EFFICIENCY OF CONSTRUCTION WASTE RECYCLING

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Abstract. Recycling is widely used in practice in various fields of activity. However, the effect of such use does not always cover the costs of the processing. The article considers the problem of recycling waste generated while constructing residential buildings and structures. We present the results of full-scale studies of construction waste generated at construction sites in the city of Samara. We also show the qualitative and quantitative composition of the elements and analyze possible ways of their reuse. In addition, we have calculated economic feasibility of reusing building materials recycled from construction waste.

1. Introduction

Currently, there is an increase in the activity of urban development. Adjoining territories are built up and already existing city buildings are renovated as well. The expansion of territories is most noticeable and occurs more actively in large cities. For example, over the past decade, dozens of residential complexes have been built and continue to be built in the territory of the city of Samara: Koshelev project has increased the built-up area of the city territory by 130 hectares, Novaya Samara residential area in Krasnoglinsky district of the city occupies about 58 hectares, Southern City project has expanded the urban development in the southern part of the city by more than 1000 hectares. Such area expansion results from the increase in the number of city residents and their need to obtain comfortable housing with necessary utility systems and social infrastructure [1-4].

It is especially difficult to carry out construction work on infill areas, when worn-out buildings and structures are replaced with more comfortable and new ones (Fig. 1). In this case, all works on preparing the territory, cleaning, planning, erection and improvement are carried out in cramped conditions. During construction, adjacent residential areas suffer from a negative impact, including a large number of various construction wastes. At first, these wastes are stored on the construction site, then they are to be transported to a landfill. It should be noted that at present more and more construction wastes are sorted at the place where they are formed and subsequently transported to specialized enterprises for processing into secondary raw materials [5-9]. This practice takes place in the cities of Moscow, Novokuibyshevsk, Togliatti and others. Despite this, unfortunately, construction waste recycling is not widely spread and is currently developing slowly. The main reason
for this is lack of economic leverage to influence construction firms or waste management companies.

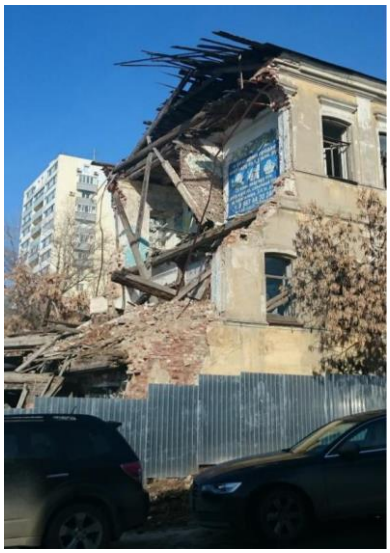

Fig. 1. A worn out building is being demolished.

To determine the efficiency of construction waste recycling and reuse, studies were conducted to determine the component composition of construction waste at city construction sites.

2. Materials and Methods

To determine the component composition of construction waste generated during the construction process, a method of field observation was used, followed by statistical analysis of the results obtained. Field observation implied surveying urban construction sites with measuring equipment and photographic fixation, and the results were automatically processed by graphic editors.

The first stage of field inspection was fixating geometric indices of a construction waste dump location. The inspection report noted its location relative to the construction site boundary, settlements, the approximate shape and dimensions of the dump (length, width, average and maximum height of waste storage).

The second stage involved sampling, fractionation and chemical analysis of the samples in the laboratory to determine the composition of the wastes as a percentage of the volume of each type of fraction to the total volume.

The types of fractions were taken in large scale, taking into account the Federal Classification Catalog of Waste acting in the territory of the Russian Federation, namely: paper and cardboard, broken glass, plastic and polyethylene, wood waste, metal waste, broken concrete and reinforced concrete, broken bricks, household waste.

The third stage of the study was determining the criteria for reusing recycled waste products. For this purpose, physical and chemical properties of the recycled semi-finished products were analyzed in the laboratory, feasibility and appropriateness of their further use was settled, and their applicability criteria were established.

3. Results

More than 30 construction sites located in different parts of the city of Samara were surveyed. The main criterion for choosing the surveyed sites was the proximity to the existing residential buildings. We selected construction sites located not farther than 100 meters from a residential building.

The surveyed construction sites satisfying the above conditions were concentrated in the central part of the city, which is densely populated; there are both private houses and new multistoried comfortable residential complexes.

The preliminary survey of construction sites showed that in 85% of cases there were no specially designated places for temporary storage of construction waste at the construction site. As a rule, the waste was stored without prior division into components in bulk either in the territory of the construction site, or outside its boundaries. More often the mass of waste was lying along the protective fence and had the following dimensions: 1.5 × 5 m, average height of waste storage was 1.5 m (Fig. 2). The dimensions are shown in Table 1.

Fig. 2. Type of waste storage area.

Table 1. Typical dimensions of construction waste dumps.

construc site №	Dimensions of the d Length, m	Width,	Height, m	Shape of the
1	3	2	1	Stretched a
2	2C	3	1	the fenc
4	2	2	1,5	Round
5	5	3	1	Rectangu
8	5	2	2	Rectangu
12	1C	3	2	Stretched a the fenc
17	1C	6	3	Rectangu
18	5	4	2	Rectangu
23	5	4	2	Rectangu
24	2	2	1	Round

Based on the results presented in Tables 1 it is possible to determine the type and volume of construction works, as well as how often the dumped waste is transported away from the site.

For example, the wastes at construction sites № 1, 10 and 29 were formed as a result of dismantling old buildings and clearing the territory for new construction. Wastes at sites № 12, 16 and 24, where there is a large proportion of broken concrete, were most likely formed during the erection of a panel building. This is indicated not only by the highest number of concrete waste, but also by lumpy iron waste.

Since the waste at construction site №27 is mainly represented by plastic and polyethylene, it can be assumed that the construction works at this site are at the final stage: installation of utility systems, windows, and so on.

At construction site № 2, a large amount of waste is stored, which indicates lack of timely waste disposal and non-compliance with sanitary requirements.

Based on all survey results, we propose to divide the construction sites into the following types of waste components: demolition-construction and finishing. Their averaged component compositions are presented in the diagrams (Fig. 3).

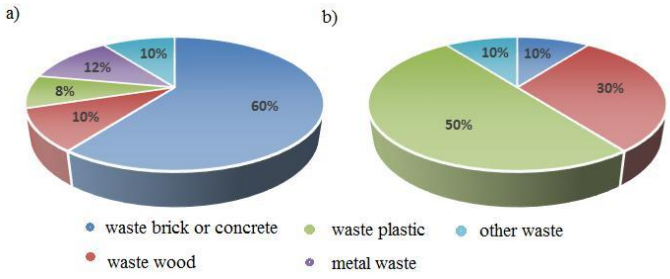

Fig. 3. Diagrams of the component composition for: a) demolition-construction, b) finishing.

4. Discussion

Analysis of construction sites research data showed that the most common wastes generated both during the dismantling of buildings and in the main construction period are broken bricks, broken concrete and reinforced concrete. It should be noted that in some cases these wastes can reach 70-80% of the volume of stored wastes. Thus, the approximate amount of concrete transported to the landfill ranges from 9 to 120 tons (excluding waste that was disposed of before the survey of construction sites). Such volumes are significant, and waste disposal to the landfill leads to losing valuable materials [5-9]. In the authors' opinion, the use of concrete waste as a material for building temporary roads, for secondary backfilling and in terrain planning [10-12], also leads to losing valuable recyclable materials.

The conducted studies of the resulting broken concrete quality showed sufficient strength of the resulting building products [13] for their use in the construction of new buildings and structures or as a concrete filler for reconstruction of hydraulic structures. Such use of concrete waste will reduce the volume of extracted natural resources, decrease the load on landfills, and also minimize the logistics costs for the transportation of waste and natural resources.

To determine the efficiency of using recycled scree, a comparative cost analysis was carried out, which showed the following. The cost of natural scree, which is used for the most common concrete of class B22.5 and mined in the quarries of the Samara region, is about 500-700 rubles per ton. The cost of processing recycled scree, including preliminary sorting, transportation or cost of receiving waste (50-70 rubles), is about 300-400 rubles per ton. Thus, recycling concrete and reinforced concrete waste is financially beneficial. Even taking into account the purchase of equipment (the cost of installation is about 60 million rubles), the costs will be recouped after processing 300,000 tons of waste, which can happen in 1.5-2 years of good load and development.

5. Conclusions

The research showed the following:

1. Large amounts of various wastes are formed on construction sites; their component composition makes it possible to determine the stage and specifics of the construction work.

2. The resulting waste is reused in small volumes, which leads to losing large quantities of valuable materials.

3. Using recycled scree in the production of building materials will minimize the cost of extracting natural resources, reduce the burden on the environment, and also make profit from processing waste concrete.

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