RSS 2022
8th Road Safety & Simulation International Conference
Road Safety and Digitalization
08-10 June 2022 • Athens, Greece

Pedestrian behaviour and safety at roundabouts: a comparative study between real and microsimulation outcomes

Chiara Gruden[1], Irena Ištoka Otković[2], Matjaž Šraml[1*]

Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor, Smetanova ulica 17 – 2000 Maribor (SI), chiara.gruden1@um.si
Faculty of Civil Engineering and Architecture Osijek, Josip Juraj Strossmayer University of Osijek, Vladimira Preloga 3 – 31000 Osijek (HR), iirena@gfos.hr
Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor, Smetanova ulica 17 – 2000 Maribor (SI), matjaz.sraml@um.si

Extended Abstract

There is substantial evidence that urban areas and intersections are problematic zones from a road safety perspective: ERSO statistics show that 37 % of all road fatalities occur in urban areas and 1 in 5 fatal accidents occur at an intersection. One of the strategies to improve road safety at these locations, is the transformation of 4-leg intersections into roundabouts. Because of their ability to decrease conflict points and to reduce speeds, roundabouts are nowadays considered safe and their use is spreading. Nevertheless, pedestrian-related issues are not clear and have not been answered yet. The present research deals with these issues, by studying pedestrian behaviour and safety on a crosswalk set on a roundabout entry leg. Two perspectives of the same problem are covered: on a hand, the study of real pedestrian behaviour and safety by recording and analysis of video footages on the location of interest; from the other hand, the development of a microsimulation model of the same location and the analysis of the same behavioural and safety aspects starting from microsimulation data.

To do so, two parallel workstreams were followed. First, a field experiment was conducted (Figure 1-I.a): the selected roundabout crossing was recorded for one week using a hidden action camera. The data obtained were analysed both from a behavioural point of view, taking into account speed, acceleration, crossing time (Figure 1-I.b) and from a safety point of view, by calculating Time-To-Collision (TTC), Time Advantage (TAdv), relative speed (Vrel) (Figure 1-I.c). Behavioural results were then compared with those found in the literature (Figure 1-I.d) in order to understand if they belong to the normal measured ranges or if there is a difference with other crossing typologies, while safety indicators were compared with widely accepted thresholds indicating risky events. On the other hand, the same location was reproduced in a microsimulation model (Figure 1- II.a) developed in Vissim/Viswalk, using default values for pedestrian behavioural parameters - such as Asoc_iso, Bsoc_iso, etc.. Moreover, both behaviour (Figure 1- II.b) and safety (Figure 1- II.c) were analysed starting from the model results, obtaining the same variables as from the real-world measurements. Finally, a comparison was made between the real results and the model results (Figure 1- III.) to gain insight into the "natural" reliability of the model in reproducing the selected site.

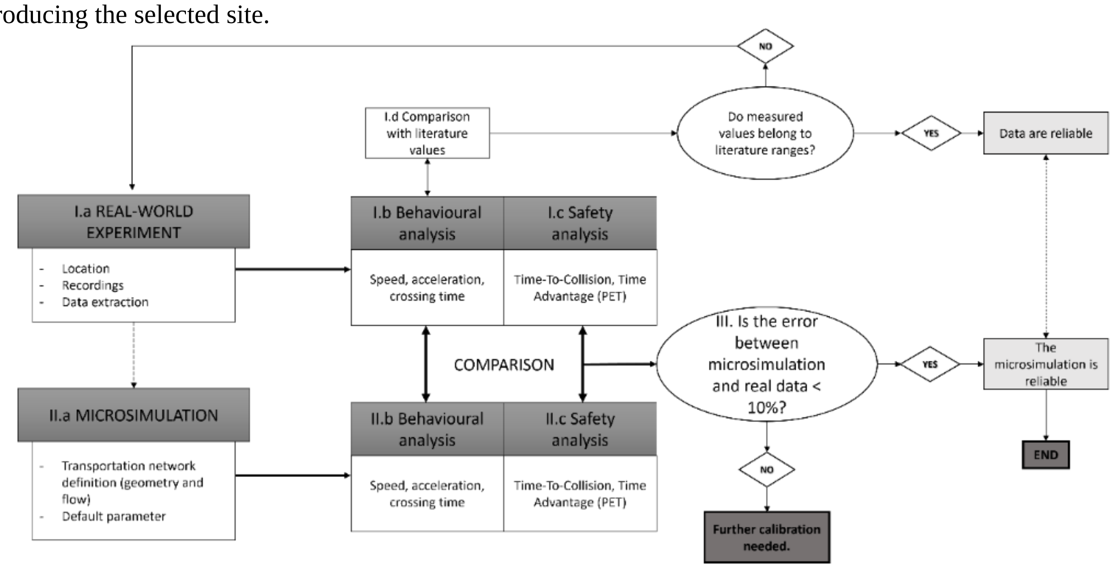

Figure 1: Schematic representation of the followed methodology.

[1] * Corresponding author. Tel.: +000-000-000-0000;
E-mail address: matjaz.sraml@um.si

Real-world data have been achieved by monitoring via video recordings a crosswalk set on a roundabout entry leg. Video footages have been recording during weekdays from 8.00 to 10.00 a.m. Footages have been analysed via a semi-automatic detection and tracking software in order to achieve behavioural variables, as well as to obtain safety parameters, i.e. surrogate safety measures (SSM), which allow to determine the level of safety of the considered infrastructure. To pass from raw videos to useful results, five tasks have been completed: calibrating the camera, detecting events, tracking road users, smoothing trajectories, and computing surrogate safety measures. The first three steps must be developed manually, while trajectory smoothing and SSM calculation are automatically worked out by the software, once the tracking phase is completed. Pedestrian behaviour on the considered crossing have been assessed by analysing the influence of personal factors, such as gender, age, movement in group, mobile texting and talking, carrying luggage, parents with children or stroller and jaywalking, on the considered behavioural magnitudes and by comparing the same to the values obtained in literature for other types of intersections. Safety level is evaluated by contrasting surrogate safety measures calculated from the video recordings to SSM's thresholds defined by well-established safety methodologies and validated also for their application to pedestrians. Additionally, the study location has been modelled via Vissim/Viswalk micro-simulation software. Firstly, the network geometry has been set: it consists of 15 vehicular links, five pedestrian areas and 12 links used as pedestrian areas. Four speed reducing zones have been also established to reproduce drivers' yielding behaviour, and finally, vehicular and pedestrian flows have been uploaded as starting data. To test the model's natural reliability, pedestrian behaviour and car-following behaviour parameters have been kept as default. Its outcomes – in terms of pedestrian crossing time and speed – have been compared to the real-world data to stress out if such a situation can be reliably reproduced by the currently available computer programs - by use of default parameters, or if parameter changes are needed.

From a behavioural perspective, the results obtained by video recordings indicate that pedestrian crossing data show a certain difference with the ones contained in literature: in particular, it was expected to obtain similar speed data for non-signalized crosswalks and the selected one, while in reality, it was highlighted the highest difference. The mean speed found by this study equals 1.55 m/s, in comparison to non-signalized ones, where – according to literature studies [9] – people have a speed of 1.26 m/s. Table 1 compares the speed values reported in literature with the ones measured for the present research.

Table 1: Comparison of the findings of the present research with literature values.

Study	Value [m/s]	Location
Present study	1.55	Roundabout crossing
HCM [1]	1.20	General locations
TEH [2]	1.37	General locations
MUTCD [3]	1.21	General crossing
Bennett [4]	1.24	General crossing
Lam, Cheung [5]	1.44	Signalized crossing
Knoblauch [6]	1.46	Signalized crossing (youngers)
Knoblauch [7]	1.20	Signalized crossing (olders)
Onelcin, Alver [8]	1.31	Signalized crossing
Lam, Cheung [9]	1.26	Unsignalized crossing

Crossing times were also recorded: a mean value of 8.27 sec was obtained and some time-ranges were obtained in relation to the age of the individuals: adult individuals have a mean crossing time of 8.02 sec, varying mainly between 7 sec and 9 sec; younger individuals cross the pedestrian crossing slightly faster, with a mean crossing time of 8 sec, varying between 7 sec and 9 sec, while older individuals are the slowest users, taking on average 9.4 sec to cross, with values ranging mainly between 8 sec and 10 sec.

Concerning the simulation, the visual check of the simulated behaviour underlines that the software can reproduce both vehicular and pedestrian behaviour at the chosen location. Nevertheless, the errors calculated between real-world and simulated crossing time and speeds are still significant – 46.4 %. Finally, the calculation of Time-to-Collision, Time Advantage and relative speed starting from microsimulation outputs, allowed to assess conflict severity in an objective manner: the percentages of values overcoming the defined thresholds for determining dangerous events are still substantial – ranging from 21 % of TTC values under 1.5 sec to 59 % of encounters with relative velocity higher than 36 km/h.

The highest speed values obtained at the considered crossing in relation to the ones on non-signalized crossings can lead to the conclusion that the behaviour of walkers on a roundabout crossing is more similar to the one on a signalized intersection, than to that of a non-signalized one. Moreover, the speeding up of the crossing action could be seen as an indicator of how safe/non-safe pedestrians perceive such a crosswalk. Furthermore, the existing

errors between real-world data and simulation outputs show that the application of model's default parameter to this kind of problem does not fit the expected reliability needs and an accurate calibration step is therefore necessary.
As regarding pedestrian safety level, the percentages of Surrogate Safety Measure values calculated from video recordings and overpassing the thresholds considered for risky events underline that there is still space to improve pedestrian safety on roundabouts. Even the safety calculations obtained from the simulation results underlined this aspect. Nevertheless, they identified a much safer behaviour at the considered intersection than the observed data indicated. Although safer situations are obviously desirable in general, the difference between the observed and simulated surrogate safety measures was too large to be acceptable. Furthermore, it would be desirable for the simulations to yield more critical safety values than values that are better than the real ones: in this way, further behavioural and infrastructural considerations could only improve the safety level of the considered intersection.
Finally, a limitation of the research should be pointed out: although a sufficient amount of data was collected to perform the analyses, only one location was taken into account. Further research will expand the number of sites of the same type considered, and different typologies of intersections will be addressed as well.

Keywords: Road Safety; Micro-simulation; Pedestrian; Surrogate Safety Measures; Roundabouts.

References

1. Transport Research Record, Highway Capacity Manual, National Research Council Washington D.C., 2016.
2. Pande, A., and B. Wolshon, Traffic Engineering Handbook. The Institute of Transportation Engineers, 2016.
3. Manual of Uniform Traffic Control Devices for Streets and Highways (MUTCD). U.S. Department of transportation Federal Highway Administration, 2009.
4. Bennett, S., Felton, A., Akçelik, R., Pedestrian movement characteristics at signalised intersections. "3rd Conference of Australian Institutes of Transport Research (CAITR 2001), Monash University, Melbourne, Australia, 10-12 December 2001. p. 1-10.
5. Lam, W.H.K., and C.-Y. Cheung, Pedestrian speed/flow relationships for walking facilities in Hong Kong. Journal of Transportation Engineering, 2000. 126(4).
6. Knoblauch, R. L., M. T. Pietrucha, and M. Nitzburg, Field Studies of Pedestrian Walking Speed and Start-up Time. Transport Research Record: Journal of the Transport Research Record, 1996. 1538(1): p. 27-38.
7. Onelcin, P., and Y. Alver, The crossing speed and safety margin of pedestrians at signalized intersections. Transport Research Procedia, 2017. 22: p. 3-12