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THE LOW OF SCIENTIFIC RESEARCH METHODS FOR THE OPERATING SPEED OF URBAN PUBLIC PASSENGER TRANSPORT ON ROUTES

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Abstract. This paper presents the theoretical foundations of experimental research, the stages of experimental planning, and the methods used to investigate the operating speed of urban public passenger transport. The study analyzes the factors influencing vehicle operating speed, including road conditions, traffic flow, weather conditions, pedestrian and cyclist movements, and traffic control devices. The stationary observation method was employed as the primary research technique to determine vehicle speed. The applicability of measuring instruments such as stopwatches, photographic and video recording equipment, radar devices, and other speed measurement tools is discussed. Furthermore, methods for collecting, processing, and analyzing experimental data are presented to improve road traffic safety and to evaluate the operating speed of public transport more effectively.

Keywords: experimental research, experimental design, public transport, operating speed, traffic flow, road conditions, road traffic safety, stationary observation method, photo-video observation, stopwatch, video camera, radar, traffic density, road elements, speed profile, traffic flow analysis.

Introduction An experiment is a method of scientific investigation through which a phenomenon is studied under controlled and manageable conditions. An engineering experiment is defined as a set of experiments united by a common objective and conducted within a single framework of spatial and temporal constraints [18].

Experimental research constitutes an integral part of scientific investigation. The reliability of experimental studies is considered one of the principal criteria for assessing the quality of research. In turn, the reliability of experimental results largely depends on the proper planning and organization of the experiment.

Experimental design is the process of determining the number, sequence, and conditions of experiments required to achieve the research objective with the desired level of accuracy.

The process of planning experimental research includes the following stages:

1. Preparation for experimental research;
2. Identification of the parameters to be investigated;
3. Selection of appropriate experimental methods;
4. Conducting the experiments;
5. Collection and preliminary processing of experimental data;
6. Generalization and analysis of experimental results;
7. Comparison of experimental findings with theoretical research results;
8. Assessment of the reliability of the obtained results.

Applying the above-mentioned stages makes it possible to achieve the objectives of experimental research efficiently and accurately.

Experimental investigation of the operating speed of urban public passenger transport is aimed at determining the influence of road conditions, traffic flow characteristics, and other external factors on vehicle speed along specific sections of the urban road network.

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The data collected during experimental investigations are used to determine free-flow speed and to analyze road geometry, characteristics of traffic accidents, and traffic flow parameters. Such investigations provide detailed information on one or more of the following:

- Average traffic intensity of motor vehicles, cyclists, and pedestrians;
- Variations in vehicle speed by traffic direction and time period;
- Road elements contributing to traffic accidents, including horizontal and vertical curves, access points, drainage systems, pavement conditions, limited sight distance, roadside objects, traffic signs, road markings, and edge lines;
- Road lighting conditions and traffic control devices;
- Recommendations regarding speed limits.

The experimental investigation of factors influencing the operating speed of public transport includes the analysis of the following variables:

- Road location and geometric configuration;
- Road geometric elements (horizontal and vertical curves, intersections, junctions, road lighting, etc.);
- Areas where speed restrictions have been established;
- Weather conditions;
- Route characteristics;
- Sections with limited visibility;
- Pedestrian traffic characteristics;
- Cyclist traffic characteristics;
- Date and time of the survey;
- Traffic control devices (traffic signs, pavement markings, barriers, etc.);
- Type and condition of the pavement;
- Presence of facilities generating intensive passenger demand;
- Schools and children's institutions located near the roadway;
- Surrounding environmental conditions;
- Landscape design of the road corridor.

In certain situations, road authorities may establish speed limits based on one or several of the factors listed above.

The experimental investigation of the operating speed of urban public passenger transport is aimed at determining the influence of road conditions, traffic flow characteristics, and other factors on vehicle speed along specific sections of the urban road network.

The data collected during experimental studies are used to determine free-flow speed and to analyze road network geometry, the characteristics of traffic accidents, and traffic flow parameters. These studies provide detailed information on some or all of the following:

- the average traffic volume of motor vehicles, cyclists, and pedestrians;
- variations in traffic speed by direction and time of day;
- road elements that may contribute to traffic accidents, such as horizontal and vertical curves, access points, drainage systems, pavement conditions, restricted sight distance, roadside objects, traffic signs, road markings, lane markings, and other infrastructure elements;
- roadway lighting conditions and traffic control devices;
- recommendations for establishing appropriate speed limits.

The experimental investigation of factors influencing the operating speed of public transport includes the study of the following variables:

- road location and alignment;

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- roadway geometric elements (horizontal and vertical curves, intersections, junctions, roadway lighting conditions, etc.);
- areas where speed restrictions have been established;
- weather conditions;
- route characteristics;
- areas with limited visibility;
- pedestrian traffic characteristics;
- cyclist traffic characteristics;
- date and time of the survey;
- traffic control devices (traffic signs, pavement markings, road barriers, etc.);
- pavement type and condition;
- the presence of facilities attracting large numbers of passengers;
- schools and childcare institutions located near the roadway;
- the surrounding environmental conditions;
- landscape design of the roadway.

In certain cases, road authorities may establish speed limits based on one or more of the factors listed above.

Since public passenger transport operates within the general traffic stream, the study of operating speed should begin with the investigation of hazardous road sections where traffic accidents are more likely to occur. Therefore, it is advisable first to identify the factors affecting vehicle speed within the study area and then evaluate the extent to which these factors contribute to traffic accidents. This process can be divided into two stages:

1. Collection, processing, and analysis of experimental data;
2. Division of the study area into homogeneous zones.

Various methods are available for measuring the operating speed of public transport along its route. Based on the equipment used for data collection, these methods can be classified into three groups:

- portable devices suitable for field measurements at multiple locations (stopwatch, radar gun, measuring tape, etc.);
- in-road devices installed within the pavement structure (such as pneumatic tubes);
- permanently installed roadside or overhead devices (radar sensors, automatic recording systems, etc.).

Ideally, speed data collection should satisfy the following requirements:

- traffic conditions should remain unaffected during observations, allowing data to be collected under normal operating conditions;
- free-flow vehicles should be selected, while vehicles traveling in platoons should be excluded (the time headway between successive vehicles should generally exceed five seconds);
- where necessary, information on vehicle type and speed should also be collected to identify the speed profiles of different categories of vehicles.

The use of modern methods for evaluating vehicle operating speed is of great importance because they make it possible to consider all influencing factors both individually and collectively. Among these factors, road conditions are regarded as the primary determinant of vehicle speed. Therefore, investigating the influence of roadway characteristics on operating speed is considered one of the key objectives of transportation research. Data for such analyses may be collected using aerial photography, mobile laboratories, or stationary observation methods.

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In the present study, the **stationary observation method** was adopted as the primary research approach. Using this method, the following traffic characteristics were determined: the **15th, 50th, 85th, and 95th percentile speeds**, vehicle trajectories, headways, spacing between vehicles, and traffic density. Data collection was carried out using a stopwatch, camera, video camera, stationary camera, and speedometer.

Public passenger transport operates within the general traffic stream; therefore, studying operating speed should first focus on identifying hazardous road sections and analyzing the factors contributing to traffic accidents. To achieve this, it is necessary to determine the factors affecting vehicle operating speed in the study area and evaluate the extent to which these factors contribute to the occurrence of road traffic accidents. This process can be divided into two stages:

- Collection, compilation, and analysis of experimental data;
- Division of the study area into functional traffic zones.

Various methods are available for measuring the operating speed of public transport vehicles along their routes. These methods can be classified into three groups according to the equipment used for data collection:

- Portable devices that can be easily deployed at multiple locations (stopwatch, radar, measuring tape, etc.);
- In-road devices installed on or within the pavement (such as pneumatic tubes);
- Stationary devices installed above or alongside the roadway (radar systems, automatic recording devices, etc.).

Ideally, speed data should be collected under the following conditions:

- Traffic should remain undisturbed, and observations should reflect normal traffic conditions;
- Free-flow vehicles should be selected, excluding vehicles traveling in platoons (where the headway between successive vehicles is less than 5 seconds);
- When necessary, information on vehicle type and speed should also be collected to identify the speed profiles of different categories of vehicles.

When evaluating operating speed, it is essential to employ modern methods that consider all influencing factors individually and collectively. Road conditions are regarded as one of the most significant factors affecting vehicle operating speed. Therefore, investigating the influence of roadway geometric and operational characteristics on vehicle speed is of particular importance. Data required for such analyses may be collected using aerial photography, mobile laboratories, and stationary observation methods.

In this study, the **stationary observation method** was adopted as the primary research technique. Using this method, the following traffic characteristics were determined:

- 15th percentile speed;
- 50th percentile speed (median speed);
- 85th percentile speed;
- 95th percentile speed;
- Vehicle trajectories;
- Headways and spacing between vehicles;
- Traffic density.

The following equipment was used for data collection:

- Stopwatch;
- Digital camera;
- Video camera;

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- Stationary surveillance camera;
- Speedometer (speed measuring device).

A stopwatch is one of the simplest and most practical instruments for measuring vehicle speed. The measurement accuracy of the stopwatch method is approximately **0.3 seconds**.

For this purpose, a **measurement section (baseline)** is selected. The baseline length is generally:

- **50 m** for road sections where the speed limit is **60 km/h**;
- **100 m** for road sections with higher speed limits.

Vehicle speed is calculated according to the travel time required to pass through the baseline. To accurately identify the entry and exit points of the measurement section, markers are installed or transverse lines are drawn across the traffic lane.

For experimental observations, at least **three measurement sections** equal to the baseline length are established. Additional observation sections should be located within the observer's field of view so that the behavior of traffic flow can be monitored without affecting normal vehicle movement.

When traffic volume is high, vehicle operating speed is measured using **video cameras or stationary surveillance cameras**. Traffic movements are first recorded and then processed using computer software for detailed analysis.

Photo-video recording represents one of the most universal methods for determining vehicle operating speed. Besides speed measurement, this technique makes it possible to estimate several important traffic flow characteristics. For example, traffic density—which is difficult to measure accurately using conventional methods—can be determined with high precision from photographic or video recordings.

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