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ДОСЛІДЖЕННЯ ПРОПУСКНОЇ ЗДАТНОСТІ АВТОМОБІЛЬНИХ ДОРІГ ТА МОСТОВИХ ПЕРЕХОДІВ

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RESEARCH OF THE PERFORMANCE CAPACITY OF HIGHWAYS AND BRIDGE CROSSINGS

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Formulation of the problem.

The full-scale war caused fundamental changes in the functioning of the road and transport complex of Ukraine. Since the beginning of martial law, the road infrastructure has performed extremely important functions - ensuring the possibility of evacuation and movement of the population, movement of military equipment and humanitarian goods, ensuring the functioning of the economy, social sphere and industries. This turned out to be quite a difficult task, primarily due to the low capacity of highways and bridge crossings. In addition, the destroyed thousands of kilometers of roads and hundreds of bridges greatly complicate the already difficult logistics routes. Therefore, an important issue in the restoration of road and transport infrastructure objects in the war and post-war periods is to take into account their capacity based on the actual parameters of the rolling stock.

The carrying capacity of a road (bridge) means the largest number of vehicles that can pass through a road (bridge) per unit of time.

The amount of bandwidth depends on many factors, in particular:

– the number of traffic lanes;
– speed of movement of vehicles;
– traffic flow composition;
– condition of the surface of the carriageway.

The carrying capacity of the road, along its entire length, is not constant and can change under various conditions:

– characteristic complex areas;
– parameters of the plan and profile of the road do not correspond to the normative ones;
– road surface condition;
– difficult weather conditions throughout the year;
– the variety of vehicles in the stream.

Also, the capacity of highways and traffic safety depends on the capacity of the bridges located on them. In the presence of insufficient carrying capacity on bridges, the number and severity of traffic accidents increases significantly.

Traffic conditions on highways, and accordingly on bridges, are constantly changing due to the improvement of the technical characteristics of cars, the increase in their dynamic properties, and the increase in the dimensions and weight of vehicles. Therefore, regulatory requirements and recommendations based on experimental data can be considered valid only for a limited period of time. When the characteristics of traffic flows and road conditions change, it is necessary to constantly monitor the compliance of the consumer properties of roads (bridges) with the conditions of traffic on them.

The study was carried out with the support of the National Research Fund of Ukraine within the framework of grant No. 2022.01/0142 "Development of a load model based on the actual parameters of heavy rolling stock to determine the load-carrying capacity of highway bridges during their restoration and operation in the war and post-war periods."

Purpose of work: To analyze the theoretical and methodological approaches to determining the carrying capacity of highways and bridges.

Analysis of research and publications.

Scientists such as: V.M. Sidenko, E.M. Lobanov, V.V. Silyanov, F. Hait, D. Drew, A. Makki, T. Nguyen, J. Ren were involved in the development of methods for calculating the maximum intensity of movement. D. Al-Jumeily, W. Hurst, O.K. Birulya, Y.V. Khomyak, M.I. Gukov, V.M. Trybunskyi, L.A. Keroglu, Y.A. Kaluzhskyi, D. Vulis .A., Palchyk A.M., Neizvestna N.V., Dodukh K.M. and many others [1-8].

Summarizing the known research results, we can conclude that the maximum intensity of traffic on a highway lane can be calculated on the basis of:

– functional dependencies based on traffic flow models;

– theoretical bandwidth reduction coefficients;

- functional dependencies obtained during the study of the characteristics of the traffic flow.

So, for example, in [6] methods for evaluating the capacity of highways are proposed, taking into account the slowing down and acceleration of the traffic flow due to heavy goods vehicles, the driver's perception of time and the level of braking competence. The authors used data on the average annual daily flow on the road connecting the container port of Liverpool with North West England and the rest of the UK.

In [7], it is noted that obtaining empirical estimates of road congestion technology based on data on traffic variables is difficult due to statistical errors that arise due to the complex interaction between traffic flow, traffic control means, and capacity. To account for such variation, the authors propose an approach based on causal statistical modeling to quantify the nature and shape of congestion technology in road networks in twenty-four cities around the world.

The impact of road functions on traffic congestion based on POI clustering and an empirical analysis in Xi'an (China) is carried out in [8].

Presentation of the main research material.

The main factor on which the maximum intensity of traffic on highways depends is the average speed of the traffic flow, which in turn depends on the average speed of free traffic and its decrease depending on the composition of the traffic flow, the radius of horizontal curves and the longitudinal slope of the road.

Theoretically, the complete failure of a road (bridge) can be considered as such a state of its capacity, when the traffic load becomes saturated, and the traffic load factor $K_{заг} = N/P = 1$, where N – hourly traffic intensity, P – road capacity. At the same time, as the load factor approaches unity, the speed of the traffic flow V_t decreases and traffic jams occur. Therefore, the road failure criterion for traffic intensity must be determined based on the estimated traffic intensity N_{es} according to DBN B.2.3-4 and theoretical (full) bandwidth P.

The carrying capacity of a highway lane at a given speed of free movement can be determined by the formula [1, 2], auto/h:

$$P = \frac{3600}{\Delta t_{min}}. \quad (1)$$

where Δt_{min} – minimum driving interval between cars, s.

The minimum driving interval between cars is determined by the formula [1, 2]:

$$\Delta t_{min} = \frac{S_{T_2} - S_{T_1}}{V}, \quad (2)$$

where S_{T_2}, S_{T_1} – respectively, the stopping distance of the second car and the braking distance of the first car.

If we assume that the technical condition of the cars in the stream is the same, then:

$$\Delta t_{min} = t_p \,, \quad (3)$$

where t_p – driver reaction time, s.

Time t_p depends on the intensity of the driver's work (intervals between cars). The study of the change in the driver's reaction time is presented in the paper [2] (table 1).

Table 1 – Theoretical capacity of a city street with continuous traffic [2]

Speed, km/h	**Duration of work**	**Reaction time at the level of security, s.**		**Throughput, auto./hour, at level security**	
		85%	**50%**	**85%**	**50%**
50–60	Lasted	3,0	2,0	1200	1800
	Short-term	1,6	1,4	2250	2570

The carrying capacity of one lane of the highway depends on the composition of the traffic flow [1, 2]. When the share of trucks in the flow increases, the bandwidth of the lane decreases, as does the speed of the traffic flow. As the throughput approaches the limit, the speed decreases and the stability of the movement deteriorates. The movement parameters for different movement conditions are given in table. 2.

Table 2 – Traffic flow parameters for different traffic conditions [2]

Flow characteristics	**Speed, km/h**	**Intensity (specific one traffic lane), car/hour**
A. Free	96–60	1000
B. Stable	88–55	1500
C. Approaching unstable	64–40	1800
D. Unstable	64–40	2000
E. Traffic jam	48–30	2000

The duration of continuous movement in the mode of maximum throughput is 10–15 minutes, and the duration of traffic jams can exceed 50% of the time. The average flow speed is 15–20 km/h and the accident rate is very high [2].

Features of multi-lane road sections - maneuvering of cars along the width. The lane change maneuver lasts 4–6 seconds. The capacity of the traffic lane and the entire road in the presence of cars that are being rebuilt is less than when driving only in its own lanes. The intensity of traffic in different lanes is not the same even at the limit load [2].

In work [3], on the basis of data processing of experimental studies, the functional dependence of the intensity-speed of traffic on the highway was obtained, taking into account the composition of the traffic flow:

$$N = (-0{,}0026l^2 + 0{,}0538l - 0{,}4678)V^2 + (0{,}00277l^2 - 0{,}1752l + 10{,}182)V + (18{,}362l^2 - 438{,}84l + 3069), \quad (4)$$

where l – car length, m;

V – average speed, km/h.

The capacity of the traffic lane of the bridge located in the plan and with a slope of up to 10‰ can be determined by the formula [4], auto/h:

$$P_b = 420 + 43D - 2{,}285L_b + 0{,}257DL_b, \quad (5)$$

where D – dimensions (width of roadway) of the bridge, m

L_b – length of the bridge, m.

The capacity of the traffic lane on the approach to the bridge can be determined by the formula [4], auto/h:

$$P_{app.b} = 413 + 43D27b - 2,285L_b - 0,7i + 0,0635R + 434,6\eta_p, \quad (6)$$

where b – the width of the carriageway on the approach to the bridge,м;

i – longitudinal slope, ‰;

R – radius of the curve in plan, m;

η_p – share of passenger cars in traffic, %.

Let's consider an example of calculating the intensity of traffic flow over a 100-m-long bridge crossing over the river on the A-B road section (Fig. 1). The width of the carriageway on the approach to the bridge on one and the other side is 7,5 m, and the width of the bridge is 6 m. The bridge is horizontal and straight. The approach to the bridge from side B has a curve in plan with a radius of 800 m, and from side A, on a straight section, the slope in plan is 8 ‰. In the transport flow, the share of passenger cars is 30%. It is necessary to determine the carrying capacity of the bridge crossing.

Figure 1 – Bridge crossing over the river on the A-B road section

According to formula (5) for the given conditions, we will have:

$$P_b = 420 + 43 \cdot 6 - 2,285 \cdot 100 + 0,257 \cdot 6 \cdot 100 \approx 604 \ auto/h.$$

Given that approaches to the bridge from two sides have different characteristics, we determine the throughput of each of them according to (6).

Approach from side A:

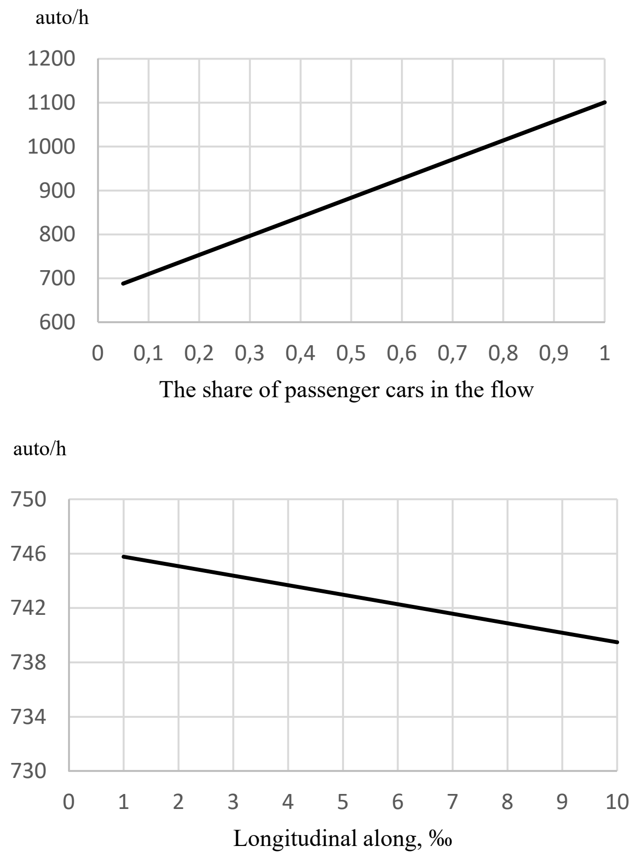
$$P^A_{app.b} = 413 + 27 \cdot 7,5 - 0,7 \cdot 8 + 434,6 \cdot 0,3 \approx 740,4 \ auto/h.$$

Approach from side B:

$$P^B_{app.b} = 413 + 27 \cdot 7,5 + 0,0635 \cdot 800 + 434,6 \cdot 0,3 \approx 796,4 \ auto/h.$$

Thus, it is possible to set the capacity of the bridge crossing at a minimum value of 604 auto/h.

On the basis of formula (4), a study of the dependence of the traffic intensity on the approaches to the bridge crossing was conducted depending on the longitudinal slope and the share of passenger cars in the traffic flow (Fig. 2).



a) b)

Figure 2 – Dependence of traffic intensity on the approaches to the bridge crossing depending on: a) shares of passenger cars in the traffic flow; b) longitudinal slope

In a state close to the theoretical throughput, the transport flow can be described by a hydrodynamic model. At the maximum upper level of service *D*, the movement of the traffic flow becomes unsatisfactory, the density of the flow of cars approaches a saturated state, overtaking are practically excluded, the speed of all cars is one constant value V_t, the mean square deviation in speed σ_v is small. Under such conditions, traffic flow becomes uneconomical.

Thus, there is every reason to believe that under such conditions the road practically does not fulfill its functions. It is necessary either to unload the road, or to arrange a new carriageway. This state of the traffic flow is taken as a failure.

From the theory of traffic flows, it is known that for the hydrodynamic model at the upper level of service *D*, the normalized speed is equal $V_t/V_f=0,67$ where V_f – speed of movement in a free stream. Then the average speed of the vehicle in the driver-car-road-environment system (VADS), at which the road failure occurs, is equal to [5], km/h:

$$V_0 = 0,67V_p;(I,E\rightarrow opt), \tag{7}$$

where V_p – permissible speed of a single car in free flow under optimal or close to them conditions (information load I and energy consumption E).

For the accepted traffic flow model:

$$N = \lambda V, \tag{8}$$

where λ – flow density, that is, the number of cars per 1 km of the traffic lane.

The relationship between the speed of the traffic flow and the density for this model can be determined as follows:

$$\lambda = \frac{\lambda_{max}}{\exp(V/V_t)}. \tag{9}$$

According to [5], the value λ_{max}, included in (9) can be determined from the ratio:

$$\lambda_{max} = \frac{1000}{1+l_{av}}, \tag{10}$$

where l_{av} – average weighted length of the vehicle for maximum hourly traffic intensity.

Thus, accepting $V=V_0$ and by substituting (9), (10) into expression (8), we obtain the ratio for determining the traffic intensity at which road failure occurs:

$$N_0 = \frac{1000V_0}{(1+l_{av})\,exp(V_0/V_t)}, \tag{11}$$

Then the traffic load factor of the road at its failure can be determined as:

$$K_0 = \frac{0{,}114V_0}{exp(V_0/V_t)}. \tag{12}$$

So, the road failure criterion:

$$\overline{V}_t \le V_0,\ N_f > N_0,\ K_f > K_0, \tag{13}$$

where $\overline{V}_t$ – average speed of traffic flow; N_f – actual traffic intensity; K_f – the actual factor of loading the road with traffic.

To determine the numerical indicators of road reliability, the average speed of the traffic flow is calculated based on the intensity of traffic. To do this, the permissible speed of a single car in free flow is first determined. The permissible speed is taken as the maximum maximum speed of the car in free flow, which is limited by a certain condition.

In the car-road subsystem, the permissible speed of the traffic flow can be determined from the condition of preventing excessive oscillations of the car when it moves on an uneven surface [5]:

$$V_p = \frac{850}{\sqrt{S}}, \tag{14}$$

where S – value characterizing the total amplitude of oscillations of the reference car on a road section 1 km long.

Depending on the marginal equality, S_{me} it is possible to determine V_p. According to the current regulations, the longitudinal evenness of the road surface is assessed by the indicators of equality in linear units per unit length of the road section [9, 10]:

$$K_{eq} = \frac{S_{me}}{S_f}, \tag{15}$$

where S_{me} – the maximum permissible evenness of the road surface, according to the profilometric method, cm/km or according to the index of the pushometer, cm/km.

S_f – the actual unevenness of the road surface, which is estimated by the profilometric method, m/km or by the index of the pushometer, cm/km.

The maximum allowable evenness of the road surface is assigned depending on the level of requirements for the operational condition of highways, according to Table 3 [9].

Then, according to formula (11), we will have the following values of permissible speed V_p in the car-road subsystem (Table 3).

Table 3 – The value of the permissible speed in the car-road subsystem depending on the evenness of the road surface

Indicator	The level of requirements for highways							
	1	2	3	4	А	Б	В	Г
The indicator of the evenness of the road surface, measured by a displacement meter, cm/km, is not more than	100	120	170	240	100	120	240	260
Estimated value of permissible speed V_p in the car-road subsystem, km/h	85,0	77,6	65,2	54,9	85,0	77,6	54,9	52,7

In the subsystem driver-car-road (DVR), the value V_p must be determined taking into account the functional state of the driver, which will depend on the evenness, roughness, defectiveness of the surface and the speed of movement. With the deterioration of the evenness of the road surface *S*, the coefficient φ of adhesion and its defectiveness *D*, the driver is forced to reduce the speed of movement or work in uncomfortable conditions, which accelerates the process of fatigue. In order to orient drivers to work in optimal functional condition or close to it, speed limit signs are installed on sections of low-quality roads.

In addition to road conditions, other factors also affect the speed of traffic. In particular, a number of researchers single out the following patterns [1, 2]:

– passenger cars move faster than trucks;
– high-class cars move faster than low-class cars;
– trucks move faster than road trains;
– buses (commercial) move faster than cars;
– new cars move faster than new ones;
- the largest distribution of speeds is observed in passenger cars.
– the longer the trip, the higher the speed;
– the more passengers in the car, the lower the speed;
- single and divorced people drive faster than family ones;
– women drive slower than men, albeit slightly;
- drivers who have a new car drive faster than those who do not have a new one.

In work [5], the ratio for determining the speed of the car under the condition of the optimal functional state of the driver V_0, km/h, was obtained:

$$V_0 = 38,8 - 0,18S + 42\varphi + 6,9D. \tag{16}$$

To assess the defectiveness of the coating according to the recommendations [5], the following scale of points is adopted: there are no inflows, cracks, potholes – 5 points; there are no inflows and potholes, there are separate cracks on the rolling strip and the edge of the coating – 4 points; there is a network of cracks, inflows, ridges, potholes (area of defects up to 50%) – 3 points; the same with the area of defects more than 50% – 2 points.

According to DSTU 3587:2022, the coefficient of longitudinal adhesion should be at least 0,35 for public highways, and at least 0,40 for streets and roads in cities and other settlements [9].

The quantitative characteristic of the reliability of the road according to the traffic intensity criterion can be expressed by its fault-free operation:

$$P(x) = 0,5 - 0,5\Phi\left(\frac{x-a_1}{\sigma_1}\right). \tag{17}$$

Parameter a_1, included in (17) characterizes the average intensity (working time) of the road before its failure:

$$a_1 = \overline{T} - K\left(\overline{T} - T_t\right), \tag{18}$$

where $\overline{T}$ – the average value of the traffic intensity of the road before failure;
T_t – general characteristics of statistical research;
K – coefficient, which is taken depending on the auxiliary coefficients ρ і h due to [5].

By the number of members of the general population $N>15$ and the number of members of the sample n, the ratio for determining ρ and h will have the form:

$$\rho = \frac{D^2}{\left(\overline{T}-T_t\right)^2} \qquad ;h = \frac{N-n}{N}, \tag{19}$$

where D^2 – variance of a statistical series:

$$D^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(T_i - \overline{T}\right)^2. \tag{20}$$

Value σ_1, included in (17) can be determined by the formula:

$$\sigma_1 = \sqrt{D^2 + k\left(\overline{T} - T_t\right)^2}. \tag{21}$$

Since failure-free operation and failure are separate and opposite events, the ratio between their probabilities is correct:

$$P(x) + Q(x) = 1, \tag{22}$$

where $P(x)$ – probability of failure-free operation; $Q(x)$ – probability of failure.

Let's consider an example of determining the probabilities of fault-free operation of a road based on the traffic intensity criterion.

Let 20 sections of the road, each 5 km long, be selected for observation. The failure criterion was determined by measuring the average actual speed of traffic flows $\overline{V}_t$ and its subsequent comparison with $V_0=0,67V_p$. The road was not repaired after failure occurred in some sections. The working time to failure of each section of the highway according to the hourly traffic intensity at the time of observations is shown in Table 4.

Table 4 – Intensity of traffic on sections of the highway before their failure

Number	1	2	3	4	5	6	7	8	9	10
Intensity of movement (working up) to failure, auto/h	470	480	520	550	570	590	610	630	650	680

So, the volume of the general population – $N=20$, sample size – $n=10$.

Value T_t we accept $T_t=N_0$, which for the average composition of traffic is equal to 1000 auto/h.

As you know, in the theory of reliability, gradual failures are subject to the normal distribution of the system's working life. Therefore, further calculations will be carried out within the framework of a normal distribution. According to formulas (17) – (21):

$$\overline{T} = \frac{470+480+...+680}{10} \approx 575\ auto/h;$$

$$D^2 = \frac{(470\text{-}575)^2+(480\text{-}575)^2+...+(680\text{-}575)^2}{10\text{-}1} \approx 3733,3;$$

$$\rho = \frac{3733,3}{(575\text{-}100)^2} \approx 0,021;\ h = \frac{20\text{-}10}{20} 0,5;$$

$$\sigma_1 = \sqrt{3733,3 + 0,8368(875 - 1000)^2} \approx 393,5.$$

According to the recommendations [5] we accept $K=0,8368$. Then the average intensity (working time) of the road before its failure according to formula (18) will be:

$$a_1 = 575 - 0,8368(575 - 1000) \approx 930,6\ auto/h.$$

Next, using formula (17), we determine the probabilities of fault-free operation of the road when the traffic intensity changes. The results and generalization of the calculations are shown in Fig. 3. Thus, with an increase in traffic intensity, the probability of road failure increases. When the intensity of traffic on the considered section of the road is reached, for example, up to 1400 vehicles per hour, the probability of failure of the road is 90%.

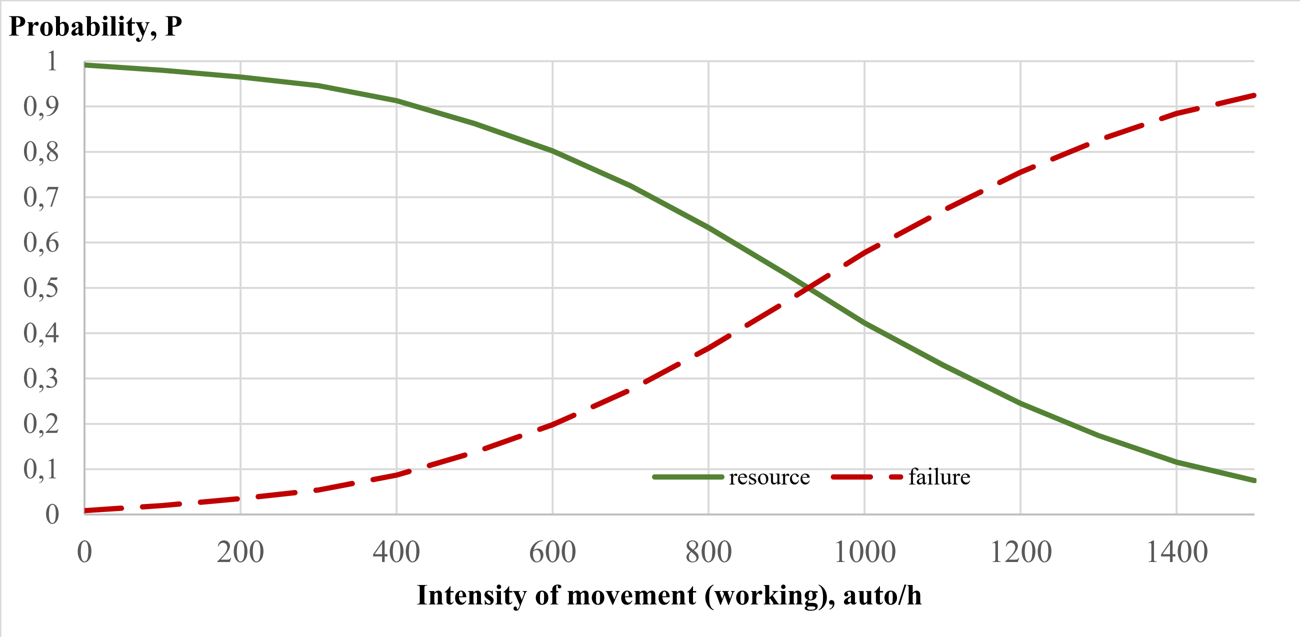


Figure 3 – The function of the road capacity resource

Conclusions and recommendations.

1. An important criterion that characterizes the functioning of highways and bridges is their capacity, which is a variable quantity and depends on the number of traffic lanes, the speed of vehicles, the composition of the traffic flow, and the condition of the surface of the carriageway.

2. The main factor on which the maximum intensity of traffic on highways depends is the average speed of the traffic flow, which in turn depends on the average speed of free traffic and its decrease depending on the composition of the traffic flow, the radius of horizontal curves and the longitudinal slope of the road. Theoretically, the complete failure of a road can be considered as a state of its capacity when the traffic load on the road becomes saturated and the traffic load factor is close to unity. Therefore, the road failure criterion for traffic intensity must be determined based on the estimated traffic intensity according to DBN B.2.3-4 and the theoretical (full) carrying capacity.

3. Based on the regulatory requirements for the operational condition of highways (evenness and roughness of the surface), the calculated value of the permissible speed of the car in the subsystem car-road is determined, and the ratio for determining the capacity of traffic lanes of highways, bridges and approaches to them is also given. The intensity of the traffic flow through the bridge crossing and on the approaches to it depends on the dimensions of the bridge, the longitudinal slope of the carriageway, the radius of the curves in the plan, the share of passenger cars in the traffic flow.

4. The quantitative characteristic of the reliability of highways and bridge crossings according to the criterion of traffic intensity can be expressed by its fault-free operation and the corresponding function of the capacity resource of the highway (bridge). With the help of the capacity resource function of the highway, it is possible to determine the probability of its fault-free operation and critical values of traffic intensity, at which the probability of failure is quite high.

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РЕФЕРАТ

Славінська О.С. Дослідження пропускної здатності автомобільних доріг та мостових переходів / О.С. Славінська, Л.П. Бондаренко, В.В. Стьожка, А.В. Севост'янова, А.Ю. Шпиг // Вісник Національного транспортного університету. Серія «Технічні науки». Науковий, науково-виробничий журнал. – К.: НТУ, 2023. – Вип. 3 (57).

В роботі проводиться дослідження теоретико-методологічних підходів щодо визначення пропускної здатності автомобільних доріг і мостів.

Об'єкт дослідження – транспортний потік на автомобільних дорогах та мостових переходах.

Мета роботи – проаналізувати теоретико-методологічні підходи щодо визначення пропускної здатності автомобільних доріг і мостів.

Метод дослідження – аналітичний, числове моделювання.

Висновки. Основним чинником, від якого залежить максимальна інтенсивність руху на автомобільних дорогах є середня швидкість руху транспортного потоку, яка у свою чергу залежить від середньої швидкості вільного руху та її зниження залежно від складу транспортного потоку, радіусу горизонтальних кривих та поздовжнього похилу дороги. Теоретично повною відмовою дороги можна вважати такий стан її пропускної здатності, коли завантаження дороги рухом стає насиченим, а коефіцієнт завантаження рухом близьким до одиниці. Тому, критерій відмови дороги за інтенсивністю руху необхідно визначати за розрахунковою інтенсивністю руху згідно ДБН В.2.3-4 і теоретичною (повною) пропускною здатністю. Виходячи з нормативних вимог до експлуатаційного стану автомобільних доріг (рівності і шорсткості покриття) визначено розрахункове значення допустимої швидкості автомобіля в підсистемі автомобіль-дорога. Наведено співвідношення для визначення пропускної здатності смуг руху автомобільних доріг, мостів та підходів до них. Розглянуто приклад розрахунку інтенсивності руху транспортного потоку мостовим переходом та на підходах до нього залежно від габаритів мосту, поздовжнього похилу проїжджої частини, радіуса кривих в плані, частки легкових автомобілів в транспортному потоці. Визначено та побудовано графічні залежності інтенсивності руху на підходах до мостового переходу від поздовжнього похилу та складу транспортного потоку. Наведено співвідношення для визначення швидкості руху автомобіля за умови оптимального функціонального стану водія, що залежить від рівності, шорсткості, дефектності покриття і швидкості руху. Наведено методику визначення ймовірності безвідмовної роботи автомобільних доріг за критерієм інтенсивності руху, що характеризує кількісну характеристику їх надійності. Розглянуто практичний приклад розрахунку та побудови функції ресурсу пропускної здатності ділянки автомобільної дороги.

КЛЮЧОВІ СЛОВА: АВТОМОБІЛЬНА ДОРОГА, МОСТОВИЙ ПЕРЕХІД, ПРОПУСКНА ЗДАТНІСТЬ, ЙМОВІРНІСТЬ БЕЗВІДМОВНОЇ РОБОТИ, НАДІЙНІСТЬ АВТОМОБІЛЬНОЇ ДОРОГИ

ABSTRACT

Slavinska O.S., Bondarenko L.P., Stozhka V.V., Sevostianova A.V., Shpyh A.Yu. Research of the performance capacity of highways and bridge crossings. Visnyk National Transport University. Series «Technical sciences». Scientific, scientific and industrial journal. – K.: NTU, 2023. – Issue 3 (57).

The paper examines theoretical and methodological approaches to determining the carrying capacity of highways and bridges.

The object of the study is traffic flow on highways and bridge crossings.

The purpose of the work is to analyze the theoretical and methodological approaches to determining the carrying capacity of highways and bridges.

The research method is analytical, numerical modeling.

Conclusions. The main factor on which the maximum intensity of traffic on highways depends is the average speed of the traffic flow, which in turn depends on the average speed of free traffic and its decrease depending on the composition of the traffic flow, the radius of horizontal curves and the longitudinal slope of the road. Theoretically, the complete failure of a road can be considered as a state of its capacity when the traffic load on the road becomes saturated and the traffic load factor is close to unity. Therefore, the road failure criterion for traffic intensity must be determined based on the estimated traffic intensity according to DBN B.2.3-4 and the theoretical (full) carrying capacity. Based on the regulatory requirements for the operational condition of roads (evenness and roughness of the surface), the calculated value of the permissible speed of the car in the car-road subsystem is determined. The ratio for determining the carrying capacity of traffic lanes of highways, bridges and approaches to them is presented. An example of calculating the intensity of traffic flow through a bridge crossing and on the approaches to it is considered, depending on the dimensions of the bridge, the longitudinal slope of the roadway, the radius of the curves in the plan, the share of passenger cars in the traffic flow. Graphical dependences of the traffic intensity on the approaches to the bridge crossing on the longitudinal slope and composition of the traffic flow were determined and plotted. The ratio for determining the speed of the car under the condition of the optimal functional state of the driver, which depends on the evenness, roughness, defectiveness of the coating and the speed of movement, is given. The methodology for determining the probability of trouble-free operation of highways based on the traffic intensity criterion, which characterizes the quantitative characteristics of their reliability, is given. A practical example of calculation and construction of the capacity resource function of a highway section is considered.

KEY WORDS: MOTOR ROAD, BRIDGE CROSSING, CAPACITY, PROBABILITY OF FAILURE-FREE OPERATION, ROAD RELIABILITY

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