Road Safety in Intersections Regulated by Roundabouts.

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Synopsis

Road safety in the different elements of an infrastructure can be analyzed by the road safety audits. From the 90's, its use in different countries has proved its usefulness.
In this paper, it is shown a summary of the most important aspects that have to be controlled in a roundabout as regards road safety. These aspects should be controlled, not only in the design of a next construction roundabout, but also in the checking of the ones already done.
The wanted purpose is to use the provided advantages by road safety audits to show some advices beyond current regulations.

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1. INTRODUCTION

In Spain, during 2004, more than four thousand people lost their lives in road accidents. Of nearly one thousand accidents with victims more than half took place in an urban area. Although accidents are divided almost equally into urban and non-urban area, it is not the same with mortal victims, there are more of them in non-urban areas. In these ones, we found the eighty percent of the victims.

The big “economic loss” generated by these accidents make the different administrations work continuously to try to reduce road accidents.

Taking into account the features of the road, accidents are classified into two categories: in intersections or out of them. The category of intersections is divided into 6 subcategories: into T or Y, into X or +, entrance ramp, exit ramp, roundabouts and others. This paper is focussed on the roundabouts intersections. In 2002, in this type of intersections took place the 8% of the accidents with victims over the total of intersections.

In Spain, there is no so much custom, as happens in other countries, of realizing road safety audits. Thanks to its application we are learning to recognize the most common mistakes as for example those made when a roundabout is designed.

2. FACTORS THAT CONTRIBUTE TO ACCIDENTS

Road traffic is defined in three factors. These factors are: human, vehicle and road. When an accident occurs it is said that one or more of these factors are involved in it. Different studies suggest that the human factor contributes between the 70% and 90% of the accidents, the road contributes around the 30% of the accidents and the vehicle in less than 10% of them.

Through the audits it is hoped to influence on the driver’s factors, the road and its environment before an accident takes place. Once the accident is going to occur, audits pretend to influence on the road and its environment so the effects over the vehicles and its occupants are the most slight possible.

According to some trends, the possibility that an accident takes place in a roundabout depend on the possible combination of trajectories between users, and the number of times they are produced by unit of time and its rate of arrival. The users of the roundabouts are pedestrians, cyclist and motor vehicle.

The accidents considered in a roundabout are two types: between users, and of users with elements of the roundabout.

In the modelling of the forecast of accidents in roundabouts, the following factors are usually considered: intensity of entrance, circular traffic, curvature of entrance, width of entrance, width of approach, radius of a ring-shaped road, curvature of exit, proportion of motorcycles and cars, angle of entrance and the number of pedestrians.

3. ROAD SAFETY AUDITS

As it is well-known for all, first countries in using road audits were Australia, United Kingdom and New Zealand.

3.1 Definition

The most widespread definition is from Austroads in his handbook *Road Safety Audit* in 1994:

“A Road Safety Audit is a formal examination of an existing or future road or traffic project, or any project which interacts with road users, in which an independent, qualified examiner reports on the project's accident potential and safety performance”

This basically involves:

- A systematic and formal review process (and not an informal checking) based on an organised procedure described in a guideline or in a similar publication. A checking of risks, and a systematic consideration of the solutions.
- An independent team of professionals auditors who goes through the design of the project.
- to do in relevant projects at appropriate stages, and always with a specific approach through safety performances.
- The writing of a report that identifies the defects and gives the advices to eliminate or reduce them.

Since 2002, when a new handbook is published updating the audits of road safety applied to the existing roads, they move into calling “Road safety review of existing roads” (Austroads, 2002). This type of safety

review is called by other authors: “Road Safety Assessment” This is it because it has to be emphasized the greater potentiality of the road safety audits when they are applied before the project has been built. (Jordan y Morgan, 2000).

3.2 Objectives

The main objective of the road safety audits is to identify problems. Audits could not always find the perfect solution, but they will give some recommendations to make them a useful process. They basically set out to:

- Identify and propose solutions to potential problems that can cause an accident.
- Guarantee that necessary elements to reduce accidents are included.
- Guarantee that the reducing elements of the seriousness of accidents, not only are placed, but are put in a suitable place and in a suitable way.
- Consider safety of all users of road, as well as drivers of vehicles of 4 or more wheels. We also have to bear in mind motorcyclists, cyclists and pedestrians.
- Study the interaction of the infrastructure that is going to be built in the adjacent to guarantee that the project doesn’t affect their safety.
- Reduce the necessity of having to carry out works to prevent road safety problems that appears in the infrastructure after being built.

3.3. Types of audits that have to be used

In a project, there are several phases (information study, draft, project of building,…), in all of them a road safety audits can act. These phases divide the audit in different stages. The number of stages of an audit differs from one country to another, although from 1998, it has been trying to standardize it. In this paper, it is explained the norm marked by Australia and New Zealand.

Each stage has a name, they are:

1) “Feasibility Audit”.
2) “Preliminary Design Audit”.
3) “Detailed Design Audit”.
4) “Pre-opening Audits”.
5) “Post-opening Audits”.

These last ones, as it has been discussed from 2000, are called safety review.

These five types of audits can be used to detect road safety problems in any type of infrastructure. In the case of the intersections controlled by roundabouts, if they are entrusted in an isolated way, the 2 or 3 first are usually included in just one.

Before going on, we have to remember that its application from the first phases of the design of a roundabout will be accompanied by the best results and profitability (Gonzalo, 2000).

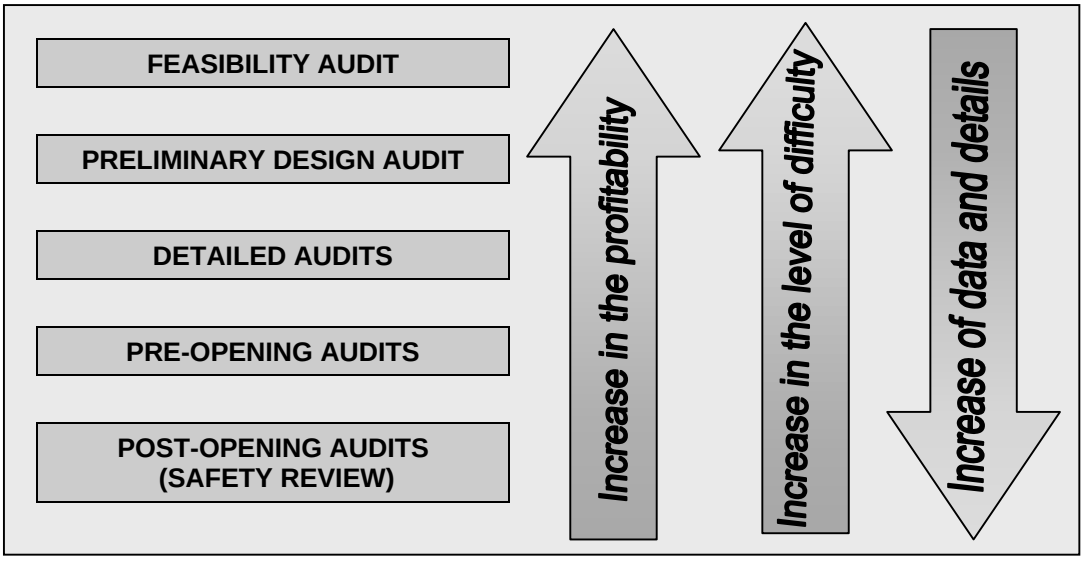

Figure 1: Types of road safety audits

Roundabouts appear in many cases inserted into more complex projects, in these cases it is necessary to consider the application of the five types of audits mentioned before.

An audit still under conception of the building work could, in some cases, indicate the necessity of executing another solution different from the roundabouts, because this could not be a good solution in view of road safety. This problem is usually arisen in the execution of a roundabout forgetting, for example, the high number of pedestrians that could make this one not the ideal solution.

4. ASPECTS TO CONTROL: CHECKLISTS

The checklists are the key instrument of road safety audits. In them, there are different questions about the most outstanding aspects that have to be borne in mind.

People in charge of studying the road safety of an infrastructure that is going to be analyzed, should answer some questions collected in the checklists. If the factors discussed by the different questions have been considered, it will be the sign that it is going well. In case of having to answer in the negative to any of the questions reflected in the lists, the auditor should recommend the taking of correction measurement, or the necessity of gathering more specific information. The correction measurements will be aimed to the elimination of that road safety problem or, when its elimination is not possible, the reduction of the consequence in case an accident takes place.

Auditors should have a suitable background to indicate which are the best corrections to make (Fernández y Gonzalo, 2002).

People in charge of analyzing road safety should fulfil some requirement, not only of grade but also of experience, be independent from the people responsible for the design of the projects, and lastly form a team.

In this section, there are shown just some of the questions reflected in the numerous checklists. These are used for the auditor as guide or reminder, but never can be considered as the replacement of experience or grade that they must have.

The checklists fit in with the type of audit it is carrying out, and that’s why specific lists are developed for each of the stages of the audit.

The aspects generally dealt in these lists are alienation, environment, width of the lanes, signposting, traffic, intersections of traffic flows, users, lighting, maintenance works, building works, as well as other special conditions. Almost all these aspects are normally collected in the different regulations, handbooks or guidelines of the design of roundabouts but not always from the perspective of the road safety.

The main parameters controlled by the regulations are the width of approach, of entrance, of exit; and after crossing the roundabout, the total diameter and the central islet, the curvature of entrance, of exit and of link between both, the dimensions of islets, the width of the lanes of a roundabout, the longitudinal and transverse slopes, the visibility of the entrance; and in the roundabout, the signposting, the warning lights, the defences and lastly the lighting.

As well as considering the phase in which the audit is being carried out, it is necessary differentiate if the roundabout is established or not in an urban area.

To simplify the presentation we will consider just two groups of aspects:

- Aspect to consider in feasibility and preliminary design audits.
- Aspect to consider in audits of detailed audits and pre-opening audits, and in the safety reviews after the opening.

4.1. Aspects to consider in feasibility and preliminary design audits

In these first phases the aspects to control are more general.
Some of the questions to make are:

- Is the proposed solution appropriate for cars, motorcycles, cyclists, pedestrians, heavy vehicles and buses?
- And the mixture of traffic flow?

- Does the relief of the land allow to fit the work?
- Will it reasonably fit in with the evolution in traffic quantity and composition?
- Are the angles of the intersection appropriate to the visibility of all users?
- Is the surrounding area of the works exempt from the elements that could affect its safety?
- Can drivers notice the presence of the intersection in enough time?
- Has the proposed solution an appropriate size to support all movements of vehicles which cross it?
- Can all types of users interpret correctly its working?
- Are the approach speeds appropriate to the considered design?
- Have been the effects of fog, dazzles because of the sunset or dawn considered when it comes to the project?

Figure 2: Roundabout with unappropriate size to support all movements of vehicles that cross it?

In these first phases it has to think about the suitability of the selection of the roundabout not only from the point of view of the ability of the vehicles but also in view of the safety of all its users. In the general checklists just some specific questions are for the roundabouts where they put special emphasis on the consideration of cyclists and pedestrians.

In 1998, in New Zealand (Transfund, 1998) a document that collects the main problems detected in the audits of the roundabout is published. For these phases they have to emphasize problems like these:

- the horizontal signposting mistakes and doesn't help to interpret the roundabout,
- the lighting is not the appropriate (there isn't or doesn't help to show the existence of a roundabout),
- its geometry doesn't guide well its users,
- inadequate visibility,
- dangerous objects in its vicinity (trees, telephone pole, lamp post, …),
- lack of islets previous to the roundabout or a bad design in the view of all users,
- height of the inappropriate central islet and
- high speeds of approach without dealing.

4.2. Aspects to consider in detailed audit, pre-opening audits and in the safety reviews after the opening

The treatment of the safety reviews after the opening is different to detailed audits and pre-opening audits, although aspects to control are the same. This is due the users or the environment have been able to change a lot since the works was opened. In these cases, a well-designed roundabout can turn into an intersection with incorrect working from the safety point of view.

The last two of the three phases to deal allow to analyse the roundabout after its implementation. For its revision after the opening, the accidents that took place in it or in other similar to it could be studied, and also carry out proposals to improve it or in others of next building, as can be the reduction of approach speed for the adopted radius of the roundabout. (Brude y Larsson, 2000).

In the detailed audits, the general checklists consider special sections for roundabouts. Among the aspects to control in these phases, apart from the mentioned in previous phases, the following ones stood out:

- Is the adopted drainage enough?
- Have the pedestrian been correctly led to the suggested cross points?
- Have the fences, closings and other means to prevent the traffic of pedestrians for non-desirable places been placed?
- Has the pedestrian crossing areas been situated where drivers can see them easily?
- Can pedestrians see clearly and in enough time vehicles that cut their crossing path?
- Has the parking of vehicles being limited to areas where would give safety problems?
- Has the bus stops been placed adequately? In many occasions buses parked in theirs stops reduce the visibility distance of drivers and pedestrian increasing the risk of accident.
- Have the roundabout signs that replace a previous situation where there weren't roundabout or any type or intersection been reinforced?
- Is the superficial road surface state adequate? If the road surface is not in good condition because of lost of goods, potholes, dirt… can appear road safety problems for the users especially for cyclists and motorcyclists.

The aspects related to pedestrians are dealt at great length in the checklist because they are a sensitive point to give problems. They are presented as keys for the reduction of accidents in roundabout against other types of intersections, the reduction of traffic speeds and the separation and reduction of points of conflict (Stone y Pillalamarrik, 2002).

Other problems which are normally detected (Appleton y Clark, 1998) are related to a bad removal or erasure of old road signs in that stretch of the road before building or relocating the roundabout, in the absence of road signs (delay of replacement) and problems with the existing vegetation as in the environment as in the central islet whose growth and lack of maintenance cause visibility problems.

Figure 3: Dangerous objects in its vicinity (lamp post),

Figure 4: Dirt on road surface

In these questions they have tried to avoid those which are dealt directly by existing regulations or recommendations in the design of roundabouts.

5. FINAL RECOMMENDATIONS AND CONCLUSIONS

The mere fact of worrying about road safety controlling the different aspects of the design, carrying out recommendations, as well as marking a monitoring of the effectiveness of the suggested actions, cause an improvement of the knowledge of the safety road. This culminates in better strategies to the reduction of road accidents.

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