Calibration of Aimsun roundabout model: Pedestrian and vehicles flow
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Abstract: Nowadays, pedestrians play an effective role on roundabout capacity and urban intersection. In this study, the results of stimulation and collaboration of Aimsun software are studied. First, the volume of pedestrians and passing vehicles is evaluated. The results showed that the average speed of pedestrian was 4.25 km/h, and the reaction time from the default of 1.35 s changed to 0.9 s. Also, the comparison results of the two moods showed that the average speed in the calibrated state decreased by 48% and the delay time decreased by 5%. Therefore, if the calibration of pedestrian movement is measured accurately.

Keywords: roundabout stimulation; pedestrian movement; Aimsun calibration; density

1. Introduction
Walking is the first mean of transportation for human. Many researchers claim that walking is the most natural, oldest and the most necessary way of movement. Walking has an essential role in the perception of spatial identity, the sense of belonging to the environment and the reception of environmental qualities (Mohammadi & shafabakhsh, 2015). Nowadays, roundabouts are one of the most common types of intersections, which have grown enormously throughout the world, especially in Iran. As a result, the precise design and engineering of these intersections have a great impact on improving their traffic performance. The capacity of roundabouts like other urban intersections is one
of the key issues in their design. Various parameters can affect this capacity, the most important of which is the rate of movement flow, the traffic flow rate of heavy vehicles, pedestrians, driver behavior in the roundabout, and its geometric characteristics (Anna, 2011; Hosseini, 2011). In the past, many studies have been conducted on roundabout capacity and the effective factors, but few of them have investigated the effects of pedestrian movement on the capacity of roundabout entrance. In this study, it was tried to analyze and determine the roundabout capacity without a traffic light and its effective factors, along with analyzing the pedestrian role on the capacity of roundabout entrance. To reach a better understanding, a roundabout of Bojnord is taken for case study and the effective parameters of pedestrians such as pedestrians’ volume, the distance of pedestrians’ cross to roundabout, and the volume of vehicles are simulated in Aimsun Software, in order to identify the effect of each variables on roundabout entrance capacity be revealed.

2. Review of the literature

Pedestrian satisfaction from the sidewalk is influenced by several factors such as the facilities of the sidewalk, physical conditions of the sidewalk, walking paths, pedestrian characteristics, and sidewalk congestion and interference. The congestion and interference could be due to the presence and movement of social groups on sidewalk. A group movement of people on sidewalks can have a significant impact on the pedestrian’s movement due to its different characteristics with pedestrians who are alone. Thus, considering this matter in designing the sidewalks to improve the level of pedestrians’ satisfaction and drawing them to walking, can improve the conditions of sidewalks.

Eric Idrom and John Holman (2014), evaluated the traffic network using the simulation and analytical modeler examined the traffic caused by a special event at a planned football stadium in Falconberg. The purpose was to evaluate the traffic simulation because of the stadium spectators designed after a major sporting event, which used VISSIM simulation software, as well as comparing the possible differences and the results and evaluations with the Capcal software, and it does the traffic simulation with both types of software. Finally, the results showed that the implementation of one traffic system is different during the final hour of the event. The obvious reason in implementing the traffic network is the presence of pedestrians in system. The time of parking discharge, especially the western parking of the stadium, is directly affected by the time of pedestrians’ discharge. As it was mentioned in the purpose, the possible differences of Capcal and Vissim results are studied. In spite of discharge time without pedestrians in Vissim, it is 5 min less than the Capcal discharge time. This is one of the results of a moving pattern in a large volume of pedestrians in Vissim. Vissim has the ability to create and analyze complex traffic systems and to run a general network, in addition to studying specific situations. In this study the average travel time and speed plus delays are used to evaluate the overall performance of the network, which cannot be done using Capcal. In addition, Vissim time intervals can be used to determine exact discharge times for different parking lots, while Capcal can only be used to estimate discharge times. In addition, Vissim is time-consuming and in terms of computation is more dependent on Capcal, thus, it is important to consider the scope of the project before deciding on using the type of software (Eidmar & Hultman, 2014). Ambadipudi in 2009 researched on similar topic, used measure speed distribution to estimate the critical headway and used it to calibrate the priority rules of the model. But there was no actual measurement of the queue length, delay collected to validate the accuracy of the model (Ambadipudi, 2009).

Wei in 2012 proposed a calibration strategy that used the capacity model in HCM 2010 as the target model and adjust the values of parameters to make the model produce a similar relation between circulating flow and the entering flow. In VISSIM, three sets of parameters were important to calibrate the VISSIM model (Wei, Shah, & Ambadipudi, 2012). In 2013, Tsakalidis et al. studied the pedestrians’ perception of the parameters that were considered effective for a pedestrian network. In this study, the purpose is to make a true analyze of walking situations in an almost populated city of Greece, trough distributing a questionnaire (including 1000 valid questionnaires) in one sidewalk and footpaths in the downtown of Larissa in Greece. According to the results of the questionnaire, it can be concluded that the sidewalk is a key element of Larissa
transportation system, which is used as an important means of daily transport and other activities such as shopping and leisure. The main reason for choosing walking is being free of charge. Despite the fact that walking is the main aspect of daily life in Larissa, a series of defects in the pedestrian network have been identified that can be noted, like inappropriate sidewalks and obstacles on the sidewalk and footpaths (Tsakalidis, 2014). Zhixia et al., (2013) used this trial and error method for the calibration of VISSIM models and verified the effect of change in traffic speed and traffic flow on driver behavior characteristics. Similarly, Arroju et al. (2015) studied the effect of deceleration on the car following parameters and observed that speed and deceleration play a vital role in the VISSIM microscopic simulation model (Arroju, 2015; Zhixia, 2013). Among these studies, various types of data were used to calibrate the model. Valdez, Cheu, and Duran (2011) used speed data to calibrate a two-lane roundabout to get the control delay and level of service. Cicu, Illotta, Bared, and Isebrands (2011) and Li, DeAmico, Chitturi, Bill, and Noyce (2013) used field estimated headway and speed data to calibrate the roundabout simulation model (Cicu et al., 2011; Schroeder, 2012; Valdez et al., 2011). Ahn et al., examined and studied pedestrian flow estimation for the design and management of a legitimate train station, with the large-scale reconstruction of the railway station implemented with increased passenger demand in various locations in Japan. These projects have created a challenge for researchers that have identified useful technical methods for developing ultrastructural designs that effectively consider passenger movement. This paper illustrates an application in relation to the Takatsuk JR station where there was a provision of a narrow island platform for high rates of passengers and their transportation. The results have shown that the accumulation on the current platform is lighter. In addition, routes connected to the new platform can be congested due to the conflict between flows between passenger transport and their disembarkation and embarkation (Ahn, Kowada, Tsukaguchi, & Vandebona, 2017). In other words, the problem of accumulation will cross from the existing platform to the local environment. From a security point of view, which is somewhat more acceptable than the current situation. In any case, it may now be possible to consider adjusting the train timetable to reduce the harmony between pedestrian traffic to a further reduction than pedestrian aggregation. In his article on pedestrians avoiding crowded roads, Monteiro researched that pedestrians and pedestrian flows, obtained by video surveillance, were analyzed in comparison to data on bus stop usage. Flows on the busiest road, lower than expected, on the road at the bus stop. The analysis obtained from this study has shown that pedestrians are opposed to avoiding the main road in crowded areas, with high levels of traffic and speed. The tendency to cross the road on deserted roads is much higher, when the number of pedestrians on the road and crossing with official facilities is compared with the tendency to cross the street, with the level of traffic decreasing, when daily traffic flows at various crossings. In the study environment and when considering changes in traffic levels during the day at the same location (Monteiro, Peixoto, & Nunes, 2006). Rebecchi et al., In the paper evaluating the pedestrian registration system of a shopping and business tower complex, reached the following results. High standards of the walking environment in urban centers and their transportation centers are important for simulating urban activities. These require urban designers to ensure that infrastructural improvements are made to sign systems to assist in destination research and user route selection processes. The project covers a case study of an expanded commercial compound purchase in major shipping centers in Osaka, Japan. They concluded that this study examined the effects of the signaling system on experimentation of travelers on the basis of experimentation with commercial and shopping malls in Osaka, Japan. The combination of trading and buying has a mark system that is classified into three types of marks based on the content of the purpose of this review. The sign system is properly implemented and the purpose of the experiment has been to reach the stated goals without prolonged deviation. The experiment is done in a way that people are forced to choose their path (Rebecchi et al., 2019).

3. Pedestrian flow in signalized intersections

According to conducted studies, the maximum time that pedestrians can stand when the light is red is 30 s, and they try to cross the street although their safety is not provided. Another reason
that pedestrians cross the street although the light is red is in rush hours that the cycle of intersections get long and becomes way more than pedestrians’ tolerance.

In these kind of intersections, the time of crossing the street by pedestrians should be in proportion to status of the traffic lights phases, in a way that when the phase of the path is red, the color changes to green and the pedestrians are allowed to cross and vice versa, when the path phase is green, the pedestrians cross should be banned by red color. In this method, paths with a low number of vehicles to right or left, the pedestrians should be allowed to cross the street with adequate safety.

4. Statement of the problem
The development and expansion of cities have raised the debate about the need for proper access to different regions of the city, which is why the intersections account for the main part of the urban network. Intersections play an important role as nodes in the urban network in network capacity, and it can be said that the capacity of an urban network is directly related to the capacity of the intersections of that network. The capacity and delay are the most important parameters in designing and controlling intersections. Therefore, it can be said that the total capacity of the city network will also increase and traffic flows in different parts of the city can be seen by increasing the capacity and reducing the delay at an intersection. Nowadays, the roundabouts are considered as a kind of urban intersection, and according to research carried out in developed countries, it can be argued that the roundabouts will perform more efficient and safe from intersections without traffic lights. This applies as long as the roundabout has not reached its capacity, and if the demands from roundabout are over its original capacity, it will run out of safety and efficiency. This purpose of this study to analyze the effects of pedestrians on roundabout capacity. Pedestrian effects are analyzed under the following two factors: pedestrian volume and the place of pedestrian crossings. The Aimsun Traffic Simulation Software has been selected based on the ability to model the passage geometry, traffic patterns and pedestrian behavior. The reason for selecting the studied case (Shahid Roundabout) is also based on access to calibrated data from the city roundabouts of Bojnourd. Roundabouts that are very close to each other and roundabouts with traffic lights are not selected.

5. The geographical location of the case study
Shahid Roundabout in Bojnourd is one of the most traffic-congested in terms of vehicles and pedestrians. It is one of the important roundabouts of the city, that shown in Figure 1. There is a great deal of interference with the vehicles and pedestrians due to the traffic load on the sidewalk around the roundabout at some hours of the day, the pedestrian lock, causing problems in the traffic of vehicles and people.
Using simulation software for traffic engineering today is common, but simulation of pedestrian movements in these software is not common in this area, due to the complexity of the process of simulating pedestrian movements compared to vehicles and non-conforming pedestrian movements with the status quo and time-consuming process of simulating and calibrating software can be considered as the major design problems. On the other hand, there is a cultural difference between pedestrian crossings in Iran and countries that have designed such software, while, as mentioned above, several other factors are involved. One of the most problematic factors is the interference of pedestrians with vehicles, which often involve accidents at intersections with paths that pedestrians intend to cross the route. The lack of attention to pedestrians, inappropriate estimates of speed and the lack of respect for priority are among the most important reasons of accidents with vehicles. In this study, it was tried to examine the pedestrian movement accurately, the Shahid roundabout of Bojnord has been considered for this study that shown in Figure 2, and its modeling in Aimsun software. The reason for choosing this roundabout is the high traffic volume of pedestrians crossing the area.

6. The statistic of the pedestrian and vehicles volume in the studied area

By visiting the study area several times, the areas with high pedestrian traffic on the Shahid roundabout were identified and the locations needed for pedestrian traffic were measured and taken at 15-min intervals and the number of pedestrians crossed the street and the length of footpaths in two intervals of 10–13 and 18–20 were considered. Also, in order to determine the service level of sidewalks, the volume of vehicles passing through the study area was divided by vehicle in two time periods of the morning and evening. In Figure 4, the volume of pedestrian traffic in both the morning and evening intervals is shown in the study area. Also, in Figure 3, the volume of vehicles has been taken in the time intervals of morning and evening in the study area.

Figure 2. The status of pedestrians crossing the roundabout and the area around it.

Figure 3. The traffic volume of vehicles going straight and turning in Shahid Roundabout.
7. Traffic volume
The traffic volume of both vehicles and pedestrians in rush hours that was used in simulation, is shown in Figures 3 and 4.

The volume of pedestrians crossing the roundabout is the most important factor that has caused traffic problems in this roundabout (Ogallo & Jha, 2014).

7.1. The locations of crosswalks
Figure 5 shows the crosswalks in Shahid Roundabout. that was considered in designing in Aimsun.

7.2. Public transportation places
Figure 6 shows the locations of bus stops and taxi station. Stopping public transport, commuters of public transport is one of the causes of traffic at peak hours of pedestrian traffic in the Shahid Roundabout. causing more traffic and more pedestrians in the area.

8. The simulation and validation process of software
In software modeling for pedestrian’s simulation is validated based on the real information of pedestrian movement. There is no statistical guarantee that the defined parameters in the software are valid for
under study area of the researchers. Therefore, to make a consistency between the analyze and results with the current status of Shahid Roundabout. We calibrated Aimsun software, which is a very time-consuming and important process and has a real significant impact on the software output. Among the items that can be mentioned in the software calibration and is reached in the field research was the pedestrians’ pace, which from 6 km/h at the default reached to an average of 4.25 km/h. The reaction time of the pedestrians in the software was 0.75 s changed to 0.1 s, and the reaction at stop from 1.35 s at the default changed to 0.9 s (Technical Note, 2014). The specified capacities for each crosswalk and the width of the existing sidewalks were the ones that were performed in software calibration and made significant changes compared to the default software. Also, in simulating a pedestrian footpath in roundabout, it should be noted that the pedestrian footpath on the roundabout are marked by crossings pedestrian and also defined by vehicles at an intersection, otherwise, if any of these conditions are not set, the vehicles will not be able to recognize the pedestrians and the desired result will not be achieved (Al-Wedyan et al., 2015).

In the validation of the constructed model, the number of pedestrians in a crosswalk is counted and the number of vehicles and crosswalks and vehicles are considered. And each path is counted separately for pedestrians and vehicles and is included in the software (Barceló, 2010; Fernandez, Seriani, & Allard, 2010; Stoker et al., 2015). This stage of validation is the most important part and
it has an immense effect on the results. The simulation of current status of Shahid Roundabout is shown in Figure 7.

8.1. The results of pedestrian simulation
This part will discuss the results of the calibrated and non-calibrated simulation results in Shahid Roundabout. The results of this study are as follows.

Figure 8 shows the delay time of pedestrians within a given time interval, in which the horizontal axis shows the time chart and the vertical axis shows the traveled distance, its unit (seconds/km) (Tsakalidis, Sdoukopoulos, & Gavanas, 2014; AIMSUN, 2015). As it is illustrated, the software in calibrated mood considered a lower average of delay for pedestrians.

Figure 9 shows the density of pedestrians in Shahid Roundabout. The horizontal axis shows the time variable and the vertical axis represents the average number of pedestrians in the simulation (ped/km).

As it was mentioned before, considering the calibration of the software in the mentioned cases, the calibration results can be clearly seen in Table 1, which many changes happened in the studied parameters. Table 1 is given the figures that in the simulation of the calibrated and non-calibrated scenarios of the Aimsun software, differentiated by vehicles.

As it can be seen in Figures 10 and 11, two different scenarios were considered in this study for this roundabout. As shown in Figures 10 and 11, Aimsun software, in addition to calibrating the sidewalk sections, also needs to calibrate the street sections. It is also indicated that the existing software needs to be calibrated. This will bring the current status of the roundabout and the surrounding sidewalks closer to the simulated state of the software, which makes the results of the software more accurate.
Table 1. Comparison of simulation in calibrated and non-calibrated mood

| Row | Parameter             | Unit  | Calibrated | Non-calibrated |
|-----|-----------------------|-------|------------|----------------|
| 1   | Delay time            | Sec/km | 349.233    | 368.739        |
| 2   | Density               | Veh/km| 176.756    | 219.016        |
| 3   | Flow                  | Veh/h | 7560       | 2187           |
| 4   | Speed                 | Km/h  | 2.48       | 3.68           |
| 5   | Time at stop          | Sec/km | 1519.08    | 1434           |
| 6   | Total distance of a trip | km | 3102.63    | 834.434        |
| 7   | Commuting time        | Sec/km | 1329.91    | 342.205        |
| 8   | Total time of commuting | hours | 1542.43    | 1474.08        |

Figure 10. The simulated status quo and the v/c status display in the calibrated roundabout.

Figure 11. Status of the roundabout v/c in the non-calibrated mood.
Considering the volume of pedestrians and vehicles in this roundabout, particularly in the entrance of Southern Shahid Beheshti St. and Eastern Taleghani St. and Northern Shahid Beheshti this roundabout requires a review and constructing proper space for facilitating the movement of pedestrians and vehicles. This study observed the quantitative evaluation of pedestrian characteristics on intersection in Iran. Peak hour flow was observed using video technique. Real data were fitted to construct Aimsun model and observe simulated data to develop pedestrian and vehicles flow models for the intersection. Finally, Required parameters were calibrated and validated.

9. Conclusion
As shown in the main text, microscopic traffic simulation is a helpful tool for analyzing and communicating pedestrian and vehicles issues; it is possible to simulate the interaction between pedestrians and vehicular traffic in a intersection. After simulating the movements of pedestrians and vehicles in Shahid Roundabout of Bojnourd, it was showed that all pedestrians had the possibility of entering and leaving the network during the simulated time.

The results of simulation and software calibration showed that the results are significantly different with non-calibrated mood and software calibration improves the simulation results.

The difference between the results of these variables in eight parameters of Table 2 is significant. These differences show that the more we include details like delay time, pedestrians’ speed, the width of the path, the distance between people, the simulation results will be more realistic. Therefore, the real simulation would help to improve the current situations and make a better ground for following researches.

Field experiences show the differences modelling of traffic and pedestrian in the intersection, so municipalities in the I.R Iran must be notice to modelling by Aimsun. To improving traffic management systems and realised new infrastructure, they should study based on the combined results of Aimsun and field evaluation.

The closer the simulation is to the current situation as a whole, the closer it can be to the reality and the results of the simulation and the different scenarios that may occur in the area under investigation. The study area was evaluated, the better the software calibration, the more accurate

| Table 2. Comparison of simulation mood in calibrated and non-calibrated mood and the difference and the change percent between parameters |
|---|---|---|---|---|---|
| Row | Parameter | Unit | Calibrated | Non-calibrated | Difference | Change percent |
| 1 | Delay time | Sec/km | 349.233 | 368.739 | −19.506 | −5.585 |
| 2 | Density | Veh/km | 176.756 | 219.016 | −42.26 | −23.9 |
| 3 | Flow | Veh/h | 7560 | 2187 | 5373 | 71.07 |
| 4 | Speed | Km/h | 2.48 | 3.68 | −1.2 | −48.38 |
| 5 | Time at stop | Sec/km | 1519.08 | 1434 | 85.08 | 5.6 |
| 6 | Total distance of a trip | km | 3102.63 | 834.434 | 2268.196 | 73.10 |
| 7 | Commuting time | Sec/km | 1329.91 | 342.205 | 1124.568 | 84.55 |
| 8 | Total time of commuting | hours | 1542.43 | 1474.08 | 68.35 | 4.43 |
the results are, so it can be said that more accurate calibration is needed to obtain accurate results and then make more reliable decisions.

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