Вестник РУДН. Серия: Инженерные исследования
RUDN Journal of Engineering Research

2024;25(4):397–404

ISSN 2312-8143 (Print); ISSN 2312-8151 (Online)
journals.rudn.ru/engineering-researches

DOI: 10.22363/2312-8143-2024-25-4-397-404
UDC 629.78
EDN: AAQHWV

Research article / Научная статья

Classification Characteristics of Some Roads in Karbala City

Hayder S. Khudhair[a], Hamid A.E. Al-Jameel[b], Vladimir N. Konoplev[a]✉, Artur R. Asoyan[a]

[a] RUDN University, *Moscow, Russia*
[b] University of Kufa, *Kufa, Iraq*
✉ konoplev-vn@rudn.ru

Article history

Received: July 12, 2024
Revised: September 12, 2024
Accepted: October 14, 2024

Conflicts of interest

The authors declare that there is no conflict of interest

Authors' contribution

Undivided co-authorship.

Abstract. A comprehensive understanding of the characteristics of the road network is imperative for implementing fundamental measures to enhance traffic efficiency and mitigate delays. The objective of the present study is twofold: firstly, to classify the urban street network in the city of Karbala; and secondly, to evaluate its effectiveness. Following the delineation of the area of study, traffic data is collected through the utilisation of video imaging technology and subsequently extracted from video files. Following this, the city streets are divided into multiple sections, and the speed of movement in each is calculated, as well as the speed of free flow. The primary objective of this study is to determine and compare the level of service (LOS) of a road based on Highway Capacity Recommendations (HCM 2000), including traffic speed, capacity to assess each segment of the network. The findings of the study revealed that roads of the first category constituted 25% of the total, while roads of the second category comprised 75% of the total. Furthermore, the level of maintenance of street sections is 25% when working with LOS C, 31.25% when working with LOS D, 12.5% when working with LOS E and 31.25% when working with LOS F, according to the assessment of transport operations based on average traffic speed.

Keywords: free flow rate, average speed, throughput, level of road service

Acknowledgement

Authors want to thank the civil department in the faculty of Engineering at Al Kufa university and RUDN University for its contribution in supporting this research and assisting in its implementation.

For citation

Khudhair HS, Al-Jameel HAE, Konoplev VN, Asoyan AR. Classification characteristics of some roads in Karbala city. *RUDN Journal of Engineering Research.* 2024;25(4):397–404. http://doi.org/10.22363/2312-8143-2024-25-4-397-404

Классификационные характеристики некоторых дорог в городе Кербела

Х.С. Худхаир[a], Х.А.Э. Аль-Джамиль[b], В.Н. Коноплев[a]✉, А.Р. Асоян[a]

[a] Российский университет дружбы народов, *Москва, Россия*
[b] Университет города Куфа, *Куфа, Ирак*
✉ konoplev-vn@rudn.ru

История статьи

Поступила в редакцию: 12 июля 2024 г.
Доработана: 12 сентября 2024 г.
Принята к публикации: 14 октября 2024 г.

Заявление о конфликте интересов

Авторы заявляют об отсутствии конфликта интересов.

Вклад авторов

Нераздельное соавторство.

Аннотация. Знание характеристик дорожной сети является важным фактором для принятия основных мер по повышению эффективности дорожного движения и сокращению задержек. Таким образом, целью исследования является классификация и оценка эффективности городской уличной сети в городе Кербела. После определения района исследования данные о дорожном движении собираются с помощью технологии видеоизображения, а затем извлекаются из видеофайлов. После разделения городских улиц на несколько участков была рассчитана скорость движения на всех участках и скорость свободного потока. Основная цель состоит в том, чтобы определить и сравнить уровень дорожного обслуживания (LOS) на основе рекомендаций по пропускной способности автомагистралей (HCM 2000), включая скорость движения, пропускную способность для оценки каждого сегмента сети. мы обнаружили, что дороги первой категории составляют 25 % от общего количества, в то время как две категории второй категории составляют 75 % от общего количества. А уровень технического обслуживания участков улиц составляет 25 % при работе с LOS C, 31,25 % при работе с LOS D, 12,5 % при работе с LOS E и 31,25 % при работе с LOS F, согласно оценке транспортных операций, основанной на средней скорости движения.

Ключевые слова: свободный поток, средняя скорость, пропускная способность, уровень дорожного обслуживания

Благодарности

Авторы выражают благодарность гражданскому факультету инженерного университета Аль-Куфа и РУДН за их вклад в поддержку этого исследования и за содействие в его реализации.

Для цитирования

Khudhair H.S., Al-Jameel H.A.E., Konoplev V.N., Asoyan A.R. Classification characteristics of some roads in Karbala city // Вестник Российского университета дружбы народов. Серия: Инженерные исследования. 2024. Т. 25. № 4. С. 397–404. http://doi.org/10.22363/2312-8143-2024-25-4-397-404

Introduction

Traffic congestion in cities is one of the biggest transportation problems. Traffic jams are very intrusive activities for people and arise owing to the high degree of saturation of traffic flow. Because of the increased trip duration, congestion will have a detrimental effect on drivers and other road users. A population with a wide range of activities leads to a mobility flow that requires suitable roads [1–5]. The effects of street network design on congestion levels and characteristics differ greatly in street network design [6]. In terms of accidents, delays and CO_2 emissions, the operational efficiency of urban street networks has a significant impact on the sustainability of urban road transport. As a result, governments must regularly inspect road networks and manage urban traffic patterns [7; 8].

The quality of traffic flow must be evaluated to find better solutions to control the increase in traffic demand [9–11]. It is necessary to assess the quality of traffic flow in order to find the best solutions to control the growth in traffic demand [12; 13]. Transportation operations can have both positive and negative effects. Traffic jams in city centers, including Palembang, are one of the undesirable consequences of transport activities. Congestion leads to a significant loss of travel time, which takes a long time and slows down, as well as financial, health and environmental consequences, such as exposure to air pollution caused by car exhaust emissions [14]. According to INRIX, lost time, wasted fuel, and carbon emissions in the 25 cities evaluated in the United States would cost drivers an estimated $480 billion over the next ten years [15].

The Highway Capacity Manual provides detailed instructions for estimating the capacity and service levels based on speed and other factors. Correction factors for estimating throughput according to various parameters are provided if the HCM handbook does not include lateral friction parameters for determining throughput and service level [16, 17]. With regard to access control, which is considered a key urban traffic issue, statistical correlations between travel speed and related variables have been documented. It is used to measure traffic congestion and quality of services on urban highways. In addition, speed regulation for accessibility purposes has contributed to improving the safety and efficiency of road network [18]. Reliability is one of the most important indicators of transport system efficiency and service quality. The large variance in travel time has become a problem for both travelers and transport management companies. Reliability indicators are increasingly used to assess traffic jams and unexpected changes in travel time [19]. Data from an investigative vehicle for 200 compounds in Beijing, China were analyzed. This study examines urban expressways, auxiliary highways, main roads, and secondary roads. First, the time distributions of the passages of various DOW are studied. The results of tests for compliance with various distributions have shown that a logarithmically normal distribution can provide higher acceptance indicators for different time periods and types of roads than other distributions. In addition, four reliability indicators (travel time per unit distance, coefficient of variation, buffer time index, and punctuality level) were used to investigate the patterns of travel time variability for various. The results showed that on weekdays, urban expressways, auxiliary roads, and important highways exhibit constant and distinct morning and afternoon peaks [20; 21].

1. Research area

The city of Karbala is a famous city in the Islamic world. It is known for its religious significance. The shrines of Imam Hussein and his brother Abbas can be found in the ancient city or in the city center. It is located approximately 110 km southwest of Baghdad. The study area is located in the center of Karbala Province, where this study examines a group of urban roads connecting central commercial areas with industrial, commercial, residential, and educational areas with high population density. Figure 1 shows the research area where embedded segments and street nodes were identified.

These segments are then displayed. Table 1 lists the main characteristics of the street segments studied, such as the local street name, segment length, and number of lanes. These characteristics were collected in this study based on a field survey.

2. Methodology

Segmenting of urban street. The methodology includes the definition of the study area, which is a network of urban roads in the Karbala province. The primary objective of the fieldwork was to conduct surveys and administer questionnaires on a street-by-street basis to identify the periods of peak traffic. The subsequent step involves the distribution of relevant data. The volume of traffic is determined by recording cameras, whereas the speed information is described by the free flow rate in each network segment. The classes were then determined using the Speed Gun device, and the average speed of movement for each segment in the network was calculated. The appropriate service level (LOS) is then calculated using HCM2000 [22].

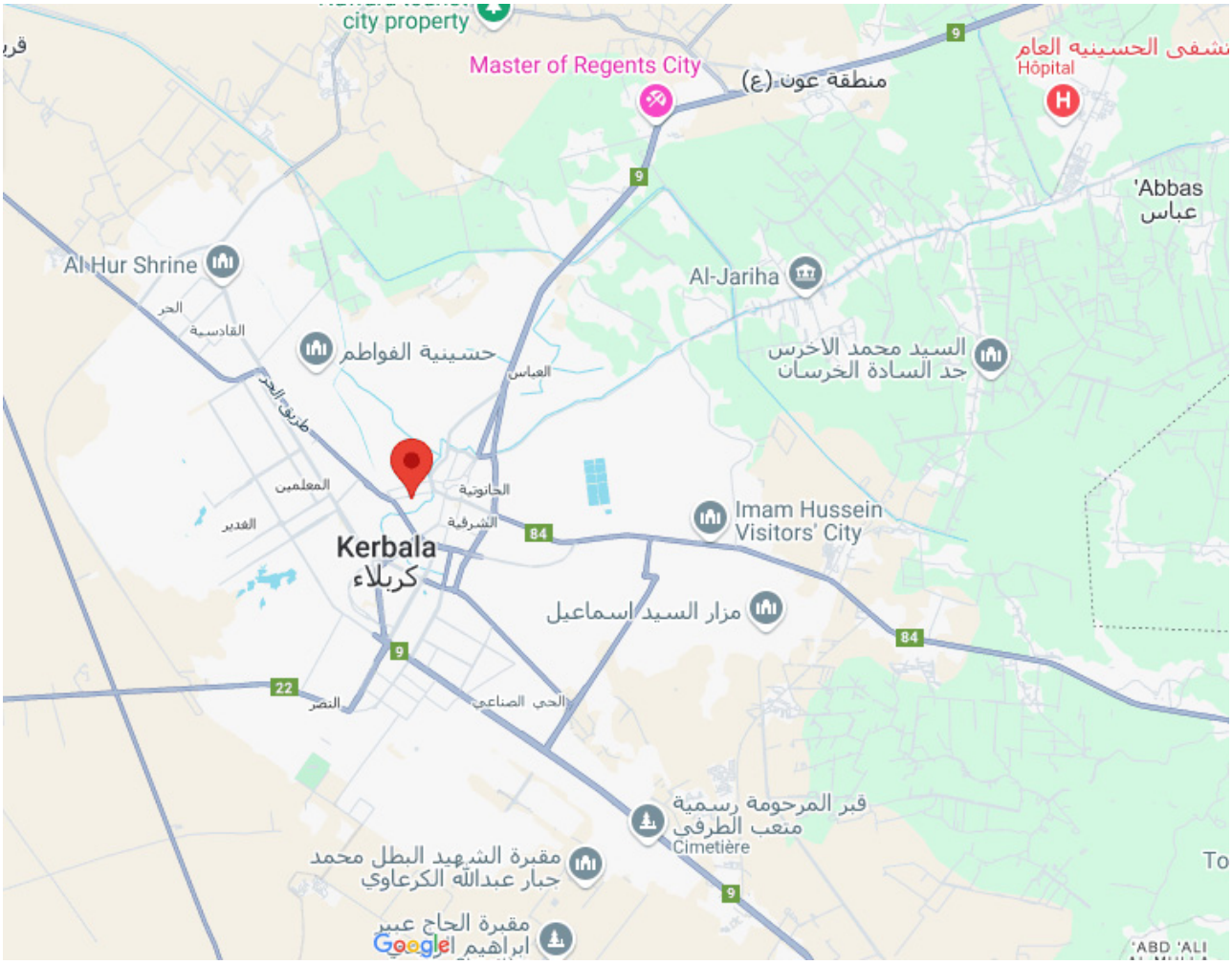

Figure 1. The selected research area
S o u r c e: Karbala Carte, Street Views. Available from: https://www.istanbul-visit.com/carte/iraq/karbala-plan.asp (accessed: 12.06.2024)

Table 1

Detailed information about the roads in the study area

Road Name	Segment NO.	Lane number / direction	Length, m
Fatima Al-Zahraa Street	1	3	234
	2		443
	3		790
	4		811
	5		418
	6		269
Al-Iskan Street	1	3	1430
	2		1380
Ramadan Street	1	3	1670
	2		1710

S o u r c e: make by H.S. Khudhair, H.A.E. Al-Jameel, V.N. Konoplev, A.R. Asoyan

3. Results and discussion

3.1. Determine the road class based on the free flow speed (FFS)

The free-flow speed (FFS) is the average speed of traffic flow when there is not enough traffic to influence drivers' decisions about speed, and when traffic control at an intersection is either absent or located at a distance that does not allow the Speed Gun device to be installed. It is used to determine the FFS, as shown in Figures 3–6.

3.2. Determine the level of service (LOS) of a road

After classifying each segment based on the FFS, city streets were evaluated using the average travel speed (ATS), which is one of the most fundamental indicators of service on city streets. It is calculated by collecting travel time data in the field. Table 2 illustrates the criteria for urban streets depending on their class and average speed. There are six levels of service, from USA (free work and absolutely free maneuvering) to the USA (congested traffic), when the need for traffic exceeds the capacity of the street (Figure 2) [23].

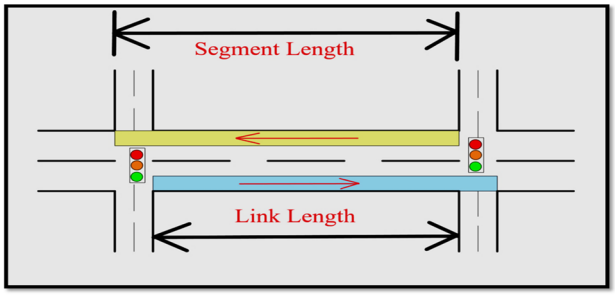

Figure 2. Segment length diagram (adapted from HCM 2010).
S o u r c e: Manual HC, HCM2D10 [6]

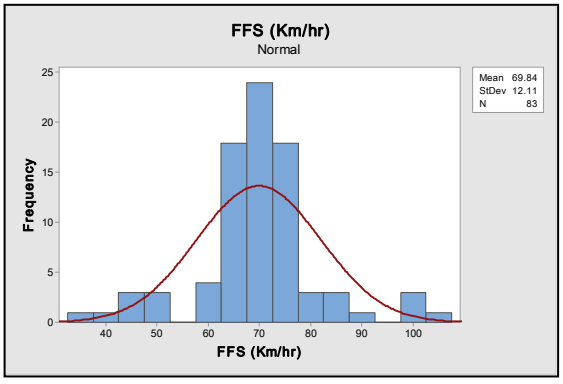

Figure 3. FFS for Fatima Al-Zahraa Street, segments 1, 2,5, and 6
S o u r c e: make by H.S. Khudhair, H.A.E. Al-Jameel, V.N. Konoplev, A.R. Asoyan

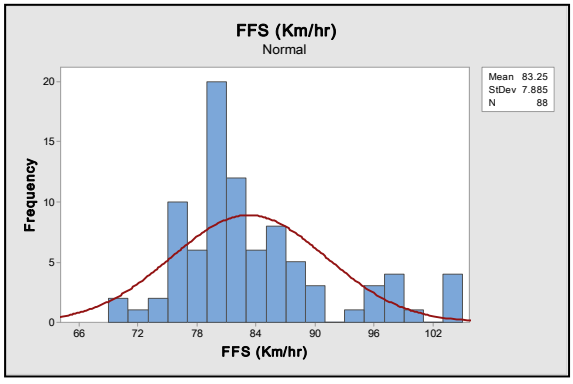

Figure 4. FFS for Fatima Al-Zahraa Street, segments 3 and 4

S o u r c e: make by H.S. Khudhair, H.A.E. Al-Jameel, V.N. Konoplev, A.R. Asoyan

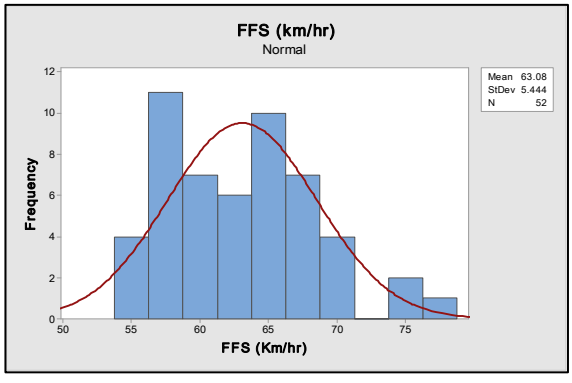

Figure 5. FFS for Al-Iskan street, segment 1 and 2
S o u r c e: make by H.S. Khudhair, H.A.E. Al-Jameel, V.N. Konoplev, A.R. Asoyan

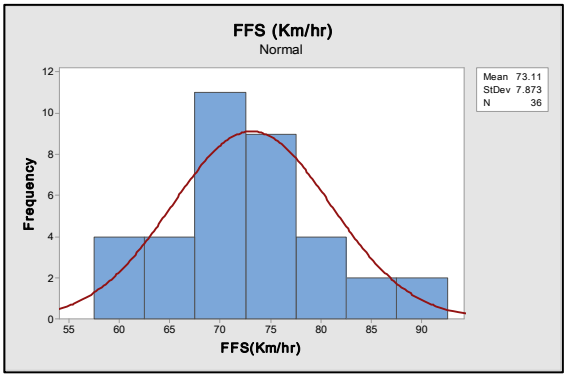

Figure 6. FFS for Ramadan street, segment 1 and 2
S o u r c e: make by H.S. Khudhair, H.A.E. Al-Jameel, V.N. Konoplev, A.R. Asoyan

Table 2

LOS of urban road based on FFS and ATS from HCM 2000

Urban street class	I	II	III	IV
Range of FFS, km/h	90 to 70	70 to 55	55 to 50	55 to 40
LOS	**Average travel speed (ATS), Km/h**			
A	> 72	> 59	> 50	> 41
B	> 56–72	> 46–59	> 39–50	> 32–41
C	> 40–56	> 33–46	> 28–39	> 23–32
D	> 32–40	> 26–33	> 22–28	> 18–23
E	> 26–32	> 21–26	> 17–22	> 14–18
F	≤ 26	≤ 21	≤ 17	≤ 14

S o u r c e: make by H.S. Khudhair, H.A.E. Al-Jameel, V.N. Konoplev, A.R. Asoyan

Table 3

LOS according to FFS data (using HCM 2000)

Road name	Seg.no.	FFS, km/hr	Class by FFS	ATS, Km/hr	LOS
Fatima Al- Zahraa Street	1	72.2	I	12	F
	2	58.5	II	24	E
	3	44.6	IV	17	E
	4	43.6	IV	12	F
	5	58.1	II	10	F
	6	67.5	II	16	F
Al-Iskan Street	1	69.6	II	13	F
	2	65.6	II	28	E
Ramadan Street	1	80	I	42	C
	2	78.2	I	26	E

S o u r c e: make by H.S. Khudhair, H.A.E. Al-Jameel, V.N. Konoplev, A.R. Asoyan

Conclusions

The analysis of Karbala roads has shown the following:

1. The length of urban roads of the first category is 25% of the total length of the number, and the remaining part of the roads belongs to the second category.

2. The structure of city streets according to the level of maintenance is characterized by 25% when working with LOS C; 31.25% when working with LOS T; 12.5% when working with LOS E; 31.25% when working with LOS Fastidios.

3. The assessment of traffic efficiency by the ratio (o/n) shows that the level of maintenance of street sections is: 50% of the segment's operating with LOS C; 18.75% of the segments working with LOAD; 25% of the segments working with LOS E; 6.25% of the segments working with LOS F.

4. According to the HCM 2000 methodology, all the considered sections of Fatima Al-Zahra and Al-Iskan streets operate under conditions of traffic disruptions, while Ramadan Street sections operate at their maximum capacity.

References

1. Akbar M., Budianto E, Doloksaribu B. Penentuan Besarnya Tarif Angkutan Dalam Kota (Angkot) Dengan Metode BOK. *Musamus Journal of Civil Engineering.* 2019;1(2):12–15.

2. Mudiyono R, Anindyawati N. Analisis Kinerja Ruas Jalan Majapahit Kota Semarang (Studi Kasus: Segmen

Jalan Depan Kantor Pegadaian Sampai Jembatan Tol Gayamsari). *Prosiding Seminar Nasional Inovasi Dalam Pengembangan SmartCity*. 2017;1(1):345–354.

3. Afrin T, Yodo N. A survey of road traffic congestion measures towards a sustainable and resilient transportation system. *Sustainability*. 2020;12(11):4660. https://doi.org/10.3390/su12114660

4. Mate NR. Indian Road Traffic Congestion Problems, its reasons with focus on Road width. *International Journal for Research Trends and Innovation*. 2022;7(8): 4–10.

5. Jing P, Seshadri R, Sakai T, Shamshiripour A, Alho A, Lentzakis AF, Ben-Akiva M. Evaluating congestion pricing schemes using agent-based passenger and freight microsimulation. *Transportation Research Part A: Policy and Practice*. 2024;186:104118. https://doi.org/10.1016/j.tra.2024.104118

6. Choi D-A, Ewing R. Effect of street network design on traffic congestion and traffic safety. *Journal of transport geography*. 2021;96:103200. https://doi.org/10.1016/j.jtrangeo.2021.103200

7. Al Ghanim AMK, Asad FHA, Al-Jameel HAE. Traffic Performance Evaluation for Selected Streets within the Southern Part of Al-Najaf City Network. *Journal of* Physics: Conference Series. 2021;1973:012226. https://doi.org/10.1088/1742-6596/1973/1/012226

8. Kareem A, Asad F. Evaluating the operational performance of urban streets within Al-Najaf city. *AIP Conference Proceedings*. 2023;2806:040002. https://doi.org/10.1063/5.0162784

9. AL-khazali DF, Al-Jameel HA, Almuhanna RR. Investigate traffic characteristics of Kerbala urban streets. *AIP Conference Proceedings*. 2023;2793:070005. https://doi.org/10.1063/5.0164252

10. Adanikin A, Ajayi JA, Oyedepo J, Adeoye I, Twaki DL. Traffic Congestion Assessment of Akure Central Business District Using Geographic Information System (GIS). *Annals of the Faculty of Engineering Hunedoara*. 2023:21(2):105–110.

11. Hashmi HT, Ud-Din S, Khan MA, Khan JA, Arshad M, Hassan MU. Traffic Flow Optimization at Toll Plaza Using Proactive Deep Learning Strategies. *Infrastructures*. 2024;9(5):87. https://doi.org/10.3390/infrastructures9050087

12. Ewadh HA. Evaluation the traffic operation for arterial highways within hilla city by using hcs. *International Journal of Civil Engineering and Technology*. 2019;10(05):148–156.

13. Ahmad S, Ali A, Ahmed HU, Huang Y, Lu P. Evaluating traffic operation conditions during wildfire evacuation using connected vehicles data. *Fire*. 2023;6(5): 184. https://doi.org/10.3390/fire6050184

14. Adha ML, Arliansyah J, Buchari E. Analysis of the Influence of Traffic Flow on Air Pollution at Simpang Angkatan 66 of Palembang City. *Journal of Physics: Conference Series*. 2019; 1198(8):082005. https://doi.org/10.1088/1742-6596/1198/8/082005

15. Atrish AK, Bhugra GS. Traffic Congestion Analysis using PTV VISSIM Software. *International Journal for Research in Applied Science and Engineering Technology*. 2022;10(2):1411–1415. https://doi.org/10.22214/ijraset.2022.40370

16. *Highway Capacity Manual*. Transportation Research Board Publ.; 2010.

17. Harrou F, Zeroual A, Hittawe MM, Sun Y. *Road Traffic Modeling and Management*: *Using Statistical Monitoring and Deep Learning*. Elsevier Publ.; 2021. ISBN: 9780128234334

18. Alkaissi AJ, Khaled TT. Travel Speed Prediction Model for Urban Arterial Road and Traffic Management. *Journal of Green Engineering*. 2020;10:13536–13548.

19. Alattar EF, Kadem AJ Travel time reliability indices for urban routes in Baghdad city. *Journal of Engineering and Sustainable Development*. 2021;25(5):1–14. https://doi.org/10.31272/jeasd.25.5.1

20. Chen P, Tong R, Lu G, Wang Yu. Exploring travel time distribution and variability patterns using probe vehicle data: case study in Beijing. *Journal of Advanced Transportation*. 2018;(1959):1–13. https://doi.org/10.1155/2018/3747632

21. Alonso E, Arpón C, González M, Fernández RA, Nieto M. Economic impact of autonomous vehicles in Spain. *European Transport Research Review*. 2020;12(1). https://doi.org/10.1155/2018/3747632

22. Manual H.C. Highway capacity manual. Washington, DC, 2000;2(1):1.

23. Manual HC. Special report no. 209. Transportation Research Board, Washington DC, USA, 2000.

About the authors

Hayder S. Khudhair, Postgraduate student of the Department of Engineering and Transport Technologies, Academy of Engineering, RUDN University, Moscow, Russia; ORCID: 0000-0002-6833-7780; e-mail: hyder.s@ uokerbala.edu.iq

Hamid Athab E. Al-Jameel, Doctor of Technical Sciences, Professor of the Department of Civil Engineering, Faculty of Engineering, University of Kufa, Iraq; ORCID: 0000-0002-1367-4421; e-mail: hamid.aljameel@uokufa.edu.iq

Vladimir N. Konoplev, Doctor of Technical Sciences, Professor of the Department of Engineering and Transport Technologies, Academy of Engineering, RUDN University, Moscow, Russia; eLIBRARY SPIN-code: 3876-1534, ORCID: 0000-0003-1662-6254; e-mail: konoplev-vn@rudn.ru

Artur R. Asoyan, Doctor of Technical Sciences, Professor of the Department of Transport, Academy of Engineering, RUDN University, Moscow, Russia; Professor of the Department of Operation of Road Transport and Car Service, Moscow Automobile and Road Construction State Technical University, Moscow, Russia; eLIBRARY SPIN-code: 1020-5089, ORCID: 0000-0002-1976-9376; e-mail: asoyan-ar@rudn.ru

Сведения об авторах

Худхаир Хайдер Салман, аспирант кафедры техники и технологий транспорта, инженерная академия, Российский университет дружбы народов, Москва, Россия; ORCID: 0000-0002-6833-7780; e-mail: hyder.s@ uokerbala.edu.iq

Аль-Джамиль Хамид Адаб Идан, доктор технических наук, профессор кафедры гражданского строительства, инженерный факультет, Университет города Куфа, Ирак; ORCID: 0000-0002-1367-4421; e-mail: hamid.aljameel@ uokufa.edu.iq

Коноплев Владимир Николаевич, доктор технических наук, профессор кафедры техники и технологий транспорта, инженерная академия, Российский университет дружбы народов, Москва, Россия; eLIBRARY SPIN-код: 3876-1534, ORCID: 0000-0003-1662-6254; e-mail: konoplev-vn@rudn.ru

Асоян Артур Рафикович, доктор технических наук, профессор департамента транспорта инженерной академии, Российский университет дружбы народов, Москва, Россия; профессор кафедры эксплуатации автомобильного транспорта и автосервиса, Московский автомобильно-дорожный государственный технический университет, Москва, Россия; eLIBRARY SPIN-код: 1020-5089, ORCID: 0000-0002-1976-9376; e-mail: asoyan-ar@rudn.ru