A Special Refereed Issue (Volume 19) – Selected articles from the International Engineering Technologies and Applied Sciences Conference and Exhibition, Baghdad, Iraq, 2024

https://doi.org/10.14525/JJCE.v19i5.10

Jordan Journal of Civil Engineering

Journal homepage: https://jjce.just.edu.jo

A Microscopic Analysis of Parking Problems in Baghdad City with the Aid of VISSIM

Ansam Majid Khamis [1]*, Ali Majeed Khudayer Al-Dahawi [2], Mohanned Qahtan Waheed [3]

[1] Department of Civil Engineering, University of Technology, Baghdad, Iraq.
** Corresponding Author. Email:bce.21.33.grad.uotechnology.edu.iq.*
2) Professor, Department of Civil Engineering, University of Technology, Baghdad, Iraq.
3) Assistant Professor, Department of Civil Engineering, University of Technology, Baghdad, Iraq.

Pages: 104 - 113

Published: August, 2025

ABSTRACT

Parking is a major concern in business districts, such as Baghdad, one of the world's largest and most populous cities. The purpose of this study is to examine parking lots to identify the existing parking issues and provide an overall solution. The study includes a survey of two parking lots, the Dream City Mall parking lot and the University of Technology parking lot, to gather information and incorporate the collected data into VISSIM, a microscopic simulation tool. Input data includes traffic data, data about the studied park, and data about the efficiency of the park. Results for Dream City Mall parking lot indicate that the maximum delay on gate is 6.5 minutes, and the maximum queue length is 18 vehicles because of congestion and high traffic volumes. The parking lot has about 45% empty spaces at 5 pm. For the University of Technology parking lot, the park was over-utilized, and many vehicles parked where they weren't meant to. Also, there is an issue with the low turnover rate, because university employees use the parking lot from early in the morning until 2:00 pm, and parking spaces cannot be used by other vehicles. This research suggests solutions to improve parking for each parking lot.

Keywords: CBD, Off-street parking, Parking demand, Parking lot, Simulation model, VISSIM.

INTRODUCTION

Parking is a major problem in urban areas (Barata et al., 2010). Insufficient parking is a serious issue for both developed and emerging cities (El-Din et al., 2017; Namdeo et al., 2009). Parking and land usage must be taken into consideration while planning for a new roadway (Jasim & Alhayani, 2017; Al-Masaeid et al., 2021). Parking facilities are primarily considered to be a necessary component of highway mobility and essential to the design of urban transportation. Any vehicle traveling on a highway has to park occasionally. High-density areas need to have adequate parking spaces to meet the demand. Demand for parking rises as there is less space available in cities, especially in the central business district (CBD) area (Jasim & Alhayani, 2017; Chrest, 2001; Mosa et al., 2015; Kawther, 2021). Parking lots must be ideally placed and sized (Mohammed et al., 2018). Insufficient parking in urban areas is a serious issue for both developed and emerging cities (Kawther, 2021; Mohammed et al., 2018; Paul et al., 1971). The time spent hunting for a parking space contributes to traffic congestion and increases emissions. There is congestion everywhere and a leading cause of urban air pollution (Ahmed et al., 2011; Ahmed, 2009; Mosa et al., 2013). Congestion could be limited by using public transport, public transit challenging in terms of its parking lots and its administration (Name et al., 2023).

In their study, Al-Taei et al. (2012) analysed Duhok Central Business Area parking lots. There were approximately 717 spaces available across three parking lots, with the highest demand. In four hours, the average parker walked 155 meters, and 1.09 vehicles were turned over at each stall. It is suggested that the control mechanism is in the form of fines or time limitations. Supply and demand for parking on Al-Mustansirya campus were examined and assessed for the target year of 2015. It was found that 644 extra parking spots are needed by the target year of 2015 to meet the increase in demand (Ismail & Al-Ubaidy, 2007). Asmael and Turky (2022) examined parking generation rates for the usage of government property. The goal is to develop parking generation models and charges. According to their study, institutional land use resulted in 0.1 space for each employee and 0.94 space for every 100 m^2 of ground floor area (GFA). Atif (2022) evaluated twelve off-street parking lots in the central business district. The parking survey results showed that parking spaces in P1 and P4 parks are more in demand than available. P1's efficiency is 102.65%, while P4's average is 110.38%, based on survey results. Kattanh et al. (2023) created a statistical model to determine how many parking spaces are required in Baghdad's business areas. The study's findings indicated that the need for parking spaces is directly correlated with the size of the commercial operations, with restaurants and retail establishments requiring more parking.

Even though the number of vehicles has been steadily rising due to population growth, Baghdad, the capital of Iraq, has not seen advancements in the transport sector since the turn of the twenty-first century (Al-Rawi et al., 2024). This population expands travel and daily activities, and parking has become more complicated and costly (Atif, 2022). The first step in managing or treating many of the issues associated with preserving supply and demand equilibrium is to study the current parks to know and solve their problems (Al-Aubaidy, 1999).

The purpose of this work is to assess parking performance by data collection for each park to identify the parking problems in order to present a general methodology by including the findings of a parking survey in VISSIM, a microscopic simulation tool. VISSIM can offer crucial information about parking and traffic conditions in the CBD (Cheng et al., 2011). Improvements and suggestions for better performance for each park will also be presented in this study.

Study Area

The study area is located in Al-Russafa of Baghdad, Iraq, which is a highly desirable neighborhood. Two off-street parking lot facilities are selected for this study. They were more representative of all parking lots in Baghdad city.

The Dream City Mall Parking Lot

The Dream City Mall parking lot is shown in Figure 1. It is a public parking lot. It was open for work in 2019, and it belongs to Dream City Mall. It is located close to Al-Rubaie Bridge in Zayona city near the intersection that leads to Al-Rubaie street. Entry and exit to the parking lot are through separate lanes. The parking lot has 513 parking spaces and a total size of 21,324 square meters. It has one lane for each of its entrances and exits. There are three lanes on the nearby road.

Figure 1. Dream City Mall parking lot

The University of Technology Parking Lot

The University of Technology is a very old institution of higher education. It is situated between Muhammad Al-Qasim Highway and Al-Sinaa Street, on the other hand. It has an administrative office, a university presidency, and 16 colleges. There are five gates for vehicles to enter and exit. Park's entry is from one of the gates on the local street, and the exit is from the commercial street gate. The parking lot area is 6,320 m^2, with 181 parking spaces. The park is shown in Figure 2.

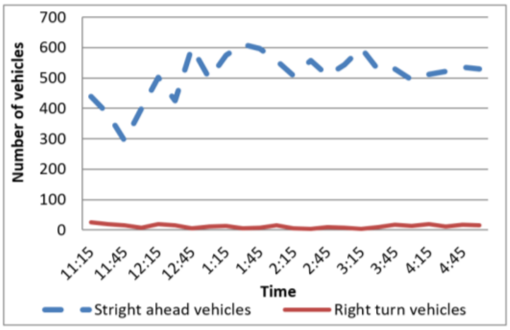
Figure 2. The University of Technology parking lot

METHODOLOGY

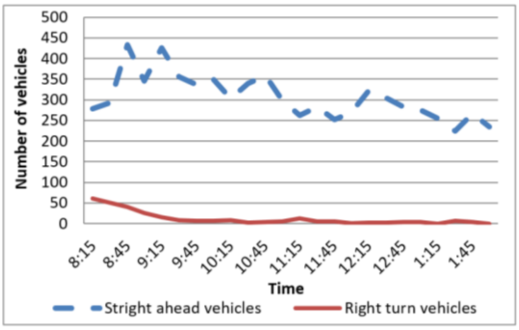
Data Collection

A six-hour on-site survey of each parking facility was conducted. The time of the survey was chosen to be the peak period for every park. Gathering data is a crucial step in the park performance evaluation process. Three data categories were in this study:

1. **Traffic Data:** Parking lots in this study are evaluated using traffic flow data. With the use of a digital camera taken from the park, traffic flow statistics were gathered. Every fifteen minutes, an observer counts the number of cars that pass. The number of cars for each park every 15 minutes is displayed in Figure 3.
2. **Parking Lot Data:** Since the parking lot attributes are crucial to the viability of any park, they were included in this study as previously discussed.



(a) Dream City Mall Parking Lot



(b) University of Technology Parking Lot

Figure 3. Straight-ahead vehicles (traffic flow) and right-turn vehicles (entering vehicles) every 15 minutes.
(a) Dream City Mall Parking Lot, (b) University of Technology Parking Lot

3. **Parking Lot Efficiency Data:** This data category includes:

***Travel Time**:* The effectiveness of the park is determined by the amount of time it takes to get from the entrance gate to the stall, which is called entry travel time, and from the stall to the departure gate, which is called exit travel time. The park is divided into regions, and then, a stall is selected from every region to record the travel time. Dream City Mall parking lot is divided into 20 regions, and the average entry travel time is 49.93 seconds, while the average exit travel time is 68.91 seconds. The University of Technology parking lot is divided into 7 regions, and the average entry travel time is 47.09 seconds, while the average exit travel time is 35.14 seconds.

***Parking, Unparking Time, and Duration of Stay**:* The time it takes a vehicle to enter a stall is known as parking time, and the time it takes to exit is known as unparking time. Both can be determined using a timer. The average duration of stay for each park is determined by first recording the plate number of the vehicle at arrival and at departure. The duration of stay depends on the park's location and the surrounding areas. Parking time, unparking time, and duration of stay for each park are shown in Table 1.

***Delay on Gates (accepted lags and gaps)**:* Using a stopwatch, lag and gap data was extracted from the video records for every parking facility and carefully analyzed by hand based on their respective categories. Dream City Mall parking lot has two critical values: 3.4s and 5.1s, so there are lags and gaps. The University of Technology parking lot has one acceptable value: 3.9; so, it is a gap only.

Table 1. Parking time, unparking time, and duration of stay for each park

Park Name	Average Parking Time (s)	Average Unparking Time (s)	Average Duration of Stay(s)
Dream City Mall Parking Lot	6.73	6.76	5029.0
University of Technology Parking Lot	11.48	13.89	14291.25

VISSIM SIMULATION

Planning Transportation Visions (PTVs) VISSIM is the best micro-simulation program. It was chosen among all the other simulation programs because of its capacity to simulate traffic flow and its effects (Li et al., 2019). After acquiring background imagery through photographs and road linkages, two off-street parking models were developed using flow data and parking characteristics. These models are displayed in Figures 4 and 5.

Figure 4. Dream City Mall Parking Lot built in VISSIM

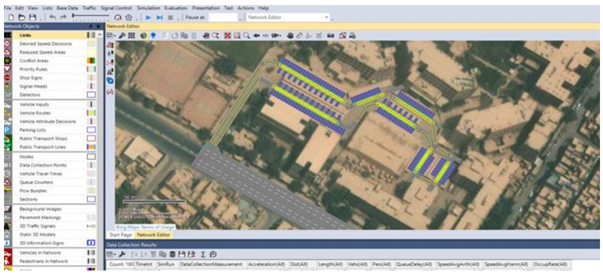


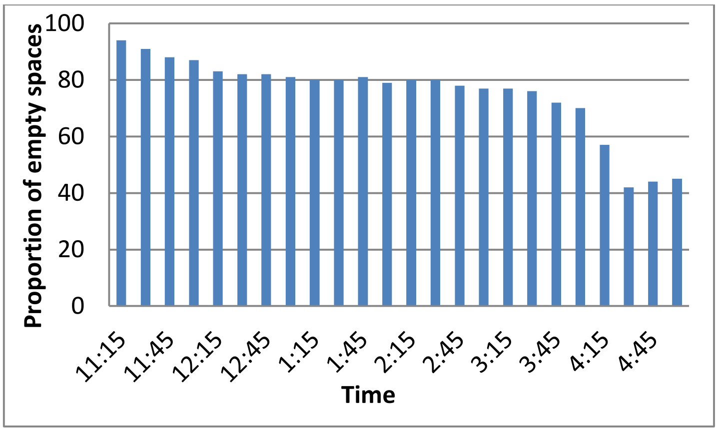
Figure 5. University of Technology Parking Lot built in VISSIM

RESULT ANALYSIS AND DISCUSSION

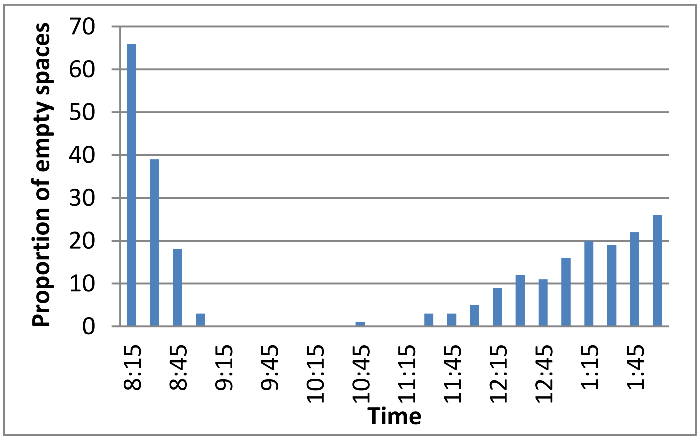
Proportion of Empty Spaces

VISSIM is used to determine the percentage of empty spaces inside the park every 15 minutes, as shown in Figure 6.

About 90% of the Dream City Mall Parking Lot is empty at the start of the survey, but as more people visit the mall, the percentage of empty spaces gradually drops. The percentage of empty areas ranges from 70%-80% during the hours of 1 and 4 pm. When the survey ends at 5 pm, it is approximately 45%. This means that the park has about 55% of unoccupied spaces to handle the volume of guests in the evening. The University of Technology parking lot has a smaller percentage of unoccupied spaces. The percentage of empty spaces at 8 am, when the survey started, is 66%. The proportion dropped until the park filled up around nine-thirty, leaving no empty spots in the parking lot. Within two hours, park visitors began to depart the area, resulting in a rise in the percentage of vacant spots. By the time the survey finished at 2 pm, that percentage had risen to 26%. The number of vehicles entering the park exceeds the total number of spaces provided, and the park can not accommodate every vehicle.



(a) Dream City Mall Parking Lot



(b) University of Technology Parking Lot

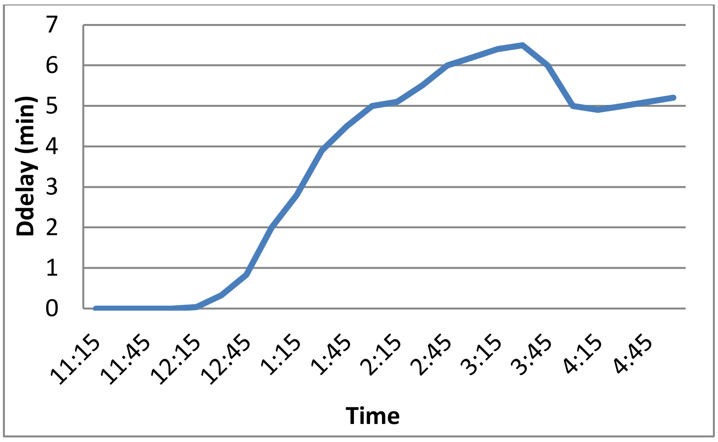
Figure 6. Proportion of empty spaces for (a) Dream City Mall Parking Lot, (b) University of Technology Parking Lot

Dely on Gates

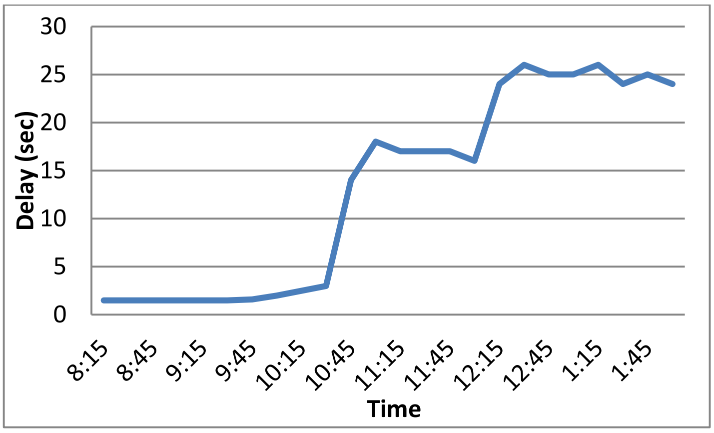
A delay is the amount of time a vehicle loses due to uncontrollable events. Every park lot was split up into regions, and the delay is calculated for each region. Figure 7 indicates delay values.

The Dream City Mall parking lot has high delay values, computed in minutes. When the mall opened at 11 a.m., there was no delay for the first hour. After that, there was a gradual increase in delay, reaching five minutes at 2 p.m. The rise in traffic is the cause of this increase. At 3:30 pm, it reached 6.5 minutes, and after that, it progressively decreased. The use of the

Advanced Parking Management System usually lowers the delay time values (Al-Ubaidy, 2009). Because of the increased traffic on the street, the University of Technology parking lot's delay values increased from less than five seconds to over five seconds between 8 am. and 10:30 am. After that, delay values vary between 24 seconds and 27 seconds, being considered acceptable values.



(a) Dream City Mall Parking Lot



(b) University of Technology Parking Lot

Figure 7. Delay on gates for (a) Dream City Mall parking Lot, (b) University of Technology Parking Lot

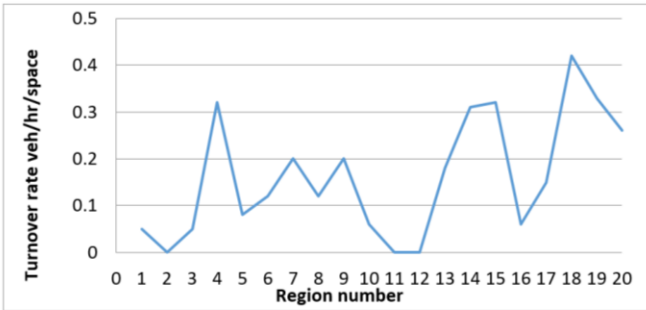
Turnover Rate

The turnover rate is the number of vehicles per unit time. The higher the parking turnover, the more a vehicle enters and exits a given space. The turnover rate for each park lot was determined for six hours every fifteen minutes. Figure 8 displays the results of each park lot's turnover rate.

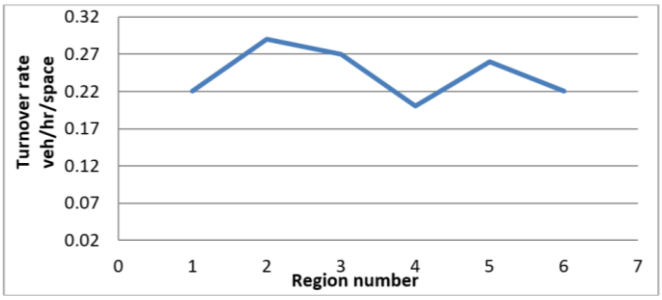
For the Dream City Mall parking lot, region nineteen had the highest turnover rate of 0.42 veh/hr/space. However, because drivers always pick the closest spot, regions 2, 11, and 12 have zero turnover rates and are not used by parkers. Since only university employees use the University of Technology parking lot from the early hours of the morning to the end of the official working hours, the turnover rate for that parking lot is limited, as seen in Figure 8(b).

Queue Length

Queue length is the total number of vehicles in the queue. Significant queue length indicates a significant likelihood of delays at the park entrance. Queue length results are shown in Figure 9.

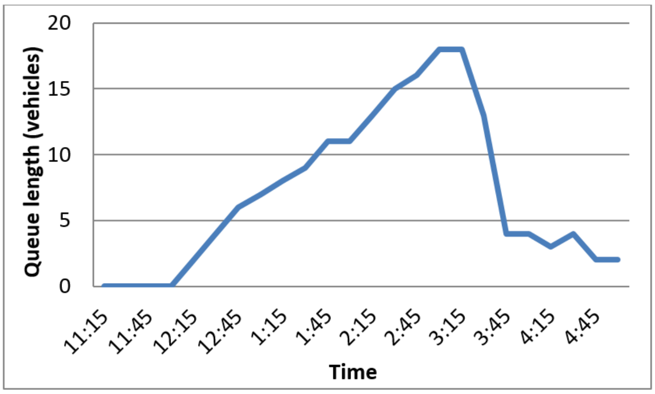


(a) Dream City Mall Parking Lot

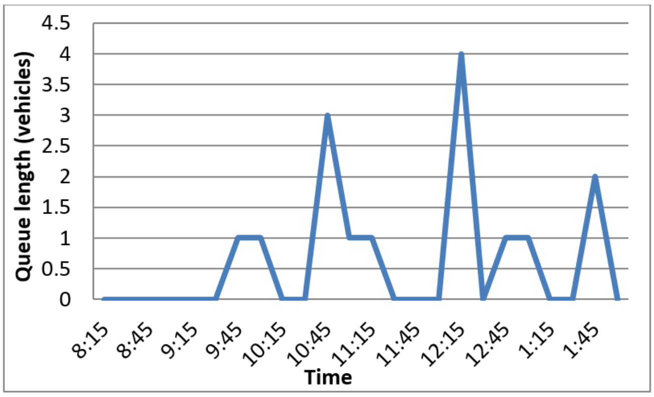


(b) University of Technology Parking Lot

Figure 8. Turnover rate values for (a) Dream City Mall parking lot, (b) University of Technology Parking Lot



(a) Dream City Mall parking Lot



(b) University of Technology Parking Lot

Figure 9. Queue length values for (a) Dream City Mall parking lot, (b) University of Technology parking lot

At the beginning of the survey, there wasn't any vehicle in the Dream City Mall parking lot queue. However, as the official working hours came to an end at 3 pm, the number of vehicles in the queue increased to 18. High traffic volumes make vehicles gather in front of the park, and parking vehicles cannot enter because of the congestion. From there, the number of vehicles in the queue decreased until there were just two, as a result of less traffic. For the University of Technology parking lot, four vehicles were in the queue at 12:15 p.m. After that, this number steadily dropped until it was zero at 2 p.m. when the survey ended.

Suggested Solutions and Improvements

For the Dream City Mall parking lot, it was suggested that a multi-story parking lot be constructed in the rear part of the park. The suggested park consists of four symmetrical stories, each with 244 parking spots. Indeed, the suggestion has been implemented and will open soon. It is assumed that traffic volume will drop by 10%, because current efforts to build more roads, bridges, and traffic management systems will help alleviate the problem of congestion. Data for the park is assumed to be the same as in the parking lot. The results are given in Figures 10,11, and 12.

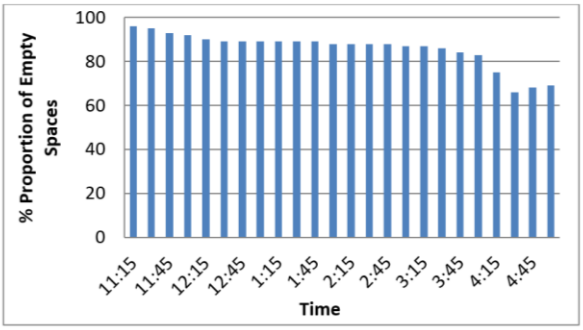


Figure 10. Proportion of empty spaces for the assumed Dream City Mall parking lot

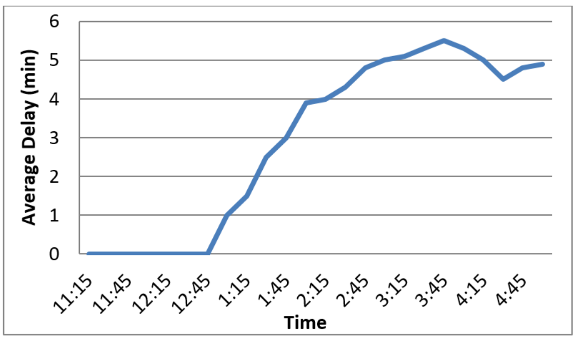


Figure 11. Delay values for the assumed Dream City Mall multi-storey parking lot

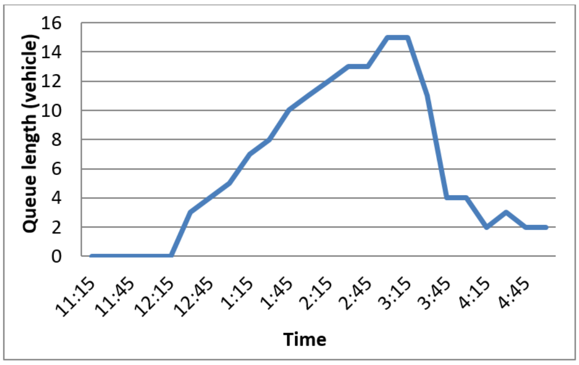


Figure 12. Queue length values for the assumed Dream City Mall multi-storey parking lot

The proportion of empty spaces was 97% when the mall opened at 11 a.m., while it was 90.5% before assumption. The proportion reduced to 65% at 5 p.m. due to the mall's increasing number of visitors over time. It was 45% before the assumption. The multi-storey park still has more than a half of its empty spots, allowing it to accommodate more vehicles in the future. Due to the heavy traffic in the area, the Dream City Mall parking lot has significant delays, which are measured in minutes. The delay was 6.5 minutes, but it was reduced to 5.5 minutes when there was a 10% drop in traffic. The mall's maximum average number of vehicles in queue was eighteen, but as traffic volume reduced, the number of vehicles in queue dropped to fifteen, and then, it dropped steadily due to a decrease in traffic on the road.

For the University of Technology parking lot, although there is another parking lot and a six-story park, the park was insufficient for the number of parked vehicles, and the other parks were constantly full. Several vehicles are parked in areas where they should not be. To address the issue, a segment of the park near the Computer Science Department is suggested to be built as a multi-story park. It is assumed to have four storeies, each with 108 parking places, as shown in Figure 13.

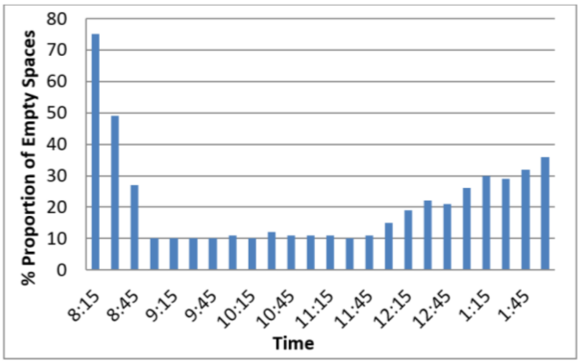


Figure 13. Proportion of empty spaces for the assumed University of Technology four-storey parking lot

For the multi-storey park with four storeies, the percentage of empty spaces was 75% at 8 a.m., but it quickly dropped to 10% and 12% between 9 a.m. and 11:45 a.m. At 2 p.m., the percentage of empty spaces increases to 36%. The four-storey park offers 432 parking spaces and still has 10% of available space in the four- storey park to meet future demand.

CONCLUSTIOS

According to the results of this study on the studies parking lots, it is observed that the studied parking lots suffer from several problems. Dream City Mall parking lot's problem was the location of the mall, which is located close to Al-Rubaie Bridge in Zayona city on the street leading to Al-Rubaie intersection, which is considered a vital area with high traffic volumes. This causes delays of up to 6.5 minutes and a high number of vehicles in the queue, up to 18 vehicles, due to the huge congestion. The park has 513 parking spaces, and all the vehicles that enter the park can find a parking space, which is a good indicator of its capacity for the future, but congestion is still the main cause of the park's problems. The current trend towards building bridges, expanding roads, and organizing traffic will help solve the problem of congestion and make the park function better. In addition, starting to build a multi-story park in a part of the park will increase the capacity to accommodate the ongoing increase in the number of vehicles.

The problem with the University of Technology parking lot is the high number of parking vehicles compared to the available spaces. The parking lot was over-utilized, with vehicles parked where they weren't supposed to. Because university employees utilize the parking from early in the morning to the end of business hours at 2:00 p.m., there is also a problem with the low turnover rate. A low turnover rate indicates that vehicles are still parked, and no other vehicles can use this parking space. Three parking facilities are available at the University: two are parking lots and one is a multi-story park. However, due to the high volume of vehicles using these places, additional parking spaces are required. The solution for the University parking lot is a multi- storey parking lot instead of this parking lot to accommodate the current and increasing number of vehicles in the future. Other solutions, like demand-based pricing or smart parking systems, could be used for both parks.

Possible future research ideas in this area of study are integrating AI-based parking management or multi-modal transport integration.

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