Operative Procedures for Safety Inspections on Two-Lane Rural Roads

S. Cafiso, G. La Cava, A. Montella, G. Pappalardo

Identificazione e Adeguamento delle Strade Pericolose
PROJECT TREN-03-ST-S07.31286
Identification of Hazard Location and Ranking of Measures to Improve Safety on Local Rural Roads
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1. Introduction

This research report describes the road safety operative procedures adopted by the IASP research project. The procedures are based on both past experience, acquired nationally [1] and internationally [2-11] in the field of safety inspections of existing roads, and new experience, acquired while working on the present project. The aim of the formalisation of procedures is to:
1. document procedures in order to provide a precise reference for the development of future safety inspections.
2. Increase the objectivity of safety audits carried out by different teams.
3. Share the experience acquired during the research project with other agencies.
2. Inspection team requisites

Main requisites of the team are independence and qualification. Independence from the design, maintenance and operation of the road to be reviewed is needed since the team has to look only at safety problems applying “fresh eyes” to the task.

Qualification is vital for the process to be effective, given that addressing the safety problems and providing recommendations to eliminate or mitigate them doesn’t give any real benefit in terms of accident reduction if the task is not based on sound road safety engineering experience and practice. In particular, the members of the inspection team must have multi-disciplinary abilities and experience in road planning, traffic engineering, road engineering, accident surveying and analyses and, more generally, a knowledge of road safety principles. Useful specialist skills regard the human factor of driver behaviour, the planning of safety improvements and the use of telecommunications and intelligent transportation technologies to improve safety and to protect vulnerable users (pedestrians, cyclists and motorcyclists).

An innovative aspect of the IASP procedures is the active participation of the client in the process and in some phases of the review process. The role of the client consists in observing the site inspections and participating in the preliminary discussions regarding general problems. The team has advantage from discussion with the client since obtains in depth information about site history, and maintenance and rehabilitation procedures and practices. Moreover, the client has advantage arising from interaction with the review team and has better understanding of the procedure and technical reasons relating to the problems identification.

The team must comprise three or more people, since diverse backgrounds and different approaches of different people are beneficial. The cross-fertilization of ideas that can result from discussions is helpful. If the team is composed by more than three people, it is not necessary to all the members to take part to all the phases of the review. Specifically, the review report can be written by only two or three members, but all the members must read the draft report before the final report is edited and signed.
3. Site Inspections

3.1 General Aspects

More site inspections are required:
- preliminary inspection, in daytime, aimed at understanding the general road safety conditions and its relationship with surrounding land use, terrain and road network;
- general inspection, in daytime, aimed at examining the general safety concerns along the road segments;
- detailed inspection, in daytime, aimed at examining in detail safety concerns of specific sites;
- night time inspection, aimed at analyzing the road perception without natural lighting.

It could also be useful to carry out further inspections in the rain or under other atmospheric conditions peculiar to the area, in order to examine pavement, road signs and delineation in critical conditions.

3.2 Preliminary inspections

Any preliminary inspection should interest various segments of road although it should not normally exceed a total extension of more than 100 km.

It is advisable for the inspection to be preceded by a meeting with the client who should supply preliminary data (maps, works recently carried out or to be carried out, traffic and accident data) and useful information regarding road use conditions.

During the preliminary inspection each road is run in both directions. The minimum number of inspection team members is three: the driver, the front-seat inspector and the back-seat inspector.

The road is ran at normal speed, that is the prevailing traffic speed, with the aim of investigating the ways in which the road environment is perceived and interpreted by its users. The analysis focuses not only on the road, but also on the surrounding environment with which it interacts and on the users themselves. Driving along the road at low speed might not allow the segment to be interpreted in a correct way, since that speed has a direct influence on the way a road segment is interpreted.

While driving, a video of the road segment is performed and reviewers comments are recorded in the same video-tape. The driver calls out their position referring to the progressive milestones (see Figure 1) on the right side of the road if they are continuously present. If there are none then the driver takes the beginning of the run as its origin and refers to the mileage recorder of the car. The driver also calls out any corrective manoeuvres undertaken during the run. The front-seat inspector comments on the safety aspects. The back-seat inspector provides integrative comments, referring particularly to unsafe factors on the roadside, at accesses and intersections.

Figure 1 Milestones and hectometre (Figure II 261, 262 Regulations of Italian Highway Code) markers.
While driving the use of a GPS receiver makes it possible to geo-reference particularly useful or interesting points, such as the milestones, and to identify those sites (intersections, dangerous curves, etc) specifically indicated by the inspection team members.

The recommended equipment for preliminary inspections is:
- a GPS receiver with external antenna to geo-reference points of interest;
- a video-camera with back-up system inside the vehicle.

### 3.3 General inspections

Once the general characteristics of the road have been understood from the preliminary inspection, a general inspection aims at obtaining the most important information regarding specific aspects, while referencing their position along the segment.

The road is run at low speed (about 30 km/h), compatibly with traffic conditions, in such a way as to allow the inspectors to record the information on the checklist. During the inspection each road is run in both directions. A single inspection can cover more than one road segment, covering a total distance normally not more than 30 km.

At least three reviewers are needed: the driver, the reviewer in front seat and the reviewer in back seat. They do not have to keep to the same position in the vehicle for each run. In order to standardise the information acquired during the inspection, the inspectors fill checklists, which are differentiated according to the position of the inspector inside the vehicle.

A video of the road segment is performed during the trip. The driver calls out the hectometres by referring to the milestones and hectometre markers on the right side, if they are continuously present. If there are none the driver takes the beginning of the run as its origin and refers to the mileage recorder of the car. The driver also calls out any corrective manoeuvres undertaken during the run.

The recommended equipment for general inspections is:
- a video-camera with back-up system inside the vehicle;
- checklists.

#### 3.3.1 Checklist format

As part of the project concise checklists were drawn up (see Tables 1 and 2) which list the safety problems to be highlighted during a daytime inspection. Such problems are often present on local rural roads. The checklist does not include aspects relating to the design alignment or to the design consistency as they can be more effectively identified using prediction models. Part of the IASP project involves carrying out design consistency analyses using quantitative methods.

The checklists must be filled for both runs in both directions. They are differentiated according to the position of the inspector: in the front or back seat. Safety issues are ranked as high level problem and low level problem and for each problem the inspector can insert a tick against different levels. If no problem exists then no sign is inserted.

The checklist evaluations are recorded for each 200 m segment (every 24 s at a speed of 30 km/h). This interval is a compromise between the possibility of easily expressing a reliable evaluation, which requires observation periods of limited length, and of having a sufficient amount of time available to compile the checklist, which requires periods that are not too short.

The tasks of the front-seat and back-seat inspectors were separated in order to distribute the effort for the completion of the checklists, also bearing in mind that the road environment is perceived differently according to their positions inside the car:
- the front-seat inspector is interested in aspects linked to roadside, alignment and accesses (see Table 1).
- the back-seat inspector is interested in the aspects linked to cross-section, pavement delineation, road signs and road markings (see Table 2).

The checklists are divided into two parts (A, B):
- Part A contains elements that must be completed during the inspection in order to have a correct evaluation;
- Part B contains elements that can also be evaluated in the office using the video recording.

Part B must be completed in the office when the complexity and number of problems is such that it is difficult to complete the form during the run.

### Table 1 Preliminary inspection checklist: module for the front-seat inspector

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### Table 2 Checklist for General Inspection: Module for Back Seat Reviewer.

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3.3.2 Checklist compilation criteria
In order to complete the checklist as objectively as possible it is necessary for the road defects to be identified and evaluated as correctly and uniformly as possible, following certain basic criteria. This paragraph illustrates those criteria, including examples that are frequently met on two-lane rural roads, but not including all the situations that can be found.

3.3.2.1 Delineation
The checklist specifies two aspects: chevrons and roadside guideposts.

Chevrons
Chevrons (see Figure 2) must be placed in series composed of a number of elements to delineate the outside of curves having a radius of more than 30m when it is necessary to improve the sight distance of the curve. The maximum longitudinal spacing of the delineators must therefore be such as to always allow at least three chevrons to be visible.

![Figure 2 Chevrons (art. 174/3e Regulations of Italian Highway Code)](image)

Chevrons must be placed on curves with a radius of less than 30m and with a lack of visibility (see Figure 3).

![Figure 3 Sharp or hairpin bend chevrons (art. 174/3c Regulations of Italian Highway Code)](image)

The most common situations in which it is advisable to report a high level problem with chevrons are the following:
- Missing chevrons on severe curves (see Figures 4 and 5);
- Chevrons number inadequate to give correct perception of the total length of the curve;
- chevrons placed in only one direction (see Figure 6);
- ineffective chevrons due to a high-level of deterioration;
- not reflective chevrons;
- chevrons with directional arrows in the wrong direction (see Figure 7);
- chevrons obscured by vegetation (see Figure 8).

Figure 4 Missing chevrons on severe curve: high level problem.

Figure 5 Missing chevrons on severe curve: high level problem.
Figure 6 Missing chevrons in one direction: high level problem.

Figure 7 Chevrons with directional arrows in the wrong direction: high level problem.
The most common situations in which it is advisable to report a low level problem with chevrons are the following:
- low reflective chevrons due to dirt or slight deterioration;
- missing chevrons on moderate curves;
- local discontinuity of chevrons (see Figure 9);
- chevrons spacing inadequate to give correct perception of the curve;
- chevrons do not continue along the whole of the curve;
- sharp bend warning chevrons installed instead of chevrons of normal type (or vice-versa);
- chevrons partially obscured by vegetation.

Figure 8 Chevrons obscured by vegetation: high level problem.

Figure 9 Local discontinuity of chevrons: low level problem.
Guideposts and reflectors
Roadside guideposts must be placed in those places, outside built-up areas, where it is necessary to provide visibility of road alignment (see Figure 10). Discontinuous placing must be avoided and on uniform road segments, there must be an unbroken installation of the same kind of delineator. When there are safety barriers, walls, parapets or other obstacles, the guideposts can be substituted by reflective elements positioned on the fixtures, placed either in the wave of the guard-rail or above it; it is advisable for the reflectors to be placed at the same height above the ground as those on the normal guideposts (the upper edge positioned between 70 and 110 cm). The spacing intervals of the guideposts must be as uniform as possible along the same road segment and reduced on curves (art. 173 of Italian Highway Code).

The most common situation in which it is advisable to report a high level problem with the roadside delineators are the following:
- missing guideposts along the roadside (see Figure 11);
- missing reflectors on roadside safety barriers (see Figure 12);
- missing reflectors on walls or in other situations;
- missing or ineffective reflectors;
- dangerous placement (e.g., inside ditches) (see Figure 13).

The most common situations in which it is advisable to report a low level problem with the roadside delineators are the following:
- variable height of reflectors along the road;
- local discontinuity in guideposts placing;
- excessive spacing between guideposts;
- low reflectivity reflectors due to inadequate maintenance.
Figure 11 Missing roadside guideposts: high level problem.

Figure 12 Missing reflectors on safety barriers: high level problem.
3.3.2.2 Signs
The situations in which it is advisable to report a high level problem with signs are the following:
- missing or not visible warning sign for severe curve (see Figure 14);
- missing or not visible warning sign for crest curve;
- missing or not visible warning sign in dangerous situations.

The situations in which it is advisable to report a low level problem with signs are the following:
- curve warning sign faded or with low visibility;
- crest warning sign faded or with low visibility;
- yield sign missing, faded or with low visibility (see Figure 15);
- advertisement located so as to disturb road users;
- indication signs incomplete or with low legibility;
- speed limits not consistent with road features;
- unclear signs (see Figure 16);
- wrong height signs (see Figure 17).
Figure 14 Warning sign not visible: high level problem

Figure 15 Intersection yield sign covered by vegetation: low level problem.
3.3.2.3 Accesses
Accesses are driveways from private areas or buildings onto public roadways, or rather the points where private roads lead onto public roads and vice-versa. The checklist specifies two aspects: the presence of accesses and dangerous accesses.
Dangerous accesses
The positioning and configuration of accesses must be such as to respect the same
distance of unrestricted visibility as required for junctions.
The most common situations in which it is advisable to report a high level problem with
dangerous accesses are the following:
- accesses located on horizontal curves (see Figure 18);
- accesses located on crest curves;
- accesses located on sites with poor visibility;
- accesses located close to intersections;
- accesses less than 30 m from intersections (distance measured between the
  access axis and the junction axis).

Figure 18 Access located on narrow horizontal curve: high level problem.

The most common situations in which it is advisable to report a low level problem with
dangerous accesses are the following:
- narrow accesses;
- accesses with no road markings;
- accesses with no delineators (see Figures 19 and 20);
- unpaved accesses (Figure 21).

Figure 19 Access delineators (Figure II 469 Regulations of Italian Highway Code).
Figure 20 Accesses with no delineators.

Figure 21 Unpaved access with no markings or signs: low level problem.

Presence of accesses
The situation in which it is advisable to report a high level problem with the presence of accesses is the following:

- high number of accesses (> three accesses over a 200 m segment) (see Figure 22).
The situation in which it is advisable to report a low level problem with accesses is when there are one or two accesses over the 200m segment under review.

### 3.3.2.4. Cross section
The checklist specifies two aspects: lane width and shoulder width. A lane width of less than 2.75 m should be considered as a high level problem (see Figure 23), while a width of between 2.75 m and 3.25 m is a low level problem (see Figure 24). In the same way excessive lane width can also constitute a safety problem. A lane width of more than 4.50 m should be considered as a high level problem, while a width of between 3.75m and 4.50 m constitutes a low level problem (see Figure 25). This recommendation should in no way be considered binding in the case of hair-pin bends and road widening on curves.

![Figure 22 High number of accesses: high level problem.](image-url)
Figure 23 Lane width less than 2.75 m: high level problem.

Figure 24 Lane width between 2.75 m and 3.25 m: low level problem.
A shoulder width of less than 0.30 m should be considered as a high level problem (see Figure 26), while a width of between 0.30 m and 1.00 m should be considered as a low level problem.

In the following phases of the inspection the width can be measured at intervals of about 3 km and wherever a substantial modification in the cross section is observed.
3.3.2.5. Alignment
The checklist specifies two aspects: inadequate sight distance on horizontal curves and inadequate sight distance on vertical curves.

Inadequate sight distance on horizontal curves.
The situation in which it is advisable to report a high level problem of inadequate sight distance on horizontal curves is the following:
- available sight distance less than about 50 m due to the presence of obstacles along the whole inside of the curve (see Figures 27 – 30).

Figure 27 Inadequate sight distance on the curve: high level problem.

Figure 28 Inadequate sight distance on the curve: high level problem.
The situations in which it is advisable to report a low level problem of inadequate sight distance on horizontal curves are the following:
- available sight distance greater than 50 m but smaller than Stopping Sight Distance or inadequate to give the correct road perception (see Figure 31);;
- presence of discontinuous obstructions to visibility on the inside of the curve (for example, isolated trees).
Inadequate sight distance on vertical curves

The situation in which it is advisable to report a high level problem of inadequate sight distance on vertical curves is the following:
- presence of a crest with available sight distance of less than 50 m (see Figure 32).

The situation in which it is advisable to report a low level problem of inadequate sight distance on vertical curves is the following:
- available sight distance greater than 50 m but smaller than Stopping Sight Distance or inadequate to give the correct road perception.

3.3.2.6 Road markings
The checklist specifies two aspects: edge lines and centre line.

*Edge lines*
The situations in which it is advisable to report a high level problem with the edge lines are the following:
- missing edge lines (see Figure 33);
- very faded edge lines.

![Figure 33 Missing edge lines: high level problem.](image)

The situations in which it is advisable to report a low level problem with the edge lines are the following:
- low faded edge lines (see Figure 34);
- edge lines partially obscured by vegetation or debris.
Centre Line
The situations in which it is advisable to report a high level problem with the centre line are the following:
- missing centre line (see Figure 35);
- very faded centre line;
- discontinuous line with no overtaking sight distance
The situation in which it is advisable to report a low level problem with the centre line is the following:

- low faded centre line (see Figure 36).

![Figure 36 Low faded centre line: low level problem](image)

### 3.3.2.7 Pavement

Pavement inspection aims only at identifying safety problems and is not therefore carried out identifying the type and degree of deterioration which is necessary for the drawing up of a maintenance programme.

The checklist specifies two aspects: friction and unevenness.

**Friction**

Since a correct evaluation of the pavement friction conditions requires instrumental measurements, a solely visual inspection does not differentiate the degree of seriousness of the problem.

The situations in which it is advisable to report a problem with friction are the following:

- polished aggregate (see Figures 37-39);
- bleeding (see Figure 40);
- low macrotexture (see Figure 41);
- raveling (see Figure 42).
Figure 37 Polished aggregate.

Figure 38 Polished aggregate.
Figure 39 Polished aggregate.

Figure 40 Bleeding.
Unevenness
The presence of pavement unevenness (cracking, shoving, potholes, patches, rutting, etc.) leads to safety problems in that it can induce risky driving behaviour (sharp decelerations, sudden changes of direction, lane axis deviations), suspension vibrations (increase in braking distances, driver tiredness) and inadequate drainage. It is therefore necessary to
evaluate not only the seriousness and extent of the problems, but also their precise location on the road (curves, tangents, intersections).

The situations in which it is advisable to report a high level problem with unevenness are the following:

- steel grates in the roadway, raised manhole covers;
- disrupted bridge joints (see Figure 43);
- potholes on curves or near intersections;
- deep potholes on tangents;
- shoving on curves or near intersections (see Figures 44 and 45);
- high shoving on tangents;
- rutting on curves;
- patches on curves.

Figure 43 Disrupted bridge joints: high level problem.
The situations in which it is advisable to report a low level problem with unevenness are the following:
- low shoving on tangent;
- shallow potholes on tangent (see Figure 46);
- rutting on tangent;
- patches on tangent.
3.3.2.8 Roadsides
The checklist specifies five aspects: embankments, bridges, dangerous terminals and transitions, trees and other obstacles, rectangular and trapezoidal ditches.

Embankments
The situations in which it is advisable to report a high level problem with embankments are the following:

- embankments of more than 5 m unshielded (see Figure 47) or shielded with ineffective barriers (see Figures 49 and 50);
- embankments of more than 3 m and steep slopes unshielded (see Figure 48) or shielded with ineffective barriers;
- embankments of more than 3 m and steep slopes shielded by low containment safety barriers, when there are dangerous obstacles at the foot of the embankment.

The situations in which it is advisable to report a low level problem with embankments are the following:

- unshielded embankments of between 1 and 3 m and steep slopes (see Figure 51) or shielded with ineffective barriers;
- embankments of more than 3 m but less than 5 m shielded by low containment safety barriers, if there is a high level of commercial-vehicle traffic;
- embankments of more than 3 m and less than 5 m shielded with discontinuous barriers.
Figure 47 Unshielded embankment of high height: high level problem.

Figure 48 Unshielded embankment of medium height: high level problem.
Figure 49 Unshielded embankment of high height with ineffective barrier: high level problem.

Figure 50 Unshielded embankment of high height with ineffective shielding caused by the shortness of the barrier: high level problem.
Figure 51 Unshielded embankment of low height: low level problem.

Bridges
The situations in which it is advisable to report a high level problem with bridge-side barriers are the following:
- unshielded bridges or with ineffective barriers (see Figures 52 and 53);
- bridges with low containment safety barriers (see Figure 54) if there is a high level of commercial-vehicle traffic.

Figure 52 Ineffective bridge barriers: high level problem.
The situations in which it is advisable to report a low level problem with bridge-side barriers are the following:

- bridge barriers incorrectly installed (for example, excessively high kerb, unprotected pedestrian footpaths);
- medium containment safety barriers if the bridge goes over roads, railways or built-up areas.
**Dangerous terminals and transitions**

The situations in which it is advisable to report a high level problem with dangerous terminals and transitions are the following:

- roadside barriers with no breakaway terminals (see Figure 55);
- bridge barriers with no breakaway terminals (see Figure 56);
- terminals buried in the ground (see Figure 57);
- roadside barriers not connected to concrete walls (see Figure 58);
- roadside barriers not connected to stone walls (see Figure 59);
- roadside barriers not connected to bridge barriers (see Figure 60);
- roadside and bridge barriers connected without transitions;
- unconnected roadside barriers (see Figure 61).

The situation in which it is advisable to report a low level problem with terminals and transitions is the following:

- inadequate transitions connecting steel barriers of different types.

*Figure 55 Roadside barrier with no breakaway terminal: high level problem.*
Figure 56 Dangerous bridge barrier terminals: high level problem.

Figure 57 Terminal buried in the ground: high level problem.
Figure 58 Roadside barrier not connected to concrete wall: high level problem.

Figure 59 Roadside barrier not connected to stone wall: high level problem.
Trees, utility poles and other obstacles

The situations in which it is advisable to report a high level problem with trees, poles and other obstacles are the following:

- high diameter trees less than 3 m from the roadway (see Figures 62 and 63);
- rows of trees;
- concrete utility poles less than 3 m from the roadway (see Figure 64);
- high diameter utility poles less than 3 m from the roadway;
- rigid obstacles with exposed front face or corner less than 3 m from the roadway (see Figures 65 - 68).

Figure 62 High diameter tree near the roadway: high level problem

Figure 63 High diameter tree near the roadway: high level problem.
Figure 64 Concrete utility pole near the roadway: high level problem.

Figure 65 Stone wall: high level problem.
Figure 66 Concrete wall: high level problem.

Figure 67 Stone post: high level problem.
The situations in which it is advisable to report a low level problem with trees, poles and other obstacles are the following:
- high diameter trees between 3 and 8 m from the roadway;
- low diameter trees less than 3 m from the roadway;
- concrete poles between 3 and 8 m from the roadway;
- high diameter metal poles between 3 and 8 m from the roadway;
- low diameter metal poles less than 3 m from the roadway (see Figure 69);
- rigid obstacles with exposed front face or corner between 3 and 8 m from the roadway;
- isolated trees or obstacles (about every 200 m).
Figure 69 Low diameter metal lamppost: low level problem.

Rectangular and trapezoidal ditches
The situation in which it is advisable to report a high level problem with ditches is the following:
- rectangular or trapezoidal ditches less than 3 m from the roadway (see Figures 70 – 72).

Figure 70 Unshielded rectangular ditch: high level problem.
The situations in which it is advisable to report a low level problem with ditches are the following:
- rectangular ditches between 3 and 5 m from the roadway;
- trapezoidal ditches between 3 and 5 m from the roadway.
3.3.3 Analysis of general problems and recommendations
Safety issues are classified as general problem if they are present along a substantial portion of the road. General problems require mass action safety programs. In the office the inspection team examine the video recordings performed during the site inspection and look again at the compiled checklists. Part B of the checklist is completed if this was not already done on-site. The checklists are filled in for runs in both directions with particular reference to the right-hand roadside.

After comparing the evaluations of the different reviewers, the checklist results are put onto the computer and the definitive version is drawn up. When analysing the problems it is advisable to consider the presence of contemporary risk factors on the same 200 m segment. Aspects of general nature, which are not on the checklist, could emerge from a discussion of the problems of the segment, and constitute a further tool while not rigidly limiting the procedure.
Tables 3 and 4 contain recommendations for the various types of solution for each of the problems highlighted in the checklists and indicate the main national or international guidelines governing them. Advice for the resolution or mitigation of general problems is elaborated in the course of the audit team discussions, using the results of the checklists and the recommendations in Tables 3 and 4.
The problems and the advice are separated so as to underline the specificity of the individual elements of the infrastructure, but safety improvements must be undertaken with a united strategy which co-ordinates the various works.
At the end of the meeting a preliminary report is drawn up regarding the general problems and consequent recommendations. Sites requiring more detailed inspection can also be identified.
## Table 3 Recommendations for delineation, road signs, accesses and alignment

<table>
<thead>
<tr>
<th>General problems</th>
<th>Recommendations</th>
<th>Main reference norms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delineation</strong></td>
<td>Install a continuous roadside delineation system using normal guideposts, reflectors on safety barriers and chevrons.</td>
<td>D.P.R. 16/12/92 n.495 “Regulations of the new Highway Code “, arts. 173 and 174.</td>
</tr>
<tr>
<td><strong>Road signs</strong></td>
<td>Draw up a road signs plan and adapt the existing signs according to the provisions of the plan. Install signs with high intensity reflective sheeting. Periodically check the efficiency and reflectivity of the signs. Remove obstacles that limit the visibility of the signs. Remove advertising material which does not respect the regulations.</td>
<td>D.P.R. 16/12/92 n. 495 “Regulations of the new Highway Code “, art. 51 and arts. 77-136. Ministry LL.PP.D.M. 31 March, 1995 n. 1584 “Approval of the techniques for determining the reflective quality levels of sheeting used in road signs”. Ministry LL.PP.D.M. 11 July, 2000 “Ministerial Decree integrating and correcting the techniques for determining the reflective quality levels of sheeting used in road signs”. UNI EN 12899-1:2003 “Fixed signs for road traffic – Fixed signs”.</td>
</tr>
<tr>
<td><strong>Accesses</strong></td>
<td>Move accesses from dangerous locations. Remove obstacles to visibility. Pave the point where the roads join. Install access delineators. Use high-performance road markings and signs. Adapt the alignment to guarantee a suitable width and roundabouts where the accesses join the main road.</td>
<td>D.P.R. 16/12/92 n. 495 “Regulations of the new Highway Code “, art. 45. D.M. 5/11/01 n. 6792 “Functional and geometric guidelines for road construction”. Supreme Public Works Council “Functional and geometric guidelines for road intersections construction”, linked to vote n. 150/02, 30.2.2004, updated by vote n. 204/04, 30.7.2004.</td>
</tr>
<tr>
<td><strong>Alignment</strong></td>
<td>Remove obstacles that limit sight distance on horizontal curves so as to guarantee a stopping sight distance at the eighty-fifth percentile speed. Adjust the design of vertical curves where stopping sight distance is not guaranteed. As a further measure take steps to reduce speed and warn drivers of the danger.</td>
<td>D.M. 5/11/01 n. 6792 “Functional and geometric guidelines for road construction”.</td>
</tr>
</tbody>
</table>
Table 4 Recommendations for cross sections, road markings, pavement and roadside.

<table>
<thead>
<tr>
<th>General problem</th>
<th>Recommendations</th>
<th>Main reference norms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross section</td>
<td>Adapt the cross section and install paved shoulders of suitable dimensions.</td>
<td>D.M. 5/11/01 n. 6792 “Functional and geometric guidelines for road construction”.</td>
</tr>
<tr>
<td>Road markings</td>
<td>Renew markings in those places where a low or high level problem was identified. Install highly reflective markings using highly-durable materials. Carry out periodic checks as to the condition of road markings.</td>
<td>D.P.R. 16/12/92 n. 495 “Regulations of the new Highway Code”, arts. 137-155. UNI EN 1436:2004 “Road marking materials – Performance of road markings for road users”.</td>
</tr>
<tr>
<td>Pavement</td>
<td>If there is a friction problem recover the worn area. If there is unevenness carry out repair works on the bitumen conglomerate layers. Periodically check the situation as regards friction and unevenness. If there are further problems, it is advisable to combine a visual inspection with instrumental measurements to obtain an exact evaluation of the situation.</td>
<td>Ministry LL.PP- General Board of Inspection for Road Traffic and Road Safety “ Preparatory study of the technical performance norms for particular specifications”, 2001.</td>
</tr>
</tbody>
</table>
3.4 Detailed site inspections

Detailed inspections aim at analysing in greater detail those sites presenting particular safety issues. Inspections of road segments and inspections of intersections are considered separately. The recommended equipment for detailed inspections is as follows:

- highly visible protective clothes for the inspection team;
- GPS receiver for geo-referencing the inspection sites;
- digital camera;
- digital video-camera to record user behaviour (in particular at intersections);
- measuring wheel or laser measurer equipment to measure sight distance and cross section width;
- inclinometer to measure transversal slope;
- inspection modules with rigid support for writing;
- laser gun (if necessary);
- traffic counter (if necessary);
- stopwatch (if necessary).

The inspection is carried out by driving slowly and stopping at those sites with the greatest number of safety problems or specific features that require a more detailed investigation. Apart from the sites already chosen during the general review, others can be identified in the course of the inspection.

During the inspection photographs of the general problems are taken to be included in the review report.

The team stop at those sites requiring detailed inspection and inspect the site on foot, taking care to observe both the road features and road user behaviour. During the inspection photographs are taken and a video is performed of the problems found and, if necessary, of dangerous driving behaviour.

Experience gained during work on the project showed that the completion of an inspection module for each site (see Table 5) is a useful aid for the inspection team in that it:

- focalises the safety problems found;
- permits observations emerging during the inspection to be recorded;
- summarises observation results thus simplifying the writing of the audit report.

The inspection module includes data also found on the general inspection checklist which, however, derive from a more detailed observation and are integrated with further information:

- available sight distance (measured with a measuring wheel or distance measuring laser equipment);
- lane and shoulder widths;
- road user behaviour (speed, queues, late braking, dangerous overtaking, use of the oncoming traffic lane, traffic volume and composition, etc.);
- signs of accidents (damaged barriers, glass on the roadway, brake marks, etc).
### Table 5 Road segments inspection module

<table>
<thead>
<tr>
<th>Site general description</th>
<th>Site general description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Street name:</strong></td>
<td><strong>Street name:</strong></td>
</tr>
<tr>
<td><strong>ID GPS waypoint:</strong></td>
<td><strong>ID GPS waypoint:</strong></td>
</tr>
<tr>
<td>− Curve: □</td>
<td>− Curve: □</td>
</tr>
<tr>
<td>− Tangent: □</td>
<td>− Tangent: □</td>
</tr>
<tr>
<td>− Longitudinal grade:</td>
<td>− Longitudinal grade:</td>
</tr>
<tr>
<td>− Embankment: □</td>
<td>− Embankment: □</td>
</tr>
<tr>
<td>− Cut: □</td>
<td>− Cut: □</td>
</tr>
<tr>
<td>− Cut and fill: □</td>
<td>− Cut and fill: □</td>
</tr>
<tr>
<td>Bridge: □</td>
<td>Bridge: □</td>
</tr>
<tr>
<td>Tunnel: □</td>
<td>Tunnel: □</td>
</tr>
</tbody>
</table>

### Problems description

#### Horizontal alignment problems
- Curve preceded by long tangent: □
- Series of curves: □
- Inadequate super elevation: □
- Super elevation measure: right lane _____ left lane
- Visibility obstructions: □
- Available sight distance: __________

#### Cross section
- Lane width: □
- Shoulder width: □

#### Inadequate access
- Presence of accesses: □

#### Inadequate friction
- Inadequate friction: □

#### Pavement unevenness
- Pavement unevenness: □

#### Inadequate markings
- Inadequate markings: □

#### Inadequate delineation
- Inadequate delineation: □

#### Road users dangerous behaviors
- High operating speeds: □
- Queues: □
- Wrong maneuvers
  - Late braking: □
  - Dangerous passing: □
  - Invasion of opposite lanes: □

#### Accident signs (damaged barriers, glasses on the pavement, braking marks, etc.): □

#### Sheet 2 (not to scale)
- Site condition diagram:
- Sketch of potential accidents:

### Notes

- Description of potential accident scenarios:
3.5 Night Inspections

The equipment recommended for night inspections is the following:
- GPS receiver with external antenna to geo-reference points of interest;
- Video-camera with back-up system inside the vehicle.

Night-time inspections aim at understanding the road users perception of the road in the absence of natural lighting. As a consequence, the main object of the inspection is an analysis of the road signs, delineation and visibility.

During a night-time inspection, carried out at normal speed, a video is performed of the segment at the same time recording the comments of the inspection team. The positioning of specific problems not highlighted by the daytime inspection is performed using a GPS receiver in dynamic mode.

Each road is run in both directions and the inspection can also be carried out over very long distances (100 km).

The day after each night-time inspection, the inspection team meets, examines the video and writes up the problems highlighted by the night-time inspection.
4. Final report
The draft form of the audit report can be written by only two members of the team. Experience shows that the presence of a number of people for the drawing up of a long document is not very effective.

The report is written with a ‘problem/recommendation’ format, where the problem is described in terms of the type of potential accident and the recommendation is an engineering solution to the reported problem.

After being read and discussed by all members of the team the final report is drawn up and signed by the whole team.

The audit report contains a detailed description of the procedures followed and reports the study results, explaining the reasons for the recommendations made.

The audit report contains the following sections:

- Introduction
  - name of the road
  - date of the inspections
  - names and qualifications of the inspection team members
  - information on the data provided by the client
  - description of the procedure used to carry out the inspection

- General problems of the segment
  - graphs summarising the nature, seriousness and extent of the problems
  - detailed description of the problems
  - identification of potential accidents
  - photographs illustrating the problems
  - recommendations for the resolution or mitigation of the problems

- Specific problems of the segment
  - detailed description of the problems
  - identification of potential accidents
  - photographs illustrating the problems
  - recommendations for the resolution or mitigation of the problems

- Problems at intersections
  - description of common problems
  - recommendations for the resolution or mitigation of common problems
  - description of the problems of individual intersections
  - identification of potential accidents at individual intersections
  - photographs illustrating the problems of individual intersections
  - recommendations for the resolution or mitigation of the problems of individual intersections

- Tables summarising the problems and recommendations

- Concluding statement and signatures of members of the inspection team.
References


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