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Evaluation of Pedestrian Facilities in Al-Najaf City

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Abstract. Less attention to pedestrian facilities significantly affects traffic flow, such asside friction and delay. It was noted that a high interaction, in Al-Najaf city, with the vehicular stream by pedestrians resulted in a reduction in the performance of this urban road network with high pedestrian interactions. Compared to vehicular movements, pedestrians continuously interact with each other and their surrounding environment, constantly changing characteristics and direction. This study aims to evaluate Al-Najaf City pedestrian facilities (Footbridges). The number and location of these bridges were investigated in 2010 and 2022 using ArcGIS10.5. Furthermore, some specific sites have been selected to indicate the intensity of interaction between the pedestrian and traffic flow. The results showed a significant lack ofpedestrian footbridges in the city with high pedestrian interaction (side friction) in theselected sites.

Keywords: Footbridges; pedestrian Infrastructure; side friction levels; urban road network

1. INTRODUCTION

Due to land restrictions, there are presently pressures and difficulties in many densely populated urban areas, such as traffic congestion and a lack of public open space. These problems are some of the most significant ones that walkers encounter. Except for cycling, walking is the most environmentally friendly mode of transit. Because of the significant increase in pedestrian-vehicle damage in traffic accidents, especially in large cities, which is considered the price of civilization, increased automobile traffic in cities harms pedestrian safety and the environment as they walk and cross streets. A significant issue in highway planning and construction is the interaction of traffic movements and pedestrians. Given their greater prevalence, urban pedestrians significantly impact roadway design factors more than rural ones [1]. A pedestrian is significantly more exposed than a driver in both positive and negative ways. Pedestrians can be more aware of their surroundings because they move considerably more slowly than other modal users. Accidents can be decreased in several ways, including by providing facilities for crossing roads, such as zebra crossings and pedestrian bridges. Unfortunately, these amenities are still rarely used, especially pedestrian bridge crossings. This situation makes determining how effectively to use the pedestrian bridge crossing necessary. 87% of pedestrians cross the pedestrian bridge at busy times, while 88% do so atnon-busy times. Installing a curb railing fence on both sides of the road is the answer to increasing the number of pedestrian bridge crossings (about 200 m) [2]. This study aims to evaluate the pedestrian facilities in Al-Najaf City. This study has just focused on footbridge facilities in the city.

Researchers have established four methods to evaluate the amount of service provided topedestrians. The first method considers sidewalk geometry and pedestrian traffic [7]. The second type is created based on the quality of the road environment [8, 9]. Theoretical principles for qualitative evaluation of the comfort levels provided along sidewalks in significantactivity hubs were given by Sarkar [8]. The method was created using research from urban design, environmental psychology, landscape architecture, and urban planning. The method contained two independent evaluations: quality level, which looked at the micro-level specifics of pedestrian comfort, and service level, which provides standards for overall desirable and unpleasant comfort conditions at the macro level. An approach to measuring pedestrian Level of Service (LOS) using pedestrian perceptions was developed by [10].

By providing six broad categories of roadside walking environments in terms of safety, security,convenience and comfort, continuity of the walkway, system coherence, and attractiveness by some specific facilities. Rahaman [11] explored the qualitative level of pedestrians' comfort in Dhaka City. The study's findings indicated that pedestrian infrastructure should be given more priority than that motorized vehicles because pedestrians were neglected interms of safety and convenience. Bansal [12] attempted to review all potential determinants and suggest the most influential ones based on classification criteria. It wasfound that among the many factors reviewed, pedestrian factors significantly influence LOS Uninterrupted pedestrian facilities. In contrast, in the case of intermittent pedestrian facilities, traffic characteristics appeared to be the most motivating factor affecting service quality.

2. PEDESTRIAN EFFECT

The pedestrian effect is considered the main effect of roadside friction. Among the elements that were considered were pedestrian crossing, bicycles, and non-motorized vehicles, whether permanently or temporarily parked on the side of the road. All of these elements were multiplied by a different weight factor assigned to each element according to the severity of its effect on the characteristics of the traffic, and the weight of each element was also based on the location of the element on the side of the road and its distance element [3, 4].

Based on the Indonesian Highway Capacity Manual (IHCM) [5]. Side Friction (SF) levels have been classified from very high to very low levels. The IHCM specifies the roadside friction elements that must be incorporated during flow and capacity calculations. The side friction was divided into five categories based on the fluctuation in the speed data. Side friction does not impact the vehicles' average speed at this very low level. The percentage decrease in average speed is substantial at very high side friction levels. Classification of side friction levels is based on IHCM [5], as indicated in Table 1. Gulivindala [6] suggests a model that estimates the average speed of vehicular streams with the effect of side friction and volume on the section of the road. The quantification of side friction events has never been done before by taking into account the number of parked vehicles and pedestrians as a single unit, as well as other dynamic activities, such as vehicle entry and exit from the surrounding area and wrong-way movements, as separate parameters to estimate theside friction.

Table 1: SF classes [5].

SF Levels	Codes	SF events/hr	Land-use conditions
Very-low	V-L	0-100	residential location, no activities
Low	L	100-300	Residential location, in forms of public transportation, etc.
Medium	M	301-500	commercial location, very-high roadsides activities
High	H	501-900	industrial location, many shops on the roadsides
Very- high	V-H	> 900	commercial location, markets activities besides the roads

3. STUDY AREA AND DATA COLLECTING

Al-Najaf is one of the middle Euphrates provinces in Iraq, and it is located between Latitude: 32°01' 33.38" N and Longitude: 44° 20' 46.50" E, as indicated in Figure 1. Referring to Figure 1, the location of footbridges spreading in the city was determined using Arc GIS 10.5. Furthermore, the details of each location and the existence of these bridges in 2010 and 2022 are shown in Table 2. Moreover, it was found no tunnel facilities exist in the city for pedestrianfacilities.

Table 2: The coordination of footbridge in the city.

Footbridge No.	Road Name	Before2010	After 2020	Coordination	
				East	North
FB1	Karabla-Najaf	Yes	Yes	436234	3542921
FB2	Manthera	Yes	Yes	438755	3538719
FB3	Kufa-Najaf	Yes	Yes	438021	3541283
FB4	Kufa-Najaf	Yes	Yes	439339	3541829
FB5	Kufa-Najaf	Yes	Yes	440929	3542552
FB6	Al-Maslak	Yes	Yes	436431	3538687
FB7	Al-Askan	Yes	Yes	438077	3542045
FB8	Al-Hawlee	No	Yes	434542	3547204
FB9	Karabla-Najaf	No	Yes	435877	3545783
FB10	Karabla-Najaf	No	Yes	436040	3544462
FB11	Manthera	No	Yes	439997	3538160
FB12	Garage Baghdad	No	Yes	436278	3544259
FB13	Garage Baghdad	No	Yes	437340	3544695
FB14	Kufa-Najaf	No	Yes	440146	3542164
FB15	Al-Matar	No	Yes	437987	3548507
FB16	Al-Sahlaa	No	Yes	440877	3545706
FB17	Najaf-Babil	No	Yes	443001	3548517
FB18	Al-Mamal	No	Yes	443839	3543808

Data was collected on a selected road network in Al-Najaf City, as illustrated in Figure 1. The urban network was chosen because of observing pedestrians and traffic activities in those areas. Traffic activities are facing significant growth. Especially in the past decade, social and economic activities such as shopping centers, schools, and universities mainlyincrease the demand for traffic and affect traffic flow, especially during peak hours. In this study,data were collected in 7 various urban locations in the city. Figure 2 shows these sites in the study area. The details of the methods are given in Table 3.

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Figure 1: The existing footbridge in the study area.

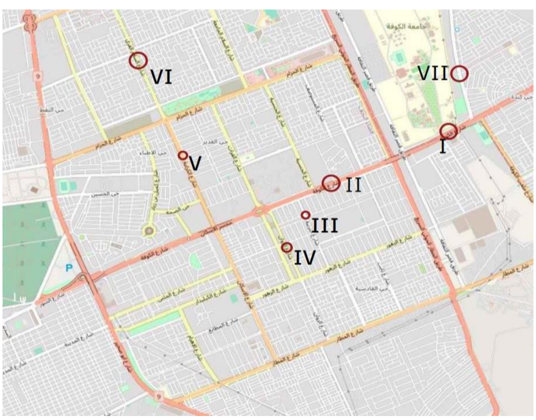

Figure 2: The study area of Al-Najaf urban roads network.

Table 3: Details of the study sections on the urban road network.

Site No.	Site name	Divided/Undivided
I	Najaf - Kufa Street (opposite the University of Kufa)	Divided
II	Najaf - Kufa Street (oppositethe College of Basic Education)	Divided
III	Al-Tarbia Street (opposite Al-Nawras Schools)	Undivided
IV	Al-Rawan Street	Undivided
V	Ghadeer-Karama Street	Divided
VI	Salam-Ghary	Divided
VII	Al-Mutanabi Street	Divided

3.1 Traffic and Pedestrian Data

Traffic data were collected in the selected network using the video recording method for traffic characteristics. Cameras were installed in the proposed locations for collecting traffic data. Traffic data include volume, speed, and pedestrians. Volume data include the number of vehiclespassing a specific location in the study area. The data were extracted from recorded videos and counted manually. The cameras were installed on the ground in some cases and mounted on the building in other cases to ensure good coverage for segments of the study area.

3.2 Method of Data Collection

All required data, including traffic and geometrical, were collected in the selected road network on typical weekdays in good and clear weather conditions. Measuring and the survey were conducted for morning and evening peaks. Trap length and tape were used for measuring road width, medians, clip length, and shoulders width. Also, the number of lanes and lane width were calculated. Table 4 Illustrate the geometrical details as follows.

Table 4: Urban road network's geometrical details.

Site NO.	Street name	Length (m)	No. of lanes per direction	Divided/ Undivided	Roadway Width (m)
I	Najaf - Kufa	250	3	Divided	12
II	Najaf - Kufa	175	3	Divided	12
III	Al-Tarbia	120	3	Undivided	12
IV	Al-Rawan	120	4	Undivided	15
V	Ghadeer-Karama	150	3	Divided	10.5
VI	Salam-Ghary	150	3	Divided	10.5
VII	Al-Mutanabi	170	3	Divided	

3.3 Pedestrians and Traffic Data

The following data related to traffic were collected at the study sections in the study area in mid-block urban road segments. At all selected sites, the number of pedestrians and cars traversing the study locations was counted manually from recorded videos in the field, as indicated in Figures 3 to 9. The vehicles passing an imaginary line were measured, and all data were aggregated to findthe hourly volume of traffic flow and pedestrians. Figures 3 to 9 indicate the intensity of pedestrian interaction with vehicular traffic streams. It was found that sites I and II represent the highest number of interactions between pedestrians and thetraffic stream.

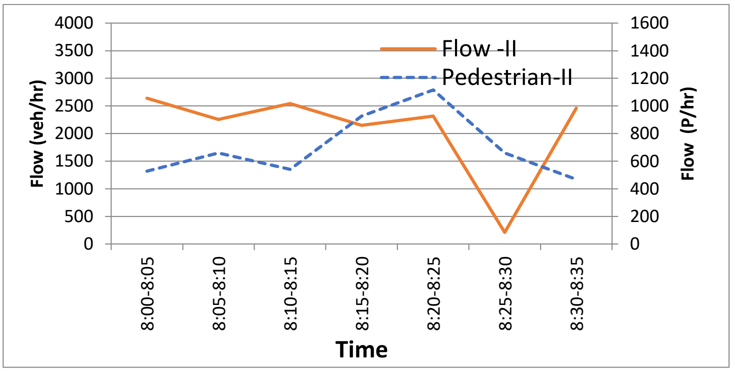

Figure 3: Flow of vehicles and pedestrians for Site I.

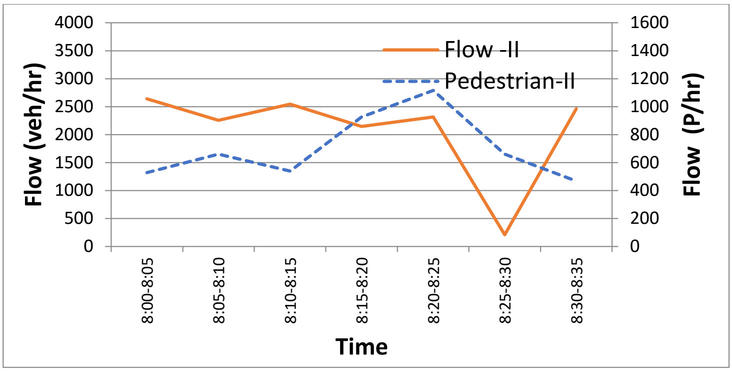

Figure 4: Flow of vehicles and pedestrians for Site II.

Whereas other sites represent the interaction from low to moderate levels. However, these sites are characterized by either high flow or high speed according to the class ofeach road, as indicated by Figure 10. This class has mainly depended on measuring free-flow speed with the Highway Capacity Manual 2010. Table 5 indicates the SF level foreach site in the study area. Table 5 shows Sites I and II characterized with very high SF according to IHCM, whereasSite VII with low SF and the rest sites with very-low SF. Referring to Figures 1 and 10 with field survey in the city, there was a need for more than 20 footbridges in the whole city. These footbridges could be installed for all multilane roads, Class I and Class II urban streets due to the high interaction along these roads, which results from commercial, industrial, and other social activities.

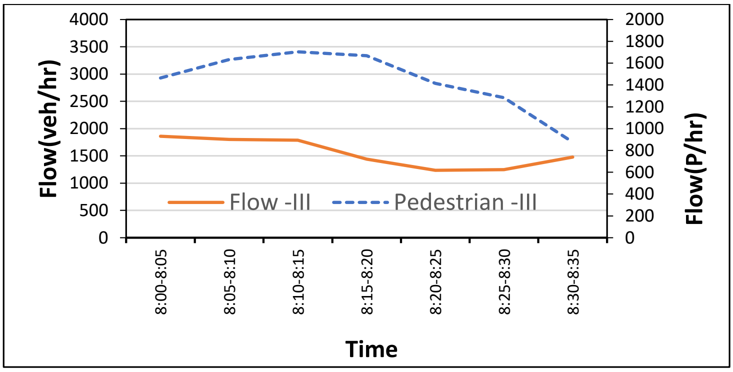

Figure 5: Flow of vehicles and pedestrians for site III.

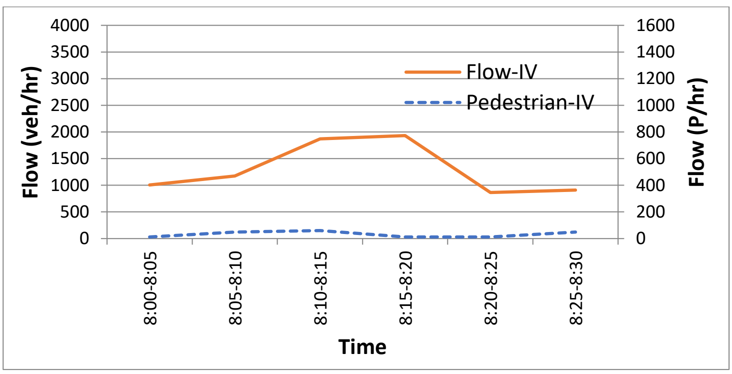

Figure 6: Flow of vehicles and pedestrians for site IV.

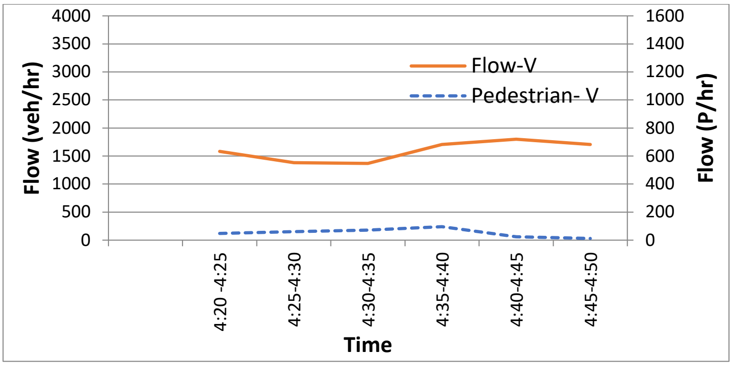

Figure 7: Flow of vehicles and pedestrians for Site V.

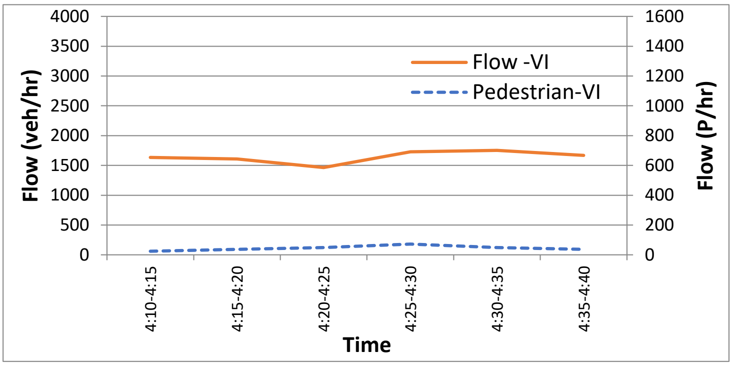

Figure 8: Flow of vehicles and pedestrians for site VI.

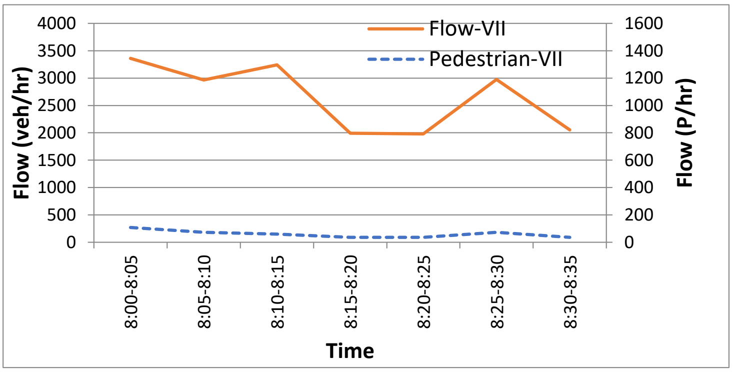

Figure 9: Flow of vehicles and pedestrians for site VII.

Table 5: Evaluation of the SF levels for the study area.

Site No.	Site name (road) RD	Pedestrian (p/ h)	SF events/hr boundary	SF Levels	Flow (veh/hr)
I	Najaf – Kufa Street (RD12)	1560	> 900	Very- high	4752
II	Najaf – Kufa Street (RD12)	1116	> 900	Very- high	2544
III	Al-Tarbia Street	1704	> 900	Very- high	1860
IV	Al-Rawan Street	60	0-100	Very-low	1932
V	Ghadeer-Karama Street (RD17)	96	0-100	Very-low	1800
VI	Salam- Ghary(RD22)	72	0-100	Very-low	1752
VII	Al-Mutanabi Street	108	100-300	Low	3360

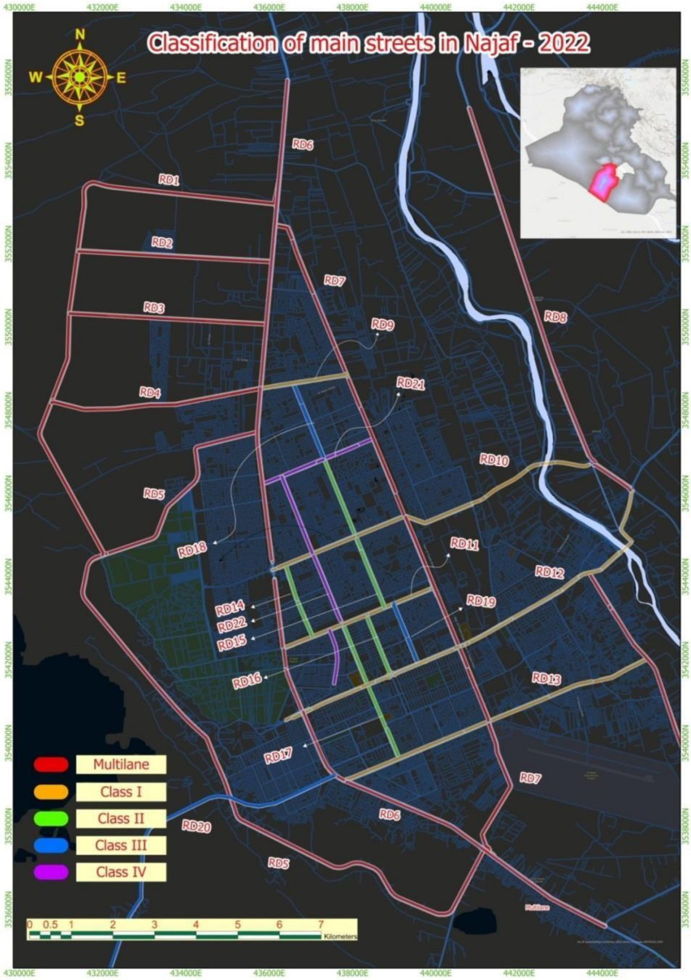

Figure 10: Classes of roads in Al-Najaf city.

4. CONCLUSIONS

The brief conclusions of the present study are as follows**:**

- The number of FBs existing in the whole city is 18. This number is limited compared to pedestrian activities along the entire city network.
- The SF between pedestrians and vehicular traffic was monitored in seven different locations on different urban streets in Najaf city and compared with the classification of side friction levels based on IHCM (1997). The result showed that the level of SF on Najaf Kufa Street at the site of the main gate of the University of Kufa, at the site of the College of Basic Education, and at the site of Al-Tarbia Street was very high. Whereas, Al-Mutanabbi gate at the University of Kufa gate site was low. For Al-Rawan Street, Ghadeer Karama Street, and Salam Gray Street, the level of SF is very low.
- This study has classified all the main roads in the city. It was found that most types of roads: multilane and arterials. There is a lack of footbridges, especially on the multilane roads in the city.
- There is a lack of regulated crosswalks within the city. Furthermore, some crosswalks were spreading on main roads (Class I), such as Kufa Najaf road with high flow.
- Expanding the study on pedestrian crossing places in the city's main streets and their relationship to vehicle speed is desirable.
- For a better understanding of side friction effects, using the simulation tools to represent the effects and the solutions is recommended.

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