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TITLE **Seminar on road safety, Malaysia : Improving safety by road engineering : Proposals for getting back on track**

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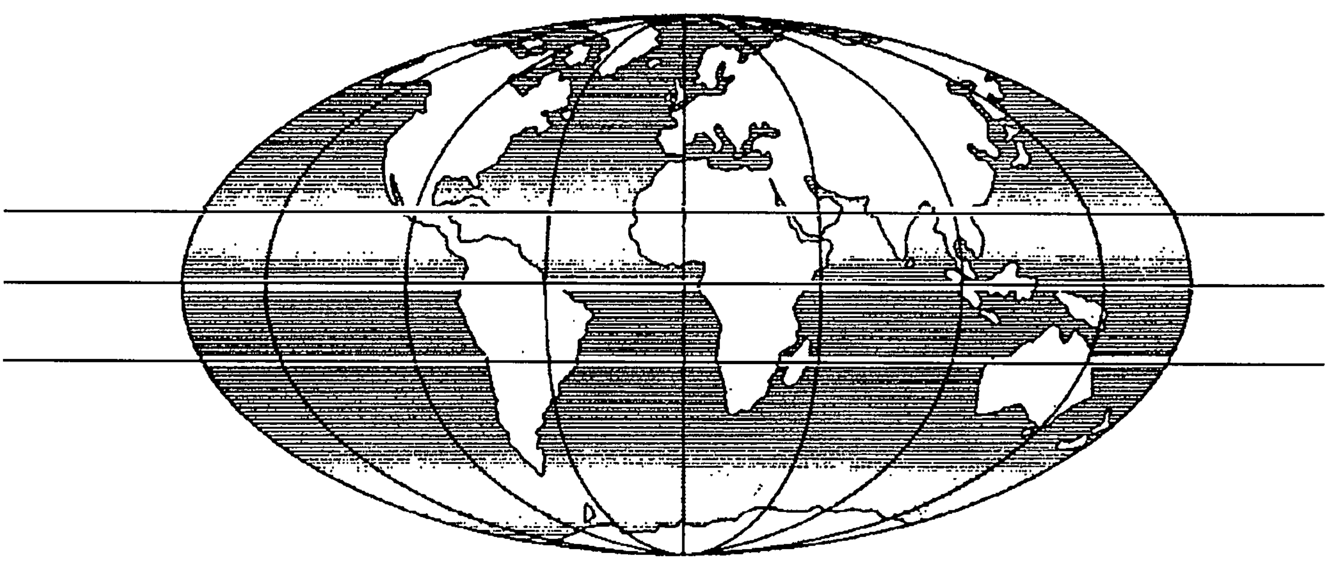

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BAGULEY, C J (1995). Improving safety by road engineering: proposals for getting back on track. In: *Proceedings of Seminar on Road Safety: The Engineering Contribution Towards The National Reduction Target. Ministry of Works, Kuala Lumpur. January 1995.*

IMPROVING SAFETY BY ROAD ENGINEERING : PROPOSALS FOR GETTING BACK ON TRACK

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1. INTRODUCTION

From the earlier papers[1,2] it has hopefully been established that much more effort is necessary in trying to reduce the road accident casualty toll by as many different groups as possible (the integrated approach). Policemen attending the scene of accidents are not generally trained in recognising road engineering factors that may have contributed to a particular accident, and tend to favour attributing blame solely to the road user(s) involved. The human error aspect is certainly an extremely important accident factor to tackle but, as Fig. 1 shows, the most common classification of error recorded by the Police for both male and female drivers or riders is that of "careless driving". This constitutes almost half of all errors recorded. Whilst it is recognised that better training, media campaigns and enforcement should have a positive effect on other driver errors such as "close following" or "speeding" or errors of judgement made when "overtaking" or making "turning" manoeuvres, they are likely to be less effective in changing this main accident group caused by "careless driving".

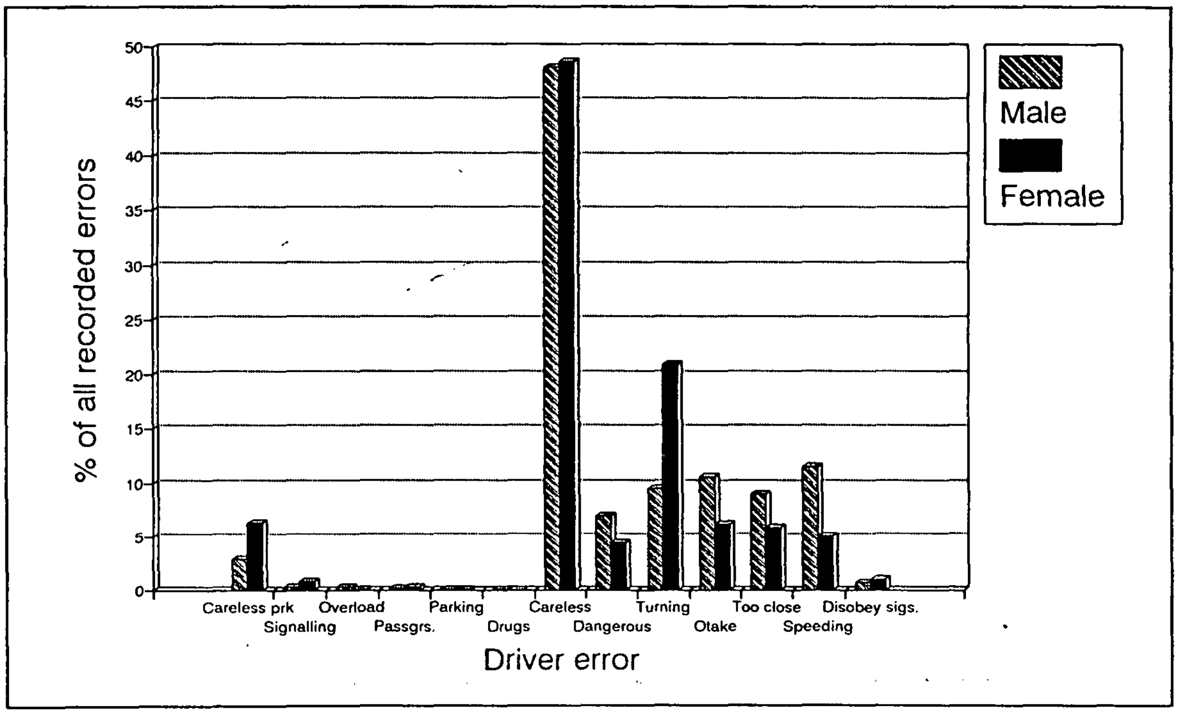

Fig. 1 Driver errors in all injury road accidents in 1992 and 1993

Road engineering, therefore, even has an important role to play here in making the road environment as "forgiving" as possible when such careless driving accidents occur. This is, of course, in addition to ensuring that the road geometry and condition minimise the chances for drivers to make mistakes and allow adequate space for effective evasive action when mistakes are made.

This paper focuses its proposals on changes in the institutional setup which it is hoped will increase the contribution that is being made by road engineers. It also introduces a new interim accident investigation guide entitled "The identifying, prioritising and treatment of hazardous locations in Malaysia" to assist in the process of change.

2. SOME GENERAL INFERENCES FROM AVAILABLE ACCIDENT DATA

As an example of some of the general areas in which engineering could contribute to improvement and also the use that can be made of the accident database and software analysis package, MAAP[3], let us first look at the 1992 and 1993 national data. The relevant database for these years and the MAAP software should, incidentally, now be available for use by all road authorities in Malaysia.

2.1 Vulnerable road users

The major casualty problem of two-wheeled riders is well known and has already been discussed in a previous paper[1]. Let us therefore first look at the types of location where two-wheeler vehicle accidents occurred. Fig. 2 shows the broad geometric features of roads where these accidents (involving at least one motorcycle or bicycle) were located on the urban and rural road networks. Perhaps surprisingly, 3.2 times more accidents occurred on straight roads or bends than at junctions on rural roads; and even in the urban situation where junctions are much more prevalent, there were 1.4 times more two-wheeler accidents on straight roads. The fact that roundabout accidents are low probably reflects the low numbers of this type of junction in Malaysia rather than relative safety. It is known from experience in several developed countries that roundabouts tend to be less safe for two-wheeled vehicles.

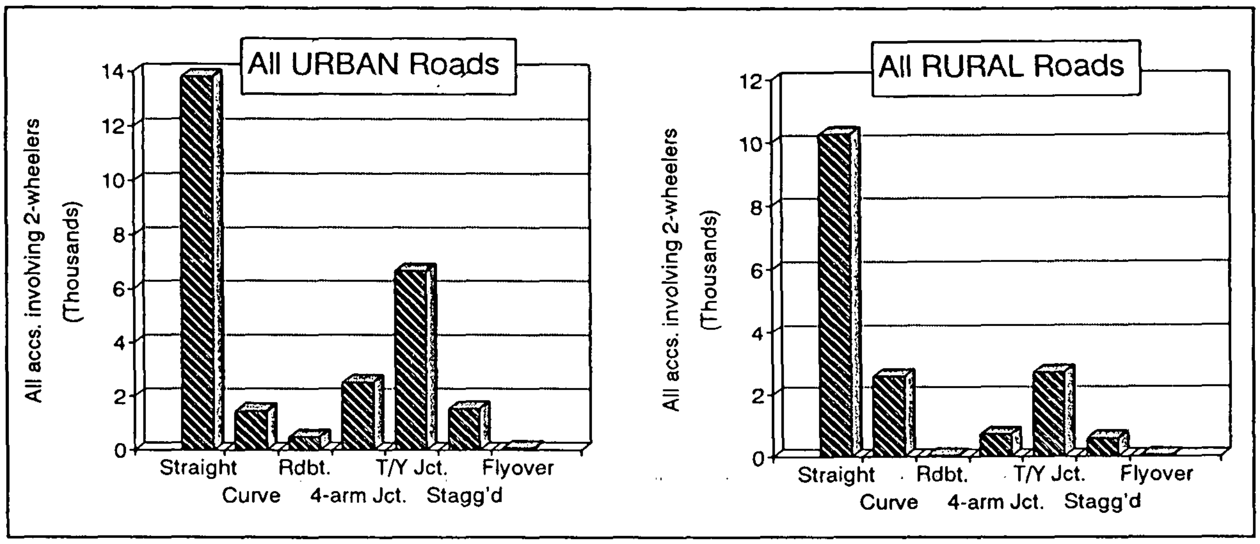

Fig. 2 Location of accidents involving Two-wheelers: 1992 & 1993 data

From Fig. 3 it would appear that despite the fact that the majority of the two-wheeler accidents were not at junctions, the types of collisions have been recorded by the police as mainly side-impact or rear-end, ie. 56.8% and 49.1% of all two-wheeler accidents on urban and rural roads respectively. In fact a separate, more detailed study by Universiti Pertanian Malaysia (UPM)[4] has demonstrated that motorcycles are much more frequently struck from the rear by another vehicle than run into the back of another vehicle themselves. Head-on

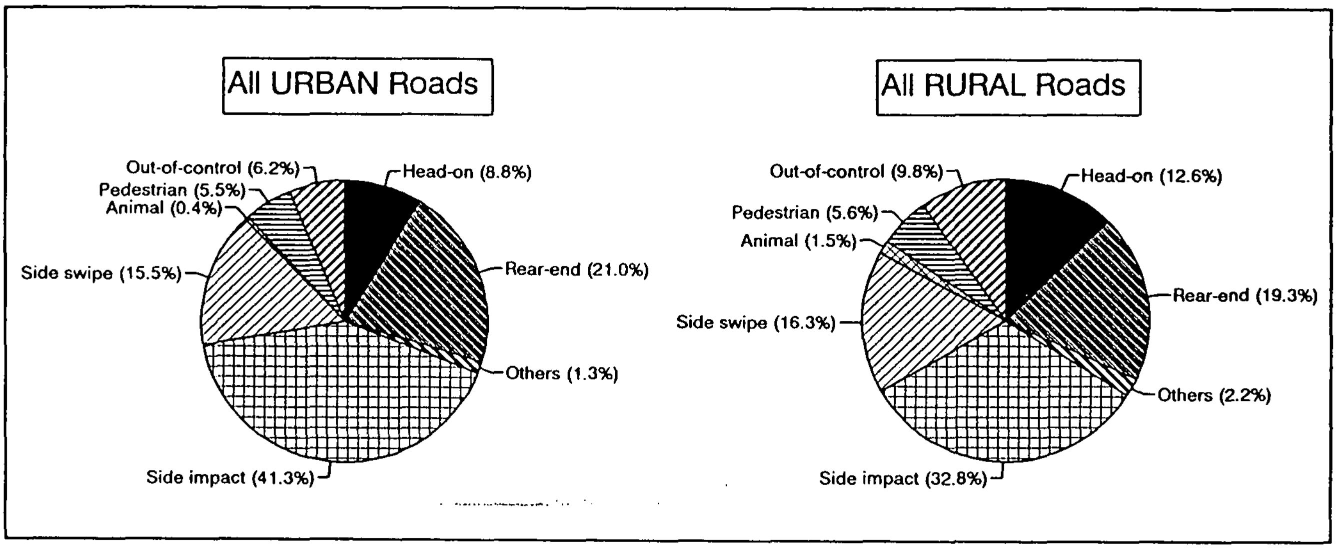

Fig. 3 Type of accidents involving Two-wheelers: 1992 & 1993 data

collisions (normally during an overtaking manoeuvre) are also a relatively common accident group with a larger proportion occurring on rural roads than urban ones.

In view of this, let us consider the effect of road width and shoulder width, with the hypothesis that extra width is safer for two-wheelers as it allows larger vehicles in opposing directions to pass more easily, or a wider 'escape' area for evasive action should an emergency arise.

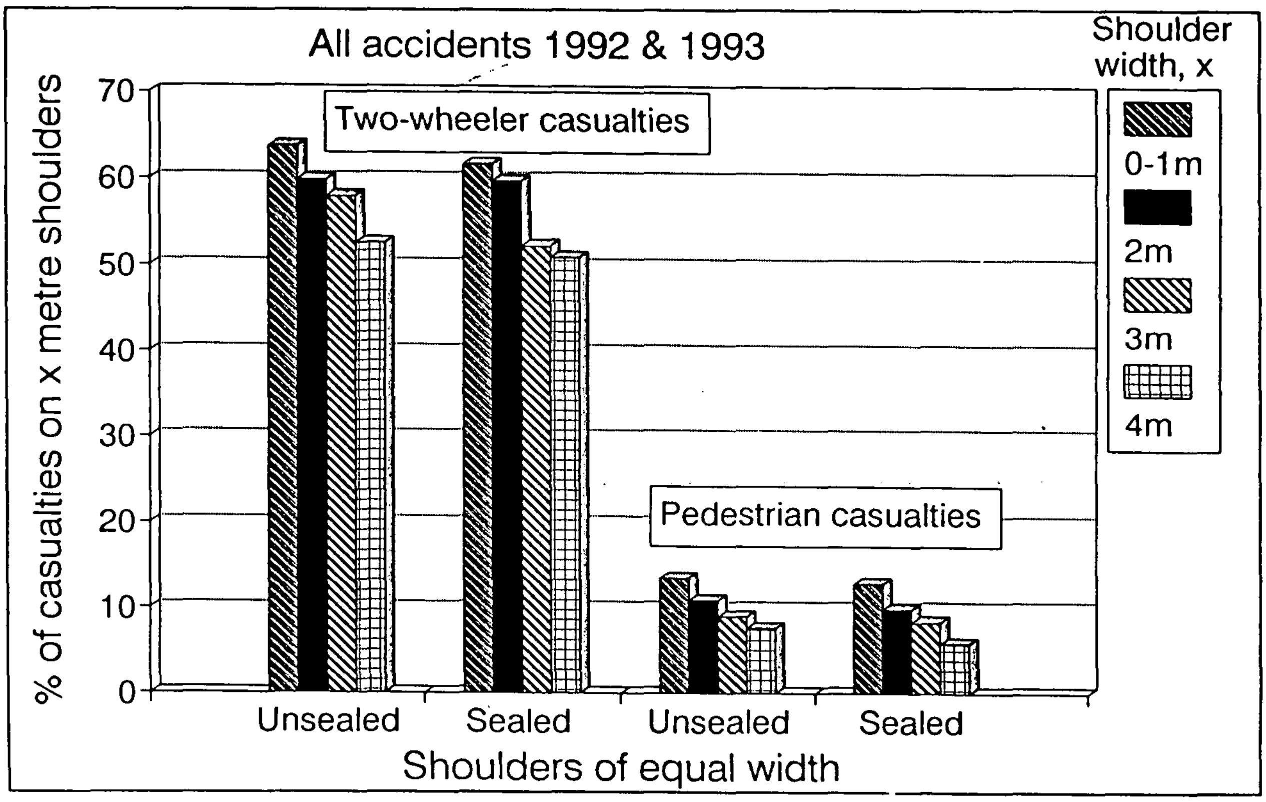

Fig. 4 Effect of shoulder width on proportion of vulnerable road-user casualties.

First for shoulders, it is not at present easy to calculate accident rates for different shoulder widths as a full computerised roads inventory is not yet available. However, we can compare accidents occurring on roads with the same shoulder width according to that measured by the police at the scene of accident and recorded on the POL27 form. Fig. 4, therefore, shows for both sealed and unsealed shoulders, the percentage of accidents on roads with the same shoulder width involving the two vulnerable road user groups. The difference in these proportions for different shoulder widths is not large, but there is perhaps some consistent indication (though not statistically significant) of a lower proportion of 2-wheeler accidents the wider the shoulder. It would appear that sealed shoulders over 2m wide may be even better than similar width unsealed shoulders. This may well reflect the fact that when the surface is sealed more motorcyclists will tend to use the shoulder as their running lane.

Again from Fig. 4 it would appear that a similar effect exists for pedestrians. This at least provides some positive indication that wider shoulders do appear to reduce the relative accident risk slightly for pedestrians.

If we now consider road width, Fig. 5 shows the proportion of two-wheeler and also pedestrian accidents expressed as a percentage of all accidents on sections of rural roads with the same width. It can be seen that both are high on narrow single track roads, which are obviously hazardous to walk and ride along, being worst at about 4 or 5m. The proportion

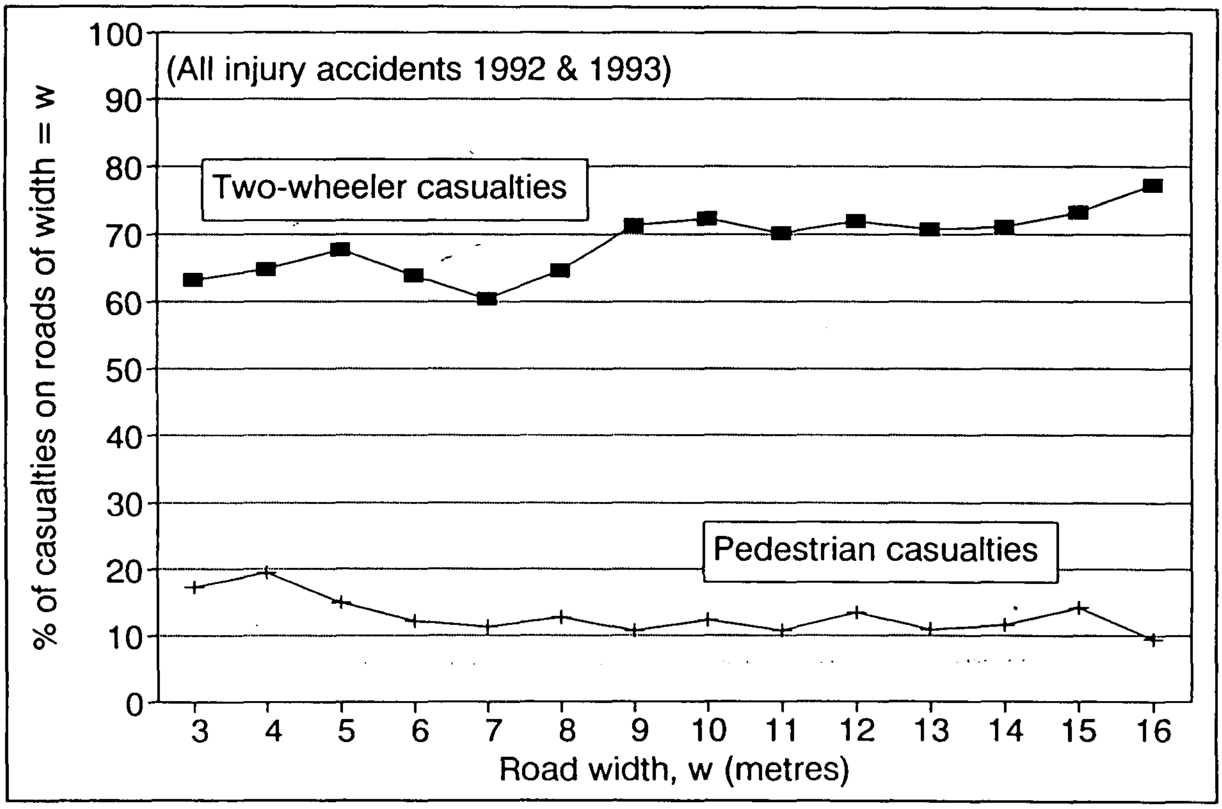

Fig. 5 Vulnerable road-user casualties on roads of equal width

of vulnerable road-user involvement appears to reduce to a minimum at a width of 7m. For wider roads than this pedestrian involvement in road accidents on roads of different width remains quite stable, at about 10-13% of the total. However, for two-wheelers the situation appears to worsen again with increasing road width up to about 9m at which the proportion of riders injured remains at just over 70% of all casualties. This may be a feature of traffic speed increasing on wider roads, thereby increasing the risks for two-wheeler riders.

It would seem that the best way to protect the vulnerable road users is by segregation. Thus where space permits, separate footways and two-wheeler lanes are recommended. For rural roads where the sealing of shoulders is gradually being implemented, it is suggested that these could be made to serve the dual purpose of designated two-wheeler lanes as well as breakdown lanes, if suitably marked and having adequate width. Special care does, of course, need to be taken around junctions and slip-roads such that two-wheelers can be led (by appropriate road marking) to make right-turning manoeuvres as safely as possible.

2.1.1 Pedestrians

Pedestrian accidents constitute the other major group of casualties after two-wheeler riders, as even on rural roads they constitute 12.7% of all casualties. Fig. 6 shows the age groups of pedestrian casualties on urban and rural roads; and the most noteworthy feature of this two year period is the extremely high proportion of the youngest age group. A very similar pattern exists for both the urban and rural environment with the peak problem being 5 to 10-year old children. Over 1000 children in this age group alone are killed or injured each year on Malaysia's roads. As reported elsewhere[3] this young child pedestrian problem is worse in Malaysia than many other countries in the Asia Region.

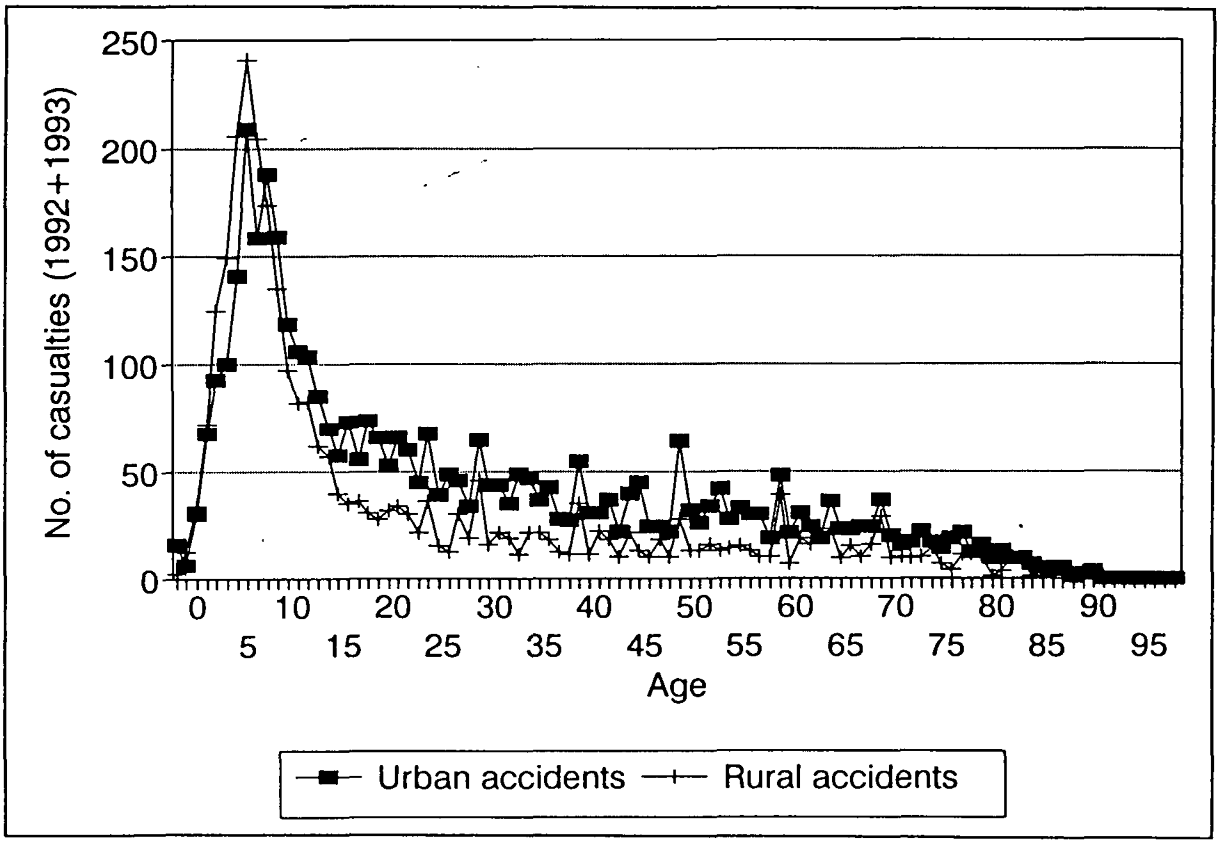

Fig. 6 Age profile of pedestrian casualties on all roads : 1992 & 1993 data

There is an obvious need for improved training and continuous reminders for school children both at school and from their parents. Despite the already packed timetables in schools, time for regular road safety lessons needs to be found.

However, there are areas where crossing the road is particularly difficult and where road authorities could provide new crossing facilities and 'traffic calming' type measures. These can be considerably cheaper than foot bridges and are often preferred by pedestrians since they do not involve climbing steps. Children have greater difficulty than adults in being able to judge gaps in the traffic and the use of pedestrian refuges can be of considerable benefit as children then only have to make a decision about one direction of traffic at a time. Raised pedestrian crossings have the advantage of being not only self-enforcing vehicle speed reduction devices placed at the most hazardous spots on the road (where pedestrians cross), but also act as an indication to drivers that the area in which they are travelling is one in which pedetrians have greater priority.

2.2 Junctions

Fig. 7 indicates the type of location where injury accidents were recorded, and it can be seen that 28.4% occurred at road junctions of which most are T-junctions. It has already been shown from Fig. 1 that female drivers have been recorded as making more turning errors than males, and this is the second most common type of error.

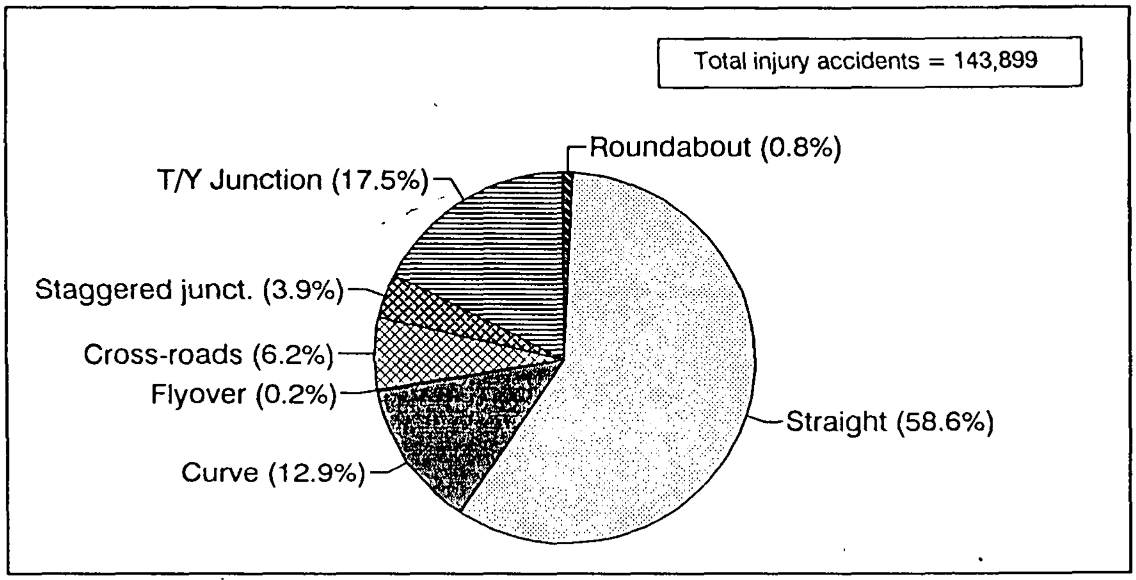

Fig. 7 Location of injury accidents: 1992 & 1993

With reference to research by UPM[4], it seems that the most common cause of collisions at junctions (at least with motorcycles) is the car driver turning in or out of a minor road and crossing a traffic stream. In so doing he/she often tends to misjudge or "does not see" the motorcycle. The motorcycle ride bright campaign has been reported to have had a beneficial effect on this type of accident[4] but unfortunately this type of accident still remains very common.

In order to minimise these driver errors, the road authority should ensure that sight distance is adequate; that there are no perceptual traps; right-turning bays are provided; and that any is adequate; that there are no perceptual traps; right-turning bays are provided; and that any local widening around the junctions is tapered in as gradually as possible to the existing edge of carriageway so that drivers follow the intended path through the junction.

Protected right-turn bays (whether by raised island or hatched road marking) should be marked out according to the proper specifications, and the signing and markings themselves should be maintained in good condition.

2.3 Overtaking

Overtaking (by at least one vehicle) has been recorded in 4.7% of all accident cases. These tend to be the more serious accidents and overtaking features in 8.9% of all injury accidents on rural roads.

Whilst this type of accident is always largely due to driver error, a contributory factor to their 'error' may well be misleading line markings. During one recent, related study by IKRAM along Federal Route 1 from Rawang to Tanjong Malim, sightline measurements showed that the positions of the start or end of the solid centrelines were incorrect in about 56% of cases (according to the minimum sightline specifications for that type of road). This brings driver confidence in the road marking into disrepute, such that solid centre lines are ignored rather than treated as points where it is not only illegal to overtake, but also dangerous.

It is recommended that the position of solid centrelines should be checked, and more use made of the broken and solid line (where sight distance is adequate for overtaking in one direction) rather than, say, starting a double centre line only before a bend. Use of "return to lane" arrows have not been used very extensively but these act as a warning and useful indication to drivers of the start of a solid line section.

Where overtaking is particularly hazardous, self-enforcing devices like the chamfered kerbstones and plastic delineators as used on the KL-Karak highway do appear to be very effective. They do prevent drivers crossing over to overtake but can be crossed in an emergency.

For crawler lanes, it is recommended that consideration be given to changing the priority of the crawler lane at its ends (see Fig. 8) . This should encourage the medium-speed lorry drivers (and indeed all vehicle platoon leaders) to use crawler lanes as they do not have to merge with faster traffic at the end of lane as they do with the present layout. This is really a change in philosophy in that the onus would now be on the overtaking (privileged) vehicle to complete his manoeuvre before the end of the crawler lane. A large hatched safety area is, of course, also required at the end of the overtaking lane.

2.4 Skidding

A study of 2 MAAP pilot areas by UPM[5] has shown that skidding accidents are 4.7 times more likely on wet roads. A higher proportion of skidding accidents occurred on bends (about three times more) than on straight roads.

For the national dataset, rather than define skidding accidents by certain collision types (out-

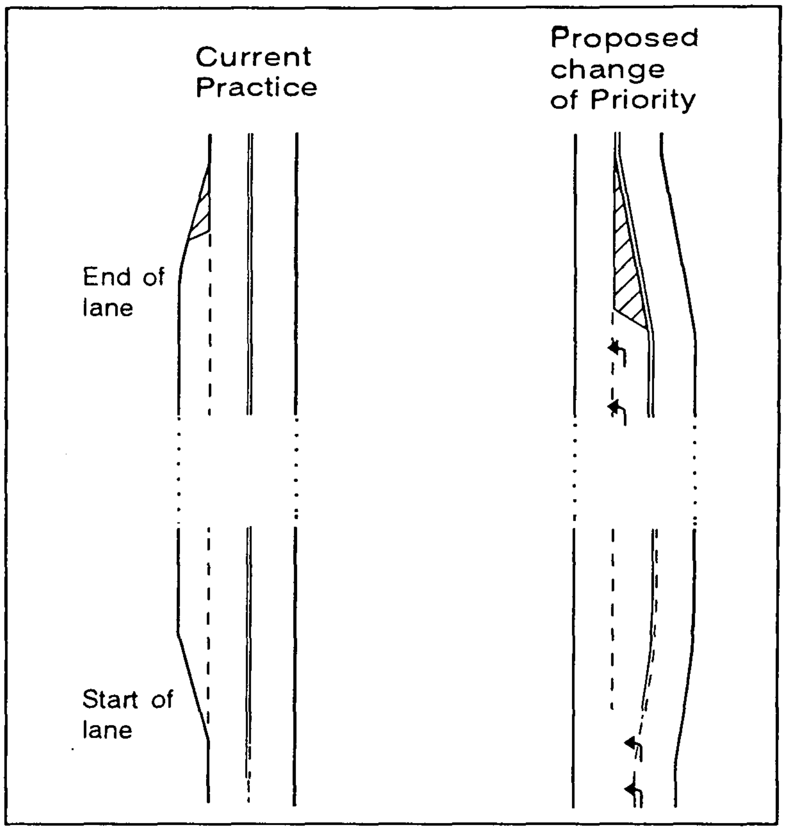

Fig. 8 Proposed change of priority for ends of crawler lanes

of-control, overturn) as has been done in the past, let us assume that skidding accidents are those either classified directly by the police as 'skidding' or with a recorded measurement of skid marks. The proportion of skidding accidents in each speed limit are compared in Fig. 9, and it can be seen that there is a remarkably good linear relation for both fatal and other injury accidents up to 90km/h (ie. including State and Federal roads), though this does not appear to extend to 110km/h, ie. the Expressways. The latter do, however, have the highest proportion of wet road surfaces, probably because the friction or adhesion between road surface and tyre is reduced with increasing speed.

More than half of the out-of-control skidding accidents (59%) were reported as occurring on straight roads, with only 20% on curves. One of the contributory factors in straight road 'out-of-control' accidents could be rainwater 'ponding', ie. aqua-planing.

Research is needed into the macro-texture qualities of wet road surfaces, especially near to bends on high speed roads. IKRAM are currently engaged in trials of SRSS (Skid Resistant Silent Surfacing), pervious macadam (BS4987) with and without rubber added, and stone chippings.

More attention is required towards maintaining adequate and uniform camber of the road and roadside drainage to avoid 'water ponding' and excessive spray which impedes driver visibility.

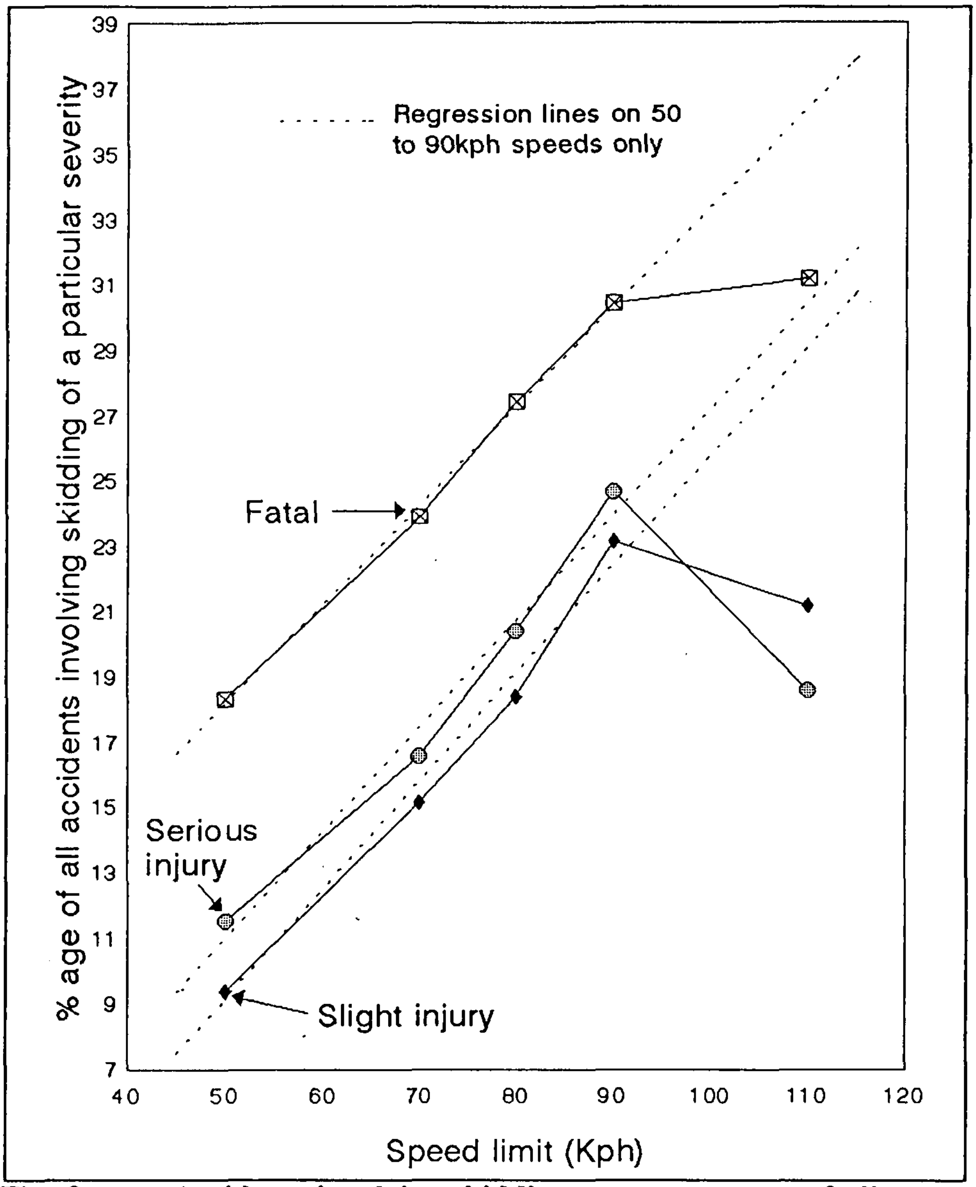

Fig. 9 Accidents involving skidding as a percentage of all accidents of given severity

2.5 Surface condition, maintenance and street furniture

The road surface condition is perhaps the most obvious area in which the road authority can play a role in improving safety. In 3.3% of all injury accident cases in 1992 and 1993 the road surface may have contributed in some way to the accident as the surface was classified as either potholed, rutted or corrugated.

Road surface manhole covers are often not raised when a road is overlaid leaving quite deep depressions which can be a serious hazards for motorcyclists, particularly at night. Stricter control of contractors work would seem to be desirable in this respect.

Almost 20% of fatal road accidents have been classified by police as a driver being "out-of-control" and so the potential for drivers to incur injury on street furniture is very high. Structures close to the roadside should therefore be made as 'forgiving' as possible in the event of a vehicle collision. Drivers should be protected from solid structures like bridge parapets by guard rail; lampposts and sign posts should be frangible; and crash cushions should be used in front of unavoidable end structures, eg. guard rail dividing a slip road. Consideration should even be given to replacing the concrete kilometre posts by plastic frangible or spring-mounted posts which are much less likely to cause severe damage or injury, particularly to motorcyclists.

3. DISAGGREGATION OF TARGETS

The previous section has discussed general areas for safety improvement based on a simple analysis of the national accident database. However, for the Government of Malaysia's casualty reduction target discussed in the previous paper to be effective, there is a need for all road engineers throughout the country to relate this to the particular network for which they have responsibility. That is, each authority should be given gradual achievable goals which they should review on an annual basis.

As no research has been carried out in Malaysia to determine the overall influence of environmental factors in accidents, it is suggested that the UK's Institute of Highways' (IHT) recommendation[6] be adopted. This states that an overall accident reduction target by highway engineering of the order of 15 per cent should be feasible. That is, the overall engineering contribution to the Government's target should be about **one half** of the 30 per cent reduction total.

In order to calculate exactly how many casualties need to be saved by the end of 1999 to achieve the Government target, it will be necessary to calculate the expected number of accidents during that year with no action taken. This is because the general upward trend due to increasing levels of traffic and other factors will also have to be part of the target. Fitting a simple regression to the annual fatality numbers since 1974 (the start date of published accident data), this predicts nationally an increase of approximately 36% of the base 1989 year by the year 2000. The recommended formula, therefore, for an individual road authority target is:-

$$n_t = \frac{1}{2} \times \frac{(0.30 + 0.36) \times N_{1989}}{y} \qquad \ldots\ldots (1)$$

where n_t = Target no. of injury accidents/year to be reduced
N_{1989} = Total no. of casualties in 1989
y = No. of years from now until end of 1999

It will be noticed that total casualties rather than fatalities have been used in the above, since it is unlikely that there will be many sites with more than one fatality per year, and these do not tend to occur regularly in consecutive years. It is assumed that if all road authorities concentrate on improving their most hazardous sites and can produce the above reductions in all injury accidents then this should also achieve the required reduction in fatalities.

4. ACCIDENT INVESTIGATION UNITS

It is strongly recommended that accident investigation teams be set up as a Unit in each road authority with the prime objective of meeting these targets. The Units could have the following main functions or objectives:

i) check and code location and other details on accident report forms, and send to HPU

ii) apply cost-effective countermeasures to reduce accidents

iii) produce an annual Road Safety Plan with details of how they will achieve their target

iv) carry out independent safety audits of new schemes and maintenance/rehabilitation of existing roads to help prevent accidents

In the U.K. where a similar casualty reduction target of 30% by the year 2000 was set in 1984, the most serious casualties have already been reduced by 24.5% and 33.0% for fatal and seriously injured respectively[7]. It is believed that much of this success was due to the setting up of these Accident Investigation Units which was in itself due to a legal requirement of the Road Traffic Act of 1988 to "carry out studies into accidents arising ...on roads...within their area...and to make measures appropriate to prevent such accidents".

It is therefore suggested that, in order to ensure that action in setting up such Units is begun swiftly, a similar mandatory requirement of road authorities should be made in Malaysia.

4.1 Staffing

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.

The IHT[6] recommend staffing levels of one engineer or technician for every 400-1000 reported injury accidents. With the additional work of accident location coding and safety audits and the currently increasing casualty trend, it is suggested that one per 300 injury accidents may be a more appropriate level to aim for in Malaysia.

Formal training for specialised staff in these Units will be required and it is suggested that the new Guide[8] discussed later (Section 6) could be used as a basis for setting up regular courses. 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.

4.2 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 an annual Road Safety Plan document which is published.

Road Safety Plans are now produced annually by most road authorities in the United Kingdom regardless of the current success or failure of each in achieving its target. They 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) and 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). It should also describe the methods used for monitoring and evaluation and should include a summary of the previous year's work and effect on accidents.

Example extracts of Road Safety Plans published by two highway authorities[9,10] in the UK are included in the new Guide[8].

5. FINANCIAL ALLOCATION

Adequate budget provision is essential to cover the cost of running the proposed Road Safety Units and, of course, of funding the remedial works they recommend.

Using the amount spent nationally on the World Bank-funded blackspot improvement programme, Malaysia has been spending an average of RM16.7million per year on safety engineering works. This is the equivalent of RM3620 per year per fatal accident or 91 Sen per head of population per year.

For comparison, the UK's estimated annual spend on pure safety engineering works is £70M (or RM280M). This means that they are spending over 5 times more per head of population and almost 10 times more per fatal accident than Malaysia.

It is not suggested that Malaysia spend equal amounts as the UK owing to differences in development and GDP, but the above figures are simply quoted to suggest that a greater capital expenditure be allocated than at present. As an approximate guide to the overall budget required to achieve the above injury accident targets, the IHT suggest the amount should be :-

$$\frac{C \times n_t}{R} \quad ....(2)$$

where C = Average cost of an injury accident
n_t = Target no. of injury accidents/year to be reduced
R = Average benefit to cost ratio for treatment

For Malaysia as a whole from now until the year 2000:

$$C = \text{RM}33{,}000$$

From eqn. (1):-

$$n_t = \frac{1}{2} \times \frac{(0.30 + 0.36) \times 30037}{5} = 1982$$

$$R = 2 \quad \ldots\ldots \text{(a conservative estimate)}$$

which gives an annual overall budget requirement = **RM32.7million**. This should be updated when a more recent accident costing becomes available or new trend in accidents is apparent. The estimates for each individual road authority can be made in a similar manner.

6. INTERIM GUIDE FOR IDENTIFYING, PRIORITISING AND TREATING HAZARDOUS LOCATIONS ON ROADS IN MALAYSIA

It was recognised by IKRAM that due to the lack of formalised accident reduction work currently being carried out in many road authorities, there is likely to be a lack of experience in this field, and thus a great need for a basic reference guide.

This Guide which has been produced at IKRAM contains much of the proposals described above. Although based on the UK RoSPA Road Safety Engineering Manual[10], it has been substantially modified for its intended for users, that is, traffic engineers and road safety officers in all road authorities of Malaysia.

An attempt has been made to make this 150-page Guide as comprehensive as possible covering the complete range of accident reduction work which it is suggested that road authorities should carry out; that is, from identifying hazardous locations and investigating individual problem sites through to producing and implementing an effective strategy plan.

The Guide comprises seven main chapters, of which the first two include an introduction to the accident problem of Malaysia, managing a strategy and responsibilities with respect to accident data. The remaining five chapters include a step-by-step approach to tackling the problems efficiently. These cover the subject areas of Investigation, Diagnosis of problems, Selection of appropriate treatments, Implementation of schemes, and Evaluation of their effect.

6.1 Accident database

Fig. 10 shows the ten steps described in the Guide. In order to be able to plan the most efficient expenditure of public money on engineering improvements, a reliable accident database is essential. The Guide therefore has made the assumption that such data on the MAAP software system is available to the road authority. Indeed the role of the various public bodies now involved (or recommended) in compiling the database is stated. This inevitably involves close cooperation between the road authority and the local Royal Malaysia Police.

As we have heard from the previous paper, greater improvement is required in the recording

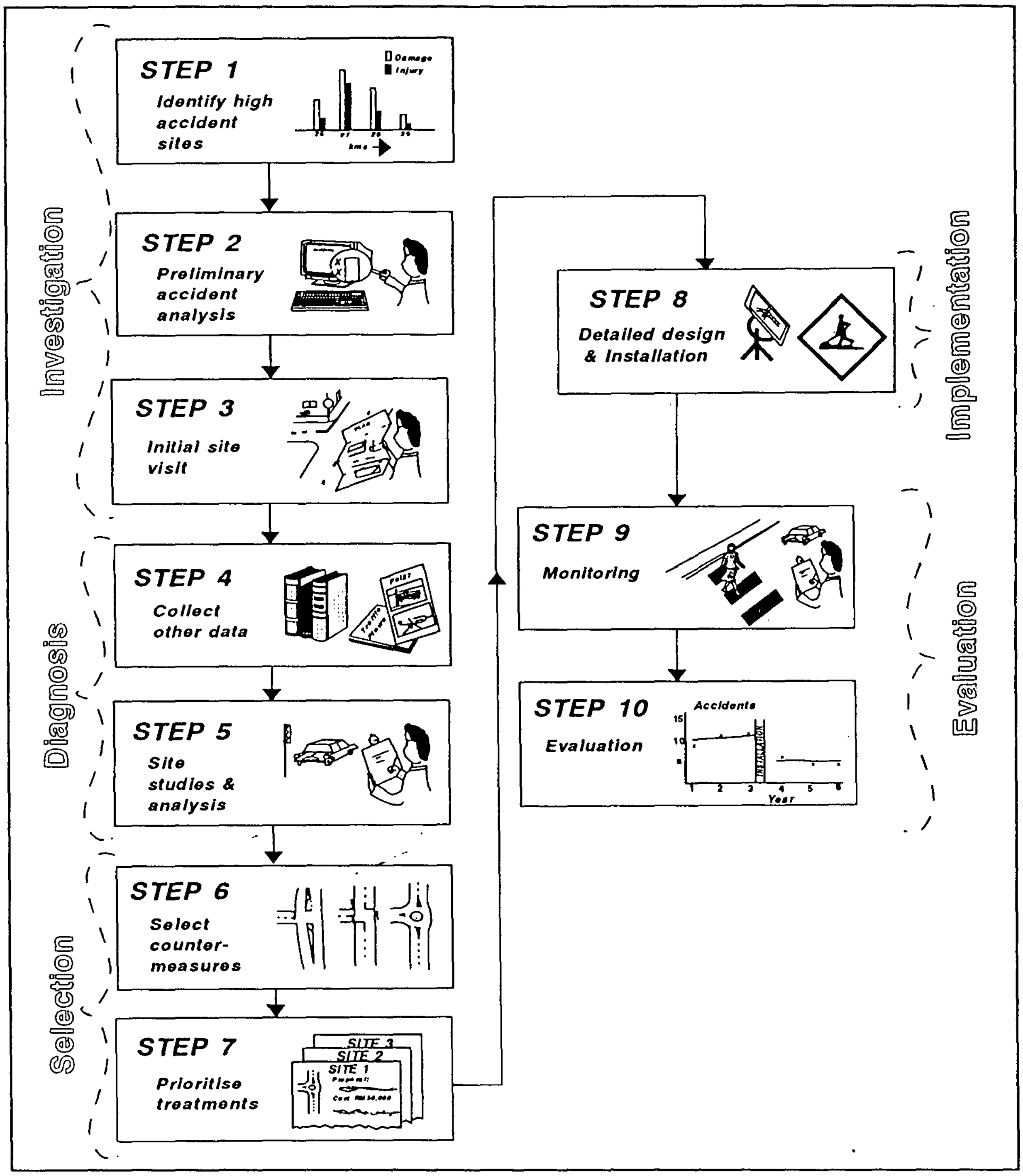

Fig. 10 The ten steps included in the Guide to reducing accidents

of accident location. Unless the database can be trusted to give accident frequencies at their true location then engineers cannot be certain they are treating the actual problems at the appropriate places, nor will they be able to judge how effective they have been in the action taken.

The Guide therefore recommends that rural road authorities produce landmark maps of their area on available 1:25000 scale national maps (eg. Fig. 11). As well as checking the police recording of the nearest 100m from a kilometre post (for which the authority will need to

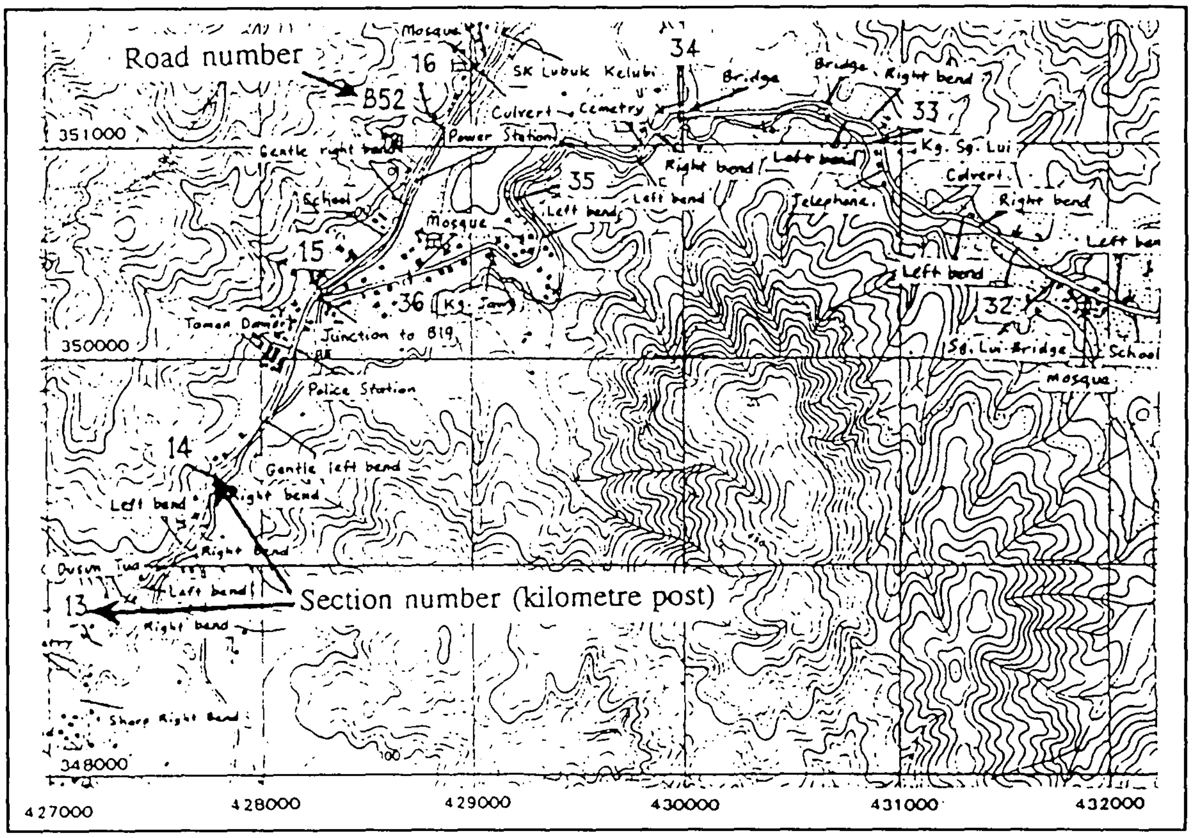

Fig. 11 Example of 1:25000 landmark map for rural roads

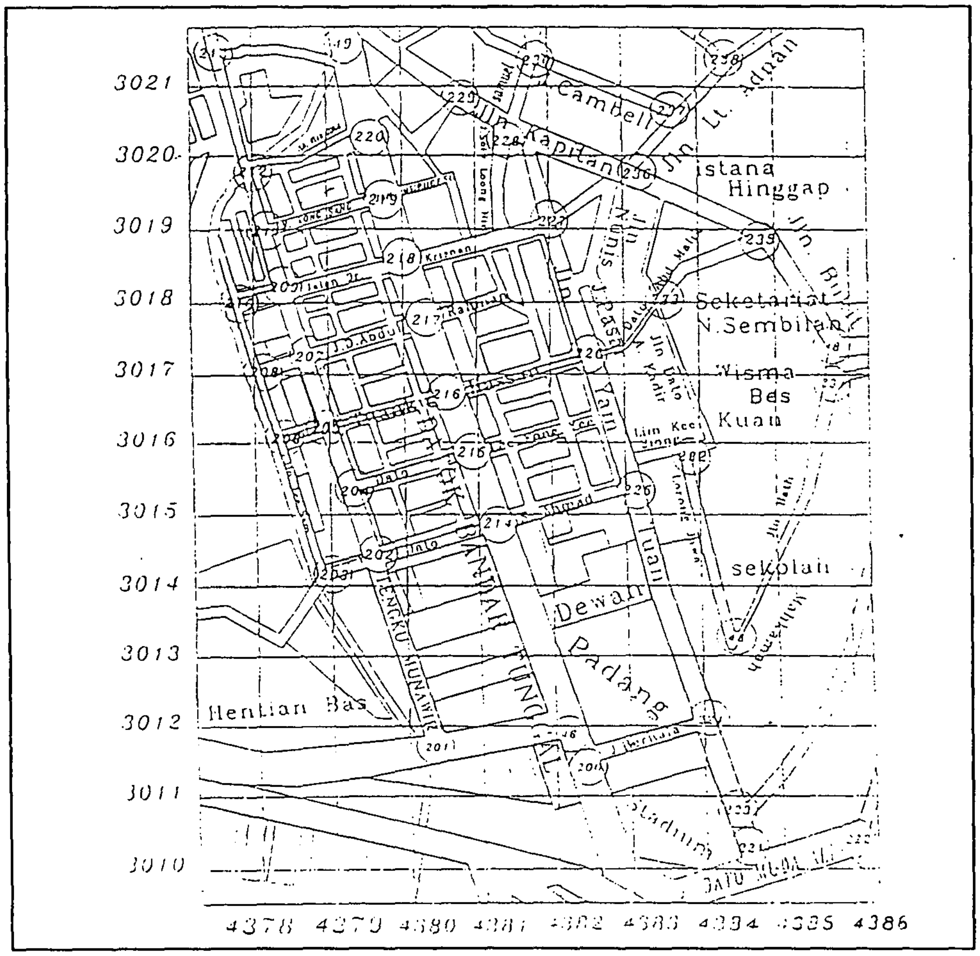

Fig.12 Example of nodal map for urban roads

locate the accident on the relevant map), they should also record the grid coordinates of the accident. The latter are gaining importance as Geographical Information Systems are introduced, and are even necessary to be able to plot accidents using the latest mapping facilities of MAAP.

For urban authorities, where accidents can perhaps be more easily located by street names, it is recommended that they produce nodal maps such as the example shown in Fig. 12. These node numbers can be more easily sorted by computer but again, national grid coordinates should also be recorded on the POL27 forms.

6.2 Step 1 - Prioritising sites

There is an initial need to rank sites in terms of their relative safety. Although exposure should perhaps be taken into account, it is recognised that traffic patterns will not be readily available for all sites, and so the Guide advises that this initial ranking should be produced using accident numbers.

Examples of how this is done for the various types of strategy, ie. single site, route, mass or area-wide action, are given. The Guide advises that the road authority should then define its own "reaction level" in terms of an accident rate above which the accident investigator should take some action.

6.3 Step 2 - Preliminary accident analysis

This above ranked list of sites should now be refined by testing whether particular sites warrant further investigation, ie. sites having higher numbers of accidents than might be expected and common patterns of accident. Some simple statistical tests are described and the concept of "stick diagram" analysis introduced.

6.4 Step 3 - Initial site visit

The Guide now advises early site visits to locations on the list. This is so that existing site plans can be checked and the investigator can visualise the accidents from the records to try to assess the likely causes. The priority list can subsequently be amended by classifying the sites into those which are likely to be "easy" and those "hard" to treat, the easy sites normally being tackled first.

6.5 Step 4 - Collection of further data & analysis

This step is really an extension of Step 2 where further existing data about individual sites is collected to try to insure that the treatable problems are diagnosed correctly, so that countermeasures are in turn specifically designed to address these problems.

This includes acquiring for each site being considered the very important sketch diagrams of accidents made by the police. These have been catalogued since 1992 by (and are available from) UPM, but it is recommended that road authorities catalogue their own copies of these for easier access. These diagrams together with the written description of the accident should help clarify the computerised record, particularly in relation to vehicle direction, so that the investigator is better able to sort out accident types or patterns.

The recognition of patterns of accidents is a skill which gradually needs to be developed.

6.6 Step 5 - Site studies

As the investigator is trying to determine the most effective engineering contribution to a site he can make, a further visit to each site is now recommended where a checklist of pertinent questions relating to the recorded accidents can be asked.

Again to help make decisions about how best to treat a site, other in-depth behavioural site studies (eg. traffic flow, speed, conflicts) are recommended dependent on the nature of the safety problem. However, it is recognised that these studies are expensive in terms of manpower and will not always be feasible.

An example of a one-day site study and results obtained are included in this section of the Guide.

6.7 Step 6 - Selection of possible countermeasures

The Guide first suggests some objectives which need to be set and met in designing suitable countermeasures for each accident reduction strategy. These are chiefly in terms of achieving a minimum percentage accident reduction at a site in a cost effective manner, ie achieving a minimum First Year Rate of Return*

Some general treatments for common accident types are listed as a guide but the reader will have to use his own engineering judgement in selecting a measure, package of measure, or indeed his own innovative treatment. As experience is built up, it would obviously be beneficial for this to be shared amongst road authorities and there is thus a need for a list of treatments and their relative successes to be compiled centrally.

6.8 Step 7 - Prioritise treatments and sites

This step describes the fairly standard approach for ranking treatments using a cost-benefit analysis based on estimated accident savings of the scheme. Accident costing is discussed and the currently calculated injury accident cost of RM33,000 used in some examples. This figure is simply based on 1983 ESCAP figures, which were approximately calculated costs for Malaysia, on which allowance has now been made for inflation. Although likely to be an undervaluation, this figure is the only one currently available: there is thus certainly a need for an a new accident costing survey to be carried out as soon as possible in which decision makers can have confidence.

6.9 Step 8 - Detailed design and installation

It is beyond the scope of the Guide to cover detailed design or all aspects of installing countermeasures; however, some general principles including road safety audit and safety at roadworks are discussed.

* *First Year Rate of Return is the net monetary value of the accident (& other) savings and drawbacks expected as a percentage of the total capital cost of the scheme.*

6.10 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.

Advice is therefore included in the Guide on monitoring accidents carefully and repeating before studies to check that the measures are 'behaving' as intended. The use of groups of control sites are also discussed.

6.11 Step 10 - Evaluation

This step of the procedure focuses on evaluation of whether the treatment has been successful in achieving its main objective of reducing the number of accidents. This therefore requires comparison of the number of accidents in the target group before the treatment with the number after treatment (with the assumption of a similar before pattern if nothing were done), and to study whether any other accident type has increased.

Simple statistical techniques are outlined with worked examples. The Guide also advises on how to deal with the various complicating effects such as regression-to-mean, accident migration and risk compensation.

The outcome of all scheme evaluations should, of course, be documented in the road authority's Road Safety Plan

7. CONCLUSIONS

1) The first part of this paper has attempted to highlight some of the general areas where there are safety problems worthy of attention by highway engineers. These include the vulnerable road user groups, junction layout, the overtaking and skidding problems. Some appropriate remedial action has been recommended but these problems are, however, only a limited selection from an overview of the national dataset. It is believed that what is really required in order to achieve the Government's accident reduction target is a much more concerted and formalised effort at every local road authority level to tackle the specific problems of the area.

2) It is strongly recommended that the national target be disaggregated to realistic local targets to be achieved annually by each road authority in Malaysia.

3) To achieve these targets much greater investment will be required and it is further recommended that Accident Investigation Units be set up in each authority with a full-time, trained staff (with sole responsibility for road safety and meeting the local target).

4) Training courses for such permanent staff will need to be provided. These could be based on the newly published IKRAM/TRL Guide but should include real practical examples using local problem sites.

5) There will be a need to allocate adequate budgets to the Accident Investigation Units to enable them to carry out proper studies and implement large numbers of chiefly low-cost accident countermeasures each year. It has been shown that this investigative approach and subsequent carefully planned treatment tailored to the specific real problems is a most efficient way of improving road safety.

6) In order that these Units can perform their task effectively, a further improvement in accident data is required. Indeed, part of their job function would be the maintenance of the accident database, particularly in relation to location data. In many JKR District offices, liaising with the police in the collection of accident reports and checking and coding of location is, at present, typically a small percentage of perhaps one technician's time. It must be stressed that this is, however, a very essential task as it facilitates the local area database to be interrogated to determine accurately where the main problems are located.

7) To help manage safety in their area and increase accountability, the Units should produce and publish an annual Road Safety Plan in which the main problems of the area are analysed, a priority list of sites given, forthcoming site work outlined, previous work reported and evaluated, and the overall progress towards the target clearly displayed.

8) It is believed that only by introducing such a new institutional change can the process of regular monitoring and treatment of safety problems be implemented on the scale required to stand any chance at all of achieving the Government's accident reduction target.

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8. ACKNOWLEDGEMENTS

The author wishes to thank the Royal Malaysia Police for making the road accident data available, to IKRAM for facilitating this cooperative safety research programme between JKR and Transport Research Laboratory, United Kingdom, and to the many staff of IKRAM for their help and support throughout this project.

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