Enhancing Pedestrian Safety from Traffic Accidents at the Jadiriya Complex within the University of Baghdad, Iraq

Suhaib M.J. Al-Ahbabi & Hoda A.S.Al-Alwan
Department of Architecture Engineering, College of Engineering,
University of Baghdad, Baghdad, Iraq.
suhaib.jassim2004d@coeng.uobaghdad.edu.iq
hoda-alwan@coeng.uobaghdad.edu.iq

Received	Reviewed	Revised	Published
12.07.2023	24.07.2023	28.07.2023	31.07.2023

Abstract

This paper examines the enhancement of pedestrian safety in the face of possible traffic accidents within the Colleges of Engineering and Science premises of the Jadiriya complex at the campus of the University of Baghdad. The study aims to identify areas where traffic accidents are likely to occur, determine the causes of them and identify the procedures to prevent or reduce them.

The research adopts a qualitative approach and is based on descriptive analysis. It identifies and analyzes the problems and finds ways to address them. A field survey was conducted, using current reality charts for the study area. Information was gathered through audio-visual and video-based observations. Comparisons between the basic charts and reality charts have been made. Information and digital data have been collected through a questionnaire form and interviews with different participants within the study area. The space syntax program was employed to validate the field study outcomes.

The results show the importance of separating pedestrian traffic from vehicular traffic, identifying the areas that witness a clear intersection between them, as well as identifying the most important causes of traffic accidents. They are the lack of pedestrian crossings, non-compliance with the speed limits, sudden stops of public transport buses, increasing numbers of cars, as well as the deviant behavior of pedestrians. The research identified the procedures to reduce traffic accidents: the use of public transport buses, reduction of the use of private vehicles, as well as education on promoting pedestrian safety. The research provides recommendations to campus designers and university administration on how to enhance safety on campus.

Keywords: On-campus transportation, Pedestrian traffic safety, Traffic accidents, Patterns of transportation, Transport system management, Design of University Campuses.

Introduction

Many universities suffer from the dominance of vehicles and roads in their urban landscape. This makes pedestrian traffic to come in conflict with vehicular traffic, as well as the unnecessary overlaps between the patterns of movements within the campuses. Driving private cars within a campus represents a serious problem. The choice of this mode by students, teaching staff, or employees depends on the number of study days or the inability to walk (for people with special needs), as well as gender and age (Rerat, 2021).

Riding bicycles is a preferable mode of transportation within a campus. It is characterized by speed, flexibility, and ease of use. It does not consume any energy and therefore does not produce any environmental pollutants or noise (Balsas, 2003). Walking is the oldest and simplest mode of transportation in general (Zegeer et al,2002), and it is also one of the main modes of transportation inside the campus. This can be seen by walking through the corridors between the campus buildings or in its outdoor spaces or from parking lots to building entrances (Sanchez et al,2010). One of the factors influencing the choice of this mode as a means of transportation within a university campus is the time and distance (Shaaban&Kim,2016).

And to clarify what solutions are adopted at universities to ensure the safety of pedestrian traffic on campus, designing patterns of transportation require the allocation of vehicles and public transport bus routes to reach any destination within a campus (Dober, 2000). Taking into account the separation of pedestrian and bicycle paths from automobile routes as much as possible. It is necessary to keep these routes as far away as possible from the main buildings and squares of the campuses (Coulson et al, 2011). In other words, it supports the principle of pedestrian crossing compliance as a reference to legal and safe pedestrian crossing areas (Sisiopiku &Akin,2000). On the contrary, intersections can become areas of traffic accidents between pedestrians and cyclists on the one hand, and between vehicles on the other if they are not designed safely. It is necessary to emphasize their importance by alerting motorists to anticipate the places where pedestrians may cross and simultaneously encourage pedestrians to use those places to cross safely (Tool & Zimny, 2009). Allocation of cycling paths and pedestrian lanes on campus, provide direct communications between the buildings and the adjacent road networks (Williams et al., 2004), with the possibility of creating suspended pedestrian walkways to avoid the intensity of vehicular traffic (Sanchez et al., 2010).

Attention should be paid to determining the locations of for public transport bus stations in a way that ensures fair use and easy access by users of campus buildings and facilities. Such stations should provide safe stops (Shu&Wu, 2018). At the same time, traffic signs are needed to guide the movement of pedestrians, cyclists, and motorists. However, compliance with them depends on their locations and visibility (Medina et al, 2007) (Al- Alwan & Al-Azzawi, 2013).

In this context, this paper examines the reduction of traffic accidents, and aims to ensure the safety of pedestrian traffic inside the campus towards those accidents, through the following:

1. To identify areas where traffic accidents are likely to occur.
2. To identify the causes leading to the occurrence of such accidents.
3. To identify the measures taken by those responsible for managing the transport system on campus to reduce such accidents.
4. To provide a model that contributes to enhancing the safety of campus users in general, it is being worked on by universities designers in general and those in charge of managing the campus transportation system in particular.

Literature Review

Previous studies have pointed out the importance of determining the speed of cars as one of the causes of traffic accidents on campuses. Dobbs (2009) has indicated that wider the roads, the more difficult it is for the pedestrians to pass them. He also shows that there is a need to limit the speed of vehicles on campuses to 40 km/h, because pedestrians who are hit by vehicles traveling at a speed lower than that do not suffer from serious injuries or death, while injuries are serious or fatal if the speed is higher than 40 km/h. He also emphasized the use of elevated pedestrian crossing corridors within specific areas on campuses to enhance the safety of the pedestrians. Similarly, Xu (2012) shows that reducing the width of carriageways inside the campuses will contribute to reducing the speeds of cars and thus could enhance safety. For example, if the width of a road is 5 m, the highest speed recorded is 34.8 km/h, and if the width is 12 m, the highest recorded speed is 64.2 km/h. He also concluded that the the carriageways longer than 180-200 m without speed reduction humps, significantly increases the speeds of vehicles. Rodier et al (2003) show that pedestrian behavior represented by running in the carriageway, moving between parked cars, walking in the wrong direction, or ignoring traffic signals are often some of the most important causes of traffic accidents.

Other studies highlight the treatments or procedures used to reduce traffic accidents on campuses. Herman& Cynecki (2000) for example, points out the importance of using techniques to reduce the speeds of vehicles, represent by reducing the width of the pedestrian crossing area, and the technique of narrowing roads by planting trees on both sides of the roads. This technique is effective in reducing the speeds of vehicles because drivers feel that they are limited to moving within less space. Taha& Ali (2021) on the other hand, show the importance of demand management for parking lots. It aims to organize them and reduce land allocated to them and thus reduce the use of cars by students and employees. As a result, it enhances the level of pedestrian safety on the campuses. Medina et al (2007) also point out that moving away from the central area of the campuses by transferring the high-density traffic to the campus perimeters and establishing parking lots near the entrances will generally make the campus environments safer and ensure pedestrian safety.

They also emphasize the importance of education programs, which are essential to enhance safety and change the behavior of pedestrians and motorists while moving within the corridors and roads. These programs include education on understanding traffic signs and the need to follow them and pay attention to bus sites that are characterized by heavy usage. (Al-Dulaimi et al., 2011). Benekohal et al (,2007) show that most universities strive to create pedestrian-and cyclist-friendly environments by following a policy of closing some roads to vehicular traffic and turning them into pedestrian-safe areas. They propose establishing traffic management committees responsible for promoting traffic safety. An example is the 'Pedestrian Center at the University of Wisconsin-Iowa Minnesota'.

In fact, Sanchez et al. (2010) show that all roads inside campuses should be completely closed to vehicular traffic, with the establishment of parking lots for them outside the campus or within the perimeter. Balsas (2003) elaborates and says that parking makes up the largest percentage of space allocated to the transport networks in general. They are the causes of traffic congestions on campuses, which have prompted many universities to find solutions to alleviate congestion, improve safety of the campus users and maintain it as a distinct community (Raheem et al., 2013).

As can be seen, identifying the causes of traffic accidents on campuses and reducing them will contribute to enhancing the safety of pedestrians within university campuses.

The Case Study

The campus of the University of Baghdad is one of the distinguished architectural landmarks in Iraq. It was designed in 1960 by the German architect Walter Gropius, one of the pioneering masters of Modern Architecture, and the founder of the Bauhaus School. UoB was regarded then as the largest architectural commission undertaken by Gropius during his lifetime, and one of the most influential projects of the Modern Movement in the Middle East (Al-Alwan et al., 2022). The campus is a peninsula surrounded by the Tigris River on three sides. The plan is divided into concentric zones. At the heart of the campus, a ring road encircles the academic area with departmental buildings of different colleges and a central plaza –the focus of the campus- around which are located the buildings for the faculty and the student' activities (Al-Alwan, 2020). The ring road is surrounded by other facilities that promote life in the campus. The study area represents the academic area surrounded by the ring road, which includes the buildings of the Colleges of Engineering and Sciences, as well as the buildings of the central area (Fig. 1).

Fig. 1: The location of the Baghdad University.
Source: Authors.

In the past years, UoB has witnessed areas with high pedestrian traffic and more frequent vehicle accidents. Many pedestrians have been injured according to UoB Security Administration, which renders pedestrian safety as a goal of utmost importance. This reinforces the strong commitment to the process of educating and raising awareness among all the members of the campus community regarding how best to be safe.

Accordingly, the aim of this study is to investigate pedestrian safety qualitatively on the campus of UoB, and to provide recommendations for safety improvement based on these analyses.

Research Methodology

This study is based on a qualitative research methodology. Data were gathered through a field survey employing the following.

1. Filming using video cameras installed in areas where there is heavy pedestrian traffic and intersects with car traffic inside the campus.
2. Conducting a field survey of all parts of the study area by researchers, through which plans were prepared showing buildings, pedestrian walkways and car routes, and then adopting them in identifying areas with heavy pedestrian traffic during peak times witnessed by the university campus, identifying areas of intersection between

pedestrian traffic and car traffic, as well as identifying places where public transport buses stop without a parking station, recording observations related to the behavior of pedestrians in their commitment to move within the lanes allocated to them or crossing car routes from areas allocated to them for transit, and taking photos that support pre-recorded observations, And record observations to find out what pedestrians suffer during their movement inside the campus from obvious interference with car traffic, or not allocating enough lanes for their movement, or not allocating areas for crossing car roads in a way that ensures their safety

3. Conducting interviews with campus transportation system management officials, where some of them were interviewed in their offices and others were interviewed while performing their work at the main entrance to the campus and within their presence areas scattered in roads and footpaths to find out what measures they are taking to ensure pedestrian safety and what measures are being taken to reduce the use of cars inside the campus, with interviews with campus maintenance officials, especially the maintenance of roads and footpaths, To find out what obstacles to pedestrian safety face and what measures they took to ensure the separation of lanes and roads, it can be said that some of these interviews were useful in determining the causes of traffic accidents, while others were not useful due to their inability to carry out the necessary maintenance of roads, the creation of pedestrian transit zones or the construction of suspension bridges for crossing in areas with high pedestrian traffic due to the lack of the necessary financial allocations for this.
4. administering a questionnaire.
5. Using the space installation program to analyze the traffic density inside the ring road surrounding the study area through the Global Integration Index, which provides the possibility of identifying areas with a clear intersection between pedestrian and car traffic, and therefore the possibility of confirming pre-selected areas from digital cameras or through field survey or not.

By integrating the observations recorded via the field survey, the results of video cameras, the results of the interviews conducted, the results of the questionnaire forms, as well as the analysis of the intensity of movement through the Space Syntax program, a comprehensive and reliable methodology for data collection was developed.

Findings and the Discussion

Visual observation and field surveyThis comprised two parts :

A-Identification of areas of possible traffic accidents within the study area:

The movement of pedestrians, cars, and public transport buses within the corridors and roads of the practical study area were monitored, in the morning peak period from 7:15 to 8:45as well as the evening peak period from 12:15 to 1:30. This clearly showed the areas that witness an intersection between pedestrian traffic on the one hand and the movement of cars and public transport buses on the other. They were noted in twelve locations, where traffic accidents are likely to occur. They involved the main entrance to the campus, passing through the ring road surrounding the academic area, and ending with the road leading to the exit from the campus (Fig. 2). The areas have been listed in the table1 which shows the location and type of possible accidents.

B- Determining the causes of traffic accidents within the practical study area:

Pedestrian traffic, especially when crossing the ring roads surrounding the study area was monitored. No areas dedicated to pedestrian crossing were observed. There were only some lanes with no signs indicating the locations of those areas for motorists to observe (Fig. 3). This explains why pedestrians cross from any area at random (Fig. 4). As a result, motorists often find it difficult to predict which areas pedestrians cross, and this can be considered one of the causes of traffic accidents.

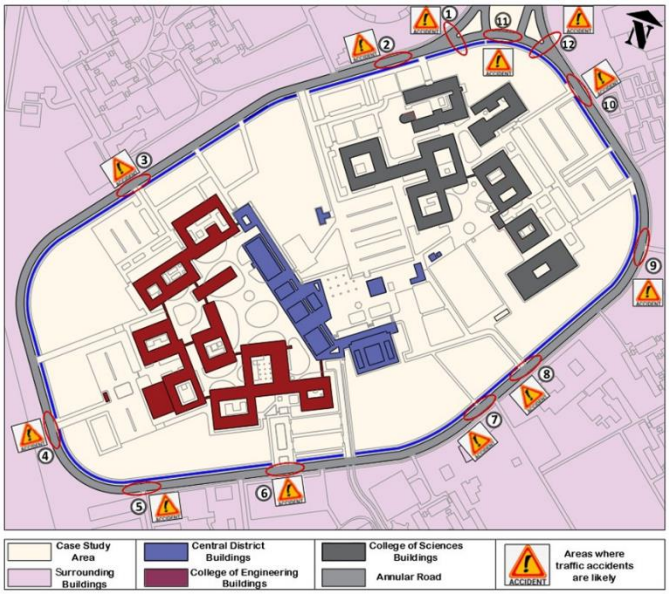


Fig. 2: Boundaries of the academic area and the ring road and the locations of possible traffic accidents
Source: Authors

Table 1: Locations and types of possible accidents.
Source: Authors

No.	Location of areas of possible traffic accidents	Type of possible traffic accidents
1	The confluence of the main axis of movement with the ring road	Collisions between cars
2	The intersection of the Deanship of the Faculty of Science and the entrance of Nahrain University	Car collisions with pedestrians
3	The entrance to the parking lot of the Department of Electrical Engineering	Car collisions with pedestrians and public transport buses
4	The entrance to the parking of the Department of Civil Engineering	Collisions between cars on the one hand and between cars and pedestrians on the other
5	The access to Al-Khwarizmi Engineering College	Car collisions with pedestrians and public transport buses
6	The entrance to the parking lot of the Deanship of the Faculty of Engineering	Car collisions with pedestrians and public transport buses
7	The access to Baghdad University Mall	Car collisions with pedestrians
8	The main entrance to the Faculty of Media	Car collisions with pedestrians
9	The main access to the Electronic Computing Center of the University of Baghdad	Collisions between cars

10	Entrance to the parking lot near the Department of Astronomy and Space Sciences	Car collisions with pedestrians
11	Pedestrian bridge leading to the Faculty of Science	Car collisions with pedestrians
12	At the confluence of the ring road with the road leading to the exit of campus	Collisions between cars on the one hand and between cars and pedestrians on the other

Fig. 3: Insufficiency of planned pedestrian crossing corridors.
Source: Authors

Fig. 4: Pedestrians crossing from areas at random.
Source: Authors

It was noted that motorists did not adhere to the speed limit of 40 km/h. , This is likely either due to the lengths of some parts of the Ring Road, which exceed 180 m (see Fig. 5), or the lack of installing speed reduction humps except for some locations, Or because of non-compliance with the traffic signs, noting the absence of traffic signs to identify pedestrian crossing areas, except for a few one-way road, no turns, the presence of a fork bump, no parking (see Fig. 6), And therefore do not forcing the motorists to reduce driving speed or stop compulsorily. And therefore, do not force the motorists to reduce driving speed or stop compulsorily.

it was noted that the public transport buses stopped at stations 7,4,2, which do not have waiting stations (Fig. 5). Motorists thus cannot predict the sudden stopping of the buses. It also impedis the smooth flow of traffic leading to traffic jams due to the lack of good design of public transport bus stops. This is one of the most important causes of traffic accidents.

It was observed that individuals drive cars and in large numbers. This is one of the modes of transportation within the university campus in general and within the study area in particular.

A field survey conducted for all parking lots, and their locations and the designed and current capacity for each of those parking lots were noted (Table 2). Officials issuing permits for cars were inquired about the reason for not adhering to the designed capacity of the parking lots when issuing these permits. They said that the issuance process does not stop throughout the semester with no specific instructions and no specific criteria. It only specifies the categories covered by the permits, namely employees, teaching staff, and students postgraduates or within the last two years of undergraduate studies, as well as students with special needs. However, the increasing number of cars and their clear intersections with the high density of pedestrians is another cause of traffic accidents.

It was also noted that the level of the ring road surrounding the study area is 3 meters higher than the surface of the aqueduct adjacent to it. It was also noted the trees planted between those roads and the aqueduct have been cut. There is also an absence of any fence to protect cars from falling into the canal, especially at high speeds exceeding 90 km/h (Figs. 5& 7). The officials pointed out that these have been done to offer clear visibility. Fences have not been erected because of the lack of financial allocations.

It is noted that there is a clear separation distance between the pedestrian walkways and the car paths. Walkways are planted with trees with a width ranging from 2 m to 2.8 m, which enhances walking in a safe environment. It also protects them from weather conditions due to the natural shading of trees. In other areas however, pedestrian walkways do not exist (Fig. 8). This is one of the causes of traffic accidents because the separation distance between lanes and roads enhances the feeling of protection for the pedestrians. It also forms a barrier against the cars.

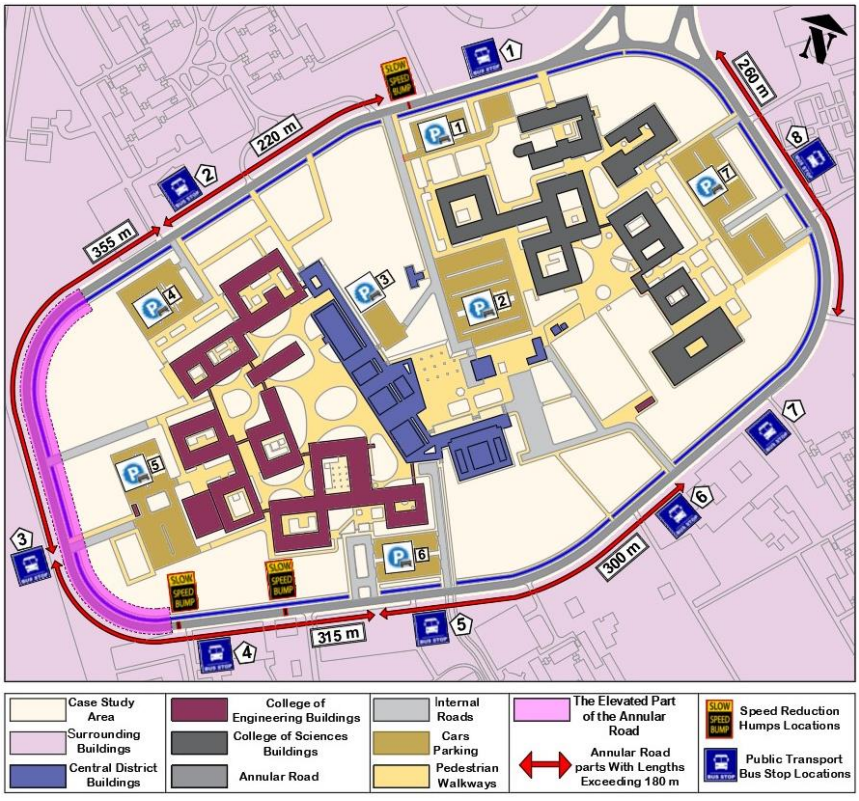


Fig. 5: Public transport bus stops in areas where there are no stations at all.
Source: Authors

Table 2: Parking lots of the study area and their locations and the designed and current capacities
Source: Authors

No.	Location of the parking lot	Parking capacity (Number of cars)	
		Current capacity	Designed capacity
1	Faculty of Science	146	120
2	Central area	378	288
3	Main Auditorium	42	36
4	Department of Electrical Engineering	144	136
5	Department of civil engineering	140	170
6	Faculty of Engineering	144	108
7	Department of Astronomy and Space	178	152

Fig. 6: Poor visibility of traffic signs and speed reduction humps.
Source: Authors

Fig. 7: The level of the ring road to more than 3 m from the adjacent canal.
Source: Authors

Visual monitoring recorded the following Improper behavior of pedestrians (Fig. 9).

1. Walking within car routes.
2. Crossing those roads suddenly.
3. Non-compliance with traffic signs.
4. Parking within certain parts of roads such as waiting for places for public transport buses.
5. Indifference to the movement of cars on the roads assigned to them.
6. Crossing in front of public transport buses and not behind them.

Undeniably, these are some of the most important causes of traffic accidents. Despite these however, follow-up departments, Diwan Affairs, Construction and projects, and the Deanship of the colleges of Engineering and Science, show that there is no special database of traffic accidents on campus.

Fig. 8: Separation distance and the areas where pedestrian walkways have been canceled.
Source: Authors

Fig. 9: Bad behavior of the pedestrians.
Source: Authors

Questionnaire Outcomes

Two forms of questionnaire were administered. Form No. 1 was administered to the students of the Faculties of Engineering and Science. Form No. 2 was administered to the employees of the follow-up, construction, and projects departments. 80 responses were accepted 60 from the students equally distributed between the two colleges, and 20 from the employees. The responses show the identification of areas where traffic accidents are likely to occur, as well as the causes of traffic accidents. They help determine the procedures followed to reduce traffic accidents and ensure pedestrian safety. They are as follows:

A- Identification of areas where traffic accidents are likely to occur within the study area: the responses to Form No. 1 showed 9 areas identified by students of the Faculty of Engineering, namely 10,8,7,6,5,4,3,2,11. As well as 5 areas identified by students of the Faculty of Science, namely 10,8,7,2,11 shown in Figure No. 2& 10 (Table 3). The reason for the difference in these areas is because the students of the Faculty of Engineering are the most frequent users of the Ring Road due to the location of the buildings of the Faculty of Engineering at the ends of that road. The districts 10,8,7,2,11 represented the highest percentages of the probability of traffic accidents in them, the districts 6,3,4,5 represented the lowest percentages of the probability of traffic accidents (Table 4). The responses to Form No. 2 also showed 7 areas where traffic accidents are likely to occur identified by the employees of the construction, projects and follow-up departments, namely 10,8,7,4,3,2,11 shown in Figures No. 2& 10 (Table 3). The regions 7,2,11 represented the highest percentages of the probability of traffic accidents, the regions 10,3,4,8 represented the lowest percentages of the probability of traffic accidents (Table 4). The responses did not show the areas 1,9,12 as having the possibility of traffic accidents.

Table 3: Areas identified according to questionnaire forms.
Source: Authors

No	Names and numbers of the specified areas	Areas identified according to the questionnaire forms			
		Model No. 1		Model No. 2	
		students of the Faculty of Engineering	students of the Faculty of Science	employees of the construction & projects department	employees of the Security department

1	The confluence of the main axis of movement with the ring road (No.1)	---	---	---	---
2	Near Deanship of the Faculty of Science (No.2)	No. 2	No. 2	No. 2	No. 2
3	Near the Department of Electrical Engineering (No.3)	No. 3	---	No. 3	No. 3
4	Near the Department of civil engineering (No.4)	No. 4	---	No. 4	No. 4
5	Near the Faculty of Engineering al-Khwarizmi (No.5)	No. 5	---	---	---
6	Near the Deanship of the Faculty of Engineering (No.6)	No. 6	---	---	---
7	In front of Baghdad University Mall (No.7)	No. 7	No. 7	No. 7	No. 7
8	In front of the Faculty of Media (No.8)	No. 8	No. 8	No. 8	No. 8
9	The main access to the Electronic Computing Center of the University of Baghdad (No.9)	---	---	---	---
10	Near the Department of Astronomy and Space Sciences (No.10)	No. 10	No. 10	No. 10	No. 10
11	Near the Iron pedestrian bridge (No.11)	No. 11	No. 11	No. 11	No. 11
12	At the confluence of the ring road with the road leading to the exit of campus (No.12)	---	---	---	---

It is noted from Table No. 3 that areas 1,9,12 were not selected by all respondents, and the reasons for the non-selection are likely due to the lack of traffic density for pedestrians or car traffic in those areas, especially during the peak period, as for areas 2,7,8,10,11 were chosen by all respondents.

Table 4: Percentages of areas where traffic accidents are likely to occur according to questionnaire forms.
Source: Authors

No	Names and numbers of the specified areas	Percentages %	
		Model No. 1	Model No. 2
1	The confluence of the main axis of movement with the ring road (No.1)	0%	0%
2	Near Deanship of the Faculty of Science (No.2)	96.66%	90%
3	Near the Department of Electrical Engineering (No.3)	28.33%	45%
4	Near the Department of civil engineering (No.4)	26.66%	55%
5	Near the Faculty of Engineering al-Khwarizmi (No.5)	21.66%	0%
6	Near the Deanship of the Faculty of Engineering (No.6)	31.66%	0%
7	In front of Baghdad University Mall (No.7)	71.66%	60%
8	In front of the Faculty of Media (No.8)	70%	55%
9	The main access to the Electronic Computing Center of the University of Baghdad (No.9)	0%	0%
10	Near the Department of Astronomy and Space Sciences (No.10)	50%	45%
11	Near the Iron pedestrian bridge (No.11)	91.66%	80%
12	At the confluence of the ring road with the road leading to the exit of campus (No.12)	0%	0%

It is noted from Table No. 4 that areas 2,11,7,8 are the ones that represented the highest percentages and therefore can be considered areas where traffic accidents are likely to occur with high percentages, while areas 3,4,5,6,10 which represented the lowest percentages and therefore can be considered areas where traffic accidents are likely to occur with lower percentages.

B- Determining the causes of traffic accidents within the study area: the responses to Form No. 1 showed the identification of 7 causes of traffic accidents (Table 5), as shown in the Figure No. 11. The reasons 1,2,3,4,7 accounted for the higher rates of traffic accidents, and the reasons 5,6 accounted for the lower rates of traffic accidents (Table 6). The results of the questionnaire Form No. 2 also showed the identification of 5 causes of traffic accidents (Table 5), shown in (Figure 11). The reasons 1,2,4 accounted for the higher rates of traffic accidents, and the reasons 3,7 accounted for the lower rates of traffic accidents, the reasons 5,6 were not identified among the results of that form (Table 6).

Table 5: Determining the causes of traffic accidents according to the questionnaire forms.
Source: Authors

No.	Causes of traffic accidents	Choosing the causes of traffic accidents according to the questionnaire forms			
		Model No. 1		Model No. 2	
		students of the Faculty of Engineering	students of the Faculty of Science	employees of the construction& projects department	employees of the Security department
1	Lack of dedicated pedestrian crossing areas	✓	✓	✓	✓
2	Failure to comply with the speed limit	✓	✓	✓	✓
3	Sudden stop of public transport buses	✓	✓	✓	✓
4	The increase in the number of cars	✓	✓	✓	✓
5	Lack of separation between lanes and roads	✓	✓	×	×
6	The difference in the level of the road floor	✓	✓	×	×
7	Bad behavior of pedestrian traffic	✓	✓	✓	✓

It is noted from Table No. 5 that the reasons 5,6 were not selected by the respondents according to the questionnaire form No. 2, while the reasons 1,2,3,4,7 were selected by all respondents.

Table 6: Causes of traffic accidents as per the questionnaire forms.
Source: Authors

No.	Causes of traffic accidents	Percentages %	
		Model No. 1	Model No. 2
1	Lack of dedicated pedestrian crossing areas	86.66%	80%
2	Failure to comply with the speed limit	88.33%	65%
3	Sudden stop of public transport buses	70%	35%
4	The increase in the number of cars	76.66%	65%
5	Lack of separation between lanes and roads	66.66%	0%
6	The difference in the level of the road floor	40%	0%
7	Bad behavior of pedestrian traffic	78.33%	45%

It is noted from Table No. 6 that the causes 1,2,4,7 are the ones that represented the highest percentages and therefore can be considered the main causes of traffic accidents, as for the causes 3,5,6 which represented the lowest percentages and therefore can be considered secondary causes of traffic accidents.

C- Identification of procedures to reduce traffic accidents and ensure pedestrian safety: the responses for the Form No. 1 showed the identification of 10 treatments to reduce traffic accidents (Table 7), they are shown in the Figure 12. The treatments 1,2,4,8,9 represented the highest rates to reduce traffic accidents, and the treatments 3,5,6,7,10 represented the lowest rates to reduce traffic accidents (Table 8). The responses to the Form No. 2 also showed 8 treatments to reduce traffic accidents (Table 7), they are shown in the Figure No. 12. The treatments 1,2,7,8,9,10 represented the highest rates to reduce traffic accidents, and the treatments 4,5 represented the lowest rates to reduce traffic accidents (Table 8). The responses also showed the most prominent traffic accidents such as a motorcycle collision with a truck on the ring road Near the Department of civil engineering, which led to the death of the owner of the bike in 2019, a run-over accident in front of the Deanship of the Faculty of science which led to serious injuries to one of the students in 2022.

Table 7: The treatments to reduce the traffic accidents as per the questionnaire responses.
Source: Authors

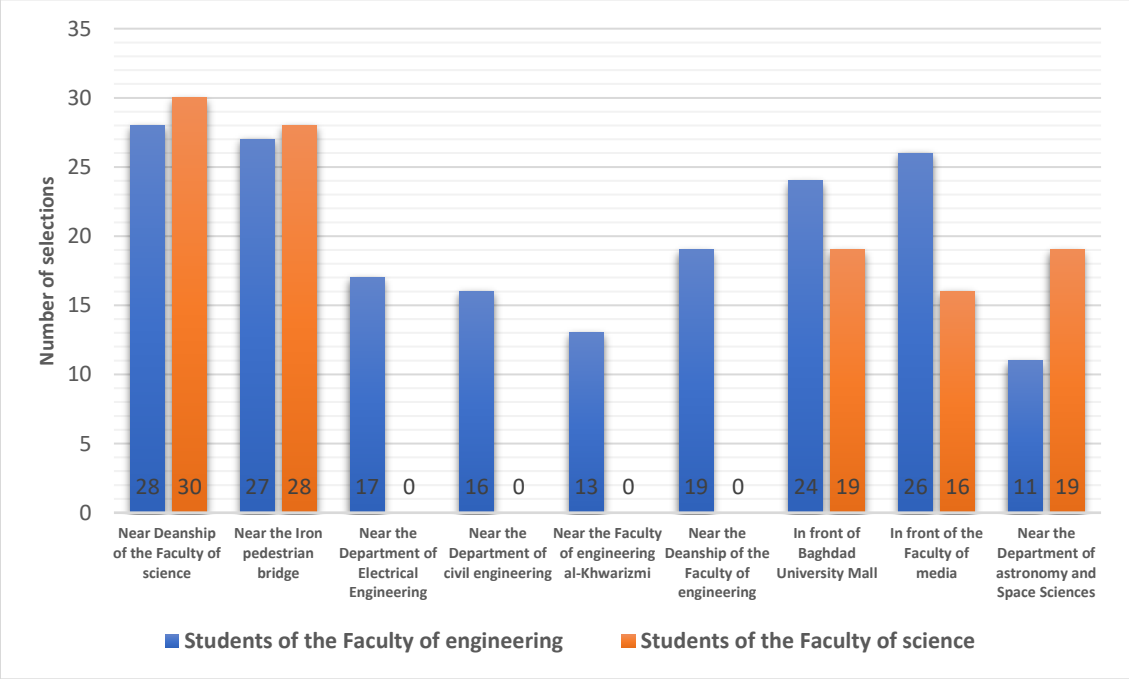
No.	Treatments	Choosing the treatments to reduce the occurrence of traffic accidents according to the questionnaire forms			
		Model No. 1		Model No. 2	
		students of the Faculty of Engineering	students of the Faculty of Science	employees of the construction& projects department	employees of the Security department
1	Allocate pedestrian crossing zones	✓	✓	✓	✓
2	Construction of suspended pedestrian crossing corridors	✓	✓	✓	✓
3	Using street narrowing technology	✓	✓	×	×
4	Installing speed relief cams	✓	✓	✓	✓
5	Activating the traffic signs and signals system	✓	✓	✓	✓
6	Securing the separation distance between lanes and roads	✓	✓	×	×
7	Construction of a security fence at elevated roads	✓	✓	✓	✓
8	Good design of public transport bus parking areas	✓	✓	✓	✓
9	Reduce car usage	✓	✓	✓	✓
10	Pedestrian safety promotion education	✓	✓	✓	✓

It is noted from Table No. 7 that 3,6 treatments were not selected by the respondents according to questionnaire form No. 2, while the reasons 1,2,4,5,7,8 were selected by all the respondents.

Table 8: The treatments to reduce the traffic accidents as per the questionnaire forms.
Source: Authors

No.	Treatments	Percentages %	
		Model No. 1	Model No. 2
1	Allocate pedestrian crossing zones	86.66%	85%
2	Construction of suspended pedestrian crossing corridors	90%	95%
3	Using street narrowing technology	55%	0%
4	Installing speed relief cams	81.66%	50%
5	Activating the traffic signs and signals system	53.33%	40%
6	Securing the separation distance between lanes and roads	43.33%	0%
7	Construction of a security fence at elevated roads	60%	75%
8	Good design of public transport bus parking areas	88.33%	60%
9	Reduce car usage	76.66%	65%
10	Pedestrian safety promotion education	66.66%	75%

It is noted from Table No. 8 that treatments 1,2,4,7,8,9,10 are the ones that represented the highest ratios and therefore can be considered as the main treatments to reduce traffic accidents, while treatments 3,5,6 which represented the lowest ratios can be considered secondary treatments to reduce traffic accidents.



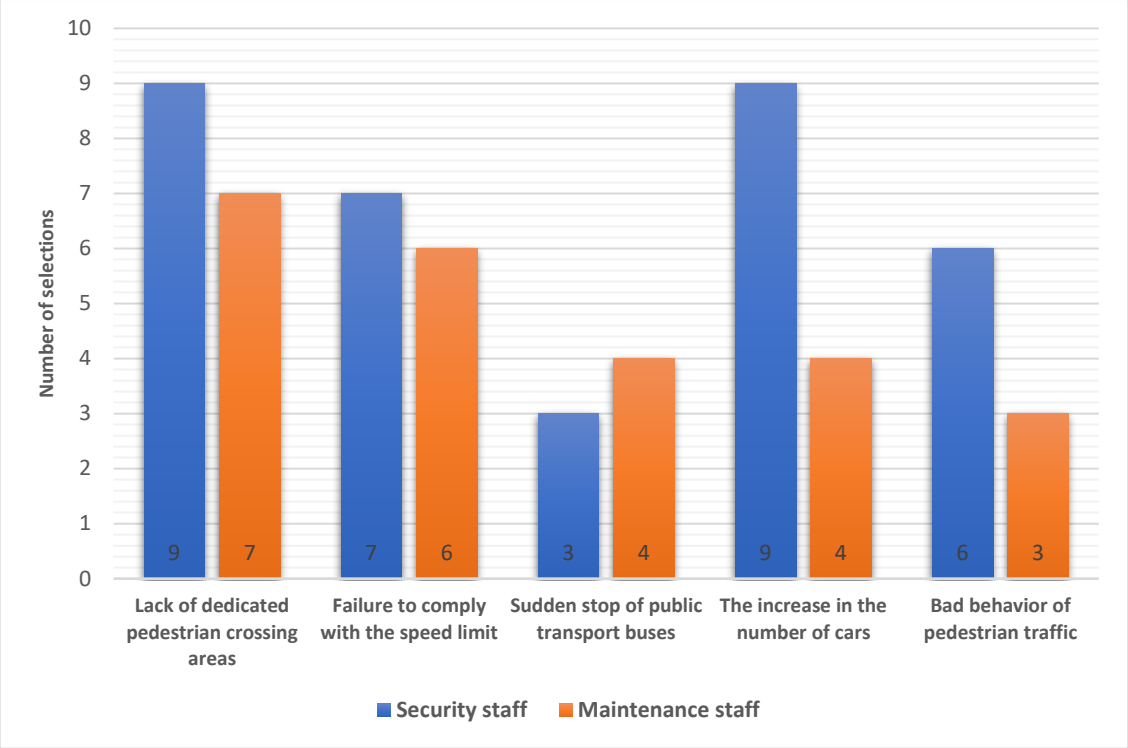


Fig. 10: Areas of traffic accidents: Responses to forms No. 1 and 2).
Source: Authors

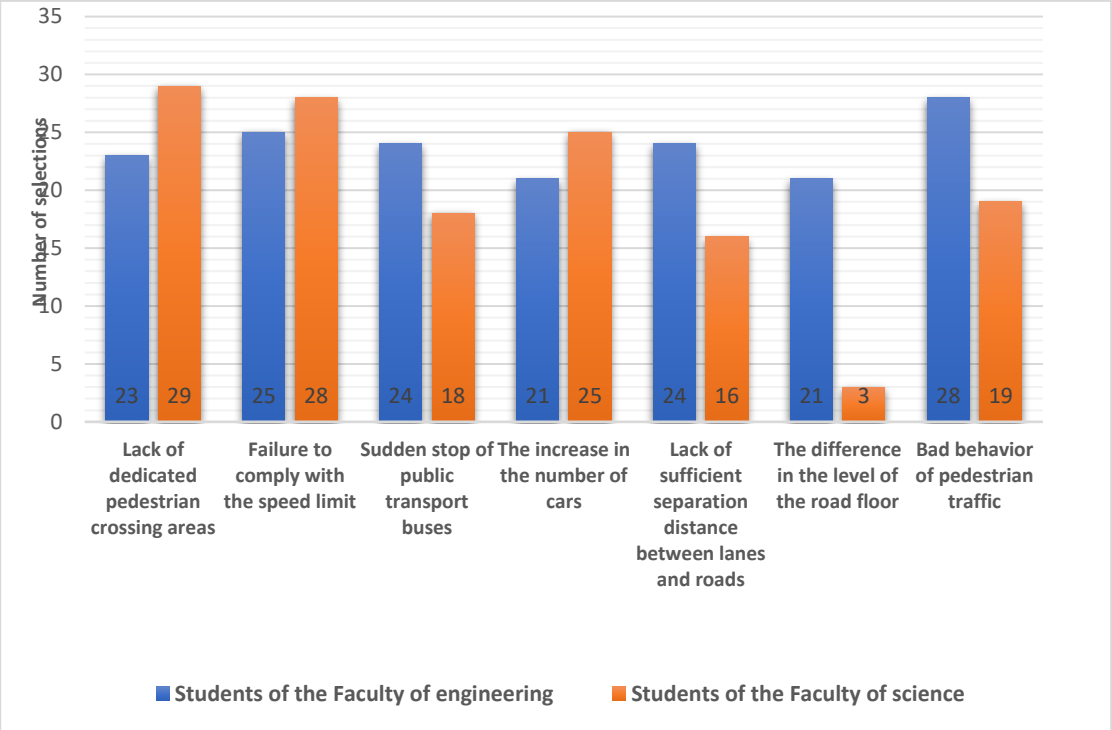


Fig. 11: Causes of traffic accidents according to the responses to forms No. 1 and 2.
Source: Authors

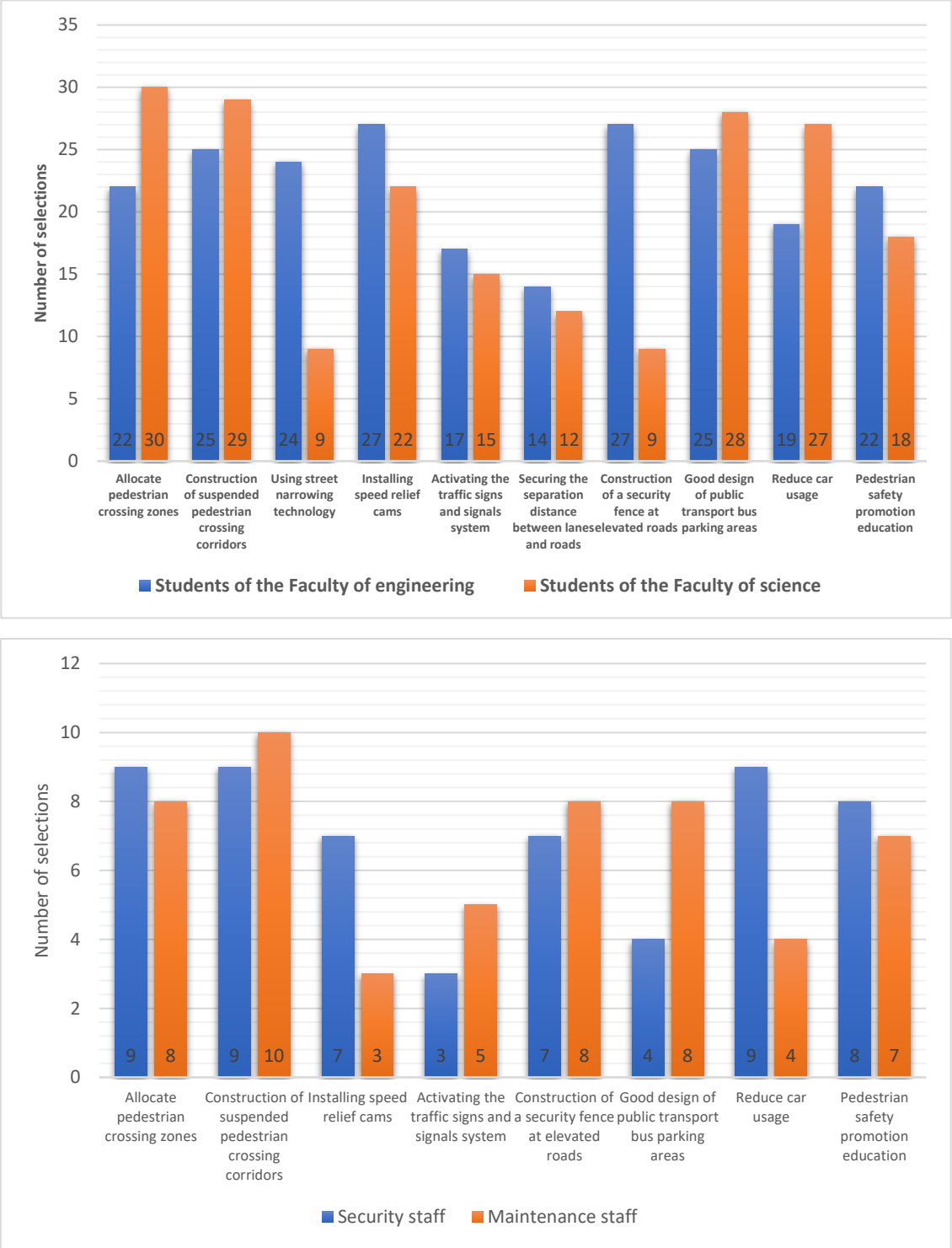


Fig. 12: Procedures to reduce traffic accidents: responses to forms No. 1 and 2.
Source: Authors

Analysis of diagrams according to the Space Syntax program

A - identification of areas where traffic accidents are likely to occur within the study area: when analyzing the current status prepared by the researcher through the field survey of the study area, it shows the axes of movement represented by pedestrian corridors and automobile roads through the Space Syntax program via the Global Integration Index. The total integration of movement within the external spaces surrounding the study area and the surrounding ring road (Fig. 13). The high Integration Index represented in red shows the areas experiencing high pedestrian and automobile traffic intensity. Other colors show the intersection between pedestrians and vehicular traffic through which traffic accidents are likely to occur. On the contrary, the low integration represented by the blue color shows the areas experiencing low pedestrian and car traffic density. There, it was noted that the areas represented by high integration match the areas identified through visual observation, which witness high traffic density by pedestrians and cars.

Fig. 13: Intersection areas between pedestrians and vehicular traffic where traffic accidents are likely to occur according to the Space Syntax program.
Source: Authors

Conclusion

It is no great secret that enhancing the safety of pedestrians towards traffic accidents inside the university campus requires separating pedestrian traffic from vehicular traffic. It will reduce the intersection areas between them, thus reducing traffic accidents and the resulting human and material losses. The study concludes the following:

1- **Identification of areas where traffic accidents are likely to occur :**
Through visual observation, field survey, the responses to the questionnaire forms, and the analysis of the schemes according to the Space Syntax program, the areas that witness a clear intersection between pedestrian and automobile traffic and where traffic accidents are likely to occur within the study area were identified as follows. High percentages of areas near Deanship of the Faculty of Science, In front of Baghdad University Mall, In front of the Faculty of Media, Near the Iron pedestrian bridge. And with low percentages of areas Near the Department of Electrical Engineering, Near the Department of civil engineering, Near the Faculty of Engineering al-Khwarizmi, Near the Deanship of the Faculty of Engineering, Near the Department of Astronomy and Space Sciences.

2- **The causes of traffic accidents:**
Through visual observation, field survey, and the responses to the questionnaire forms, the causes of traffic accidents were identified within the study area. Those which accounted for the highest percentages were: Lack of dedicated pedestrian crossing areas, Failure to comply with the speed limit, The increase in the number of cars, Bad behavior of pedestrian traffic. The reasons that formed the least appropriate are Sudden stop of public transport buses, Lack of separation between lanes and roads, The difference in the level of the road floor.

3- **The procedures followed to reduce traffic accidents:**
Through visual observation, field survey, and the responses to the questionnaire forms, the procedures used to reduce traffic accidents were identified within the study area. They were: allocate pedestrian crossing zones, construction of suspended pedestrian crossing corridors, installing speed relief cams, construction of a security fence at elevated roads, good design of public transport bus parking areas, reduce car usage, pedestrian safety promotion education. Those accounting for the highest rates of impact to reduce traffic accidents. And using street narrowing technology, activating the traffic signs and signals system, Securing the separation distance between lanes and roads, Those accounting for the lowest rates of impact to reduce traffic accidents.

4- It is thus concluded that while University of Baghdad is a pedestrian-focused campus, vehicular traffic and pedestrians can co-exist provided safety measures are adopted as follows:
* Reduce the use of cars on campus by following a number of policies, such as managing the demand for access permits, closing the campus to car use on specific days of each week during the semester period, or charging parking fees.
* Raising awareness of the motorists inside the university campus, the need to adhere to the speed limit, which does not exceed 40 km/h, with the need to reduce the speed to less than that, especially near areas designated for pedestrian crossings.

* The establishment of courses and educational programs on pedestrian traffic safety within the university campus by adhering to the areas designated for crossing and walking through the traffic lanes allocated to them and avoiding walking within the car routes or crossing those roads randomly.
* Organizing traffic signs within automobile roads and pedestrian traffic lanes, creating dedicated pedestrian crossing areas to avoid traffic accidents, and designing public transport bus stops in a way that does not affect the safety of its users or the smooth movement of cars.

In conclusion, it can be said that this paper has achieved its stated goal of providing information to enhance pedestrian safety against traffic accidents on campus by identifying the accident areas and what causes them and how to address or reduce those accidents. However, a number of difficulties were faced in preparing this paper, such as the lack of an approved database infrastructure of the intra-campus transport system. For all of the above, this paper can be the starting point for establishing a model that will help create a transport system that enhances the safety of pedestrian traffic within it.

References

Al-Alwan, H. & Al-Azzawi, A. (2014) ' Wayfinding performance in the built environment', *Emirates Journal for Engineering Research,* 19(2), 1-17.

Al-Alwan, H. (2020) 'Assessing the efficiency of sunscreens in University of Baghdad campus', *IOP Conf. Ser.: Mater. Sci. Eng. 745012179.*

Al-Alwan, H. et al. (2022) ' The potency of architectural probabilism in shaping cognitive environments: A psychophysical approach', *Ain Shams Engineering Journal,* 13(2022) 101522, Elsevier.

Al-Dulaimy, M. & Al- Alwan, H. (2011) ' Parameters of safe environment in high density residential complexes in city centers', *Engineering Journal, College of Engineering, University of Baghdad,* 17(3), 2011.

Balsas, C. (2003) 'Sustainable transportation planning on college campuses', *Transport* policy10, pp. 35-49.

Benekohal, R. et al. (2007) 'Crosswalk safety for UIUC campus: executive summary', *Published by traffic operation laboratory university of Illinois*.

Coulosn, J. et al. (2011) *Universities planning architecture: the search for perfection,* First published by Rutledge, USA.

Dobbs, G. (2009) 'Pedestrian and bicycle safety on a college campus: Crash and conflict analyses with recommended design alternatives for Clemson University', Clemson university pro quest dissertations publishing, 1464129.

Dober, R. (2000) *'Campus Landscape: function, forms, features'* , USA, John Wiley & Sons.

Herman, H. & Cynecki, M. (2000) 'Effects of traffic calming measures on pedestrian and motorist behavior', *Transportation research record,* 1705(1) pp. 26-31.

Medina, J. et al. (2007) 'Analysis of pedestrian and drivers' opinions on crosswalk safety at UIUC campus', *Vol.1: pedestrian and drivers, published by traffic operation laboratory university of Illinois at urban-champaign*.

Raheem, M. & Al-Alwan, H. (2013) 'The integration between university building sites and their landscapes', *Journal of Engineering Sciences, Association of Arab Universities,* 20(1), 1-29.

Rerat, P. (2021) 'A campus on the move: modal choices of students and staff at the university of Lausanne, Switzerland', *Transportation research interdisciplinary perspectives* Vol. 12, 100490.

Rodier, C. et al. (2003) 'Unsafe at any speed: what the literature says about low-speed modes.

Sanchez, R. et al, (2010) 'Integrating the transportation system with a university campus transportation master plan: a case study', *Texas transportation institute*.

Shaaban, K. & Kim, I. (2016) 'The influence of bus service satisfaction on university students mode choice', *Journal of advanced transportation*. incomplete

Shu, Z. & Wu, X. (2018) 'The route planning on campus bus in H university', *American journal of industrial and business management,* Vol.8, no.3, pp. 473-486.

Sisiopiku, V. & Akin, D. (2000) 'Assessment of pedestrian crossing options', *Michigan state university,* paper no.00-1494, Washington, d.c. incomplete

Taha, M. & Ali, H. (2021) 'Parking study at university of Mosul main campus', *AL-Rafidain engineering journal vol.2, no.2, pp. 104-117*.

Toole, J. & Zimny, B. (2009) 'Bicycle and pedestrian facilities chapter 16: transportation planning handbook', Federal highway administration, u s department of transportation.

Willims, K. et al. (2004) 'Model regulations and plan amendments for multi model transportation districts', *National center for transit research*.

Xu, J. (2012) 'The campus road planning and design research', *Procedia social and behavioral sciences* 43, pp. 579-586.

Zegeer, C. et al. (2002) 'Pedestrian facilities users guide-providing safety and mobility', *Diana publishing*.