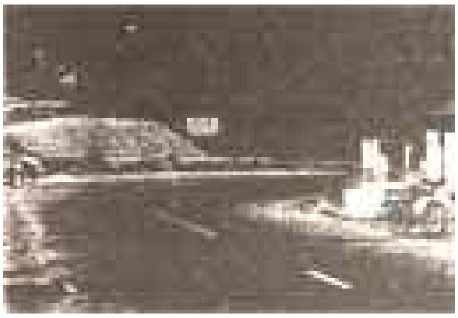
His Majesty's Government of Nepal

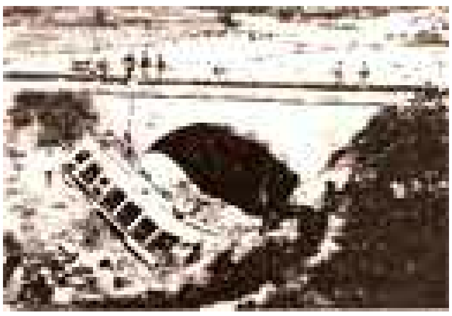
Road Safety Note 8

# Identifying and Treating Accident

**Before treatment**



**After installation of signs and safety barrier**




Traffic Engineering and Safety Unit
Design Branch, Department of Roads
Ministry of Works and Transport


June1997 Jestha 2054

# ROAD SAFETY NOTES

Road Safety Notes are produced by the Traffic Engineering and Safety Unit of the Department of Roads as a means of Increasing road safety awareness amongst highway engineers and others. Some of the Notes provide Information on aspects of the road accident situation Nepal, whilst others give detailed technical advice on highway safety measures. The Traffic Engineering and Safety Unit was set up In Balsakh 2052 to provide a road safety and traffic engineering service, and Is based In the Design Branch of the Department of Roads at Babarmahal, Kathmandu. The Unit Head (telephone/fax 262 843, e-mail: tesu@dor.mos.com.np) will be pleased to receive comments and suggestions which will help Improve the Road Safety Notes.

# Content

# Introduction

This is a simple guide to identifying and treating hazardous sections of roads - for convenience this will be termed "accident remedial work" from here onwards. The guide has been written for use by the Traffic Engineering and Safety Unit (TESU) of the Department of Roads, or any other organisation or individual who needs to do accident remedial work. TESU is leading the way by doing a number of demonstration schemes, but it has neither the funds nor the staff to do accident remedial work throughout Nepal. Eventually it is hoped that the Divisions will take on this work themselves with technical help from TESU. Accident remedial work is only just beginning to be done in Nepal, and there is so much still to be learnt. Consequently this is only a provisional guide to the subject, and is not a comprehensive reference work. Further technical advice on what is being done in other countries is available from manuals and reports held in the TESU library. It is hoped that with more experience it will be possible to improve the effectiveness and suitability of the practices and procedures outlined in this manual.

# Overview

The task is to identify where accidents are happening and investigate them to determine the factors involved so that appropriate and effective remedial or preventative measures can be applied. Taking actual accidents as the starting point is of fundamental importance, because it is not possible to reliably identify and analyse hazardous locations from the look of the road alone. Unfortunately it will be a long time before there is good reliable accident data for all parts of the road network - this does not mean that there can be no accident remedial work in these areas, but extra care and caution will be needed.

Road accidents happen in many forms and in many locations and it is not feasible nor useful to analyse everyone of them in detail. The key is to try and identify locations where accidents are most frequent (accident clusters) as these are potentially worthwhile sites for investigation and treatment. Road safety practitioners recognise four main approaches to the task of treating these accident clusters:

*single site*: treatment of individual sites (e.g. junctions, bends, or short lengths of road) at which accidents are clustered

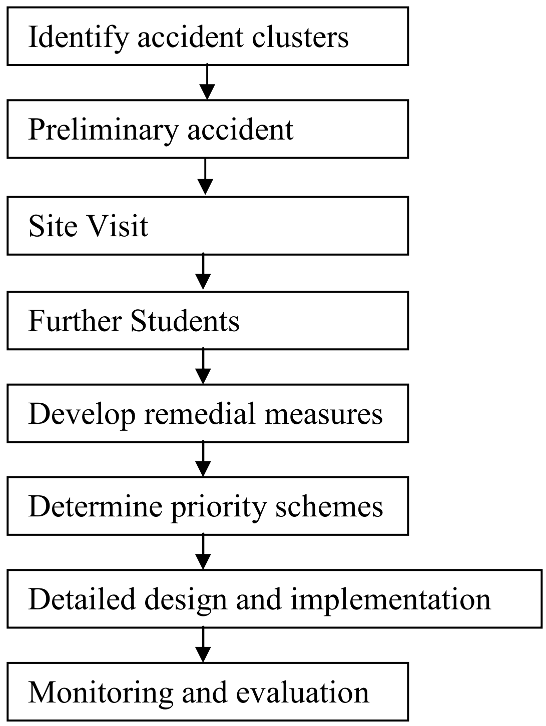
*route action*: safety treatments applied to the whole length of a road which has a bad overall accident record

*mass action*: application of standard treatments to locations having common accident features (e.g. provision of central refuges at pedestrian crossings on wide roads)

*area action*: safety treatments applied throughout an area (often a section of town) which has a bad overall accident record.

The single site approach is likely to be the most productive at this early stage in the development of the accident remedial work, but in practice there is often overlap between the approaches. For example TESU's recent accident remedial work along the Naubise - Mugling section of Prithvi Highway can be looked at as a route action programme but it also involves elements of single site and mass action treatments.

To tackle accident problems effectively it is necessary to adopt a disciplined step-by-step working process, involving investigation, diagnosis, and development of remedial action. Sometimes the solution may seem obvious, especially to an experienced safety engineer, but it is best to follow the process through and not jump to conclusions. The standard process is set out below.



Each step in the process will be the subject of a separate section in this manual. But before this it is necessary to look at the accident data collection system on which the whole process is very dependent.

# Accident Data Collection

The Nepal Police have taken steps to improve accident recording procedures but there is still some way to go before we have a reliable and comprehensive system. The lack of a standard report form means that what is reported and how it is reported can vary. The recording of the location of the accident is usually very imprecise. And it is possible that some police districts may not always remember to report their accidents to headquarters.

The police accident data has its uses, but it is nowhere near good enough for accident investigation and remedial work. It is for this reason that the Microcomputer Accident Analysis Package (MAAPS) system was introduced in, 1995.

The MAAP5 system of accident data collection currently covers Kathmandu, Lalitpur and the Naubise-Mugling section of the Prithvi Highway. A copy of the accident report form appears in the appendices. The form, if fully and accurately completed, provides all the basic information necessary for accident analysis. Policemen get a one-day training in the completing the form, and are given an instruction manual written in Nepali.

**Guidelines for the management of the accident data collection system**

Police need to be given every encouragement to maintain and improve the system. They should be provided with regular reports (monthly, six-monthly and annual reports) and these should be discussed with them. Police should be given training in the use of the MAAP software so that they can produce their own reports and analyses.

TESU engineers need to visit Valley Traffic regularly to transfer the accident records onto the main database. Long absences may suggest to the Police that the accident data is not important to the DoR. TESU engineers must monitor the accident reporting and data entry carefully and take action if problems are spotted. Delays in reporting and entry win inevitably occur but it is important that large back-logs are not allowed to build up. The staff responsible for data entry should be encouraged and advised as much as possible. Check the records carefully before transferring them to the main database, and when checking the location codes make use of the strip maps and the standard list of junction coordinates. TESU engineers must report regularly to senior Police officers on how well the system is working.

Existing data entry (ledgers) and back-up procedures must be strictly followed. Regular checks should be made on the integrity of the main data file by producing and verifying some sample tables - this should always be done before creating the transfer disk. Before copying the main data file onto DoR computers check the transfer disk for viruses.

Training sessions must be organised occasionally to teach more policemen how to complete the accident report form. These must include a practical session where the trainee is required to complete a form for a staged accident. Full use should be made of the instruction manual and this may be need to be updated and improved at intervals. An attempt should be made to gradually transfer responsibility for this training to the Police.

TESU engineers must monitor the stock of accident report forms held by the Police and resupply when necessary.

# Identify Accident Clusters

The first step in the accident remedial process is to identify locations where there is a high incidence of accidents. Usually we are looking for single sites (short sections of road or junctions) with bad accident records and these are usually termed "accident clusters". Sometimes we may be looking for roads which have an abnormal number of accidents (in route action programmes) or areas of towns (in area action programmes).

**Use casualty accidents**

A casualty accident is one In which one or more persons were Injured or killed. A casualty is a person who has been injured or killed. It is advisable to ignore damage-only accidents when searching for accident clusters, because the proportion of such accidents that are reported to the Police Is quite low and variable - so to include them could give a misleading picture. However, they may provide useful information in later stages of the analysis. Of course the casualty accident data is far from being 100% reliable but the risk of error is less.

**An Informal approach**

Because the coverage of the data base Is still quite limited It Is feasible to adopt a fairly informal approach to identifying accident clusters. For Kathmandu the easiest way is to plot the Injury accidents on the scanned maps and look for the largest clusters. Remember though that reporting levels are likely to be greatest close to Police stations - this is probably the reason why the worst site in Kathmandu Is the Singh Durbar junction just outside Valley Traffic Police HQ. For Naubise-Mugling use the kilometre analysis option In MAAP to produce histograms of accidents by 500m or 100m sections - this gives a very quick picture of where most accidents are happening. You may sometimes want to focus on particular types of accidents - pedestrian accidents for example - and these can be easily plotted with MAAP.

**Program "WORST"**

Another option Is to use the MAAP program called "WORST". With the present (June 1997) configuration of the system It is necessary to type "worst" at the c:\MAAP5 prompt. It Is not referred to in the MAAP manual. This produces a list of the worst sites based on fields you select - selecting the X Coordinate and Y Coordinate fields will give you a list of the worst accident locations. "WORST" can also weight the accidents by severity, which can be useful (severity weighting is treated in more detail below). And because you can also set conditions on the search you can easily produce a list of, for example, the worst pedestrian accident sites

**A structured approach**

As the coverage of the accident database expands to include more roads and towns it will become necessary to adopt a more structured and rigorous approach to identifying accident dusters. One of the key requirements Is to try and define a "REACTION LEVEL" - the level of accidents which makes the site, route or area worthy of Investigation. The appropriate level can only be defined with experience. Some of the indices that can be used are listed below:

- the number of accidents per unit length of road (or per junction) per year. [Note that on Naubise - Mugling the overall average has been 1.4 casualty accidents per km p.a. Asauj 2052 to Bhadra 20531

- the accident rate (in ten-ns of accidents per hundred million vehicle kilometres) - this has the advantage that it takes account of exposure to accident risk and thus can be used to compare roads with different traffic volumes [Note that on Naubise - Mugling the rate has been 186 casualty accidents per hundred million vehicle kilometres - the vehicle kilometres is derived by multiplying the Average Annual Daily Traffic (currently 2129) by 365 and then by the road length (83)1; the disadvantage of using this rate Is that it generally means that bad accident sites on very busy roads are devalued; yet these may be the most cost-effective sites to treat (greatest number of accidents prevented per unit of expenditure)

- weighting accidents by severity. to produce an index value (e.g. fatal accidents score 5, serious accidents score 3 and minor accidents score 1) - this is a useful technique to identify the sites with the more severe accidents, but care should be taken not to put too high a weighting on fatal accidents, as whether severe accidents result in fatalities or serious injuries often depends on extraneous factors (e.g., age of victim, speed with which medical treatment was obtained).

- for identifying hazardous areas you could use the number of accidents per square kilometre or the number of accidents per kilometre of road

**Statistical significance**

There is considerable randomness in the way accidents are distributed over time and from place to place. As the accident database -builds up over time it win become possible to use simple statistical techniques to determine whether apparent accident dusters may have come about due to these random fluctuations or are "statistically significant". The tests typically compare the accidents at the site with some overall pattern or "NORMS". The Poisson and Chi Squared tests are the most common, and good descriptions of them appear in the RoSPA Road Safety Engineering Manual.

# Preliminary Accident Analysis

Now that sites worthy of investigation have been identified we can proceed to in-depth analysis in order to formulate some remedial action. The key objective is to look for a pattern (or patterns) in the accidents which might help us to identify one or more main contributory factors - which we might be able to change. Of course there is no guarantee that there will be a pattern - or if there is a pattern that the contributory factor can be treated in a cost-effective way.

The key tasks to be done in the preliminary analysis are:

- open an office file for the accident site - in which to record details of the analysis and any subsequent remedial action
- produce basic cross tabulations of the data at the site, e.g., Day of Week by Hour of Day, Collision Type by Hour of Day
- produce an accident factor grid, i.e. a STICK DIAGRAM
- check the site against the "norms"
- retrieve the accident forms and verify location and other information
- produce a composite collision diagram

**Stick Diagram**

Use the STICK "Text Stick Analysis" option in MAAP5 to produce a Stick Diagram for the accident site, such as that shown in Figure 1 overleaf.

Figure 1 - Example of Stick Diagram

| | | | |
|---|---|---|---|
| ACCIDENT RECORD FILE | AC53-54A<br>AC52-53A | | |
| CONDITIONS SET | DOR ROAD NUMBER<br>KILOMETRE POST | = H04??<br>= 59-60 | |

| | 1 | 4 | 9 | 11 | 2 | 3 | 5 | 6 | 7 | 8 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COM | 009 | 040 | 135 | 131 | 023 | 037 | 066 | 012 | 101 | 129 | 140 |
| SEV | D | M | F | M | S | M | M | F | M | S | D |
| NOV | 02 | 03 | 02 | 02 | 01 | 01 | 02 | 01 | 01 | 01 | 02 |
| HH | 04 | 09 | 14 | 14 | 12 | 19 | | 09 | 23 | 17 | 10 |
| *N* | | | | | | | | | | *N* | |
| PED | | | | | | | | | | PED | |
| >< | >< | >< | >< | >< | | | | | | | |
| >> | | | | | | | | | | | |
| \|< | | | | | | | | | | | \|< |
| Rol | | | | | | Rol | Rol | Rol | Rol | | |
| Obj | | | | | | | | | | | |
| N-J | N-J | N-J | N-J | N-J | N-J | N-J | N-J | N-J | N-J | N-J | N-J |
| Jun | | | | | | | | | | | |
| Day | 3 | 2 | 4 | 2 | 7 | 4 | 5 | 1 | 6 | 6 | 5 |
| Wet | | | | | | | Wet | | | | |

| | | | | |
|---|---|---|---|---|
| COM= Computer No | SEV- Severity | NoV- | No of Vehcles | HH = Hour |
| *N*- Nighttime | PED- Pedestrian | >< - | Head On | >> = Rear En |
| 1< - 90deg/SideSwp | Rol- Rollover | Obj= | Object Off Rd | N-J= Not Junction |
| Jun= Junction | Day- Day of Week | Wet- | Wet/mmd/Flood | |

Stick Number = Accident Code Number:-
1=000009 2=000023 3=000037 4=000040 5=000066 6=000012 7=000101 8=000129 9=000135 10=000140 11=000131

This is useful technique for Identifying whether there is a pattern to the accidents example In Figure 1 shows that head-on collisions and rollovers are common at that site. You can define the location and set conditions at the Initial screen, but, If you are go do a lot of analysis, It may be worth creating a working file containing just the records are interested In - this can be done with the "Find Selected Records" option or by using the Polygon Analysis option in the Scanned Mapping module (rename the POLY.DAT working file that MAAP5 creates). MAAP5 gives you the option to use one of several "Sticks" so that you can develop ones that are suited to different accident situations, e.g. urban / rural/ pedestrian accidents, etc. Damage-only accidents can be Included in the Stick Diagram analysis, because they may help in showing whether there is a pattern to the accidents. You may want to manually add information to the "Sticks" once you have studied accident forms - and it may occasionally be necessary to amend the information if you spot a coding error or confusion.

**Checking the site against "norms"**

It is always worth checking the site accident history against the "norms", i.e. accident averages. The most common norms are:

- About one-third of casualty accidents In the database area happen at night (all sites)
- About 15% of casualty accidents on Naubise-Mugling happen in the wet
- About 4% of casualty accidents In Kathmandu / Lalitpur happen In the wet

If the accidents at the site do not follow this pattern, It may indicate that there Is a particular problem. Statistical tests can be used to determine whether the difference could be due to random fluctuations or Is "statistically significant". The above norms need to be recalculated regularly as more data is added to the database, and new ones can be developed, such as the percentage of casualty accidents Involving pedestrians or motorcycles. - or some other factor of particular Interest.

**Checking the accident form**

Accident record numbers are listed In the Stick Diagram printout. They can also be traced by using Find Records with the Accident Codes option and with the Conditions set to the location (kilometre or coordinates). Once you have a list of the records you should trace the accident forms at Valley Traffic (they should all be filed in order by district / year/computer number) and make a photocopy of each. Study the location sketch to check that the accident is where you think It Is - and, if necessary, confirm the location with the reporting officer. Accidents that appear to be clustered can turn out to be quite -scattered, due to problems or errors In Identifying and coding the accident locations. Study the reporting officer's account of what happened but keep an open mind on what or what was to blame until you have done more analysis.

**Drawing the collision diagram**

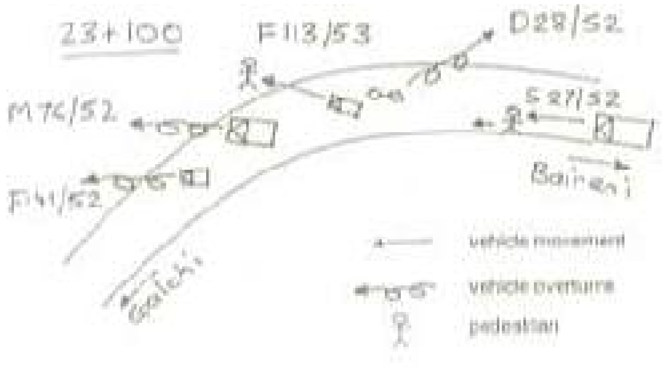
A collision diagram is a schematic representation of all the accidents (casualty and damage only) that have occurred at the site and is a fundamental tool in understanding what has been happening. It is a composite of all the collision diagrams on the individual accident forms. An example is shown In Figure 2. It may not be possible to show the accident locations precisely, but it is important to indicate the directions of movement of all vehicles and pedestrians - this is key Information that Is not available In the computer record and thus does not appear on the stick diagram.

Figure 2 Example of Collision Diagram

Key: (see also Appendix B)

113/53 - fatal accident/record number 113/year 2053

(S=serious M=minor D=damage only) pedestrian




**Analysis of accident factors**

The next stage is to look for the underlying -factors behind the accidents, using the collision diagram and the other analyses that you have done. Remember that accidents are multifactor events, so took beyond what may be the obvious cause. You are looking for underlying factors for which there is a remedial action. In many cases these underlying factors will not appear in the accident form. Common examples Include:

• obstructions to visibility, such as parked cars, roadside furniture, trees;

• lack of visual clues, e.g., it Is difficult to recognise that there Is a bend or junction ahead;

• lack of pedestrian facilities.

## Site Visit

It is always necessary to inspect the site where the accidents have happened. But to avoid jumping to conclusions do not do this until you have carried out an initial analysis of the accident data. Take the accident reports and analyses with you to the site. There are two main reasons for doing the site inspection

- to accurately assess the road conditions and other site factors which may be relevant
- to try and experience the problems that road users are facing

Ideally the Investigator should walk, drive and perhaps cycle through the site in both day and night-time conditions, and should carry out the manoeuvres that have been causing problems. It is rarely practicable to do all this, but a lot can be learnt from just walking and driving through the site. You have to try and understand why a minority of road users are failing to cope with the situation. Where possible take photographs of the site and each approach, as It can be difficult to visualise it exactly once you are back In the office, Talking to the local people can often be very rewarding, as they may have witnessed many of the accidents. It is always useful to have the Traffic Police with you as well as the DoR engineer responsible for the road; apart from them being able to tell you what they know of the accident situation, it gives you an opportunity to discuss your Initial diagnosis with them and this will probably make it easier to get their agreement to the remedial measures.

A suggested check4ist for the site inspection is set out below and this should be expanded as experience is gained:

***Road cross-section***

lone widths, shoulder widths, design of drains, kerbs, footpaths

***Road geometry***

curves, gradients, widening on curves, superelevation

***Road surface***

type, effectiveness of drainage, slipperiness (with experience you can check this with the palm of your hand, but use a skid resistance tester If there Is one available)

***Visibility***

for through traffic, side road traffic, pedestrians

***Junction layout***

type, layout, geometry

***Signs and markings***

type, condition, legibility, conspicuity, credibility

***Traffic signals***

type, visibility, timing

***lighting***

type, positioning, effectiveness

***Traffic volume and mix***

samplee traffic count, non-motorised vehicles

***Traffic speed***

speed limit, safe speed, actual speeds

***Parking***

On-road and off-road, bus stops

***Pedestrians***

Numbers, age, routes, facilities available

***Roadside objects***

Poles, posts, trees, side slopes, other hazards

***Environment***

Roadside development, presence of schools

***Evidence of problems***

skid marks, broken glass, damaged walls or parapets

***Other human factors***

Driver and pedestrian expectancies, i.e., what the look of the site leads them to expect

# Further Studies

It may sometimes be necessary to carry out additional surveys and studies in order to determine and design appropriate remedial measures. These could include:

- traffic counts
- surveys of vehicle turning movements at junctions (always necessary before redesigning junctions)
- pedestrian counts (along the road and across the road)
- surveys of pedestrian crossing behaviour
- measurement of road surface skid resistance
- speed surveys
- measurement of visibility distances
- conflict studies (see below)

**Conflict studies**

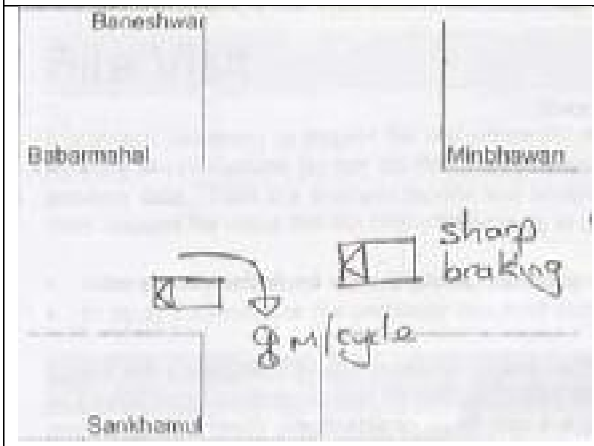
One of the major problems we face in doing accident investigation in the Valley is that very few of the accident forms include a collision sketch. The accident conflict technique can help provide some dues as to what is happening, and is particularly appropriate for urban junctions. It involves observing the interaction of traffic at the site and recording the conflicts or "near-misses". Conflicts are those events where there would be a possibility of an accident if one or more of the road users did not take avoiding action. Road users in Kathmandu are not very disciplined (and priorities at junctions are not made clear) and consequently there are continual conflicts - so it is best to record only the most serious of them, which can be recognised as those involving severe braking or swerving. Observers need to practice the technique together so that they are recording the same degree of conflicts. It is not a very precise or wholly objective assessment technique, but a few hours of observation can produce useful information on the problems that road users are facing.

Figure 3 shows a completed accident conflict survey form. In Figure 4 the individual accident conflict data has been grouped together to give a composite picture of the accident conflict situation.

Figure 3 Example of Completed Accident Conflict Survey Form

**CONFLICT REPORT SHEET DATE: 1/1/97**

Name of junction: Naya Baneshwar Chowk

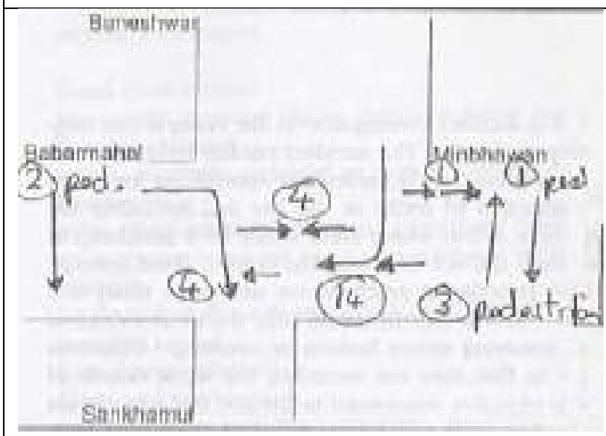
<table>
<tr><td>Diagram of occurrence</td><td colspan="2">Conflict severity</td></tr>
<tr><td rowspan="3">
</td><td>1</td><td>Rapid deceleration, lane change or stopping to avoid collision, resulting in a near miss situation. No time for steady controlled manoeuvre.</td></tr>
<tr><td>2</td><td>Emergency braking or violent swerve to avoid collision resulting in very near miss situation, or occurrence of a minor collision.</td></tr>
<tr><td>3</td><td>Emergency action, followed by collision</td></tr>
</table>

Time 13:00 Note on diagram direction, colour, vehicle type and evasive action taken.

Figure 4 Example of Composite Accident Conflict Diagram

**CONFLICT REPORT SHEET DATE:- Totals**

Name of junction: Naya Baneshwar Chowk

<table>
<tr><td>Diagram of occurrence</td><td colspan="2">Conflict severity</td></tr>
<tr><td rowspan="3">
</td><td>1</td><td>Rapid deceleration, lane change or stopping to avoid collision, resulting in a near miss situation. No time for steady controlled manoeuvre.</td></tr>
<tr><td>2</td><td>Emergency braking or violent swerve to avoid collision resulting in very near miss situation, or occurrence of a minor collision.</td></tr>
<tr><td>3</td><td>Emergency action, followed by collision</td></tr>
</table>

# Develop Remedial Measures

Hopefully you will now have identified one or more dominant accident types and have reached some conclusion about the causal factors involved. And it is to be hoped that these causes are capable of being treated or remedied. When thinking about remedial measures you need to consider the following:

*is the remedy cost-effective?* - some measures may be effective without being cost-effective generally we should be looking for low-cost measures

*is it likely to be long-lasting?* - some speed-reduction measures for example have an immediate effect but this wears off as drivers get used to them e.g., rumble areas

*will it result in an excessive increase in other types of accidents?* - for example, in some circumstances the introduction of traffic signals can result in an increase in nose -to - tall accidents

*will it have any unacceptable effects on traffic or the environment?* - road humps for example can cause traffic noise nuisance as vehicles brake, and may result in traffic diverting onto other less suitable roads

*will it be very unpopular with road users?* - if so, you could come under strong pressure to remove it, unless you can prove it is effective in preventing accidents

*will it need to be heavily enforced by the Police or need considerable publicity and education?* - if so, consider whether this is really achievable

Set out overleaf are two tables which give a guide to what remedial measures might be effective for each common accident type. Generally the measures at the top of the list are likely to be the most cost-effective. Remember though that our experience of accident remedial work in Nepal is extremely limited, so the recommendations are very tentative and will need to be revised as we get more experience. TESU engineers should make full use of other reference works ( TRL's "Towards Safer Roads", RoSPA's "Road Safety Engineering Manual", Ogden's "Safer Roads") when considering remedial measures. It is worth emphasizing once again the importance of: studying the accident data, identifying the dominant accident types, identifying the causal factors, and selecting remedial measures which are likely to be effective in remedying the deficiencies that have been found. Do not select remedial measures from these tables without doing this analysis.

### Table 1 - Remedial Measures for Rural Accident Situations

| Accident type | Possible remedy |
|---|---|
| Single vehicle loss of control (usually recorded as overturn) | • improved delineation (centre and edge line markings, delineator posts, chevron signs, reflective studs if a night-time problem)<br>• safety barrier (especially if there is a big drop) containment parapet on bridges<br>• bar markings on the road (especially on the approach to a very sharp bend)<br>• warning signs (if they already exist, consider increasing their size, or making them reflective, or positioning them better)<br>• seal the shoulder (if unsealed)<br>• impose speed limit<br>• improve skid resistance<br>• re-align bend and/or improve superelevation |
| Head-on collisions | • improved delineation (as above)<br>• if collisions happen while overtaking consider prohibiting this using a continuous centre line and possibly "No Overtaking" regulatory sign<br>• if collisions happen at narrow sections (e.g. bridges, culverts) ensure that these are clearly signed (warming signs, hazard markers, bar markings, rumble strips, etc)<br>• if collisions happen while a parked vehicle is being overtaken consider banning parking and/or providing a parking area or lay- by |
| Pedestrian Accidents | • traffic calming measures within villages and at the entrances(place name signs, gateways, rumble strips, build-outs) (make it very clear to drivers that they are going through a village)<br>• impose speed limits<br>• warning signs ("Children" "Pedestrians in Road")<br>• provide footways (on bridges and elsewhere)<br>• provide pedestrian crossings (but only if they will be well-used) |

| | |
|---|---|
| Collisions with roadside object | • remove object if possible<br>• install hazard marker in front of object<br>• use safety barrier to protect vehicle from object (e.g. in front of the end of a bridge parapet) |
| Collision with stopped or parked vehicle | • consider banning parking<br>• provide bus lay-by or off-road parking area |
| Accidents at junctions and access points | • better signing and marking (make the priorities clear)<br>• channelisation (splitter islands in minor road approach and protected lanes for vehicles turning right out of the major road) using paint ("ghost islands") or physical islands<br>• remove any obstructions to visibility (e.g. trees, bushes, poles, walls etc)<br>• provide service roads for frontage development thereby making it possible to greatly reduce the number of access points. |
| Accidents on gradients | • safety barrier (if vehicles run out of control)<br>• provide crawler (overtaking) lanes or shorter passing places |

### Table 2 - Remedial Measures for Urban Accident Situations

| **Accident type** | **Possible remedy** |
|---|---|
| Juction accidents | *There is a great variety of junction situations and not all the remedies listed below will apply to every one - moreover all remedial measures will need to be carefully designed to suit the specific circumstances - it is advisable to consult manuals before making major alterations to junction layout* |
| Conflicts between traffic streams - **at priority (T or cross-roads) junctions** | • if traffic is very heavy - such as at many junctions in Kathmandu- consider installing a roundabout (if there is space) or traffic signals (traffic signal installation needs to be done as part of a project covering a number of junctions)<br>• improve the signing and marking (make the priorities clear)<br>• channelisation - show drivers the correct path to take by means of road markings (e.g. "ghost islands", lane markings, right-tum bays, lane arrows, etc) and physicalislands |

| | |
|---|---|
| | • control and channelise pedestrian crossing movements<br>• modify the layout to encourage slower approach speeds (e.g. by reducing comer radii and providing splitter islands)<br>• prohibit and discourage parking and stopping near the junction(e.g. by signs and pedestrian guardrail) - move bus stops away from the junction<br>• improve lighting<br>• remove any obstructions to visibility<br>• ban difficult turning movements (but only if the ban can be easily enforced and the alternative route is not too long or awkward)<br>• consider reducing the number of conflicts by converting one or more roads to one-way traffic (but consider the area-wide implications)<br>• improve skid resistance<br>• |
| Conflicts between traffic streams - at **roundabouts** | • improve the signing and marking (make the priorities clear)<br>• install splitter islands on the approaches<br>• increase deflection (e.g. by increasing the diameter of the centre island or changing the approach geometry)<br>• control and channelise pedestrian crossing movements<br>• prohibit and discourage parking and stopping near the junction bus stops and pedestrian guardrail) (e.g. by - move signs away<br>• improve lighting<br>• remove any obstructions to visibility<br>• improve skid resistance |
| Conflicts between traffic streams - at **signalised junctions** | • upgrade the signal equipment (brighter lights, stronger colours)<br>• improve signal visibility (extra signals, better positioning, backing boards, etc)<br>• improve the signing and marking (STOP lines, lanes and lane markings, turn arrows, advance warning signs)<br>• check the timing (additional inter-green time may be needed for clearance)<br>• consider changes to the staging- (if there is a right-tuming problem consider giving this traffic a separate stage or a priority overlap)<br>• control and channelise pedestrian crossing movements<br>• prohibit and discourage parking and stopping near the junction(e.g. by signs and pedestrian guardrail) - move bus stops away<br>• improve lighting |

| | |
|---|---|
| | • remove any obstructions to visibility<br>• improve skid resistance |
| Pedestrian accidents at all types of junctions | • control and channelise pedestrian crossing movements<br>• provide pedestrian crossings<br>• provide pedestrian refuges<br>• prohibit and discourage parking and stopping near the junction (e.g. by signs and pedestrian guardrail) - move bus stops away<br>• improve lighting<br>at signalised junctions consider introducing a pedestrian stage |
| **Accidents not at junctions** | |
| Pedestrian accidents | • provide 'Pedestrian footways<br>• provide pedestrian crossings (busy crossings may need to be signal - controlled)<br>• provide pedestrian refuges<br>• control and channelise pedestrian crossing movements<br>• install speed reducing road humps (residential areas)<br>• install other traffic calming measures (gateways, build-outs, chicanes, rumble areas, etc., designed to encourage low speeds, and careful, disciplined driving |
| Single vehicle loss of control | • largely as for rural accident situations |
| - Head-on collisions | • largely as for rural accident situations |
| - Accidents involving two-wheelers and NMVs | • consider increasing width of nearside lane or providing a special lane |

# Develop Remedial Measures

When we have more schemes than funds available it is necessary to develop an assessment procedure to help in deciding which schemes should go in the annual programme - and which can be deferred to a later year. The main factor should be cost-effectiveness, but there are many other considerations.

**Cost-benefit analysis of accident remedial schemes**

The standard way of ranking schemes according to cost-effectiveness is to do a cost-benefit analysis comparing the value of the likely accident savings with the estimated cost of the scheme. The easiest and most widely-used method is to calculate what is known as the First Year Rate of Return (FYRR). This is simply the net monetary value of the accident savings expected in the first year of the scheme, expressed as a percentage of the total capital cost. The main steps are:

- estimate the capital cost of the scheme
- estimate the likely number of accidents to be saved in the first year
- calculate the monetary value of those savings
- adjust the gross value of accident savings to a net amount by taking account of other consequential changes in accidents (some types of accidents may increase) possible increased maintenance costs, and other disbenefits
- express the net value of accident savings as a percentage of the capital cost

Estimating the likely accident saving may seem difficult, given that we have little experience so far, but it is unlikely to be so different from British and Australian experience which is described in various reference works. In most cases it can be assumed that the average reduction in accidents of the kind being treated will be in the range of one-third to two-thirds. It is standard practice to work with casualty accidents only (because of poor reporting of damage-only accidents) but take account of damage-only accidents in the costings (see next paragraph),

Accident costs are set out in Road Safety Note 3 "Road Accident Costs 2051-52". It is hoped that these will be regularly updated, but if not they should at least be revalued to account for inflation since 2051-52. The cost to use is the cost of the average casualty accident with an allowance for damage-only accidents - which RSN 3 gives as NRs 187,000. This was-calculated by dividing the estimated total cost of all road accidents (casualty and damage accidents) by the estimated number of casualty accidents.

**Example of First Year Rate of Return (FYRR) calculation**

***Scheme:*** installation of chevron signs at a bend

***Accident record:*** 5 casualty accidents in a year (4 x single vehicle loss of control and 1 x pedestrian/vehicle, - so 4 treatable accidents)

***Estimated accident saving in first year:*** 66% reduction in treatable accidents, - so 2.6 accidents saved

***Cost value of accident savings:*** 2.6 x 187,000 = Nrs 486,200 Capital cost of signs (including installation): Nrs 12,000

$$\text{FYRR (\%)} = \frac{\text{Accident Savings x 100}}{\text{Capital Costs}} \quad \frac{486{,}200 \text{ x } 100}{12{,}000} \quad = 4{,}052\%$$

This may seem an incredibly high rate of return, but experience from other countries proves that such returns are achievable, especially in the early years of an accident remedial programme when there are many easily treatable problem sites.

For major remedial schemes with a significant maintenance and renewal cost element (such as the installation of traffic signals) it will be better to us an economic assessment method such as **Net Present Value** which takes account of costs and benefits over a number of years.. RoSPA's -Road Safety Engineering Manual" (Chapter 5, page 17) explains it well.

**Other considerations**

Ranking the potential schemes by FYRR will give you an initial priority ranking, but other considerations could include:

***Demonstration value:*** give a high priority to innovative schemes which could have a wide application - especially if they are low-cost and very cost-effective

***Views of the Police, the Regional Director and the Divisional Engineer*** : it is worth giving priority to schemes which they are enthugiastic about, because their support could be critical to getting the schemes implemented and working properly

***Likelihood of public support:*** give high priority to schemes that are highly visible, will work well, and be well underst6od and liked by the public, because public support for accident remedial work (as reflected in media interest for example) could be valuable in promoting expansion of the programme

# Detailed Design and Implementation

**Detailed design**

The amount of design work involved will vary considerably depending on the nature of the remedial measures. A sketch may be all that is needed for some simple signing works, with the final locations being determined on site. But for anything more complicated you will need to produce design drawings. And in the case of large or specialised schemes, it may be necessary to call in experts, such as Bridge Unit, or employ consultants. The first step in doing your own design is to get an accurate site plan, but this is not easy. It may be possible to enlarge a Dept. of Surveys plan and then fill in some of the detail yourself from on-site measurement. If you are not fully confident of the accuracy of the site plan you must be ready to adjust the design on-site during construction, and this means constant supervision. When finalising designs for junction improvements and any works in the road, make the following checks:

- will it be clear to road users what they are meant to do?
- can all vehicle manoeuvres be made easily and safely? - use turning circle templates to check that trucks and buses can get through easily
- Will any of it present a hazard to road users? - especially at night and to motorcyclists

Try and visualise what it will be like to drive through the scheme - from all approaches and making all possible manoeuvres. Consider how the scheme might be abused by lazy or errant road users. Schemes which require a constant police presence to make them work are not feasible.

**Site trial**

A trial of the scheme on site can give you a good idea of how well it will work. It is particularly appropriate for urban schemes where you are introducing new features (e.g.

splitter Islands, refuges) on the road. And it is probably essential, if you have had to design the scheme without an accurate site plan. It also gives you an opportunity to demonstrate the scheme to the Traffic Police and other DoR staff. The simplest way of doing the trial is mark out the new kerb lines and Islands with traffic cones and, If possible, install temporary traffic signs. You can then observe how well road users cope with the new layout. If the cones get knocked out of place it may indicate that the layout is too restrictive. You can use sandbags or concrete blocks Instead of traffic cones, but be careful not to create a hazard at night.

**Implementation responsibilities**

It has become an established principle that TESU's demonstration accident remedial – either schemes be Implemented by the DoR Divisional staff –either by using their own labour or by bringing in contractors. This ensures that the Division has an interest in the scheme and therefore is more likely to maintain it. The overall responsibility for accident remedial work rests with the Divisions, because TESU has neither the funds nor the staff to carry out such work throughout Nepal. TESU's role is to design the schemes (if requested) and help Divisions with the implementation - this may include the provision of reflective traffic signs, reflective studs, and other items which the Divisions might find difficult to obtain.

**Funding arrangements**

To avoid delays it is best to transfer the funds to the Division before the work starts. TESU should send the detailed design to the Division, who will then prepare a detailed cost estimate. Remind Division to make allowance for any work site signing and traffic control that will be needed, Once TESU has approved this estimate, the funds can be transferred. It should be made clear to the Division that procurement and award of contracts must be in accordance with HMGN financial regulations.

**Site Instructions**

It is essential that the Division's engineer responsible for the scheme be fully briefed on what is required. Clear written instructions should be provided. In signing schemes for example the sign locations should be agreed with the Division's engineer on-site and preferably marked with paint. Mounting heights, orientation, and clearance from the edge of the road, must all be specified. It is not unknown for unfamiliar signs to be mounted upside down, so ensure that the Division's engineer fully understands what is to be done. Remind him of the need to be on-site to supervise critical stages of the work. Try and ensure that the work site is properly signed and that there is a clear and efficient system of traffic control where necessary. TESU's demonstration schemes must set a good example to others - refer to the Roadworks Signing Code of Practice and the Traffic Signs Manual (to be published) for advice.

**Record-keeping**

Make sure that the work is properly recorded in the accident site file. The dates when and things were done are particularly important - it is difficult to evaluate the effectiveness of a scheme when you cannot remember what was done when.  It is also vital to keep a record of the costs. A standard record format, such as that in Figure 5 may be useful.

Figure 5 Example of Scheme Implementation Record

# Scheme Implementation / Diary of Events

Sitename: Khahare Khola Bridge KM12+400 Prithivi Highway

| Date | Event |
| --- | --- |
| 11/12/2052 | Two multiple chevron signs( B13)installed on the Naubise approach ( Cost : Rs 8,000 excluding installation Gabon safety barriers constructed on both approaches ( cost Rs. 45,000) |
| 21/7/2053 | One Single chevron sign installed for the Mugling approach (cost Rs. 2,600) |
| 16/8/2053 | Exiting warning signs ( BIO) replaced by partly-reflective versions ( Cost Rs 4,600 approx.) |

**Publicity and Enforcement**

When the scheme requires road users to do something that is unfamiliar to them, consider mounting a publicity campaign to tell them why it has been done and how to use it safely. This is particularly important if the scheme could be hazardous to those who do not understand it or misuse it. You are unlikely to be able to afford to mount a major campaign that will reach most road users, but even putting a few notices in the daily newspapers is well worth doing. It demonstrates that we have a caring attitude to the safety of road users and helps prevent criticism arising from misunderstanding of what has been done. If road users are likely to resist using the scheme properly you may need to have policemen on site to enforce it, at least during the first few weeks. This will need to be agreed in advance with the police. Bear in mind that, although the police are usually very willing to help, it is unrealistic to expect them to maintain a presence at the site for more than a few weeks.

# Monitoring and Evaluation

**Introduction**

Proper monitoring and evaluation of the work is of fundamental importance. Much of what is being done is new and untried, and some of it is quite expensive. Only by monitoring its performance closely will we learn what is cost-effective - and such information will help us gradually build up a sound basis for road safety engineering In Nepal. Evaluation is not easy and it will rarely be possible to obtain 100% clear proof that particular measures have prevented accidents, but it can give indications which are helpful in developing future accident remedial programmes. In addition to measuring cost-effectiveness, we should be looking for any unintended effects (on road user behaviour, traffic patterns, etc) and trying to gauge public acceptability of what we have done. Finally, remember that the scheme needs to be soundly-based, if you are going to be able to learn anything useful from it – this means that there must have been a clear statement of the objectives of the scheme, a prediction of its effects, and a logical link between the treatment and its effects.

**Initial observations**

It is advisable to monitor the scheme particularly closely in the first few days and weeks after completion. You can expect that road users will take a little time to get used to new traffic schemes, and junction improvements, etc, and a few accidents may happen during this time, but you should be ready to review the scheme and alter it (or even change it back to the way it was before) If there is evidence of serious problems. Schemes may work well generally but cause problems for the drunk or reckless driver, and in these cases judging whether the costs are beginning to exceed the benefits is not always easy. This is the time when there may be public criticism of the scheme, and you should be prepared to respond promptly to this - by explaining what has been done and why, and showing that you are taking a responsible attitude to any problems that are occurring.

**"Before" and "after" studies**

The basic method of measuring the effect of a scheme is to compare the situation before it was implemented with that after it was implemented. It seems simple, but there are some complications, including the need to make allowance for:

- extraneous factors (e.g. changes In weather, traffic patterns, vehicle mix, traffic rules) which could account for some or all of the change that has been observed
- the fact that accidents are to some extent random, which adds extra variability into the accident data, thus making the effects of the scheme more difficult to detect
- the likelihood that scheme construction will disturb the traffic situation for a little while - for this reason, data on the traffic and accident situation during and immediately after the construction period is usually ignored

In practice one of the biggest complications arises when the remedial scheme includes several measures, such as improved signing and changes to alignment and layout – because it then becomes very difficult to separate the effect of the different measures.

**Short-term measures of performance**

The most important measure of success Is whether the scheme has improved the accident situation at the site, and the statistical analysis required for this will be discussed in the next section. However it takes three years to build up the data necessary for a proper statistical analysis, and you are likely to want to make some assessment of scheme performance long before, then. In most cases there are other variables which when measured "before" and ‘after" will give you an indication of whether safety at the site has improved. Examples include:

*traffic speeds* - many schemes aim to improve safety through reducing traffic speeds, so speed surveys will tell you whether the hoped-for reduction has occurred

*conflicts* - a "before" and "after" conflict study can show whether the conflicts that were causing the problem have reduced

*the number of pedestrians using crossings* - a simple count can show whether measures to promote the use of crossings (better signing, refuges, etc) has increased usage

*road user perception* - it can sometimes be useful to interview road users to see whether they think the road is now easier and safer to use

**Analysis of accident statistics - the Chi Squared Test**

There are a number of statistical tests for comparing the safety performance at a site before and after a scheme has been implemented, but the most commonly-used is the Chi Squared Test. Like other tests it compares before and after data from the treated site with before and after data from similar but untreated sites, known as control sites. The test indicates whether there is a significant difference between the two sets of data.

*Before and after periods* - These must be long enough to even out the random variations in accident frequency, and it is generally assumed that three years is enough (i.e. three years before and three years after). The test can be used with less data, but the margins of error are larger. The periods must be the same for both the treated site and the control sites or at least normalised to the same period.

*Choosing control sites* - The purpose of comparing the treated site with the control sites is to take account of the extraneous factors such as weather and traffic flow changes which may be causing an area-wide change in the accident situation. The best control sites are those which are similar to the treated site and in the same area - in this way you can be sure that both sites have been similarly affected by local variation in extraneous factors. In practice this is difficult, especially as you need enough control sites to give you about ten times as many accidents as at the treated site(s). You may have to take control data from a wider area, but try and ensure that the sites are broadly similar to the treated site.

*Worked example of Chi-Squared Test*

Improvements were carried out three years ago at a priority junction in the Kathmandu central area and the effect of the scheme on accidents needs to be checked. The control data is from other priority junctions in Kathmandu. The accident data is arranged as shown below:

| | **Accidents at site** | **Accidents at control sites** | **Total** |
|---|---|---|---|
| **Before** | 10 (a) | 75 (c) | 85 (g) |
| **After** | 2 (b) | 66 (d) | 68 (h) |
| **Total** | 12 (e) | 141 (f) | 153 (n) |

The data is then entered into the following formula:

$$x2 = \frac{(|ad - bc| - n(2)^2\ n}{efgh}$$

This gives:

$$\frac{(\ |10X66 - 2X75| - (153/2))^2 X\ 153}{12x14lx85x68}$$

$X^2 = 2.939$

Refer to a Chi Squared Distribution Table (RoSPA Road Safety Engineering Manual or any set of statistical tables) and looking along the first line. (degrees of freedom = 1) you will find that the value for $x^2$ of 2.939 lies between 2.706 and 3.841. This corresponds to a value of the significance level (on the line above) between 0.10 and 0.05. This means that there is less than a 10% likelihood that the change in accidents at the treated site is due to random fluctuations. Looked at the other way it means that there is a better than 90% probability that a real change In accidents has taken place at the junction.

*Checking whether it makes sense*

The test tells you nothing about how the change in accidents came about. So before you use the test result to demonstrate how well your scheme has worked it is important to check that the accident data supports your case. Usually your scheme will have targeted a particular type (or types) of accident, so check (by redoing the collision diagram) that this type of accident has in fact decreased. And ask yourself whether there is any other plausible reason why the accidents may have decreased at the site. Once you have discounted any other possibility you are left with the probability that the decrease in accidents has come about as a result of your remedial scheme.

*Economic analysis*

It is worth calculating the First Year Rate of Return again (see explanation on page 16) now that you know the actual costs of the scheme and the accident saving. It will be instructive to compare the result with that which you calculated at the earlier stage, and this should help you to improve the accuracy of your forecasts. It is important to be able to demonstrate that the accident remedial programme gives good value for money.