OPTIMAL DEVELOPMENT OF TRANSPORT FLOWS AND NETWORK IN SURFACE TRANSPORT

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Annotation: Multimodal transportation is an important component of modern logistics systems and take into account many factors. For example, transportation costs, cost and distance of transportation, additional costs when reloading from one type to another, and so on.

The article presents the justifications and solutions of the mathematical model of the problem of the development of multimodal transportation and the transport network in the region, which provides for the expansion and increase of the transportation efficiency of all elements of the transport network, technical and technological means. The problems of distribution of cargo flows in a regional multimodal network using the proposed computer program are considered.

Keywords: transport network, automobile, railway, phased development, reconstruction, expansion, optimum, throughput, low cost, task, solution, freight traffic, multimodal, production, ground transportation, computer software.

It is known that in the Address of the President of the Republic of Uzbekistan Sh.M. Mirziyoyev to the Oliy Majlis, it was noted that in 2022, investments worth 23 billion dollars will be absorbed and 206 new capacities will be put into operation. In addition, opinions were expressed about the most important guarantee of sustainable economic growth - the production of competitive products, finding new international markets for them and increasing exports, full use of transit potential.

The need to establish free trade zones in Andijan, Termiz and Kungirot districts and develop cross-border trade through them has been determined.

It was mentioned that it is extremely necessary to build a modern infrastructure with all conveniences for economic growth, i.e., continuous provision of raw materials to industries, and in this regard, 9.8 trillion soums have been allocated for road construction in the next 3 years.

Also, in the Address, priority tasks were defined in order to sharply increase the production of fruit and vegetable products for the export of 2 billion dollars this year and 3-4 times more in the next 5-7 years, turn tourism into a strategic branch of the economy, protect the environment and improve the ecological situation[1].

Modernization and further development of production, technical updating and diversification, requires extensive introduction of innovative technologies. It is known that the modernization and further development of production requires, respectively, the expansion of transportation capabilities and efficiency of all elements of the transport infrastructure - railway and road transport networks, technical and technological means. Such an infrastructure for the

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[1] Ўзбекистон Республикаси Президенти Ш.М.Мирзиёевнинг Олий Мажлисга Мурожаатномаси, Халқ сўзи, 2020 йил 25 январ, №19 (7521)

development of the transport services market at the modern stage is a multimodal transport network [1]. Multimodal transportation is an important component of modern logistics systems and takes into account various factors. For example, transportation costs, shipping cost, transportation distance, surcharge for transferring from one type to another, etc. Multimodal transport combines the advantages of several types of transport (road, rail, sea) and plays an important role in reducing carbon emissions in transport, and it is called a model of ecological transport.

The analysis of the literature devoted to the development of multimodal networks, planning of multimodal freight transport, it was shown that researchers use three main levels in their planning work, i.e. strategic, tactical and operational levels, that the issues of the tactical level are widely studied, and the issues of the strategic and operational levels are in the next place [2]. Despite the great attention paid to the above-mentioned issues, there are many problems and issues that await their solution in this regard.

In particular, optimization of transport flows and transport network and setting the issue of their optimal development in the future, substantiation of the mathematical model and development or selection of solving methods are the current issues of today [3].

[4]-[7] articles analyze the possibilities of using regional transit multimodal transport using Petri Net (E-Net), Firework and other simulation modeling programs, solving problems of multimodal transport networks using multi-objective optimization, evaluating the change of its transport networks based on the regional development plan done. Based on the analysis of existing literature, this article considers the issue of optimal distribution of cargo flows in the region by type and networks of surface transport on the example of Surkhandarya region.

Usually, taking into account the limited financial resources, it is envisaged that the development of local road networks will be carried out step by step on individual nodes. In this case, the improvement of the transport-operational characteristics of transport networks is carried out by changing the low type of road pavement to the type of permeable pavement [8].

Methodological foundations of multimodal transport network design patterns and capacity are seen in [9].

The article [10] analyzed the prospects of building roads in Slovakia to increase transport capacity, reloading stations ("Increasing transport capacity, building reloading stations in Slovakia") and wide-gauge roads in Europe to reduce the transit time of the cargo flow from Eastern Europe and Asia.

Adoption of schemes for improving the level of development of road sections is based on the following considerations: each stage of development of a road section means either an increase in the road category, or an improvement in the type of pavement, or both an increase in the road category and an improvement in the pavement type at the same time.

In order to formulate the problem and develop the model, we introduce the basic concepts and parameters of the transport network.

The main concept of the road and railway transport network is the destinations (nodes) where different road links (arcs) converge (join) [11]. We call such points junction points (JP). JPs are destinations where cargo is sent or received, cargo is transferred from one mode of transport to another, railway or road links in different directions intersect. As JPs of the network, it is also possible to accept the addresses of the sender, receiver or transfer of goods from one mode of transport to another. Thus, the set of existing or possible JP (nodes)

representing the current or prospective state of the transport network in the area of the economic zone is given N. This set includes the set of sender (S) and receiver (t) addresses, that is, $S, t \in N$.

A large-scale transport-transit system is represented in the form of graphs, which represent ordered pairs, that is, a set of finite vertices (airport, railway, car, bicycle stations and other terminals) and a set of finite arcs (transport lines between various terminals) [12].

We define the parameter variable characterizing the transport flow by $X_{ij,l}^{p}$ [11]: where ij represents the link (arc) connecting the transport network address i with address j, l indicates the type of cargo related to this flow, and p indicates the level of development for which the transport flow is being formed in this arc. In general, $i = 1, 2, ..., n$ is the sender address, $j = 1, 2, ..., m$ is the destination address index, a_i^l refers to the volume of j types of cargo sent from each destination and i received to each b_j^l destinations, where λ=1,2,..., k is a set of indices indicating the type of cargo.

Now let's move on to the analysis of the characteristics of the arc of the trasport network regarding the passing of the load flows. One such parameter is indicator C_{ij}^{p}, that is, the cost of transportation of one unit of cargo. In general, as a criterion for the optimality of the considered problem, the sum of the products of the parameters C_{ij}^{p} and X_{ij}^{p} of the elements of transportation costs for all l types of cargo in all ij arcs of the network can be accepted. But in this case, it is necessary to determine the content of C_{ij}^{p} parameters differently according to the level of development of the transport network considered for P. For example, if the problem is being solved for the actual existing network, i.e. $P = 0$, then $C_{ij,l}^{p} = C_{ij,l}^{p(ж)}$. In this case, $C_{ij,l}^{p(ж)}$ is the current cost of transportation per unit of transportation. Conversely, if $P > 0$ is $C_{ij,l}^{p} = C_{ij,l}^{p(жк)}$, and $C_{ij,l}^{p(жк)}$ is the sum of current and capital costs per unit of freight.

Another important issue in the formulation of the mathematical model of the problem [11] is to ensure that the parameter $X_{ij,l}^{p}$, which should be optimized, does not exceed the limiting value range determined for each ij arc of the transport network according to its level of development. This restriction is expressed in the form of different parameters for each type of transport. For example, the level of development for the highway network is determined by road categories, and the ij road sections in each category are characterized by the maximum possible number of vehicles passing the road in an average day of $D_{ij}^{p\,\max}$. In order to express this limitation in the model of the problem, it is necessary to change the parameters of the flow of transported goods from $X_{ij,l}^{p}$ to the maximum possible number of vehicles passing through ij arc sections per day to $D_{ij}^{p\,\max}$. Such a transition can be carried out by means of the expression $X_{ij,l}^{p} \cdot \dfrac{1}{Д_к \cdot q_{ij}^{p}} \cdot K_{ij}^{p}$, where $q_{ij}^{p} - ij$ is the average carrying capacity of motor vehicles passing through the section at the level of development p, t; $K_{ij}^{p} -$ is the coefficient indicating the weight of other types of vehicles except trucks in the traffic flow passing through this

section; $Д_к$ – is the number of calendar days. The volume limiting the flow of cargo for railway transport arcs is characterized by the maximum value of $Q_{ij}^{p\,max}$, the volume of transportation that this section can carry in one day. Due to the fact that the limiting parameters imposed on the load flows in the arcs of different transport networks are different, it is necessary to divide the set of arcs in the area IJ into local sets of arcs for each type of transport, that is, into local sets of arcs of $IJ_{AЙ}$ highways and $IJ_{TЙ}$ railway arcs.

Thus, the formulation of the problem and the mathematical model are formed as follows: determination of non-negative $l-$-cargo flows $X_{ij,l}$ transported along arcs ij between given connecting addresses in the area of the economic zone, i.e.

$$X_{ij,l}^{p} \geq 0,\ ij \in IJ \quad \text{and} \qquad\qquad (1)$$

in which the speed of traffic passing through the arcs of all highways will not exceed the maximum traffic flow capacity of this section $D_{ij}^{p\,max}$

$$\sum_{l=1}^{k} X_{ij,l}^{p} \cdot \frac{1}{Д_к \cdot q_{ij}^{p}} \cdot K_{ij}^{p} \leq D_{ij}^{p\,max},\ ij \in IJ_{AЙ}\ ; \qquad (2)$$

the traffic flow of all types of cargo transported on all arcs of the railway network does not exceed the maximum possibility of passing cargo from this section $Q_{ij}^{p\,max}$

$$\sum_{l=1}^{k} X_{ij,l}^{p} \leq Q_{ij}^{p}\ ,\ ij \in IJ_{TЙ}\ ; \qquad\qquad (3)$$

the volume of flows sent from JP on all arcs is equal to the volume of flows received at the next address

$$\sum_{i} a_i = \sum_{j} b_j \quad \begin{cases} i = 1,2,...,n; \\ j = 1,2,...m; \end{cases} \qquad (4)$$

for each node i =1,2,..., n and for each load l =1,2,..., k ;

$$\sum_{j}\sum_{l} X_{ij,l} - \sum_{j}\sum_{l} X_{ji,l} = \begin{cases} a_i, if, i \in S; \\ 0, if, i \notin S, t; \\ b_j, if, i \in t. \end{cases} \qquad (5)$$

Current $(F_Ж)$ or full (F_T) costs of transporting regional cargo flows are minimal

$$F_Ж = \sum_{ij}\ \sum_{l} C_{ij,l}^{p(Ж)} \cdot X_{ij,l} \to MIN \qquad\qquad (6)$$

$$F_T = \sum_{ij}\ \sum_{l} C_{ij,l}^{p(ЖК)} \cdot X_{ij,l} \to MIN\ . \qquad (7)$$

Such a view (formulation) of the issues of optimal development of the transport network takes into account various options for expansion, reconstruction and reconstruction of existing transport network links. It is possible to add new sections of various transport modes to the network. In general, any type of transport section ij can be entered into the model as a link with a specific transport cost. It should only be determined based on this cost.

Solving this issue has its own challenges. The main ones are: multivariate and large size; that the nature of the change of the transport cost function depending on the volume of the cargo flow is not linear; the need to solve the problem dynamically; the complexity of calculating freight costs between the compared modes of transport.

Due to this, it is necessary to solve the problem in a simplified form. For simplification, it is possible to accept the average value of the variable parameters and reduce the size of the considered problem on this basis. Such variable parameters include: type of load; road utilization ratio; vehicle carrying capacity; vehicle type; transport distance; type of wagon; the ratio of the carriage without load to the load; the coefficient of utilization of the load-carrying capacity of the wagon and so on. It should be noted that the values of the selected variables should affect the optimality of the obtained solution as little as possible, that is, this influence should not exceed the deviation of the value of the objective function from the optimal value by a certain limit.

The size, composition and direction of the future cargo flow is the most basic information for solving the problems of the development of the transport network. The composition of transported goods determines the possible options for using certain types of transport in the development of transportation. Given the location of the production, the load flow parameters are known in advance. In order to reduce the size of the problem, the load flow can be assumed to be uniform in composition, where the average value of the load capacity utilization is used in the calculations.

Thus, it may not be appropriate to use exact calculation methods to solve the given problems, because the initial data may often contain significant errors. In such cases, the use of approximate methods is more effective and faster than exact methods. This can be decisive in some cases. At the same time, the efficiency of using approximate approximation methods does not reduce the need and importance of developing exact algorithms. They may be needed to evaluate the accuracy of approximate methods. With the help of the proposed computer program, the issue of distribution of cargo flow in the regional multimodal network was considered. At the first stage, the correctness of the initial data was checked, and several options for the distribution of the traffic for the case where "narrow" sections in the network, i.e., roads with limited capacity for cargo flow were not taken into account, were solved, including the distribution of the cargo traffic flow was carried out in the order of increasing flow volume. From the analysis of the solution results, it was found that some adjacent plots have an external additional value[2]. As a result, an additional path with a higher level of development is made for this case. In this case, the cost of transportation increases due to the high probability that the transportation between neighboring points will be diverted, and the solution obtained in the process of distribution of the load flow may not be optimal.

At the next stage of solving the problem, the cargo flow was considered in the case where it is distributed in the multi-network in the order of increasing transportation distance, that is, in the order of transferring short-distance transportation to the car.

It allows to reduce the cost of transportation by 19.7%. Based on the analysis of the results of distribution of cargo, the following conclusions were formed:

1. it is appropriate to use automobile transport for cargo transportation in the region;

2. It became known that the capacity of the regional road network Kumkurgan-Shorchi, Shorchi-Denov, Denov-Sariosiyo to carry the growing cargo flow is below the required level. Therefore, it is necessary to gradually expand and reconstruct road sections of the motor transport network in this direction;

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[2] Қўшимча баҳонинг иқтисодий мазмуни-йўлнинг ўтказиш қобилияти етишмаслиги туфайли мазкур йўлни кенгайтиришга қўшимча харажат.

3. It would be expedient to transfer cargo transportation in enterprises directly connected with the railway on the Termiz-Sariosiyo, Termiz-Denov routes to railway transport, because the cost of transportation is cheap and this measure reduces the speed of cars in these heavily loaded sections;

4. International goods in transit from the Surkhandarya region (Republic of Tajikistan) mainly pass through the Darband-Sherabad-Denov route. If the crossing is made via the Darband-Boysun-Denov route, the travel distance will be reduced to 85.6 km. This allows us to increase our transit capacity.

In this regard, as stated in the Address of the President of the Republic of Uzbekistan Sh.M. Mirziyoev to the Oliy Majlis, "According to the conclusion of international experts, there is an opportunity to increase the transit potential of our republic from 7 million tons to 16 million tons due to the improvement of infrastructure, the use of flexible tariffs and the formation of new promising routes." The Darband-Boysun-Denov highway is also convenient for transportation of our region (Shorchi, Denov, Oltinsoy, Sariosiyo and Uzun districts) with other regions of our republic. Therefore, it will be necessary to reconstruct this section of the road as a highway that meets modern requirements.

The analysis of the results obtained in the study suggests that it is appropriate to use road transport for internal transportation in the region and for transportation of small-scale agricultural products grown in the region across the territory of our republic. Today, small production enterprises, firms and farms are being established. This further increases the demand for small volume transportation. Therefore, it is necessary to gradually develop road transport and roads in the region. In order to solve this problem, research works are being carried out within the framework of the practical project No. OT-Atex-2018-352 on the topic "Optimum development of the regional transport network and wide application of logistic principles in the efficient utilization of future cargo flows".

The use of the results of this research provides a great opportunity for planning and designing the future development of the road and rail transport network. The development of the transport network is mainly carried out in turn based on the transport operational condition of the roads. This provides an opportunity to rationally distribute capital funds allocated for the development of the transport network of the region.

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