GOVERNMENT OF THE PEOPLE’S REPUBLIC OF BANGLADESH
MINISTRY OF COMMUNICATIONS
ROADS AND RAILWAYS DIVISION

SECOND ROAD REHABILITATION AND MAINTENANCE PROJECT
INSTITUTIONAL DEVELOPMENT COMPONENT

Road Safety Engineering

Procedure Note 6.

Manual for Road Safety Audit in Bangladesh
SUMMARY

In many developed countries, the practice of using specialists to carry out safety audits of highway schemes during the design and construction stages has undoubtedly led to safer roads being produced. The adoption of Safety Audit Practice is one of the key activities identified by the National Road Safety Council and the introduction of the practice is specified in the National Strategic Road Safety Action Plan, launched last year.

The main aim of safety audit is to ensure that all new highway schemes operate as safely as practicable. This means that safety should be considered throughout the whole of the preparation and construction of any project. Specific aims are:

- to minimise the risk of accidents occurring on the scheme, and to minimise their severity
- to minimise the risk of accidents occurring on adjacent roads, i.e. to avoid creating accidents elsewhere on the network
- to recognise the importance of safety in highway design to meet the needs and perceptions of all types of road user; and to achieve a balance between needs where they may be in conflict
- to reduce the long term costs of a scheme, bearing in mind that unsafe designs may be expensive or even impossible to correct at a later stage
- to improve the awareness of safe design practices by all involved in the Planning, design, construction and maintenance of roads

The principles of safety audit are established through experience of effective accident remedial programmes, planned studies of the influence of design and traffic management on safety, and of the factors contributing to the occurrence of accidents. Figure 1. shows Road SafetyAudit in relation to other road safety engineering practices.

The outcome of the audit is the identification of any potential problems, together with recommendations on how to rectify the problems.

For this practice to be successful in Bangladesh, the following principles need to be kept in mind:

- safety audit needs to be an integral part of highway planning, design, construction and maintenance
- the audit shall to be carried out by persons with Road Safety Engineering experience, working independently of the design team
- the audit report shall refer only to matters relating to road safety
- experience of the practice in Bangladesh shall be fed back, monitored, and the procedures adapted in the light of that experience. After a reasonable period, say two years, the revised version of this practice should be incorporated within highway legislation

The basic framework on which the following guidelines are based are as set out in the Road Safety Audit Manual (December 1996), Traffic Engineering and Safety Unit Design Branch, Department of Roads, Nepal. We fully acknowledge the contribution of that manual in the preparation of this work. Finally we also wish to express our gratitude to Dr. Md. Mazharul Hoque, Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka for his help and assistance.

Roger Legassick
February 1998 (Amended September 1998)
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1. EXPLANATION OF ROAD SAFETY AUDIT

1.1 What is road safety audit?

In simple terms safety audit is ‘a systematic method of checking the safety aspects of new roads in order to detect potential safety hazards before the road is open to traffic’. The principle behind it is that ‘prevention is better than cure’. Road user error is the major cause of road accidents, but defects in the road environment (poor alignment, inadequate signing, dangerous obstacles, etc.) are a contributory factor in many cases. Remedying these defects at the design stage is an economical and effective way of reducing road accidents. Road safety audits assess how the road will work once it is open to traffic, focuses on the safety of users - including pedestrians, cyclists, motorcyclists, truck and bus drivers, car drivers, and others. A Road Safety Audit Report identifies any road safety deficiencies and recommends ways in which these can be overcome. The report is submitted to the project director, who, after discussing the recommendations with the project manager, will decide what changes are to be made to the design.

1.2 Who does the auditing?

To be effective the audit needs to be carried out by a specialist (or team of specialists) empowered by standing procedure,¹ who are independent of the design process. In this way the auditors will be taking a fresh look at the project without the distraction of having been involved in their design. The audit will be carried out by road safety engineers who, through practice will have gained experience in identifying potential hazards, see Figure 1.

Note: If the subject of the audit involves a complex - unusual structure or traffic signals the Head of the Road Safety Unit shall consider co-opting a specialist with relevant design and construction experience into the Audit Team. Safety Audit in many countries has benefited by including the experience of traffic police officers. It is recommended that Safety Audit in Bangladesh works towards including traffic police in Audit Teams as soon as possible.

¹ In future Safety Audit Practice will be covered by Regulations.
1.3 What should be audited?

All road projects, even those involving no more than a new access onto a highway, can have safety implications, but in practice, and until staff and skill resources increase, it will be best to limit safety audit to the larger projects. Minor projects where safety clearly is an issue, such as alterations to busy junctions, should also be audited. Whilst the scope for safety audit is greatest with new roads and bridges, it is also appropriate for rehabilitation projects, as many of these involve significant changes to the road layout and geometry.

1.4 At what stages will projects be audited?

The earlier a project is audited the more scope there is to make improvements. In projects where there is a choice of route or standards, or there are known safety problems, the design team should discuss these matters with the Road Safety Unit at the earliest opportunity. The main audit is done after the detailed design is complete. Any changes to the design arising from the audit ought to be incorporated before the project goes out to tender. In some cases there will not be time for this, and any major changes or additions will have to be carried out by variation orders. A final audit should be made after completion of the works and prior to the opening of the road - this is for checking signing, road markings, and placement of road furniture. It is conventional to refer to audit stages as follows:

Stage 1 Audit feasibility
Stage 2 Audit draft design
Stage 3 Audit detailed design - the main audit
Stage 4 Audit pre-opening

1.5 Responsibilities

Safety audit is not a comprehensive check on the technical aspects of the project. It does not check if design standards have been followed. The audit will not check if structures such as bridges can safely take the loads that may be imposed on them. It is an assessment of the road safety aspects only. The highway design team remain responsible for all technical aspects and continue to report to the project manager for these matters.
Audit involves one set of professionals checking the work of other professionals, and this calls for much diplomacy and respect. Auditors must understand the background to design decisions and avoid commenting on any issue other than safety. Highway designers whose work is being audited should accept that the audit team may be able to improve on the safety aspect of the design to the benefit of everyone. The audit process brings specialist advice into the design process - it is not a test of the competence of the highway designers.

Highway designers must be given an opportunity to respond to the findings of the audit team, but the decision as to whether to adopt the recommendations rests with the Project Manager.

1.6 Costs and benefits

There is concern that this task increases the cost of the project, but this is rarely the case. Most changes involve minor issues for example signing, marking, and adjustments to the layout, these improvements cost little, if they are adopted in the early stages of the design process. And it has been suggested (from a limited British study) that one-third of future accidents at road improvements could be prevented by road safety audit. If the impact on costs is likely to be significant, the audit team will have to consider if the cost is justified by the likely savings in accidents and the matter may need to be referred to the Client.
2. PRINCIPLES FOR DESIGNING SAFER ROADS

2.1 Introduction

This section of the manual looks briefly at the basic safety principles. Safety audits are completed by assessing schemes with the help of detailed checklists. Points can still be overlooked unless the auditors have basic principles in mind. This section will also help scheme designers get a better understanding of how to produce safer road design.

The key principles are:

- DESIGNING FOR ALL ROAD USERS
- PROVIDING EARLY, CLEAR AND CONSISTENT MESSAGES TO THE DRIVER
- ENCOURAGING APPROPRIATE SPEEDS AND BEHAVIOUR BY DESIGN
- REDUCING CONFLICTS
- MAKING ALLOWANCES FOR THE BAD OR IMPAIRED DRIVER
- CREATING A FORGIVING ROAD

2.2 Designing for all road users

There has been a tendency in the past for scheme designers to focus on pavement engineering aspects of new and improved roads. It is quite common to find that when a highway passes through a town or village there is no change in design, when the road is opened to traffic, the higher speeds made possible by the improved road surface result in increased pedestrian accidents. But it is not just pedestrian needs that are forgotten - it is the needs of rickshaw drivers, bus drivers and their passengers, people who need to park their vehicles at the roadside, and people whose property fronts the roads and need access to it. They have all got a legitimate need to use the road and, if this is ignored, there will be problems and accidents. The speed limit needs to be frequently displayed, giving suitable early warning of all hazardous areas with appropriate reduced speed limits.
2.3 Providing a clear and consistent message to the driver

Good highway design will result in a driving task which is clear, simple and consistent. Safe designs are those which result in a road which can be easily read and understood by the driver and present him or her with no sudden surprises. This is a particularly important consideration when designing alignment - a sharp bend after a long straight section or just beyond a summit curve is sure to produce accidents - but it is also relevant to the design of junctions. Drivers can be warned of difficult or potentially confusing situations (and guided through them) with good signing and road markings. Provisions should be made for safe vehicle overtaking, pedestrian activity, non motorised vehicles, bus stopping points, segregated roadside activities.

2.4 Encouraging appropriate speeds and behaviour by design

In a way this is a refinement of 'providing a clear and consistent message to the driver'. We can influence traffic speed by altering the look of the road. If a high-speed road looks the same (same width, same shoulder treatment, etc.) as it passes through a village it is not surprising if drivers do not slow down. Where we want drivers to slow down we must give them clear visual clues, such as changing the shoulder treatment, providing a footway, and installing highly conspicuous signing and road markings.

2.5 Reducing conflicts

Conflicts, whether between vehicle streams, or vehicle types, or vehicles and pedestrians are always associated with accidents. In some cases conflict can be reduced or designed out - making the scheme safer by design; for example replacing a cross-road layout to a roundabout or staggered junction, by separating service areas from the main carriageway and by using guard-rail to channel pedestrians to safer crossing points.

2.6 Making allowances for the bad or impaired driver

A safe road is one which recognises the realities and limitations of human skills of the road user who will use that road. It must not place demands upon the driver which are beyond his or her ability to manage. To say that drivers are wholly to blame for their accidents is not helpful or constructive. Where possible we must produce roads that allow for a margin of error - a forgiving road.
2.7 Creating a forgiving road

A safe road is one which foresees a driver's mistakes or a failure of the vehicle. Many accidents involve the vehicle leaving the road, hitting a roadside object or running over an embankment. More needs to be done to reduce the severity of these loss of control accidents. This can be achieved by trying to maintain a roadside clear zone and putting more effort into protecting the motorist from those roadside hazards which cannot be removed.
3. CONDUCTING A ROAD SAFETY AUDIT

3.1 Introduction

This section of the manual contains a step-by-step guide to the practice of road safety audit. The process is illustrated in the flowchart, Figure 2.

Figure 2. The Steps in producing a Road Safety Audit

<table>
<thead>
<tr>
<th>The Step</th>
<th>Responsibility of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project referred to the Road Safety Unit for audit</td>
<td>Project Director, Project Manager</td>
</tr>
<tr>
<td>Project report and plans assigned to the Audit team</td>
<td>Head of Road Safety Unit</td>
</tr>
<tr>
<td>Study plans and inspect site</td>
<td>Head of Road Safety Unit</td>
</tr>
<tr>
<td>Hold commencement meeting with the designers</td>
<td>Head of Road Safety Unit</td>
</tr>
<tr>
<td>Undertake the audit</td>
<td>Audit team members</td>
</tr>
<tr>
<td>Write the audit report</td>
<td>Audit team members</td>
</tr>
<tr>
<td>Discuss and agree changes Project Manager</td>
<td>Project Manager and Head of Road Safety Unit</td>
</tr>
<tr>
<td>Hold completion meeting with Project Manager and designers Report on action to be taken is then sent to design team and to the Project Director</td>
<td>Project Manager and Head of Road Safety Unit</td>
</tr>
<tr>
<td>Follow up</td>
<td>Head of Road Safety Unit and Project Manager and Project implementation team</td>
</tr>
</tbody>
</table>

Audit practice will vary according to circumstances and in the case of minor projects some of the steps may be quite brief and informal, but the sequence of steps will remain broadly the same. It is important that the project manager takes an active interest, retains overall control, and makes the key decisions. The audit team should avoid direct contact with the design team.
3.2 **Sending the project to the road safety unit for audit**

In most cases projects will be referred to the Head of the Road Safety Unit by the project manager. It is worth repeating that the earlier a road is audited within the design and development process the better. The Head of the Road Safety Unit must keep himself informed about forthcoming road projects, and, if it seems that the need for a safety audit has been overlooked, the matter should be raised with the appropriate Project Manager.

3.3 **Administration**

Each new audit must be recorded in a central safety audit register as soon as the request is received. The register is a management tool and will help the Head of the Road Safety Unit to track the progress of each audit. *It is strongly recommended that all documentation, and files relating to safety audit are stored separately in the Road Safety Unit.*

It is suggested that the safety audit register contains the following details:

- the audit file number
- date of request
- source of that request
- the site location and Thana
- the name of the engineers who will carry out the audit

A master file will be opened for each audit. The master file (bearing the audit file number) will contain a copy of all the administration papers and documentation, and as the work proceeds, it will also contain a record of all relevant developments (meetings, notes, working papers, correspondence etc.) that arise during the course of the audit.

3.4 **Obtaining the project reports and plans**

The project manager must supply the Road Safety Unit with all necessary information for a thorough audit. This will include scheme reports, drawings and detailed items of
works and specifications. It may be necessary for the Road Safety Unit to seek extra information.

3.5 **Studying the plans - inspecting the site**

These two tasks take place about the same time. The auditors will familiarise themselves with the design details and if possible carry out a preliminary visit to the site and make an early assessment of the safety performance and accident potential of the scheme.

3.6 **Holding a commencement meeting with the highway design team**

The purpose of this meeting is to exchange information. It is an opportunity for the auditors to clarify issues of the works. There is merit in getting the designers' initial reaction to some of the amendments that are being considered. It will often be necessary to explain the purpose and workings of the audit process to the design team.

3.7 **Undertaking the audit**

Past experience indicates that the use of checklists or memory prompts are valuable aids to ensuring that nothing is forgotten or overlooked during the audit. A list of the types of issues and problems that can arise are presented in the Appendix A. These are considered to be 'generally appropriate' for carrying out audits in Bangladesh. In December 1997, the road safety engineering training class at RHD were requested to review the design details of an imaginary 20 kilometre section of highway. As a result, the class produced a list of topics. This list forms the basis of a wider checklist and is reproduced in Appendix A.

When familiarising and assessing the scheme (3.5 above) the audit team will review the checklists, disregard any items that are not relevant and add items that they consider to be appropriate to that particular scheme. The key principles for a good safety audit are:
- consider the needs of all road users (including pedestrians, especially children, non-motorised vehicles, cyclists, motor-cyclists, truck and bus drivers, as well as car drivers)
- be thorough and comprehensive
- be realistic and practical
- focus entirely on matters of road safety
- check compliance with relevant standards and guidelines (while remembering that compliance with standards does not guarantee that the road will be safe)
- use a team of at least two auditors - one to do the audit proper and the other to review it

It is recommended that the site be revisited at this stage. Inspecting the site during darkness as well as daylight is important, especially if it is either an urban scheme, or a Stage 4 audit. The inspection should include adjacent sections of road, because there will often be safety problems at the connection between the new and existing sections.

3.8 Writing the road safety audit report

The audit report sets out clearly what the problems are and makes recommendations on how they can be remedied. The recommendations on corrective action should give a clear indication of what needs to be done, but it will not normally be appropriate to provide a detailed design - that is the job of the highway designers. In some cases there may be no obvious solution to the problem, but the problem should still be identified in the report. The audit report does not give an overall assessment of the design, so there is no need to refer to the good points of the design. It is essential that the location of the problems be clearly identified and this can usually best be done by referring to the chainage. However, it may sometimes be necessary to provide diagrams, sketch plans, or annotated copies of the scheme drawings. Appendix B contains two examples of the presentation of the identified problems and the recommendations to overcome these problems that is used in Britain. It is strongly recommended that this method is adopted in Bangladesh.

Once the report is finalised it is submitted to the Project Manager and a copy is sent to the Project Director.
3.9 Agreeing the changes with the project director and the project manager

When the Project Manager has had time to read and assess the audit report, the auditors should arrange a meeting to consider the action to be taken. Decisions will be taken at this meeting about the changes (if any) that are to be made to the project. If the project is funded by an external donor it may be necessary to consult them, particularly if additional costs are likely.

3.10 Holding a completion meeting with the project manager and the designers

The purpose of this is to discuss the corrective action with the designers, make any necessary amendments, and agree how to follow these up. By the end of the meeting the Project Manager must have given the designers clear instructions, and a written copy will confirm this action. A copy will also be sent to the Project Manager for final approval.

3.11 Follow-up

To ensure that the recommendations are correctly implemented it is advisable that the audit team continue to provide advice and technical support to the designers and the implementation team.
4. SOME COMMON PROBLEMS

4.1 Introduction

This section sets out some of the more common safety problems that have been found in schemes that have been audited elsewhere.

4.2 Inappropriate use of standard designs

Standard designs for side slopes and side drains (which are often designed for worst case situations) are sometimes used in circumstances where they are not appropriate. This results in side drains which are far too deep and side slopes which are unnecessarily steep - both of which make the road more hazardous than it need be.

4.3 Schemes ignore roadside communities

Roadside communities generate substantial conflict. Activities involving pedestrians, buses, parked vehicles, roadside markets, non-motorised vehicles, need to be catered for.

4.4 Signing is inadequate

The general standard of traffic signs in Bangladesh is poor. This is believed to be one of the key elements in bad accident record. The standard for signs and road markings must be consistent. All schemes must specify retroreflective sign facings and thermoplastic road markings.
5. ROAD SAFETY AUDIT CHECKLISTS

5.1 Purpose and use of the checklists

There are many aspects to cover when carrying out a safety audit, the use of checklists can help the auditor to consider the basic issues. Eight sets of checklists have been devised which are appropriate to most highway schemes. They are detailed in the Appendix A and deal with:

1. planning
2. cross-section
3. alignment
4. roadside communities and facilities
5a. junctions - general
5b. junctions - additional checks for roundabouts
5c. junctions - additional checks for signal-controlled junctions
6. special road users
7. signs, markings and lighting
8. roadside hazards

These are to be used as a guide, to focus the audit towards typical matters that should be covered. Each scheme is different and will raise specific issues that may contain further safety implications. At the commencement of each audit, the audit team should review these lists and plan the work accordingly. If a route or a section of road is to be the subject of the audit it will be necessary to include other items. For example, will standards be consistent along the routes? In December 1997, the road safety engineering training class at RHD were requested to review the design details of an imaginary twenty km section of highway. As a result, the class produced a list of items. This list forms the basis of a wider checklist and may be useful for those about to carry out a safety audit on a route. This list is reproduced in Appendix B.

In the past there have been cases when audit teams have just ticked off items from checklist. This limits the potential of the audit. The audit team must always keep in mind that they are seeking to identify road safety deficiencies and in many cases these will be outside of the range of the checklist items.

When reviewing each of the points the audit team members should consider that the road user will have to cope with conditions at night and in adverse weather conditions.
As highway design teams become familiar with the checklists they will have a better understanding of the objectives of safety audit, and will be better able to anticipate and design out many problems.
6. PREPARATION OF THE SAFETY AUDIT REPORT

The findings of the Safety Audit shall be presented in an entirely self contained report. It is recommended that the report is compiled as follows.

6.1 Section 1. Background of the report

Specify the terms of reference for the report.

Set out the full circumstances leading to the production of the report. Has the scheme been the subject of earlier audit reports, if so have the recommendations been incorporated into the design?

List all documents and drawings on which the report is based.

List the name and designation of all officers contributing to the report.

If more than one member of the Road Safety Unit is assigned to carry out the audit, the most experienced person shall be nominated as Audit Team Leader, and the second person nominated as Team member.

Record all dates of significance. For example the dates of meetings, the dates of the audit survey.

6.2 Presentation of the audit findings

This is the most important section in the report.

The duty of the audit team is to focus only on matters relating to road safety. If during the course of working on the audit the audit team members discover an issue that may be helpful to the project design or management team, that matter shall be informally passed on, but kept outside of the audit procedure.
It is important to present the findings of the report in a clear and concise manner. Set out and number (sequentially) of each problem and recommendation. Each problem shall be identified by a clear description of the location and chainage. Two examples of clear presentation of identified problems and recommendations to overcome those problems are shown in Appendix C.

6.3 Completing the reports

The final draft reports shall be submitted to the Head of the Road Safety Unit for internal approval. When the Head of the Road Safety Unit is satisfied with the contents, the reports will be returned to the audit team. All audit team members will sign and date the original copy of the report, the copy reports can then be prepared and issued to the clients.
7. MONITORING SAFETY AUDIT

7.1 Objectives

Good Safety Audit practice evolves and develops as the knowledge and understanding of the road traffic accidents grows. The practice and procedures set out in this manual are elementary. Whilst every effort has been made to cover the most likely and common areas of present day design, construction deficiency, the author recognises that in its the present form it is not complete. This practice is workable and will identify many problems that can be treated. Through monitoring and evaluating, the practice can be modified and refined by local practitioners to become an effective tool in preventing future accidents in Bangladesh.

7.2 Internal circulation

When a Road Safety Audit report is produced an additional copy of that report should be circulated, for information, to all engineers in the Road Safety Unit.

7.3 Safety audit library

A library of published Road Safety Audits shall be maintained in each Road Safety Unit. Access to this library shall be made as wide as possible but at the discretion of the Head of the Road Safety Unit.

7.4 Developing the practice in Bangladesh

International practice of Road Safety Audit has developed quickly in recent years. Considerable improvements in audit standards have been achieved by practitioners meeting to review and discuss the latest experiences and Road Safety developments. This will work well in Bangladesh by first setting up informal links with other Road Safety Units and then arranging regular Road Safety Audit Forums to discuss ways of improving all areas of the service.
The main focus of these meetings shall be directed towards:

- procedures, problems encountered and ways to make the system more efficient
- refinement of the checklists in the light of experience in practice and new research becoming available
APPENDIX A

Road Safety Audit Checklist
### CHECKLIST 1 - PLANNING

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Is there a development plan or development strategy for the area and, if so, does the project conform to this?</td>
</tr>
<tr>
<td>1.2</td>
<td>Is the proposed design appropriate in relation to the forecast traffic volumes and traffic characteristics?</td>
</tr>
<tr>
<td>1.3</td>
<td>Does the route fit in with the physical constraints imposed by the topography?</td>
</tr>
<tr>
<td>1.4</td>
<td>Does the route serve major generators of traffic in a safe and adequate manner?</td>
</tr>
<tr>
<td>1.5</td>
<td>Is the frequency of junctions and their type appropriate for the function of the road and its design speed?</td>
</tr>
<tr>
<td>1.6</td>
<td>Does the project road fit in well with the existing road network? <em>(Check for potential problems at the connections - Will changes in traffic volumes cause problems?)</em></td>
</tr>
<tr>
<td>1.7</td>
<td>Does the project road relieve routes or sites with bad accident records? Does it have any harmful effects on safety on the surrounding road network?</td>
</tr>
</tbody>
</table>
### CHECKLIST 2 - CROSS-SECTION

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Are the widths of the lanes, shoulders, medians (if any) in accordance with standards and adequate for the function of the road and the mix of traffic likely to use it?</td>
</tr>
<tr>
<td>2.2</td>
<td>Are there narrow sections (at bridges, culverts as well as other places) where there could be safety problems? If they are unavoidable, check whether they are designed as safely as possible.</td>
</tr>
<tr>
<td>2.3</td>
<td>Have the shoulders and side slopes been designed to a safe standard? <em>(Check whether shoulders are constructed to a good standard, there is no drop at the carriageway/shoulder join, and that; side slopes are no steeper than 1.4)</em></td>
</tr>
<tr>
<td>2.4</td>
<td>Have the side drains be designed to a safe standard?</td>
</tr>
<tr>
<td>2.5</td>
<td>Is the connection between the project road and the existing road(s) designed consistently and safely?</td>
</tr>
</tbody>
</table>
## CHECKLIST 3 - ALIGNMENT

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Is the proposed design speed appropriate to the function of the road, the mix of traffic likely to use it, and the road environment? (Check whether different sections need different design speeds).</td>
</tr>
<tr>
<td>3.2</td>
<td>Do the horizontal and vertical alignments generally give sufficient forward visibility for the selected design speed? <em>(Check for inadequate stopping sight distances)</em>.</td>
</tr>
<tr>
<td>3.3</td>
<td>Are there major inconsistencies in the alignment (such as a sharp bend following a straight downgrade section) and, if so and they are unavoidable, have adequate measures been taken to make drivers aware of them?</td>
</tr>
<tr>
<td>3.4</td>
<td>Do the horizontal and vertical alignments fit together comfortably? <em>(Check for bad combinations, such as a sharp bend immediately after a summit curve, and a sag curve within a bend)</em>.</td>
</tr>
<tr>
<td>3.5</td>
<td>Does the alignment provide regular, safe overtaking opportunities? Does it avoid creating situations where overtaking is permitted but the forward visibility is unsafe for overtaking?</td>
</tr>
<tr>
<td>3.6</td>
<td>Does the design of bends adequately consider the following points, warning the approach transition curves, superelevation, carriageway widening, curve delineation?</td>
</tr>
<tr>
<td>3.7</td>
<td>Does the vertical alignment pose excessive demands on the power of heavy vehicles?</td>
</tr>
<tr>
<td>3.8</td>
<td>Is the transition between the project road and the existing road(s) handled safely?</td>
</tr>
</tbody>
</table>
### CHECKLIST 4 - ROADSIDE COMMUNITIES AND FACILITIES

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Does the cross-section, alignment and signing encourage drivers to adjust their speed on entering the town or village and maintain it at an appropriate level? <em>(Check that it will be quite clear to drivers that the road environment is changing and that they must slow down - consider traffic calming measures).</em></td>
</tr>
<tr>
<td>4.2</td>
<td>Is there adequate and safe provision for pedestrians to walk alongside the road and to cross it? <em>(Check for provision of footways and safe crossing places. In the busier places check whether pedestrian movements are controlled and channelled by guard-rail. Check whether side drains are pedestrian-friendly).</em></td>
</tr>
<tr>
<td>4.3</td>
<td>Is the design and provision of roadside parking and access to properties adequate, controlled and safe? <em>(Check provision at the popular bus and truck stopping places especially. Check that the opportunity has been taken to improve any problem sites).</em></td>
</tr>
<tr>
<td>4.4</td>
<td>Has the opportunity been taken to improve the traffic and parking situation in the towns and villages through which the road passes? <em>(Check for junction improvements, access control, provision of service lanes, parking areas and bus stops).</em></td>
</tr>
</tbody>
</table>
CHECKLIST 5A - JUNCTIONS - GENERAL

5.1 Is the junction in a safe location? (Check whether there are other junctions too close to it. Check whether approaching drivers will get a clear view of it. Check whether the site permits the junction to be of a proper layout and standard).

5.2 Is the type of junction (T-junction, staggered junction, signal-controlled junction, roundabout, etc.) suitable for the function of the two roads, the traffic volume, the traffic movements (pedestrian and vehicular), and the site constraints? Is it the safest alternative?

5.3 Is the layout of the junction adequate for all permitted vehicular movements and for all types of vehicle? (Check using turning circle templates for buses and trucks).

5.4 Will the general type of the junction, its layout and the priority rules be recognised by approaching drivers in adequate time? Is the route through the junction as simple and clear as possible? Do the decisions that need to be made by drivers follow a simple, logical and clear sequence? (Check for unusual or over-complicated layouts. Check that the signing and marking is correct and clear - if in doubt refer to the Traffic Signs Manual).

5.5 Does the layout encourage slow controlled speeds at and on the approach to STOP/GIVE WAY lines and other critical decision points? (Check for Y and skew junctions which can be a problem. Also roundabouts with inadequate deflection).

5.6 Are the sight lines at and on the approach to STOP/GIVE WAY lines and other critical decision points adequate and unobstructed? (Check for Y and skew junctions which can be a problem. Check signs, lighting columns, pedestrian guard-rail, etc.).

5.7 Is there adequate provision for channelling (and protecting where necessary) the different streams of traffic? (Check the provision for right-turn lanes and storage areas, deceleration and acceleration lanes).

5.8 Is adequate provision made for pedestrians and non-motorised vehicles? (Check whether it is convenient, easily-seen and understood, capable of being used safely (check intervisibility between pedestrians and vehicles) and large enough to meet demand).

5.9 Is the provision of night-time lighting adequate? (Consider the need for drivers to recognise and understand the junction, and see pedestrians. Consider the needs of pedestrians who are negotiating the junction. Check that the layout of the lighting columns illuminates the junction effectively).
<table>
<thead>
<tr>
<th>CHECKLIST 5B - JUNCTIONS - ADDITIONAL CHECKS FOR ROUNDABOUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.10 Is the geometry simple and easily understood? (Beware of roundabouts which are not circular, or which have awkward entry paths)</td>
</tr>
<tr>
<td>5.11 Are there too many entries for safe, efficient operation? Are they sufficiently separated from each other to avoid confusion?</td>
</tr>
<tr>
<td>5.12 Does the design deflect entering traffic sufficiently to ensure entry speeds are no greater than 50 km/h? (Check entry path curvature, centre island size and positioning).</td>
</tr>
<tr>
<td>5.13 Is the visibility for entering traffic adequate? (Note that if visibility is too good, it may encourage entry speeds which are too high).</td>
</tr>
<tr>
<td>5.14 Is the visibility for circulating traffic adequate? (Check that visibility across the centre island is not unduly obstructed by signs, landscaping or structures).</td>
</tr>
<tr>
<td>5.15 Has the centre island been designed to be forgiving to errant vehicles?</td>
</tr>
<tr>
<td>5.16 Has adequate provision been made for pedestrians to cross the arms of the junction? (Guardrail will usually be necessary to channel pedestrians to safe crossing points on the arms).</td>
</tr>
<tr>
<td>5.17 Have the needs of cyclists and other non-motorised vehicles been considered?</td>
</tr>
<tr>
<td>5.18 Does the signing make the priorities clear? (Entering traffic must give way to circulating traffic).</td>
</tr>
</tbody>
</table>
### CHECKLIST 5C - JUNCTIONS - ADDITIONAL CHECKS FOR SIGNAL CONTROLLED JUNCTIONS

<table>
<thead>
<tr>
<th></th>
<th>Checkpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.19</td>
<td>Do the signal colours and signal sequence conform with National Standards?</td>
</tr>
<tr>
<td>5.20</td>
<td>Do the signals clearly indicate which movements are allowed at any one time?</td>
</tr>
<tr>
<td>5.21</td>
<td>Are the signal heads positioned so that drivers can see them easily, and in time to stop? <em>(Check this for drivers at the stop line as well as those approaching at speed - it will usually be necessary to have secondary signals).</em></td>
</tr>
<tr>
<td>5.22</td>
<td>Are the signals for competing phases located so that they are visible only to the traffic for whom they are intended? <em>(Check also that there is no risk that pedestrians may be misled by the traffic signals into thinking that it is safe for them to cross).</em></td>
</tr>
<tr>
<td>5.23</td>
<td>Are all right-turning movements protected (i.e. there are no conflicting movements) as far as possible?</td>
</tr>
<tr>
<td>5.24</td>
<td>Does the signing, marking and channelisation make it clear to drivers what path they should take through the junction?</td>
</tr>
<tr>
<td>5.25</td>
<td>Are pedestrian crossing places marked, and are pedestrians channelled to crossings? Are there pedestrian refuges?</td>
</tr>
<tr>
<td>5.26</td>
<td>Are the pedestrian crossings signal-controlled where appropriate? If so, is there a need for the crossing movements to be fully protected from conflicting traffic movements for example where there will be serious conflicts with turning traffic?</td>
</tr>
<tr>
<td>5.27</td>
<td>Are the pedestrian signals positioned so that pedestrians can see them?</td>
</tr>
<tr>
<td>5.28</td>
<td>Are signal inter-green periods adequate?</td>
</tr>
</tbody>
</table>
**CHECKLIST 6 - SPECIAL ROAD USERS**

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Has there been a survey of non-motorised vehicle and pedestrian flows?</td>
</tr>
<tr>
<td>6.2</td>
<td>Will there be any major conflicts between motorised traffic and pedestrians and other road users?</td>
</tr>
<tr>
<td>6.3</td>
<td>Have pedestrians needs for crossing, and walking alongside the road been provided for? (<em>Check particularly in towns and villages and at all junctions.</em>).</td>
</tr>
<tr>
<td>6.4</td>
<td>Have the needs of cyclists and other non-motorised vehicles been provided for? (<em>Check the need and feasibility of cycle / cycle rickshaw lanes in towns.</em>).</td>
</tr>
<tr>
<td>6.5</td>
<td>Is the provision for pedestrians and non-motorised vehicles at bridges and narrow sections adequate in relation to pedestrian and vehicular traffic volumes and traffic speeds?</td>
</tr>
<tr>
<td>6.6</td>
<td>Is the provision of bus stopping places suitable? Is the location, design and signing adequate?</td>
</tr>
</tbody>
</table>
## CHECKLIST 7 - SIGNS, MARKINGS AND LIGHTING

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Is the provision for signing (regulatory, warning and informative signs and delineation) adequate and in accordance with National Standards?, Are retroreflective sign facings specified?</td>
</tr>
<tr>
<td>7.2</td>
<td>Are the sign sizes, placement and construction adequate, safe and in accordance with standards ?, Is the ‘x’ height (height of lettering) sufficient for the speed of oncoming traffic ?</td>
</tr>
<tr>
<td>7.3</td>
<td>Are the proposed road markings adequate and in accordance with standards ? Are thermoplastic materials specified ?</td>
</tr>
<tr>
<td>7.4</td>
<td>Is the delineation adequate, especially on sections with difficult alignments ? <em>(Check signs and road markings).</em></td>
</tr>
<tr>
<td>7.5</td>
<td>Is there a need for the project road, or parts of it, to be lit at night ?</td>
</tr>
<tr>
<td>7.6</td>
<td>Is the proposed lighting scheme (if any) adequate ? Are there any hazardous dark areas ?</td>
</tr>
<tr>
<td>7.7</td>
<td>Has the siting of lighting columns been considered from a safety viewpoint ?</td>
</tr>
<tr>
<td>7.8</td>
<td>Are frangible or slip-base columns to be provided ?</td>
</tr>
</tbody>
</table>
### CHECKLIST 8 - ROADSIDE HAZARDS

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Will bridge and culvert parapets, and other obstructions be close to moving traffic? If so, can they be relocated? If not, are they adequately signed and, where necessary, protected by a safety barrier?</td>
</tr>
<tr>
<td>8.2</td>
<td>Are bridge parapets designed to contain errant vehicles?</td>
</tr>
<tr>
<td>8.3</td>
<td>Are the ends of bridge parapets protected by a safety barrier? <em>(Check that any safety barrier is properly secured to the bridge structure and that the design of the barrier is safe).</em></td>
</tr>
<tr>
<td>8.4</td>
<td>Are bridge parapets, bridge railing, and pedestrian guard-rail safely designed? <em>(Check that horizontal elements are strongly supported and cannot come loose if hit by a vehicle).</em></td>
</tr>
<tr>
<td>8.5</td>
<td>Are there any poles or columns located close to moving traffic that could be located elsewhere?</td>
</tr>
<tr>
<td>8.6</td>
<td>Is a safety barrier provided where necessary and where traffic volumes and traffic speeds warrant it? <em>(Check for large drops (over 3 m) especially on the outside of sharp bends and on bridge approaches, as well as hazardous roadside objects that may need protecting).</em></td>
</tr>
<tr>
<td>8.7</td>
<td>Is the type, detailing, and placement of proposed safety barrier in accordance with safe practice?</td>
</tr>
<tr>
<td>8.8</td>
<td>Where a safety barrier is provided does it protect all roadside objects? <em>(Check that there are no signs, lighting columns, etc. in front of the barrier).</em></td>
</tr>
</tbody>
</table>
APPENDIX B

Safety Audit on Routes
PRELIMINARY CHECKLIST FOR ROUTES

In December 1997 Engineers attending the Road Safety Engineering class at RHD were requested to produce a list of topics to consider in reviewing the design standards of a theoretical 20 km section of highway. The object of the exercise was to introduce a higher standard of safety in the design, Safety Audit. The following list is the result of this exercise. It is expected that the list will be a useful basis for those about to undertake Safety Audit on Routes.

1 Consistency of the design

- all routes must be consistent, avoid any situation that may take the driver by surprise
- Are standards the same along the route?
- Are standards the same at the connection of the new road to the existing road network?

2 The design of bends

- **Radius**
  Is the radius appropriate for the speed of traffic?
- **Sight distance**
  Are sight distances appropriate?
- **Superelevation**
  Has superelevation been provided, if yes, is it adequate?
- **Speed of traffic**
  Is it necessary to consider a reduction of speed limit?
- **Widening of the bend**
  Are lane widths adequate?
- **Crash barrier**
  Will a crash barrier improve safety?
- **Vertical curve**
  Do vertical curves obstruct forward visibility?
- **Road markings**
  Are road markings adequate, edge of carriageway markings, hazard markings, etc?
• **Divider**
  If there is a high probability of a head on accident consider a divider.

• **Street lighting**
  Will street lighting improve safety?

• **Road surface.**
  Is it necessary to improve the skid resistance of the bend?

• **Drainage**
  Will the carriageway drain quickly/efficiently?

• **Advance signs**
  Do they clarify the message, considering day/nighttime conditions and future obstructions?

• **Junction activities**
  Does a minor road join the highway?
  Can this be avoided?
  Is the design safe?

• **Delineation of the bend**
  Will the curve of the bend be clear to drivers?

• **Transition curve**
  Has a transition curve been included?

• **Footways for pedestrians**
  Are facilities required?

• **Non-motorised vehicles**
  Are facilities required?

3 **The design of junctions**

• **Direction sign**
  Is the sign and the message clear? Is the location correct?

• **Sight distance**
  Check the sight distances of all manoeuvres

• **Advance junction warning**
  Is the sign clear and readable for the speed of the traffic?

• **Identify conflicts**
  Can the conflicts be reduced or removed?
• **Right turning accidents**
Can these be avoided or made more safe?

• **Road surface on the approaches to the junction**
Is it necessary to improve the skid resistance of the junction?

• **Road markings**
Are road markings adequate, edge of carriageway hazardous etc.?

• **Street lighting**
Will street lighting improve safety?

• **Pedestrians**
Consider pedestrian movements - can these be made more safe?

• **Bus stops**
Are these located safely, i.e.: off carriageway?

• **Parking**
Will parking present problems?

• **Slow moving vehicles**
Consider NMVs-can these be made more safe?

• **Road side activities**
Will roadside activities create conflicts, hazards?

• **Drainage**
Will the carriageway drain quickly/efficiently?

• **Unnecessary road connections-access points**
Can secondary road connections be designed out or made safer?

4  **Narrow bridges and culverts**

• **Warning signs**
Are they clear? Are they located suitably in advance of the hazard?

• **Speed reduction**
Is it necessary to reduce the speed limit?

• **Increase conspicuity of bridge approach at night**
Reflective materials, posts, studs etc..

• **Forward visibility**
Are all sight lines adequate for the speed of traffic?

• **Barrier**
Has a crash barrier been specified? Is the layout safe?
• **Pedestrian facilities**
  If pedestrians will use the area?
  Are the facilities safe?

• **NMV**
  If NMVs will use the area, consider if the facilities are safe.

5 **Bus-Stops**

• **Identify the locations for bus stops?**
  Are the bus-stops off the carriageway?
  Are the entrances, exits to the bus-stop areas safe?
  Are there “bus stop ahead” signs?
  Pedestrians, What facilities are there for pedestrians? Are they safe?

6 **Roadside activities**

Is it possible to segregate activities from both the highway and the immediate highway areas?

7 **Pedestrian facilities**

Pedestrian traffic along the carriageway
Across the carriageway

8 **Connection to the existing road network**

Avoid any sudden change of highway standards
Avoid a connection on a curve, at bridge approaches, level crossings etc..

• **Hierarchy**
  Have the hierarchy rules been applied?
  Avoid connections near densely populated areas
  Is it possible to avoid connection with existing junction?

• **Visibility**
  Check all sight lines.
• **Pedestrians**
  Are high pedestrian volumes expected?
  Have suitable facilities been included?

• **Accident history**
  Examine accident records on the existing road network. Does the proposal include measures to reduce the identified problems?

• **Signs**
  Is advance information and warning signs provided on the new road?
  Are they adequate?
  Do they include directions from / to the new road? Do they take into account the changes that the new scheme will introduce?

9 **Slow moving vehicles**

  What facilities are provided at the connection between the new and the existing road?
  Are they segregated on the new road?

10 **Street lighting**

  Review street lighting
  Connection to existing network
  At conflict points

11 **Signs and road markings**

  Are the signs consistent along the route?
  Does the specification of the materials include retroreflective sign facings, thermoplastic road markings?

• **Sign locations**
  Check all sign locations.

• **Readability**
  Is the height of the letter suitable for the speed of traffic?
  Are the signs likely to confuse road users?
- **Foliage**
  Is there any possibility of sign obstruction?
- **Street furniture**
  Is there any possibility of sign obstruction?

12 **Roadside objects**

trees adjacent to the roadside - develop safe policy
Are they close to the carriageway?
- **Lamp columns**
  Are they collapsible?
- **Crash barriers**
  Are they safe?

13 **Check sight distances**

  Horizontal and vertical curves
  Junctions
  Bus-Stops, lay-bys

14 **Drainage**

Will the carriageway drain (dry) efficiently?-Will the drainage system draw rain water away efficiently?
- Check crossfall
- Bends, superelevation
- SAG curves
- In areas where the carriageway is in cutting

15 **Speed limit policy along the route**

- stage reduction of speed limit if required
16 Overtaking facilities along a route

- Does the design provide areas for safe overtaking?

17 Road users facilities, stopping rest areas etc.

- only for the longer routes

18 Emergency service facilities

- Consider emergency facilities

19 Policy for roadside deep ditches high embankment

- Does the carriageway run parallel to high embankment, deep ditches?

20 Cross-section

- Lane widths
  Has a hard shoulder been provided?
APPENDIX C

Presentation of the Audit Findings
### EXAMPLE A - A HIGHWAY IMPROVEMENT SCHEME

**Bend at chainage 56+375 to 56 +670**

1. **Problem.**

   1.1.1 The eastbound approach to the bend (approx. 400m radius) is potentially hazardous. It follows a long section of straight carriageway and it is likely to result in loss of control accidents, particularly at night. The situation is made worse by the fact that there is a 3m deep ditch running parallel to the north of the carriageway, to the outside of the bend.

1.2 **Recommendation**

   1.2.1 Reduce the speed of traffic and increase drivers awareness of the bend. This can be achieved by displaying duplicate Advisory 40Kph speed signs, located on both sides of the carriageway, both signs mounted on a yellow backing board. The signs positioned xm from the bend tangent point.

   1.2.2 Displaying duplicate ‘Bend Ahead’ signs, these to be located on both sides of the carriageway, both signs to be mounted on a yellow backing board. The signs positioned xm from the bend tangent point.

   1.2.3 Widen edge of carriageway markings from 100mm to 150mm wide on final 100m approach to and throughout the bend.

   1.2.4 Lay raised reflective carriageway studs on the final 100m approach to and throughout the bend.

   1.2.5 Extend ‘No overtaking’ markings for a distance of 200m.

1. All Carriageway markings to be Thermoplastic or similar approved material.

2. All traffic sign facings to be fabricated from retroreflective materials.
EXAMPLE B - IMPROVEMENT SCHEME AT A JUNCTION.

6.1 Problem.
6.1.1 There is a significant volume of traffic turning right (south to east) on this high speed road. Drivers of vehicles will have to complete the right turn movement through gaps in oncoming southbound traffic. This will expose these drivers to the risk of error in either misjudging the speed or the distance of oncoming vehicles, resulting in serious high speed accidents.

6.2 Recommendations.
6.2.1 Channelise right turning traffic on the approach to the junction and control the movement on a separate vehicle signal phase.

6.2.2 To display the lane distribution early on the approach to the junction, provide an Advance Direction Sign 200m from the junction. Reinforce the message by installing a Local Direction Sign 100m from the junction. Set out appropriate lane carriageway markings, with lane direction arrows.

6.2.3 High speed road red running. Provide vehicle actuated green stage extension on both main carriageway approaches. This can be achieved by installing vehicle detection equipment (in the carriageway) linked to the signal controller.

6.2.4 There will be heavy vehicle braking on both main carriageway approaches to the junction. It is advisable to include 70m of anti-skid road surfacing on these approaches.