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DESIGN CONCEPT OF MOTORWAYS & TRANSPORT CORRIDORS IN UKRAINE

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Abstract. The design concept of the new structure of Ukrainian highways in the form of transport corridors with high road and transport potential as elements of the design environment of the state is substantiated. A new approach is applied that allows taking into account the landscape of the area, road architecture, traffic management design and peculiarities of traffic flow conditions. A planning analysis of the road network in terms of linear and quadratic density is presented, the new highway network is built on the basis of the theory of connection graphs. A radical method of increasing the speed of transport, increasing the capacity of the network of streets and roads and ensuring traffic safety is the construction of intersections at the intersections of urban highways at different levels.In the practice of design and construction, transport intersections at two, three, four or more levels are used. Highways or expressways are considered as the total potential of the economy, consisting of the potential of transport routes and roads, infrastructure facilities and the potential of vehicles (car flows, carriage flows). i.e. exergy, a powerful characteristic of the transport corridor, where power is the product of a variable in the cross-section of the path (flow intensity) by a variable in the path space (speed). Of particular importance is the capacity of transport corridors or specific flow intensity, which is the inverse of intensity and characterizes the distribution of intensity along the length of the roadway of highways. The instantaneous load is determined by the flow density. The maximum load of the roadway lane is achieved at the optimal value of the flow speed and the optimal flow density per kilometer of road. An analysis of the distribution of traffic intensity on the German highway as an analog of a transport corridor is made.

Keywords: highway network, transport corridors, road and transport potentials, linear and quadratic densities, capacity, specific intensity**.**

General statement of the problem and its connection with important scientific and practical tasks. With Ukraine's acquisition of the status of a candidate for accession to the EU, the need to bring legislation into line with EU law, implement international standards and integrate the national transport network into the Trans-European Transport Network (TEN-T) is becoming even more urgent. The National Transport Strategy also needs to be harmonized with the priorities and objectives of the European Green Deal in the transport and mobility sector. This, in turn, requires sufficient organizational, human and material resources and proper legal regulation.

The updated National Transport Strategy of Ukraine will allow increasing the institutional capacity of transport sector management bodies, will promote the development of human capital, digitalization of the industry with the aim of further implementing sectoral reforms and supporting Ukraine's European integration course.

The economy of any state, including Ukraine, will not be able to develop successfully without appropriate provision of transport infrastructure with high-speed delivery of goods and passengers, which requires the urgent creation of transport corridors in the form of new high-class multi-lane

highways. But a new approach is being used that allows taking into account the landscape of the area, road architecture. design of road traffic organization and the peculiarities of traffic flow conditions.

In some areas that require strategic development planning, there are no program documents, and the current strategic and program documents in certain areas of the transport sector do not contain provisions that establish strategic priorities for their development, taking into account the challenges of martial law and post-war reconstruction, and also do not take into account the need to integrate the transport complex of Ukraine into the EU transport system, taking into account Ukraine's receipt of candidate status for accession to the EU.

Thus, the issue of significantly improving sectoral program documents and developing new program documents in the transport sector in order to improve state policy in priority areas, determine the sequence of actions to solve identified problems, and achieve the development goals set in the relevant areas of the transport sector based on the results of implementing planned interrelated tasks and measures is important and relevant [1].

An analysis of recent studies and publications that have initiated a solution to this problem and highlighted previously unsolved parts of the overall problem. Congested roads cause people to delay less urgent trips, change modes and destinations, and forgo avoidable trips. The traffic generated consists of diverted travel (a shift in time and route) and induced travel (an increase in total motor vehicle travel).

Highway expansion can stimulate sprawl (dispersed, car-dependent development), which contributes to a further increase in per capita car travel. The following are examples of solutions that generate traffic:

- consumers choose closer destinations when roads are congested, and further destinations when traffic is lighter. “I want to try the new restaurant downtown, but traffic is a mess right now. Let’s just grab something at the local deli.” This also affects the long-term viability of solutions;
- travelers change modes to avoid traffic jams;
- longer trips may seem cost-effective when traffic jams are light, but not when traffic jams are heavy.

Large research show that people tend to have a fixed travel time budget, the so-called Marchetti Stash (Litman 2021; Marchetti 1994). Regardless of the conditions, people devote about 75 minutes per day to personal travel (Ahmed and Stopher 2014). As a result, travel speeds increase, as do their travel distances. Road improvements that increase travel speeds tend to encourage additional vehicle traffic in the long run (Krol 2020). Therefore, it is unreasonable to assume that improvements to the road surface provide travel time savings; instead, their benefits tend to result from the ability to travel to more distant destinations, such as taking longer commutes to work or traveling to a more distant vacation spot.

Generated traffic can be viewed from two perspectives. Highway planners are primarily concerned with the traffic generated on the expanded road section, as this affects the congestion-reducing benefits of the project. A broader perspective concerns the changes in total vehicle travel (induced travel), which affects overall benefits and costs. Table 1 describes the different types of generated traffic. In the short term, most of the generated traffic consists of trips diverted from other routes, times, and modes, which is called triple convergence. Over the long term, an increasing proportion is induced travel. In some situations, adding road capacity can reduce the overall efficiency of the network, which is called Braess's paradox. Increasing the capacity of a highway can cause additional vehicle travel on adjacent roads, encouraging more dispersed, car-dependent development. Although these indirect impacts are difficult to quantify, they are potentially significant and should be considered in transport policy and planning analysis [2].

The purpose of the article is to substantiate practical ways to overcome the existing lack of transport infrastructure capacity to meet the needs of all carriers. Namely, the congestion of the transport system in certain areas, in particular in the direction of border crossings with the EU countries and Moldova, as well as seaports controlled by Ukraine.

Presentation of the research material with full justification of the obtained scientific results. In the current circumstances, it is rational to use the laws of traffic flow, and not only a separate car, as stipulated by the state building codes (DBN), to improve the quality, external attractiveness, road safety and capacity of expressways as part of transport corridors.

To solve the set goal, new developments in the theory of transport flows [3, 12] and applied research [7, 8, 11] are used. Unfortunately, in modern Ukrainian technical literature, a new generalized theory of transport flows, as such, and almost with criticism, is not stated. Motorways or expressways are considered as the total potential of the economy, consisting of the potential of transport routes and roads, infrastructure structures and the potential of vehicles (automobile flows, wagon flows). i.e. exergy (*E*). power characteristic of the transport corridor operation, where power (*M*) is the product of the variable in the path cross-section (flow intensity *N*) by the variable in the path space (speed *V*), km/h^2:

$$M = NV_{\text{авт}}.$$

Of particular importance is the capacity of transport corridors or the specific intensity (*U*) of vehicles/hour.km, which must correspond to a sufficient level of throughput. The flow is the reciprocal of the intensity [4] and characterizes the distribution of intensity *N* along the length of the roadway *L*:

$$U = \frac{N}{L}. \quad (1)$$

The instantaneous load is determined by the flow density, that is, the number of cars on a section of road, therefore the specific intensity, or specific load, is better determined through the density *Q* [3]:

$$U = \frac{V_0 Q(Q_m - Q)}{LQ_m}, \quad (2)$$

де V_0 – free movement speed, km/h;

Q_m – traffic jam density, cars/km.

The maximum loading of the carriageway lane U_m is achieved at an optimal value of the flow velocity equal to $0.5V_0$ and an optimal flow density equal to $0.5Q_m$ per kilometer of road and is 2500 cars /h.km on the inner lane. At the same time, the lane capacity allows 50 cars to be accommodated per kilometer, which provides a distance of 15 meters, and a dynamic clearance of 20 meters. Reducing the distance leads to traffic congestion or to column traffic and traffic jams after 2 ... 3 minutes. The distributions of the existing road density by region and the planned one are shown in Fig. 1.

The number of lanes on the transport corridor is determined by the size of the demand for trips, but the need to create a network of transport corridors for the country is proposed to be established by their standard linear density from 2 km to 4 km per km^2 of the country's area. Planning analysis of the existing linear density of highways in Ukraine, compared to the road network of developed countries, indicates its very low level - 0.28 km/km^2, which is ten times less than the optimal value. At the same time, the existing roads are not highways, but only directions, with a very low value of quadratic density - 280 m^2/km^2, which takes into account the width of the roadway [6].

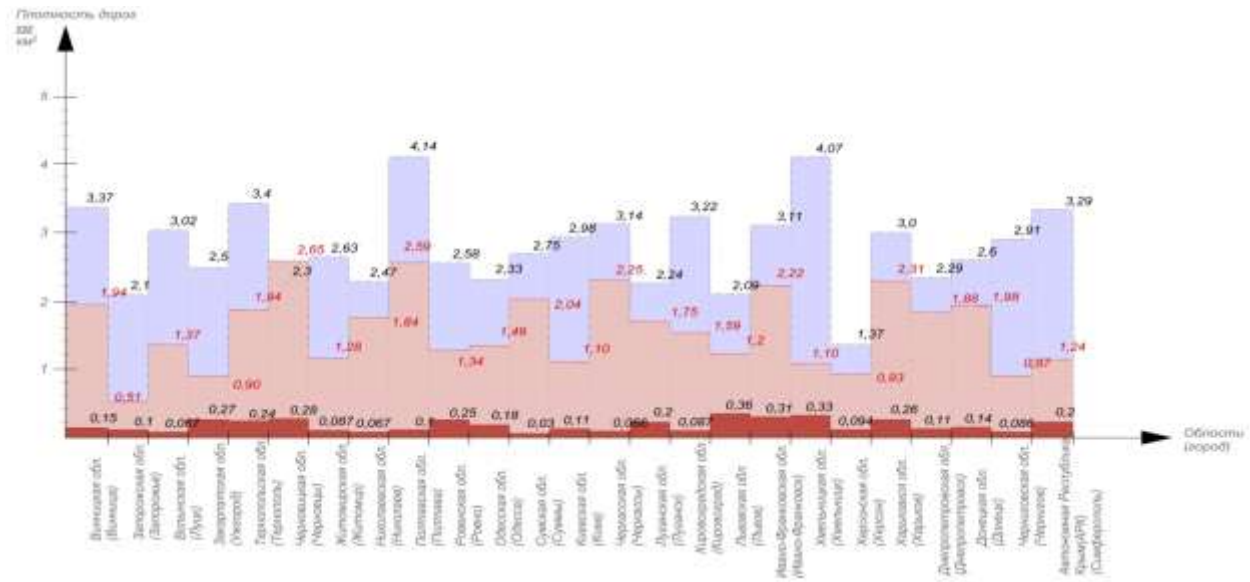

Fig. 1. Distribution of existing and planned road density by region

Based on graph theory [13], a new structure of the road network of highways has been developed in the form of extensions of the transport corridors of the countries bordering Ukraine in the West-East and South-North directions. The new, close to rectangular, structure of the highway network has a linear density of 2.8 km/km^2 and a quadratic density of 700 m^2/km^2 with a carriageway width of 4 to 8 lanes, excluding local secondary roads (Fig. 2).

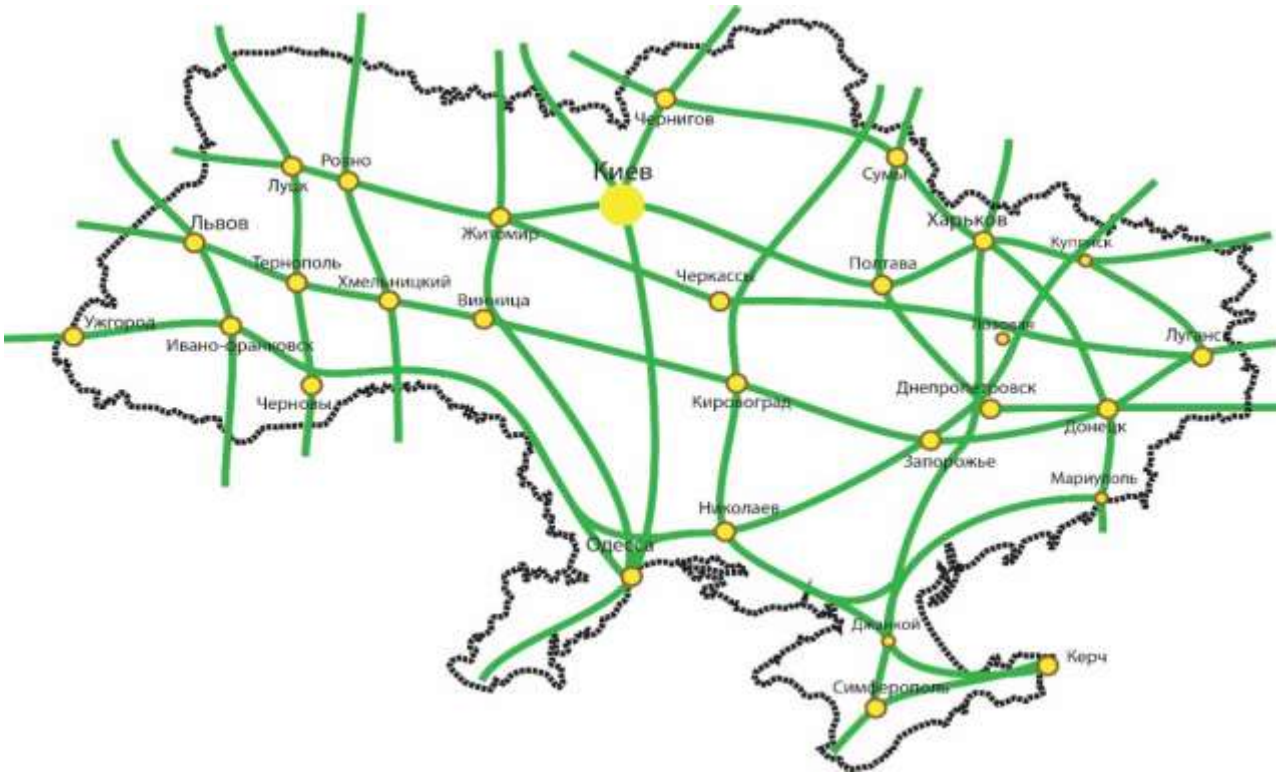

Fig. 2. Planned network of transport corridors in Ukraine

A radical method of increasing the speed of transport, increasing the capacity of the network of streets and roads and ensuring traffic safety is the construction of intersections at different levels at the intersections of urban highways. Such intersections eliminate transport delays and ensure the continuity of its movement. Analysis of literary sources shows that different specialists in their design see only the functional feature of the intersection [10 - 12] and do not take into account the architectural requirements and urban environment of the location of the intersections. In the practice of design and construction, transport intersections are used at two, three, four and more levels. And this is from 6 to 24, 30 meters in height, that is, 10-story buildings [16 - 18].

The most important factor determining the choice of the type of intersection and the design of the overpass is the architectural appearance of the structure, its compositional combination with the surrounding urban ensemble, i.e. design. The practical and aesthetic qualities of the road largely depend on its technical compliance with the type of transport prevailing in a given era.

As an example, from the transport corridors routed through the Kharkiv region, branches of expressways are planned for the city center, taking into account the planning studies of the basic general plan of 1967-87, according to which the city of Kharkiv developed.

Expressways are laid on 4 sides of the center and therefore, together with interchanges at different levels, create a ring that intercepts traffic flows from the central part of the city. Taking into account the above, the Kharkiv Development Strategy until 2030 and beyond solves transport and logistics problems of international cooperation, interconnection with regional centers of Ukraine, with cities of the Kharkiv region and with the city of Kharkiv itself. Taking into account the further growth of motorization of the population of Ukraine to 500 cars per thousand inhabitants, the density of highways should be increased to 4 km/km^2, and for transit traffic, separate lanes should be provided where the speed should be more than 100 km/h (200 ... 250 km/h).

There are no state regulatory documents for the design of highways, but there is a problem in predicting capacity. Therefore, an analysis of the distribution of traffic flow intensity on the German autobahn, as an analogue of a transport corridor, was made (Fig. 3).

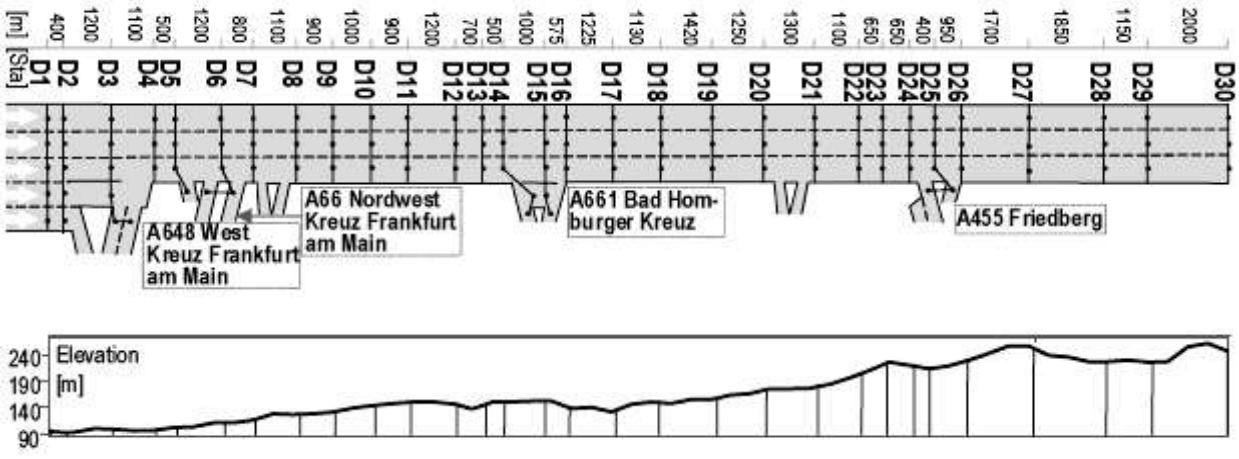

Fig. 3. Example of traffic flow intensity distribution on the German Autobahn

The field observation data presented in Table 1 and in the graph in Fig. 4 indicate a complete inconsistency of domestic regulatory recommendations on road capacity with the realities of traffic. The highest capacity on a multi-lane highway occurs on the inner lane, where the flow speed is highest, and gradually decreases with the variability of traffic lanes to the intersection at different levels to the first outer lane (movement in one direction).

Table 1 - Actual distribution of traffic flows on the 3rd lanes of the autobahn

Traffic flow behind the car/hour lanes		Traffic flow by lanes auto/h			Bandwidth coefficient			Total banding coefficient for		
		left	average	rights	1:2	1:3	2:3	2-x lanes	3-x lanes	4-x lanes
4220		1790	1440	990	1,45	1,81	1,24	2,45	4,26	6,51
5180		2070	1850	1260	1,47	1,64	1,12	2,47	4,11	5,95
4710		1860	1640	1210	1,36	1,54	1,13	2,36	3,89	5,64
5320		2120	1930	1270	1,52	1,67	1,10	2,52	4,19	6,02
5030		2010	1780	1240	1,44	1,62	1,13	2,44	4,06	5,89
4760		1910	1690	1160	1,46	1,65	1,13	2,46	4,10	5,96
5050		1960	1820	1270	1,43	1,54	1,08	2,43	3,98	5,64
4710		1860	1710	1140	1,50	1,63	1,09	2,50	4,13	5,91
4280		1690	1500	1090	1,38	1,55	1,13	2,38	3,93	5,67
5260		2070	1830	1360	1,35	1,52	1,13	2,35	3,87	5,59
4650		1940	1480	1230	1,20	1,58	1,31	2,20	3,78	5,85
4610		1870	1550	1190	1,30	1,57	1,21	2,30	3,87	5,77
4910		1970	1630	1310	1,24	1,50	1,21	2,24	3,75	5,57
4700		1890	1610	1200	1,34	1,58	1,17	2,34	3,92	5,77
5110		2010	1750	1350	1,30	1,49	1,15	2,30	3,79	5,50
4630		1970	1650	1010	1,63	1,95	1,19	2,63	4,58	6,91
4790		2030	1530	1230	1,24	1,65	1,33	2,24	3,89	6,08
4770		1950	1540	1280	1,20	1,52	1,27	2,20	3,73	5,66
5100		2040	1760	1300	1,35	1,57	1,16	2,35	3,92	5,74
Average value	4831	1948	1668	1215	1,4	1,6	1,2	2,4	4,0	5,9

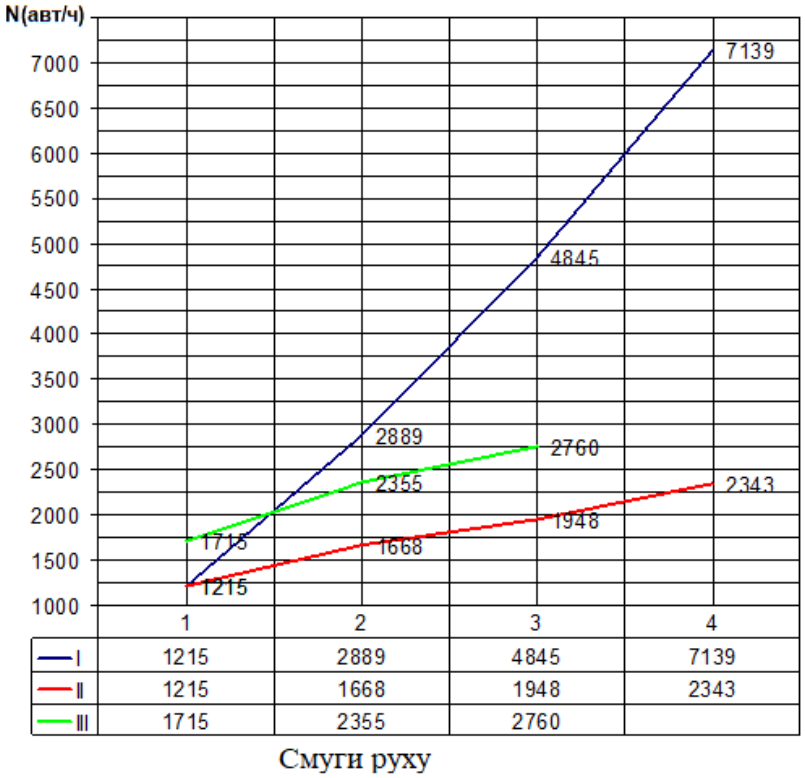

Fig. 4. Current traffic volume on the 3-lane and projected traffic volume on the 4-lane on the autobahn

Scientific novelty, scientific and practical significance of the research results, prospects for further scientific developments. Road projects that are considered cost-effective according to traditional analysis may actually provide little long-term benefit to motorists and worsen society as a whole due to induced external travel costs. In general, other strategies may be better. Another consequence is that highway capacity expansion projects should include strategies to avoid increasing external costs, for example, stricter vehicle emission regulations to avoid increasing pollution and land use regulations to limit the spread.

The introduction of new technologies, the development of a new generation of construction industry within the framework of the formation of the largest urban systems on the globe - megalopolises, allows us to talk about transport facilities (corridors) as complex integral urban structures that sprout into the environment of the state and, in fact, shape it anew [19].

The highest capacity on a multi-lane highway occurs on the inner lane, where the highest flow speed is, and gradually decreases with the alternation of traffic lanes to the intersection at different levels to the first outer lane (movement in one direction). The proposed solutions, in addition to the possibility of application not only in a general architectural sense, can also contribute to the development of narrowly professional industries of applying new options for traffic flow solutions. And also contribute to more effective cooperation between stakeholders and higher education institutions [20].

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ДИЗАЙН-КОНЦЕПЦІЯ ДО АВТОМАГІСТРАЛЕЙ І ТРАНСПОРТНИХ КОРИДОРІВ УКРАЇНИ

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Анотація Обґрунтовано дизайн-концепцію нової структури автомагістралей України у вигляді транспортних коридорів з високим дорожнім та транспортним потенціалами, як елементи дизайн середовища держави. Застосовується новий підхід, який дозволяє враховувати ландшафт місцевості, архітектуру доріг. дизайн організації дорожнього руху і особливості станів руху транспортних потоків. Наведено планувальний аналіз дорожньої мережі за показниками лінійної та квадратичної щільності, Нова мережа автомагістралей побудована на основі теорії графів зв'язків. Радикальним методом підвищення швидкості транспорту, збільшення пропускної спроможності мережі вулиць і доріг і забезпечення безпеки руху є споруда на перехрестях міських магістралей перетинів в різних рівнях.У практиці проектування і будівництва застосовуються транспортні пересічення у двох, трьох чотирьох і більше рівнях. Автомагістралі, або швидкісні дороги розглядаються як сумарний потенціал економіки, що складається з потенціалу транспортних шляхів та доріг, споруд інфраструктури та потенціалу транспортних засобів (автопотоків, вагонопотоків). тобто ексергія ,потужну характеристику роботи транспортного коридору, де потужність є добуток змінної в перерізі шляху (інтенсивності потоку) на змінну в просторі шляху (швидкість). Особливе значення має місткість транспортних коридорів або питома інтенсивність потоку, яка є зворотна величина напруженості і характеризує розподіл інтенсивності по довжині проїжджої частини автомагістралей. Миттєве завантаження визначається щільністю потоку. Максимальне завантаження смуги проїжджої частини дороги досягається при оптимальному значенні швидкості потоку і оптимальній щільності потоку на кілометрі дороги. Зроблено аналіз розподілу інтенсивності транспортного потоку на автобані Німеччини, як аналога транспортного коридору.

Ключові слова: мережа автомагістралей, транспортні коридори, дорожній та транспортний потенціали, лінійна та квадратична щільності, потужність, питома інтенсивність.