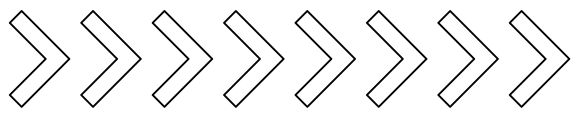


DEMOLITION WASTE DISPOSAL AND PROCESSING ISSUE





Demolition waste disposal and processing issue



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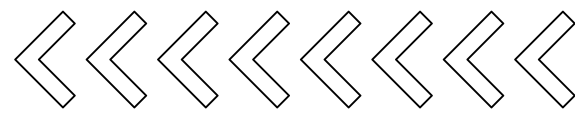
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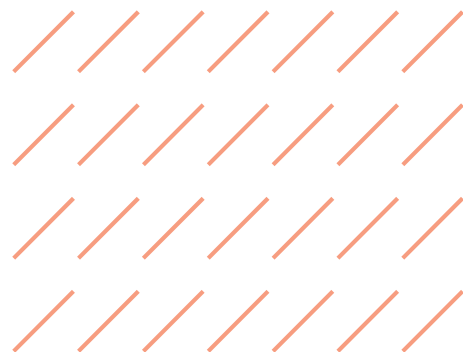
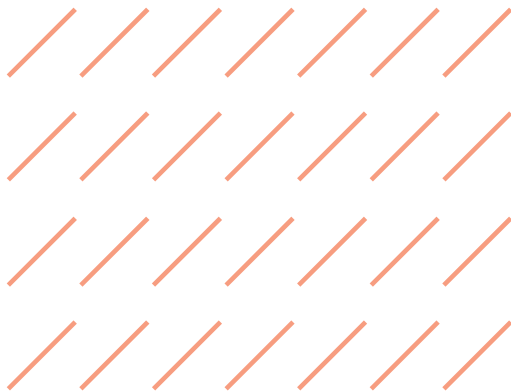
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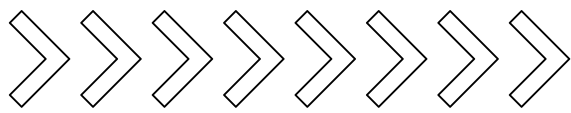
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Introduction

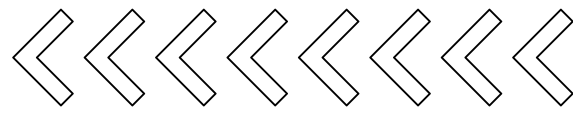
Thousands of tons demolition waste pollute Ukrainian lands. As of mid-November 2022, the Russian occupiers have already destroyed or damaged more than 12,000 multi-story buildings, more than 100,000 private estates, and more than 500 industrial enterprises in Ukraine [11]. Since then, shelling of Ukrainian cities and hostilities on our land have not actually stopped.

Unexploded shells and thier fragments, burned vehicles and military equipment, used disposable NLAW systems, batteries and ruined buildings. All this is waste that remains in cities, towns, forests, fields, beaches, in the water and on our land after hostilities. We call this waste of war, and it is our duty to prevent the merciless impact of improper processing and senseless and harmful burial of these items on the territory of Ukraine. [12]

Today, work is already underway to dismantle the debris created as a result of hostilities and shelling, and to clear populated areas of destroyed objects. A significant part of destruction waste can be reused not only during restoration of damaged objects, but also during building materials production and restoration of the country.

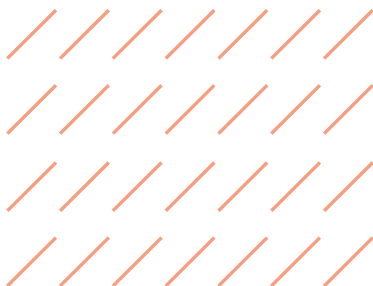
Demolitions waste handling system must definitely start with checking for explosive substances presence and demining, and then sorting. Demolition waste is different from construction waste, because it is mixed with plastic and glass, facade decoration materials, reinforcing mesh, mineral wool, interior decoration materials, wall materials, roofing, household items and wood fragments. Separately, most of these residues could be used, but in the existing state when they are all mixed up in ruins, very careful sorting is necessary.

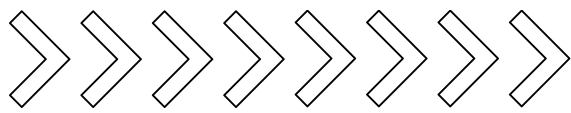
All this must be disassembled manually and mechanically, since there may be unexploded shells or even human bodies inside. Previously, such situations were isolated cases, for example, after the explosion of a gas cylinder. In such cases, the analysis of rubble is within the competence of the State Emergency Service. But such explosions did not happen often, and now we have a much larger amount of work.



Demonstration photo

Therefore, the first thing that needs to be done is to regulate legislation that determines processes course of temporary storage, transportation, sorting, processing and waste of destruction disposal. It is important to develop an appropriate regulatory framework for the use of secondary products from demolition waste for building materials production, to create favorable conditions for the construction of new processing enterprises, as well as to repurpose existing ones that have insufficiently loaded production areas. Further scientific research directed at research and substantiation of building materials production using recycled waste is needed.





1. Review of world practices of construction waste processing

It is difficult to predict how long the war will continue and how many buildings and structures will be destroyed or damaged by the Russian invaders in Ukraine. At the same time, before rebuilding, it is necessary to deal with the destroyed buildings. That is why the improvement of handling this type of waste system is an important environmental problem the solution of which is recycling. It allows disposal of construction waste without harming the environment.

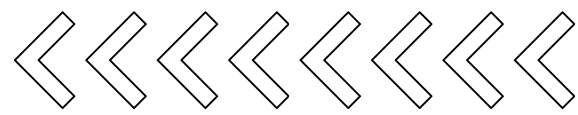
Every year in the modern world the amount of construction waste increases by 2.5 billion tons which has a very detrimental effect on the ecological situation of the entire Earth. This conclusion was reached by experts from the European Association which includes building demolition companies [2].

All over the world, the recycling of construction waste is quite a profitable industry. In most European countries the level of processing is quite high. Thus, about 90% of construction waste is reused in the Netherlands, 87% in Belgium, 81% in Denmark, 45% in Great Britain, 43% in Finland, and 41% in Austria. In European countries and In the United States the problem of waste disposal has been solved at the state level for a long time: in some countries, construction waste landfills are prohibited altogether, and in the USA and Canada they still exist, but cost of transporting such waste there is much higher than cost of processing it. Depending on country type of scrap and location of landfill, removal of 1 ton of construction waste costs from 4 to 150 euros. Therefore, it is more profitable for many developers to spend money, time and effort on processing and disposal of construction waste than to take it to a landfill.[3]

In many countries, the share of recycled construction waste is on average about 50% of the total production of building materials. This is due to the improvement of technologies and legislation.[3]

For example, in Great Britain, in order to preserve natural resources and encourage recycling, a tax of 1.6 pounds has been introduced on use of each ton of natural aggregate ("primary raw materials"). In the Netherlands for about 10 years there has been a law prohibiting collection of recyclable construction waste in landfills. Many other countries require official evidence that the waste being imported cannot be recycled.

An increasing number of contractors in the United States are involved in the disposal or reuse of construction materials. Metal, concrete, wood, some plastic and glass can all be used in construction projects in one way or another. Along with the states of California and Massachusetts, reuse of construction materials has already been legalized materials. Austin (Texas) announced recently that construction of structures with an area of more than 500 square meters requires disposal of at least half of waste generated. In state of Arizona there are already companies that are fully engaged in giving a second life to construction waste.[7]



Entrepreneurs are convinced that processing of construction waste is profitable and economical. Moreover, if building is demolished and built on the same site, the need for most building materials is solved by waste. Savings in processing of construction waste are also achieved by the fact that there is no need to transport these materials from place of dismantling, that is, to bear the costs of loading, transportation and unloading. Buyers of broken bricks, secondary crushed stone and other construction waste themselves come to place of dismantling of structures in their own vehicles and take away everything they need for construction.

What kind of waste suitable for reuse and recycling is generated after analysis of buildings and structures remains?

Construction waste includes concrete and reinforced concrete, brick, metal, soil; sand contaminated with clay; sanitary, technical and other ceramics, wood, glass, plasterboard, plastic, heaters, wall materials and asphalt concrete. According to researchers the mass content of construction waste is approximately as follows:

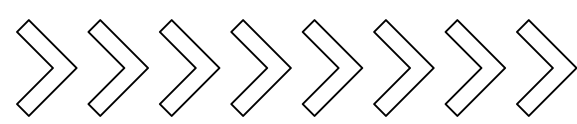
- 52% concrete and reinforced concrete,
- 32% stone wall materials (bricks, wall blocks, foam and aerated concrete),
- 8% asphalt and construction mortar waste,
- 4% metal waste,
- 2% wood and plastic waste,
- 1% ceramic products (sanitary ceramics, ceramic tiles),
- 1% – plasterboard, glass and other waste.[6]

Calculations are made for demolition buildings in peacetime. As part of the waste of destruction there are also clothes, household appliances and furniture, household chemicals, dishes, hazardous waste in the form of first-aid kits, thermometers, fluorescent lamps, etc. There may also be bodies of people and animals, remnants of explosives from military equipment. All these items are difficult to sort. Therefore, the situation with decommissioning waste is much more complicated but still solvable.

Prevention and minimization of waste generation, its transformation into valuable resources and introduction of innovative technologies are the main trends of developed economies of EU countries and a reference point for Ukrainian industry.

The Mineral Products Association (MPA) in the UK has launched a campaign to highlight that history of building materials industry as one of the UK's success stories in recycling and the circular economy/

This campaign is entitled "The contribution of recycled and secondary materials to the UK building materials market". More than 70 million tones of scrap materials are reused in the UK construction materials markets, and 90% of these recycled materials come from construction activities after road demolition and repair. Although the main focus is on prevention and reduction of construction waste, construction in previously built-up areas will invariably involve future demolition and generate waste, such as bricks and concrete



that will be reused in construction materials markets.[15]

The main principles of the circular economy are:

Reduce (reduction in the use of resources and preference for renewable materials);

Reuse (efficient and repeated use of products);

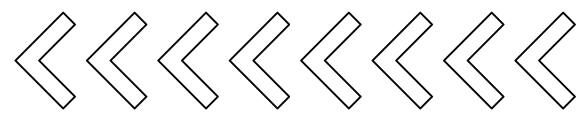
Recycle (restoration of products and waste for further use).

Implementation of these principles in Ukraine will stimulate the creation of new jobs and attraction of significant investments and European technologies. Within the framework of the Green Deal, the circular economy and approach to reuse and recovery of resources are no less important for achieving the goal of climate neutrality in Europe in 2050 than decarbonization and renewable energy. To finance the measures of the Green Deal, the EU will mobilize at least EUR 1 trillion of investments over 10 years, which is 25% of all financing of the European Union. Only from 2021 to 2027, the EU plans to mobilize up to 150 billion dollars. Of course, these funds will be available to countries that have implemented the necessary European directives into national legislation. That is why we must as soon as possible conduct a full analysis of our legislation regarding its compliance with European directives and form a step-by-step plan for implementation of legislation with its further enactment.

Section conclusions

Unfortunately, our country still lacks regulations that would encourage entrepreneurs to recycle.

During martial law period the development of a sustainable waste management system becomes imperative. Therefore, the authorities, scientists, public and business representatives should unite to develop regulatory acts, search for and implement new technologies, and form short-term and long-term action plans. Conducting a full analysis of Ukrainian legislation for compliance with European directives, which is ongoing now and in which SPKR actively participates, forming a step-by-step implementation plan is another important step in enactment a systemic approach to the problem of ecological restoration of the country.



Legislation changes have already begun (adopted framework Law of Ukraine "On Waste Management" entered into force in July 2023) while situation with the search for new technologies is more difficult. After all, in recent years the greatest attention was paid to solving the problem of household waste management, conceptual approaches were changing in this area. Much has been said about transition from waste disposal to prevention, reduction of generation and introduction of sorting, recycling, and use of solid household waste as material and energy resources. Unfortunately, almost no attention was paid to construction waste, but now due to a significant amount of destruction as a result of military aggression on the territory of Ukraine this problem has become very acute. Therefore, we should already analyze global experience of solving sustainable management and reuse of construction waste problem. Having signed the Association Agreement with the European Union in 2014 Ukraine has made a European choice, including in field of waste management. Therefore, even in this extremely difficult time we must look for ways to solve the problem of processing waste from destruction into other products that can be used in various spheres of life.

That is why recycling is a step forward which will significantly reduce time and financial costs. Recycling is our direction towards a circular economy, it is an opportunity to reuse processing products, to make new products from recycled raw materials, to split or break up to extract the necessary components, to obtain energy from waste incineration, necessarily with the arrangement of proper emission cleaning from such installations.

2. Use of demolition waste as recycled material

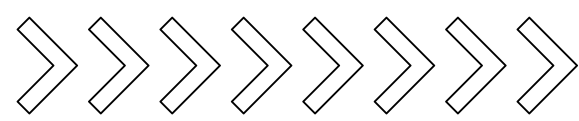
We have considered many options and below we give several examples of destructions waste management that can be implemented in Ukraine as well.

Concrete and reinforced concrete waste. Since 70s of the last century many countries have conducted large-scale research in the field of processing concrete and reinforced concrete waste, studying the technical, economic, social and ecological aspects of usage secondary products in construction.[4]

Secondary raw materials are not a full-fledged building material, it has a low cost and a limited scope of application. The waste of construction industry belongs to 4th class of danger, they are multi-tonne and have too large areas for storage, which is why they must be processed.

There are two directions of disposal of construction waste:

1. Reuse without recycling. Some building elements (columns, beams, and wall elements) can be used in new construction, provided they are intact and in good condition, properly dismantled and transported.



2. Construction waste processing (recycling). It includes the following stages: extraction of waste, its processing and use as secondary raw materials. Thus, the most common types of recycling are the remains of reinforced concrete products, broken bricks and glass, plastic, and wood.

After buildings dismantling mainly reinforced concrete remains, which is sorted using special equipment. Pieces that are too large are break up into smaller pieces using a hydraulic hammer or hydraulic shears. Special construction equipment is often used for dismantling and destruction: diamond saws, drilling units and non-explosive expanding cements.

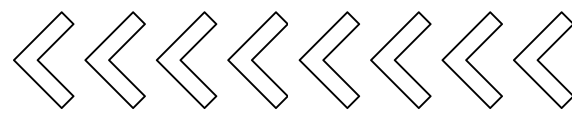
Next step is grinding of concrete, reinforced concrete and bricks with subsequent classification of the resulting mixture. As a result of grinding, we get:

crushed stone, fractional concrete, granite screening — 70%;
brick and stone fragments - 25%;
scrap metal - 5%.

All these materials can be recycled to obtain secondary products. Crushed stone is divided into fractions of 10–20, 20–40, 40–80 mm and is used as an aggregate during concrete and reinforced concrete production. Screening with particle sizes less than 5 mm should be used as filler for porous concrete and construction mortars production. In addition, crushed stone is used in construction of low-rise buildings, pouring foundations of warehouses and production facilities, in the process of building utility rooms, building roads, creating engineering infrastructure, during concrete production, construction and repair of railway tracks, for land improvement works, land reclamation.

Secondary rubble can fully replace from 20 to 60% of granite rubble total volume, depending on type of construction project. Its usage allows you to significantly reduce cost of purchasing expensive building materials (up to 40%) since the quality of secondary crushed stone is slightly inferior to natural with high-tech processing methods. The cost of concrete made using such an aggregate is two times cheaper than when using natural rubble. In addition, 25% less binders are needed during concrete preparation on such an aggregate. Given the fact that solid phase of various fractions is used as a concrete aggregate, we can talk about virtually zero-waste technology.

It was established that 8 times more energy is consumed during natural crushed stone extraction than during extraction of crushed old concrete. If we take into account that according to estimates of ecologists [4] about 420 million tons of concrete scrap have accumulated in the USA, Japan, and EU countries, then the savings reserve is very large.



In addition, it is worth noting that cost of concrete obtained from of secondary crushed stone is 25% lower than concrete based on natural crushed stone. When using secondary crushed stone the physical and mechanical parameters of concrete increase and cement consumption decreases. Crushed concrete scrap has an active surface that contributes to formation of a strong contact layer with cement stone. Obtaining concrete rubble, fine-grained screenings and their repeated use is the final stage of closed cycle of concrete and reinforced concrete waste processing - "demolition - removal - processing - realization".[1]

There are certain features of using secondary crushed stone and other fillers in the process of roads building. So, for example, the use of secondary crushed stone as a filler for lower layer also improves its physical properties, stability and endurance. This improvement in the properties of road surface allows to reduce the costs of laying the top layer due to reduction of its thickness. In Europe this method of laying is quite common. In Denmark, for example, the bottom road surface consists of crushed asphalt and crushed concrete in a ratio of 50 to 50. Such practices allow not only to reduce economic costs, but also to improve the quality of final products.

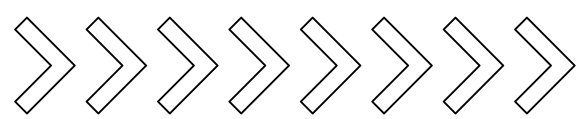
In addition to crushed asphalt and concrete the crushed roofing tiles, broken wall products, tiles, etc are used as solid filler for road surface. The technology of its grinding is similar to the one described above, but the final product is finer, so it is also used as an analogue of sand or gravel. For example, in Germany, 70% of the raw materials for road construction are construction waste processing products.

In addition to laying roads, secondary fillers can be used in the process of laying any surfaces (stadium surface, tennis courts, etc.).

Asphalt is also reused in road construction, but first it is also hydrothermally processed at a very high temperature. Fittings are used in construction in this way. Plastic and scrap glass can be sent for remelting or processing to appropriate glass manufacturers. It is possible to use broken glass as filler in road construction, to obtain building ceramics, the impact strength of which is 0.83 kg/cm². Bricks using broken glass (up to 50 — 90%) can be used in harsh climatic conditions.

Today 15% of wood waste is recycled. It can be used after grinding to obtain wood-cement mass, from which wood-cement boards are made. In addition, 169 kg of artificial silk, 150 kg of paper, 20 kg of dry yeast, 170 kg of thick wool, and 90 liters of alcohol can be obtained from 1 m³ of wood waste [5]. Pressed wood of aspen, birch, alder and poplar is used for manufacture of machine parts, bearings, gaskets, which were previously made of metal. Parts made of pressed wood last several times longer, and their cost is 3 to 20 times lower. Also, this type of waste is often used to obtain heat.



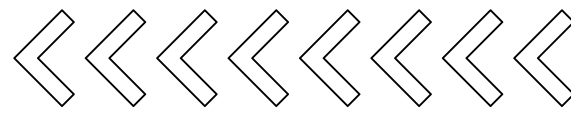


Waste paper in combination with organic and inorganic components is used in the production of various plates, thermal insulation panels based on perlite, powdered solid and gaseous fuel, ethanol, nitrogen fertilizer with addition of potassium and calcium.

Processing of certain waste such as linoleum or soft roofing is accompanied by release of a significant amount of toxic gases, which requires the installation of complex treatment facilities. Therefore, it is expedient to grind them and burn them in cement kilns, where due to high temperatures (1300...14500C) they are completely decomposed into non-toxic components and combusted with release of additional heat. Such waste can serve as fuel at enterprises where there are similar furnaces.[1]



Demonstration photos



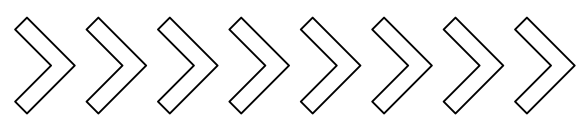
3. Pilot projects implemented in Ukraine

Today in difficult times for us when the Russian occupier is destroying everything around us, turning our cities and villages into ruins, there are companies in the world that are starting to help our country not only in words, but also in deeds. Well-known company from Israel GreenMix will participate in building of construction waste processing plant in the Kyiv region and dismantling of destroyed high-rise buildings near Kyiv. Foreign investors from an Israeli company were shown the consequences of hostilities with Russian terrorists in Bucha. In this community the amount of destruction waste after the rubble demolition is more than two million tons. The problem of the future of high-rise buildings is acute. To date, the survey and documentation of damage to about 90% of such buildings has been completed. In general, thousands of objects were destroyed in the Kyiv region as a result of the war. The company from Israel whose representatives held negotiations with Ukrainian authorities, specializes in processing of construction waste. Company representatives offered their experience and a set of technologies that will help effectively solve the issue of dismantling damaged multi-story buildings. The company's fleet includes demolition machines designed to operate with buildings over 10 stories high. As a result those become building material for reconstruction of destroyed cities. This is the latest technology which has not yet been available in Ukraine. [9].

Since 1989 the innovative GreenMix group of companies has focused its activities in the field of building demolition, construction waste management and the creation of plants for processing of demolition waste into high-quality construction materials with high environmental friendliness and economic value (closed-loop economy). GreenMix is a leader in the field of construction waste processing and promotion of ecological solutions in Israel, and also has international experience, in particular, processed all waste from destruction caused by military operations in Mosul (Iraq).

The French company Neo-Eco has started work on a pilot housing renovation project in Hostomel with a total budget of 45 million euros, which will provide housing for 310 families and show the advantages of recycling construction waste into new materials. For the construction, materials from the destroyed objects near the Hostomel airport will be used to restore buildings and roads near them. Experts claim that reuse of construction waste will make it possible to optimize reconstruction budget of Ukraine approx by 20 — 25%.

The project will be implemented with funds allocated by French government. French architects from BLAU company and Ukrainian company «Нью Іммо Сервісез» are working on its development. Samples of materials from several points of construction have already been taken, and they are currently being studied in laboratories in France and Ukraine. Sent to France close 200 kg of samples, which investigate as thoroughly as possible the presence of pollutants and possibility of reusing building structures (or their parts) for residential construction. Research continues in two stages: 1) analysis from the point of view of the safety of reuse, 2) development of recipes for concrete that will be produced, so that it meets the requirements for quality, strength, thermal conductivity, etc. [16]



The demolition of the buildings began on January 20 and was completed in eight weeks, twice as fast as planned. During the sorting process 10% of the waste was sent for disposal — it contained toxic substances, including asbestos. The remaining 90% of construction waste was simply processed on site with the help of machinery.

According to preliminary estimates by experts before the destruction houses contained 50,000 tons of solid materials, after destruction and fires many materials were burned, so it was possible to process about 15,000 tons of construction waste into new construction materials.

Over 17 years of operation Neo-Eco has already processed about 10 million tons of concrete used in large French projects. And during this time there were no problems with its operation.

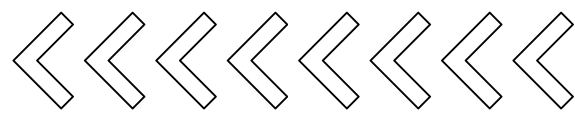
Another pilot project for processing of construction waste is underway in Irpin. Japan has handed over equipment to the city for construction of a site for destruction waste management caused by hostilities. The Japanese government provided the city with two excavators and five wheeled backhoe loaders to assist in removal of rubble from destroyed buildings. Soon, 10 more units of similar equipment are expected in Irpin.

Within this project all construction waste will be processed. Now, after dismantling, they are taken to temporary sites, and soon special equipment for sorting and processing will be installed there.[16]

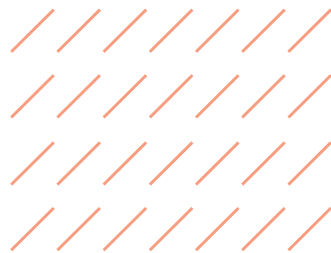
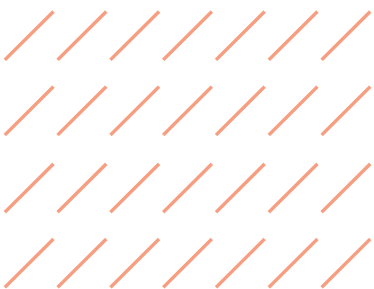
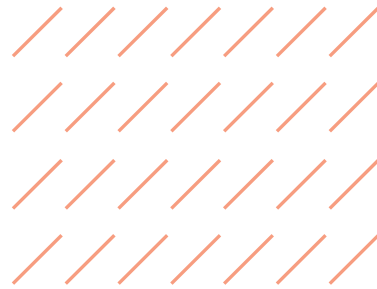
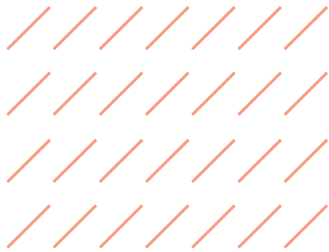
Conclusions to the section

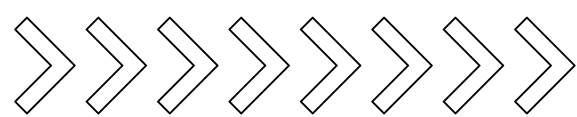
Thanks to global companies that have already started implementing pilot projects in Ukraine today, we gain experience and a set of technologies that will help to effectively solve the issue of dismantling damaged multi-story buildings and processing waste from destruction into building materials with high environmental and economic value. Reuse of construction waste will make it possible to optimize reconstruction budget of Ukraine by approximately 20-25%.

Our Ukrainian companies are actively involved in the processes of development and implementation of such projects, which is quite positive, because then they will be able to independently continue work in this direction. Unfortunately, as a result of hostilities on the territory of Ukraine and merciless Russian shelling of our towns, the number of destroyed buildings and structures is still increasing. We hope that soon the Ukrainian business will independently start construction of plants for processing of construction waste and purchase, and possibly produce, equipment for dismantling of destroyed objects.



Demonstration photo





4. Ukrainian companies engaged in construction waste processing

In Ukraine companies have already begun to appear that provide services for processing of waste from destruction:

- preliminary sorting of generated waste;
- their primary processing at the crushing and sorting complex and removal to waste management facilities or temporary storage facilities;
- loading them onto dump trucks and taking them to burial sites.

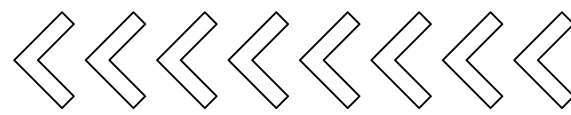
As mentioned, it is more difficult to dispose of demolition waste than construction waste. After all a significant part of it consists of a mixture of different structure and origin materials which are sorted in prewar conditions before dismantling. In "khrushchevkas", for example, on average almost 1 thousand out of 6.4 thousand m³ are made up of dismantled materials: glass, polymers, wood, wires. There are 450 tons of metal alone, and 30 tons of ceramic tiles, 15 tons of lumber, and 5 tons of glass. In Soviet times the strength of buildings and foundations was usually achieved due to the thickness of the walls, a large amount of metal, and reinforced concrete. Therefore, dismantling such structures without use of special equipment will take too long and be expensive.

Let's outline in more detail the stages of destruction waste management:

First step. Preliminary sorting of generated waste is the most time- and effort-consuming stage of transforming ruins into secondary raw materials. In our conditions millions of tons will have to be sorted practically by hand, since the ruins may contain unexploded shells, planted explosives or bodies fragments. Based on this government programs will be needed to stimulate recruitment of human resources, in particular, motivated volunteering and labor mobilization.

It makes sense to work out the universal rules for disassembling and sorting typical buildings on pilot projects. It is necessary to determine the percentage composition of waste to be disposed of and buried, optimal technologies and industrial capacities for dismantling. A mandatory condition is laboratory research that determines the mechanical properties, crushing parameters, and the level of main materials toxicity. Understanding these factors will allow us to apply universal approaches in the future.

The second step, after sorting, is primary processing (processing of waste at the crushing and sorting complex). The task of this stage is to radically reduce amount of waste. Active participation of the government in stimulating professional dismantling market at the local communities level with the involvement of modern technologies will be required in these issues. Currently, in Ukraine, the business related to industrial dismantling and processing of construction waste is in its nascent stage. Before the war there was a critical shortage of equipment, practice and orders. Today the processing of construction waste should become an important, necessary and profitable direction in business and stimulate manufacturers to create special equipment. Constant improvement of equipment and technologies allows achieving a higher level of processing and accordingly profit.



Manufacturers are constantly working on improving equipment that is manufactured.

Whereas 25-30 years ago they used bulky stationary complexes, today they mainly buy mobile (tracked).

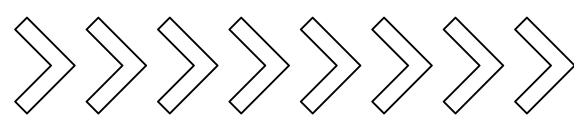
The stationary construction waste shredding line includes:

- loading unit;
- coarse crushing unit with jaw crusher;
- iron separators;
- sorting unit with a three-sieve screen;
- medium crushing unit with a rotary crusher;
- control unit;
- conveyors.

Mobile units of this type carry out concrete processing immediately on the site of dismantling buildings and structures on a single wheeled chassis. The weight of such complexes ranges from 30 to 100 tons, productivity is from 100 to 450 tons of secondary products per hour. Such installation is fully automatic and does not require additional maintenance. The mobile complex is able to receive, sift, grind and return road construction waste to the technological process [8]. Despite their compactness, mobile installations are also able to process up to 120 tons of removed asphalt covering, that is not inferior to the same stationary equipment.

The advantages of the mobile complex include the absence of waste transportation costs and possibility of using recycled product immediately on the construction site. The disadvantage of such installations is the potential negative impact on the environment.

The field of application of such equipment is processing of concrete and brick waste, railway concrete sleepers, as well as the production of granite rubble in quarries. In addition to processing, the program of each manufacturer also offers mobile sorting complexes, so-called "screens", which allow to separate secondary crushed stone into fractions of size from 0 to 120 mm. That is, you can get secondary crushed stone of sizes 0 - 15, 15 - 30, 30 - 70 mm, etc. It is also worth mentioning that only one crushing and sorting complex is not enough to organize processing process. It is mandatory to purchase an excavator with an appropriate set of attached equipment for dismantling buildings and structures: hydraulic hammers, cutters, concrete crushers, hydraulic shears, and grapples.

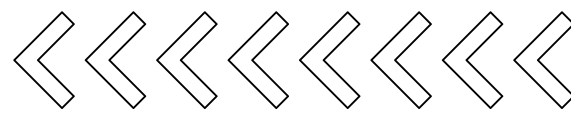


Mini excavators are often used to work in limited conditions, under ceilings. In addition, when dismantling high-rise buildings, tower cranes, various loaders, including tracked mini-loaders for work on soils with weak bearing capacity, bulldozers, concrete pumps and diesel generators, vibratory rollers and other means of small mechanization are used. Hydraulic rotary shears are able to cut reinforcement and concrete, grab and transfer cut parts of the building. In addition, disc and rope diamond cutters, drilling units with diamond crowns, hydraulic splitters are used in buildings demolition.

Modern equipment for dismantling buildings is able to maintain filigree accuracy in work in limited urban conditions. Technological difficulties in selection process arise in the center of the city. It is necessary to put protection against accidental splinters and collapses there. Narrow roadways greatly complicate demolition. Builders literally have nowhere to turn around and place equipment. Sometimes the excavator is disassembled and in this form is brought to the courtyard, where it is then assembled again. Unfortunately, the price of such equipment is quite high. An excavator with attached equipment costs from 200,000 Euros, a crushing and sorting complex from 350,000 Euros and up to 1 million Euros. Given the amount of necessary investments and the difficulty of obtaining loans, the purchase of such equipment is possible only for companies with large initial capital. [14]

The price policy leads to the fact that Ukrainian entrepreneurs are not in a hurry to invest in waste processing equipment. However, in connection with the war, it becomes obvious that destruction waste dismantling and processing will become important directions in the business of Ukraine. There are already factories for production of concrete from remains of construction structures. The Institute of SE "NDIBK", which is the representative of Ukraine in the International Federation of Concrete, has already placed a corresponding appeal on the possibility of applying experience of European countries in using concrete from construction waste. According to the company's management, there is already feedback from certain manufacturers who are ready to work and supply special equipment to Ukraine.

In our difficult times Ukrainian companies are faced with the fact that significant volumes of demolition waste must be reduced, which means that technological solutions must be sought for this. For example, in Kharkiv (a city that suffered significant destruction), a special shredder is currently used, which reduces the volume of waste by five to eight times depends on the materials used in construction. Only one employee is required to manage such a complex, so time and labor costs are significantly reduced. The HAMMEL complex is equipped with a grinder and a magnetic separator, which makes it possible to grind concrete slabs into crushed stone, and to sort metal fittings with a magnet. This complex is manufactured in Ukraine by a German concern. Its value is about 1 million 150 thousand Euros. There are only a few working teams in Ukraine that have similar equipment and can be involved in sorting destruction waste, but this is still not enough.[8]



There are companies on Ukrainian market, and among them Hummel Ukraine LLC and OLNOVA JV, which are engaged in sale of waste processing equipment. Therefore, other entrepreneurs can start their own business by purchasing the necessary items from them. JV "OLNOVA" manufactures equipment that provides a complete technical solution both for crushing and sorting household, non-toxic commercial and mixed SHW (solid household waste), construction waste, organic and inorganic waste, waste paper and polymers for their further secondary use and disposal. [17]

"Hummel Ukraine" LLC is a more developed company and has a larger number of equipment, not only for sorting and grinding, but also for disassembling building materials. Including:

Sorting lines is a comprehensive solution to the problem of waste for waste processing enterprises, landfills, individual industries, both industrial and agricultural. Individual projects are possible.

Cutting machines:

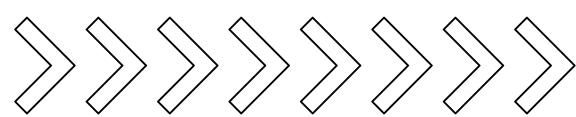
Wood chipping machine DP 660 E 30 kW with an electric motor is intended for grinding woodworking waste into technological chips.

Wood chipping machine DP 660 T (mounted on a tractor) is intended for shredding woodworking waste into chips.

Wood chipping machine DP 660 R (rotor type) driven by an electric motor is intended for shredding lumpy woodworking waste generated during the production of lumber and plywood, as well as wood chips into chips.

Primary shredder carries out preliminary grinding of a wide range of materials for further use as raw materials or components for enterprises of the chemical, construction, woodworking, metallurgical industries, in agriculture, etc. Primary shredders are also used before further processing of solid household (and mixed commercial) waste on sorting lines and final disposal at landfills (or disposal at waste processing enterprises).

Secondary shredder NZS 1000 is designed for secondary grinding of wood waste after primary shredder into technological chip. The size of the chip fraction obtained in this way is from 10 to 40 mm, and depending on the structure it can be used in the wood processing industry or be thermally disposed of. The fraction final size at the output depends on the cells size of installed sieve. The installed system of sieves is intended for distribution of chips by fractions. The shredder is equipped with a metal detector, and if necessary, a magnetic separator can be installed to separate metal inclusions.



від 10 до 40 мм, і вона може, залежно від структури, використовуватись у деревообробній промисловості або бути термічно утилізована. Кінцевий розмір фракції на виході залежить від розмірів комірок встановленого сита. Установлена система сит призначена для розподілу щепи по фракціях. Подрібнювач оснащений металодетектором, а за необхідності можна встановлювати магнітний сепаратор для відокремлення металічних включень.

Problems of disposal of household appliances and furniture

In Ukraine, it is quite difficult to get rid of household and computer equipment which also remains at the site of destruction. After all, most companies do not work with individuals and prefer large consignments of equipment.

Companies that accept equipment will separate dangerous substances, for example, pump out freon from refrigerators and air conditioners. Then metal is pressed and sent for processing. Almost the same thing happens with office equipment: it is disassembled manually, and then parts of the equipment are sent for recycling. Frames from system units are processed separately from boards.

Currently there are certain companies, among them "Ecological Investments" and "Waste Management Center", that accept household appliances.

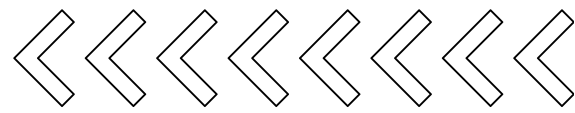
As for furniture the situation is not better because in manufacture of chipboards from which a significant part of modern furniture is assembled, special adhesive mixtures are used. Most of them are toxic. Quite often modern furniture includes metal fittings, plastic and glass elements. Such elements do not decompose so they must be sorted and recycled.

Disposing of furniture takes place in several stages:

- removal of old furniture for recycling;
- sorting to separate wood from plastic, metal and glass;
- secondary processing of waste;
- disposal of non-recyclable waste in special landfills.

Such services in Ukraine are provided for example by "UtilVtorProm" company. Also on the Internet you can find many enterprises that are engaged in removal and disposal of such waste.

After mechanical and biological processing of waste, secondary raw materials (organic, PET, metal, plastic) are obtained which can be reused. As well as RDF fuel for high-temperature installations, for example, cement kilns. [13]



Section Conclusions

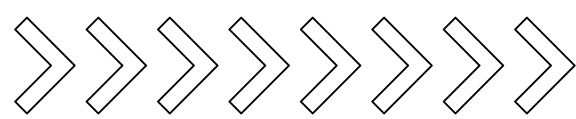
Disposal of construction waste is an important environmental problem solution of which must be given government emphasis especially in current situation. It is necessary to build new processing enterprises as well as to repurpose existing ones that have insufficiently loaded production capacities. It is also important to develop an appropriate regulatory framework for use of secondary resources from construction waste production of building materials. Further scientific research directed at the development of construction materials using recycled construction waste is necessary.

Unfortunately, there are currently very few enterprises engaged in processing of construction waste in our country, but the right system of encouraging entrepreneurs can change the situation. For example, reduced business taxes, discounts on rent, reduced duty on waste processing equipment, etc. That is why changes in legislation should also take into account business benefits as an incentive argument. Why on-site processing of demolition waste is beneficial and necessary for entrepreneurs:

1. Zero costs for removal and disposal of residues beyond destruction limits.
2. Environment protection from pollution by destruction waste.
3. Reduction of costs for construction materials.
4. Possibility of selling secondary building materials.



Demonstration photo



5. Legislative changes in the waste management system during the war

Despite the full-scale war with the Russian Federation, the reform of waste management system continued in Ukraine. At the same time as solving problem of waste management from destruction caused by hostilities, the state authorities urgently need to solve the problems of undeveloped processing industry, spontaneous landfills, and overflowing solid waste disposal sites that do not meet EU requirements.

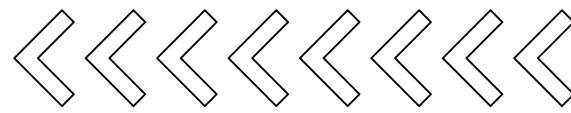
The Verkhovna Rada of Ukraine adopted the Law of Ukraine "On Waste Management", which was registered back in 2020. Its norms enter into force on 07/09/2023.

The law provides for the following:

1. Local self-government bodies must decide on the placement of waste treatment facilities on their territory and create points for separate collection of household waste, in which separate collection of textile waste, wood, large-sized and repair waste, waste of green spaces, hazardous waste as a part of household waste, paper waste, cardboard, metal, plastic, glass, electronic and electrical equipment, batteries and accumulators, other types of waste.

Today, separate collection of waste is practiced only in some large cities. Unfortunately, Kryvyi Rih is not one of them. At the same time, it is worth noting that the ban on burying unprocessed household waste was established as early as January 1, 2018 (paragraph and part 1 of Article 32 of the Law on Waste). That is, waste subject to secondary processing (cardboard, glass, plastic) should be collected separately from 2018. The organization of separate collection of useful components of household waste is entrusted to local self-government bodies (Article 21 of the Law on Waste). However, as time has shown, the effectiveness of the government's measures to implement the sorting of household waste, particularly in the city of Kryvyi Rih, is low.

2. Each region must develop regional waste management plans, which are approved by regional state administrations. Local waste management plans are approved by local self-government bodies and must be coordinated with regional ones. Waste management plans define a management system for the following classes of waste: municipal, hazardous, industrial, construction and demolition waste, agriculture, packaging, electrical and electronic equipment, used batteries, batteries and accumulators, medical waste, as well as decommissioned vehicles, sewage sludge water from municipal treatment facilities.



As of the beginning of the summer of 2023, the Cabinet of Ministers has not yet approved Procedures for the development, approval and validation of regional and local waste management plans developed by the Ministry of Environment in accordance with requirements of the Law of Ukraine "On Waste Management". The drafts of the specified documents are subject to public discussion.

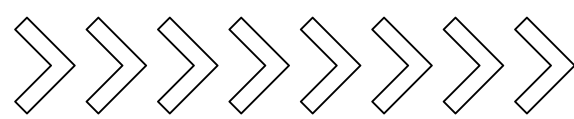
Order of the Ministry of Environment dated September 10, 2021 No. 586 "On the approval of Methodological recommendations for the development of regional waste management plans" (hereinafter - Methodological recommendations) should be recognized as invalid, since according to Article 19 of the Law of Ukraine "On Waste Management" the approval of this document is currently within the powers of the government.

In accordance with the requirements of these Methodological Recommendations, the Regional Waste Management Plan (RWMP) in Dnipropetrovsk Region until 2030 was developed. Considering the innovations established by the Law "On Waste Management" we believe that the RWMP should be revised. A local waste management plan in the city of Kryvyi Rih must be developed within a year after the entry into force of the regional waste management plan.

3. Non-hazardous construction and demolition waste is subject to preparation for reuse, recycling, other material recovery, including backfilling.
4. Waste disposal is carried out at landfills that meet legislation requirements and technological equipment that ensures protection of groundwater, extraction and neutralization of biogas and leachate, control of emissions into the atmosphere, soil and groundwater pollution. The business entity managing the landfill must have a permit to carry out waste processing operations, and in the case of disposal of hazardous waste, a license to carry out hazardous waste management business.
5. The law establishes that local self-government bodies must ensure the fulfillment of target indicators regarding preparation for reuse and recycling of household waste:
 - by 2025 — at least 10% of their mass;
 - by 2030 — at least 20% of their mass;
 - by 2035 — at least 25% of their mass;
 - by 2040 — at least 35% of their mass.

The law stipulates that from January 1, 2030, it is prohibited to operate waste disposal sites (landfills) that are not equipped with biogas and leachate extraction and disposal systems, atmospheric air emission monitoring systems, and soil and groundwater pollution monitoring systems.

This is a very important environmental legislative requirement, since a large part of Ukrainian landfills for waste disposal were built decades ago and are not properly equipped: they have neither groundwater protection systems nor biogas removal systems.



The Law also contains restrictions: these requirements do not apply if the business entity that manages the existing waste disposal site implements a plan to bring it into compliance with the requirements of the law in accordance with the schedule established by the terms of the permit for waste processing operations.

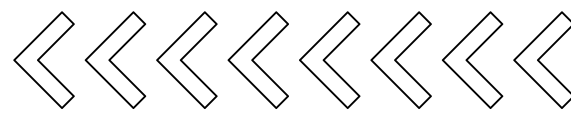
Understanding the condition, terms of operation of landfills in Kryvyi Rih and the amount of waste accumulated there, we can say that it will be extremely difficult to bring them into compliance with the above requirements. Therefore, landfills that do not meet the established modern requirements of environmental safety should be closed, and waste should not continue to be transported to them, because they are dangerous both for the environment and for human health.

Law of Ukraine No. 2320-IX "On Waste Management" is a framework law. Sectoral laws should be adopted next, including "On waste from the extractive industry", "On scrap metal", "On packaging waste", "On batteries, and accumulators", "On waste of electrical and electronic equipment", "On decommissioned vehicles" . At the same time, Law No. 2320-IX establishes that waste management of the extractive industry before the adoption of the sectoral law is carried out in accordance with the norms of the Law "On Waste Management".

Separately, to fulfill the requirements of the Framework Law, the following by-laws must be developed and approved:

- National list of waste I Waste classification procedure.
- National waste prevention program.
- Procedure for development and approval of regional waste management plans.
- Procedure for developing, agreeing and approving local waste management plans.
- Rules for the technical operation of waste incineration plants and waste co-incineration plants.
- Rules for technical operation of landfills, termination of operation, reclamation and maintenance of landfills after termination of their operation.
- Rules for composting biowaste by its generators on homestead, country and garden plots.

Resolution No. 556 of the Cabinet of Ministers of Ukraine dated 05/07/2022 "Some issues of submitting a waste declaration" defines the procedure for submitting a waste declaration in electronic form through the Unified State Web Portal of Electronic Services "Portal Diya". Based on the information and data provided by the applicant, the waste declaration is entered into the relevant Register automatically, without the need to adopt any administrative acts or officials' decisions, with registration number assignment and the publication of this information on the Unified Environmental Platform "EkoSystem".



The Order of the Ministry of Health of Ukraine dated 09/06/2022 No. 1602 approved changes to the State sanitary and anti-epidemic rules and norms regarding the handling of medical waste.

The purpose of changes is to prevent medical waste from entering landfills, as they carry risks of chemical, toxic, carcinogenic, mutagenic and radiation effects on human body. The changes made are as follows:

- health care institutions that are engaged in the processing, disposal, utilization and removal of hazardous medical waste must obtain a license for handling hazardous waste;
- disinfection of infectious hazardous waste by chemical method is prohibited;
- designated responsible person must develop a standard waste management scheme and is responsible for its subsequent compliance.

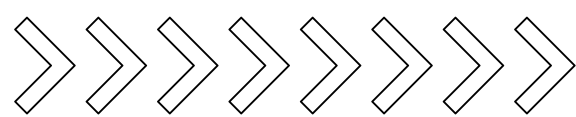
Resolution No. 1073 of the Cabinet of Ministers of Ukraine dated September 27, 2022 approved the Procedure for handling waste generated in connection with damage (destruction) of buildings and structures as a result of hostilities, terrorist acts, sabotage or carrying out works to eliminate their consequences and amendments to some Cabinet Ministers of Ukraine resolutions.

The procedure defines the mechanism of handling such waste in order to prevent and reduce their negative impact on surrounding natural environment and human health.

Demolition waste management operations include:

- primary clearing of territories (demolitions waste collection, in particular, sorting of individual components of waste from demolitions);
- transportation of waste from destruction from the place of their generation to waste management facilities or temporary storage sites;
- final (after carrying out work on dismantling of damaged (ruined) objects) removal and cleaning of territories (if necessary);
- storage of demolition waste at temporary storage sites or other waste management facilities (before disposal or removal);
- processing (recycling) of waste from destruction and/or their disposal (if necessary);
- disposal of destruction waste (waste usage as secondary material or energy resources);
- removal of destruction waste, including its burial.

Works on clearing territories adjacent to damaged (ruined) objects can be performed in the absence of a threat of emergency collapse of the object as a whole or its individual parts.



In case of dangerous objects, explosive devices, remains of the dead people, smell of gas or other characteristic odors, an electric current breakdown, as well as related deterioration of well-being are detected during such work it should be stopped immediately and territorial bodies of State Emergency Service and law enforcement agencies should be immediately notified.

Management of demolition waste is organized and carried out:

- the owner/manager of the object, as a result of destruction of which such waste was formed, or the owner or user of land plot within which such waste is placed;
- by executive body of the village, settlement, city council (military administration of the settlement) regarding waste from destruction placed on the streets and roads of settlements, public roads, public places, in particular on the territories of parks, squares, embankments, residential areas, beaches, cemeteries.

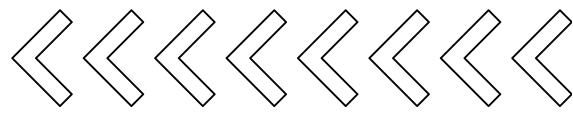
In case there are no landfills in the relevant territories or their capacity is insufficient to accommodate demolition waste, the Procedure provides temporary storage at designated locations. Such places of temporary storage should be organized in compliance with requirements of ecological and fire safety, natural environment protection, rational use and reproduction of natural resources, as well as the necessary sanitary and protective zones. By the order is approved the list of demolition waste components (bricks, ceramics, concrete, wood, scrap metal, broken glass, etc.) and possible ways of its reuse in construction, building materials industry.

As of the beginning of the summer of 2023, the draft resolution of CMU "On approval of the Waste Classification Procedure and the National List of Waste", which was published on Ministry of Environment official website on January 13, 2023, is under consideration.

Section Conclusions

Adoption of the Law of Ukraine "On Waste Management" in 2022 was a significant step forward in the field of sustainable waste management as well as Ukrainian integration into EU legislation.

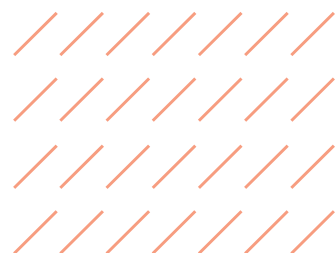
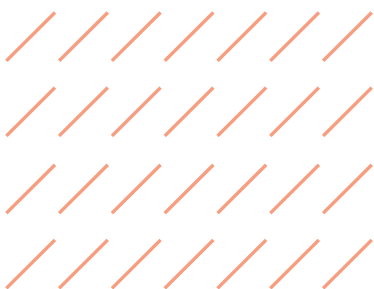
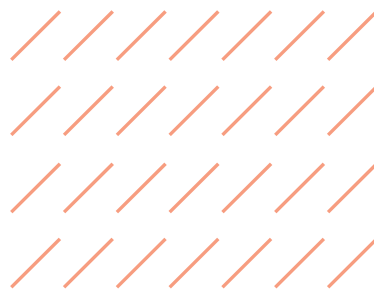
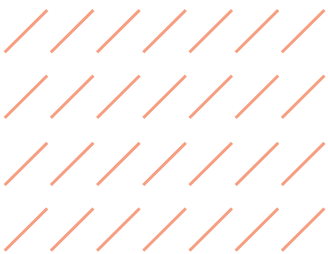
The law was developed in accordance with requirements of Directive 2008/98/EC on waste and Council Directive 1999/31/EC on waste disposal. It creates the conditions for construction of a modern waste management infrastructure in Ukraine, but unfortunately, the issue of incentives for circular economy development remains unresolved. Law of Ukraine "On waste management" is a framework and sets the stage reforming the waste management system. Now it is necessary to develop and adopt specialized laws that will determine procedure for handling waste from mining industry, scrap metal, packaging waste, batteries, etc.

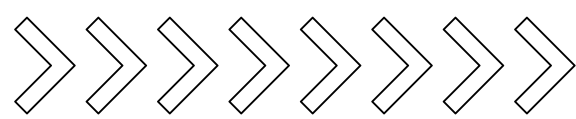


Amendments to the State sanitary and anti-epidemic rules and norms regarding the treatment of medical waste are important, as they will allow to partially solve the problem of medical waste treatment, since 90% of its quantity currently ends up in landfills. This is unacceptable and poses a threat to sanitary and epidemic well-being.

The problem of accumulation of significant volumes of destruction waste caused by military aggression on the territory of Ukraine should be gradually solved by the adopted Procedure for handling waste generated in connection with the damage (destruction) of buildings and structures as a result of hostilities, terrorist acts, sabotage or carrying out works to eliminate their consequences. It is important to implement the norm on the need to conduct research into the possibilities of reusing components of this class of waste for construction, industry, and production.

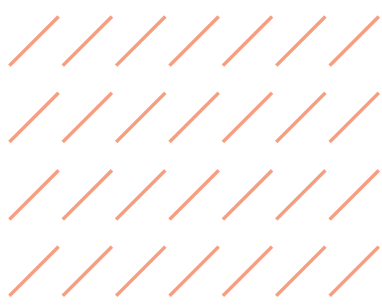
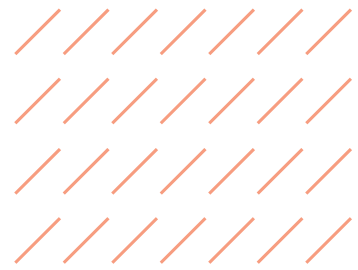
One thing can be said with confidence: our legislation in the field of sustainable waste management is actually undergoing changes, and this cannot but please. It is important that its implementation was not only on paper.

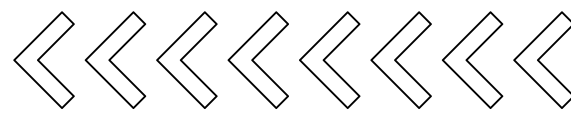




Based on the conducted research, we offer an action plan:

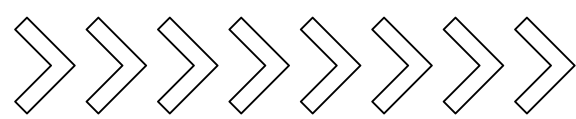
1. Regulation of the legislation, which determines processes outcome of temporary storage, transportation, sorting, processing, utilization and reuse of waste. Development and implementation of the appropriate regulatory framework for usage in buildings secondary resources from destruction waste.
2. Creation of government programs to stimulate recruitment of human resources, in particular, motivated volunteering and labor mobilization.
3. Stimulation of professional dismantling market at the territorial communities' level with the involvement of modern technologies and world experience use.
4. Creation of a program to encourage entrepreneurs, which includes: reducing tax rate percentage for conducting activities, access to credit system, reducing amount of equipment for dismantling and recycling, etc.
5. Creation of universal rules for dismantling and sorting typical buildings.
6. Formation of a list of waste to be disposed of and buried.
7. Development a program to encourage companies to purchase sorted raw materials at the site of destruction, which reduces the number of temporary storage places and transportation costs.





List of references

1. ASPECTS OF CONSTRUCTION WASTE RECYCLING/Yakimechko G.Ya., Popovych O.R.//Lviv Polytechnic National University, Department of Ecology and Environmental Protection/ 2011., art. 279
2. Lyaluk O. G. Evaluation of the ecological life cycle of construction products / Lyaluk O. G., Ratushnyak O. G. // Modern technologies, materials and structures for construction. - Vinnytsia: Universam - Vinnytsia, No. 1, 2014. - pp. 136-140.
3. POSSIBILITY OF RECYCLING CONSTRUCTION WASTE IN UKRAINE NO / H.V. Shpakova/Ways of increasing construction efficiency in formation of market relations conditions/ vol. 26, 2012.- Art. 137
4. Lviv PolytechnicNational University, Department of Applied Ecology and Balanced Environmental Management PROBLEMS OF DISPOSAL AND PROCESSING OF CONSTRUCTION WASTE © O.R. Popovych, Y.M. Zakharko, M.S. Malyovaniy, 2013
5. Disposal of waste in various areas of national economy. Access mode: <http://pidruchniki.com>
6. Interesting examples of European trends implementation in the field of industrial waste / "ECOBUSINESS. Ecology of the enterprise" No. 4, 2020
7. Temarry resource.temarry.com
8. Waste of war: what is it and how to deal with it? Heading. July 4, 2022 <https://rubryka.com/article/waste-from-war/>
9. A construction waste processing plant will be built in the Kyiv region. Comments.ua August 15, 2022 <https://kyiv.comments.ua/ua/news/money/investments/11595-zavod-z-pererobki-budivelnogo-smittya-pobuduyut-na-kiivschini.html>
10. The procedure for handling waste generated in connection with damage (destruction) of buildings and structures as a result of hostilities, terrorist acts, sabotage or carrying out works to eliminate its consequences. <https://zakon.rada.gov.ua/laws/show/1073-2022-n#Text/>
11. Ministry of the Environment: The scale of the damage caused to the environment of Ukraine by the Russian Federation aggression shocks the whole world. Government portal. November 11, 2022 mindovkillya-masshtabi-shkodi-zavdanoyi-dovkillyu-ukrayini-vid-agresiyi-rf-vrazhayut-ves-svit
12. How the Capital Region copes with the waste of war and destruction after: experience after de-occupation November 28, 2022 <https://stolreg.dei.gov.ua/post/451>



13. "WE WILL NOT RECYCLE EVERYTHING." WHAT IS KNOWN ABOUT THE WASTE PLANT BEGINNING TO BE BUILT IN Lviv. your city March 3, 2022 https://tvemisto.tv/exclusive/use_ne_pererobymo_smittievyy_zavod_u_lvovi_zapratsyui_e_nastupnogo_roku_126901.html

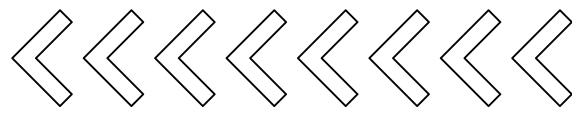
14. ON THE BENEFITS OF CONSTRUCTION WASTE PROCESSING. Ukr.Bio. <https://bio.ukr.bio/ua/articles/2467/>

15. Japan handed over equipment to Irpen for a pilot project on the construction waste processing. Big KYIV April 12, 20223 <https://bigkyiv.com.ua/yaponiya-peredala-irpenyu-tehniku-dlya-pilotnogo-proyektu-z-pererobky-budivelnyh-vidhodiv/>

16. French Neo-Eco is working on a pilot project of housing renovation in Hostomel near Kyiv with a budget of EUR45 million. Interfax-Ukraine. November 28, 2022 <https://interfax.com.ua/news/general/875052.html>

17. Olnova Recycling Technologies <https://olnova.com.ua/>





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Authors: Yulia Orekhanova, ecologist, Anna Ambrosova, industrial ecologist, Kateryna Taran, attorney.

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