



New Approaches to Improving Protection of the Urban Environment from Transport Accidents Based on the Use of Safe Materials



Eduard S. Tskhovrebov

*Centre of Federal State Budgetary Institution All-Russian Scientific Research Institute
for Civil Defence and Emergencies of the Ministry of the Russian Federation for
Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters,
Moscow, Russia.*

✉ rebovstanislav@rambler.ru.

Eduard S. TSKHOVREBOV

ABSTRACT

The relevance of safety problems of a wide range of anti-icing materials and chemical anti-icing reagents used in the municipal economy is predetermined by a number of aspects and factors associated with the negative impact of anti-icing products on the natural environment, property and health of citizens, its lack of effectiveness in terms of ensuring transport safety, preventing causes, conditions of occurrence of transport accidents, the growth of injuries of the population in winter. The objective of the study was to study the possibility of using ash and slag mixtures that are practically harmless to the environment together with organic additives from plant waste as complex anti-icing materials.

The objective of the work was to study possibility of using practically environmentally friendly ash and slag mixtures along with organic additives as complex anti-icing materials. The main tasks comprised comparative analysis of effectiveness and safety of anti-icing materials used, justification of the possibility of

replacing them with ash and slag secondary disposals, assessment of the current situation with handling of ash and slag waste, technical feasibility, environmental acceptability, economic feasibility of their reuse as designated at road transport infrastructure facilities.

The projected results of the study were reduction of the technospheric load on the natural environment, prevention of all types of negative impact on the health of citizens, their personal property, replacement of valuable natural raw materials with secondary ones, prevention of transport accidents and related man-made emergencies. Based on the results of the study, it is planned to conduct full-scale tests and, in case of obtaining positive results that determine safety and effectiveness of the use of a new anti-icing material, to apply for a patent for an invention with further implementation of an innovative proposal in various regions of the Russian Federation.

Keywords: environmental safety, transport accidents, anti-icing material, chemical reagent, ash and slag waste and raw materials, municipal economy, resource saving, emergency situations.

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INTRODUCTION

As far as a significant part of the territory of the Russian Federation is concerned, the most difficult period in the work of organisations operating the road transport infrastructure is the winter season. The rate of safe state of coverage of elements of the street-and-road network (SRN) for road users (sidewalks, roadways, underground and ground crossings, pedestrian zones) during this period are determined by the spectrum of road, weather-climatic, sanitary-hygienic, environmental, transport and technological factors.

One of the most important tasks of ensuring transport safety, preventing transport accidents and injuries to the population is to build a well-organised and effectively managed system of measures for monitoring, forecasting, preventing, and timely elimination of winter slipperiness on SRN, which includes mechanical removal of snow masses, the use of solid mineral anti-icing materials and liquid chemical anti-icing reagents as a chemical method for destruction of ice and snow [1–3].

Many years of domestic and foreign experience indicate that chemical anti-icing agents are rather effective means of combating winter slipperiness, but their use entails the need to comply with rational technological consumption rates, safe concentrations, safety and labour protection, control, and monitoring of the level of environmental pollution. When working with such chemically hazardous substances, hygienic requirements regulate the mandatory availability of special clothing and personal protective equipment for the eyes, skin, and respiratory organs [2–4].

An important limiting factor is the negative mechanical, chemical impact of such materials on natural objects and components of the natural environment: dusting and release of toxic compounds to varying degrees into the atmospheric air, washout and further ingress into surface, underground water sources, soil, impact on vegetation, wildlife. According to various expert estimates, the content of chlorides in roadside snow masses exceeds MPC (maximum permissible concentration) by more than 25 times. The content of sodium chloride in the aquatic environment in the range of 100–200 mg/l leads to the death of some plant species, 200–500 mg/l of insects, reptiles, more than 1 g/l of aquatic biological resources. Salinisation of water and soil is a stress factor in the habitat of

flora. Even very low salt concentrations (10–20 mg/l) have a negative effect on the root system. Depending on endurance of flora species, salinity disrupts the metabolism of plants, affects the growth, reproduction, and settlement of their species. Negative factors form threats to the state of ecological safety of populated areas, which, in turn, dictates the need to allocate additional financial costs for monitoring, warning, and eliminating dangerous effects of anti-icing materials [5; 6].

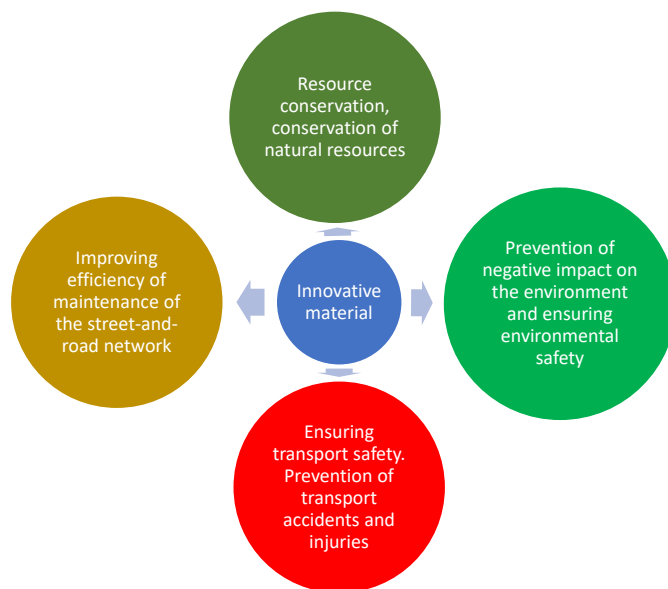
Considering the current situation, the work examines environmental acceptability, economic and technical feasibility of replacing the anti-icing materials now in use with the products of processing ash and slag mixtures formed during combustion of solid coal fuel at thermal power plants (TPP) and boiler houses.

The proposed idea of using ash and slag waste (ASW) for the purpose of ensuring safety of road transport infrastructure, preventing transport accidents allows reuse of a significant amount of accumulated ASW in storage facilities of energy enterprises. As of 2017, the amount of accumulated ASW in our country reached 1,5 billion tons, occupying an area of about 28000 hectares in the form of open ash and slag dumps, which significantly pollute water and land resources, atmospheric air, and surrounding vegetation. At the same time, their annual output is estimated by experts in the range of 22–23 million tons, which gives reason to conclude that the reuse of these wastes is relevant to prevent negative environmental impacts. This problem continues to be one of the most pressing in the fuel and energy complex. The current situation is practically not improving: the reuse of ASW is about 2,5 million tons per year (no more than 10 % of the annual amount of their formation) [7–10; 13–15].

The analysis of world practice of ASW processing indicates the presence of developments related to the use of ash and slag raw materials in construction industry, the road sector [11–14], however, no information has been found on the use of such raw materials for the purpose under consideration.

Economic feasibility of the proposed idea is favoured by the low cost of ash and slag raw materials as a commodity, but this is not the sole reason. Replacing traditional raw materials based on non-renewable mineral reserves with secondary raw materials from ASW contributes to implementation of the strategic goal of





Pic. 1. Planned result from introduction of innovation [performed by the author].

Russia's sustainable development based on the principles of resource conservation and rational use of natural resources.

Thus, relevance, novelty and practical significance of the ongoing research is predetermined by its idea and plan for implementation of several important scientific and practical tasks. The planned result from introduction of innovative material is presented in the scheme developed by the author (Pic. 1).

Materials and Methods of Research

The study was based on the published works of scientists, specialists, researchers in the field of transport safety, prevention of transport accidents, related emergency situations of a man-made nature, the practices of using solid mineral anti-icing materials and chemical anti-icing reagents [1–4], in the field of processing, re-use of ASW, organic substances from plant materials and waste [11–15], own results of research in the field of waste management and secondary resources, including in housing and communal services and transport, resource conservation, environmental safety of territories [5–7].

The concept of this study is based on the priority areas of the state policy in the field of waste management, as well as of monitoring, forecasting, prevention and timely elimination of natural and man-made emergencies, the principles generally accepted in the world community: «Zero waste», «Circular Economy» [16–20].

The research *methodology* includes: collection, generalisation, systematisation, comparative analysis of data in the field of research.

RESULTS

The first stage of the study was dedicated to summarising materials on the current use of anti-icing materials and liquid chemical anti-icing agents in various regions of Russia. It has been established that, as a rule, the composition of mineral anti-icing materials includes quartz sand, crushed granite stone of a fraction of 2–5 mm, marble chips, which improve the grip of vehicle wheels and shoe soles with a road surface in a slippery winter period.

At the same time, a significant problem for utilities is clogging with such materials of SRN, drainage grates, storm sewers, and for road users – the ingress of fractions of high-hardness reagents under the action of the centrifugal force of wheel sets into the windows of vehicles, external coatings, open areas of the bodies of passers-by followed by damage, respectively, to the property and health of citizens. In some cases, loose anti-icing materials reveal an increased content of radionuclides, which creates a serious danger to residents in the process of inhalation when sprayed in the atmospheric air and to biological resources of the natural environment – as a result of washout with surface runoff into water bodies and onto the soil.

The range of chemical anti-icing reagents that are toxic to human health and hazardous to the

environment is extremely wide and includes technical sodium chloride, sand and gravel material (SGM) based on calcium chloride and/or sodium, carbamides, liquid chlorides, bischofite (magnesium chloride); combined preparations: «Antisneg», «Nordix-P» (based on ammonium acetate), NCMM (carbamide, magnesium and calcium nitrates); CCM (chlorides of magnesium and calcium) and others. Also, the composition of the reagents includes additives – modifiers (corrosion inhibitors).

The components of anti-icing reagents (calcium, magnesium, sodium chlorides) are classified as moderately hazardous compounds in terms of human impact (irritating effect on the visual organs, skin upon direct contact) and belong to the third and fourth hazard classes in relation to the natural environment.

The accumulation of reagents in the roadside occurs not in the surface layer of the soil, but at a depth of up to 60 cm, reaching groundwater and the root system of plants. At negative temperatures and the absence of runoff, the reagents are intensively absorbed by snow and are then thrown by harvesting machines to the sides of the roadway at a distance of up to 50 m. Part of the unreacted salts remain on the surface and are carried by the wind over a considerable distance with spray from cars, snow, and dust.

An intense source of negative impact on the environment within a radius of tens to hundreds of meters are the places of storage of sand-salt mixtures, in most cases representing areas open to the influence of weather and climatic factors, with no embankment, collection and purification of polluted surface water.

Inorganic-based reagents have an aggressive effect on the metal structures of road transport facilities, vehicle coatings, especially under conditions of atmospheric corrosion activation. According to the results of a few studies, a combined reagent with corrosion inhibitors in the composition of technical salt (halite), bischofite solution (magnesium chloride) has the highest corrosive activity. The corrosion rate is influenced by the type and material of the corroded surface, concentration of the oxidising agent, various impurities in the coating of vehicles, road structures and devices, the level of temperature and humidity, and the intensity of precipitation. The negative effect of reagents on vehicles mainly leads to electronics failure, destruction, clouding, rusting of the coating,

corrosion of discs, exhaust pipes, and premature wear of brake pads.

Reagents containing calcium and potassium compounds under the influence of low temperatures and wind form a sliding surface on the roadway, increasing the braking distance and creating an increased accident rate. Traces of reagents of this group are clearly observed on shoes, and service life there-of is reduced to one or two winter seasons.

Fauna is especially vulnerable to the toxic effects of chemical reagents. The most dangerous is the eating by animals and birds of polluted snow with toxic reagents: materials and substances. It is no less dangerous for both long-term and short-term interaction of sensitive skin, especially of a pet, with contaminated snow masses or ice. These effects cause diseases of the skin, digestive systems of animals, vision, and smell, and can lead to death.

Causing damage to the health and property of citizens as a result of the negative impact of toxic highly corrosive chemical anti-icing reagents causes massive objective discontent, complaints, and leads to lawsuits. Environmental and sanitary-epidemiological supervision authorities regularly initiate administrative prosecution of road operating organisations for violating the rules of handling hazardous anti-icing reagents that pose a real threat to human health and nature.

The foregoing gives grounds to argue about the need to develop new safe anti-icing materials that do not adversely affect human health, natural objects, but provide sufficiently effective protection against slipperiness on SRN and, ultimately, increase the transport and environmental safety.

Scientific and practical novelty of the idea: to replace environmentally, sanitary and hygienic hazardous chemical methods for breaking ice and snow, a safe physical method has been developed to eliminate slipperiness of SRN, based on the use of solar energy, physical properties and characteristics of secondary resources from practically non-hazardous waste – granular fuel slag and biological organic compounds of the waste of the agro-industrial complex.

The study showed that currently used solid anti-icing materials based on natural minerals (sand, crushed crumbs of various rocks, rock salts) are similar in their technical and operational characteristics and properties (true density, hardness, compressive strength) to

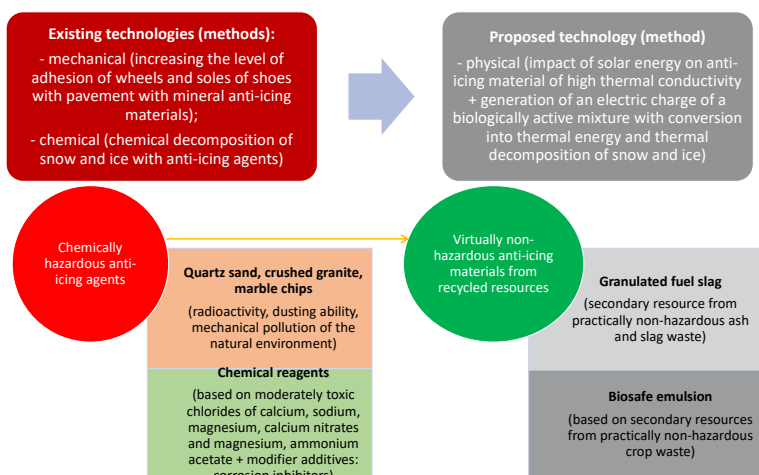


Expected Effects from the Introduction of Innovation [performed by the author]

| Types of effects | Description of the effect |
|---|--|
| Ecological | Replacement of moderately hazardous components of anti-icing reagents with practically non-hazardous ones; elimination of the negative impact of chemical anti-icing agents on bioresources and components of the natural environment: air, water resources, soils, flora and fauna, as well as mechanical impact – clogging of water bodies, soils, spraying solid bulk anti-icing materials in the atmosphere. |
| Sanitary and hygienic | Elimination of the negative impact of toxic anti-icing reagents on human health. The use of non-threatening to life and human health de-icing materials processed from recycled materials. |
| Resource-saving | The use of practically non-hazardous vitrified granulated slags from coal combustion and waste from the agro-industrial complex in economic circulation as secondary material resources. Possibility of reuse of spent anti-icing materials from fuel slags, including in road construction instead of traditional natural raw materials. Saving non-renewable mineral natural resources: sand, rocks, marble, granite, industrial water for manufacture of chemical reagents |
| Social | Reducing the level of injuries to the population from accidents related to winter slipperiness, the flow of complaints from citizens about damage to health and personal property as a result of the negative impact of toxic highly corrosive chemical anti-icing reagents, and the growing dissatisfaction of the population with this urgent problem. |
| Economical | Reducing the cost of 1 ton of anti-icing reagents by 20–30 %, depending on the territorial location of the region and ash and slag dumps; reducing the costs of organisations operating SRN and municipal budgets associated with penalties, claims for compensation for damage to components of the natural environment as a result of mechanical and chemical pollution with anti-icing reagents, property of citizens; reduction of costs associated with repair and restoration work of contaminated storm sewers, receiving grates, replacement, painting of road transport facilities and devices that have undergone corrosion. |
| Technical and technological, associated with safety | Growth by two to three times of the rate of destruction of the ice cover on SRN; no effect on the braking distance; reduction in the level of transport accidents, possible concomitant emergencies of a man-made nature |

materials based on secondary resources obtained from ash and slag waste. At the same time, the ratio in terms of heat capacity, considering the colour scale, is significantly in favour of secondary raw materials obtained from ASW, which contributes to a higher intensity of ice melting in sunny weather. Moreover, such secondary raw materials obtained in the process of separate collection, isolated accumulation, processing of ASW

(grinding, crushing, storage in a certain way), in accordance with the Federal Classification Catalogue of Waste, are practically not dangerous for the natural environment and its components. Among the characteristics of the material, the following should be noted: the density of coal and anthracite combustion slag is 1700–1990 kg / cubic meter, in bulk – from 980 kg / cubic meter; specific surface area – 4000–6700 cm² / g, increased water demand.



Pic. 2. Scientific and practical novelty of the proposed method (technology) [performed by the author].

Treating the roadway with the proposed anti-icing material with the help of specialised vehicles is carried out from a technological point of view just similarly to the treatment with currently used mineral materials, therefore, changes in storage technologies, treatment, subsequent collection, and reuse on the road network in this case are not required. Its dimensions are designed in such a way that at the maximum wind force for a given city, the simulated weight of particles of anti-icing material makes it possible to prevent dusting of the environment.

However, not all winter and late autumn days are characterised by sunny weather. This weather is typical for most regions of our country. In this case, an important property of the new anti-icing material is lost – it heats up under the influence of sunlight and melts ice and snow masses under the influence of temperature.

In this case, if temperature is below zero, an additional component of the complex anti-icing material is a bioadditive made by extraction method from specially treated plant waste based on the processes of natural biological decomposition and release of thermal energy. An example of a similar action is the processes that occur during the decay of hay, straw, as well as in manure or bird droppings. At the same time, the liquid additive is non-toxic, practically not dangerous, does not emit unpleasant scents, its consumption is determined by the appropriate quantitative ratio with the anti-icing material based on ash and slag secondary resources distributed evenly throughout the territory of the

road network. The composition of the bioadditive, the quantitative ratios of anti-icing material and bioreagent are registered as know-how (production secret) at the Russian Research Institute for Civil Defence and Emergencies (Federal Centre).

Thus, the proposed innovative solution makes it possible to switch from mostly costly and environmentally hazardous mechanical and chemical methods of combating winter slipperiness to physical, mechanical, and biological ones. The scientific and practical idea is reflected in the basic scheme developed by the author (Pic. 2).

The expected effects from introduction of the proposed innovative method (technology) are systematised in Table 1.

CONCLUSIONS

The present work was based on the solution of three research problems. Firstly, a performed systematic analysis of the used anti-icing materials and chemical anti-icing reagents has shown their danger to the environment and public health.

Secondly, a new approach is proposed to improve the protection of the urban environment from transport accidents based on the use of safe materials.

Thirdly, the possibility of a resource-saving approach to creation of a new, environmentally friendly anti-icing material based on reuse of ash and slag and organic waste instead of the use of natural resources for these purposes, admissibility of replacing mechanical and chemical methods of combating winter slipperiness with an environmentally safe mechanical and physical one, is substantiated.



Based on the results of the work, considering additional laboratory and instrumental studies, it is planned to apply for a patent for an invention and formalise it in the form of know-how.

REFERENCES

1. Samodurova, T. V. Operational management of winter road maintenance: Scientific foundations: Monograph [*Operativnoe upravlenie zimnim soderzhaniem dorog: Nauchnye osnovy: Monografiya*]. Voronezh, Voronezh State University, 2003, 168 p. ISBN 5-9273-0323-4.
2. Kuznetsov, Yu. V. Problems of road surface slipperiness control and ways to solve them [*Problemy kontrolya skolzkosti dorozhnykh pokrytii i puti ikh resheniya*]. *Avtomobilnie dorogi*, 2022, Iss. 8 (1089), pp. 117–118. [Electronic resource]: <https://elibrary.ru/item.asp?id=49341209>. Last accessed 14.02.2023.
3. Nyud, A. S., Kiryakov, E. I. Existing problems of revealing and removing the winter slipperiness on highways and bridge constructions. *Vestnik TGASU*, 2013, Iss. 2 (39), pp. 354–361. [Electronic resource]: <https://elibrary.ru/qbvckt>. Last accessed 14.02.2023.
4. Samodurova, T. V., Andreev, A. V. Investigation of the conditions for formation of various types of winter slipperiness on road surfaces [*Issledovanie uslovii obrazovaniya razlichnykh vidov zimnei skolzkosti na pokrytyakh avtomobilnykh dorog*]. *Izvestiya vuzov. Stroitelstvo*, 2003, Iss. 5 (533), pp. 91–96. [Electronic resource]: <https://elibrary.ru/item.asp?id=18247865>. Last accessed 14.02.2023.
5. Tskhovrebov, E., Velichko, E., Niyazgulov, U. Planning Measures for Environmentally Safe Handling with Extremely and Highly Hazardous Wastes in Industrial, Building and Transport Complex. Materials Science Forum, 2019, Vol. 945, pp. 988–994. DOI: 10.4028/www.scientific.net/MSF.945.988.
6. Tskhovrebov, E. S., Niyazgulov, U. D. Regulation of Waste and Secondary Resources Management. *World of Transport and Transportation*, 2019, Vol. 17, Iss. 1 (80), pp. 192–201. DOI: 10.30932/1992-3252-2019-17-1-192-201.
7. Kozhukhovskiy, I. S., Velichko, E. G., Tselykovskiy, Yu. K., Tskhovrebov, E. S. Organizational, economic and legal aspects of creating and developing technological complexes on recycling ash and slag waste in construction and other products. *Vestnik MGSU*, 2019, Vol. 14, Iss. 6 (129), pp. 756–773. DOI: 10.22227/1997-0935.2019.6.756-773.
8. Malchik, A. G., Litovkin, S. V. Study of ash and slag waste for their use as secondary resources [*Izuchenie zoloshlakovykh otkhodov dlya ikh ispolzovaniya v kachestve vtorichnykh resursov*]. *Mezhdunarodnyy zhurnal prikladnykh i fundamentalnykh issledovaniy*, 2015, Iss. 9 (part 1), pp. 23–27. [Electronic resource]: <https://applied-research.ru/article/view?id=7431>. Last accessed 14.02.2023.
9. Tselykovskiy, Yu. K. Utilization of ash and slag waste from coal-fired thermal power plants (legislative and regulatory documents): Study guide [*Utilizatsiya zolotozhlakovykh otkhodov ugolnykh TES (zakonodatelnye i normativno-tekhnicheskie dokumenty): Ucheb. posobie*]. Moscow, VTI publ., 2014, 63 p. [Electronic resource]: <https://masters.donntu.ru/2017/feht/metlina/library/article4.htm>. Last accessed 14.02.2023.
10. Efimov, N. N., Yatsenko, E. A., Smoly, V. A., Kosarev, A. S., Kopitsa, V. V. Ecological aspects and problems of utilization and recycling ashes and the slag waste of thermal power stations. *Ekologiya promyshlennogo proizvodstva*, 2011, Iss. 2, pp. 40–44. [Electronic resource]: <https://elibrary.ru/item.asp?id=16217499>. Last accessed 14.02.2023.
11. Bredel, G. Tackling India's coal ash problem. *Mining Engineering*, 1995, Vol. 10, P. 51. [Electronic resource]: <https://me.smenet.org/abstract.cfm?preview=1&articleID=3636&page=21>. [limited access]
12. Liu, Hongjun; Yuan, Feng; Yang, Donghai. The strength varieties of the seibsurface made of lime and fine coal ash of the Hingwaj from Changba to Baichengt. Dongbei linie daxue. J. Nort-East Forest. Univ., 2000, Vol. 28, No. 1, P. 45.
13. Putilin, E. I., Tsetkov, V. S. The use of fly ash and ash and slag mixtures in construction of roads: Overview of domestic and foreign experience in the use of waste from combustion of solid fuels at thermal power plants [*Primenenie zol unosa i zoloshlakovykh smesei pri stroitelstve avtomobilnykh dorog: Obzornaya informatsiya otechestvennogo i zarubezhnogo opyta primeneniya otkhodov ot szhiganiya tverdogo topliva na TES*]. Moscow, SoyuzdorNII publ., 2003, 60 p. [Electronic resource]: <https://files.stroyinf.ru/Data2/1/4293854/4293854006.pdf>. Last accessed 14.02.2023.
14. Fedorova, N. V., Mokhov, V. A., Babushkin, A. Yu. The analysis of foreign experience of using of the thermal power plants ash and slag waste and the capabilities of multi-agent simulation of the recycling processes (review). *Ekologiya promyshlennogo proizvodstva*, 2015, Iss. 3 (91), pp. 2–7. [Electronic resource]: <https://elibrary.ru/item.asp?id=24863456>. Last accessed 14.02.2023.
15. Bishnya, B. V., Ufimtsev, V. M., Kapustin, F. L. Promising technologies for removal, storage and use of ash and slag from thermal power plants: Monograph [*Perspektivnye tekhnologii udaleniya, skladirovaniya i ispolzovaniya zoloshlakov TES: Monografiya*]. Yekaterinburg, SEI HE UGTU-UI, 2006, 186 p. ISBN 5-321-00634-2.
16. Hertwich, E., Lifset, R., Pauliuk, S., Heeren, N. Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future. A report of the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya, IRP, 2020, 173 p. ISBN 978-92-807-3771-4. DOI: 10.5281/zenodo.3542680.
17. Elgizawy, S. M., El-Haggag, S. M., Nassar, Kh. Slum Development Using Zero Waste Concepts: Construction Waste Case Study. *Procedia Engineering*, 2016, Vol. 145, pp. 1306–1313. DOI: 10.1016/j.proeng.2016.04.168.
18. Domenech, T., Bahn-Walkowiak, B. Transition Towards a Resource Efficient Circular Economy in Europe: Policy Lessons from the EU and the Member States. *Ecological Economics*, 2019, Vol. 155, pp. 7–19. DOI: 10.1016/j.ecolecon.2017.11.001.
19. Kirchherr, Julian, Reike, Deniso, Hekkert Marko. Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation & Recycling*, 2017, No. 127, pp. 221–232. DOI: 10.2139/ssrn.3037579.
20. Hart, J., Adams, K., Giesekam, J. [et al]. Barriers and drivers in a circular economy: the case of the built environment. *Procedia CIRP*, 2019, No. 80, pp. 619–624. DOI: <https://doi.org/10.1016/j.procir.2018.12.015>. ●

Information about the author:

Tskhovrebov, Eduard S., Ph.D. (Economics), Associate Professor, Senior Researcher at the Centre of the Federal State Budgetary Institution All-Russian Scientific Research Institute for Civil Defence and Emergencies of the Ministry of the Russian Federation for Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters, Moscow, Russia, rebrovstanislav@rambler.ru.

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RESTORING THE PAGES OF HISTORY

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The destiny of the MIIT University female students who volunteered to the army and joined the 19th Separate Battalion of air surveillance, warning and communications during Great Patriotic War.



HISTORY WHEEL



HUMAN RESOURCES

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As long as 130 years ago human resources were recognised to be core for effective operation of railways. Historical documents, experience, retrospective analysis.