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## The experience of using “smart demolition” technology for residential buildings in Moscow

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**Abstract.** This study discusses the issues related to the reconstruction of old housing stock and the corresponding improvement of existing infrastructure for more efficient use of urban areas, which, in turn, leads to better living conditions for citizens and an improved quality of life. It also addresses the issue of construction waste disposal as a by-product of renovation works, outlining a number of measures to regulate the handling of construction, demolition, and excavation waste (CD&E waste) (e.g., the mobile app “Mobile hard — and software unit”). The study also examines the procedures for dealing with construction, demolition, and soil waste in accordance with the Ministry of Ecology of the Moscow Region Order No. 134-RM, dated February 25, 2021. The aim of the study is to analyze the application of the technology of “smart demolition” of residential buildings in urban environments and the control of construction waste removal from renovation sites, followed by recycling into materials suitable for secondary use in order to reduce environmental pollution.

**Keywords:** renovation, disposal, technology demolition, ecology, recycling, construction waste, demolition waste, excavation waste

**Contribution.** All the authors participated in the development of the concept of this review, drafted the manuscript, and formulated the conclusions.

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## Московский опыт применения технологии «умного сноса» жилых домов

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**Аннотация.** Рассмотрены вопросы реконструкции старого жилищного фонда и сопутствующего ей улучшения действующей инфраструктуры для более рационального использования городских территорий и, как следствие, улучшения условий жилищной среды граждан и качества их жизни. Затронуты вопросы утилизации строительных отходов как побочного продукта работ по реновации. Приведен ряд мер, позволяющих регулировать обращение с отходами строительства, сноса и грунта (внедрение мобильного приложения «Мобильный КПТС» и др.). Рассмотрен порядок обращения с отходами строительства, сноса и грунта согласно Приказу Министерства экологии Московской области от 25 февраля 2021 г. № 134-РМ. Цель исследования — анализ применения технологии «умного сноса» жилых домов в городской среде и контроля вывоза строительных отходов с объектов реновации для их последующей переработки в материалы, пригодные для вторичного использования с целью снижения загрязнения окружающей среды.

**Ключевые слова:** реновация, утилизация, технология сноса, экология, вторичная переработка, отходы строительства, отходы сноса, отходы грунта

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## Introduction

Renovation comes from the Latin word (*renovatio* — renewal, renewal). It is the process of updating, replacing elements of fixed assets that are being eliminated as a result of physical and moral deterioration with new ones<sup>1</sup>. That is, this process is directly aimed at improving the housing environment of citizens, as well as the conditions and quality of their lives.

The problems of this study were considered in the works related to landscaping and land use, solid waste disposal, the concept of green construction, improving

<sup>1</sup> Kuznetsov SA, comp. and chief editor. *The Great Explanatory Dictionary of the Russian Language*. St. Petersburg: Norint; 1998. 1535 p. (In Russ.).

the quality of the urban environment and smart city management, as well as in international issues [1–6].

The prerequisite for the renovation program currently operating in the Moscow region was the resolution of the Central Committee of the CPSU and the Council of Ministers of the USSR “On the development of housing construction in the USSR”, issued on July 13, 1957<sup>2</sup>. The document marked the beginning of the construction of “khrushchevki” and the liquidation of communal apartments, it was believed that it would serve to significantly improve the living conditions of citizens. Nikita Khrushchev, the first secretary of the Central Committee of the CPSU and chairman of the Soviet government, led this project. On the outskirts of Moscow, neighborhoods of five-story buildings began to appear, apartments and stairwells in the houses were so small that they deserved the name “khrushchevki” and even “khrushchoby”, but at that time it was much better than communal apartments. Decades later, these “apartments” certainly seem small to current residents compared to new apartment buildings with large areas and much more functional living conditions, but before these apartments were considered luxury housing. Both economically unprofitable and extremely costly was the process of major repairs of the Khrushchev buildings, as well as it was impossible to reconstruct the buildings, since the construction process and construction technologies did not contribute to this. The “khrushchevki” had insufficiently thick outer walls and heat-shielding properties.

In the late 1990s, Moscow Mayor Yuri Luzhkov signed the first program for the demolition of five-story buildings in the capital. The operation of this program was regulated by the Decree of the Government of Moscow dated July 6, 1999 No. 608 “On the tasks of complex reconstruction of five-storey building areas of the first period of industrial housing construction until 2010”<sup>3</sup>. The main purpose of this document is to switch to a comprehensive reconstruction of areas where massive five-storey buildings erected during the first period of industrial construction are concentrated.

On February 21, 2017, at a meeting between Russian President Vladimir Putin and Moscow Mayor Sergei Sobyenin, an initiative was discussed

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<sup>2</sup> *Decisions of the Party and the Government on Economic Issues. In 5 volumes: Collection of documents for 50 years.* Vol. 4. 1953–1961. Moscow: Politizdat; 1968. URL: <https://docs.historyrussia.org/ru/nodes/355256> (accessed: 09.19.2024) (In Russ.).

<sup>3</sup> *Resolution No. 608 dated 07.06.1999 “On the Tasks of Comprehensive Reconstruction of Five-storey Building Areas of the First Period of Industrial Housing Construction until 2010” (As amended by Decree of the Government of Moscow dated 11.01.2005 No. 860-PP).* URL: <http://pravo.gov.ru/proxy/ips/?docbody=&prevDoc=120037072&backlink=1&nd=120022203> (accessed: 09.19.2024) (In Russ.).

to create a program aimed at demolishing all five-storey buildings in the capital. On July 1, 2017, Federal Law No. 141-FZ was adopted, which amended the current Law of the Russian Federation “On the Status of the Capital of the Russian Federation”, as well as some other legislative acts. This law specifies the specifics of regulating certain legal relations related to housing renovation projects in Moscow, which is a city of federal subordination<sup>4</sup>. The document underwent a number of changes, however, on June 14 it was approved by State Duma in the third (final) reading: 399 deputies voted for its adoption, 2 opposed it. On June 28, the Federation Council also gave support to this document (147 senators supported, 4 abstained). It was impossible to adopt a program similar to the 1999 program, since in the period from 2001 to 2004, Land, Housing and Urban Planning Codes were developed and adopted, which came into conflict with this program. Anatoly Konstantinov took over the post of head of the Housing Renovation Assistance Fund on September 26, 2017 (this non-profit organization is the construction customer), previously he was the general director of the House-Building Plant No. 1 (DSK-1). According to the program, residents whose houses are to be demolished must be relocated to new housing located in the same area or adjacent to it. For residents of the Zelenograd Autonomous Okrug and “new Moscow”, resettlement is carried out within the district. An important aspect is that the total and living area of the new apartments will be no less than in the old ones — this guarantees the preservation of comfortable living conditions, as well as it should have an equivalent number of rooms and high-quality repairs. In Moscow in May 2017, according to the Ministry of Internal Affairs of the Russian Federation<sup>5</sup> a march coordinated with the authorities took place, which ended with a rally. The protesters were concerned that the demolition of houses in a habitable condition would be carried out, and that they could be provided with housing space equivalent in square footage, but not in value. The march was directed against the renovation of dilapidated housing.

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<sup>4</sup> *Federal Law No. 141-FZ dated July 01, 2017 “On Amendments to the Law of the Russian Federation ‘On the Status of the Capital of the Russian Federation’ and Certain Legislative Acts of the Russian Federation regarding the Establishment of Specifics of Regulating Certain Legal Relations for the Renovation of Housing Stock in the subject of the Russian Federation — the federal city of Moscow”*. URL: <http://publication.pravo.gov.ru/Document/View/0001201707010003> (accessed: 09.26.2024) (In Russ.).

<sup>5</sup> Official information. *The press service of the Ministry of Internal Affairs of Russia in Moscow*. 05.28.2017. URL: <https://77.мвд.рф/news/item/10350268> (accessed: 09.26.2024) (In Russ.).

## Features of the application of the technology of “smart demolition” of houses

The technology of “smart demolition” of houses was first tested in the Severnoye Izmailovo district on August 23, 2018. Using this technology, a five-storey house was demolished, which fell under the renovation program.

Shmeleva A.N. and Rybakov M.B. in the article “Tools of the digital economy in the implementation of the housing renovation program in Moscow” [7] describe the process of dismantling houses, which goes through several stages. First, the building is disconnected from all engineering networks, after which its disassembly into its component parts begins. Waste such as glass, wood, plastic and metal are sorted separately for the convenience of subsequent transportation to specialized sites (landfills), where they are recycled for reuse. At the next stage, the demolition of the reinforced concrete structure is carried out using special equipment equipped with hydraulic scissors. To reduce the amount of dust that occurs during the demolition of a building, hydraulic guns are used that spray water under high pressure. At the same time, the noise level is reduced by installing a special protective wall made of mesh, placing it on the side of residential buildings.

The main principles of “smart demolition” of houses are: safety, environmental friendliness, minimum noise and dust, as well as maximum waste recycling and reuse (fig.)<sup>6</sup>. The head of the Moscow Department of Construction, A.Y. Bochkarev, in an interview with RIA Real Estate, noted: “With the use of smart demolition technology, it is possible to recycle and reuse up to 90 % of the construction debris that occurs during the renovation process”<sup>7</sup>.

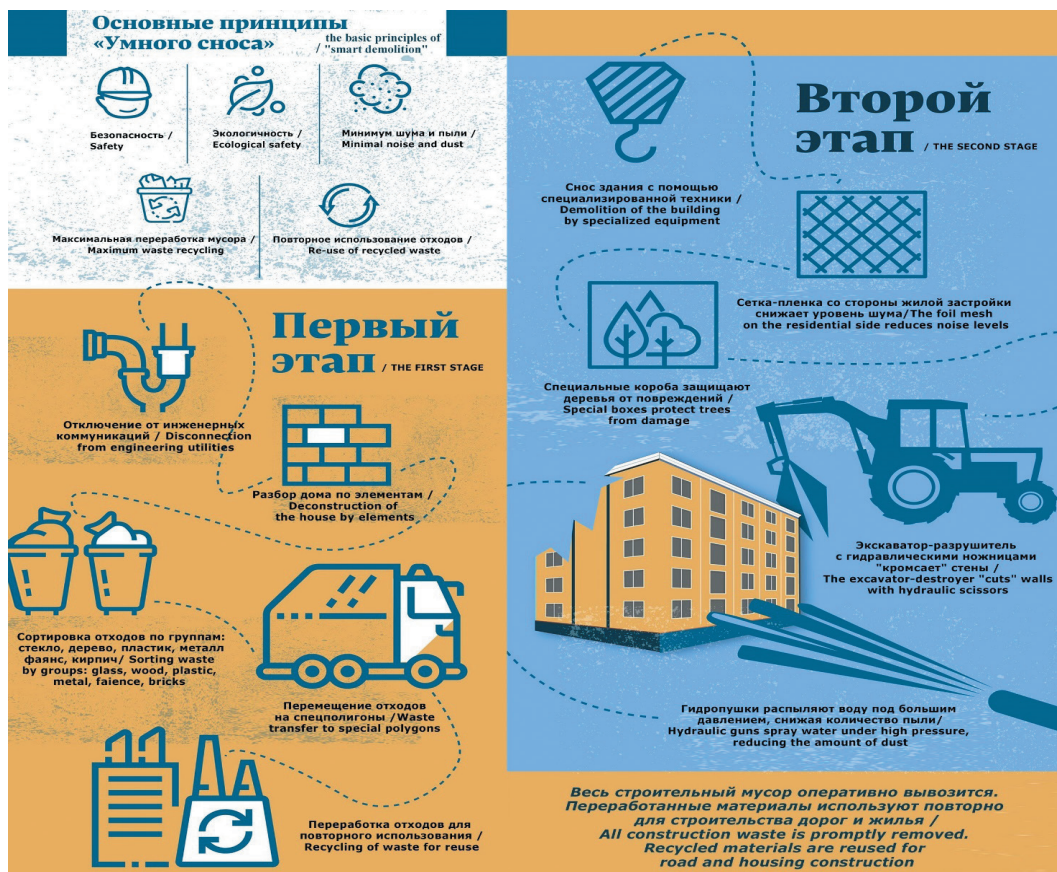
Smart Demolition is aimed at significantly improving and maintaining the environmental situation in the country. So one of the absolute advantages of “smart demolition” is the ability to preserve the surrounding trees as much as possible, at this time they are covered with special boxes to protect them from damage. Also, unlike conventional demolition, with “smart demolition” waste can be recycled — for example, crushing ceramic waste into crumbs for filling pedestrian paths or glass can be recycled into glass wool, roofing into tar. Although this technology slows down the demolition process itself, it significantly reduces waste volumes.

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<sup>6</sup> *The Technology of “Smart Demolition” of Buildings*. URL: <https://stroj.mos.ru/infographics/tiekhnologhiia-umnogho-snosa-zdaniy> (accessed: 09.26.2024) (In Russ.).

<sup>7</sup> “Smart Demolition” Will Allow Moscow to Reuse up to 90 % of Renovation Waste. *RIA News*. 25.10.2018. URL: <http://realty.ria.ru/20181025/1531456678.html> (accessed: 09.19.2024) (In Russ.).





Stages of “smart demolition” of buildings

Source: URL: <https://stroj.mos.ru/infographics/tiekhnologhiia-umnogho-snosa-zdaniy> (accessed: 26.09.2024).

For effective monitoring and management of the implementation of smart demolition technology of residential buildings at the government level, a number of measures have been developed and approved to regulate the handling of OSSiG.

Thus, according to the Decree of the Government of Moscow dated August 26, 2020 No. 1386-PP “On the procedure for handling construction and demolition waste in Moscow”<sup>8</sup>, Waste producers are required to monitor the weight and/or dimensions of the exported waste, as well as their volume and the transport that carries out their export. To ensure effective monitoring of measurement results at the waste collector’s control point, the responsible person must use the mobile application “Mobile KPTS”.

<sup>8</sup> Resolution No. 1386-PP dated August 26, 2020 “On Approval of the Procedure for the Management of Construction and Demolition Waste in the City of Moscow” (As amended by Resolutions of the Government of Moscow dated 05.12.2021 No. 602-PP, dated 12.23.2021. No. 2173-PP). URL: <http://pravo.gov.ru/proxy/ips/?docbody=&prevDoc=120047772&backlink=1&&nd=120273494> (accessed: 09.19.2024) (In Russ.).

The application was developed to control and coordinate the movement of construction waste. Users of the application can specify the starting and ending points of the carrier's route, as well as an important aspect is the permission to move waste.

Upon registration, the user confirms the e-mail: address to identify the user logging into the application. So that the user does not have the opportunity to specify incorrect data regarding the vehicle and the type of waste it transports, the application requests a number of photos, for example: a photo of the state registration plate number and a photo of the filled body.

All data that the user transmits to the application is stored in a secure form on the servers of the Moscow Department of Information Technology.

By the Resolution of the Ministry of Ecology of the Moscow Region dated February 25, 2021 No. 134-RM "On Approval of the Procedure for Handling Construction Waste, Demolition of Buildings and Structures, including soils, on the territory of the Moscow Region", the procedure for managing construction waste, demolition of buildings and structures, including soils, on the territory of the Moscow Region was established (OSSiG). This resolution was developed in order to minimize the negative impact of production and consumption waste on human health and the environment. It is also aimed at reducing the amount of waste generated and their inclusion in economic turnover. In addition, the purpose of this document is to create universal norms and requirements for the organization of OSSiG management processes in this region. In addition, it provides for the formation of a system of accounting and control over the process of handling OSSiG, starting from the moment of their occurrence and ending with disposal or involvement in their reuse.

Based on the adopted resolution, to allocate secondary resources and separate potentially hazardous categories of waste to be disposed of at specialized recycling facilities, it is necessary to sort, as well as separate storage and accumulation of construction, demolition and soil waste into separate categories or groups of homogeneous materials at the renovation facility. These actions must be carried out in strict accordance with the requirements and norms established by the legislation of the Russian Federation.

The classification of the above-mentioned wastes should be carried out according to different types or groups of homogeneous materials. This should be done in accordance with the directions of their disposal, including reuse, and provide for the formation of the following categories (groups of homogeneous OSSiG):

- 1) mixed (unsorted) OSSiG, with an impurity content of more than 5 %;
- 2) waste of concrete and reinforced concrete (cement-based products), as well as the rubble of brick buildings and the trimming of asphalt pavement (asphalt concrete);

- 3) waste materials for construction based on plastics and polymers (PE, PVC, HDPE);
- 4) waste of construction soils;
- 5) glass;
- 6) waste of thermal insulation materials;
- 7) waste wood materials;
- 8) scrap waste of ferrous and non-ferrous metals.

Recycling is considered on the example of concrete and reinforced concrete (cement-based products), as well as the secondary use of old brick buildings and asphalt concrete. Crushed stone obtained as a result of crushing and sorting waste (hereinafter referred to as crushed stone, products or articles) is used for construction purposes.

Use cases:

- during the construction and landscaping of territories;
- for the foundation of the carriageway of temporary roads at construction and production facilities;
- for the foundation of a pit for machinery;
- as inert materials for the technological needs of landfills of solid household and industrial waste, reclamation facilities.

The use of rubble from the construction battle is not allowed in capital construction, as well as for landscaping and planning in areas with increased risks, such as educational institutions, sports complexes and playgrounds in residential areas, as well as recreational areas and similar facilities.

The production of crushed stone is carried out in several fractions: 0–5 mm; 5–20 mm; 20–40 mm; 40–70 mm; 70–100 mm.

An example of product designation in the order processing process and/or in other documents: “Secondary Crushed Stone from Demolition and Construction Waste” TS 23.61.12-003-44921646–2020. Types of crushed stone produced from construction waste:

- Concrete. (GOST 25137–82. Non-metallic building materials, crushed stone and sand are dense from industrial waste, aggregates for concrete are porous). It is a mixture consisting of cement stone particles of various sizes. According to its characteristics, it is slightly inferior to the natural material in terms of strength, but generally fully meets the requirements of GOST. It is allowed to use it in all cases when technology does not require the use of higher-quality building materials.
- Brick (Crushed granulated brick fight). This material is most suitable for creating drainage systems, as well as sound and thermal insulation



of walls. Brick cutting is often used for filling under building foundations and for laying trails in swampy areas. It is also suitable for the preparation of building mixes, the strength requirements of which are low. Fireclay brick is more expensive than silicate brick, and it can be used as a filler in refractory solutions.

- Asphalt chips (GOST R 55052–2012. Granulate of old asphalt concrete. Technical specifications). It contains an admixture of bitumen, fine-grained crushed stone (up to 5 mm in size), as well as sand and other materials. This material is obtained by cold milling during the removal of old road surfaces. Unlike ordinary crushed stone, this material has greater moisture resistance and does not fly out from under the wheels of cars while driving. Crushed asphalt is also used in creating paths in cottages and gardens, for parking lots, on secondary roads, as well as in the construction of sports facilities and in filling blind areas. The disadvantages of this material include the presence of bitumen, which, being a product of oil refining, cannot be fully recognized as environmentally friendly. Crushed stone should not contain impurities<sup>9</sup>.

Requirements for materials and purchased products:

- The raw materials used must be safe for human health and not cause harm to the environment under all stipulated conditions of its use.
- It is forbidden to use reinforced concrete, which is susceptible to corrosion under the influence of aggressive industrial liquids (for example, acids or alkalis) as a starting material.
- The quality, as well as the basic properties of the raw material, must be supported by official documents confirming its compliance with established standards. If there are no such documents for a specific material, then it is necessary to carry out all the required tests at the manufacturing plant during the production of crushed stone.
- In the production of secondary crushed stone from OSSiG, the following can be used as starting materials: Scrap of concrete and reinforced concrete products in a mixture; Scrap bricks; Scrap of the roadway.

## Conclusion

Thus, based on the above, we see that the use of smart demolition technology for residential buildings, followed by recycling and the use of the resulting material, can be an economically beneficial and technologically effective solution to the tasks

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<sup>9</sup> TS 23.61.12-003-44921646-2020. Secondary Crushed Stone from Construction and Demolition Waste. (In Russ.).

of urban development. However, it is necessary to take into account the specifics of this technology and the possibilities of its application at each facility in order to achieve maximum results.

The experience of using smart demolition technology in Moscow shows a significant reduction in the cost of material resources, which entails lower costs and increased production efficiency, as well as reducing the negative impact on the environment through the recycling of production and consumption waste.

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