SELECTED ABSTRACTS OF D.SC. AND PH.D. THESES SUBMITTED AT RUSSIAN TRANSPORT UNIVERSITIES

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ABUJWAID Hussam Abbas Mohsin. Improving urban transport systems in Iraq. Abstract of Ph.D. (Eng) thesis [*Sovershenstvovanie gorodskikh transportnykh sistem Iraka. Avtoref. dis… kand. tekh. nauk*]. St. Petersburg, Emperor Alexander I St. Petersburg State Transport University, 2023, 19 p.

The development of any city largely depends on improvement of urban transport systems (UTS). International experience highlights the importance of developing and regulating public transport sectors as they play a vital role in various aspects of modern life. Social and economic activity increasingly depends on development of transport services to meet the transportation needs of individuals.

The relevance of the work lies in the need to improve the hydraulic system of Iraq. Research on hydraulic structures in Iraq is few and insufficient. There is a fundamental problem associated with planning transportation by public transport due to the increase in population due to its annual growth of 2,5 %, high demand for transportation, significant urban population growth and widespread use of personal vehicles. Since 2003, the number of private vehicles has increased by 122 %. In addition, there are seasonal transport problems due to the influx of tourists in some Iraqi cities such as Karbala and Najaf.

The purpose of the study was to develop a methodology for improving the structure of the road network and urban transport system, ensuring the efficiency of their functioning in the cities of Iraq.

The characteristics of Iraqi cities are analysed and studied: population size and density, city areas, level of motorization, maximum extent of territory. Based on the analysis of the modern functioning of transport systems, the classification of cities was clarified, considering the specifics of Iraq.

An analysis of research on the selection of types of urban public transport (UPT) was carried out and a classification of rolling stock capacity rows and UPT options for Iraqi cities was developed, the volume of transportation for each type of rolling stock was calculated as a percentage, rows of rolling stock capacities were selected, and the volume of traffic per each type of rolling stock was calculated.

The boundaries of the intervals of average intensity of passenger traffic for groups of cities in Iraq have been adjusted, which allows selecting the type of UPT vehicle and its share of traffic for each type of rolling stock.

A comprehensive assessment of efficiency of transport systems in modern conditions was conducted based on economic, social, and environmental indicators, and a block diagram of an algorithm for determining economic, environmental and social effects was developed.

As a result of calculations of economic, environmental, and social indicators for the cities of Iraq, it was noted that these indicators are not effective enough and it is necessary to improve the road network, therefore possible options for improving the structure of the urban network were considered.

The analysis of research on improving the topological structure of urban transport networks was conducted. An algorithm is proposed for planning the connectivity and efficiency of the road network using indices based on topological characteristics.

A comprehensive methodology has been developed for improving the Iraqi UTS, which includes four stages. At the first stage, the main characteristics of cities are justified and determined, as well as the division of trips by time, needs and services. At the second stage, a comprehensive assessment of the efficiency of transport systems in modern conditions is conducted according to economic, social, and environmental indicators. At the third stage, the type of UPT is selected. At the fourth stage, the structure of transport networks is analysed and improved. The first three determine the methodology for choosing a mode of transport, and the fourth – improving the structure of transport networks.

Recommendations have been developed for development of the transport network of the city of Najaf. For this city, justification and selection of types of UPT safety standards are presented, and studies have been conducted to assess the effectiveness and improvement of the street road network. A topological map of the city was developed, based on which an assessment of the connectivity and efficiency of the street-road network was calculated and recommendations for its improvement were developed.

It is recommended to increase the share of public transport and when choosing types of UPT, to consider not only economic indicators, but also environmental and social ones.

Prospects for further development of the topic are in the area of developing Iraqi urban systems and opening prospects for cooperation in this area between Russia and Iraq and are also associated with improving the methodology for designing urban transport systems.

2.9.1 – Transport and transport-technological systems of the country, its regions and cities, organization of production in transport.

The work was performed and defended at Emperor Alexander I St. Petersburg State Transport University.

Chunin, V. V. Forecasting the safe operation of cargo car wheels using fracture mechanics methods. Abstract of PH.D. (Eng) thesis [*Prognozirovanie bezopasnoi ekspluatatsii koles gruzovykh vagonov metodami mekhaniki razrusheniya. Avtoref. dis… kand. tekh. nauk*]. Moscow, RUT (MIIT) publ., 2023, 24 p.

The analysis of operating conditions and failure statistics of railway wheels shows that the strength criteria specified in the current standards cannot fully guarantee their failure-free operation; there are no requirements and, accordingly, methods for assessing the stage of crack development. If the viscosity of the metal is insufficient and its sensitivity to stress concentrators is high, a fatigue crack may begin to propagate up to its critical length, which is dangerous due to the possibility of brittle fracture of the wheel due to the influence of seasonal factors.

At the design stage, wheel developers do not predict the stage of development of fatigue cracks before the onset of the limit state. As a rule, the time between repairs of a car is established based on the period of maintenance of parts and assemblies and does not consider the survivability of the main load-bearing elements. For example, with an increase in axial load and the use of new materials and structures, the likelihood of fractures increases.

Currently, the issue of the possibility of using cast wheels in Russian railways is being actively discussed. But considering that the technology for production of cast wheels does not imply multi-stage hot deformation, and the formation of the wheel is conducted by casting metal under pressure into a mold. This manufacturing technology causes a number of differences in the properties and quality of the metal of cast wheels compared to solid-rolled wheels.

Thus, to eliminate possible risks, there is a need to develop a unified methodology for assessing the stage of crack development from dynamic influences in operation, conducting studies of the behaviour of wheel metal when the temperature drops to –60 °C, and determining the degree of change in properties and fracture parameters. Based on the results, indicators that affect the safe operation of the wheel must be determined, and their minimum acceptable values for Russian operating conditions must be obtained.

The purpose of the study is to ensure safe operation of the car by predicting its mileage after the occurrence of a fatigue crack in the wheel disk before it breaks, by determining scientifically based requirements for overhaul intervals.

The analysis of regulatory, scientific, and technical documentation showed the absence of requirements and, therefore, a lack of methods for assessing survivability of wheels, as well as taking into account low climatic temperatures, at which the mechanical properties of the metal of the wheels change and the rigidity of the track increases. To ensure safe operation, it has been established that it is necessary to predict the mileage of a car after a crack occurs in the wheel, especially with an increase in the axle load to 27 tf, a reduction in the tare weight of cars by 25 % and the use of new materials and structures.

The studies have shown that the most dangerous are wheel metal defects located in the zone of maximum operational stress amplitudes, which with a certain probability may not be detected by NDT, which will lead to crack growth, bypassing the stage of accumulation of fatigue damage and accelerated destruction.

Experimental tests of standard samples cut from wheels manufactured using different technological processes and from different steel grades for a cast wheel made from AAR B steel, and for a solid-rolled wheel from grade 2 steel showed that the characteristics of the cyclic fracture toughness of metals differ: for solid-rolled steel wheels at a temperature of 20 °C are higher than for cast steel, but when the temperature drops to –60 °C the values become comparable.

The analysis of methods for assessing the strength of car wheels showed that when testing using the circular bending method, their loading is closest to the operational one. Experimental survivability curves were obtained, and the number of cycles before failure of solid-rolled and cast wheels was 8,1 and 1,0 million load cycles, respectively.

A virtual model of a stand for testing wheels by circular cyclic bending has been developed for numerical modelling of development of a crack in the disk of cast and solid-rolled wheels from the initial defect to calculate the SIF values, according to which the need to estimate the moment of crack starting and breaking of the wheels is justified based on the *KI* values at the crack front corresponding to type I opening.

A dynamic model of a cargo car with an elastic wheel set has been developed, with inertial, rigidity, elastic-dissipative and geometric parameters corresponding to the vehicle of the cargo car. According to the results of running dynamic and strength tests, the model has satisfactory convergence in terms of dynamic indicators and adequately describes car movement in operation. The proposed methodology makes it possible to determine the SSS of a cargo car wheel set, evaluate the strength, service life and survivability of various designs of axles and wheels, and can be applied at the design stage to predict the period of development of a crack in a wheel in order to ensure its safe operation.

Based on the modelling results, summary diagrams of distribution of dynamic stress amplitudes versus the frequency of their occurrence in cast and solid-rolled wheels were obtained. The survivability of cast and solid-rolled wheels in operation, that is, the growth of a crack from an initial defect to a fracture at a temperature of 20 °C was 944,2 thousand km and 671,8 thousand km, and at a temperature of –60 °C – 283,8 thousand km and 669,6 thousand km, respectively.

For safe operation of cargo cars, it is proposed to set the minimum allowable safety factor for wheel survivability to 2,0. Thus, safe operation of a cargo car with cast wheels will be ensured over a time between overhauls of 110 thousand km, with a survivability safety factor of 2,58, and with solid-rolled wheels – 210 thousand km, with a survivability safety factor of 3,19.

The results obtained can be used to establish requirements for the overhaul intervals of cargo car wheel sets.

Further research prospects may be related to the issue of clarifying the requirements for the sensitivity threshold of NDT methods used to detect wheel defects.

2.9.3. – Railway rolling stock, train traction and electrification.

The work was performed and defended at Russian University of Transport.

Petrov, A. V. The influence of low temperatures on the rigidity of rail fastening units of a ballastless track structure. Abstract of Ph.D. (Eng) thesis [*Vliyanie nizkikh temperature na zhestkost uzlov relsovykh skreplenii bezballastnoi konstruktsii puti. Avtoref. dis… kand. tekh. nauk*]. Moscow, RUT (MIIT) publ., 2023, 24 p.

The development of high-speed railway traffic in our country involves construction of new dedicated railway lines for high-speed railway traffic. The most promising at present is the high-speed rail (hereinafter HSR) «Moscow – St. Petersburg» with speeds of up to 400 km/h. All high-speed rail projects involve the use of new technological and engineering solutions that ensure the highest level of reliability and safety of passenger and cargo transportation, which will provide the necessary comfort for passengers.

World experience in construction and operation of high-speed lines has confirmed the effectiveness of using ballastless track design (hereinafter referred to as BTD). For example, development of Moscow–Kazan HSR project implied the use as a base of a ballast-free slab track structure CRTS III RUS, adapted to Russian operating conditions. It is known that in BTD, rail fastenings with an intermediate elastic layer are the main element, the elastic properties of

which form from 80 to 95 % of the elastic properties of the entire track structure as a whole. This is confirmed by field measurements of rail deflection under the influence of loads from rolling stock.

Foreign regulatory and technical documentation regulates the requirements for the elastic characteristics of rail fastenings with an intermediate elastic layer for BTD, considering the influence of low temperatures. The lower threshold test temperatures in German and Chinese standards are set at –20 °C and –35 °C, respectively. According to the requirements of the pre-design documentation for Moscow–St. Petersburg HSR line, for Russian operating conditions it is necessary to consider a minimum temperature of –50 °C. Thus, the issues of improving the calculation model for determining the elastic deflection of the rail from the influence of rolling stock on BTD, taking into account the influence of low temperatures, with the subsequent formation of requirements for the elastic characteristics of rail fastenings with an intermediate elastic layer for BTD operating in the conditions of the designed HSR line Moscow – St. Petersburg when exposed to low temperatures down to –50 °C; and to adjust methods for confirming compliance with these requirements.

The purpose of the dissertation work is to determine the influence of low temperatures on the rigidity of rail fastening units of BTD operating under the conditions of the designed HSR line «Moscow – St. Petersburg».

The influence of low temperatures on the rigidity of BTD rail fastening units has been determined. The calculation model for determining the elastic deflection of a rail from the influence of rolling stock on BTD has been refined by introducing coefficients that allow considering the influence of low temperatures on the change in rigidity of rail fastenings with an intermediate elastic layer.

The coefficients of change in the static and dynamic stiffness of elastic gaskets made of EPDM and Byrel materials in a factory-made state in the temperature range from –50 °C to +50 °C, obtained in laboratory conditions, were determined. It has been experimentally confirmed that with a decrease in temperature to –50 °C for elastic gaskets made of EPDM and Byrel material, there is a corresponding increase in static stiffness by 2,11 and 3,57 times, and there is also a corresponding increase in the dynamic rigidity of elastic gaskets made of EPDM and Byrel materials by 17,54 and 9,06 times.

Tests were conducted on the Experimental Ring of JSC VNIIZhT to determine the deflection of the rail on a section of the ballast-free track designed by Feste Fahrbahn Boegl. The adequacy of the calculations is confirmed by satisfactory convergence with experimental data. The agreement between the calculated results and the experimental data was 94,8 %.

Additional requirements have been formed for the elastic characteristics of BTD rail fastenings for Russian operating conditions for sections of high-speed railway communication with speeds up to 400 km/h of the projected HSR line «Moscow – St. Petersburg», recommended for inclusion in GOST 32698:

– the vertical rigidity of the rail fastening unit must be within the range, kN/mm – 16–27.

– the change in the static rigidity of elastic gaskets operated at low temperatures (from –50 °C to +23 °C) should not exceed a factor of – 4.

– the ratio of dynamic stiffness to static stiffness of elastic gaskets should not exceed the coefficient: at a temperature of 23 °C – 1,5; at a temperature of 0 °C – 2,0; at a temperature of –10 °C – 2,5; at a temperature of –20 °C – 3,0; at a temperature of –30 °C – 3,5; at a temperature of –40 °C – 5,0; at a temperature of –50 °C – 18,0.

Recommendations have been developed on methods for determining the elastic characteristics of a rail fastening unit with an intermediate elastic layer for BTD, considering the influence of low temperatures.

The prospect for further development of the topic is to conduct research into the operation of rail fastenings with an intermediate elastic layer of BTD at real speeds under loads from real high-speed rolling stock at a high-speed test site, which should become a section of Moscow–St. Petersburg HSR line.

2.9.2. Railway track, survey, and design of railways.

The work was performed and defended at Russian University of Transport.

Zubkov, V. V. Methodology for formation of transport and information space in the conditions of cluster development of the market for complex transport services. Abstract of D.Sc. (Eng) thesis [*Metodologiya formirovaniya transportno-informatsionnogo prostranstva v usloviyakh klasternogo razvitiya rynka kompleksnoi transportnoi uslugi. Avtoref. dis… dok. tekh. nauk*]. Yekaterinburg, UrGUPS publ., 2023, 48 p.

The development of the economy, in particular the digital economy, increases the need for transport services. Transport provides the opportunity for digital market exchange, while market virtual interactions stimulate development of both the country's transport system (development of clusters of integrated transport services) and improvement of the global transport complex.

The organization of processes and their management during the market formation of transport and production services are in the area of coordination influences of regulators (regional, interregional, and federal authorities) on the subjects of transport and production activities, social and economic activities. The influence of regulators is aimed at involving a larger number of subjects in the socio-economic space, as well as at the effective use of available resources for gradual and systematic development of regional and interregional relationships and economic ties, ensuring achievement of the highest level of development of regions (territorial entities of the Russian Federation) and the state as a whole through the prism of increasing the growth of life activity of the country's population.

The influence of regulators is based on regulatory activities, restructuring functions, methods, and mechanisms of management, subject to compliance with the target conditions of the influencing factors.

The development of clusters is a multi-stage and complex process that is formed not only from the point of view of improving production processes and improving the quality of meeting consumer demand, but also from the point of view of the socio-economic development of society, since structuring and dynamics of growth of the social environment directly depend on the level of performance of economic processes.

Currently, industrial clusters are developing most of all, including participants in the main production process, resources necessary for production, sets of sub-processes of activity, which are interconnected by common goals and objectives of improvement, construction of an integrated

technological process and unified protection from current competitive factors.

The development of industrial clusters creates the prerequisites for formation of regional clusters, in particular, clusters of integrated transport services since production of products and their delivery are closely related to consumption of types of transport services.

The cluster of integrated transport services is an economically rational direction for development of the industrial and transport segments of the economy, increasing the vitality of the country's population. The main source of development of transport clusters is integration of production and transport processes, based on which stable economic relationships are built between production entities, transport service entities and socio-economic entities.

The purpose of the dissertation research was to develop a methodology for formation of the transport and information space in the conditions of cluster development of the market for complex transport services.

During the research, methods of system analysis, the theory of active systems, control theory, the theory of self-adaptive, self-organizing and self-sustaining systems, the theory of the information society and digital economy, the theory of cluster development, the theory of the synergetic approach and assessment of integrating processes were used.

The study on constructing a methodology for formation of a transport and information space in the conditions of cluster development of the market for complex transport services makes it possible to substantiate conclusions and corrective actions, the vector of which is aimed at formation of a consolidated development strategy for the constituent entities of the Russian Federation.

As a result of the analysis of functioning of the current model of transport services in the cargo transportation market in the railway industry, it was established that guaranteed responsibility for implementation of the main quality indicators is provided only within the boundaries of responsibility of the railway complex, while coordination and mutual influence on the quality criteria of transport services in other types of transport in the general transport system is not ensured, which increases the cost of finished products.

A methodology has been developed for assessing the quality of transport services in a model of integrated transport services, which tracking and evaluate the influence of each subject on ensuring the quality of services using maximum values of the quality coefficient.

A method has been developed for detailing the structure of the impact of subjects of a complex transport service cluster on improving the quality of service, which determines the degree of their responsibility for compliance with the plan for provision of transport services, which are calculated for each category of transportation.

A methodology has been developed for optimizing the transport and production processes of a complex transport service cluster, which makes it possible to determine the total best (optimal) options for the process parameters for implementation of types of transport services, which are determined and calculated on the basis of the best (optimal) options for the parameters included into the main process of subprocesses.

A comparative model of the optimal option for optimizing the transport and logistics process has been developed, which allows studying the properties of transport and production processes for formation and implementation of complex transport services as the main product of the transport industry.

A methodology has been developed for constructing a virtual integration system that provides rational and logically dependent design of the most important architectural elements of a directed (quoted) intelligent system at the interregional and regional levels.

A conceptual model of interaction of information flows of a complex transport service cluster has been developed, which ensures the acquisition of experience and knowledge from the transport information environment from the processes being implemented and the formation of technologies for their application.

A methodology has been developed for constructing a matrix of indicators that reflects the actual and forecast volumes of complex transport services by region of the country, structures regional, interregional, export and import complex transport services, dividing them by mode of transport.

A methodology has been developed for formalizing information flows of a cluster of complex transport services, interlinking transport and technological processes (subprocesses) between cluster subjects and executors of processes (subprocesses) based on the acquired knowledge about the areas of their implementation and the resource capabilities of cluster subjects, providing conditions for effective optimization of the process of managing transport and logistics systems and a cluster of integrated transport services.

An intersectoral information and intellectual model for integrating information flows of subjects at the interregional level has been developed, accumulating, and concentrating information knowledge in a single transport and information space and representing a quota-based information and intellectual system.

A methodology has been developed for constructing an intersectoral information-intellectual model for integrating information flows of subjects of the interregional level, which ensures concentration in one perimeter of information flows emanating from integrating information systems of subjects of the intersectoral, interregional levels, federal regulators and business associations, and provides the ability, without human influence, to implement centralized accounting, analysis and control over implementation and actual state of the processes of making optimal management decisions.

A methodology has been developed for formation of a virtual system of integration of coordinated subject cooperation at the regional and interregional levels, which ensures formation of quota-based information and intellectual products aimed at determining optimal coordination and management decisions in the context of cluster development of the complex transport service market.

A methodology for assessment actions has been developed to determine the synthesis of interaction and integration of subjects of the transport and information space, on the basis of which representatives of government bodies (regulatory subjects) form complex programs that motivate the processes of integration, virtual cooperation and the processes of development of clusters of integrated transport services and development subjects of the Russian Federation.

2.9.1 – Transport and transport-technological systems of the country, its regions and cities, organization of production in transport.

The work was performed and defended at Ural State University of Railway Transport. ●