ASSESSMENT OF IMPACTS OF ROAD SAFETY AUDIT RECOMMENDATIONS FOR IMPROVING VULNERABLE ROAD USERS SAFETY IN INDIA AND BRAZIL

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ABSTRACT

To increase the level of safety of Vulnerable Road Users in Emerging Economies, the project *SaferBraIn* has been developed within the 7th Framework Programme of the European Commission.

SaferBraIn aims at increasing the level of safety of VRUs, contributing to the overall scope of reducing the number of fatalities and the severity of injuries caused by road accidents. The project had a special focus on India and Brazil.

During the project the road safety conditions in India and Brazil (especially that of VRUs) were analysed and, basing on the knowledge acquired, tools and methodologies were developed (e.g. a Transferability Audit, to check the applicability and acceptability of road safety measures from EU countries to the EE; a Decision Support System, to supports technicians and decisions makers in selecting safety measures reducing risk of accidents of VRUs and in realizing road safety audits on projects or existing infrastructures).

These activities were complemented by tests of the developed methodologies and tools at sites in India and in Brazil. The effectiveness of the outputs obtained was verified and feedbacks for the definition of recommendations and guidelines were provided.

The pilot tests relied with executing a Road Safety Audit of project being implemented in Sao Paulo and in Pune, with special focus on VRUs issues.

The selected sites are located in urban areas being partially renovated. The audits were executed by independent experts and submitted to the Local Authorities in charge of implementing the projects. Different kind of issues arose in India and in Brazil concerning the acceptability of measures proposed and the project implementation.

The results of the project implementation and the impacts of measures proposed by the audits were analysed. Especially pre- and post-evaluations, based on behavioural changes verified on the field, were realised to assess the impacts of Road Safety Audits recommendations.

Keywords: Vulnerable Road Users, Road Safety Audit, Emerging Economies, Assessment.

INTRODUCTION

Walking and cycling are transport modes where relatively unprotected road users interact with traffic of high speed and mass, making pedestrians and cyclists vulnerable. Children below the age of 12 and adults aged 75 and above are particularly engaged in walking. The bicycle is used most frequently by adolescents (12-17 years of age).

Of all traffic fatalities in EU countries, in 2009, the proportion of pedestrian fatalities was about 17% and the proportion of cyclist fatalities is about 6%. Age groups that have the highest percentage of pedestrian fatalities are children younger than 10 years of age and adults aged 65 years or older. Cyclist fatalities have the highest share among children between 6 and 14 years of age.

In India, from 1995 to 2006, the number of accidents increased by some 22%, while the number of fatalities increased by some 31%. In 2006. 105.725 people died on the road (13% of which were pedestrians and 4% were cyclists), compared to the 43.400 died on the EU-25 road network (and we can reasonably assume that the level of "underreporting" in India is higher than in Europe). While in India the number of registered vehicles is about 10 times lower than the European average, the number of road fatalities per number of registered vehicles was about 6 times higher than in Europe.

In Brazil, in 2006 there were about 35.000 road traffic fatalities. The trends show a quite constant situation since 2000. In 2006, the pedestrians and the cyclists died in road accidents were respectively the 28% and the 5% of the total. While the number of registered vehicles were about 49 millions (about 2,5 times lower than the European average), the number of road traffic fatalities per registered vehicles was about 3 times higher than in Europe.

These data shows the gaps between both India - Europe and Brazil - Europe and suggest that Europe could give a strong effort in improving Vulnerable Road Users (VRUs) safety in these two Emerging Economies by transferring and adapting to the local context the results of the European research and experiences (Mohan & Tiwari, 1998).

The main objective of *SaferBraIn* (i.e. a project co-funded by the European Commission within the 7th Framework Programme – started in October 2009 and completed in March 2012) was to increase the level of safety of the whole

Brazilian and India road transport system and its components, focusing the attention on VRUs, thus contributing to the overall scope of reducing the number of fatalities and the severity of injuries caused by road accidents.

After having analysed the road safety conditions in India and Brazil (e.g. local accident databases regarding VRU's, the actual situation of road infrastructure, land-use planning and the local current road safety management procedures), some methodologies and tools were developed dealing with road safety measures transferability, development of a Decision Support System to support technicians and decision makers in selecting the most appropriate measures, development of recommendations and guidelines for the road system infrastructure design to safely carry VRUs in Emerging Economies.

Some of the developed methodologies and tools were tested in two pilot sites (one in India and one in Brazil), where renewal projects allowed verifying the actual applicability and the results of the project outcomes, as well as evaluation and comparison of results and refinement of developed methodologies, tools and recommendations and guidelines.

Two pilot sites in Brazil (Sao Paulo) and India (Pune) were selected and data about actual situation of infrastructures, designs and information about accidents and traffic were collected. Based on these information a **Road Safety Audit** (RSA) was realised on the renewal designs and additional road safety measures were proposed for implementation.

Road Safety Audit is a standard procedure described in a set of guidelines with checklists and issued in many national manuals (New Zealand, the United Kingdom, Australia, Denmark, USA, Norway, France and Italy). A common feature of such handbooks is the provision of checklists for every stage of the project and for road safety inspections, but only two Countries have implemented guidelines for Road Safety Audits of projects dedicated specifically to Vulnerable Road Users: USA (Nabors et al, 2007) and the UK (HD 42/05, 2005). The first provides guidelines for every road element; the second, in addition, highlights the differences among the various Vulnerable Road Users: pedestrians, mobility and visually impaired users, cyclists and equestrians. With these characteristics, both manuals are more suitable for urban projects than the other generic Road Safety Audit guidelines. In general, Road Safety Audit is considered an efficient and recommended tool for the improvement of road safety, within a comprehensive safety management system.

Within *SaferBrain*, the RSA was realized by an independent audit team according to the most commonly used international guidelines (TRB, 2004; Cafiso et Al., 2007; EURO-AUDITS, AA.VV., 2007; Cardoso et al., 2007; Baran, 2008). At the end of the audit process a concise report about the proposed measures was submitted to the local authorities (in Pune and in Sao Paulo) in charge of design and implementation. The recommendations were discussed and most of them were included in the final designs.

While it was not possible, due to political changes, to implement the proposed measures in Pune (despite the fact that they were officially agreed with the local authorities), most of the measures proposed for Sao Paulo were realized. It was thus possible to realize a safety assessment of the new road design.

The RSA experience realized in Sao Paulo, as well as the results assessment are discussed in the following paragraphs.

ROAD SAFETY AUDIT IN SAO PAULO

The city of Sao Paulo has more than 10 million inhabitants (heading a Metropolitan Area with more that 25 million inhabitants). It is composed by a great variety of road and traffic conditions. There are several big arterial roads (more than 3 lanes per direction) inside the city. Due to its territorial extension, one can find rural zones (very far from the city centre) as well as very poor areas (e.g. favelas). The city centre is quite well developed and maintained in term of road infrastructures.

Facilities for pedestrians exist in all the city areas, while cycle paths are not very frequent. VRUs are very risky road users in Sao Paulo. The motorization rate is constantly increasing since some years. Due to high levels of congestions inside the city, the level of motorcyclists is also very high. Traffic conditions are generally dangerous.

DESCRIPTION OF SELECTED SITE

The road subject to renewal design was the **Avenida Deputado Cantitio Sampaio**, located in the far northern part of Sao Paulo. Its length is about 7,5 km connecting the districts Freguesia do Ó and Vila Nova Cachoeirinha (Figure 1).

The road is passing as well the district Brasilandia which has a very high population density. It also has to be considered that this region is one of the poorest in Sao Paulo (close to a Favela region). The traffic function of this road can be described as an arterial road.

Based on the description of the local authorities, the road infrastructure is meant to be completely precarious and inadequate for motorized traffic as well as for pedestrians. The aim of the new road design was thus to improve the safety of pedestrians.

The main issues leading to realize a new design were: foot paths destroyed or occupied by extended buildings, foot paths occupied by parking cars, high speed and (especially motorcycles) overtaking at inadequate places, bad or no illumination of road and intersections, no consistent regulation of speed, speed humps flattened and broken by heavy duty traffic, few traffic lights.

The accident data from 2007 to 2009 showed an average of 3,2 accidents per month. The numbers of accidents decreased from 49 in 2007 over 38 in 2008 to 30 in 2009. Participation of motorcycles on accidents increased from 41% in 2007 to 50% in 2009.

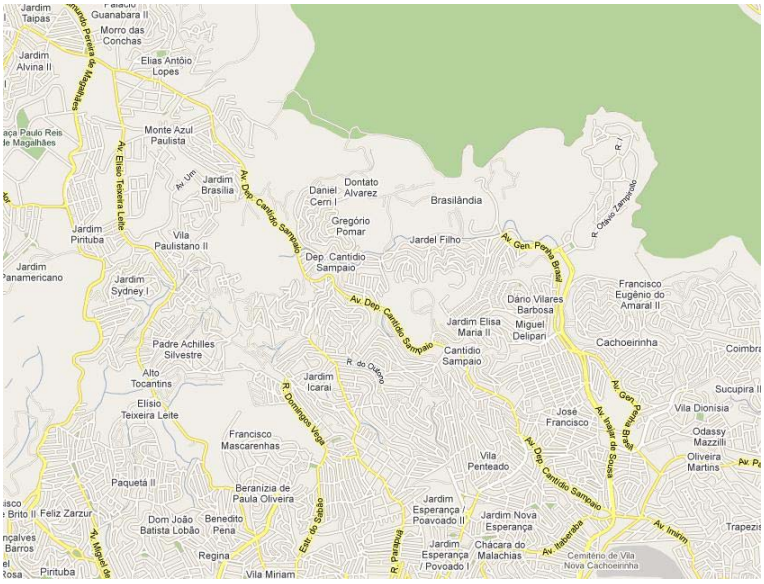

Figure 1 Overview of Av. Deputado Cantidio Sampaio

The design analysed through a RSA was in a final design state, focusing mainly on improvement of pedestrian safety in that area. The RSA particularly focused on the intersection between Av. Cantidio Sampaio and R. Padre G. Orlando da Silveira (Figure 2) and general indications for the whole area were also provided.

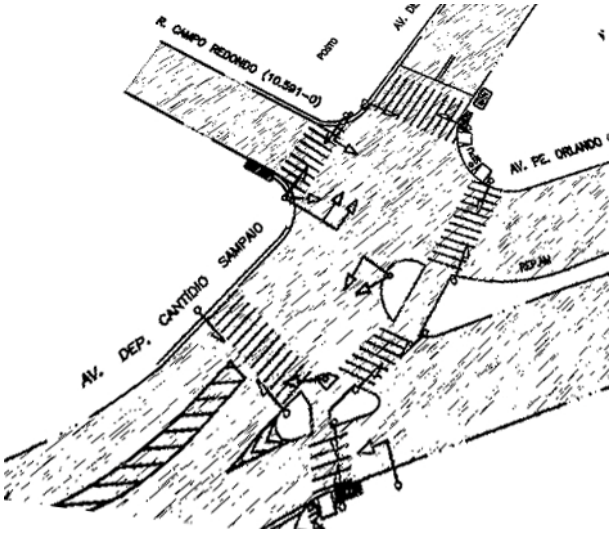

Figure 2 Schema of intersection between Av. Cantidio Sampaio and R. Padre G. Orlando da Silveira

The intersection analysed is located in an urban environment, along Av. Cantidio Sampio, on which converges three other roads (Figure 3). The main road (AB) has a slight slope. The roads E and C arrive from another intersection on flat, while the road D exits from the intersection with a strong slope descending. In the area, the traffic conditions are heavy (especially during pick hours) and mainly comprise of cars and buses.

The site is not symmetric, thus the conflict points between the manoeuvres had an homogeneous distribution inside the intersection area. Fixed manoeuvres trajectories in entry and exit of vehicles from the intersection area cannot be located. This situation made more difficult defining a solution to minimise the intensity and number of conflict points both for motorised flows and for VRUs flows. The pedestrian routes were developed with continuity and covered the entire perimeter circuit of the intersection.

The interventions designed covered the following aspects:

- Improvement of horizontal signs;
- Realization of a divisional island to separate the itineraries;
- Realization of ramps for disabled users;
- Improvement of vertical signs.

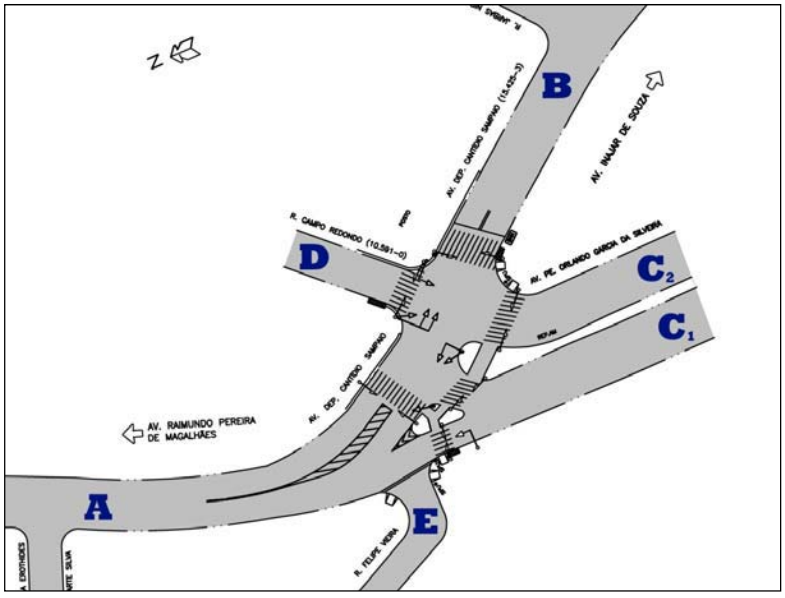

Figure 3 Schema of concurrent roads in Sao Paulo RSA area

RSA RECOMMENDATIONS

The following main recommendations were made after undertaking the RSA, and comments were provided to the local authorities to verify whether implementation was possible (reasons for eventual rejection were also provided by local authorities):

- Improvements of pedestrian routes visualization.
- Improvement of vertical signage, preparation of vertical signs plan proposed, with the aim to improve the knowledge of manoeuvres allowed for motorised traffic.
- Absence of vertical signs for disabled users, introduction of tactile signs and acoustic alarms.
- Provision of traffic lights plan in order to check cycles and manoeuvres.

Some of the recommendations obtained from the RSA are synthesised in the following paragraphs.

Footpaths

The project had no executive details concerning the profile of footpath kerbs. In particular, there were several kerbs which were very damaged, absent or collapsed due to passage of vehicles. This condition increased the risk conditions for pedestrians as it eliminated the conditions for operations of pedestrian itineraries, thus increasing the risk of pedestrian collisions. For bicycles users, the absence of well defined kerbs can cause a loss of control of the vehicles in case of impact with not well visible footpaths.

Recommendations

The project should consider aspects concerning the clear visualization of pedestrian itineraries and the definition of the height and signalling of kerbs.

Absence of vertical signs

The project seemed to not have a clear vertical signs plan. The actual vertical signs were inefficient and poor. This can lead to an increase in risky conditions for users as the motorised users are not informed about the regulation system and about indications to be followed to cross the intersection.

Recommendations

It is necessary to prepare a vertical signs plan to be integrated with the horizontal plan, with the aim of improving knowledge of manoeuvres allowed and mobility conditions inside the intersection.

Absence of vertical signs for disabled users

The intersection had some devices for helping the disabled users (i.e. wheelchair) but there were no tactile signs for visually impaired users. The project included a good plan for traffic light regulation of the pedestrian crossings but there were no details about the presence of acoustic alarms for visually impaired users.

Recommendations

It is necessary to integrate a plan for tactile signs and acoustic alarms for the traffic lights cycles. This allows a punctual verification of the continuity of the pedestrian crossings and of their comfort and safety.

Absence of detailed traffic lights plan

The project included designs about position of traffic lights but nothing was said about the management of the intersection. Details about traffic lights cycles and manoeuvres were absent.

Recommendations

It is important to verify the traffic lights plan and to provide details about cycles and manoeuvres (based on traffic flows).

Divisional Island

At the right in Figure 4, the implementation of island for saving pedestrians was designed. These islands also divided the traffic flow between the main itineraries.

The divisional island at the north seemed to be designed having the same height of the road. This could cause problems when it rains as the water would go inside the island making it impossible to use. Also, this made it more easy for debris to accumulate in this area.

Recommendations

It is necessary to ensure that the footpath platform inside the divisional island has adequate ramps for disabled users.

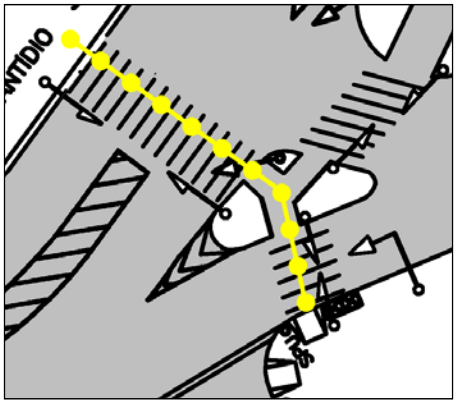

Figure 4 Detail of divisional islands in Sao Paulo RSA area

Kerbs of divisional island

This scheme did not show the height of the kerbs of the two islands. This seemed to be achieved with rigid elements fixed to the paving and with high kerbs with sharp edges. Vertical signs to improve the performance in term of visibility of islands were absent.

Recommendations:

- It is necessary to make more visible the elements of delimiting the divisional islands and in particular those having the function to protect the pedestrians.
- The height of kerbs should be specified.
- The edges of kerbs have to be moulded with rounded sections instead of sharp edges.
- It is necessary to place adequate vertical signs to improve the visibility of safety island elements.

Pedestrian crossing

The horizontal sign indicating the pedestrian crossing way was not coherent with the width of sections available for movement of pedestrians (Figure 5). This condition could lead to uncertainties in the movements of pedestrians who cannot use straights trajectories during the crossing or unprotected paths. In all cases the result could be a higher risk exposure time.

Recommendations:

It is necessary to provide adequate widths of pedestrian crossings through effective dimensions of the entry and exit ways from footpaths.

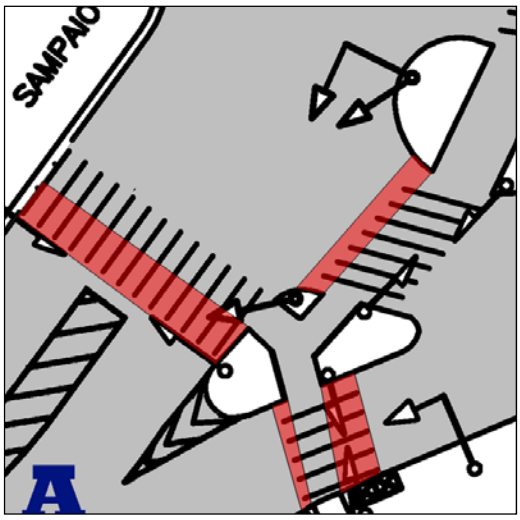

Figure 5 Detail of pedestrian crossing width in Sao Paulo RSA area

RESULTS ASSESSMENT

After the new design implementation, including most of the RSA recommendations, an assessment of the new VRUs safety conditions was realised. Especially the assessment was performed comparing accident data before and after the measures implementation and comparing pedestrian behaviours by videos.

Assessment by accident data

By the end of *SaferBraIn*, the accident data for September 2011 to February 2012 were available. It was not possible to collect data for a longer period. Despite the common duration of accident data collection should be at least one year, the available data were used to obtain preliminary results after the implementation.

The change of the number of accidents at the pilot site intersection has been considered. Since the project deals with VRU safety, Table 1 shows the accident data with pedestrians involved. These data are compared with the accident data of the same months of the previous two years.

While in the period from September 2009 to February 2010 9 accidents with pedestrian involved occurred and, in the same period one year after, 7 accidents with pedestrian involved occurred, in 2011 only one accident was counted (in November) until February. The measures implementation seemed thus to have a beneficial impact on pedestrian safety conditions.

Table 1 Accidents data at the intersection

Year	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
2009 / 2010	2	1	1	2	2	1	**9**
2010 / 2011	2	3	0	0	1	1	**7**
2011 / 2012	0	0	1	0	0	0	**1**

Assessment by video

The video assessment was especially used to verify the behaviors of pedestrians while using the footpaths. This was considered an important safety indicator in Sao Paulo due to the high level of non-respect of rules of road users in that area.

The comparison was made between an “Ante” video and two “Post” videos of different duration. The before-after comparison was made according to the following criteria:

- A check on how many people cross the street during the same period of time, to confirm that the pedestrian flows are comparable.
- A check to verify if the pedestrian crossings are more used in the ex-post situation.

Table 2 shows that the pedestrian flows before and after the measures implementation are comparable (6-8 crossings per minute). In both the "Post" videos, an increase of pedestrian walking inside the footpaths was verified, compared to the "Ante" video.

Table 2 Comparison of pedestrian flows

Video	N° of pedestrians walking inside footpaths	N° of pedestrians walking outside footpaths	Ratio between outside/inside use of footpaths
Ante	61	17	78,22
Post 1	43	5	90,10
Post 2	611	78	89,11

CONCLUSIONS

The evaluation of the RSA pilot in Sao Paulo showed a preliminary trend of pedestrian safety improvement (i.e. reduction of number of accidents with pedestrians involved and reduction of risky behaviors).

The improvement of road safety in Sao Paulo pilot of course should be monitored for a longer period with analysis of accident data of at least one year. Also further investigations in terms of driving behavior of road users should be realized, as well as the effect of global measures like traffic education, enforcement and encouragement as they can possibly have much more influence on road safety than technical measures. This has also to be appraised against the background that in Sao Paulo speed reduction measures on all roads were introduced.

The assessment of new design implementation has been necessarily realized referring to the whole road system of the intersection analyzed. The results are thus related with all the measures implemented and currently no information can be given about the impacts of specific RSA recommendations. This kind of assessment is anyway difficult to be done and needs to be approached through detailed methodologies.

Further developments could thus consist in:

- Collecting the road safety conditions for a longer time period, to verify if the common use of the new road conditions can cause a road safety detriment.
- Defining a methodology for assessing the road safety impacts of single measures implemented (i.e. impacts separated from the whole ones).

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