GENERAL DIRECTORATE OF HIGHWAYS

ROAD IMPROVEMENT AND TRAFFIC SAFETY PROJECT

TRAFFIC SAFETY PROJECT

SAFETY AUDIT HANDBOOK

Final Report
December 2001

SWEROAD

Foreword

Safety audit is a method for improving the safety of existing and new roads which was introduced in the late 1980's in Great Britain. In principle, the method implies that a small team of safety specialists systematically examine either an existing road section or a plan of a new road in order to identify accident risks. After this, a plan for the elimination of the observed deficiences is prepared and implemented. The method has turned out to be very effective and has been spread to many countries.

This report is a first handbook for KGM on how to conduct safety audits on existing and new roads. Over time, and especially when more knowledge and experience have been gained, and when new design and equipment guidelines have been published, the handbook will need to be revised.

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Ankara, December 2001

Karl-Olov Hedman
Team Leader

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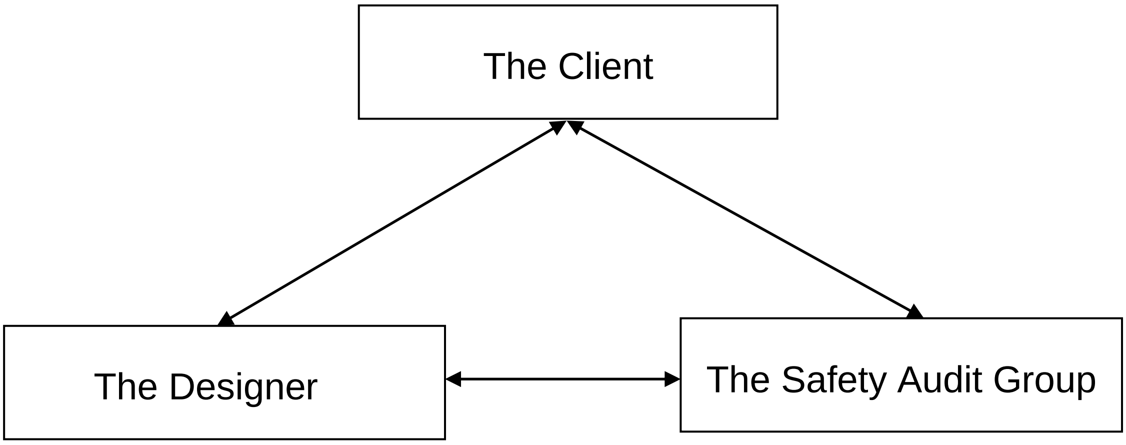
1 Introduction

Safety audit is a relatively new method for improving traffic safety. It was introduced in Great Britain and some other countries in the late 1980's. In Sweden, this method has been used for more than five years.

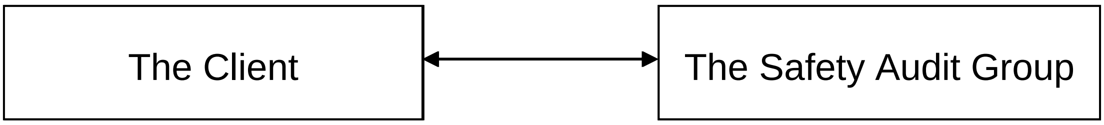
By using this method it is possible to identify and locate hazards, obstacles and deficiencies along an existing road. It is also possible to identify details in the design of a new project, which might have a negative effect on traffic safety.

A safety audit is a systematic examination or inspection of a planned road project or an existing road from a safety point of view. The audit should be done in a group with cooperation between different professionals. Normally, the group should consist of one traffic engineer, one designer and – particularly in urban areas - one behavioral expert. The examiners should not have been involved in the design of the project, that is, they should be able to look at the project with "fresh", impartial eyes.



In the chart above the relations between the different bodies in a safety audit of a planned project are illustrated.

For a safety audit of an existing road there are only two bodies involved.



The client, which is normally one of the regions within KGM, has the overall responsibility for the project, that is traffic safety, accessibility, level of service, environmental effects, etc.

The designer, often a consultant or a construction company appointed by KGM, prepares the project drawings according to the existing standards.

The safety audit group, which can be formed by people from another region, from the

KGM Headquarters or from an independent consultant, checks the project drawings or an existing road from the safety point of view.

During the checks, the proposed or existing design, is compared with the standard given by the guidelines.

If the safety audit group finds some deficiencies from the safety point of view, they discuss the design with the designer. If they cannot agree on an acceptable solution, the client has to make the final decision about the design.

A safety audit can be carried out in different phases. For planned projects, it could be carried out during the Preliminary Design Phase (Feasibility Study) and during the Detailed Design Phase (Project Plan). It can also be carried out after the completion of the construction work but before the road is opened for traffic. For existing roads, it could be carried out during any phase, for example, as a part of an analysis of an accident prone road section. For road works, during reconstruction or improvements, the temporary traffic solutions can be examined before they are installed.

Planned Projects	Existing Roads
1. Preliminary Design	
2. Detailed Design	
	3. Black Spots or accident prone road sections
4. Road works	4. Road works

Most kinds of existing or future roads or other traffic projects can be examined. For example, all proposals of black spot improvements should be examined by a safety audit group, before approval.

In this brief handbook, the methodology of safety audits is described. Together with the attached checklists it can be used as help or as support. However, the most important factor is the experience of the persons in the safety audit group.

The handbook is divided into two parts. The first part is for planned projects and the second part for existing roads. In each part an action plan for the audit is presented. The action plan for planned projects follows the steps given in the checklists. For each step, some comments are given about important issues to be considered.

2 Planned projects - safety audit action plan

Safety audits of planned projects should be made at each stage of the planning and design process. Normally this means at least on two different occasions; at the end of the preliminary design (Feasibility Study) and at the end of the detailed design (Project Plan).

The proposed contents of the two audit steps is shown in Table 1.

The geometric design is reviewed in both audits. In the Preliminary Design Safety Audit, the review is concentrated on general aspects, such as the choice of road width and the location of intersections. In the Detailed Design Safety Audit, the review includes more details, such as curve radii and crossfall.

Table 1. Safety audit of planned projects

	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	Roadside facilities
8	Facilities for pedestrians and other vulnerable road users

	2. Detailed Design *(Project Plan)*
C	**Geometric Design**
1	Alignment
2	Cross section
3	Intersections
4	Interchanges
5	Roadside facilities
6	Facilities for pedestrians and other vulnerable road users
D	**Road Equipment**
7	Guardrails and fences
8	Signs
9	Markings and delineation
10	Road lighting

2.1 Preliminary design phase - general

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 redesign of the local road network. A feasibility study often includes different alternatives, for example different road locations or different road standards. The safety audit should then be a part of the evaluation of those alternatives.

The basis for the audit should be a report from a feasibility study, or similar. The report should include both a written description and drawings. The text should contain general information on the project, such as planning conditions and design criteria. Detailed drawings are usually not available. However, drawings showing the general design principles, such as an overview of the horizontal and the vertical alignments, and location and type of intersections, are needed.

An overview of the contents of the Preliminary Design Safety Audit is shown in the tables below. The full extent is shown in checklist 1 in Appendix 1.

2.2 Preliminary design phase - general project data

The audit of the general project data should be performed at an early stage of the planning process, normally at the end of the feasibility study. If a Preliminary Design Safety Audit is not performed, the audit of general project data should be the first part of the Detailed Design Safety Audit.

Table 2. Preliminary design phase - general project data

General Project Data	
Project layout	• Road function and road standard • The extent of the project • Local roads • Pedestrians and other vulnerable road users • Roadside facilities
Design criteria	• Design speed and road standards • Traffic forecast and road standards

The audit of general project data should include the following:

2.2.1 Project layout

Road function and road standard

- Determine the road function. What kind of traffic uses the road - long distance traffic, regional traffic and/or local traffic?
- Do pedestrians and bicyclists also use the road? Are they separated from motor traffic?
- Is the standard of the new road adapted to the road function?

The extent of the project

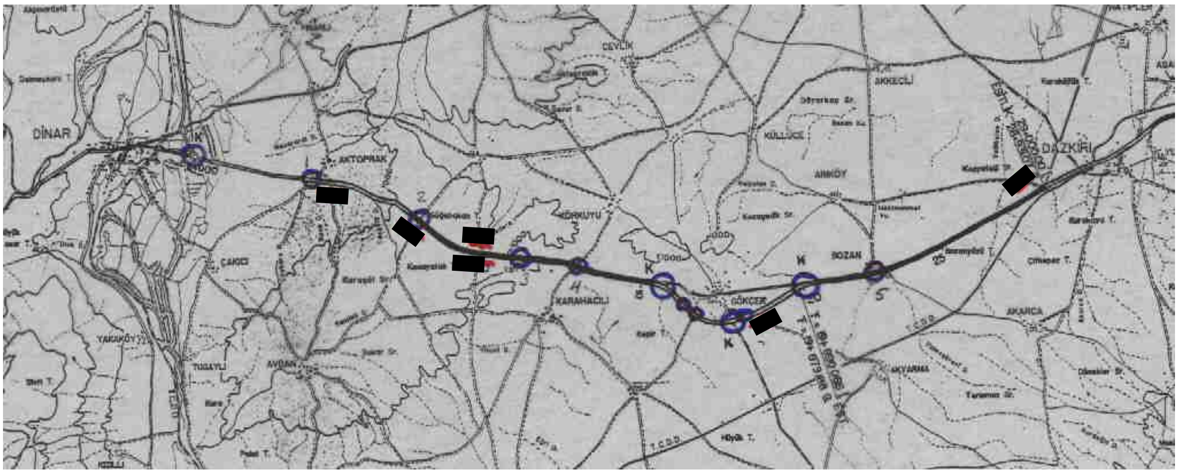
- Are the end points of the project suitably chosen?

Local roads

- Are solutions provided for local traffic?
- Is the local road network adapted to the project?

This means that the number of accesses or intersections should be minimized by connecting local distributors to a limited number of intersections.

In the drawing below, the circles indicates intersections in the new road, the strokes indicate local roads that will be closed.



Pedestrians and other vulnerable road users

- ❑ Are solutions provided for pedestrians and other vulnerable road users?

If pedestrians are expected to walk along the road or to cross it, sidewalks, separate walking-lanes and pedestrian crossings should be provided.

Roadside facilities

- ❑ Are solutions provided for roadside facilities?

When reconstructing an existing road, there might be some facilities along the road already, for example, petrol stations or restaurants. The new entrances and exits should be included in the project. (Even if the owner of the facility has to pay for it.)

2.2.2 Design criteria

Design speed and road standard

- ❑ Does the design speed correspond to the road function?
- ❑ Does the road standard correspond to design speed?

The design speed and the road standard should correspond to the road function. This means that, for example, for a national road the design speed should be 90 km/h, there should not be any local accesses, and pedestrian and other vulnerable road users should be separated from the motor traffic, etc.

Traffic forecasts and road standard

- ❑ Is a traffic forecast made for the road?
- ❑ For what time period is the traffic forecast made? Usually it should be 20 years.
- ❑ Is the annual traffic growth reasonable? (Turkish traffic growth has normally been about 5% per year.)
- ❑ Does the road standard correspond to the expected traffic volume?
- ❑ If there is a 4-lane section in the project, is the traffic volume large enough to justify such a cross-section?

2.3 Preliminary design phase - geometric design

Table 3. Preliminary design phase – geometric design

Geometric Design	
Alignment	• horizontal alignment • vertical alignment • alignment consistency
Cross section	• roadway elements • roadside elements
Intersections	• number and distances between accesses • capacity and sight • geometric design • signalized intersections
Interchanges	• need of interchanges • location of interchanges
Roadside facilities	• requirements • location
Facilities for pedestrians and other vulnerable road users	• requirements • location

The audit of geometric design should include the following:

2.3.1 Alignment

Horizontal alignment

- ❑ Does the radius exceed the minimum value for the design speed in all horizontal curves?

Design Speed	Sweden		Turkey
km/h	High standard	Low standard	-
60	-	**-**	**150**
70	300	**200**	**200**
80	400	**300**	**250**
100	600	**500**	**400**

Comparison between Swedish and Turkish requirements for minimum horizontal curve radii (m)

Vertical alignment

- ❑ Does the vertical radius exceed the minimum value for the design speed in all vertical curves, crest curves as well as sag curves?
- ❑ Does the longitudinal grade comply with the specified maximum and minimum?

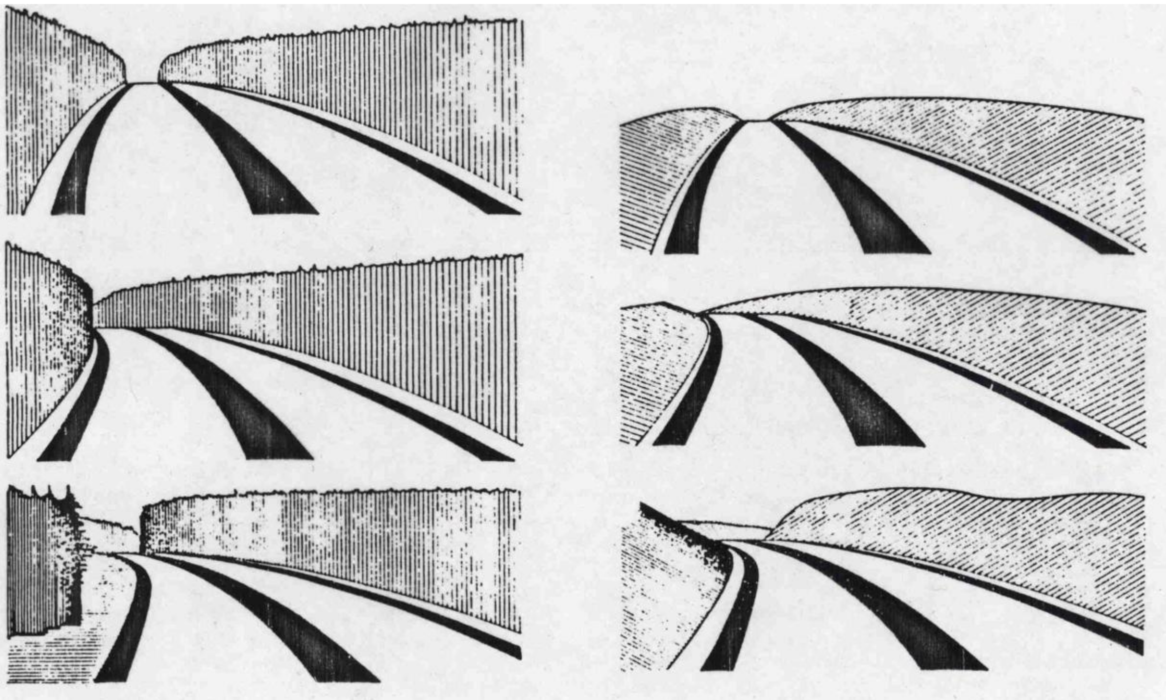
Design Speed km/h	Sweden		Turkey	
	High standard	Low standard	High standard	Low standard
60	-	**-**	**1 000**	850
70	3 000	**1 800**	**1 650**	1 150
80	5 000	**3 000**	**2 500**	1 500
100	11 000	**7 000**	**6 100**	3 200

Comparison between Swedish and Turkish requirements for minimum vertical crest curve radii (m)

Alignment consistency

- ❑ Are there any horizontal curves hidden behind vertical crest curves?

Compare the location of vertical and horizontal curves. For example, a horizontal curve should not start immediately after a vertical crest.



Examples of optical (visual) guidance.

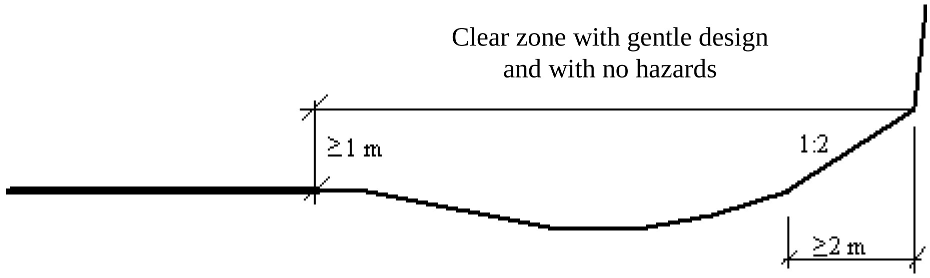
2.3.2 Cross section

Roadway elements

- ❑ Does the number of lanes correspond to the expected traffic volume? See above under "Traffic forecasts and road standard".
- ❑ Are climbing lanes provided where required?
- ❑ Are locations of changes in number of lanes and/or road width suitably chosen? For example changes in the cross section should not start short after a vertical crest.
- ❑ Are there any changes in the number of lanes and/or road width at the start/end points of the project? If there are, are the locations suitably chosen?

- Is the width of the median sufficient, that is, is it wide enough to avoid vehicles to run over it? If not, are guardrails provided?

Roadside elements
- Is a clear roadside area (safety-zone) provided? This includes the shape of the side slopes and existence of hazardous obstacles. If not, are guardrails provided?



Typical design of the clear zone

2.3.3 Intersections

Number and distances between accesses
- Do the number of and distances between intersections correspond to the road standard? If the number is too low, the traffic volumes on local roads will be too high. If the number is too high, there will be too much local traffic on the main road.
- Do the types of intersections correspond to the road standard?
- Is the location of each intersection suitable? Intersections should not be located close to crest-curves or horizontal curves with small radii.

Capacity and sight
- Does each intersection provide adequate capacity to handle peek period traffic demand?
- Is the number of lanes for different movements suitable? (Not too few – due to capacity. Not too many – due to complexity and speed.)

Geometric design
- Are required lanes for left turning provided?
- Are facilities for pedestrians and bicyclists provided where such are needed?

Try to find out the number of turning vehicles and if there are significant numbers of pedestrians and bicyclists.

Signalized intersections
- Are required traffic signals provided to handle capacity or for safety reasons.

2.3.4 Interchanges

Need of interchanges
- Has the need for grade separated interchanges been examined? This depends on the traffic flow.
- Are required interchanges provided?

Location of interchanges
- Are the locations of interchanges suitable?

2.3.5 Roadside facilities

Requirements
- Are there any bus stops, rest areas and service stations required?
- If required, are bus stops, rest areas and service stations provided?

Location
- Are the locations of each facility suitable?

On a national high speed road, bus-stops should be provided in the form of lay-bys. Parking areas, rest areas and service stations enable drivers to make short stops without stopping on the road.

2.3.6 Facilities for pedestrians and other vulnerable road users

Requirements
- Are facilities for pedestrians and other vulnerable road users required? See above about the need of such facilities.
- Are the required facilities provided?

Location
- Are they suitably located? At grade crossings should be located where the speed is low.

2.4 Detailed design phase - general

The purpose of the audit in the detailed design phase is to check the safety aspects of the final design as shown in a Project Plan or similar. For some items, this can be done by checking the accordance with standards or guidelines. For other items the check has to be made according to practices or the experience of the safety audit group.

A problem in Turkey is that there are no comprehensive standards or guidelines. Therefore, some examples from Swedish guidelines are included in the handbook, where Turkish guidelines are missing.

Often there are alternative solutions to many design problems. The audit should help to chose the best solution from the safety point of view.

The Detailed Design Safety Audit is mainly a review of drawings. Drawings showing the following should be available:

Geometric Design

- Horizontal alignment
- Vertical alignment
- Cross sections
- Design of intersections
- Design of interchanges
- Roadside facilities

Road equipment

- Guardrails and fences
- Signs and signals
- Marking and delineation
- Road lighting

An overview of the contents of the Detailed Design Safety Audit is shown in the tables below. The full extent is shown in checklist 2 in Appendix 2.

2.5 Detailed design phase - geometric design

The audit of geometric design should be made at the end of the detailed design phase but before it is too late to make any changes in the design.

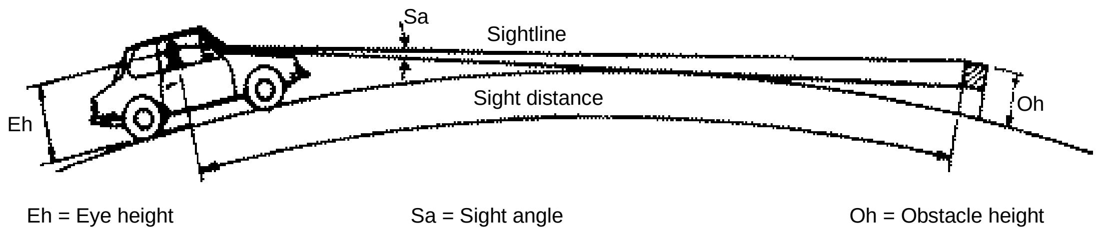
Table 4. Detailed design phase – geometric design

Geometric Design	
Alignment	• sight distance • horizontal alignment • vertical alignment • alignment consistency
Cross section	• roadway elements • roadside elements
Intersections	• number and distances • capacity and sight • geometric design • signalized intersections
Interchanges	• location • sight distance • exit and entry design
Roadside facilities	• location • exit and entry design
Facilities for pedestrians and other vulnerable road users	• location • access • design

The audit of geometric design should include the following:

2.5.1 Alignment

Sight distance



Definition of stopping sight distance

- ❑ Is enough stopping sight provided in all horizontal and vertical crest/sag curves regarding the design speed?

Suggested stopping sight distances (m) on a horizontal road.

	Standard		
Design speed (km/h)	Good	Acceptable	Poor
70	110	100	85
90	165	150	135
110	235	215	195

Check also if there is a need of sight clearance outside the road in horizontal curves, such as cutting down trees or widening the slope cutting.

Horizontal alignment

- ❑ Does the radius exceed the minimum value for the design speed in all horizontal curves?
- ❑ Is the tangent between reversing curves long enough to provide an acceptable super-elevation transition?

Suggested minimum horizontal radius (m) to provide enough stopping sight distance.

	Standard		
Design speed (km/h)	Good	Acceptable	Poor
70	300	250	200
90	500	450	400
110	800	700	600

Vertical alignment

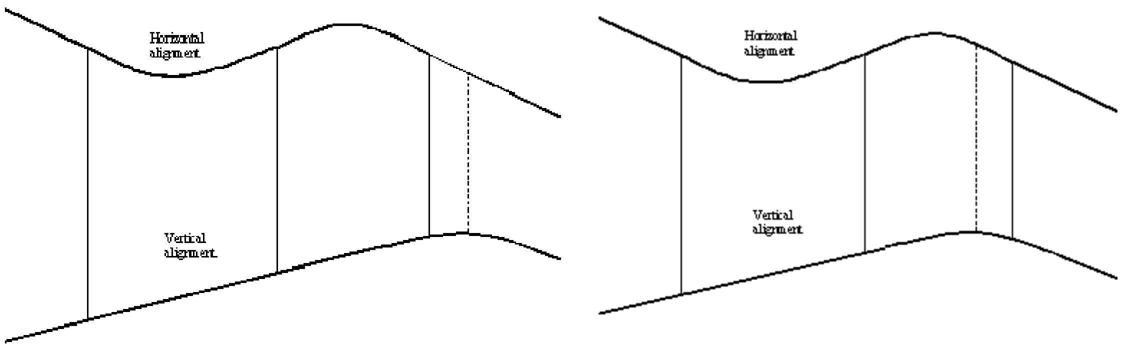
- ❑ Does the vertical radius exceed the minimum value for the design speed in all vertical curves, crest curves as well as sag curves?
- ❑ Is the length of each vertical curve suitably chosen? (This item is mainly related to comfort but has an indirect influence on safety.)
- ❑ Does the longitudinal grade comply with the specified maximum and minimum?

Suggested minimum vertical radius (m) to provide stopping sight distance in crest curves.

	Standard		
Design speed (km/h)	Good	Acceptable	Poor
70	3000	2300	1800
90	7000	6000	5000
110	16000	13000	11000

Alignment consistency

- ❑ Are there any longitudinal curves hidden behind vertical crest curves?



In the picture above, the left example has a horizontal curve starting after the vertical crest when driving from the right to the left. In the right example the horizontal curve will start before the crest. Then the optical/visual guidance will be improved.

2.5.2 Cross section

Roadway elements

- Do the number of lanes provide adequate capacity?
- Are climbing lanes provided where required?
- Are the widths of the lanes according to standards?
- Are locations of changes in number of lanes and/or road width suitably chosen? Also at the start/end points of the project?
- If there are changes in number of lanes and/or road width, is the number of changes in accordance with the road standard?
- Are the widths of the shoulders according to standards?
- Are vertical drops between driving lanes and shoulders avoided?
- Is the width of the median enough? If not, are guardrails provided?
- Are median openings safely designed?
- Does the width of the median, close to the opening, provide enough space for a waiting vehicle?

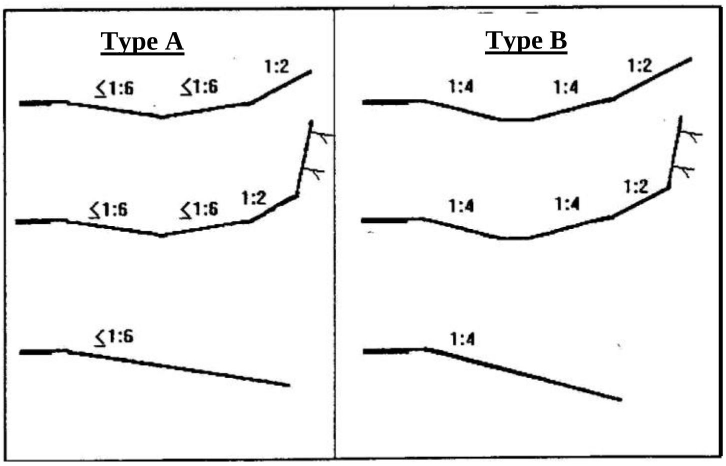
Roadside elements

- Is a clear roadside area (safety-zone) provided?
- Are cut slopes (including rock cuts) safely designed?
- Are fill slopes safely designed? If not, are guardrails provided?

Suggested width of the safety zone (m) measured from the outer edge of the shoulder.

	Standard		
Speed limit (km/h)	Good	Acceptable	Poor
50	>3	<3	
70	>7	>3	<3
90	>9	>4,5	<4,5
110	>10	>6	<6

Shape of the safety zone according to Swedish guidelines.



Type A = good standard. Should be applied on national roads with design speed 90 km/h or more.

Type B = acceptable standard. Could be applied on national roads with design speed 70 km/h and on other roads depending on traffic volume.

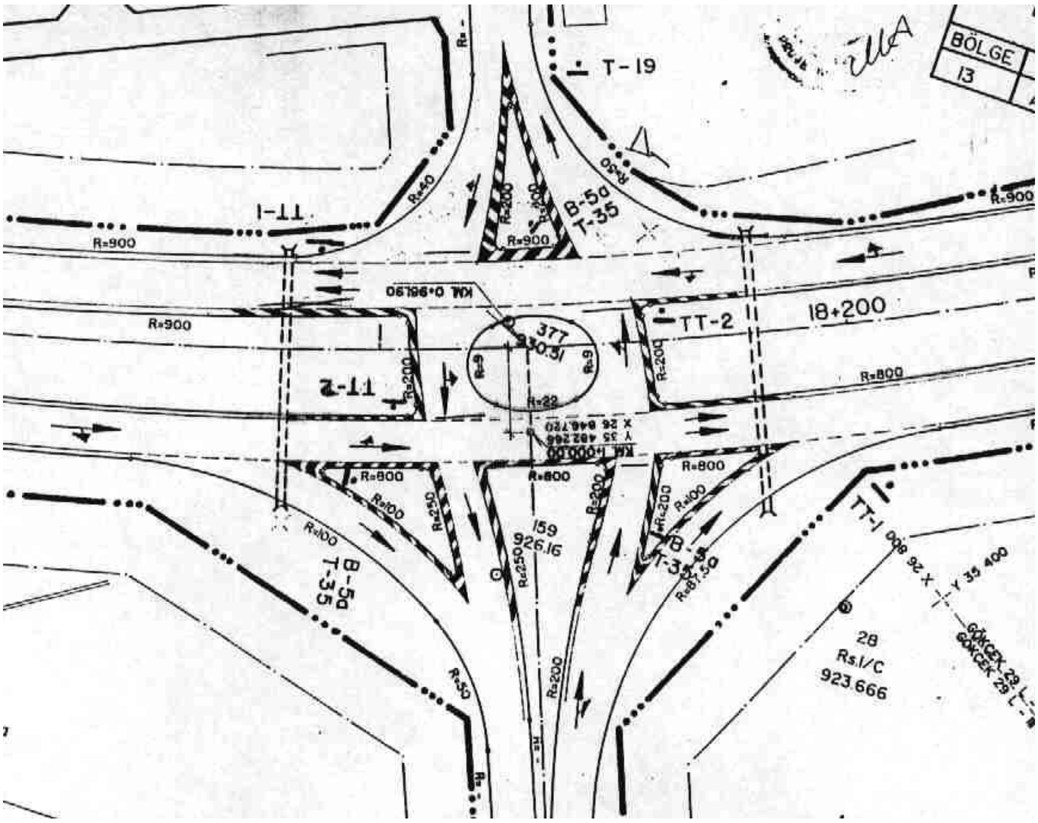
2.5.3 Intersections

Number and distances

- Do the number of and distances between intersections correspond to the road standard?
- Do the types of intersections correspond to the road standard?
- Is the location of each intersection suitable?

Capacity and sight

- Does each intersection provide adequate capacity to handle peek period traffic demand?
- Is the number of lanes for different traffic movements suitable? (Not too few – due to capacity. Not too many – due to complexity and speed.)
- Is required sight distance along the main road for each intersection provided?
- Is required sight distance along the connecting road to each intersection provided?
- Is the required visibility area provided?

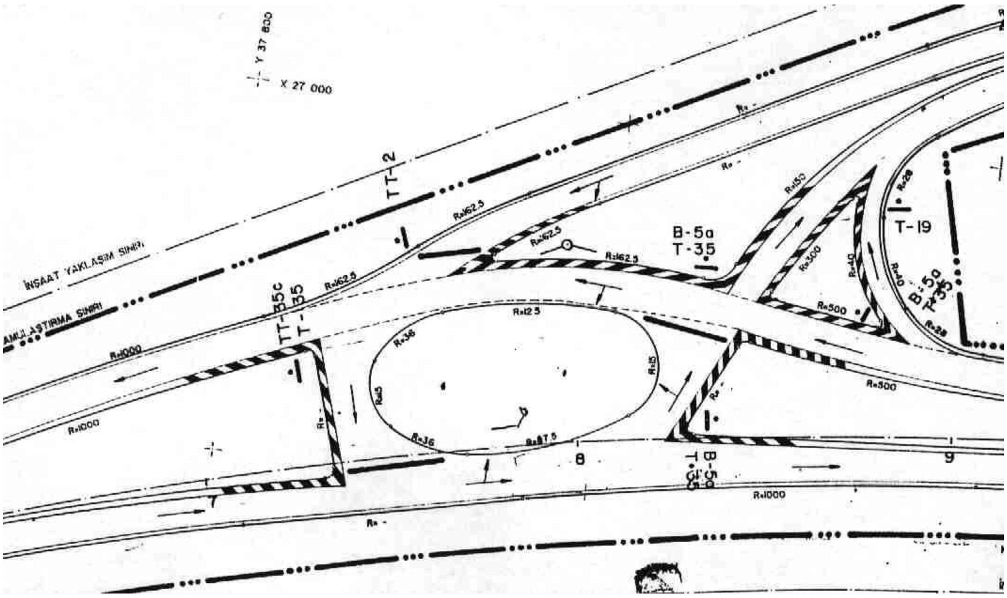


In this junction the approach and the exit in the upper side are too wide due to large curve radii, R=40 m and R=50 m respectively.

The approaches and exits in the lower side are too wide, 8 m between the painted shoulders, regarding the traffic volume, which is less than 2000 vehicles per day in both directions.

Geometric design

- Is the crossing angle between 75 and 105 degrees?
- Are required lanes for left turning provided and are the lengths, the widths and taper lengths according to standards?
- Are required lanes for right turning provided and are the lengths, the widths and taper lengths according to standards?
- Are sufficient swept areas for long vehicles provided?
- Is each intersection designed to avoid wrong-way movements? This is especially important on divided road sections.
- Are islands appropriately located and designed to protect and guide traffic?
- Are gaps in central/median islands large enough for waiting/turning traffic?
- Are curb-stones avoided on islands adjacent to high-speed traffic lanes?
- Are facilities for pedestrians and bicyclists provided where such are needed?



In this three-leg junction, the angel between the approach and the main road is very small. The drivers stopping in the approach (there is a stop sign) will have problems seeing vehicles approaching in the main road.

Signalized junctions

- Are required traffic signals provided? Capacity and/or safety reasons.

Detailed design of traffic signals – see the checklist.

2.5.4 Interchanges

Location

- Do the number of and distances between interchanges correspond to the road standard?
- Do the types of interchanges correspond to the road standard?
- Is the location of each interchange suitable?

Sight distance

- Are required sight distances to all ramp exits and ramp entries provided?

Exit and entry design

- Are all ramps designed for safe deceleration and acceleration?
- Are the connections between ramps and the secondary road safely designed?

2.5.5 Roadside facilities

Location

- Are there any bus stops, parking areas, rest areas and service stations provided?
- Are the locations of each facility suitable?

Exit and entry design

- ❑ Are all exits and entries to and from road side facilities safely designed?

2.5.6 Facilities for pedestrians and other vulnerable road users

Location

- ❑ Are required facilities for pedestrians provided?
- ❑ Are required facilities for bicyclists provided?
- ❑ Are required facilities for slow moving vehicles, like tractors or carts drawn by animals, provided?
- ❑ Are the facilities suitably located?

Access

- ❑ Are the accesses for pedestrians to pedestrian crossings, bus stops, etc. safely designed?

Design

- ❑ Are the pedestrian crossings safely designed?
- ❑ Are the bicycle crossings safely designed?

If such facilities are provided, check the detailed design according to the checklist.

Criteria for use of different types of pedestrian crossings according to Swedish guidelines.

Suitable type of pedestrian crossing depending of traffic volume (vehicles/hour) and design speed is shown in the diagram below.

<table>
<tr><th>Design speed km/h</th><th>Type of crossing</th><th colspan="6">Quality</th></tr>
<tr><td rowspan="4">70</td><td>Grade separation</td><td colspan="6">Good</td></tr>
<tr><td>Signalization</td><td colspan="3">Good</td><td colspan="2">Acceptable</td><td>Poor</td></tr>
<tr><td>Marked</td><td colspan="6">Poor</td></tr>
<tr><td>Unmarked</td><td colspan="6">Poor</td></tr>
<tr><td rowspan="4">50</td><td>Grade separation</td><td colspan="6">Good</td></tr>
<tr><td>Signalization</td><td colspan="5">Good</td><td>Acceptable</td></tr>
<tr><td>Marked</td><td colspan="3">Good</td><td colspan="2">Acceptable</td><td>Poor</td></tr>
<tr><td>Unmarked</td><td colspan="6">Poor</td></tr>
<tr><td rowspan="4">30</td><td>Grade separation</td><td colspan="6">Good</td></tr>
<tr><td>Signalization</td><td colspan="6">Good</td></tr>
<tr><td>Marked</td><td colspan="5">Good</td><td>Acceptable</td></tr>
<tr><td>Unmarked</td><td colspan="6">Poor</td></tr>
</table>

Traffic volume 0 100 200 300 400 500 600 v/h

Unmarked pedestrian crossings should only be used if the number of pedestrians is low.

2.6 Detailed design phase - road equipment

Table 5. Detailed design phase – road equipment

Road Equipment	
Guardrails and fences	• requirements • location
Signs	• requirements • location
Markings and delineators	• requirements
Lighting	• requirements

The audit of road equipment should include the following:

2.6.1 Guardrails and fences

Requirements
- ❑ Are required guardrails and fences provided?

Location
- ❑ Are the start point and end point of the guardrails suitably located with respect to the location of the hazard?

If they are, use the checklist for detailed design.

2.6.2 Signs

Requirements
- ❑ Are required signs provided?

Location
- ❑ Are the provided signs well located regarding their message?
- ❑ Are the signs safely positioned?

If signs are provided, use the checklist for detailed design.

2.6.3 Markings and delineators

Requirements
- ❑ Are required markings and delineators provided?

If they are, use the checklist for detailed design.

2.6.4 Lighting

Requirements
- ❑ Is required road lighting provided?

If it is, use the checklist for detailed design.

3 Existing roads – safety audit action plan

A safety audit of an existing road is usually carried out if the road is considered as unsafe with more accidents than average for that kind of road.

A safety audit can also be the first step in preparation of a rehabilitation plan of an existing road.

In both cases, the purpose is to identify obstacles and other deficiencies in order to be able to remove the obstacles and to improve the deficiencies.

Example of dangerous obstacle close to the road.

The main work is therefore to identify hazardous locations, such as poor vertical or horizontal alignment, poor junction design, hazardous obstacles close to the road – inside the "safety zone", or other deficiencies.

Example of sharp curve with limited sight distance due to bushes.

Table 6. Safety audit of existing roads

Existing Road
Office Work
General project data Preparations
Examination
The field-study
Results
Investigation form Report

3.1 Office work

The audit starts with work in the office. This work mainly contains of gathering background information about the road - the function of the road, the standard of the road, traffic volumes, accidents, etc. The purpose of this work is to get overall information about the road and its surroundings.

Table 7. Office work

Office Work	
General project data	• Prerequisites • Road function • Traffic situation • Road standard • Surroundings
Preparations	• The field-study • Investigation form

The office work should include the following:

3.1.1 General project data

Prerequisites
It is necessary to have some maps or drawings. Suitable scales are 1:10 000 – 1:2 000. Maps or drawings should be used as an instrument during the field-study but also as support for presentation of the results of the audit.

At an early stage, the extent of the project should be determined. That is to define the starting and ending points of the audit. Usually it is suitable to use well known intersections as starting and ending points.

The kinds of problems that should be examined must be determined. The accident analysis will sometimes indicate the most common types of problem.

In the table below, some typical deficiencies are listed.

Table 8. Some typical deficiencies

Road Design	Road Side Area
❑ Improper junction design ❑ Small horizontal or vertical radius ❑ Improper or dangerous pedestrian crossing	❑ Dangerous fixed object in the roadway, roadside, traffic island or median ❑ Dangerous rock cutting ❑ High, steep side slope without guardrail
Regulations	
❑ Speed limit too high ❑ Wrong, misplaced or worn-out sign or road marking	

The method of identifying different locations has to be determined at an early stage. Examples of different methods are:

- The Control Section Number together with km-posts.
- The trip meter of the car used during the field-study.
- The distance or the coordinates measured in the map or the drawing.

Often you have to use a combination of all three methods.

It is important that the system chosen is reliable over time, since the contractors need the location when it comes to improvement. Because of this, it is better to state the location in relation to the starting point or larger intersections rather than only using the kilometer posts, which can be changed or moved.

Road function

- Describe the function of the road. Is it a national, provincial or local road?
- What kind of traffic uses this road? Is it long distance or short distance traffic, or maybe there is a mix of different kinds. Is the road a part of a major route?
- Is it a tourist road, for its own qualities, such as beautiful scenery, nice surroundings or tourist attractions, or because it is a part of a route to other tourist locations?
- What about heavy traffic? Is the proportion more or less than average? Is the road a part of a cargo route?
- Is the road used by vulnerable road users, such as pedestrians or bicyclists?
- Describe the surroundings in general. Is the road situated in rural, sub-urban or urban areas?
- If the road passes through agricultural areas, there are probably many slow moving vehicles along the road.

Traffic situation

<u>Traffic volumes</u>

- Determine the traffic volume and which year it stands for. Try also to determine the traffic growth during the last five years.
- Determine how the traffic is composed. That is, the proportion of private cars, the proportion of busses and trucks, etc.
- Is there any traffic forecast for the road? Try to find out the expected traffic volumes for coming years.

Traffic accidents

- Gather information about accidents during the last three years.
- Study the locations of the accidents. Check if there are any accident prone locations, so-called black spots.
- Study the type of the accidents. Check if there are any accident patterns indicating a specific problem. For example, if there are many accidents with left-turning vehicles in a junction or many single vehicle accidents where the vehicles are leaving the roadway.
- Study also the severity of the accidents.
- Summarize the result in a table and compare the result with average values for comparable roads. Make comments about any differences from average values.

Road standard

- Describe the road standard in general. Make comments on the standard regarding road function, traffic volume, speed limits, etc.
- Analyze the speed-limits. Are they reasonable for built-up areas, presence of vulnerable road users, especially children, the alignment of the road, etc.?

Example of a small vertical crest radius.

Surroundings

- Describe the surroundings in general – rural, urban or suburban.
- What kind of surroundings are there, forest, agricultural area, built-up area or a mixture of these?
- If there is a built-up area, describe the type more in detail, such as industrial area, shopping area, residential area, etc.
- Make specific notes if there are facilities that generate heavy traffic.
- Does the road pass through any towns or villages?

3.1.2 Preparations

The field-study
Calculate with more than one field-study trip.

Before the first field-study trip, the activities have to be planned in detail.

Estimate the time for travelling to the starting point. Estimate the time needed to travel through the actual section in both directions. If video recording is carried out, the speed should not exceed 70 km/h. Several stops may have to be made during the trip, which means that the average speed will be low, 30 – 50 km/h, depending on the number of stops.

Is it possible to carry out the field-study in one day or are several days needed?

Investigation form
Before the first field-study, an investigation form has to be prepared. There is an example of an investigation form in Appendix 3. Below the most common deficiencies and hazardous obstacles are listed.

Table 9. Common deficiencies and hazardous objects

Road Design	Road Side Area
❑ Road shoulder missing, too narrow or unpaved ❑ Improper junction design ❑ Improper exit or entrance to shop, petrol station or other commercial activity ❑ Improper connection to small access road ❑ Limited sight distance ❑ Improper or dangerous pedestrian crossing ❑ Small horizontal or vertical radius ❑ Temporary road narrowing (for example bridge) **Regulations** ❑ Speed limit too high or too low ❑ Wrong, misplaced or worn-out sign or road marking	❑ Dangerous fixed object in the roadway, roadside, traffic island or median ❑ Dangerous bridge fixed object in the roadside or median (for example massive poles, pillars, fences, trees ❑ Dangerous rock cutting, loose stones or rocks ❑ House or other building ❑ High, steep side slope without guardrail ❑ Guardrail endings ❑ Culvert endings

Example of a high and steep side slope without guardrails.

3.2 Examination

When the preparations are ready, it is time for the examination.

Table 10. Examination

Examination	
The field-study	• Participants • Observations • Video recording • Detailed studies

The examination should include the following:

3.2.1 The field-study

Participants
During the field-study at least three persons should participate:

- The driver reads off the trip meter, where obstacles or hazards are identified.
- The observer identifies different obstacles and hazards along the road.
- The third person takes notes about obstacles and hazards and their locations.

Observations
During the trip, the observer makes comments on what he is observing. Every time a deficiency or hazardous obstacle is observed, the observer mentions what kind of

deficiency or obstacle it is. The driver tells the reading of the trip meter. The third person makes notes about the obstacle and the location.

Video recording
If a video recording is to be made (this is recommended), the observer should operate the video camera. If possible, the camera should be mounted to a stand of some kind. However, the stand has to be of a shock absorbing type. Otherwise the vibrations from the vehicle will be transferred to the camera which makes it difficult to see what has been recorded.

When a video recording is made, the sound should also be recorded. It will then be easy to use the video to add more information to the investigation form in the office. It is also good if the driver every kilometer mentions the distance from the start. If there are km-posts along the road, they should also be mentioned when they are passed.

Detailed studies
Sometimes it is necessary to stop the car and take a more detailed look of the obstacle, for example, to determine the distance from the road to the obstacle. It is also advisable to take many photos. The photos can then be used in the office as a help to describe the obstacle in more detail. Some of the photos can also be used as illustrations in the final report, see below.

3.3 Results

The results should be presented in a way that makes it easy to carry out the necessary countermeasures later.

Table 11. Results

Results	
Investigation form	• Computer works • Additional information
Report	• Contents • Illustrations

The results should include the following:

3.3.1 Investigation form

Computer works
Back in the office the investigation form has to be completed. The notes from the field-study have to be entered into an EXCEL-sheet or a WORD-document in a computer. In Appendix 4, there is an example of an EXCEL-sheet that can be used.

Additional information
To the notes from the field-study, information that can be gathered from the videotape should be added. Sometimes additional information also can be gathered from maps and drawings. Usually the location has to be determined in more detail than what is possible by the trip meter during the trip. That can be done by measuring the distance in the project drawings. It is also possible to use the time indicator in the video to calculate the exact location. The calculation can be based on the assumption that the speed is constant between two well-known locations, such as junctions or km-posts. The principle is to note the time when the known locations and the obstacle are passed. Then divide the time in seconds between the first known location and the obstacle with the time in seconds between the known locations. Multiply the result with the distance between the two known locations and the distance between the first known location and the obstacle will be the result.

$L1 = T1 / T2 * L2$

where; $L1$ = the unknown distance
$L2$ = the known distance
$T1$ = the time between the first location and the obstacle
$T2$ = the time between the two known locations.

When the investigation form has to be completed, the following questions should be answered:

- ❑ Are the locations of all deficiencies, obstacles and hazards determined?
- ❑ Are the locations of all changes in speed limit determined?
- ❑ Are the locations of all km-posts determined?
- ❑ Are the locations of major intersections determined?
- ❑ Is there a need for an additional field trip?

If some information still is missing, another field-study should be carried out. During this trip more photos can be taken that later can be used as illustrations in the final report. (If the road is located far away from the office or if the section is not too long, the photos can be taken in a second round trip during the first field-study.)

If no more field-study is necessary, the investigation forms should be finalized and the report should be prepared.

3.3.2 Report

Contents
An example of the report lay-out is presented below, as a table of contents.

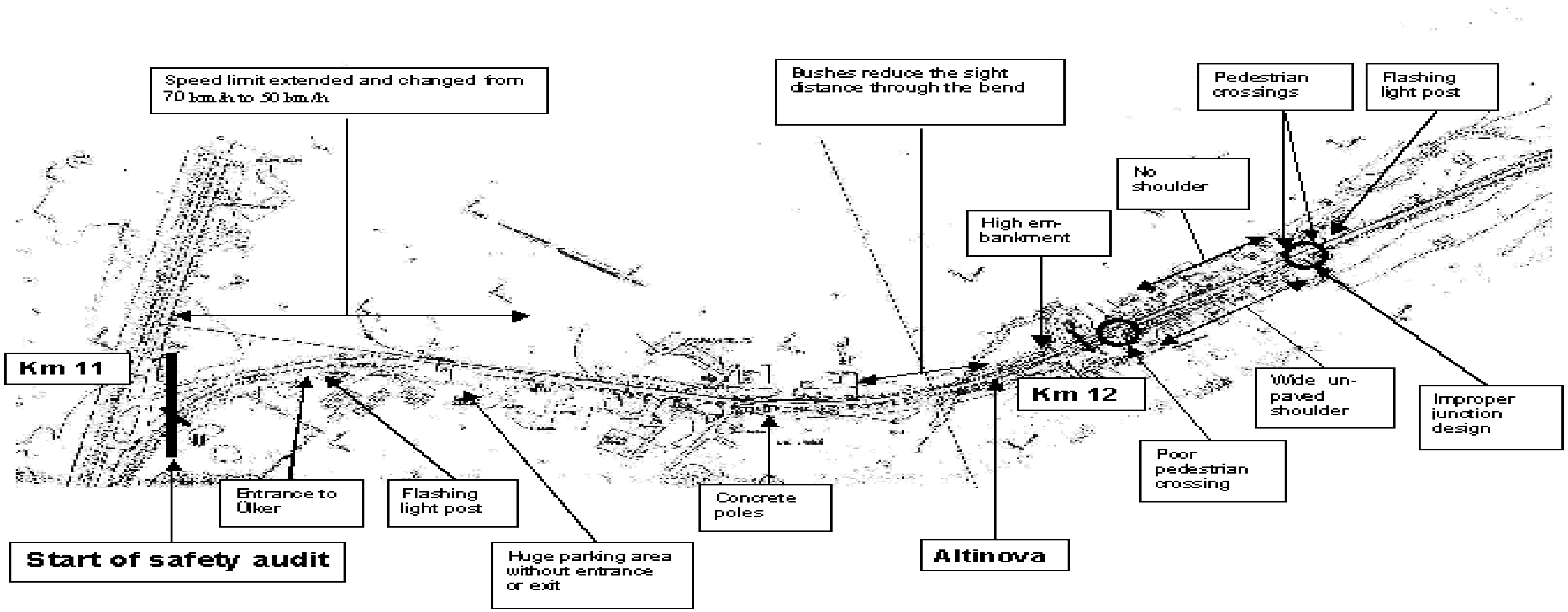
- **Introduction**
- **Prerequisites**
  - → General project data
    - Road function
    - Traffic situation
    - Road standards
    - The surroundings
- **Problem investigation (field-study)**
  - → Performance
  - → Problems, deficiencies
    - The safety zone
    - Observations made during the audit
- **Proposals of countermeasures**
  - → General countermeasures in rural areas
  - → General countermeasures in built up areas
  - → Specific countermeasures
- **Oncoming work**
- **Meetings**
- **References**
- **Appendix**
  - → Maps
  - → Investigation form

Illustrations

In order to clarify the results different kinds of illustrations can be used.

- Photos to show different obstacles.
- Sketches to explain possible countermeasures.
- Drawings or maps to show the location of the hazardous obstacles and other deficiencies (see next page).

Example of dangerous culvert ending close to the road.


Speed limit extended and changed from 70 km/h to 50 km/h
Bushes reduce the sight distance through the bend
Pedestrian crossings
Flashing light post
No shoulder
High em-bankment
Km 11
Km 12
Wide un-paved shoulder
Improper junction design
Poor pedestrian crossing
Entrance to Ülker
Flashing light post
Concrete poles
Altinova
Start of safety audit
Huge parking area without entrance or exit