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Performance assessment of turbo-roundabouts in corridors

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Abstract

There is a widespread agreement in the scientific community that the transformation of a conventional multi-lane roundabout into a turbo-roundabout results in a significant increase of road safety levels. However there is no consensus regarding its effect in terms of capacity, as there are some authors that point towards a small reduction in capacity, namely in the major roads entries. The concept of turbo-roundabout is quite recent and therefore there are only a few studies of its performance, in particular, when applied in a network or in a corridor.

In this context, this paper focuses on the evaluation of the performance of the turbo-roundabout solution, when applied in corridor, compared to a normal double-lane roundabout. The analysis was based on two key components: capacity and pollutant emissions. The work was supported by microsimulation techniques using the AIMSUN software, based on a real case study calibrated and validated for this purpose.

It was possible to conclude that the turbo-roundabout performance is strongly influenced by the traffic load of the network, severely losing its performance in oversaturation conditions. The performance of the solution was also particularly sensitive to the traffic directional distribution, both in the entries as well as in the corridor. In global terms, it was found that the results for the environmental indicators follow the progress of the capacity indicators.

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Keywords: turbo-roundabout; microsimulation; Aimsun; performance evaluation

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1. Introduction

Roundabouts are internationally recognized for being solutions that ensure high levels of fluidity, capacity and road safety (FWHA, 2000; Brilon, 2011), and usually they are credited for having advantages in terms of pollutant emissions. When compared to other conventional at-level solutions, turbo-roundabouts are usually associated to a simple operation and as being easily understandable by drivers. This type of solution provides high performance levels, which is reflected in a reduction of road accidents that, depending on the geometric characteristics and country considered, can reach a 70% reduction of accidents frequency and a reduction above 90% in the number of fatalities (FHWA, 2000; Brown, 1995; Bastos Silva et al, 2011). The improvement on the safety levels compared to priority junctions is mostly due to the reduction of conflict points (from 32 to only 8) and homogenization of the speeds profiles resulting in a significant reduction in both the frequency and severity of collisions.

In terms of capacity, a single-lane roundabout can provide a geometric capacity close to 1200 veh./h. However, the need to accommodate high traffic levels has been justifying the use of multi-lane solutions to ensure higher capacity levels. Despite multi-lane roundabouts ensuring a good level of global performance, these solutions are usually associated with some of safety issues mainly caused by erratic driving behaviors which result in weaving maneuvers both in the entries and in the circulatory carriageway, as well as a tendency to invade adjacent lanes (Bastos Silva et al., 2004). These practices tend to generate a large number of conflicts, often resulting in accidents, although generally with low severity.

This type of problems has been worrying the technical and scientific community, as over the last two decades several alternative solutions have been tested without success, of which can be highlighted the innovative solutions in terms of road markings implemented in Australia (Austroads, 1993 and England (DfT, 2007). The turbo-roundabout started in the Netherlands, in the late XX century, as an alternative solution to conventional multi-lane roundabouts, introducing continuous spiral circuits in the circulatory carriageway, physically delineated by raised kerbs meant to prevent weaving movements trough lane changing and to induce low crossing speeds, by imposing higher deflection levels. The Dutch experience showed significant advantages of this solution over conventional double-lane roundabouts, in particular with a significant increase in road safety levels (Fortuijn, 2009a).

The success of this new solution has attracted the interest of the scientific community, which has motivated the development of scientific studies concerning the real performance provided by these solutions. Although there is a general consensus about the improvements to road safety, the same is not true in terms of capacity, as there are authors who point to a general increase in capacity, while others contest these results. In turn, the studies about pollutant emissions are still extremely scarce (Vasconcelos et al., 2014) as there are no general conclusions about its true impact in terms of local and global pollutants. Therefore the development of further research is justified so that it can contribute for a better understanding of the real performance of turbo-roundabouts, based on different levels of demand and traffic distribution.

2. State of the art

Several authors have shown that the transformation of a double-lane roundabout into a turbo-roundabout results in increased performance in terms of road safety. These benefits are usually associated with a reduction in the number of conflict points due to the placement of physical kerbs which prevent lane changing on entries, circulatory carriageway and exits (Bastos Silva et al, 2011; Fortuijn, 2009a, 009b; Giuffrè et al, 2009; Corriere and Guerrieri, 2012) and thus eliminate the weaving conflicts. In addition, the application of raised lane dividers prevents the practice of straight trajectories by imposing deflection levels that ensure the adoption of safer speeds.

According to Fortuijn (2009a), based "before-after" type studies, the transformation of conventional at-level intersections (priority intersections, multi-lane roundabouts) into turbo-roundabouts results in a reduction of about 70% of the accidents frequency, reaching safety levels similar to a single-lane roundabout. These results are consistent with those presented by SWOV (2007). Mauro and Cattani (2010), based on conflict analysis technics, point to lower values. The transformation of a conventional two-lane roundabout into a turbo-roundabout resulted in a reduction of the frequency of potential accidents between 40 and 50%, as there is a positive linear correlation between the potential number of accidents and the traffic volume. Also Vasconcelos et al. (2014) found benefits in terms of safety. Using microsimulation techniques and SSAM software (Surrogate Safety Assessment Model), a