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TRAFFIC AND ROAD STUDY IN CONSTANTINE CITY: ANALYSIS OF TRAFFIC IN CONSTANTINE CITY

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ABSTRACT

This study primarily aims to shed light on the traffic and road conditions in the city of Constantine. As a crucial measure in the transportation sector, traffic and road studies play a pivotal role in evaluating the efficiency of existing road networks, determining current and future traffic volumes, identifying bottlenecks, and proposing solutions through traffic redistribution and planning. To assess the current state of traffic and roads in Constantine and their adequacy in relation to the city's area and population, this study was conducted. Constantine was chosen due to its unique position as a hub for numerous major roads with high traffic volumes. Six out of the seven national roads traversing the entire province pass through Constantine. To comprehensively address the subject, the research is divided into three main sections:

- Section One: Provides essential definitions related to the topic, such as road network, road capacity, traffic volume, etc.
- Section Two: Delves into the details of traffic volume, its types, methods, and the significance of its study.
- Section Three: Conducts a detailed analysis of traffic volume and roads in Constantine. Initially, the study relies on the administrative classification of roads to identify those within the study area. Subsequently, it analyzes the average traffic volume and traffic density on these roads.

KEYWORDS

Traffic, Traffic Volume, Traffic Density, Road Capacity

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Introduction.

The study of road traffic or traffic volume is considered one of the most important metrics in the field of transportation. The significance of measuring traffic on any network lies in its ability to illuminate the economic and social importance of any region. Moreover, the study of traffic volume aims to analyze both the current and future capacity of a transportation network, as well as to determine the current and future traffic volumes that the road can accommodate. This, in turn, helps identify bottlenecks and seek solutions through traffic redistribution and planning.

This study aims to shed light on the traffic and road conditions in the city of Constantine. Given that Constantine is traversed by numerous major roads with high traffic density, including six out of the seven national roads that pass through the entire province, it was selected as the focus of this research. Notably, National Road No. 03, which connects the coastal regions to the southern areas, passing through Constantine, Skikda to the north, and Oum el Bouaghi and Batna to the south, extending all the way to Biskra and Touggourt, is characterized by a significant traffic volume. The presence of such a dense road network in the city reflects its substantial importance at both the national and local levels.

Despite the significance of this network, it suffers from severe congestion and an inability to accommodate the growing traffic volume. This is attributed to the city's substantial urban expansion, which

has not been accompanied by corresponding developments in transportation infrastructure. Additionally, another contributing factor is the noticeable increase in the national vehicle fleet.

Materials and Methods.

I. General Concepts Related to the Subject.

1. Concept of a Road Network.

A road network is a system of interconnected roads that form a structure. This concept complements the concept of a road, as a road facilitates movement between two specific points, while a network enables movement within a two-dimensional area. When studying transportation networks to understand spatial organization in a specific region, the analysis goes beyond the overall characteristics of the network. It seeks to identify the spatial structure of the relationship between the nodes and the roads that make up the network. (GHOURABI NADJLA, 2009).

2. Road Capacity.

Also known as road throughput, capacity refers to the maximum number of vehicles that can pass a given point on a free-flow section of road within a specific time period. Roads are designed to accommodate a specific capacity and a projected traffic volume. For example, the capacity of a single lane on a freeway is estimated at 200 passenger cars per hour according to the 1994 HCM. It's important to note that the operational capacity of roads can be significantly lower than their design capacity due to various factors, including the presence of large vehicles such as trucks and buses, random traffic interactions, and geometric design elements like lane width and shoulders. Therefore, a lane with a theoretical capacity of 200 passenger cars per hour (under ideal design conditions) may not actually accommodate this volume, and the capacity may decrease by a certain percentage depending on the aforementioned factors. (ALI BIN SAEED AL- GHAMDI 2001).

Several factors affect road capacity and can lead to a decrease in the level of service, such as road width (capacity increases by approximately 500 vehicles per hour for every 3 meters increase in width), pedestrians (average vehicle speed decreases by 6.5 km/h for every 1000 pedestrian-km/h), and weather and road surface conditions (uneven surfaces and rainy weather reduce traffic speed). (ALI BIN SAEED AL- GHAMDI 2001).

3- Traffic.

Traffic is the movement of vehicles within a road network within a city or between cities. This movement is a means for people and goods to move to achieve specific goals within a road and transportation network in different directions.

4- Traffic Volume.

Traffic volume is defined as the number of vehicles (regardless of type) passing a specific point on a road during a specific time period. Its unit is vehicles/day or vehicles/hour. In some cases, the counting period may not exceed an hour, such as (15, 20, 30 minutes), in which case we call the traffic volume "flux". It is worth noting that the most common counting periods are:

- 24 hours a day throughout the year
- 24 hours a day throughout the week
- 16 hours of the day only
- Peak periods only (the peak hour is the hour during which traffic volume reaches its peak at a specific section) (TAWFIK SALEM 1985).

5- Traficc Density.

Traffic density is the number of vehicles occupying a specific length of road at a given moment. In some cases, density may be a better indicator than volume to measure the road condition and assess the level of service of the road (AHMED KAMAL AL-DIEN AFIFI).

II. Detailed Study of Traffic Volume.

1- Definition of Traffic Volume.

Traffic volume is often referred to as traffic count, traffic flow, or traffic intensity. Essentially, it involves counting the number of vehicles, classifying them, and determining their direction at a specific point on a road over a defined period. This period could be the peak hour, several hours of the day, or even months of the year. The duration of the count varies depending on the study's objectives. There are various types of

traffic counts, such as street counts, intersection counts, traffic composition counts, passenger counts, and directional counts, among others. However, the most common and widely used is vehicle counts.

Traffic volume is one of the most important factors in determining the elements of highway engineering design, such as the number of lanes and the road's classification.

2- Purpose of Studying Traffic Volume.

The significance of studying traffic volume lies in:

- Measuring the current traffic volume and composition and predicting future traffic volume that the road can accommodate.
- Determining the importance of a road.
- Studying intersections, traffic systems, and how to control traffic flow to improve capacity.
- Understanding the annual increase in traffic on major roads to forecast future traffic volumes.
- Clarifying the picture in terms of choosing alternative routes or not.
- Engineering the road network based on current and future traffic volumes.
- Improving the existing network.
- Justifying the opening of new roads. (TAWFIK SALEM 1985).

3 -Types of Traffic Volume.

3-1 Average Daily Traffic (ADT).

TJM This is the total number of vehicles that pass a given point on a road, divided by the number of days of the count (more than one day but less than a year). The unit is vehicles per day. ADT is a common measure in traffic engineering used to assess the volume of traffic on a road. It provides a general indication of the level of traffic congestion and is often used for planning and design purposes:

$$ADT = \frac{\textbf{Total Measured Traffic Volume}}{\textbf{Number of measurement days}}$$

3-2 Annual Average Daily Traffic (AADT).

This is the total number of vehicles that pass a given point on a road in a year, divided by the number of days in a year (365). The unit is vehicles per day. AADT is a refinement of ADT, providing a more accurate representation of the annual traffic volume. It is useful for long-term planning and for comparing traffic volumes between different years or locations. Annual measured traffic volume:

$$AADT = \frac{\textbf{Annual measured trffic volume}}{\textbf{Number of days in a year}}$$

3-3 Peak Hour Volume (PHV).

This is the highest hourly volume of traffic during the peak period of a day, averaged over a 13-week period. The unit is vehicles per hour.PHV is a critical measure for traffic engineers as it helps identify the periods of maximum congestion. It is used for designing roadways, traffic signals, and other transportation infrastructure.

4 - Methods and Techniques of Traffic Volume Measurement.

Traffic volume measurement is conducted by specialized personnel using either traditional or automated methods.

4-1 Manual Counting.

This method is considered very traditional and one of the oldest counting methods. An observer manually counts vehicles and fills out a form to classify them. Although this method is less accurate than the automated method, it allows us to count vehicles in addition to their type, direction, and number of passengers, if necessary.

4-2 Automated Counting.

This method uses traffic counting devices equipped with an air tube that spans the counting line and records a pulse for each vehicle that passes over it. It is generally known that there is an acceptable error rate

in this type of counting, ranging from 3% to 5%. This type of counting is used for long periods to determine annual traffic volume. Traffic counting can also be done using counters placed in the middle of the road between intersections to count the number of passing vehicles. Additionally, traffic can be counted using imaging, which is one of the latest methods used in counting. Digital cameras are placed on the desired traffic axes, and the cameras sequentially undertake the task of counting vehicles.

4-3 Moving Vehicle Method.

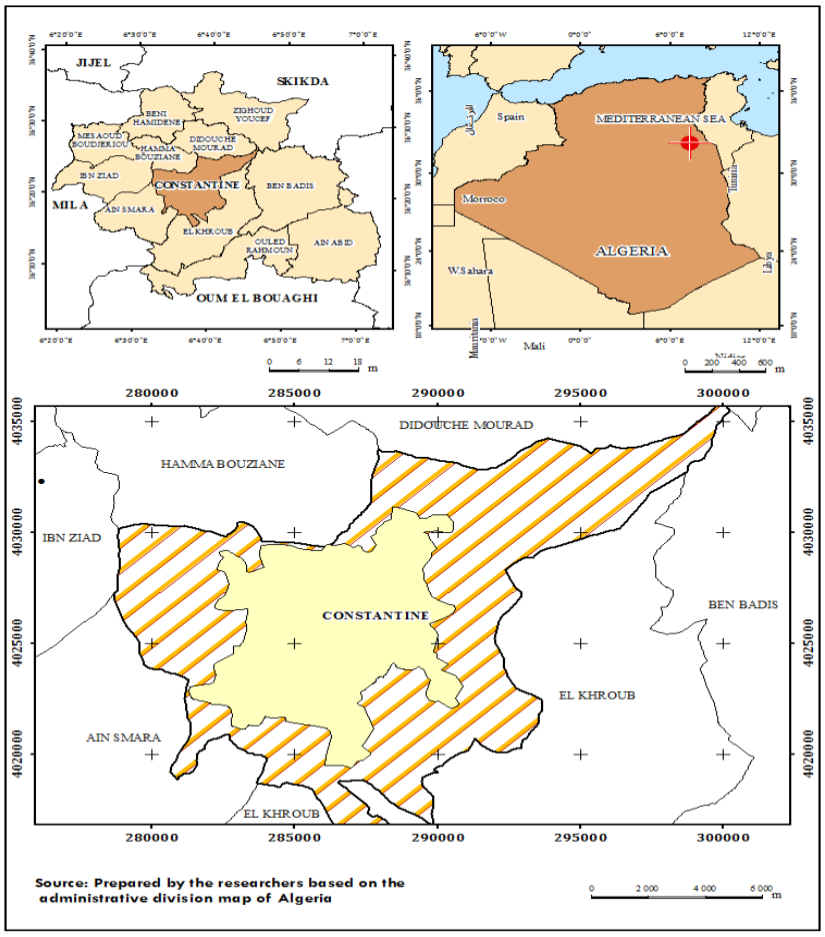
In this method, vehicles are counted using a vehicle that moves along a specific section of the road for a specific period. An observer inside the vehicle counts the number of vehicles passing in the direction of their vehicle, as well as the vehicles traveling in the opposite direction.

Result and Discussion.

I. Traffic Volume and Road Network Study of Constantine City.

1. Location Constantine City.

Constantine city occupies an important and strategic location in the province as it is located in its center, giving it great importance at the provincial, regional, and even national levels. It also lies in the center of a large urban agglomeration, making it an open area for all flows from all directions. It extends over an area of approximately 232 km². It is located at the center of the vital triangle formed by the surrounding cities. To the north, we find the agglomeration of Bekira, Hamma Bouzian, and Didouche Mourad. To the south, we find the Mohamed Boudiaf International Airport. To the southwest, we find the new city of Ali Mendjeli, and to the southeast, we find the city of El Khroub. Constantine city also represents the center from which the road network of the large urban agglomeration branches out. It also represents the most important node for roads that branch out towards different cities and the highway with its completed and uncompleted sections that pass through its southern and eastern parts. (BEN CHALAL & BEN KADEM WAFA, 2018).



Map number (01): Location of city of Constantine

2- Classification of Roads in Constantine City:

A road is defined as a paved surface above ground for the passage of vehicles and pedestrians, facilitating their movement from one place to another. Several indicators can be used to classify roads, as road classification is subject to various considerations, including:

- Classification based on importance and capacity ,This classification considers the significance of the road in the transportation network and its ability to accommodate traffic volume.
- Classification based on the responsible authority,This classification is based on which government agency is responsible for the construction, maintenance, and use of the road.
- Classification based on morphological and engineering characteristics**,** This classification considers the physical shape and structure of the road, as well as traffic characteristics such as traffic volume and composition.
- Classification based on topography and location, This classification takes into account the geographical features and the specific location of the road.
- Classification based on road condition, function, and type of use**,** This classification considers the current state of the road, its purpose, and the types of vehicles that use it.

Roads in Algeria are classified according to administrative, technical, and functional criteria.

a- Administrative Classification: Under this classification, roads are categorized into highways, national roads, provincial roads, and municipal roads.

b- Technical Classification: This classification divides roads into four types: primary roads, secondary roads, tertiary roads, and rural tracks.

c- Functional Classification: Based on their usage, roads are classified into pedestrian paths, residential streets, industrial service roads, and roads for general use.

In this research, we relied on the first classification, which is the administrative classification. We have highlighted the national and provincial roads of the city of Constantine and conducted a study on them, as shown in the following table and map number (02).

Table 1. National and Provincial Roads in the City of Constantine

Roads	Length of Roads (m)	Width of Roads (m)
RN 05	10.38	26
RN 27	5.11	17
RN 79	11.04	20-29
RN 03	9.63	25-30
CW 175	3.03	6
CW 133	2.32	16
CW 50	1.02	15
CW 51	4.63	17
CW 02	4.21	7
CW 02A	2.65	5
CW 21	3	16

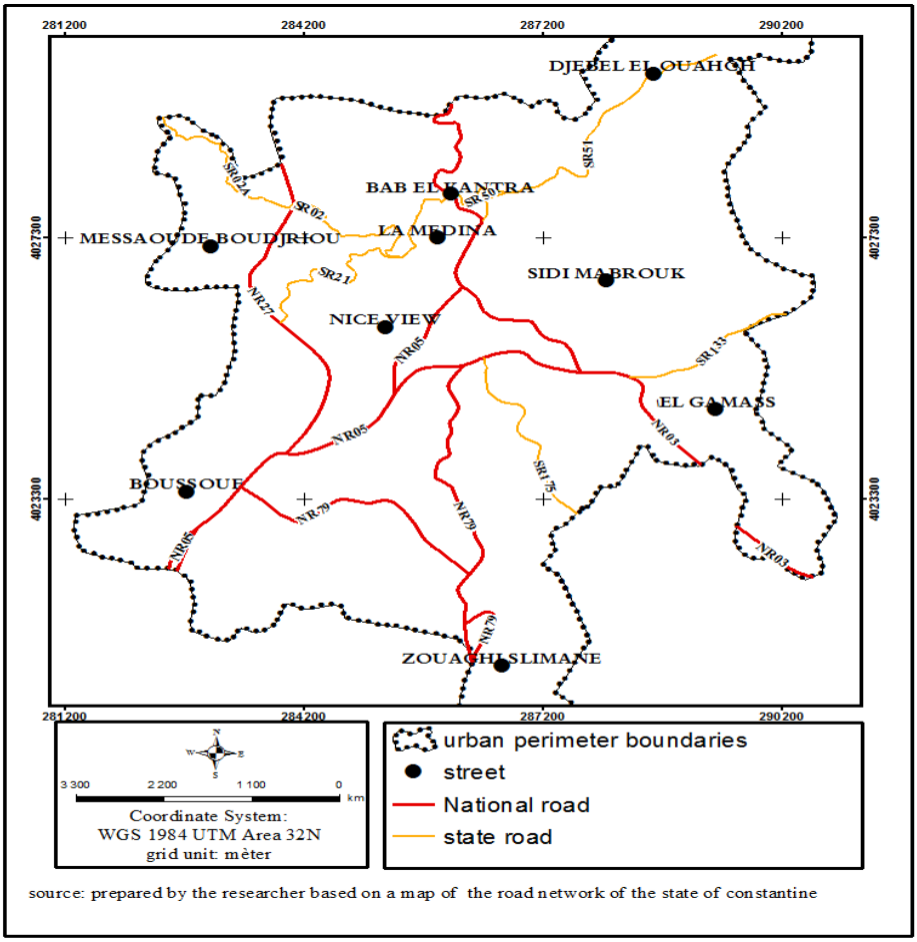
Source: Researchers, based on the Transportation Plan.

3- Analysis of Traffic in Constantine City.

3.1 Study of Average Annual Daily Traffic (AADT).

Traffic studies are conducted to obtain traffic characteristics. These studies employ new methods to measure the level of service of a road by relying on the average daily vehicle traffic and the road's traffic capacity. Consequently, the resulting costs can be calculated. Traffic volume on any road is measured by the number of vehicles passing a specific point or station on the road within a given time period. It is expressed as the average daily traffic (ADT) or the average annual daily traffic (AADT), with units of vehicles per time (GHOURABI NADJLA , 2021).

The latter is more commonly used to determine the need for future expansion, as well as to identify the most suitable periods for maintenance. It is also used in the field of traffic safety in relation to calculating estimates of distances traveled by vehicles on road networks.



source: prepared by the researcher based on a map of the road network of the state of constantine

Map number (2): National and Provincial Roads in the City of Constantine

The AADT data can be obtained from the National Directorate of Public Works, which is responsible for conducting field surveys. During this process, they rely on 9 vehicle classifications, namely:

- Passenger cars
- Trucks
- Light trucks
- Buses
- Tractor-trailer
- Agricultural vehicle
- Private vehicle
- Semi-trailer truck
- Motorcycles

Although this field study is of utmost importance, it is not conducted annually. Consequently, the data from this study is outdated, dating back to 2008. To update this data, we have estimated the TJMA values obtained from the Directorate of Public Works using the following equation:

$$T = (1 + t)^n \times t_0$$

T*:* Average traffic volume to be estimated
***t*:** Annual growth rate of the population, estimated at 5%
***n*:** Difference in years between the estimated rate and the base rate
t_0: Base year average daily traffic

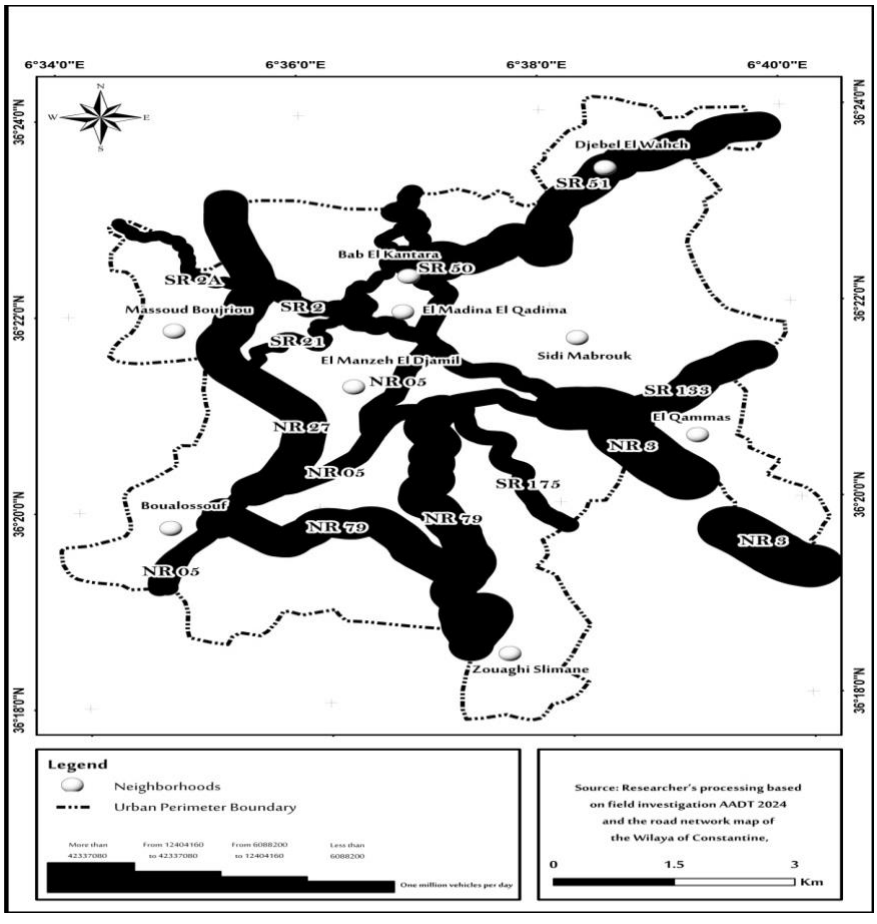
Based on the preceding experiment, we generated Table 2 and Figure 3.

Table 2. Average Daily Traffic Volume in Constantine City

Roads	AADT 2024
RN 05	9802440
RN 27	18352200
RN 79	13052400
RN 03	42337080
CW 175	9084120
CW 133	16442520
CW 50	6088200
CW 51	12404160
CW 02	6762720
CW 02A	676720
CW 21	2470320

Source: Directorate of Public Works and Researcher's Analysis

Based on the data from the previous table and Map 03, National Road 03 (RN03) recorded the highest average annual daily traffic volume of 4,233,780 vehicles/day. This is attributed to the fact that this road connects the coastal regions to the southern regions, linking Constantine to Skikda in the north, and to Oum el Bouaghi and Batna in the south, extending all the way to Biskra and Touggourt. Additionally, National Road 27 recorded the second-highest average annual daily traffic volume of 2,200,183. This is due to the road's significance as one of the city's main thoroughfares. Located in the northwestern part of the city, it connects Constantine to Jijel in the northeast and passes through two districts of the province: Constantine and Hamma Bouzian. Furthermore, this road serves as a ring road for the city, encircling the western and southwestern neighborhoods of Constantine and culminating at National Road 5. Its length within the city constitutes approximately 59.85% of its total length within the entire province, which is 27.4 kilometers.



Map (03) Annuel Average daily traffic on national and state rods in the city of Constantine.

The existence of such a road network within the city of Constantine gives it significant national and provincial importance. However, despite its importance, this network is characterized by severe congestion along its entire length and an inability to accommodate traffic flow. This is due to the significant urban expansion that the city is experiencing, leading to the expansion and development of infrastructure, as well as a rise in the national vehicle fleet.

3-2 Traffic Density Study.

Traffic density refers to the number of vehicles in a unit length of road and is field-measured as the number of cars per number of in habitants, the number of cars per road length, and finally, the number of vehicles per area (SAID ABDE 2010).

3-2-1 Traffic density per capita is a measure of the number of vehicles passing a given point on a road during a specific time period, divided by the total population of the area served by that road. In this case, it involves calculating [AADT] and determining the population of the municipality where the road is located.

$$\textbf{Traffic density per capita} = \frac{\boldsymbol{AAADT}}{\textbf{Population served by the road}} = \textbf{Vehicles/pop}$$

3-2-2 Vehicle density per road length: Vehicle density per road length: This is calculated by dividing the number of vehicles on the network at a given time by the total length of roads.

$$\textbf{Vehicle density per road length} = \frac{\boldsymbol{AAADT}}{\textbf{Road length in the network}} = \textbf{Vehicles/km}$$

Table 3. Constantine City: Traffic density relative to road length

Roads	Length	AADT	density Vehicle/km
RN05	10.38	9802440	944358.38
RN27	5.11	18352200	359142857
RN79	10.04	13052400	129983711
RN03	9.63	42337080	4396244.91
CW175	3.03	9084120	2995852.04
CW133	2.32	16442520	7084770.51
CW50	1.02	6088200	5950602.64
CW51	4.63	12404160	2681217.308
CW02	4.21	6762720	165137.30
CW2A	2.65	676720	254806.41
CW21	3	2470320	823575.410

Source: Prepared by Researcher's 2024.

Constantine recorded a moderate traffic density relative to road length, estimated at 13,050807.27 vehicles/km. Both the CW133 and CW50 provincial roads recorded extremely high traffic densities, estimated at 78477.51 vehicles/km and 2681217.308 vehicles/km, respectively. The increase in density on these two roads is attributed to the high average traffic volume, in addition to the short length of each road.

The national roads number 03 and 27 recorded the highest traffic densities, which is due, as previously mentioned, to the importance of these roads within the city of Constantine and their strategic locations. The lowest traffic density relative to road length was recorded on the provincial road number 02.

3-2-3 Traffic density per unit area.

This represents the number of vehicles passing through an open-ended time period over the area of the network, and is expressed as vehicles per square kilometer.

Table 4. Constantine City Traffic density per unit area

Roads	The municipality's area traversed by the road	AADT	Density Vehicles/km²
RN05	387.73	9802440	25281.61
RN27	312.81	18352200	58668.84
RN79	686.23	13052400	19020.45
RN03	686.23	42337080	61695.18
CW175	476.28	9084120	19073.07
CW133	787.1	16442520	20890
CW50	231.63	6088200	26284.16
CW51	231.63	12404160	53551.61
CW02	231.63	6762720	29196.22
CW2A	231.63	676720	29196.22
CW21	231.63	2470320	10664.94

Source: Prepared by Researcher's 2024.

The average traffic density per square kilometer in the city of Constantine was found to be 20,522,353 vehicles/km². The highest traffic density was recorded on both RN05 and RN27 roads, with densities of 695,1861 vehicles/km² and 586,688.4 vehicles/km², respectively. Conversely, the lowest traffic density per square kilometer was recorded on the provincial road CW21 and the national road RN79.

Conclusions

Constantine is characterized by a highly significant road network that covers the entire urban fabric and serves as a vital link between different parts of the country. The total length of this network is estimated at 157.5 km according to the Directorate of Public Works (highways account for 44 km, national roads for 59.5 km, provincial roads for 42.8 km, and municipal roads for 21.2 km). Despite the importance of this network, it suffers from an inability to accommodate the traffic volume. This is due to the weak infrastructure of facilities and services on the one hand, and urban sprawl and the high density of areas on the other. This has resulted in numerous problems, primarily traffic congestion and road deterioration. Most roads are congested and difficult to navigate, especially during peak hours, reflecting a low level of service. Therefore, it is necessary to implement traffic control measures to improve the situation, in addition to allocating specific roads for heavy vehicles. This will help improve traffic flow, reduce road deterioration, and alleviate congestion.

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