Osintsev, N. A. Methodological foundations for sustainable development of logistics chains of cargo flows. Abstract of D.Sc. (Eng) thesis [*Metodologicheskie osnovy ustoichivogo razvitiya logisticheskikh tsepei gruzopotokov. Avtoref.dis… dokt.tekh.nauk*]. Moscow, RUT publ., 2023, 48 p.

The objective of the thesis work is to develop a methodological basis for sustainable development of logistics chains of cargo flows using the principles and tools of green logistics for effective promotion of cargo flows while simultaneously reducing the negative impact on the environment.

The results of the thesis research were used in carrying out research work commissioned by PJSC Magnitogorsk Iron and Steel Works, PJSC Uralasbest and Delta LLC. The results were reported at a meeting of the Regional Strategic Committee dedicated to the development of a strategy for socio-economic development of the Chelyabinsk region for the period until 2035.

The analysis of global and domestic experience in managing transport systems and supply chains revealed that the increase in production and consumption volumes has a negative impact on the environment, which led to an increase in carbon dioxide emissions from 23,1 to 31,5 Gt from 2000 to 2020. The need has been revealed to improve approaches to managing logistics chains of cargo flows for the conditions of the Russian Federation, which ranks 4th in the world in terms of CO_2 emissions and 75th in the world according to the LPI logistics efficiency index.

It has been established that the complexity of managing logistics chains of cargo flows lies in the absence of a universal system of logistics principles that ensure formation of a balance between the economic, social and environmental sustainability of cargo logistics chains (CLC); in the variety of approaches to the content of green solutions, which is the reason for the lack of consistency in their implementation in practice; in the absence of an integrated and system approach to assessing all types of logistics flows, based on consideration of the relationship between indicators and parameters of flows from the perspective of the concept of sustainable development.

A new system of principles of green logistics has been formed based on a synthesis of the principles of logistics and the principles of sustainable development. The formulated 19 principles of green logistics are the basis for implementation by CLC elements of their key, basic or supporting functions to achieve sustainable development goals.

The methods and tools of green logistics were systematised. The systematisation is based on factors of sustainable development of CLC, as well as on the basic and supporting functions of all elements of the CLC to achieve sustainable development goals. The proposed system of methods and tools of green logistics includes 27 methods and 105 tools, ensuring the achievement of 13 sustainable development goals.

A concept for sustainable development of logistics chains of cargo flows has been developed. The basis of the concept is the idea of forming a balance between the economic, environmental and social sustainability of CLC, based on the use of principles, methods and tools of green logistics, multi-criteria methods and decision-making models for managing the parameters of logistics flows and elements of CLC.

An original system of indicators and parameters of logistics flows in CLC is proposed, including five groups of parameters (economic, energy-ecological, quality, statistical and controllable) and 15 indicators. A feature of the proposed system is assessment not of individual elements of CLC, but a comprehensive assessment of logistics flows for compliance with aspects of the concept of sustainable development and the effectiveness of management of CLC.

A methodology has been developed for determining the weighting coefficients of parameters and indicators of logistics flows in the CLC. The basis of the methodology is the idea of comparing the results of using various multi-criteria weighing methods to determine the weight of logistics flow indicators using fuzzy, Grey and traditional (CRiSP) rating scales. This will make it possible to perform a comprehensive two-level assessment of the indicators of logistics flows in the CLC, determine the relationships both between groups of parameters and between indicators of

293

logistics flows, assess the strength of the influence of parameters (indicators) on each other, and ultimately determine the weight of each parameter (indicator) of the logistics flow in CLC.

A system has been proposed and a methodology has been developed for a comprehensive assessment and ranking of indicators of logistics chains of cargo flows using the DEMATEL method. The use of the methodology will allow to improve the quality of assessing the state of cargo flows for compliance with the SDGs to increase the efficiency of management decisions on the selection and use of green logistics tools.

A multi-criteria model for assessing CLC elements in formation of a sustainable development strategy for CLC has been developed. The model is based on the use of a combination of multi-criteria methods DEMATEL, BWM-SAW in combination with approximate interval numbers and STEEP analysis. The result of using the model is the ranking of management decisions (optimisation, constructive, changing the principles or changing the system) for all elements of the CLC under the influence of STEEP factors (social, technological, economic, environmental and political ones).

A combined MCDM model has been developed for ranking methods and tools of green logistics in CLC considering their impact on the parameters and indicators of CLC and achievement of sustainable development goals. The ranking of green logistics methods and tools is based on the integrated use of multi-criteria models of management decision-making. The results of using 14 multicriteria models showed high consistency (Spearman's rank coefficient averaged 0,689–0,919). The most consistent methods are WASPAS, MABAC, MARCOS, MAIRCA, SAW and COPRAS. The least consistent methods are CoCoSo, PROMETHEE, VIKOR and CODAS.

A mathematical model has been developed for determining the optimal combination of green logistics tools for their use by CLC elements, considering the available material, financial, information and service resources. The final decision on the implementation of a specific green logistics tool and the determination of its optimal parameters is made using the developed Grey linear programming mathematical model, which allows for flexibility, reliability and accuracy of assessment in conditions of lack and inaccuracy of information about the simulated objects.

The dependence of the increase in the effect of implementing green logistics tools on changes in the share of supply of logistics resources has been established. Redistribution of the share of logistics resources for implementation of tools within the range of 7,5–15 % allows us to achieve the maximum effect from implementation of tools in the CLC.

A methodology is proposed for managing the parameters of logistics chains of cargo flows to achieve sustainable development goals, based on identifying the parameters and indicators of CLC, building a fuzzy model of the relationship between parameters and indicators of CLC, assessing the sustainability of CLC and making decisions on selection and implementation of green logistics tools to bring manageable parameters of logistics flows in accordance with the required values and sustainable development goals.

Examples of implementation of green logistics tools of three types of management solutions for transport and mining enterprises are presented: optimisation, constructive and changing operating principles. The implementation of green logistics tools made it possible to increase the comprehensive sustainability indicator from an average of 0,39 to 0,48, economic efficiency by 8,69–10,77 %, environmental efficiency by 7,67–9,42 %, social efficiency by 8,47–10,5 %.

The main provisions and results of the thesis are recommended to be used by federal and regional authorities when developing strategic programs for formation and development of logistics transport systems; by managers of transport enterprises to assess the effectiveness of decisions on implementation of measures aimed at reducing the negative impact of transport on the environment; by potential investors when choosing options for projects to create logistics infrastructure based on forecasts of cargo flow parameters.

The prospect for further development of the thesis topic is formation of a logistics flow management system based on a combination of multi-criteria methods with simulation modelling. This will make it possible to evaluate the effectiveness of decisions on sustainable development of logistics centres, predict changes in the parameters and indicators of logistics flows and make decisions considering these changes.

2.9.9. – Logistics transport systems.
The work was performed at Nosov Magnitogorsk State Technical University, defended at Russian University of Transport.

Petryaev, A. V. Mechanical stabilisation of sleeper foundation soils with geosynthetic materials. Abstract of D.Sc. (Eng) thesis [*Mekhanicheskaya stabilizatsiya gruntov podshpalnogo osnovaniya geosinteticheskimi materialami. Avtoref.dis… dokt.tekh.nauk*]. St.Petersburg, PGUPS publ., 2023, 32 p.

The objective of the work is to improve the design of the railway track through mechanical stabilisation of the sleeper foundation soils with geosynthetic materials.

The thesis solves a scientific problem of great economic importance, which is to improve the track design to ensure dependability of the sleeper base under increased vibration-dynamic load from passing trains. New scientifically based engineering solutions are outlined in the field of stabilisation of railway track under sleepers foundation with geosynthetic materials.

Based on complex long-term field studies carried out on heavy-duty and high-speed sections of the railway track, the features of distribution of amplitudes of vibration displacement of soil particles and the stress-strain state of the soil under the sleeper base of the railway track during their mechanical stabilisation with geosynthetic materials were identified.

A wide range of field surveys made it possible to identify directly proportional dependences of changes in vibration amplitudes, dynamic stresses and deformations on axial and linear loads, as well as train speed when stabilising the sleeper base with geosynthetic materials. Laying geogrids under ballast leads to a reduction in horizontal stresses in the under-rail zone and their more uniform distribution over the main area of the subgrade.

For the first time, the influence of geosynthetic material on changes in the strength and deformation characteristics of stabilised massifs has been established qualitatively and quantitatively. It has been established that deformation properties of ballast directly depend on the magnitude of the stresses that arise at the level of geosynthetic material layers and on its rigidity. Conducted studies of the behaviour of ballast under conditions of triaxial compression have shown the effectiveness of using a geogrid for its stabilisation.

As a result of experimental and theoretical studies, a mechanism for stabilising the sleeper base with geosynthetic materials has been identified, which consists in transversely limiting the mobility of soil grains. The effect of the mechanical stabilisation mechanism depends on the level of deformation. It has been established that laying geosynthetic material in ballast reduces its contamination with small particles formed during deformation of crushed stone.

A method has been developed for calculating the strength and stress-strain state of a sleeper base stabilised with geosynthetic materials, considering the decrease in the strength and deformation characteristics of soils under the influence of a vibro-dynamic load and its attenuation in the soils of the sleeper base. The calculations performed using the developed complex methodology are in good agreement with the data of laboratory and field studies.

The results of calculations using the developed methodology established that during the thawing period, significant shear deformations are concentrated on the main area of the subgrade in the under-rail section, which causes deformation of the subgrade observed in operating conditions. With mechanical stabilisation of the under-sleeper base, the concentration of shear deformations is localised in the area of geosynthetic material layer, while in the under-rail section on the main site it is reduced.

Analysis of data from field studies and numerical modelling, carried out based on the developed complex methodology, made it possible to propose new scientifically rationale approaches to development of effective design solutions for reducing deformability of the sleeper base when it is stabilised with geosynthetic materials. A rational depth for laying geosynthetic material has been established to effectively reduce the vibration-dynamic impact from passing trains. The technical and economic efficiency of practical solutions developed based on the research results has been confirmed during their implementation at Moscow, Far Eastern, Sverdlovsk and Oktyabrskaya Infrastructure Directorates – branches of JSC Russian Railways, in organisations developing measures to stabilise the under-sleeper base of the railway track.

The proposed direction for mechanical stabilisation of soils is one of the promising solutions in the field of creating engineering foundation structures. Due to inclusion of geosynthetic materials in the soil, it is possible to purposefully change its strength and deformation characteristics, as well as to reduce the unevenness of track settlement by changing the rigidity of the base. The choice of a rational type of stabilisation from a technological, economic and design point of view depends on the operating conditions of the railway track, the physical and mechanical properties of ballast and subgrade soils.

2.9.2 – Railway track, survey and design of railways.

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

295