Effects of Crosswalk Location and Pedestrian Volume on Entry Capacity of Roundabouts

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ABSTRACT

At roundabout approaches, vehicles must yield to pedestrians who are using crosswalks. The presence of pedestrians using the crosswalk at a roundabout approach thus decreases the entry capacity of the approach. This research used a calibrated microscopic traffic simulation model to study the effect of crosswalk location and pedestrian volume on the capacity of a two-lane approach entering a two-lane roundabout. The simulation results show that (i) at the same pedestrian volume, the crosswalk located further upstream from the yield line causes a smaller magnitude of reduction in the entry capacity, but there is no significant change in the entry capacity when the crosswalk is beyond three car-length upstream from the yield line; (ii) for the same crosswalk location and conflicting volume, the entry capacity reduces with increasing pedestrian volume, but the marginal reduction diminishes with increasing pedestrian volume. Linear regression equations for entry capacity adjustment factor for pedestrians as a function of conflicting volume have been developed. The adjustment factors are found to be lower than the values provided by the Highway Capacity Manual 2010 which are based on research conducted in Germany.

1. INTRODUCTION

Roundabout is a type of priority or non-signalized intersection that is popular in Europe and is gaining popularity in U.S. In 2003, there were only 310 known roundabouts in U.S. [1]. The number of roundabouts in U.S. has since grown to more than 2300 in 2009 and is still increasing [2]. Transportation engineers and users have realized that roundabouts have the potential to reduce delay, number of stops, crash frequency and crash severity compared to other forms of intersection control. Although there have

been efforts to develop guidelines for roundabout design, for examples see [3,4,5], many aspects of the roundabout operations are yet to be fully quantified. One of the aspects is the effect of pedestrians on roundabout's entry capacity. As in other types of intersection, pedestrians and vehicles compete for the right-of-way to use the intersection. The presence of pedestrians at the crosswalk reduces the roundabout approach's entry capacity for vehicles.

Factors that should be considered in designing crosswalks at roundabouts are discussed in Chapter 6 of the Roundabouts: An Informational Guide, 2nd Edition [3]. The Manual of Uniform Traffic Control Devices (MUTCD) [4] has guidelines for signs and sign placement for pedestrian crosswalks at roundabouts. The U.S. Highway Capacity Manual 2010 (HCM2010) [5] provides equations to calculate the capacity of roundabout entry lanes, and the entry capacity adjustment factor due to the presence of pedestrians at crosswalks. The above guidelines are based on the relatively recent experience gained in roundabout operations in U.S., combined with research and field experience in other countries (especially U.K., Germany and Australia). The capacity and reduction factor formulae, presented in [5], have not taken into account the location of the crosswalk relative to the intersection.

The objective of this research is to investigate the reduction of a roundabout's entry capacity caused by the presence of pedestrians. The roundabout of interest is a two-lane roundabout (which has two circulating lanes) with a two-lane approach. This type of roundabout geometry is most commonly found in U.S. More specifically, this research aims to study the entry capacity adjustment factors with respect to (i) crosswalk location; and (ii) pedestrian volume. Table and equations for entry capacity reduction factor due to pedestrians will be developed and compared with the guidelines provided by HCM2010.

2. LITERATURE REVIEW

The U.S. National Cooperative Highway Research Program (NCHRP) Report 672 [3] states that "pedestrian crosswalk placement at roundabouts requires consistency, based on the balance between pedestrian convenience, pedestrian safety, and roundabout operations." According to this report, a typical and minimum crosswalk setback of 20 ft (6.1 m or approximately one car-length), measured from the yield line, along the left edge of the left entry lane, is recommended. At some sites, it may be desirable to place the crosswalk at 2 or 3 car-lengths upstream of the yield line. A longer crosswalk setback creates additional walking distance for pedestrians but allows more vehicles to queue between the yield line and the crosswalk while seeking a gap between conflicting vehicles in order to enter the roundabout. It appears that crosswalk setback has an impact on the approach's entry capacity. This effect is not elaborated further in [3] but will be investigated in this research.

Chapter 21 of HCM2010 [5] has a section that is devoted to the pedestrian impedance to vehicles entering a roundabout. The materials focus on pedestrians using a crosswalk to cross a roundabout approach near the yield line.

Figure 1 shows the geometry of a typical roundabout with two circulating lanes and two-lane northbound approaches. According to Chapter 21 of HCM2010 [5], the