4.5

IMPROVEMENT OF HAZARDOUS LOCATIONS

Road Safety Guidelines

for the Asian and Pacific Region

Asian Development Bank

IMPROVEMENT OF HAZARDOUS LOCATIONS

The safety benefits that can be derived from identifying hazardous locations through the careful analysis of accident data, studying sites, and then designing appropriate remedial measures have proven to be particularly high. The benefits achieved by low-cost remedial measures can be many times the cost of their implementation.

The effectiveness of this approach can be maximized by a planned program of remedial measures based on accident reduction targets for highway authorities. The authorities will, of course, need to allocate a specific annual safety budget for their plans, or at least ensure adequate funding is set aside within the maintenance budget.

The four main strategies are: single site or black spot programs, mass action plans, route action plans, and area-wide schemes.

The stages of the hazardous location improvement process are as follows:

- a good accident database;
- agreeing a local hazardous location improvement program;
- accident analysis to identify accident black spots;
- design of remedial measures;
- implementing the measures; and
- monitoring the effectiveness of remedial measures.

Remedial measures can include better signs, road markings, pedestrian facilities, fencing, guardrails, junction modifications, and improvements to visibility. Traffic calming through various speed reduction measures has proven particularly effective where vulnerable road users are at risk.

PRIORITY ACTIONS NEEDED

1. All road authorities must establish and train a small team to monitor the operational safety and efficiency of their road network.

2. Identify and improve the most hazardous locations on the major inter-urban road networks according to annual targets.

3. Identify and improve the most hazardous locations on the road networks of each of the major cities and towns according to relevant annual targets, focusing on speed reduction near schools, and in residential and other areas where there are high numbers of pedestrians and cyclists.

Improvement of known hazardous locations is one of the most cost-effective investments that can be made in the transport sector and should be a high priority for every government.

1 INTRODUCTION

These sector guidelines on “Improvement of Hazardous Locations” are from a set of *Guidelines on Road Safety for the Asian and Pacific Region* policymakers, developed as part of a regional technical assistance project (RETA 5620: Regional Initiatives in Road Safety) funded by the Asian Development Bank (ADB).

One of the main responsibilities of all governments is to ensure as safe a living environment for the country’s inhabitants as is realistically possible. There are strong moral and political arguments for this, but of equal concern is the economic importance. Road accident costs can strain the resources of any country, whether developed or developing, and experience shows that one of the most cost-effective ways of using funding in the roads or transport sector is to apply it to the identification of hazardous locations and the design of appropriate remedial measures.

This document contains guidance on accident data analysis, the identification of hazardous locations, determining priorities for action, remedial measures, and the evaluation of results. Examples of countries using simple but effective systems are included.

2 WHY IDENTIFY HAZARDOUS LOCATIONS?

As the number of vehicles increases in a country so does the number of road traffic accidents. In the early stages of motorization, the impact of these accidents in financial terms is small. However, as the number of vehicles reaches a high rate of growth, the cumulative financial impact of accidents becomes much greater, impinging noticeably on the country’s economy. Accidents typically can cost a country up to 2 percent of its gross domestic product. It is possible to alleviate this situation before it becomes too great by establishing a system of accident reduction. This is best achieved by setting a researched, realistic, long-term accident or casualty reduction target for highway authorities, and also by ensuring that appropriate institutional arrangements are in place as well as annual budgets for safety improvements.

Highway authorities should ideally be constantly working towards achieving their own annual accident or casualty reduction target on their network and, with budgets that are inevitably limited, they need to be sure that they are getting maximum value (in terms of accidents saved) for money spent on safety improvements.

On any road network, accidents have been shown not to be completely randomly distributed but to be clustered at certain locations; i.e., hazardous locations or black spots. If the accidents occurring at these locations are studied, it is often found that there are common patterns of, say, driver error to which a particular engineering feature may have contributed. An appropriate road improvement could prevent or ameliorate similar occurrences in the future. By definition, black spots are locations in which many accidents occur and thus, logically, treatment of these sites first should provide the best return in terms of accidents saved.

The application of low-cost engineering at hazardous sites has generally been proven to produce high returns over many years. Simple measures can significantly reduce problems at such sites and can often be shown to pay for themselves in a few months in terms of the monetary value of accidents prevented. For example, the use of road signs and markings to channel traffic through complex intersections, or to provide safe waiting areas for turning vehicles, can often result in a substantial reduction in accidents.

These techniques are always most cost-effective if they are based upon good accident data systems that allow hazardous sites to be located accurately, causal factors to be identified, and appropriate remedial measures designed to address the problems. It is important that governments realize that the most effective use of often scarce transport resources is by applying them to low-cost remedial work at accident black spots.

The techniques described in this *Guidelines* have been used successfully for several decades in the United Kingdom (UK) and other countries, particularly Australia and New Zealand. More recent experience shows that this process is also effective when applied in developing countries, as the accident problems are usually of greater magnitude and the simple low-cost remedial measures have an immediate and fairly easily identified effect.

3 KEY COMPONENTS

3.1 Target Setting

Experience in several developed countries has demonstrated that good progress can be made towards reducing a nation's accident numbers significantly if all highway or roads authorities adopt realistic accident or casualty reduction targets.

These targets, if achievable and treated seriously, tend to focus the minds of engineers in finding appropriate cost-effective solutions regularly and on a wide scale. This does, of course, assume that a reliable road accident database is in place for the highway authority's network (see Sector Guidelines 4.2, "Road Accident Data Systems" for information on setting up a suitable data system).

3.2 Identification

A good accident data system will allow the easy determination of where accidents cluster and will thus allow the preparation of priority lists of hazardous sites needing attention. This is carried out in various ways around the world, typically by ranking sites by actual accident numbers, injury accident numbers or a weighting system to take account of the severity (e.g., a points scale with more points given to higher severity accidents), and perhaps the cost of the accidents. There will, of course, need to be further analysis to determine those accident types that would respond to remedial measures, as not all locations will have easily identifiable patterns that can be improved.

The actual definition of a black spot will depend upon local conditions and should be determined after a preliminary summary of all the worst sites has been carried out. Then a cutoff can be made at the level of perhaps the 50 worst sites.

Thus a black spot in a county in the UK may well have only five injury accidents in three years, while a city in Bangladesh may have black spot defined as having more than 10 injury accidents in a year.

In the definition of "black spot" it is important to use the same time period (usually accidents are expressed per year) and also to be consistent about type of highway unit compared or have a number of different black spot groups (e.g., 200 meter [m] or 1 kilometer length of highway, within 50 m of a junction) such that the highway authority is really identifying the worst accident clustering within road group type.

3.3 Analysis at Hazardous Locations

Many accident databases in the developing world do not record all the information desirable for identifying the real cause of an accident, often because the police collecting the data focus on blame in order to enable prosecution and compensation issues to be resolved. In developing countries, accident data systems will often need to be expanded and modified to include appropriate information necessary for the accident investigating engineer.

There are four basic strategies for accident reduction at hazardous locations. These are, as follows:

1) **single sites or black spot programs:** the treatment of specific types of accidents at a single location, where large numbers of accidents occur;
2) **mass action plans**: the application of a known remedy to locations with a common accident problem;

Figure 1:
Collision diagram.

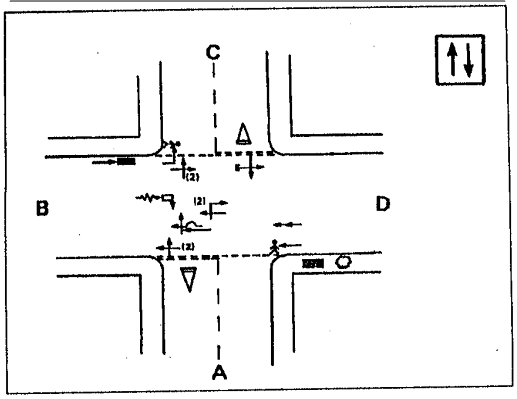
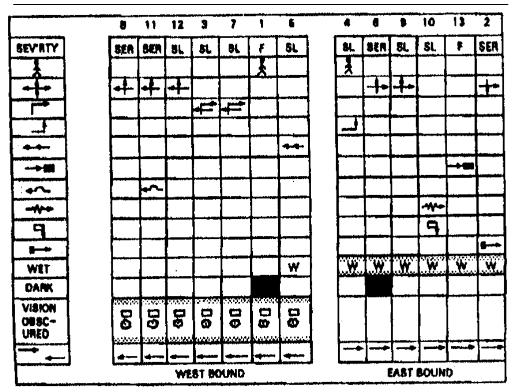


Figure 2 (far right):
Accident factor grid.



3) **route action plans**: the application of known remedies along a route with a high accident rate; and
4) **area-wide schemes** the application of various treatments over an area of usually a town or city.

Most countries, at the earlier stages, commence with single site or black spot programs and then later move onto mass action plans, area-wide schemes and route action plans. Other documents[1,2,3,4] give guidance on the sorts of activity needed or each strategy, so the following section simply outlines the process involved in developing single site improvement programs to illustrate the general approach. Once the accident sites for investigation have been determined, there usually follows a three- stage investigation process, as follows:

1) a preliminary analysis is carried out on the accident data to understand the accident types and conditions. Collision diagrams and accident factor grids (or stick diagrams) are useful tools here (see Figures 1 and 2 for examples);
2) a site investigation is carried out by specialist accident investigators to determine the exact conditions at the location. The investigation will observe traffic flows and road user behavior at the times accidents most frequently occur, determine what other information may be required (such as speed measurements and skid resistance), and start to define the problems associated with the location. Where data are limited, observation of conflicts (either simply by watching traffic informally to see typical maneuvers and conflicts or via formal conflict studies) can provide insights into the problems to be addressed; and
3) a detailed analysis of the accidents occurring at that location is then carried out. This should include simple statistical tests to determine whether the accidents have resulted from a real increase in risk or are a result of random fluctuation.

The information should be presented in a report, which will typically include a collision diagram and an accident factor grid, the accidents having been classified into types and the

Plate 1:
Traffic calming in Tokyo, Japan.

Plate 2:
Town center traffic calming, UK.

dominant causal factors determined. Perhaps the most important part is to recommend remedial measures for the location and justify them on a cost benefit basis. This is done by estimating the cost of the improvements and predicting the accidents that will be prevented to ensure “value for money”.

Once all black spot sites have been investigated, a prioritized list for action over the road network can be established and the implementation process set in motion.

3.4 Design and Implementation of Remedial Measures

The main objective in deciding on remedial measures is to consider solutions that ideally will remove the main accident patterns identified. This can involve one or more of the following:

1) removing the conflict causing the problem;

Table 1: Accident Situations and Remedies

General Accident Situation	Remedial Measures
Skidding	Restoring surface texture
	Resurfacing
	Improve drainage
Collisions with roadside objects	Better delineation
	Guardrails or fencing
	Frangible posts
	Remove objects
Pedestrian/vehicle conflicts	Pedestrian/vehicle segregation
	Pedestrian crossing facilities
	Pedestrian fences or other protection
Loss of control	Bigger or better road signs
	Road markings
	Speed controls
	Safety fencing
	Superelevation
Nighttime accidents	Reflective signs
	Delineation
	Road markings
	Street lighting
Poor visibility	Trim or remove vegetation
	Improved sightlines
	Realignment
Poor driving behavior or lane discipline	Road markings
	Enforcement
	Median barriers
	Overtaking lanes

2) improving the situation (e.g., give earlierwarning) so that road users can cope better; or

3) reducing speeds, thus reducing the chance of the accident happening or its severity.

Table 1 lists typical accident situations along with the proven remedial measures known to have been effective in both developing and industrialized countries.

Often the remedial measures relate in detail to the type and positioning of all the road furniture. This is particularly true in urban areas and at intersections. Further measures that are relevant in city centers include:

1) turn prohibition, channelization, or protected turns;

2) traffic signals, roundabouts, or revised intersection designs;

3) refuges, pedestrian crossings, bridges, or underpasses;

4) segregated bicycle tracks or defined bicycle lanes;

5) parking restrictions or controls;

6) speed limits or enforcement; and

7) traffic calming

The most important part of this whole process is a mechanism that ensures the following:

1) up-to-date data are available to the engineers investigating hazardous locations; and

2) their recommendations are implemented either by a specific budget being set aside or by ensuring that the remedial measures are implemented within existing maintenance or other budgets.

3.5 Traffic Calming

In recent years, speed reduction or traffic calming has developed as almost a separate science to accident remedial work, as it can produce significant environmental improvements as well as accident reduction. Because of this, it has proved to be popular with engineers and residents.

Traffic calming can be defined as the improvement of the traffic situation by reducing traffic speeds and perhaps numbers of vehicles, particularly in residential areas, with emphasis on the safety of pedestrians, cyclists, and vulnerable road users, such as children or the elderly. It has been shown that when pedestrians are hit by vehicles traveling at a given speed:

95 percent survive at speeds up to 32 kilometers per hour (km/h);
55 percent survive at speeds up to 48 km/h;
15 percent survive at speeds up to 65 km/h;

and so the use of traffic calming to ensure low speeds can have a pronounced effect on reducing the severity of injury in accidents.

Traffic calming commonly includes:

1) speed humps;
2) road narrowing;
3) gateway features;
4) footway widening;
5) pedestrian crossing areas;
6) landscaping and environmental features;
7) special warning signs;
8) possible reduced speed limits;
9) miniroundabouts;
10) horizontal carriageway deflection; and
11) priority systems.

Examples of traffic calming schemes are shown in Plates 1, 2, and 3 and much more information on such measures is included in References 2 and 5.

Traffic calming is particularly useful for area-wide schemes and particularly so in residential areas, as illustrated above.

It is also, however, increasingly being used to slow traffic on rural routes in many countries, particularly on the approaches to villages, see Plate 4.

Plate 3:
Rural gateway, UK.

Traffic calming is one way of avoiding the increased road safety problems that can occur when major roads are rehabilitated, often via aid-funded projects. Speed though settlements and villages along the route often increase dramatically and result in increased deaths and injuries. Such gateways on entry to traffic calmed sections of route have been implemented in Fiji (see Plate 3) and are being used in Samoa (see Figure 3).

Not all the traffic calming techniques listed above will be relevant to all countries within the region. What is important, however, is that speed reduction reduces accident occurrence, and countries need to discover what traffic calming methods work best for their particular road users and traffic mix.

3.6 Monitoring and Evaluation

While many of the countermeasures listed above are well-tried remedies that have been used for many years all around the world, it is still important that all treated accident sites are monitored for actual accident reduction and then the true cost and benefit evaluated. It is important to use equivalent before and after periods (ideally two to three years) when making comparisons or evaluations and the construction period should be treated separately. This has at least two beneficial effects: first, it helps determine what remedial measures are most effective and appropriate for local conditions; and second, it is an excellent way of illustrating the benefits to be obtained in a manner that can readily be understood by the policymakers responsible for allocation of workforce and financial resources.

4 STAGES OF DEVELOPMENT

The first stage is to establish an effective accident data system. As mentioned above, all these techniques rely on an accurate accident data and the development of such systems is described in the accompanying Sector Guidelines 4.2 "Road Accident Data Systems." The importance of appropriate and accurate accident data cannot be overemphasized; they are the base measure of safety and are indicators of how and where improvements can be made.

The second stage is defining the staffing and financial resources needed to carry out the investigation and remedial work. It has been stressed how cost-effective these techniques are and thus all countries would be wise to set aside sufficient resources for the task. It does, however, assume that the costs of road accidents to the community have been

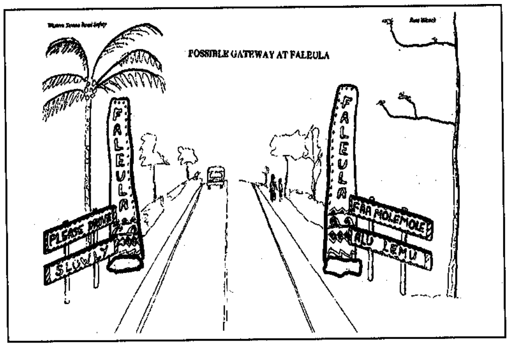


Figure 3: Gateway feature, Samoa.

established and accepted within the country. These costs are firmly established in most developed and some developing countries, but in others the concept of putting a realistic price on death and injury has not yet been fully adopted. It is important that this is accomplished (see Sector Guidelines 4.14) in order to evaluate correctly the benefits of highway and traffic schemes, and thus establish priorities for infrastructure development between different options. For example, will the inclusion of additional safety features, such as guardrails, be worth including in the scheme? If the accident "savings" are greater than the cost of such guardrails, they may be worth including.

The most common problem facing developing countries is finding experienced accident investigation engineers. The techniques originated in the UK more than 30 years ago and are still strong throughout road authorities there. There are now many skilled teams operating around the world, particularly in Australia, New Zealand, UK, and a number of countries in the Asian and Pacific region; e.g., Fiji, Republic of Korea, and Papua New Guinea.

One way of developing a local team of experts is by forming a link with an experienced country and then tailoring training schemes to suit local conditions and/or setting up exchanges of staff or arranging for specialists to assist (often via aid funding, as in Fiji and Papua New Guinea) in establishing a road safety unit within the public works department.

The finances needed for the remedial measures are always relatively low as almost all the remedies mentioned above are low cost. For instance, they are low when compared with highway construction costs or maintenance budgets and thus one way of earmarking sufficient resources for hazardous locations may be to reassign small percentages of the funds from the highways or maintenance budgets (say 5 percent) to specific road safety improvement work.

When an accident investigation team has been established, it is often useful for it to publicize its work to the traffic police, and the design and maintenance engineers. Many workers in these roles are surprisingly unaware of what can and is being achieved and as a result of the liaison between the disciplines there are often several benefits. First, accident data from the police can improve in accuracy if they understand how it is being used; and second, the police and the engineers improve their understanding of the causes of accidents and can start improving their own effectiveness in accident reduction in their own fields of enforcement, design, or maintenance.

In addition, following the accident analysis at a problem site, there is often a need to reinforce the recommended engineering measures with enforcement or publicity. The closer the disciplines work together, the more effective the accident reduction becomes.

5 BENEFITS AND EFFECTS

Assuming that realistic costings for particular accident types have been established, many accident remedial schemes can be shown to pay for themselves in a matter of months. For any new country adopting these techniques, it is unlikely that their priority lists for action would include any schemes that would take more than one year to return the investment and many (via savings in accidents) will pay for themselves within a matter of a few months.

Figures vary from scheme to scheme, but where there is a well-defined accident problem with many accidents of a similar type, the accident reductions that can be achieved are likely to be between 30 percent and 50 percent. If, however, there is a specific problem, such as run-off-the-road accidents on a severe bend, then in many cases low-cost signs, road marking, and perhaps delineation may remove the problem altogether, giving an 80-100 percent reduction.

6 EXAMPLES OF GOOD PRACTICE

As described above, the accident black spot investigation techniques described in these guidelines originated in the UK during the 1960s. In recent years, several developing countries, including Fiji, have set up accident data systems and have established accident investigation teams.

Plate 4:
Rumble bars, Fiji.

Plate 5 (far right):
Road humps, Fiji.

Plate 6:
Gateway, Fiji.

Examples of their remedial schemes are shown in Plates 4 and 5. Figure 3 shows a gateway feature planned for villages in Samoa following an accident analysis project funded by the World Bank and based upon the success of similar features in Fiji (see Plate 6).

Reference 2 was developed specifically for developing countries and provides step by step guidance on how to improve road safety through engineering measures. Reference 6 is an example from India of analyses of various black spot sites, including remedial action recommendations, and Reference 7 includes an evaluation of some treated black spot sites in Malaysia.

7 REFERENCES AND KEY DOCUMENTS

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Road Safety Guidelines for the Asian and Pacific Region

The guidelines cover 14 individual sectors affecting road safety, with four introductory chapters and four appendices. Information is presented in a series of freestanding documents that can be extracted for distribution and discussion.

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