

# **Road Safety Management of the Highway Network.**

by

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## Abstract

*Whilst the improvement of road safety within a country should always be carried out as an integrated approach which is co-ordinated between all government authorities, researchers and other organisations able to contribute, this paper presents the author's view of how road safety should ideally be managed within the highway authority; that is, it focuses on the highway engineering aspects only. It discusses the importance of highway engineering, casualty reduction target setting, and proposes the formation of special accident investigation units.*

*Such units have been shown to be effective in several countries. Their main objective is in achieving the local safety improvement target, and their various functions in monitoring the network are described. These include the production of annual safety plans, carrying out safety audits, investigating blackspots, designing appropriate countermeasures, and evaluating and reporting on all the schemes introduced.*

## 1 Introduction

It is essential that the scarce resources which are available for improving road safety are applied efficiently and not wasted. Whilst the quality of highway engineers in many developing countries may be high, there may also be an absence of technical resources and expertise to ensure that unsafe roads are not being constructed and safety problems on the existing network are being treated effectively.

As well as the trauma to victims and their families of road accidents, the cost of such accidents to the community are high. Where the number of vehicles is increasing rapidly, as in China and many other countries, the road infrastructure is being extended and improved, and unfortunately accidents are likely to increase. If accidents can be reduced, the whole community will benefit from the decreased costs and the monies saved may be utilised elsewhere.

This paper draws on procedures that are followed in a number of European countries and North America to manage road safety by those responsible for the engineering side of the highway network. It outlines the ways in which "Accident Prevention" can be included in the design and operation of roads and advises on "Accident Reduction" by showing how hazardous locations can be analysed and what types of countermeasures can be used to reduce accidents at such locations.

## 2 Why highway engineering?

Figure 1 summarises the findings of research carried out by TRL over 25 years ago in the UK when members of a specially trained on-the-spot team attended the scene of all accidents within the local area. The team was called to the scene of road accidents by the emergency services, but independently recorded what they considered to be the causes of the accidents. This research was replicated in Australia and the USA and very similar findings were produced. The ranges quoted in the Figure represent the results from different sources.

Although some element of human error is present in almost all accidents (95% of cases in the sample), it was found that only in up to about 2/3rds of cases was this the only major cause, and there were often other important factors that contributed to the collision. Indeed up to about 28% of all accidents in the sample, there was some deficiency in the road environment and in up to 8% of cases there was a vehicle fault.

Although the causes of accidents are *multi-factoral*, there are likely to be common reasons for the clustering, ie. why different levels of risk exist (eg. due to poor road geometry, lack of/deterioration in skills of road user group etc.). Hence there should be potential for treating and even removing some of these problems. The targeting of road user groups, locations, routes or areas on the network for special remedial action has been proven to be very effective. For example, many low-cost accident countermeasures like chevron boards on bends have proved to be extremely cost beneficial: the value of accidents saved in just the first year being several times the cost of the scheme's installation.

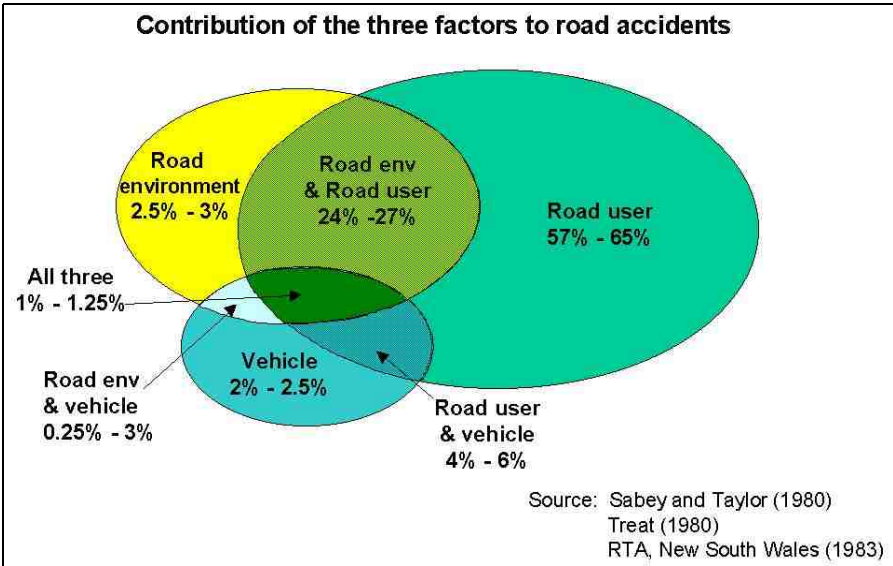


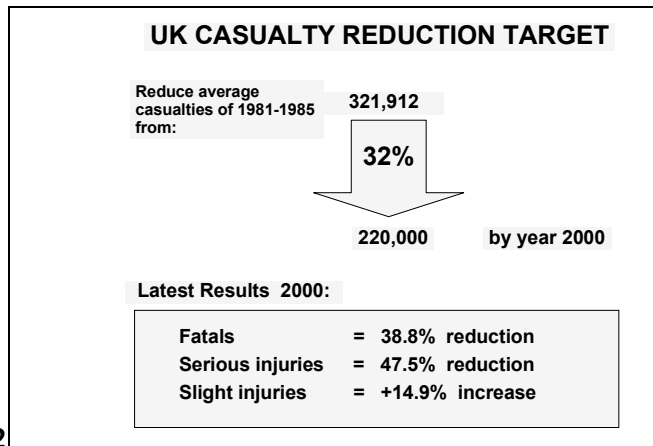
Figure 1

It is likely that if one of the factors is removed (e.g. poor visibility in one direction at a priority T-junction) then the accident event may not actually occur. The fact that in almost a third of accidents in the survey involved a road environment factor has probably been the reason that highway engineers have tended to lead the battle against road accidents in developed countries.

**3 Target setting**

The setting of accident or casualty reduction targets has also proven to be a very useful safety management strategy. As long as the targets are realistic and resources are put in place to make them achievable, it has been found that this often galvanises workers into action to try to achieve it.

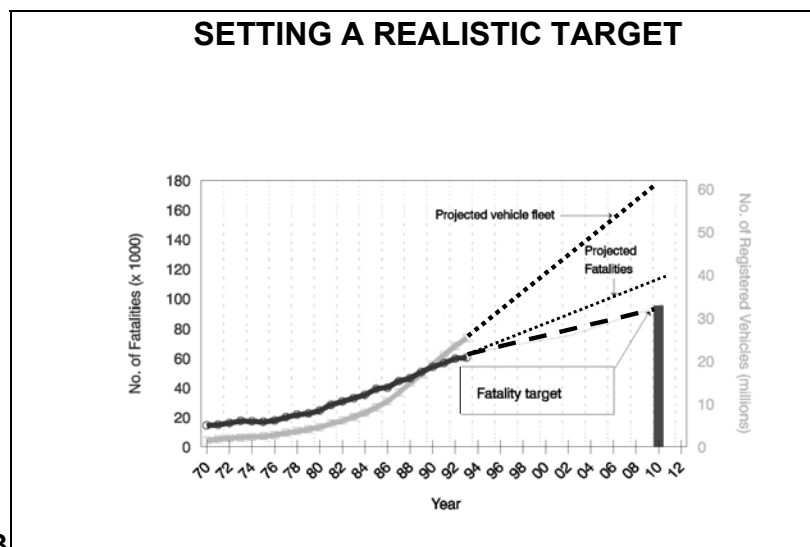
In 1986 the UK government specified a target of reducing all casualties by 32 per cent by the year 2000. It is assumed that largely as a result of all the efforts by the various bodies involved in improving safety, the latest percentage changes, as shown in Figure 2 reveal that this target has been largely achieved. However, whilst the target has been well exceeded for both fatal and severe injuries, accidents resulting in minor injury have actually increased by about 15%. What appears to have happened is that the road environment has been improved and made much more forgiving in many places, resulting in a shift down the severity scale of accidents that do occur.



**Figure 2**

It is important, however, that a realistic target is set so that those involved in trying to achieve it can manage their efforts accordingly and can monitor improvements as the work progresses. The UK targets were based on earlier research that indicated what was likely to be achievable from engineering means. Unfortunately, several countries have appeared to adopt similar casualty percentage reduction targets without this background research and, owing to high traffic growth rates, the targets do not appear to be used effectively as they are certainly not being achieved.

An example from India is shown in Figure 3 where initially a fatality reduction target was set on 1993 figures. This was stated as a reduction in fatality rate to between 10 and 12 per 10,000 registered vehicles by the year 2001 (Baguley and Robson, 1996). In terms of actual fatalities this meant a reduction of between 20 to 33 per cent over a 7-year period. Given the traffic growth simple projection shown in the Figure, this was simply not feasible. A more realistic, though still very challenging target was set by assuming (from experience in countries with relatively low traffic growth), that a 30 percent reduction could be achieved largely by engineering means over a 15-year period. However, it is still necessary to take account of the accident increases that will inevitably occur as a direct result of traffic growth, which means that fatalities will still unfortunately grow in numbers by the year 2010, as shown in Figure 3. However, this would result in a saving of over 18,000 fatalities per year in India which is obviously a very worthwhile result from the extra resources and effort that the government will need to apply.



**Figure 3**

To summarise: it is important to set targets that are challenging but achievable and able to be monitored simply and easily. To this end, it is important to devote some research effort to determining what is appropriate for the country, whether it is quoted in terms of fatalities, casualty numbers or specific road user groups. Although accident rates may be desirable, the author believes that it is still important to state what is required in terms of actual numbers of casualty or accident reductions so that the interested parties can be clear about the precise figures they need to plan to reduce.

## **4 Achieving the targets**

The national targets need to be disaggregated to the local level; that is, the amount each authority responsible for a particular local network should be using. As already stated, this is so that all concerned can be clear what numbers of accidents need to be prevented during each of the years over which the target applies.

### **4.1 Accident investigation Units**

It is the author's belief that the best way of achieving this is to set up an Accident investigation Unit (AIU) within each highway authority who are wholly devoted to this task. It may also be necessary to pass legislation to require the highway authorities to form such Units and to ensure that they do act in this way. This was deemed necessary in the UK in the early 1980's. This will, of course, need new resources to be allocated and a separate annual budget (from the normal maintenance budget) earmarked to cover the costs of not only the Units' operation, but also implementation of the safety improvement schemes they design.

### **4.2 Staffing and responsibilities**

These AIU's will need to be staffed with engineers that are formally trained in accident investigation and prevention techniques and, if not already available, special regular courses will need to be organised. Much of the skill of recognising potential safety problems and designing appropriate countermeasures will, however, probably be gained "on-the-job" within the specialist Unit. It is considered most important that the staff for these Units work full-time on safety and are not simply staff in existing posts with road safety occupying only a proportion of their time. The responsibility of achieving the targets will require them to concentrate fully on the accident reduction goal and not be diverted by other tasks.

As a guide, for the AIU team, the Institution of Highways and Transportation in the UK have recommended that one engineer or technician per 400 to 1000 injury accidents occurring in a region per year is employed full time (IHT, 1990). The suggested responsibilities of the AIU's are listed in Figure 4.

It is considered that one of the AIU's initial and important functions is to try to maintain the integrity of the accident database. It is likely that when AIU's begin to work closely with this database they will find deficiencies, perhaps generally or with particular records, and thus they will need to consult closely with the officers who are responsible for recording accidents. Ideally they would check all records that they receive from the police for logical accuracy and, in particular, check that the location of the accident has been coded correctly. This is necessary since the accident data is the fundamental measure of safety on which they are dependent in order to plan their actions effectively and against which their success or otherwise will be judged.

The other functions of the AIU are discussed in the following sections.

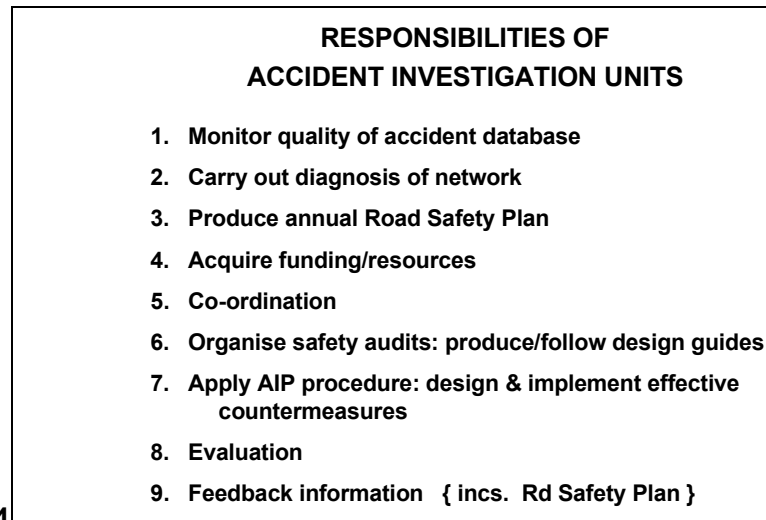


Figure 4

### 4.3 Road Safety Plans

In order that a gradual programme of safety improvement is managed efficiently, it is strongly recommended that all road authorities are required to produce a Road Safety Plan document and that this document is published on an annual basis. This is again considered to be an efficient management tool as it helps to ensure a degree of accountability of the highway authority. The Plans would report the current success or failure towards achieving its individual target and would also provide the public and higher authorities with a valuable record of the efforts the authority is making on their behalf towards improving the safety of the road network.

Within the Plan the local casualty reduction target should be clearly stated and a strategy for achieving the target developed. The authority will need to review existing highways and transportation policy and investigate accident trends for various road user groups in the authority's geographical area.

The Plan should contain background to the road accident situation in the authority area (accident trends with respect to road user groups, road features etc) as illustrated in the UK examples of Figure 5. It should contain a summary of proposals planned (including major capital schemes, smaller remedial engineering work, safety audit, maintenance, costs, relationships with other agencies, and could also include safety publicity and traffic law enforcement). If possible, it is also desirable to illustrate some of these with photographs

It should also describe the methods used for monitoring and evaluation. Indeed one of the most important items of content should be a summary of the previous year's work and effect on accidents. An example of such a table is also shown in Figure 5.

The actual safety work carried out by the AIU would be along the traditional ways of both:-

- a) Accident **Prevention** , and
- b) Accident **Reduction**

Both terms are ways of preventing accidents happening in the future but the actual accident *Prevention* term in this context is taken to be methods of ensuring that unsafe designs are not introduced when a road is initially built or upgraded. This means following all safe design practices and introducing the process of safety audit for new schemes.

Accident *Reduction* requires the AIU to continually monitoring the present road network and follow the accident investigation and prevention process (outlined below) to design and implement a programme of appropriate countermeasures at blackspots.

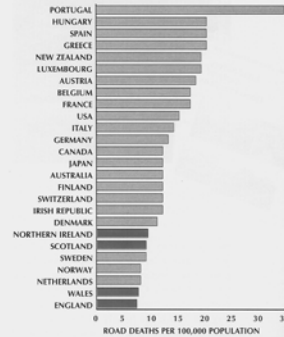
# Examples of Annual Road Safety Plans

## 4. THE CASUALTY PROBLEM

### 4.1 GENERAL

Overall the Scottish record for road safety is... were 399 people... 1993, the lowest... with a range... land was one of... casualties per... However the... safety is less... than the other 25

FIG 4.1: INTERNATIONAL COMPARISON OF ROAD DEATHS 1992

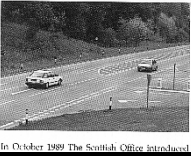


## 5. RECENT AND CURRENT ACTIVITIES

In considering how Scotland's roads might be made safer in the future, it is appropriate to look at how recent road safety policies have helped to bring about casualty reductions. A multi-disciplinary approach is taken to tackle road safety issues through engineering, education, enforcement and encouragement measures. This section outlines recent achievements and current activities in each of these areas.

**5.1 ENGINEERING**  
**5.1.1 Policy and Legislative Activities**  
 The Scottish Office has sought to provide the necessary framework for road safety engineering activities in Scotland through the activities of the National Roads Directorate, part of

calming measures, village gateways and cycling in pedestrianised areas.  
**5.1.2 Executive Responsibilities**  
 The Scottish Office has promoted measures which have significantly improved safety on trunk roads in recent years. On these strategic routes there is a higher proportion of fatal and serious injury incidents than elsewhere on the network and, as through routes, trunk roads carry most of the long distance traffic in Scotland. There are therefore particular, characteristic road safety issues to be tackled and this is being addressed in a number of ways including localised, cost effective roadwidening schemes, route accident reduction plans, mass action plans and road safety audits for schemes to change or improve the network.



ambitious target of one-third compared to the year 2000. By 1995 had fallen by one-third and slight injuries fell. Figure 4.3 shows the principal casualties by the shows progress towards and slight injuries, one for each road reduction,

been achieved, fatal and serious road deaths behind target to required by the small casualties is action required to if achieved by a

FIG 4.2: INTERNATIONAL COMPARISON OF PEDESTRIAN ROAD DEATHS 1992

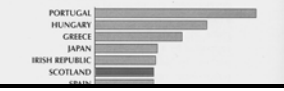


Figure 5

## APPENDIX C

### LOW COST ENGINEERING ACCIDENT REDUCTION MEASURES IMPLEMENTED IN 1990/91 BEFORE & AFTER SUMMARIES

#### Road Humps

Site Location	Cost (£)	No. of Accidents	
		3 yrs Before	3 yrs After
Beech Lane, Earley	8,390	13	5
Boyn Valley Road, Maidenhead	11,500	3	1
St Paul's Ave/Belgrave Rd/Mill St/Petersfield Ave, Slough	20,000	11	4
Honey End Lane/Hogarth Ave/New Lane Hill, Reading	18,000	6	1
Culver Lane/Palmer Park Ave, Reading	12,300	8	0
Long Furlong Drive, Slough	22,200	13	0
<b>TOTAL:</b>	<b>92,390</b>	<b>54</b>	<b>11</b>

#### Red Light Cameras

Site Location	Cost (£)	No. of Accidents	
		3 yrs Before	3 yrs After
A4 London Rd/A33 London St junction, Reading	11,000	7	5
A33 Southampton St/A4 Crownell St junction, Reading	11,000	10	14
<b>TOTAL:</b>	<b>22,000</b>	<b>17</b>	<b>19</b>

#### Traffic Signal Works

Site Location	Cost (£)	No. of Accidents	
		3 yrs Before	3 yrs After
A4/Leigh Road, Slough	30,200	25	10
A4/Twinches Lane, Slough	29,700	13	20
A4/Ipswich Road, Slough	5,500	8	8
<b>TOTAL:</b>	<b>65,400</b>	<b>46</b>	<b>38</b>

#### Surfacing Works

Site Location	Cost (£)	No. of Accidents	
		3 yrs Before	3 yrs After
Tilehurst Rd/Western Elms Ave junction, Reading	4,000	10 (9 wet)	4 (0 wet)
Oxford Rd/Love Lane junction, Donnington	1,200	12 (8 wet)	3 (0 wet)
A330 Church Lane, Winkfield	3,000	4 (4 wet)	0
A4 Langley Road to Lascelles Road, Slough	4,000	13 (10 wet)	4 (2 wet)

#### 4.4 Road safety audits

The AIU should carry out, or at least be responsible for commissioning, safety audits on all new or upgraded road schemes in their area. The road safety audit was first developed in the UK in the early 1980's and is simply a formalised system of checking procedures by independent expert(s) in this field. It gives these road safety engineers the opportunity to feed their experience into the highway design process and should improve awareness of safe design practices by all concerned in road design, construction and maintenance

Safety audit considers the safety of all road users and, in particular, vulnerable road users such as pedestrians, cyclists, motorcyclists, and the visually and mobility impaired. Although it should look at the road from each road user's point of view, it is not concerned with ensuring that provision has been made for every type of road user (the latter would be a road user audit). A safety audit tries to identify potential safety problems and suggest ways in which these problems can be minimised. For example, it would hopefully have suggested that the solid concrete end posts of the steel rail bridge protection shown in Figure 6 was not constructed in this way or was protected by some deflecting, energy-absorbing barrier. This could possibly have prevented the kind of collision shown which, in this case, resulted in a fatality.



Figure 6

The audit process is normally recommended to be carried out at various stages of a new road scheme (see Figure 7).

<b>AUDIT STAGES</b>	
<b>Stage F - Feasibility/initial design</b>	Route choice, standards, impact on the existing network and continuity with it, and junction provision.
<b>Stage 1 - Preliminary design/draft plans</b>	Draft plans: assess horizontal and vertical alignments, sightlines, layout, land implications of junctions, slip roads, lay-bys, road marking and signing in relation to alignments and overtaking strategy. Major changes to the scheme after this stage are limited - land take.
<b>Stage 2 - Detailed design</b>	Before preparation of contract documents, assess details of junction layout, markings, signs and signals, lighting, and impact protection.
<b>Stage 3 - Pre-opening</b>	Essential to drive, cycle and/or walk through the scheme to see it as the road user sees it. N.B. during the hours of darkness as well as in daylight, & poss. inclement weather.

Figure 7



It should be noted that the definitions of when and where audits are performed tend to differ slightly around the world. For example, the 3 or 4 stages listed in Figure 7 are specified for the UK (though the Feasibility stage is not required in many circumstances), whereas Denmark always includes a Feasibility stage as well as an additional Post-opening phase (5 phases). This latter phase is regarded as the monitoring and evaluation process elsewhere.

Different types of Checklists are recommended for differing types of scheme type as a Guide to the auditor, and an example is illustrated in Figure 8. These are particularly useful for new auditors, but the list should be flexible and added to as experience and perhaps new types of applications are developed

<b>CHECKLISTS</b>		<b>ROAD SAFETY AUDIT - Checklist 2 - Detailed Design</b>
		General Review any previous audit in order to allow for subsequent design changes
<b>ROAD SAFETY AUDIT - Checklist 1 - Preliminary Design</b>		Issues extensive at this stage, so the auditing, issues which affect visibility and safety
<b>General</b>  Review any previous audit in order to allow for subsequent design changes For major schemes, determine need for land take for safety requirements		Approach speed
<b>Alignment and Sightlines</b>  Any elements of horizontal and vertical alignments which may produce hazards due to reduced sightlines, especially where these are combined and/ or there are departures from standards Sightlines obstructed by bridge abutments, parapets, landscaping, structures or street furniture		Hazards, without obscuring visibility or  Road perception warnings (e.g. chevrons,
<b>Junctions</b>  Minimising potential conflict points at junctions (including numbers of private accesses) Conspicuity of junctions on approach, and sightlines from minor road approaches and private accesses Control of approach speed, and layout of approach roads Provision for turning traffic Location and access of lay-bys		Network Signal equipment  Ensure clarity to appropriate road user and Signal equipment
<b>Other</b>  Impact of landscaping on visibility and road user perception Concept of road marking/signing for road user perception Provision of safety aids on steep hills Facilities for pedestrians, cyclists and animals Potential for flooding due to inadequate drainage Compatibility with adjacent network at tie-ins Servicing access and maintenance arrangements		to account future growth appropriate species  at vehicle conflicts or roadside objects obscuring visibility  i. bends), which are potentially hazardous  holds to villages or residential areas in

Figure 8

The audit team should always prepare a report which should include a brief description of the scheme, dates of audit, details of team members etc. It should clearly state the road safety problems found (non-safety items identified should be noted in a separate report) and how serious they are, and finally practical recommendations for change should be recorded.

Details of the audit process can be found in IHT, 1990a and PIARC, 2001, and much practical advice based on wide experience is contained in Proctor et al, 2001.

**4.5 Accident Investigation and Prevention: the blackspot treatment process**

As demonstrated by the research summarised in Figure 1, it is now well established that a major contributory factor to many road accidents is inadequacies in the road environment. Thus by investigating locations where accidents are clustering, it is often possible to make appropriate engineering changes, which are often (and ideally), relatively low-cost, then the accident situation at these locations can be significantly improved.

Possibly one of the first highway authorities to demonstrate this was the Greater London Council back in the late 1970's. They evaluated over 200 schemes in London classifying them into different types and their effect on accidents is summarised in Figure 9. The percentage reductions in injury accidents range from 16 to 48 with an average accident saving over all sites of about 25 per cent. If the monetary value is applied to the accidents

that were saved in the first year after installation and expressed as a percentage of the various installation costs (termed the First Year Rate of Return, FYRR), an overall average FYRR of 530 per cent was obtained. Indeed the lower cost schemes like 'signing improvements' or 'parking restrictions' yielded very high figures, recovering over 25 times the cost in the first year alone.

LONDON ACCIDENT REMEDIAL MEASURES ( ~200 SCHEMES)			
	% of all measures	% inj. acs. saved	Typical FYRR (%)
Traffic signals	14	28	400
Lighting	2	16	180
Pedestrian facilities	8	17	320
Signing	2	30	3,660
Parking restriction	2	27	2,530
Channelisation	6	20	640
Road surfacing	19	24	200
Traffic management	4	39	790
Miscellaneous	1	48	1,250
Combinations	42	25	420
<b>OVERALL AVERAGE</b>	<b>100</b>	<b>25</b>	<b>530</b>

Figure 9

The main objective of this engineering safety work is to change the road environment in the most efficient manner (ie. within a specified budget) such that the maximum benefit in terms of accident savings is gained. It is proposed, therefore, that the AIU's use the following suggested 10-step process of accident investigation and prevention.

**STEP 1- Identifying & prioritising sites**

The first task should be concerned with finding out where problem locations exist and the preliminary investigation required in order to determine the nature of the particular safety problems. It is helpful if the highway authority defines its own reaction level above which action should be taken. The accident data ideally covering a period of 3 years can then be searched on computer to produce an initial ranking of sites. These can be:-

- Route action listing in descending order of accident totals (or points) per Section Number per year.
- Single site listing by worst nodes and links, ie. descending order of accidents.
- Mass action sites can be ranked according to numbers of accidents of a selected factor (eg. night-time accidents)
- For Area-wide action, residential areas need to be divided into approximately 1km squares (though irregular shapes bounded by rail lines, roads, rivers etc. will ultimately be used). These areas are usually ranked by numbers of vulnerable road user accidents.

Again using the analysis software, 'stick' diagrams should be made at this point to help look for common patterns of accident.

**STEP 2 - Preliminary accident analysis**

This step can be regarded as refining the ranking by statistical techniques. Before embarking on an in-depth investigation at any site, it is advisable to check that the site has higher numbers of accidents than might be expected, and that this difference is statistically

significant. Simple statistical techniques may be used to test the sites in the first listing to ensure that high accident numbers have not occurred by chance, for example, to determine whether the number of skidding accidents at a site is more than average for the network.

### **STEP 3 - Initial site visit**

The site visit is a very important element of any accident investigation. During the course of an investigation it may be necessary to visit the site several times. The main purpose of the first site visit is to become familiar with the site and to ensure that available plans are up to date and detailed enough to identify specific features which may be contributing to accidents; for example, visibility sight lines, street furniture, buildings.

The investigator should identify the manoeuvres indicated in the accident reports and try to visualise the accidents, particularly those with common characteristics, and a preliminary judgement of causes made. It might be necessary to make visits at different times of the day, or in dark and/or wet conditions, in accordance with the factors revealed in the stick diagram. The sites should be photographed.

Having made these initial visits the sites should, if possible, be classified as 'easy' or 'hard' to treat.

### **STEP 4 - Collection of further data and analysis**

This step is concerned with collecting further data about sites selected for study, and using these to diagnose what are the common prime contributory factors that caused the road users involved in the accidents to "fail to cope", resulting in the actual collisions. This in-depth analysis of an accident site, area or group of road users is necessary in order to devise or select an appropriate remedial measure (or package of measures).

The accident data at the site should be studied in more detail including sketch diagrams produced by the Police investigator, and *collision diagrams* produced, classifying the accidents into types.

The 'stick' diagrams may need to be amended at this stage to include any further information and then searched for dominant accident patterns. Any likely common human factors, for example, any perceptual traps should be identified. Finally any available data such as traffic flow, dates of road alterations etc. should be collated.

### **STEP 5 - Site studies**

A further site visit should be made, looking for likely features which may be contributing to accidents. The engineer should try to detect any common human factors; for example, any perceptual traps should be identified.

Before embarking on expensive new data collection studies it is important to ensure that all existing data about the site has been obtained. Having studied this, together with the accident analysis above, it should then be possible to decide on any necessary studies that are relevant to the actual safety problems at the site. The types of further studies that might be planned at this stage, as necessary, include:-

- Traffic flow manoeuvre counts.
- Pedestrian road crossing flow in marked road lengths - if relevant.
- Speed measurements on approach to junctions or bends - indication of possible problems.
- Still photographs and/or video as a record for report, or use to study problem behaviour.
- Conduct traffic conflict study - most useful at junctions to:-  
    supplement accident data,

help diagnose problems, and use in future evaluation of remedial work implemented.

#### **STEP 6 - Select possible counter measures**

A road hierarchy should have been established and, with this in mind, this step is the selection of a package of possible countermeasures for a site and prioritising the potential treatments. This is done by simply deciding on appropriate objectives of the various safety strategies based on achieving satisfactory accident reductions that match or exceed the expenditure planned.

As an example, a strategy for single site treatment might be:-

- To achieve an accident reduction of at least 33% at treated sites.
- To obtain a significant FYRR.
- To carry out the remedial work at a cost per site not exceeding a fixed maximum amount.

It is desirable to consider a number of alternative proposals for each site.

For every proposal it should be checked that:-

- a) The measures are likely to decrease the type of accident at which they are aimed.
- b) No further increase in other types of accident is likely to occur as a result of the selected measure.
- c) There are not likely to be any unacceptable effects on traffic movement or the environment.

For area-wide residential schemes, the main aim is normally to reduce speeds as opposed to restricting vehicle movements. Good consultation with locals and the emergency services is essential and there is a need to consider whether schemes need to incorporate road user training and media campaigns.

#### **STEP 7 - Prioritise treatments & sites**

This step is concerned with prioritising of the selected sites and potential treatments from a package of possible countermeasures for each site. The selection of countermeasures to be implemented should be based on achieving satisfactory accident reductions whose cost savings match or exceed the expenditure planned. The costs and benefits of each treatment need to be estimated, as well as any estimate of any disbenefits.

Sites are then normally selected on the most cost-effective solution in terms of best First Year Rate of Return (FYRR) or best Net Present Value (NPV) to Present Value Cost (PVC) ratio. A list can then be drawn up of sites in priority order of best NPV/PVC ratio, and a line drawn above which will be the sites that can be treated in the current year within the available budget.

#### **STEP 8 - Detailed design & installation**

Having selected an appropriate measure or package of measures to deal with the accident problem(s) at a site or area, the next stage is detailed design and implementation. In general construction standards should be those used for general highway construction.

It is advised that even for specific safety improvements, a road safety audit be carried out at the design stage and immediately before opening to traffic; and that adequate safety standards are followed at the improvement construction site.

A log of dates of the works and of actual costs should, of course, be maintained, not least for future evaluation.

### ***STEP 9 - Monitoring***

Having introduced a countermeasure or package of measures it is important to establish the effectiveness of the safety engineering work carried out; first to check that nothing has gone wrong and that it is working as intended, and later to learn lessons which may influence future decisions on improvements.

Monitoring should be carried out at different levels: for the whole area covered by the road authority, immediately after each individual scheme, and for longer-term conclusions. Variables other than accident frequency can be used to monitor the effectiveness, particularly in relation to the objectives of the particular countermeasure. A series of other measurements are strongly recommended for area-wide schemes.

It is important to monitor other surrounding areas which could be affected by the scheme and to identify as large a group of control sites as possible of similar nature but well away from the study sites.

### ***STEP 10 - Evaluation***

Remedial action schemes should always be evaluated so that knowledge can be gained about relative performances. This will assist decision-making on efficient allocation of resources in the future.

Statistical tests should be used in before and after studies to compare accident changes at the treated sites with the control sites. The investigator should make allowance for the known other factors that can affect the estimate of the effect of the measure on accidents (eg. regression-to-mean effect).

As a guide to overall effectiveness of a road authority's road safety programme, and for other authorities to learn from their experience, a summary list of individual schemes, grouped in an appropriate manner, should be produced and included in the Road Safety Plan document as already discussed in Section 4.3 above.

## **5 Conclusions**

As one of the largest and expanding nations in the world, China also suffers one of the largest injury and death tolls on its road network than any other country. The authority in charge of the highways in a region or small local area has a duty to the public to try to ensure that their network is operating much more safely than it is at present. It is believed that road safety can be improved considerably by proper management of the highway engineering aspects, and this paper has focussed on these.

It has been recommended that central government should review and set achievable accident or casualty reduction targets as a management tool which can provide the initial challenge to generate road improvement activity. It must also, of course, allocate appropriate resources and funding to fuel this activity.

It is suggested that the most effective way of ensuring effective safety improvements by means of road engineering is to require highway authorities to set up accident investigation units (AIU's) working in close collaboration with the traffic police. The paper has outlined the two main approaches that the AIU's would employ to tackle safety improvement, namely by accident prevention and accident reduction techniques. Safety audits have been described in brief as an effective way of ensuring that new roads are built or upgraded without building in new safety problems. Finally a 10-step process for managing blackspot improvements following the proven accident investigation and prevention process has also been proposed.

By considering and following all or some of these suggestions, it is hoped that China can add to the current efforts it is making in reducing accidents, and that these will help accelerate that process. Significant success needs to be gained as early as possible in reducing the vast amount of human suffering that road accidents create on a daily basis throughout China.

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