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ON
ROAD SAFETY AUDIT

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MANUAL ON ROAD SAFETY AUDIT

INTRODUCTION

This Manual on Road Safety Audit is based on the research study sponsored by the Ministry of Road Transport and Highways to the Central Road Research Institute (CRRI), New Delhi. The study report was submitted by the CRRI in April, 2003 and the research work was initially done by its Project Team headed by Dr. S.M. Sarin and later by Shri R.K. Bajpai and Dr. (Ms.) Nishi Mittal under the directions of Prof. P.K. Sikdar, the then Director CRRI.

The draft of the Manual was considered and reviewed by the Transport Planning, Traffic Engineering and Road Safety Committee (H-1) of the Indian Roads Congress. As desired by the Committee, the draft document was revised by the CRRI team headed by Dr. (Ms.) Nishi Mittal under the direction of Dr. S. Gangopadhyay, Director, CRRI and supported by Shri D.P. Gupta in editing the whole document in the light of comments made by the Members of the H-1 Committee (Personnel given below) :

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This Manual is aimed at decision-makers, engineers and technicians throughout the Indian roads sector, irrespective of whether they work at National, State, District or Local level. It is intended for all those who can and should contribute to improve safety on Indian roads. It provides procedures for applying quality assurance to road projects, from the standpoint of road safety. The methodology is known as 'road safety audit'. When its application becomes widespread, it is expected to make a significant contribution to the prevention of accidents on roads.

The application of cost-effective measures on existing roads as a basis for accident reduction is established through accident investigation procedures, whereas, the application of safety principles in the provision, improvement and maintenance of roads as a means of accident prevention can be established through road safety audit. Thus, the purpose of this audit is to ensure that all road schemes should function as safely as possible, which means that the road users will be exposed to minimal risks of accidents, on new roads as well as on existing roads. The purpose of the Manual is to introduce the subject of road safety audit and to provide guidelines for conducting audit by qualified and experienced road safety auditors.

The Manual describes the concept of road safety audit, stages when the audit may be taken up and the process for both new and existing roads. A section has been separately added for rural roads with special reference to the PMGSY roads. Check Lists related to different stages and various aspects of road safety have been added to facilitate the task of Road Safety Audit.

The draft of the Manual, revised by the CRRI team, was considered by the Transport Planning, Traffic Engineering and Road Safety Committee in their meeting held on 18 September 2009 and it authorized the Convenor Shri S.C. Sharma to finalise the draft in the light of comments made by the Committee members and send it to IRC for consideration by the Highways Specifications and Standards Committee.

The Highways Specifications and Standards Committee approved the draft in its meeting held on 20 October, 2009. Subsequently the draft was approved by the Executive Committee on 31 October, 2009 and by the Council in its 189th meeting held at Patna on 14 November, 2009. The document was finalized later taking into consideration the comments made by the Council Members and those received subsequently, by a small group comprising S/Shri C.Kandasamy, S.K.Verma and D.P.Gupta under the chairmanship of DG(RD) and SS, MORTH, Shri Nirmal Jit Singh.

1 GENERAL

1.1 Road Safety Situation In India

India with 1,05,725 fatalities per annum (in year 2006), accounts for about 10 percent of total world's road fatalities. The share of National Highways and State Highways in the total road network is just 6 percent but these cater to 70 to 75 percent of total road traffic in India. However, the National Highways, which constitute less than 2 percent of the total road network, account for 20 percent of total road accidents and 25 percent of total road traffic fatalities occurring on Indian roads. Further, the severity of road traffic accidents on National Highways is more because of higher speeds as compared to other roads. The road safety situation in India is worsening. Accidents, fatalities and casualties have been increasing dramatically over last 20 years - about 5 percent growth rate over last two decades - partly due to exponential growth of vehicles. The death rate per vehicle is 10 to 20 times higher in India as compared to high-income countries like Sweden, Norway, Japan, Australia, UK and USA. It is much higher even when compared to many low-income countries like Brazil, Mexico and Malaysia.

There is loss of productivity, property damage and costs to the hospital system and emergency services. In addition, there is incalculable personal loss of loved ones. For India, the socio-economic cost of road accidents in 1999-2000 was estimated at 3 percent of GDP (Tenth Five-Year Plan Vol.II page 963). Pedestrians, bicyclists and motorised two-wheeler riders are the Vulnerable Road Users (VRU), which constitute 60-80 percent of all traffic fatalities in India. This seems logical as this class of road users forms the majority of those on roads. On highways, the proportion of VRU and other motor vehicle occupants are 32 percent and 68 percent respectively. In addition, they sustain relatively more serious injuries even at low velocity crashes, unlike car occupants who are protected by impact absorbing metallic body of the vehicles.

Table 1.1 shows the worsening situation of road accident fatalities and injuries in India. Accident prevention can be enhanced by the application of road safety audit over the road network at its different stages of development.

1.2 Accident Prevention

Accident reduction and accident prevention are the two main strategies in road safety work. In accident reduction, we use the knowledge of accidents that have occurred on our existing roads to improve the design of the roads or to influence the behaviour of road users, so that similar accidents do not occur again.

Accident prevention is the application of expertise in safe road design - road geometry, as well as the materials used - when we construct new streets and roads or redesign the existing roads, regardless of the reasons for which an individual project is undertaken. This expertise is the result of research and to a significant extent of practical experience gained through working on accident reduction.

Table 1.1 Year-Wise Road Accident Statistics In India

Year	Number of Accidents		Number of Persons		No. of persons killed per 100 accidents
	Total	Fatal (Figures within brackets give percentage of total)	Killed	Injured	
2001	405,637	71,219(17.6)	80,888	405,216	19.9
2002	407,497	736,50(18.1)	84,674	408,711	20.8
2003	406,726	73,589(18.1)	85,998	435,122	21.1
2004	429,910	79,357(18.5)	92,618	464,521	21.5
2005	439,255	83,491(19.0)	94,968	465,282	21.6
2006(P)	460,920	93,917(20.4)	105,749	496,481	22.9

Source : National Road Safety Profile of India (2008) Central Bureau of Health Intelligence

Accident prevention should be the objective of any highway authority to ensure that the roads are safe. A road is considered safe when only a few - or, in the best case, no accident occurs. If many accidents occur, a road is not safe, regardless of whether all standards and norms were observed during its planning and design, and regardless of whether any accidents can be attributed to contravention of the law or other inappropriate behaviour on the part of road users.

In road safety work, the concept of 'contributing accident factors' is used. There are factors, which, by their very presence, or which, through their absence have contributed to the occurrence of an accident. Such factors can be related to the road user, the vehicle and the road and its surroundings. Each element, constituting many factors within, contribution (in percentage) in the occurrence of accidents is presented in **Table 1.2**.

Table 1.2 Percentage-Wise Contribution of Various Elements in Road Accidents

Element	Percentage
Road User	65.0
Road & Surroundings	2.5
Vehicle	2.5
Road User, Road & Surroundings	24.0
Road User and Vehicle	4.5
Road User, Road & Surroundings and Vehicle	1.5

Road users are not perfect. Behaviour of road users appears as a contributing factor in all road accidents. This does not mean, however, that road engineering measures have no effect on the

frequency of accidents. On the contrary, it demands that we guide road users into law-abiding and appropriate behaviour through the design of 'forgiving' roads.

1.3 Road Safety Audit - Part of Road Safety Strategy

The management of accident risk is both a short-term and a long-term strategy, which requires support of central and state authorities. The most effective way of managing accident risk is through the development of a 'safety culture'. A safety culture is 'the ideas and beliefs shared by all members of an organisation about accidents and the risk of their happening'. Highway authorities have the task of delivering products and services to road users, and there are many practical ways in which they can do to foster the interest of road safety. The most important requirement within any highway authority is to have a commitment to road safety. This commitment allows assuming responsibility for their actions, be it designing a road, implementation on the ground, approving a development access, allocating resources or training staff. It is not necessary for accidents to occur before steps are taken to both reduce the likelihood of them occurring and minimize their consequences. Road safety audit should be viewed as part of an overall strategy to reduce accident risk.

Road safety audit has the greatest potential for improving safety when it is applied to a road or traffic design before the project is built. It can be conducted on any design proposal, which involves changes to the ways road users will interact, either with each other or with their physical environment. Purpose of the audit is to look at the accident potential and safety performance of the proposal. It is a formal process using a defined procedure and not an informal check. To be effective, it must be conducted by persons who have appropriate expertise, experience and training and who are independent of the design team. An audit may also be conducted on an existing road, since it permits hazards to be identified and opportunity becomes available to identify preferred road engineering measures to improve safety.

2 ROAD SAFETY AUDIT - AN OVERVIEW

2.1 What is Road Safety Audit?

Road Safety Audit (RSA) is a formal procedure for assessing accident potential and safety performance in the provision of new road schemes and schemes for the improvement and maintenance of existing roads.

However, its systematic application can also ensure that a growing awareness about good road safety principles is achieved throughout in highway planning, design, construction and maintenance organisation. The essential elements of the definition are that it is:

a) A formal process and not an informal check,

b) Carried out by persons who are independent of the design and construction,

c) Carried out by persons with appropriate expertise, experience and training, and

d) Restricted to road safety issues.

The main aim of road safety audit is to ensure that all new road schemes operate as safely as practicable. This means that safety should be considered throughout the entire cycle of design, construction and pre-opening of any project facility and also during operation & maintenance of the highway. Specific aims of RSA are :

a) To minimize the risk of accidents likely to occur/occurring on the project facility and to minimize their severity.

b) To minimize the risk of accidents likely to occur/occurring on adjacent roads i.e., to avoid creating accidents elsewhere on the network.

c) To recognise the importance of safety in highway design to meet the needs and perceptions of all types of road users; and to achieve a balance between needs of different road user types where they may be in conflict with one another.

d) To reduce long-term costs of a project facility, bearing in mind that unsafe designs may be expensive or even impossible to correct at a later stage.

e) To increase awareness about safe design practices among all those involved in the planning, design, construction and maintenance of roads.

Road safety audits assess the operation of a road, focusing on road safety as it affects the users of the road. These users include pedestrians, cyclists, motorcyclists, truck/bus drivers, on-road public transport users, etc. The outcome of a road safety audit is the identification of any road safety deficiencies and formulation of recommendations aimed at removing or reducing those deficiencies.

2.2 Road Safety Audit and Quality Assurance

Road safety audit is an important aspect of Quality Assurance (QA), applied to the implementation of a road project. It is a management process in which the provider of goods or services assures the customer or client of the quality of those goods or services, without the customer or client having to check each time.

Quality assurance is done by the implementation, in the organization, of a set of procedures designed to ensure that agreed standards are met. Quality assurance procedures for the design and implementation of new road or traffic projects are to input road safety engineering expertise into the design. Often the client and the customer are the same person or organization. In case of roads, the client for whom the road is designed and built is usually the highway authority, whereas the customer is the road user. A road safety audit is undertaken for the highway authority to ensure that the customer is afforded a level of protection from unsafe design and construction.

'Getting it right the first time' is the underlying theme of quality assurance. Road safety audits seek to ensure the road operates 'right the first time' once it opens and that the road users make fewer mistakes. Quality assurance is a continuous process. So far as the safe design of roads is concerned, quality assurance starts with a safety culture in an organization. While designing a

road, engineers will apply quality assurance techniques by established procedures and regularly check the details of their own work. This regular checking includes checking safety aspects. This type of assessment, however, is not 'road safety auditing' because it is not done with a 'fresh pair of eyes' and it probably is not applying road safety engineering skills and experience required for the task. Road safety audit, on the other hand, is a 'step-by-step' process, performed at all stages. An independent road safety audit of the design is sought, to permit independent road safety engineering advice to be input, for the benefit of the future road users. Presently, it has become practice of involving safety engineers during the life of project, liaising informally with professionals of all disciplines at all stages, from feasibility/concept stage to completion. In turn, quality assurance can be applied to the providers of road safety audit services.

2.3 Where Did the Idea of RSA Start and How?

Traffic engineers in UK developed the idea of Road Safety Audit as a safety check for new and improved road projects and schemes in the early 1980s. The Road Safety Audit process in the UK started to gather momentum when safety engineers realized that they were carrying out accident remedial schemes on relatively new roads. Common mistakes in carriageway layout, positioning and type of street furniture, poor signing and marking, inappropriate surfacing materials, lack of facilities for vulnerable road users such as pedestrians and cyclists were being repeated over and over. There was no feedback from the safety facilitators to the highway designers and constructors in the same way as vehicle crash investigators fed their findings into the car design process. Safety audit was born.

Adopting the principle of 'precaution is better than cure', they decided to use some of the safety experience they had gained from the remedial work and design safety into new road schemes. The Institution of Highways and Transportation Guidelines on Accident Investigation and Prevention produced during that time emphasized on 'safety checking', as an accident prevention mechanism. The widespread growth in the use of road safety audits has been helped by two facts namely, the concern with improving road safety and the application of quality assurance principles to road projects. The road safety audit is a snapshot in time that checks to see if the quality is being implemented. Many countries have formulated comprehensive strategies to reduce crash toll, which in turn have identified safety audits as a part of overall strategic approach.

2.4 Why Road Safety Audit?

Road safety audit must assess projects on the basis of road user knowledge, attributes and skills, day/night and wet and dry road conditions. Safety audit is only a study of safety aspects and an auditor may indicate road safety problems inherent in designs that conform to our road standards. This is due to the fact that our road standards are an expression of a socio-economic balance between road safety, accessibility, environment and economy.

The goal of road safety audit is to ensure that all new road projects - and major operating and maintenance activities on existing roads - are assessed from the standpoint of road safety, so that any parameters of the project that are unsuitable from the standpoint of road safety are

corrected in time. The benefits of conducting road safety audit are that:

- The likelihood of accidents on the road network can be reduced,
- The severity of accidents can be reduced,
- Road safety is given greater prominence in the minds of road designers and traffic engineers,
- The need for costly remedial work is reduced, and
- The total cost of a project to the community, including accidents, disruption and trauma, is minimized.

The cost of road safety audit and the consequent cost of changing a design are significantly less than the cost of remedial treatments after works are constructed. It is easier to change the lines/alignment or so on a plan than to move concrete structures. With less remedial work included in a highway authority's works programme, budgets can be kept down or the same money can be utilized more effectively.

2.5 Road Safety Audit : What is Done and Not Done

ROAD SAFETY AUDIT IS :

a) Minimizing the likelihood of crashes occurring through safety-conscious planning and design;

b) Ensuring that, if a crash occurs, then the likelihood of the injury is minimized (such as provision of anti-skid surfacing and crash barriers);

c) Ensuring that safety related design criteria (e.g. critical sight distances) have been met;

d) Managing risks, such that the risk of major safety problems occurring is less than the risk of minor problems occurring;

e) Reducing the whole-life cycle costs of a design (unsatisfactory designs are expensive to correct after they are built);

f) Minimizing the risk of crashes on the adjacent road network (particularly at intersections) as well as on the new road scheme;

g) Enhancing the importance and relevance of road safety engineering in highway design work and to enhance consideration for the safety of all categories of road users in all new and existing schemes.

ROAD SAFETY AUDIT IS NOT :

a) A way of assessing or rating a project as good or poor;

b) A means of ranking or justifying one project against others in a works programme;

c) A way of rating one option against another;

d) An accident investigation;

e) A redesign of a project;

f) Something to be applied only to high cost projects or only to projects involving safety problems;

g) The name you use to describe informal checks, inspections or consultations;

h) An opportunity to raise subjective concerns.

2.6 Who Does The Safety Audit?

To be effective, the safety audit needs to be carried out by specialists, who are independent of the design process. In this way auditors will be taking a fresh look at the project without the distraction of having been involved in their design. Road safety audit involves one set of professionals checking the work of other professionals. Crucial factor is that auditors should be independent and impartial. Road safety auditor must not question the justification for a project but must bring to light its consequences on road safety and endeavour to ensure that the project as presented in the brief is as safe as possible. Auditors need to be objective in their assessments, yet sensitive to the fact that no one likes criticism. Designers and clients need to consider audit recommendations objectively as brought out from the audit outcome.

Expertise and experience in road safety engineering are the essential ingredients in any road safety audit team. This should be linked to an understanding of:

- Traffic engineering and traffic management, and
- Road design and road construction techniques

A person who has an understanding of road user behaviour and human perception is also likely to be able to develop road safety audit skills. This understanding is in fact a desirable skill because of the interactive nature of road user behaviour with the road environment. An audit team leader must not only have knowledge and skills in road safety engineering, but also should have received training and participated in a number of audits. It is expected that the safety auditors will apply due diligence in identifying the deficiencies and evolving audit recommendations which should be supported with reasons.

The Authority, which engage safety auditors should ensure that the team leader has:

- Adequate road safety engineering experience for the stage of the audit,
- Successfully completed a recognised audit training course,
- At least five years experience in a relevant road design, road construction or traffic engineering field, and
- Undertaken at least three road safety audits including design stage, etc.

It is not practical or necessary to have a multi-member team conducting an audit. An audit of a low budget project, a road safety audit by more than two persons may not be justified. For large projects, three persons are needed where as for small projects two persons will be required.

2.7 Organisations Involved In Road Safety Audit

Road Safety Audit is based on the principle of an independent review. Road safety audit process reveals that three parties will be involved in this process - Client, Designer and Auditor. For the Public Private Partnership projects (PPP) the client would be both the Govt. and the Concessionaire with their respective obligations as provided in the Concession Agreement. One fundamental idea is that disagreements between the designer and the auditor are resolved not by the designer but by the client. So it is an interaction between different parties, whose roles are predefined at specific stages. In India, for large and small projects client may be National Highways Authority of India (NHAI)/Ministry of Road Transport and Highways/concerned Public Works Departments (PWD). Designer may be one consultant and Auditor may be another consultant. Sometimes design may be done by the design section of concerned client. Here the client and the designer are same. In such cases, some other divisions of concerned highway/ road authorities could carry out the task of auditing. Main functions of the key stages in road safety audit are shown in **Table 2.1.** In case of PMGSY projects of road connectivity to villages and other rural habitations, the National Rural Roads Development Agency (NRRDA) and the State Rural Roads Development Agency (SRRDA) at the State level would be concerned. Their State technical agencies would need to be sensitized to check the estimate, alignment, etc., from safety angle also, keeping in view the constraints of the availability of land. For roads in urban areas, the client may be local urban bodies, municipal corporations, urban development authorities etc.

2.7.1 *Role of designer*

Designer is responsible for planning/designing the project. Designer bears the responsibility for ensuring that a road safety audit is conducted and that the necessary measures are agreed on the basis of the auditor's recommendations and / or the client's decisions. The designer is also responsible for ensuring that the audit input information is unambiguously defined and that all circumstances are described in an easily understandable manner. For existing roads, it is the responsibility of operating organisation of the relevant highway authority which requests the auditor to prepare accident analysis of the project and which arranges for the road operator to be notified about the results of the audit. The project manager, or design engineer should be responsible for initiating the safety audit process for each scheme and for responding to the audit. The role of the designer is thus to:

- Attend commencement and completion meetings.
- Bring out the action proposed in response to the audit report and its recommendations and to document these proposed actions.
- Implement the decisions given by the client on the proposed action by amending the original design
- Feed the experience back into the designer's organization and to avoid similar design problems recurring.

Table 2.1 Main Functions of the Key Players in Road Safety Audit

Key Player	Main Functions
Project Owner (Govt. and/or Concessionaire)	• Expresses a commitment to road safety • Provides funding and resources • Considers safety audits and reviews as an essential quality control requirement • Commissions audits and reviews at appropriate times • Selects road safety audit team • Facilitates the response to the recommendations of audits and reviews and arranges implementation of recommendations that are accepted • Attends commencement and completion meetings
Design Team	• Attends commencement and completion meetings • Provides relevant information to safety team • Acts upon and documents response to recommendations of audit
Safety Audit Team	• Identifies safety issues in the proposed design • Makes constructive recommendations to enhance safety • Documents safety issues and recommendations • Holds commencement and completion meetings with the client and design team

2.7.2 *Role of client*

Client is one who allots the project to the designer and owns the project. As the party responsible for the basic conditions of the project, it is the task of the client to decide in cases where the designer and auditor disagree. Disagreements are presented to the client who conveys its decision to the designer and the auditor. Road operator assumes this responsibility in case of existing roads. The client should be responsible for ensuring that clear terms of reference are laid down to cover the whole range and scope of audit and for commissioning audits at appropriate stages. The role of the client is thus to:

- Select an appropriate auditor,
- Provide all the relevant and necessary documents, and
- Hold a commencement meeting with the auditor and the client.

2.7.3 *Role of auditor*

Auditor's responsibility is to carefully review the presented project material in its entirety, in the light of best road safety expertise and from the viewpoints of all relevant road users. Auditor also

indicates all circumstances that cause misgivings concerning road safety. Persons designated as Road Safety Auditors work with, and have experience of, road accident analyses and road accident reduction. Auditors must be familiar with road planning, design and construction work and must undertake to keep their expertise up-to-date.

Auditors should comply with the terms of reference. They should comment only on the safety implications of schemes and provide constructive recommendations as to how any potential difficulties can be resolved. The role of the auditor is thus to:

- Review all the documents and audit the drawings and designs,
- Inspect the site (including during night time),
- Repeat these two steps,
- Prepare a report,
- Hold a completion meeting with the designer or client or both,
- Participate in the meeting organized by the client sequel to designers reactions in the Auditor's Report.

2.8 What Type of Projects should be Audited?

Road safety audits are applicable to all types of road projects and to all categories of roads in both urban and non-urban areas. Road safety audits can be conducted on road projects as diverse as:

- Expressways,
- Major four-laning and multi-laning projects,
- Reconstruction and realignment projects,
- Intersection projects both signalised and non-signalised
- Pedestrian and bicycle routes,
- Rural roads providing access to villages/habitations
- Access roads near project roads,
- Local area traffic management schemes in urban areas
- Accident reduction schemes,
- Traffic calming measures through built-up areas
- Approaches to bridges, rail over/under bridges
- Grade separators and interchanges

Some road authorities require a percentage of design projects on major roads to be audited. Others require all projects, or a percentage of projects, above a set value to be audited. It is unrealistic to audit all projects at all possible design stages. When deciding which projects should be audited

ahead of any other, the effective allocation of resources should be a deciding factor. Choose a range of project sizes and seek to audit them earlier rather than later. Audits can also be conducted on projects, which are 'off-road', but which affect nearby roads or create off-road areas, which effectively operate like roads. Audits would also prove useful in rural roads being constructed under the PMGSY and other state government programmes for the reasons that due to policy of land contribution by the community, situations could arise in some stretches where geometrics are compromised. However, safety audit in respect of such roads should be simplified but process should be effective. Chapter 7 describes the essential elements of such a process along with safety aspects that may be considered by the road agencies in design stage itself.

For some schemes it may be possible to omit or combine stages. For example, PPR and DPR stages can be combined for smaller improvements, or for traffic management, feasibility and PPR stages can be combined. **Table 2.3** sets guidelines for organizing the road safety audit system. There is need for post delivering monitoring of RSA after its recommendations are implemented. This would provide feedback for its effectiveness.

Table 2.3 Guidelines for Organizing RSA at Different Stages of the Project

Sl. No	Scheme Type	F	PPR	F+ PPR	DPR	PPR+ DPR	During Const.	Pre-Opening
1)	Major Road Schemes	*	*		*		*	
2)	Major Rehabilitation Schemes	*	*		*		*	
3)	Minor Road Schemes		*			*		
4)	Traffic Management Schemes/ Traffic Calming			*	*			
5)	Accident Remedial Schemes					*		
6)	Major Maintenance Schemes			*	*			
7)	Major Development Schemes	*	*		*			*
8)	Minor Development Schemes			*	*			
9)	Temporary Traffic Management of Major Schemes					*	*	

Source: MORTH Manual For Safety in Road Design (1998)

F=Feasibility; PPR = Preliminary Project Report; DPR = Detailed Project Report

2.9 Ways of Organising a Road Safety Audit

There are many ways of organizing a road safety audit. However, the two essential attributes of road safety auditor are that the person should be skilled and independent. Practically, two options are there for conducting a road safety audit:

- Audit by specialist auditors,
- Audit by those within the original design team or by other road designers.

In case of audit by specialist auditors, team needs to be a separate entity from the normal road design functions of an organisation and team members should not, except for the purpose of an audit, be involved with the design of the project. There needs to be a clear understanding, prior to commencement of an audit, about how the audit findings and recommendations will be dealt with. Someone has to consider the safety recommendations and resolve the inevitable trade-offs i.e., project cost, road capacity, likelihood of severity of accidents, etc. In every case where an audit recommendation is rejected, the reasons must be stated and documented. Other ways of dealing with audit recommendations can include:

- A requirement that each recommendation must be formally considered by the client with a view to its acceptance in a normal course and the work cannot proceed to the next stage until formal written approval has been issued by the client based on the recommendations of the audit team.
- The audit recommendations are considered by the designers, or by the project manager. This has the risk that the safety concerns may be rationalized away, in the atmosphere of keeping the project moving with minimal changes.

Instead of using specialist auditors, another designer or design team could undertake the audit. This approach may be applicable in organisations, which have sufficient road design work to have two or more separate design teams. This separation provides a level of independence. But this arrangement does not provide for the one essential ingredient in any road safety audit experience in road safety engineering. Using auditors from within the same organisation also has its limitations. It may be considered that the original designer can audit his or her own designs, on the basis that this is better than nothing. However, this option does not meet requirement of independence. Experience shows that no matter how concerned a designer or design team is about road safety, it is almost inevitable that they will be too close to the issues in the design to apply the 'fresh pair of eyes' needed to inquire into design policies, approaches or details. A more effective way to organize a road safety audit is to engage specialist auditor(s) who is(are) independent and possess requisite road safety engineering skills and experience. The independence of the RSA Team is vital to ensure that the design team does not influence the recommendations of the Safety Audit and, therefore, compromise safety at the expense of other issues. This, however, does not mean that there should not be any interaction between the Design Team and the Safety Auditors. A meeting between Safety Auditors at the start and at the end of the audit process would be useful and Safety Auditors could be asked to provide advice on safety issues during the design. However, the independence of the Audit Team is critical and should not be compromised.

2.10 Road Safety Auditors and Key Personnel in RSA

2.10.1 *Qualifications and background*

A road safety audit is performed by an individual or team with expertise in one or more areas of road safety. Typical backgrounds include traffic or transportation engineering, highway design and construction, crash investigation and analysis and human factors/road-user behaviour.

While it is not always feasible or practical to use a team in conducting audits, it is very important that auditors possess an understanding of traffic engineering and road design techniques and have some experience in crash investigation. An understanding of human factors is also important, because of the strong interaction between road users and road environment.

The desirable qualifications and background of the auditors at different stages of the Road Safety Audit are as under:

a) For Feasibility and Preliminary Project Report (PPR) Stages

- Road Safety Specialist with experience in accident investigation, safety management, safety engineering principles and assessment of potential user risks;
- Road Design Engineer with familiarity in geometric design standards;
- Person with Safety Audit Experience and/or with specialist knowledge of any aspect of proposal and who can generate discussion.

b) For Detailed Project Report (DPR) Stage

In addition to the safety specialist person with specialist skills as in DPR, depending on the type of the scheme; e.g., experience in traffic signal control of facilities for Vulnerable Road Users (VRU), experience in geometric design standards, traffic control devices etc.

c) For Pre-opening Stage and In-service Roads

Additional representatives are recommended, e.g.,

- Police Officer experienced in regulation of traffic;
- Engineer who will be responsible for maintenance of the scheme with experience of similar roads; and
- Person familiar with road user needs for schemes which are particularly relevant for VRU.

d) For Smaller Schemes

Two persons with safety and traffic engineering specialization.

2.10.2 *Size of RSA team*

The most appropriate size of an audit team depends on the size of the audit task; there is no optimum number of members in a team. Teams of more than four persons, at times, can be unmanageable. Major projects require at least two persons. Experienced auditors often discourage one-man teams.

Experience has shown that two persons carrying out a Safety Audit will identify more potential safety issues than a single Safety Auditor. In many cases, the Senior Auditor will be the Team

Leader with the second person being a team member. Ideally, it is desirable to have a team of individuals rather than a single auditor for the following reasons:

a) Diverse backgrounds and different approaches of different experts are beneficial.

b) The cross-fertilization of ideas that can result from discussions is helpful.

c) More than one "pair of eyes" can be an advantage

Therefore, it is recommended that a Safety Audit Team should comprise normally two persons who are independent of the team, involved in project design or construction.

2.10.3 *Training of auditors and training content*

Training in the audit process must be recognized, as vital, if the road safety audit is to retain credibility as a powerful road safety engineering tool. Training of Road Safety Auditors is essential and any Audit Team member should have attended recognized road safety engineering and Safety Audit training courses. The situation in India, at present, is that there is no formal qualification in Safety Audit or Road Safety Engineering. It is possible for staff with very little safety engineering experience to produce audits that are at best a check on design standards. In the initial stages of introduction of safety audit for road projects, the safety audit inputs may be provided by research/ academic institutions. Three groups of individuals need specific RSA training:

- Those who need awareness of the process (typically road safety professionals, senior managers);
- Those who are to understand the audits; and
- Those who are to use and respond to the audit outcomes (typically project managers).

The minimum requirements of road safety audit training course should be:

- The definition of an RSA and why it is needed?
- How road safety audit is applied and managed?
- How to present an audit report, and how to respond to an audit report;
- Geometric Design Principles, Traffic Control Devices, Intersections and Interchange Design
- At least one real-life case study, preferably a design stage audit or a pre-opening stage audit.
- Road Safety Engineering and Principles of Traffic Flow

Other associated and preferable training in the following topics should be encouraged:

- Black-spot investigations
- Road side hazards and the use of crash barriers

- Road work sites
- Risk assessment/management
- The preparation of response action reports.

It may be mentioned that the Transit New Zealand has a training process whereby a potential auditor is first an observer on an audit team, then a team member on a group led by an experienced auditor and eventually moves to a team leader position. This is interpreted as an informal accreditation process.

2.11 Success Factors

It is understandable that some design engineers may perceive safety audits as unnecessary check on design skills. The success of the road safety audit process depends on trust and commitment from all parties. Audits identify deficiencies and could be viewed as threat to road designers. It is critical that the focus be on the process and audit report not be viewed as criticism of the project design. A designer may have legitimate reasons for making decisions that consider factors other than safety in the proposed design and the compromise could be identified in the audit. Factors influencing a decision would be identified in a response to the safety audit. Since a structured safety audit can usefully identify potential problems and make recommendations for alleviating them, a safety audit, as such, should be regarded as an aid to design of safer roads.

2.12 Costs and Benefits

Due to infancy of the road safety audit process, there is only limited documented information on costs and benefits. Evidence to date indicates that auditing a large-scale new project (requiring audit at various stages) will add about 4 to 6 percent (total) to the road design costs. As design costs can be in the order of 2 to 3 percent of total implementation costs for projects, the increase in total project costs is insignificant. The cost of rectifying any inadequacies depends on how early in the design process they are identified and the consequent amount of redundant design time.

- An evaluation study, (Schelling, 1995) which involved a cost-benefit analysis of 13 projects in Denmark that had been subject to road safety audit, gave a first year rate of return of 146 percent.
- A study in the Middle East, which considered a number of projects that were not subject to road safety audit but developed problems soon after construction, concluded that road safety audit would have provided a first year rate of return of 120 percent. (Al Masaeid, 1998)
- One British road safety expert (Sabey, 1993) has reported that the systematic application of road safety audit procedures (including audit of existing roads) across Britain has the potential to give a 3 percent saving in casualty accidents.

The benefits of road safety audit are numerous. They range from the more obvious direct improvements in a design to aspects as broad as enhancement of corporate safety policies. Other important benefits are:

- Safer roads through accident prevention and accident severity reduction.
- More explicit consideration of the safety needs of vulnerable road users.
- Enhancement of road safety engineering.
- Reduced whole life-costs of road schemes.
- Eliminating or avoiding need to modify new schemes after they are built.
- Incorporating safety parameters in standards and procedures.

There are clear, positive benefits from the road safety audit process. The cost of an audit is low (in the order of 0.1 percent of the total project cost). With such low costs and potential for high returns, road safety audit is a process that should become a practice at all levels of governments.

3 STAGES OF ROAD SAFETY AUDIT

Safety Audit can be applied on (a) new roads and (b) existing roads. On new roads, safety audit will lead to avoiding building accident-prone situations and on existing roads, audit will lead to improved roads from the safety point of view. It should be realized that safety audits are a necessary cost, and not an additional expense. As project is audited, it provides further scope to improve/ enhance safety. In projects where there is a choice of route or standards, or there are known safety problems, the designer should discuss these with auditors at the initial stage. The safety audit shall be carried out on road and traffic improvement projects. Safety audit during construction stage is a new concept and no country has developed any checklists for carrying road safety audit during construction stage.

a)	**New Construction**		
	During Feasibility Study	-	Stage 1 Audit
	During Preliminary Design	-	Stage 2 Audit
	Completion of Detailed Design	-	Stage 3 Audit
	During Construction Stage	-	Stage 4 Audit
	Completion of Construction (Pre-opening)	-	Stage 5 Audit
b)	**Existing Roads**		
	On Existing Roads (Monitoring)	-	Monitoring

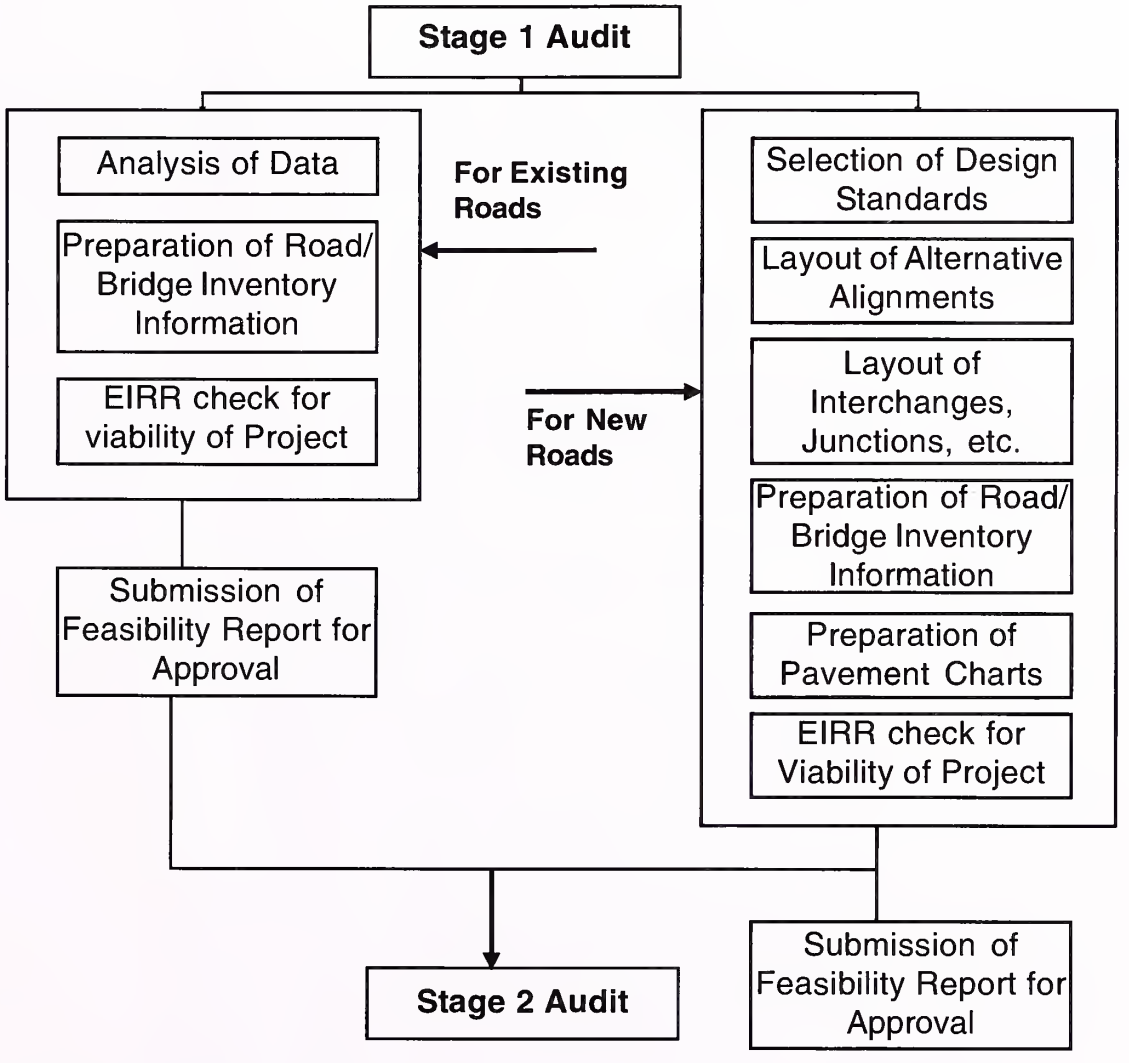
3.1 Stage 1 Audit (During Feasibility Study)

Stage 1 is recommended for major schemes, including in urban areas, in order to influence route choice, alignment selection, standards, impact on and continuity with the existing network, junction provision, possible hazards from roadside development etc. Reviews of initial project/planning

study. Important subjects for assessment at this stage will include:

- Choice of route options
- Alignment and ease of achieving design standards
- Standards and cross-section
- Effects on existing network
- Number of junctions, their types, etc.
- Possible hazards from roadside development

The road safety auditor should not question on planning information or reassess matters of strategy. Auditor should only concern himself with the presented planning information. Steps involved in Stage 1 Audit are given in **Fig. 3.1.**



EIRR: Economic Internal Rate of Return

Fig. 3.1 Steps Involved in Stage 1 Audit

3.2 Stage 2 Audit (Completion of Preliminary Design)

Stage 2 is recommended on completion of preliminary design, to assess horizontal and vertical alignments, sight lines and layout of junctions including slip roads and lay-byes. After this stage, land acquisition may be taken up.

Examination when preliminary design is completed i.e., where the alignment has largely been decided, but can still be modified before approval. Important subjects for assessment at this stage are:

- Project changes since Stage 1 Audit
- Alignment
- Cross-section
- Arrangement of Junctions
- Any Interim Measures

All groups of road users, including those who have special needs and users of the adjoining areas, should be taken into consideration. If there is any risk of special road safety problem occuring during the construction phase, the risk must be assessed. Steps involved in Stage 2 Audit are given in **Fig. 3.2**.

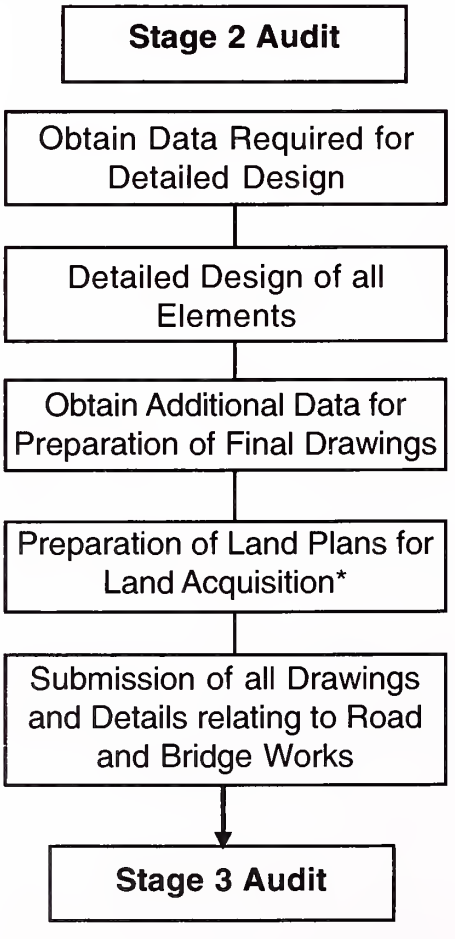


Fig. 3.2 Steps Involved In Stage 2 Audit

3.3 Stage 3 Audit (Completion of Detailed Design)

Stage 3 is recommended on completion of detailed design and before preparation of contract documents, to assess detailed junction layout, markings, signs, signals, lighting details, etc.

Examination when detailed design is completed and the limits of expropriation have been set, but before the tender documents are prepared and tenders are invited. Vital subjects for assessment at this stage are:

- Project changes since Stage 2 Audit
- Detail Design of junctions
- Design of geometrics
- Cross-fall
- Markings and Signs
- Side drains
- Embankment slopes
- Presence of clear zone
- Traffic Signals
- Lighting
- Interim Measures

Tender documents must not be issued to bidders until auditing at this stage has been completed and all agreed changes have been incorporated in the project documents. Steps involved in Stage 3 Audit are given in **Fig. 3.3.**

3.4 Stage 4 Audit (During Construction Stage)

Construction zone is that area of the road which is affected by the works and which affects traffic flow and safety of workers and road users. In this context it can also be called 'Traffic Control Zone'. In rural areas, problem at these zones is accentuated by the reduced availability of carriageway, acquisition of land for diversions, etc. In urban areas, the problems are even more acute as diversions may have to be over adjacent road street of the road network as well as the sharing of road space by different categories of road users. Traffic control zone can be divided into three major components i.e., Advance Warning Zone, Transition Zone and Work Zone. Manual on Traffic Management at Construction Zones is published by the Indian Roads Congress as IRC:SP:55 should be referred to. Steps involved in Stage 4 Audit are given in **Fig. 3.4.**

- Examination of Terminal Transition Zone, Work Zone, Approach Transition Zone and Advance Warning Zone with respect to safety point of view.
- Examination of safety measures adopted for workmen and road users.
- Examination of traffic control devices adopted at construction zone.

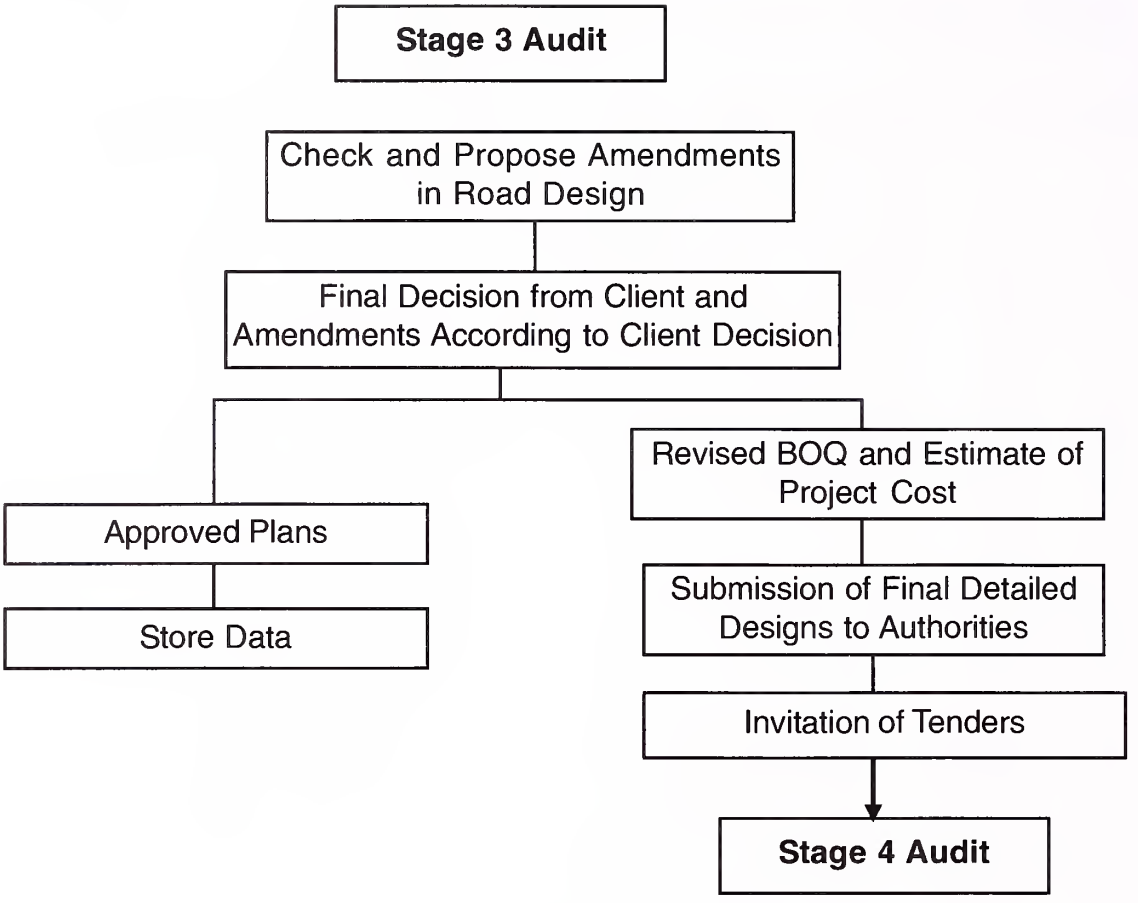


Fig. 3.3 Steps Involved in Stage 3 Audit

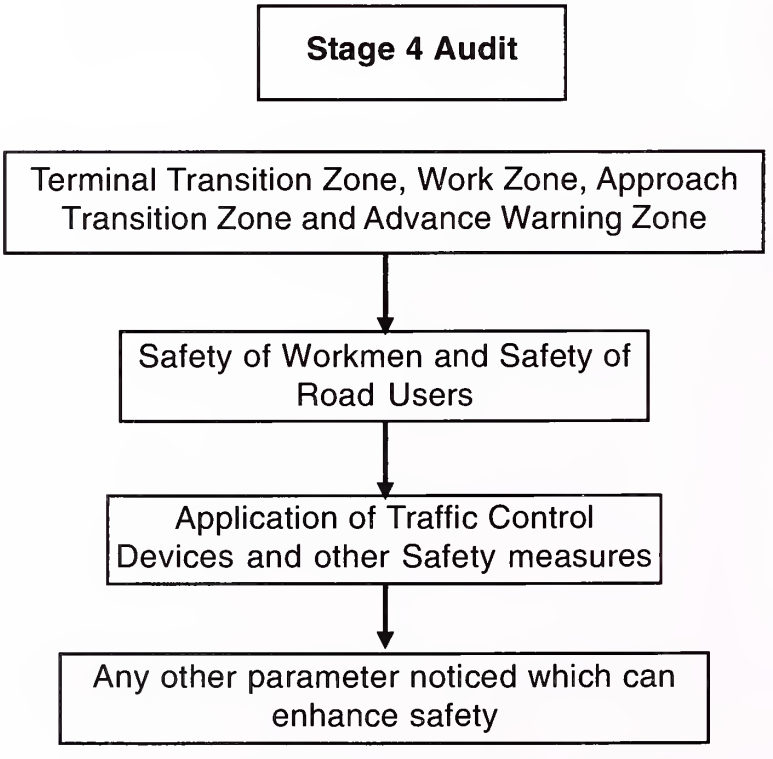


Fig. 3.4 Steps Involved in Stage 4 Audits

Motorists need to know about safe driving requirements in construction zones. Major problems in work zones are attentiveness and speed. It is necessary to help the drivers to be more attentive by using signages, rumble strips and any thing that brings alertness and gets them to realize that there is something different about this stretch of road and there would be lower speed limits in the work zones. Work zone safety measures should be aggressive and comprehensive. It should include public service announcements, safety training for workers in work zones, lower speed limits in work zones, rumble strips and other speed reducing measures, proper signages, flagman to control and guide traffic, stepped-up enforcement.

3.5 Stage 5 Audit (Completion of Construction) (Pre-opening)

Stage 5 is recommended immediately prior to opening of scheme, involving the site staff and local traffic police in car and truck. This should take the form of driving and when appropriate, walking and/or cycling the new route. This is checked during night time also to ensure that required night time safety standards have been achieved.

- A final review of the finished construction, to check from the standpoint of road safety that it is ready to be opened for traffic. It is particularly important to check the location and visibility of markings and other traffic control devices especially where changes were made during the construction period. The finished scheme should be assessed from the road users' point of view in daylight and in darkness.
- After opening for one or two months, the auditor should examine whether or not road users are using the project facility in an appropriate manner.

Many schemes are constructed with the road open to traffic throughout the entire construction phase. When there is no question of an actual opening for traffic, an overall examination is to be carried out to audit whether the markings and all traffic control devices are in place. This examination is to be carried out by the auditor independently in the first instance and thereafter along with the Project Manager of the Contractor. Steps involved in Stage 5 Audit are given in **Fig. 3.5.**

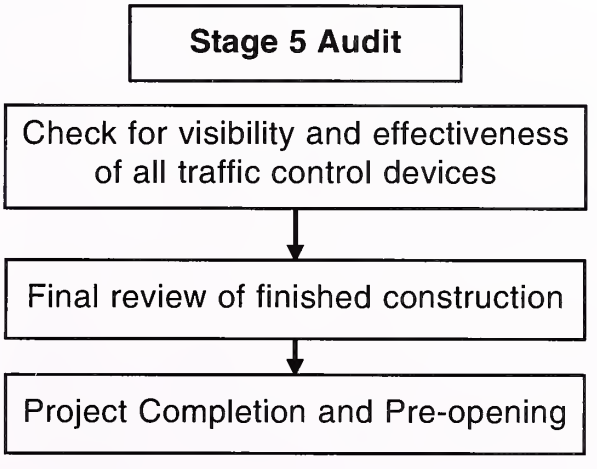


Fig. 3.5 Steps Involved in Stage 5 Audit

3.6 Stage 6 Audit-Audit on Existing Roads and During Operation and Maintenence of Concession Projects

Safety Audit methodology is also successful on existing roads which includes both Operation and Maintenance (O&M) of existing roads. The existing roads represent the present condition of the road after completion of construction as well as any hazardous conditions that may have been created during its lifetime such as encroachments, ribbon development or deterioration of road conditions as well as traffic conditions, etc.

An analysis of any accident data and inspection of the scheme every year, with a view to determine whether or not road users use the scheme appropriately. Subjects for monitoring include:

a) Does the prevailing speed correspond to the design speed?

b) Are the visibility and sight distance criteria still satisfied?

c) Have any changes been made which could affect road safety?

d) For carriageway and paved shoulders examine things like any breach or blockade, roughness value, pot holes, cracking, rutting, skidding, damage to pavement, edge drop at shoulders.

e) Check the roadside furniture including road signs and markings damage to their shape or position, loss of retro-reflectivity

f) Street lighting and Highway Traffic Management System (HTMS)

g) Rest areas - cleaning, defects in electrical, water and sanitary installations.

h) Bridges - super structure, foundations, bearings, joints, etc.

3.7 What are the Safety Issues to be Focused in Different Stages of the Project?

There are at least four distinct phases at which a road safety audit may be conducted. Only experience with the process will enable one to determine how and when the audits should occur. At different stages of the project, the safety issues focused will be different as these are not the same at all stages. **Table 3.1** details the safety issues that need to be focused at different stages of the project. On the various highway upgradation programmes being carried out in India, it is suggested that road safety audit be carried out at PPR, DPR and Pre-opening stages. It is to be recognized that safety audits at DPR stage in case of EPC contracts and development stage in case of BOT contracts would be most advantageous to all key players in the sector.

3.8 What are the Data Requirements for RSA?

The database for conducting an audit should include plans and drawings; site information, such as detailed crash history and traffic volumes; design standards that have been used; environmental effects; and on-site evaluations, which examine a location from the perspective of the road users (motorists, drivers of buses and trucks, pedestrians, or bicyclists). The RSA must encompass a review of all types of movements, special needs of the elderly and disabled, weather and environmental problems.

Table 3.1 Safety Focus in Different Stages of the Project

Stage of the Project	Focus of the Audit
Feasibility	Safety issues associated with options such as route locations, fixing design speeds and standards, impact on adjacent network, provision of fixing intersections and interchanges, access control, number of lanes, traffic control, functionality, future needs.
Preliminary Project Report (PPR)	Evaluation of general design standards, alignment, sight distance and lines of sight, layout of intersections, grade separators and interchanges, lanes and shoulder widths, cross-slopes and super elevation, provision for cycles, pedestrians, emergency vehicles, bus bays, truck laybyes, rest areas, parking, etc, provision of traffic control devices, safety during construction.
Detailed Project Report (DPR)	Examining safety issues of specific geometric design features, traffic control devices, delineators, roadside clear zones, detailed design of intersections, interchanges, grade separators, glare concerns and lighting, safety issues related to landscaping, provision for special road users like elderly, school children, persons with disabilities, buses, equestrian, rail roads, heavy trucks, etc.
• Construction sites • During Construction	Examining the maintenance of existing lanes during construction, ensuring safe and smooth flow of traffic, safety of all road users, construction workers, required road signs, markings and other traffic control devices, lighting at work zones.
Pre-opening	Final check prior to opening the facility to ensure that the safety concerns of all road users have been addressed and that there are no apparent hazardous conditions. The Audit team needs to actually travel both during the day and the night on a bus, on a truck as well as a car. Should include day/night checks; evaluation considering dry/wet weather; and driving/ riding and walking.
On existing Roads and during O&M of concessions	An audit of existing roadway to determine, if the safety needs of all road users are currently being served. It recognizes that a roadway may change over time. Changes may have resulted from changing road use, encroachments, design inconsistency, ageing infrastructure and inadequate maintenance of road and traffic control devices and other measures. Points to be emphasized are adequacy of roadway, roadside and intersections, interchanges, grade separators, location of bus stops, truck laybyes, needs of VRU, access management.

4 ROAD SAFETY AUDIT PROCESS

4.1 Audit of New Roadway Sections

Road Safety Audit is a relatively straightforward process. For smaller projects some of the steps shown may be brief, but the sequence of the steps will still apply. Responsibility for the planning, design and construction of the project always remains with the road authority and the implementation team. On new roadway sections Stage 1 Audit to Stage 5 Audit will be applied depending upon the stage of the project. The steps in the road safety audit process are illustrated in flow chart in **Fig. 4.1.** The details of each step of the flow chart should be adapted to suit the nature and scale of particular project. It is not the role of the road safety auditor to take over or redesign the project. The role of the auditor is to provide independent advice in the form of written recommendations. The designer and/or client then consider the advice and a formal

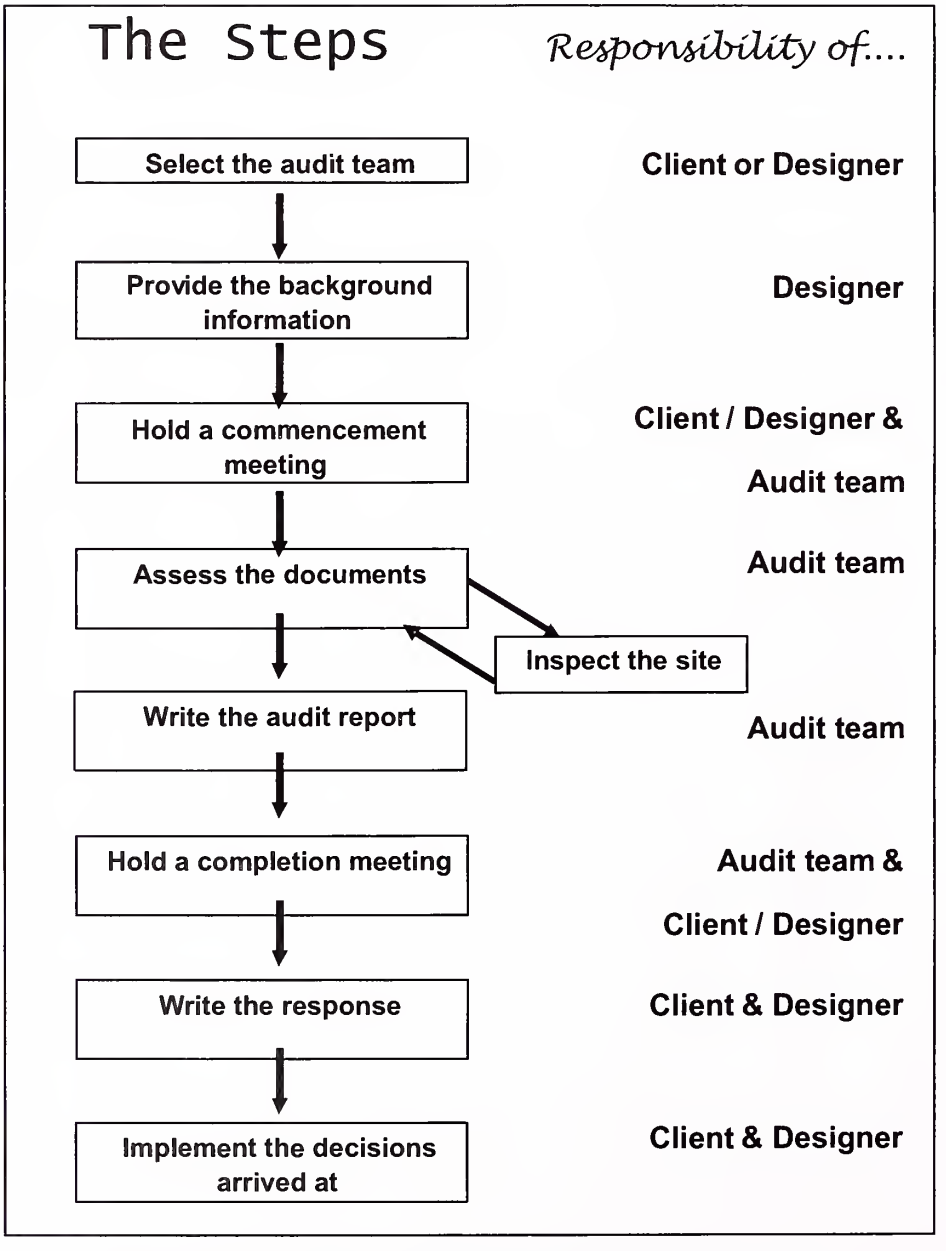


Fig. 4.1 Steps Involved in Road Safety Audit Process

decision is taken by the road authority on whether or not to adopt each of the safety measures recommended by the Audit Team. The key steps in a successful road safety audit are:

a) Selecting an appropriate auditor and audit team

b) Obtaining all the relevant background information and related documents covering plans, designs, etc.

c) Conducting a site inspection.

d) Providing a written report.

To carry out safety audit on new roadway sections scheme/rehabilitation scheme, the following should be thoroughly cross-checked. The team should check planning, cross-sections, alignment, road side furniture and facilities available, junctions, facilities for road users, signs, markings and lighting and also road side hazards. The process is described in Sections **4.1.1 to 4.1.9.** Some of the important considerations in a road safety audit include:

a) Alignment inconsistency - no unexpected sharp curves or steep grades. If unavoidable, such stretch should have proper road signages and speed management measures.

b) Cross-sections must be consistent - no narrow sections. If unavoidable, they should be preceded with cautionary signs.

c) Hard shoulders of required width.

d) Proper super elevation and extra widening (on curves).

e) Side slopes and side drains.

f) Signages on curves and other difficult sections.

g) Signages and safety barriers at hazardous locations.

h) Footways, parking areas and service roads in towns.

i) Layout and design of intersections, interchanges, grade separators.

j) Provision of lay-byes at bus stops and important truck stops.

k) Road signs, pavement markings, other Traffic Control Devices, roadside furniture and crash barriers.

l) Guard rails, crash barriers on bridges and in medians on multilane highways.

m) Marking of overtaking sections and treatment of sections with deficient sight distance and substandard horizontal curves.

4.1.1 *Selecting road safety audit team*

Objective: To select an audit team which is independent, has appropriate skills for the particular project and would exercise due diligence in preparing the Audit Report.

The audit team may comprise of two members for small projects and three members for large projects. One of the team members should be nominated as Road Safety Audit Manager.

Where specific additional skills are required in case of complex projects, a specialist can be invited to be part of the audit team for a limited time to provide advice on the relevant issues. The one essential ingredient in any road safety audit team is road safety engineering experience. Selection of audit team for different stages of audit is presented in Section **2.10.** The audit team should fulfill the following checklists:

a) Is the auditor independent? - Can he/she apply 'fresh eyes' to the task?

b) Is the auditor trained and/ or experienced? - At least attended a training workshop and worked on a previous audit.

c) Has the auditor got the necessary skills in the areas of road safety engineering, traffic engineering, traffic management, road design and accident investigation and prevention?

d) Does the auditor have an aptitude for the task? - To see potential safety problems from different road users' points of view.

4.1.2 *Enhancing availability of skilled personnel for road safety audit*

The Audit Team should associate one person to get groomed in Road Safety Audit work under orders of Auditor/Employer.

4.1.3 *Providing The background information*

Objective: To provide the audit team with the necessary information and documents for assessment of the project from safety point of view

The client should arrange to provide all the necessary information and documents in a usable form for the audit team. This should not be left to the audit team to do. Information will include project reports, design details, data, drawings, etc. It may be necessary to collect additional information, such as traffic volumes, vehicular speed, etc. This should be considered early enough to avoid delays to the road safety audit process. As a minimum, the audit team is to be provided with the following documents :

a) ***Statement of the Expected Outcome***

The client should provide the auditor with the expected outcome from the audit. This may require a written brief or a simple TOR (Terms of Reference) for the proposed audit of the project.

b) ***Project Intent***

This sets out the purpose of the project and the design standards adopted. The client may highlight, any deficiencies that need to be addressed, any design compromises that have been made and the reasons and any community input from prior discussion, correspondence and consultations.

c) ***Site Data***

1) Accident history, including period, type, time and frequency to assist with site inspection.

2) Classified Traffic volume counts as available

3) Safety issues which remain unresolved from previous audits, if any

4) Design standards

5) Environmental impacts

6) Any other information relevant to safety enhancement

d) ***Plans and Drawings***

1) All Drawings including the vertical and horizontal alignment and other relevant information, at that particular stage of the audit.

2) Any plans of adjacent roads or land and its uses, which may be affected by the project or by the traffic changes, it may induce.

3) If the engineering designs and drawings for different parts of the project have been prepared by different consultants or in-house teams of the client, a set of all such designs and drawings to be furnished.

Zero date for commencement of Audit would be after these documents are provided to the Auditor.

4.1.4 *Commencement meetings*

Objective: To acquaint the auditor with the background of the project, to hand over the relevant information and documents and also share with the designers and the client with the proposed audit process

Holding a meeting between client, designer and auditor, provides the opportunity to explain to the audit team the project's purpose, any issues specific to the project and any particular problems which have been experienced in achieving planning, design or construction objectives. The audit team will not be able to inspect the site under all traffic or weather conditions, so if particular conditions are important, the auditors should be advised. The audit team's task is to identify and document any road safety concern and recommendations.

4.1.5 *Assessing the documents*

Objective: To review the designs, drawings and other background information to form an opinion on the safety performance and accident potential of the road.

This phase takes place at the same time as the site inspection, the documents being reviewed both before and after the site visit. Before inspecting the site, initially study the documents to record the first impressions: list possible issues to be checked on site. Plans and drawings, traffic and accident data and other information should be assessed.

The audit team then identifies the areas, which are deficient in respect of safety or require further explanation from the designer using the checklists as required. The audit team should confine itself to relevant road safety aspects and consider the designer's compliance with engineering standards and guidelines.

Safety does not come automatically by complying with the standards and guidelines. But they provide the road user with consistent treatments and they should be applied unless, in a particular situation, they are unlikely to result in a satisfactory level of safety performance.

4.1.6 *Inspecting the site*

Objective: To see how the project proposal interacts with its surroundings and nearby roads; to visualise potential impediments and conflicts for road users.

This gives the audit team the opportunity to see how the project interacts with the surroundings and to visualise the potential obstacles and conflicts, which the road user is likely to encounter.

Prior to the site inspection the team should review the proposed checklists. A night time inspection is also essential, except where road access is not yet available to the project site or to its connection points to the existing road system. The information available to road users can be markedly different at night time and it can be surprising what additional issues can be identified on a night time inspection, even where work has not yet commenced.

The inspection should also include adjacent sections of road as it is at these locations that the greater hazards could occur:-

- Road layouts and devices that operated safely can be changed once traffic volumes, speeds or movements have been altered.
- Road users may be unaware that they must adjust their behaviour due to the new project, which often disrupts the existing traffic and pedestrian movement patterns.

The audit teams site visit leads it to appreciate any future problems relating to the existing arrangement and to visualise the proposals and their possible effects. The inspection should be carried out from the point of view of all road user groups and not just motorists. The inspection for different user groups should include different types of movements such as crossing the road, entering the traffic flow as well as for travelling along the highway.

4.1.7 *Preparation of safety audit report*

Objective: To report on the findings of the audit team and to make appropriate recommendation, regarding how these deficiencies may be overcome.

The report should contain the features of the project, deficiencies which involve hazards and make recommendations about corrective actions. The recommendations must reflect sound judgement of the audit team and should be backed with convincing reasons for appreciation by

the decision makers. Further, these recommendations will indicate the directions rather than details of the solutions to improve safety. The responsibility for acceptance of the directions will rest with the client. On acceptance, the responsibility for detailing the solutions will rest with the designer.

The report should be a concise, brief document setting out a summary of the measures to be taken, the reasoning behind recommendation of such measures and the items identified that require remedial measures/ treatment from the safety point of view. The recommendations should be numbered or identified in a way, which make them easy to refer to in the follow-up reports.

Any safety issue, which is considered to be of sufficient concern to warrant immediate attention should be identified in the recommendations with the words **'FOR IMMEDIATE ATTENTION'** and any safety problem, considered to have great potential danger should be identified as **'IMPORTANT'**. In line with the need to maintain good communication with the designer and the client, the audit team should share the draft Audit Report with them and endeavour to resolve any uncertainties or misunderstandings by talking with the designer before drawing conclusions. However, the audit team must maintain a position of independence while finalizing the recommendations and the Audit Report.

Consistent with the scale of the project and subsequent scale of the audit, the report should be presented as under:

Project Information

- A report title which gives the name of the project and its extent, together with the stage of construction or development at which the audit is being undertaken.
- A very brief description of the proposal with an overall plan.

Background Information

- A list of the supportive material which was made available, such as reports and plans
- Names and particulars of the audit team
- Information about when the audit team members visited the site and conducted their assessment
- Records of Minutes of Meetings that the Audit Team had with the Client and the Designer(s)

Findings and Recommendations

For each aspect of the project which was identified as justifying attention for safety enhancement:

- A brief statement of what deficiency was found by the audit team. This could be in the form of statements cross-referenced to annotated plans. Provide photographs where considered appropriate.

- Recommendations proposed for corrective action.

Formal Statement - A signed and dated statement by the audit team indicating that they have completed the audit together with a forwarding letter by the Auditor

4.1.8 *Holding a completion meeting*

Objective: To discuss the recommendations for corrective action.

This meeting will involve auditors, client, road authorities or the concessionaire and the designers to discuss recommendations in the report and should be conducted in a way that the independence of the auditor is maintained and respected. However, it is expected that the auditor shall defend his recommendations based on his findings. Financial and budget constraints may sometimes influence the decision on, whether the recommendations can be adopted. However, it is not auditors task to take these into consideration; it is the duty of client and designer.

Efforts should be made to resolve misunderstandings if any, prior to the report being finalized.

4.1.9 *Responding to the audit report*

Objective: To deal with audit recommendations in an effective manner; to decide whether and how the recommendations of the road safety audit should be implemented and, where it is decided otherwise, to give reasons in writing for the decision; to put agreed audit recommendations into effect.

When audit report is received, it has to be acted upon so that safety is enhanced. A management and monitoring control system may be kept in place to keep the track of audits. The client would do well to respect the outcome of the safety audit. The objective is to deal with audit recommendations in an effective and objective manner; to decide whether and how the recommendations of the road safety audit should be implemented and, where it is decided otherwise, to record the reasons in writing for such a decision; to put agreed audit recommendations into effect.

4.1.10 *Implementing the agreed recommendations*

Once the client has taken decision on the Audit Report and finalized the list of recommendations that are accepted and agreed, they need to be implemented. The designer has to develop design changes, which address the safety problems. If audit has been carried out at the pre-opening stage, the actions need to be implemented as soon as possible on site. If a serious problem is identified, temporary warning, delineation or other treatment may be needed until the agreed solution is implemented.

As a way of gaining knowledge from audits, audited and unaudited design projects need to be monitored for about three years after they are built, to see whether accident problems are occurring and, if so, whether the problems were anticipated in an audit. This can provide

valuable feedback to refine the audit procedures and skill enhancement of the members comprising the Audit Team and sensitize the Road Agencies to not only encourage the system of Road Safety Audits for their important projects but also to enhance implementation of the recommended measures.

4.2 Audit of Existing Roadway Sections

The steps described in Section **4.1** refer to new roadway sections. Existing road also can be audited to assess their accident potential. It provides a systematic way of being proactive in reducing the future likelihood of accidents. Audits of existing roads involve a similar approach to that for new road projects. The steps given in the flow chart in **Fig. 4.1** should be followed, but the steps of inspecting the site and assessing the documents will vary. Accident records will be an important part of the information to be assessed, but they must be supplemented by informed judgements about the potential for other types of accidents. The aim is to identify any existing safety deficiencies of design, layout and road furniture, which are not consistent with the road's function and use. There should be consistency of standards such that the road user's perception of local conditions assists safe behaviour.

For conducting safety audit on existing roadway sections field studies like road inventory, classified volume counts, speed survey and study of first information reports from police records are essential. Ideally audits of an authority's existing road network should be done on a regular basis. It may be several years between successive audits, but a rolling programme of audits should be developed which covers every road in the network. As the road is already built, the inspection plays an important role. As with a road safety audit of any type of project, the road should be inspected from the point of view of all the likely road user groups and not just motorists. The road should be inspected for each user group and for the different types of movement. Following completion of road, safety audit report for an existing road, the highway authority will need to make an assessment of the cost effectiveness of the recommended solutions. Some solutions may be in the nature of maintenance treatment and can be easily implemented. Some solutions may be expensive. In some cases lower cost options may be available and they may provide benefits only marginally less than the expensive option. In some cases, expensive option may be the only effective solution. It will also usually be necessary to set priorities for action on the road under review, as not all recommended improvements can be funded immediately. Audit report should highlight those problems, which are considered so urgent that they require immediate attention. Issues and problems will vary, depending on the road's environment, the topography and terrain, when it was built and whether it has previously been audited.

4.2.1 *Road inventory*

Highway features determine road traffic safety, besides road capacity and economic traffic operations. Highway features are visible elements of highway and consist of various components. So, the safe and efficient operation of highway is governed by road geometric parameters, traffic control devices, lighting system of the stretch, composition of traffic, drainage condition, junction layout, parking facilities, cross drainage structures and the adjoining land use of the stretch.

Road geometry comprises parameters like road width, shoulder width, footpath, height of embankment, sight distance, horizontal curvature, vertical curvature, etc. The traffic control devices comprise signs, markings, delineators, crash barriers, guard rails, etc.

4.2.2 *Classified volume counts*

The magnitude of traffic volume, composition and their variation has a decisive effect on the accident rate and quality of traffic flow on all categories of roads. The traffic counts comprise of fast moving vehicles like cars, jeeps, taxis, LCV, MCV, HCV, 2-wheelers, 3-wheelers and slow-moving vehicles like bicycles, cycle-rickshaws, etc. The available traffic data is to be analyzed systematically to determine the temporal and vehicle-wise traffic flow characteristics and the directional distribution of traffic on the selected stretches. Volume/capacity ratio for different stretches should be determined based on classified volume counts and road inventory surveys and analyzed with the available guidelines.

4.2.3 *Speed surveys*

Speed is one of the most important characteristics of traffic and its measurement is necessary for quality evaluation of traffic problems. Speed study is a necessary input for regulation and control of traffic and for analysing causes of accidents, identifying any relation between speed and accidents. This will be conducted to observe the speed characteristics at selected points of the stretch to determine the prevailing speeds on the stretch. For this, measurements can be done in peak and off-peak hours also.

4.2.4 *First information reports from police stations*

First Information Reports (FIR) should be collected from the concerned police stations on the identified stretches. After getting the FIR information, database is to be created for analysis of day-wise, month-wise, year-wise, km-wise distribution of accidents. This would help in identifying the locations experiencing higher accident frequency.

5 SALIENT FEATURES AND PRINCIPLES FOR SAFE ROAD DESIGN

5.1 Principles of Road Safety

Road Safety Audit is a formal process; it describes how road safety considerations are brought into scheme design at the proper time and how road safety is weighed against other considerations at the appropriate level of responsibility. The principles of road safety form the basis of the technical content of the design and audit process. It deals with the conditions, which are of particular significance to road safety when designing road geometry and traffic control devices. When designing a road, consider safety by asking:

- Can the road design be misunderstood by road users?
- Can design cause confusion?

- Can it create ambiguity?
- Does the road design give insufficient information or too much information?
- Does it provide inadequate visibility or cause obstructions to vision?
- Are there stretches where compromise on design standards has been made.

If answer is 'yes', to any of these questions, then a series of open questions (such as 'how', 'why', 'when', 'where', 'what', etc.) should be used to find the source of the problem and find possible solutions. Drivers and other road users must perceive and process information, make decisions and react, all within specific time intervals. Comfortable and safe driving and good road user behavior occur when vehicles are operating well below a stressful processing and decision-making rate and above a minimum level of arousal. This is a critical component in the development and maintenance of a safe road environment.

Road users represent a broad cross-section of the public and there are limits what road users can cope with when converting information - from the layout of the road, signs, markings, etc. into their response and action. Road users overestimate their own abilities and misunderstand each other's intentions when the situation becomes too complex, unclear or unusual to think and to react. It is a vital task expected of the designers and road safety auditors to design out road installations keeping human criteria and behaviour in mind, so that they do not demand too many actions per unit time.

A safe environment should:

- Warn the driver of any substandard or unusual features.
- Inform the driver of conditions to be encountered.
- Guide the driver through unusual sections.
- Control the driver's passage through conflict points or sections, and
- Be forgiving of the driver's errant or inappropriate behaviour.

Similar situations must be treated in similar way; it is better to avoid:

- Insufficient or deficient treatment
- Incorrect or misplaced treatment
- Exaggerated treatment
- Dissimilar treatment for similar situations

Road Safety Audit is the systematic application of safety principles. Specific aims are:

- To minimize the risk of accident occurring on the road project and to minimize the severity of accident that does occur.

- To minimize the risk of accidents occurring on adjacent roads in the network as a result of a scheme.
- To recognize the importance of safety in highway design to meet the needs and perceptions of all types of road users and to achieve a balance between needs where they may be in conflict.
- To reduce the long-term costs of a road project, bearing in mind that unsafe designs may be expensive or even impossible to correct at a later stage; and
- To improve the awareness about safe design practices among those involved in the planning, design, construction, operation and maintenance of roads.

There are two basic concepts underlying the aims of road safety audit. The concepts are:

- ***Prevention is better than Cure:*** While efforts to reduce the accidents on existing roads through systematic accident investigation procedures must be sustained, safety audit seeks to minimize the risk of accidents occurring as a result of changes to the highway.
- ***Drive, Ride, Walk in Safety:*** The emphasis on the mode of travel on the roads should highlight the needs of the more vulnerable road users. In a safety audit, the road scene should be visualised through the eyes of all the different categories of road users.

Some special safety issues relating to road designs are brought out below. These illustrate that safety is influenced by a complex interaction of elements and that the standards do not necessarily result in the safest possible design. This can especially be the case when the standards are adopted keeping purposes other than safety also in view.

5.2 Special Safety Issues Related to Road Designs

5.2.1 *Designing for the users*

A design should cater for all road users. Special attention needs to be given to the safety aspects associated with heavy vehicles like trucks and buses. The requiriments of these vehicles may be different from those of cars. Particularly, effort may be needed to seek data to assist the design in safely handling such traffic. Also, the special needs of pedestrians and non-motorised traffic are to be considered **(Fig. 5.1 and 5.2)**.

5.2.2 *Design speed*

The design speed adopted should be compatible with the project objectives and be appropriate for the adjoining roadside activity and terrain. If drivers are in a hilly terrain, the road should continue to make them aware of it. At intersections, the design speed for turning traffic should be compatible with expected intersection activity. **Fig. 5.3** depicts how the speeds are to be kept low at critical and difficult locations even on expressways as overspeeding results in accidents **(Fig. 5.4)** and speed controls are essential for safety **(Fig. 5.5)**.

Footways

Fig. 5.1 Lack of Pedestrian Facilities on an Urban Road

Fig. 5.2 Provision of Tiled Footpath in front of a Metro Railway Station

Fig. 5.3 Critical Location Requiring Speed Controls

Fig. 5.4 Over Speeding Results in Accidents

Fig. 5.5 Speed Controls are Essential for Safety

5.2.3 *Design context*

The safe designs are different for major and minor roads. Narrow sections or slow points may be suitable on minor roads to slow down traffic and improve safety. However, on major roads such squeeze points may well cause frustration and become accident blackspots. The function of a road should be clear to its users and treatments should not give conflicting messages about this. Functional grouping of roads is a necessary pre-requisite for a safe road network **(Fig. 5.6).**

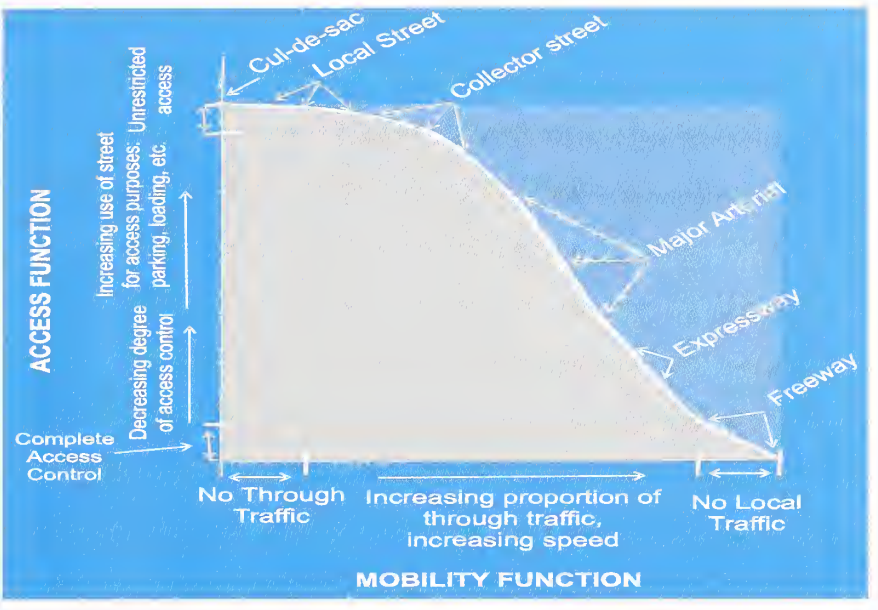


Fig. 5.6 Schematic Relationship between Access and Movement Functions of Roads

5.2.4 *Horizontal and vertical curves*

Accident frequency increases at crests and in dips. Increasing the degree of horizontal curvature also tends to increase accident frequency. To achieve coordination of alignments and terrain fitting, it is possible that a crest may mask the flow of the horizontal curve. Avoid tight horizontal curves particularly in combination with crests or dips **(Fig. 5.7 to 5.9)**. In attempting to maintain intermediate sight distance, a design may adopt a vertical curve, which avoids the marking of barrier lines. However, adequate safe overtaking opportunities may actually be reduced because of the excessive length of the vertical curve. A combination of shorter vertical curve and a stretch with barrier line may be safer in some circumstances.

5.2.5 *Intersections*

- Priority and layout

  The layout and control arrangement at an intersection should be simple and obvious to approaching motorists **(Fig. 5.10)**. It is useful to remember that straight priority is usually expected and that modifications to this can require additional visual reinforcement. Even where priority is straight, some existing fencing lines or lines of trees on the minor legs can suggest the continuation of the road so strongly that the control sign and markings are not noticed by some motorists. Roundabouts are a form of intersection control with their own set of priority rules. It is essential that roundabouts look like roundabouts and that other types of intersection island treatments do not. At roundabouts, the approach radius should be tighter than the exit radius. Also remember that motorists tend to drive in lines as straight as possible: re-entrant curves on outer kerblines will not be trafficked and will collect debris. Within intersections with simple priority, it is still possible to guide motorists with proper arrangements and hazard markers **(Fig. 5.11)**.

Fig. 5.7

Fig. 5.8

Fig. 5.9

Fig. 5.7 to 5.9 Visibility at Critical Locations such as Crest of the Summit Curves and on Sharp Horizontal Curves can be a Determining Factor on the Safety Levels on Highways

Fig. 5.10

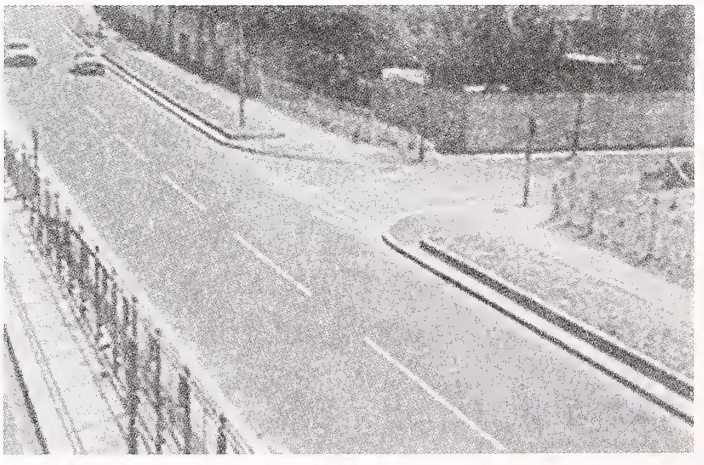


Fig. 5.11

Examples of Good Practice

Fig. 5.10 and 5.11 Priority Junctions (Give-way/Stop)

- Visibility

  Provide adequate visibility distances for emerging traffic; don't confuse visibility distances with warrants for stop signs. Avoid creating obstructions by street furniture or landscaping. Provide adequate visibility to control features; for instance on crests and curves line marking and other devices can be hidden yet they need to be visible for decision-making. Use line marking & signs to improve driver's safety **(Fig. 5.12 to Fig. 5.14)**.

Uncontrolled Y-Junction with no markings, priority or traffic islands causes conflicts and uncertainty between merging and opposing traffic

Improved Junction conspicuity by providing channelisers

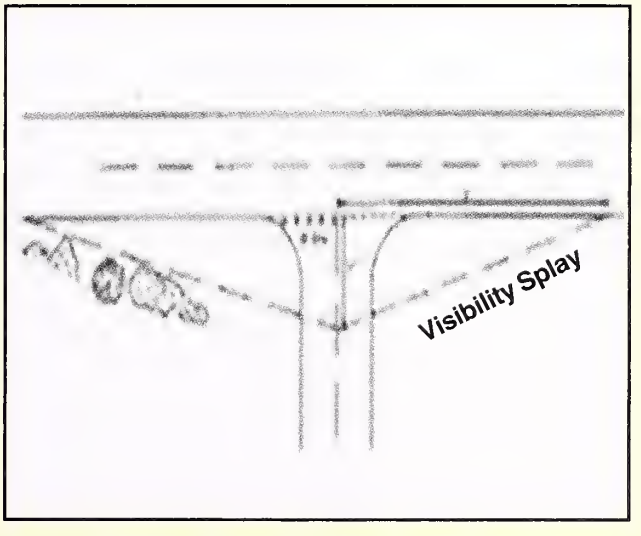
Fig. 5.12 Improving Junction Control and Conspicuity

Elements to Improve Road Safety-Visibility

Safety Issues

Dangerous T-junction due to Very Poor Sight Lines

Safer Practice



Visibility Splay on Straight Section

Fig. 5.13

Fig. 5.14 Well Marked Junction with Proper Road Markings to Assist Drivers and Enhance Safety

- Other issues at Intersections

  Provide safe pedestrian and cyclist crossing points. Consider central refuges, which permit people to cross traffic from one direction at a time, which is a much easier task than judging gaps in both directions at once and safer than waiting on a centerline **(Fig. 5.15 and 5.16)**. Use appropriate corner radii. Large radii allow excessive speeds and cause hazards for pedestrians. On the other hand, radii, which are tighter than the turning path of a design vehicle at a low speed, will result in these vehicles swinging out wide or hitting kerbs. Balanced approach is required.

Fig. 5.15 Channelisation Providing Refuge to Pedestrians

Fig. 5.16 Large Channelising Island

5.2.6 *Access control*

At each point on the road system where vehicles have access to adjacent land, there is the potential for conflict and accidents. Where service roads have been provided to separate through traffic from local traffic movements, the spacing of breaks should not be reduced. Further, there should be sufficient warning ahead of such breaks. The same is true for median openings. Motorists need time to react at conflict points, particularly where traffic flows are heavy **(Fig. 5.17 and 5.18).**

Fig. 5.17 Lack of Details at Access Points and Minor Junctions Fail to give Proper Guidance to Motorists

Fig. 5.18 Wrong/Incorrect/Unplanned Opening in the Median Likely to Result in Serious Accidents

5.2.7 *Cross-section*

- Narrow lanes

  There is a view that traffic management has often gone too far in reducing the lane-width (from standard 3.5 m lane) of urban roads to create additional lanes on multi-lane roads. This becomes hazardous on horizontal curves where larger vehicles need extra width to tract. The existing urban design standards do not provide for curve transitions and widening. These may be satisfactory when wide lanes - proper lane width are used but they are unsatisfactory when narrow lanes are adopted **(Fig. 5.19)**.

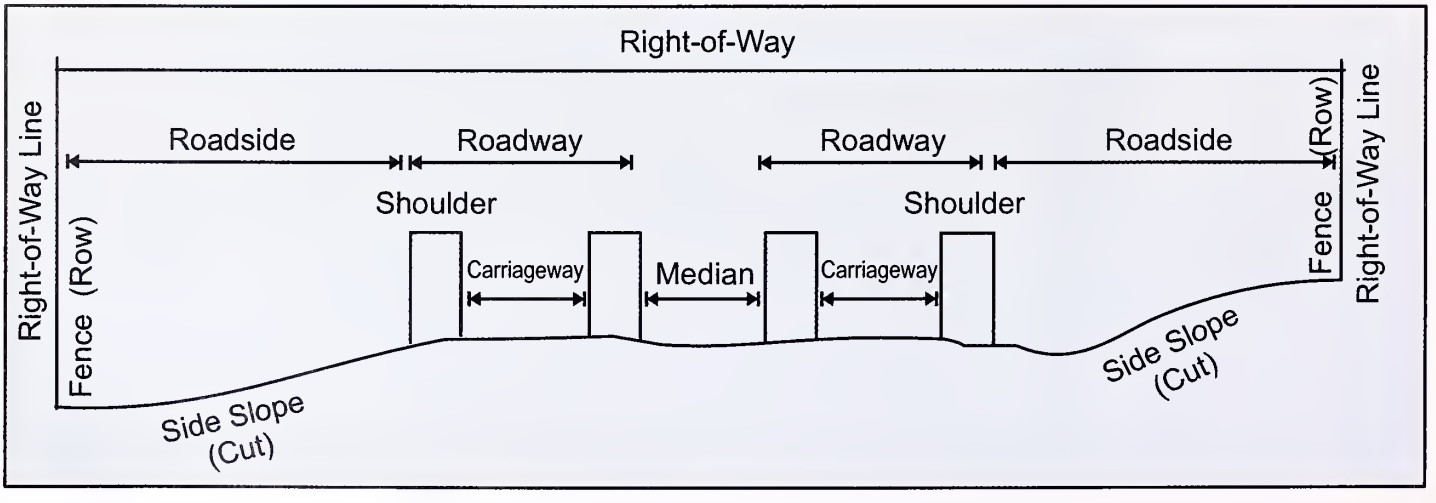


Fig. 5.19 Cross-sectional Features

- Shoulder widths

  There is a safety benefit in providing reasonably wide shoulders throughout the length of the road. It is best not to reduce widths or eliminate shoulders **(Fig. 5.20)**. Fencing can be very effective in discouraging parking. But fencing should not itself create a hazard.

  The shoulders should be adequate and well-maintained for enhancing road safety **(Fig. 5.21).** Rumble Strips can be provided on shoulders on sharp curves to alert drivers who have strayed from carriageway **(Fig. 5.22)**.

Fig. 5.20 Poorly Maintained Shoulder of Inadequate Width and Strength

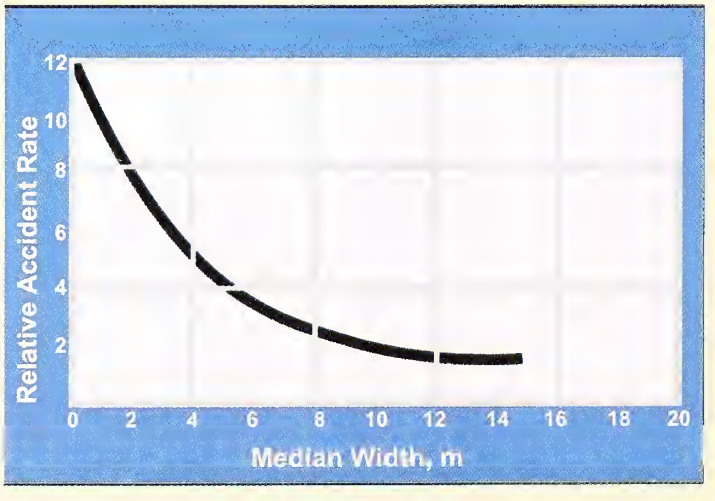
Fig. 5.21 Adequate and Well-Maintained Shoulders

Fig. 5.22 Rumble strips on Shoulder to Alert Drivers who have Strayed from Carriageway before Sharp Curve

- Median widths

  In rural areas, medians less than 3 m wide should be avoided. Where turning or crossing vehicles do not require a greater width, there is little safety advantages on median more than 10 m wide. In urban areas minimum of 2 m width is necessary **(Fig. 5.23).** The minimum width of median, subject to availability of right of way, for various locations shall be as given in **Table 5.1**.

Well Maintained Median Width with Proper Median Markings



Impact of Median Width on Accidents

Fig. 5.23 Medians and Kerbs

Table 5.1 Width of Median

Type of Section	Minimum Width of median (m)		
	Plain & Rolling Terrain		Mountainous & Steep Terrain
	Raised	Depressed Median	Raised
Open country with isolated built-up area	4.5	7.0	2.0
Built-up area	2.0	Not Applicable	2.0
Approach to grade separated structures	4.5	Not Applicable	2.0

5.2.8 *Trees*

Survey information is often deficient on the location and size of trees within the road reserve. The designer, therefore, cannot be sure that the plans have provided protection against vehicles hitting roadside trees. Trees also grow so that what is not a substantial tree at the design stage may well become a roadside obstacle by the time the road is built and is in operation **(Fig. 5.24 and 2.25).**

Fig. 5.24 Trees on the Edge of Roadway can be a Cause of Very Severe Accidents

Tree on Edge of the Road

Trees on Carriageway Edge can be Hazardous

Fig. 5.25 Plantation

5.2.9 *Road signs*

It is often too tempting to use traffic signs instead of working out an appropriate design of road signs on the project highway in an attempt to solve a real or perceived problem. Before using a traffic sign:

- Demonstrate a need for the sign

  Use a sound traffic engineering assessment to determine the need. Check the warrants and appropriate uses in the standards or guidelines. If no standard signs exist, ask why. Is one needed for this situation?

- Ensure that the sign conveys a clear message to all users under all conditions

  The ability to choose an effective and appropriate message and design an effective sign is important. Signs given in IRC standards have been prescribed keeping this in view and should be chosen for standard situations. Otherwise seek expert advice. Ensure that sign messages are compatible with the messages of other devices like line markings. Keep it simple. Locate it where the information can be received **(Fig. 5.26 to 5.30)**.

Fig.5.26 Inadequate and Incomplete Signage Results in Confusion

Fig. 5.27 Traffic Control Devices for Better Road Safety

Fig. 5.28 Improving Driver Expectancy

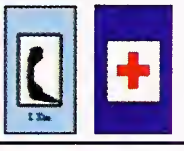
Type of signs	Shape	Example	Remarks
Mandatory/Regulatory Signs			Blue Circles give a positive instruction (what must be done) Red circles give a negative instruction (what must not be done)
Cautionary/Warning Signs			Triangular signs give warning to drivers of a hazard
Informatory Signs			Rectangular signs give information and directions

Fig. 5.29 Road Signs

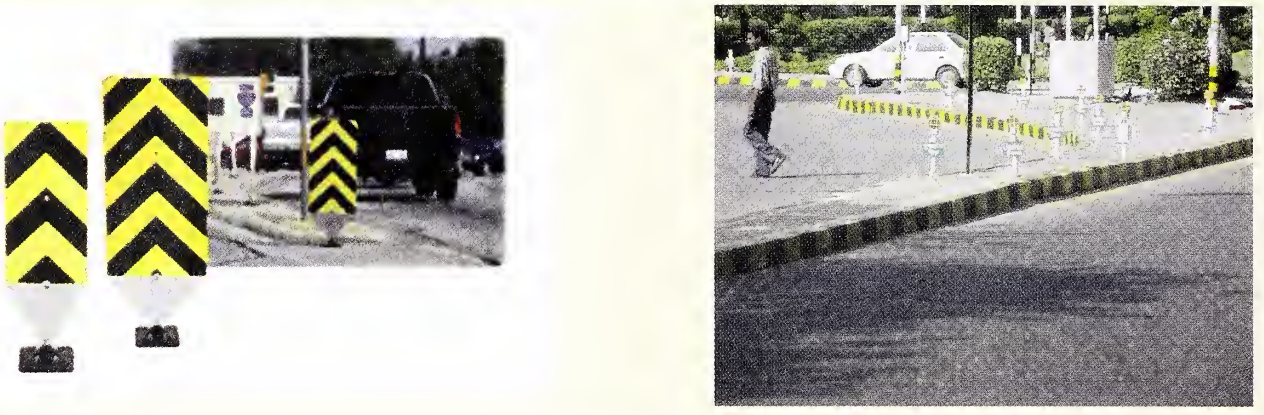


Fig. 5.30 Delineators and Chevron Signs

- Ensure that the sign or its supports are not a hazard

  Keep sign support structures away from the edge of the carriageway. Avoid or protect sign supports on the outside of curves and other vulnerable places. Ensure that signs or their supports do not obstruct visibility of other devices or the view between conflicting road users.

5.2.10 *Merges*

Adequate sight distance is required in advance of any merging situation to allow drivers to recognize and plan their merge. Inadequately or improperly designed merging areas can be a cause of road accidents **(Fig. 5.31 and 5.32)**. The length of acceleration and deceleration lanes should not be insufficient, otherwise, it may lead to road accidents. In addition it is important to provide a length of mutual sight to allow the gap to be selected for the merging manoeuvre. Merging should be avoided just prior to the start of left hand curves. They force the vehicles on the left hand lane to veer to the right to merge and then be immediately faced with a movement to the left to negotiate the curve.

Fig. 5.31 Merging Area Inadequately Designed and Provided with Proper Signs

Fig. 5.32 Improperly Designed Merging Point of Expressway and National Highway

5.2.11 *Sight distance*

The effect of horizontal and vertical curves and the cross-section is generally closely examined during road design. However, trees, raised medians and concrete barriers can also affect sight distance. Further, sight distance to the end of a queue, rather than to the control point at the start of the queue, may need to be considered on approaches to busy intersections.

5.2.12 *Night visibility*

Perception of widths as well as distances is usually more difficult at nighttime or under poor light conditions. Where minimum width lanes are used or there are island to narrow the road, a high standard of street lighting and delineation should be used **(Fig. 5.33)**. In the tunnels, adequate lighting should be provided **(Fig. 5.34)**.

Reflecting Kerbs for Night-time Visibility on Curves

A Glare Screen

Use of Retroflective Tapes Increase Night-time Safety

Fig. 5.33 Improving Night Time Safety

Fig. 5.34 Adequate Lighting should be provided in Tunnels

5.2.13 *Parked vehicles*

Vehicles parked on the carriageway affect safety in several ways: as physical obstructions that are run into or sideswiped, obstructions which cause sudden braking and nose-to-tail accidents, obstructions which deflect vehicles into adjacent vehicle paths, hazards to passing vehicles from opening doors, obstructions which hide pedestrians and obstructions which block visibility at intersections and access points. For parked vehicles, designs should ideally avoid or remove/ relocate parking in traffic lanes. With isolated improvement schemes like intersection treatments, parking can influence well beyond the limits of the design plan. Parking on side streets close to busy arterial roads can be a hazard to turning vehicles. Check the interaction of parked vehicles, turning vehicles and any queued emerging vehicles in these locations **(Fig. 5.35)**. Do not rely on parking control signs to eliminate parking in hazardous locations: enforcement will not always be available.

Trucks Parked on the Roads Create Safety Problem for through Traffic

Vehicles Parked Haphazardly

Fig. 5.35 Parking

6 SPECIFIC PARAMETERS TO BE CONSIDERED IN THE PRESENT DAY TRAFFIC SCENARIO IN INDIA

Two of the most significant issues to be considered in the present day traffic scenario in India are:

a) Safety issues for non-motorized traffic and

b) Safety issues on high speed corridors

6.1 Safety Issues for Non-Motorized Traffic

6.1.1 *Pedestrian walking facilities*

As pedestrians form a significant group of vulnerable road users, it is vital that the footpaths of pedestrians one given full and detailed attention. Footpaths have great potential for enhancing pedestrian safety. Every effort should therefore be made to segregate pedestrians and vehicles. Separation makes travel much safer for vulnerable road users. In areas of high pedestrian activity, it would be desirable to provide greater road space to pedestrian activity. Care must be taken to ensure that footpaths are not encroached upon and that the surfaces are comfortable to walk on.

On some stretches, passing through habitations and settlements, 1.5 m footways are provided, which is the absolute minimum width recommended for any footway. At times, the footways are only 1.0 m wide while at other places there is none; in most cases any constructed footway is the cover of a channel drain that is adjacent to the building line. Footways in urban areas become blocked in a matter of days by commercial use, rubbish or other impediments to walking **(Fig. 6.1).** Where footways are not provided on highways, shoulders are used by the pedestrians for walking. These shoulders become un-walkable due to water logging **(Fig. 6.2).**

Lack of rural footways forcing pedestrians to walk on the carriageway in India

Fig. 6.1 Inadequate and Faulty Pedestrian Facilities

Fig. 6.2 Water Logging at Shoulders

Substantial conflict problems usually exist where the road passes through rural settlements as the road often passes very close to existing buildings leaving no footpaths for pedestrians. Also, in India, roads in open area are often used by the local population as footpaths; particularly in the rainy season as these usually provide the easiest and most convenient routes between communities. Also many intersection roads have a cross-sectional profile which makes it difficult to cater easily for pedestrians. The natural camber of the carriageway is carried over into the shoulder and this is followed by a steeper slope into the side drain. The side drains too are often deep U-type channels, which, particularly in mountainous terrain where the road is in a cutting, force pedestrians to walk on the roadway and expose them to increased risk.

6.1.2 *Pedestrian crossings*

There is a strong necessity and desire for pedestrians to cross the road all along it and suitable provision must be designed to allow for it at appropriate locations. There is clearly a case for increasing both the capacity and safety of the new upgraded road sections. When located and used correctly, these can be effective in reducing pedestrian-vehicle traffic conflicts. Pedestrians usually tend to take the shortest routes between any two points. If using a crossing imposes much additional walking distance, or no perceived risk reduction **(Fig. 6.3)** then there will be a marked reluctance to use it. Great care is needed, therefore, in siting pedestrian crossings so that use is maximized and pedestrians are clearly visible to drivers.

Crossings based on priority rules rather than signals demand a degree of driver compliance that is rarely found in cities and towns of India. While there is considerable improvement in enforcement for the past few years, driving culture and self discipline needs lot of improvement. Pedestrian crossings on high-speed roads can lead to rear-end collisions if drivers are not given sufficient advance warning. Where driver compliance is low and vehicle speeds are high, pedestrian crossings can be amalgamated with road humps to give a raised pedestrian crossing (80-100 mm high). These are very cost-effective but must be clearly marked and require adequate advance warning.

Fig. 6.3 Poor Quality Design of Subway at Access Controlled Highway

It has also been observed that pedestrians often avoid using pedestrian bridges and underpasses due to substantial differences in elevation, perceived lack of public safety in underpasses, lack of maintenance and encroachments. Also, where pedestrian barriers have been erected especially in front of the school gates, recreation grounds and footpaths, pedestrians cross at any point along a length of road rather than be channelled to specially provided crossings where the risk of accident is lower. Also pedestrian refuges which divide the two traffic streams and create a relatively safe waiting area for pedestrians are often observed to be narrow in width, too high to climb, unmarked and not provided with lighting thus becoming an additional hazard.

There is need for special features to be constructed where pedestrians have to cross an open drain or mount an embankment. It is observed that required pedestrian crossing facilities are not being provided and in the absence of these, the local population devise their own unauthorized ways to facilitate crossing the highways. This type of activity is more hazardous at many of the road sections passing through the inhabited areas proposed on high embankments. Therefore, it is essential that for all highway upgradation projects, careful thought is given as to where pedestrians may be allowed to cross and where they should be prohibited from crossing and provision must be made to achieve the same.

6.1.3 *Lay-byes/bus bays*

Lay-byes and Bus stops are an essential element in providing for access as they separate stopping traffic from the main carriageway. However, their location is critical and every effort should be made to avoid physical or visual obstruction. They should not be located on the outside of curves, or very close to junctions and pedestrian crossings so that buses do not obstruct crossing pedestrians. It is observed that mostly the bus bay dimensions are fixed, not allowing any flexibility for busy stops. The location of the bus bays shall be fixed on the basis of following principles:

a) The bus stops shall be sited away from bridges and other important structures and embankment sections more than 3 m high.

b) As far as possible, bus bays shall not be located on horizontal curves or at the summit of vertical curves.

c) The location shall have good visibility, not less than the safe stopping sight distance.

d) The bus bays shall not be located too close to the road intersections. A gap of 300 m from the tangent point of intersections to start/end of the bus bay shall be desirable. At minor intersections (e.g. junctions with village roads), distance of 60 m may be adopted. However, if a substantial volume of buses is to turn right at the intersection, it is necessary that the bus bay shall be located sufficiently ahead of the intersection so that the buses can be manoeuvered easily from the pick-up stop on the left hand side to the extreme right lane for turning. The location of the bus bays may be fixed after due consultation with the local communities expected to use such facilities.

e) At major four-way intersections involving transfer of a substantial number of passengers from one pick-up stop to the other, it might be desirable to construct a single, composite bus stop of suitable design to cater to all the bus routes collectively.

f) In hilly areas, the bus bays shall be located, preferably, where the road is straight on both sides, gradients are flat and the visibility is reasonably good (usually not less than 50 m). Subject to these requirements, it will be advisable to choose locations where it is possible to widen the roadway economically for accommodating bus bays.

g) Where grade separator is provided, the location of bus bays shall be as under:

   i) Sufficiently away from the ground intersection.

   ii) Sufficiently away from the longitudinal slope of the approaches.

h) The bus bay and passenger shelter shall be designed to provide for safe and convenient use by persons with disabilities as well.

There is a need to design a facility to meet the needs of the waiting passengers and the number of buses **(Fig. 6.4).**

Also bus bays are most effective in terms of collecting the waiting passengers in a safe location if they provide protection from the sun and rain. If there is no natural protection from a tree, then it needs to be provided. If the passengers wait in the shade off the road then the bus is likely to stop in middle of the road or at some other unsafe location. Many road agencies are now planning such bus bays on their road upgrading projects. This is a good development. It needs to become a standard practice on all main highways. It is important that this aspect is given due recognition and importance by all road agencies.

Fig. 6.4 Passengers are Forced to Enter on Main Carriageway in Absence of Bus Bays

6.1.4 *Bicyclists, rickshaws and animal drawn carts*

The mixed traffic conditions and the wide variety of road users on highways create a safety challenge of significant magnitude. These non-motorized road users are an important part of the traffic stream **(Fig. 6.5)**. They deserve special consideration for their safety due to their different characteristics of movement, poor conspicuity and vulnerability in the event of an accident. On the highways, as they are exposed to motor vehicles travelling at much higher speed, it is imperative that they are provided with as much lateral separation from the through motor vehicles as possible. This should preferably be through the provision of separate tracks on which these non-motorized slow vehicles, can travel in relative safety. An alternative to this is a minimum 2.5 m wide shoulder fully paved along the highways (excepting where service roads exist) so that these road users move on a smooth surface with some separation from the faster vehicles. An associated requirement is roadway lighting at locations that can enhance nighttime conspicuity of these non-motorised road users.

Fig. 6.5 No Bicycle Facilities are Provided

6.2 Safety Issues on High Speed Corridors

In India, highways pass through rural areas with high-density populations where most people do not have access to motorised vehicles. These four-lane divided highways in India do not have continuous parallel service roads for local traffic including non-motorised traffic. This forces the local traffic to use these highways and cross them under hazardous conditions. So it is not surprising to find that a majority of the victims in road traffic crashes on intercity highways are vulnerable road users. On the existing upgraded highways, service roads provided are sometimes invisible due to encroachments. In the absence of adequate truck parking facilities on these highways, truckers have a tendency to park their vehicles on service roads, thus negating the benefits of service roads to these vulnerable road users **(Fig. 6.6)**. In the absence of such service roads, the pedestrian-vehicular conflicts increase and road safety is threatened.

Fig. 6.6 Parking of Vehicles at Service Roads

In India, the newly upgraded highways will lead to significantly increased speeds due to the new smooth surface and increased width. While it is expected that the road will produce many safety benefits, there is likelihood of increases in both accident frequency and severity at certain locations, particularly in urban areas, rural settlements and near schools, markets and factories unless location specific measures are taken to ensure that the speeds are restrained to an appropriate level **(Fig. 6.7)**. It is recommended that an appropriate speed management strategy for upgraded highways should be developed as soon as possible and before they are open for traffic. Such a speed management strategy should recognise the need for realistic speed limits and for a differential in speeds between urban and rural areas. The changes in speed zones will need to be well signed with duplicate speed signs at the commencement of a new zone and repeater signs at agreed distances thereafter and physical measures on the carriageway.

Traffic calming measures are usually most effective if several different kinds are used in combination and in a co-ordinated manner to slow down traffic in stages. They should be used with care on any highway but will be particularly relevant where there is a cross-section change from say six lane to four lane dual carriageway or from rural to urban conditions. Traffic calming may also be needed on some important side and access roads at their approaches to the highway and at the start of the service roads.

Fig. 6.7 Accident at Access-Controlled Highway

Uncontrolled access to premises abutting a main road can substantially impede traffic flows and create severe road safety hazards as vehicles attempt to leave, merge with or cross traffic streams. A difference in levels makes it very difficult for non-motorised or other slow moving vehicle to enter the main road safely as it becomes very difficult to stop and re-start. Unless part of the side road or access is constructed to similar standards to the main road, it will quickly deteriorate, start damaging the main road and lead to loose materials being deposited on the edge of the main road. This can happen at all kinds of entrances or exits to petrol stations, parking areas, factories or local communities. For these reasons, attempts should be made to limit or control frontage access on primary and district distributors except for situations where this is not feasible.

On high speed and main roads, efforts should be made to keep cyclists off the main carriageway by providing them with separate continuous cycle tracks **(Fig. 6.8)**. Cycle tracks must be attractive to use, coherent and direct. They should be well-maintained and should be minimum 2.5 m wide. The slow-moving road users need segregation whenever possible from fast traffic vehicles. Where animal drawn vehicles are common, provision of wider shoulders can act as a track for slow vehicles. The provision of wider shoulders also benefits the cyclists and pedestrians. These shoulders could be delineated with devices like, cat's eyes, studs, rumble strips (300 mm in width) between the main carriageway and the shoulder. A provision of frequent and convenient under-passes (at the same level as surrounding land with highway raised to provide clearance) for pedestrians, bicycles and NMT.

The vehicular under/overpass structures should be provided at the intersection of the high traffic density roads with all the National Highways and State Highways. The structure may be either an underpass or an overpass depending upon the nature of terrain, vertical profile of road, availability of adequate right of way, etc. Following aspects may be kept in view :

i) The width of pedestrian or cattle crossing shall not be less than 5 m.

ii) The pedestrian crossings shall have provision for movement of persons with disabilities.

Fig. 6.8 Bicyclists and Two-Wheeler Riders Using the Highway

iii) Underpasses shall be preferred to overpasses.

iv) Pedestrian underpass/overpass shall also be provided within a distance of 200 m from a school or hospital or factory/industrial area.

Whenever feasible, non-motorised vehicles should be separated from the carriageway by a barrier or edge line marking. Barriers are not appropriate on National Highways and State Highways in rural areas where separation by road marking is appropriate.

7 SAFETY AUDIT PROCESS FOR RURAL ROADS (OTHER DISTRICT ROADS AND VILLAGE ROADS) WITH SPECIAL REFERENCE TO PMGSY ROADS

7.1 Context

Rural roads are generally single lane with low design speeds and low volumes of traffic both motorised and non-motorised. There has been a distinct improvement in the riding quality of rural roads being constructed under the PMGSY and other state government programmes. Further, due to economic uplift of rural areas, ownership of motorised vehicles is also increasing at an accelerated pace. These factors are resulting in higher average speeds on the rural road network. Because of constraints of land availability, some stretches of the rural roads may not be in accordance with the required geometric standards. These may then be prone to safety hazards unless the driver is alert. At the same time, some engineering measures can be identified for such stretches while planning and designing such alignments.

7.2 Safety Aspects in Rural Roads

The road agencies concerned with rural roads may consider the following aspects for improving safety on these roads:

a) Road signs and pavement markings should be integral part of road construction and upgradation works. These signs and markings will also require regular maintenance to serve the intended purpose. There should be no compromise whatsoever on this requirement being ensured in all rural roads projects and programmes.

b) Where the existing geometrics of the road alignment are poor, efforts should be made to undertake spot improvements identifying such spots. In the meanwhile, appropriate cautionary and speed limit signs should be posted in such locations. Where there is history of frequent accidents, physical measures such as speed breakers (hump type), rumble strips should be provided with proper advance warning signs.

c) Intersections and junctions of rural roads with main roads need special emphasis. The layout design calls for special attention in consultation with traffic specialists. Provision of rumble strips on rural roads just ahead of their meeting point with the main highway would be of help.

d) Provision of bus bays at suitable location close to villages en-route and ramps for providing access to agricultural fields may also be considered. At the end of the road, adequate space needs to be ensured so as to enable turning of buses and other commercial vehicles.

e) Some states set-up district level road safety committees because of an all-round emphasis on improving safety on the road network in the state. The Head of the PIU of PMGSY roads could be inducted either as a full-fledged member or special invitee to such committees.

7.3 Safety Audit

7.3.1 *Projects to be audited*

Responsibility for the planning, design, construction and maintenance of rural roads would basically remain with the concerned road agencies and the implementing teams. In case of rural roads, safety audit may be considered initially in respect of PMGSY projects. After gaining experience from the safety audits of these projects, the states may consider upscaling the same to other rural roads for both new construction and improvement/upgradation of existing roads.

7.3.2 *Audit team*

The safety audit team should comprise two members. One member should have adequate traffic

engineering and traffic management experience and the other should be an engineer with experience in road design and construction techniques.

7.3.3 *Stages of safety audit*

a) For PMGSY roads, the safety audit may be confined to the following stages:

1) Completion of design and estimate preparation stage

2) Completion of construction, pre-opening stage

3) On completed projects

b) Stage 3 audit described in para **3.3** may be applied for the completion of design and estimate preparation stage. The findings and recommendations of the Audit Team at this stage should be discussed with the PIU, STA and the SRRDA Headquarters. Final decision for amendments in design and BOQ based on the recommendations of the Audit Team should rest with the SRRDA. The SRRDA may keep NRRDA informed of such decisions.

c) Stage 5 audit described in para **3.5** may be applied for the pre-opening stage on completion of construction. It would be sufficient to involve only the local site staff. The Team should travel in a car, on two wheeler and also in a non-motorised transport on the road stretch in question. Travel should be undertaken both during the day and dark hours. The Team should check the presence and effectiveness of road signs, pavement markings, speed management measures (speed humps, rumble strips), intersection layout, etc. Findings of the Audit Team at this stage and measurers recommended by it should be discussed with the PIU, STA and the SRRDA Headquarters. Final decision on measures recommended should rest with the SRRDA. The SRRDA may keep NRRDA informed of such decisions.

d) Stage 6 audit described in para **3.6** may be applied for the completed projects. Such audits amy be taken selectively on roads where there are reports of accidents taking place. The Audit Team would be expected to determine if the safety needs of all types of road users including pedestrians, cyclists, animals and animal drawn carts are being met. Findings of the Audit Team and measurers recommended by it should be discussed with the SRRDA Headquarters. Final decision on measures recommended should rest with the SRRDA. The SRRDA may keep NRRDA informed of such decisions.

7.3.4 *Audit process*

The steps in the rural road safety audit process would essentially be as indicated in Chapter 4. For PMGSY roads, the designer may be either in-house staff of PIU or outsourced consultant. Interaction of the Audit Team with the State Technical Agencies is also required since the latter are mandated to oversee the design and project estimates.

7.3.5 *Check lists*

The following checklists are relevant for the PMGSY projects.

Sl.No.	Stage	Check List NO.
1)	Completion of design and project preparation	3,8,9,10,11,12
2)	Completion of construction, pre-opening	5,8,9,10,11,12
3)	Completed projects	6,8,9,10,11,12

The Audit Team may develop specific check lists keeping the above check lists in view for the PMGSY projects. For example, in check list 3, item no. 8,10,11,17,18 and 20 to 32 may not be necessary. Similarly, in check list 5, item no. 11, 12, 13, 14 may not be necessary. Also the auditors may add other checklist considered relevant for rural roads.

8 CHECKLISTS

8.1 General

Checklists are useful to assist the audit team. These checklists describe the performance and situations that can affect the road safety of selected types of project and audit stage. Checklists have been prepared for Stage 1 to Stage 6. These checklists will cover planning, alignment, cross-section, junctions, link road, traffic signs, road markings, road lighting, roadside hazards, road side furniture, vulnerable road users, cross-drainage structures etc. These checklists should be used as a guide to focus audit towards important matters that should be covered and not overlooked. Each project is different and will raise specific issues that may contain further safety implications. When reviewing each of the points, the team should consider that the road user would have to cope with conditions at night and in adverse weather conditions also.

The safety audit team should visit the site for identifying the deficiencies from safety angle of the stretch and should suggest remedial measures. The team should check planning, cross-sections, alignment, roadside furniture and facilities available, junctions, facilities for vulnerable road users, signs, marking and lighting and also road side hazards as suggested in the previous paragraph. Some sort of questionnaire should be prepared for each kilometre. The questionnaire should include various aspects covered under the methodology of the safety audit.

8.2 Purpose of Checklists

Road Safety Audit checklists are presented in **Annex A**. These checklists have been designed as a prompt. They are not a substitute for knowledge of local conditions and experience: they are an aid for the application of that knowledge and experience. The checklists are to help an auditor not to overlook something important. It is stressed that a road safety audit is not an audit of the design standards, though these will need to be referred to, and their proper use makes a good

starting point with any design. The written audit report should contain sufficient explanation of its recommendations, without any need to refer to notes on checklists. Designers can make use of the checklists to help them identify potential safety problems and cover the solutions in their designs.

8.3 When to use Checklists

The checklists are for use during an audit when

- Assessing the documentation; in particular, when the project drawings are being examined
- Inspecting the site. At this point, it is important to visualise how the project will fit into the existing features
- Writing the audit report - to re-check that the relevant issues have been addressed

These checklists can be used on existing roads, new roads, roadwork traffic schemes, rehabilitation works, etc.

8.4 How to use Checklists

Determine which set of checklists is needed. It should be remembered that an audit may cover more than one stage in the design process. More details can be entered on checklists, on plans. A successful audit is not achieved by simply ticking off checklists. The topics listed in **Annex A** cover the more common elements of design and practice. While the list is sufficiently exhaustive, the audit team should use their own skills, experience and judgement in refining and amplifying these checklists.

9 ELEMENTS OF A GOOD RSA AND MEASURE OF ITS SUCCESS

As to what makes a good safety audit report will depend on the audit team and its due diligence in assessing the designs and drawings and a detailed inspection of the project. A good safety audit report will restrict itself to road safety issues, explain each of the safety issues in some depth and provide practical and implementable recommendations. A good report would also not indulge in blame game.

The success of a safety audit shall not be measured by cost-benefit approach, but by the depth of analysis of the design features, identification of issues of safety concerns and the recommendations that are accepted by client.

In the initial stages, good number of recommendations may be found to be acceptable by the client. However, with more and more awareness raising among designers safety features would get in-built into the design of the project and it may not be surprising to find that the number of recommendations from the audit team get reduced. The objective of carrying out RSA would have then served its intended purpose.

10 HOW TO GET ROAD SAFETY AUDIT STARTED IN THE ROAD ORGANISATION?

In order to ensure safety conscious planning, design, construction and maintenance and operation of roads and highways, it is paramount that the agencies and organisations responsible for development of roads and implementation of projects are committed to road safety. As the experience from those countries which have undertaken Road Safety Audits of their roads and road projects reveal, positive benefits towards enhancement of road safety, the top management cadre of these agencies should include it as an essential ingredient of the project cycle.

The various steps and actions for initiating road safety audit in engineering organisations (engineering departments at National. State or Local levels) including engineering consultants, etc. are outlined in **Fig. 10.1**. It is not uncommon to find that the term 'audit' may generate negative feelings because it may seem to indicate that the aim is to catch someone making an error. Therefore, an important component of the process of introduction of road safety audit should be to create the desire and resolve of all parties concerned to be committed to it as part of overall road safety efforts without blame game. Awareness raising among engineers of the road agencies and other stakeholders at various levels would be an advantage.

The road organisations usually set apart some funds for engineering measures for road safety in their budget. To start with, part of these funds could be utilised in initiating the process of RSA and training in RSA for some of their projects.

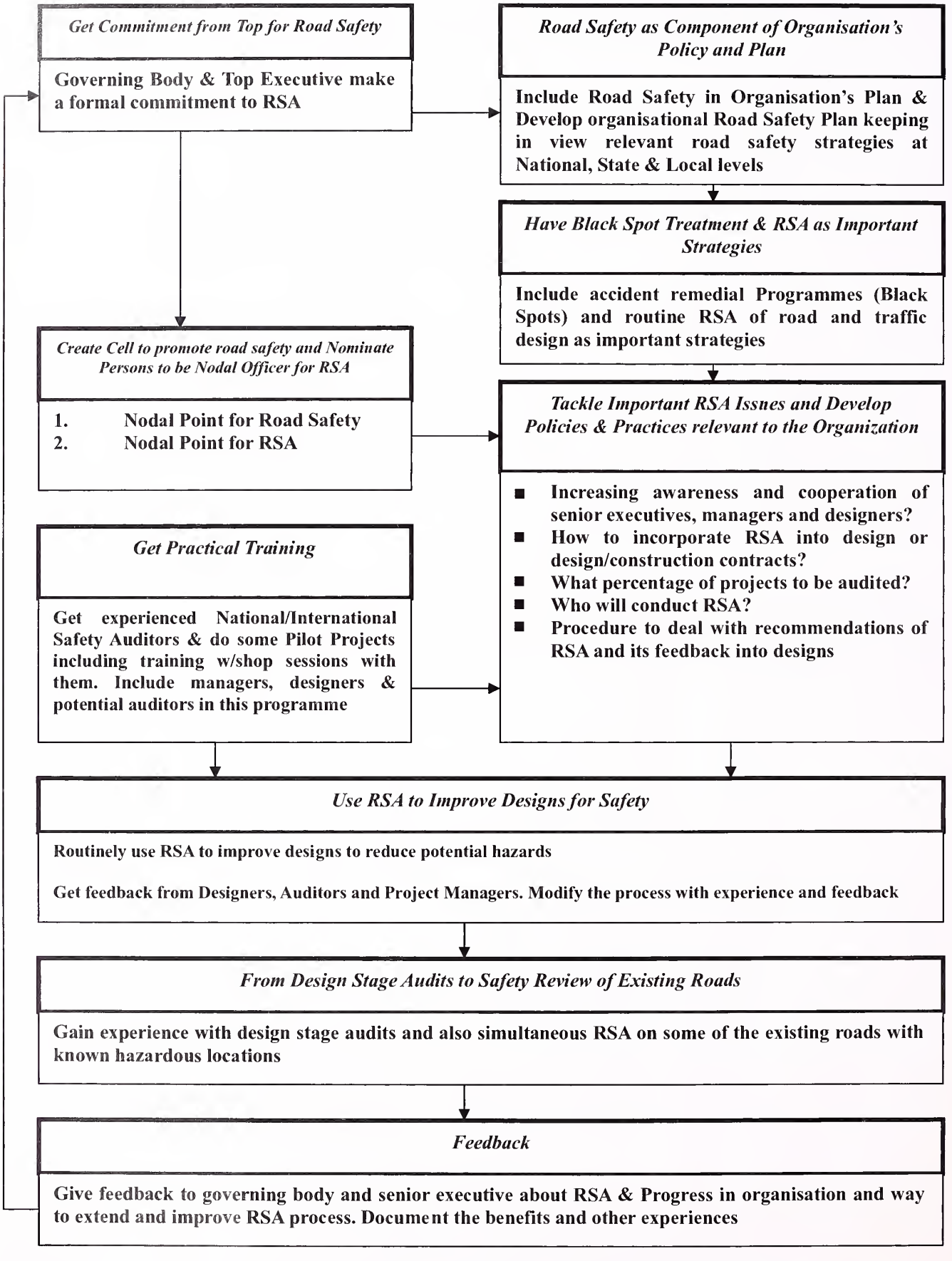


Fig. 10.1 Suggested Model for Initiating RSA in an Organisation

ANNEX A
(Clause **8.4**)

CHECKLISTS FOR CARRYING OUT ROAD SAFETY AUDIT FOR DIFFERENT STAGES OF THE PROJECT

Checklists have been prepared to assist the members of the Audit Team. These checklists describe the problems and situations that can affect the road safety of selected types of project and audit stage.

The checklists for different stages of audit are presented hereunder:

Checklist 1	-	Stage 1 Audit
Checklist 2	-	Stage 2 Audit
Checklist 3	-	Stage 3 Audit
Checklist 4	-	Stage 4 Audit
Checklist 5	-	Stage 5 Audit
Checklist 6	-	Stage 6 Audit
Checklist 7	-	Planning
Checklist 8	-	Alignment
Checklist 9	-	Cross Section
Checklist 10	-	Intersections and Interchanges
Checklist 11	-	Road Signs
Checklist 12	-	Road Markings
Checklist 13	-	Lighting
Checklist 14	-	Roadside Hazards
Checklist 15	-	Roadside Facilities
Checklist 16	-	Vulnerable Road Users
Checklist 17	-	Development Proposals
Checklist 18	-	Maintenance Work

CHECKLIST 1 - STAGE 1 AUDIT (DURING FEASIBILITY STUDY)

1) What is the category of road for which the feasibility study has been carried out e.g., expressway, national highway, state highway or other roads?

2) Is the road intended to carry high-speed traffic or serve local access needs only?

3) What kind of traffic is likely ranging from high speed mixed traffic or for more general use, including bicycles and significant pedestrian traffic?

4) Do the chosen type of road and the standards, alignment and cross-section offer optimum road safety to all groups of road user including disabled in combination with the expected traffic density and speeds?

5) Does the project follow existing roads or is it a 'green field project' and what are the effects of this?

6) Check whether appropriate design standards have been used having regard to the scope of the project, and its function in relation to the traffic mix.

7) Check the appropriateness of the designs for the design volume and traffic characteristics.

8) Has access control been proposed?

9) Will the proposed scheme be compatible with the standard of conjoining road sections?

10) Will there be sufficient opportunities for overtaking?

11) Are the number and distribution of intersections appropriate in relation to:

    a) The desired function of the new road?

    b) Impact on the surrounding, adjacent and/or off-loaded road network (does the project simply move present problems?)?

    c) Accessibility for public transport and emergency vehicles?

12) Are junction types shown the safest available at each location, in relation to the expected turning volumes?

13) Are the proposed horizontal and vertical alignments consistent with visibility requirements both along the road and junctions?

14) Has lighting been planned? If so, does the lighting offer maximum safety, both on links and at junctions?

15) Will the project have any effect on existing pedestrian and cycle routes?

16) Does the project include measures for vulnerable road-users and if so, do these measures offer maximum safety?

17) Do the available accident data for the existing/adjacent road network give reason to expect particular road safety problems in the proposed project?

18) Whether non-motorised traffic is expected to cause problems?

19) What is the likelihood of future widening?

20) Do the gradients, curves and general design approach fit in with the class of terrain and likely weather or environmental aspects?

21) Check any special events creating unusual or hazardous conditions and any other matter, which may have a bearing on safety.

22) Other checks pertinent to the project at discretion of auditor or client.

CHECKLIST 2 - STAGE 2 AUDIT (COMPLETION OF PRELIMINARY DESIGN)

1) Have all recommendations from the previous stage been followed? If not, why not?

2) Is the desired speed compatible with the cross-section and other design elements and is the desired speed realistic?

3) Cross-section:

   a) Has delineation of the carriageway with a kerb been proposed?

   b) Is there adequate space for all groups of road users ?

   c) Is there appropriate separation between various groups of road users?

4) Horizontal and Vertical alignment and visibility:

   a) Do the proposed alignment satisfy any demands on visibility at junctions and sight distances on free sections?

   b) Will sight distances/visibility be blocked by traffic signs, guardrails, bridge parapets, buildings, rigid obstacles or plantations (now and in the future)

   c) Can parts of the project constitute a risk, especially in combination (e.g. peaks in the vertical alignment plus sharp horizontal bends, crests of hills plus traffic signals)?

5) Are the lane widths, shoulders, medians and other cross-section features in accordance with standard design and adequate for the function of the road?

6) Check whether there are undesirable variations in cross-section design. Check cross-falls, which could affect safety, particularly where sections of existing highway have been utilized, or where there have been compromises to accommodate access to abutting properties.

7) Check the safety aspects of shoulder provision, including the provision of paved and earthen shoulders, the width and treatment on embankments and cross-fall of shoulders? Are the shoulders likely to be used by slow-moving vehicles or cyclists?

8) Check for the provision of climbing lanes in hilly sections where vertical gradients are steep for considerable length of the highway?

9) Junctions, interchanges and their design:

   a) Will road users coming from all directions (including side roads) be able to see that they are approaching a conflict area? Are give-way lines, stop lines, turning lanes and ramps clearly visible?

   b) Are existing conjoining and intersecting roads appropriately adjusted and matched to the new road (without sharp bends and gradients)?

   c) Do the routes of road users through the junction seem clear for all directions and manoeuvres?

   d) Is there sufficient space for all types of vehicles to undertake all manoeuvres?

   e) Are the crossing facilities for pedestrians and non-motorised traffic adequate and safe?

   f) Can parking cause problems?

   g) Have roundabouts been considered?

   In urban areas, ghost markings and left-turning lanes with islands are safest; they prevent overtaking and assist pedestrians and cyclists who are crossing the road.

10) Decide whether or not old, unremoved section of road can give undesired optical directions.

11) Special points at roundabouts:

   a) Are all entrance lanes curved and is speed adequately reduced?

   b) Will the central island be visible?

   c) Are the measures taken for the benefit of pedestrians from a safe stopping distance and cycle traffic adequate?

12) At the junction/transition to existing roads (especially from multi-lane to two-lane, dual to single carriageway):

   a) Are there sudden changes of alignment?

   b) Does the road standard change too rapidly, or can road users clearly see and recognize the transition in good time?

   c) Would a roundabout be able to mitigate any sudden changes in standards and alignment?

13) Are existing junctions and intersections adjusted and matched to the new road appropriately (without sharp bends and gradients)?

14) Are there any constructions that will be difficult to drain and are the cross-fall and any gutter gradient adequate at the critical spots?

Are there places where there is a risk of flooding?

15) Will overtaking be prevented at critical places (not simply by restrictions, but also by making it quite apparent that overtaking is prohibited)?

16) If signs and road markings have been proposed:

a) Are the markings consistent and are they adequate?

b) Has the quantity of information been kept at a reasonable level?

17) If markings have not been proposed: will special markings be necessary?

18) Is there any risk that cannot be "marked out of existence"?

19) Will there be any large sign constructions? Is so; will guardrails or breakaway safety devices protect them?

20) Has it been proposed that lighting be located on the outside or inside of bends?

21) Will it be possible to carry out maintenance work (on lighting, gantries, plantations, etc.) safely and without using the carriageway or cycle path?

22) Is the landscaping design or plantation likely to lead to a lowering of safety with mature or seasonal growth? Is frangible vegetation appropriate?

23) Are there arrangements for safe access by emergency vehicles? Check the design of medians and barriers, and the ability of emergency vehicles to stop without necessarily disrupting traffic?

24) Pedestrians

a) Have pedestrian needs been considered?

b) If footpaths are not specifically provided, is the road layout safe for use by pedestrians, particularly at blind corners and on bridges?

c) Are pedestrian subways or footbridges sited to provide maximum use?

d) Is the avoidance of footbridges or subways possible by crossing the road at grade?

e) Has specific provision been made for pedestrian crossings, school crossings or pedestrian signals?

f) Are pedestrian refuges/kerb extensions needed?

g) Whether needs of disabled road users taken care of?

25) Have the needs of public transport users been considered? Are bus stops positioned for safety?

26) Is lighting envisaged in specified locations of the project? Are the difficulties of illuminating sections of the road caused by trees or over bridges, for example? Are there any aspects of the provision of the lighting poles, which would require consideration from the safety point of view in their being struck by vehicles?

27) Is adequate safe access to the work site available?

28) Are there any factors requiring specific road safety provision, including maintenance?

29) Are there any traffic management features, which would require special attention during construction or during the transition from construction to full operation?

30) Other checks made at discretion of auditor or client.

CHECKLIST 3 - STAGE 3 AUDIT (COMPLETION OF DETAILED DESIGN)

1) Have all recommendations from the previous stage been followed? If not, reasons thereof?

2) Visibility, sight distance

   a) Are horizontal and vertical alignments consistent with the required visibility requirements?

   b) Confirm whether the standard adopted for provision of visibility in the design is appropriate for the ruling design speed and for any unusual traffic mix.

   c) Check whether sight lines are obstructed by:

      - Safety fences
      - Boundary fences
      - Street furniture
      - Parking facilities
      - Signs
      - Landscaping
      - Bridge abutments

   d) Check whether railway crossings, bridges and other hazards are conspicuous.

   e) Will sight lines to be obstructed by temporary features such as parked vehicles in lay-byes or parked or queued traffic has been taken care of?

3) Check whether the design standards are appropriate for all the new requirements of the proposed project and check for consistency of general standards and guidelines such as lane widths, camber and cross-fall.

4) Cross-sections:

   a) Are cross-falls appropriate?

   b) Is there a suitable gutter gradient or is the carriageway laid at a suitable height above the shoulder?

5) Lighting columns, traffic signals, sign standards, etc:

   a) Have requirements on safe distances to carriageway and cycle path been observed?

   b) Have breakaway safety devices or such like been proposed?

6) Signs and markings:

   a) Are markings consistent along the entire road section?

   b) Is the information clear?

   c) Are there enough signs?

   d) Are there too many signs?

   e) Will signs mask each other or traffic signals (be sure to include all plans for signs and markings in your assessment)?

   f) Are the signs correctly positioned, without obstructing sight distances/visibility in any way?

7) Are the proposed types of kerb stone/edge marking appropriate?

8) Lighting:

   a) Is there any risk that the lighting can be optically misleading and will it have any detrimental effects on traffic signals and signs?

   b) Are there any unlit areas that could conceal hazards?

   c) Will an illuminated side road mislead road users on the planned, unlit road?

   d) Are all pedestrian crossings illuminated (not merely the formally marked crossings, but also unmarked places where pedestrians could be expected to cross)?

   e) Will powerful illumination of adjoining areas or strongly illuminated advertisements cause problems?

9) Junctions, interchanges and their design:

   a) Will road users coming from all directions (including side roads) be able to see that they are approaching a conflict area? Are give-way lines, stop lines, turning lanes and ramps clearly visible?

   b) Are existing conjoining and intersecting roads appropriately adjusted and matched to the new road (without sharp bends and gradients)?

   c) Do the routes of road users through the junction seem clear for all directions and manoeuvres?

   d) Is there sufficient space for all types of vehicles to undertake all manoeuvres?

e) Are the crossing facilities for pedestrians and non-motorised traffic adequate and safe?

f) Can parking cause problems?

g) Have roundabouts been considered?

In urban areas, ghost markings and left-turning lanes with islands are safest; they prevent overtaking and assist pedestrians and cyclists who are crossing the road.

10) Decide whether or not old, unremoved section of road can give undesired optical directions.

11) Special points at roundabouts:

a) Are all entrance lanes curved and is speed adequately reduced?

b) Will the central island be visible?

c) Are the measures taken for the benefit of pedestrians from safe stopping distance and cycle traffic adequate?

12) At the junction/transition to existing roads (especially from multi-lane to two-lane, dual to single carriageway):

a) Are there sudden changes of alignment?

b) Does the road standard change too rapidly, or can road users clearly see and recognise the transition in good time?

c) Would a roundabout be able to mitigate any sudden changes in standards and alignment?

13) Are existing junctions and intersections adjusted and matched to the new road appropriately (without sharp bends and gradients)?

14) Guardrails, hedges and railings:

a) Are all vulnerable areas protected?

b) Are bridge pillars, steel posts, trees etc., protected by guardrails where necessary?

c) Are there places where hedges are necessary to prevent pedestrians from crossing?

d) Are the chosen hedges/guardrails "light" enough?

e) Do guardrails/road side furniture have any hazardous sharp protruding edges?

15) Road surface:

a) Has a porous type of surface been chosen?

b) Will an exceptionally high-friction surface be necessary in especially exposed places?

c) Would a change of surface as a purely visual signal to road users be of benefit? Used in this way, could a change of surface be misunderstood by road users?

16) At junction/transition to existing road network (especially from multi-lane to two-lane, end of central reserve)

a) Is there sufficient advance warning?

b) Are reflector posts correctly positioned?

c) Are ghost markings appropriate in connection with the merging of two lanes?

d) Is there continuity of edge markings?

17) For two-lane sections prepared for expansion to four lanes with central reserve (e.g. expressways built as "semi-motorways")

a) Will road users be clear everywhere that they are not on a one-way, two-lane carriageway?

b) Should night illumination of signs be of extra high standard?

c) Is overtaking prevented at all points where prevention is necessary?

d) Should special measures be adopted at bridges built with a view to future expansion?

18) Examine adjoining areas for potential safety problems (airfield, signals for maritime traffic and railways, flying golf balls etc.)

19) Additional temporary signs will be necessary for most new constructions. In this context consider:

a) Is the text, etc. comprehensible and correct?

b) Have all signs etc., been positioned safely?

c) When will they be removed?

Be sure also to use the separate checklists for specific facilities and measures.

20) Landscaping:

a) Is there advertising conflict between landscaping and visibility requirements? Has ultimate growth height been considered and potential obstructions to pedestrian visibility and potential for trees to become collision objects?

b) Will maintenance of soft landscaping be safe?

21) Plantations:

a) Will plantations obscure visibility and has a maximum height been specified?

b) Are plantations likely to encroach on markings or lighting?

c) Will fully-grown trees constitute a hazard (have the requirements on distances to rigid obstacles be observed?)?

d) Can maintenance be carried out safely?

22) Lay byes:

a) Are there any lay-byes available in the section?

b) Is the by bye properly located and it is not inconvenient to the drivers to stop the vehicles?

c) Is there any need to modify the lay-bye design (if yes, suggest the parameters that need modification)?

d) Are advance warning signs and markings properly guiding the driver about the lay-bye?

e) Is there any need of any additional signs and markings?

23) Check provision for pedestrians to cross safely at intersections, signalised and pedestrian crossings, refuges, kerb extensions and at other locations.

24) Are median barriers necessary and have they been properly detailed? Are there any design features such as end conditions which require special attention?

25) Are there any poles located adjacent to moving traffic which could be sited elsewhere?

26) Have frangible or breakaway poles been detailed?

27) Is the unprotected median width adequate to accommodate lighting poles?

28) Are there any obstructions, which are likely to create a safety hazard and can they be mitigated or relocated?

29) Is a crash barrier provided wherever necessary and is it properly detailed?

30) Check whether access to structures and road furniture is safe. Check that the road or utilities in the road reserve can be maintained safely. Both road users and maintenance personnel should be considered.

31) Check that the requirements for the traffic management of the construction site and safety measures needed for workers and road users have been adequately spelled out from the safety point of view including the transition from the existing arrangements to the construction site and from the construction site to the final layout can be effected safely.

32) Check for the arrangement for temporary and permanent traffic control devices, including possible signals, temporary diversion etc.

33) Check that the design duly considers the needs of persons with disabilities.

34) Other checks made at discretion of auditor or client.

CHECKLIST 4 - STAGE 4 AUDIT (DURING CONSTRUCTION STAGE)

1) Have all recommendations from the previous stage been followed? If not, why not?

2) Whether information regarding the construction zone approaching has been provided well in advance or not?

3) Whether standard procedure and contract conditions provided for proper management of the construction site and road users are properly and safely accommodated?

4) Whether the transitions from the existing road to the site of works safe and clearly laid out?

5) Whether the width of the lanes is satisfactory for the traffic passing through the works area?

6) Whether sight and stopping distances adequate at site of works and at intersections?

7) Whether bus stops appropriately located with adequate clearance from the traffic lane for safety and visibility.

8) Whether appropriate street lighting or other delineation provided at the road works to ensure that the site is safe at night? Check the night time visibility of traffic control devices.

9) Check for proper education and training programme for site operators and managers, which would assist in creating and maintaining safer environment for construction workers and road users.

10) For clear and sufficient information to the road user, advance warning signs installed or not?

11) Is there any provision of marked lanes for safe and clearly guiding road users?

12) Whether suitable measures provided through construction zones to control driver behaviour?

13) Check for the adequacy of traffic control devices (such as signs, markings, cones, drums, delineators, barricades, flashing lights etc.) required for each zone i.e., at advance warning zone, at approach transition zone and at work zone? Check for placement and visibility of these control devices.

14) Has permission been taken while changing the standard layouts from safety point of view.

15) Whether police and other emergency services been consulted?

16) Check for proper care and attention for pedestrian and non-motorised traffic at construction sites.

17) Check for adequate safety provisions for the elderly and persons with disabilities.

18) Whether construction workers provided with protective clothing etc. reflecting jackets, hard hats, gloves etc.?

19) Whether flagmen are available on duty at the appropriate places? Check for proper traffic management practice to avoid inhibiting traffic to pass clear of work site and necessary attention to roadside safety.

20) Whether the temporary diversion is provided at work zones in compliance with the contract and traffic management plan approved by the Engineer.

21) Whether the Traffic Management Plan at work site prepared and submitted by the Contractor to the Engineer for approval.

22) Is the Supervision Engineer ensuring the required quality of traffic management plan?

23) Whether arrangements of First Aid Box and other emergency care exist for persons getting injured.

24) Whether suitable speed reducing measures are provided at work zones.

25) Other checks made at discretion of auditor or client.

CHECKLIST 5 - STAGE 5 AUDIT (COMPLETION OF CONSTRUCTION/PRE-OPENING)

1) Have all recommendations from the previous stages been followed? If not, why not?

2) Involve the site engineer

3) Test the installations of traffic control devices as a road user: by car, by truck, by bus, by cycle and on foot - from disabled road user angle. Also in the dark/ night hours.

4) Examine the carriageway for defects, especially at junctions to existing roads.

5) Has the opening of the road facility been adequately publicized?

6) How will the transition phase proceed?

7) Check that provision for emergency vehicle access and stopping is safe?

8) Check that all delineators and pavement markings are correctly in place.

9) Check that all signs and other traffic control devices are correctly in place. Check that they are likely to remain visible at all times.

10) Check that the road markings as installed have sufficient contrast with the surfacing and are clear of debris.

11) Check that all lighting operating is effective from safety point of view.

12) Check that no roadside hazard has been installed or overlooked.

13) Check that the form and function of the road and its traffic management are easily recognised under likely operating conditions.

14) Check that all temporary arrangements, signing, etc, have been removed and replaced by permanent arrangements.

15) Other checks made at discretion of auditor or client.

CHECKLIST 6 - STAGE 6 AUDIT (ON EXISTING ROADS OR DURING OPERATION & MANAGEMENT)

1) Carryout inspection - do not forget to take the results of accidents analysis and relevant checklists with you.

2) Does the actual function of the road correspond to its intended function?

3) Are the prevailing speed levels within desirable limits?

4) Do the equipment and standard of the road correspond to its function, speed level and classification? (Use checklist 2 and 3, as well as any specific checklists, which are relevant.)

5) Do road users park in ways that could constitute hazards?

6) Do plantations obscure visibility or the view of signs?

7) Are the surface and carriageway markings in good condition?

8) Are there any signs that road users drive over islands or kerbs or that the routes taken by motorists through junctions and bends are less than ideal?

9) Are there signs of other conflict situations and minor accidents?

10) Are the specified distances to rigid obstacles maintained for all groups of road users?

11) Are medians and islands of adequate width for the likely users.

12) Are there signs of pedestrian traffic in places that seem hazardous to pedestrians?

13) Does there appear to be a need for more or better crossing facilities for pedestrians?

14) Does there appear to be a need for more or better facilities for cyclists?

15) Has due consideration been given to children, the elderly, persons with disabilities?

16) Are bus stops and bus bays safely located with adequate visibility and clearance to the traffic lane.

17) Any provisions for parking satisfactory in relation to traffic operations and safety?

18) Are all locations free of construction or maintenance equipment, and any signing or temporary traffic control devices that are no longer required?

19) Are overtaking opportunities available for heavy vehicles where volumes are high?

20) Are the road boundaries free of any activities that are likely to distract drivers?

21) Is the location of rest areas and truck parking areas along the route appropriate and adequate?

22) Is sufficient warning provided in advance of breaks in service roads and openings in medians for traffic using multilane highway?

23) Are there reasonable traffic calming measures in place for the road stretches passing through habitations and built up areas?

24) Other checks made at discretion of auditor or client.

CHECKLIST 7 - PLANNING

1) Is there a development plan or development strategy for the area and, if so, does the project conform to this?

2) Is the proposed design appropriate in relation to the forecast traffic volumes, traffic characteristics and the adjoining land use?

3) Does the route fit in with the physical constraints imposed by the topography?

4) Does the route serve major generators of traffic in a safe and adequate manner?

5) Is the frequency of junctions and their type appropriate for the function of the road and its design speed?

6) Does the project road fit in well with the existing road network? (Check for potential problems at the connections - will changes in traffic volumes cause problems)

7) 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?

CHECKLIST 8 - ALIGNMENT

1) 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?).

2) If the speed is not up to the mark of design speed, whether proper cautionary sign have been provided?

3) Does the alignment (horizontal and vertical) give sufficient forward visibility for the selected design speed? (Check for inadequate stopping sight distances)

4) Check for consistency throughout the route; note any location where alignment standard changes abruptly and is not as would be expected by drivers.

5) Do the horizontal and vertical alignments fit together comfortably? (Check for bad

combinations, such as a sharp bend immediately after a summit curve, and sag curve within a bend).

6) Does the alignment provide safe overtaking opportunities? Does it avoid creating situations where the forward visibility is marginal for overtaking (neither clearly adequate nor inadequate)?

7) Does the treatment at curves, proposed if any, make appropriate, adequate and safe provision for transition curves, super elevation and carriageway and formation widening?

8) Does the vertical alignment pose excessive demands on the power of heavy vehicles? Has it been designed so those maximum grades are interspersed with recovery grades? Are there passing places to enable faster vehicles to overtake slow-moving heavy vehicles?

9) Is the transition between project road and the existing road(s) i.e., access roads handled safely?

CHECKLIST 9 - CROSS-SECTION

1) Are the widths of the carriageway, shoulders, medians (if any), service roads in accordance with standards and adequate for the function of the road and volume and the mix of traffic likely to use it?

2) Check whether bridges have footpaths and they have proper gradients/crash barriers.

3) Note any location where the cross-section standard changes abruptly along the route or is otherwise inconsistent with driver expectations.

4) Identify any locations where the capacity of the roadway is restricted and note locations of regular traffic congestion.

5) Have the shoulders and side slopes been designed to a safe standard and note any locations with inadequate shoulder width?

6) Have the side drains been designed to a safe standard? Are the batter slopes and drains safe for run-off vehicles to traverse?

7) Is the transition between the project road and the existing road(s) handled safely? (Check for major changes in standards).

8) Check whether the cross-section has adequate provision for the Vulnerable Road Users including persons with disabilities:

   a) Pedestrians: Have paved footpath, adequate refuge width on median and proper ramps, up and down kerbs, where there is regular pedestrian traffic?

   b) Bicyclists: Segregated areas (e.g. paved shoulders) where numbers are significant

CHECKLIST 10 - JUNCTIONS

a) General

1) Is the general layout of junction caters safely for all road users including disabled road users? (Check whether there are other junctions too close to it. Check whether approaching drivers will get a clear view of it. Check with respect to pedestrians, cyclists and two wheelers etc.)

2) The type of junction (T-type, staggered, signal controlled, roundabout) suitable for the function of the two or more roads, the traffic volume, the traffic movements (pedestrians and vehicular) and the site constraints? Is it safest alternative?

3) Is the layout of the junction adequate for all permitted vehicular movements and for all types of vehicles?

4) Will the general type of junction, its layout and the priority rules be recognised by approaching drivers well in time? Is the route through junction as simple and clear as possible? (Check for unusual or over-complicated layouts? Check that signages and marking are correct and clear?)

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 roundabout with inadequate deflection?)

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 junction, which can be problem. Check signs, lighting columns, pedestrian guardrails etc.?)

7) Is there adequate provision for channelising the different streams of traffic? (Check the provision for right turn lanes, deceleration lanes and acceleration lanes?)

8) Is adequate provision made for pedestrians and non-motorised vehicles?

9) Is the provision of nighttime lighting adequate, if not what are the deficiencies?

10) Are junction(s) at that stretch having proper markings, signs and studs to avoid accidents?

b) Roundabouts

11) Is the geometry simple and easily understood? (Pay attention to roundabouts which are not circular, or which have awkward entry paths).

12) Are there too many entries for safe efficient operation? Are they sufficiently separated from each other to avoid confusion?

13) Does the design deflect entering traffic sufficiently to ensure entry speeds are safer? (Check entry path curvature, centre island size and positioning).

14) Is there visibility for entering traffic adequate? (Check if visibility is too good, if encourage entry speeds which are too high)

15) Is the visibility for circulating traffic adequate?

16) Has the Central Island been designed to be forgiving to errant vehicles?

17) Has adequate provision been made for pedestrians to cross the arms of the junction?

18) Have the needs of cyclists and other non-motorised vehicles been considered?

19) Does the signing make the priorities clear? (Entering traffic must giveway to circulating traffic).

c) Signal-Controlled Junction

20) Does the signal sequence conform to the requirements of the regulations and standards?

21) Do the signals clearly indicate which movements are allowed at any one time? Are the timings of various phases of signal cycle adequate?

22) Are the signal heads positioned so that drivers can see them easily, and in time to react (stop or go)?

23) Are the signals for competing phases located in such a way that they are visible only to the traffic for which they are intended?

24) Are all right turning movements protected as far as possible?

25) Does the signing; marking and channelisation make it clear to drivers what path they should take through the junction?

26) Are pedestrian crossing places marked, and are pedestrians channeled to these crossings?

27) Are the pedestrian signals positioned so those pedestrians can see them?

28) Whether the pedestrian crossing signal controls are provided where appropriate? If so, there is 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.

d) Vegetation and Plantation

29) Is the top of vegetation in the traffic island as well as channelisers, dividers less than 600 mm above the road top level for a length of 15 m from the end of the dividers?

30) Is the vegetation/plantation at the corners of the junction retracted for enough back from the edge of the shoulders to afford clear view of approaching traffic to the driver?

31) Are there no branches of trees projecting over the road berms/pavement at a height less than 7 m?

CHECKLIST 11 - ROAD SIGNS

1) Is the provision for road signs (regulatory, warning and informatory signs and delineators) adequate and in accordance with standards? (Check with respect to size, shape and placement etc.)

2) Check for any unauthorized traffic signs and use of non-standard signs (colour and shape).

3) Location and spacing of signs

   a) Note locations where there are too many signs placed

   b) Note the signs placed too close to each other

4) Note if all traffic signs are clearly visible and are prominently displayed for the intended road users.

5) Find any instances where the legibility of the information on traffic signs is inadequate, bearing in mind the speed of vehicles and the amount of information displayed.

6) Determine effectiveness of traffic signs by observing them at night and identify any lack of reflectivity.

7) Examine type of sign posts used and record situations where sign posts constitute a fixed roadside hazard or where the use of frangible sign posts should be considered.

8) Are there any situations where traffic signs themselves are obstructing essential 'Line of Sight' for drivers and pedestrians.

9) Regulatory and Warning signs

   a) Are appropriate regulatory signs provided where necessary?

   b) Are warning signs provided only where they are warranted?

10) Informatory signs

   a) Has signing been done on a systematic route or regional strategy that it is logical and meets needs of unfamiliar driver?

   b) Are all important junctions provided with advance direction sign, distance information sign and intersection sign etc.?

   c) Are these signs correctly positioned to enable the required timely action to be taken by the intended drivers?

d) Find instances of poor legibility and poor arrangement of information on signs.

e) Overhead signs - size, message information adequate, languages as per IRC standards.

CHECKLIST 12 - ROAD MARKINGS

1) General adequacy and visibility of road markings, during day/night time and in wet/ dry weather conditions

2) Has correct type of markings been used in various situations (e.g. lane line, edge line etc.)?

3) Are correct colours used for laying road markings?

4) Is there any deficiency in the delineation of merge and diverge areas, including situations where 'through' traffic may inadvertently lead into auxiliary and turn lanes?

5) Are zebra crossing markings provided at junctions and mid-blocks of the sections (depending upon the movement of pedestrian)?

6) Is positioning of stop lines appropriate?

7) Are the directional arrows marked on the pavement guiding the driver or creating confusion to the driver?

8) Are there locations where there is a lack of 'Hazard markings' at approach end of island, medians and culverts/ bridges etc.?

9) Have retro-reflective markers been installed? Where coloured markers are used, have they been installed correctly?

10) If chevron alignment markers are installed, have the correct types of markers been used?

CHECKLIST 13 - LIGHTING

1) Is there any need of lighting on the project roads, or parts of it, to be lighted at night (particularly where there are pedestrians and parking along the road) important interchanges, bus bays, truck lay byes, toll plazas?

2) Are the proposed lighting scheme and illumination levels of an appropriate standard, consistent with the needs of the location, pedestrian and other factors?

3) Identify the locations where street lighting columns constitute a hazard to traffic (on the outside of sharp curves, on small islands, noses of medians) or which may conflict visually with traffic signals or signs?

4) Does the existing street lighting enhance as 'route guidance', rather than confuse the drivers ability to 'see the direction of the route ahead'?

5) Are the appropriate types of poles used for all locations and correctly installed (e.g. slip-base at correct height, rigid poles protects if within clear zone)?

6) Has lighting for signs, particularly overhead signs, been provided where necessary?

7) Are there any lighting or telephone poles close to the edge of the berms so as to pose hazard to traffic?

8) Are there any lighting poles in the median unprotected by crash barriers?

CHECKLIST 14 - ROADSIDE HAZARDS

1) Is a clear zone provided in accordance with the guidelines? Is the appropriate treatment or projection provided for any objects within the clear zone?

2) Are bridge and culvert parapets and other obstructions close to moving traffic? If so, can they be relocated? If not, are they adequately provided with signs and, where necessary, protected by safety barrier?

3) Are bridge parapets designed to contain errant vehicles, where the speed and volume of traffic warrants them?

4) Are the ends of bridge parapets, bridge railing and pedestrian guardrail/crash barriers of a safe design?

5) Are there any poles or columns along the road and comment on whether some or any of them can be removed, relocated to less hazardous positions etc.

6) Is there a degree of hazard associated with large trees, boulders, etc. and whether these can be treated to improve roadside safety?

7) Do the trees and other vegetations obstruct driver and pedestrian sight lines, which are essential for safe traffic operation?

8) Are there any 'fixed roadside objects', which occur within the roadway? Comment on the need to treat them in terms of road safety?

9) Is there an existence of roadside stalls and other roadside business activities within the right of way of the road?

10) Are the provided crash barriers suitable for the purpose?

11) Is the length of crash barrier at each installation adequate? Are the crash barrier installed correctly?

12) Is the provided barrier/fencing in the clear zone free of separate horizontal rails?

13) Is there adequate delineation/visibility of barriers and fences during nighttime?

14) Are there any thorny bushes by the roadside, whose branches are likely to hurt the passengers occupying the window seat of a vehicle, especially a non-AC bus?

15) Is any thick growth of vegetation by the roadside enough far back from the edge of the pavement to enable a driver to take protective steps in time if any human or animal should run across the road from behind or within the vegetation?

16) Are there any sharp edged or pointed fixtures or tops of supporting verticals on the median crash barriers or on dividers which can hurt a motor cyclist in case of a collision or crash or loss of balance.?

17) Are there any village name boards or direction boards by the roadside with pointed ends to hurt a passenger in a bus on window seat?

18) Bridges/Canal crossings: Are the open spaces by the side of ends of Parapets covered by protective crash barriers or walls to prevent vehicles going into the river or canal?

19) Have the roadside trees close to edge of berms, which cannot be removed for want of permission of tree authority been made visible at night and day by white washing/ pasting reflective tape on them?

20) Is the height of vegetation in the median at breaks in median at junctions or for U Turns or for pedestrian crossings reduced to less than 60 cm for a length of 20 m to afford complete visibility to drivers?

21) Is the height of vegetation in the median less than 60 cm on curves?

22) Is the median clear of any trees with trunks with girth greater than 30 cm? If not, are such locations enveloped by protective crash barriers?

23) Are fixing details of pipe railing such that the entire length of pipe is smooth and continuous without any projection on roadward side?

24) Are entrances to abandoned roads properly fenced off?

CHECKLIST 15 - ROADSIDE FACILITIES

1) Do the cross-section, alignment and signages encourage drivers to adjust their speed on entering the town or village and maintain it at an appropriate level? (Check that it will be quite clear to drivers that the road environment is changing and that they slow down).

2) Is there adequate and safe provision for pedestrians and non-motorised traffic to walk alongside the road and to cross it? (Check for provision of footpaths, shoulders and safe crossing places and whether pedestrian movements are controlled and channelled by guardrail in busy places?)

3) Are the design and provision of roadside parking and access to properties adequate, controlled and safe?

4) Has the opportunity been taken to improve the traffic and parking situation in the town and villages through which the road passes? (Check for junction improvements, access control, provision of service lanes, parking areas and bus stops).

5) Are bus stop locations safe and proper and whether the provision for buses to stand clear of traffic lanes has been made? Also is there need for lighting at these locations for the security and safety of passengers?

6) Is there any need for overtaking opportunities along the route at regular intervals on divided roads, particularly where traffic flows are high or in hilly terrain?

7) Consider the need for rest areas and other roadside stopping places e.g., truck stops, scenic view points, wayside picnic areas etc, and note any current 'unofficial' places where vehicles stop and the degree of hazard that this involves.

CHECKLIST 16 - VULNERABLE ROAD USERS

1) Has there been a survey of non-motorised vehicle and pedestrian flows?

2) Will there be any major conflicts between motorised traffic and pedestrians and other disabled / handicapped road users?

3) Have pedestrians need for crossing the road and walking safely alongside it been adequately provided for? (Check particularly in towns and villages and at all junctions - check shoulder width - check whether it is desirable and feasible to provide a segregated footway - check whether steps are provided where pedestrians will have to climb high embankments).

4) 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?

5) Have measures been taken to reduce the accident risk for children going to and from roadside schools (Pedestrian guardrail may be needed to prevent children from running out into the road)?

6) Have the need of cyclists and other non-motorised vehicles been provided for (Check shoulder width - check the need and feasibility of segregated cycle/cycle rickshaw lanes, especially in towns)?

7) Are bicycle safe grates provided at drainage pits where necessary?

8) Does the volume of motorcycle traffic justify the provision of separate lanes? (Check in towns).

9) Are bus stops appropriately located with adequate clearance from the traffic lane for safety and visibility?

10) Where necessary, is fencing installed to guide pedestrians and cyclists at crossings or overpasses?

CHECKLIST 17 - DEVELOPMENT PROPOSALS

1) Horizontal Alignment:
   - a) Is visibility satisfactory at proposed access, including that for pedestrians?
   - b) Are curve radii and forward visibilities satisfactory?
   - c) Are verge widths satisfactory?

2) Vertical Alignment:
   - a) Are gradients satisfactory?
   - b) Are sight and stopping distances maintained?

3) Parking Provision:
   - a) Is off-site parking adequate to minimise on street parking and associated risks?
   - b) Are parking areas conveniently located, with adequate turning facilities?

4) Servicing Facilities:
   - a) Are off street loading/unloading areas provided?
   - b) Are there any turning facilities for large vehicles?
   - c) Is emergency vehicles access provided for?

5) Landscaping:

a) Does landscaping affect visibility at junctions, bends or access points?

b) Is tree planting proposed where vehicles are most likely to run off road?

6) Traffic Signs and Road Markings

a) Have necessary traffic signs and road markings been provided as part of development?

7) Other Traffic Control Devices - Road Side furniture, delineators, crash barriers, guard rails, etc.

8) Others :

a) Will there be area-wide effect on other roads?

b) Will design keep speeds down where necessary?

c) Are number of access points to busy roads minimised by layout?

d) Are footpaths (side walks) necessary and provided adequately?

e) Are cycle tracks required?

f) Is street lighting required/ adequate?

g) Are bus bays and stops safely located?

h) Are dropped crossings provided at preferred pedestrian route or crossing points?

i) Is pedestrian guardrail provided where walkways join the highway?

j) Are truck lay byes required?

k) Are toll plazas congestion free?

CHECKLIST 18 - MAINTENANCE WORK

1) Is it publicised to the necessary extent about road works, including applicable speed limits and diversions?

2) Are temporary traffic signals or road markings adequate and does the message reach all road users?

3) Has a temporary speed limit been suggested and is it proper?

4) Will the unaffected road users misunderstand temporary traffic signals?

5) Is the standard of proposed signs adequate?

6) Will it be necessary to illuminate critical points?

7) Will the work site, enclosing material, etc. behave as a rigid obstacle?

8) Will there be safe access to the work place?

9) Has a safety zone been proposed and is it adequate?

10) Has due consideration been given to all groups of road users in the layout of staggering and diversions?

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)