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Current state, issues and perspectives of construction waste recycling in Ukraine

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Abstract: The article analyzes the problem of construction and demolition waste disposal in Ukraine, which is especially relevant due to the increasing number of housing renovation projects and the intensification of national construction projects. Construction waste accounts for almost a third of the waste generated in most developed countries. The most efficient disposal method is recycling, i.e. recycling of secondary building resources (SBR). However, the share of recycled construction waste in Ukraine lags far behind developed countries (it is about 6% of its total volume). The high level of waste generation and low rates of its use as secondary raw materials (SRM) have led to the fact that a significant amount of solid waste accumulates annually in the industrial and civil sectors of Ukraine, only a small part of which is used as SRM, the rest ends up in landfills. The difference between waste management in Ukraine, compared with other developed countries, is in the large volumes of waste generation and the lack of infrastructure to recycle it. The issues of the environmental impact of construction waste are considered, and the main cost-effective technologies for processing SBR are identified and considered in this research. With the help of market mechanisms and government regulations, these technologies may become promising for investment and their development will be beneficial for small and medium-sized businesses. Perspective areas of construction waste recycling in order to obtain demanded products are presented; existing advantages and technologies of processing SRM are also considered: solid waste processing, biothermal composting, wood waste processing, recycling of construction waste and metallurgical slag, etc.

Keywords: recycling, construction waste recycling, waste disposal, secondary raw materials, reuse, waste management, environmental safety, latest technologies, materials.

1. Introduction

The high level of global construction industry growth leads to a large amount of construction waste being generated. Due to this fact, the question arose about its removal, recycling or disposal

(burial, incineration, etc.). Construction waste is one that generated during the construction of buildings, repair and other types of construction work.

The anthropogenic impact of construction has a diverse nature and is manifested at all stages of construction activity - from the extraction and production of construction materials to the disposal of construction waste during the demolition of buildings and structures. Thus, the natural environment is affected by both construction and its products.

2. Object and subject of research

Object of research - secondary raw materials (SRM) processing organizations.
Subject of research - SRM processing.

3. Target of research

The target of research is to consider and justify the necessity of processing construction waste in the closed economic system and life cycle of capital construction objects.

The objective of the research is to identify the peculiarities of construction waste disposal, its impact on the environment and to find ways of rational recycling and reuse.

4. Literature analysis

Nowadays, scientists around the world frequently raise the issue of waste management. Among them - O. Melen-Zabramna [1], Y. Golik, O. Ilyash, M. Bilous [2], H. Mazura. Issues related to the recycling of construction waste are studied by E. Shishkin, Y. Hayko, K. Vyatkina and A. Chala [3].

Analysis of world experience [4] shows that countries treat waste differently.

Works [5, 6, 7, 8] analyze the use of construction waste, classify construction waste according to various criteria, and consider systemic issues related to the construction waste recycling organization.

5. Research methods

Analytical methods of studying objects of construction waste generation, their possible classification and obtaining SRM components.

6. Research results

One of the major drawbacks of the Ukrainian construction industry is in its high resource intensity, caused, among other things, by the low level of use of SRM. Even the most polluted - municipal waste - can be involved in reuse by 30-40%. In the countries of the European Union, reuse of this potential reaches approximately 70%.

Depending on the quality, waste can be processed in the following directions:

• "qualified" waste with a high concentration of useful components - a source of obtaining valuable materials and products (“profitable” part of municipal solid waste (MSW), paper, plastics, chemical industry waste);

• large-tonnage industrial waste, which can be used mainly for obtaining construction materials (construction waste, metallurgical, mining, or processing industry waste). Currently, more than 300 million tons of natural raw materials are extracted for the production of construction fillers, while a third of these raw materials can be replaced by industrial waste;

• unprocessed waste (residues from MSW sorting, medical, contaminated with components that prevent recycling) can also be used by incineration using the energy potential.

The main goals that are achieved when involving waste in the recycling process are:

• reduction of energy and economic costs for the production of products compared to products from primary raw materials;

• reduction of environmental damage by reducing the extraction of mineral raw materials that are replaced by waste;

• reduction of environmental damage from waste burial and reduction of alienated land resources [9-11].

In this research, the most promising trends and technologies of SRM processing to obtain the demanded products are considered.

Rubber waste products recycling. The most massive rubber waste is used car tires. They are valuable SRM containing 45-52% of natural rubber, 25-35% of carbon black, 10-15% of high-quality metals.

Nowadays, the main direction of waste rubber processing is grinding and separation to obtain rubber crumbs. An example of used tire recycling is a technology developed by REC "Mekhanobr-Tekhnika" which includes the following operations:

• primary destruction of tires to a size of less than 100 mm using a rotary knife crusher ("shredder");

• secondary crushing to a size of less than 20 mm using a smaller twin-rotor knife crusher;

• disclosure of the rubber-metal-cord-textile-cord system in a high-speed crusher (shock-impulse disintegrator);

• separation of textile cord;

• iron separation;

• grinding of large rubber fragments on rollers;

• screening with sifting into size classes; at the same time, several fractions of crumbs of at least 5 mm are separated, which are prompt to become commercial products; fractions of 10-5 mm, becomes the feed for the regeneration unit;

• regeneration of rubber mass on the regeneration screw unit. This additional stage makes it possible to obtain a universal raw material similar to primary rubber - regenerated rubber.

Rubber crumb, depending on the size, can be used:

• grain size 0.2 - 0.45 mm - as an additive in the production of high-quality products to increase their resistance to impact and bending;

• wider grain size ranges - as a raw material additive in various products in the amount of 50 - 80% with preservation of its quality; as a raw material for the production of mats, rail substrates, roofing and waterproofing materials, as an additive in asphalt coatings (which doubles the service life of the coating), sorbent, etc. [11,12].

An alternative method of recycling rubber waste is pyrolysis with the production of carbon black, liquid products (fuel, plasticizers, softeners for rubber regeneration, film-forming solvents), and methanol. With 1 ton of recycled rubber waste it is possible to obtain 450 liters of synthetic oil, 300 kg of pyrocarbon (with synthetic carbon content of 85%), and 10 m^3 of syngas.

Paper and cardboard waste recycling. Traditionally, waste paper is processed at pulp and paper mills. However, due to the small amount of generated waste and the distance from the operating pulp and paper mills, the costs of their accumulation and transportation are not always paid off.

Alternative technologies are aimed at the local recycling of waste paper with a capacity of approximately 1 ton per hour. Recycling of waste paper can be carried out with the production of heat-insulating material for low-rise construction - "ecowool" or molded paper pulp packaging.

The technology of "ecowool" production is extremely complicated: two stages of disintegration of waste paper in a high-speed shock-pulse disintegrator, because of which the paper mass is crushed and loosened; then – mixed with additives that give it biological stability and fire resistance. The resulting thermal insulation material is not inferior in properties to traditional insulation based on mineral wool and has a thermal conductivity coefficient of 0.04 W/(mK).

Further wet disintegration of waste paper in a cone vibro-inertial crusher complete with a paper molding machine allows for the production of disposable packaging that replaces expensive polystyrene foam - boxes, transport forms, etc. [13].

Wood waste recycling. One of the main methods of recycling and disposal of clean wood waste is the production of artificial wood - a durable material that can be processed by cutting, molding and stamping. In this way, wood-cement masses, chipboards, fiberboards, wood-laminate boards are produced.

Clean technological wood chips are also used as raw materials in the production of sulfite and sulfate pulp, semi-finished packaging cardboard, hydrolyzed alcohol, and fodder yeast. Clean spruce sawdust and shavings from woodworking shops are considered the best raw materials for the production of flour, which is used as a filler in the production of phenolic plastics, linoleum, explosives, and piezo-thermoplastics [14,15].

The problems begin with substandard (including contaminated) wood waste. One of the ways of using such waste is as fuel in boiler houses operating on unprepared wood waste, wood briquettes or pellets.

Briquetting and pelletizing of wood waste facilitate transportation, make the raw material conditioned and easy to process, as well as improve their calorific value due to drying. Briquettes and granules ("pellets") are used as a factory fuel, as well as for supplying the local population with solid fuel. The calorific value of coniferous wood briquettes is 15500 J/kg.

Contaminated sawdust is also used as a bulking material in the production of porous materials with a porous structure, such as expanded clay.

Construction waste and metallurgical slags recycling. Construction waste containing reinforced concrete and metallurgical slag containing metallurgical crusts can be processed with the release of metals and obtaining construction rubble. The unique technology for the disposal of construction waste containing reinforced concrete includes the following stages: crushing, iron separation and sorting of the resulting crushed stone into two classes of size. The use of vibrating jaw crushers in the first stage of crushing ensures effective destruction of particularly strong materials with 100% separation of reinforcing material, as well as conical vibro-inertial crushers ensure the production of crushed stone above 90% and minimal contamination with cement bond [14]. The technology differs from the traditional technology of crushed stone production by the absence of material grinding and does not require the use of a centrifugal cube.

7. Prospects for further research development

The National Waste Management Strategy in Ukraine is now active until 2030, it provides certain measures for the reuse of waste, in particular areas - construction and repair works, electrical and electronic equipment, waste batteries and accumulators. Ukraine aims to increase the volume of recycled waste from 5 to 10% by 2030. These goals are planned to be achieved through the development of recyclable waste collection and establishment of waste collection centers for its repair or further recycling (primarily electrical and electronic equipment waste).

8. Conclusions

To sum up, it can be concluded that waste processing is not only a necessary condition for environmental protection but also a means of global resource and energy saving. The rational organization of the waste recycling process in combination with efficient modern equipment allows obtaining products from SRM at a cost of 2-2.5 times lower than for similar products from primary raw materials, when comparing them.

For the full functioning of a waste management enterprise, it is necessary to collect and process the most valuable SRM and include them in a unified system of handling production and consumption waste. It is also important to provide a legislative framework that stimulates the collection of SRM

and waste processing, as well as establish a system of economic regulation of waste management and the sale of products from SRM.

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