The possibility of using materials based on secondary gravel in civil construction

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Abstract. By now, the wear and tear of housing stock is more than 50%. Each year the number of old and dilapidated housing is growing, but it is gradually replaced by modern buildings. However, wastes accumulated from dismantling of buildings and constructions, are underutilized and, usually are just stored at landfills, or used for temporary roads construction. The purpose of this research is to define construction wastes characteristics and to explore possibilities for recycling of wastes from construction materials production. The paper also analyzes housing stock condition and basic requirements to building materials used in construction; and demonstrates results building materials based on secondary gravel investigation. While working with materials based on waste requirements the authors conducted laboratory research. Thus, the paper presents the analysis of laboratory tests results that made it possible to draw conclusions about the possible use of building materials based on secondary gravel and about their conformity to specified requirements. The researchers also developed proposals and recommendations to improve the competitiveness of such materials.

1 Introduction

Solid wastes generated by human activity are divided into domestic and industrial wastes. Construction wastes are a special type of wastes that can be found in almost all spheres of human activity: production of construction materials, construction of residential and industrial buildings, as well as various structures in agriculture, environment, hydropower, navigation, and so on [1-3].

Construction wastes are quite different in their physical and chemical characteristics. There are solid and liquid components in construction wastes, for example, half-emptied paint or lacquer tins and cans, etc. Solid wastes, such as scrap bricks or concrete, wood and metal wastes, make up a large part of construction wastes.

Due to the wide variety of wastes and their general warehousing wastes reuse might be in many cases difficult or even impossible [4-5]. Currently, the main directions of using solid wastes are temporary construction of access roads, land leveling and others [6-8].

Construction wastes generated directly on construction sites in the process of dismantling worn-out buildings and structures are of particular interest (Fig. 1). After

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temporary warehousing at construction sites such wastes are usually utilized at landfill site. However, the process of wastes disposal in this way can be called irrational, i.e. wastage of valuable resources. It is advisable not only to separate wastes generated from dismantling, but to explore their qualitative characteristics, aiming to recycle and use them in the construction of new buildings and structures or just to use these wastes in building materials production.

Fig.1. General view of a dismantled building and generated construction wastes

Papers [9-13] stress the importance of the issue of wastes recycling. Participants of round table discussions which were held in Samara region several times also discussed recycling and reuse of construction wastes stressing the aim of reducing anthropogenic burden on the city and adjoining territories.

Construction wastes include [14-15] asphalt wastes, concrete and reinforced concrete wastes, ceramsite concrete wastes, ferrous steel scrap, waste wood, broken glass, ceramics wastes and other types of wastes. Concrete, and reinforced concrete and brick wastes make the largest part of all construction wastes. According to rough calculations concrete wastes year will reach 800 million tons by 2020 [12].

Papers [14-19] consider the possibility of concrete wastes recycling and reuse as a filler in concrete products manufacture. However, at present, only 5-10% of wastes are processed.

The main problem here is caused by a lack of interest from construction companies carrying out demolition of buildings and structures, as well as by the failure of the conducted researches of chemical and physical properties of secondary resources. Water absorption, clay particles content and strength are usually named among the main characteristics of concrete fillers [2, 5, 12, 19-23]. The quality of concrete filler affects durability and safety facilities as well as economic efficiency of building materials based on recycled concrete.

As characteristics of original building materials used in demolition and construction wastes might not be known and as concrete mixture of different strength characteristics is generated when wastes are recycled, it is actual to examine wastes of this particular type to improve the use of secondary resources.

2 Materials and Methods

Secondary gravel obtained from concrete wastes is natural gravel with particles of cement mortar. Its properties depend both on the properties of the crushed stone and of concrete. To determine its water absorption, the researchers made a series of laboratory tests. The share of "stuck" mortar was determined during the tests. It has been suggested that when the item size of deviation was larger and, accordingly, the mass of cement stone which remained on

the surface of natural crushed stone was greater, the volume of absorbed water also increased.

To conduct this research, the authors carried out preliminary preparation of the researched wastes while separating and crushing them in laboratory crushers, then they held additional screenings to select two fractions of secondary crushed gravel: 5-20 mm and 40-70 mm (fig. 2). At least five identical experiments were conducted in order to obtain reliable results of the tests.

Fig. 2. Initial material of the experiment

In accordance with the methodology, secondary crushed gravel obtained in the lab was measure out into five identical and moistened in water for 48 hours. Then these weight quantities were extracted from water and weighed on the scales to a tolerance not more than 1g.

To determine the amount of dust-like and clay particles in secondary gravel the researchers took weight quantities of secondary gravel in its original state and placed them in a vessel with water up to complete slaking. Then the content of the vessel was stirred and desilted within 2 minutes. After removing water the weight quantities were washed and subjected to drying in a special drying to constant weight.

As one of the main characteristics of concrete ensuring security of building structures is its strength, the third test consisted in determining secondary gravel breakability. Weight quantities of secondary gravel were plunged into water for two hours. Then the excess water was deleted from the surface of the gravel and placed into a special cylinder under press. Press force was gradually brought up to 200 kN. To determine the balance after shrinking the secondary gravel was weighed and sifted through a sieve. The balance left in the sieve was also weighted.

3 Results

The results of investigation of secondary gravel water absorption ability are giveninTable 1.

Table 1. Determinations of secondary gravel water absorption ability

Fraction, mm	Water absorption,%				
	Test 1	Test 2	Test 3	Test 4	Test 5
5-20	4.50	4.75	4.86	5	4.68
40-70	4.44	4.69	4.57	4.89	4.99

Based on the obtained data, the following average values of water absorption were found: for the fraction 5-20 mm – 4.76%, for the fraction of 40-70 mm – 4.71% ppb mass.

Weighing results are represented as a diagram (see Fig. 3): for the fraction 5-20 mm – values fluctuate between 0,8 and 1,3%, for the fraction of 40-70 mm – values fluctuate between 0,7 and 0,91%.

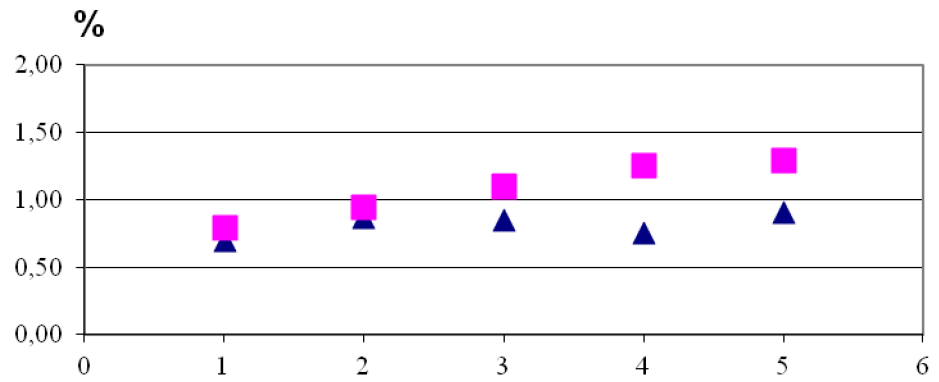

Fig. 3. The results of secondary gravel examination for the content of dust-like and clay particles: Δ – the results of 40-70 mm fraction, □– the results of 5-20 mm fraction.

The results of investigation of secondary gravel breakability aregiveninTable 2.

Table 2. Determinations of secondary gravel breakability

Fraction, mm	Breakability, %				
	Test 1	Test 2	Test 3	Test 4	Test 5
5-20	28.45	27.94	28.73	29.06	28.63
40-70	18.07	18.12	17.87	18.44	17.64

The obtained results were statistically processed and analysed.

4 Discussion

The research of the main characteristics of secondary gravel yielded the following conclusions Firstly, the difference between two factions according to water absorption is not more than 1.5%, which corresponds to a valid amount allowed when conducting experiments because of possible errors of measuring devices. Therefore, water absorption of secondary gravel does not depend on the size of fractions, and initial assumption was incorrect.

Secondly, the obtained quantities of dust-like and clay particles in the secondary gravel do not exceed averages and correspond to 1.1% for fractions of 5-20 mm, and to 0.8% for fractions of 40-70 mm. It means that a decrease in the fraction size leads to an increase of dust-like and clay particles volume. Therefore, when recycled gravel is uses a filler there is a possibility of diverse materials formation. This process can affect the quality of adhesion of particles in the product, and hence its strength and durability. The fact that the maximum allowable values for this parameter equals 3%, secondary gravel examined in the lab is suitable for use as concrete filler.

Thirdly, the average breakability for gravel fraction of 5-20 mm is equal to 28.56%, and for fraction of 40-70 mm – to18.03%. Since in the beginning of this research it was assumed that indicators were defined for mixtures of various concrete (manufactured on the basis of natural gravel of different breeds) wastes, we get the following: On the basis of secondary use of 5-20 mm gravel fraction we can get concrete filler of Grade 200-400 according to its strength, because the possibility that only the waste gravel of intrusive igneous rocks is contained in the wastes is very low. Strength characteristics of large

fraction gravel correspond to Grade 400-600. It should be noted that for heavy concrete products production it is enough to take concrete of Grade 300 according to breakability of its filler.

Conclusions

The research produces the following conclusions:

1. Now large quantities of building wastes are generated. Primarily, it is concrete wastes. Their use as secondary resources is insufficient.

2. Laboratory experiments were conducted to identify the major physical characteristics of recycled concrete. Their aim was to find a possibility to expand the use of concrete wastes during construction in urban areas. The research proved that a mixture of concrete wastes can be used not only as temporary structures or for temporary roads construction, but also as a filler in the manufacture of building materials based on heavy concrete, such as foundation wall blocks.

3. Using recycled gravel will not only reduce the anthropogenic load on the environment, but also reduce the amount of extracted natural resources, as well as the cost of energy and new construction projects.

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