ENGINEER

international scientific journal

ISSUE
4, 2024 Vol. 2
ISSN
3030-3893

A bridge between science and innovation

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

ENGINEER

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ISSN 3030-3893

VOLUME 2, ISSUE 4

DECEMBER, 2024

engineer.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY

ENGINEER

INTERNATIONAL SCIENTIFIC JOURNAL
VOLUME 2, ISSUE 4 DECEMBER, 2024

Founder of the international scientific journal “Engineer” – Tashkent State Transport University, 100167, Republic of Uzbekistan, Tashkent, Temiryo‘lchilar str., 1, office: 465, e-mail: publication@tstu.uz.

The “Engineer” publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

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- Architecture.

Tashkent State Transport University had the opportunity to publish the international scientific journal “Engineer” based on the **Certificate No. 1183** of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. **ISSN 3030-3893.** Articles in the journal are published in English language.

Traffic flow velocity analysis on urban roads: a study of Uzbekistan's key transportation route

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Abstract: The velocity of traffic flow is the primary indicator of road traffic performance and reflects the main goal of movement on the road. This study investigates the velocity characteristics of traffic flow on selected urban road segments in Uzbekistan, including sections of 4R21 (17–18 km), A373a (23–24 km), and 4R2 (20–21 km). By analysing modal speeds, velocity distribution curves, and cumulative density, the research highlights the impact of road conditions and traffic density on overall traffic dynamics. The findings aim to provide actionable insights for improving urban transportation systems.
Keywords: traffic flow velocity, modal speed, urban road conditions, traffic density, traffic analysis

1. Introduction

The speed of traffic flow is an essential parameter for assessing the efficiency and safety of road networks. In Uzbekistan, understanding the dynamics of traffic flow has become increasingly important due to urban expansion and the growing number of vehicles. Traffic speed is influenced by factors such as road conditions, vehicle characteristics, and driver behaviour, making it a critical focus area for transportation studies.

As emphasized by [1], "The development of road infrastructure is a crucial element in fostering economic growth and ensuring regional connectivity, requiring substantial investments and innovative approaches to modernize and maintain the transportation network."

The most objective indicator on the road is a graph showing the variation in speed along the entire route. However, plotting such a speed variation curve requires the use of a laboratory vehicle along the route. This presents certain practical challenges and, in most cases, is not feasible. Therefore, in practice, conclusions are drawn by measuring the instantaneous speed of vehicles at characteristic sections of the road when organizing traffic.

The speed of vehicles and traffic flow is largely dependent on the "Vehicle – Driver – Road – Pedestrian – Environment" (V-D-R-P-E) system. Speed selection is determined by two main criteria: minimizing travel time; ensuring traffic safety [2].

Moreover, the driver's skill, experience, psychophysical state, and purpose of travel significantly influence speed selection. Additionally, factors such as the technical condition of the vehicle, road conditions, environmental factors, and pedestrian activity play a major role in speed variability.

Traffic flow velocity serves as a critical parameter for assessing road network performance, influencing both safety and efficiency. According to Zhu et al. [3], analysing traffic velocity patterns helps identify congestion hotspots and optimize road usage. Similarly, Wang et al. [4] highlight the role of traffic flow analysis in reducing urban transport emissions. Li and Song [5] emphasize that integrating speed distributions into urban planning can improve traffic safety and efficiency. Furthermore, studies by Kim et al. [6] demonstrate the effectiveness of real-time monitoring systems in managing traffic flow and mitigating congestion.

This study examines traffic flow velocity on specific road sections in Uzbekistan. It aims to analyse modal speeds and evaluate the effects of road conditions and traffic density on the velocity of individual vehicles and overall flow.

2. Research Methodology

The process of changing the reactive power of power supply systems from symmetric three-phase primary currents to the output signal in the form of secondary rated voltage and the modeling and research of the devices and sensors involved in this process are carried out on the basis of the following algorithms:

ATPCCS devices with different physical and technical characteristics that provide the conversion of electrical energy into a secondary signal, the process of energy and signal conversion in energy sources, and the process of monitoring and modeling the structure of the control sensor:

A graphical representation of the process by which the magnetic transformer converts the magnetic flux Φ_μ into a three-secondary output voltage U_{out}.

This study utilized empirical formulas and observational techniques to analyse traffic flow velocity. Data were collected on three road segments using a combination of manual and automated methods. Zhu et al. [3] advocate for the use of GPS and sensor-based tools for precise traffic measurements. Wang et al. [4] emphasize the importance of employing dynamic data collection methods to capture temporal variations in traffic flow. Li and Song [5] suggest that incorporating automated video analysis enhances the accuracy of traffic studies. The research also drew from methodologies outlined by Kim et al. [6], focusing on adaptive techniques to analyse speed distributions under varying road conditions.

The maximum constructive speed of a vehicle ($Vmax$) depends on the power of its engine. Observations indicate that drivers only occasionally operate at $Vmax$ for short durations. Under good road conditions, vehicle speeds typically range between 0.7–0.85 $Vmax$, which is primarily observed on straight, level road segments.

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In practice, road conditions often include inclines, declines, minor curves in the plan, reduced visibility distances, and vertical curvature. Additionally, variations in traffic volume and composition significantly affect instantaneous speed values. Under real-world road conditions, the speed of individually moving vehicles can range from 150–120 km/h to as low as 40–30 km/h [7].

We will examine the variation in traffic flow velocity in relation to road conditions and traffic volume using examples from urban roads in Uzbekistan.

The average traffic flow velocity under different road conditions can be determined using the following empirical formula:

$$Vavg = Va \times Kd \qquad (1)$$

Where:

Va: instantaneous speed of free-flowing vehicles (km/h),

Kd: coefficient accounting for speed variations based on road conditions.

To determine the effect of traffic volume on traffic flow velocity, the following formula is used:

$$Vavg = Va \times (1 - R \times N) \qquad (2)$$

Where:

R: coefficient accounting for speed reduction due to traffic volume,

N: traffic volume (vehicles/hour).

Measuring Traffic Speed. The simplest and most convenient method for measuring traffic speed involves using a stopwatch. For this, a 50–100 m section of the road is marked. To precisely record the time of entry and exit, markers or transverse lines are placed on the road. Observers are positioned 10–15 m from the road to start and stop the stopwatch as vehicles enter and exit the marked section. The results are recorded in a prepared table [8].

Automatic Measurement Methods. The following automatic measurement methods and detectors are used to study traffic speed:

Table 1

Measurement Methods and Detectors

Measurement Method	Detector Types
Mechanical-Contact	Pneumatic, electronic contact, magnetic, vibrational, roller
Inductive-Magnetic	Electromagnetic, magnetic
Pulsed Sensing	Infrared, ultrasonic, radiolocation
Vehicle Radiation	Infrared radiation of engines, vehicle noise measurement
Photoelectric	Photography, stereography, cinematography
Television	Video recording, pulse-transmitting devices
Mobile Laboratory Vehicles	Speed measurement using various onboard apparatus

For urban roads in Uzbekistan, variations in Kd values based on surface roughness are provided in the following table:

Table 2

Surface Roughness and Kd Values [9]

Surface Roughness (km/cm)	≤80	80–120	120–170	170–220	220–300	>300
Kd Value	0.96	0.92	0.88	0.85	0.80	0.68

To measure and analyse traffic flow velocity, observations were conducted on selected road sections:

— 4R21 (17–18 km);

— A373a (23–24 km);

— 4R2 (20–21 km).

Data were collected using mechanical, optical, and automated measurement tools, including contact sensors, inductive-magnetic devices, and video-based systems (Figure 1).

Figure 1. Determining Traffic Flow Velocity

3. Results and Discussion

Speed distribution for each section was analysed. Graphs

(Figure 2 and Figure 3) were created to represent density and cumulative density.

Modal Speeds:

- 4R21: 53 km/h;
- A373a: 52.5 km/h;
- 4R2: 54 km/h.

Key factors affecting velocity include:

Road Conditions: Surface quality, visibility radius, and gradients.

Traffic Composition: Variations in vehicle types and driver behaviour.

Environmental Conditions: External factors such as weather and pedestrian activity.

Velocity distribution and cumulative density curves were plotted for all sections. These curves help identify critical speed thresholds (e.g., 15%, 50%, 85%).

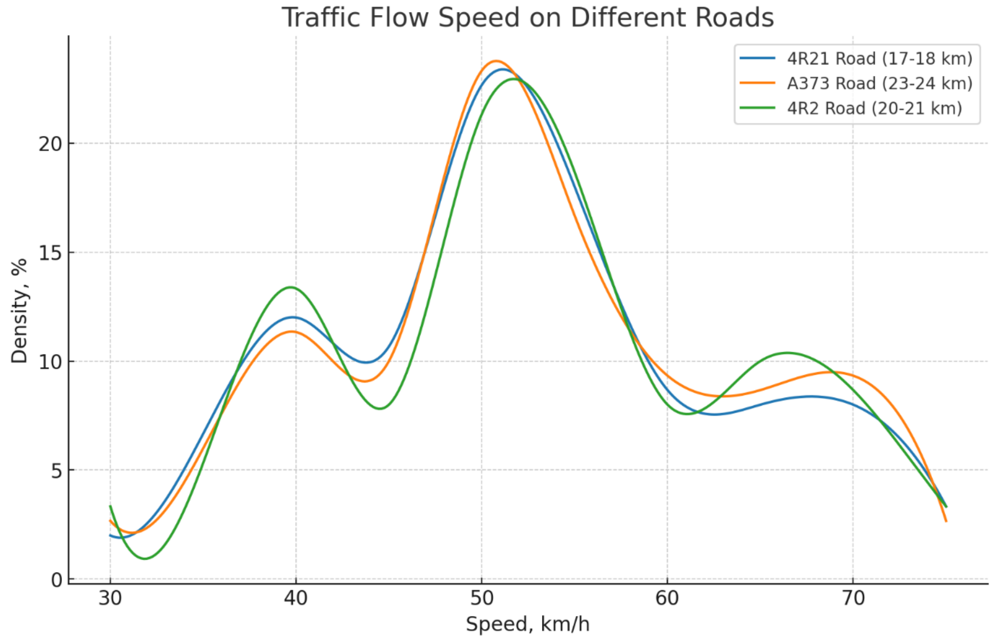

Figure 2. Speed Distribution Curve

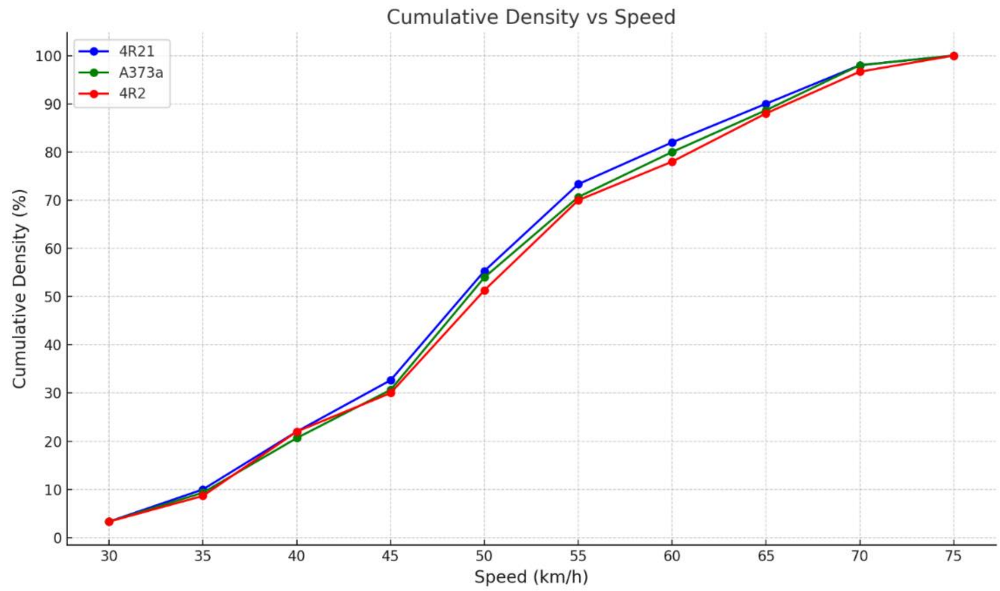

Figure 3. Cumulative Distribution Curve

Traffic flow velocity measurements on three road sections in Uzbekistan—4R21 (17–18 km), A373a (23–24 km), and 4R2 (20–21 km)—revealed variations in modal and percentile speeds.

For section 4R21, the modal speed ($Vmod$) was 53 km/h, with 15th, 50th, and 85th percentile speeds of 40 km/h, 52.5 km/h, and 63.5 km/h, respectively. Section A373a had a modal speed of 52.5 km/h, with percentile speeds of 41 km/h, 53 km/h, and 65 km/h. Section 4R2 recorded a modal speed of 54 km/h and percentile speeds of 41.5 km/h, 51 km/h, and 66 km/h.

These findings highlight the variability in traffic flow dynamics and underscore the importance of modal and percentile speeds in traffic management and road safety optimization.

4. Conclusion

This study on traffic flow speed in Uzbekistan highlights the impact of road conditions, vehicle status, driver skills, and environmental factors on movement. The derived empirical formulas offer a way to predict speed based on factors like sight distance, road smoothness, and curvature. Experiments on sections of roads such as 4R21, A373a, and 4R2 revealed key speed values, showing how traffic density and road conditions affect vehicle speeds. The findings provide valuable insights for improving traffic management, road design, and safety in Uzbekistan.

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