Modern methods of increasing the level of resource saving in construction

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Abstract. The problem of increasing the level of resource saving and reducing the formation of the amount of construction waste is relevant in the construction of any buildings and structures. The solution to this problem will improve the quality of construction and installation work, reduce the time and cost of construction of facilities, as well as reduce the impact on the natural environment. It is possible to reduce the volume of construction waste generation during the construction of buildings and structures at the stage of development of project documentation, since one of the reasons for the generation of construction waste at the construction site is poor design documentation. The article identifies and analyzes the reasons for increasing the amount of generated building waste and reducing the level of resource conservation at the stages of both the development of design documentation and the implementation of construction and installation works. To solve this problem, it is proposed to use information modeling of buildings and structures, mobile information devices, robots and unmanned vehicles to control the work.

1. Introduction
Construction is one of the most material-intensive industries. The construction of buildings and structures requires a large number of different types of natural resources. Also, construction has a significant impact on the environment at each stage of the project, from the time the preparatory work is completed to the liquidation of buildings and structures [1-5]. To solve the problems of resource conservation and environmental protection, it is proposed to pay attention to the generation of construction and demolition waste.

Construction waste can be generated as a result of the construction of new buildings and structures, as well as reconstruction, renovation, overhaul and demolition of existing facilities. The use of construction and demolition waste as secondary resources can contribute to the development of a resource-saving system. During repair work, during the construction and reconstruction of buildings and structures, the bulk of the waste is: concrete and reinforced concrete; ferrous scrap; broken brick; chipped asphalt; expanded clay concrete; wood waste; roofing material; bitumen; used mineral wool; broken asbestos and glass; used faience sanitary ware; linoleum; paints and varnishes; broken ceramic tiles; used paper, metal and wooden containers. A significant part of the above wastes are light and heavy reinforced concrete. After carrying out crushing, sorting and fractionation procedures, reinforced concrete can be used in the construction of roads, the construction of monolithic buildings and structures, as well as the manufacture of irresponsible reinforced concrete structures. With
subsequent processing or even without it, construction waste products can be effectively used in new
production cycles [6-10].

The life cycle of buildings and structures can be divided into three main periods: the creation of an
object, the operation of an object and the liquidation of an object [11]. Each of these periods includes
certain phases. The construction period of the facility contains the phases of production of building
materials, pre-design developments, surveys, development of project documentation, construction and
installation works, etc. The period of operation of the facility may include work on ongoing or
overhaul, reconstruction, maintenance, improving the energy efficiency of the facility, etc. The
liquidation period of the facility includes demolition or dismantling of the facilities, as well as
subsequent waste treatment [12; 13]. At each of these stages, it is necessary to introduce and use
modern methods of resource saving and reducing the negative impact on nature, using the latest
achievements of science and technology.

In the modern world, technologies for building information modeling, organization and control
systems for construction and installation works are actively developing, unmanned equipment is used,
mobile information devices are being introduced at construction sites, etc. [14-17].

2. Theoretical Basis
It is possible to reduce the volume of construction waste generation during the construction of
buildings and structures even at the stage of development of project documentation, since one of the
reasons for the generation of construction waste at the construction site is poor design documentation.
The following main causes of waste generation and inefficient spending of resources during the
construction of buildings and structures can be identified, associated with the development and
transfer of project documentation:
1. Wrong design decisions, the implementation of which has already begun at the construction site.
Demolition of already constructed structures is required.
2. Low level of detail of architectural nodes.
3. Poor coordination of interaction between the customer, the designer and the building contractor
(transfer of design drawings not on time, transfer of irrelevant, outdated versions of the project;
lengthy coordination of design decisions, client requests for changes without written notice and their
registration, etc.) . As a consequence of this, it may also be necessary to dismantle already constructed
structures, to correct the results of the work performed.
4. Errors in calculating the volume of work and the amount of required material and technical
resources, errors in the specifications and in the name of materials, etc. Transfer to the procurement
department of materials of incorrect and inconsistent specifications. As a result of this, surplus
materials remain, which also often fall into the category of waste.

During the construction period, more reasons can be identified for the irrational use of material
resources and the generation of additional waste. At the ordering stage, errors may occur in calculating
the required amount of building materials at a given time, improper planning of ordering materials for
calendar periods and quarters of building construction, poor coordination of interaction with suppliers
of materials and responsible workers at the construction site. When moving materials from the place of
production to the construction site, material may be lost during loading, transportation and unloading,
adverse weather conditions during movement (rain, snow, wind, negative temperature, hot weather,
etc.).

In the construction and installation works, the rational use of resources depends primarily on the
organization of a quality control system on the part of the customer and contractor. Control should be
carried out both for quantitative and qualitative characteristics of materials, for compliance with
material consumption standards. Also, the amount of construction waste depends on the qualifications
and accuracy of the workers when performing technological processes (the minimum number of
defective products, the use of materials without the formation of surpluses, etc.). The causes of waste
at the construction site can also lead to:
1. Wrong organization of storage of building materials, structures and equipment, violation of technological requirements for storage places, etc.
2. The use of low-quality materials to speed up the process of implementation and delivery of the result of work.
3. The use of low-quality obsolete tools and equipment that lead to the appearance of defective products.
4. Theft of materials, tools and equipment from the construction site.

3. Results and Discussion
The solution to many problems considered at the stages of design documentation development and construction and installation works is possible through the use of modern information modeling technologies for buildings and structures, the introduction of mobile information devices and the introduction of robots and unmanned vehicles for monitoring and production work (Fig. 1).

![Diagram](image-url)
Building information modeling technologies at the design documentation development stage allow avoiding errors in designing and making adjustments to sections of the project. BIM allows you to detect conflicts in drawings at the earliest stage of design, and not at the construction site, when making changes will require significant financial investments [18-20].

The use of information technology in construction allows you to accurately calculate the amount of work and the required amount of material resources.

When planning supplies of materials and carrying out construction and installation works, BIM allows you to link the work schedule to the information model of the object. Thus, you can clearly see which building structures should be erected at a given point in time, and plan the delivery of the necessary resources [21].

Today, Green BIM technology is gaining popularity. Green BIM allows you to combine information modeling of structures and environmentally sound design. One of the main tasks of using Green BIM is to minimize the environmental impact, including by creating a systematic approach to waste management in the construction, operation and demolition of buildings or structures.

The use of mobile information devices at the construction site significantly speeds up and simplifies the interaction between the construction participants, facilitates the rapid transfer of documents, reports, photographs, protocols, etc. [22-23]. Today, there are many mobile applications that save time and resources of designers, designers, civil engineers, etc. The presence of mobile devices at the construction site allows you to quickly access all sections of the project documentation, find the necessary regulatory and reference documents, quickly send information to interested parties about the progress of construction and installation works. The installation of CCTV cameras helps to reduce the number of thefts of materials and tools, and also allows you to monitor compliance with construction deadlines.

The use of mobile information devices in addition to positive features may have certain disadvantages that limit the freedom of use of the device, for example:

1. For the exchange of information between users requires an uninterrupted Internet connection, which is not always possible to provide at the construction site during the construction of facilities.
2. It is necessary to constantly monitor the battery level.
3. It is possible to limit the amount of internal memory of the device.
4. The need to purchase specialized mobile applications.
5. Lack of skills and insufficient qualifications of workers who will need to use the device.
6. Data loss may occur if the device is damaged.
7. When using the device, it is necessary to follow safety precautions, as as a result of its use, the worker may lose his vigilance and get injured.

The low quality of construction and installation works leads, as a rule, to their repeated implementation, as well as the use of additional material resources and the formation of construction waste. Defects can be associated with poor-quality welding operations, incorrect breakdown of the axes of buildings and structures, lack of necessary maintenance for the safety of structures and storage of materials in warehouses, etc. Today, unmanned aerial and ground vehicles can be used to control the quality of work (fig. 2).

Among all modern methods, unmanned aerial vehicles are the most cost-effective due to their relatively low cost and accuracy. Drones (unmanned aerial vehicles and non-aircraft) are devices without a crew on board that have a different degree of autonomy - from remotely controlled to fully automatic. They perform tasks such as examining and documenting the condition of objects, creating a variety of cartographic materials, aerial photographs of the construction site and construction objects.

In addition to remote collection of information, they can perform various functions. The devices allow real-time monitoring of construction, automatically detect defects, deviations and quickly transmit information to the operator. There are some research [24], which clearly demonstrate the advantages of using unmanned aerial vehicles when comparing the design solution and the current construction moment (fig. 3). Unmanned aerial vehicles are also equipped with a thermal imager function. Today it is one of the fastest ways to detect hidden defects in buildings and structures.
Unmanned aerial vehicles can be widely used in construction due to the fairly budgetary cost. However, for the effective use of this kind of technology, updating of regulatory documents is necessary.

Figure 2. Unmanned aerial vehicle

Figure 3. Use of unmanned aerial vehicle

4. Conclusions
Increasing the level of resource saving and reducing the generation of building waste during the construction of buildings and structures is inextricably linked with the level of development of technology and information systems. The reasons indicated in this article for increasing the amount of generated construction waste and lowering the level of resource saving can be solved by introducing BIM design approaches and using modern equipment. Using the potential of BIM will reduce the cost and construction time, reduce the impact on the environment, and also improve the quality of construction projects.

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