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A case study on multi-lane roundabouts under congestion: Comparing software capacity and delay estimates with field data

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ABSTRACT

Existing studies on modern roundabouts performance are mostly based on data from singe lane roundabouts that are not heavily congested. For planners and designers interested in building multilane roundabouts for intersections with potential growth in future traffic, there has been a lack of existing studies with field data that provide reference values in terms of capacity and delay measurements. With the intent of providing such reference values, a case study was conducted by using the East Dowling Road Roundabouts in Anchorage, Alaska, which are currently operating with extensive queues during the evening peak hours. This research used multiple video camcorders to capture vehicle turning movements at the roundabouts as well as the progression of vehicle queues at the roundabout entrance approaches. With these video records, the number of vehicles in the queues can be accurately counted in any single minute during the peak hours. This study shows that unbalanced entrance flow patterns (i.e., one entrance has significant higher flow than others) can intensify the queue and delay for the overall roundabouts. Then various software packages including RODEL, SIDRA and VISSIM were used to estimate several performance measurements, such as capacity, queue length, and delay, compared with the collected field data. With the comparison, it is found that all the three software packages overestimate multi-lane roundabout capacity before calibration. With default parameters, SIDRA and VISSIM tend to underestimate delays and queue lengths for the multi-lane roundabouts under congestion, while RODEL results in higher delay and queue length estimations at most of the entrance approaches.

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1. Introduction

The number of modern roundabouts in the U.S. has significantly increased in the last decade (Robinson et al., 2000). Success stories from early applications of roundabouts in Europe and Australia led many communities to embrace roundabouts as a preferred alternative for intersection control (Jacquemart, 1998). It can be anticipated that the number of roundabouts will continue to increase in the era of energy consciousness. Compared with signalized intersections, roundabouts require no energy to operate except for lightings in the dark (Roundabout Benefits, 2010). As interests in roundabout applications continue to increase, researchers have raised questions about the effectiveness of existing analytical tools for roundabout planning and design in the U.S. Currently, practitioners rely on studies and software packages from other countries (e.g., United Kingdom and Australia) when designing and analyzing roundabouts. Since roundabout performance is believed to be sensitive to local conditions, such as geometric designs, driving rules (i.e., left-hand drive, right-hand drive, etc.), and driver behaviors, questions about the appropriateness of the applications of international studies and practices in the U.S. have come to the surface.

The National Cooperative Highway Research Program (NCHRP) addressed this issue in 2007 in its Report 572, which describes a comprehensive study of roundabout operational and safety performance in the U.S. The report discussed the appropriateness of the foreign studies under the U.S. conditions (Rodegerdts et al., 2007). However, the conclusions were limited since there were not sufficient data from roundabouts operating at capacity. Few roundabouts in the U.S., particularly multi-lane roundabouts, were identified as operating at capacity when the study was conducted. Recently, two multi-lane roundabouts named Dowling roundabouts were found operating at capacity for a period of time during the PM peak hours. They provide an opportunity to fill the gap in NCHRP Report 572 on analysis of roundabouts operating at capacity.

Dowling roundabouts, the first multi-lane roundabouts in Alaska, were completed in 2004 at the ramp terminals of the East Dowling Road and New Seward Highway interchange in the city of Anchorage. Those roundabouts consist of two "teardrop" roundabouts of two inside circulating lanes in a "dumbbell" arrangement (Fig. 1), connected to each other by a roadway segment of approximately 200 feet under the New Seward Highway. There are four entrances to Dowling roundabouts: 1) Eastbound (EB) entrance at the west roundabout; 2) Westbound (WB) entrance at the east roundabout; 3) Southbound (SB) entrance at the west roundabout; and 4) Northbound (NB) entrance at the east roundabout. As can be seen in Fig. 1, the left-lane is the left-turn only lane at the NB entrance approach of the east roundabout and the SB entrance of the west roundabout. At the WB approach of the east roundabout and the EB approach of the west roundabout, entering lanes can be utilized through movements.

Currently, during most of the day, the Dowling roundabouts are operating smoothly without noticeable delay at the entrance approaches. However, for approximately 15–20 min during the evening peak hours (i.e., from 5 p.m. to 6 p.m.), the roundabouts are operating with queues of more than 5 vehicles at three of the four entrance approaches (i.e., EB, SB, and NB) during the entire capacity-saturated period. At the EB entrance approach, the queue can reach for over 1600 feet (Fig. 2). The spill back blocking the upstream signalized intersection between the Old Seward Highway and East Dowling Road are clearly observed (Fig. 3).

The Dowling roundabouts, completed after the data collection for the NCHRP research, offer much needed opportunity to traffic engineers to study the performance characteristics of congested multi-lane roundabouts in the U.S., and to see how the performance measurements estimated by software applications compare with the results in the field under congestion. The purpose of this paper is to describe such a research effort.

Video cameras were used to record the roundabout turning movements and queue progression at the entrances during the entire PM peak hours. With the collected data, typical

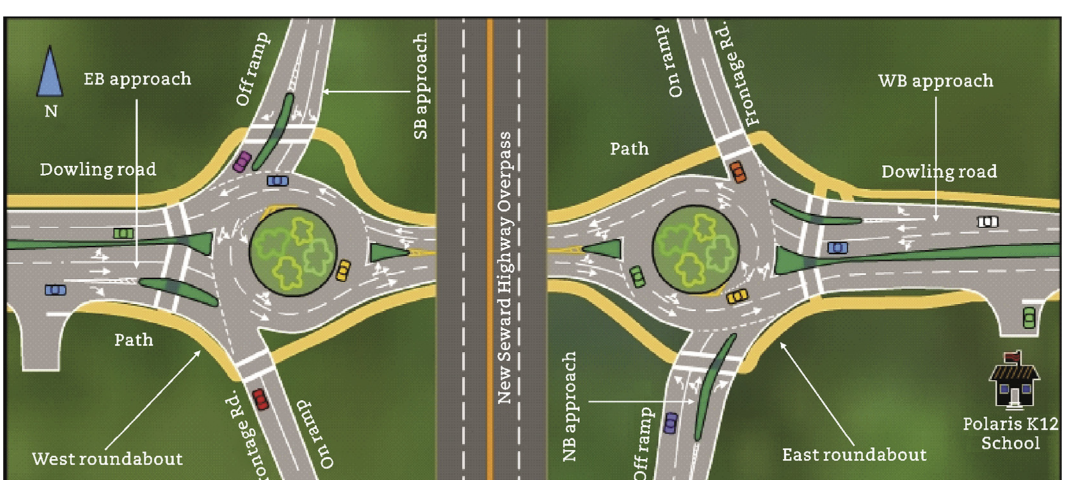

Fig. 1 – Lane configuration of Dowling roundabouts (Dowling Roundabout Diagram, 2010).