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‘’EFFECTS OF CROSSWALK LOCATION AND PEDESTRIAN VOLUME ON ENTRY CAPACITY OF ROUND ABOUTS’’

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ABSTRACT

At round about 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 check 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 identical pedestrian volume, the crosswalk located further upstream from the yield line causes a smaller magnitude of reduction within the entry capacity, but there's no significant change within the entry capacity when the crosswalk is beyond three car-length upstream from the yield line; (ii) for the identical crosswalk location and conflicting volume, the entry capacity reduces with increasing pedestrian volume, but the marginal reduction diminishes with increasing pedestrian volume. Rectilinear regression equations for entry capacity adjustment factor for pedestrians as a function of conflicting volume are developed. The adjustment factors are found to be below the values provided by the Highway Capacity Manual 2010 which is predicated on research conducted in Germany.

Keyword:

Pedestrian Volume, identical pedestrian, simulation model.

1. INTRODUCTION

Roundabout could be a sort of priority or non-signalized intersection that's popular in Europe and is gaining popularity within the U.S. In 2003, there have been only 310 known roundabouts within the U.S. [1]. the amount of roundabouts within the U.S. has since grown to quite 2300 in 2009 and remains increasing [2]. Transportation engineers and users have realized that roundabouts have the potential to cut back delay, the quantity of stops, crash frequency, and crash severity compared to other styles of intersection control. Although there are efforts to develop guidelines for roundabout design, for instance, see [3, 4, 5], many aspects of the roundabout operations are yet to be fully quantified. one amongst the aspects is that the effect of pedestrians on the roundabout's entry capacity. As in other sorts of intersections, 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 ought to 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 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 therefore the entry capacity adjustment factor thanks to the presence of pedestrians at crosswalks. The above guidelines are supported the relatively recent experience gained in roundabout operations within the U.S., combined with research and field experience in other countries (especially the U.K., Germany, and Australia). The capacity and reduction factor formulae, presented in [5], haven't taken into consideration the placement of the crosswalk relative to the intersection.

The objective of this research is to analyze the reduction of a roundabout's entry capacity caused by the presence of pedestrians. The roundabout of interest may be a two-lane roundabout (which has two circulating lanes) with a two-lane approach. this sort of roundabout geometry is most typically found within the U.S. More specifically, this research aims to check the entry capacity adjustment factors with regard to (i) crosswalk location; and (ii) pedestrian volume. Table and equations for entry capacity reduction factor because of pedestrians are going to be developed and compared with the rules 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, supported the balance between pedestrian convenience, pedestrian safety, and roundabout operations.” in line with 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 fringe of the left entry lane, is usually recommended. At some sites, it's going to be desirable to position the crosswalk at 2 or 3 car-lengths upstream of the yield line. an extended crosswalk setback creates additional walking distance for pedestrians but allows more vehicles to queue between the yield line and therefore the crosswalk while seeking a spot between conflicting vehicles so as to enter the roundabout. It appears that crosswalk setback has a control on the approach's entry capacity. This effect isn't elaborated further in [3] but are investigated during this research.

Chapter 21 of HCM2010 [5] includes a section that's dedicated to the pedestrian impedance to vehicles entering a roundabout. The materials concentrate on pedestrians employing 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. In keeping with Chapter 21 of HCM2010 [5], the capacity of an entry lane (e) of a two-lane approach of a roundabout, supported the gap acceptance theory but modified to suit field data collected within the U.S., follows

$$C_{e,R} = 1130e^{-0.70x10^3}v_e \tag{1}$$

$$c_{e,L} = 1130e^{-0.75x10^3 v_e} \tag{2}$$

where ce, R is that the capacity of the correct entry lane (R) in passenger cars per hour per lane (pc/h/lane); ce, L is that the capacity of the left entry lane (L) in pc/h/lane; and vc is that the conflicting (c) volume in passenger cars per hour (pc/h, total of two lanes). Heavy vehicles are converted to passenger cars equivalent in vc before the calculation. supported equations (1) and (2), the entry capacity reduces exponentially with increasing conflicting volume but the speed of decay is quicker for the left entry lane.

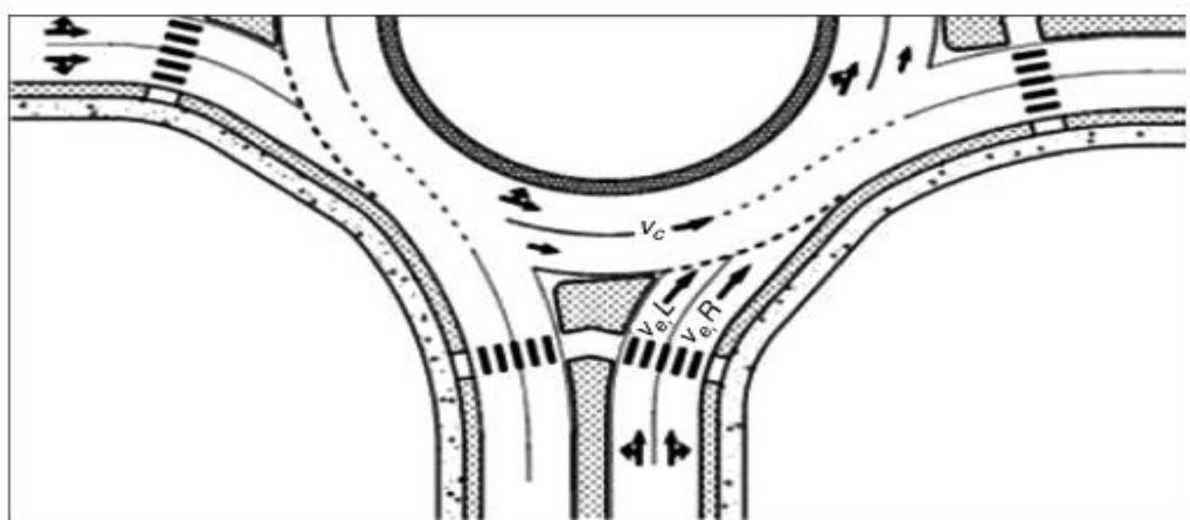


FIGURE 1. Geometry of a roundabout with two circulating lanes and two-lane approaches (from [5])

Equations (1) and (2) assume no pedestrian presence. The presence of pedestrians at the crosswalk effectively reduces the entry capacity of the roundabout approach. Consistent with HCM2010 [5], when VC is tiny, pedestrians could also be considered conflicting vehicles that reduce the gaps for the approaching vehicles that try to enter the roundabout (cross the yield line). When VC is high, pedestrians may cross between the vehicles already queuing at the roundabout approach. The effect of pedestrians on the entry capacity, therefore, isn't the maximum amount in high VC. The HCM2010 estimates the capacity adjustment factor for pedestrians (free) using the subsequent equation:

$$f_{ped} = \begin{cases} \min\left[1 - \frac{n_{ped}}{100}\left(1 - \frac{1260.6-0.329v_c-38.1}{1380-0.5v_c}\right), 1\right] & if n_{ped}\ \text{\<}\ 100\text{p/h} \\ \min\left[\frac{1260.6-0.329v_c-38.1}{1380-0.5v}, 1\right] & if n_{ped} \geq 100\text{p/h} \end{cases} \quad (3)$$

In the above equation, need is that the pedestrian volume in persons per hour (p/h). The computed value of 0 > feed ≤ 1 is multiplied by ce, R, and ce, L. The above equation is predicated on research conducted in Germany [5]. How the various behavior of the pedestrians and drivers between Germany and therefore the U.S. will affect feed remains to be seen. Besides, equation (3) doesn't specify the placement of the crosswalk. This equation is employed in HCM2010 because there had been very limited studies on the effect of pedestrians on roundabout capacity within the U.S. Until more roundabouts are built-in high traffic sites, research during this topic is best performed in an exceedingly laboratory environment via microscopic traffic simulation, which is that the approach taken during this research.

The roundabout approach as shown in Figure 1 is also modeled as two sequential queues per lane [6]. the primary (upstream) queue is caused by pedestrians using the crosswalk while the second (downstream) queue is caused by the circulating vehicles. If the upstream vehicle's arrival rate is λ (in pc/h/lane), the primary queue is also modeled as an M/M/1 queue with infinite capacity. The service rate μ1 could also be derived from need, lane width, and therefore the walking speed. The second queue could also be modeled as an M/M/1 queue with a capacity adequate the amount of cars that may be stored between the crosswalk and therefore the yield line. The arrival rate of the second queue depends on the departure rate of the primary queue. The service rate of the second queue, μ2, depends on VC and also the critical gap. A closed-form solution for such a spatial queuing model has not been found. Therefore, this research performed the required analyses using results generated by microscopic traffic simulation.

3. MODEL DEVELOPMENT AND CALIBRATION.

In this research VISSIM Version' 5.20 [7] was accustomed perform roundabout modeling to live the entry capacity under different conflicting volumes, crosswalk locations, and pedestrian volumes. VISSIM was selected because it allowed the authors full control of the conflicting volume, crosswalk location, and pedestrian volume. It also provided graphical animation for the authors to validate the gap acceptance behavior which was critical to the current experiment.

Before performing the simulation experiment, a roundabout that was modeled after the particular two-lane roundabout at the intersection of Sheridan St. and Rogers Rd in Olathe, Kansas, was developed in VISSIM. Conflict areas were accustomed model the gap acceptance behavior of vehicles within the entry lanes. Parameters of the conflict areas were calibrated with the period of time data extracted from the video recordings of this roundabout operating. The video recordings employed in the calibration were provided by the NCHRP Project 3-65 research team [1]. The video recordings failed to show any roundabout approach with the persistent queue. Therefore it had been impossible to estimate the entry capacity from the video because the benchmark for calibration. The calibration exercise, therefore, attempted to match the period of time distributions of the four through movements produced by the VISSIM model with the period distributions obtained from the video recordings of the location. The calibration process adjusted the subsequent parameters that affected the gap acceptance behavior of vehicles at the conflict areas of the roundabout entrances: front gap, rear gap, and safety distance factor. The calibrated values were: front gap = 0.5 second, rear gap = 1.5 second and safety distance factor = 0.9. Details of the calibration are reported in [8]. because the entry capacity of the roundabout was of interest during this research, the entry capacity produced by the calibrated VISSIM model (without pedestrian) was plotted and checked against the capacity values calculated by using equations (1) and (2). Figure 2 compares the capacity curves of a two-lane approach (without pedestrian) generated by the calibrated VISSIM model against the HCM2010 equations. The VISSIM model was run 10 times, each with a special random number seed. The minimum, maximum, and average capacities produced by the VISSM model among the ten repetitions are plotted. The VISSIM model produced higher approach capacity than the HCM2010 equations when VC = 200 pc/h. When VC ≥ 600 pc/h, the VISSIM model slightly underestimated the approach capacity. Nevertheless, the 2 curves were considered reasonably close enough for the simulation experiment to proceed when VC is between 200 to 1600 up.

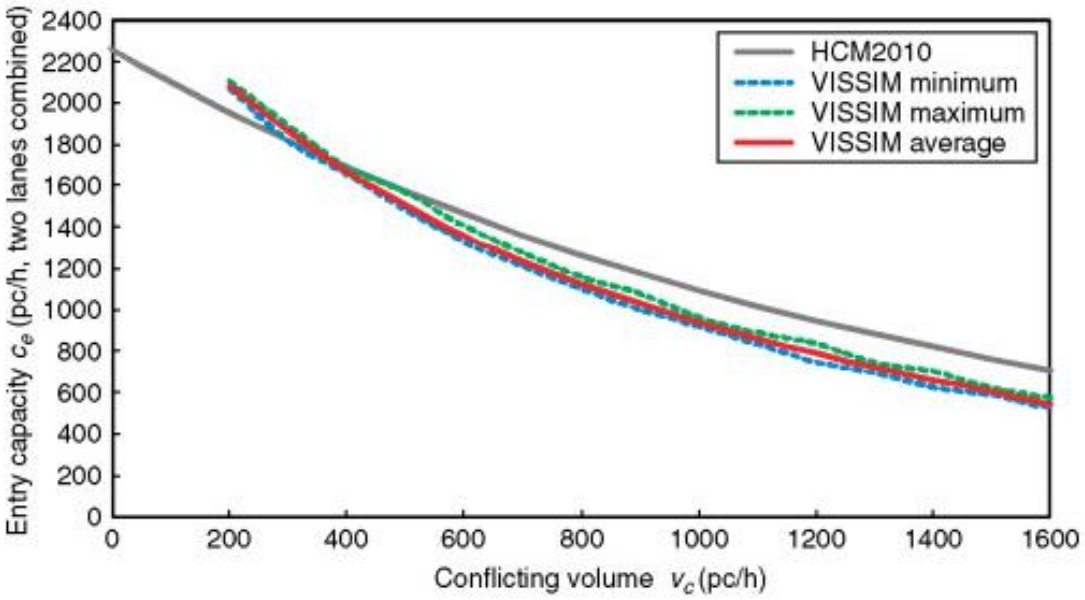


FIGURE 2. Entry capacity of a two-lane approach

4. EXPERIMENTAL PLAN.

As reviewed in equations (1) to (3), the entry capacity of an approach lane depends on the conflicting volume VC, and pedestrian volume needs. It also depends on the situation of the crosswalk, defined by x, the gap between the yield line (measured along the left fringe of the left entry lane) and therefore the downstream fringe of the crosswalk. With these considerations, the subsequent simulation scenarios were planned:

- $x = 20, 40, 60$ and 80 ft ($6.1, 12.2, 18.3$ and 24.4 m)
- $n_{ped} = 0, 100, 200, 300$ and 400 p/h
- $v_c = 200$ to 1600 pc/h at increments of 100 pc/h

The ranges of need and VC were supported the exhibits of the entry capacity adjustment factor for pedestrians in HCM2010 [5]. The values of x corresponded to queue lengths of 1, 2, 3, and 4 passenger cars, respectively. Note that NCHRP Report 672 [3] recommends crosswalk setbacks of 20, 45, and 70 ft (6.1, 13.7, and 21.3 m) for 1, 2, and three passenger cars, respectively. These four x values were decided and therefore the research was completed before the publication of [3]. Nevertheless, within the simulations, queue capacities of 1, 2, 3, and 4 passenger cars were observed with these specified x values. for every combination of x, need and VC values, the VISSIM model was last 10 repetitions, each with a singular random number seed. a complete of 3000 simulation runs were made. Each simulation run lasted for one hour. Performance statistics were measured at five-minute intervals after the warm-up time of 5 minutes. The measured capacities (in pc/h/lane) were averaged over the various five-minute intervals and 10 simulation replicates.

Figure 3 shows a screenshot of the VISSIM model during a simulation run, with x = 20 ft. to live the entry volume at five-minute intervals, “data collection points” were placed at the yield line of every entry lane within the northbound approach. to make a permanent queue in each entry lane within the northbound approach (so that the info collection points measured the entry capacities), the entry volume within the northbound approach was set to 1130 pc/h/lane, the utmost capacity given by equations (1) and (2) within the absence of conflicting vehicle and pedestrian. The presence of queues in both the entry lanes was visually verified from the VISSIM animation, even at the minimum VC of 200 pc/h employed in the experiment. The turning percentages of the northbound approach were set as follows:

•From the left entry lane: 71% left turn, 29% through

•From the correct entry lane: 41% through, 59% right turn

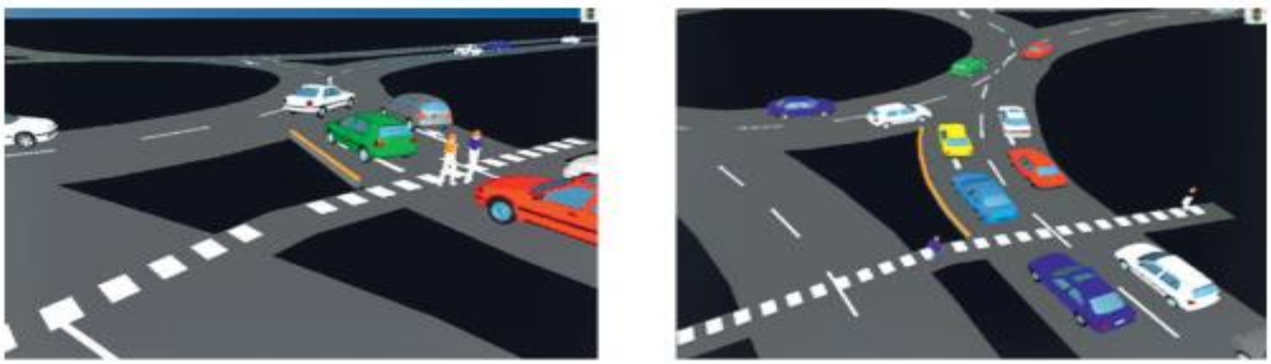
FIGURE 3. Two-dimensional screenshot of VISSIM model

To ensure that the northbound entry flow experienced the required vc value, all the conflicting vehicles were set to enter the roundabout from the southbound approach and exit to the east. The vc value was split equally between the 2 southbound entry lanes. They were also split equally between the inner and outer circulating lanes. The vc value was counter checked by placing a knowledge collection point at the six o'clock position within the circulating lanes.

There were two crosswalks within the model (see Figure 3), one placed across the northbound entry lanes at 90° to the curb line while another one was placed at the exit lanes at 90° to the curb line. Each crosswalk was coded by using two opposing one-way links with a behavior typeset as “footpath”. Pedestrians were defined mutually and therefore the only kind of vehicle that might use the footpaths. The pedestrian volume need was split equally between the 2 opposite directions.

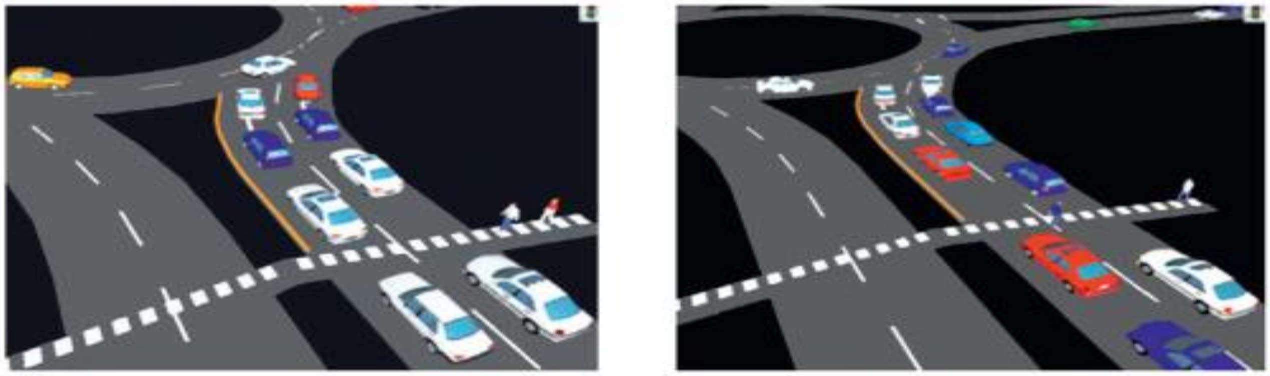
The pedestrian walking speed determines how long the crosswalk is occupied by a pedestrian. Given the identical pedestrian volume, a slower average walking speed means vehicles need to wait longer for the pedestrians to clear the crosswalk
which successively reduces the entry capacity. The MUCTD [4] recommends a walking speed of three.5 or 4.0 ft/s (1.07 or 1.22 m/s) within the design of traffic signals. The Transit Cooperative Research Program (TCRP) Report 112/NCHRP Report 562 [9] recommends a walking speed of three.5 ft/s (1.07 m/s) for general population and three.0 ft/s (0.91 m/s) for older population. the identical study also produced walking speed distributions for young pedestrians (aged 60 or less) and old pedestrians (aged above 60 years). Pedestrians within the VISSIM model were thus divided into two classes: young and old pedestrians; each has its own customized speed distribution. The VISSIM's desired speed distribution function was wont to approximate the 2 walking speed distributions reported in [9]. The proportion of young pedestrians (83.73%) and old pedestrians (16.27%) were taken from the national census statistics [10].

The concept of conflict area was applied to the crosswalks to confirm that the approaching vehicles yield to pedestrians. The setting and parameters of the pedestrian-vehicle conflict areas followed the rules provided by the VISSIM vendor [11] – kept the default values of visibility = 328 ft (100 m), front gap = 0.5 seconds, rear gap = 0.5 seconds, and safety distance factor =1.5. Several preliminary runs were made to validate the utmost queue lengths between the yield line and crosswalk, and therefore the desired behavior when vehicles yielded to pedestrians. Figure 4 shows the screenshots taken during the simulations when the crosswalk setback was set to x = 20, 40, 60, and 80 ft (6.1, 12.2, 18.3, and 24.4 m) respectively.



(a) $x = 20$ ft or 6.1 m

(b) $x = 40$ ft or 12.2 m



(c) $x = 60$ ft or 18.3 m

(d) $x = 80$ ft or 24.4 m

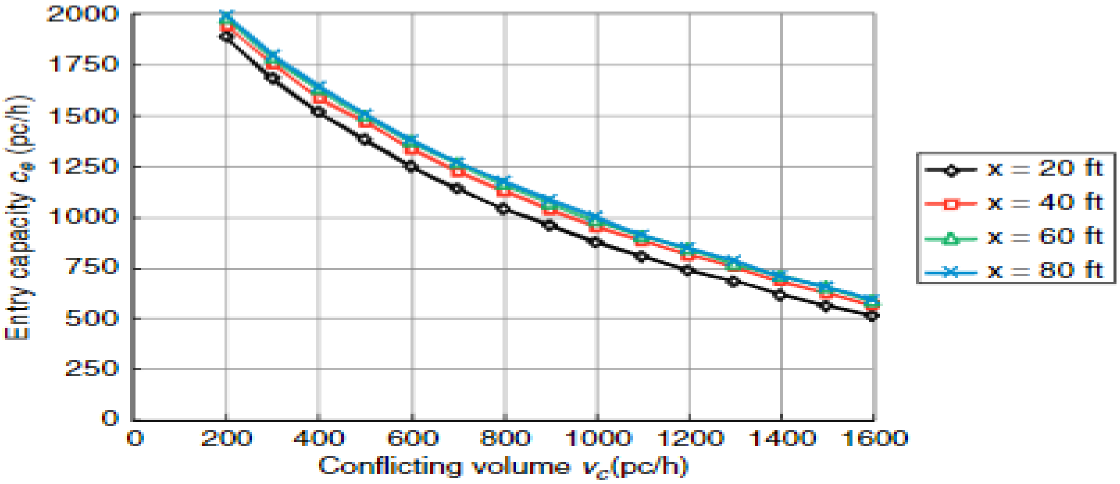
FIGURE 4. Three-dimensional screenshots of VISSIM models

5. RESULTS AND DISCUSSIONS

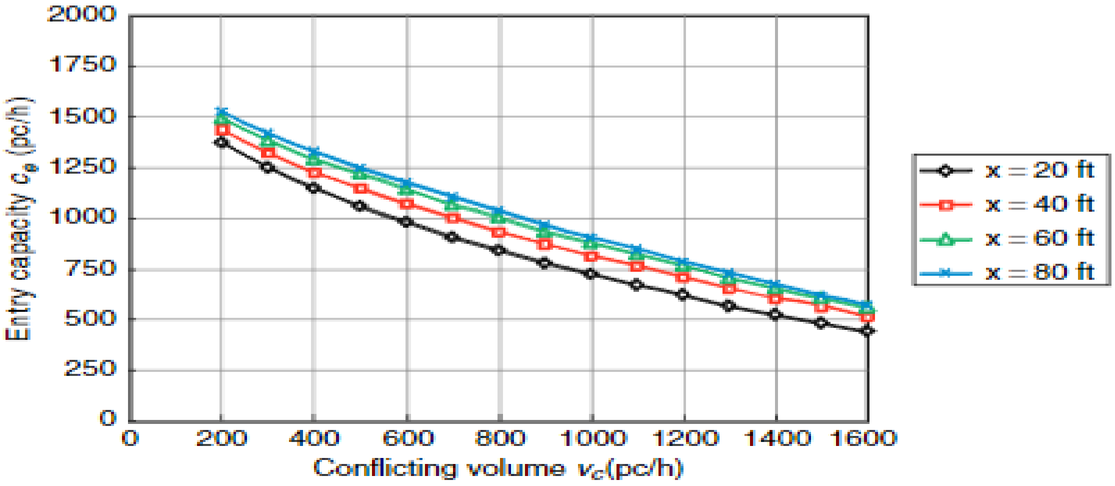
The results generated by the 3000 simulation runs were analyzed in several ways. The combined entry capacities of the left and right entry lanes, i.e., ce = ce, L + ce, R, measured by VISSIM in five-minute intervals, were averaged over the one-hour simulation then over the ten simulation replicates with the identical combination of conflicting flow vc, crosswalk setback x, and pedestrian volume need. The entry capacity ce was analyzed concerning vc, x, and need.

5.1. Entry Capacity with Fixed Pedestrian Volume

Figure 5 plots the ce against vc. Figure 5(a) presents the entry capacity curves for need = 100 p/h while Figure 5(b) presents the curves for need = 400 p/h. These two need values were selected during this figure to indicate the contrasts caused by the best and lowest need experimented. Each curve joins the info points for the identical x value. As can been seen in Figure 5(a), when need = 100 p/h, as x increases from 20 ft (6.1 m) to 40 ft (12.2 m), ce actually increases. From x = 40 ft (12.2 m) to 60 ft (18.3 m), the rise in ce is marginal. The effect of x on ce diminishes when x is moved from 60 ft (18.3 m) to 80 ft (24.4 m). Compare the set of 4 curves between Figure 5(a) and Figure 5(b), it's easy to note that ce decreases with increasing need;



(a) Pedestrian volume n_{ped}= 100 p/h



(b) Pedestrian volume n_{ped}= 400 p/h

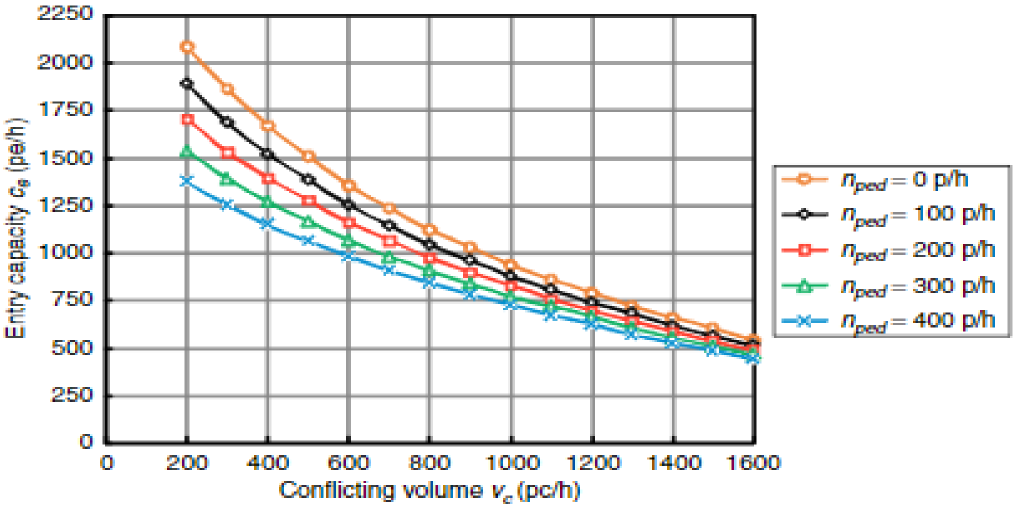
FIGURE 5. Entry capacity with fixed pedestrian volume but different crosswalk setbacks

However, when nped is comparatively high (as in Figure 5(b)), increasing x could increase ce slightly. The margin of improvement in ce decreases when increasing x.

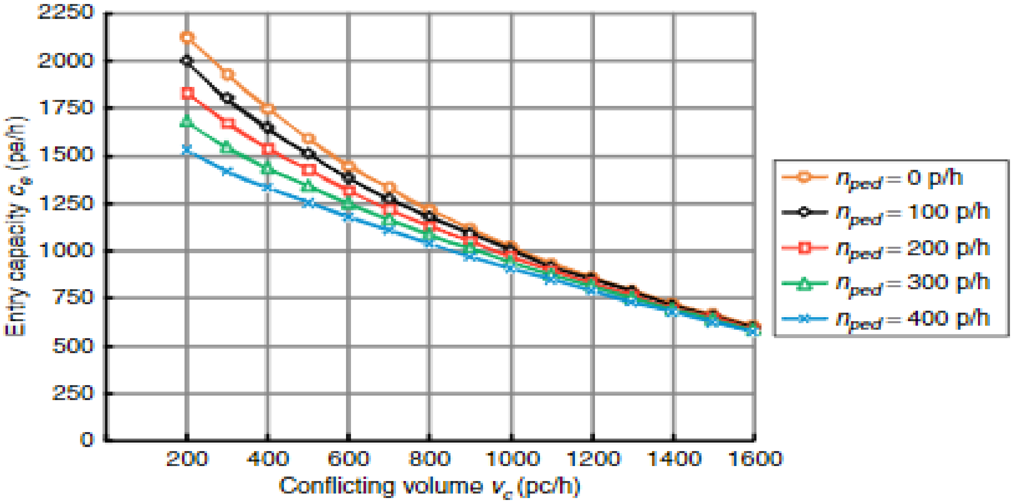
The above analysis reveals that (i) when the pedestrian volume is that the same, increase the crosswalk setback ends up in a rise within the entry capacity. this can be because vehicles after passing the crosswalk have more room to queue while seeking a spot among the conflicting vehicles. They're less likely to forgo a suitable gap within the circulating lanes; (ii) when the pedestrian volume is that the same, the development in entry capacity is more pronounced when the setback is increased from 20 ft to 40 ft but becomes less obvious with the further setback. The margin of improvement is perhaps proportional to the duration when the extra space for storing is employed by vehicles; (iii) with the identical crosswalk setback, increase pedestrian volume causes a discount in entry capacity. This observation are analyzed further within the next sub-section.

5.2. Entry Capacity with Fixed Crosswalk Setback

This sub-section investigates the results of nped on entry capacity when x is fixed. The entry capacity curves for x = 20 ft (6.1 m) are shown in Figure 6(a) because it is that the most ordinarily used crosswalk setback within the U.S. The curves for x = 80 ft (24.4 m) is included in Figure 6(b) to point out the contrast within the highest possible setback value. Each curve joins the information points for the identical nped value.



(a) Crosswalk setback x = 20 ft



(b) Crosswalk setback x = 80 ft

FIGURE 6. Entry capacity with fixed crosswalk setback but different pedestrian volume

Figure 6(a) and 6(b) are compared first. The curves when nped = 0 p/h in Figure 6(a) and 6(b) are the identical. In both charts, as nped increases, the ce curve moves downwards. This reflects that, when x is fixed, increasing nped reduces ce. However, as nped increases, the curves in Figure 6(b) are closer to every other. They bunch as vc increases. this means that as x, vc, and nped increase the negative impact of pedestrians on entry capacity diminishes.

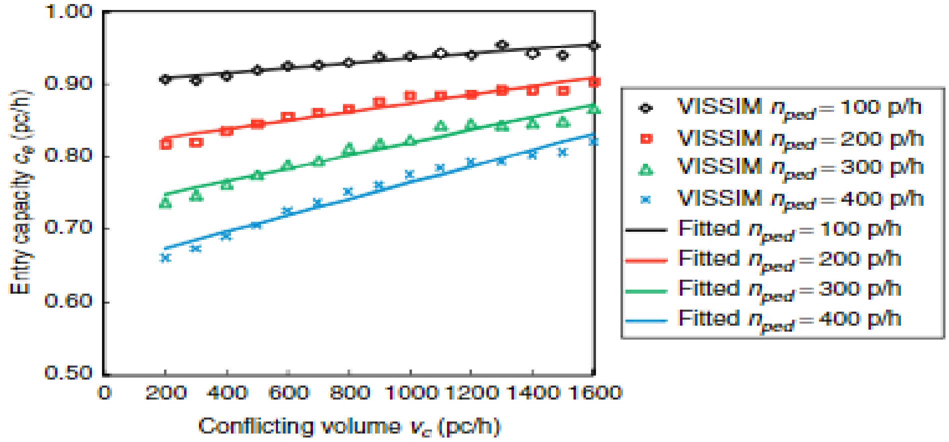
5.3. Entry Capacity Adjustment Factors

Another way of analyzing the results is to compute the entry capacity adjustment factors for pedestrians, denoted by fped. This provides a basis for comparison with the values calculated by equation (3).

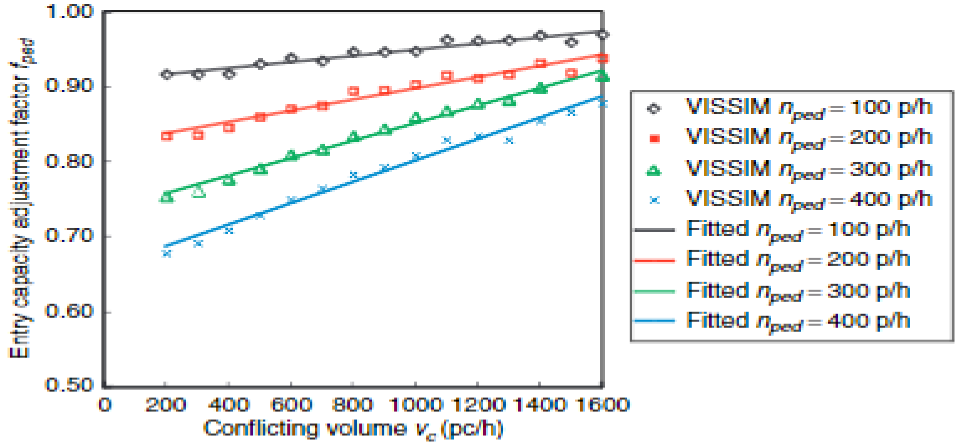
Figures 7 presents the fped obtained for x = 20 ft (6.1 m) and 40 ft (12.2 m) respectively from the simulation results. The fped values in Figure 7 were calculated by dividing the ce values on the curves for nped = 100, 200, 300, and 400 p/h (in Figure 6(a)), by the corresponding ce values on the curves for nped = 0 p/h. it absolutely was obvious from the scatter plots that, for the identical x and nped values, the information points of fped versus vc followed a linear trend. Simple regression analysis was thus performed to suit an equation of fped as a linear function of vc, that is:

$$\hat{f}_{ped}(v_c \mid x, n_{ped}) = a + bv_c \qquad (4)$$

where is that the fitted estimate of fped, a is that the intercept and b is that the slope of the fitted equation. The calculated fped values (based on the simulation results), for various x, nped, and vc values are presented in Table 1. This table also lists the slope, intercept, and R2 values of each fitted equation.



(a) Crosswalk setback $x = 20$ ft or 6.1 m



(b) Crosswalk setback $x = 40$ ft or 12.2 m

FIGURE 7. Simulation results and best fit lines of entry capacity adjustment factor

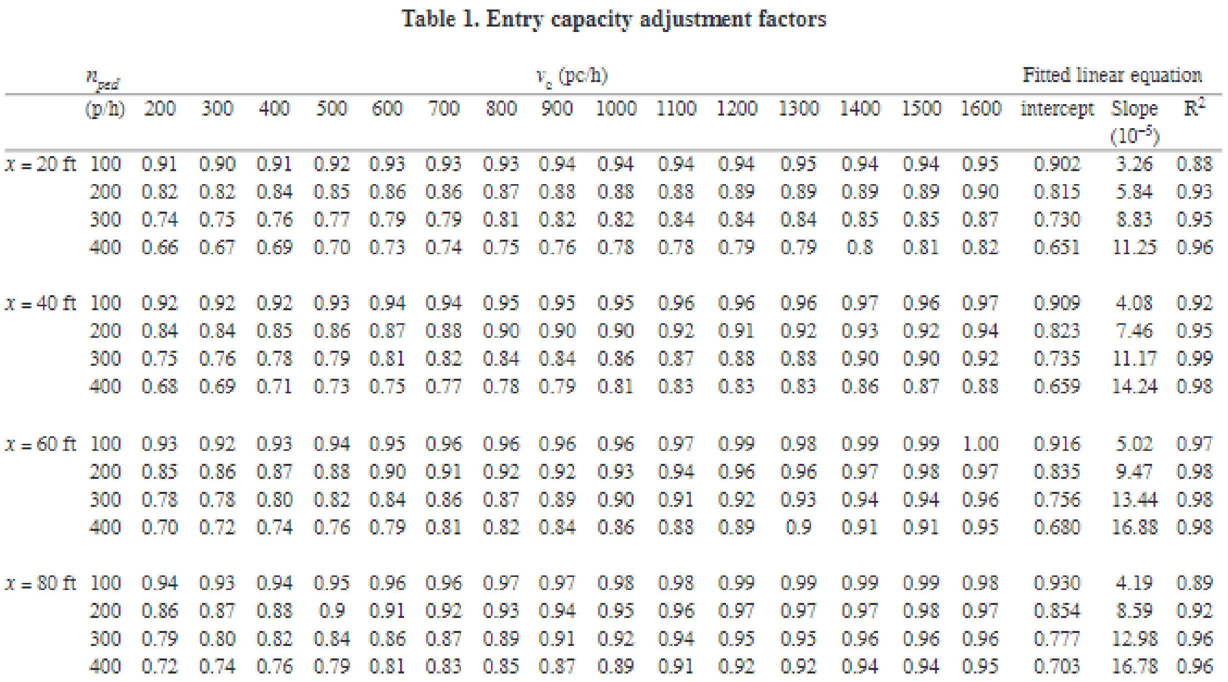


Table 1. Entry capacity adjustment factors

	n_{ped}	v_c (pc/h)															Fitted linear equation		
	(p/h)	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	intercept	Slope (10^{-5})	R^2
x = 20 ft	100	0.91	0.90	0.91	0.92	0.93	0.93	0.93	0.94	0.94	0.94	0.94	0.95	0.94	0.94	0.95	0.902	3.26	0.88
	200	0.82	0.82	0.84	0.85	0.86	0.86	0.87	0.88	0.88	0.88	0.89	0.89	0.89	0.89	0.90	0.815	5.84	0.93
	300	0.74	0.75	0.76	0.77	0.79	0.79	0.81	0.82	0.82	0.84	0.84	0.84	0.85	0.85	0.87	0.730	8.83	0.95
	400	0.66	0.67	0.69	0.70	0.73	0.74	0.75	0.76	0.78	0.78	0.79	0.79	0.8	0.81	0.82	0.651	11.25	0.96
x = 40 ft	100	0.92	0.92	0.92	0.93	0.94	0.94	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.96	0.97	0.909	4.08	0.92
	200	0.84	0.84	0.85	0.86	0.87	0.88	0.90	0.90	0.90	0.92	0.91	0.92	0.93	0.92	0.94	0.823	7.46	0.95
	300	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.84	0.86	0.87	0.88	0.88	0.90	0.90	0.92	0.735	11.17	0.99
	400	0.68	0.69	0.71	0.73	0.75	0.77	0.78	0.79	0.81	0.83	0.83	0.83	0.86	0.87	0.88	0.659	14.24	0.98
x = 60 ft	100	0.93	0.92	0.93	0.94	0.95	0.96	0.96	0.96	0.96	0.97	0.99	0.98	0.99	0.99	1.00	0.916	5.02	0.97
	200	0.85	0.86	0.87	0.88	0.90	0.91	0.92	0.92	0.93	0.94	0.96	0.96	0.97	0.98	0.97	0.835	9.47	0.98
	300	0.78	0.78	0.80	0.82	0.84	0.86	0.87	0.89	0.90	0.91	0.92	0.93	0.94	0.94	0.96	0.756	13.44	0.98
	400	0.70	0.72	0.74	0.76	0.79	0.81	0.82	0.84	0.86	0.88	0.89	0.9	0.91	0.91	0.95	0.680	16.88	0.98
x = 80 ft	100	0.94	0.93	0.94	0.95	0.96	0.96	0.97	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.98	0.930	4.19	0.89
	200	0.86	0.87	0.88	0.9	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.97	0.98	0.97	0.854	8.59	0.92
	300	0.79	0.80	0.82	0.84	0.86	0.87	0.89	0.91	0.92	0.94	0.95	0.95	0.96	0.96	0.96	0.777	12.98	0.96
	400	0.72	0.74	0.76	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.92	0.92	0.94	0.94	0.95	0.703	16.78	0.96

Table 1. Entry capacity adjustment factors

Since Table 1 and Figure 7 present the fped values for the assorted site conditions, it'd even be of interest to work out how these values compare against the values recommended by HCM2010. Figure 8 superimposes the fitted lines for x = 20 ft (6.1 m) on the HCM2010 fped curves computed using equation (3). Note that the HCM2010 fped equations don't take under consideration the crosswalk setback and so the HCM2010 fped are the identical in both Figures 8(a) and 8(b). Form Figures 8(a) and 8(b), it's obvious that the (i) two sets of curves have different functional forms; (ii) for the identical nped, the fitted line is usually not up to the corresponding HCM2010's fped curve. the sole exception is when nped = 100 p/h and vc ≤ 300 p/h. As mentioned earlier, the HCM2010 equation doesn't specify the x value. The setback of x = 20 ft (6.1 m) and 40 ft (12.2 m) are selected to plot these two figures because there's the foremost common crosswalk setback employed in a roundabout within

the U.S. supported the regression results provided in Table 1, it's possible to plot the lines for other x values. thanks to the limitation in paper length the lines for other x values don't seem to be shown here. Inspection of the fped values in Table 1 or a fast calculation would result in the conclusion that even with x = 80 ft (24.4 m), the HCM2010 equation still gives higher fped values than our fitted equation.

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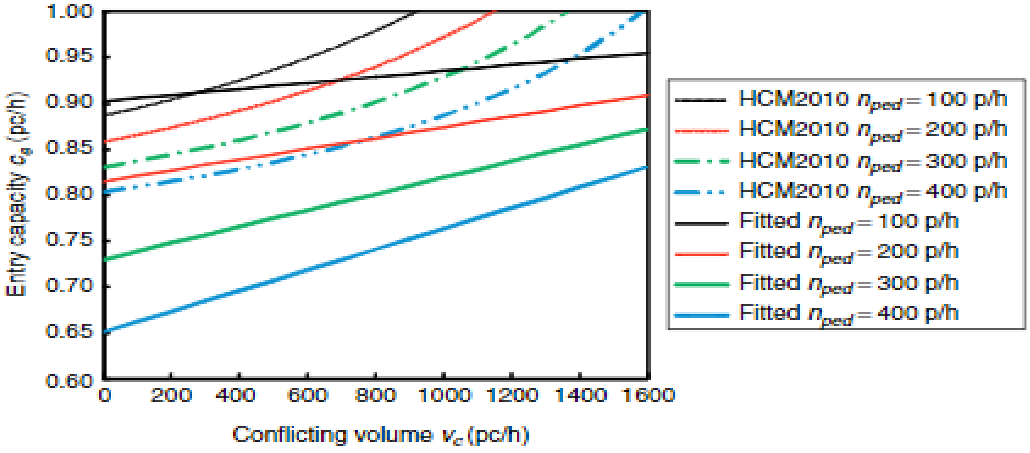
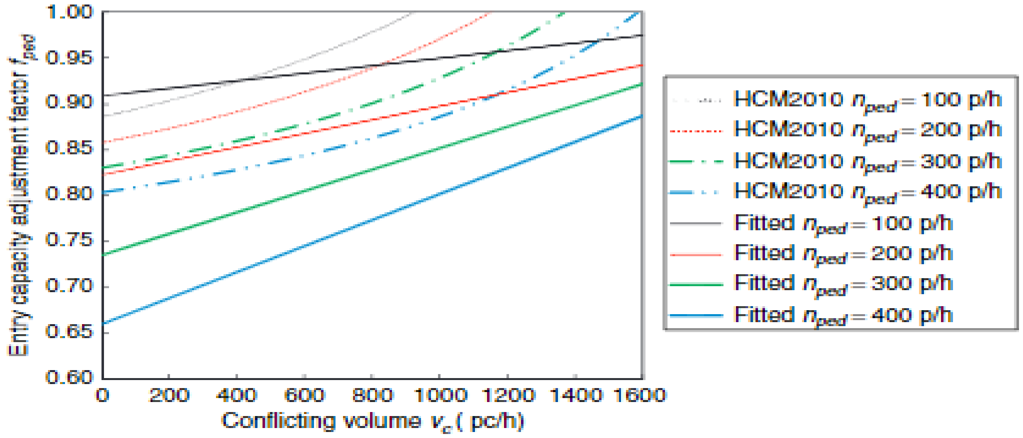


(a) Crosswalk setback $x = 20$ ft or 6.1 m



(b) Crosswalk setback $x = 40$ ft or 12.2 m

FIGURE 8. Comparison of entry capacity between simulation and HCM2010

The difference between the resulting from this research and also the fped calculated from the HCM2010 equation is also thanks to the subsequent reasons:

1.The HCM2010 equation relies on research conducted in Germany. This equation was developed supported field data collected in Germany. Drivers in Germany and also the U.S. may behave differently in terms of gap acceptance and complying with the priority rule for pedestrians. The difference in behavior will cause a difference in ce, fped, and. as an example, if some drivers don't yield to pedestrians, the ce, fped, and values are going to be higher. The NCHRP Report 572 has reported that but

100% of vehicles at roundabout approaches yielded to pedestrians [1]. this could even be the case in Germany.

2.In our VISSIM model, vehicles are programmed to behave perfectly in line with the principles in conflict areas. They never didn't yield to pedestrians once the latter appeared within the conflict area. They also never queued on top of the crosswalk. In practice, some vehicles might not yield to pedestrians at crosswalks. they'll also queue on top of the crosswalks. the proper behavior in VISSIM has caused the simulation model to underestimate the ce values and led to lower fped values.

Until more field data is collected and therefore the simulation model modified to account for rule-breaking by a particular percentage of the drivers, such events aren't possible to duplicate within the simulation at now. One possible way of using the fped values in Table 1 and Figures 5 to eight is to treat nped because the number of pedestrians that receive yield by approaching vehicles. for instance, if there are 400 p/h crossings an approach and also the vehicle yield rate is 75%, nped might be taken as 300 p/h.

6. SUMMARY, LIMITATIONS, AND FUTURE RESEARCH

This research has, using microscopic traffic simulation, studied the effect of crosswalk setback and pedestrian volume on the entry capacity of a two-lane approach at a two-lane roundabout. Although the simulation model was calibrated to just one operational roundabout, the trends observed within the results can still be wont to guide engineers in roundabout design. There are:

1.The entry capacity of a roundabout approach increases when the crosswalk is placed further upstream from the yield line. However, the marginal capacity gained by increasing the setback diminishes with the increasing setback. The setback of three or more car lengths appears to cause no further improvement within the entry capacity.

2.The entry capacity of a roundabout approach decreases with increasing pedestrian volume. the identical pedestrian volume causes a smaller reduction in entry capacity when the crosswalk setback is farther from the yield line.

3.For a hard and fast crosswalk setback and pedestrian volume, the entry capacity adjustment factor for pedestrians could be a linear function of the conflicting volume. The adjustment factor is linearly proportional to the conflicting volume.

4.The entry capacity adjustment factors found during this research are smaller than those recommended by HCM2010.

The actual relationships between entry capacity, crosswalk setback, pedestrian volume, and other geometric design elements can only be understood until more roundabouts are built-in high foot traffic sites, field data collected and analyzed. Until then, the findings of this research, through a simulation experiment, serve to produce some guidance on the look of crosswalks at roundabouts. The difference within the entry capacity adjustment factors also highlights the need to conduct further research during this topic using field data, if sites with sufficient entry volume and pedestrians are found.

The percent of vehicles (drivers) that observed the priority rule at crosswalks and yield to pedestrians, also called the yield rate, also has an impression on entry capacity. Future research should incorporate the yield rate as an element in determining the capacity reduction factors because of pedestrians.

This research has focused on roundabouts with non-signalized crosswalks. Signalized crosswalks at roundabouts are proposed to boost pedestrian safety [12]. The signals group multiple pedestrians to cross in platoons, which affects the entry capacity of an approach lane [12]. The impact and therefore the interactions of the signalized crosswalk, pedestrian volume, crosswalk locations, and conflicting volume on the entry capacity of roundabouts could also be a direction of future research.

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