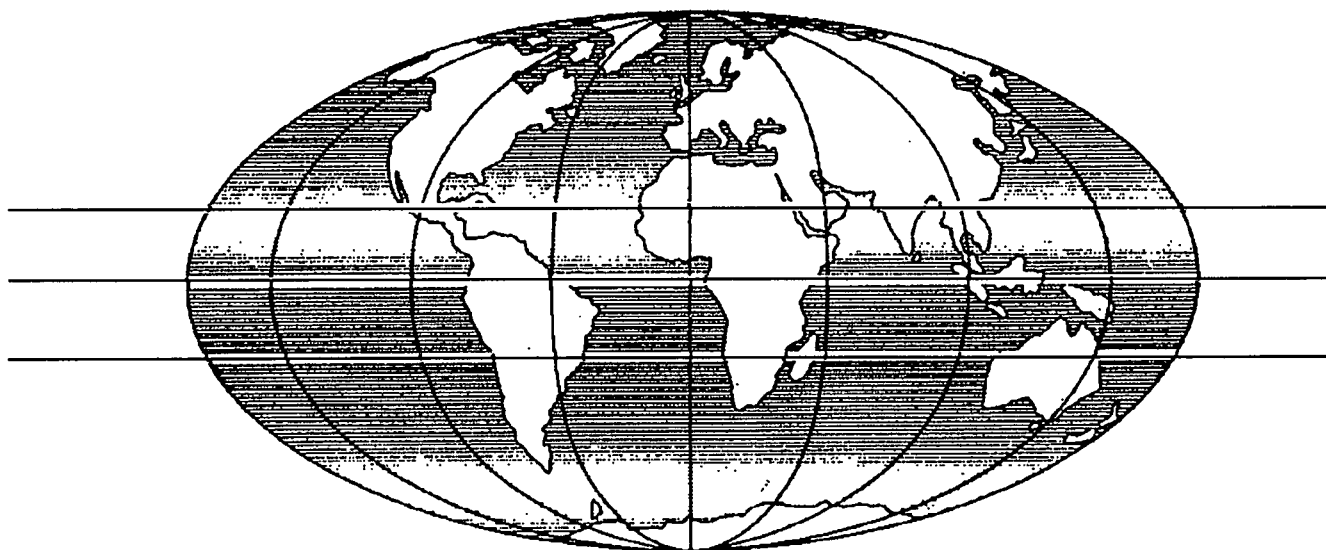




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**Engineering Approaches To Accident Reduction & Prevention
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Engineering Approaches To Accident Reduction & Prevention in Developing Countries

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ABSTRACT

Although road accidents are usually the result of a range of contributory factors, the most common being road user error, 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 Many developing countries have outdated or inappropriate design standards and modern accident prevention and reduction methods have yet to be introduced in spite of their considerable potential. In order to encourage more effective approaches, TRL has published a road safety Guide for planners and engineers and begun a programme of evaluating improvements. This paper outlines some of the key principles contained in the Guide and includes an example of a joint evaluation study being carried out in a developing country.

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 was often heard during the 1960's, and perhaps could be regarded as epitomising the attitude of many - but not all - highway engineers up to that time. It was then 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 road safety objectives, therefore, of TRL's Overseas Centre was to produce a Guide which would bring safety to the forefront of the minds of these planners and engineers. This paper describes the background to why the Guide, "Towards Safer Roads in Developing Countries" (TRL, 1991) was developed. It outlines some of the key safety principles that the Guide contains, and gives an example of its approach from the Overseas Centre's joint evaluation studies in Papua New Guinea (PNG).

2. TRL ROAD SAFETY RESEARCH IN DEVELOPING COUNTRIES

The Overseas Centre of TRL has been engaged in road safety research in developing countries since 1972. This research was reviewed by Downing, Baguley & Hills (1991) and 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 and Hutchinson 1973); and even today a few have rates over 100 times that of the United Kingdom (Jacobs & Baguley, 1995).
- the economic cost of road accidents in developing countries was in the region of 1% of their Gross Domestic Product, that is proportionately just as much as in developed countries, despite the lower levels of motorisation (Fouracre & Jacobs, 1976).
- road accidents were a major cause of death, particularly amongst 5-44 year olds (Jacobs & Bardsley, 1977). 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 TRL 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 Centre 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 (eg 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 Centre directed its research into the design of police accident report forms (Gaber & Yerrell, 1983), the development of the TRL Microcomputer Accident Analysis Package (Hills and Elliott, 1986), and a programme of countermeasure research (Hills, Thompson and Kila, 1991; Sayer, Baguley and Downing, 1991).

TABLE 1

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

<p style="text-align: center;">ROAD SAFETY COUNTERMEASURES: DEVELOPED v. DEVELOPING COUNTRIES</p> <ol style="list-style-type: none">1. Wide differences in behaviour/attitudes2. Wide differences in roads/traffic3. Differences in the 'appropriateness' of measures <p>Conclusion: Need to develop and EVALUATE appropriate measures in developing countries</p>
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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 lead to low levels of awareness of the potential of engineering 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, TRL 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 Centre, TRL 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 affect 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 free standing, double page format to deal with a particular topic. Each topic consists 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 Figure 1, which is taken from TRL 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:

- 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 Figure 1. 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 (eg Dept of Transport, 1977).

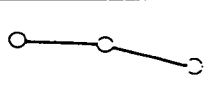

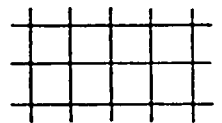

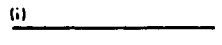


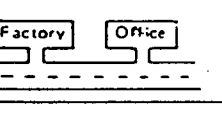
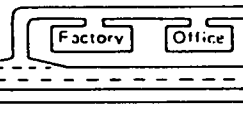
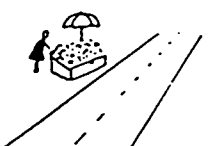

	Undesirable	Desirable	Principle applied
Route planning			Major routes should by-pass towns and villages
Town planning			Maximum possible use of cul-de-sacs and loops in residential areas
Road layout	(i)  (iii) 		Gently curving roads have lowest accident rates
Roadside access			Prohibit direct frontal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

Figure 1 Early examples of planning & engineering design concepts that affect road safety

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

<p>ACCIDENT PREVENTION:</p> <ul style="list-style-type: none"> * Land-use should be distributed to minimise vehicle trips and pedestrian vehicle conflicts. * Networks should be classified into a hierarchy with the emphasis on speed management. * Layouts of roads in residential areas should be designed to keep out through traffic and keep speeds down to appropriate levels² * New schemes should be checked for safety ie road safety audits³. 	<p>Improved planning and design of new roads and developments¹. Basic principles include:</p>
<p>ACCIDENT REDUCTION:</p> <ul style="list-style-type: none"> * Low-cost engineering improvements at hazardous locations^{4,5}. * Area (urban) wide schemes^{6,7,8}. * Traffic calming⁹. 	<p>Application of cost effective measures on existing roads.</p>

References for Table 2:

- | | | |
|------------------------------|-----------------------------------|--------------------------|
| 1 = IHT, 1990 and 1991; | 2 = DoE/Dtp, 1977; | 3 = IHT, 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 |

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 TRL Overseas Centre currently has a research programme in Papua New Guinea that is examining the effects of certain highway design elements on accident rates, in particular the road cross-sectional profile.

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 with segregated junctions 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/TRL research programme). 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 (Helliard-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) is described elsewhere (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 Centre 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 measures that are self-enforcing and also on schemes aimed at helping the most vulnerable road-users. These trials, which have been made possible by the introduction of the TRL 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 300m 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 programme 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 TRL 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 clearly shows that this was not the case. This study illustrates the value of evaluating schemes in some depth so that both benefits and disbenefits can be identified and quantified. With this information, future schemes can be modified and the optimum benefits obtained.

3.4.5 Checklists

The Design Guide also contains two sections comprised of basic road safety checklists. The first section is concerned with accident prevention (see section 3.3) and contains a series of checklists that are intended to be used as a formalised system of checking that should be carried out at the planning and design stage, now commonly referred to as the "Safety Audit". Safety Audit procedures are rapidly being adopted in many industrialised countries as a simple way of ensuring that the chances of unsafe roads being constructed are reduced to a minimum. It is generally considered important that application of the checklists should be carried out by independent persons who are not involved in the detailed planning and/or design.

TABLE 3

Hubert Murray Highway, Port Moresby, Papua New Guinea: The effects on accidents of constructing 300m of central reservation in 1986.

ACCIDENT TYPE	BEFORE SCHEME				Implem-entation	AFTER SCHEME		
	82	83	84	85		86	87	88
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
SUB-TOTAL	42	47	49	42	28	16	14	21
Hit Object Off Road	0	1	0	2	0	3	1	3
Pedestrian	1	0	1	2	1	2	2	3
SUB-TOTAL	1	1	1	4	1	5	3	6
TOTAL ACCI-DENTS	43	48	50	46	29	21	17	27

The second series of checklists in the Guide is concerned with the process of accident reduction and refers to specific accident types; it provides a list of possible inadequacies in the existing road layout which might be contributory to each type and which the accident investigator should consider when analysing blackspots.

All the checklists are presented as a series of questions under various planning, design and countermeasure topics. It is inevitable that these general checklists will not cover every safety issue in every country and thus it is recommended that users modify the lists as necessary for their local conditions.

4. CONCLUDING REMARKS

Ten years ago, road safety professionals visiting a developing country for the first time might have been shocked to find that road safety in general, and the problems of the pedestrian in particular, were not priorities in Planning and Highway Engineering departments. Sadly, even today it is possible to see young countries building some of the

mistakes into their road networks that countries in Europe and North America are now spending large amounts of money to correct. Undoubtedly, there are signs that engineers in developing countries are becoming more safety conscious, but greater impetus is required. It is sincerely hoped that the new TRRL 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. Reactions to the Guide have been very favourable with well over 5,000 copies having been distributed (largely with ODA funding) around the world. A training pack using material from the Guide and containing about 200 slides has recently been completed to assist those providing training for road engineers and planners.

5. ACKNOWLEDGEMENTS

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