	APPROVAL CRITERIA
1. Work zone begins		
1.1	An information board providing information of the construction site is installed	An information board showing information of the construction site and providing contacts to the contractor and the client. The information board is placed at the beginning of the construction site.
1.2	The site is marked with a road construction work sign	The realization is in accordance with the plan and requirements.
1.3	Warning lights have been installed	The warnings lights are operating in accordance with requirements.
2. Traffic operation issues		
2.1	Speed limits have been reduced	Speed limits are reduced gradually so that the work zone is safe and easy to drive through. Very low speed limits can be emphasized with rumble strips.
2.2	Temporary traffic signals have been installed	Temporary traffic signals are installed when needed.
2.3	The temporary traffic signals are operating correctly	The temporary traffic signals are operating in accordance with requirements.
2.4	The flagger is in an appropriate location	The flagger is in a safe and appropriate location in relation to the work zone activity, equipment, and travel roadway. The flagger has a flag or preferably a hand sign and can communicate clearly.
3. Work zone		
3.1	Barriers, fences, cones and other warning devices are installed	The realization is in accordance with the plan and requirements.
3.2	Temporary road signs as well as temporary directional and guidance signs have been installed	The work zone signs are installed and convey the proper message. Signs are spaced so that drivers are able to read each sign and take appropriate actions.
3.3	Temporary road markings have been installed	The road markings are installed and are not in conflict with other markings.
3.4	The work zone is separated from the traffic with barriers and fences	The realization is in accordance with the plan and required number of barriers, so they create a continuous and seamless traffic lane.
3.5	A crash cushion is installed	A crash cushion is installed in front of the construction area.
3.6	The work zone is easy to navigate through	Optical guidance is realized. The work zone is safe and easy to navigate through with all vehicles and for drivers unfamiliar with the roadway.
3.7	Travel directions are separated	The realization is in accordance with the plan and requirements.
3.8	Unnecessary traffic control devices have been removed or covered	Unnecessary existing traffic signals, traffic signs and other devices have been removed or covered properly.
3.9	Unnecessary road markings have been removed or covered	Unnecessary road markings have been removed or covered properly.
3.10	The quality of the detour is in accordance with requirements	The detour is adequate in terms of speed limits, weight restrictions, height-width, capacity and geometrics.
3.11	Routes for construction site vehicles are marked	The routes for construction site vehicles are marked and separated from other traffic.
3.12	Traffic is warned about construction site vehicles	The realization is in accordance with the plan and requirements.

4. Work zone ends		
4.1	The end of the road construction site is marked with a traffic sign	The realization is in accordance with the plan and requirements.
4.2	Speed limits are restored	The realization is in accordance with the plan and requirements.
5. Pedestrian, bicycle and public transport arrangements		
5.1	Pedestrian and bicycle traffic is separated from vehicle traffic	Pedestrian and bicycle traffic is separated from vehicle traffic and the safety for intersecting pedestrian and bicycle traffic is adequate.
5.2	Directional and warning signs for pedestrian and bicycle ways are installed	The realization is in accordance with the plan and requirements.
5.3	Bus stops are accessible	Bus stops are accessible.
6. Other		
6.1	The work zone has been checked from both travel directions	Each task on the checklist has been checked from both travel directions.
6.2	Road worker's equipment and working clothes are in accordance with safety requirements	Equipment and working clothes are in accordance with safety requirements.
6.3	All traffic control devices and signs are in accordance with passive safety requirements	The realization is in accordance with the plan and requirements.
6.4	All traffic signs and barriers have high visibility in day and night conditions	The traffic signs and barriers have high visibility and the material used display similar colors in day and night conditions.
6.5	All traffic signs and barriers are undamaged and clean	The realization is in accordance with the plan and requirements.
6.6	Construction site vehicles are visible to other traffic	Visibility of construction site vehicles during day and night conditions is in accordance with requirements. Vehicles can be marked for example with flashing lights, visible colors etc.
6.7	The work site is illuminated when working at night	The illumination is in accordance with the plan and safety requirements

WORK ZONE CHECKLIST

Project: _____
 City: _____
 Date/time: _____
 Inspector: _____

Road number: _____
 Road section: _____
 Name of the road: _____

THE WORK ZONE HAS TO BE CHECKED FROM BOTH DRIVING DIRECTIONS

YES	NO	N/A	1. Work zone begins	Please note	When corrected?
			1.1 An information board providing information of the construction site is installed		
			1.2 The site is marked with a road construction work sign		
			1.3 Warning lights have been installed		

N/A = not applicable

YES	NO	N/A	2. Traffic operation issues	Please note	When corrected?
			2.1 Speed limits have been reduced		
			2.2 Temporary traffic signals have been installed		
			2.3 The temporary traffic signals are operating correctly		
			2.4 The flagger is in an appropriate location		

YES	NO	N/A	3. Work zone	Please note	When corrected?
			3.1 Barriers, fences, cones and other warning devices are installed		
			3.2 Temporary road signs as well as temporary directional and guidance signs have been installed		
			3.3 Temporary road markings have been installed		
			3.4 The work zone is separated from the traffic with barriers and fences		
			3.5 A crash cushion is installed		
			3.6 The work zone is easy to navigate through		
			3.7 Travel directions are separated		
			3.8 Unnecessary traffic control devices have been removed or covered		
			3.9 Unnecessary road markings have been removed or covered		
			3.10 The quality of the detour is in accordance with requirements		
			3.11 Routes for construction site vehicles are marked		
			3.12 Traffic is warned about construction site vehicles		

YES	NO	N/A	4. Work zone ends	Please note	When corrected?
			4.1 The end of the road construction site is marked with a traffic sign		
			4.2 Speed limits are restored		

YES	NO	N/A	5. Pedestrian, bicycle and public transport arrangements	Please note	When corrected?
			5.1 Pedestrian and bicycle traffic is separated from vehicle traffic		
			5.2 Directional and warning signs for pedestrian and bicycle ways are installed		
			5.3 Bus stops are accessible		

YES	NO	N/A	6. Other	Please note	When corrected?
			6.1 The work zone has been checked from both travel directions		
			6.2 Road worker's equipment and working clothes are in accordance with safety requirements		
			6.3 All traffic control devices and signs are in accordance with passive safety requirements		
			6.4 All traffic signs and barriers have high visibility in day and night conditions		
			6.5 All traffic signs and barriers are undamaged and clean		
			6.6 Construction site vehicles are visible to other traffic		
			6.7 The work site is illuminated when working at night		

10. REFERENCES

1. World Health Organization (2004), *World Report on Roads Traffic Injury Prevention*.
2. ARROWS A Transport RTD Project financially supported by the European Commission under the 4th Framework Programme
3. US Department of Transportation, Fatal Analysis Reporting System, National Highway Traffic Safety Administration
4. ASFINAG (2008), *Annual Report on Road Safety*
5. TRL (2006), *Safety Performance of Minor Road Works on Trunk Roads and Motorways*, Published project report PPR 190, TRL Limited, G. A. Coe, M. E. D. Gillan, J. C. Mitchell, P. Turner, and J. Weekley (December 2006)
6. OECD/ITF, *Towards zero: Ambitious road safety targets and the safe system approach* – Transport Research Centre of the OECD and The International Transport Forum, ISBN 978-92-821-0195-7 © OECD/ITF, 2008
7. *In-depth Investigation of Fatal Road Accidents in Finland 2009*, Finnish Motor Insurers' Centre, Traffic Safety Committee of Insurance Companies (VALT)
8. Harry Lum and Jerry A. Reagan (1995). *Interactive Highway Safety Design Model: Accident Predictive Module. Public Roads*