DEVELOPMENT OF A HIGHWAY SAFETY AUDITING PROGRAM FOR TURKEY

by

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To my wife

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ABSTRACT

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Road accidents are serious problems throughout the world, in social, health and economic terms. The number of road accidents in Turkey tend to increase at a rate of approximately 20 per cent a year and most of the road accidents, around 87 per cent, occurs in urban areas.

Improving highway safety requires consideration of three factors, the road environment, road user and motor vehicle. The safety programs developed in Turkey have mostly considered the road user as the main factor responsible from traffic accidents. Although a majority is attributed to road user factor in the crashes, the improvements in the road environment are expected to be more effective.

The aim of this study was to develop road safety audit, a newly developed proactive strategy to reduce the road casualties, for municipalities in Turkey. After a thorough review of the existing techniques for road safety auditing in various countries, a procedure has been developed for Turkey. The developed procedure was tested on Dolmabahçe Street in İstanbul, and the findings of this audit and possible recommendations for solutions have been reported. Finally, conclusions of the research and recommendations for further research have been summarized.

ÖZET

TÜRKİYE İÇİN BİR YOL GÜVENLİK DENETİMİ PROGRAMI GELİŞTİRİLMESİ

Trafik kazaları bütün dünya ülkeleri için sosyal, sağlık ve ekonomik açılardan ciddi bir tehlike oluşturmaktadır. Türkiye'deki trafik kazaları her yıl yaklaşık olarak yüzde 20 oranında artma eğilimindedir ve trafik kazalarının büyük bir çoğunluğu şehiriçinde gerçekleşmekte olup tüm kazalara oranı yüzde 87'dir.

Yol güvenliğinin geliştirilmesi üç temel unsurun iyileştirilmesine bağlıdır; yol ve çevresi, taşıt kullananlar ve motorlu araçlar. Türkiyede geliştirilen yol güvenlik programları çoğunlukla trafik kazalarının baş müsebbibi olan taşıt kullananlar üzerine yoğunlaşmıştır. Her ne kadar taşıt kullananlar kazaların büyük çoğunluğuna sebep ise de yol ve çevresi üzerinde yapılan iyileştirme çalışmaları daha etkin olmaktadır.

Bu çalışmanın amacı Türkiye'nin şehiriçi yollarında kullanılmak üzere bir yol güvenlik denetimi programı geliştirmektir. Yol güvenlik denetimi trafik kazalarını azaltmaya yönelik geliştirilmiş kaza öncesi önlemlere dayanan yeni bir stratejidir. Bu çalışmada, çeşitli ülkelerde kullanılan mevcut yol güvenlik denetimi tekniklerinin ayrıntılı bir biçimde incelenmesinden sonra Türkiye için bir metod geliştirilmiştir. Geliştirilen bu metod İstanbul, Dolmabahçe Caddesi'nde denenmiş, denetim sonuçları ve olası çözüm önerileri sunulmuş, son olarak da bu çalışmanın sonuçları ve ileriki araştırmalar için öneriler özetlenmiştir.

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1. INTRODUCTION

1.1. Problem Statement

As society celebrates the new millennium, the challenge of enhancing safety is a formidable one. It is a tragedy that more than 1.17 million people die and 10 million people are injured in road crashes around the world every year. The majority of these deaths, about 70 per cent occur in developing countries, 65 per cent of deaths involve pedestrians and 35 per cent of pedestrian deaths are children [1]. This means that more than 2 people die and 20 people are injured in every minute around the world in traffic accidents.

According to the study undertaken by the World Health Organization (WHO), Harvard University and the World Bank it is forecasted that by the year 2020 road crashes would be the third important health problem, while wars would be the eighth and HIV would be at the tenth place [2].

While developed countries have in general succeeded in checking and even reversing the annual of road accident fatalities, the number of fatalities in developing countries have trebled 1968 and 1990, and will, following current trends as in Figure 1.1 continue to increase if no effective remedial actions are taken [3].

Road accidents in developing countries have been shown to cost around one per cent of these countries' annual gross national product (GNP). These are resources that they can ill afford to lose. Since, in many cases, replacement vehicle parts, medicines and hospital equipment all have to be imported to such countries, these losses to the economy can often include a significant foreign exchange element [4]. In addition to these costs the social cost caused by accidents as pain, grief and suffering is not acceptable for any nation [5].

To understand Turkey's position in international perspective, crash rates as number of fatalities per ten thousand vehicles of some countries between 1990 and 1994 are introduced in Figure 1.2. As indicated, the number of fatalities per ten thousand vehicles

for Turkey is 9.5 for the year 1994. However, this rate does not reflect actual casualties since source data contains only the fatalities that occurred within the day in which accident happened. In contradiction with Turkey, fatalities in the succeeding 30 days are included to the statistics in most of the other countries. The studies conducted by insurance companies reveal that official numbers are able to represent only around 70 – 75 per cent of actual fatalities [2]. One may figure out that situation in Turkey is not as bad as many developing countries but this miscalculation should be remembered while comparing our country with others [2].

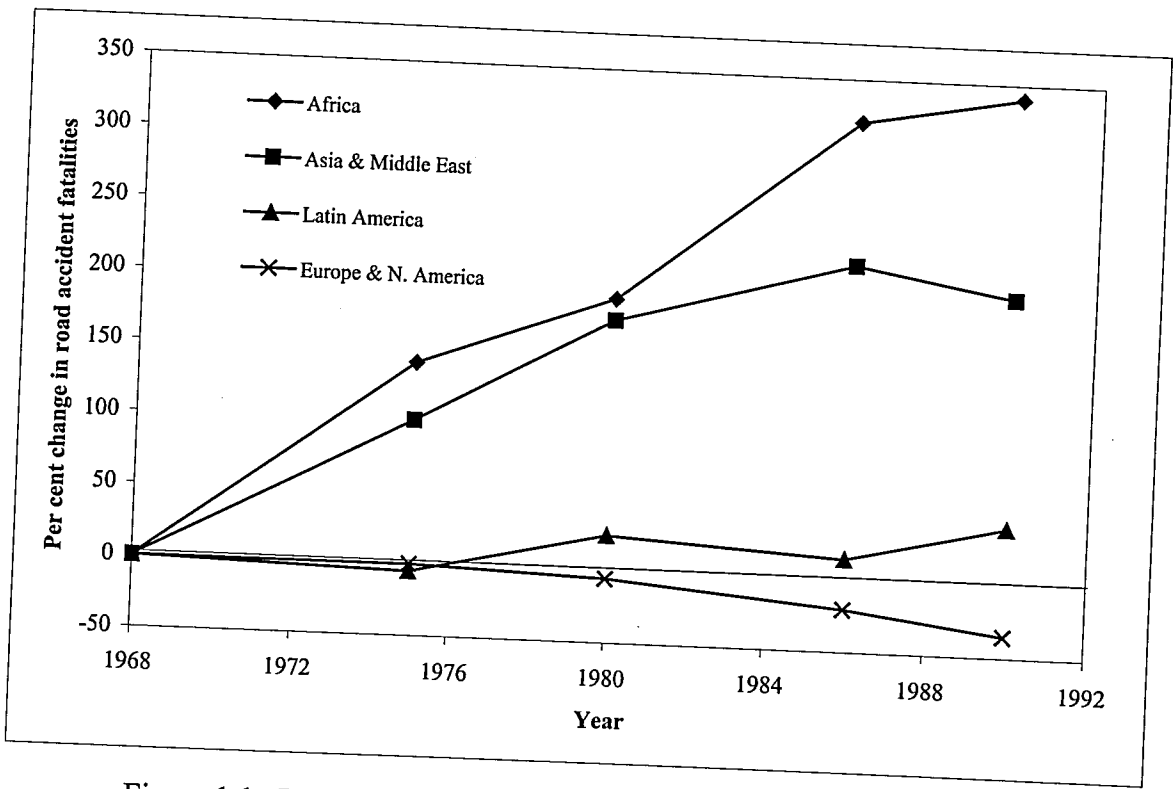


Figure 1.1. Per cent change in road accident fatalities (1968-1992) [3]

Similar to the case in other developing countries, road accident figures in Turkey tend to increase as shown in Table 1.1 with a ratio of 15 – 20 per cent per year. As expected the total national cost of road accidents rises around the same rate. However, it should be pointed out that spending a much less amount on safety related features might be able to prevent these huge losses. On the other hand the number of injuries does not increase and fatality rates even decrease which can be thought as a natural result of improvements in vehicle designs such as padded dashboards, compulsory use of seat belts and harnesses, air bags, anti-locking brake systems, side beams, and other features.

Table 1.1. Accident statistics of Turkey 1995 – 1998 [6]

		1995	1996	1997	1998
ACCIDENTS	URBAN	242,281	305,784	332,358	375,824
	RURAL	37,382	38,857	55,175	64,325
	TOTAL	**279,663**	**344,641**	**387,533**	**440,149**
FATALITIES	URBAN	2,932	2,524	2,197	1,847
	RURAL	3,072	2,904	2,984	3,088
	TOTAL	**6,004**	**5,428**	**5,181**	**4,935**
INJURIES	URBAN	70,882	61,445	59,979	63,254
	RURAL	43,437	43,154	46,167	51,298
	TOTAL	**114,319**	**104,599**	**106,146**	**114,552**
COST (US $)	URBAN	118,013,743	157,262,796	135,434,222	221,495,898
	RURAL	47,826,492	43,262,476	87,428,212	134,013,692
	TOTAL	**165,840,235**	**200,525,272**	**222,862,434**	**355,509,590**

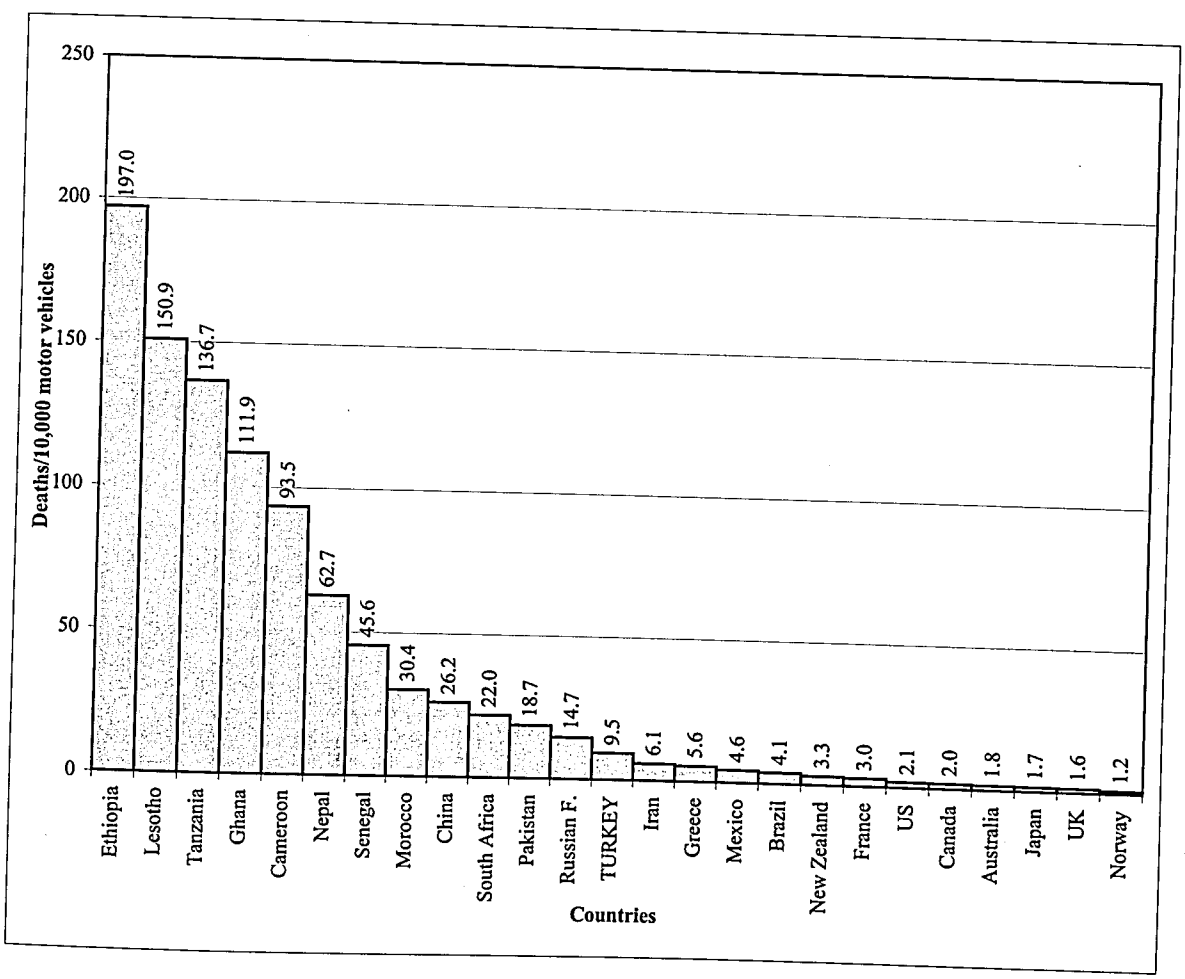


Figure 1.2. Deaths /10,000 motor vehicles 1990 – 1994 [1]

The factors contributing to accidents for Turkey are drivers by 96.48 per cent, pedestrians by 2.77 per cent, passengers by 0.21 per cent, vehicles by 0.53 per cent and road environment by 0.01 per cent [6]. The most interesting rate for the factors is road environment, which is very small comparing the most developed countries. This is because accident data is collected by traffic police officers who are not experts in road designs and accident data collection system of our country is very insufficient [2]. Careful analyses of accidents conducted by British and US in-depth studies are presented in Figure 1.3.

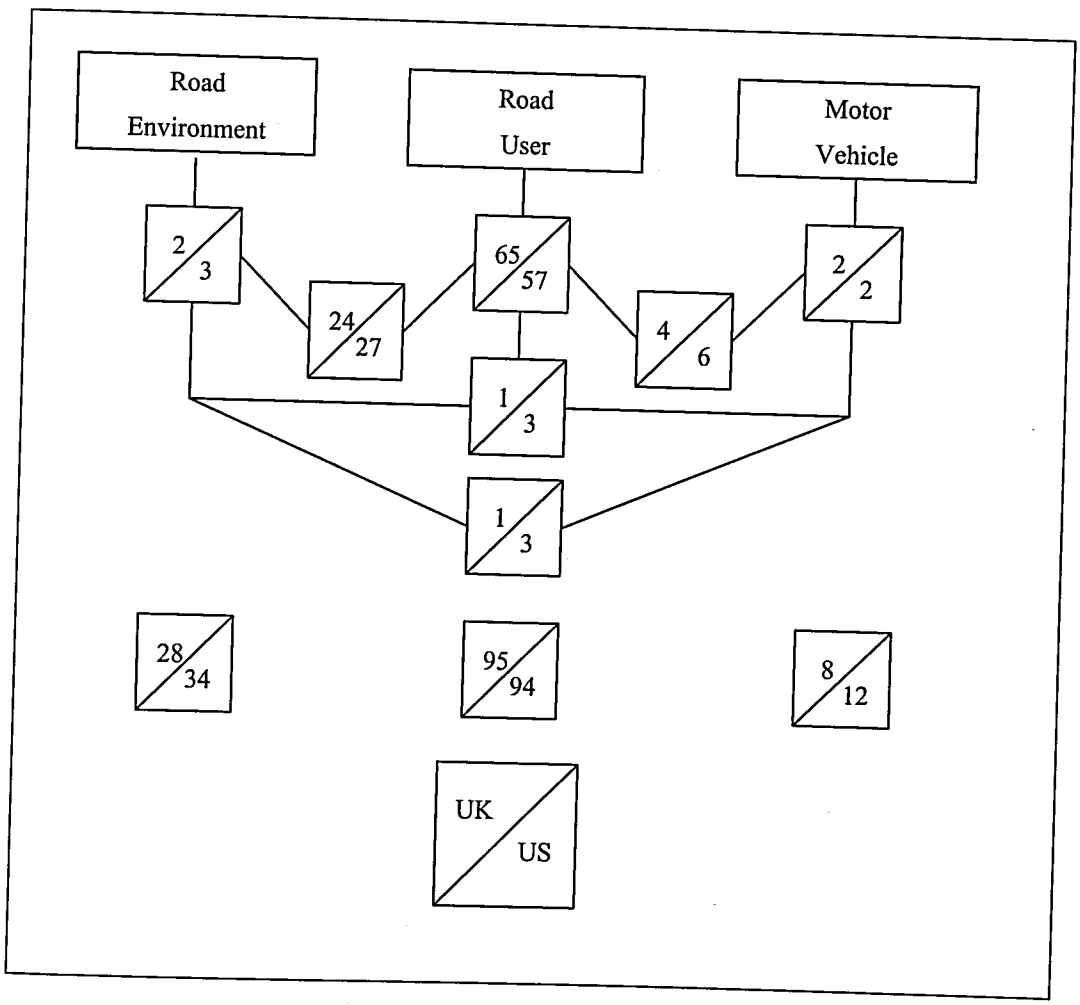


Figure 1.3. Per cent contributions to traffic crashes in UK/US [3]

The figure shows that British and American in-depth studies have found that road environment alone is responsible for 2 and 3 per cent of the crashes in UK and US respectively. However, when road environment is combined with other factors it becomes

responsible for 28 and 34 per cent of the crashes. The main factor contributing the traffic accidents are road users with combined effect of 95 and 94 percentages, the last contributing elements are vehicles with percentages of 8 and 12.

According to the data given in the Table 1.1, the accidents that occurred in the urban areas are 87 per cent of the total accidents occurred in Turkey. Istanbul, which is the biggest metropolitan city of Turkey, has very high accident statistics. By the end of the first six months of the year 2000, there have been 83,289 traffic accidents occurred, of which 79,653 had property damage only, 3,506 had injuries and 130 had fatalities. 146 people died and 5,510 people injured in these accidents [7]. Increases in traffic accidents and traffic congestion on road networks in the urban areas are caused by growth in urbanization and in the numbers of vehicles. In addition unplanned urban growth has led to incompatible land-uses, with high levels of vehicle and pedestrian conflicts. Contrary to the rural areas, hazardous conditions may occur in the urban centers by different classes of road users such as pedestrians, cyclists, large trucks, etc., of the road system. Additionally poor road maintenance, badly designed intersections and inadequate provisions for pedestrians cause inherent dangers. All of these problems contribute to the road safety in urban areas [4].

Over the years, road safety has become a principal concern of many transportation agencies. The rapid growth of the highway network, changing vehicle population, number and age of drivers, economic constraints in road construction, and technological advances, have contributed to increases in accidents.

Improving highway safety requires consideration of above mentioned three factors, the road environment, road user and motor vehicle. The safety programs developed in Turkey have mostly considered the road user as the main factor responsible from traffic accidents due to their high rates in accident contribution. Although the major factor contributing to the traffic accidents are road users, the improvements in the road environment are expected to be more effective for decreasing the number and severity of traffic accidents [5]. This study focuses mainly on the improvement of a safety strategy for road environment, especially in the urban areas which have very critical statistics.

In an effort to reduce the accidents in the world, some transportation agencies have introduced safety programs specifically designed to address some of the more prevalent elements contributing to highway accidents. At the same time, engineering design has greatly improved in terms of incorporating safety into road building. In earlier years, engineers designed and built "stay-between-the-lines" highways, which provided little means of protection to vehicles colliding with infrastructure or roadside elements outside travel lanes. In the 1960s and 1970s, engineers started building "forgiving highways" which incorporated critical design elements that mitigated the consequence of colliding with elements beyond the travel lanes. More recently, engineers have begun to develop "caring highways" by emphasizing the need to prevent rather than mitigate collisions. Nevertheless, there is still an entrenched practice of designing infrastructures to minimum standards using a cookbook approach. This practice is largely driven by the desire or need to keep initial construction costs to a minimum. At issue is the consequence that a roadway designed to a series of minimum standards does not necessarily ensure a facility that is safe overall [8].

Many road authorities have active "blackspot" programs in which millions of dollars are spent each year alleviating problem sites. Confronting the challenge of safety requires proactive strategies that treat the root causes of crashes and levels of severity before they occur.

1.2. Goals and Objectives

The main goal of this study was to develop and adopt a program for safety auditing the existing or newly designed roads for municipalities. To serve this main goal, the following objectives were aimed:

- To do a thorough review of the existing road safety auditing procedures used in various parts of the world.
- To adopt the procedures to Turkish municipalities
- To test the developed procedures in a pilot area selected in İstanbul and do the necessary changes in the procedure if needed.

2. LITERATURE REVIEW

2.1. Road Safety Audit Concept

The original objective of the road safety audit (RSA) process is the reduction of road casualties by incorporation of a proactive approach. Traditional blackspot analysis is a reactive measure of addressing safety problems and can be considered the end result of a failure on the part of the designers to recognize the full safety implications of their work [9]. Roads are still being built with problematic locations resulting in disproportionate rates of road collisions although they are closely linked to prevailing design standards. Introducing road safety audits early in the design of a highway is a cost-effective way of eliminating potential safety problems before roads are built.

2.2. What is Road Safety Audit?

The national association of road transport and traffic authorities in Australia (AUSTROADS), defines a road safety audit as [10];

"RSA is a formal examination of an existing or future road or traffic project, or any project which, interacts with road users, in which an independent, qualified examiner looks at the project's accident potential and safety performance."

Department of Transportation of the United Kingdom (UK DTp), defines a road safety audit as [11];

"RSA is the evaluation of physical elements and their interaction having a direct bearing on the safety of road users and others affected by a road construction scheme in order to detect foreseeable potential safety hazards before a new road is opened to traffic."

Although many other definitions exist, most include the concept that a RSA is a formal and independent examination, which applies safety principles from a multi-disciplinary perspective.

An audit concentrates solely on the safety implications of a project and aims to[12];

- consider the safety of all road users,
- ensure that preventable collision-producing elements are absent,
- ensure that injury reducing elements are provided at suitable locations,
- ensure that suitable collision-reducing elements are included, and
- ensure that the project does not impact safety of the adjacent roads.

Safety audit will [13];

- minimize the risk and severity of accidents that may be attributed to the existing road conditions,
- reduce the whole-life-operating costs of road,
- improve the awareness of safe maintenance practices [13].

An audit is formal since it requires documented recommendations from the safety team, and a documented response from the design team outlining how the safety recommendations are being addressed. An audit is independent since the safety team has no other association with the project, and the safety team is not part of the design team. The safety team consists of individuals who have demonstrated road safety engineering expertise. Finally, an audit requires that safety be addressed from a multi-modal perspective, so that the safety performance for all road users is considered and optimized.

2.3. What Road Safety Audit is not?

There has been some misuse of the term 'road safety audit' since its inception a decade ago. Below are some basics about what a road safety audit is not [14]:

- It is not a way of assessing or rating a project as good or poor.
- It is not a means of ranking or justifying one project against others in a works program.
- It is not a way of rating one option against another.

- It is not a check of compliance with standards.
- It is not an accident investigation.
- It is not a redesign of a project.
- It is not something to be applied only to high cost projects or only to projects involving safety problems.
- It is not the name you use to describe informal checks, inspections or consultations.

If there is a need to do any of the above, it should not be called a road safety audit.

2.4. Road Safety Audit History

The development of roadway audits is generally attributed to Bulpitt of the United Kingdom [15]. Bulpitt applied safety audit concepts that were originally introduced on railroad networks during the Victorian Period. At that time, the government appointed officers to inspect all aspects of a new railway line before it could be opened for use. Bulpitt applied the concept of independent checking to improve operational safety on road projects carried out by the Highways and Transportation Department of the Kent County Council in the early 1980's.

2.5. Why Road Safety Audits?

Many new road projects immediately become accident blackspots after they have been opened. Looking at how and why such sites slip through the traditional system of engineering design and checking yields a very positive answer to the question of why we need road safety audit.

- Sometimes a design may include standards, which are inappropriate for the type of road.
- In some cases, outdated standards may be used in a design.
- Sometimes the combination of various elements of the design may yield a result, which is not the best in terms of safety.
- Often, compromises between capacity and safety are made which lead to a degradation of safety.

- Sometimes changes are made during construction which do not fully consider operational safety factors.

Road safety audit will not necessarily make every new design totally "safe" but it increases the level of safety and it causes deliberate decisions to be made on the basis of carefully considered safety advice. The earlier in the design that the audit is carried out, the easier and cheaper it is to achieve change.

2.6. International Perspective of Existing Road Safety Audit Practices

2.6.1. United Kingdom

In 1988 legislation placed a responsibility on road controlling authorities to take action to reduce the road toll [16]. In response to this, the Institution of Highways and Transportation (IHT) produced their "Guidelines for the Safety Audit of Highways" in 1990. The United Kingdom Department of Transportation (UK DTp) made safety audit mandatory for all national trunk roads and motorways from April 1991. They published their Standard and Advice Note in 1990. These have been updated in 1994.

2.6.2. Australia

The states of New South Wales, Victoria and Queensland have published road safety audit guidelines [16]. Road safety audit manual for New South Wales was published in July 1991. The Roads and Traffic Authority (RTA) carried out its first safety audit in 1990 of the Pacific Highway using specially prepared checklists. This audit followed a series of truck crashes and two horrendous bus crashes in 1988 and 1989. The RTA require that each of its regional offices complete a minimum of 20 safety audits of new work proposals each year plus safety audits on the existing road system. It is envisaged that the complete state road network will be subject to systematic safety audit over a period of 5 years. In Victoria, road safety audit is known as safety review. The state road authority, VICROADS produced its safety review manual in 1993. The implementation of safety review is seen as an integral part of a quality management process. The facility to conduct safety reviews of the existing network appears in the VICROADS procedures for

investigating hazardous locations. Queensland has interim road safety audit guidelines and has actively promoted safety audit through local government. The other Australian states are considering the way in which safety audit can best be implemented [16].

AUSTROADS set up a working party to develop safety audit guidelines, with representatives from state and local government as well as Transit New Zealand (TNZ). The guidelines aimed to provide a national approach to safety auditing and expected to be especially useful to local government. The guidelines were published in 1994 [16].

2.6.3. New Zealand

Safety Audit commenced in New Zealand with a series of post-construction safety audits in 1990 [16]. These identified features of the project development or the final construction, which could be improved. The need for a comprehensive policy for pre-construction safety audits was identified. With the help of experienced safety auditors from the UK and Australia, a series of pilot audits on state highway projects was conducted in 1992 and 1993. A safety audit working party was set up with representatives of all sectors. Using the experience of the pilot state highway audits the working party developed safety audit policy and procedures. These were adopted by the TNZ Authority and published in 1993. The policy has been implemented on a 20 per cent sample of state highway projects in 1993 and 1994. The policy has been reviewed in the light of the experience on state highways. Two local authorities have implemented their own procedures, and several more are considering doing so [16].

2.6.4. United States

In 1996, the Federal Highway Administration (FHWA) dispatched a scanning team to evaluate the road safety audit process in Australia and New Zealand. The group consisted of a multi-disciplinary delegation of highway engineers, safety specialists, and educators. In a report entitled, FHWA Study Tour for Road Safety Audits - Parts 1 [15] and 2 [17], the scanning team concluded that road safety audits could maximize safety of roadways design and operation. The program participants recommended that a United

States pilot study be conducted. The team provided the FHWA with a nine-goal implementation strategy.

These goals are the following:

- Goal 1: "Get the word out".
- Goal 2: Gain support and enlist pilot agencies.
- Goal 3: Pilot the RSA Process.
- Goal 4: Revise the RSA Process.
- Goal 5: Develop "best practices" guide.
- Goal 6: Train support group.
- Goal 7: Develop training course.
- Goal 8: Monitor implementation.
- Goal 9: Adopt guidelines.

Subsequently, the FHWA started a Road Safety Audit Pilot Project in 1998 to determine the feasibility of national implementation of road safety audits into the process of roadway project development, construction and operation. Fourteen states are currently involved in the pilot project. Pennsylvania and Kansas had already been conducting road safety audits prior to the FHWA pilot project. The FHWA has sponsored road safety audit workshops for all parties engaged in the pilot project. The Pennsylvania Department of Transportation's (PennDOT) Road Safety Audit Process Pilot Study has been completed [18]. The PennDOT closely evaluated the pilot study following an ending meeting conducted on 1998. A detailed report was developed which outlined the pilot study and provided information that prepared PennDOT for statewide incorporation of the Road Safety Audit Process [18].

2.6.5. Canada

There is a growing recognition among Canadian provincial jurisdictions that a more pro-active approach to road safety is needed. Although Ontario is currently establishing a structured framework to enhance safety, other efforts have focussed on isolated reviews of specific projects [19].

2.6.6. Europe

Some European countries have shown interest but none have yet adopted safety audit as a formal procedure, guidelines of The Institution of Highways and Transportation of the United Kingdom was translated into French [16].

2.6.7 Turkey

A safety audit of Bolu mountain pass was prepared by Ergün during the construction stage. A consulting organization (SWEROD) working for Turkish Highway Department is currently developing guidelines for rural roads of Turkey [20].

2.7. Economic Implications of Road Safety Audits

2.7.1. Cost of Conducting Road Safety Audits

In the safety audit manual published by TNZ [17], the cost of audits was divided into three categories: consultant fees, the client's time to manage the audit, and costs associated with implementing recommendations that are adopted. The client's time on a project averaged about 1 day per audit. It is important to note that additional costs may result from changes to a project's scope and schedule. RTA indicated that a safety audit of a new facility cost approximately the same as a geotechnical survey.

Recent experience places the average cost of a conventional audit for small to mid-sized projects between $1,000 and $5,000 [18]. TNZ found that fees range from NZ$1000 to $8000 (US$700 to $6000) with most falling in the NZ$3000 to $5000 (US$2000 to $3600) range [19]. The actual cost depends greatly on the size and complexity of the project and composition of the required audit team. Hamilton Associates estimate that audits add approximately 5 to 10 per cent to design costs, or less than one-half of 1 per cent to construction expenses [12]. AUSTROADS approximates that audits will add 4 to 10 per cent to the road design costs [9]. As design costs are roughly 5 to 6 per cent of the project sum, the increase in total cost is usually quite small. On smaller projects (traffic

calming or retrofits), the costs may be a higher percentage of the overall capital cost. Costs of redesign and rectification should be considered which will vary on a project-to-project basis. The cost of rectifying deficiencies depends on how early in the design process the problem is identified as well as the amount of time required to redesign the area.

2.7.2. Benefits of Conducting Road Safety Audits

Benefits of road safety audits extend from economics of reduced accidents to improvements in policy and design.

Some of these benefits include [19]:

- Safer highways through accident prevention and accident severity reduction. Research in the United Kingdom indicated that up to 1/3 of collisions may be prevented on a road that has been audited. Other research indicated a 1 to 3 per cent reduction in injury collisions.
- Safer road networks.
- Enhancement of road safety engineering.
- Reduced whole life costs of road schemes.
- Reduced need to modify new schemes after construction.
- A better understanding and documentation of road safety engineering.
- Safety improvements to standards and procedures in the future.
- More explicit consideration of the safety needs of vulnerable road users.
- Educating other personnel on road safety.
- Foster a principle of safety conscious design among owners and designers.
- By providing a high quality product, the potential for future remedial work may be reduced, thus reducing the overall risk taken by the agency.
- Claims cost savings, lower health care and societal costs due to reduced collisions.
- Design improvement.
- Enhancement of the corporate safety culture.
- Cross-fertilization between specialists within a highway department (eg. Design, Maintenance, Traffic, etc.).

2.7.3. Benefit-to-Cost Ratios Associated with Road Safety Audits

Although cost effectiveness of road safety audits is difficult to estimate, Scotland has estimated a benefit-to-cost ratio of 15:1 based on experience, while New Zealand has estimated the ratio to be closer to 20:1 [19]. A 1994 study of minor works projects in Surrey compared 2 groups matched by project type; one group having been audited, the other not [19]. It was determined that the economic benefits would be well in excess of the audit cost for these small projects. For larger projects, the potential saving in casualties is likely to be greater, justifying the greater resources incorporated within their audits.

2.8. Road Safety Audit Stages

Road safety audits can be effective for most projects, regardless of size, and at any or all-key milestones in the development of a highway project. Traditionally, audits have been undertaken at the following key stages [21]:

- Feasibility (Planning);
- Draft (Preliminary/Layout) Design;
- Detailed Design;
- Pre-Opening; and
- Post-Opening (and Existing).

The complexity and level of effort of the audit process changes with each stage. An overview of what each of the audit stages entails is provided below.

2.8.1. Feasibility (Planning) Stage

At this stage, a safety audit can make recommendations relating to route choice, layout options, treatment alternatives, road design standards, and project scope. Safety is viewed on a "macro" scale and the focus is on how the project will impact or affect the continuity of the existing network and movements to and from the adjacent communities and surrounding land use. During this stage, changes or improvements to enhance and promote safety are highly cost effective and relatively inexpensive.

2.8.2. Draft (Preliminary/Layout) Design Stage

At this stage of the project, the specific design standards applied to the elements like, horizontal and vertical alignment, cross section, sight distances, intersection and interchange layouts and traffic control, integration of pedestrian and cyclists, and parking movements should be addressed by the audit.

Major changes to the project after this stage are limited since right-of-way requirements may already be determined. It may be useful to review the concept of pavement markings and signing at this stage in relation to alignments and passing strategy.

2.8.3. Detailed Design Stage

At the detailed design stage, before the preparation of contract documents, the detailed geometric design elements like road, intersection, and interchange design details, signing plan and pavement markings, channelization, lighting, road side features, clear zones, guard rails and barriers, median barriers, and landscaping and street furniture should be addressed.

2.8.4. Pre-Opening Stage

Before opening, a site inspection should be conducted by the safety team, preferably under a variety of conditions (night and day, wet and dry), to evaluate the safety performance of the facility. The inspection should be carried out from the perspective of all road users, including pedestrians and cyclists.

This stage is essential to ensure that the safety implications of changes to the final design, which were implemented during construction, are addressed. While physical changes to the facility may be difficult at this stage, mitigation measures such as the addition of roadside barriers and warning signs, and the relocation of hazards (trees, utility poles) can still be implemented in response to the inspection.

The cost effectiveness of the audit decreases for the latter stages of audits and reviews as changes become more difficult to implement. The resources and details required also increase for each audit or review stage. However, the early audit stages typically are more conceptual in nature, and are more difficult to conduct, requiring higher skill levels. The relationships are illustrated in Figure 2.1.

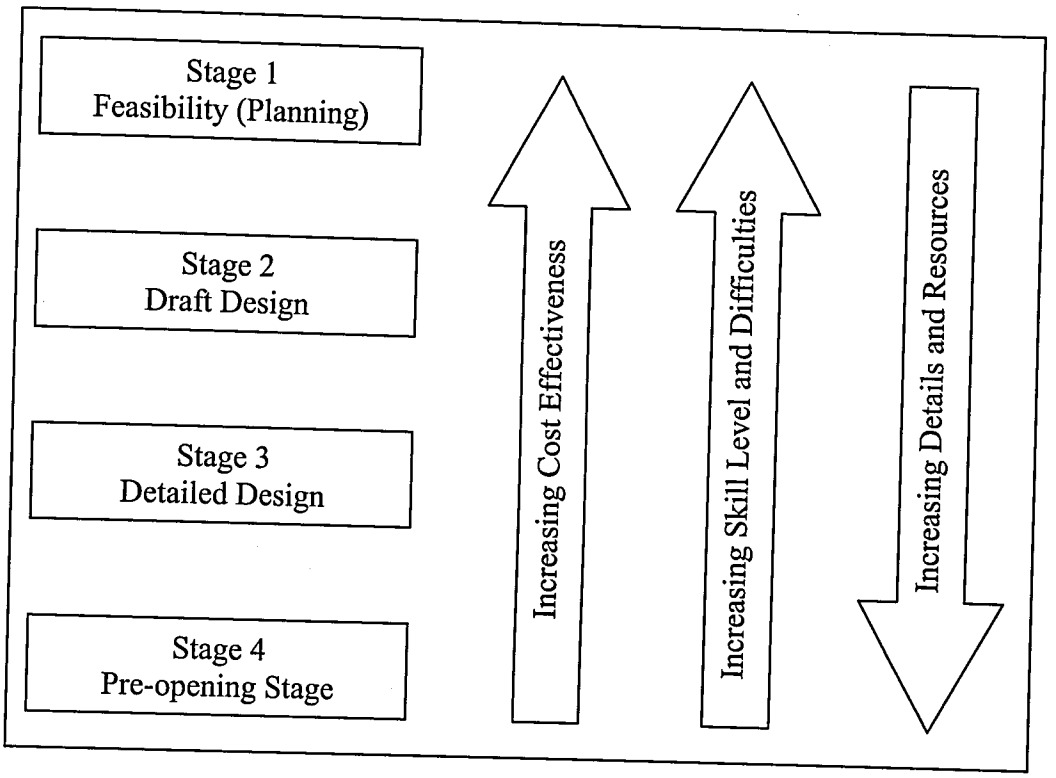


Figure 2.1. Audit and review stages [12]

2.8.5. Post-Opening (and Existing) Stage

Road safety audits can be undertaken soon after opening a new facility to the public. Insight into operational behaviour and subsequent problem areas can be gained through observation, which may not have been readily apparent before opening the facility. Corrective measures, although much more expensive to carry out at this stage, may still be cost effective.

Road Safety Audits can also be conducted on any section of an existing road network to identify safety-related deficiencies. The information collected from accident reports is an important component for these audits; however, as an extension of traditional blackspot

analyses they should be supplemented by informed judgements surrounding the potential for other accidents.

2.9. Applications of Road Safety Audits

Road Safety Audits can be applied to all types of projects. The types of projects can be categorized as follows [12];

- existing road improvement (rehabilitation and retrofit) projects,
- new road construction projects,
- development-driven projects; and
- traffic calming projects

A road agency needs to decide which projects to audit and at what stage. Some agencies require that all major road projects be audited, while others may require that only a certain percentage of projects be audited due to financial constraints. Conducting road safety audits on all projects would be ideal, however, resource allocation is a major factor in determining which projects to audit. It is often necessary for road authorities to develop methods for ranking projects, which should be audited, and at which stage. Hamilton Associates [19] have developed recommendations, as given in Table 2.1, which summarizes a range of project types, and the corresponding recommended stages for audits. Table 2.1 is intended to help road agencies decide which projects to audit and at what stage and should only be used as a guide. Each road agency may decide to devise its own system in road safety programming, which should be flexible and cost effective to respond to the needs of individual projects

Road authorities must be aware that audits of large projects do not always produce the greatest benefits. Often larger projects have sufficient expertise and labor to provide internal checks on design. Smaller projects may lack team members with the expertise to identify safety-related design flaws. Conducting an audit on such projects may make them a more effective use of the audit process as it encourages a more careful review of safety issues.

Table 2.1. Recommended stages for various projects [19]

PROJECT	AUDIT STAGE				
	Feasibility/ Planning	Preliminary Design	Detailed Design	Pre-Opening	Post-Opening
Major New Highway	✓	✓	✓	✓	✓
Minor New Highway		✓	✓	✓	✓
Major Rehabilitation/Retrofit		✓	✓	✓	
Minor Rehabilitation/Retrofit		✓	✓		
Major Development	✓	✓	✓	✓	✓
Minor Development		✓	✓		
Traffic Calming			✓	✓	✓

2.10. Road Safety Audit Team

Most practitioners agree that road safety auditors should be independent of the project design team to ensure that those who are unbiased and those who may have a different perspective are reviewing the project. Audit teams can be established within large organizations or by using consultant firms or consortia. It is essential that an environment exists which fosters good communication between the audit team and the client/design team to ensure the audit is effective [19].

Road safety audits should be conducted by an individual or a team with adequate experience in road safety engineering principles and practices, accident investigation and prevention, traffic engineering and road design. Additionally, members with experience in enforcement, maintenance, and human factors can be added to the team on a project by project basis and at different audit stages. Human factor expertise may, in selected areas,

contribute to a road safety audit by providing an understanding of the interactive nature of user behaviour with the road environment [22].

The associated benefits of conducting an audit with a multi-disciplinary team are the diverse knowledge and approaches of each individual, cross fertilization of ideas that can be the result of discussions, and more than one pair of eyes reviewing the project. Using a multi-disciplinary team also provides the opportunity to expand the number of persons in an organization that are experienced in the audit process. The size of the audit team will vary depending upon the size and type of project. It is recommended that the team consist of two to five multi-disciplinary individuals. The use of at least two individuals provides cross-fertilization. When the team becomes too large, it becomes difficult to reach a consensus and develop a focussed audit. Additional expertise may be added to the project team as required at different stages of the audit process (i.e., police officers, maintenance personnel, human factors, and others). There may be projects that –due to their size– only require the review of a single plan, a field visit, and a one-page report. In this situation, an audit by two or more individuals may not be justified. A carefully selected individual may be sufficient to conduct the audit and raise issues that could result in significant safety-related savings [19].

2.11. Roles and Responsibilities of Participants

From one agency to another, the roles and responsibilities of the parties involved in an audit will vary depending upon the resources available and the operating procedures for highway design and implementation. It is the responsibility of all parties to maintain good communication throughout the audit. This is to ensure the audit is conducted efficiently and to provide a means for resolving conflicts. The typical roles and responsibilities of all parties involved in the safety audit process are outlined in the following sections [16].

2.11.1. Client (Highway Authority)

Road safety audits should be considered an integral component of highway conception, feasibility and design processes. It is therefore essential that highway

authorities allocate sufficient funding and resources to support the road safety audit process.

Highway authorities should: (1) consent to road safety audits as a quality management requirement; (2) commission audits at the proper project stages; and (3) review the formal audit report and act upon recommendations whenever appropriate and feasible. Without the client's full commitment to the process, particularly by giving genuine consideration to recommendations, the audit process becomes ineffective.

The highway authority should provide training at all levels within the organization to ensure that safety is an integral component of all phases of a highway project (i.e., planning, design, construction, and maintenance). Correct training of personnel increases the potential of safety issues being identified by the audit team.

It is the responsibility of the highway authority to: (1) select an audit team with the appropriate training and experience; (2) provide project documentation; (3) ensure the auditors have satisfied the requirements described in the terms of reference; (4) attend the initial and completion meetings; and (5) refer all design changes to the audit team.

2.11.2. Design Team/Project Manager

It is the responsibility of the design team/project manager to provide the audit group with project background information, design drawings, traffic composition and characteristics, accident reports where available, and any other documentation affecting the design. The design team/project manager initiates audits when required; attends the initial and completion meetings; and reviews the issues raised by the audit report.

The audit report, in turn, provides the design team/project manager with a list of safety-related deficiencies; however, it should not provide specific design solutions or recommendations, that means the audit may list "possible" mitigative measures, but specific recommendations are not given. The responsibility of developing and adopting corrective solutions lies with the design team/project manager.

The design team/project manager in turn provides the audit team with a written response addressing all safety issues. This includes either: (1) accepting the possible mitigative measures and providing a design solution for the hazard; or (2) rejecting the measures and stating the reasons for this action.

It is the responsibility of the design team/project manager to assess financial and budget constraints to determine whether, how, or when to adopt an audit's suggested solutions. The design team/project manager is responsible for all design decisions; however, decisions may sometimes require the involvement of the highway authority if design is being undertaken externally. Any design changes must be submitted to the audit team who decides whether to audit the revised design further or to incorporate it into the next audit stage.

2.11.3. Audit Team

The primary role of the audit team is to identify potential safety problems of a highway project by reviewing project documentation and drawings, and conducting site inspections. They typically do not redesign the project or implement changes. The audit team use a developed set of checklists to assist them while conducting the audit. Checklists identify issues and problems that can arise at the relevant stages of an audit. They also provide a measure of continuity from audit to audit.

The audit team is required to submit a report to the design team/project manager, identifying critical issues based on safety engineering experience. A completion meeting is held between the audit team, the design team/project manager, and the client to discuss the audit findings.

2.12. Organization of Road Safety Audit

There are several methods of organizing a road safety audit while ensuring the audit team has the appropriate training, expertise and independence of the design team. AUSTROADS has developed a list of recommendations outlining how a road safety audit should be organized [23]. As indicated by AUSTROADS, there are three preferred ways

of organizing a road safety audit: (1) audit by a specialist auditor or team; (2) audit by other road designers; and (3) audit within the original design team.

2.12.1. Audits Conducted by a Specialist Auditor or Team

Specialist audit teams can be established within a highway organization or by consulting firms or consortia. Road safety audits should be conducted by an individual or team with adequate experience and training, and independent of the design team.

In cases where an audit is conducted by a specialist team, the audit findings can be reported in one of the following ways: (1) the specialist can report the findings to the client or an independent third party on behalf of the client; or (2) the specialist can report the findings directly to the original designer.

The road safety audit team may submit a formal report to a third party who is responsible for deciding what actions are to be taken regarding the safety issues raised by the audit team. The independent third party provides the audit team and the Highway Authority with a documented response addressing all safety issues.

Similar to the first method, the audit team report can be submitted to the original designer or design team who provides the audit team and client with a documented response.

2.12.2. Audits Conducted by Other Road Designers

Audits conducted by another design team are an alternative means of conducting a road safety audit. A weakness of this approach is the lack of multi-disciplinary knowledge that designers bring to the process. In cases where a safety audit is conducted by other road designers, the findings from the audit can be either submitted to the client, or an independent third party on behalf of the client; or to the designer/project manager for their comments.

In the first type, the project is audited by another design team and a written report is submitted to an independent third party on behalf of the client for review. The individual who provides the response to the audit report should have no direct line of management to the original or auditing designers. This is to make certain that independent appraisals can be made where disagreements arise.

Second type is similar to the previous one; however, the audit report is submitted to the original design team or project manager. The disadvantages of this method are that the original designer may reject criticism of the design either for genuine reasons or time constraints. The original design team provides the auditing designers with a documented response addressing all safety issues raised.

2.12.3. Design Team Self Audit

This type of road safety audit, which is the least desirable due to the lack of independence, is conducted by a member of the original design team. While all designers and design teams are typically concerned with safety, they are too familiar with the design process; therefore, they are prone to offer biased opinions about the design.

2.13. Training and Accreditation of Auditors

A prime factor identified by AUSROADS and mentioned in discussion with all agencies was the use of experienced and skilled auditors. This raises the issue of training and possible accreditation. Currently, formal training experiences are varied. VICROADS has conducted an in-house workshop for its staff. Federal Office of Road Safety has sponsored the development of a road safety audit training course by a University in South Australia and is considering the issue of accreditation. One opinion was that AUSTROADS should manage accreditation issues. RTA has conducted some 2-day workshops in cooperation with the Institute of Municipal Engineers. The program consists of presentations by RTA staff and private consultants, including slide shows and group exercises in the training process [22].

TNZ use a pool of local experts to train auditors on the job. It has a 5-day safety course, one day of which is devoted specifically to road safety audits. TNZ also 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 [19].

2.14. Monitoring and Evaluation

All highway organizations involved with safety audits should monitor and evaluate their road safety audit procedures. This may be accomplished by maintaining a complete record of the safety audit projects conducted by the organization. The record would contain a list of common deficiencies identified during all stages of road safety audits. This, in turn, provides feedback for designers and auditors performing future projects. The intent is to prevent recurring deficiencies from being designed into road projects. Otherwise, designers will continue to "build blackspots" into the road system.

2.15. Legal Liability Issues

Another concern at present, based on discussions locally, interstate and international is the question of legal liability. There has been a view held by some engineers that by commissioning an audit report and then not acting on the report's recommendations, a highway authority will be opening the door to legal difficulties. The AUSTROADS project recognized the shortage of useful information available to engineers on this sensitive topic. It has been emphasized that safety audit is not likely to increase an authority exposure to litigation but rather will demonstrate to a court that the authority was concerned for public safety and was prepared to apply resources. "Safety audit will create a safer road environment. A major aim of litigation is to encourage safety, therefore the use of road safety audits will be encouraged by the legal system" [24].

2.16. Road Safety Audit Process

There are eight main steps in conducting a road safety audit. National or provincial policies, or the client's requirements, will direct project managers in the use of road safety

audits. Once it is established that a project is to be road safety audited, the following steps need to be undertaken [25]:

2.16.1. Appointment of the Road Safety Audit Team

The project manager, unless otherwise directed by the client, is responsible for the appointment of an audit team. The team is to be fully independent of the design and the project.

2.16.2. Providing the Necessary Background Information

The project manager is required to provide the audit team with a comprehensive set of drawings, reports and associated background information so that a full understanding of the project, its key objectives and any associated issues can be gained. Information must include (1) project intent including the purpose of the project, how it will be achieved, any design compromises and community inputs, (2) site data including traffic data, known safety issues which remain unresolved from earlier audits, the design standards used, and site constraints such as historic buildings, underground services, weather, trees etc., (3) plans and drawings including a full set of the plans and drawings relevant to the stage of audit, together with any plans, which may affect adjacent roads.

2.16.3. The Commencement Meeting

The background information is handed over to the road safety audit team during a commencement meeting. This meeting is arranged by the project manager, and is usually held in the project offices. The objective of the meeting is to acquaint the road safety audit team with the background to the project as well as to familiarize the project team with the audit process.

During the meeting, the audit team is briefed on the scope of the project, the timetable for the completion of their report and any other relevant matters. The meeting provides the opportunity for the audit team to ask questions about the project and to establish the relevant contact in the project office for further queries. It is important that

the project team and the audit team both understand that communication during the audit is necessary and is generally positive. The audit team must be aware however that it should not leave a safety concern unreported simply on the verbal advice of a project officer.

2.16.4. Carrying Out the Audit

The road safety audit team then carries out the audit generally starting with a desktop evaluation of all of the material provided by the project manager. The desktop audit and the site inspections usually take place in parallel. This step is important, and the technical skills and experiences of the audit team are put to use in auditing the potential safety problems in the proposal.

The audit team must remain focussed on safety issues only, and not digress into other matters such as costs, alternative treatments, possible design options or other project related matters.

After the desktop audit, the audit team must inspect the site preferably during both daytime and nighttime. The site inspection is essential in order that the team can gain a complete idea of the environment in which the project is located. It allows the road safety audit team to see how the proposal interacts with its surroundings and the nearby roads, including the sections of existing road immediately either side of the site. The team gains the opportunity to visualize potential conflicts for road users and to anticipate any potentially misleading features at this time.

The audit team is expected to put itself into the shoes of the road user and to drive, walk and even bicycle the area in order that potential safety concerns can be identified. A checklist is a valuable tool for the audit team to use during the desktop audit as well as the site inspections. If necessary, and especially for larger projects, the audit team may need to return to the site a number of times and to repeat the desktop audit several times until all safety issues have been addressed. Appendix B contains a typical checklist for new projects including all stages, which was provided by e-mail by Mr. Pieples, the district traffic engineer in PennDOT. The same checklist was sent to the author by fax by Mr.

Appleton, the safety audit manager in Transfund New Zealand and by Mr. Jordan, the project manager in AUSTROADS.

2.16.5. Writing the Audit Report

After conducting the audit, the audit team is responsible for the preparation of a formal report, which includes the following information:

- A brief description of the project and its background.
- A list of the background information provided to the audit team during the commencement meeting.
- A list of the members of the audit team.
- A record of when the audit was carried out, detailing times and dates of site visits.
- A logically arranged list of potential safety problems identified by the audit team, including a brief explanation of each safety concern.
- Photographs of relevant safety concerns should be included in the report if possible.
- A signed and dated statement by the audit team that they have completed the audit.

2.16.6. The Completion Meeting

The completion meeting is held at a mutually convenient time and should involve the full audit team, the client, the project manager and those in the project office required to respond to the audit report. It provides an opportunity to discuss the report findings, especially the recommendations for corrective action. During this meeting, the Project Manager receives the audit report, asks questions of clarification of the audit team's findings and agrees on a timetable for the completion of a response report.

The meeting should be run so that the independence of the audit team is not affected. The meeting is not an opportunity to disagree with the audit report findings and recommendations, but is an opportunity for mutual constructive discussion.

2.16.7. Writing a Project Manager's Response Report

This step is to judge whether the findings and recommendations of the road safety audit report should be implemented and, where it is decided otherwise, to give written reasons for the decision. If necessary, the project manager (or the client if applicable) may wish to call on the expert technical assistance of an independent road safety engineer who can provide details on how to respond to each audit finding.

This step is the most overlooked step in the process. It is also one of the most important because completion of this step affords the best documented defense against any possible future legal liability cases involving accidents on the new project.

The project manager is required to respond to each individual safety concern with a statement on whether the safety concern is acknowledged or not and what action if any is to take place.

This response report is a public document. As such it could be used in a court of law at a future date. The project manager needs to be aware of this and to give the appropriate consideration not only to the technical matters of the countermeasures to be undertaken, but also the sensitivity involved in explaining why some actions may not take place.

2.16.8. Ensuring the Safety Concerns Are Followed

The project manager and the project team are responsible for the delivery of the finished project to the client. The road safety audit team is one specialist group, which can assist the project team in delivering a safe project. The project manager must follow through from the response report and ensure that the necessary changes are made to the project to accurately reflect the agreed improvements detailed in the audit report. Independent technical experts may be called in to assist with this step as well. It is important to remember that a road safety audit achieves little unless the recommendations and safety concerns are followed through to create a safer road system.

3. DEVELOPMENT OF A HIGHWAY SAFETY AUDITING PROGRAM FOR TURKEY

The literature reviewed up to here has focused primarily on safety concerns associated with freeways and rural highways. Although identifying the safety issues associated with municipal roads is a relatively new concept in the field of safety audits, a safety audit can also be conducted on a section of an existing road or a network of streets within an urban or municipal setting.

3.1. Methodology

This model road safety audit for municipalities is aimed to provide a viable starting point for Turkey to begin a systematic process for road safety auditing and examining safety needs. For implementing a safety auditing program in Turkey, it is important to have some organizations dealing with highway safety issues like National Road Safety Council (NRSC) as suggested for Turkey by Ergün [2]. This council should promote a national policy on the use of road safety audit and allocate some resources for a series of pilot audits. After some pilot audits have been conducted at roads with different characteristics by professionals in traffic engineering, the suggested model have been reviewed, guidelines and procedures should be adopted for Turkey and training courses should be developed nationwide. The key steps in this model process are:

- Selection of road or street network to audit,
- Appointment of the audit team,
- Conducting the safety audit,
- Reporting,
- Follow-up evaluation.

3.1.1. Selection of Road or Street Network to Audit

A five-year plan and an annual safety audit programs should be prepared and reported to NRSC. It is recommended to start safety auditing with high accident locations

and their networks. Second priority should be given to urban arterial and principal roads which have greater traffic densities.

Prior to the audit, the municipality authorities should provide the audit team the project intent, site data including traffic data and site constraints such as historic buildings, underground services, weather, trees etc., and plans and drawings including a full set of the plans and drawings relevant to the audit together with any plans, which may affect adjacent roads.

3.1.2. Appointment of the Audit Team

Municipal audits can be conducted by a single person or a team of experts. The selection of an auditor or audit team depends on the nature of the project and the city in which the audit is to be performed. Ideally, a municipal audit should be conducted by two or three auditors knowledgeable in traffic management and safety, road design, driver behaviour, and crash investigation and prevention and preferably trained in NRSC courses. Members of a municipal audit team should also have experience at street safety audits and must be able to assess and identify safety concerns of urban streets in an independent and objective manner.

The transport and safety arrangements for the Audit Team are important to ensure that the audit can be undertaken safely. It is important that the vehicle allows all team members a sufficient view of the road and a portable rotating light should be used when travelling slowly or stopped. If possible this light should be mounted with a "road survey" sign. The team should have a video camera, a camera, a tape measure and if possible a dictaphone. Team members should wear high visibility safety cloths when outside of the vehicle.

3.1.3. Conducting the Safety Audit

Audit inspections should be limited to a maximum of 3 days to ensure a good level of concentration is maintained. The first day of the audit should begin with opening meeting covering health and safety, background information, the audit and reporting

program and selecting the first day's detailed audit inspection program as pre-inspection. Site inspections should be undertaken both night and day. At second day of auditing notes should be prepared for the first draft of first day's audit report and second day's audit inspection program should be refined. Again day and night inspections should be undertaken. At the last of auditing notes should be prepared for the first draft of second day's audit report. The third day's audit inspection could be made about the points that were missed in previous inspections or require re-inspection.

For the sections of arterial and principal roads to be inspected it is recommended that these routes first be driven at normal speed in each direction. Following this inspection the detailed inspection is then undertaken by checking for any items requiring detailed checking from the checklist. The recording of these items will be made on a route progressive basis for summarization by the team at the post inspection meeting. Nighttime inspections of some routes should be undertaken on the same day, only noting items not recorded during the daytime inspections. If possible these items should be recorded on a dictaphone and preferably transcribed before the team post-inspection meeting.

3.1.4. Reporting

After completion of each street safety audit, a final report is produced providing a description of the identified safety needs. Auditor(s) may include general recommendations of possible corrective actions. It is desirable the report be kept as concise as possible. Report format and information included in the report should be the same as stated in the previous chapter.

3.1.5. Follow-Up Evaluation

A follow-up meeting provides an opportunity to discuss the findings of municipal audit between the auditor(s), a representative from municipality in which the audit process implemented and a representative from NRSC. Documenting the safety actions and project scope including programming and scheduling recommended. If there is uncertainty whether a safety problem exists or what the most appropriate corrective action to an identified safety need maybe, it is desirable to consult with qualified individuals.

Considering the economic condition of Turkey, priorities among improvements are necessary to set, documented and discussed at a follow-up meeting. The independence and objectivity associated with the safety audit program is an important point when requesting resources to conduct safety.

3.2. Checklists

As stated in conducting the safety audit section, audit team use checklist to assist them while conducting the audit as an aid to ensure that no potentially unsafe design elements or practices exist. A checklist was prepared for municipalities of Turkey by using the checklists used by transportation agencies or authorities in the world, especially in New Zealand [26] and in Canada [19]. In selecting the items to be included in this checklist the following things were taken into consideration:

- Checklists vary slightly from country to country, manuals often reflect local road systems, characteristics, climatic conditions of the country in which the audit process is implemented. While preparing the checklist for Turkey, items that are suitable for Turkey were selected.
- Checklist was prepared for both existing roads and newly designed roads.
- Checklist for municipalities differ from checklist that are prepared for freeways and major highways. For example, items for parking facilities, non-motorized traffic, etc. are much more detailed in municipal checklist than in major highway and freeway checklist.
- There are mainly nine sections in the checklist, namely; general topics, alignment and cross sections, intersections, interchanges, skid resistance, visual aids, physical objects, road users and parking.

4. A CASE STUDY: AUDITING OF DOLMABAHÇE STREET

The highway safety auditing program developed in previous chapter was used in a pilot road in İstanbul. The purpose of this audit was first, to field test a newly developing approach to safety and second, to provide an example road safety audit for municipalities of Turkey. In doing this, the steps suggested in Chapter 3 were followed.

4.1. Selection of the Road to be Audited

For fulfilling the above purposes, Dolmabahçe Street was selected as the study road. The reason of choosing Dolmabahçe Street was that, it was selected as blackspot in 6-month report of İstanbul Emniyet Müdürlüğü (Directorate of Police Department of İstanbul) Statistics Department [7]. As stated in the report, traffic accidents occurred in the street are generally caused by sharp curves along the route. In the first six months of the year 2000, 517 traffic accidents occurred in Dolmabahçe Street, 496 accidents have property damage only (PDO) and 21 accidents have disabling injuries. The number of injured people was 31, which is very high value for such a relatively short distance (approximately 1 km-long), in 6-month period.

Dolmabahçe Street begins at the intersection of Bostan Gazhanesi Street, Meclisi Mebusan Street and Dolmabahçe Street, and ends at the intersection of Cezayir Street, Beşiktaş Street and Dolmabahçe Street as shown in Figure 4.1. The study area covers all Dolmabahçe Street. Dolmabahçe Street is surrounded by Dolmabahçe Palace at sea side (west) and small sized forest which is used to serve as hunting area for Ottoman Emperors and a military zone at the other side which corresponds to the east. At sea side, there is a small campus of Mimar Sinan University after Dolmabahçe Palace, near Beşiktaş Intersection.

Initial information such as, maps, accident statistics and traffic data were obtained by visits to İstanbul Emniyet Müdürlüğü and APK (Research, Planning and Coordination Department of İstanbul Metropolitan Municipality).

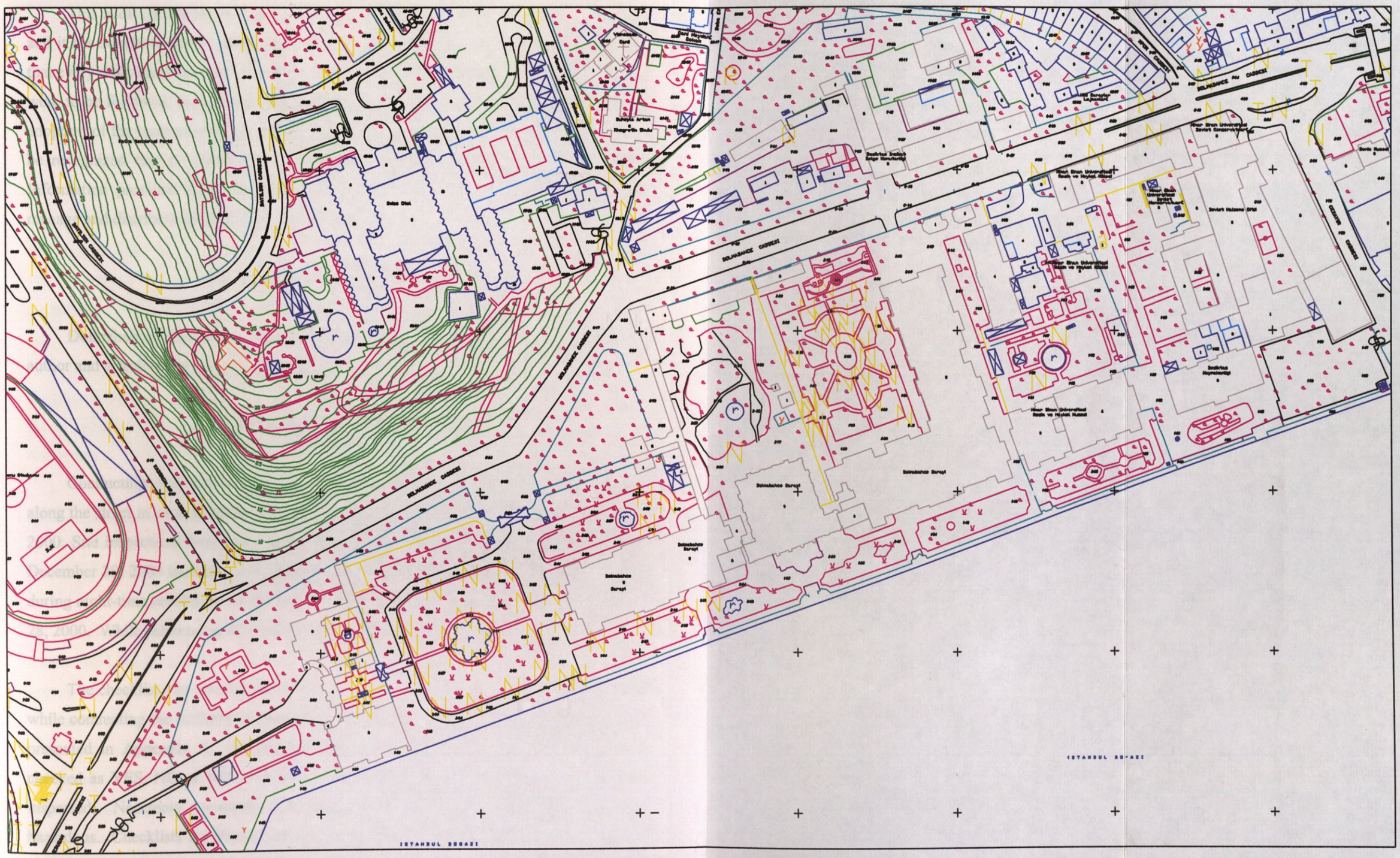


Figure 4.1. Layout of Dolmabahçe Street. Scale: 1/2500

This audit covers physical features of the study area that may affect road user safety and it has sought to identify the major safety hazards. However, it can not be guaranteed that every deficiency has been identified. Further, if all the recommendations in this report were to be followed, this would not guarantee that the street will be totally 'safe'; rather, adoption of the recommendations should improve the level of safety of the street. It must be recognized that no jurisdiction can afford to correct all infrastructure deficiencies. Information provided here, therefore, can be used to prioritize work programs and to manage and distribute limited resources more effectively.

4.2. Appointment of the Audit Team

Dolmabahçe Street was audited with an audit team consisting of Professor Ergün, the author and a civil engineering graduate student.

4.3. Conducting the Safety Audit

Conducting road safety audit of Dolmabahçe Street began with driving two times along the street in each direction with the supervision of Professor Ergün on December 26, 2000. Site inspections have been performed over a three-day period on December 27 to December 29, 2000 including investigation of safety issues associated with the study area during night-time conditions on the first two days of auditing, December 27 and December 28, 2000. While performing site inspections, photographs and video films were taken

The checklist that was developed in this study as stated in previous chapter was used while conducting the auditing of Dolmabahçe Street as a case study. The filled checklist is presented in Appendix A. During the inspections at both day and night, items were checked as YES, NO or NOT APPLICABLE depending on the conditions of the items inspected. Necessary comments were taken where the locations are presumed to be hazardous. Checklists are studied not only during the site inspections but also during the desktop study. Reading and studying the checklist at the office before and after the site inspection on every day of auditing was very helpful. Before the inspections it helped as a memory aid and after the day of inspection it was helpful in checking on which locations and/or items to be paid more attention, at the next day's inspection.

4.4. Audit Findings and Recommendations for Solutions

The audit findings and recommendations for corrections are listed for each checklist heading separately as given below.

4.4.1. General Topics

4.4.1.1. Scope. According to the traffic count data obtained from APK, peak hour volume and average daily traffic at both directions of Dolmabahçe Street are approximately 4,000 vehicle per hour and 35,000 vehicle per day respectively in both directions. The composition of traffic consists of automobiles 65 per cent, taxis 18 per cent, pick-ups 10 per cent, public transportation vehicles 6per cent and heavy vehicles 1per cent. Dolmabahçe Street is oversaturated at peak hours and it mostly carries traffic to and from Bosphorus Bridge from and to Taksim and Karaköy. The right-of-way of Dolmabahçe Street is limited by sycamore trees that are very close to the edge of the street in both directions.

4.4.1.2. Traffic Barrier Warrants. There are old sycamore trees with very large trunks and street poles very close to the edge of the roadway. Hitting these sycamore trees and street poles may cause severe injuries or even fatalities.

Because the sycamore trees and poles are very close to the edge of the traveled way, a semi-rigid barrier system should be used to reduce the severity of the accidents. Most appropriate system is a "Blocked-Out Thrie-Beam System (Strong Post)" selected from various barrier systems in AASHTO's Roadside Design Guide as shown in Figure 4.2 [27]. It has convenient dynamic deflection for Dolmabahçe Street. This system has successfully redirected vehicles ranging from an 820-kg subcompact car to a 1990- kg van (97 km/h, 25°) at crash tests. The dynamic lateral deflection observed during strength testing with a 1800-kg car and with the van was 0.5 m. and 1.0 m. respectively. Considering vehicle characteristics of Dolmabahçe Street Blocked-Out Thrie-Beam Barrier System seems to be the most convenient type. Top railing height of this barrier should be 900 mm., as recent researches have suggested as optimum. The design details of a "Blocked-Out Thrie-Beam System" are shown in Figure 4.3.

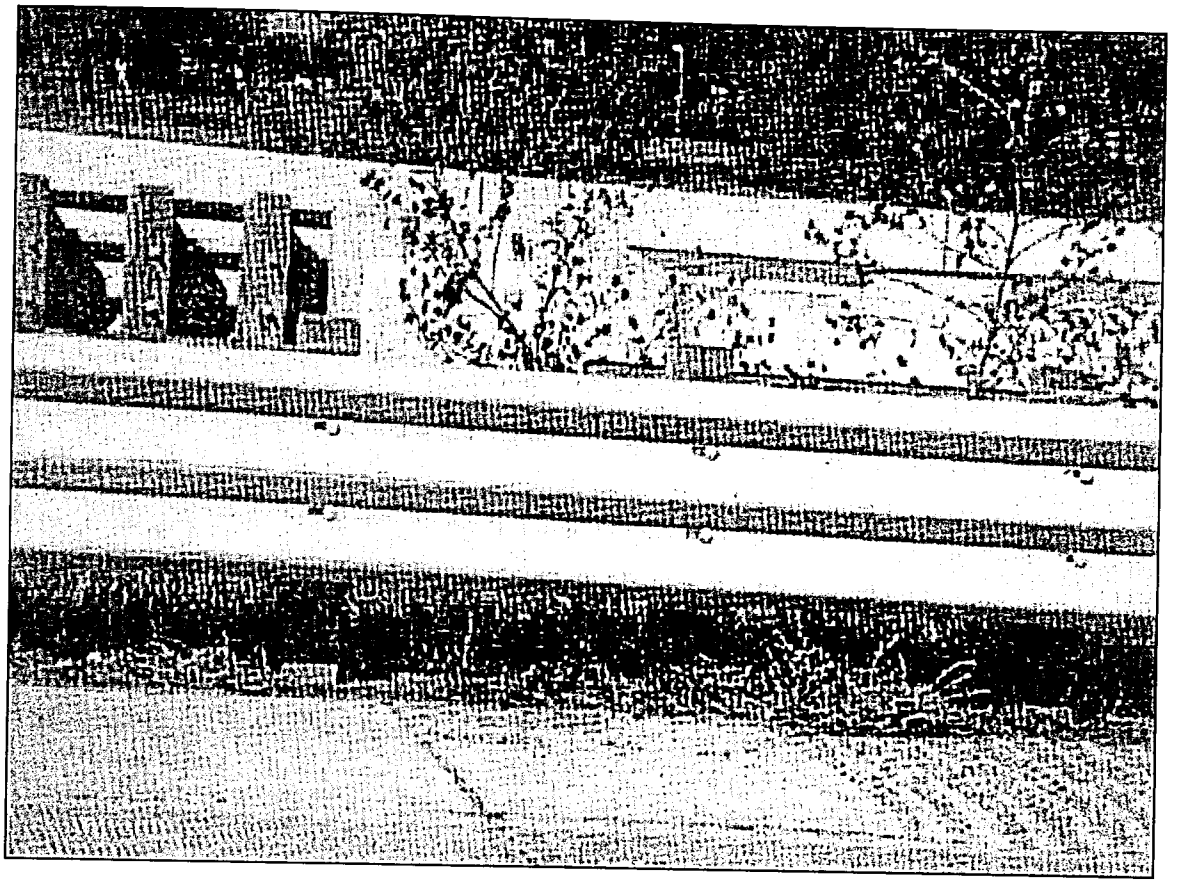
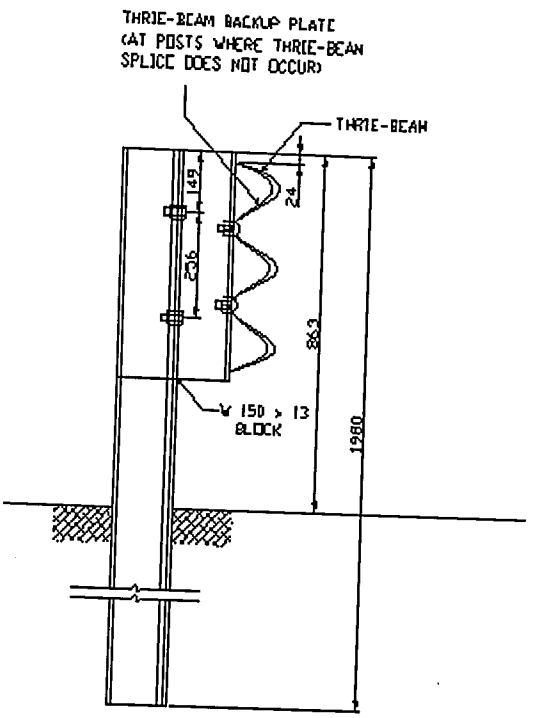


Figure 4.2. Blocked-out thrie-beam barrier [27]

There is a high-potential risk for vehicles crossing over the median into the path of an opposing vehicle, because of the high traffic, non-existing median and adverse horizontal alignment. This will cause head-on accidents which are usually very serious and can cause injuries and fatalities.

In order to prevent head-on collisions, median barrier system should be used. Considering the right-of-way of the street is very limited because of the trees, "Strong-Post Thrie-Beam Type" median barrier system [27] or rigid concrete "New Jersey" median barriers, because it has zero dynamic deflection [27] should be used. Figure 4.4 and Figure 4.5 show the design details of these median barriers.

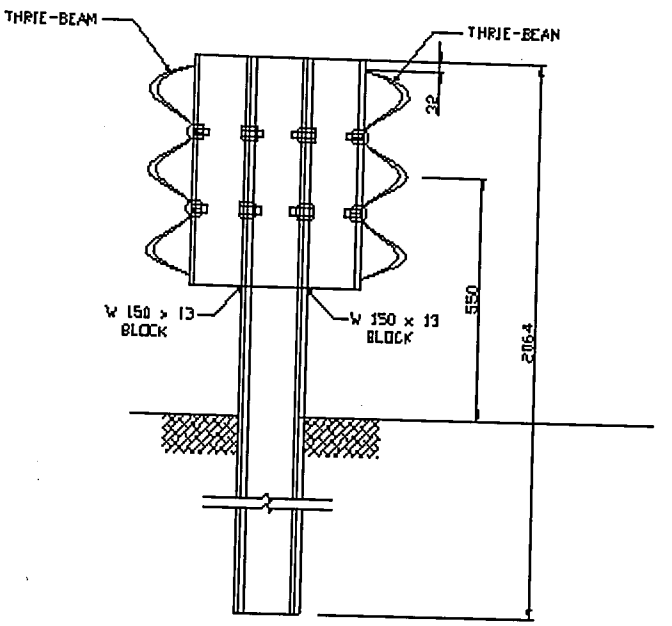
4.4.1.3. Landscaping. There are old, huge sycamore trees and street poles very close to the edge of the traveled way blocking sight distances and clearances. Some of the trees inclined along the route and some foliage has been found on the road that may interfere with delineation or traffic control devices on the road.



AASHTO Designation:	**SGR09a**
Post Type	W 150 x 13 steel or 150 x 200 wood
Post Spacing	1905 mm
Beam Type	2.67 Thrie-Beam
Maximum Dynamic Deflection	Approximately 0.6 m.

Figure 4.3. Blocked-out thrie-beam barrier design details (SGR09a) [27]

Although they are blocking sight distances, clearances and the right-of-way of the street, the hundreds of years old sycamore trees are invaluable and indispensable, considering the historical, natural and sightseeing characteristics of the street. Roadside barrier system that suggested before protects trees also. Annual maintenance program should be implemented by giving ID numbers and open a file for each tree, controlling health, physical condition, size, etc., in order to prevent any accident that caused by



AASHTO Designation:	**SGM09a**
Post Type	W 150 x 13 steel or 150 x 200 wood
Post Spacing	1905 mm
Beam Type	Two Thrie-Beams
Offset Brackets	W 150 x 13 steel or 150 x 200 wood
Maximum Dynamic Deflection	Approximately 0.5 m.

Figure 4.4. Blocked-out thrie-beam median barrier design details (SGM09a) [27]

dropping of a dead tree to the roadway or inclination of a tree by time as shown in Figure 4.6. Also an annual foliage maintenance program for monitoring the foliage that interferes with the visibility of traffic control devices should be prepared.

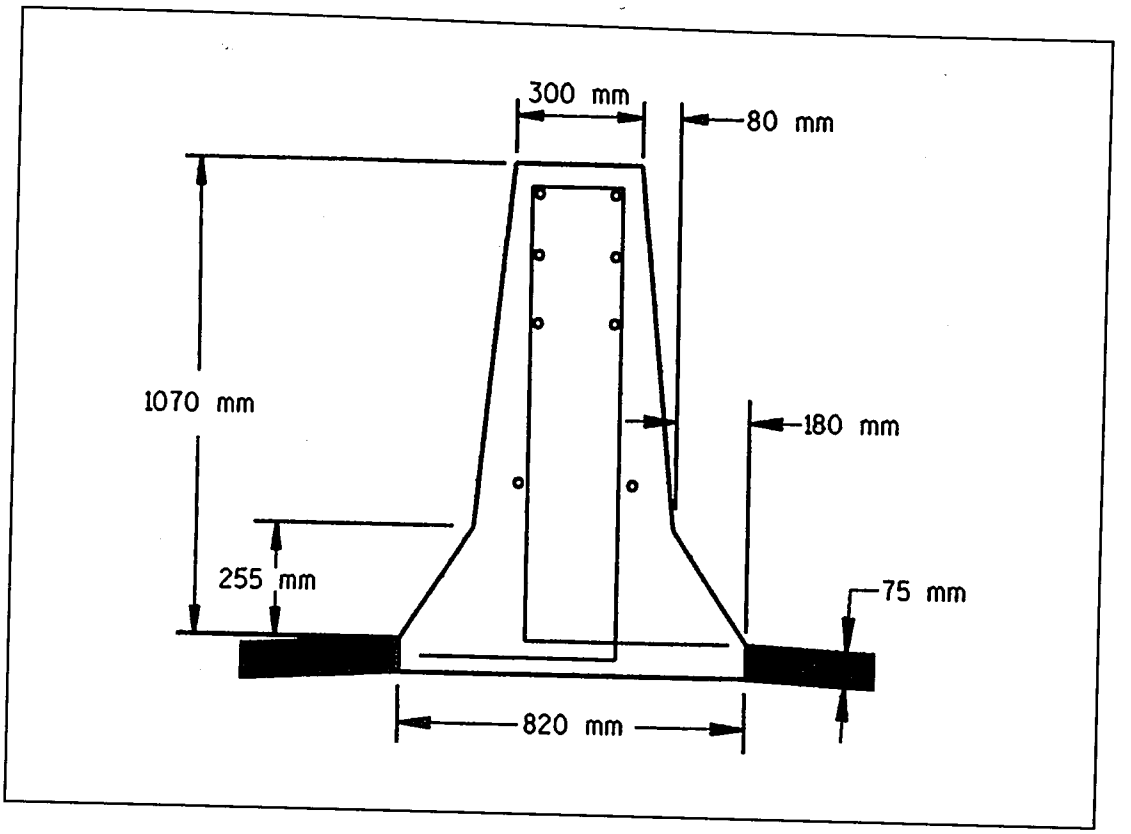


Figure 4.5. New Jersey median barrier design details [27]

Figure 4.6. Some old, inclined trees and sharp turns

4.4.1.4. Glare. Large portion of the street has severity of headlight glare in nighttime operations.

Median barrier systems that suggested at Section 4.4.1.2 could prevent the headlight glare.

4.4.2. Alignment and Cross Sections

4.4.2.1. Design Speed/Posted Speed. There is a design inconsistency at both curves. At these curves traffic speed changes more than 15 km/h and this situation can increase the accident possibility significantly (From Beşiktaş to Dolmabahçe traffic speed reaches 70 km/h just before the first curve, decreases to 45 km/h at curve, after this curve it reaches 60 km/h and at the second curve it decreases less than 40 km/h and than reaches 70 km/h again. From Dolmabahçe to Beşiktaş traffic speed reaches 60 km/h just before the first curve, decreases to 50 km/h at curve, after this curve it reaches 60 km/h again and at the second curve it decreases less than 45 km/h and than reaches 70 km/h.). There is no warning or advisory speed signage before curves exist on both directions.

Since the curves are too sharp, advisory speed signs and sharp curve warning signs must be put before curves as shown in Figure 4.7. They must be put together -one is at the top of the other- and yellow flashing light should be put at the top of them. Advisory speed sign for curves should be 30 km/h and for tangents 50 km/h as shown in Figure 4.8. In addition improve delineation by using advisory speed and/or speed control (hatching) pavement markings.

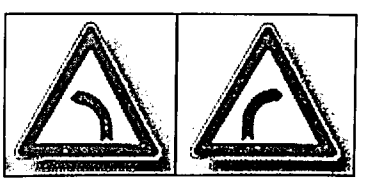


Figure 4.7. Warning signs - sharp curve to the left or right

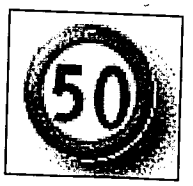


Figure 4.8. Regulatory maximum speed sign for 50 km/h

4.4.2.2. Drainage. There is a strong possibility of surface flooding from intersecting streets, which have high graded approaches towards Dolmabahçe Street hence carrying floodwater towards it and drainage at Dolmabahçe Street is not sufficient. In addition, most of the storm grates oriented parallel to traffic flow.

Drainage system should be applied to these downhill streets by using appropriate gutters between the curbs and pavement edge at both sides of the streets ending with a storm grate on the Dolmabahçe Street. Same drainage system with gutters along sidewalk curbs should be used at Dolmabahçe Street also. Horizontal and vertical grades must be corrected for drainage, since it has been observed that inundation occur even at the center of the roadway when it is rainy.

The storm grates which oriented parallel to traffic flow as shown in Figure 4.9 should be renewed by perpendicular ones for cyclists' safety, especially the storm grate which is in front of a wheelchair path of a sidewalk in Figure 4.10.

Figure 4.9. Storm grates oriented parallel to traffic flow

Figure 4.10. Storm grate oriented parallel to wheelchair path

4.4.2.3. Lane Widths. There are some changes in the lane width and in the number of the lanes without signage and the lane widths of some sections are inadequate.

In order to reduce conflicts, there should be signs for lane width changing as shown in Figure 4.11. There is a sudden drop in the lane number from 3 to 2 from Dolmabahçe to Beşiktaş without any warning sign. An appropriate information sign must be put to indicate the lane change.

Figure 4.11. Warning sign – narrow lanes at both ends

Some sections of the street, especially along the curves, have inadequate lane widths. After suggested treatments done, like the roadside and median barrier systems and gutters to be installed along the route, lane widths will decrease even more. The treatment that should be done is the realignment of sidewalk curbs by getting them as close as possible to the trees.

4.4.2.4. Cross Slopes / Superelevations. Cross slopes at the curves are the same as at the tangents so superelevation problems exists at curves and cross slopes vary along the route.

Although it is very difficult to change roadway layout at urban streets, superlevation at sharp horizontal curves must be corrected. Correction can be made during resurfacing the pavement. Since the sidewalk curbs are too high, increasing the pavement thickness would not have adverse effect on them.

4.4.2.5. Pavement Widening. There is insufficient pavement widening at the first curve from Dolmabahçe to Beşiktaş.

The pavement width can be increased more by changing the position of the curbs as shown by the dash-lines in Figure 4.14.

4.4.2.6. Curbs and Gutters. Gutters are not used along Dolmabahçe Street and curbs are too high.

Gutters should be used as suggested in Section 4.4.2.2. Resurfacing the pavement would reduce the curb height also.

4.4.2.7. Sidewalks. Although the physical condition of sidewalks is generally good, there are some places that need to be repaired. Some landscaping and drainage problems have also been noted.

Annual maintenance program for sidewalks should be implemented. At some portions of the sidewalk, walking area and the planted area are separated by borders to prevent earth-moving or water-moving from planted to walking area as shown in Figure 4.12. Drainage is attempted to be applied at some portions of sidewalks but they do not have outlet structures so they are meaningless. Therefore drainage of all sidewalk area of the street must be checked and corrected.

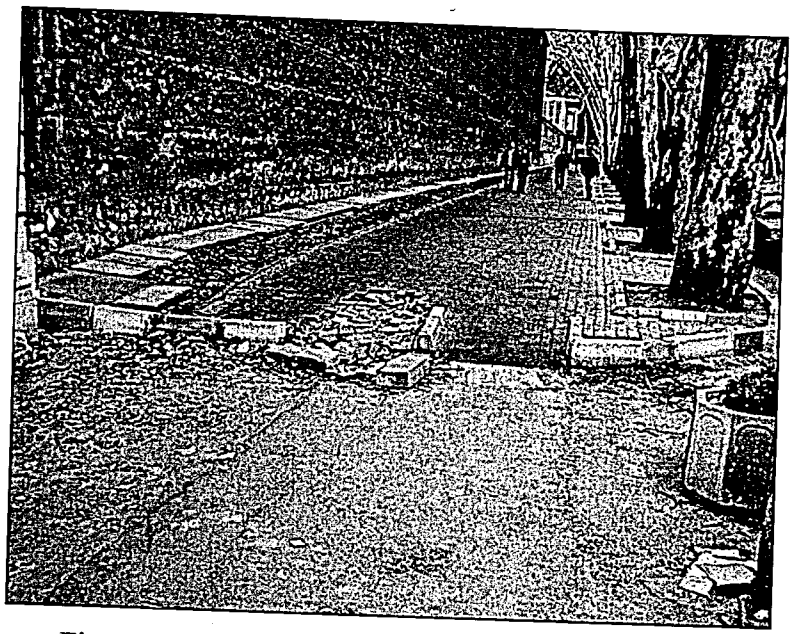


Figure 4.12. Sidewalks in physically poor condition

4.4.3. Intersections

4.4.3.1. Maneuvers. The channeled Maçka-Taksim turn in front of İnönü Stadium may create conflict for drivers coming from both Bostan Gazhanesi Street and Meclisi Mebusan Street. Because the channelization begins just after the intersection and it is very long. In addition the turning sign is located at the end of the channel where it is so late to put as shown in Figure 4.13. Due to lack of signage driver can miss the turn lane and there is no turning provided until Akaretler Intersection.

Shortening the channelization to allow drivers to catch the lane and/or allocate proper signage for turn before the traffic signals of both Bostan Gazhanesi Street and Meclisi Mebusan Street and just before the channelization begin.

4.4.3.2. Channelization. Prohibited right turn to and left turn from Vişneli Tekke Street is violated. Although it is prohibited to turn Vişneli Tekke Street to traffic flowing toward Beşiktaş to Dolmabahçe by -No Left Turn- sign, the layout and geometry of the intersection is very convenient to these vehicles to turn one-way Vişneli Tekke Street. Besides, the same condition is valid for traffic flowing from Vişneli Tekke Street to make prohibited left turn to Beşiktaş direction.

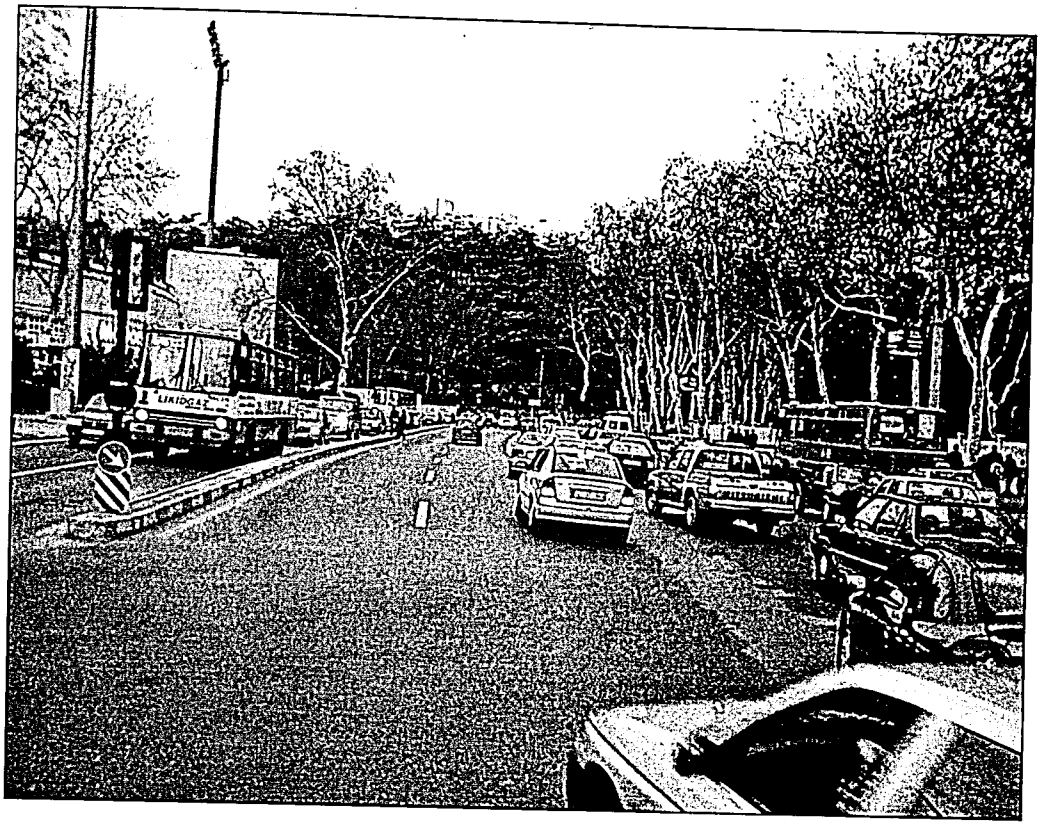


Figure 4.13. Channelization in front of İnönü Stadium

If median barrier suggested at Section 4.4.1.2 is installed then it becomes impossible to make illegal left turn towards Beşiktaş. Also changing the geometry of the intersection a little by channelization as indicated in Figure 4.14, prevents the illegal right turn to Vişneli Tekke Street from the street. At Figure 4.14 some treatments on widening the pavement for Problem 2.8 is implemented.

4.4.3.3. Controls-Markings. All pavement markings faded and lost their retro-reflectivity. Pavement repainting should be considered.

4.4.3.4. Controls-Signs. There is a need for warning sign for Vişneli Tekke Intersection for vehicles coming from Vişneli Tekke to stop before turning right with taking care of approaching traffic from Beşiktaş.

A stop sign must be put on Vişneli Tekke Street before the intersection for vehicles to give right of way to approaching traffic from Beşiktaş as in Figure 4.15.

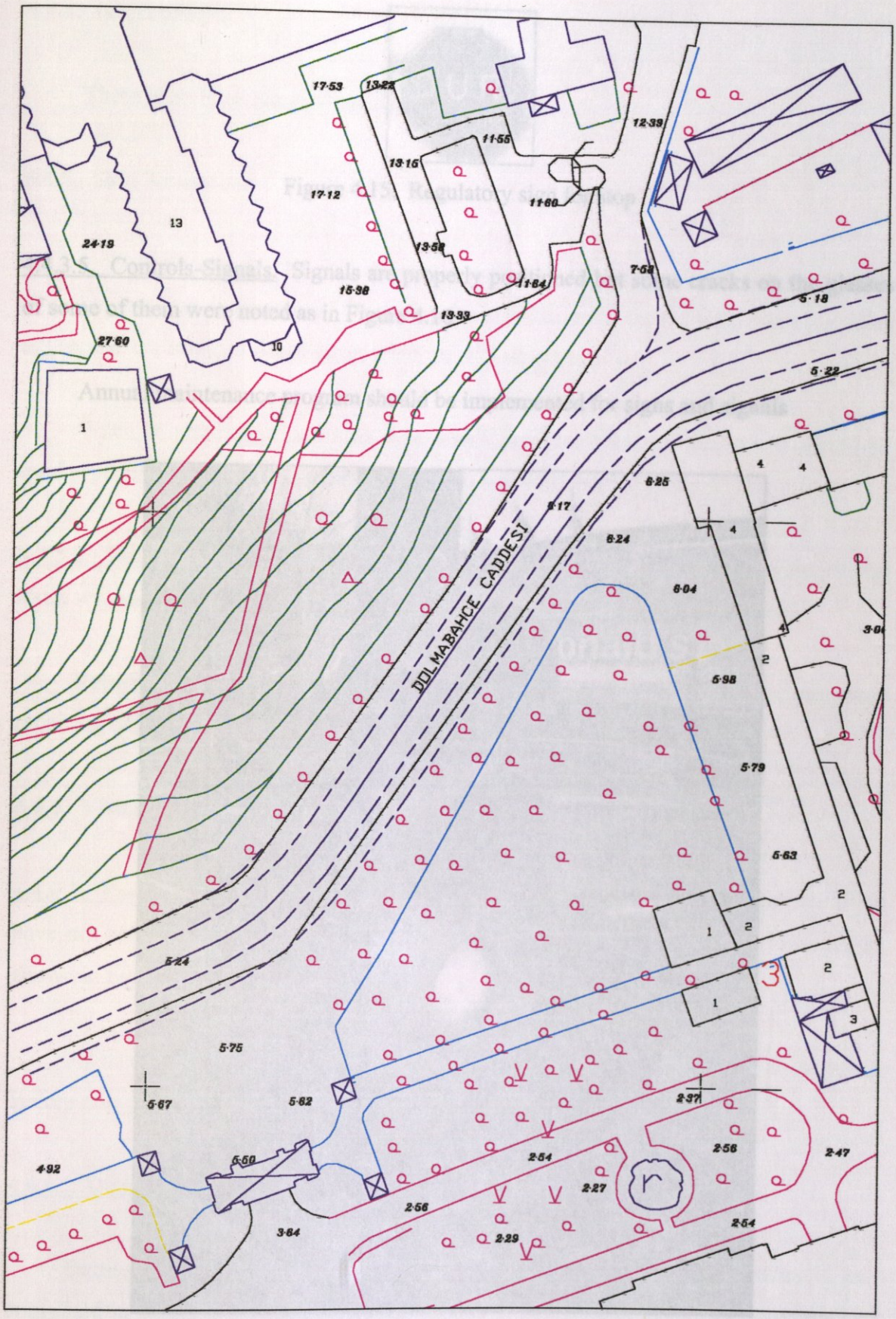


Figure 4.14. Some treatments on Dolmabahçe Street

Figure 4.15. Regulatory sign for stop

4.4.3.5. Controls-Signals. Signals are properly positioned but some cracks on the glasses of some of them were noted as in Figure 4.16.

Annual maintenance program should be implemented for signs and signals

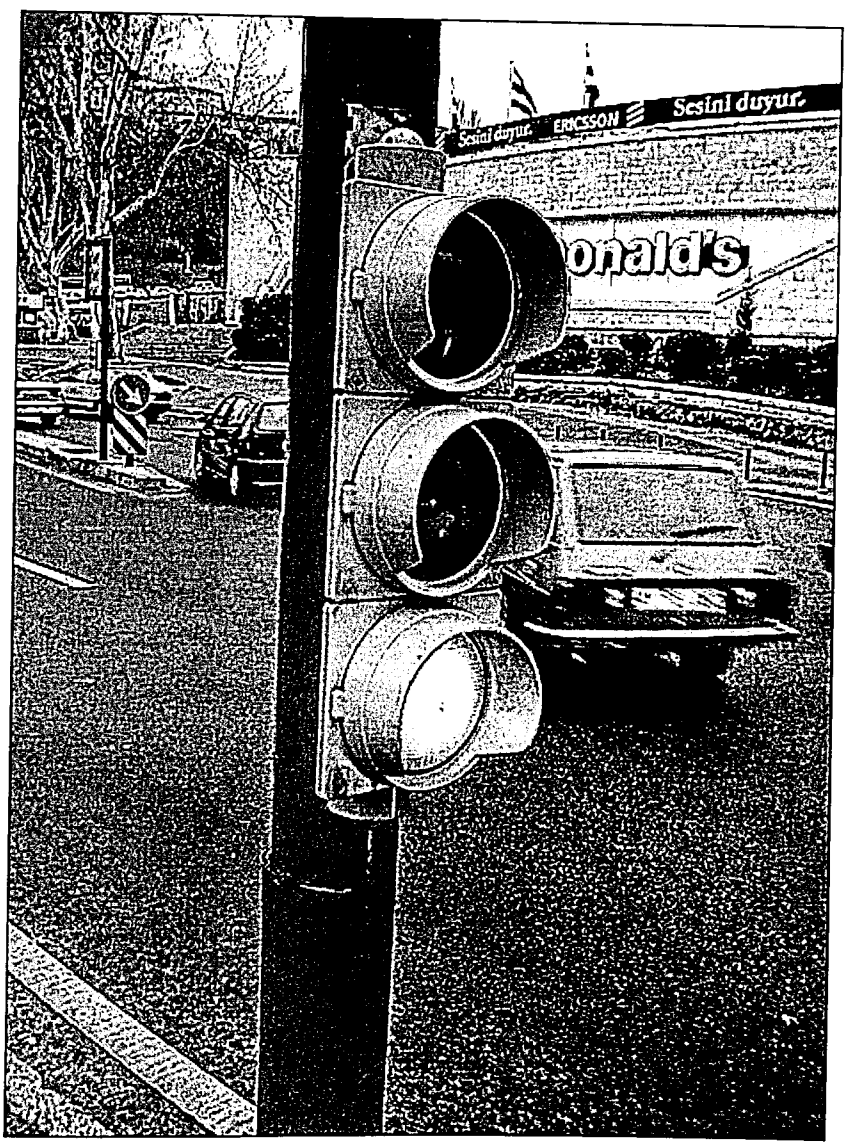


Figure 4.16. A crack on traffic signal

4.4.4. Interchanges

There is no interchange along the route.

4.4.5. Skid Resistance

4.4.5.1. Skid Resistance. No skid resistance measurement has been made along the route. However, on close inspection of the surface it seems that surfaces are very smooth and the aggregates are rounded which suggest loss of skid resistance.

When resurfacing, a pavement type which provides high skid resistance should be used especially on the curves considering hazardous horizontal alignment.

4.4.5.2. Pavement distress, Loose Screenings and Ponding. There are some potholes and loose screenings found on the pavement as shown in Figure 4.17 and Figure 4.18.

Resurfacing the pavement should be considered. If this is not possible, pavement repairing of some locations are needed.

4.4.6. Visual Aids

4.4.6.1. Pavement Markings. Most of the centerlines are faded, old pavement markings have not been removed and most pavement markings have lost their retro-reflectivity as shown in Figures 4.19 and 4.20.

As suggested in the intersections part repainting of markings should be considered. Before doing repainting old markings must be removed.

4.4.6.2. Delineation. Delineation is not adequate.

Delineation should be improved by putting all delineation signs required and suggested in previous sections, removing the old and repainting pavement markings and putting advisory speed and / or speed control (hatching), direction arrow markings on the

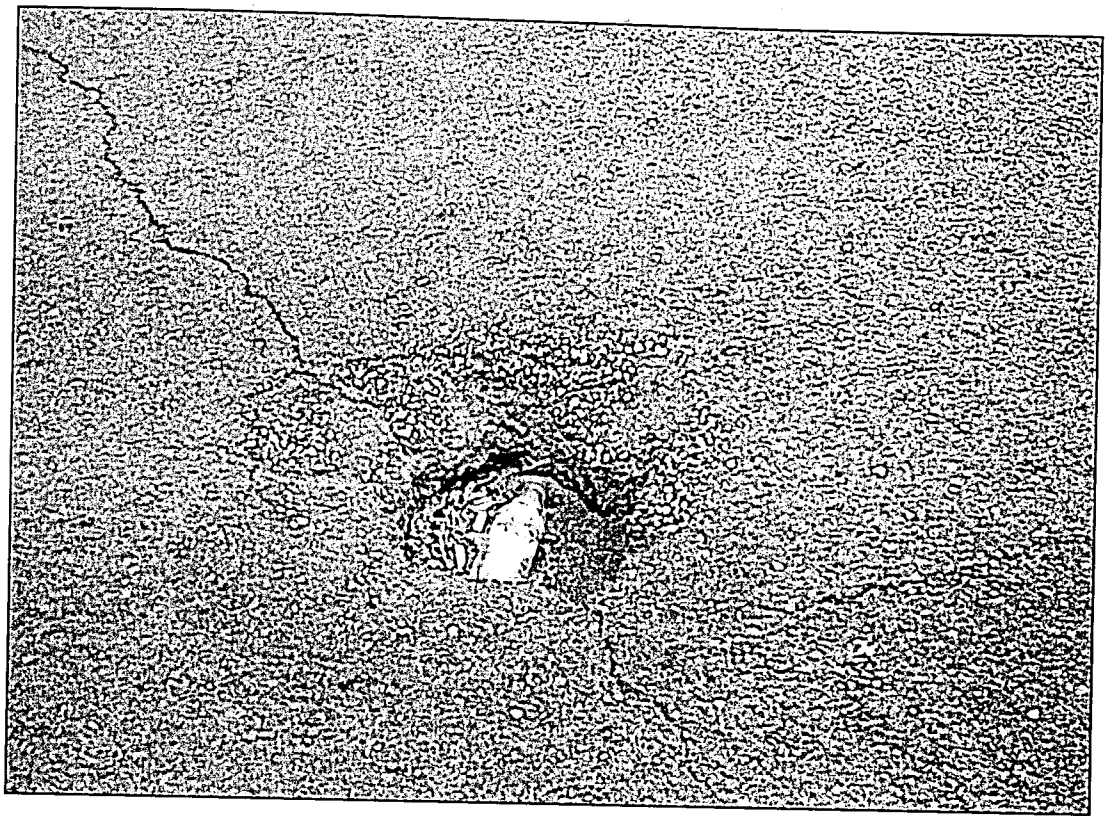


Figure 4.17. A pothole on the pavement

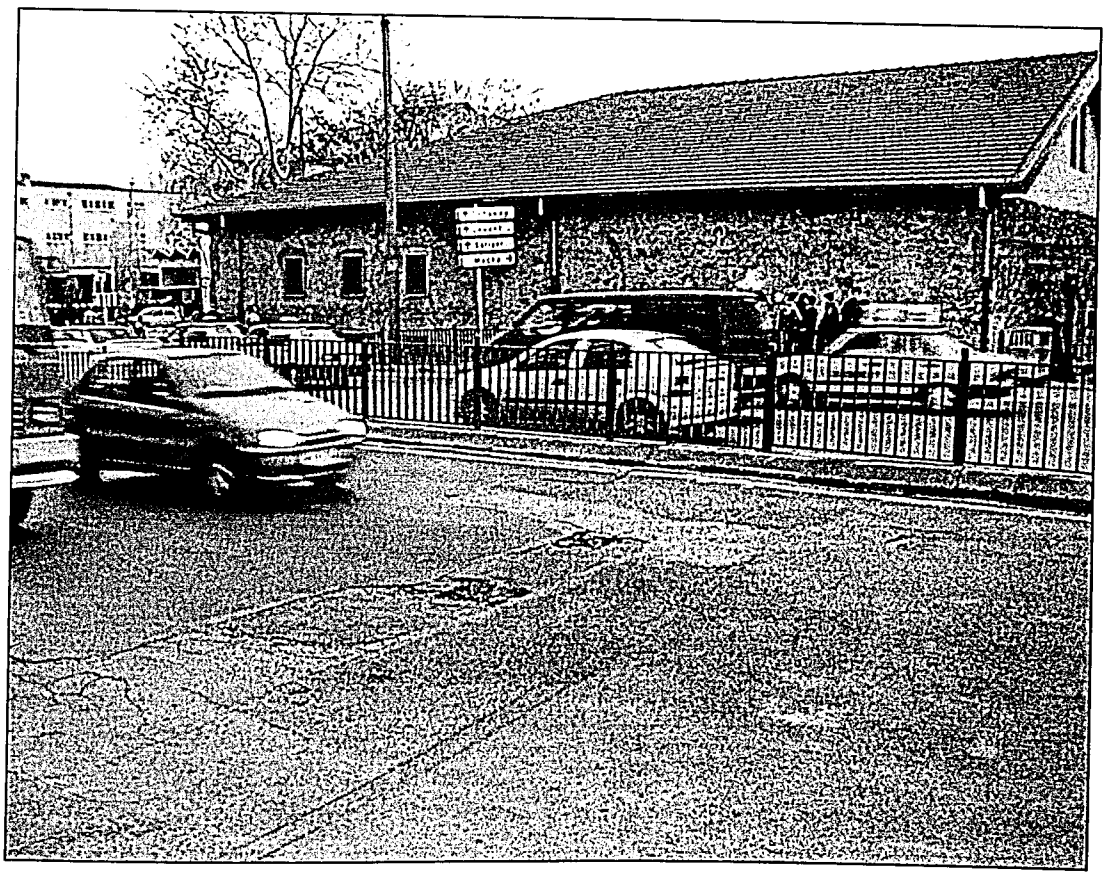


Figure 4.18. Poor condition of the pavement

Figure 4.19. Faded centerlines

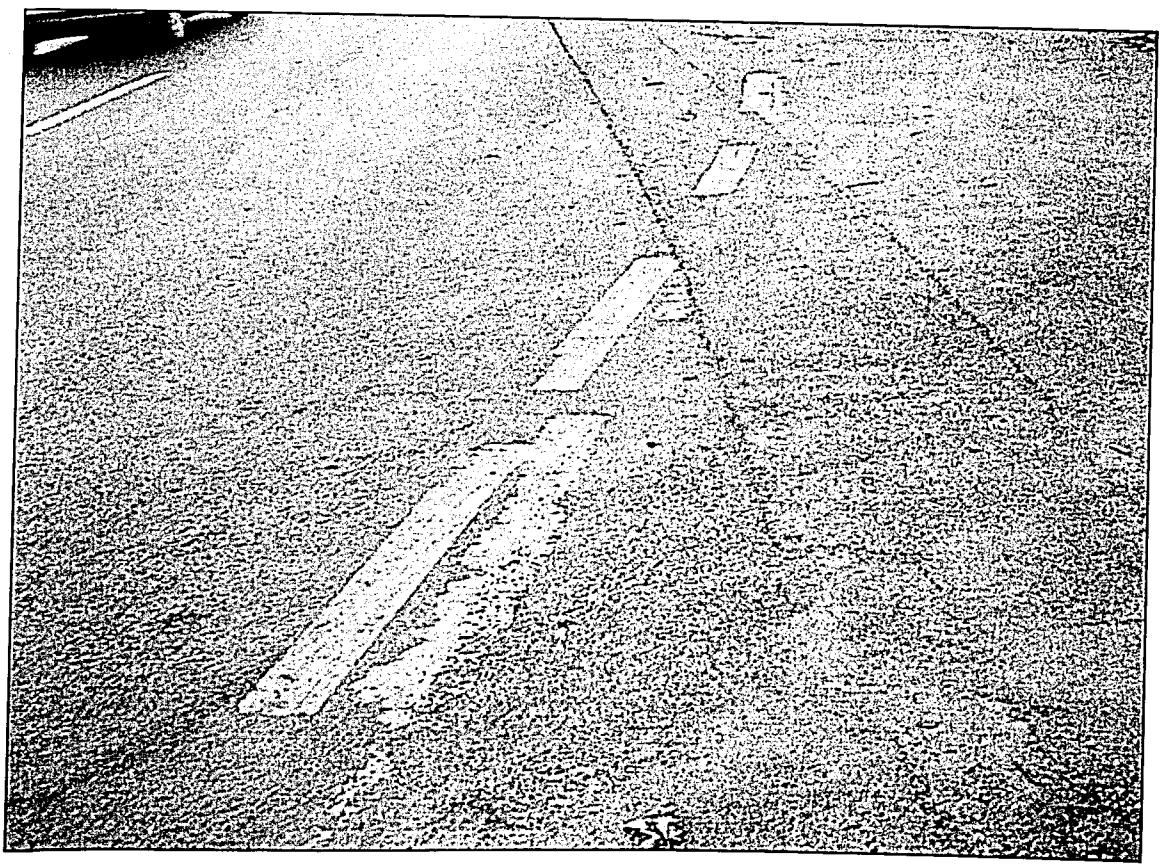


Figure 4.20. Old markings have not been removed

pavement. In addition, delineators should be used on the suggested barrier systems as shown in Figure 4.21.

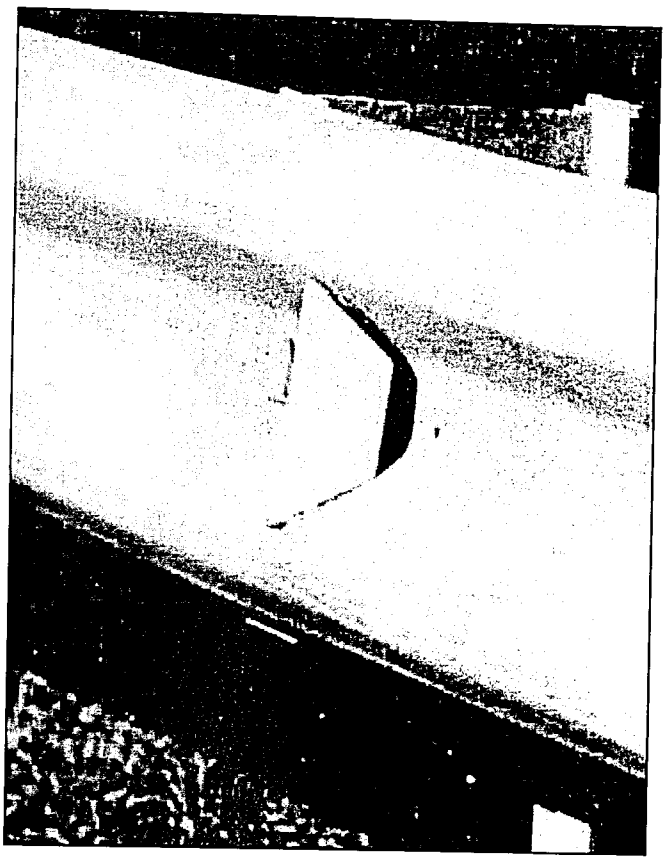


Figure 4.21. Delineators used with barriers [28]

4.4.6.3. Lighting. Luminares along route are dangerous and some of them are out of service.

Current lighting system of Dolmabahçe Street is very old and consists of concrete poles with huge supports at both side of the street as shown in Figure 4.22. These concrete poles connected with a cable carrying two old fashioned, heavy, dirty lamps as shown in Figure 4.23. The concrete poles are full of cracks, which cause reinforcing steel bars to corrode, and there are some lamps, which are loosely hanging from these poles and can drop to the roadway anytime. There is no need for an earthquake for these poles and lamps to collapse .The lighting system must be changed with a modern street lighting system, preferably with decorative ones in conformity with the beautiful sycamore trees lining along the street.

Figure 4.22. A poor concrete pole with high-raised base

Figure 4.23. Lamps hanging dangerously

4.4.6.4. Signs. Most of the signs have lost their retro-reflectivity and some of them are not legible as shown in Figure 4.24. In addition, at Vişneli Tekke Intersection signs contradict.

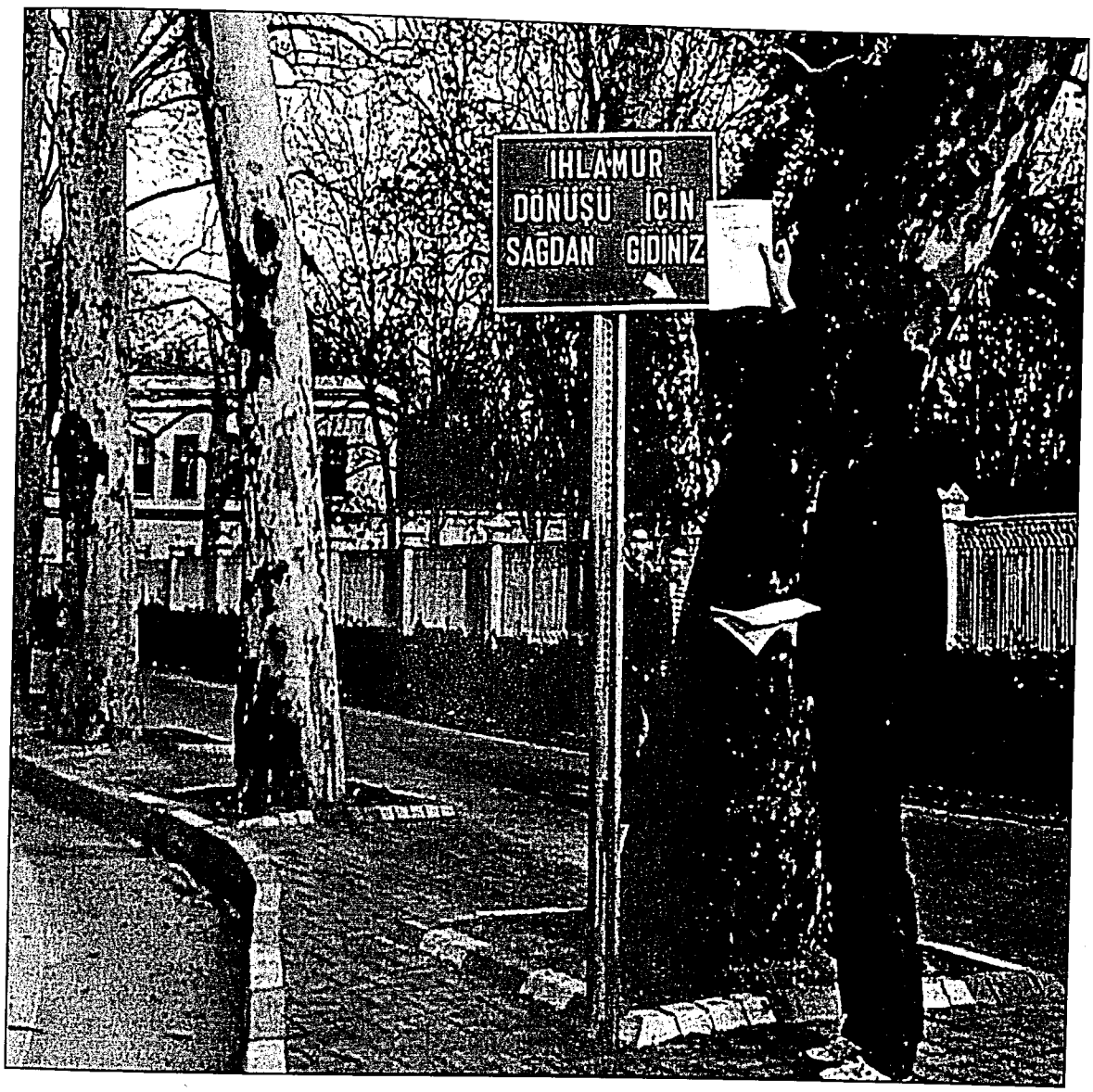


Figure 4.24. Sign not legible

The signs that are not legible and the signs that have lost their retro-reflectivity, must be upgraded.

As can easily be seen from the Figure 4.25, contradiction of these two signs can be solved by putting the second sign -Maçka-Taksim left turn at 150 m. - 50 meters away and changing the sign as -Maçka-Taksim left turn at 100 m.-

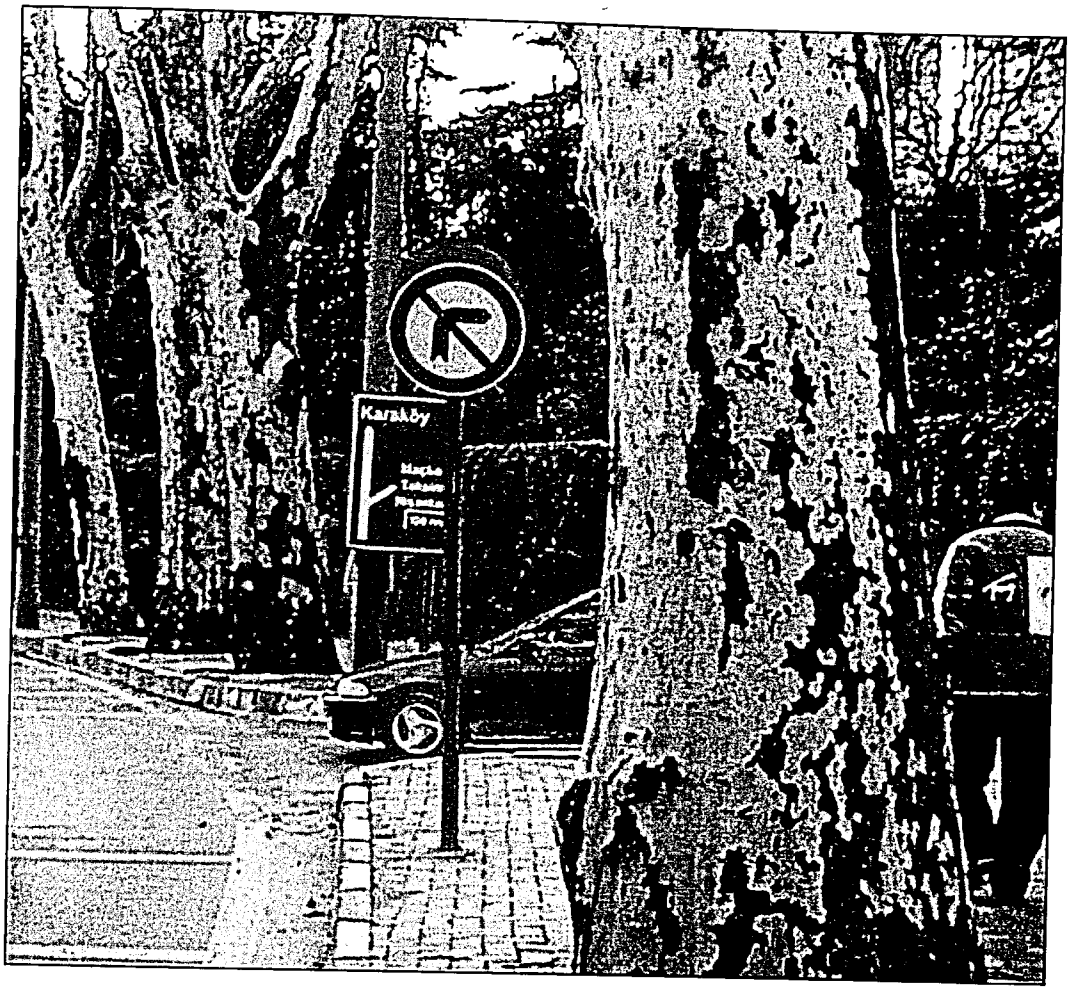


Figure 4.25. Contradicting signs.

4.4.7. Physical Objects

4.4.7.1. Crash Barriers. The use of Blocked-Out Thrie-Beam Median Barrier needs an end treatment to function as a crashworthy energy absorbing device when impacted head-on by errant vehicles. The use of Blocked-Out Thrie-Beam Roadside Barrier needs an end treatment also.

The most convenient barrier end treatment system for strong-post thrie-beam system, is Crash Cushion Attenuating Terminal (CAT) as shown in Figure 4.26 [27]. The CAT is a three-stage system utilizing energy absorbing beam elements, breakaway wood posts, and a cable anchorage system. It can also redirects side hits from either side. This terminal has succeeded in the tests with 820 kg and 2000 kg passenger cars for impacts on both sides.

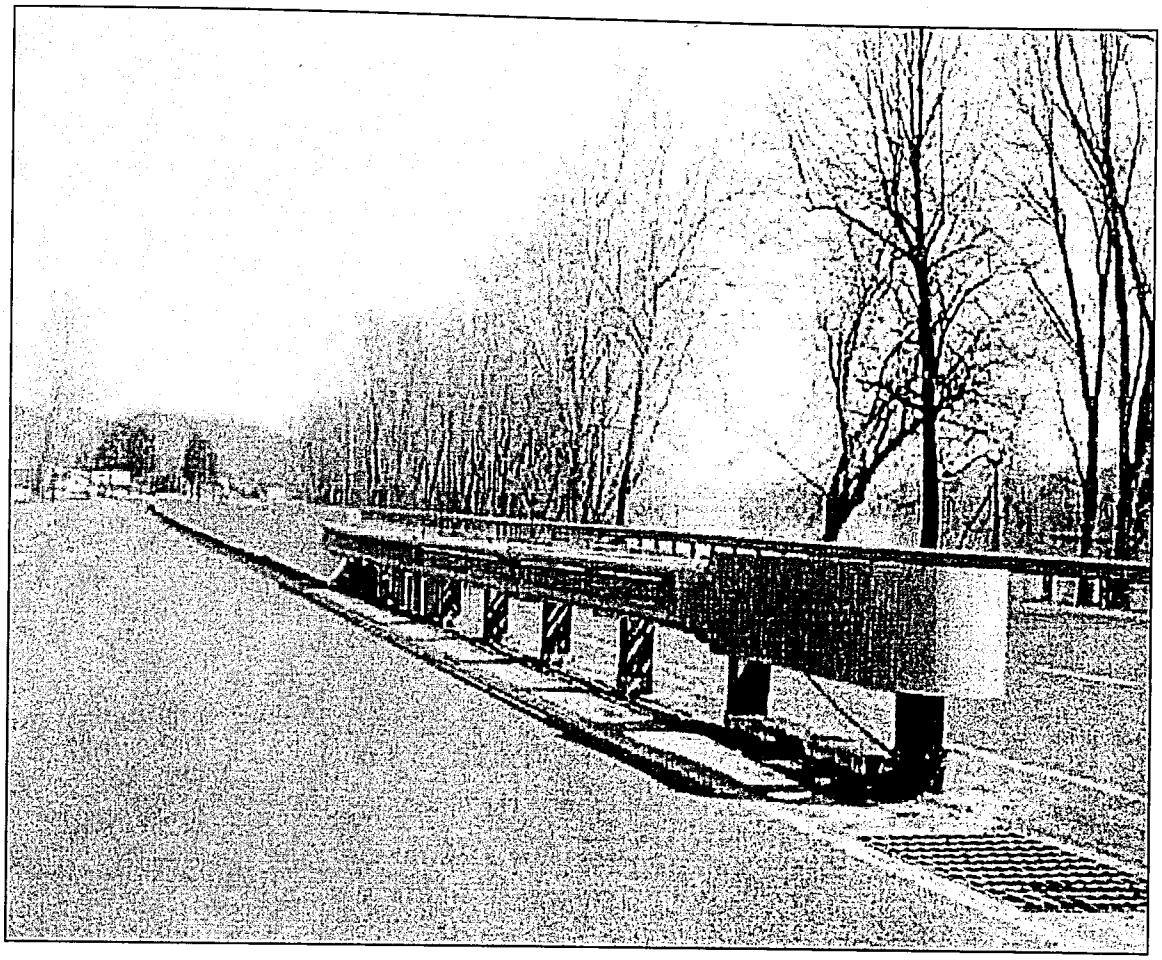


Figure 4.26. Crash-cushion attenuating terminal (CAT) [27]

The use of Blocked-Out Thrie-Beam Roadside Barrier needs an end treatment.

The most convenient barrier end treatment system for strong-post thrie-beam roadside barrier system, which suggested at Recommendation 1.1., is Safety End Treatment Terminal (SENTRE) as shown in Figure 4.27 by its design geometry [27]. The SENTRE unit consists of telescoping thrie-beam fender panels, slip base support posts, and sand-filled plastic containers which dissipate a portion of the collision energy. This terminal also has succeeded in the tests with 820 kg and 2000 kg passenger cars for two layouts: parallel to the line of rail, which is important for us and with a 1220 mm offset. The SENTRE end treatment is 7 m in length, including thrie-beam to w-beam transition panel. Top of rail height is set at 800 mm. The SENTRE can be attached directly to strong-post thrie-beam.

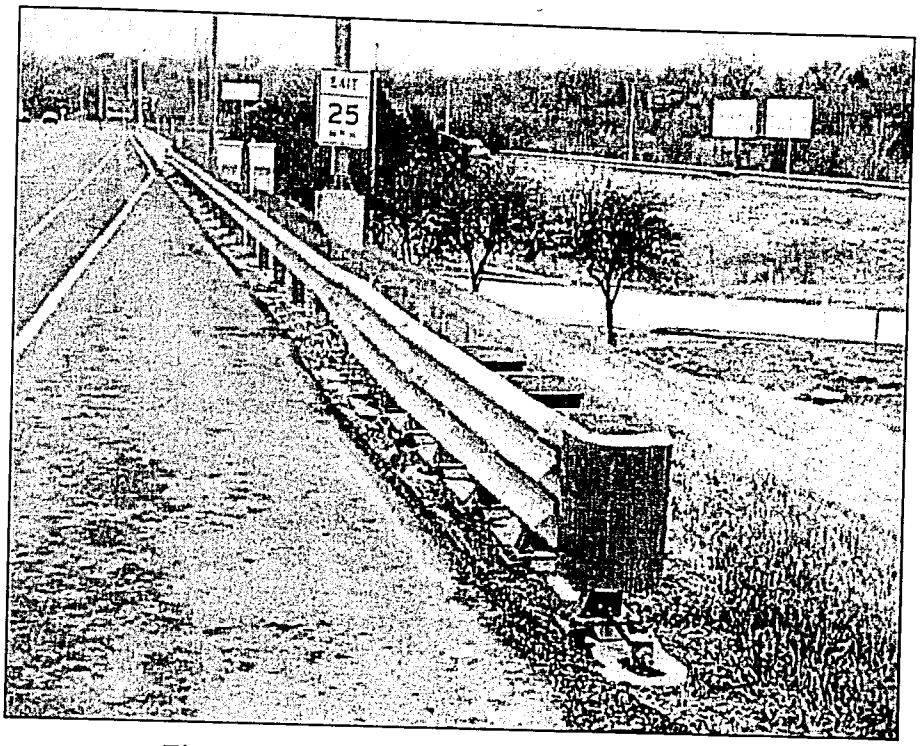


Figure 4.27. SENTRE guardrail terminal [27]

4.4.7.2. Manholes. Some manholes are too low as shown in Figure 4.28.

Figure 4.28. Manholes not raised

Raising up manholes that are too low should be considered.

4.4.8. Road Users

4.4.8.1. Motorized Traffic. There is no clean height sign for heavy vehicles passing under the pedestrian crossover.

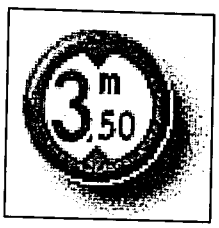


Figure 4.29. Regulatory sign - no pass for vehicles higher than 3.50 m

Pedestrian Crossover height must be signed as in Figure 4.29 on the bridge.

4.4.8.2. Non-Motorized Traffic. There no signage for cyclists and pedestrian crossings and the pedestrian crossing bridge need some renovations. In addition, crosswalk markings are inadequate and need repainting.

Signage for cyclists should be considered at appropriate locations as in Figure 4.30 and signage for pedestrian crossings should be considered at appropriate locations as in Figure 4.31.

Figure 4.30. Warning sign – beware of cyclists.

Figure 4.31. Warning sign – pedestrian crossing.

The physical condition of the pedestrian bridge is very bad. Annual maintenance for pedestrian bridges should be implemented. First of all it is not clean and attractive. Therefore people do not want to use it and cross the street at other points as shown in Figure 4.32. For making the bridge useful for all people, cleaning and painting must be done first. Lighting conditions should be considered for making people safe at nighttime. Also handrails, wheelchair and baby carriage paths should be provided.

Figure 4.32. Pedestrians not using the bridge

Crosswalks at intersections are not clearly defined. Crosswalk hatching should be provided and delineated clearly. Some of them need repainting as in Figure 4.33.

4.4.9. Parking

Parking is prohibited along the route.

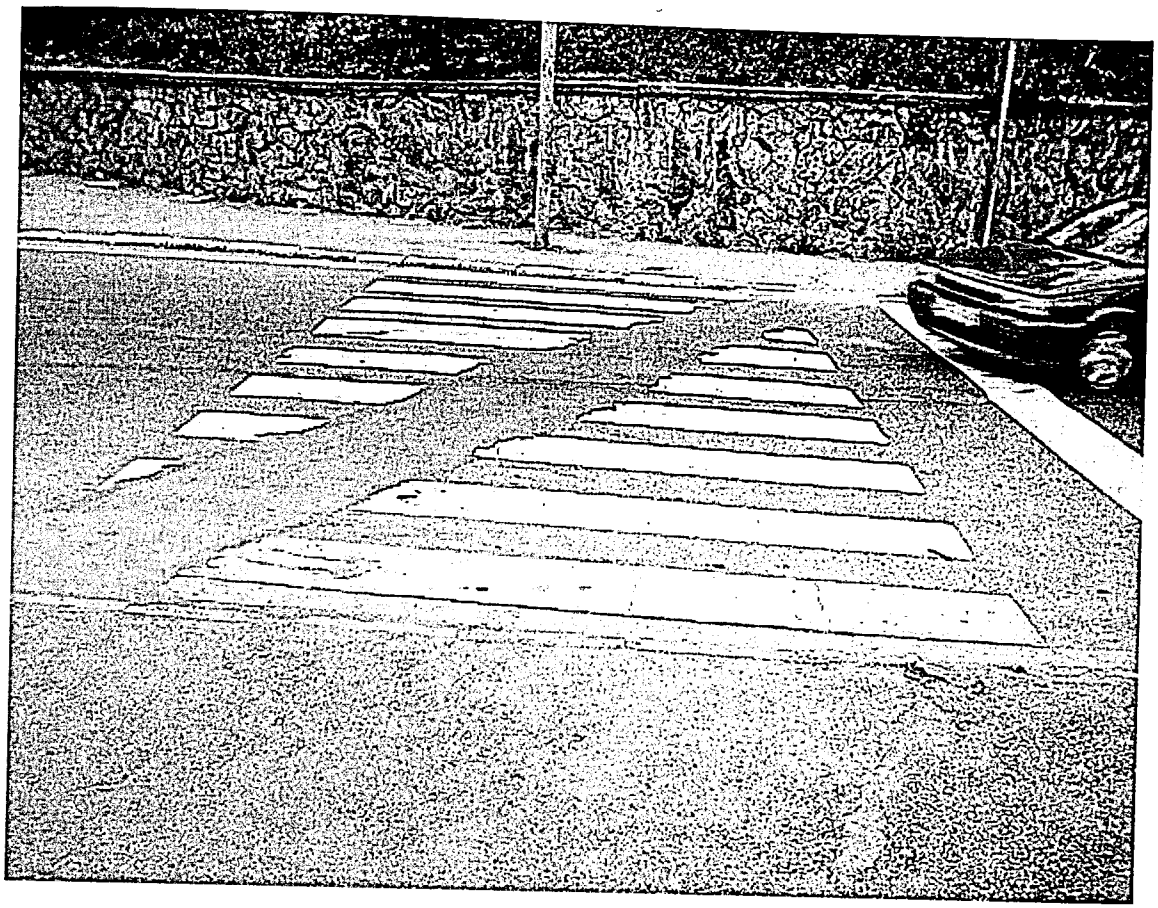


Figure 4.33. Crosswalk needs repainting

5. CONCLUSIONS AND RECOMMENDATIONS

Following are the main conclusions and recommendations of the study:

- Road accidents are serious problems all over the world. While developed countries have succeeded in checking and even reducing the number of road fatalities, current trends in developing countries including Turkey indicate that accidents will increase unless effective remedial actions are taken.
- Factors contributing the road safety can be classified as road users, road environment and vehicles. The safety programs developed in Turkey have only considered the road user as the main factor responsible from traffic accidents. Although a majority is attributed to road user factor in the crashes, the improvements in the road environment are expected to be more effective. Especially in the developing countries which are attempting to build up their networks, incorporating concepts such as "forgiving highways", "caring highways", "design consistency" is vital.
- Many road authorities have active "blackspot" programs in which millions of dollars are spent each year identifying high accident potential sites. However, reducing the accidents with proactive strategies – so called Road Safety Audits - that treat the root causes of crashes and levels of severity before they occur is more important. Road safety audit focuses on the safety principles and practices of road network delivery and aimed to correct deficiencies before road users are exposed to them. It considers all road users (drivers, pedestrians, cyclists, etc.) and provides safer roads for them. It is a relatively low cost process for road authorities especially at the design stage (correcting mistakes with a pen on a project very cost effective and easy way comparing reconstructing) and for the community in reduced accidents and casualties on the roads. It will not necessarily make every new design or an existing project totally "safe" but it will raise level of safety and it will cause deliberate decisions to be made on the basis of carefully considered safety advice.
- For implementing a safety auditing program in Turkey, it is important to have some organizations dealing with highway safety issues like National Road Safety Council.
- This council should promote a national policy on the use of road safety audit and allocate some resources for a series of pilot audits. After some pilot audits have been

conducted the suggested model has been reviewed, guidelines and procedures should be adopted for Turkey and training courses should be developed nationwide.

- An evaluation should be carried out for the cost effectiveness of the process, and how effective it is in firstly, persuading designers to change their plans, secondly whether the accident rate has been reduced after pilot audits conducted.
- The omission of the items in the checklist should be done after pilot audits have been conducted. Because the checklist is quite detailed and it takes long time to check all of the items during the inspections. Some of the items that are not suitable for Turkey's characteristics in the checklist were omitted after the field study.
- It is strongly recommended that audits should be conducted under the supervision of an authority in highway safety principals. In this study, Dolmabahçe Street was audited under the guidance of Professor Ergün. Especially the pilot studies of road safety audit principals for Turkey should be supervised by such an authority to reach clear and exact conclusions and ideas for the procedure.
- The vehicle of the audit team should have portable rotating light and if possible this light should be mounted with a "road survey" sign. The inspections conducted with a normal car can create safety problems to the audit team.

APPENDIX A: CHECKLIST FOR MUNICIPAL AUDITS DEVELOPED FOR TURKEY

The checklist for municipal audits of Turkey, which is developed in this study, is presented in Appendix A. The checklist developed in this study based on the checklists was prepared by transportation agencies or authorities in the world, especially in New Zealand [26] and in Canada [19]. As an example application, the checklist that was filled while conducting the road safety audit of Dolmabahçe Street, is presented. The checklist includes 9 sections as (1) general topics, (2) alignment and cross sections, (3) intersections, (4) interchanges, (5) skid resistance, (6) visual aids, (7) physical objects, (8) road users, (9) parking. Each section has its own items and items were checked as YES, NO or NOT APPLICABLE depending on the conditions of the items inspected. Necessary comments that were taken where the locations are presumed to be hazardous are also presented.

Checklist 1 *General Topics*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Scope	Review all pertinent documentation to gain an understanding of the scope of the project; including project objectives, user characteristics, design vehicles, access, adjacent development, right-of-way, roadside development, existing network information, and future network expansion.	✓			
2 Traffic Barrier Warrants	Presence of non-traversable or fixed object hazards within clear zone?	✓			There are old and thick sycamores and street poles very close to the edge along the street.
	Does a potential risk exist for vehicles crossing over the median into the path of an opposing vehicle?	✓			Yes. There is a great risk for vehicles crossing over the median.
3 Landscaping	Is landscaping in accordance with guidelines (e.g., clearances, sight distance)?		✓		There are old and thick sycamores very close to the edge along the street.
	Are required clearances and sight distances not likely to be restricted following future plant growth (landscaping and natural)?		✓		There are old and thick sycamores very close to the edge along the street
4 Temporary Work Area (Maintenance/ Construction)	Is temporary work site adequately signed for approaching traffic?			✓	
	Does temporary work signage remain even though construction is complete?			✓	
	Visibility of temporary work area from approaching traffic?			✓	
5 Glare	Severity of headlight glare during night time operations?	✓			Some portion of the street has severity of head light glare during nighttime operations.
	Do areas exist along a road or at an intersection where sunlight reduces visibility?		✓		There is no possibility of sunlight glare because of the trees are shading on both sides of the street.

Checklist 1 *General Topics*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
6 School and Recreation Areas	Is posted speed limit appropriate for neighbourhood activities?			✓	
	Is speed limit effective at controlling traffic speed?			✓	
	Is existing signage sufficient at notifying motorists of upcoming activities, or is some other traffic control device necessary?			✓	
	Visibility of signage from approaching traffic adequate?			✓	
	Visibility of school and recreational areas by approaching traffic?			✓	
	Does on-street parking exist near school? If so, will visibility of children be obstructed by parked vehicles?			✓	
	Do crosswalks exist in area? If so, what is their condition?			✓	
	Does approaching traffic adhere to pedestrian rules at crosswalks or are further traffic control measures necessary? (Crossing guard, pedestrian corridors, etc.)			✓	
7 Environmental Considerations	Are there any effects of adverse weather conditions on the facility?				Due to drainage problem rain and snow may cause severity.

Checklist 2 *Alignment and Cross Sections*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Classification	Is road classification appropriate for current traffic distribution and volume?		✓		Dolmabahce Caddesi is insufficient for traffic flow.
	Are one-way streets clearly marked at intersections and along the street?	✓			
2 Design Speed/ Posted Speed	Is the horizontal and vertical alignment suitable for the (85th percentile) traffic speed? If not:		✓		Traffic speed changes more than 15 km/h along the route due to design problems in horizontal alignment (i.e., curves).
	(a) Are warning signs installed?		✓		No warning signs installed before two sharp curves.
	(b) Are advisory speed signs installed?		✓		No advisory speed signs installed.
	Are the posted advisory speeds for curves appropriate?			✓	No advisory speed signs installed.
3 Cross Sectional Elements					
3.1 Drainage	Is there possibility of surface flooding or overflow from surrounding or intersecting drains and watercourses?	✓			There is a strong possibility of surface flooding from intersecting streets, which have high graded downhill.
	Does the roadway have sufficient drainage?		✓		Drainage is insufficient.
	Are the slits of a storm grate oriented perpendicular or parallel to traffic flow? (i.e., cyclist safety)		✓		Most of the storm grates oriented parallel to traffic flow.
3.2 Lane Width	Is the lane width adequate for the road classification and/or traffic volume?		✓		The lane widths of some sections are inadequate.
	Is the number of lanes adequate for the road classification and/or traffic volume?		✓		The numbers of lanes of some sections are inadequate.
	Are changes in the lane width or in the number of lanes adequately signed/marked?		✓		Most of the lane width changes are not marked/signed along the route.
3.3 Cross Slopes/ Superelevation	Do crown and cross slopes provide sufficient storm water drainage and facilitate de-icing treatments?		✓		Cross slopes at the curves are the same as at the tangents so there are superelevation problems exists at curves.
	Do different rates of cross slope exist along adjacent traffic lanes?	✓			Cross slopes are changes along route.

Checklist 2 *Alignment and Cross Sections*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
3.4 Pavement Widening	Is sufficient pavement width provided along curves where off-tracking characteristics of vehicles are expected?		✓		Pavement widening on curves are insufficient.
3.5 Curbs and Gutters	Are curbs and gutters installed where necessary?		✓		Gutters are not used along route.
	Are curbs and gutters constructed according to guidelines?		✓		Curbs are too high.
	Are condition of curbs and gutters appropriate?	✓			
3.6 Sidewalks	Is physical condition of sidewalks good?		✓		Most of them are in good condition.
	Is sidewalk width adequate for pedestrian volumes?		✓		Sidewalks near Besiktas have inadequate widths.
	Do objects exist on or near sidewalk that cause pedestrians to use street?		✓		
4 Alignment					
4.1 Horizontal	Are there excessive horizontal curves that cause sliding in adverse weather conditions?	✓			Superelevation problem of horizontal curves may create very hazardous situations.
	Signage of excessive horizontal alignment adequate?		✓		There is no signage of excessive horizontal alignment.
4.2 Vertical	Are there excessive grades which could be unsafe in adverse weather conditions?		✓		There is no excessive grade which could be unsafe.
5 Sight Distance	Are there any obstructions that could interfere with sight distance along route?	✓			Trees are blocking the sight distance
6 Readability by Drivers	Are there any sections of roadway which may cause confusion e.g.:				
	(a) Is alignment of roadway clearly defined?		✓		There is no signage of alignment.
	(b) Have old pavement markings been removed properly?		✓		Old pavement markings have not been removed.
	(c) Do streetlight and tree lines conform with the road alignment?	✓			

Checklist 3 *Intersections*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Type	Are types of intersections selected appropriate for current and future traffic volumes as it relates to safety?	✓			
	Can intersection designs accommodate all design vehicle classifications?	✓			
2 Location/ Spacing	Is there sufficient spacing between intersections?	✓			
	Are intersections located safely with respect to horizontal and vertical alignment?		✓		Visneli Tekke Sokak Intersection is very close to the reverse curve.
3 Visibility/ Conspicuity	Does the horizontal and vertical alignment provide adequate visibility of the intersection?	✓			
	Are sight lines to the intersection obstructed by buildings, trees, etc.?		✓		
4 Layout	Is layout of the intersection appropriate for the road function?	✓			
	Are the lane widths adequate for all vehicle classes?	✓			
	Are there any upstream and downstream features which may affect safety? (i.e., "visual clutter", angle parking, high volume driveways)		✓		At Akaretler Intersection there are many visual clutters (such as pedestrian overcross, trees, busy bus stops close to the intersection).
	Junctions and access adequate for all vehicle movements?	✓			
4.1 Maneuvers	Are vehicle maneuvers obvious to all users?	✓			
	Are there any potential conflicts in movements?	✓			The channeled Macka-Taksim turn in front of Inonu Stadium may create conflict.
	Do certain traffic movements need to be prohibited/discouraged by using one-way streets, cul-de-sacs, chokers or medians?		✓		

Checklist 3 *Intersections*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
4.2 Channelization	Are channelization features effective?	✓			Channelization features are effective but confusing.
	Any areas of uncontrolled pavement that may require channelization features?	✓			Prohibited right turn to and left turn from Visneli Tekke Sokak is open to misuse..
4.3 Auxiliary Lanes	Are they of appropriate length?	✓			
	Is decision sight distance for entering/leaving vehicles adequate?	✓			
	Are tapers installed where needed? Are they correctly aligned?		✓		
4.4 Islands	Presence of visual clutter on island affecting sight distance?		✓		
	Is an island required to channel vehicle traffic at the current location?		✓		
	Are the dimensions of the island adequate for the intersection (width, length, turning radius)?	✓			
	Is the existing island clearly visible to drivers?	✓			
6 Controls					
6.1 Markings	Are pavement markings clearly visible in day and night time conditions?		✓		Pavement markings are faded.
	Retro-reflectivity of markings?		✓		Most of the markings are not retro-reflective.
	Are all necessary pavement markings present?		✓		Advisory speed markings are needed at curves.

Checklist 3 *Intersections*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
6.2 Signs	Visibility and readability of signs to approaching users?	✓			Sign post of the channeled Macka-Taksim turn in front of Inonu Stadium is installed at the end of the channel.
	Are there any missing/redundant/broken signs?		✓		There is a need for warning sign Visneli Tekke Intersection for vehicles to take care of approaching traffic from Besiktas.
	Is adequate warning provided for signals not visible from an appropriate sight distance?		✓		Sign post of the channeled Macka-Taksim turn in front of Inonu Stadium is installed at the end of the channel.
6.3 Signals	Have high intensity signals/target boards/shields been provided where sunset and sunrise may be a problem?		✓		
	Check location and number of signals. Are signals visible?	✓			
	Are primary and secondary signal heads properly positioned?	✓			Signals are properly positioned but some cracks on them noted.
	Are auxiliary heads necessary?		✓		
6.4 Signal Phasing	Are minimal green and clearance phases provided?	✓			The minimal green and clearance phases provided but the intersections are oversaturated during peak hours.
	Is a dedicated left turn signal required?		✓		
	Is the signal phasing plan consistent with adjacent intersections?	✓			
7 Landscaping	Will current or future plant growth interfere with required clearances, traffic flow devices, or sight distances?		✓		

Checklist 4 *Interchanges*

Project.....**DOLMABAHCE CADDESI**.....

Audit Team Members .....

Date .....**26-27-28/12/2000**.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Considerations	Check the appropriateness of the interchange design with respect to topographical, environmental and operational considerations.			✓	No interchange exists along the route.
	Is interchange layout consistent with other designs throughout the corridor or network?			✓	
2 Location/ Spacing	Does the location of the interchange service the needs of the surrounding community?			✓	
	Determine if spacing between interchanges in the network is sufficient.			✓	
3 Weaving Lanes	Ensure appropriate length and number of weaving lanes.			✓	
4 Ramps	Is the design speed appropriate for site limitations, ramp configurations, and vehicle mix?			✓	
	Adequate distance between successive entrance and exit noses?			✓	
	Is design of main lane adequate at exit/entrance terminals?			✓	
4.1 Exit Terminals	Is the length adequate for deceleration?			✓	
	Is adequate sight and decision sight distance provided?			✓	
	Are spiral curves warranted? If so, do spirals begin and end at appropriate locations?			✓	

Safety Audit for Existing Roads/Municipal

Checklist 4 *Interchanges*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
4.2 Entrance Terminals	Is the length appropriate for acceleration and safe and convenient merging with through traffic?			✓	
	Are spiral curves warranted? If so, do spirals begin and end at appropriate locations?			✓	
	Is the length of acceleration adequate for traffic composition (i.e. truck, buses, etc.)			✓	
	Is there an adequate view of the speed change lane at the nose?			✓	
	Is visibility obscured by traffic barriers and other obstructions?			✓	
5 Service Road Systems	Is there adequate distance between the highway and the service road to allow for future development?			✓	
	Does service road traffic adversely affect traffic flow along the highway?			✓	
	Is there sufficient access to/from the service road?			✓	
6 Lane Balance/ Basic Lanes/ Lane Continuity	Is the number of lanes appropriate for safe operations and to accommodate variations in traffic patterns?			✓	
	Is there coordination of lane balance and basic lanes?			✓	
	Is lane continuity maintained?			✓	
7 Auxiliary/ Turning Lanes	Are they of appropriate length?			✓	
	Is there advance warning of approaching auxiliary lanes?			✓	
	Is sight distance for entering/leaving vehicles appropriate?			✓	
	Are tapers installed where needed? Are they correctly aligned?			✓	
	Is the service road being used for its original intent?			✓	

Checklist 5

Skid Resistance

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Skid Resistance	Does adequate skid resistance exist along curves, intersection approaches and steep grades?	✓			No skid measurement has been made along the route.
2 Pavement Distresses	Pavement is free of distresses? (i.e., potholes, rutting, etc.)		✓		There are some potholes along the route.
3 Surface Texture	Wet conditions effect texture visibility?		✓		
	Can visibility be reduced due to sunlight conditions?		✓		
	Headlight response during nighttime operations effect texture visibility?		✓		
4 Loose Screenings	Is the pavement free of loose screenings?		✓		There are some loose screenings found on the pavement.
5 Ponding	Pavement is free of depression areas where ponding can occur?		✓		Ponding can occur at wet conditions.
6 Pavement Edge Rounding	Is pavement edge rounding adequate?			✓	

Checklist 6

Visual Aids

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Pavement Markings	Are centerlines clearly visible at all times?		✓		Most of the centerlines are faded.
	Have old pavement markings been removed?		✓		Old pavement markings have not been removed. Some of them still visible
	Retro-reflectivity of existing markings?		✓		Most pavement markings has lost retro-reflectivity.
2 Delineation	Is delineation adequate? Effective in all conditions?		✓		Delineation is not adequate and effective.
	Are retro-reflective devices intended for heavy vehicle operators at their eye height?			✓	
	Are chevron markers placed correctly? Has retro-reflectivity been measured?			✓	
3 Lighting	Will luminares create glare for road users on adjacent roads?		✓		
	Location of luminares at interchanges, intersections, along route, roundabouts, bicycle crossings, etc. are appropriate?		✓		Luminares along route is dangerous and some of them are out of service.
	Do locations exist where lighting may interfere with traffic signals or signs?		✓		There is no contradiction between luminares and signals or signs.
4 Signs	Are all current signs visible and in current location?		✓		Most of them are visible in current location but some are not legible.
	Do conditions exist which require additional signs?	✓			Advisory speed and warning for alignment signs must be installed .
	Do any signs restrict the sight distances of road users?		✓		
	Are signs effective in all operating conditions (day, night, rain, fog, snow, etc.)		✓		Most of them lost their retro-reflectivity.
	Are any signs redundant/missing/broken?		✓		
	Do any signs contradict one another?	✓			At Visneli Tekke Intersection signs contradict
	Are signs and supporting structures in good condition?		✓		All concrete sign posts and supporting posts of the luminares are in dangerous condition (corrosion of steel bars and bases)
	Are any existing signs no longer applicable?		✓		

Checklist 7

Physical Objects

Project.....**DOLMABAHCE CADDESI**.....

Audit Team Members .....

Date .....**26-27-28/12/2000**.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Medians	Is type of median chosen appropriate for width available?		✓		There is a need to install median barrier along route.
	Are median barriers sufficiently offset from roadway?			✓	
	Check appropriate spacing between median crossovers.			✓	
2 Hazardous Object Protection	Is adequate protection provided where required? (i.e., barriers, energy attenuators)		✓		There is a need to install roadside barriers because trees are too close to the edge of the roadway.
	Is pavement buildup reducing the effectiveness of roadside guardrails/barriers?			✓	
	Are dimensions (i.e. length) of protection appropriate?			✓	
	Is there appropriate transition from one barrier to another?			✓	
3 Crash Barriers	Are safety barriers installed at all necessary locations, including on bridges in accordance with guidelines?		✓		There is a need to install crash barriers at some locations.
	Are the crash barrier systems suitable for the purpose?			✓	
	Is the length of crash barrier at each installation adequate? Are the crash barriers correctly installed?			✓	
	Are the guard rail energy absorbing terminals (GREAT) or crash cushions installed where necessary (e.g., off ramp, bridge piers)?			✓	
	Is there a safe run off area behind breakaway terminals?			✓	

Checklist 7 *Physical Objects*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
4 Clear Zone	Any object (temporary or permanent) are within the required clear zone?	✓			There is no area between the edge of roadway and sidewalk border.
	Is clear zone of adequate dimensions?		✓		There is no area between the edge of roadway and sidewalk border.
5 Culverts	Adequate protection of culverts at abutting driveways and intersecting roads is present?			✓	
6 Poles and Other Obstructions	Are poles and other obstructions adequately protected?		✓		Barrier system is needed.
	Unprotected median widths appropriate for lighting poles?			✓	
	Have frangible or slip-base poles been used?		✓		Only the new poles are frangible and have slip-base supporting system.
	Is positioning of traffic signal and other service poles appropriate?	✓			
7 Railroad Crossings	Proper active/passive signing and pavement markings?			✓	
	Are gates of adequate width?			✓	
	Are at-grade crossings approximately level with traveled roadway?			✓	
	Sight distances for signing and also approaching trains are adequate?			✓	
8 Manholes	Are manholes too high or too low?	✓			Some of the manholes are too low.

Safety Audit for Existing Roads/Municipal

Checklist 8 *Road Users*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Motorized Traffic					
1.1 Heavy Vehicles	Can facility accommodate movements of heavy vehicles? (clearances, turning radii, shoulder widths, operational capacity)		✓		Lane width along the curves are not sufficient.
	Is there adequate signage of heavy vehicle activity?		✓		There is no signage of heavy vehicle activity.
1.2 Public Transport	Can facility accommodate movements of public transport vehicles? (clearances, turning radii, shoulder widths, operational capacity)		✓		Lane width along the curves are not sufficient.
	Is there adequate signage of public transport activity?		✓		There is no signage of public transport activity.
	Locations of bus stops and clearance from the traffic lane are appropriate?		✓		They must be redesigned.
	Visibility of bus stops by approaching traffic?	✓			Bus stops are visible by approaching traffic.
	Are bus bays/lanes required?		✓		
1.3 Emergency Vehicles	Can facility accommodate movements of road maintenance and emergency vehicles (clearances, turning radii, shoulder widths)		✓		Lane width along the curves are not sufficient.
1.4 Tramways	Do certain vehicular movements require restriction to minimize conflict between traffic and tramway system?			✓	
	Location of tramway stops with respect to road			✓	

Checklist 8 *Road Users*

Project.....DOLMABAHCE CADDESI.....

Audit Team Members .....

Date .....26-27-28/12/2000.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
2 Non-Motorized Traffic					
2.1 Cyclists	Is there adequate width along the shoulder for cyclists sharing the street with motorists?		✓		There is no space between the edge of the roadway and sidewalk border. They must share the roadway.
	Are shoulders properly maintained for cyclist traffic?		✓		There is no space between the edge of the roadway and sidewalk border.
	Are alignment and cross section for bicycle facilities appropriate?	✓			
	If bike route exists, are adequate markings and signage provided?			✓	There is no route for bicyclists but they can share the roadway if adequate signage provided..
2.2 Pedestrians	Signal timing is appropriate (cycle length, pedestrian clearance time)?	✓			
	Are handrails provided (on bridges, ramps)?	✓			Yes. There are handrails for healthy pedestrians.
	Is there adequate signage for pedestrian paths?		✓		Signage.for pedestrian paths is not adequate
	Are sight lines for pedestrians clear? (i.e., around parked cars)			✓	
	Are pedestrian bridges necessary?		✓		The bridge is adequate for pedestrians but some renovations required.
2.2.1 Elderly and Disabled Pedestrians	Are there adequate provisions for the elderly, the disabled, children, wheelchairs and baby carriages (curb and median crossings, ramps, raised crosswalks, curb cuts, etc.)?		✓		Some provisions necessary on the bridge.
	Distances between stop line and pedestrian crossing at signalized intersections are appropriate (for visibility of pedestrians from truck driver's seat)?	✓			
2.2.2 Paths and Crosswalks	Location of crosswalks along the road are appropriate (signage, sight distance, spacing)?		✓		Signage of the crosswalks at intersections are insufficient.
	Visibility of traffic from the crosswalk and the visibility of pedestrians from the traffic flow is adequate?	✓			
	Are crosswalk markings in good condition?		✓		Some of them need repainting.

Checklist 9

Parking

Project.....**DOLMABAHCE CADDESI**.....

Audit Team Members .....

Date .....**26-27-28/12/2000**.....

ITEM	ISSUES TO BE CONSIDERED	YES	NO	N/A	COMMENTS
1 Parking Lots	Visibility of entrance/exit by approaching vehicles?			✓	Parking is prohibited along route.
	Visibility of vehicles entering and exiting parking facilities?			✓	
	Signage of parking lot facilities?			✓	
	Visibility of pedestrians on sidewalks near parking lot entrance/exits?			✓	
2 Street Parking	Is parking orientation (parallel, angled) along route appropriate?			✓	
	Are parked vehicles obstructing sight distances?			✓	
	Parking restrictions during peak hours?			✓	
	Are excessive manoeuvers required to park a vehicle within the dimensions of the parking space?			✓	
	Are the parking facilities along a route appropriate for the classification of the route? If not, should off street parking be provided?			✓	
	Are parking restrictions near intersections sufficient?			✓	
	Visibility and circulation of pedestrians around parked vehicles?			✓	

APPENDIX B: A TYPICAL ROAD SAFETY AUDIT CHECKLIST FOR ALL NEW PROJECTS

A road safety audit checklist for all new projects is presented in Appendix B. This is a typical checklist which was provided by e-mail by Mr. Pieples, the district traffic engineer in PennDOT. However, exactly the same checklist was sent to the author also by fax by Mr. Appleton, the safety audit manager in Transfund New Zealand and by Mr. Jordan, the project manager in AUSTROADS.

This checklist includes all five stages:

- Feasibility,
- Preliminary Design;
- Detailed Design;
- Pre-Opening; and
- Post-Opening Stages.

Each stage has its own sections like general topics, design issues, intersections, etc. and these sections have their own specific items.

Checklist 1-1

General Topics

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Scope of project, function, traffic mix	A broad appreciation of the scope of the project will assist in addressing topics further on in this check list.		
	What is the general type of project for which the design has been carried, e.g: freeway, major arterial, or a minor improvement?		
	Is the road intended to carry high speed traffic or serve local access needs only?		
	Is there a mixed function, or a potential confusion to the driver about the road's function?		
	What kind of traffic is likely, ranging from high speed mixed traffic (i.e., including a significant number of trucks) or for more general use, including bicycles and significant pedestrian traffic?		
2 Type and degree of access to property and developments	Check the general layout of the project, including:		
	Questions of visibility and speed, related to the number and type of intersections and accesses to adjacent property.		
	Check the width of the right of way, or the detailed design within that width, as affected by access requirements.		
3 Significant adjacent developments	Check major generators of traffic and parking, including housing or shopping centers, developments that may have a significant influence on the form of the design.		
	Check for distance of accesses from intersections and visibility of and from accesses to significant traffic generators.		

Checklist 1-1

General Topics

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
4 Influence of staging	Check the design against staging requirements.		
	Will this project be one stage or several?		
	Will future projects be either linear extensions of the project, or will possible redundancies be caused by widening?		
5 Future widening and/or realignments	What is the likelihood of: (a) Future widening?		
	(b) The addition of a complete second directional roadway?		
	If designed for eventual divided operation, will the interim two-way operation create problems (e.g., overtaking)?		
	(c) Later realignments?		
	(d) Introductions of major geometric changes at intersections?		
6 Wider network effects	Are there any harmful or beneficial safety aspects within the proposed project or on the surrounding network?		

Checklist 1-2

Design Issues

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Route Choice	Consider the broad concept involved in the choice of a route or alignment.		
	Does the project follow existing roads or is it a completely new project and what are the effects of this?		
	Does the project fit in with the physical constraints of the landscape and major network considerations?		
2 Impact of continuity with existing network	Check the potential for problems where the proposed project joins the existing network.		
3 Broad design standards	Check that the appropriate design standards have been used having regard to the scope of the project, and its function in relation to the traffic mix.		
	What design vehicles are used?		
4 Design speed	Check the design speed for horizontal and vertical alignment, visibility, merging, weaving, and decelerationg or accelerating traffic at intersections.		
	Check the effects of sudden changes in the speed profile or posted speed limit.		
	Check the appropriateness of both the design speed and speed limit on the proposed road project.		
5 Design volume and traffic characteristics	Check the appropriateness of the design for the design volume and traffic characteristics (including the effects of unusual proportions of heavy vehicles, cyclists and pedestrians, or lateral acceleration effects).		
	Check the possible effects of unforeseen or large increases in traffic volume or changes in the traffic characteristics.		

Checklist 1-3 *Intersections*

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Number and type of intersections	Check the appropriateness of intersections with respect to the broad concept of the project, its function and traffic mix and also the need to serve intersecting roads appropriately to their function.		
	Check the number and type of intersections, including the relationship both of spacing and type of one intersection with another.		
	Are there any traffic or safety aspects of the project or of the traffic in the area which would favour or disfavor any particular layout?		
	Are there any physical or visibility constraints which would influence the choice or spacing of intersections?		
	Are all of the proposed intersections necessary or essential, or can the surrounding network be modified beneficially?		
	Does the vertical geometry or horizontal alignment have any influence on the style or spacing of intersections?		

Checklist 1-4

Environmental Constraints

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Safety aspects, including weather and natural features	Check the surrounding terrain for physical or vegetation defects which could affect the safety of the project - for instance, heavy planting or forestry, deep cuttings, physical features such as steep or rocky bluffs which constrain the design.		
	Check the project for the effects of wind.		
	Check for the effects of fog, mist or ice.		
	Do the gradients, curves and general design approach fit in with the likely weather or environmental aspects of the terrain?		
	Are there scenic vistas or overlooks which may distract a driver or cause a vehicle to unexpectedly slow down or otherwise maneuver?		

Safety Audit Stage 1/Feasibility

Checklist 1-5 *Other Issues*

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Safety aspects not already dealt with	Check any aspects which do not readily fall into any of the above categories, such as:		
	(a) Flooding.		
	(b) Moving stock.		
	(c) Low flying aircraft, advertising or other matters which could be distracting to drivers.		
	(d) Turn outs or parking may be needed (e.g., for tourist routes, picnic or rest areas).		
	(e) The potential of the route or site to attract roadside stalls.		
	(g) Any other matter which may have a bearing on safety.		

Checklist 2-1 *General Topics*

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Changes since Stage 1	Check for any major changes in principle since the Stage 1 Audit was carried out.		
	Check that the conditions for which the project was originally designed still apply, i.e., there have not been significant changes to the surrounding network or area to be served, or traffic mix.		
2 Drainage	Will the new road drain adequately?		
	Is there a possibility of surface flooding or overflowing from surrounding or intersected drains and water courses?		
3 Climatic conditions	Do weather records or local experience indicate a problem (e.g., snow, ice, wind, fog)?		
4 Landscaping	Is the landscaping design or planting likely to lead to a lowering of safety with mature or seasonal growth? (i.e.through loss of visibility, obscuring signs, shading or light effects, leaves, flowers, or seeds dropping on the highway) ?		
	Is "frangible" vegetation appropriate?		
	Consider pedestrian visibility in particular.		
5 Services	Does the design adequately deal with buried and overhead services?		
	At this stage the location of fixed objects or furniture associated with services should be checked, including the position of poles.		
6 Access to property and developments	Can all accesses be used safely?		
	Are there any downstream/upstream effects from development accesses, particularly near intersections?		
	Check rest area accesses.		

Checklist 2-1

General Topics

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
7 Emergency vehicles and access	Has provision been made for safe access by emerging vehicles and vehicles?		
	Check the design of medians and barriers, and the ability of emergency vehicles to stop without necessarily disrupting traffic.		
8 Future widening and/or realignments	If the project is only a stage towards a wider or divided roadway, is the signing and design adequate to impart this message to drivers?		
	Is the transition from two way to divided roadway handled safely?		
9 Staging of the project	If the scheme is to be staged or constructed at different times, are the construction plans and program arranged to ensure maximum safety and do they include specific safety measures, signing, and adequate transitional geometry for any temporary arrangements?		
10 Staging of the works	If the construction of this project is to be staged or split into several contracts check that these are arranged for maximum safety.		
11 Significant adjacent developments	Check that the design handles accesses to major adjacent generators of traffic and parking and developments safely.		
	Check that lighting or traffic signals on an adjacent road do not affect the drivers' perception of the road ahead.		
12 Stability of cut and fill	Check that the geological conditions in the country through which the road is to be constructed do not pose a significant threat to safety of vehicle occupants.		
13 Maintenance	Check if maintenance vehicles can be safely located.		

Checklist 2-2

Design Issues

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Geometry of horizontal and vertical alignment	Do the horizontal and vertical design of the project fit together comfortably?		
	Check the design for adequacy with regard to the function of the road.		
	Check the possibility of drivers not being able to read the road characteristics due to visual illusions, subliminal delineation, etc., (e.g., line of trees, line of poles, etc).		
2 Typical cross-sections	Are the lane widths, shoulders, medians and other cross section features in accordance with standard design or adequate for the function of the road?		
3 Effect of cross-sectional variation	Check that there are no undesirable variations in cross section design.		
	Check cross slopes which could affect safety, particularly where sections of existing highway have been utilised, or where there have been compromises to accommodate accesses, etc.		
	Check where compromises have been made such as narrowing at bridge approaches or to avoid physical features.		
4 Roadway layout	Check that total traffic management features in addition to horizontal and vertical alignment and cross section) are not likely to create unsafe conditions.		
	Check the layout of road markings and reflective media both on the road and on the surrounds to deal with changes in alignment, particularly where these are substandard.		

Checklist 2-2

Design Issues

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
5 Design standards	Check the appropriateness of the design speed and speed limit.		
	What design and check vehicles are used?		
6 Shoulders and edge treatment	Check the safety aspects of shoulder provision, including the provision of sealed shoulders, the width and treatment on embankments and cross slope of shoulders.		
	Are the shoulders likely to be used by slow moving vehicles or cyclists?		
	Check safety aspects of rest areas.		
7 The effect of departures from standards or guidelines	Are there any approved departures from standards or guidelines which affect safety?		
	Are there any hitherto undetected departures from standards which should be brought to the attention of the designer?		

Checklist 2-3 *Alignment Details*

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visiblity, sight distance	Are horizontal and vertical alignments consistent with the required visibility requirements?		
	Check that sight lines are not obstructed by:		
	(a) Fences and crash barriers		
	(b) Boundary fences		
	(c) Street furniture		
	(d) Parking facilities		
	(e) Signs		
	(f) Landscaping		
	(g) Bridge abutments.		
	Inappropriate consideration of horizontal and vertical alignment (e.g. horizontal curve just over a crest vertical curve).		
	Check that railway crossings, bridges and other hazards are conspicuous.		
	Are there any other local features which affect visibility?		
	Will sight lines be obstructed by temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		

Checklist 2-3 *Alignment Details*

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
2 New/existing road interface	Have implications for safety at the interface been considered? Are there sudden changes in the speed profile or access or lateral acceleration characteristics?		
	Does the interface occur near any hazard, i.e., at a crest or bend or where poor visibility or distractions occur?		
	Check that the change is affected safely where roadway standards differ.		
	Check transition is safe where road environment changes, for example, urban to rural, fast to slow, lit to unlit.		
	Check the need for advance warning.		
3 Readability by drivers	Will the general layout, function and broad features be recognized by drivers in adequate time?		
	Check the approach speed and general likely position of vehicles as they track through the project.		

Checklist 2-4

Intersections

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility to and visibility at intersection	Are horizontal and vertical alignments consistent with the required visibility requirements? Will drivers be aware of the presence of the intersection (especially if facing a Stop/Yield sign)?		
	Check that sight lines are not obstructed by:		
	(a) Fences and crash barriers		
	(b) Boundary fences		
	(c) Street furniture		
	(d) Parking facilities		
	(e) Signs		
	(f) Landscaping		
	(g) Bridge abutments.		
	Check that railway crossings, bridges and other hazards are conspicuous.		
	Are there any local features which require affect visibility?		
	Will sight lines be obstructed by permanent or temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		

Checklist 2-4

Intersections

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
2 Layout, including appropriateness	Is the type of intersection selected (crossroad, T, roundabout, signalized, etc.) appropriate for the function of the two roads?		
	Are the proposed controls (Stop, Yield, signals, etc.) appropriate for the particular intersection being considered?		
	Are junction sizes appropriate for all vehicle movements?		
	Are there any unusual features which could affect road safety (e.g., cyclists, heavy truck movements, public transport operations, etc.)?		
	Are the lane widths and swept paths adequate for all vehicles?		
	Are there any upstream or downstream geometric features which could affect safety, e.g., merging of lanes?		
3 Readability by drivers	Will the general type, function, priority rules and broad features be recognized by drivers in adequate time.		
	Check the approach speed and general likely position of vehicles as they track through the project.		

Checklist 2-5

Special Road Users

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Adjacent land	Will adjacent activity and intensity of land use have an adverse safety effect on the project? Are special measures needed?		
2 Pedestrians	Have pedestrian needs been considered?		
	If footpaths are not specifically provided, is the road layout safe for use by pedestrians, particularly at blind corners or on bridges?		
	Are pedestrian subways or footbridges sited to provide maximum use?		
	Is the avoidance of footbridges or subways possible by crossing the road at grade?		
	Has specific provision been made for pedestrian crossings, school crossings or pedestrian signals?		
	Are these sited to provide maximum use ?		
	Are pedestrian refuges / curb extensions needed?		
	Is specific provision required for special groups, e.g., the young, elderly, sick, disabled, deaf, or blind?		

Checklist 2-5

Special Road Users

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
3 Cyclists	Have the needs of cyclists been considered, especially at intersections?		
	Is a bicycle lane needed?		
	Are any bikeways separate from the main roadway, of standard or adequate design?		
	Is there a need for shared pedestrian/cycle facilities?		
	Where bikeways terminate at intersections or adjacent to the roadway, has the transition treatment been handled safely?		
	Are there any needs for special bicycle facilities (e.g., bicycle signals) if not already provided?		
4 Equestrians and stock	Have the needs of equestrians been considered, including the use of verges or shoulders and rules regarding the use of the roadway?		
	Can underpass facilities be used by equestrians/stock?		
5 Freight	Have the needs of truck drivers been considered, including turning radii and lane widths?		
6 Public Transport	Have the needs of public transport users been considered?		
	Are bus stops positioned for safety?		
7 Road maintenance vehicles	Has provision been made for road maintenance vehicles to safely be used at this site?		

Checklist 2-6

Signs and Lighting

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Lighting	Is this project to be lit?		
	Are there difficulties of illuminating sections of the road caused by trees or overpasses, for example?		
	Has the question of siting of lighting poles been considered as part of the general concept of the project?		
	Are frangible or slip-base poles to be provided?		
	Are any special needs created by ambient lighting?		
	Are there any aspects of the provision of lighting poles which would require consideration from the safety point of view in their being struck by vehicles?		
2 Signs	Are sign structures needed?		
	Are signs located at points to allow adequate readability?		
	Are signs located to limit visibility from accesses and intersecting roads?		
	Are signs appropriate to the drivers needs (i.e., destination signs, advisory speed signs, etc)?		
	Have the safety aspects of signs been considered as part of the general concept?		
	Are there any aspects of the provision of sign posts which would require consideration from the safety point of view in their being struck by vehicles?		
3 Marking and delineation	Check that the appropriate standard of delineation and marking has been adopted.		

Checklist 2-7

Construction and Operation

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Buildability	Are there any features which could inhibit safe construction (e.g., through traffic, construction vehicles.)?		
2 Operation	Is adequate safe access to the works available?		
3 Traffic management	Are there any factors requiring specific road safety provision, including maintenance?		
4 Network management	Are there any traffic management features which management would require special attention during construction or during the transition from construction to full operation?		

Checklist 2-8

Other Issues

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Safety aspects not already covered	Safety auditors are to check for any issue or item not already covered.		
	This could include unusual events, special effects of land uses alongside, including stock being driven onto or along the road.		
	The ability of the road to take overweight or over-dimension vehicles or other large vehicles - trucks - buses - emergency vehicles - utility/road maintenance vehicles.		
	The ability to close the road for special events in a safe manner.		
	The special requirements of scenic or tourist routes.		
	The provision of rest areas with safe access and egress.		

Checklist 3-1

General Topics

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Changes since Stage 2	Check for any major changes in principle since the Stage 2 Audit was carried out.		
	Check that the conditions for which the project was originally designed still apply, i.e., there have not been significant changes to the surrounding network or area to be served, or traffic mix.		
2 Drainage	Will the new road drain adequately?		
	Is there a possibility of surface flooding or overflowing from surrounding or intersected drains and water courses?		
	Is pit spacing adequate to limit flooding?		
3 Climatic conditions	Do weather records or local experience indicate a problem (e.g., snow, ice, wind, fog)?		
4 Landscaping	Check the landscape design or planting species for a lowering of safety.		
	Is it likely to lead to a lower safety with mature or seasonal growth (e.g. through loss of visibility, obscuring signs, shading or light effects, leaves, flowers or seeds dropping on to the highway)?		
	Is frangible vegetation appropriate?		
	Consider pedestrian visibility in particular.		
5 Services	Does the design adequately deal with buried and overhead services?		
	Check the location of fixed objects or furniture associated with services, including for loss of visibility and check the position of lighting and other poles for accuracy.		
	Check the clearance to overhead wires.		
6 Access to property and developments	Can all accesses be used safely? Are there any downstream or upstream effects from accesses, particularly near intersections?		

Checklist 3-1

General Topics

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
7 Emergency vehicles and access	Has provision been made for safe access by emergency vehicles?		
	Check the design of medians and vehicle barriers, and the ability of emergency vehicles to stop without necessarily disrupting traffic.		
8 Future widening and/or realignments	If the project is only a stage towards a wider or divided roadway, is the signing and design adequate to impart this message to drivers?		
	Is the transition from two way to divided roadway handled safely?		
9 Staging of the project	If the project is to be staged or constructed at different times, are the construction plans and program arranged to ensure maximum safety and do they include specific safety measures, signing, also adequate transitional geometry for any temporary arrangements?		
10 Staging of the works	If the construction of this project is to be staged or split into several contracts check that these are arranged for maximum safety.		
11 Significant adjacent developments	Check that the design handles accesses to major adjacent generators of traffic and developments safely.		
	Check the need for screening against glare from lighting of adjacent developments.		
	Check that lighting or traffic signals on an adjacent road do not affect the drivers' perception of the road ahead.		
12 Stability of cut and fill	Do the geological conditions in the country through which the road is to be built pose significant threats to the safety of vehicle occupants?		
	Check batters for stability, potential for loose material.		
13 Skid resistance	Check the need for high level skid surface on grades or where braking or good road adhesion is essential.		
14 Maintenance	Check that maintenance vehicles can be safely located.		

Checklist 3-2

Design Issues

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Geometry of horizontal and vertical alignment	Check that the horizontal and vertical design of the project fit together comfortably.		
	Check the design for adequacy having regard to the function of the road.		
	Check the possibility of drivers not being able to read the road characteristics, i.e., visual illusions, subliminal delineation, etc.		
2 Typical cross sections	Are the lane widths, shoulders, medians and other cross section features in accordance with standard design or adequate for the function of the road?		
3 Effect of cross sectional variation	Check that there are no variations in cross section design which could affect safety, particularly where sections of existing highway have been utilized, or there have been compromises to accommodate accesses, etc.		
	Check where compromises have been made, e.g., at bridges or to avoid physical features.		
4 Roadway layout	Check that total traffic management features (i.e., in addition to questions of horizontal and vertical alignment and cross section) are not likely to create unsafe conditions. This includes the installation of signs and markings both on the road and nearby to deal with changes in alignment, particularly where these are substandard.		
5 Shoulders and edge treatment	Check the safety aspects of shoulder provision, if any, including seal shoulders, the width and treatment on embankments and cross slopes of shoulders. Are the shoulders likely to be used by slow moving vehicles or cyclists?		
6 The effect of departures from standards or guidelines	Are there any approved departures from standards or guidelines which affect safety?		
	Are there any hitherto undetected departures from standards which should be brought to the attention of the designer?		

Checklist 3-2

Design Issues

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
7 Visibility, sight distance	Are horizontal and vertical alignments consistent with the required visibility requirements?		
	Confirm that the standard adopted for provision of visibility in the design is appropriate for the ruling or 85th percentile speed and for any unusual traffic mix.		
	Check that sight lines are not obstructed by:		
	(a) Safety fences and barriers		
	(b) Boundary fences		
	(c) Street furniture		
	(d) Parking facilities		
	(e) Signs		
	(f) Landscaping		
	(g) Bridge abutments.		
	Check that railway crossings, bridges and other hazards are conspicuous.		
	Will sight lines be obstructed by temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
8 Signs and markings	Has the design approach taken into account the provision of signs and road markings?		
	Are they adequately detailed so as to promote good traffic management and safety?		

Checklist 3-3

Alignment Details

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility, sight distance	Are horizontal and vertical alignments consistent with the required visibility requirements?		
	Confirm that the standard adopted for provision of visibility in the design is appropriate for the ruling or 85th percentile speed and for any unusual traffic mix.		
	Check sight lines are not obstructed by:		
	(a) Safety fences and barriers		
	(b) Boundary fences		
	(c) Street furniture		
	(d) Parking facilities		
	(e) Signs		
	(f) Landscaping		
	(g) Bridge abutments.		
	Check that railway crossings, bridges and other hazards are conspicuous.		
	Will sight lines be obstructed by temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
2 New/existing road interface	Have implications for safety at the interface been considered?		
	Include the accident rate and severity on the adjacent network, and the effect of sudden changes in the speed profile or access and side friction characteristics.		
	Does the interface occur near any hazard, i.e., at a crest or bend or where poor visibility or distractions occur?		
	Check that the change is affected safely where roadway standards differ.		
	Check transition is safe where road environment changes, for example, urban to rural, fast to slow, lit to unlit.		
	Check the need for advance warning.		

Checklist 3-3

Alignment Details

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
3 Readability by drivers	Will the general layout, function and broad features be recognized by drivers in adequate time for safety not to be impaired?		
	If new work is of higher geometric standard - is there clear and unambiguous advance warning or reduction in standard?		
	Is there need for a transition zone between higher standard of new road and lower standard of old road (especially perception of horizontal curvature, which is the primary determinant out of desired speed).		
	Check the approach speed and general likely position of vehicles as they track through the project.		
4 Detail of geometric design	Check that the design standards are appropriate for all the new requirements of the proposed project.		
	Check for consistency of general standards and guidelines such as lane widths and cross slopes.		
5 Treatment of bridges and culverts	Check that the geometric transition from the standard cross section to that on the bridge is handled so as to promote safety.		

Checklist 3-4

Intersections

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility to and visibility at intersection	Are horizontal and vertical alignments consistent with the required visibility requirements? Will drivers be aware of the presence of the intersection?		
	Confirm that the standard adopted for provision of visibility in the design is appropriate for the ruling or 85th percentile speed and for any unusual traffic mix.		
	Check that sight lines are not obstructed by:		
	(a) Safety fences and barriers		
	(b) Boundary fences		
	(c) Street furniture		
	(d) Parking facilities		
	(e) Signs		
	(f) Landscaping		
	(g) Bridge abutments.		
	Check that railway crossings, bridges and other hazards are conspicuous.		
	Will sight lines be obstructed by permanent or temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
2 Layout	Check junctions and accesses are adequate for all vehicle movements.		
	Check turning paths to establish that the layout caters for the design vehicles and other road users.		
	Checks safety of any unusual features.		
	Check if heavy truck movements or curvature of the roadway may suggest that the opposing left turn lanes be offset to gain sight distance.		
	Check need for crash attenuators or pedestrian fences.		
	Check need for channelization islands and signs.		
	Check features for visibility intrusion e.g., crash attenuators, pedestrian fences, signs, and traffic signals.		
	Check safety where vehicles (including buses and taxis) may park or service premises within the intersection area.		

Checklist 3-4

Intersections

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
3 Readability by drivers	Will the general type, function, priority rules and broad features be recognized by drivers in adequate time?		
	Check the approach speed and general likely position of vehicles as they track through the project. Is there anything misleading?		
4 Detail of geometric design	Check the layout adopted for traffic safety, compliance with standards or reason for variation, swept paths, ability to handle unusual traffic mixes or circumstances safely.		
	Check that receiving lanes are 12 ft. (3.6m) wide with a 4 ft. (1.2m) outside shoulder, minimum.		
	Check that roadways meet at angles of 90 degrees, and no less than 75 degrees.		
	Check the correctness of the design approach speed and general likely position of vehicles.		
5 Traffic signals	Check visibility of signal head. Can drivers be confused by seeing other signal aspects within the intersection or elsewhere?		
	Check need for high intensity signals, strobes, and/or back plates if likely to be affected by sunrise/sunset.		
	Check if separate signal heads are used to control movements in each lane.		
	Check to see that the protected left turn phase is leading, not trailing.		
	Check markings for left and right turn vehicles.		
	Determine if protected-only phases can be used without an unacceptable reduction in level of service.		
	Check if right-turn-on-red has been prohibited at skewed intersections if angle is less than 75 degrees or greater than 105 degrees.		
	Check if street name signs are included.		
	Check if overhead lane control signs are appropriate.		
	Check need for pedestrian phases and/or protected turning movements.		

Checklist 3-4

Intersections

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
6 Roundabouts and approach islands	Check that deflection angles of approach roads are adequate.		
	Check need for splitter islands.		
	Check that center island is prominent.		
	Check need for hazard markers and markings and that they are correctly located.		
	Check need for dedicated lanes.		
	Check that speeds are not likely to be greater than 50 km/h (or lower in local street).		
	Check that speeds are not likely to be greater than 50 km/h (or lower in local street).		
	Check pole location on central island and nearby curbs.		
7 Other intersections	Check the need for curbed or painted islands and refuges.		
	Check intersection has adequate storage space for turning movements.		
	Check that staggered crossroads can accommodate all vehicle types and movements.		

Checklist 3-5

Special Road Users

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Adjacent land	Check that access to and from adjacent land/properties is safe.		
	Consider the special needs of agriculture, movements of stock.		
2 Pedestrians	Check that fencing is adequate on freeways.		
	Check need to deter pedestrians from crossing road at unsafe locations.		
	Check if raised channelization is used in low speed areas.		
	Check provision for pedestrians to cross safely at:		
	(a) Intersections		
	(b) Signalized and pedestrian crossings		
	(c) Refuges		
	(d) Curb extensions		
	(e) Other locations.		
	Check the following for each crossing (bridges, subways, at grade) as necessary:		
	(a) Visibility		
	(b) Use by disabled		
	(c) Use by elderly		
	(d) Use by children/schools		
	(e) Need for pedestrian fencing on reservations and medians		
	(f) Signs		
	(g) Width and gradient		
	(h) Surfacing		
	(j) Avoidance of channels and gullies		
	(k) Need for deterrent curbing		
	(I) Need for lighting		
	(m) Sited to provide maximum use		
	(n) Can their use be avoided by crossing at grade or elsewhere?		

Checklist 3-5

Special Road Users

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
3 Cyclists	Check needs of cyclists have been considered:		
	(a) At intersections (particularly roundabouts)		
	(b) On roads having speed in excess of 50 km/h		
	(c) Bicycle routes and crossings.		
	Check shared bikeway/footway facilities including subways and bridges are safe and adequately signed.		
4 Equestrians and stock	Check needs have been considered and adequately signed and catered for.		
5 Freight	Check needs have been considered and adequately signed and catered for.		
6 Public Transport	Check that needs have been considered and adequately signed and catered for.		
7 Road maintenance vehicles	Check that needs have been considered and adequately signed and catered for, i.e., crossovers, radii, sight distance concerns, etc.		

Checklist 3-6

Signs and Lighting

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Lighting	Is this project to be lit?		
	Are there difficulties of illuminating sections of the road caused by trees or overbridges, for example?		
	Has the question of siting of lighting poles been considered as part of the general concept of the scheme?		
	Are frangible or slip-base poles to be provided?		
	Are any special needs created by ambient lighting?		
	Are there any aspects of the provision of lighting poles which would require consideration from the safety point of view in their being struck by vehicles (e.g., traffic islands)?		
2 Signs	Are sign structures needed?		
	Are signs located at points to allow adequate readability?		
	Are signs located to limit visibility from accesses and intersecting roads?		
	Are signs appropriate to the drivers needs, i.e., destination signs, advisory speed signs, etc.?		
	Have the safety aspects of signs been considered as part of the general concept?		
	Are there any aspects of the provision of sign posts which would require consideration from the safety point of view in their being struck by vehicles?		
3 Marking and delineation	Check that the appropriate standard of delineation and marking has been adopted.		

Checklist 3-7

Physical Objects

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Median barriers	Are median barriers necessary and have they been properly detailed?		
	Are there any design features such as end conditions which require special attention?		
2 Poles and other obstructions	Are there any poles located adjacent to moving traffic which could be sited elsewhere, (i.e., at the property boundary)?		
	Have frangible or breakaway poles been detailed?		
	Is the unprotected median width adequate to accommodate lighting poles?		
	Check the position of traffic signal controllers and other service apparatus.		
	Are there any other obstructions which are likely to create a safety hazard and can they be mitigated or relocated?		
3 Crash attenuators and guide rail	Is a crash attenuator provided where necessary and is it properly detailed?		
	Are there any features about the design or presence of the crash attenuator which could create danger to any road user, including pedestrians?		
	Are the end conditions of the crash attenuator likely to create a safety problem?		
	Do any guide rail installations restrict sight distance?		
	Is the guide rail designed according to standards: - end treatments - NCHRP 350 requirements - driveway treatments - intersecting road treatments - anchorages - post spacings - block outs - post depths - rail overlaps - minimum unobstructive distances		

Checklist 3-7

Physical Objects

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
4 Bridges and culverts	Check bridge barrier and culvert end walls for:		
	(a) Visibility		
	(b) Ease of recognition		
	(c) Proximity to moving traffic		
	(d) Possibility of causing injury or damage		
	(e) Collapsible or frangible ends		
	(f) The need to be able to see through bridge guard railing for safety purposes		
	(g) Signs and markings		
	(h) Connection of bridge railing to bridge posts		
	(i) Connection of approach barriers to bridge		
	(j) End post transition of stiffness between approach barrier and bridge end post.		

Checklist 3-8

Construction and Operation

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Construct ability	Check that traffic management provisions are adequate during construction period.		
	Check that site access routes are safe.		
	Check need for construction safety zones, including overhead work.		
	Check need for restrictions on any road.		
	Check that law enforcement and other emergency services have been consulted.		
2 Operation	Check 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.		
3 Traffic management	Check that the traffic management of the construction site has been adequately spelled out from the safety point of view, and that the transition from the existing arrangements to the construction site and from the construction site to the final layout can be effected safely, and has been adequately detailed.		
4 Network management	Check that all parking and clearway matters affecting road safety have been considered.		
5 Temporary traffic control and management	Check that the arrangements for temporary traffic control or management, including possible signals, temporary diversions including signing and lighting of the site have been adequately detailed from the safety point of view.		

Checklist 3-9

Project..... ***Other Issues***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Safety aspects not already covered	Safety auditors are to check for any issue or item not already covered.		
	This could include:		
	(a) Unusual events		
	(b) Special effects on land uses alongside		
	(c) Stock being driven onto or along the road		
	(d) The ability of the road to take overweight or over-dimension vehicles or other large vehicles - trucks - buses - emergency vehicles - utility/road maintenance vehicles.		
	(e) The ability to close the road for special events in a safe manner.		
	(f) The special requirements of scenic or tourist routes.		
	(g) Signals not at intersections.		

Checklist 4-1

General Topics

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Changes since Stage 3 and translation of design into practice	Carry out a general check - particularly for matters changed at previous audits.		
	Check the translation of the design into its physical form and any changes that could affect safety.		
2 Drainage	Check drainage of road and surrounds is adequate.		
3 Climatic conditions	Check effectiveness of any facilities put in place to counter climatic effects.		
4 Landscaping	Check that planting and species selection is appropriate from safety point of view.		
	Check for frangibility, visibility and pedestrian safety in particular.		
5 Services	Check that boxes, pillars, posts and lighting columns are located in safe positions.		
	Are they of appropriate materials or design?		
6 Access to property and developments	Check that accesses are safe for intended use.		
	Check on adequacy of design and visibility in particular.		
7 Emergency vehicles and access	Check that provision for emergency vehicle access and vehicles and stopping is safe.		
8 Future widening and/or realignments	If the project is only a stage towards a wider or divided roadway, is the signing and design adequate to impart this message to drivers?		
	Is the transition from two way to divided roadway handled safely?		

Checklist 4-1

General Topics

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
9 Staging of the project	If the project is to be staged or constructed at different times, are the construction plans and program arranged to ensure maximum safety and do they include specific safety measures, signing, also adequate transitional geometry for any temporary arrangements?		
10 Significant adjacent developments	Check effectiveness of screening of adjacent developments and other special features.		
11 Batter treatment	Check that batter treatment will prevent or limit debris falling on to the roadway.		
12 Shoulders and edge delineation	Check that all delineators and pavement markings are correctly in place.		
13 Signs and markings	Check that all signs and pavement markings are correctly in place and that the appropriate signs have been used (i.e., Chevron Alignment Markers, etc.).		
	Check that they will remain visible at all times. Check that old delineation (signs, markings) has been removed, and are not liable to confuse.		
14 Surface treatment, skid resistance	Check all joints in surfacing for excessive bleeding or low skid resistance.		
	Check all trafficked areas for similar problems, Including loose stones.		
15 Contrast with markings	Check that the road markings as installed have sufficient contrast with the surfacing and are clear of debris.		
16 Roadside hazards	Check that no roadside hazard has been installed or overlooked.		
17 Natural features	Check that natural features do not create hazards or loss of visibility: - Trees - Rocks - Ditches - Cut slopes - Embankments - Bodies of water		

Checklist 4-2

Alignment Details

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility, sight distance	Check sight lines are not obstructed by.		
2 New/existing road interface	Check the need for additional signs and/or marking.		
3 Readability by drivers	Check that the form and function of the road and its traffic management are easily recognized under likely operating conditions (e.g., under heavy traffic or poor visibility conditions.)		
	Check the transition between old and new alignment that the road is «readable» and does not create uncertainty at the point of transition.		
4 Treatment at bridges and culverts	Check that all markings and signs are in place and readable.		

Checklist 4-3

Project..... ***Intersections***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility to intersection	Are drivers aware of the presence of the intersection (especially if facing a Stop/Yield sign)?		
2 Visibility at intersection	Check that all visibility splays or parts of the right of way required for visibility are clear for cars, trucks, and vehicles with restricted visibility (e.g., vans, cars towing trailers).		
3 Readability by drivers	Check by driving each approach that the form and function of the intersection is clear to all drivers.		
	Check that the stop/yield line is clear, and that the driver is given sufficient cues to stop before protruding into conflicting traffic.		
4 Traffic signals	Check alignment and general correctness of installation and that all aspects are visible from each approach lane at that appropriate distances.		
	Where right-turn-on-red is permitted and a pedestrian crosswalk is delineated on the intersecting roadway, check if appropriate or if signing can be used to identify potential conflicts.		
	Check that the appropriate lens size is used.		
	Check markings for left and right turning vehicles.		
5 Roundabouts and approach islands	Check that the roundabout or island is fully visible and recognizable from all approaches and that signs, markings, and lighting are correctly in place.		

Checklist 4-4

Non-Motorized Traffic

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Adjacent land	Check fencing is adequate, particularly on roads where pedestrians and animals are not allowed.		
2 Pedestrians	Check the following at all pedestrian facilities:		
	(a) Visibility in both directions. Can pedestrians see and be seen?		
	(b) Signs		
	(c) Surfacing		
	(d) Fencing		
	(e) Operation of other hardware, including lighting		
	(f) Are disabled pedestrians catered for?		
3 Cyclists	Check the following at all cycle ways and facilities:		
	(a) Visibility		
	(b) Signs		
	(c) Surfacing		
	(d) Fencing		
	(e) Operation of other hardware, including lighting.		
4 Equestrians	Check the following at all facilities (or restrictions):		
	(a) Visibility		
	(b) Signs		
	(c) Other special features.		

Checklist 4-5

Signs and Lighting

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Lighting	Check operation and efficiency from safety point of view.		
2 Signs, visibility and positioning	Check visibility, legend or symbol, locations and legibility both during daylight and hours of darkness.		
	Check correct reflectivity or illumination.		
	Check operation of variable message signs.		
	Check need for additional/fewer signs or for signs to be moved.		
3 Passing zones	Check that changes in roadway that reflect necessary changes to passing zones are adequately identified.		
4 Marking and delineation	Ensure that delineation and markings are placed correctly and will remain fully visible.		
	Ensure continuity in delineation type/standard between new and old road sections, or ensure appropriate transition.		

Checklist 4-6

Project..... ***Physical Objects***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Median barriers	Check they are in place and properly marked, where appropriate.		
	Check that they do not limit visibility or form a hazard.		
2 Poles and other obstructions	Check that no poles or obstructions have been missed in other checks, and that potentially dangerous objects are properly marked, or signed or protected by crash barriers.		
3 Crash attenuators and guide rail	Ensure all crash barriers are in place and do not form a hazard.		
	Are there any features about the design or presence of the crash barrier which could create danger to any road user, including pedestrians?		
	Will the crash attenuators and guide rail create sight distance concerns?		
	Are the end conditions of the guide rail likely to create safety problems?		
	Is the guide rail designed according to standards: - end treatments - NCHRP 350 requirements - driveway treatments - intersecting road treatments - anchorages - post spacings - block outs - post depths - rail overlaps - minimum unobstructive distances		

Checklist 4-7

Construction and Operation

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Operation	Check all operating features and ensure that access to them is satisfactorily installed.		
2 Traffic management	Check function of all traffic management devices including readability from moving vehicles.		
3 Temporary traffic control and management	Check all temporary arrangements, signing, etc. have been removed and replaced by final arrangements.		

Checklist 4-8

Project..... ***Other Issues***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Safety aspects not already covered	Drive the site and identify any potential problems not already raised.		

Checklist 5-1

Project..... ***General Topics***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Landscaping	Is landscaping in accordance with guidelines (e.g., clearances, sight distance)?		
	Are required clearances and sight distances not likely to be restricted following future plant growth (landscaping and natural)?		
2 Parking	Are provisions for parking satisfactory in relation to traffic operations and safety?		
3 Temporary works	Are all locations free of construction or maintenance equipment, and any signing or temporary traffic control devices that are no longer required?		
4 Headlight glare	Have any problems due to headlight glare (e.g., two-way service road close to main traffic lanes) been addressed?		

Checklist 5-2

Alignment and Cross Section

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility, sight distances	Is sight distance adequate for the speed of traffic using the route?		
	Is adequate sight distance provided for intersections, crossings (e.g., pedestrian, cyclist, cattle, railway) etc.?		
2 Design speed	Is the horizontal and vertical alignment suitable for the (85th percentile) traffic speed? If not:		
	(a) Are warning signs installed?		
	(b) Are advisory speed signs installed?		
	Are the posted advisory speeds for curves apropriate?		
3 Overtaking	Are adequate passing opportunities provided?		

Checklist 5-2

Alignment and Cross Section

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
4 Readability by drivers	Are there any sections of roadway which may cause confusion e.g.:		
	(a) Is alignment of roadway clearly defined?		
	(b) Has disused pavement (if any) been removed or treated?		
	(c) Have old pavement markings been removed properly?		
	(d) Do streetlight and tree lines conform with the road alignment?		
5 Widths	Are all traffic lanes and roadway widths, including bridges, adequate?		
6 Shoulders	Are shoulder widths appropriate (e.g. for broken down or emergency vehicles)?		
	Are shoulders traversable for all vehicles and road users?		
	Is the shoulder cross slope sufficient to provide proper drainage?		
7 Batter slopes	Are the batter slopes and table drains safe for run off vehicles to traverse?		

Checklist 5-3

Project..... ***Intersections***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Location	Are intersections located safely with respect to horizontal and vertical alignment?		
2 Warning	Where intersections occur at the end of high speed environments (e.g., at approaches to towns), are there traffic control devices to alert drivers?		
3 Controls	Are pavement markings and intersection control signing satisfactory?		
4 Layout	Is the alignment of curbs, traffic islands and medians satisfactory?		
	Is the intersection layout obvious to all users?		
	Are turning radii and tapers appropriate?		
5 Visibility, sight distances	Is sight distance adequate for all movements and all users?		

Checklist 5-4

Auxiliary Lanes and Turn Lines

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Tapers	Are starting and finishing tapers located and aligned correctly?		
2 Shoulders	Are appropriate shoulder widths provided at merges in accordance with design guidelines?		
3 Signs	Is signing and marking installed in accordance with standards?		
4 Turning traffic	Is there advance warning of the approaching auxiliary lane?		
5 Visibility, sight distances	Have right turn movements within the length of the auxiliary lane been avoided?		
	Has stopping sight distance been provided to the rear of turning vehicles?		
	Has stopping sight distance been provided for entering and leaving vehicles?		

Checklist 5-5

Project..... ***Non-Motorized Traffic***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Paths	Are there appropriate travel paths and crossing points for pedestrians and cyclists?		
2 Barriers and fencing	Where necessary, is fencing installed to guide pedestrians and cyclists to crossings or overpasses?		
	Is fencing of your design (e.g., avoid solid horizontal rails)?		
	Where necessary, is crash barrier installed to separate vehicle, pedestrian and cyclist flows?		
3 Bus stops	Are bus stops appropriately located with adequate clearance from the traffic lane for safety and visibility?		
4 Elderly and disabled	Are there adequate provisions for the elderly, the disabled, children, wheelchairs and baby carriages (e.g., holding rails, curb and median crossings, ramps)?		
	Where necessary, are hand rails provided (e.g., on bridges, ramps), and are they adequate?		
	Distance between stop line and pedestrian crossing at signalized intersections (for visibility of pedestrians from truck driver's seat).		
	Signal timing - cycle length - pedestrian clearance time - are pedestrian buttons operable?		
5 Cyclists	Is the pavement width adequate for the number of cyclists using the route?		
	Is the bicycle route continuous, i.e., free of squeeze points or gaps?		
	Are bicycle safe grates provided at drainage pits where necessary?		

Checklist 5-6

Project..... ***Signs and Lighting***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Lighting	Is appropriate lighting installed at intersections, roundabouts, pedestrian and bicycle crossings, pedestrian refuges, etc?		
	Is all lighting operating satisfactorily?		
	Are the appropriate types of poles used for all locations and correctly installed (e.g. slip base at correct height, rigid poles protected if within clear zone)?		
	Are all locations free of any lighting which may conflict visually with traffic signals or signs?		
	Has lighting for signs, particularly overhead signs, been provided where necessary?		
2 Signs	Are all necessary regulatory, warning and direction signs (including detours) in place? Are they conspicuous?		
	Are there any redundant signs?		
	Are traffic signs in their correct locations, and properly positioned with respect to lateral clearance and height?		
	Are the correct signs used for each situation, and is each sign necessary?		
	Are signs placed so as not to restrict sight distance, particularly for vehicles?		
	Are all signs effective for all likely conditions (e.g. day, night, rain, fog, rising or setting sun, oncoming headlights, poor lighting)?		
	Do sign supports conform to guidelines?		

Checklist 5-6

Project..... ***Signs and Lighting***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
3 Marking and delineation	Have retro reflective markers been installed? Where colored markers are used, have they been installed correctly?		
	Is all necessary pavement marking installed?		
	Are pavement markings (center lines, edge lines, transverse lines) clearly visible and effective for all likely conditions (e.g. day, night, rain, fog, rising or setting sun, oncoming headlights, light colored pavement surface, poor lighting)?		
	On light colored pavement surfaces (e.g. concrete) are RRPMs used to simulate traffic lanes?		
	Has raised profile edge marking been provided where necessary (e.g. fatigue zones)?		
	Is delineation adequate and in accordance with guidelines (e.g. post-mounted delineators, RRPMs, chevron alignment markers)?		
	Is delineation effective for all likely conditions (e.g. day, night, rain, fog, rising or setting sun, oncoming headlights)?		
	If chevron alignment markers are installed, have the correct types of markers been used?		
	Are vehicle paths through intersections delineated where required?		
	On truck routes, are reflective devices appropriate to driver's eye height?		

Checklist 5-7

Traffic Signals

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Operation	Are traffic signals operating correctly? Is the number and location of signal displays appropriate?		
2 Visibility	Are traffic signals clearly visible to approaching motorists?		
	Is the end of likely vehicle queues visible to motorists so that they may stop safely?		
	Have any visibility problems caused by the rising or setting sun been addressed?		
	Are signal displays shielded so that they can be seen only by the motorists for whom they are intended?		
	Where signal displays are not visible from an adequate distance, are signal warning signs and/or flashing lights installed?		
3 Other provisions	Where necessary, are there provisions for visually impaired pedestrians (e.g., audio-tactile push buttons, tactile markings)? Are they working?		
	Where necessary, are there provisions for elderly or disabled pedestrians (e.g., extended green phase, phase displacement)?		

Checklist 5-8

Project..... ***Physical Objects***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Clear zone	Is a clear zone provided in accordance with the guidelines?		
	Is the appropriate treatment or protection provided for any objects within the clear zone (e.g., slip-base or frangible poles, crash barrier, crash cushions, sloping culvert, headwalls)?		
2 Crash barriers	Are safety barriers installed at all necessary locations, including on bridges, in accordance with guidelines?		
	Are the crash barrier systems suitable for the purpose?		
	Is the length of crash barrier at each installation adequate? Are the crash barriers correctly installed?		
	Are Guard Rail Energy Absorbing Terminals (GREAT) or crash cushions installed where necessary (e.g., off ramp, bridge piers)?		
	Where works are subject to stage construction, are temporary barriers installed in accordance to guidelines?		
	Is there a safe run off area behind breakaway terminals?		
3 Fencing	Is pedestrian fencing where needed?		
	Is fencing in the clear zone free of separate horizontal rails?		
	Is there adequate delineation/visibility of barriers and fences at night?		

Checklist 5-9

Project..... ***Delineation***

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Line marking	Are all line markings (center line, edge line, transverse lines) in good order?		
2 Guide posts	Are guide posts correctly placed, clean, and visible?		
3 RRPMs	Are RRPM's in good order?		
4 Chevron Alignment Markers	Are Chevron Alignment Markers placed correctly, and used only according to standards?		

Checklist 5-10

Pavement

Project.....

Audit Team Members .....

Date .....

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Pavement defects	Is the pavement free of defects (e.g., excessive roughness or rutting, potholes, etc.) which could result in safety problems (e.g., loss of steering control)?		
2 Skid resistance	Does the pavement appear to have adequate skid resistance, particularly on curves, steep grades and approaches to intersectsion? Has skid resistance testing been carried out where necessary?		
3 Ponding	Is the pavement free of areas where ponding or sheet flow of water may occur with resultant safety problems?		
4 Loose screenings	Is the pavement free of loose screenings?		

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