OPERATIVE PROCEDURES FOR ROAD SAFETY INSPECTIONS

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ABSTRACT

Nowadays, Road Safety Inspections (RSI) are recognized as an effective tool for identifying safety deficiencies of road infrastructures. They represent a low cost process for the evaluation of the network safety performance. Its applicability in rural local roads, where accident data generally do not give enough information for the safety analysis, make the procedure very attractive. However, due to the subjective nature of the process RSI may give rise to disagreements which limit their effectiveness.

The paper describes the RSI procedures defined by the IASP research program. The IASP project is funded by European Commission (DG TREN) and Province of Catania (Italy) with the scientific support and collaboration of the Department of Civil and Environmental Engineering of University of Catania. The project is aimed at defining a methodological approach for the safety analysis and the restoration of rural highways specially suited for local rural roads.

Various countries adopted RSI procedures but, in the main, they are not operational in nature. As part of the project, safety inspections of 100 km of two lane rural roads have been carried out. The IASP safety inspection procedures reflect the scope of the project and give some quantitative safety evaluation, to the best extent compatible with a methodology mainly based on subjective evaluations.

The research was aimed at defining a RSI operative procedure able to improve the effectiveness and reliability of the methodology. For this purpose, the research was focused on the review framework, on the reviewers and client roles and, with special emphasis, on the methodologies used for identifying and ranking the safety problems. Phases of the inspection procedures have been defined: preliminary inspection, general inspection, detailed inspection and night time inspection. For each phase, objectives of the inspection, needed equipments, inspection methodology and roles of each team member have been defined and synthetically described in the paper. General inspection checklists, relative to the main safety features which may be present with continuity along two lane rural roads, and detailed inspection modules, differentiated for segments and intersections, have been defined. Moreover, criteria for identifying and ranking safety issues have been briefly reported. Last, the review report contents and format have been described.

The procedure has proved to be effective to identify most safety issues. As far as alignment geometric defects and design consistency evaluation is concerned, RSI are not as valuable such as the quantitative methods, that may usefully integrate the inspection results.

As a research outcome, a RSI operative manual has been edited. It allows to transfer to other road agencies the acquired knowledge and to obtain a greater objectivity in the inspection process.

1 INTRODUCTION

The paper describes the Road Safety Inspection (RSI) procedures defined by the IASP research program. The IASP project is funded by European Commission (DG TREN) and Province of Catania (Italy) with the scientific support and collaboration of the Department of Civil and Environmental Engineering of University of Catania. The project is aimed at defining the methodological approach for the safety analysis and restoration of rural highways specially suited for local rural roads. As part of the project, safety inspections of 8 two lane rural roads, of total length equal to 100 km, have been carried out in the period September 2004 – March 2005. The IASP safety inspection procedures reflect the scope of the project and give some quantitative safety evaluation, to the best extent compatible with a methodology mainly based on subjective evaluations. Various countries adopted safety inspection procedures which are defined in guidelines but, in the main, they are not operational in nature. Basing both on the international experience (Austroads, 2001; EC, 2003; ERF, 2002; Italian Public Works Ministry, 2001; Montella and Proctor, 2002; PIARC, 2004; Road Directorate DK, 1997; TNZ, 2003, TAC, 2004) and on the project experience (Cafiso et al., 2004), a safety inspection operative manual has been written (Cafiso et al., 2005). The paper gives an overview of the RSI procedure and the operative manual.

2 REVIEW 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.

An innovative aspect of the IASP procedures is the active participation of the client in the process. The client participates as an observer to the site inspection and to the preliminary in office discussion about general problems and recommendations. The team has advantage from discussion with the client since obtains in depth information about site history, and maintenance and rehabilitation procedures and practices. 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 ROAD 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.

3.2 Preliminary Inspections

Main objective of the preliminary inspections is trying to investigate how the road environment is perceived, and ultimately utilized by different road users. The analysis has to look not only the road, but also the environment which can interact with the road and the road users.

Any preliminary inspection should interest not more than 100 km. Recommended equipments are a GPS receiver and a digital video camera. During the preliminary inspection, each road is ran in both directions. At least three reviewers are needed: the driver, the reviewer in front seat and the reviewer in back seat.

The road is ran at normal speed, that is the prevailing traffic speed. During the inspection a video recording is performed and reviewers comments are recorded in the same video-tape. Driver calls traveled distance any 100 m and refers about any corrective maneuver. Reviewers on front seat and back seat make safety comments. GPS receiver is used to georeference useful points of the road such as mile stones and intersections.

3.3 General Inspections

Main objective of the general inspections is to obtain main information about the safety issues and their location along the route.

Any preliminary inspection can interest not more than 30 km. Recommended equipments are a digital video camera and checklists (see Table 1 and Table 2). The road is ran in both directions at very low speed (about 30 km/h). At least three reviewers are needed: the driver, the reviewer in front seat and the reviewer in back seat.

The road is ran and checklists are compiled. Video recording is performed and the driver calls traveled distance any 100 m.

3.3.1 Checklists Format

IASP checklists are very synthetic, since they relate only to main safety features which usually are present with continuity along two lane rural roads. Features which concern design consistency are not considered because in the IASP project design consistency is performed as a separate quantitative procedure (Lamm et al., 2002).

Checklists must be filled in both directions. Front seat and back seat reviewers, which have different views of the road, compile different checklists (see Table 1 and Table 2) with a step of 200 m. In order to simplify the reviewers task, any checklist is split in two parts: part A has to be compiled on site, part B can be compiled during the video examination performed in the office. Safety issues are ranked as high level problem and low level problem. If an high level problem occurs, the reviewer fills the gray box, if a low level problem occurs, the reviewer fills the blank box. Since a good friction evaluation requires instrumented measures, the friction problems are not ranked.

Table 1 Checklist for General Inspection: Module for Front Seat Reviewer.

	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
PART A										
Roadside										
Embankments										
Bridges										
Dangerous terminals and transitions										
Trees, utility poles and rigid obstacles										
Ditches										
Alignment										
Inadequate sight distance on horizontal curve										
Inadequate sight distance on vertical curve										
PART B										
Accesses										
Dangerous accesses										
Presence of accesses										

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

	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
PART A										
Cross section										
Lane width										
Shoulder width										
Pavement										
Friction										
Unevenness										
Delineation										
Chevrons										
Guideposts and barrier reflectors										
PART B										
Signs										
Warning signs, regulation signs										
Markings										
Edge lines										
Center line										

3.3.2 Checklists Compilation Criteria

Criteria for identifying and ranking safety issues are briefly reported in tables 3-10. In the main report (Cafiso et al., 2005) detailed explanations and reference photographs are reported.

Table 3 Criteria for assessing safety problems related to roadside.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Embankments	Unshielded or shielded with ineffective barriers embankments (h > 5 m) Unshielded or shielded with ineffective barriers embankments with great slope (h > 3 m) Embankments shielded with low containment safety barrier with great slope (h > 3 m) if dangerous obstacles in the bottom are present	Unshielded or shielded with ineffective safety barriers embankments with great slope (1 < h ≤ 3 m) Embankments shielded with low containment safety barrier (h > 3 m) if high commercial vehicles traffic is present Embankments shielded with discontinuous barriers (h > 3 m)
Bridges	Ineffective barriers Low containment barriers if high commercial vehicles traffic is present	Not correct installation conditions Medium containment barriers if the bridge overpasses roads or railways
Dangerous terminals and transitions	Not breakaway terminals (fish tails, buried in the ground, etc.) Not connected barriers and walls Not connected roadside barriers and bridge rails Not connected roadside barriers Barriers and walls connected without transition Roadside barriers and bridge rails connected without transition Roadside barriers connected without transition	Inadequate transition between steel barriers
Trees, utility poles and rigid obstacles	High diameter trees located at distance less than 3 m from carriageway Concrete utility poles located at distance less than 3 m from carriageway High diameter steel utility poles located at distance less than 3 m from carriageway Rigid obstacle with exposed front face or corner located at distance less than 3 m from carriageway	Low diameter trees located at distance less than 3 m from carriageway High diameter trees located at distance between 3 and 8 m from carriageway Concrete utility poles located at distance between 3 and 8 m from carriageway Low diameter steel utility poles located at distance less than 3 m from carriageway High diameter steel utility poles at distance between 3 and 8 m from carriageway Rigid obstacle with exposed front face or corner located at distance between 3 and 8 m from carriageway
Ditches	Rectangular or trapezoidal ditches located at distance less than 3 m from carriageway	Rectangular or trapezoidal ditches located at distance between 3 and 5 m from carriageway

Table 4 Criteria for assessing safety problems related to alignment.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Inadequate sight distance on horizontal curve	Available sight distance less than 50 m caused by continuous visibility obstructions inside the curve	Available sight distance greater than 50 m but smaller than SSD or inadequate to give the correct road perception Discontinuous visibility obstructions inside curve
Inadequate sight distance on vertical curve	Available sight distance less than 50 m	Available sight distance greater than 50 m but smaller than SSD or inadequate to give the correct road perception

Table 5 Criteria for assessing safety problems related to accesses.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Dangerous accesses	Accesses located on horizontal curves Accesses located on crests Accesses located on sites with poor visibility Accesses located close to intersections	Narrow accesses Accesses without markings Accesses without delineators Unpaved accesses
Presence of accesses	Three or more accesses in one stretch 200 m long	One or two accesses in one stretch 200 m long

Table 6 Criteria for assessing safety problems related to cross section.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Lane width	Width < 2.75 m Width > 4.50 m	2.75 ≤ Width < 3.25 m 3.75 < Width ≤ 4.50 m
Shoulder width	Width < 0.30 m	0.30 ≤ Width < 1.00 m

Table 7 Criteria for assessing safety problems related to pavement.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Friction	Polished aggregate Bleeding Raveling Low macro texture	
Unevenness	Steel drains on carriageway Disrupted joints Potholes on curves or close to intersections Deep potholes on tangent Shoving on curves, approach to curves or close to intersections High shoving on tangent Rutting on curve Patches on curve	Low shoving on tangent Low potholes on tangent Rutting on tangent Patches on tangent

Table 8 Criteria for assessing safety problems related to delineation.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Chevrons	Missing chevrons on severe curves Chevrons placement inadequate to give correct perception of the total length of the curve Chevrons placed only in one direction Ineffective chevrons since high deterioration Not reflective chevrons Chevrons with directional arrows in the wrong direction Chevrons obscured by vegetation	Missing chevrons on moderate curves Chevrons spacing inadequate to give correct perception of the curve Low reflective chevrons Local discontinuity of chevrons Partially obscured chevrons
Guideposts	Missing guideposts Missing reflectors on guideposts Missing reflectors on roadside safety barriers Missing reflectors on roadside walls Ineffective reflectors Guideposts with dangerous placement (e.g., inside ditches)	Variable height of reflectors along the road Low reflective guideposts Local discontinuity of guideposts

Table 9 Criteria for assessing safety problems related to signs.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Warning signs, regulation signs	Missing curve warning sign Missing crest warning sign Not visible curve warning sign Not visible crest warning sign Missing warning sign in dangerous situations	Curve warning sign faded or with low visibility Crest warning sign faded or with low visibility Yield sign missing, faded or with low visibility Advertisement located so as to disturb road users Indication signs incomplete or with low legibility Not consistent speed limit Unclear signs Wrong height signs

Table 10 Criteria for assessing safety problems related to markings.

Safety issues	Criteria for assessing high level problems	Criteria for assessing low level problems
Edge lines	Missing edge lines Very faded edge lines	Low faded edge lines Edge lines partially obscured by the vegetation
Center line	Missing center line Very faded center line	Low faded center line

3.3.3 General Problems and Recommendations

In the office, the team analyzes video and compiles part B of the checklists. Checklists are compiled in both directions referring in particular to the right side. By brainstorming between the team members checklist results are examined and the final computerized version of the checklists is edited.

In the problem analysis it is valuable to take into account both sides of the road. General problems not contained in the checklists can arise since checklists are an aid but must not limit the flexibility of the procedure.

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. The manual (Cafiso et al., 2005) suggests for each general problem the recommendation typologies. The manual recommendations, the checklists review and the team members suggestions must be used as a support to formulate recommendations for general safety problems.

Problems and recommendations are disaggregated in order to highlight the safety issues of each road feature, but road safety improvement requires an integrated approach where interaction between different measures must be taken into account.

As final result of the meeting, a preliminary report containing general problems and recommendations is edited. Moreover, some sites requiring specific inspection might be identified.

3.4 Site Detailed Inspections

The detailed inspection is aimed at closer examination of sites which present specific safety issues. Above, inspection of road segments and intersections are separately addressed.

Equipments recommended for detailed inspections are the followings: protective clothes with high retro reflectivity, GPS receiver, digital video camera, digital photo camera, measuring wheel or laser measurer, inclinometer, inspection modules with rigid support (see Table 11 and Table 12), stopwatch, laser gun (optional) and traffic counters (optional).

3.4.1 Road Segment Inspections

The road is ran in both direction at low speed, stopping the car in sites which show the greatest safety problems or specific features which require investigation deepening. Other than those selected during the general analysis, more sites can be identified during the drive through.

Photos related to general problems are taken. These photos can be added to the review report.

In the selected sites, the review team performs the inspection by walking and observing both the road features and the road users behavior. Photos of identified problems and videos of dangerous behaviors are helpful both in the problem analysis and in the report writing.

Compilation of the site inspection module (see Table 11) is strongly recommend since it gives the following benefits:

- focuses the identified safety issues;
- gives a chance to record the concerns raised during the inspection;
- synthesizes observation results simplifying the report writing.

Inspection module has some similarities with general checklists but contains more information which are acquired by detailed observations and are integrated by further information, such as:

- available sight distance;
- lane and shoulder widths;
- road users behaviors (speed, queues, braking, overtaking, traffic volume and composition, etc.);
- accident signs (damaged barriers, braking marks, etc.).

3.4.2 Intersection Inspections

Each intersection is ran both by car and by walking. The inspection module (see Table 12) is an aid for the reviewers but must not limit the reviewers task which is flexible and can comprise also integrative surveys that seem more appropriate in relation to the site conditions.
Road users behavior analysis is one of the main task in the investigation. If critical traffic conditions occur, traffic counts (in the rush hour) and speed measurements can be acquired.
If speed measurement are not carried out, sight distance adequacy evaluation can be performed by the stopwatch method (SETRA, 1998).

3.5 Night Time Inspections

Night time inspections are focused at understanding how the road is perceived in the night. Consequently, main focus is on markings, delineation and legibility of the road alignment. Any night time inspection can interest not more than 100 km. Recommended equipments are GPS receiver and digital video camera.
Videos of the road and comments of the auditors should be recorded. Location of specific night time problems may be carried out by using the GPS receiver in cynematic modality. Each road is ran at normal speed in both direction.
The day after the inspection, a meeting in the office is carried out. Videos are examined and identified problems are annotated in the report.

4 FINAL REPORT

The review report may be written in the draft version by only two members.
The report is written in "problem/recommendation" format, where the problem is described in terms of safety issues and accident risk to a road user, and the recommendations are engineering solutions to the reported problem.
All the members must read the draft report. After discussion on the report, the final report is edited and signed.
The report describes the analysis procedure and contains the study results, which are detailed and explained. It contains the following sections:

- introduction (road name and location, dates of inspections and other phases of the review, review team members and qualifications, information on meetings, information on data provided by the client, description of the procedure used to conduct the review);
- segment general problems (graphs relative to nature, severity and extension of the safety issues, detailed description of the safety problems, identification of the potential accident scenarios, photos exemplifying the problems, description of recommendations aimed at eliminating or alleviating the safety problems);
- segment specific problems (detailed description of the safety problems, identification of the potential accident scenarios, photos exemplifying the problems, description of recommendations);
- intersection problems (description of the general safety problems, description of the general recommendations, detailed description of the specific safety problems of each intersection, identification of the potential accident scenarios of each intersection, photos exemplifying the problems of each intersection, description of recommendations of each intersection);
- synthesis, in tabular format, of problems and recommendations;
- concluding statement and signatures of the reviewers.

Table 11 Road Segments Inspection Module.

Site general description	
Street name:	Problem number:
ID GPS waypoint:	ID first and last photo:
– Curve: ☐ – Tangent: ☐ – Longitudinal grade: level ☐ slope ☐ – Embankment: ☐ Cut: ☐ Cut and fill: ☐ Bridge: ☐ Tunnel: ☐	
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: _____ Notes:	Vertical alignment problems – Crest: ☐ – Inadequate visibility: ☐ – Available sight distance: – Sag: ☐ – High longitudinal grade: ☐ Notes:
Cross section – Lane width: – Shoulder width: Notes:	Roadsides – Embankment inadequately shielded: ☐ – Bridge inadequately shielded: ☐ – Dangerous terminals and transitions: ☐ – Trees, utility poles, rigid obstacles: ☐ – Unrecoverable ditches: ☐ – Others: _____ Notes:
Presence of accesses: ☐	Notes:
Inadequate friction: ☐	Notes:
Pavement unevenness: ☐	Notes:
Inadequate markings: ☐	Notes:
Inadequate signs: ☐	Notes:
Inadequate delineation: ☐	Notes:
Road users dangerous behaviors – High operating speeds: ☐ – Queues: ☐ – Wrong maneuvers o Late braking: ☐ o Dangerous passing: ☐ o Invasion of opposite lanes: ☐ Notes:	
Accident signs (damaged barriers, glasses on the pavement, braking marks, etc.): ☐	Notes:
Sheet 2 (not to scale)	
Site condition diagram:	Sketch of potential accidents:
Notes	Description of potential accident scenarios:

Table 12 Intersections Inspection Module.

Intersection general description	
Intersection type: ☐ T ☐ X ☐ Y ☐ Roundabout ☐ Other (specify)	
Name of intersecting streets:	
ID GPS waypoint:	ID first and last photo:
Problems description	
Horizontal alignment – Intersection located inside a curve: ☐ yes ☐ no – Intersection located outside a curve: ☐ yes ☐ no – Curve in one of the approach legs: ☐ yes ☐ no Notes:	Vertical alignment – Intersection located on a crest: ☐ yes ☐ no – Crest in one of the approach legs: ☐ yes ☐ no – High longitudinal grade: ☐ yes ☐ no – Intersection located on a sag: ☐ yes ☐ no – Continuity of the secondary road profile: ☐ yes ☐ no Notes:
Left turn and right turn lanes – Left turn lane: ☐ yes ☐ no – Too high left turn volume: ☐ yes ☐ no – Left turn volume count: – Right turn lane.: ☐ yes ☐ no – Too high right turn volume: ☐ yes ☐ no – Right turn volume count: Notes:	Channeling – Ghost island on secondary road: ☐ yes ☐ no – Curbed left turn lane: ☐ yes ☐ no – Inadequate canalization islands: ☐ yes ☐ no Notes:
Visibility obstructions: ☐ yes ☐ no	Notes:
Presence of accesses: ☐ yes ☐ no	Notes:
Roadside obstacles: ☐ yes ☐ no	Notes:
Inadequate friction: ☐ yes ☐ no	Notes:
Inadequate notice signs: ☐ yes ☐ no	Notes:
Inadequate direction signs: ☐ yes ☐ no	Notes:
Inadequate regulatory and warning signs ☐ yes ☐ no	Notes:
Inadequate markings: ☐ yes ☐ no	Notes:
Inadequate delineation: ☐ yes ☐ no	Note:
Road users dangerous behaviors – High approach speeds: ☐ yes ☐ no – Long queues: ☐ yes ☐ no – Wrong maneuvers o Late braking: ☐ yes ☐ no o Poor compliance of traffic regulations: ☐ yes ☐ no o Invasion of opposite lanes: ☐ yes ☐ no o Short gap acceptance : ☐ yes ☐ no	
Accident signs (damaged barriers, glasses on the pavement, braking marks, etc.): ☐ yes ☐ no	Notes:
Sheet 2 (not to scale)	
Intersection condition diagram:	Sketch of potential accidents:
Notes	Description of potential accident scenarios:

5 CONCLUSIONS

Nowadays, Road Safety Inspections (RSI) are recognized as an effective tool for identifying safety deficiencies of road infrastructures.

Safety inspections represent a low cost process for the evaluation of the network safety performance. Its applicability in rural local roads, where accident data generally do not give enough information for the safety analysis, make the procedure very attractive. However, due to the subjective nature of the process they may give rise to disagreements which limit their effectiveness.

The research was aimed at defining a RSI operative procedure able to improve the effectiveness and reliability of the methodology. For this purpose, the research was focused on the review framework, on the reviewers and client roles and, with special emphasis, on the methodologies used for identifying and ranking the safety problems. Phases of the inspection procedures have been defined: preliminary inspection, general inspection, detailed inspection and night time inspection. For each phase, objectives of the inspection, needed equipments, inspection methodology and roles of each team member have been defined. General inspection checklists, relative to the main safety features which may be present with continuity along two lane rural roads, and detailed inspection modules, differentiated for segments and intersections, have been defined. Moreover, criteria for identifying and ranking safety issues have been briefly reported in the paper. Last, the review report contents and format have been described.

The procedure, which has been developed during the safety inspections of 100 km of two lane rural roads, has proved to be effective to identify most safety issues. As far as alignment geometric defects and design consistency evaluation is concerned, RSI are not as valuable such as the quantitative methods, that may usefully integrate the inspection results.

As a research outcome, a RSI operative manual has been edited. It allows to transfer to other road agencies the acquired knowledge and to obtain a greater objectivity in the inspection process.

ACKNOWLEDGMENTS

This research was conducted as part of IASP project funded by EU DG TREN and by Province of Catania.

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