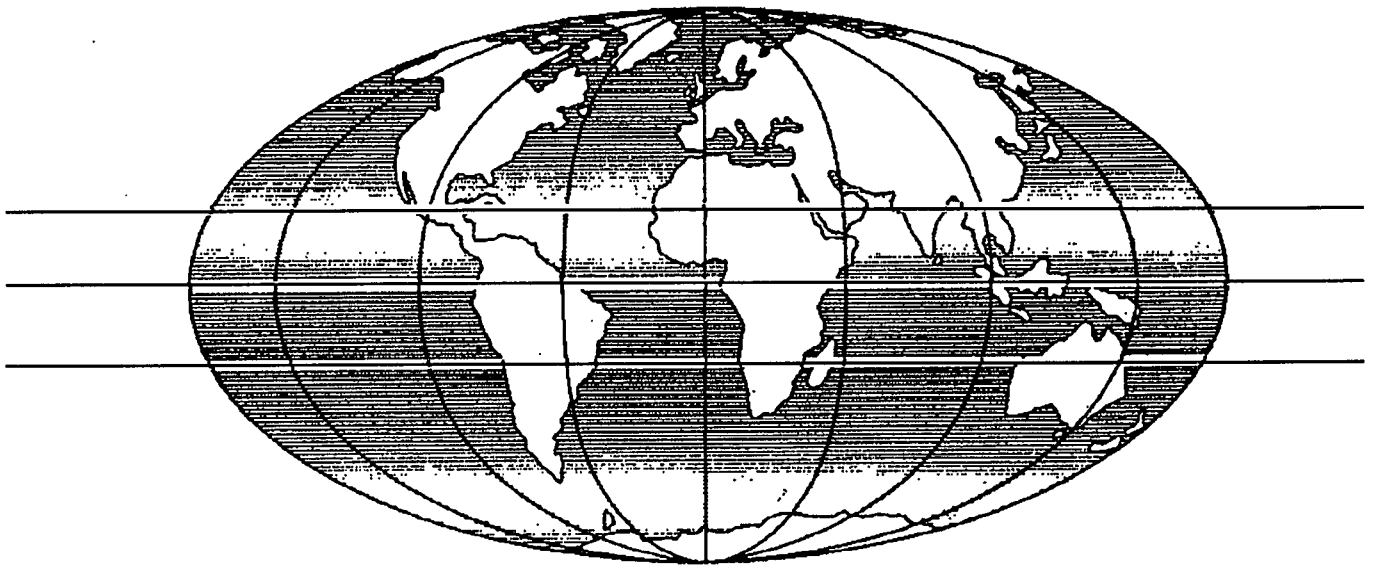




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# ENGINEERING APPROACHES TO ACCIDENT REDUCTION AND PREVENTION IN DEVELOPING COUNTRIES

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## ABSTRACT

*Although road accidents are usually the result of mistakes made by road users, it is clear that poor road design and planning will often have contributed to or compounded these errors. Many developing countries have outdated or inappropriate design standards and modern accident prevention and reduction methods have yet to be introduced in spite of their considerable potential. Therefore, to encourage more effective approaches, the TRRL has published a road safety Guide for planners and engineers and begun a program of evaluating improvements. This paper outlines some of the key principles contained in the Guide and includes an example of one of the Overseas Unit's joint evaluation studies being carried out in SE Asia.*

## 1. ENGINEERS' ATTITUDES TO ROAD SAFETY

'Road accidents are not the fault of my roads ... It's all the fault of those reckless drivers and pedestrians who use them.' This view, which was heard during the 1960s, could be regarded as epitomising the attitude of many—but not all—highway engineers up to that time. Then, it was the problems of construction and maintenance that almost entirely dominated their concerns. Attitudes in many developed countries have greatly changed since that time, to such an extent that now in the United Kingdom, for example, it is the highway engineers and planners who are leading the attack on the road accident problem. One of the main reasons for this change of attitude has been the increased appreciation of the fact that planning and engineering improvements can reduce the opportunities for road-users to make errors; and that when errors do occur, the environment can be made to be more forgiving.

In developing countries, it would seem that past attitudes still predominate, with planners and engineers still almost exclusively pre-occupied with the problems of construction and maintenance. All too frequently, roads and road systems are being built or upgraded with little consideration being given to road safety; as a result blackspots are still being created. One of the main objectives, therefore, of the recently published TRRL Guide 'Towards Safer Roads in Developing Countries' was to bring safety to the forefront of the minds of these planners and engineers. This paper describes the background to why the Guide was developed. It outlines some of the key safety principles that the Guide contains, and gives an example of its approach from the Overseas Unit's joint evaluation studies in Papua New Guinea (PNG).

## 2. TRRL ROAD SAFETY RESEARCH IN DEVELOPING COUNTRIES

The Overseas Unit of TRRL has been engaged in road safety research in developing countries since 1972; this research has recently been reviewed by Downing, Baguley and Hills (1991). The key findings of the early studies were:

- accident rates in terms of fatalities/10,000 vehicles registered were typically 20 or more times those of developed countries (Jacobs *et al.* 1973).
- the economic cost of road accidents in developing countries was in the region of 1 per cent of their Gross Domestic Product, that is proportionately just as much as in developing countries, despite the lower levels of motorisation (Fouracre and Jacobs 1976).
- road accidents were a major cause of death, particularly amongst 5-44 year olds (Jacobs and Bardsley 1977). Recently, it has been estimated that 350,000 people per year are killed on the roads of developing countries out of an estimated world-wide total of 500,000 (World Bank 1990).

This early TRRL research attributed the high levels of casualties in developing countries to a wide range of factors (Jacobs 1977):

- (i) road-users' attitudes and behaviour;
- (ii) the traffic mix, and the condition and use of vehicles; and
- (iii) the design and state of the roads themselves.

In 1979, the Overseas Unit carried out a review of research needs for road safety in developing countries (Hills and Downing 1980). *Table 1* summarises the problems seen in transferring developed country experience with accident countermeasures to developing countries. It was clear that certain designs and countermeasures (e.g. standard pedestrian crossings) were inappropriate for many, but not all, developing countries. It was therefore concluded that appropriate solutions should be developed and that a key objective should be to EVALUATE such improvements by field trials. In order to implement and evaluate these measures it was also evident that a good, suitable road accident database was needed.

To help meet the requirements identified by the review, the Overseas Unit directed its research into the design of police accident report forms (Gaber and Yerrell 1983), the development of the TRRL Microcomputer Accident Analysis Package (Hills and Elliott 1986), and a program of countermeasure research (Hills, Thompson and Kila 1991; Sayer, Baguley and Downing 1991).

## 3. 'TOWARDS SAFER ROADS IN DEVELOPING COUNTRIES' DESIGN GUIDE

In many developing countries regional planners and engineers face very real problems in acquiring the latest road safety information. This lack of advice is likely to result in low levels of awareness of the potential of engineering

Table 1  
The problems of technology transfer for road safety (from Hills and Downing, 1980)

ROAD SAFETY COUNTERMEASURES: DEVELOPED v. DEVELOPING COUNTRIES	
1.	Wide differences in behaviour/attitudes
2.	Wide differences in roads/traffic
3.	Differences in the 'appropriateness' of measures
Conclusion: Need to develop and EVALUATE appropriate measures in developing countries	

improvements and to design and planning errors being repeated. Therefore, to encourage countries to adopt appropriate solutions and at the same time to help them learn from other countries experiences, the TRRL initiated the development of its comprehensive guide 'Towards Safer Roads in Developing Countries'.

### 3.1 Objectives of the Guide

The Guide was designed to be a first point of reference on road safety issues.

The specific objectives of the Guide are:

- (i) to bring safety to the forefront of the minds of planners and engineers practising in developing countries and to bring to their attention important details of design affecting road safety that they might otherwise overlook or consider insignificant;
- (ii) to act as an introduction for policy-makers in developing countries and aid agencies to the wide range of issues in highway planning and design that can affect road accident rates and the mitigating actions which can be taken to reduce the number and severity of road accidents;
- (iii) to bring together in a single document the joint experience of the Overseas Unit, TRRL and those UK consultants who have had significant developing country experience in road safety and traffic engineering, together with relevant material from standards, guidelines and design guides of developed countries to act as a first source of information for professionals in developing countries;
- (iv) to act as a source of ideas for new designs and countermeasures so that hazardous locations in developing countries can be made safer; and
- (v) to stimulate evaluation of and research into road safety countermeasures in developing countries so that the most effective can be identified.

### 3.2 Development of the Guide

The Guide was developed in association with the Ross Silcock Partnership. In writing it, the authors were well aware of the need for much more developing country research but at the same time they recognised the urgent need for such a document and that there was a considerable amount of useful advice which could be given. Also there was reason to believe that many of the underlying general principles for planning and engineering design that effect safety were to some extent universal although the differences stressed in *Table 1* above indicated the need for more emphasis on low cost and self-enforcing measures. The Guide therefore draws upon appropriate material from many existing manuals and standards and relates these to the typical conditions found in developing countries.

### 3.3 Structure and Format of the Guide

The four main parts of the Guide are:

- I Introduction
- II Planning and Design
- III Operations and Countermeasures
- IV Road Safety Checklists

The main body of the Guide uses a double page format to deal with a particular topic (see *Fig. 1*). Each topic makes up a free standing section, consisting of an Introductory/Background panel and a Problems panel on the left hand page, a Possible Solutions/Benefits panel on the right hand page and a Summary Panel running across the bottom. Each Problems and Solutions panel incorporates either photographs or diagrams to illustrate good and bad practices. The origins of this format can be found in papers by Hills and Downing (1980), Ross (1984) and *Fig. 2*, which is taken from TRRL Overseas Road Note 5 (TRRL 1988).

### 3.4 Accident Prevention and Reduction

The two largest sections of the Guide, Parts II and III deal separately with two distinct planning/engineering mechanisms for improving safety:

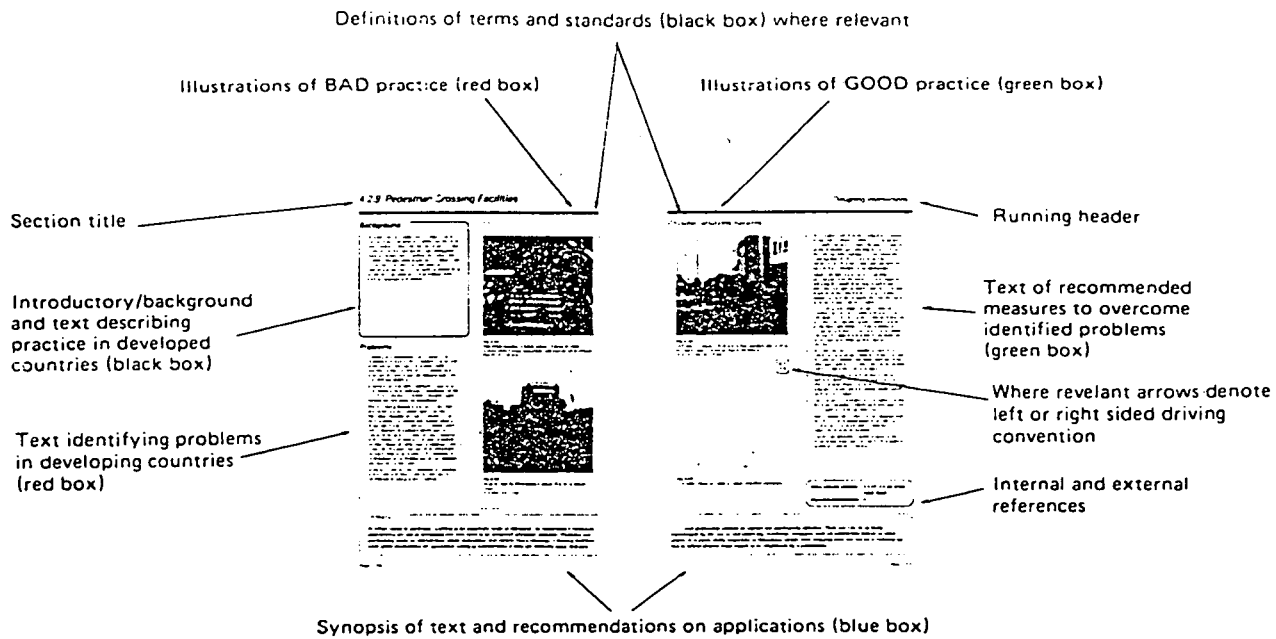


Fig.1 General format of each double page

	Undesirable	Desirable	Principle applied
Route planning		 + Land use controls	Major routes should by-pass towns and villages
Town planning			Maximum possible use of cul-de-sacs and loops in residential areas
Road layout	(i) (ii)		Gently curving roads have lowest accident rates
Roadside access			Prohibit direct frontal access to major routes. Use Service Roads
			Use lay-bys or widened shoulders to allow villagers to sell local produce

Fig.2 Examples of planning and engineering design that affect road safety

- (1) ACCIDENT PREVENTION, resulting from good 'safety conscious' standards of design and planning of *new* road schemes and related development; and
- (2) ACCIDENT REDUCTION, resulting from remedial measures applied to problems identified in the *existing* road network.

### 3.4.1 Accident Prevention and Planning

Examples of key planning principles are listed in *Table 2* and illustrated in *Fig. 2*. The Guide puts considerable emphasis on the need to establish the road hierarchy within a road network and discusses the function and design of each level. An example of a 'safety principle' for this particular topic is:

'Each road should intersect only with roads in the same class or one immediately above or below it in the hierarchy.'

Planning and road safety are also considered for different land uses. The planning of residential areas has received particular attention in developed countries over the past 20 years (e.g. Dept of Transport 1977).

### 3.4.2 Accident Prevention and Geometric Design

Early research by Jacobs (1976) showed that, for Jamaica, reducing road width may have had a much more severe effect on accident rates than in a typical developed country. Also Kosasih, Robinson and Snell (1987) examined geometric design research and standards around the world, and made recommendations for developing countries; these have been incorporated in the Guide. The TRRL Overseas Unit currently has a research program in Papua New Guinea that is examining the effects of certain highway design elements on accident rates, in particular the road cross-sectional profile.

TABLE 2  
Some recent approaches to improving the safety of the road environment in developed countries

<p>ACCIDENT PREVENTION: Improved planning and design of new roads and developments<sup>1</sup>. Basic principles include:</p> <ul style="list-style-type: none"> <li>* Land-use should be distributed to minimise vehicle trips and pedestrian vehicle conflicts.</li> <li>* Networks should be classified into a hierarchy with the emphasis on speed management.</li> <li>* Layouts of roads in residential areas should be designed to keep out through traffic and keep speeds down to appropriate levels<sup>2</sup></li> <li>* New schemes should be checked for safety ie road safety audits<sup>3</sup>.</li> </ul> <p>ACCIDENT REDUCTION: Application of cost effective measures on existing roads.</p> <ul style="list-style-type: none"> <li>* Low-cost engineering improvements at hazardous locations<sup>4,5</sup>.</li> <li>* Area (urban) wide schemes<sup>6,7,8</sup>.</li> <li>* Traffic calming<sup>9</sup>.</li> </ul>
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References for Table 2:

- |                              |                                   |                          |
|------------------------------|-----------------------------------|--------------------------|
| 1 = IIT, 1990 and 1991;      | 2 = DoE/Dtp, 1977;                | 3 = IIT, 1990;           |
| 4 = Dept of Transport, 1986; | 5 = Helliar-Symons & Lynam, 1989; | 6 = Mackie et al., 1990; |
| 7 = OECD, 1979;              | 8 = OECD, 1990;                   | 9 = Tolley, 1990         |

It must be acknowledged, however, that much more research is required before optimum standards can be determined for all developing countries. Many developing countries have just adopted standards from developed countries or have modified such standards without evaluating the consequences; but, as observed in Section 2, the traffic mix and road usage is often very different in a developing country from that encountered in more industrialised countries. The Guide encourages highway engineers to incorporate the needs of all road-users into their designs. For example, in certain countries, high numbers of pedestrians on rural highways can be observed and, in other countries, there are high proportions of two-wheeled vehicles. In either case, consideration should be given to special provisions for these road-users; a good example of this is in Malaysia, where a motorcycle lane has been constructed from Kuala Lumpur to Kelang; and in Papua New Guinea, some 10 km of footpath alongside the Highlands Highway are under construction using local village labour (as part of a joint PNG/TRRL research program). Also, there is usually a greater need to minimise costs; the challenge for developing countries is to achieve this whilst at the same time maintaining an acceptable level of safety.

### 3.4.3 Accident Reduction

Table 2 lists some key approaches used by developed countries for accident reduction and they offer considerable potential for developing countries. In particular, it is recommended that countries with limited resources should place initial emphasis on introducing low-cost improvement schemes at hazardous locations. Such schemes have proved very effective in industrialised countries; for example, in a survey of UK schemes (Helliar-Symons and Lynam 1989) First Year Rates of Return were estimated to range from 65 to 950 per cent. The application of this approach in a developing country (Papua New Guinea) was described in an earlier REAAA paper (Hills *et al.* 1990). The techniques of accident investigation at hazardous locations are summarised in the Guide and numerous

examples of countermeasures given from both developing and developed countries.

A few developing countries have begun to introduce low-cost engineering schemes on a trial basis and the Overseas Unit is currently carrying out joint research to evaluate their effectiveness in Egypt, Ghana, Indonesia, Malaysia, Pakistan and Papua New Guinea (Sayer *et al.* 1991; Hills *et al.* 1991). Emphasis (in the trials) has been placed on testing self-enforcing measures and some of the schemes often aimed at helping the most vulnerable road-users are described in subsequent papers of this session. These trials, which have been made possible by the introduction of the TRRL Microcomputer Accident Analysis Package (see section 2), are still at an early stage with many sites not yet improved. However, preliminary findings indicate that countries which have relatively low levels of road-user discipline are less likely to have success with measures which are not self-enforcing such as road signs and markings. For example, a study in Pakistan of the effects of introducing stop lines and lane lines at junctions and no overtaking lines at bends indicated no improvements in driver behaviour apart from a small reduction in overtaking violations from 19 to 14 per cent (Downing 1985). On the other hand, preliminary results from Papua New Guinea indicate that the introduction of roundabouts at uncontrolled major/minor junctions has halved the average injury accident rate (Hills *et al.* 1991).

### 3.4.4 The Importance of Evaluation

The summary of developed and developing country differences in Table 1 concluded that it was as important for developing countries as it was for developed countries to evaluate their road safety (and traffic management) schemes. In this section, this point is emphasised with the analysis of a scheme carried out in Port Moresby, Papua New Guinea.

During 1986, a 300 m section of the Hubert Murray Highway in Port Moresby was upgraded from a single carriageway to a dual carriageway.



This involved associated road widening and the closure of one T-junction. The scheme was carried out more for traffic management purposes than for road safety. For the pedestrian, the median helps the crossing task but the inevitable increase in vehicle speeds will have made judgements more difficult. ('Before and After' speed measurements are not available as the scheme began before the research program got under way.)

Table 3 shows an analysis of accidents along the stretch of road for the period 1982-1989. The analysis was carried out using the TRRL Microcomputer Accident Analysis package. It can be seen that Head On, Rear End, 90 Degree and Sideswipe accidents halved after the scheme; these accidents were large in number but their severity was almost exclusively minor injury or damage only. On the other hand, 'Hit object off the road' and Pedestrian accidents show a

completely opposite picture: they have doubled since the scheme was introduced, and although they are small in number, they are high in severity, with eight out of the 22 accidents being fatal or resulting in hospitalisation (six were pedestrians). The need to prevent pedestrian accidents on this section of road has thus become a high priority, despite there being a very large drop in accident numbers.

It might have been predicted that the central median would have improved pedestrian safety, but the analysis guide 'Towards Safer Roads in Developing Countries' will accelerate the necessary change in attitudes and put safety firmly in the minds of engineers and planners at the very first stages of design. Initial reactions to the Guide have been very favourable and a slide training package is planned to further assist with dissemination.

TABLE 3

Hubert Murray Highway, Boroko, NCD: The effects on accidents of constructing 300m of central reservation in 1986.

ACCIDENT TYPE	BEFORE SCHEME				AFTER SCHEME			
	82	83	84	85	86	87	88	89
Head On	5	1	6	8	3	1	0	0
Rear End	24	30	22	17	17	8	8	12
90 degree	6	6	10	7	1	2	3	2
Sideswipe	7	10	11	10	7	5	3	7
<b>SUB-TOTAL</b>	<b>42</b>	<b>47</b>	<b>49</b>	<b>42</b>	<b>28</b>	<b>16</b>	<b>14</b>	<b>21</b>
Hit Object Off Road	0	1	0	2	0	3	1	3
Pedestrian	1	0	1	2	1	2	2	3
<b>SUB-TOTAL</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>1</b>	<b>5</b>	<b>3</b>	<b>6</b>
<b>ALL ACCIDENTS</b>	<b>43</b>	<b>49</b>	<b>50</b>	<b>46</b>	<b>30</b>	<b>21</b>	<b>18</b>	<b>28</b>

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