Organization of a logistics system for waste streams during the renovation of territories

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Abstract. The construction of new buildings and structures on the territory of major cities is limited by the tightness and lack of available building space. However, within these cities there are often huge areas that are practically not used. This is the territory of industrial enterprises, the production activity of which is placed on the outskirts of the city or suspended in connection with environmental requirements. Renovation of industrial zones has a huge potential and can contribute to improving the living standards of the population and the development of the city's economy. The development of these territories will create new residential areas, social infrastructure facilities, green park areas. The process of renovation of the territory is connected with the dismantling and demolition of existing buildings and structures, engineering communications, road coverings, improvement elements, etc. This can lead to the formation of a significant amount of construction waste. To increase the efficiency of the operation of the construction and demolition waste management system, it is proposed to use a logistics toolkit that allows the management of material, financial and information flows to be integrated into a single system. Logistic management of waste streams will allow to expand the raw material base of the economy, increase the output of secondary products while reducing its cost, prevent pollution of the environment. It is proposed to create logistics centers that perform specific functions of coordination of material and information resources. This will allow tracking and coordinating the entire life cycle of the waste from the source of education to the burial or processing site. The article considers the organizational structure and functional composition of the territorial and branch logistics centers operating in the sphere of construction waste management, as well as the principles of their interaction with other participants in construction.

1. Introduction
The processes of moral and physical deterioration take place in all spheres of economic activity. Instead of old technologies and organizational methods, new ones are emerging. Ineffective or non-working production is subject to reconstruction or complete elimination, together with a complex of obsolete industrial buildings and structures. At the location of these facilities it is advisable to create modern enterprises or change the functional purpose of the liberated territories for the construction of objects of a completely different status. Physical deterioration is the cause of changes in the housing stock, when instead of old objects that are not subject to reconstruction, new residential houses of increased area and storeys are being built.

The change in the functional purpose of industrial territories is caused by the inexpediency of keeping production enterprises within the city. Such a complex reconstruction of the urban
The environment is called renovation (lat. «renovation» - renovation, renewal, repair). Renovation of the territories of old industrial enterprises should be comprehensive and ensure the emergence of not only new residential neighborhoods with social infrastructure facilities, but also new innovative environmentally friendly production facilities that provide jobs to the population. In addition, it is necessary to provide for the creation of green areas, pedestrian areas, bicycle paths and other attributes of comfortable living rights [1-5].

Renovation of territories is inevitably linked with the processes of dismantling and demolition of existing buildings and structures, engineering communications, road surfaces, etc., which will lead to the formation of a huge amount of construction waste. The problem of management of construction waste is one of the most relevant in the construction industry, including in terms of security. According to the classification catalog, the main construction waste can be used as a secondary resource in new construction. Moderately dangerous, low-risk and practically harmless (III, IV, V hazard classes according to the catalog) include wastes of building crushed stone, wood timber, bricks, concrete products, construction debris, etc.

To increase the efficiency of the operation of the construction and demolition waste management system, it is proposed to use a logistics toolkit that allows the management of material, financial and information flows to be integrated into a single system. Logistics is a scientific direction, the purpose of which is to develop methods and organizational forms of managing resource flows to maximize the demand for products and bring it to the consumer within a fixed time frame with minimal costs [6; 7]. Logistic principles are now used in many industries. However, the opportunities for using a logistics approach to develop and improve the management system for construction and demolition wastes have not been given due attention [8].

2. Theoretical Basis

Logistics is a multifaceted science and includes a whole range of different types of activities. The principles of logistics are widely used in the management of stocks of material and technical resources, workers, fleets of vehicles, warehouses, modern information systems and financial means. Logistic management of waste streams of construction production will allow to expand the raw material base of the economy, increase output, while reducing its cost, prevent pollution of the environment [9].

When renovating the territories and using the logistics approach, it is necessary to give due attention to the processes of secondary processing of raw materials [10-13]. The skeleton of the majority of demolished buildings is reinforced concrete, therefore during demolition and dismantling the bulk of the waste will be made of reinforced concrete products. As a rule, their processing is carried out in two stages: separation of reinforcement from concrete and crushing of large pieces of reinforced concrete, pre-sorted by brand. To obtain finished products in the form of crushed stone, special crushing and sorting complexes are used, which allow to pre-destroy the product, extract the reinforcement and crush it to a fraction of the required size. Crushing plants are divided into mobile, collapsible and stationary. The choice of the installation depends on a set of factors: the noise parameters of the plants, the availability of free areas for their installation, the possibility of organizing temporary storage of elements, the quality of sorting incoming waste, etc. The obtained crushed stone of secondary production can be used in many processes, for example, when pouring foundations for warehouses or processing equipment, for manufacturing irrelevant reinforced concrete structures, constructing highways, walking alleys and sidewalks. The scrap metals formed during the demolition and timber after processing can be used in the construction of new buildings and structures. Glass from window binders is used in the manufacture of insulation - glass wool. From the soft roofing after the processing, tar is obtained; of ceramic tiles - crumbs to create pedestrian paths; plastic can be processed into packaging materials, linoleum, paving slab (with sand additives).

The management of construction waste directly on the construction site begins with the organization of their collection and preparation for transportation to processing enterprises. Analysis shows that waste is not sorted on many objects under construction and demolished. Therefore, first of
all, it is necessary to organize separate waste collection, when already sorted disassembly materials are loaded into containers, and each type of material is loaded with a minimum content of impurities of foreign substances.

On construction sites there are often situations with untimely delivery of garbage containers. This leads to the accumulation of waste in the area of the work site. Clear coordination of the delivery and removal of garbage containers, the provision of specialized construction equipment, the transportation of waste, the readiness of enterprises for seasonal changes in the volume of waste entering the processing are all the basis for the effective functioning of the construction waste management system.

3. Results and Discussion

In the sphere of the management of construction waste there is no connection between transport, material and information flows, which leads to the appearance of the above-listed problems. To improve the waste management system, it is necessary to create a logistical information flow that includes the collection of data on the flow of waste, its transfer, processing and systematization, followed by the delivery of finished final information. Experts who are involved in the process of moving construction waste at a certain stage (collection, transportation, processing, disposal) should have operational information about what happened to the waste at the previous stage and whether the infrastructure of the next stage is capable of accepting them. To estimate and plan the formation of construction waste, the technology of building information modeling (BIM) has great potential [14-16].

The reserve in terms of the effectiveness of management of construction waste streams can be the optimization of their transportation and dispatching. The development of urbanization processes, the increase in the volume of waste generation, the tightening of environmental requirements lead to the need for the location of enterprises for the disposal and recycling of construction waste at large distances from their education sites, which leads to an increase in transportation costs. In the production of construction and dismantling works in the central part of large cities, it is necessary to organize vehicle routes along streets loaded with cars, to try to minimize losses from traffic jams in urban traffic jams.

The sphere of transport transportation develops on an equal basis with other branches of the world economy and absorbs all modern developments of existing production and economic systems. To date, the trends in the development of transport services are in close relationship with the processes of resource allocation. In order to improve this relationship, it is necessary to create unified models of information and technological schemes for stable and sustainable economic development, both in regions and in individual companies [17; 18]. When optimizing transport flows, it is possible to achieve a significant reduction in the share of transport costs and, consequently, to reduce tariffs for the export of construction waste to consumers. In some countries, special solid waste management strategies are being developed that involve unifying the methods of handling them in the Best Practicable Environmental Option (BPEO). The BPEO procedure includes the development of unified documentation, the standardization of the characteristics of specialized vehicles for the transport of solid waste, and the like. In addition, the concepts of solid waste management are based on the principles of "shortest distance", the main points of which are the delivery of waste from the places of their formation to the places of disposal and processing along the optimal path, as well as preventing the movement of waste to unreasonably long distances.

Modern achievements of scientific and technical progress expand the boundaries of the application of logistics in the sphere of handling construction waste. Under the influence of scientific and technological progress, computer technology, telecommunications facilities, software and computer complexes are created and widely distributed, which lead to a new level of management of material, financial and information flows. Thanks to the introduction of automated control systems, it is possible to increase the efficiency of dispatching the waste transportation process, improve the quality of information support, ensure the relevance and accuracy of statistical reporting [19; 20]. A waste
management scheme for construction production has been developed to improve the transport component of the system (Figure 1).

To improve the efficiency of the management system of waste streams in the construction industry, it is proposed to create logistics centers for the coordination of material and information resources. This will allow tracking and coordinating the entire life cycle of the waste from the source of their formation to the burial or processing site.

It is proposed to create regional logistics centers of two types: integrated and information logistics centers. Complex logistics centers will provide the entire range of waste management services for construction, including:

- processing of wastes and obtaining of secondary raw materials from them;
- provision with specialized equipment for waste transportation, as well as machines for demolition of buildings and structures;
- informatization and dispatching of the waste management process in the construction industry in the region.

The main function of information logistics centers will be the dispatching and informatization of the management of construction waste in the region.

Complex logistics centers should be located at the intersection of major transport highways and in regions where construction (demolition) of objects is most intensive. At the same time, there must be a shortage of waste processing enterprises in the region, otherwise it will not be possible to ensure the full utilization of new capacities within the logistics center.

The list of services of a complex logistics center can include the transportation of construction waste from the place of education to the point of reception or processing. The presence of a fleet of trucks and the provision of transportation services will allow the logistics center to ensure the timely disposal of waste from construction sites. Implementation of complex logistics center selection of transport with optimal characteristics of the loading hopper will reduce economic losses from incomplete car loading. Eliminate downtime and timely delivery of goods to processing plants will be possible thanks to the well-established vehicle dispatching mechanism created on the basis of interactive maps of the area.

**Figure 1.** Scheme for improving the transport component of the waste management system for construction.
One of the main services of a complex logistics center can be the recycling of construction waste into secondary raw materials. Centralization of processing enterprises in the territory of the logistics center will ensure a constant loading of their production capacities, will allow improving methods of processing and expanding the range of construction waste taken for processing. The variety of processing plants contributes to the increase in the number of types of secondary raw materials. On the territory of the logistics center, it is necessary to provide a full complex of processing of construction and demolition waste, including processing of bitumen-containing coatings, wood and polymer waste.

On the basis of complex logistics centers, it is expedient to create research and experimental laboratories that will be engaged in the development of technological processes for converting construction waste into secondary raw materials and also certify the products received. For successful functioning of the logistics center, it is necessary to monitor the secondary market, identify its needs and promptly respond to them.

In order to implement an effective model for management of construction waste, it is required to create a mechanism for the movement of information flows between all participants of the logistics process. Implementation of this condition will lead to optimization of traffic flows, a clear analysis of the characteristics and volumes of construction waste, timely provision of up-to-date information of construction and installation organizations, transport companies, recycling and demolition facilities, and secondary resource consumers.

It is necessary to organize analysis and collection of initial data on the planned volumes and composition of construction waste for the prospective period. This task involves close interaction with construction organizations, obtaining information from them on the planned construction and dismantling works. It is necessary to generate databases of construction waste to ensure that the total amount of waste generated and the amount of waste directed to use, processing, neutralizing and dumping are recorded annually. To successfully coordinate the actions of all participants in the process of handling construction waste, it is required to create regulatory, financial, economic, information and technical and technological support for operations.

4. Conclusions
The using of logistics systems contributes to the creation of an effective waste management scheme for construction. With the maximum coordination of material and information flows, significant progress can be made in the rationalization of the waste management system. Centralized management of construction waste allows for better coordination of waste movement, which is especially important when constructing large construction projects.

The creation of logistics centers will allow to automate and optimize all processes for managing construction waste in the region. The logistics center should be a kind of informational core of the region, in which data on the characteristics of the functioning of the logistics system and the factors that affect it will accumulate. The logistics center should receive information from all organizations involved in the management of construction waste, or significantly affecting it. Specialization in waste management of construction production will allow information and logistics centers to formulate proposals for their use in the remediation and improvement of certain areas of the region, timely attention to the creation of additional production capacities for waste processing, and regularly supply information on the volumes of waste generation, processing, burial and use in statistical structures.

The relevance of the research areas for waste management of construction and demolition is confirmed by the statistics of the development of the construction industry, as well as the rate of waste generation. Special attention should be paid to the problem of waste in the regions where implementation of programs for the renovation of territories is planned. The availability of effective mechanisms of management of construction waste allows to obtain economic benefit from their secondary use, as well as to protect the environment.

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