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Driver behavior characterization in roundabout crossings

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Abstract

Roundabouts are widely accepted for their safety, capacity and environmental advantages. Although it can be easily recognized that the driver behavior is mostly related with the roundabout geometry.
This paper presents a detailed characterization of the driver behavior while crossing three consecutive double-lane roundabouts in an arterial road.
Driver behavior was described in three main levels: i) speed profiles; ii) lateral acceleration profiles; iii) roundabout geometry. It is shown that roundabouts can substantially reduce speed in the negotiation zone. The entry speed and influence zone depends on the desired speed in the upstream sections and on the roundabout geometric characteristics.

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Keywords: Roundabout; driver behavior; speed profile, influence zone, lateral acceleration profile.

1. Introduction

Roundabouts are gaining wide acceptance as a viable alternative to traditional intersections around the world, but particularly in Europe and in North America. There are several studies reporting an increase of service levels and traffic flow when converting traditional intersections into roundabouts (Kimber, 1980; Louah, 1984; Stuwe, 1992;

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Akcelik et al., 1996). Increasing safety levels have also been mentioned in studies comparing before and after conditions (Flannery and Datta, 1996; FHWA, 2000; Persaud et al., 2001; Jensen and ApS, 2013), and in historical analysis studies (Gross et al., 2013). Therefore, roundabouts are increasingly proposed as an alternative method of managing conflict points in intersections (NHCRP, 2010).

It is widely accepted that the roundabout geometry influences the driver behavior and consequently his global performance (Bastos Silva and Seco, 2005). In fact, speed reduction is a benefit of a well-designed roundabout that usually results in homogeneous behaviors (Turner and Roozenburg, 2009).

However, when roundabout offer multiple circulation lanes, even with additional short lanes, providing higher capacities (Lindenmann, 2006), their speed and driver behavior control is less efficient (Bastos Silva, 2004; St-Aubin et al., 2013). The increase in the number of lanes allows drivers to have greater freedom in their behavior resulting in an increase of potential conflicts (Bastos Silva et al., 2006). An insufficient deflection of movements can also lead to a deficient speed control at the entry of the roundabout (Bastos Silva and Seco, 2005) and, consequently, to higher accident rates. These results increase the need for a detailed knowledge of drivers' behavior based on real observations as well as the main cause-effect relations between the geometric characteristics and the drivers' behavior.

Roundabouts have been studied since the 60's, mostly sponsored by Transport and Road Research Laboratory – TRRL (Brown, 1995). The experimental work requires high human and economic resources (Violette and Cardon, 1992; Bastos Silva, 2004), and because of that only a few studies were conducted. Nowadays, technological evolution allows extensive data collection in a systematic and highly accurate way, thus opening new research perspectives. Therefore, this work aims to assess at the evaluation of driver behavior when crossing roundabouts, with a detailed analysis before, during and after the roundabout crossing.

2. Methodological Approach and Site Characterization

In Portugal, the use of roundabouts with double-lane circulatory rings has become more frequent, namely in arterial roads. For this research a road stretch with 3.6 km was chosen comprising five consecutive double-lane roundabouts, three of them used by drivers in the through movement and two others only used to U-turn maneuvers. The analysis focuses only the through movement because it is the movement with high driver degree of freedom namely when compared to the turn left and right movements, and the one where the deflection level's influence is more important to the speed control. This road stretch is one of the most important arterial routes in the city of Coimbra, Portugal. The distance between two consecutive roundabouts, measured between the exit and the entry sections of two consecutive roundabouts, varies between 400 and 470 m which allow vehicles to stabilize their speed after crossing one roundabout and before starting decelerating to the other. The selected stretch has grades below 2% and a legal speed limit of 50 km/h, which is often exceeded.

Economics constraints justified the little sample of drivers adopted. An homogeneous sample of five different drivers (two females and three males), with more than 20 years of driving experience and ages ranging between 40 and 55, were invited to drive along the same circuit and to do multiple laps. All the drivers were advised to use alternatively the left and right entry lanes and then to follow the correct path along the roundabout's crossings, that is, respecting the lane markings.

The work focused on the two-way through movements in roundabouts 1, 2 and 3 (see Fig. 1), leading to six case studies (1-A, 1-B, 2-A, 2-B, 3-A and 3-B). Each driver completed five laps under free flow conditions (with low traffic levels, allowing drivers to select their speeds with no conditioning by other drivers, and without having to yield at the entrance of the roundabouts), and no longer than 30 consecutive minutes to minimize any fatigue or habituation related constraints.