

# Construction waste processing management and demolition of five-storey apartment blocks in Moscow

Shamil Taushunaev<sup>1</sup> and Muhammet Fachratov<sup>2</sup>

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

E-Mail: <sup>1</sup>taushunaev94@gmail.com <sup>2</sup>fahratov@mail.ru

**Abstract.** Data on waste processing management in waste processing technology. Processing of scrap concrete waste, similar in composition and condition to traditional raw materials, is economically and ecologically feasible. The research suggests that concrete with scrap concrete waste shows strength properties similar to primary concrete and helps organize waste-free production.

The methods of waste recycled usage, especially, usage of secondary crushed stone made of crushed concrete scrap are becoming ever more relevant with every passing year. Imported concrete aggregate volumes can be reduced by 15-30% due to usage of secondary crushed stone. Consideration of industrial waste problem and methods of solving this problem by using waste in construction industry including secondary crushed stone made of crushed concrete scrap.

Annually, about 11.5 million tons of construction waste is generated in Moscow, in the near future concrete scrap volumes are expected to rise to 13-15 million tons per year because of building demolition, reconstruction, overhaul and piling of reject structures.

One of the problems in modern development in the production of concrete and reinforced concrete parts and products is a matter of replacing the traditional scarce raw materials while maintaining the placeability of the concrete mix and strength of the finished products. The use of industrial waste similar in terms of composition and condition of traditional raw materials unquestionable from economic and environmental point of view. Studies show that concrete, using from fine granulated blast furnace slag as cement additives, have higher initial strength characteristics of concrete.

**Key words:** Construction waste, resource recycling, five-storey apartment blocks, house demolition, waste processing

## 1. Introduction

Construction waste in Moscow is generated as a result of demolition and reconstruction of buildings and structures, while producing construction materials, details and components; after utility systems reconstruction etc.

Waste volumes generated by five-storey typical apartment buildings clearance (first period of prefabricated construction), account for the bulk of total balance of construction waste producing in the city. Further, more than 4 million m<sup>2</sup> of new buildings are built annually, road construction works



produce about 90 million m<sup>2</sup> of extracted soil and asphalt, up to 22 thousand m<sup>2</sup> of apartment are repaired by residents, large amount of works are done to overhaul housing stock.

For the moment, most of the produced construction waste in Moscow is transported to landfills and dump sites, including unauthorized landfills, located within the city limits and in the Moscow region, which adversely affects ecology in the entire Moscow region. While construction waste is a secondary raw material, its usage after processing into secondary crushed stone and sand and crushed stone mix can reduce costs for new urban building, reduce the load on municipal landfills, exclude formation of unauthorized landfills, and preserve land resources currently used as landfill zones to construct, for example, parks.

Due to the lack of natural aggregates, the expansion in the number of old worn-out concrete buildings subject to demolition, and the need to comply with environmental protection requirements, great attention was paid to the problem of concrete utilization in the construction industry in the USSR during the 70s. However, to reach expected great volume of crushed stone and sand, produced from crush products of concrete and reinforced concrete elements, it requires codes and standards, which specify certain requirements for new types of products.

In England and Germany concrete scrap, produced during WWII, was used as big aggregate while producing concrete mixture. In some countries (Japan, Denmark, Luxembourg, etc.) there are practically no territories for landfill sites or utilization grounds for concrete scrap. Large scale experiments to study the properties of secondary aggregates and concretes on their base have been made in Japan since 1947. The USA have many years of experience in concrete utilization. For more than 10 years over 20 million tons of concrete waste has been processed annually. According to a number of the American manufacturers, during processing concrete into crushed stone fuel consumption is 8 times as low as during its natural production, the cost of concrete with secondary crushed stone being lower by 25%.

In world practice there are a lot of various crushers for real processing of various concrete scrap, however suitable and effective only two types of crushers – shchekovy and rotor. Shchekovy crushers of Paker (Great Britain, Vashinenfabrik) (Liezen, Austria). Hinged splitting up the cutting equipment of Caterpillar, Leibherr, Hitachi, Atlas and also drobitel – scissors of Vibra-ram Wack GmbH. The main characteristic of the crusher (type the SB 1215 size) is the unique size of an entrance crushing piece 1400x800x500mm.

The organization and processing of withdrawal of construction and demolition of shabby five-floor houses - a subject which has to be considered separately as it is the project of the state scale it is necessary to develop the uniform scheme of accounting of elimination of waste and also further his rational use as resursoenergoberegayushchy technology in production of construction materials of products and designs. To quickly process waste in the course of demolition of five-storey buildings it is necessary to count to government institutions actual scales of formation of waste of construction and demolition of shabby five-storey buildings.

At demolition of capital five-storey buildings within the program of renovation about 100% of construction debris intend to overwork.

In particular has become possible to apply technology of so-called "clever demolition". She provides stage-by-stage analysis of the house since utilities.

Concrete with secondary crushed stone is used for production of construction products: plates of a paving, plates under the bases, etc. Concrete with the activated secondary crushed stone is used for production of more various nomenclature of construction products and reinforced concrete designs.

The economic effect gained from recycling consists of many factors often specific to this or that type of waste. According to a number of the American firms, when receiving crushed stone from concrete, fuel consumption is 8 times less, than at his production in nature, and the prime cost of concrete on secondary crushed stone is reduced by 25%.

In too time waste of construction production represents secondary raw materials which use after processing in secondary crushed stone and sand-crushed-stone mix will allow to lower costs of new construction of facilities and at the same time to reduce load of city grounds, to exclude formation of

unauthorized dumps and also to reduce the earth resources which are taken away under placement of new dumps.

The annual volume construction and demolition waste production (CDW) in Moscow is about 7 million tons today and shows increasing tendency.

The demolition of 4,500 five-story apartment blocks in Moscow will start in early 2018. In fact, they resemble the five-story apartment blocks demolished in the city over the past 20 years, during which the first phase of demolition has been implemented.

It was decided to demolish buildings of 1-515,1-510,1-511,1-447 series starting in 2018.

About 53 million tons of construction waste will be produced after closure of the renovation program.

It is planned to process up to 100% of construction waste, under demolishing the capital's five-storey apartment blocks as part of the renovation program.

In this article, based on the analysis of domestic and foreign experience, the optimal technological schemes for the processing of construction waste are given, the existing equipment is described, its advantages and disadvantages are discussed, the possibility and expediency of its use are given, the technological and economic characteristics and recommendations for the products of construction waste processing are given.

Analysis of experimental data obtained both in Russia and abroad showed deterioration of serviceability of concretes obtained with the use of crushed concrete as a fine aggregate (in crusher-run-stone aggregate fractions less than 5 mm to 30%). The effectiveness of the use of crushed concrete as a large aggregate is beyond doubt.

The following quality indicators should characterize crushed stone as a large aggregate for heavy concrete: grain composition, grain form, crushing capacity, impurity content, and density (real, average, poured), porosity, voidness and water absorption, which are determined in accordance with GOST 8269-87. Special requirements for crushed stone's frost-resistance may not be presented. The content of impurities in crushed stone in the form of lime plaster, gypsum, organic inclusions, etc. should not exceed 1% by weight. Based on the analysis of domestic and foreign experience, it can be concluded that the secondary crushed stone after processing of concrete is recommended to use: a) during construction of an underlayer of driveways and by-pass roads; and foundations for storage and industrial facilities and small mechanisms; b) for the construction of groundwork base or topping of sidewalks, parking lots and promenade alleys, as well as slopes along rivers and canals. The material, undergone processing concrete, can also be used for concrete mixing, which is quite suitable for covering sidewalks, rural roads and inner garage territory, as well as in the factory production of reinforced concrete products with density up to 30 MPa or class B 22.5.

Studying physical and mechanical properties of concretes from concrete scrap waste, it was concluded that they are equal to normal-weight concretes with natural crushed stone. In these concretes, F225 frost-resistance grade and high values when calculating Poisson's ratio (0.2) were achieved. Also, the concrete showed high results in the adhesion between reinforcement and concrete (13 MPa).

Using concrete scrap waste in building concrete and reinforced concrete products and structures, mankind solves several problems at once: saving energy and natural resources, as well as capital investments; reduction of dumps and litter-free territories; non-waste production of concrete and reinforced concrete products, of repair works, of reconstruction and demolition of old buildings etc. This is certainly the right way for both man and environment. But insufficiency of processing methods and technologies throws back the process of wider use of concrete scrap waste.

Concerning the economic side of the issue, it is noted that concrete with aggregates made of concrete scrap waste is cheaper than concrete with natural aggregate (Table).

Taking the above into account, it is advisable to add values for the Poisson's ratio, for adhesion between concrete and reinforcement, for brand, for frost-resistance of secondary crushed stone in SNiP (GOST) for the introduction of secondary crushed stone into the production of concrete and reinforced concrete products and structures, which can solve many problems.

As a result, adding aggregates of the above mentioned, we obtain concrete with high performance property (for lifetime, waterproofness, frost-resistance, chemical resistance, durability and bending resistance and compression breaking strength), with high early strength for prefabricated reinforced concrete with early timbering and shorter construction times; as well as conveyed concrete of best properties for conveying and placing, with reduced water demand, ensuring wear- reduction of the conveying equipment.

Secondary crushed stone, obtained by crushing scrap of reinforced concrete panels in demolished five-storey apartment blocks of the first phase, was investigated. In the fine fraction of secondary crushed stone, there is not enough primary aggregate, while the fractions of 10-20 and 20-40 mm are approximately equal in their ratio of aggregates and binder. There is more than half of concrete mortar in such crushed stone. It is established that the frost-resistance of crushed stone of concrete corresponds to the frost-resistance class from F15 to F125, depending on fraction.

**Table 1.** Composition and basic physical characteristics of concrete with secondary crushed stone.

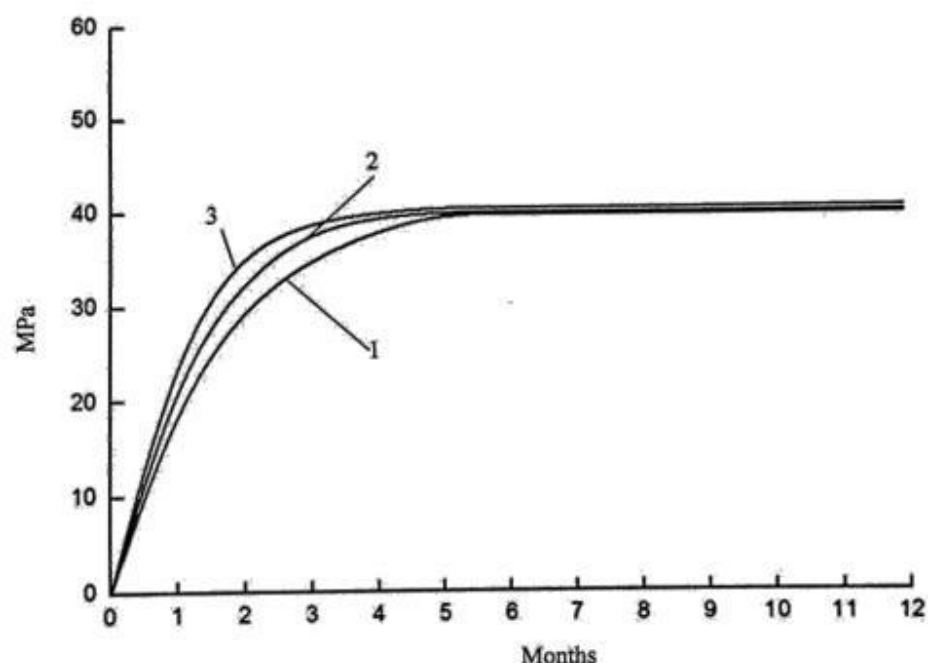
N	Specification	Unit of measurement	Structure code	
			Test specimen	A-1
1	consumption of materials per 1 m <sup>3</sup> of concrete mix			
1.1	Cement	kg	330	540
1.2	Secondary crushed stone fracture 5-20 mm	kg	-	960
1.3	Natural crushed stone GOST 8276-93	kg	980	-
1.4	Sand	kg	852	590
1.5	Water	kg	165	210
2	Cement-water ratio	-	0.41	0.39
3	Fluidity of concrete	cm	6-8	6-7
4	Fluidity class	-	P2	P2
5	Average density of concrete mix	Kg/m <sup>3</sup>	2327	2300

6	Strength of compression at age	MPA	27.1	25.4
	7 days			
	28 days		36.9	35.3
7	Bending resistance at age	MPA	2.6	2.4
	7 days			
	28 days		3.7	3.3
8	Class of compression breaking strength	-	B25	B25

Compositions are given in the Table. Physical characteristics of concrete with secondary crushed stone are equal to concrete GOST 25192-82\*, GOST 26633-91\*. This said, if we track strength gain in concrete with secondary crushed stone with time, we see that initially less resistant concrete in early stages in time is becoming equal in time to concrete with natural aggregate.

As a result of studying physical and mechanical properties of concretes with secondary crushed stone, it is clear that these concretes are equal to those of normal-weight concrete with natural crushed stone. Frost-resistance of such concrete reached F200, the adhesion between reinforcement and concrete -13 MPa. If we track strength gain of concrete with secondary crushed stone for a period of time, it can be seen that the concrete (1), that was initially less durable in early stages, is becoming equal in time to concrete (2) with natural aggregate, and concrete with agent C-3 shows excellent results.

Studying physical and mechanical properties of concretes with secondary crushed stone, it is clear that these concretes are equal to those of normal-weight concrete with natural crushed stone.



1 - Concrete with second crushed stone; 2 - concrete with natural crushed stone; 3 - concrete with secondary crushed stone of crushed concrete with agent C-3. M 300. B 22.5 classes of concretes

**Figure 1.** Strength gain of concrete in process of natural hardening

Increasing utilization of construction and demolition waste will also reduce the destructive impact on the source of raw materials; in the future it is necessary to increase the use of concrete scrap as a component for the production of concrete and reinforced concrete. Reinforced concrete upgrades the quality of buildings constructed. Buildings, made of reinforced concrete structures, have high physical properties, such as sound insulation, fire and thermal characteristics. These qualities are achieved without using additional materials.

Mass construction of such buildings increases residents' safety from destruction under external and environmental influences. Ultimately, in order to maintain such a positive impact, we have to build more durable buildings that will last 150-200 years, rather than 50-60 years, as it was during the construction of five-storey apartment blocks of the first phase.

Based on the research conducted, the materials in question were put into production at 'Khoroshevsky 'DSK-1' Precast Concrete Plant, 50m<sup>2</sup> of reinforced concrete palettes for three-dimensional utility block were produced. 100 m<sup>2</sup> of reinforced balcony plates were produced at 'Rostokinsky 'DSK-1' Precast Concrete Plant, 100 m<sup>2</sup> of reinforced inner wall plates were produced at 'Krasnopresnensky 'DSK-1' Precast Concrete Plant. All products passed quality control tests and were delivered to construction sites for to construct a P44-TM series block of flats.

## References

- [1] GOST 25916 Resources, material secondary. Terms and Definitions.
- [2] Kikava O Sh and Solomin I A *Utilization of construction waste* (Moscow) 2000, p 5-9.
- [3] Bazhenov Yu M 1975 *Method for determining the composition of various types of concrete* (Moscow) pp 22-149.
- [4] GOST 8267 'Crushed stone and gravel of dense rocks for construction works. Technical conditions'.
- [5] GOST 25192 'Concretes. Classification and general technical requirements'.
- [6] GOST 26633 'Concretes heavy and fine-grained. Technical conditions'.
- [7] Fakhratov M A and Kalmykova E V 2010 Effective use of crushed concrete waste in the production of concrete and reinforced concrete products. Management of investment and construction and housing and utilities complex: Int. Collection of Sci. Wor., Ed. by V O Chuzhova (Moscow: Moscow State Academy of Municipal Economy and Construction).
- [8] Fakhratov M A, Sokhryakov V L, Kalmykova E V and Belov A A. Effective use of concrete scrap waste as aggregate in the production of concrete and reinforced concrete products. Magazine for Professionals *Str.Prof.* No. **7(98)** 2012 publisher LLC Publishing house 'StroyProm'. Printing house LLC 'Rosbalt', 197374 Russia, St.Petersburg, Optikov st.,4.
- [9] Kalchin A A, Fakhratov M A, Kikava O Sh and Baev V V. 2002 *Industrial waste in the production of building materials*. Manual for graduate students (Tver: Publishing house 'Elite') p 130.BBK 38.626.2 to 61 ISBN-12-2.
- [10] Fakhratov M A 2003 Effective technology for the use of industrial waste in the production of concrete and reinforced concrete. Magazine *Build. Mater.* **No.12** December pp 48-49.