CAREC Road Safety Engineering Manual 2

SAFER ROAD WORKS

MARCH 2018

CAREC
Central Asia Regional Economic Cooperation Program

ADB

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Photo credits: Phillip Jordan, ADB road safety engineering consultant.

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Abbreviations

CAREC	-	Central Asia Regional Economic Cooperation
km/h	-	kilometer per hour
m	-	meter
mm	-	millimeter
TMA	-	truck-mounted attenuator
TMP	-	traffic management plan
VMS	-	variable message sign

Purpose of this Manual

The Central Asia Regional Economic Cooperation (CAREC) countries committed to road safety at the 14th CAREC Ministerial Conference in Mongolia in September 2015. More recently, the ministers from all CAREC countries endorsed the CAREC Road Safety Strategy 2017–2030 during the 15th Ministerial Conference in Pakistan in October 2016. The strategy supports and encourages governments and road authorities to plan, design, construct, and maintain roads with road safety as a key and specific objective.

The strategy supports practices that improve road safety at road worksites to prevent collisions and minimize trauma to road workers and road users. Road authorities within the CAREC program are encouraged to include road safety as an integral part of the planning, design, and operation of all road worksites under the CAREC program.

This manual explains good practices for road worksites. It provides clear and simple guidance for national road authorities to improve road safety at these sites. Road authorities within the CAREC program are encouraged to promote the use of this manual, to refer to it in contracts and specifications, and to build up technical expertise in this subject. In particular, this manual shall be the main reference document for road works in all contract documents used in CAREC road projects.

This manual was written to expand the understanding and use of safe traffic management plans (TMPs) at worksites on CAREC highways. It provides full information about the six-zone process, how to plan, design, implement, and operate a TMP; and how to manage road safety for road users and road workers alike. This information is essential for officials in road authorities, project managers, designers, supervision consultants, contractors, works supervisors, and all others who have a responsibility for safe worksites.

It presents current best practice regarding road safety for road worksites, emphasizing

- the “hierarchy of controls” approach to control the hazard and reduce risk at worksites;
- the importance of designing safe TMPs and having them approved for safety by the road authority;
- the six-zone concept for designing, implementing, and reviewing TMPs;
- close attention to the safety of road workers;
- good practice in the use of signs and delineators at road works; and
- safe operating instructions for traffic controllers.

This manual was prepared under a technical assistance grant for Enhancing Road Safety for Central Asia Regional Economic Cooperation Member Countries (TA 8804-REG) from the Asian Development Bank (ADB). The production of this manual was administered and managed by the CAREC Secretariat at ADB. The Secretariat team includes Ko Sakamoto, Oleg Samukhin, Ian Hughes, Charles Melhuish, Pilar Sahilan, and Debbie Gundaya. The principal author of this manual is Phillip Jordan.

I. Background

1. Road works are an inevitable and necessary part of managing a national road network. New roads and highways must be built; existing roads must be maintained, or sometimes duplicated or upgraded. Bridges, culverts, intersections, and interchanges are built or replaced, and many traffic management improvements take place. All the while, traffic needs to keep flowing while these works go on. Road works usually take place while roads are still used by traffic.

2. Those responsible for building new roads, or maintaining and/or upgrading existing roads, often need to take over some part of the road for their work. This can disrupt traffic and it may lead to traffic congestion, delays, and frustration. It may also lead to collisions at the worksite.

3. In the management of any road project, there are competing objectives. This is also true when considering options to manage risk. For temporary traffic control at road works, the key objectives are to

- maximize safety for road users and workers at the site,
- minimize the disruption and delay to motorists, and
- ensure the cost of the temporary traffic control arrangements is commensurate with the overall project value.

4. This manual offers assistance to help meet these objectives.

A. Attention to road safety at CAREC road worksites

5. Building new roads and maintaining existing roads can be dangerous occupations. Unless carefully managed, road worksites can become locations of increased risk for those using the roads as well as for the road workers working at the site. Road safety at worksites is an important but often neglected part of road construction and maintenance in the CAREC program.

6. Several international studies confirmed the risks involved at road worksites.[1]

- American research shows that the risk of a serious and/or fatal road crash is three times greater in road works than on an equivalent section of road.
- German research shows that approximately one-quarter of collisions happening on national routes occur in work zones.
- Studies in Finland and Slovenia show that "motorists are up to five times more likely to be injured when traveling through a work zone than on other sections of road."

7. The problem of crashes at road worksites has become so serious that many countries now have higher penalties (double fines and/or double demerit points) for drivers and/or riders who commit traffic offences in a worksite. Harsher penalties are intended to deter unsafe driver behavior and, in turn, to reduce trauma at worksites.

8. Crash data for road worksites in the CAREC program are limited; not a lot is known about the number of crashes at worksites on CAREC highways, nor their severity. However, it is generally acknowledged that there are many crashes at road worksites on CAREC highways, and that a significant percentage of these are serious and/or fatal crashes. As in many other parts of the world, road safety at worksites is now becoming an important issue for the CAREC program.

9. Employers have a responsibility to create a safe working environment for their employees. Employers also have a responsibility for the safety of any other person moving through or around work areas under their control. Employers must, therefore, ensure the proper training of supervisors and workers, as well as the provision of equipment, protective clothing, and resources for the performance of their work in a manner that is safe and minimizes risks.

[1] A. Berses. 2012. *Improving Worker Safety Through Better Visibility.* Sydney: Safe Work Australia, New South Wales, Australia.

10. Contractors and work supervisors should

- be aware of their responsibility to provide safe and convenient traveling conditions for the public, and safe working conditions for personnel under their control.
- appoint a safety officer to be responsible for all road safety matters, as well as occupational health and safety during the road work.
- ensure all personnel involved in traffic signage and traffic control are aware of what is needed and of their responsibilities.
- provide training for all personnel involved in traffic signage and control.
- inform other road stakeholders of the road work.
- inform road users about the road work. For long-term work, information on the duration of the road work should be provided so road users can anticipate the effect of the road works. If there is congestion, they may wish to choose a different route.
- manage the site to avoid damage to private property.
- be familiar with the provisions of this manual and act accordingly.

11. Workers should

- take responsibility for their own safety by looking out for danger and being observant.
- take care of the safety of other personnel and visitors to the worksite.
- wear the protective clothing provided for their safety.
- engage only in work practices that do not put themselves or any other person at risk.
- follow the instructions of their employers in carrying out the requirements of this manual.

12. Road users should

- comply with all the regulatory requirements of the worksite, including the instructions and directions from any traffic controllers.
- travel at a speed that is safe, given the road and traffic conditions.

B. Engineers can make a difference

13. One of the main messages underpinning the technical information in this manual is that engineers have a vital role to play in providing safer roads for all, and especially at road worksites.

14. Most members of the public blame the human factor (the driver, the rider, the pedestrian) for all the crashes on the roads. Most people will say that more effort must be put in to improve human behavior on the roads. Many will add that the police should work harder to enforce traffic rules. Their common belief is that, by altering human behavior, road trauma will be reduced.

15. Many national efforts are devoted to such objectives and, while many national road safety strategies emphasize the need to make people aware of their responsibilities on the roads, there is often a tendency to forget the importance of the road in road safety. Many highway engineers forget that the road itself contributes to the number and consequences of crashes. They believe their role is to construct highways that will stand up to heavy traffic and severe weather for the next 20 years; they underestimate the importance of their work in reducing road trauma. Studies show that up to 30% of road crashes are due to the road and its interaction with the road user.

16. At road worksites, for instance, too many engineers do not recognize that many driver errors are due (at least in part) to engineering failings. By not placing warning signs where they were needed, by using a short taper leading into a lane closure, or by allowing workers to be on-site without their essential personal protective equipment, engineers are failing road users and the road workers.

17. An engineer concerned for road safety as well as for the safety and well-being of workers at a worksite will take steps to provide a site with clear signs, with clear delineation and conspicuous, sensible speed restrictions. This is not difficult nor costly to achieve. It requires some basic guidelines to be followed, and these can be implemented at low cost.

18. Engineers can make a positive difference in road safety. Engineers can save lives, prevent injuries, and reduce road trauma. By putting themselves into "the shoes of the road user" and by empathizing with their needs, an experienced engineer overseeing a road worksite will always ask the critical questions: What will road users make of this? Is it clear, or not? Will they understand it, or not? A positive answer can assure the engineer that the efforts will assist road safety.

19. The good news is that road safety at road worksites can be improved at little cost. It takes dedication to safety by all responsible for the project: the client, the contractor, and the consultant. It also requires the technical knowledge about what to do, and how to do it. This manual gives you that knowledge. Putting it to good use at road worksites in a country should now be one of the main tasks.

C. Defining road work safety

20. Road work safety is a general term given to the provision of signs, barriers, delineators, and other safety devices at a road worksite to ensure the risk to road users passing through the worksite, and to road workers at the road worksite, is as low as practical. The objectives of safe and effective worksite traffic management are to

- provide a safe working environment for road workers;
- warn approaching road users and pedestrians of the road works;
- guide road users safely through, past, or around the road worksite;
- provide minimum inconvenience for the traveling public; and
- provide minimum disruption to the work.

21. In most cases, road work takes place in, or close to, moving traffic. Even when a new road is built through a "green field" environment, and can be constructed free of traffic, it must eventually join an existing road at each end. Safely managing the moving traffic is a serious and important task.

22. Those responsible for building new roads or maintaining existing roads, therefore, usually need to take over a part of the road to do their work. This will invariably cause some disruption to the traffic using the road, which may last for a few minutes, some hours, several days, or many months.

23. It is vital to remember not to surprise road users and/or drivers as they use roads and highways. Some drivers may come across a new worksite unexpectedly. They may have driven that highway recently and seen nothing; but today they find one lane is closed to them due to road works. Without adequate advance warning signs and devices to warn, inform, and guide the drivers, there is a risk that they may be startled by the changed traffic situation and may, in turn, take action that leads to an incident or collision.

24. To make sure to not surprise any road users, the quality of traffic management required at worksites often demands higher standards of safety than on the rest of the road network. For example, a lane closure in a worksite must be appropriately designed for speed, advance warning, and delineation to provide road users with clear warnings and guidance. The number of signs and delineators needed for this at a worksite may be several times the number typically used at other locations where a permanent lane drop exists. The temporary nature of road works increases the risk of "surprise" among road users. Traffic management must address and counter this increased risk.

D. Planning for safety at a road worksite

25. A traffic management plan (TMP) is a drawing (or series of drawings) showing the traffic control devices proposed for use at a worksite, together with a list of the programming of the works, stating the days and times the worksite will operate.

26. Planning ahead for safety at a worksite is time well spent. It is a necessary part of road work. There are some key decisions along the way, and by carefully considering each one, it is possible to design, implement, and manage a safe TMP for a worksite.

27. Developing a TMP takes knowledge and experience. A TMP cannot simply be "cut and pasted" from the internet, or photocopied from a manual. Each site needs careful and detailed attention because no two worksites are the same. Factors such as vertical and horizontal geometry, road classification, traffic volumes, speeds, abutting development, and the duration of the project all add up to make each and every worksite unique.

28. However, there are some common factors with all worksites. By following a series of key steps, make considered and consistent decisions on how to manage risk, and then gather all the necessary information to develop a safe and effective TMP. Chapter II outlines how it is possible to manage risk at worksite. Full details about how to design a TMP are then given in Chapter III of this manual.

29. Subsequent chapters go through the implementation, operation, and closing out phases of a worksite. The manual continues with a description of some new safety devices to be considered for worksites. Importantly, a series of generic TMPs are then provided in Chapter VIII to guide at worksites on CAREC highways. The manual concludes with a chapter of practical safety tips for safety officers, and another which offers instructions for traffic controllers.

II. Managing Risk and Planning for Safety

30. Road projects are many and varied. Some may be very big (duplication of CAREC highways), while others may be quite small (patching potholes). They may take place on national highways or on local streets. The works may last for months or years, or only for a few minutes. Each project requires a safe TMP.

31. Before a large road project begins, a number of decisions have to be made about the most cost-effective way to complete the work to the required standard within minimum time and with maximum safety. The need to complete the work on time and on budget is always a major factor which, in turn, leads to decisions about the staging of the work, the equipment and other resources to be used, and the duration of the works. The contractor is usually keen to minimize time and resources as important steps toward maximizing profit. The contractor will think carefully about the staging of the work and the resources needed.

32. Once these primary decisions are made, the contractor should then consider the risks involved with the work and how best to mitigate these. There will be occasions when road safety considerations may cause earlier decisions about the staging or timing of the works to be changed. This iterative process of planning the works is integral to all road projects.

33. There are numerous road safety risks at road worksites. These risks are generated from the interaction between the traffic and the road works, and from the interaction between vehicles due to the works. These risks exist for road users (motorists, truck drivers, bus drivers and passengers, motorcyclists, pedestrians, and cyclists) as well as for road workers.

34. Managing risk requires consideration of the two components of risk: the likelihood of an event occurring, and the consequence if that event occurs. The consideration of these components (likelihood and consequence) occurs via a risk matrix, the outcome of which helps to identify a measure of the risk associated with the defined event.

35. To manage the risks at a worksite, there is a simple step-by-step process that leads to the development of a TMP (Table 1). The first step is to consider the project to be undertaken, and to make decisions about the resources needed and the staging of the work. The issues involved in this step will vary enormously, depending on the type of road project. A major project involving the duplication of many kilometers of national highway will take much more consideration in this step than will a small pothole-patching task on a low-speed urban street.

36. The next step is to ascertain a risk rating for the site. This rating should then guide in deciding the level of protection and the amount of signage and traffic control necessary to reduce the risk to an acceptable level.

37. The third step is to consider the specific risks at the site. The site may be rated a high-risk site, but what exactly are the risks that can be foreseen? It is essential to list these, and then make sure each one is explicitly addressed.

38. Once the foreseen risks are listed, the task is to explore all options to reduce those risks. The hierarchy of controls (Figure 1) can help in this step; it offers a range of options to control safety at a worksite. But while the hierarchy of controls pyramid can offer the options, decisions have to be made about the risk control measures to adopt.

39. Once the direction is clear, design a TMP that incorporates these control measures, and which shows clearly all the signs and traffic control devices needed for the task. The TMP requires approval of the highway authority before work can commence, and attention to accuracy and timeliness is, therefore, essential if the works are to progress in a timely manner.

Table 1: Process Flowchart for Traffic Control at Road Works

Step	Action	Considerations
Step 1	Make decisions about managing the project. How will the work be undertaken?	Will the project be long term or short term? How many stages of work are needed? What equipment will be needed? How many workers? Are there constraints on work times?
Step 2	Determine the risk rating for the site.	Will the works be taking place in a location of high risk or low risk?
Step 3	Consider the risks.	
Step 4	Explore options to reduce risk.	The hierarchy of control. Begin at the top and explore all options as you move downward.
Step 5	Decide on risk control measures	Decide how best to manage the traffic using accepted measures appropriate to the size of the road project.
Step 6	Design a traffic management plan (TMP), and seek approval from the highway authority.	Design a TMP to suit each stage of the road project. If the works will have multiple stages, there must be multiple TMPs.

Source: AUSTROADS. 2012. *Implementing National Best Practice for Traffic Control at Worksites—Risk Management, Auditing and Field Operations.* No. AP–R403-12. Sydney.

Step 1: Make decisions about how to manage the work

What will be the duration of work?

40. Long-term and short-term work often require different decisions about the safest management for each. There are four general categories for the duration of road works:

- Very short-term road works. Works that take no longer than 5 minutes to complete.
- Mobile short-term works. Works that move along a road, either at a constant low speed (such as line marking) or with intermittent stopping (such as patching). These works may obstruct or partially obstruct traffic lanes.
- Short-term works. Work that is limited to the duration of a single work shift or less. Short-term works have durations of less than 24 hours. Unlike long-term works, a TMP for short-term works is required only while work personnel are in attendance.
- Long-term works. Sites where a TMP is required to operate both day and night (that is, for at least 24 hours and usually much longer), and may be left unattended at times.

Establish the staging of works

41. How many different stages of work will be needed? The decisions made on the staging of large road projects have an impact on the safety of the worksite. This is a critical matter; depending on the staging of the works, the preparation of the TMP can either be a simple task, or it can become a complex task. And, depending on the staging of the works, the cost of providing the required traffic management signs and devices may be quite low (for a single work area), or it may increase to become a significant amount (for multiple work areas).

42. If a decision is made to manage a project by working on a number of individual sections at the same time, the project may be able to be completed earlier. The contractor will need more machinery and more workers for this arrangement, and road users will encounter multiple worksites along their route. This arrangement places a greater demand on the contractor to correctly and adequately sign all the worksites.

Step 2: Determine the site risk rating

43. The site risk rating considers the road environment where the worksite will be established,

and it determines if a low or high risk will exist without any protective measures being applied or without special management of the traffic. International experience shows that the major input parameters for site risk are:

- the existing speed zone (higher speed = higher risk),
- the functional hierarchy of the road (major roads = higher risk), and
- the lateral clearance between the proposed worksite and the moving traffic (closer to the works = higher risk).

44. The site risk rating should guide in the amount of planning required to reduce the risks in the context of the work. A high-risk site will require decidedly more planning and preparation to reduce the risks to acceptable levels. A low-risk site will require less planning and preparation to manage the identified risks.

45. The site risk rating should also guide on the level of planning, the experience of the person preparing the TMP, and the amount of documentation required to design and implement the TMP.

Step 3: Consider the risks at the worksite

46. Typical risks that may occur at a CAREC worksite, and which need to be addressed in a TMP, include:

- high-speed traffic through the worksite;
- high-volume of traffic through the worksite;
- high volume of trucks and buses passing through the worksite;
- narrow pavement with no escape route options;
- workers close to the passing traffic;
- poor advance sight distance to the worksite;
- presence of unshielded hazards, including deep excavations, close to traffic;
- rough or unsealed road surface (due to the road works), including loose material on the road surface;
- works vehicles entering and/or leaving the worksite; and
- high numbers of bicyclists and/or pedestrians moving through the worksite.

Step 4: Explore options to reduce risk at the worksite

47. Every road worksite is unique. Each one is a little different to all the others. For this reason, it is important to look at each worksite with "fresh eyes," to scrutinize it for potential hazards and then to ascertain the risk control measure that best suits the conditions.

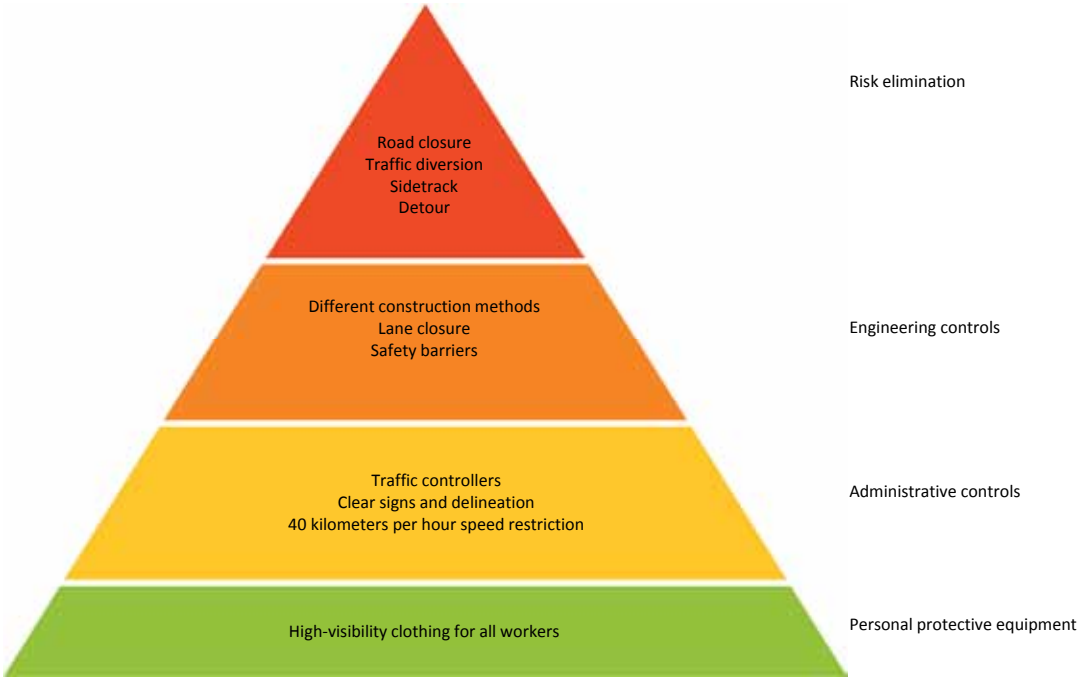
48. A common approach for treating risk is the hierarchy of controls approach. This approach reviews risk control measures in a hierarchical manner, allowing decisions based on key risk control objectives. The hierarchy of controls approach has four categories of control measures that detail the ability to control the hazard and to reduce its risk. The four categories are:

- risk elimination,
- engineering controls,
- administrative controls (to influence behavior), and
- personal protective equipment.

49. Use the hierarchy of controls pyramid (Figure 1) to assist to reduce risks at the worksite. Begin by asking if the traffic can be taken somewhere else for the duration of the works. If this is not possible, ask if engineering measures such as lane closures or safety barriers can be adopted. If this is not possible, ask if suitable signs and a speed limit reduction can be applied. In most cases, this will be possible, and they should be applied in a consistent and clear manner. The fourth category of control is the use of personal protective equipment by workers and engineers on-site. This may include solid working boots, hard hats, and high-visibility clothing (including reflective strips for added visibility under adverse light conditions). With all control categories, workers and engineers on CAREC worksites must wear protective clothing, which must include a high-visibility reflective safety vest or coat.

50. For some risks, certain levels of control may not be practicable or feasible, while for others, a combination of controls may give the best risk reduction. In most cases, there will be a range of decisions to be made when determining the optimum outcome. Risk-reduction ability, overall cost, and disruption to the work and to the traffic are the main deciding factors at most worksites.

Figure 1: Hierarchy of Controls Pyramid



Source: AUSTROADS. 2012. *Implementing National Best Practice for Traffic Control at Worksites – Risk Management, Auditing and Field Operations.* No. AP–R403-12. Sydney.

51. As a person responsible for providing a safe worksite, start at the top of the pyramid and implement those countermeasures, if possible. In real life, however, such countermeasures may not always be possible (there may not be a nearby route that can serve as a detour for instance) or the costs may be prohibitive. It may be necessary to resort to examining the next level of control such as lane closures. Traffic volumes may become a critical factor with this control (if a lane is to be closed, will the remaining lane(s) be sufficient to handle the traffic?), and so, examine other options until a combination of controls is achieved that offers a minimum level of estimated risk "as low as reasonably practical."

52. Practical questions to be asked within each Risk Control Measure include:

- Risk elimination. Can the risk be eliminated?
  - » Close the road and detour all traffic for the duration of the works.
  - » Divert the traffic away from the worksite.
  - » Construct a side track past the works.
- Engineering controls. What engineering measures or protective devices can be implemented to minimize risk?
  - » lane closures, which may then require additional traffic control depending on the remaining lanes;
  - » reversible (counter) traffic flows;
  - » portable traffic signals to control traffic;
  - » safety barriers to protect workers;
  - » crash attenuators (on ends of barriers);
  - » truck-mounted attenuators (TMAs) (on the rear of work vehicles);
  - » escort (pilot) vehicles (to guide traffic through the worksite in tight platoons); and
  - » increased lateral clearance to the worksite.

- Administrative. What can be used to adjust the behavior of motorists traveling through the worksite:
  - » speed restrictions;
  - » signage (warning, regulatory, informative);
  - » traffic cones and bollards (to delineate the travel path);
  - » traffic controllers (with Stop/Slow batons);
  - » variable message signs (VMSs);
  - » vehicle-mounted signs and devices (such as illuminated flashing arrow signs); and
  - » alter work times and work at night (if nighttime traffic volumes are substantially lower, there may be reduced traffic and work delays by working at night).

- Personal protective equipment. Do the workers have all the necessary protective equipment and clothing? This is an essential risk control measure that must be adopted regardless of any other measures. High-visibility clothing is essential for all road workers. All road workers at CAREC worksites shall wear reflective high-visibility clothing at all times.

53. In considering the risk control measures that could be used at the road worksite, questions need to be asked about how best to satisfy competing objectives such as:

Consider where the traffic will go

54. How the traffic at the worksite be managed (Figure 2):

- pass through the work zone under closely controlled conditions; or
- move past the work zone on a delineated path beside but clear of the work zone; or
- move around the work zone by a detour, which may be temporary side track or an existing network of roads; or
- close the road, usually for short periods, while work is carried out.

Pass through the work zone

55. Passage of traffic through a work zone should only be permitted where both the traffic and the work can be effectively controlled. Traffic controllers (or flag persons) may be necessary to further slow traffic on the approach to the work zone and to stop the traffic for short periods, if required.

56. Traffic controllers (or flag persons) may also be required to control the movement of work vehicles and machinery within and/or across the traffic path.

57. In extra special cases, pilot vehicles may be used to lead platoons of vehicles through the work zone. This is still an unusual practice in the CAREC region.

Past the work zone

58. This will be the normal method of traffic management at sites where the complete exclusion of traffic from the work zone is sought (other than by a full road closure). Traffic is directed past the work zone in a clearly delineated lane of high-visibility plastic cones and/or bollards and delineators. (Do not allow the use of concrete blocks, tree branches, rocks, or concrete barricades for this.)

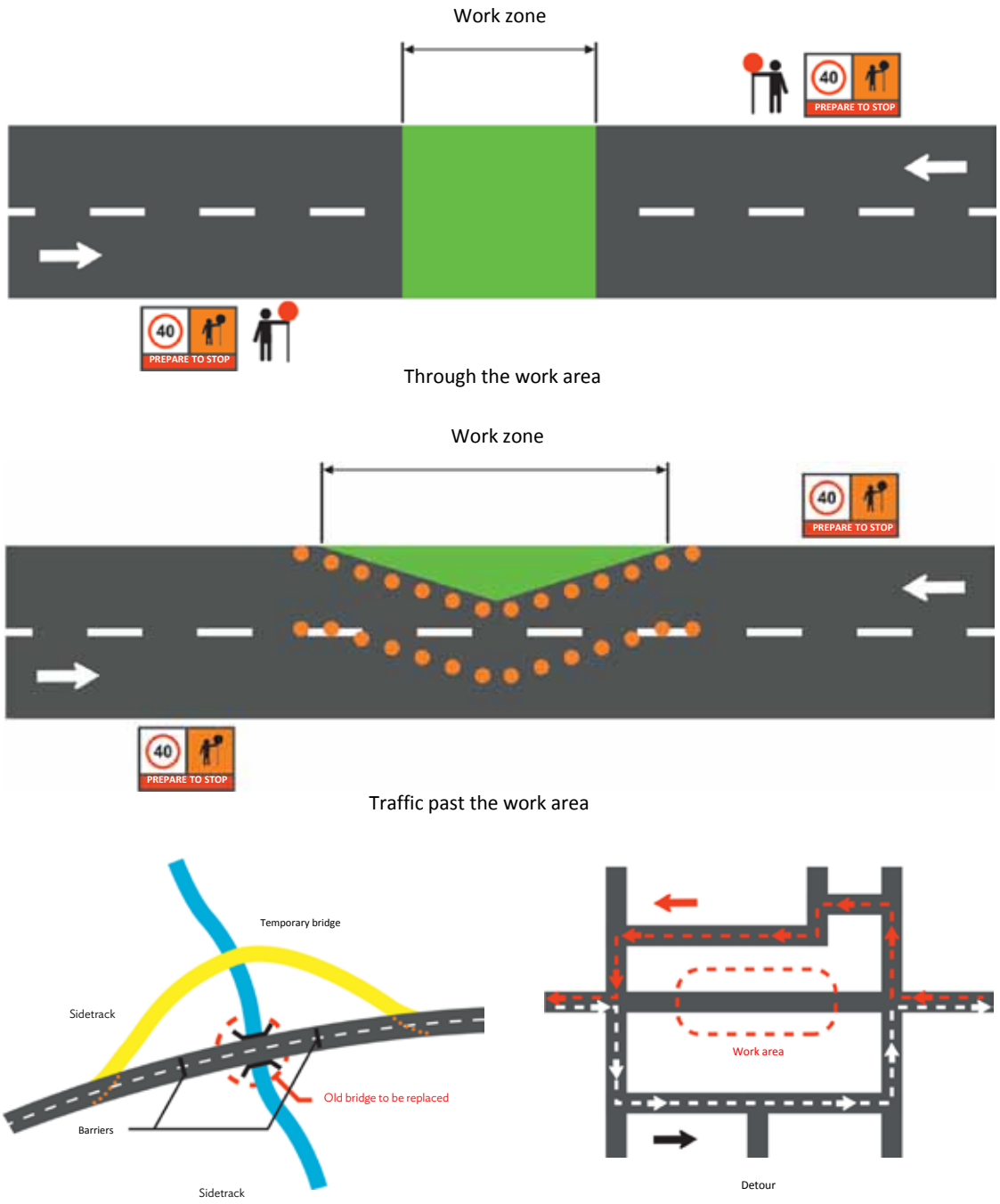
59. Traffic may be taken past the work zone by moving one direction of traffic onto a shoulder so both directions can pass the works simultaneously, but at reduced speed. The quality of the shoulder may be an issue, and it will be essential to avoid significant pavement drop-offs and potholed shoulders.

60. Traffic may also be taken past the work zone by using the second carriageway of a divided highway. By constructing a crossover to the other carriageway, and by permitting counterflow on that carriageway a suitable diversion may be possible. Detailed planning is always required for these situations. In particular, it is important to inform drivers and/or riders in both directions that they are no longer on a one-way carriageway. Consistently, remind them they are now sharing a carriageway with traffic from the other direction. Use "Two Way" traffic warning signs at frequent intervals, and use cones and/or bollards between opposing traffic streams to remind them of this point.

61. While this may seem overly cautious to some, a safety-conscious engineer will remember traffic keeps moving day and night. In the small hours of the morning, when traffic volumes are very low and when speeds tend to be higher, the risk of head-on collisions in such locations rises greatly unless warning and delineation is clear and obvious to all.

62. Speed control under all of these arrangements is critical; effective enforcement from the police will be necessary in such arrangements.

Figure 2: Four Alternatives for Traffic to Pass Through, Past, or Around a Work Zone



Source: Asian Development Bank.

Moving around the work zone (sidetracks and detours)

63. When it is not practicable to close the road, or to allow traffic through or past the work zone, a side-track or a detour is needed. A sidetrack is usually a short specially constructed all-weather path that takes traffic around one side of the work zone. It is usually a two-way track although the management of the side track and its length and cross sectional width are dependent on site factors, including vehicle volumes and the expected duration of the works.

64. If a sidetrack is to be built, even for a short period, you need to ensure it has suitable geometry and a suitable surface for the speed and type of traffic that will be using the sidetrack. To avoid drivers and/or riders from being caught by surprise when they need to change path to access a side track, it is vital to provide

- very clear signs for early warning and advance warning zones on the approach (see sample in Figure 3).
- a reduced speed limit, and clear signs (this is an integral part of an advance warning zone). Forty kilometers per hour (km/h) is the recommended speed limit through, past, or around CAREC work zones.
- good, all-weather pavement for the sidetrack. (Do not expect drivers and/or riders to negotiate a poorly constructed unsealed sidetrack. Heavy rains will turn it into a muddy track, while dust will be a problem at other times.)
- geometry suitable for the expected operating speeds.

Figure 3: "Road Worker" Warning Sign

Source: United Kingdom, Her Majesty's Stationery Office. 2008. *Traffic Signs Manual.* Sydney (Chapter 4: Warning Signs).

65. Be aware that sidetracks can be costly to construct. This is one reason why planning for the road works should be undertaken very early in the tendering stage so sufficient budget can be allocated to allow a correct and safe job. No one wants to build a sidetrack that ends up causing a fatality.

66. A detour involves using parts of the existing road network adjacent to the road work area. Detours are often a low-cost option but may not be easily established in rural areas (where there are fewer roads) and they may not be well received by local residents in urban areas who have to tolerate much higher traffic volumes in their local streets for the duration of the works.

Closure of the road for short periods while work is carried out

67. Full road closures of a road or highway for the full duration of most road projects usually require a traffic diversion to be created. Contemplate full closure of the road for short periods (a few minutes at a time) if work methods require, if the through traffic will not be adversely affected by the delay, and if it is possible to reopen the road without prolonged operation. In making this decision, have a good idea of the traffic volumes and the likely queue lengths that will form. Placing large dynamic information signs that pre-alert motorists to the possibility of such delays is always advisable. It gives them a chance to seek an alternate route.

68. A full closure of very low volume roads for the duration of the works (allowing local vehicle access only) may be an option if the work can be safely carried out in such conditions.

Consider when the work will take place

69. Road works are more easily seen and understood by motorists during daytime. From a road safety perspective, it is desirable for the works to take place in daylight. However, traffic volumes and other matters may come into consideration. For example, some road works on busy roads may be restricted by the highway authority to take place only between agreed times. If a worksite is on a heavily congested road in an urban area, the client may stipulate that the works can only take place outside the peak hour periods. In some cases, this may lead to significant amounts of work at night or on weekends. In rural areas, where traffic volumes are lower but speeds may be higher, there is merit in daytime work unless other factors markedly influence the decision. If

the works are to take place during the hours of darkness, an additional array of safety devices (such as temporary lighting for the work zone, dynamic signs, more reflective bollards and/or cones, and more traffic controllers) may likely need to be factored into the TMP.

Step 5: Decide the risk control measures

70. Having considered all risks, decide on the risk control measures to apply and begin to develop a TMP. In making this decision, it is useful to consult those working on the worksite or supervising the works. They often have useful practical inputs to help design a TMP. The generic TMPs in Chapter VIII of this manual can serve as a useful starting point.

Step 6: Design a TMP, and have it approved by the highway authority

71. Site-specific points of detail for a TMP may include:

- arrangement of traffic control devices for each stage of the works;
- arrangement and number of traffic controllers required for each stage of the works;
- any site-specific requirements such as access to a nearby school or hospital, or access to shops;
- provision for very large vehicles;
- provision of safe passage for pedestrians, bicyclists, and people with disabilities;
- impacts on public transport;
- potential for traffic to queue into conflict areas (such as across an adjacent railway crossing);
- provision for access to abutting properties;
- duration and times for conducting the works (such as day or night operation);
- traffic management arrangements at the worksite outside normal working hours or when workers are not present at the site ("after-hours' care");
- emergency contact details; and
- communication arrangements.

72. Each TMP should include details of the requirement to manage traffic through the worksite outside normal working hours (that is, when workers are not present at the site). This will include removing (or covering) any signs not applicable outside normal working hours, particularly temporary worksite speed limits.

Road work signs should comply with national standards for color, shape, and symbols. The six-zone approach puts signs to effective use in positions where their message is most needed.

Good delineation is essential at road worksites, but it must be forgiving and reflective. Concrete blocks inside painted barrels are hazards.

III. Designing a Traffic Management Plan

A. Traffic management plans

A traffic management plan (TMP) shows clearly all the signs, barriers, barricades, and other devices to be installed and maintained at a worksite for the duration of the works. If work has several stages, there should be a TMP developed for each stage expected to last longer than 1 week.

73. It is a requirement in all contracts for road projects on CAREC roads and highways that a TMP (or a series of TMPs) will be prepared and submitted to the road agency for approval before any work may commence. A contractor is expected to prepare most of these TMPs. If the contractor does not have suitably experienced staff for this task, another group (such as a design institute) can be commissioned.

74. All TMPs shall be prepared by a person who is suitably experienced and competent in traffic management with regard to the risk rating of the site, the nature and complexity of the works, and the type of TMP required. Consultation with workers who have experience in working on trafficked worksites is very beneficial in ensuring a practical TMP is prepared.

75. The contractor shall designate a member of staff (usually an engineer or technician) to be the safety officer for the worksite. The safety officer is the responsible individual for road safety at the worksite, and is responsible for the preparation of the TMP(s) for the site, either in-office or via an external group such as a design institute. The safety officer is also responsible for obtaining approval of the TMP(s) from the road agency, implementing it, checking it twice daily (at least) while it is in operation, changing it over if and when a new work stage begins, and finally removing it when the work is completed.

76. A TMP will be prepared for all road works, both short- and long-term. For short-term works (stationary or mobile), a TMP should be prepared and submitted for approval to the road agency (the project engineer) before commencing the work. In many cases, the TMP may be generic, and the safety officer may make use of one of the diagrams in Chapter VIII of this manual.

77. For long-term works (when the TMP is required to operate both day and night, and may be left unattended at times), a TMP should be specifically designed for approval by the road agency. Again, a diagram from Chapter VIII may be used, but there will be need for a second TMP that shows clearly the "after care" signs and delineation for the worksite. In other words, there is need for a TMP for when work is happening, and a second TMP for when workers leave the site and nothing is happening ("after care").

B. The six-zone concept

78. A TMP for a road worksite comprises six individual but interrelated zones. The "six-zone concept" (Figure 4) is a method of breaking down a worksite into separate zones according to the purpose each zone serves. If beginning to consider these six zones, the design of the TMP and the safety needs of the worksite become much clearer and easier to develop. The six zones are:

(i) **Early warning zone** is the first section of a road worksite in which signs are placed to alert approaching drivers and riders of the presence of road works ahead. Specifically, this zone alerts drivers of the advance warning zone ahead and its reduced speed limit. The early warning zone helps compliance by giving early warning of the reduced speed limit ahead.

(ii) **Advance warning zone** alerts drivers and riders of the work zone ahead. It uses advance warning signs and regulatory signs to warn users of the work zone ahead, and to regulate their behavior.

(iii) **Taper zone** is used if motorists are required to move from their lane to pass around a work zone. A taper zone is the one zone of the six that may not be needed. It is only used where drivers and riders are required to change lanes to pass the work zone. Taper zones use conspicuous and forgiving devices to guide road users past or around the work zone.

(iv) **Safety buffer zone** is a longitudinal safety buffer immediately in advance of, and beside, the work area. At CAREC worksites, it is to be at least 20 meters (m) in length and kept free of equipment, materials, and workers. It can be extended if the work area is hidden from approaching road users by a curve or crest. This zone includes a narrow lateral zone beside the work area (1.5 m wide) to provide additional protection for workers.

(v) **Work zone** is the area in which the works are physically carried out, and is set aside for workers, equipment, and materials. It may be a small area (replacement of a small pit cover on a road), or it may be quite large (constructing a new climbing lane over a length of more than a kilometer on a national highway). In some work zones, there may be disturbance to the pavement; in others, there may be excavations; in others, it may involve pavement works and patching, or it may involve curb and channel work. The location of the work zone and its proximity to the traffic lanes will dictate if a taper zone is required.

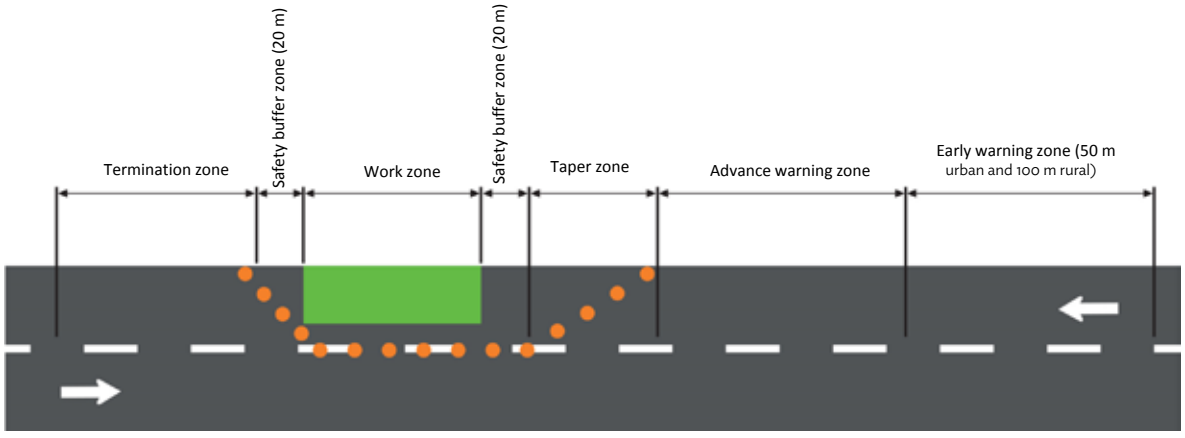
(vi) **Termination zone** is the zone where traffic resumes normal operation after passing the work zone. This is the last of the six zones that drivers and riders pass through. It informs drivers and/or riders that they are now past the work zone, and it informs them of the speed limit that applies on the road ahead. Signs may be used to thank them for driving carefully through the works, and to remind them to drive safely.

C. Early warning zone

79. The function of the early warning zone is to give an early warning to drivers and/or riders of a road worksite ahead. Drivers and riders must be able to see the warning signs, understand there will be changed conditions ahead, and know what is expected of them to prepare for these changes. The early warning zone raises awareness of the road works before the motorists are legally required to reduce speed, and (possibly) take other actions.

80. For uniformity, the early warning zones used at road works on CAREC highways shall be 50 m long (in urban areas including small towns and villages, and other places where the operating speed of traffic is 60 km/h or less), and 100 m long (in rural areas, and places where the normal operating speed of the traffic is above 60 km/h) (Table 2).

Figure 4: The Six-Zone Concept



m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Table 2: Early Warning Zone Lengths

Speed Zone	Length of Early Warning Zone
Up to 60 km/h	50 m
Above 60 km/h	100 m

km/h = kilometer per hour, m = meter.
Source: Asian Development Bank.

81. The signs are always the same for the early warning zone. If multimessage signs are used (Figure 5), the top signs are a symbolic "Road Worker" sign and a "Road Work Ahead" sign. The lower sign is "Prepare to Stop."

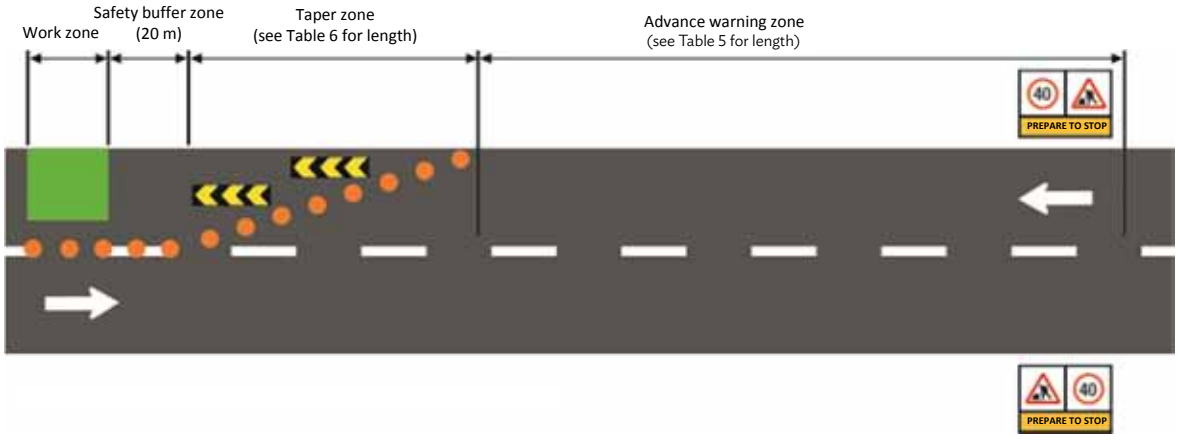
Figure 5: A Commonly Used Multimessage Sign for an Early Warning Zone

Source: AUSTRALIAN STANDARD AS 1742.3-2009. *Manual of uniform traffic control devices – Part 3: traffic control devices for works on roads.* (Modified for European sign conventions).

D. Advance warning zone

82. The function of the advance warning zone (Figure 6) is to give advance warning to drivers and riders of a road worksite ahead. Drivers and riders must be able to see the warning signs, understand the conditions ahead, and know what is expected of them. The advance warning zone is the point at which a reduced speed restriction is introduced to restrict motorists to a lower speed limit (typically 40 km/h) through the remaining zones.

Figure 6: Typical Advance Warning Zone



m = meter.
Note: The traffic management plan is for one direction of travel only.
Source: Asian Development Bank.

83. Advance warning of road worksites creates an expectation of changed traffic arrangements so drivers and riders can modify their driving or riding and look for appropriate guidance. The advance warning signs should be obvious, and the layout of the worksite management scheme should be clear and definite, allowing only one course of action from the driver and/or rider.

84. Reduced road work speed limits shall be used at all CAREC road works where workers are on the road or within 1.5 m of moving traffic. A 40 km/h speed limit shall be consistently applied at all works on CAREC highways while works are underway and workers are on the road or within 1.5 m of the traffic (Table 3).

Table 3: Speed Limits at CAREC Road Works Where Workers are on the Road or within 1.5 Meters of Moving Traffic

Speed Limit	Safety Buffer Zone	Road Work Speed Limit
Up to and including 80 km/h	Not applicable	40k m/h
Above 80 km/h	60k m/h	40 km/h

km/h = kilometer per hour.

Source: Government of Australia. 2010. Road Management Act 2004: Code of Practice: Management of Road and Utility Infrastructure in Road Reserves. *Government Gazette.* August.

85. Where workers are not working on the road and are more than 1.5 m from moving traffic, there is no need for a buffer zone, and a 60 km/h speed zone shall be consistently applied at all worksites on CAREC highways (Table 4).

Table 4: Speed Limits at CAREC Road Works Where Workers are not Working on the Road nor within 1.5 Meters of Moving Traffic

Speed Limit	Safety Buffer Zone	Road Work Speed Limit
Up to and including 80 km/h	Not applicable	60 km/h
Above 80 km/h	Not applicable	60 km/h

km/h = kilometer per hour.

Source: Government of Australia. 2010. Road Management Act 2004: Code of Practice: Management of Road and Utility Infrastructure in Road Reserves. *Government Gazette.* August.

86. The length of the advance warning zone needs to reflect the operating speed of the road so drivers receive adequate notice before they are required to take any action, including speed reduction. All speed reduction associated with a worksite is implemented within the advance warning zone.

87. One of the common failings in the CAREC region is to place warning signs only a few meters in advance of the work zone. This is inadequate and unsafe. The advance warning zone must be sufficiently long that drivers and/or riders are given adequate time to recognize the worksite and slow down.

88. The distance needed to reduce speed to the safe speed required through the work zone is critical for determining the length of the advance warning zone. Table 5 gives the minimum lengths of the advance warning zone to be used at CAREC worksites. The length is a function of the estimated approach speed of the traffic and desired speed in the work zone.

89. Forty km/h is to be the normal road work speed limit at CAREC road works. However, if traffic signals or traffic controllers are used to control traffic, and some traffic will be required to come to a stop, the advance warning zone must be longer.

90. Be alert to possible safety problems occurring in the advance warning zone under conditions of heavy traffic or with lengthy delays. In such conditions, long queues may form. Depending on the approach speed of traffic and the sight distance to the end of a queue, this may increase rear-end crash risk. Use additional pairs of advance warning signs, approximately half way along the advance warning zone, to reduce such risks.

91. If a site requires a taper zone, remember that the length of the advance warning zone is measured outward from the beginning of the taper zone.

E. Taper zone

92. The taper zone (Figure 7) is the length of road where drivers are directed out of their normal path of travel (if necessary). Many road works require a lane of traffic from one direction to be diverted around a work zone. Other road works require two lanes of traffic to

Table 5: Minimum Length of Advance Warning Zones

	Length of Advance Warning Zone (m)	
	Desired Speed at the End of the Advance Warning Zone	
Approach Speed (km/h)	**40 km/h**	**0 km/h (STOP)**
50	30	75
60	60	100
70	120	160
80	170	225
90	200	295
100	250	370

km/h = kilometer per hour.

Source: Asian Development Bank.

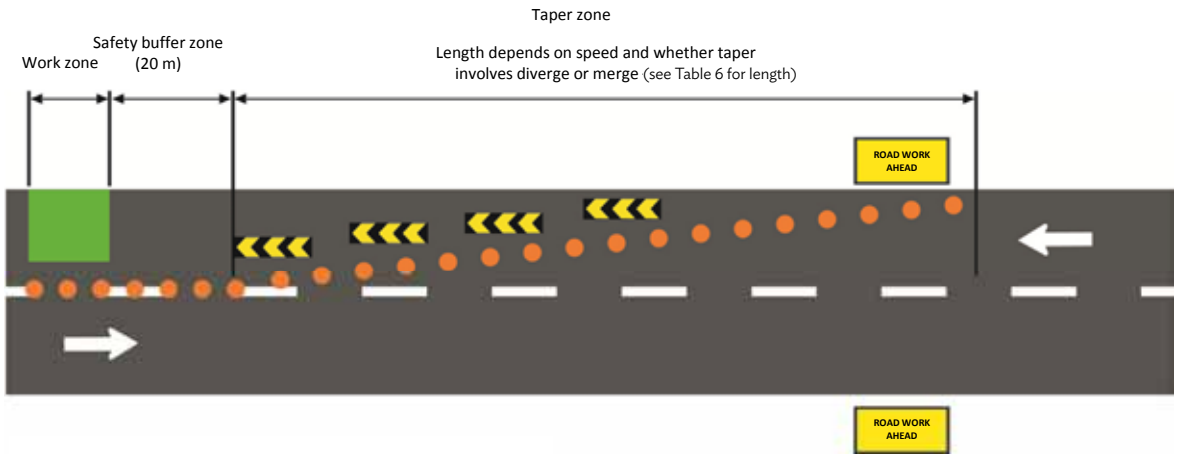
merge into one before passing the work zone. All such locations require a taper zone.

93. There are two common types of tapers:

- A diverge taper shifts a line of traffic sideways, but does not need to merge with another line of traffic traveling in the same direction.
- A merge taper shifts a lane of traffic sideways where the traffic must merge with another line of traffic traveling in the same direction. A merge taper requires a longer distance because drivers and/or riders are required to combine from two lanes of traffic into one lane of traffic.

94. The amount of taper to be provided depends on the width of the roadway that traffic is being diverted across. The taper length needed to move motorists into their new travel path is provided fully within this zone. Desirably, the full length of the taper should be visible to motorists at its beginning. This is to permit drivers to see and understand their route ahead.

Figure 7: Taper Zone



m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Table 6: Recommended Lengths of Taper (Transition) Zones

Approach Speed Entering the Taper Zone (km/h)	**Diverge Taper** (m)	**Merge Taper** (m)
40	50	90
50	50	100
60	60	120
70	70	140
80	80	160
90	90	180
100	100	200

km/h = kilometer per hour, m =meter.

Note: Speeds entering the taper zone from the advance warning zone should always be around 40 km/h or less. However, if they cannot be restricted to this speed, the taper zone needs to be longer.

The taper zone length is based on:
- width of lane to be closed is typically 3.5 m,
- diverge taper length is equivalent to 1.0 m lateral shift,
- merge taper length equivalent to 0.5 m lateral shift, and
- use the operating speed of traffic to guide the taper length.

Source: Asian Development Bank.

95. The length of a taper zone depends on the speed of traffic as well as the lateral distance through which the traffic is to be diverted. Table 6 gives taper zone lengths for CAREC highways.

96. The single exception to Table 6 is when a traffic controller is used, a 30 m taper may be adopted as the traffic will be approaching at a much slower speed. Drivers will be preparing to (possibly) stop.

Traffic cones and bollards are best placed 5 meters apart in a taper.

97. For safety, the only devices used to create tapers should be bright, conspicuous, reflective, and forgiving. These include plastic cones, bollards, plastic delineators, and traffic cones. They are very conspicuous, highly visible and, if struck, they are forgiving and do not cause injury or damage.

Devices used to delineate traffic paths are to be highly visible, reflective, and forgiving if struck. Plastic bollards, 1,200 millimeters high are an excellent form of delineator. They have a heavy base to keep the bollard vertical under most weather conditions.

F. Safety buffer zone

98. The safety buffer zone is a 20 m length of road immediately before and after the work zone kept clear of workers, vehicles, plants, stockpiled materials, or any other activity. The safety buffer zone also includes a 1.5 m wide lateral buffer between the work area and the nearest traffic lane (for a 40 km/h posted speed limit). If the speed limit or the operating speeds are higher than this, a safety barrier shall be placed between the work area and the traffic to provide physical protection for workers in the work zone.

99. Safety buffer zones are the final measure available to minimize the risk of an errant vehicle colliding with workers in the work zone.

G. Work zone

100. This is the area on or beside the road where the work is done. It is where workers are located and where most of the machinery is likely to be. It may be small and contained, or it may extend for several kilometers. Its size depends on the project at hand.

101. Vehicle speeds must be controlled through or past the work zone. This is a key action to reduce the risk a vehicle will inadvertently enter the work area.

The work zone is where the road work is undertaken. It may be a few meters in length or it may extend for several kilometers during highway rehabilitation works.

Personal protective equipment suitable for the climate is essential for all road workers, and must be worn at all times while working on the road.

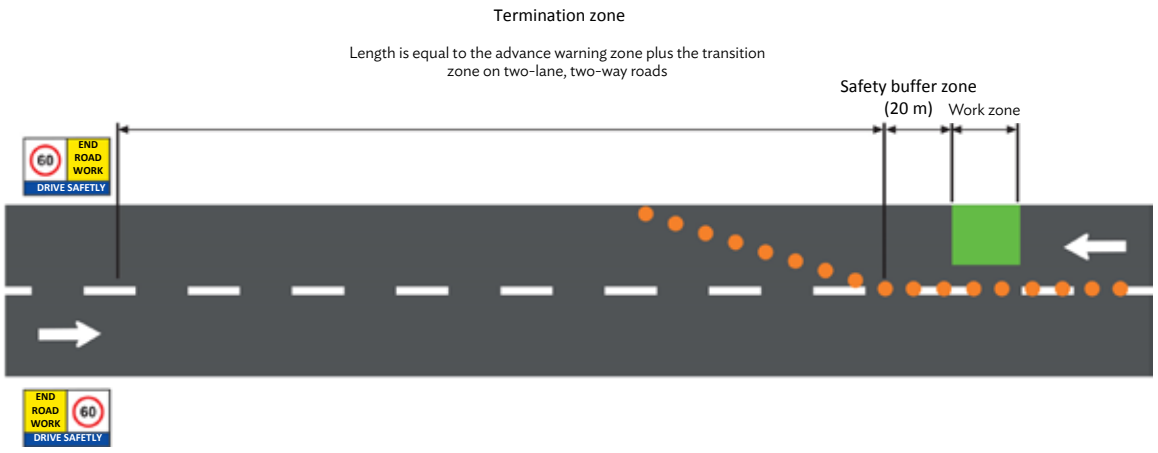
H. Termination zone

102. It is important to advise drivers and riders when they have passed the end of the work zone and have come to the end of the worksite. It is also important to guide and control them back onto their normal driving and/or riding conditions and route. The termination zone (Figure 8) is where traffic resumes normal operation after passing the work zone. If traffic has been diverted (via tapers and maybe a side track) past the work zone, they will be diverted back to their correct travel path within the termination zone.

103. When designing a TMP, create a termination zone that is neither too long (drivers and/or riders will ignore it) or too short (they will not be far enough beyond the work zone for suitable traffic control and safety). As a rule, use a 50 m termination zone in urban areas and where speeds are 60 km/h or less. In higher-speed environments or rural areas, use a 100 m long termination zone. One way to remember these is that they are the same as the lengths for an early warning zone in these conditions.

104. Keep in mind, when designing a TMP, that the termination zone for one direction usually ends at the same point the advance warning zone starts for the other direction. This gives the opportunity to place signs on the back of the signs for the other direction. The use of slide-in signs in a multimessage sign frame is well suited in such cases. The signs can be used to give a clear and accurate message to both directions of travel. Typical signs used in the termination zone

Figure 8: Typical Termination Zone



m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

include "End Road Work," "End Detour," and "End Road Work Speed Limit" signs as applicable.

105. After this point, normal traffic conditions resume. The road work speed zone should end at the end of the termination zone. A pair of speed restriction signs should be placed here to inform drivers and/or riders of their ability to return to normal highway speed beyond that point.

I. Approval of a traffic management plan

106 A TMP will show all the zones to use at the worksite. This will be six zones unless a taper zone is not needed, in which case the number of zones drops to five. It will show clearly all the signs and devices to install at the worksite, as well as the locations for each. If work has several stages, all stages that last longer than 1 week are to have their own TMP.

107. A TMP shall be sent to the highway authority for approval at least 10 working days before work commences. Highway authority approval is required as a check that all safety risks were considered, and risk control measures are considered reasonable for the site. Approval is also needed because regulatory changes will be proposed to the posted speed limit (in particular, a required 40 km/h speed restriction through the site), and these require government agency approval to be legally enforceable.

108. Work at the site shall not commence until the highway authority gives written approval of the TMP. If necessary, the contractor's safety officer and a representative of the highway authority shall meet to discuss and resolve any issues that may be delaying approval.

109. Once written approval of the TMP is granted, the safety officer makes arrangements to set up the site.

J. Auditing a traffic management plan

110. To ensure that a TMP is adequate and is implemented correctly, the highway authority (via the project manager) shall commission an audit of the TMP on two occasions.

111. First, an independent road safety audit team conducts a desktop (or "before") audit of the TMP. Then, once the TMP is implemented, the same team conducts a second site (or "after") audit. This audit involves inspections of the site both in daytime and at nighttime.

112. Road safety audits look at the traffic management arrangement from the road users' point of view. The audit team members put themselves in "the shoes of road users" (or "in the driver's seat") and look for safety concerns. Common safety concerns include missing or wrong signs, too-short tapers, and hazardous items. Assessment of signs and devices for both day and night is critical for the total safe operation of the traffic management scheme.

113. A road safety audit should also be carried out whenever the road works advance from one stage to the next, or whenever there are major changes to the TMP. An experienced audit team will consider road safety concerns such as:

- The volume and approach speed of the traffic. Higher speeds and higher volumes increase risk at a site.
- Approach sight distances. Is there a risk of "surprises"?
- Can all the signs be seen, and do they comply with the 6Cs of good signage (Chapter VII. A)?
- Are there any conflicting signs or markings, especially permanent signs (such as speed restrictions) that conflict with temporary road work signs? Remove these or fully cover them.
- Is the intended travel path clear for all drivers and/or riders?
- Are the taper lengths too short, possibly because of horizontal or vertical geometry on site?
- Is the travel path delineated with forgiving materials?
- Are lane widths adequate?
- Have all roadside hazards been removed or shielded with suitable safety barrier?
- If safety barrier is needed, is it correctly installed? Does it have safe terminals and secure connections between units?
- Have workers been trained in worksite safety, and are they all wearing their personal protective equipment (such as high-visibility vests)?
- Is there an escape path for traffic controllers, and workers?
- Have pedestrian paths been considered through and around the site?
- Will construction entry and exit points be safe for work vehicles, and unlikely to be used by the public?

114. In urban areas especially (but also in some rural areas), check to ensure appropriate signs and devices have been installed on all nearby roads (including side roads) that will be impacted by the road work.

115. All the safety concerns detected in either audit are to be resolved between the project manager and the safety officer. Only after all safety issues are resolved from a "before" audit will highway authority approval be given for the TMP. Only when all safety issues are resolved from an "after" audit can work continue on the site. The project manager is empowered to stop the works if any safety concern is not addressed quickly and professionally.

These are large signs, but there are too many in one place, making it difficult for drivers to take in all the information. They should be advance warning signs, but these are placed after the road closure.

These regulatory signs are too close to the work zone. The concrete barriers are not secured together, and are roadside hazards.

IV. Implementing a Traffic Management Plan

A. Implementing a traffic management plan

116. Before road work commences, all the signs and devices shall be set out in accordance with the approved TMP. This setting out is done in the following sequence:

- Start with signs with the greatest distance away from the work zone; work inward toward the work zone.
- Determine the distance from the work zone to the early warning zone from Tables 2, 5, and 6.
- Place the early warning zone signs (the furthest signs from the work zone) first.
- Follow these with the warning and regulatory signs that commence the advance warning zone.
- Then install the signs in advance of the taper zone or (if there is no need for a taper zone) near the start of the safety buffer zone.
- Place all delineating devices required for the taper zone (if used) such as plastic cones, reflective bollards, and merge arrows.
- Ensure that a 20 m safety buffer zone is retained before and after, and 1.5 m beside the work zone
- Add all the delineation required for the work.
- Place the termination zone signs at the end of the worksite. These include the end of the 40 km/h road work speed limit.
- Add any other required warning and regulatory signs.

117. A useful "safe work method" is to have all the signs and cones and other items placed initially along the footpath (or the shoulder if no footpath) at their correct distance from the work zone. Only when placed at the correct spacing, and checked they are the correct signs for the zone in question, should they be moved, quickly and efficiently, onto the road. This process helps to set out the signs and devices away from the traffic, while allowing time to make adjustments and corrections as necessary. It then allows the setting out of devices correctly and efficiently on the road, causing minimum disturbance to road users at that time.

118. After a TMP is implemented, arrange for a road safety audit to be undertaken by an independent audit team to ensure it is installed and operating as expected. This audit should take place before (or very soon after) the road work commences on site. If changes are found necessary, these should be made straight away.

119. If some signs are erected before they are required for their intended use, these should be covered by a suitable material (a plastic sheet or a bag). Make sure it is tightly fixed to the sign so that it cannot loosen in inclement weather. The covers are removed just prior to the commencement of the activity specific to that sign.

120. Removing or retrieving the signs and devices at the conclusion of the work should be done in the reverse order using the same work method as for setting out.

B. Positioning the signs and devices

121. All the signs and devices used at the worksite should be positioned and erected so that:

- They are properly displayed. Signs should be placed at least 1 m off the road or from the nearest open traffic lane, if a lane is closed.
- They comply with national sign standards, and are reflective if they are to be used at night. A height of between 0.8 m and 1.5 m above the ground is acceptable.
- They are within the line of sight of the approaching road users.
- They are not (and cannot be) obscured from driver's view by vegetation or parked vehicles.
- They do not obscure other devices from the line of sight of approaching road users.
- They do not become a potential hazard to workers, pedestrians, or vehicles.
- They do not direct traffic into an unsafe path.
- They do not restrict sight distance for drivers and/or riders entering from side roads or private driveways.

122. The conspicuousness of the signs can be affected by many things: by shade, the direction of the sunlight, background conditions (including lighting), and oncoming headlights from other vehicles. These factors are just some that need to be considered when signs and devices are erected at the worksite.

123. On curved alignments, signs should be placed approximately at right angles to the line of sight of a motorist when the motorist is about 50 m in advance of the sign. It is desirable on curves approaching a road worksite to duplicate the signs, placing one on each side of the road.

C. Inspect the site immediately after the traffic management plan is set up

124. At the worksite, when all the signs and devices have been installed along the road, one further inspection is needed to ensure the intended message is properly conveyed to road users. This inspection should be carried out within a very short time of setting out the TMP, and before the road work starts. The inspection should be undertaken by the safety officer from within the normal traffic stream at normal traffic speed. The safety officer should observe each sign and device to see it is fulfilling its intended use.

125. You should also undertake a nighttime inspection (with headlights dimmed) to ensure the signs and devices are functioning correctly after dark. This shall take place during the first nightfall after the TMP is set out. Similar inspections should be carried out after any major change is made to the TMP(s).

126. Any deficient or confusing signs or devices must be changed and/or improved, or removed and/or replaced immediately. Safety is too important to leave for a day, a week, or longer.

D. Providing for vulnerable road users

127. Where numbers of vulnerable road users (including people with disabilities) move through, past, or around a CAREC worksite, they should be provided with (and directed to) suitably constructed temporary footpaths and crossing points. Pedestrian and bicycle paths should be provided on the same scale and to the same width as any facilities for pedestrian or bicycle traffic that were existing prior to the works.

128. Where footpaths or crossings are temporarily relocated due to the works, the following temporary facilities are recommended:

- The surface of the temporary footpaths and/or crossings should provide conveniently for wheelchairs as well as for the visually impaired.
- Any crossing(s) should be located as near as practicable to the point(s) where the pedestrians naturally wish to cross. Crossings should be to the same standard (width and surface smoothness) as the crossings they replace, including provisions for the visually impaired. Ensure the correct regulatory signs are installed at the crossings for regulatory compliance.
- Anywhere that pedestrian traffic is diverted onto a roadway, separate a pedestrian path from the vehicular traffic lane(s). A line of plastic cones and/or bollards may be used for this, provided traffic speeds are restricted to 40 km/h or less, and sufficient space is available beside the traffic lane(s).
- In a high-speed environment (above 60 km/h), concrete barriers should be used to separate pedestrians from the traffic if pedestrians have been directed onto the road way. The concrete barriers must be securely joined (in accordance with the manufacturer's instructions) to create a strong and continuous barrier.
- In both cases, street lighting should be not less than the level provided on the original footpath or crossing. This may mean the contractor has to plan to retain power to the lights.

V. Operating a Traffic Management Plan

A. Operating a traffic management plan

129. The contractor's team commences the works only after receiving approval for the TMP from the highway authority. This will usually be shortly after any road safety audit findings from the "desktop audit" have been discussed, agreed on, and signed off.

130. Further surveillance inspections are to be conducted twice daily throughout the duration of the road works. Written records (dates, times, findings, and engineers involved) should be made and kept. The daily surveillance should check all the signs and devices on the TMP. If signs are damaged, or if bollards are knocked over, these need to be recorded and rectified as a priority.

131. Road works should not surprise a driver and/or rider. If this will be achieved, road works across the CAREC region will be much safer for all. The key point in road work safety is that under no circumstances should drivers and/or riders be surprised by disruptions to normal traffic conditions due to road works. They must be given proper advance warning of all road works.

B. Check the site for safety twice every day

132. The safety officer is responsible for inspecting the entire worksite twice each day. During each inspection, the safety officer shall look carefully at the following:

- The TMP is still fully and correctly set out in accordance with the approval from the highway authority.
- All signs and devices are in clean operating order.
- All signs are upright and facing approaching drivers.
- Any barriers are correctly joined, with safe end terminals.
- No vehicles, equipment, materials, or other objects are placed in positions that could cause some signs to be hidden, or seen too late.
- The tapers are well-delineated and continue to be of adequate length for the conditions.
- All unnecessary or confusing permanent signs are covered for the duration of the works.
- Vulnerable road users (pedestrians, bicyclists, and animal-drawn vehicles) are able to safely negotiate the worksite.

133. One inspection shall be undertaken before work starts for the day. This inspection allows an opportunity to correct any deficiencies or overnight damage before workers again enter the work zone. A second inspection shall be undertaken later in the day, most likely mid-afternoon. Both inspections are undertaken from a vehicle traveling in the usual traffic stream, and at a speed around the average through the worksite.

134. The safety officer shall keep a written record of each inspection, noting when the inspections were carried out, what safety issues were detected, and what was done to rectify the situation.

C. "After care"

135. Long-term work means the traffic management devices will be in place at night at the road worksite. At some work zones, the work will take place through the night. But at most work zones on CAREC highways, the work will stop at night and will resume the next day. Any period when no work is going on at the site (when workers leave the site) requires management of the site known as "after care." This term applies to the signs and/or delineators and barriers required for safe travel through the worksite "after hours."

136. The following "after care" conditions are recommended for safe operation when leaving an uncompleted worksite:

- Retain all the zones at the site (whether it is five zones or six).
- Remove (or cover) all signs that indicate "Road Workers" or "Traffic Controllers." These workers will not be on-site and signs should not suggest they

are. Remember to establish and maintain credibility with all signs at all times. Motorists must trust and comply with the signs always.

- Consider the speed limit. Is it necessary to retain a 40 km/h limit (the same as when workers are on-site) or can a 60 km/h speed limit be safely introduced after hours? If so, check that the road surface can accommodate this speed.
- Make sure travel conditions for nighttime traffic are considered to ensure it can safely travel through or past the work zone. This could mean sweeping the pavement to be free of sand, gravel, and mud, and/or clearly delineating the path with reflective cones and delineators.
- Whenever possible, any part of the normal roadway closed to traffic during the day should be opened to traffic at night.
- The traveled path for nighttime traffic needs to be of reasonable standard to ensure drivers and/or riders are not caught by surprise by rough or uneven surfaces.
- Temporary traffic lighting through the work zone should be considered, if there is a substantial deviation of the travel path from normal and the approach speeds to the work zone are high.
- Temporary lighting is also desirable, if conditions for pedestrians have changed.
- If single lane operation (two-way traffic using a single lane) is still required at night, careful consideration of its safe operation is essential. If traffic volumes are low (typically less than 50–100 vehicles per hour total both directions), and the length of the single lane operation is quite short (typically less than 50 m) the single lane operation can operate adequately, provided both directions of traffic are alerted to the possibility of traffic from the opposite direction. This is a give way arrangement where a driver and/or rider from one direction gives way to an opposing vehicle before proceeding.
- If traffic volumes are higher than the prescribed level, or if the length of the single lane operation exceeds 50 m, a pair of traffic controllers may be needed, or a set of temporary traffic signals at each end of the narrow section, to adequately and safely control traffic. Instructions for traffic controllers and for portable part-time traffic signals are contained later in this manual.
- In these situations, ensure the correct warning signs (“Traffic Controller Ahead” or “Traffic Signals Ahead”) are installed.

VI. Closing Out

Closing out when the work is finished

137. The "close out" phase occurs after road works have ended. It is the period when traffic management arrangements are removed, and the road returns to its normal (or perhaps very new) operating arrangements. The most critical safety issue to watch during this phase is to make sure to not take away necessary signs and/or delineators too early or in ways that may leave hazards exposed.

138. Removing the signs and devices at the conclusion of the work is best done in the reverse order to the setting out. Therefore, instruct staff to work in the following order:

- Begin by removing the signs closest to the work zone; work outward from the work zone.
- Next, remove the termination zone signs, including "End of Road Works" and end of temporary speed zone signs. If these are in the same multimessage frame (on the reverse side of advance warning signs), retain those advance warning signs for now.
- Then remove any delineation around the work zone and in the termination zone.
- Follow this by removing any delineating devices in the safety buffer zone, followed by the taper zone (if used).
- Remove the signs in advance of the taper zone or at the work zone.
- Finally, remove all remaining signs, including advance warning zone and early warning zone signs.

139. Signs and devices should be removed from a worksite as soon as practicable after the work is finished. However, make sure appropriate signs remain in place until all work (including loose stone removal and line marking) is completed.

140. Do a double check a few hours later to be sure no signs are inadvertently left in place, or no permanent signs are left covered. It is important to return the site to its original or improved condition.

VII. Devices for Use at Road Worksites

A. Signs and devices for road worksites

141. Drivers and riders are expected to comply with the signs and devices at a worksite. To achieve this objective, signs must appear clear and credible to drivers and riders. This means signs should satisfy the 6Cs of good signage (para. 146), and they are displayed only when needed for the work. For example, if work has finished for the day, and all workers have gone home, the "Road Worker" sign should be removed or covered.

142. All efforts should go toward gaining driver and rider compliance with traffic management work. Confusing, dirty, or irrelevant signs and devices should not be visible to motorists as these will lead to disrespect for the good work. Old and damaged signs must be replaced immediately. Ensure only signs that comply with all CAREC regional standards are used at a worksite. Always strive to ensure motorists are given a clear and credible message on how to negotiate a worksite safely. Once a trusting relationship is built with highways' road users, the result is better driver compliance. Better driver compliance equals safer worksites.

143. As the safety officer for a worksite, the task is to:

- warn (warning signs);
- inform (direction and information signs);
- guide (line marking, delineation);
- control (traffic controllers, intersection control, regulatory signs); and
- forgive (clear zones, safety barriers) drivers and/or riders as a routine part of managing safety on the road network.

144. Motorists need suitable warning, appropriate information, clear guidance, suitable traffic control, and (finally) a forgiving environment if they make a mistake. The signs and devices used at road worksites are a vital form of communication to the road user. Without a rational and consistent system of signage at road worksites, the safety of workers and traveling public is compromised. The proper use of signs is necessary to gain the confidence of road users. Signs must be used correctly and consistently so they mean what they say. Road users will quickly learn to respect good signage schemes.

145. All signs and devices used for traffic control at road worksites shall

- Give warning, guidance, and instructions to road users about the road work ahead.
- Advise of the presence of workers and equipment on or near the road ahead.
- Ensure appropriate speed control.
- Advise road users of their correct path.
- Prohibit road user access to the work zone (assisting the safety of workers).
- Advise road users when they reach the end of road works.

146. As a simple guide, ensure the signs used at road worksites satisfy the 6Cs:

- **Conspicuous** – able to be easily seen
- **Clear** – able to be read
- **Comprehensible** – able to be understood.
- **Credible** – relevant to the situation
- **Consistent** – with all other similar situations across the nation
- **Correct** – not just similar, but correct

147. People are more likely to take notice of signs and to obey their message if they see them used appropriately and repeatedly at each worksite. National uniformity in high-quality road works signage is a worthwhile objective.

Sign design and format

148. All road agencies in the CAREC program have nationally agreed standards for their road signs. These cover the formats, fonts, shapes, colors, and sizes for its signs. Officers of the national road agencies are expected to comply with these standards on all road projects.

149. Standards are important for safety as drivers become used to seeing the same shape and colored sign in the same position time after time. They will understand what the sign is used for, and they will react more quickly and more correctly when they see "standard" signs and devices. This has been demonstrated many times over, and is the single most important reason for having "standards." It reduces decision time, and reduces the potential for misunderstanding.

150. Some of the most common signs used at CAREC road worksites are shown in Figure 9. Some countries use a different sign convention. These signs are shown for a general understanding of the need for consistency and high-quality reflectivity.

151. As a general rule, larger signs are used at road works on all CAREC highways and expressways. Smaller signs are typically used on local streets, collector roads, and low-volume rural roads.

Multimessage signs

152. Multimessage signs are a new initiative for use at road works on CAREC highways. They are a useful and low-cost initiative worthy of consideration by national highway authorities and contractors.

153. A multimessage sign is a lightweight metal frame into which a combination of lightweight signs can be slid according to the needs of the worksite (Figure 10). The frames are modular (1,200 millimeter [mm] wide by 900 mm deep), and the signs are either 600 mm x 600 mm or 1,200 mm x 300 mm. The signs may be made of plastic (core flute or similar), metal, or painted sheet timber. The sign face is reflective and should conform to all national requirements (size, reflectivity, shape, word, and symbol). Being lightweight, the signs are easy to carry to the site and easy to change when necessary.

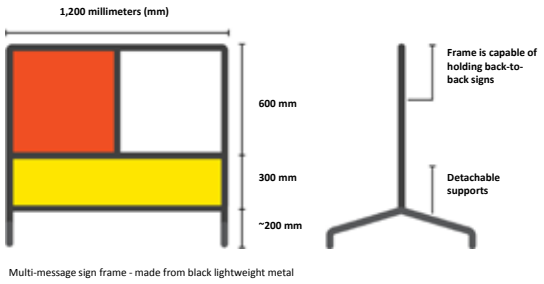
154. Multimessage signs are a good alternative to stand-alone signs. They make road work signage easier and cheaper due to the lightweight compact sign materials. National highway agencies are encouraged to examine the merits and costs of multimessage signs and to introduce them into their works. Multimessage signs are:

- quick and easy to install;
- stable in windy conditions and from the effects of moving traffic;
- suitable for use on all types of road and shoulder surfaces;
- easily handled, transported, and stored; and
- a low-risk hazard to road users, if struck.

Figure 9: Some Typical Road Work Signs Used in CAREC Countries

Source: 1968 United Nations Economic and Social Council Convention on Road Signs and Signals, commonly known as the Vienna Convention on Road Signs and Signals.

Figure 10: Modular Multimessage Frame



Source: Asian Development Bank.

Messages can be changed quickly to accurately reflect the type of works underway at the time. Regulatory signs must conform to national road rules so they can be enforced.

There are many variations of messages that may be used in a multimessage frame. Some jurisdictions encourage the use of small flags on top of the first signs to make them more conspicuous.

Simple frames can be constructed to carry the multimessage signs to and from the worksite in a small truck or van.

155. Workers will find the lightness of the multimessage signs to be a real bonus. They will be able to place these signs, and relocate them as necessary, much more easily than with the heavier conventional signs.

General guidelines

156. Multimessage signs used at worksites shall meet the following requirements:

- Individual message plates shall comply with the requirements for the same stand-alone sign.
- All sections of the frame shall be filled. A blank yellow plate should be used, if necessary, in any unused sections of the frame.
- When used, regulatory speed limit sign plates should be placed in the top position of the multimessage frame on the side closest to the traffic.
- If the assembly does not include a speed limit sign plate, the 1,200 mm x 300 mm panel may be placed at either the top or bottom of the assembly. The most important message is always at the top of the sign.

- Signs and devices that are bent, broken, or which have substantial surface damage are not to be used at road worksites on CAREC highways.
- Signs and devices are to be free from mud, dirt, road grime, or other contamination. Wash them as necessary, and keep them clean.
- Fluorescent signs that have become color-faded to a point where they have lost their daylight impact are to be replaced.
- Signs that are needed to be effective at night should be checked for retroreflectivity. Those with degraded retroreflectivity (either from long use or surface damage) are to be replaced. Nighttime effectiveness is best checked by viewing the signs under vehicle headlights in the dark.

What if road work signs are stolen?

157. The theft of signs from road worksites is a reported problem at some CAREC highway projects. This may be so, or it may simply be an excuse from the contractor for not placing the correct signs in the first place. Regardless of the reason, correct road signs are essential at road worksites, and their theft or damage cannot be accepted. Signs are essential at worksites. Peoples' lives are put at risk without the correct signs.

158. As a works supervisor or as the safety officer in charge of road safety at a worksite, consider the following:

- Take down all unnecessary signs that are not needed at night (if there is no work proceeding).
- Use signs that are part of an integrated system such as the "core flute" system (for multimessage signs) or a system where signs are welded to a frame. These may be less attractive to thieves as they have little "scrap" value.
- Consider having signs made of inexpensive material such as plastic, core flute, or a composite material. These will also be less attractive to thieves.
- Employ security guards to patrol the worksite day and night to counter theft.
- Report all thefts to the police as soon as possible.
- Have a separate budget for, and be prepared to spend on, replacement signs.
- Keep a stock of the most commonly used signs in the depot for immediate replacement of any missing or damaged signs.

B. Speed zones at road worksites

159. Road worksites are typically locations where unexpected things tend to happen more often than on other parts of the road network. Trucks reverse onto the road, workers move across the road, and dust can obscure visibility. Some drivers may be uncertain where to go, and make last-second changes of direction. Road worksites are, therefore, locations where all the traffic should travel more slowly than elsewhere on the road network.

160. A vehicle traveling at high speed takes much longer to stop than the same vehicle traveling at low speed. High vehicle speeds result in more crashes, and they certainly result in more severe consequences when a crash does happen.

161. Managing speed is an important task for engineers and police in the CAREC program. It takes on added importance at road worksites, where conditions may change often and where workers are sometimes close to traffic.

162. Engineers have one important tool available to them for use in managing speeds: speed restriction zones. These are zones that start and end with speed restriction signs. The speed restriction signs are regulatory devices; they are enforceable by law and any driver or rider who disobeys these signs may be fined. However, this requires traffic police to be present and active in their enforcement. For this reason, engineers and police need to discuss the speed restrictions well before the start of the road works. They must agree on the road work speed limit (40 km/h is the recommended road work speed limit for CAREC highways), and they should have an agreed understanding about an enforcement strategy.

163. Signs must be correctly used and placed to give the police something legally binding to enforce. Then, with consistent police enforcement, drivers and riders quickly learn speeding will not be tolerated at the worksite.

164. If the speed restriction signs are not legally enforceable, the police cannot carry out their enforcement. If the police do not enforce the speed limit, any signs you use will be treated with contempt by some drivers and/or riders. Perhaps no other simple working arrangement more clearly demonstrates

the need for close cooperation among government agencies in the battle to reduce road trauma.

165. Cooperation and coordination among agencies is the secret to reducing crashes in the long term. Compliance with road work speed limits at present in most parts of the CAREC program is poor, but is getting better. More drivers are beginning to recognize the need to travel more slowly through or past work zones. No one wants to hit, kill, or seriously injure a road worker.

166. A reduced road work speed limit should be used at all road worksites that affect traffic flow. They are an essential tool at those worksites where other methods (such as a detour or a sidetrack) are needed, but cannot be made to fit or work.

167. On the other hand, simply installing a reduced speed limit should not be an excuse to mask poor road worksite traffic management practices. The road work speed limit should "glue together" all the good advanced signage and other delineation necessary at the worksite. It is not a solitary treatment.

168. After the traffic has passed the worksite, advise drivers and riders the road work speed limit has ended. Give them the appropriate speed restriction sign that allows them to return to their normal operating speed.

Factors to consider in setting a road work speed limit

169. When determining the speed limit to be adopted through a road worksite, the issues to consider include:

- Clearance between the traffic lanes and the work area. If this is less than 3 m, without barrier, use a 40 km/h speed zone.
- Traffic volume and vehicle composition (in particular the number of trucks and buses).
- Type of work (manual, heavy machinery, trenching).
- Duration of work (long term, short term, mobile).
- Time of work (night works, daytime only).

170. For simplicity, and as a general rule, all CAREC road work projects shall have a 40 km/h speed restriction, unless traffic is more than 3 m from the work zone and is traveling at 60 km/h or less.

C. Safety barriers

171. A safety barrier system for use in a work zone is designed to provide a physical barrier between the traveled way and the work area. If a safety barrier is used at the worksite, it must be designed and installed to inhibit penetration by an out-of-control vehicle. It must also redirect the impacting vehicle. A correctly installed safety barrier provides protection for road workers from passing traffic.

172. Safety barriers come in several shapes and are made from a variety of materials, usually concrete, metal, or water-filled plastic. Highway authorities are urged to use only approved barriers, and to use these in accordance with the manufacturer's instructions. New barrier systems are regularly developed; keeping up-to-date with changing and improving barrier options can be a challenge. Always keep in touch with the manufacturers about their new products. Use only those products that have been tested to current European, United States, or international standards. Safety barriers are devices to improve safety in road work zones. Improper use of these will be a hazard for road users, and may fail to protect the road workers if and when needed.

173. For short-term works and for road works with little effect on the routing of the traffic, the use of safety barriers is unlikely to be practicable or necessary. In such cases, other control measures (such as speed reduction, warning signs, traffic cones, and maybe vehicle-mounted attenuators) should be considered.

174. For long-term works, safety barriers may be required where any of the following occur:

- There is inadequate safe clearance between workers (or plant and equipment) and moving traffic. A 3 m minimum clearance should be adopted.
- There is potential for traffic conflicts (such as head-on collisions) between opposing streams of traffic.
- The works place moving traffic closer to hazardous objects or deep excavations. If the new path places traffic within the clear zone for the highway, barrier is needed.
- There is inadequate safe clearance between (temporary) footpaths or bicycle paths and moving traffic.

175. In fact, overseas experience indicates safety barrier protection should be considered wherever practicable for worksites adjacent to moving traffic.

Shape and strength requirements

176. Any safety barrier used at a road worksite should satisfy one of the leading international testing standards. Therefore, ensure any safety barrier used at a site is of a type certified and tested in accordance with procedures specified in acceptable international standards.

177. The design of a safety barrier system for a worksite should include an analysis of the appropriate performance test level required for the road worksite. Also be sure the selected safety barrier is crash-tested to the required performance level for the worksite. In particular, ask the manufacturers about the following characteristics:

- performance test level of the safety barrier, and
- maximum deflection of the barrier at test level loading.

178. Barriers that deflect excessively have little value at road worksites. If safety barriers are to be used at a road worksite, take into consideration:

- the type, shape, protection, performance, and test characteristics of the safety barrier (as stated by the manufacturer);
- the speed of traffic traveling through the worksite;
- the clearance between the traffic and work area;
- terminal treatments and protection;
- minimum length of safety barrier;
- connection details of individual units to ensure that when joined together, they act correctly; and
- base or footing requirements and whether they need horizontal support or "anchoring" into the existing pavement.

(Note: The small individual concrete barricades common on roads and highways through Central Asia are unsafe roadside hazards. Their value as delineators is outweighed by their dangers as solid roadside hazards. Therefore, they must not be used at worksites on CAREC highways. They are not recognized safety barriers, and they present a high risk to road users.)

Moving safety barriers

179. One of the worksite activities that has additional risk is moving safety barriers into place. Barriers are heavy, and cranes are often needed to lift them into place. There is a risk a crane could be struck while doing this. There is also a risk a section of barrier could be struck before it is fully installed. This "interim" period is a time of considerable risk at a road worksite. For safety during this activity, there are several general principles to be followed:

- The work should be carried out during daylight hours (wherever possible).
- Have all the six zones set up and operating at the worksite.
- Ensure the appropriate speed limit in place at a worksite (usually 40 km/h).
- Carefully consider the direction of erection (and removal) of the safety barriers. Generally, start at the end facing oncoming traffic, ensuring a safe terminal or crash attenuator is installed first (and removed last).
- Consider using a shadow vehicle in advance of the barrier installation. The shadow vehicle will need a vehicle-mounted impact attenuator, if the worksite is on a highway with high speeds and/or high traffic volumes.
- Always comply with the manufacturer's specifications for moving or lifting safety barriers.

Debris and sight screens

180. Where safety barriers are used on high-speed roads, debris protection screens may be used to protect workers from debris falling from passing vehicles. These screens are usually attached to the top of the barrier, and are high enough to entrap most likely objects that might drop from passing vehicles. These screens also have the added advantage of protecting motorists and motorcyclists from work-related activities (such as flying stones or mud).

181. Where safety barriers are used on heavily trafficked roads (generally volumes higher than 20,000 vehicles per day), consider erecting sight restriction screens. These screens "hide" activities from road users to avoid creating a distraction. They are generally made from a flexible mesh fabric or shade cloth placed over a debris protection screen.

182. When considering erecting such screens, think of the following:

- the effect of a screen on the stopping sight distance along the road (especially roads with small radius curves);
- the stability of a screen (and safety barrier) under all conditions at the worksite (such as wind load, including passing vehicle wind load);
- the effect of the height of a screen on the stability of the safety barrier;
- crash testing evidence or engineering analysis to show the screen is acceptable;
- the need for emergency access (such as in the form of an access gate or door in the screen); and
- the effect of the screen on the sight distance of drivers of construction vehicles when entering the highway from the worksite.

D. Portable traffic signals

183. Traffic signals are a form of traffic control that may be considered for use at a CAREC road worksite where traffic from opposing directions is required to share a single lane. In these situations, the safety officer usually has a choice of using:

- a give way sign at one end of the single lane operation,
- two traffic controllers, and
- traffic signals.

184. The first option is only suitable for low-volume roads (under 100 vehicles per hour) and for short lengths (up to 50 m).

185. Traffic controllers are suitable for higher traffic volumes and over greater lengths. However, traffic controllers need to have breaks, and it is less common to engage them overnight to control traffic. When traffic volumes are substantial, and the length of the one-way section of road is much longer, the use of portable traffic signals may be the best option.

186. Portable traffic signals are flexible signals useful in temporary situations. They are usually mounted on small trailers. They can be moved into position quickly, and started with minimum effort. They are usually powered by solar energy, but alternatives such as diesel generators are available. Portable traffic signals are an expensive but effective form of traffic control that can assist in managing traffic safely at road works.

187. One important point to remember here is that the person(s) operating portable traffic signals do not have authority to direct vehicles to proceed through red signals. It is vital for safety that drivers and riders stop (and remain stopped) at every red signal they face on the road network. It undermines the effectiveness of red signals if anyone directs drivers and riders through a red signal.

Operation

Fixed-time shuttle operation

188. Shuttle operation is where a portion of the roadway is closed so a single lane is alternately used by traffic in opposite directions.

189. The setting of the red and green times must be realistic to ensure the safety of drivers and workers at the road worksite, and to ensure motorists are not kept waiting for an "excessive" period against a red signal. As a guide, the distance between the "master" and "slave" units should not be greater than 500 m. The green time is calculated by dividing the length of the single lane operation by the estimated operating speed, with an allowance for "tail enders" to pass through. The closing amber signal display should be limited to no more than 5 seconds.

Signals for works vehicle crossings

190. When signals are used to allow works vehicles to cross a road, manual activation of the signals should be applied. Also instruct workers to select "natural" gaps, wherever possible, in the main road traffic, rather than forcing gaps when a large platoon is approaching.

Flashing amber

191. The equipment must be able to automatically switch all phases to "flashing amber" when any hazardous or incompatible conditions occur in its operation. This is the "fail safe" requirement. But flashing amber should not be used as a regular mode of operating traffic signals, even under light traffic conditions. It has been shown in many evaluations to lead to increased conflicts and reduced safely.

Signal "Not In Use"

192. When traffic signals at road worksites are not in use, the signal heads should be lowered or turned away from approaching traffic to avoid distracting drivers and/or riders who may expect the signals to illuminate. If the mast is not lowered, the faces of inoperative lanterns are to be covered with metal or opaque plastic "Not In Use" plate or similar. Alternatively, ensure they are covered by an opaque material tied around the lantern face.

Use of traffic signals "Out of Hours"

193. Mostly, portable traffic signals are used during road work times only. It is not so common to leave them operating on auto overnight. If there is a situation where portable traffic signals are installed for "Out of Hours" operation in auto mode, ensure a contact person is available to ensure a quick response if a fault is reported.

General layout

194. Approaches to portable traffic signals must be single lane. On multilane roads, a reduction to one lane must be completed a distance of 150 m in advance of the portable traffic signals. Lane reductions must not take place any closer than this as it can lead to congestion (and possible incidents) close to the signals as multiple lanes try to merge into a single lane.

195. Traffic signal units must not be located on the travel path. They must never be used as a barrier to slow traffic. The signal unit should be between 1 m and 2 m from the edge of the traveled path with the beam aligned at approaching vehicles about 200 m before the signals. The lights must be in the vertical position to ensure maximum beam intensity.

196. Take care there is no background interference from other lights of the same color, such as advertising signs. Similarly, lighting in advance of traffic signals can reduce the effectiveness of the signals. Make sure to inspect the location at night before deciding where to place the portable signals.

Approach speeds

197. It is necessary to control vehicle speeds approaching portable traffic signals. Portable traffic signals should not be used in speed zones exceeding 60 km/h. As a general rule, the 85th percentile speed of approaching traffic should be no more than 60 km/h as it approaches the signals. Approach speeds can be reduced through the use of regulatory speed restriction signs and consistent police enforcement.

Sight and stopping distance

198. Traffic signals rely on drivers seeing them, understanding them, and acting on them. It is, therefore, critical to locate the portable signals in a location that makes them highly conspicuous, and gives approaching drivers and/or riders maximum visibility of the lanterns. This then gives them sufficient time to stop on a red signal. The minimum sight distance to the signal lantern required for stopping depends on a number of factors, mainly vehicle type and approach speed. Site conditions such as pavement surface also affect the required stopping sight distance.

199. It is desirable that drivers can see the signals for a minimum period of 10 seconds when approaching them. This equates to a minimum sight distance required of 150 m (at about 60 km/h).

200. Where the sight distance of 150 m cannot be achieved, possibly because of a horizontal curve, or equipment and works, consider locating a duplicate portable traffic signal on the other side of the road.

Signs to use with portable signals

201. A "Traffic Signals Ahead" warning sign shall be installed on the approach to any portable traffic signals on a CAREC highway. It shall be placed in the multimessage sign frame as part of the advance warning zone signage.

202. It may be necessary to repeat the "Traffic Signals Ahead" signs where the traffic signals cannot be seen or where traffic queues back beyond the signs. To draw attention to these signs, flashing yellow lamps may be used, especially for nighttime operation.

203. In addition, a "Stop Here on Red Signal" sign shall be used in conjunction with the portable traffic signals to indicate where traffic must stop, even if a stop line is provided. This sign is typically installed approximately 5 m in advance of the portable traffic signals.

E. Electronic variable message signs

204. An electronic variable message sign (VMS) is a traffic control device that can be programmed to display a message to road users. The message, which may include a number of rotating screen messages, should provide only essential information. Typical messages refer to construction works, maintenance, road incidents, traffic congestion, or roadway conditions for approaching motorists.

205. An electronic VMS can be either:

- Mobile VMS. A mobile VMS is usually trailer-mounted or vehicle-mounted, and can be quickly moved into location as required. A mobile VMS allows information to be given at the point of maximum impact. Because of their portability, they are ideally suited for use at road worksites.
- Fixed VMS. These are erected above or beside high-speed, high-volume multilane highways for traffic control purposes. Although these are mainly used for traffic control and to alert drivers to congestion or collisions ahead, they may also be used to give information and warning for road works ahead.

Where should VMS be used?

206. A VMS may be used to provide added advance warning to road users on high-speed and/or high-volume roads where road works may cause delays, or may demand drivers to stop, slow down, and/or merge. They are effective devices, but they are also expensive. Take care to limit VMS use to worksites with a significant degree of hazard (such as on high-speed or multilane roads, or where the traffic arrangements are complex). In addition to being quite expensive, studies show excessive use of VMSs may reduce their effectiveness.

207. Examples of road worksite applications where a VMS can be effective include:

- providing advance warning on expressways and high-speed roads where workers are exposed to traffic;
- notifying of current delays and future work activities on expressways and other high-speed, high-volume roads;
- in advance of temporary traffic conditions including closures, detours, and restrictions on vehicle dimensions; and
- in advance of changes in alignment, surface conditions, roadway width, lane drops, traffic delays, congestion, and a required decrease in traffic speed.

208. A VMS may also be used:

- to provide advance information about work dates, alternative routes, anticipated delays, and other time-related information;
- to advise road users of the reason for reduced speed limits; and
- to encourage speed reduction within the advance warning zone. For this, a VMS can be combined with radar to generate a speed readout. Due to unit response time (and the need for drivers to know which displayed speed refers to which vehicle), they should only be used on roadways with low to moderate traffic volumes.

Limitations on VMS usage

209. A mobile VMS should not replace static signs at a worksite. Even if you need to use a mobile VMS, it is still a requirement to display all the necessary signs that the TMP requires. A VMS is used in addition to the static signs; it is not a replacement for them.

210. Mobile VMSs are still quite novel in the CAREC program. Take care to maximize their value. Use them on high-speed, high-volume roads only.

Message screens on VMS

211. At a minimum, road users need to know what they should do and why they should do it. A VMS can inform them of these. When choosing the text for the message in a VMS, remember that the message should:

- be as brief as possible,
- be quickly and easily understood,
- be unambiguous,
- be accurate and timely, and
- avoid sensational incident information.

212. To ensure a message is readable and understandable on a VMS, and to maximize its road safety impact, it should be kept to a maximum of two screens in all speed zones. This gives enough time for most road users to read and understand the entire message.

213. Limit messages to a maximum of eight words in three lines, with each line centered. This enables road users to quickly read the message without being distracted from the road. Where words need to be abbreviated, they should be clear and unambiguous. Do not use full stops. Do not use unnecessary words and filler words (such as ahead, caution, danger, hazardous, a, an, the).

214. Screens should alternate. The messages should not scroll either horizontally or vertically. Scrolling is more difficult for a driver to read and understand. The task is to convey a message to drivers as simply, quickly, and efficiently as possible. Do not flash the message or cause it to change in any way. It should show consistently to approaching drivers and riders.

215. If a message is displayed on one screen, the top line should refer to the problem, the center line should advise of the location, and the bottom line should indicate the road user action required. Single screen messages should be displayed continuously.

216. Symbols should only be used when the VMS has sufficient clarity for these symbols to be clearly read and understood by drivers.

217. Use of a second language is unlikely unless messages are kept very short and sharp, with the second language on each alternate screen.

Messages on VMS

218. For messages that require two screens, the format in Figure 11 (an example for nighttime works on an expressway) is preferred:

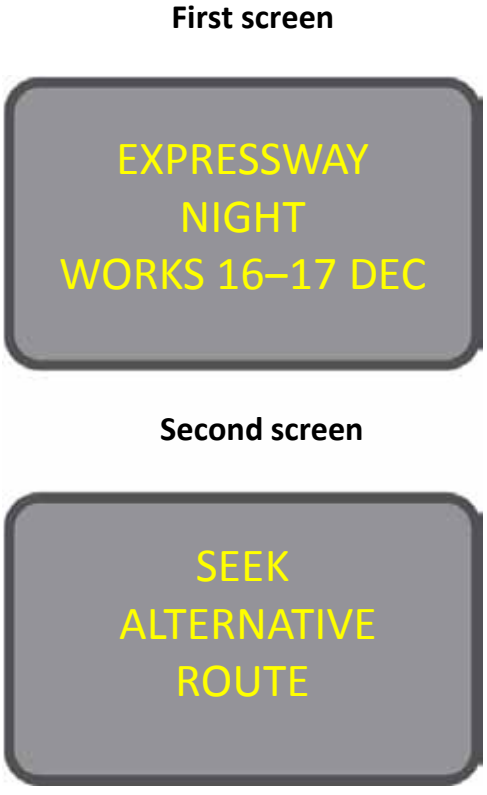
219. The message should update frequently enough for the full message to be read by a driver approaching at typical operating speed. From practical experience, update rates are typically:

- duration of display of each message screen: 1.2–2.0 seconds,
- pause between screens of the same message: 0–0.1 second, and
- pause between the second screen and a repeat of the first screen: 0.2–0.5 second.

220. If the message cannot be condensed to fit on two screens, consider an additional VMS. If so, the second VMS should be located 300 m downstream (approximately 10 seconds of travel time at 100 km/h.) of the first VMS.

221. In these situations, only one VMS should display a double screen message at any given time. This is to reduce the risk some drivers may not be able to read and understand the full message in time. Using two VMSs in this way doubles the cost of providing the information to drivers and riders. Therefore, rethink the entire message, and reduce it to a simpler message. A short and simple message may fit on one VMS.

Figure 11: An Example of a Message over Two Variable Message Sign Screens



First Screen: State the problem and the location, distance and/or date.

Second Screen: State the expected action.

Source: Asian Development Bank.

An example of a trailer-mounted variable message sign located just off the shoulder of a rural highway with a speed limit of 100 kilometers per hour (driving on the left side).

There are two screens. The first one outlines what and where. The second states when.

Placing a VMS

222. When considering the lateral position of a VMS at a worksite, give attention to the following:

- A VMS should be placed on the side of the roadway closest to the affected travel lane, being normally the side of the roadway on which vehicles travel.
- The bottom of the sign should be at least 2.15 m above the ground, if there are any pedestrians in the vicinity. This is to prevent anyone's head striking the underside of the VMS.
- A VMS should not be placed in dips or just beyond crests. Sight lines should be maximized.
- Ensure the VMS is not obstructed from view by vegetation, parked vehicles, or other obstructions.
- On curved alignments, to meet sight distance requirements, the VMS should be located at the start of the curve. If this is not practicable, locate it in such a way as to maximize the sight distance to it.
- As a VMS can be a roadside hazard, always position the mobile VMS safely and, where practicable, behind the barrier.
- For urban roads, the mobile VMS is not to interfere with the safe passage of pedestrians, bicyclists, or other footpath users.
- Where there is a curb, the mobile VMS should be positioned behind it.
- If there is no curb, it should be placed on the verge outside of the shoulder or emergency lane.
- If placing a mobile VMS behind a curb is not an option, a parking lane can be used to store it. However, take care to ensure it does not encroach into any traffic lanes. The parking lane should also be properly closed off to through traffic.
- A vehicle-mounted VMS may be used for slowly moving and mobile operations. With these, there should be adequate shoulder width along the road to permit the vehicle-mounted mobile VMS to be approximately 1 kilometer behind the operation. Judgment is needed to ensure the mobile VMS is not so far from the worksite that its effect is diminished.
- The VMS should be clearly visible and legible from all traffic lanes, and it should remain legible until the driver and/or rider is within 30 m of the sign.
- Elevating the VMS increases the visibility of the sign to oncoming traffic so it can be viewed from behind other vehicles.

F. Vehicle-mounted attenuators

223. One significant danger when trucks and equipment are stationary on a high-speed, high-volume road (even for a few minutes) is that an approaching vehicle may strike any of the stationary items at high speed from the rear. Such crashes tend to be very severe. They often lead to fatalities in the impacting vehicle, and they can lead to casualties among workers, if they push the first vehicle into the work zone.

224. One of the best pieces of equipment that can be used for such situations is a truck- (or trailer-) mounted attenuator (TMA). A TMA is a "crash cushion located on the back of a truck or on a trailer." TMAs provide physical protection for workers at road worksites where the provision of safety barriers

or road closures is not practicable. Because of their high cost, they are typically used on high-speed, high-volume roads such as expressways and CAREC highways (often in urban areas). They are particularly good and efficient for use in shielding short-term and mobile road work situations.

225. If using a TMA in a TMP, place it at the beginning of the safety buffer zone (the zone to be kept clear of workers, equipment, and materials). This means the TMA will be at least 20 m in advance of workers or equipment it will be shielding. This allows for the TMA to move forward into the safety buffer zone should it be struck from behind. Under no circumstances should workers or equipment enter the safety buffer zone between the TMA and the work zone.

226. TMAs can also be used to provide temporary protection in emergencies, or when erecting or dismantling traffic control devices and barriers at long-term worksites.

227. TMAs used on CAREC highways must be crash-tested to an agreed national test level, and are to be installed and operated strictly in accordance with the manufacturer's specifications.

G. Personal protective clothing and equipment

228. Road work can be a tough, dirty, and demanding task. There is often dust (or mud), noise, fumes, and heat. Heat, wind, rain, ice, fog, and snow can add to the difficulties of such work. Under such conditions, authorities cannot and should not rely on the vigilance of drivers to protect their road workers.

229. Road workers do have a responsibility to look out for moving traffic. However, in the hectic situation of a work area, the dangers of working near traffic can easily be forgotten, maybe only for a few seconds. High-visibility clothing and safety vests increase worksite safety and road worker visibility.

230. It is, therefore, important that all workers be given full personal protective equipment appropriate to local conditions. They must wear this protective equipment all of the time on site because they never know when they may inadvertently step into danger. All road workers on or adjacent to a CAREC road worksite shall wear high-visibility clothing at all times while working.

Workers and traffic controllers must be provided with personal protective equipment suited to the climatic conditions. It should include a high-visibility jacket or vest, which offers high-visibility for daytime and good reflectivity for nighttime conditions.

Truck-mounted attenuators provide physical protection for workers at road worksites, where the provision of safety barriers or road closures is not practicable.

231. The most suitable vests and coats are usually fluorescent red or orange in color. They should have at

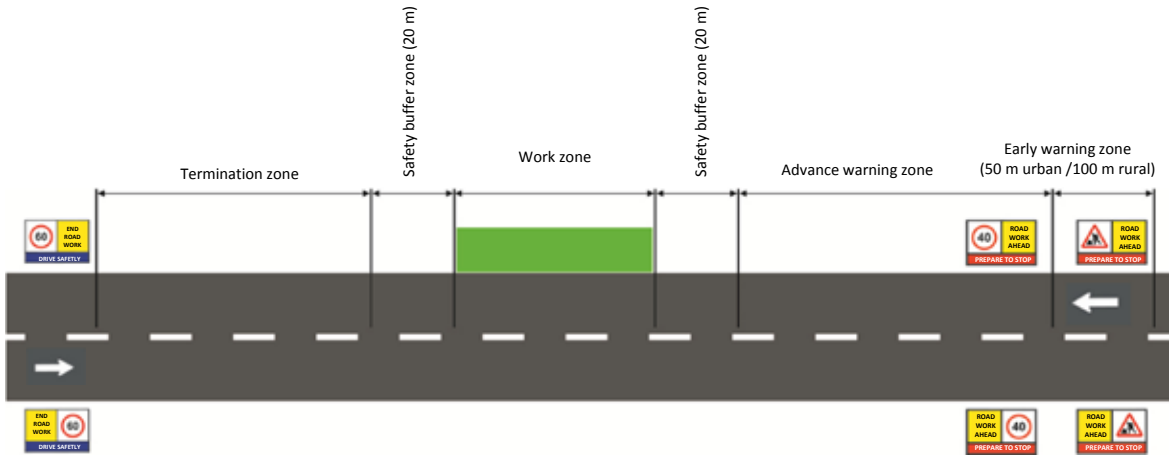
least two strips of yellow retroreflective material front and back. This maximizes visibility of workers both day and night. The vest or coat should be properly fastened so the entire available area of high-visibility material can be seen in any direction. To maximize effectiveness, the vest or coat should be kept clean and in good condition.

232. Remember that it is an obligation of the employer to provide good-quality personal protective equipment for every road worker appropriate to the climate. It is also a requirement that each worker wears the safety clothing at all times while working on or near a road.

VIII. Standard Layouts for Traffic Management Plans

233. Figures 12-21 present standard (or generic) TMPs suitable for use at worksites on CAREC highways, subject to the other conditions detailed in this manual. Where risks have been assessed and the hierarchy of controls has been considered, the following arrangement of zones may be suitable for application at a worksite.

Figure 12: Works along the Shoulder or beside the Road

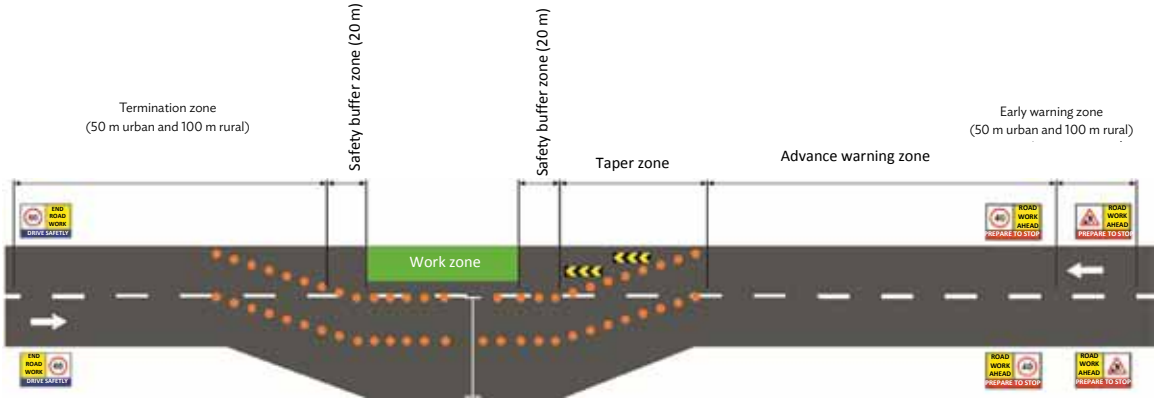


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 13: A Reduction in the Available Road Width but with Sufficient Width for Two-Way Traffic

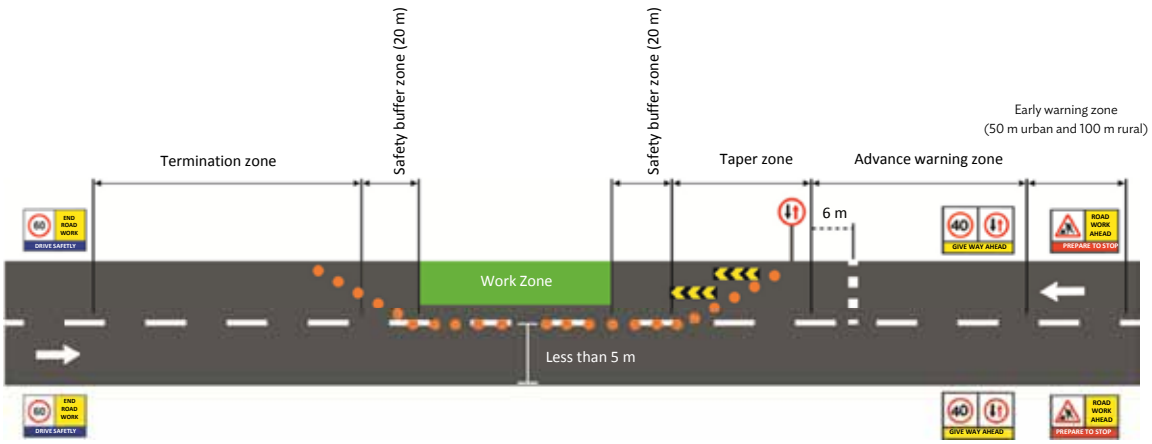


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 14: Works on a Two-Way Highway Requiring Closure of One Lane with Priority to One Direction

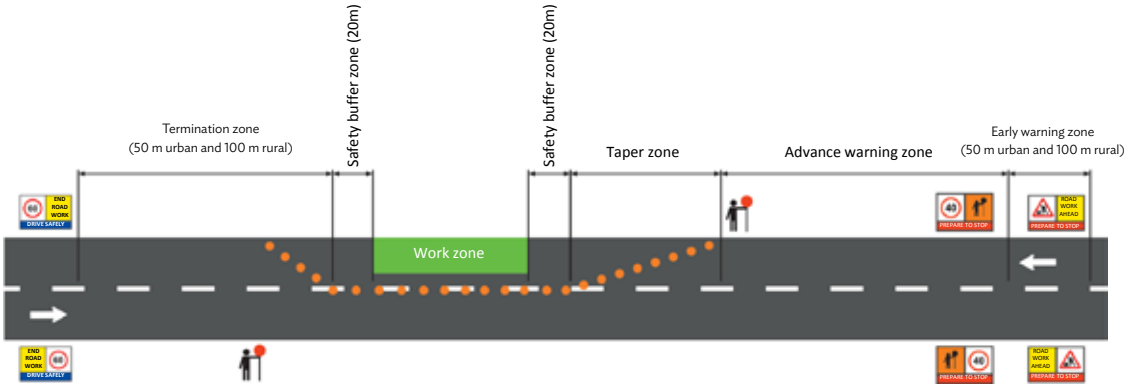


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 15: Works on a Two-Way Highway Requiring Closure of One Lane with Traffic Controllers Controlling Remaining Single Lane

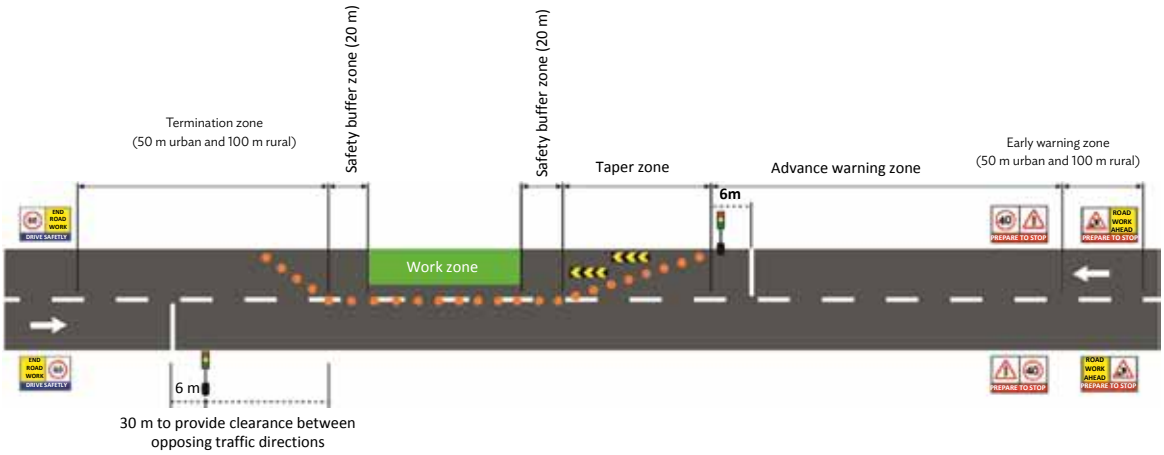


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 16: Works on a Two-Way Highway Requiring Closure of One Lane with Temporary Traffic Signal Control

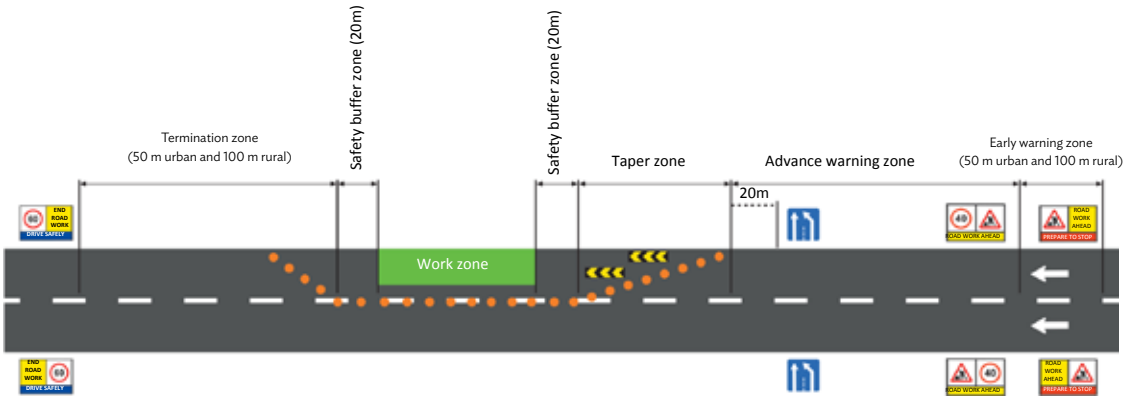


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 17: Closure of the Right-Hand Lane of a Multilane Carriageway

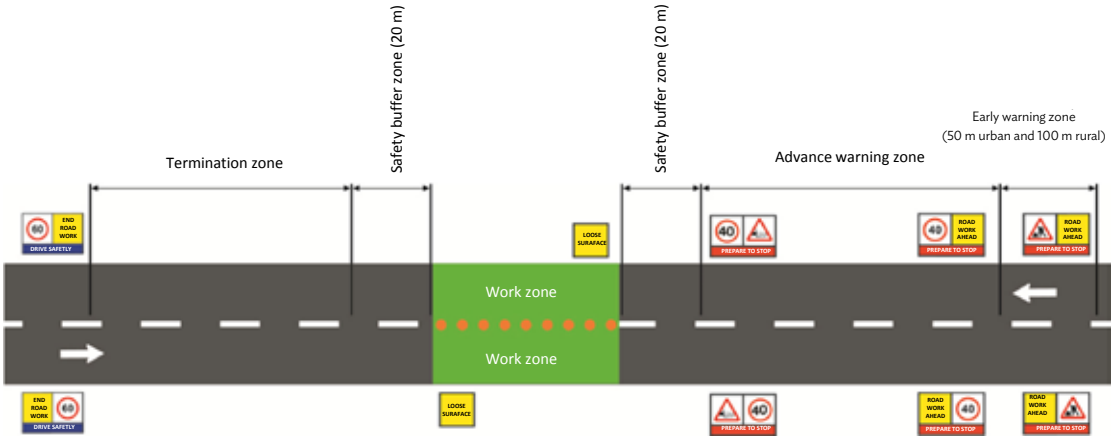


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 18: Road Works Extending across a Road

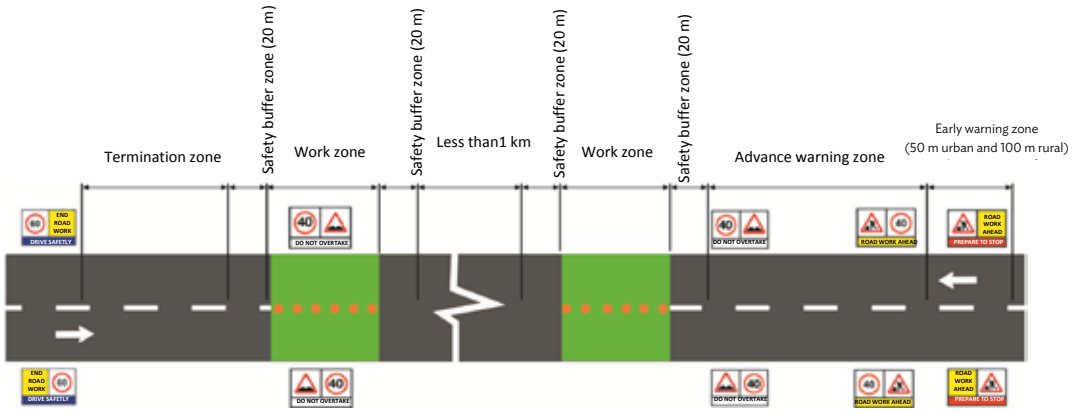


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 19: Closely Spaced Works across the Road Less Than 1 Kilometer Apart in a Long Worksite

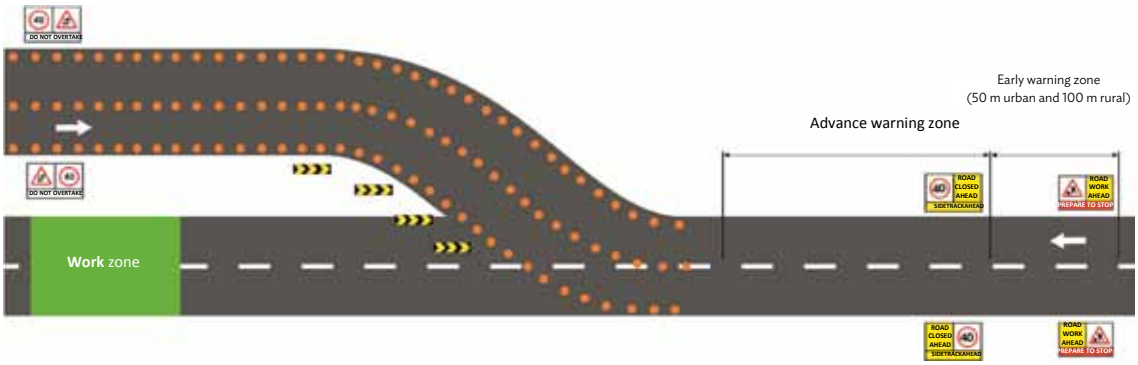


km = kilometer, m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 20: Two-Way Side Track due to a Full Road Closure

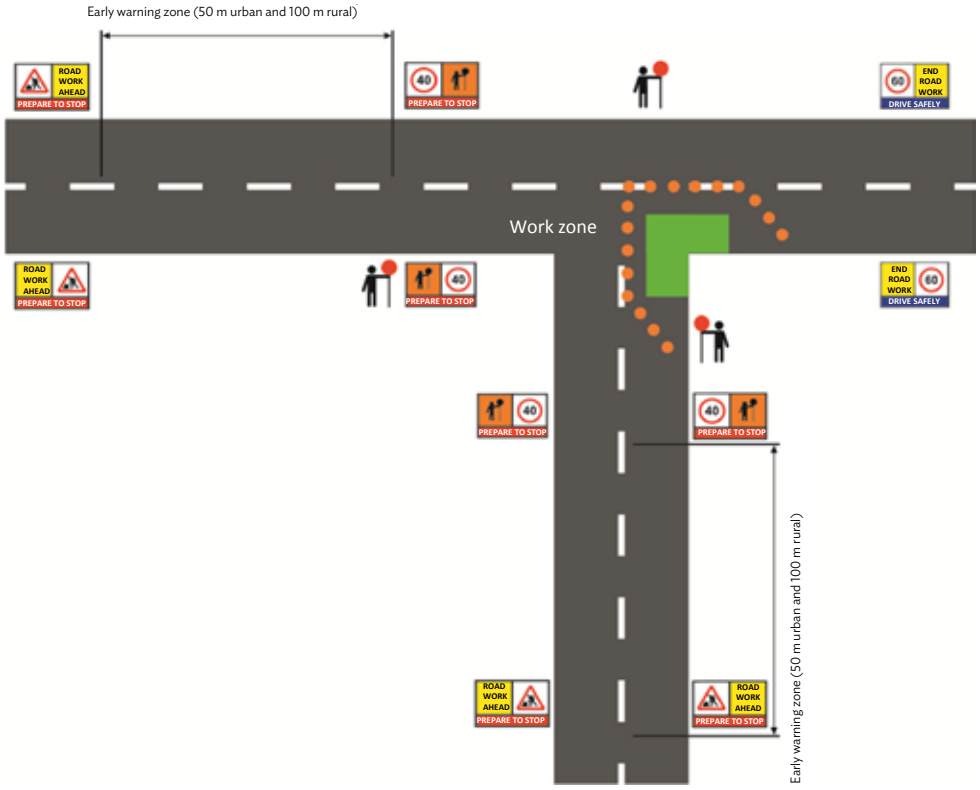


m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

Figure 21: Road Work within an Intersection



m = meter.

Note: The traffic management plan is for one direction of travel only.

Source: Asian Development Bank.

IX. Helpful Tips for Safety Officers

234. The safety officer for any road worksite has an important role for ensuring safety. The safety officer is responsible for ensuring the safety of road workers and road users at the site. To achieve the safest possible worksite, it is recommended that safety officers keep the following essential points in mind when they work:

- All worksites on CAREC highways shall have consistent 40 km/h speed limits.
- Use the figures in this manual to help with general TMPs.
- Pace out the required distances starting from the work zone. Walk toward the approaching traffic.
- The safety buffer zone is the first zone set out. It is 20 m long on each side of the work zone, and 1.5 m wide beside it.
- Use Tables 5 and 6 in this manual for advance warning zone and taper zone lengths.
- Pace out the taper zone length next (if needed).
- Then pace out the length for the advance warning zone.
- Add on the early warning zone. This is a consistent 50 m long (in urban areas and where speeds are 60 km/h or less) or 100 m (in rural areas or where speeds are more than 60km/h).
- These early warning signs shall advise drivers of "Road Work Ahead," a symbolic "Road Worker" sign, and a "Prepare to Stop" sign.
- Set up the signs and bollards along the side of the road first (on the footpath, if there is one), to ensure the spacing is correct. Do not face them toward traffic just yet. Wait until it is certain all locations where the signs will be placed are suitable. Be sure the signs will be conspicuous to approaching drivers from those locations. When fully satisfied, quickly move them into place on the road (or the shoulder) depending on the nature of the road a worksite is taking place on.
- The typical spacing between traffic cones (or bollards) at a worksite is 5 m.
- Symbolic "Road Worker" signs must be shown if workers are on-site. They must be removed or covered when workers leave the site.
- Symbolic "Traffic Controller" and "Prepare to Stop" signs are to be used together if a traffic controller will be controlling traffic.
- As safety officer, make sure to inspect the worksite twice every day: morning and late afternoon or evening. Repair or replace any missing or damaged signs, bollards, or devices.
- Record details of all and/or any crashes in a worksite. Learn from these and keep asking if safety improvements can be made.

X. Instructions for Traffic Controllers

235. Traffic controllers have an important role to play in road safety at road works. They provide a warning to drivers and riders of the road work ahead, and they give positive and clear guidance about where the road user is to go and when they may go.

236. Traffic controllers should be outfitted in high-visibility clothing (suitable for the climate) so they are readily identifiable to approaching drivers and riders. They should be provided with suitable "Stop" and "Slow" batons to provide clear directions to drivers and riders. These batons may or may not be a commonly used device in a country, but they are widely used around the world.

Traffic controllers are trained to control their worksites. They give clear and positive directions to road users.

237. Some road authorities engage flag persons rather than traffic controllers. A flag person usually operates with a small colored flag (or sometimes a battery-operated plastic wand) to attract driver attention. Once noted, it is assumed drivers will understand there is road work somewhere ahead, and they should take care and slow down. Such flags and flashing wands do provide some use in assisting flag persons to attract driver attention; but they do not provide the necessary clear direction and regulatory authority needed for safety at a road worksite.

238. Drivers at road works need to be informed where they are to travel, when, and at what speed. This is especially important on two-lane, two-way highways when one direction of traffic (one lane) is closed for works. It is imperative to reduce the risk of head-on collisions in the remaining lane. While flag persons can offer some assistance, it is traffic controllers who offer the clearest and most flexible form of traffic control for these situations.

239. As a client, ensure the national road rules recognize the use of "Stop/Slow" batons by suitably trained traffic controllers.

240. As a contractor, make sure to engage and train traffic controllers, and provide them with high-visibility clothing and the correct equipment (clean legally compliant "Stop/Slow" baton) to do their job well.

241. As a traffic controller, it is in the best interests to observe the following instructions:

Setting up

(a) Wear the high-visibility clothing provided. A day or night vest, overalls, or jacket are normally provided. These should be fluorescent for daytime visibility and with retroreflective strips for night work.

(b) Use the "Stop/Slow" baton in a positive and clear way, as detailed below. The traffic controller is responsible for traffic control at the site. Act clearly and decisively and command respect from drivers and riders.

(c) The traffic controller is the person on-site responsible for setting up the symbolic "Traffic Controller" sign at the beginning of the shift, and taking it away at the end. If taking over traffic control part way through a shift, check that this sign is in the correct place.

Source: Asian Development Bank.

Traffic controller's positioning

(d) Stand to the side of the traffic lane(s), in a position where both the end of the nearest work area and also the traffic controller at the other end of the job (if there is one) can be seen. If the other traffic controller is not clearly seen (due to distance, a crest or a curve, or because of some other sight restriction), there are two options:

- position a third person in a location where that person can see both traffic controllers, and use that person to direct the controllers in their work, or
- use two-way radios to connect with the other traffic controller.

(e) The traffic controller must also be able to see approaching vehicles at least one and a half times the speed limit in meters away. For example, if the speed limit on the approach is 80 km/h, the traffic controller must be able to see approaching traffic at least 120 m away, and they must be able to see the traffic controller at the same distance.

(f) In particular, the traffic controller should take care to be seen:

- at dawn or dusk;
- in fog, snow, and mist;
- against low sun in the morning or evening on an east or west road; and
- in shadows on a sunny day.

(g) Stand facing the traffic, but just outside the path of vehicles.

(h) Ensure to not obstruct an approaching driver's view of any signs or devices, and also be sure to not be partially hidden by one of these.

(i) Work out what to do if a vehicle is heading toward you and appears not to be stopping. Have an escape path ready.

Controlling traffic

(j) Act decisively. The traffic controller is the person drivers and riders look to for traffic control. They need clear positive information. The traffic controller is also the person fellow workers rely on to safely manage traffic through the work zone.

(k) Give definite and clear signals to drivers:

- To stop a vehicle, turn the baton to "Stop" and, while facing the traffic, raise the other hand into the stop position with palm toward the traffic.
- To slow traffic, show the "Slow" side of the baton, face the traffic, extend the free arm, and wave it up and down (but not above shoulder level) steadily and firmly.
- When traffic on the approach has stopped, change position (if necessary) to be clearly visible to further traffic as it arrives; stay at the head of the traffic queue and stand alone (do not permit people to congregate around).
- Make sure a clear escape path is always available.
- Keep the "Stop" baton in position and hand raised throughout the time the traffic on the approach is to be stopped.
- Remember that the time that vehicles must remain stopped depends (mainly) on two-way traffic volumes and the length of the worksite. Stopped times range from a few seconds up to several minutes. Do not be rushed or hurried into allowing traffic through prematurely. Safety is the number one consideration.
- Before allowing traffic to proceed, wait until all traffic from the other direction has passed and exited the worksite.
- Then, move slightly toward the side of the road, and turn the baton to "Slow." Turn side on to the traffic, and use the other hand to give a "Proceed" signal.
- If controlling a single lane section of road with another traffic controller, each traffic controller is responsible for changing the traffic direction by turns or alternatively if next to stop traffic. This operating rule gives both traffic controllers a degree of safety. It provides for both "Stop" signs (but not two "Slow" signs) to be displayed to traffic simultaneously. This procedure reduces the risk of head-on conflicts in single lane operation.

Glossary of Terms

Advance warning sign. A sign placed in advance of the road works to provide advance warning to approaching traffic.

Advance warning vehicle. A vehicle located in advance (up to 1 kilometer [km] or more) of short term mobile works (such as line marking) to provide advance warning to approaching traffic.

Advance warning zone. The second of (up to) six zones encountered by drivers at a road worksite. It alerts them to the works ahead.

After care. The term used for the traffic management required during occasions when the road work has ceased for a short time (overnight, weekends, or holiday periods).

CAREC highway. One of the designated national and/or international highways under the CAREC program.

Client. The road authority responsible for the road and/or highway.

Consultant. The client's representative for the project.

Contractor. The company contracted to undertake the road work for the client.

Delineation. A general term for the signs and devices used to provide clear definition of the designated traffic path through a road worksite.

Detour. An existing route onto which traffic is directed to bypass a closed work area.

Diversion. A travel path that is not the usual route for traffic, onto which traffic is directed to bypass a closed work area. A diversion may take traffic onto the shoulder, along a temporary road next to the carriageway, onto a sidetrack, or onto a detour.

Early warning sign. The first sign a driver encounters approaching a road worksite. It is placed either 50 m (urban) or 100 m (rural) before the advance warning signs to provide warning of a reduced speed limit ahead to approaching traffic.

Early warning zone. The first of (up to) six zones encountered by drivers at a road worksite. This zone provides early warning of a reduced speed zone ahead in the advance warning zone.

Flag person. A person whose duty is to alert drivers of the works and to encourage them to slow down using a red flag or some other alerting device (such as a plastic wand).

High-speed road. A road where vehicle speeds are typically greater than 60 km per hour.

Lead vehicle. A vehicle used at the head of short-term mobile works (such as line marking works) on two-way roads to give advance warning of the line marking work to traffic approaching from the opposite direction.

Long-term works. Sites where a traffic management plan is required to operate both day and night (that is, for at least 24 hours and usually much longer), and may be left unattended at some times.

Low-speed road. A road where vehicle speeds are typically 60 km per hour or less.

Mobile short-term works. Works that move along a road, either at a constant low speed (such as line marking) or with intermittent stopping (such as patching), and obstruct or partially obstruct traffic lanes.

Multilane. Two or more traffic lanes in one direction.

Road user. Any driver, rider, passenger, or pedestrian using the road.

Roadway. That portion of the road for the use of vehicles, including the shoulders and auxiliary lanes.

Road work. Any work on a road or a roadside with potential to disturb traffic flow and/or safety.

Road worker. Any person engaged in work on a road or the roadside.

Safety barrier. A physical barrier separating a work area from the traveled way, designed to resist penetration by an out-of-control vehicle, and (as far as practicable) to redirect the colliding vehicle back into the traveled path.

Safety buffer zone. The unoccupied space between the taper and work areas. Buffer areas are designed to compensate for driver error and protect workers by allowing errant vehicles to slow down and stop prior to the work area. This area also protects road users from hazards in the work area, such as work vehicles and equipment. The buffer zone is typically 20 meters (m) front and back, and 1.5 m along the side.

Safety officer. the person designated by the contractor for occupational health and safety, as well as road safety at the worksite.

Shadow vehicle. A vehicle which provides protection to the rear of workers who are on the road.

Short-term works. Sites where the work is limited to the duration of a single work shift or less. Short-term works have durations less than 24 hours, and a TMP is required only while work personnel are in attendance.

Sidetrack. A short road constructed to take traffic away from the work zone. It may be a one-way or a two-way road, and is similar to a diversion.

Spotter. A person whose only responsibility is to watch for, and warn workers of, approaching traffic.

Tail vehicle. A vehicle used at the tail (end) of line marking works to provide advance warning of the works to following and/or approaching traffic, to divert traffic around the work area, and to enable the driver to alert workers ahead of any impending danger.

Taper zone. The third of (up to) six zones encountered by drivers. This is the zone in which drivers are (if necessary), redirected out of their normal path of travel and guided into their correct path at a safe speed. It is the one zone not needed at all road worksites.

Termination zone. This is the zone where traffic resumes normal operation after passing the work area. This zone informs drivers and riders of the end of the road worksite.

Traffic. All vehicles (including cars, trucks, buses, bicycles, motorcycles, and animal-drawn vehicles), persons, and animals traveling on the road.

Traffic control devices. The signs, cones, barriers, and other devices placed on or near the road to regulate, warn, or guide road users.

Traffic controller. A person whose duty is to control and direct traffic at a worksite with a Stop/Slow baton.

Traffic management plan. A TMP is a plan that clearly shows all of the signs, barriers, barricades, and other devices to be installed and maintained at the road worksite for the duration of the works. If the work has a number of stages, a TMP is needed for each stage.

Traveled way. The route through, past, or around a work zone.

Two-way roadway. A roadway with lanes allotted for use by traffic in opposing directions without physical separation between them.

Very short-term road works. Works which take no longer than 5 minutes to complete.

Vulnerable road user. A road user group that is considered most vulnerable, due to their relative frailty, in the event of a collision with a motor vehicle. The most common groups of vulnerable road users on CAREC highways are pedestrians, bicyclists, motorcyclists, and animal-drawn vehicles and/or carts.

Work area. The specific area where the work is undertaken, and which is occupied by workers, materials, and plant item and/or equipment.

Worksite. An area which includes the work area and any additional length of road required for advance signing, tapers, sidetracks, or other areas needed for the road works.

Works supervisor. The person nominated by the contractor to supervise the works.

Work vehicle. A vehicle necessary for the road works. In line marking works, a vehicle or plant item immediately preceding the work area and undertaking the work (such as a line marking machine), or supporting workers on foot behind it.

Work zone. The zone (or area) where the work takes place. It can vary from a few meters up to several kilometers in length.

CAREC Road Safety Engineering Manual 2

Safer Road Works

This manual explains how to provide safer road worksites on CAREC roads. It explains good practices for roadwork sites, offering clear and simple guidance for CAREC road authorities to use to improve road safety at these sites for road users and workers alike. It offers information about the six-zone process, how to plan and implement a traffic management plan, and how to manage a safe worksite. This manual is essential reading for project managers, designers, supervision consultants, contractors, works supervisors and others who have a responsibility for safe worksites.

About the Central Asia Regional Economic Cooperation Program

The Central Asia Regional Economic Cooperation (CAREC) Program is a partnership of 11 member countries and development partners working together to promote development through cooperation, leading to accelerated economic growth and poverty reduction. It is guided by the overarching vision of "Good Neighbors, Good Partners, and Good Prospects." CAREC countries include: Afghanistan, Azerbaijan, the People's Republic of China, Georgia, Kazakhstan, the Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan. ADB serves as the CAREC Secretariat.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to a large share of the world's poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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