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Efficiency of Pedestrian Bridges in Urban Area

كفاءة جسور المشاة في المناطق الحضرية

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KEY WORDS

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ABSTRACT

Pedestrian bridges are important, and they cannot be dispensed. They transport people from one sidewalk to another without obstructing the movement of vehicles and creating congestion, and they are conducive to individuals' lives. This research deals with pedestrian bridges in Baghdad and their use efficiency. So, the researchers did the monitoring and surveying of the site. The researchers also surveyed a random sample to find if they use pedestrian bridges near their work site or housing. Whether they use these pedestrian bridges or not. How do they evaluate the effectiveness of these bridges? If these pedestrian bridges need different types of Maintenance. What is the efficiency of use? As well as their suggestions for places that need pedestrian bridges. The research found a weakness in constructing these bridges and their efficiency. People have suggested bridges near educational land uses. The bridge near the University of Technology was considered a study area because it is one of the most widely used bridges, especially since it is close to the University of Technology and its location is above the expressway. The research concludes that the Technology pedestrian bridge is very high but has great benefits, and people need to cross the highway safely and smoothly. The research recommended a set of suggestions presented by the participants, such as surveillance cameras, electric bridge building, and many other suggestions.

الكلمات المفتاحية

كفاءة ، جسور المشاة، المنطقة الحضرية، الجامعة التكنولوجية.

الملخص

تعتبر جسور المشاة ذات أهمية، ولا يمكن الاستغناء عنها، فهي تنقل الأشخاص من رصيف إلى آخر دون إعاقة حركة المركبات وتسبب الازدحام، كما أنها تساعد على حياة الأفراد. يتناول هذا البحث جسور المشاة في مدينة بغداد وكفاءة استخدامها. لذلك قام الباحثون برصد ومسح الموقع. وكذلك قام الباحثون باستطلاع عينة عشوائية لمعرفة ما إذا كانوا يستخدمون جسور المشاة القريبة من موقع عملهم أو سكنهم. كيف يقيمون فعالية هذه الجسور؟ إذا كانت جسور المشاة هذه بحاجة إلى صيانة. ما هي كفاءة الاستخدام؟ وكذلك اقتراحاتهم للأماكن التي تحتاج لجسور للمشاة. وقد توصلت إلى وجود ضعف في صيانة هذه الجسور وكفاءتها. واقترح الناس إقامة جسور بالقرب من استخدامات الأراضي التعليمية. واعتبر الجسر القريب من الجامعة التكنولوجية منطقة دراسة لأنه من أكثر الجسور استخداماً، خاصة أنه قريب من الجامعة التكنولوجية وموقعه يقع فوق الطريق السريع. ويجد البحث إلى أن جسر المشاة المحاذي للجامعة التكنولوجية مرتفع جداً ولكن ذو فائدة كبيرة، وضروري لعبور الطريق السريع بأمان وسلاسة. وأوصى البحث بمجموعة من المقترحات التي قدمها المشاركون مثل كاميرات المراقبة، إنشاء الجسور الكهربائية، وغيرها من المقترحات.

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1. Introduction

A pedestrian Bridge (or footbridge) is designed solely for pedestrians. While a bridge's fundamental definition is a building that connects "two places at a height above the ground," a pedestrian bridge can also refer to a lower building, like a boardwalk, that lets people travel across damp, delicate, or marshy terrain. (Oxford English Dictionary) Stepping stones, probably Bridges, can be anything from elaborate steel constructions to the first artificial structure to "bridge" water. Another early bridge would have been a straightforward tree that had fallen. Sometimes, a pedestrian bridge will serve both functional and aesthetic reasons. Skyways are a type of enclosed pedestrian bridge that connects two buildings. Green bridges accommodate pedestrians and cycling and are crucial to a sustainable transportation system.

In places without nearby highways, pedestrian bridges are frequently placed to allow pedestrians to cross water or trains. Additionally, they are placed across streets so pedestrians can cross securely without impeding vehicles. Examples of the latter, such as pedestrian separation construction, can be seen particularly close to schools.

Because of its shape and weight, the pedestrian bridge has the opportunity for imaginative design with the aid of Space Frame. It can function as an urban symbol and have a distinctive form. Also, the area on the bridge can be used as a location for leisure, tourism, and cultural activities. A well-designed -area will improve the aesthetics and readability of these bridges and motivate onlookers.

One of the oldest pedestrian bridges in Baghdad city is the intersection of Bab Al-Moazem / Al-Jumhuriya Square, See Figure (1). there are pedestrian bridges that existed in Baghdad city before (2003). A total of these bridges are (24) bridges. "The number is small, especially since most of them have stopped working on them due to extinction due to the long past period, as well as their design according to traffic regulations and studies that differ from the current vision." (Baghdad Municipality)

Some existing bridges need to be re-maintained, and areas in Baghdad that need new bridges for highways and main streets need to be developed and expanded, especially as they contain a large population density with commercial centres, universities, and markets.

Goals And Objectives: The research aims to evaluate and assess the state of the pedestrian bridges in Baghdad city through the residents' questionnaire, which identifies the different areas of Baghdad's pedestrian bridges and their advantages and disadvantages. The research also aims to evaluate the efficiency of pedestrian bridges near the University of Technology practically. See Figures (2), (3), (4), and (5).



Figure 1. Pedestrian crossing Bridge in Baghdad (Bab Al-Mueazam) in the eighties, Source: (Mudawanat Bilad Alraafidayn, 2012).



Figure 2. An electric staircase for a pedestrian bridge in Baghdad city – Allawi / Museum Square in the nineties, Source: (BlogSpot, 2016).



Figure 3. A new pedestrian bridge on Attaba bin Ghazwan Road, Source: (Mawazin News, 2022).



Figure 4. Rehabilitation and maintenance of pedestrian bridge in Palestine Street, Source: (Al-Eshraqtv TV, 2020).



Figure 5. Rehabilitation and maintenance of pedestrian bridge in Palestine Street, Source: (Al-Eshraqtv TV, 2020).

2. Literature Review

Road crossings are considered an inevitable aspect of walking where pedestrians' preferred routes come into contact with vehicles. Walkers may experience dangers or delays as a result of these interactions. Pedestrian fatalities are relatively common, according to statistics on traffic accidents. One of the key factors causing this scenario is the inappropriate gap acceptance when people cross highways. (Al Bargi - et al, 2017)

Since most people use pedestrian paths at some point each day, an essential form of transportation, pedestrian safety should be considered. As (Xu J. -et al., 2018), the purpose of their study was to examine the connections between pedestrian behaviour, the traffic safety environment, and the inconveniences that pedestrians.

As (Barry, 2018), Pedestrian Bridges allow "slower" mobility and provide specific spaces for travelling through urban regions in a particular way while also allowing for distinct sense, feeling, and mobility. With the effort of walking, the bridge structure sways and oscillates, transforming it into a place of encounter. It is possible to examine the human scale in connection to nature and culture.

The design of pedestrian bridges often adheres to the same guidelines as other bridge designs. However, they are often much lighter than automobile bridges, making them more vibration-resistant. Hence, dynamic effects are frequently given greater consideration in design. (Bennett, D. 2000)

Nowadays, as required by applicable law (such as the UK's Disability Discrimination Act 1995), considerable consideration is also given to the provision of access lifts or ramps to guarantee that pedestrian bridges are accessible to disabled and other mobility-impaired people. Stairlifts have been installed to make it easier for those with disabilities to cross some older bridges in Venice.

The short-distance, residential-scale pedestrian bridges can be utilized for various purposes. The pedestrian bridges do not require complex engineering, and they are constructed using materials that are easily accessible and simple tools. (Jeswald, P., 2005), (Wahab, S. N. -et al, 2021)

Different types of designed pedestrian bridges include:

- Timber pedestrian bridges.
- Steel pedestrian bridges.
- Concrete pedestrian bridge.

In particular, suspension and beam bridges can be constructed in the same manner as road or rail bridges. Some old road bridges became pedestrian when traffic was moved to other crossings. In the UK, examples include The Iron Bridge at Iron Bridge, Shropshire, The Old Bridge in Pontypridd, and the Windsor Bridge in Windsor, Berkshire.

Guard rails are typically on pedestrian bridges to lessen the possibility of walkers' falls. They may also have a fence or other barrier crossing busy roads or railroads to prevent pedestrians from jumping over them.

A pedestrian overhead bridge is designed to keep pedestrians away from busy roadways while reducing accident rates. According to (Rizati et al., 2013), using pedestrian bridges will maintain traffic flow on the roadways and keep all road users in a safer environment, See Figure (6).



Figure 6. A pedestrian bridge in Abu Dhabi city, Source: (Youmone, 2022).

A pedestrian bridge must have improved accessibility to its location and be highly functional. By giving pedestrians a safer means to cross, constructing a pedestrian bridge in an urban area lowers accident rates and traffic congestion (Rizati et al., 2013). As part of the pedestrian roads, the pedestrian bridge must be characterized by providing security for pedestrians, amenities, and lighting at night to be effective areas (Hassan, R. H., et al., 2021).

Overpasses for pedestrians over roads or trains are expensive, particularly when long ramps or elevators are needed for wheelchair users. People with mobility issues cannot use the building without elevators or ramps. People may prefer to cross a busy road on foot rather than ascend a bridge, which may be explained by their impatience and their perception that the pedestrian bridge offers little in the way of safety and security (Oviedo-Trespalacios, O. et al., 2017) or simply because of feeling tiredness when climbing the stairs (Hasan, R. et al., 2020). It is recommended that overpasses should only be used where the number of users justifies the costs. (Pedestrian Overpasses/Underpasses". Pedestrian Bicycle Information Center). The operational concept of the pedestrian bridge is based on the notion that pedestrians need to walk a longer distance and exert more physical effort so that the traffic flow is not interrupted. This is not in line with the sustainability goals of the transport system promoting active travel such as walking and cycling. A policy change to increase safety and walkability could involve transferring that effort of crossing the road to drivers who will need to wait longer so pedestrians can cross the road safely at street level (Hasan R. et al., 2020).

As Kawther K. k. et al. (2020), "Special paving at intersections and on pedestrian refuges makes crossing more comfortable; special paving can define any zone" Therefore, it is important to consider the paving of the bridge floor (Kawther k. k. et al., 2020).

2.1. Materials of Pedestrian Bridges

All materials and tests must adhere to the appropriate standards specified in the AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing or the standards of the American Society for Testing and Materials, per the AASHTO LRFD Bridge Construction Specifications.

- Masonry (brick, rock) bridges.
- Timber bridges: Nominal resistance for wood products shall be based on specified size and conditions of use concerning moisture content and time effect.
- Reinforced concrete (RC) bridges: Designs should consider the material qualities listed here and the usage of materials that adhere to the specifications for the grades of building materials as described in AASHTO LRFD Bridge Building Specifications.
- Pre-stressed concrete (PC) bridges.
- Iron bridges.
- Steel bridges: Structural steels shall conform to the requirements, and the design shall be based on the minimum properties indicated.
- Aluminum bridges - Composites bridges - Plastics bridges.

2.2. Loads of pedestrian bridges

Pedestrians and cycling loads are frequently treated as a single entity. Due to its more mobile and compact character, pedestrian loading predominates; it comes in various forms. The static loading brought on by a specific pedestrian density is well recognized. The loads on the handrails are visible; less obvious loads come from a single person. A vandal or vandal group could put unexpected loads on the structure and harm it. Due to the flexibility of pedestrian bridges, a bridge vibration caused by a single person crossing it or by some individuals intentionally engaging in activity must also be considered. It can be uncomfortable for some community members when vibration occurs in vertical or horizontal directions; thus, it must be avoided.

Consideration must be given to the likely usage of a pedestrian bridge and its maintenance. If a pedestrian bridge is in a remote site, e.g. a park, it is unlikely to suffer loading from a crowd of people. However, it may be used by a vehicle maintaining a park to access all park areas. Either this must be considered in the design, or special steps must be taken to prevent vehicle use of the pedestrian bridge. In the case of a major, large-span pedestrian bridge crossing a river in a central city area, higher usage of the bridge should be expected. The bridge may be used for special events such as viewing fireworks or regattas

on a river. Maintenance of this type of bridge is also likely to be a major consideration as it is unlikely to be maintained by any means other than from the bridge itself.

AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, dated, contains requirements that must be followed while designing pedestrian bridges. The AASHTO Guide Specifications for LRFD Seismic Bridge Design must be followed while performing seismic design of pedestrian bridges. Dead Load, A: Dead loads are continuously applied to the structure (AASHTO-LRFD, 2010), as shown in Table (1).

Table 1. Base Pressure according to AASHTO LRFD (Source: Authors).

Super Structure Component	Windward load, ksf	Leeward load, ksf
Trusses, Columns And Arches	0.05	0.25
Beams	0.05	NA
Large Flat Surfaces	0.05	NA

2.3. Installation and Site Accessibility

The installation of truss bridges and boardwalk systems differs significantly, and these variances must be considered during the design stage. Truss bridges are frequently manufactured in a single huge piece and placed utilizing independently designed abutment foundations. Transporting the bridge to the site or bringing a big crane there to install and transport the bridge can be quite challenging in isolated areas, but installation can be quick. Some truss bridge designs can be transported in pieces to remote research locations and put together there before being installed. On the other side, precast abutments that are a part of the design are used to construct and install boardwalk systems. Even though installation would take longer, transferring parts to the (20) pedestrian bridge site might be simpler, especially in outlying places. Top-down construction can be done on sensitive research sites as well.

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2.4. Types of pedestrian bridges

A pedestrian bridge is frequently one of the development's most noticeable features, displaying the park or path and giving it a unique character. Consequently, it must be aware of the many forms of pedestrian bridges. Pedestrian bridges fall into four general categories:

- Truss: Almost any site can be used to construct this style of pedestrian bridge. They can be constructed with spans between (30) feet (10 meters) and 200 feet (67 meters). They can be constructed in any width and can be made to fit cars. They are generally made out of steel.

Pedestrian Truss Bridges are easy to install and state-of-the-art. Pedestrian Truss Bridges are simple to erect and need little upkeep. Reduced building costs and time follow. Pedestrian truss bridges are the best option for spanning slopes, rivers, train tracks, and roads. It is a park in a rural or urban area, a bustling freeway overpass, or both. Pedestrian bridges improve the environment and the aesthetics of the terrain. Pedestrian bridges come in a wide variety of styles, see Figure (7):

- Underhung Floor Beam.
- H-Section Floor Beam.
- Bowstring.
- Box.



Box-style bridge design



Bowstring bridge design



Underhung- bridge design

Figure 7. Pedestrian Truss Bridges types, Source: (Canada's Best Managed Companies, 2019).

- Girder (Beam): Most municipal and highway bridges are constructed with beams (girders) spanning the opening and a deck perpendicularly above it. The girders, which are located underneath the roadway, support the weight. The side railing serves only to keep traffic on the bridge; it is not a structural component. From a little creek bridge to a major highway bridge, this sort of pedestrian bridge can be constructed in any length, breadth, deck type, or material. A log used to span a creek is technically a girder. The quantity of girders, the width, the style of the deck, and the style of the railing are unrestricted. The only significant difference between the possibilities is cost, which can be easily built. See Figures (8), (9), (10).



Figure 8. Copr Bay Pedestrian Bridge, Swansea, Source: (Copr Bay, 2021).



Figure 9. Hams Way Pedestrian bridge, Source: (Hams Way, 2021).



Figure 10. Enclosure at Oldham Way Pedestrian bridge, Source: (Oldham, 2019).

- Arch: Bridges with arches can be very beautiful. They are cast-in-place foundations with corrugated steel or precast concrete plates and need high-quality backfill all around the building. This pedestrian bridge can have a decorative retaining wall, rock riprap, or simple grass on the outside face. Even though they are a great choice sometimes, arches are not always a viable alternative. The amount of gravel needed to fill in an arch may depend on the site's geometry. For passersby, it might also be an extremely long, dim building.
- Long span: Long span is the last form of a pedestrian bridge, and it includes several different bridge types exclusive to big, long bridges. This group comprises cable-stayed bridges. Suspension bridges (26) are beautiful and provide a lasting structure, but they are also very expensive. These bridges must be designed years in advance and need substantial design and construction resources.

3. Practical Study

- In order to conduct the questionnaire the questionnaire was conducted through the Google Class platform, and the questionnaire link was published on several social media sites, such as the Telegram app.
- For the Pedestrian bridge to the University of Technology, the calculation of the number of people was done manually, so the wait was carried out at the beginning of the bridge from the side of the university, and the number of people was counted from the period (7.00 am-4.00 pm).

3.1. Study Area: University Technological Pedestrian Bridge

It is a bridge located towards the back door of the University of Technology, which overlooks the main street connecting Bab Al-Sharqi and Baghdad Al-Jadida. The main purpose of the pedestrian bridge is for students to cross from the University of Technology to the opposite side of Muhammad Al-Qasim Street, see Figures (11), (12), (13), (14).



Figure 11. University technological pedestrian bridge, Coordinate 33.3127163, 44.4517706. Source: (Google Earth)



Figure 12. Al Ghadeer - Maysaloon pedestrian bridge, Source: (Google Earth).



Figure 13. The pedestrian bridge on Muhammad Al-Qasim Road near the University of Technology (Source: Authors).



Figure 14. Al Ghadeer Maysaloon pedestrian bridge (Source: Authors).

3.2. Conducting a Questionnaire on Pedestrian Bridges

A questionnaire will be given on the pedestrian bridges. People will be asked questions related to pedestrian bridges according to the type of region, the nature of the individual and his gender, and age, and the focus will be on a set of solutions that the voters propose on the questionnaire.

4. Results & Discussion

The most prominent results from the University of Technology pedestrian bridge survey, will be included in the general questionnaire for pedestrian bridges in Baghdad. This research revolves around pedestrian bridges and the extent to which they are used by people and those who use them. Therefore, a questionnaire was conducted on the topic of pedestrian bridges, and a study area is a bridge located towards the back door of the University of Technology (Bab Al-Saaea), which overlooks the main street connecting Bab Al-Sharqi and New Baghdad. The main purpose of the pedestrian bridge is for students to cross to and

from the University of Technology to the opposite bank of the main street. The number of people who crossed the University of Technology pedestrian bridge has been collected, as shown in Table (2).

Table 2. People crossed the Pedestrian bridges of University of Technology (Source: Authors).

Time	7:00-7:30	7:30-8:00	8:00-8:30	8:30-9:00	9:00-9:30	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00
People	84	283	394	223	125	107	86	71	77	123	189	96	113	154	476	198	43	48

Table (2) represents the number of individuals who crossed the pedestrian bridge from seven in the morning until four in the afternoon. It was found that the highest number of individuals (479) during the period (2.00-2.30 pm) and the lowest number of individuals (43) at the period (3.00-3.30 pm). See Figures (15), (16), (17).

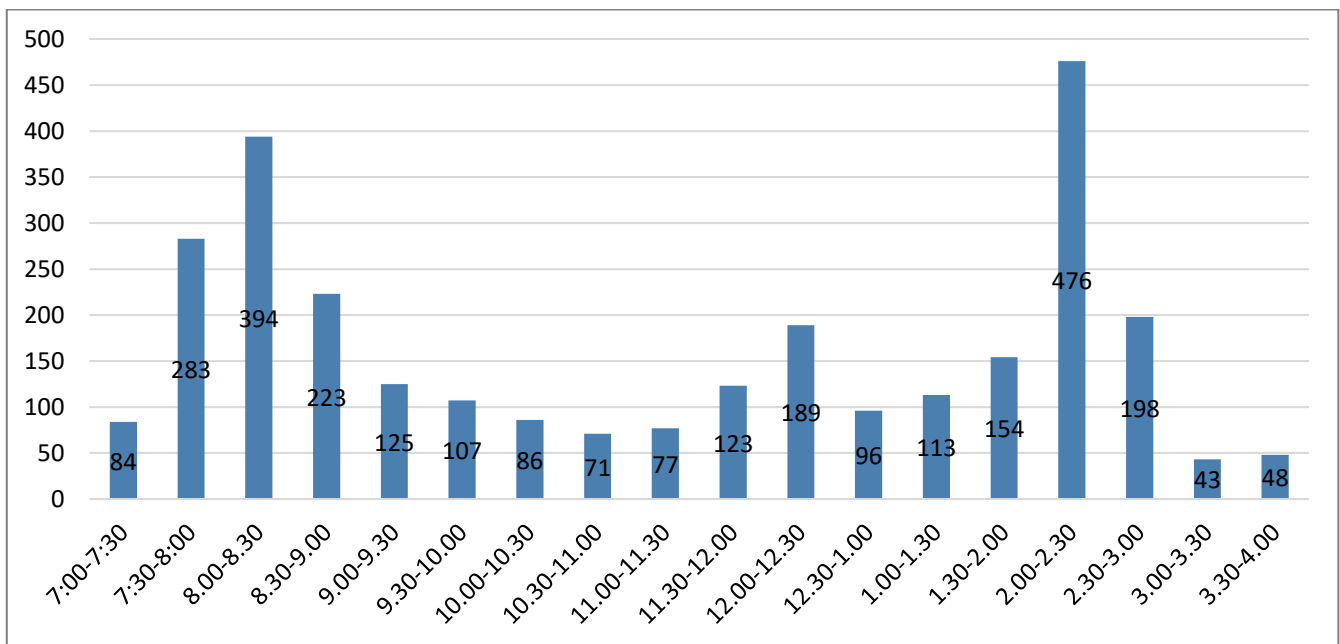


Figure 15. The (30) min flow of people crossing the Pedestrian Bridge at University of Technology (Source: Authors).



Figure 16. The Stair of Pedestrian Bridges of University of Technology, (Source: Authors).



Figure 17: Pedestrian bridges of the University of Technology, worn out floor pavement (Source: Authors).

The results of the poll will be summarized in the following tables.

- As for the gender of the participants, it will be clarified as the gender of the percentage was (51.32%) for females and (48.67%) for males, see Figure (18).

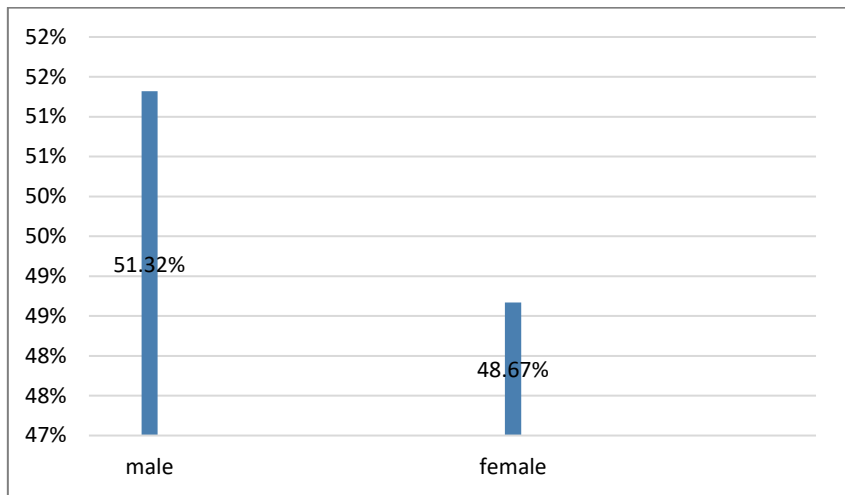


Figure 18. Gender of the participants (Source: Authors).

- As for the age of the participants, the gender of the percentage was (21%) for (11-20) and (67%) for (21-30) and (7%) for (31-40) and (3%) for (41-50) and (1%) for (51-60) and (0.66%) for (61-70), see Figure (19).

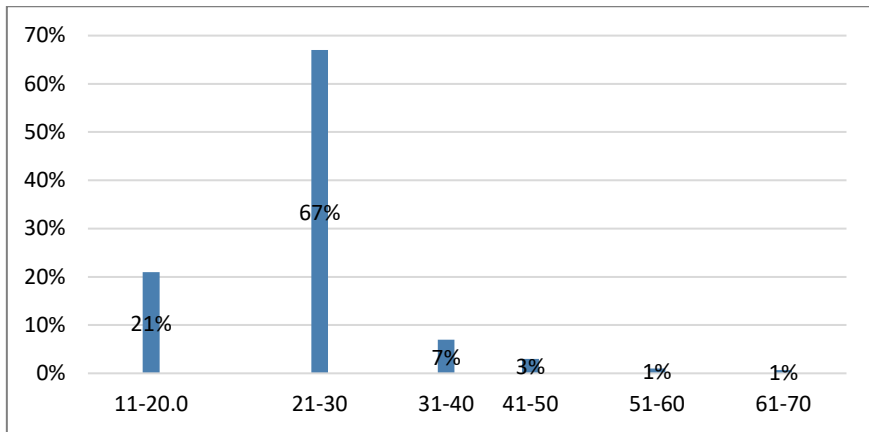


Figure 19. Age of the participants (Source: Authors).

- As for the workplace of the participants, the percentage was (19.86%) for (nonworkers) and (24.17%) for (UOT) and (13.5%) for (Baghdad) and (5.29%) for (karada) and (8.9%) for (oil ministry) and (28.14%) for (student), see Figure (20).

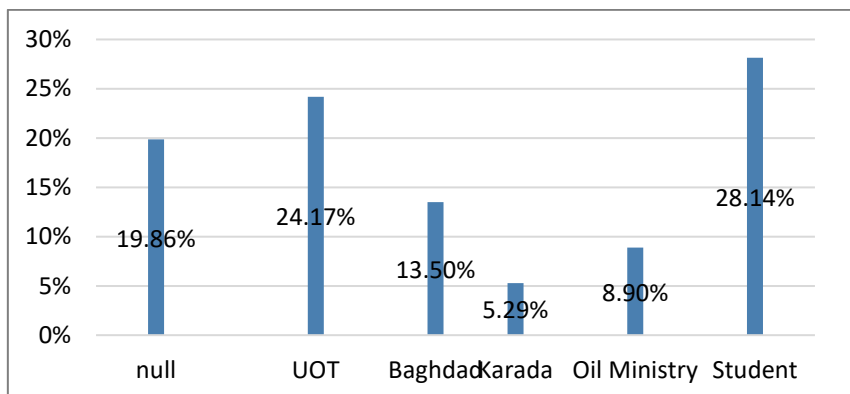


Figure 1: Workplace of the participants (Source: Authors).

- Academic achievement of the participants, the percentage was (24.5%) for (secondary) and (39.4%) for (bachelor) and (2.3%) for (PhD) and (6.6%) for (master) and (4%) for (diploma) and (23.10%) for (student), see Figure (21).

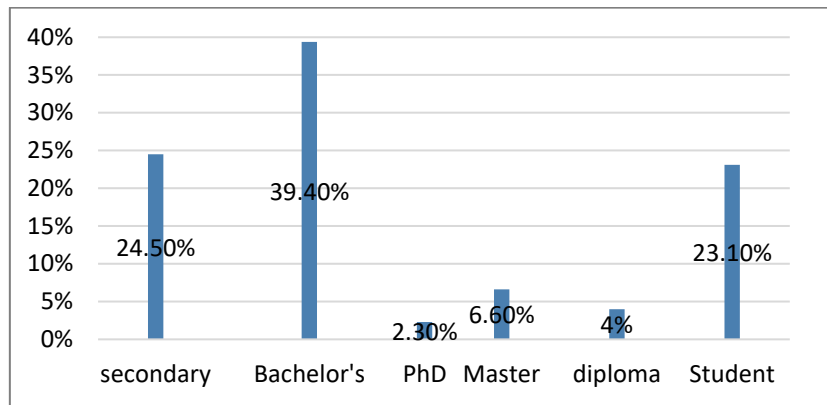


Figure 2. Academic achievement of the participants (Source: Authors).

- The participants were asked if there was a pedestrian bridge near the place of residence; the percentage was (57.28%) for (yes) and (42.72%) for (no), see Figure (22).

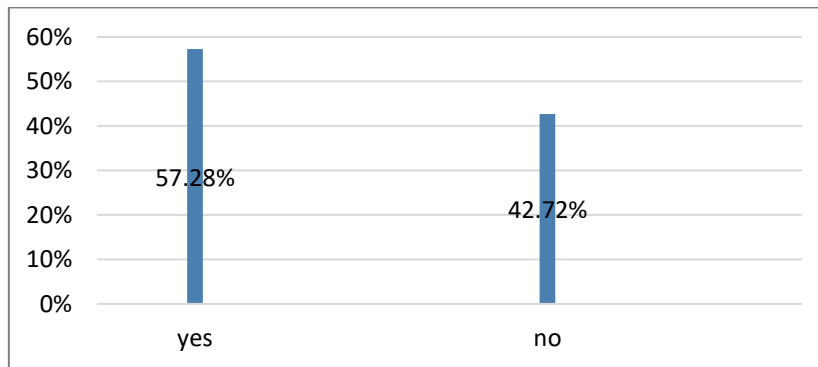


Figure 3. pedestrian Bridge near the place of residence of participants (Source: Authors).

- The participants were asked if they use a pedestrian bridge while going to work, a market and a school; the percentage was (74.8%) for (yes) and (25.16%) for (no), see Figure (23).

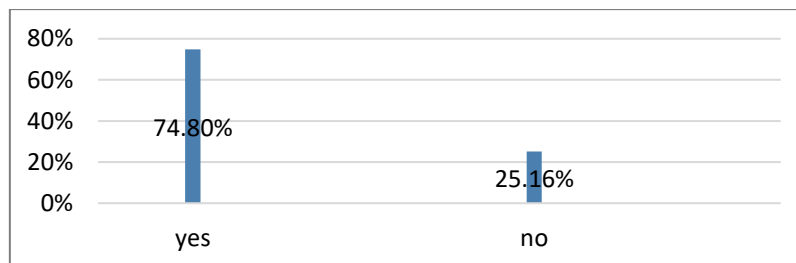


Figure 4. Participants were asked if they use a pedestrian bridge while going to work, a market and a school (Source: Authors).

- The participants were asked if they use a pedestrian bridge; the percentage was (9.6%) (while going to the market) and (16.88%) for (while going to work) and (55.29%) for (while going to study) and (18.54%) (do not use it), see Figure (24).

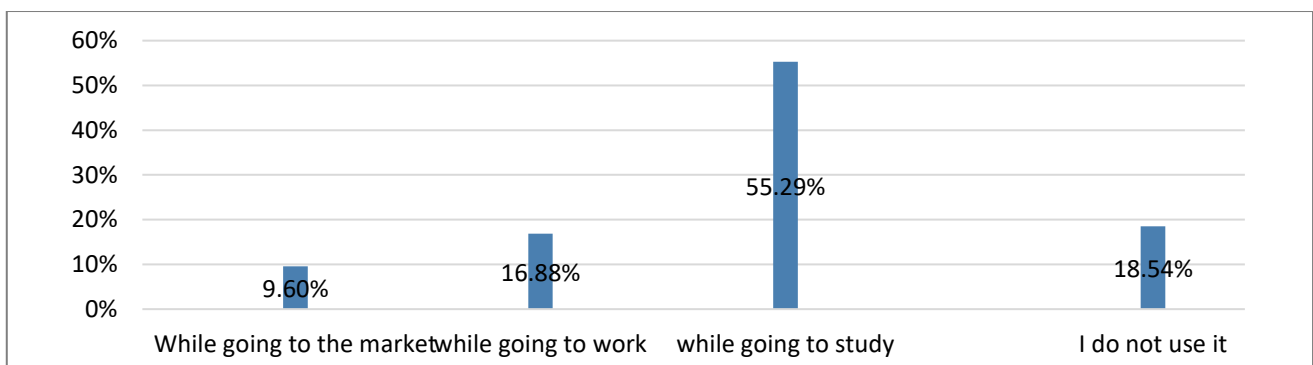


Figure 5. The participants were asked if they use a pedestrian bridge (Source: Authors).

- The participants were asked if they considered the pedestrian bridge that they were using as safe. The percentage was (79.13%) for (yes) and (20.86%) for (no), see Figure (25).

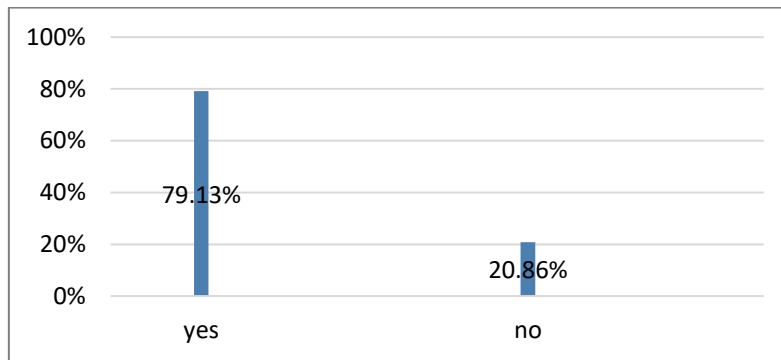


Figure 6. The participants were asked if they considered the pedestrian bridge they were using safe (Source: Authors).

- The participants were asked for their opinions on whether bridges lack Maintenance; the percentage was (93.04%) for (yes) and (6.95%) for (no), see Figure (26).

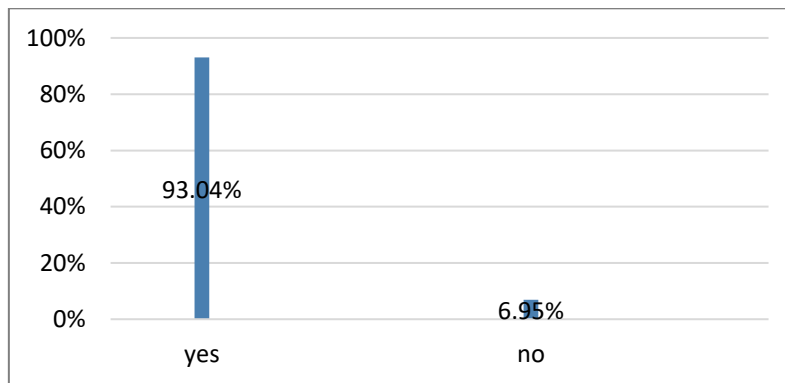


Figure 7. The participants were asked their opinion on whether the bridges lack maintenance (Source: Authors).

- The participants were asked: What places do bridges need to be built? They are crowded areas, and the crossing is unsafe.
- The percentage was (48%) for (highways) and (26%) for (near universities) and (17.88%) for (near schools) and (7.61%) for (near intersections), see Figure (27).

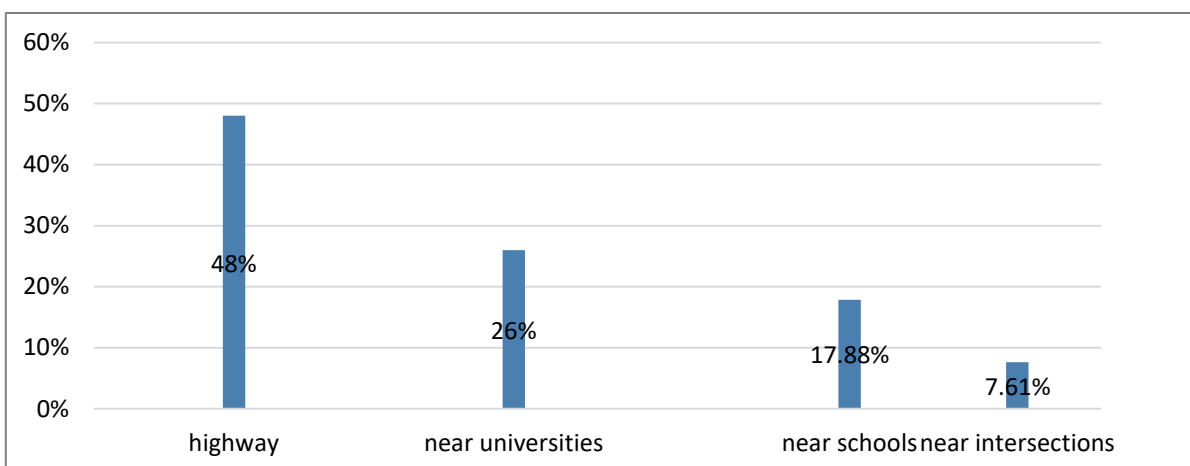


Figure 8. The most important places where pedestrian bridges should be built are as follows (Source: Authors).

- The participants were asked if there was enough lighting at night... on a bridge...; the percentage was (4%) for (yes) and (96%) for (no), see Figure (28).

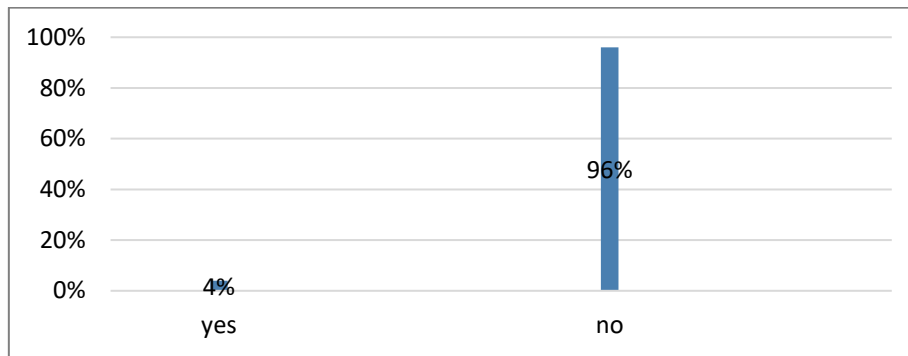


Figure 9. The participants were asked if there are lighting facilities at night on the pedestrian bridge (Source: Authors).

Observing the bridge did not have an architectural or aesthetic design, nor did it have surveillance cameras; with a lot of hanging advertisements, as well as the lighting of the bridge; the lights of the bridge were dim and affected the movement of vehicles under it. As for the bridge floor pavement, it was worn out and destroyed and needed great care.

5. Conclusion and Recommendation

- The role of Space Frame structures in distinguishing pedestrian bridges and creating a beautiful symbol for them in urban space is significant.
- The University of Technology pedestrian bridge is highly leveraged and of great benefit, and people need to cross the highway safely and smoothly.
- From observing the pedestrian bridge of the University of Technology, the research found that the bridge needs Maintenance. The floor pavement of the pedestrian bridge suffered from problems and damages, and the pedestrian bridge does not have an electric elevator for the elderly and people with disabilities. Moreover, it does not have surveillance cameras.

Set of suggestions were presented by the participants and are explained below:

- Surveillance cameras should be placed over the pedestrian crossing
- Establishing electric bridges to assist the elderly in using them
- Bridges must be maintained regularly.
- Very few bridges. Some highways have no bridges.
- Beautiful architectural designs should be made for pedestrian bridges because pedestrian bridges in Baghdad lack an architectural touch.
- Reconstruct all pedestrian bridges in Baghdad city.
- The use of electric elevators in addition to pedestrian bridges to help the elderly, the sick and children
- Make sure that the bridge is durable
- Pedestrian bridges need night lighting
- There must be accuracy and good quality in the construction of pedestrian bridges because they are considered very important in the design of roads.
- Suggest the presence of a high friction floor to prevent slipping or being pushed by the high winds.

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