

GENERAL DIRECTORATE OF HIGHWAYS

ROAD IMPROVEMENT AND TRAFFIC SAFETY PROJECT

TRAFFIC SAFETY PROJECT

**HIGHWAY DESIGN REPORT
Amendments and Changes
in Design Guidelines**

June 2000



Foreword

According to the Terms of Reference of the Traffic Safety Project, SweRoad has made a review of present guidelines and practices for highway design and developed proposals for amendments and changes. The review and the proposals are described in this report, which consists of one main report and five appendices.

The work with highway design has to be continued at KGM. In the longer term perspective, we think it is necessary to develop a set of modern comprehensive design guidelines adapted to Turkish conditions. We hope and believe that the ideas and suggestions in this report can be used when developing these new guidelines. We also think that, in the mean time and after thorough review by a KGM working group, some of the proposals in this report can be used as a basis for interim guidelines.

The report has been prepared by Mr. Rolf Lövkvist, SweRoads's specialist on highway design, in close contact with the design experts at KGM.

SweRoad, Ankara, June 2000

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Summary

Purpose

According to the Terms of Reference and the Technical Proposal for the Traffic Safety Project, the National Road Traffic Safety System shall include a review of guidelines and practices for Highway Design as well as recommendations for amendments and changes. The purpose of this report is to describe the review and to present proposals for recommended amendments and changes.

Traffic safety considerations in road design

As an introduction, the importance of road design and the responsibility of road designers in the efforts to create a safer road network are described. A short background on which safety problems road design should be focused is also given.

Review of existing guidelines and practices

The review of existing guidelines and practices has been made in cooperation with KGM and in four stages; as part of the Pilot Project, identification of design items, discussions in October 1999 and further discussions in January-February 2000.

Proposal for amendments and changes

The recommendations for amendment and changes are divided into three parts:

- Planning and design prerequisites
 - road planning
 - design procedures
- Proposals for new guidelines
 - selection of intersection type
 - modern roundabouts
 - road side areas and guardrails
 - city passings
- Proposed amendments and changes in existing guidelines
 - alignment
 - 3- and 4-way intersections
 - climbing lanes

Continued work

The continued work is suggested to be made in a working group within KGM, composed of representatives from related departments. The objective should be to consider if the present proposals are suitable for Turkey and to adapt the proposed changes to Turkish conditions. The working group should also consider and plan the implementation of the new guidelines.

1 Purpose and contents

1.1 Purpose

According to the Terms of Reference (ToR), the Traffic Safety Project shall include a proposal for a National Road Traffic Safety System in Turkey. In the ToR it is said that SweRoad, within this part of the Project:

“will review the existing methods, standards and directives for application about the activities of the relevant organizations that affect traffic safety directly...”.

In the Technical Proposal, it is suggested that this part shall include a review of guidelines and practices for Highway Design and recommendations for amendments and changes. The scope of the work is described in the Technical proposal, section 3.4.7 Infrastructure.

“ Highway design standards in Turkey appear to meet high international standards. Nevertheless the Consultants will make a review of the present practices aiming at recommending any amendments or changes that could improve the safety standard. It is particularly important that design parameters take into account the special problems of unprotected road users. The review is also suggested to comprise planning procedures and practices.”

Based on the Terms of Reference and the Technical Proposal, SweRoad’s intention has been first to review existing guidelines and practices in cooperation with KGM and then, when a comprehensive overview has been obtained, work out and present preliminary recommendations to be studied and elaborated by KGM.

The purpose of this report is to describe the review and to present proposals for recommendations for amendments and changes.

1.2 Contents

The report contains the following four parts:

Traffic safety considerations in road design

This part is an introduction to show the importance of road design and the responsibility of road designers in the efforts to create a safer road network. It also gives a short background on which safety problems road design should be focused.

Review of existing guidelines and practices

In this part, the cooperation between KGM and SweRoad in the review of existing guidelines and practices is described. The review has been made in four stages; as part of the Pilot Project, identification of design items, discussions in October 1999 and further discussions in January-February 2000.

Proposal for amendments and changes

In this part, recommendations for amendment and changes are described. The proposal is divided into three parts: planning and design prerequisites, proposals for new guidelines, and proposed amendments and changes in existing guidelines.

Continued work

In this last part, the continued work is outlined. This is suggested to be made in a working group within KGM. The first step should be to study and elaborate the recommendations, and the second step to revise and adapt the amendments and changes to Turkish conditions. Eventually, the revised proposals should be included in comprehensive Turkish design guidelines and implemented.

2 Traffic safety considerations in road design

2.1 Introduction

The view on traffic safety and traffic safety work has changed with the development of traffic and the role of road traffic in the society. In the early years of motorization, cars were looked upon as horse drawn carriages. Safety measures were mainly focused on vehicle requirements. The development of technology, especially increased power and speed of motor vehicles, made the comparison with horse-drawn carriages out-of-date. Safety measures were focused on adapting people to this new traffic situation.

Today, the whole transportation system, of which the road traffic system is one part, is contemplated. Safety measures are focused on reducing the exposure of risks, eliminating risk factors and reducing the consequences of accidents. Typical measures are speed limits and separation of motorized traffic from other types of traffic. With this approach, the purpose of traffic safety work in road design is mainly to eliminate the risk factors and mitigate the consequences of accidents.

2.2 Safety responsibility

Research has shown that the human being is an unreliable operator in the road traffic system. The most typical mistakes made by drivers and other road users are common for almost all of them and not limited to only a few. Consequently, sometimes all road users can be expected to make mistakes which can lead to accidents. A road traffic system, in which such common human mistakes lead to fatal and serious injuries, cannot be accepted. Common human mistakes should not lead to catastrophes.

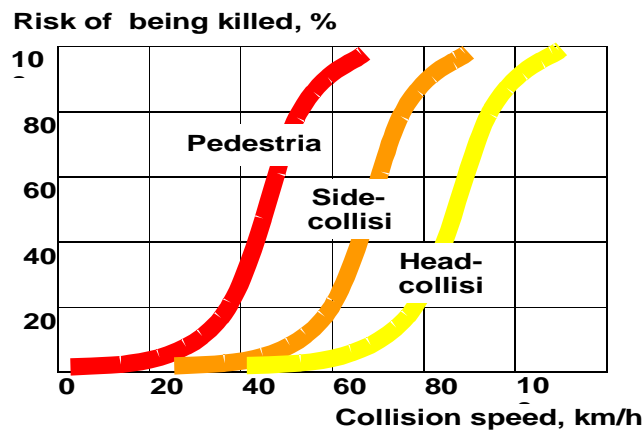
The responsibility for road safety must be shared between the road users and the road transport system providers (mainly road authorities, vehicle manufacturers, legislative, surveillance and enforcement bodies). The road users' responsibility, with minor deviations, is to follow the system requirements. That is to obey the traffic laws and regulations, use available protection equipment and conduct with good judgement and responsibility. The responsibility of the system provider is to provide a road system designed to minimize the risk of accidents and to only allow accidents imposing forces to the human body that can be resisted without serious injuries.

2.3 Injury risks

The risk of being injured or killed in an accident increases considerably with increased speed. In summary, many studies have shown that:

- The number of injury accidents increases with the square of the average vehicle speed.
- The number of fatal accidents increases with the fourth power of the average vehicle speed.

The following diagram shows collision-casualty graphs for the risk of being killed in accidents with different collision speed (“Calm Streets!” The Swedish Association of Local Authorities, 1999). The graph for pedestrians is well supported by research results, while the graphs for car/car collisions are partly based on expert assessments.



The risk of being killed in traffic accidents depending on collision speed

The collision-casualty diagram shows that the risk of being killed increases rather slowly with increased speed up to a speed (different for different types of collisions) where the risk to be killed is around 10 percent and then the risk increases rapidly. The conclusion is that a road transport system should be designed to avoid conflicts at speeds where the risk to be killed is higher than around 10 percent. This means that speeds should not exceed:

- 30 km/h in a **pedestrian/vehicle** collision,
- 50 km/h in a **side-on vehicle/vehicle** or **vehicle/object** collision,
- 70 km/h in a **head-on vehicle/vehicle** or **vehicle/object** collision.

From this, some basic planning and design rules can be derived, for example:

- Vulnerable road users should be separated from motor vehicle traffic.
- At points of conflict between vulnerable road users and motor vehicles, speeds should be low (preferably 30 km/h or lower).
- Intersections should be designed to reduce collision speeds, especially for side-on collisions (preferably to 50 km/h or lower).
- The risk for head on collisions and collisions with rigid objects must be reduced to the greatest possible extent.

However, measures to lower the speed, for example in intersections, are not sufficient. Measures to reduce the risk of conflicts and the consequences of collisions must also be taken. Examples on such measures are: the use of standard type intersections and reducing the number of potential conflict points and the sizes of conflict areas.

2.4 Accidents locations

One basis for the safety efforts in road design should be to consider the accident locations, that is, where on the road accidents occur. In the table below, the relations between location and the number of killed persons on the Pilot Project roads in 1999 are compared with a Swedish study. Vulnerable road users are separated and other accidents are classified according to accident location. The number of fatalities on the Pilot roads was 135 and in the Swedish study the number was 123.

The statistics are not directly comparable since there are differences in the accident reporting systems and the included road types are different. The Pilot Project roads are main roads, while the Swedish study includes all state roads, even the minor roads. That is probably the explanation why the percentage of vulnerable road users is higher in the Swedish study.

	All accidents on Pilot Project roads	Fatalities	
		Pilot project	Swedish study
Vulnerable road users	1%	6%	12%
Intersections	16%	10%	4%
Road side area	52%	30%	26%
Roadway	31%	54%	58%
Total	100%	100%	100%

Relation between fatalities and accident location on Pilot Project roads in 1999 compared with a similar study in Sweden.

The table shows that both in Turkey and in Sweden about one out of four killed persons is killed in the road side area. It also indicates that the safety problems with intersections and the road side areas are bigger in Turkey than in Sweden. Both in Turkey and Sweden more than half of the fatal accidents occurs on the roadway. Most of these accidents are collisions between oncoming vehicles. Such accidents are difficult to decrease with traditional design measures, which is indicated by the fact that the portion of roadway accident is slightly higher in Sweden in spite of an (on the average) higher road standard. In order to decrease accidents with oncoming vehicles, tests with median barriers on two-lane roads have been made in Sweden in recent years.

3 Review of existing guidelines and practices

3.1 Pilot Project

As part of the Black Spot Analysis and the Safety Audit, the design of the Pilot Project roads was studied. In a working group with two representatives from KGM Survey and Design Division and one representative from SweRoad, the following design items were discussed:

- Intersection types
- Roundabouts
- Climbing lanes
- Guardrails
- Cross sections

The working group had three meetings and a seminar on roundabouts, attended by about 15 persons, was held on 1999-04-27.

3.2 Identification of design items

In September 1999, the following design items were chosen to be discussed in cooperation with KGM Survey and Design Department:

1. At grade intersections
2. City passings from vulnerable road users' point of view
3. The road side area
4. Vertical curve and horizontal curve radii
5. Climbing lanes
6. Simple grade separated intersections (interchanges)

3.3 Discussion on design items

3.3.1 October 1999

At eight meetings in October 1999, the chosen design items were discussed between KGM and SweRoad. The purpose was to study the existing guidelines and practices and to identify the need for amendments and changes.

There are no comprehensive modern Turkish guidelines for road design. The basic design is made according to design tables for two lane rural highways (1) and motorways (2). To these tables, some amendments (based on US and German guidelines) have been made. Since all design items are not covered by these design tables and amendments, the design is sometimes made according to non-documented principles, partly based on different foreign guidelines.

The following documents were presented to SweRoad:

- Geometric standards for two lane rural highway. (1983)
(Karayolu geometrik standartları)
One sheet with design standard values.
- Geometric standards for motorways. (No date)
One sheet with design standard values.
- Intersection Types. (1997)
(Kavşak Tipleri)
Selection and detailed design of intersection and interchanges.
- Guardrail Notes. (1997)
(Otokorkuluk Notları)
Use and design of guardrails and crash cushions.

A work to prepare new guidelines based on recent AASHTO standards has been started. So far, no documents from this work have been shown to SweRoad. Based on the discussions, the following suggestion for the continued work was made:

- Type solutions should be prepared by SweRoad in cooperation with KGM for:
 1. design of roundabouts,
 2. design of the road side area,
 3. design of cross sections for city passings.
- SweRoad and KGM should together further review the guidelines concerning:
 4. type drawings for 3- and 4-ways intersections,
 5. the use of guardrails as alternative to a clear zone,
 6. stopping sight distances and horizontal and vertical curve radii,
 7. the use of climbing lanes.
- SweRoad and KGM should together develop:
 8. a method for type selection and design of intersection.

The previous report, "Traffic Safety Strategy – Highway Design, Studies on Design Items 4-20 October 1999" (November 1999) was reviewed by KGM, Survey and Design Department. Some remarks were given on the description of the present design practices and procedures concerning, for example, the use of type intersections and guardrails. Some requests for Swedish examples, for instance, for city passings and type intersections, and for clarifications, for example, of the clear zone concept, were also made.

3.3.2 January-February 2000

The work was continued in January 2000. SweRoad's intention was to, parallel to the preparation of the proposals (items 1-3 and 8 above), continue with the review (items 4-8 above), following the recommendations from October 1999 and the comments made by KGM. In order to carry out the further review, it was suggested to work in a smaller group with three to four persons, but KGM wanted to continue with presentations open to all personnel at the Survey and Design Department.

For the review, two meetings (February 1 and 4) were agreed upon. For these meetings SweRoad prepared a list of questions. KGM was asked to bring any other guidelines than those previously shown and to bring examples on existing and planned projects on at-grade

intersections and city passings. Specific questions were asked concerning the following items:

- At-grade intersection
- Road side objects and guardrails
- Climbing lanes
- City passings
- Sight distances

A draft report with the following preliminary proposal was submitted to KGM, dated March 2000, including:

- | | |
|-----------------------------------|--|
| Planning and design prerequisites | - road planning
- design procedures |
| Proposals for new guidelines | - selection of intersection type
- modern roundabouts
- road side areas
- city passings |
| Comments to existing guidelines | - alignment
- 3- and 4-way intersections
- climbing lanes |

3.3.3 May-June 2000

After studying the draft report the KGM Survey and Design Department made some comments and suggestions for changes and amendments. The comments were discussed in two meetings. After the meetings the draft report was completed with mainly the following:

- Diagrams for selection of intersection types as an attachment to Appendix 1.
- Summary of the Swedish guidelines for guardrails in Appendix 3.
- Turkish and Swedish examples of city passings in Appendix 4.
- Summary of the Swedish guidelines for climbing lanes as an attachment to Appendix 5.

The final proposals were presented in a seminar at KGM 2000-06-09 attended by about 20 persons mainly from the Survey and Design and Maintenance Departments. At the seminar, wishes for Swedish standard drawings and examples of constructed and planned projects were put forward.

4 Proposal for amendments and changes

4.1 Introduction

4.1.1 Selection of design items

The selection of design items for which amendments and changes should be proposed is based both on the need for changes and the importance to traffic safety of different items. The need for changes was noticed in the review of present guidelines and practices described in chapter 4. The evaluation of the importance to safety of different design items is mainly based on experiences supported by accident statistics, exemplified in chapter 3.

4.1.2 Contents

It is evident that there is a great need for modern road design guidelines based on Turkish conditions. It is, however, also clear that some of the safety problems related to road design are due to lack of general safety principles for road planning. In addition to suggestions for amendments in the design guidelines, the proposal includes some suggestions for safety considerations in road planning. The proposals are divided into three parts:

Planning and design prerequisites	- road planning - design procedures
Proposals for new guidelines	- selection of intersection type - modern roundabouts - road side areas and guardrails - city passings
Proposed amendments and changes in existing guidelines	- alignment - standard intersections - climbing lanes

4.1.3 Restrictions

Focus on safety

The proposed amendments and changes are focused on safety aspects in road design. In addition to this, there are a number of aspects and details to be considered in the preparation of complete guidelines. Consequently, the proposals are, according to the Technical Proposal, presented as recommendations from a safety point of view and not as complete guidelines, worked out in all details. The procedure to prepare detailed, complete guidelines is too extensive to be included in the Traffic Safety Project. This work also includes a number of technical, organizational and economic considerations which must be handled by KGM.

Need of adaptation to Turkish conditions

The proposals are mainly based on Swedish and international guidelines and experiences which may not be directly transferable to Turkey. The examples are mainly from Sweden, since it has been difficult to obtain sufficient Turkish examples. There are, however, many differences in traffic composition, driver behaviour, urbanization rate and terrain

conditions etc. between Turkey and Sweden. Consequently, all suggestions must be adapted to Turkish conditions.

4.2 Planning and design prerequisites

4.2.1 Road planning

Introduction

All safety problems related to the traffic environment cannot be solved by road design. Safe crossings for pedestrian and local traffic can, for example, be difficult to arrange if the road cuts through a village or residential area with many activities on both sides of the road. In many cases this is more of a planning problem than a design problem.

Road classification

Based on our experience so far, it seems as if very little attention to traffic safety is paid in road design. Sometimes not even the traffic volume is considered. One reason for this lack of attention to safety and traffic demand is probably that the decision on road standard is primarily based on an administrative classification of roads (motorways, state roads and provincial roads). According to our opinion, the basis for standard decision and design should rather be a functional road classification than an administrative one.

One reason for this is that the road design should be adapted to the road users' expectations, since the drivers' response is often to the expected situation rather than to the actual situation. If the actual condition differs from the expected, the drivers' decision can be delayed or wrong. To avoid such mistakes, the design should be consistent with what the driver expects and is willing to accept.

One example of the use of a functional classification is the selection of intersection type. The acceptability of at-grade intersections and/or traffic control measures (stop or yield control) should preferably be related to the road function. For some important roads, at-grade intersections or traffic control measures may not be acceptable. A *functional classification* of the road network is then needed to be able to choose the intersection type.

It is, therefore, suggested that a functional classification of Turkish roads should be developed. This could, for example, be based on the administrative units (İl, İlçe, Bucak and Köy) the road connects. A draft to such a functional classification is shown in the table below.

Administrative classification	Functional classification	Connects....	with.....
State road	State road, type I	Province (İl)	Province (İl)
	State road, type II	Province (İl)	District (İlçe)
Provincial road	Provincial road, type I	District (İlçe)	District <u>or</u> Town <u>or</u> Village (İlçe <u>or</u> Bucak <u>or</u> Köy)
	Provincial road, type II	Town <u>or</u> Village (Bucak <u>or</u> Köy)	Town <u>or</u> Village (Bucak <u>or</u> Köy)

Draft functional classification of Turkish roads

4.2.2 Design Procedures

Safety audit

It is important that safety aspects are considered in the planning as well as in all design phases. One way to assure this, is to introduce safety audits for planned roads in the planning and design phases. A suggestion for a safety audit was made in the report “Road Traffic Safety Audit of Planned Projects” submitted to KGM, Maintenance Department, Traffic Division in September 1999. In the report, it was assumed that the planning and design process was divided into at least two stages with different purposes.

1. Preliminary Design (Feasibility Study)		
A General Project Data		
1	Project layout	
2	Design criteria	
B Geometric Design		
3	Alignment	
4	Cross section	
5	Intersections	
6	Interchanges	
7	Road side facilities	
8	Facilities for pedestrians and other road users	
		2. Final Design (Project Plan)
		C Geometric Design
		1 Alignment
		2 Cross section
		3 Intersections
		4 Interchanges
		5 Road side facilities
		6 Facilities for pedestrians and other road users
		D Road Equipment
		7 Guardrails and fences
		8 Signs
		9 Markings and Delineation
		10 Road Lighting

Suggested Road Traffic Safety Audit

In the *preliminary design*, the purpose of the audit is to identify safety problems that must be or are best solved by major changes in the project. Such changes could be relocation of the road, change of road standards or a redesign of the local road network. The audit should also be part of the evaluation of alternatives studied in the preliminary design.

In the *final design*, the purpose of the audit is to check the safety aspects as shown in a project plan or similar. For some items, this can be done by checking the fulfillment of standards, guidelines and practices. Often there are optional solutions to design problems. The audit should help to choose the best solution from a safety point of view.

The implementation of a safety audit requires cooperation between all parties engaged in the planning and design procedure. For example, the decision on the location of the road made in the earlier stage of project planning can be of great importance for the possibilities for safe design of the road network for local traffic and pedestrians. It is also important that, for example, the use of guardrails, which is often decided too late in the detailed design, is coordinated with the cross-section design. Referring to KGM, this means that not only the Survey and Design Department but also the Planning, Construction and Maintenance Departments should take part in the safety work at the design stage.

It is important that there is a close cooperation between different bodies involved (e.g. KGM Departments), and that the safety work is accomplished by personnel with appropriate training and knowledge. It is suggested that a review of the organization of the safety work related to highway design is made within KGM. However, such a review

requires good knowledge of present organization, procedures and work distribution and lies mainly outside this Traffic Safety Project.

4.3 Proposals for new guidelines

The proposals for new guidelines are presented in Appendix 1-4. In this report, only short descriptions of the contents are included.

4.3.1 Proposed principles for selection of intersection type

The proposal includes:

- Classification of at-grade intersections
- Proposal for a model for the selection of at-grade intersection type
- Examples based on Swedish selection criteria
- Diagrams for selection of intersection type

4.3.2 Proposed design principles for modern roundabouts

The proposal includes:

- General description of modern roundabouts
- Proposal for design principles for modern roundabouts
- Examples of Swedish standard drawings

4.3.3 Proposed design principles for road side areas and guardrails

The proposal includes:

- Description of the road side safety problem
- General design principles
- Proposal for design principles
- Swedish guidelines for guardrails

4.3.4 Proposed design principles for city passings

The proposal includes:

- Description of the safety problems related to city passings
- General design principles
- Proposal for design principles
- Turkish and Swedish examples

4.4 Proposed amendments and changes in existing guidelines

The proposals for amendments and changes in existing guidelines are presented in Appendix 5. In this report, only short descriptions of the contents are included.

4.4.1 Alignment

It is suggested that the requirements are revised for the following design parameters:

- Sight distances
- Horizontal curve radii
- Vertical crest curve radii
- Vertical sag curve radii

4.4.2 Standard intersections

The following amendments and changes are proposed:

- Systematic use of standard intersections
- Restrictive use of right turn lanes
- Longer widenings for extra lanes

4.4.3 Climbing lanes

It is suggested that:

- AASHTO guidelines are revised and adapted to Turkish conditions.

5 Continued Work

5.1 Revision of the proposed amendments and changes

The first step in the continued work should be to study and elaborate these proposals. This is suggested to be made in a working group within KGM with representatives from concerned departments. The objective should be to consider if the proposals are suitable for Turkey and what could be changed or added.

The following are examples of what should be checked:

- Concerning proposed principles for selection of intersection type:
 - Model design
 - Policy for applicability of at-grade intersections
 - Policy for applicability of control intersections
- Concerning proposed design principles for modern roundabouts
 - Policy for the use of roundabouts
 - Basic design
 - Detailed design
- Concerning proposed design principles for road side areas and guardrails:
 - Widths of the clear zone
 - Road side types A-C

- Design of the road side area
- Policy for the use of yielding supports
- Concerning proposed design principles for city passings:
 - Classification of city passings
 - Design criteria
 - Standard cross sections
 - Use of speed control measures

5.2 Adaptation to Turkish conditions

The second step should be to adapt the proposed changes to Turkish conditions. This must probably be made in steps. Some of the needed adaptations can hopefully be made in a rather short period of time, while other adaptations probable will take a longer time.