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Presenting a Model for Evaluating the Operation of Urban Docks

(Case Study: Tehran Bazaar (Panzdah-e-Khordad St.)

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Abstract

This study aimed to present a mathematical model to evaluate the operation of urban docks. To do this, the dock located in Tehran bazaar (Panzdah-e-Khordad St., between Pamanar intersection and Mostafa Khomeini intersection) has been selected as a case study sample.The proposed mathematical model is based on Queueing theory which with the necessary data, has undergone a three-step process.Finally, it examines the operation of dock based on the density rate parameter (ρ).In this research, the value of the density rate parameter (ρ) has been calculated by applying the mathematical model for the studied dock area, and the necessary analyzes have been performed according to the obtained value.Based on the analysis, the mean time to stop of freight vehicles is high according to the number of stations and it is necessary to manage this time,and the number of stations should be increased.In addition, since the dock is not separate from the traffic route of motor vehicles and motorcycles, and as a result of traffic problems in this area, it was concluded that the dock should be separated from vehicle traffic route.

Keywords: Dock, Mathematical Model, Density Rate, Queueing Theory

Introduction

In general, the prosperity of markets located in the central part of cities requires existing of the goods needed by citizens.The supply of these goods is facing many problems; one of the most important of which is the problems related to how to load and transport goods. Loading and transportation of goods is difficultbecause of the limited traffic space in the central markets and the many vehicles and pedestrians in these areas.Therefore, the necessary measures should be taken to plan the movement of freight vehicles in these areas through the relevant authorities and with the cooperation of merchants, drivers of freight vehicles, and citizens (1).

In this regard, in many countries of the world, separate areas have been allocated for unloading and loading cargo, which are known as separated urban docks to facilitate the transportation of goods.Allocating a separated unloading and loading places for shopping centers located in the city center facilitates the movement of citizens in these areas (3).In theareas where special spaces

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for unloading and loading of goods are not provided, freight vehicles are parked on the side of streets and cause reducing the capacity of the passage and creating traffic jams in the passage of vehicles (2).Therefore, the design and management of urban dock spaces in high-traffic areas is of particular importance (1). Considering the relevant standards, the design of these spaces improves the traffic of freight vehicles and the satisfaction of businessmen and citizens (3).In addition, the proper management of how to enter, how to load and unload cargo, how to exit and optimize the loading time, the necessary measures can be taken to optimize the operation of urban docks (4).

Proper design of dock spaces requires careful studies;It is necessary to determinethe appropriate space to buildthemandthe other necessary measures.Theappropriate methods must be adopted to evaluate how they work which;In the first step, it should be determined the connection between shopping centers and problems of vehicle traffic on communication routes (2).Determining this connection, a suitable method can be adopted to evaluate the operation of docks.

2. Statement of the Problem and Goals of the Research

In general, the existence of shopping centers causes a demand for citizens to visit and shop, and as a result, the volume of vehicle traffic on the related routes is significantly increased.However, the traffic, stopping, loading, and docking of freight vehicles is also inevitabledue to the need to provide goods needed by citizens.Within the area of many shopping malls, the presence of freight vehicles along with passing vehicles causes traffic problems.Regarding the special role of the central market of Tehran, which in addition to the citizens of Tehran, there is a demand to visit it from allcities of Iran,it is necessary to study the status of unloading and loading cargo in this center. Therefore, this study focuses on the situation of loading and unloading space in the grand bazaar of Tehran, located on Panzdah-e-Khordad St., (between Pamanar intersection and Mostafa Khomeini intersection) and examines the need to build a separate dock space.

3. Literature Review

In this paper, the area related to loading and unloading of Tehran Central Bazaar in Panzdah-e-Khordad St.(between Pamanar intersection and Mostafa Khomeini intersection) has been selected as a case study to analyze and evaluate how to respond to existing demands and determine the need to provide the separate dock spaces. For the mentioned analysis, mathematical modeling method has been used, which is based on Queueing theory, and is performed on the study areathrough the mathematical analysis to determine how the existing demands are met.Thus, Queueing theory goes through a three-step process to evaluate the target as follows.

- Determining the entry rate of vehicles: The entry rate of vehicles to the desired location is determined using Equation (1).

$$\lambda = \frac{N}{T}$$

which in:

$\boldsymbol{\lambda}$: Vehicle entry rate in terms of vehicle per minute

N: Number of incoming vehicles

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T: Statistics time in minutes

- Determining the presence rate: The attendance rate of vehicles in the study area is determined by Equation (2).

$$\mu = \frac{1}{T} \quad (2)$$

which in:

μ: Vehicle attendance rate

T: The mean time to stop of vehicles in minutes per vehicle

- Determining the density rate of vehicles: In this step, the density rate of vehicles that are present in the study area is determined using Equation (3).

$$\rho = \frac{\lambda}{\mu C} \quad (3)$$

which in:

ρ: Vehicle density rate

λ: Vehicle entry rate in vehicles per minute

μ: Vehicle attendance rate

C: Number of neighborhoods to stop

The basis of the analysis performed in this theory is the vehicle density rate (ρ) in the desired area.Accordingly, if the value of the parameter ρ is less than 1, no queue is created for the vehicles, and if the value is equal to 1, the vehicles use the maximum available capacity of the desired area.If the value of parameter ρ is greater than 1, a queue of vehicles is formed in the desired area and the demand exceeds the capacity of passages.

5. Findings

According to the field visits and surveys from the study area and the statistics, the demand for freight vehicles at different hours of the day and night is in accordance with the bar chart presented in Figure 1.It should be noted that the demand was very low during other hours of the day and night, andpresent of them was canceled due to the lack of movement problems during these hours.

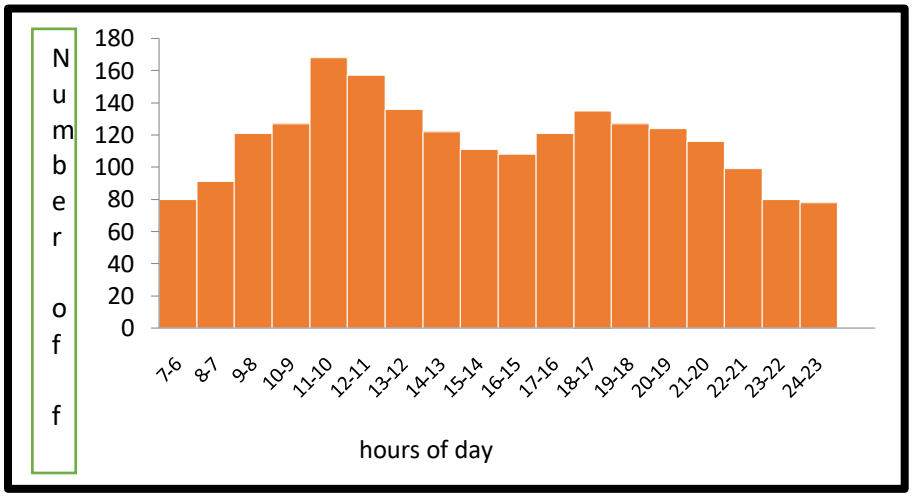

Figure 1. Demand for freight vehicles at different times of day

In addition, according to the research need to determine the mean time to stop of freight vehicles, a sample of 100 vehicles was selected and their time of stop was

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determined.Thus, intervals of 0-30 minutes, 30-60 minutes, 60-90 minutes, and 90-120 minutes and more were considered as the time of stop. by asking the drivers of freight vehicles, the average stopping time. Questioning the drivers of freight vehicles, the mean time to stop in each of the mentioned time periods was determined as presented in Table (1).

Table 1.The mean time to stop of freight vehicles

interval	mean time to stop	Number of vehicles
0-30 minutes	21 minutes	32
30-60 minutes	38 minutes	52
60-90 minutes	68 minutes	10
90-120 minutes and much	115 minutes	6

Therefore, the time of stop percentage of freight vehicles in each of the mentioned time intervals is as presented in Figure (2), which is observed accordingly:

32% of trucks hadthe stop for unloading and loading on average 21 minutes, 52% of trucks on average 38 minutes, 10% of vehicles on average 68 minutes, and 6% on average 115 minutes.Thus, the mean time of stop of freight vehicles is estimated to be 40.18 minutes and subsequent calculations are performed based on this time.

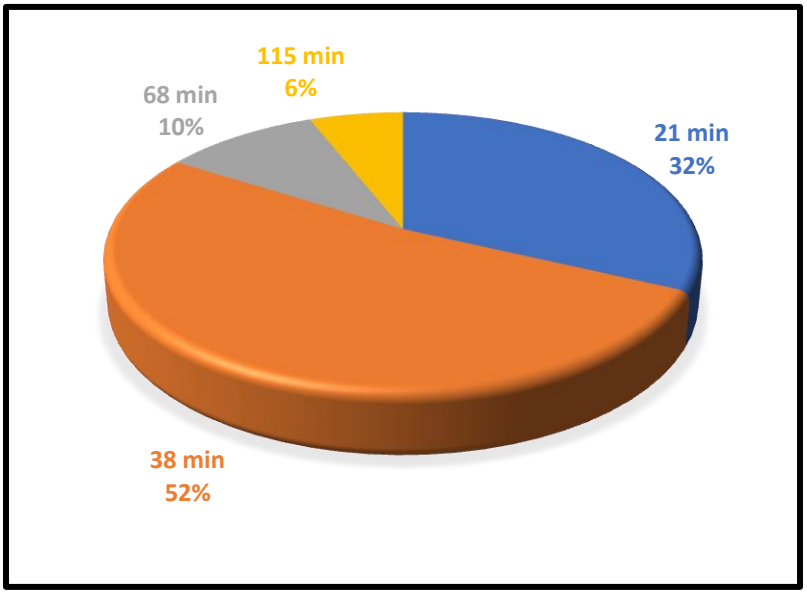

Figure 2.Estimatethe time of stop for freight vehicles

In addition, it should be noted that 80 stations have been provided for loading and unloading in the study area;Based on that, the value of parameter C in the calculations

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is considered equal to 80.Therefore, according to the available data, the results of the calculations are summarized in the table below.

Table 2. Simulation output information

interval	index		
	Traffic rates(λ)	Attendance rate(μ)	Density rate(ρ)
-6:00 7:00	1.33	0.025	0.67
-7:00 8:00	1.52	0.025	0.76
-8:00 9:00	2.02	0.025	1.01
-9:00 10:00	2.12	0.025	1.06
-10:00 11:00	2.80	0.025	1.41
-11:00 12:00	2.62	0.025	1.31
-12:00 13:00	2.27	0.025	1.14
-13:00 14:00	2.03	0.025	1.02
-14:00 15:00	1.85	0.025	0.93
-15:00 16:00	1.80	0.025	0.90
-16:00 17:00	2.02	0.025	1.01
-17:00 18:00	2.25	0.025	1.13
-18:00 19:00	2.12	0.025	1.06
-19:00 20:00	2.07	0.025	1.04
-20:00 21:00	1.93	0.025	0.97
-21:00 22:00	1.65	0.025	0.83
-22:00 23:00	1.33	0.025	0.67
-23:00 24:000	1.30	0.025	0.65

According to Table (1), it is observed that the density rate parameter (ρ) calculated for the time periods 8:00-14:00 and 16:00-20:00 is more than 1 and for other time periods the value is equal to or less than 1.In this way, during the hours when the density rate is more than 1, freight vehicles are forced to park illegally and cause traffic problems in this area.In addition, since the dock is not separate from the traffic route of other vehicles (non-freight vehicles), traffic problems have doubled, so that during non-peak hours, traffic problems occur due to the interference of freight and non-freight vehicles.

6-Conclusion

According to the evaluation, the existing capacity at the dock located on Panzdah-e-Khordad St. in Tehran (between Pamanar intersection and Mostafa Khomeini intersection) is not appropriate for freight vehiclesin the absence of the time of stop.Within 10 hours of the day, the density rate of freight vehicles exceeds 1;This is followed by improper stopping of vehicles for unloading and loading and creating traffic jams and delays in dock operation.

According to the calculations in this article, either the number of stations (at least 40 ones) should be increased or the mean time of stop of freight vehicles in the area should

be managed to meet the existing demand for docking in the desired area.In this regard, if the mean time of stopof freight vehicles is reduced in the range from 40.18 minutes to about 30 minutes, the current 80 stations meet the existing demand for unloading and loading.Given the limited space to create station, it makes more sense to implement time management techniques to achieve the ideal mean time.

It was determined that in case of a ban on the stop time of freight vehicles more than 1 hour, the mean time of stop will be reduced to about 31.16 minutes.In this case, the mean time is only 1.16 minutes different from the ideal mean time;Applying other time management methods, the ideal time can also be achieved.In addition, another problem identified in this study is the lack of separation of the dock locationwith the traffic route of non-freight vehicles which results in improper interference of freight and non-freight vehicles.To solve this problem, in addition to implementing various proposed methods to increase the dock capacity, it is necessary to take the necessary measures to separate the dock location and the traffic route of non-freight vehicles.

Thus, to evaluate how the urban docks work, it is necessary to first determine the optimal mean time for unloading and loading vehicles according to the number of stations in the portand then determine the mean loading and unloading time done in this place.Therefore, if the mean time available is less than the optimal mean time, it is concluded that the dock capacity (number of defined stations) is more than demand and the allocation of this number of stations is non-economic.If the mean time available is equal to the optimal mean time, it is concluded that the existing capacity of the dock is in line with existing demand.However, if the mean time of stop is higher than the optimal stop time, the necessary action must be taken to manage the stop time and bring it to the optimal value.Of course, it is necessary to mention that if time management is not possible (due to the need for the available time to carry out landing operations), capacity should be increased (number of stations) or other management methods should be implemented.Before constructing the dock, it is necessary to carry out the necessary studies to balance the number of stations required and the time required for docking operations to achieve the best possible design.Also, in the case of a dock design, the mean time required for unloading and loading can be calculated first through a query, and then the required number of stations can be calculated based on that.

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