Modern Applied Science; Vol. 9, No. 4; 2015
ISSN 1913-1844 E-ISSN 1913-1852
Published by Canadian Center of Science and Education

Strength and Strain Properties of Concrete, Comprising Filler, Produced by Screening of Waste Crushed Concrete

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Received: November 6, 2014 Accepted: November 16, 2014 Online Published: December 10, 2014

doi:10.5539/mas.v9n4p32 URL: http://dx.doi.org/10.5539/mas.v9n4p32

Abstract

The presented paper is dedicated to the topical issue of utilization of screenings waste crushed concrete, which is produced as a result of crushing of waste materials, formed during dismantling buildings and facilities, and a production of fine aggregate concrete on its basis. The paper presented analysis of economic situation in the region and results of the study of screened waste materials in order to increase efficiency of an application of that product as fine aggregate and fine-ground active filler for a production of fine aggregate concretes.

Particle size distribution, mineral and chemical composition of waste crushed concrete were studied, as well as features of their structure, taking into account heterogeneity of crushed material. Transitional zone of secondary aggregate and cement matrix was studied and it was proved, that the strength of adhesion with cement matrix of grains of that kind of secondary material, produced from screenings of waste crushed concrete, is significantly higher, than strength of the grain itself, which is indicative of an active influence of that aggregate on a formation of both characteristics of structure of cement matrix and dense transitional zone between them.

Optimal composition of multicomponent binders, comprising fine-ground filler, produced from screenings of waste crushed concrete, is designed. Compositions and properties of cement matrix based on the designed binders are studied. Compositions of concretes, based on multicomponent binders with anthropogenic filler, are obtained and their strength and strain properties are studied.

Keywords: anthropogenic raw materials, screenings of crushed concrete, secondary fine aggregate, features of screenings of waste crushed concrete, active filler, multicomponent binder, fine aggregate concrete, concrete strength, environmental safety

1. Introduction

In the period from 1994 to 2002 as a result of military actions in the Republic of Chechnya, thousands of buildings and facilities, made of of brick, concrete and reinforced concrete were partially or completely destroyed (Figure1), which resulted in a formation of an extremely large number of anthropogenic raw materials in a form of debris of concrete, reinforced concrete and bricks (Bazhenov, et al., 2011; Lipey, et al., 1981; Murtazaev, & Ismailova, 2008).

The highest portion of all wastes, formed during disassembly of buildings and facilities, consists of debris of brick, concrete and reinforced concrete, which currently are partially recycled at various crushing-and-sorting facilities (Zashkova, et al., 2008; Pazhani, & Jeyaraj, 2010; Yasuhiro, 2007). The final product after crushing, refining and fractionation of that raw material is 70-75 % of secondary gravel and 25-30 % of screenings of crushed concrete (Murtazaev and Bataev, 2009, Dosho et al., 1998).

Secondary gravel nowadays is becoming a serious alternative to traditional coarse aggregates .Waste crushed concrete screenings hadn't yet found a wide practical application in construction materials industry, because their composition and properties was not studied sufficiently, therefore, they are accumulated at crushing-and-sorting facilities (Kikuchi, et al., 1998; Yanagibashi, et al., 2004). Moreover, screenings of crushed stone significantly increase dust level of urban air, because stacks of the anthropogenic product contain 15-25 % or, possibly, more, of powdered particles of size less than 0.16 mm.

2. Methodology

Raw materials, produced from waste crushed concrete, formed during disassembly of buildings and facilities, must meet requirements, which are listed in technical specifications TU-5711-001-02066502-08 "Gravel from waste crushed concrete, formed during disassembly of buildings and facilities" and state standards GOST 25137-82 "Rock products used in construction, solid broken stone and sand made from industrial waste, porous aggregates for concrete. Classification", GOST 9758-86 "Non-organic porous aggregates for construction work. Test methods", GOST 8736-93 "Sand for construction works. Specifications", GOST 9757-90 "Artificial porous gravel, crushed stone and sand. Specifications" and others.

Research methods, applied in a framework of the studies on that scientific topic, are based on well-known points of theory of hardening of clinker minerals with fillers of varying composition, in particular, waste products of crushed stone and products of stone milling, mathematical logic, technology of composite materials, theory of automation and control of manufacturing processes and plants. The studies were carried out considering state standards and recommendations.

Figure 1. The capital of the Chechen Republic – Grozny (End of 1990s)

The validity of the obtained results of scientific research is confirmed by use of:

- approved methods of experimental research;
- calibrated equipment and mathematical planning of experiment;
- modern software for experimental data processing.

3. Results

The secondary use of concrete in the construction industry became the topical issue in 1990s due to an increase of deficiency of natural aggregates, need for environment protection and an increase of number of old, obsolete and physically worn out buildings and facilities from reinforced concrete, which were demolished.

In some countries, for example, Japan, Germany, Denmark, the Netherlands, Luxembourg and others, there is virtually no territory for landfills or disposal sites for waste crushed concrete. At the same time, some of the countries use imported gravel.

In Japan from 1974, there are large-scale studies of properties of secondary aggregates and concretes based on them.

The USA have significant experience in recycling of concrete. In recent years, in the USA more than 20 million tons of waste concrete are recycled annually. According to data of a number of US companies, fuel expenses are 8 times less in a case of production of gravel from concrete, than in a case of its production in natural conditions, and cost of concrete based on secondary gravel is reduced to 25 %.

Studies on an application of waste crushed concrete in construction in European Economic Community countries were conducted in the first time in 1977 by scientists from the Netherlands. In further, experiments were conducted jointly by scientists form the Netherlands, Belgium and Germany, which formed «Repeated use of waste crushed concrete and stone" research and development committee.

An increase of reconstruction of buildings and facilities, engineering communications and roads is accompanied by significant progress in a field of building structures demolition technology. Manual mechanisms were used for that purpose in the most cases. In the recent years there is a trend for a decrease of use of manual mechanisms in a demolition of building structures. Good results were achieved in an improvement of building structures demolition technology by means of impact methods, cutting, splitting, crushing and expansion. Among implements for demolition by impact methods, the most widely spread are hydraulic and pneumatic hammers, which was beneficial for a development of self-propelled machines, allowing to use hammer and their remote control. The main advantages of that kind of machines, equipped with hydraulic and pneumatic hammers, is their high mobility, productivity, capability to precisely concentrate energy of an impact and capability to expand zone of a demolition. Technology of demolition of concrete and reinforced concrete structures by means of hydraulic wedges allows to use it during a reconstruction of functioning plants and doesn't contradict with requirements for explosion hazard, fire hazard and sanitation. That technology is not related with harmful influence of vibrations and noise on an operator and personnel in a zone of reconstruction. In a case of demolishing of structures by means of hydraulic wedges, there are no scattering of concrete pieces and dust formation.

Along with discussed methods of demolition, in a practice of construction industry methods of cutting are also used, which allow to cut a building or a separate structures into independent elements (blocks, slabs, columns, etc.), which will be suiTable for repeated use. The methods, which belong to a group of cutting methods, are cutting using diamond cutter wheel, thermal cutting using oxygen lance, powder-oxygen cutter, plasma cutting equipment and equipment for electric arc melting.

Depending on conditions of an object and strength of demolished materials, sometimes there is a need to use explosives with high and low speed of detonation. There are many methods of there use, which comprise using them as an explosive charge.

In an international practice, there are 3 variants of an organization of production and repeated use of secondary aggregate, produced from waste crushed concrete:

1. Concrete debris are transported from a demolition site to a plant, producing aggregates, and obtained aggregate is then transported to concrete factory (two transport operations).
2. Equipment for a production of aggregate from waste crushed concrete is installed directly on a demolition site, and obtained aggregate is then transported to concrete factory or construction site (one transport operation).
3. Obtaining of aggregate from waste crushed concrete and manufacturing based on it is organized on a demolition side (in-plant transportation).

In a practice of construction industry in Russia the widely used variant is the second variant of territorial scheme (Figure 2) of a technology of recycling and use of waste crushed concrete, in that case secondary aggregate is mainly used for gravel base layer of roads and foundations.

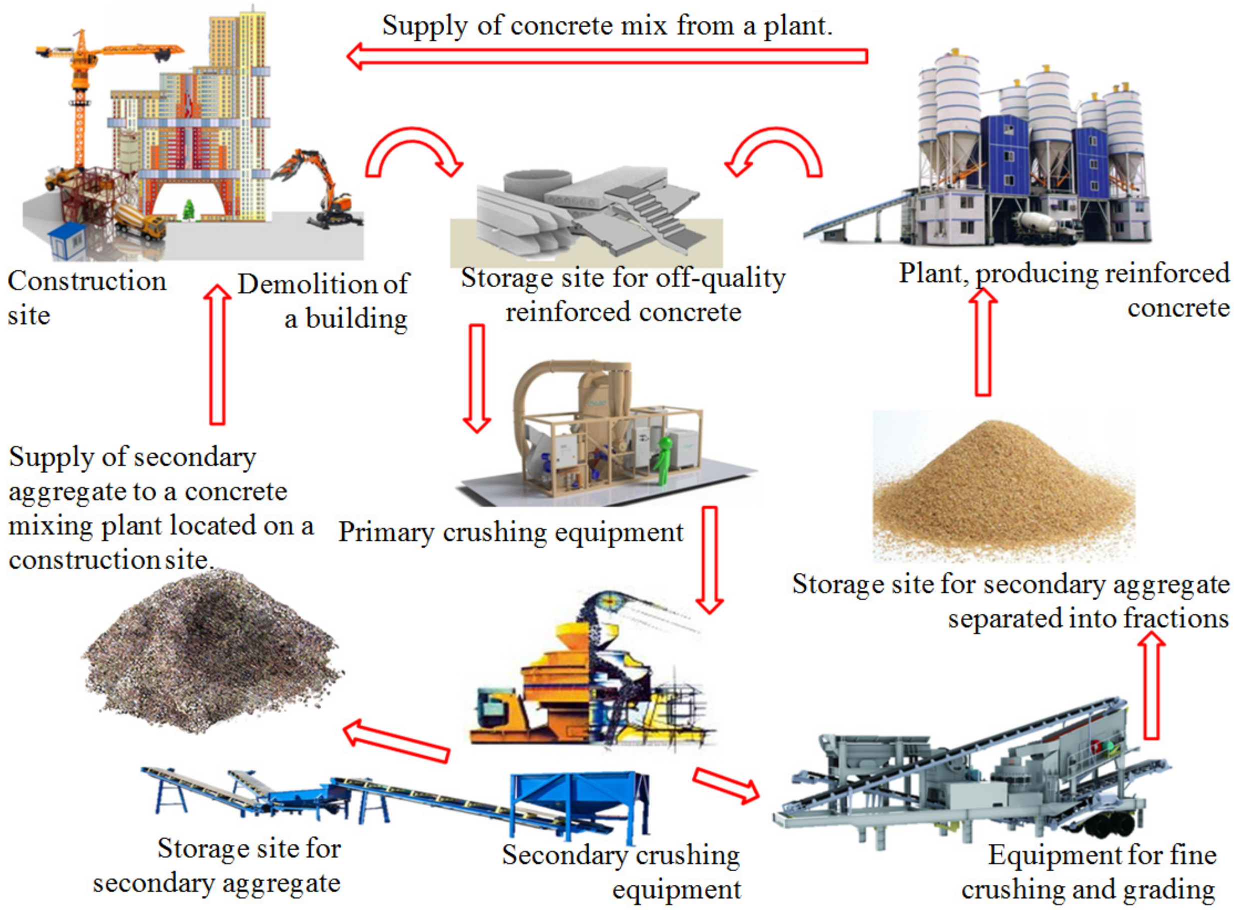

Figure 2. Flowchart of a process of utilization of concrete and reinforced concrete

In Japan, the most widely spread method is the third variant of scheme of recycling and secondary use of concrete (Figure 3).

In order to increase economic efficiency of use of waste crushed concrete use as secondary aggregate for concrete, it is reasonable to prepare that kind of aggregate on a construction site using small-sized crusher and sieving machine. Further mixing and casting of concrete during construction of new structure is carried out at the same place.

Production technology of secondary aggregate using "closed system" (Figure 4), is the most widely used in the Netherlands.

Let's discuss following schemes of construction material utilization:

1. A building is demolished, formed debris are transported to disposal sites;

2. A building is demolished, part of debris is transported to disposal sites, another part is transported to stationary centers of construction waste products recycling;

3. A building is demolished and all concrete and reinforced concrete structures are transported to stationary centers of construction waste products recycling;

4. A building is demolished and all concrete and reinforced concrete structures, which doesn't contain thermal insulation materials, are transported to stationary centers of construction waste products recycling. Structures, containing thermal insulation material, and other waste products are transported to disposal sites.

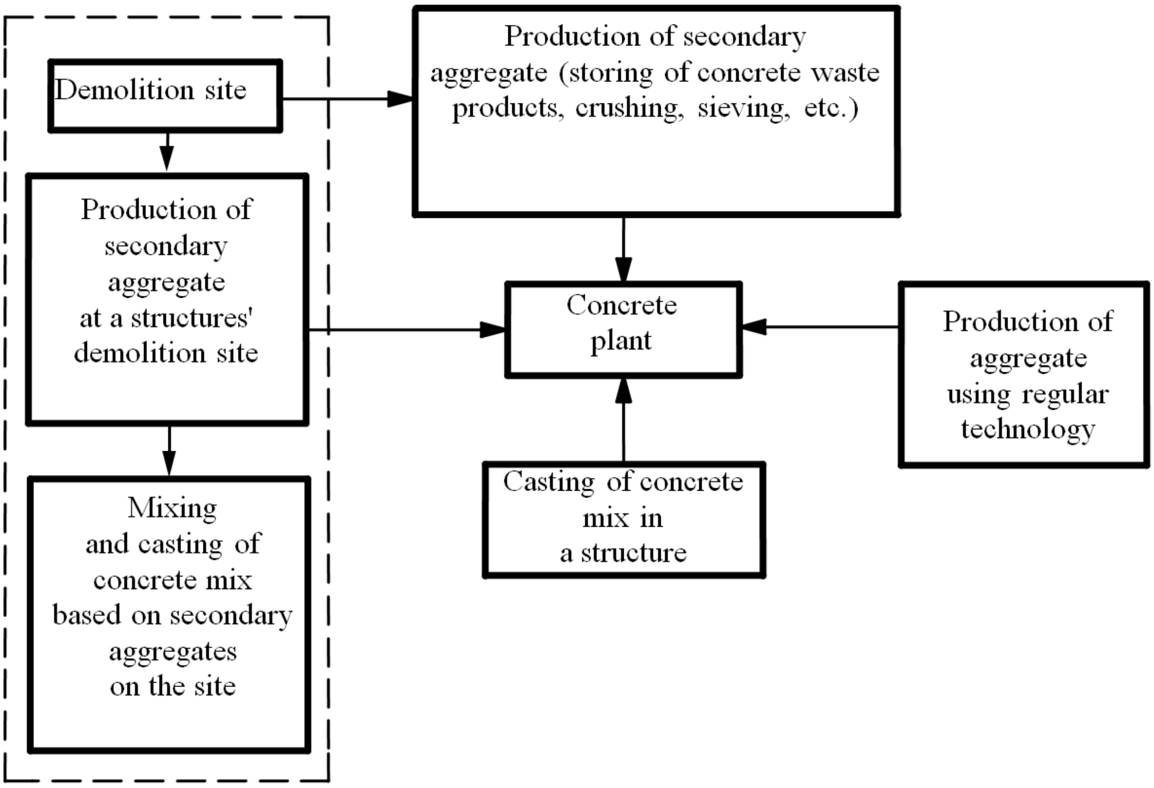

Figure 3. Approximate scheme of production of secondary aggregate and concrete on its basis (Japan)

Analysis of discussed schemes showed, that:

- the most economically efficient variant of construction waste products' utilization is variant No 1;
- the most ecologically safe variant of construction waste products' utilization is variant No 3.

In the recent years, an intensive demolition of dilapidated five-stories residential buildings is carried out, as well as replacement of bridge structures and road pavements, that's why a problem of recycling of elements of demolished buildings and facilities with an aim of a production of secondary construction materials, which are not comprising ore, becomes topical.

A crushed material, produced from demolished structures, is proposed for the first time in 1946 by engineer Gluzhge P.I. from VNIIG ("Vsesoyuzni Nauchno Issledovatel'ski Intitut Gidrotehniki" – "All-Soviet Union Research Institute of Hydraulic Engineering") of Vedeneev's name for Dneprostroi company. After WWII, use of elements of buildings and facilities, destroyed during the war, was a very important topic. In 1947-48 the similar research was conducted by R.R.Ploger and O.Graf (Germany). After a production and a delivery to construction sites and plants of natural, non-ore, construction materials was organized, use of aggregate from waste crushed concrete and reinforced concrete stopped being topical.

European researchers started to study a possibility of use of crushed products in 1960s, especially in those countries, where there were limited deposits of mineral raw materials and housing stock was undergoing a renovation, and, therefore, problems of a disposal from produced wastes were becoming increasingly important.

In former Soviet Union that problems became topical in 1980, when plants, manufacturing products from reinforced concrete, accumulated a significant volumes of off-limit products, as well as waste materials, formed during manufacturing of concrete and reinforced concrete products.

Practice demonstrated, that in order to produce gravel of required quality, it is necessary to conduct preliminary complex on-site investigation of technical, technological and ecological condition of buildings and facilities, using modern methods, including nondestructive testing methods. Gravel, meeting modern construction requirements, can be produced only in a case of dismantling of buildings and facilities with sorting of elements, their initial preparation, further crushing, sieving and storage, on a condition of a presence of control posts for all stages of a production and respective regulatory documents.

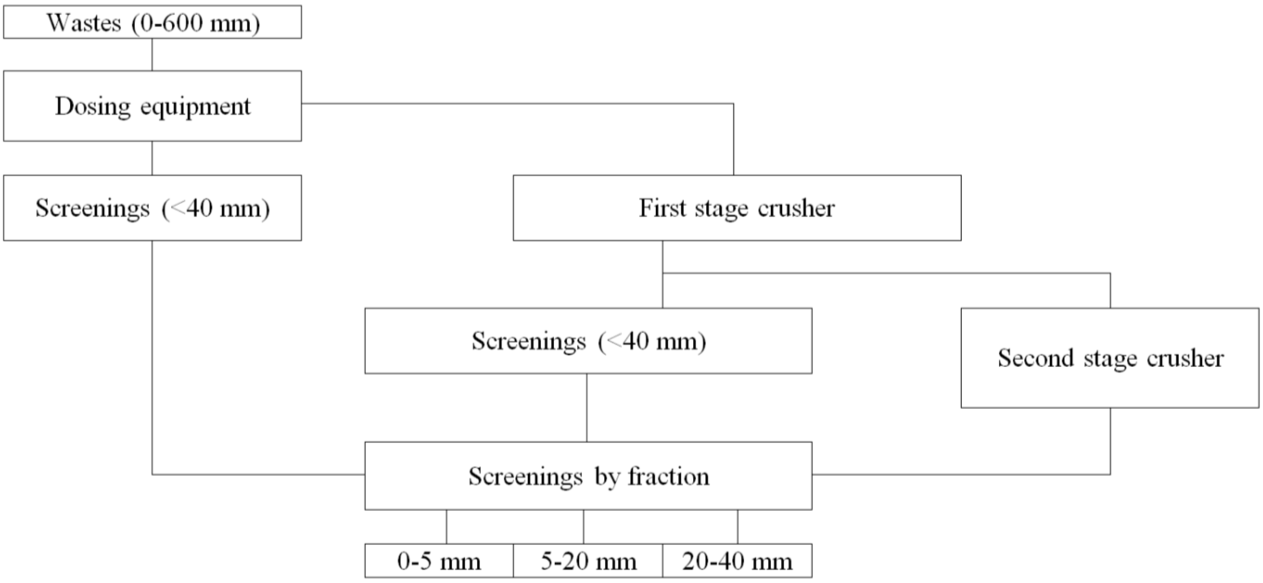

Figure 4. Looped system of construction waste materials recycling (the Netherlands)

The most suiTable equipment for waste crushed concrete processing, from technical characteristics point of view, is mining machinery and equipment for a production of non-ore construction materials.

Analysis was carried out of equipment, which is used during initial crushing of waste crushed construction materials for non-ore materials (crushers of hammer, cone, jaw, rotary and roll types).

Conducted comparative analysis of crushing equipment, including taking into account its technical-economic indicators, as well as maximum allowable sizes of processed pieces of waste crushed concrete, allowed to develop scheme of processing unit (Figure 5) for recycling of waste materials, produced during a demolition of buildings and facilities into markeTable gravel. The production line comprises two-stage processing of waste crushed concrete using loop conveyor (Figure 6).

It is proposed to use for initial crushing jaw crusher of SMD-117B type and for medium crushing rotary crusher of SMD-75A type.

As it was mentioned above, after crushing and fractionation of waste crushed concrete, obtained materials are secondary big size gravel (70-75 % of crushed raw materials' weight) and sand (25-30 %).

For purposes of fine aggregate concrete production, a fraction, which is of a high interest, is fine fraction with sizes of 0-5 mm, formed during crushing of waste crushed concrete.

Screenings of waste crushed concrete are mixture of acute-angle fragments with sizes from 0 to 5-10 mm. Color is gray. Sieve analysis results showed, that studied screenings contain approximately 19% of grains larger than 5 mm and up to 3% of weight of the sample of grains larger than 10 mm (Klose, 1994; Sonner, 1992). Currently, those materials are rated as waste materials of the primary product – gravel. For that reason, performance and cost of screenings is determined, generally, according to type of initial raw materials (Alexandrov, 2003; Schumacher, 1991).

One of the major advantages of crushing screenings is their relatively low cost. It is caused by an absence of special and costly methods of their production. The cost of that by-product is several times lower than the cost of gravel. The deficit of sand with characteristics necessary for manufacturing of high quality concretes, leads to a situation, in which it is much more cost-effective to purchase a by-product of crushing and to use it as fine aggregate. However, purchasing of by-product of crushing of waste concrete will be more cost effective, than searching for natural sand with suiTable quality (Bazhenov, & Bataev, 2000; Popov, 2002).

However, rational use of screenings of waste crushed concrete, as a practical aspect of construction materials science, can be discussed only after a preliminary study of their particle size distribution, chemical and mineral compositions and other properties (Greune, 1994, pp. 185-190; Gewiese, 1990, pp. 643-647).

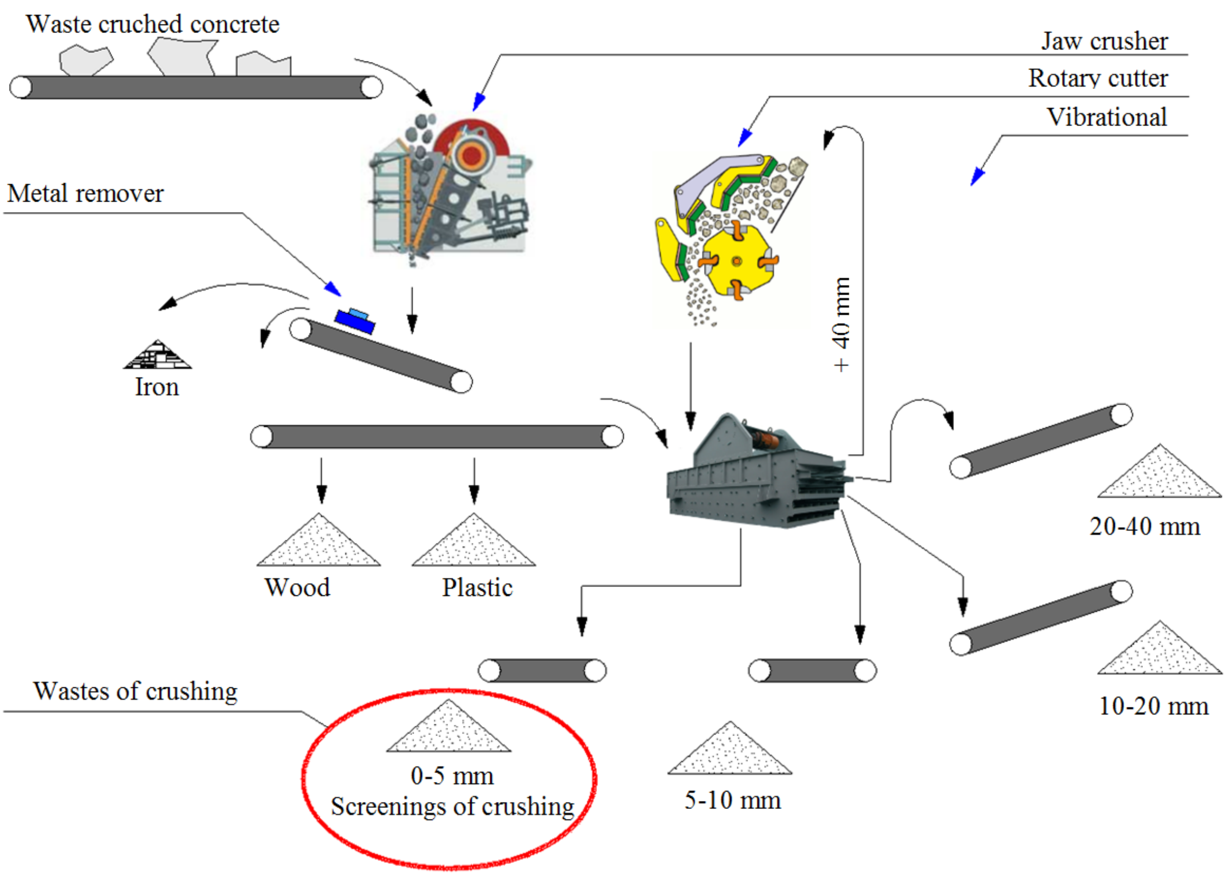

Figure 5. Scheme of production line for recycling of waste crushed concrete into markeTable gravel

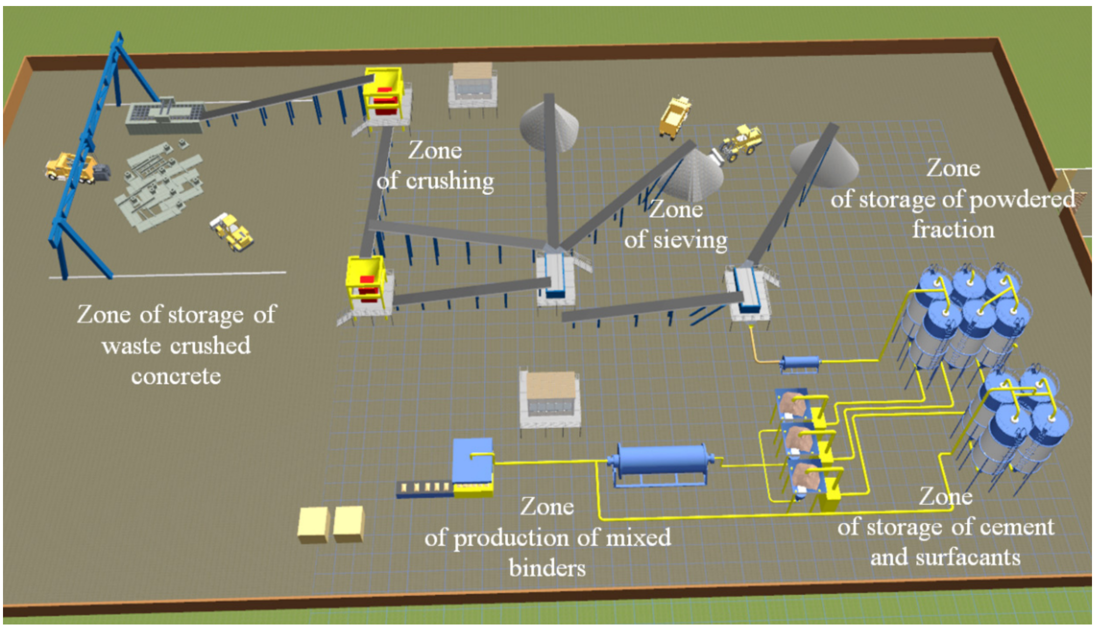

Figure 6. 3D-model of crushing-and-sorting facility (CSF) for recycling of waste crushed concrete

In order to effectively implement screenings of crushed concrete in construction materials technology, in the scientific and technical center of collective use "Modern building materials and technology" of Grozny State Petroleum Technical University of Academician M.D. Millionshikov name complex studies of their compositions and properties were conducted.

Studies were conducted on screenings of crushing of such prefabricated units, as floor slabs, beams, lintels, columns, stair flights, taking into account their initial strength and service life.

Studied parameters were particle size distribution (Table 1), mineral (Table2) and the chemical compositions of those products.

Screenings of waste crushed concrete contained, % (by weight): SiO_2 – 51.40; CaO – 35.23; $A1_2O_3$ – 5.01; Fe_2O_3 – 3.72; K_2O – 1.50; MgO – 1.25; SO_3 – 0.60; Na_2O – 0.51; TiO_2 – 0.31; MnO – 0.08; other inorganic components – 0.29; ignition losses – 0.10.

Table 1. Particle size distribution of screenings of waste crushed concrete.*

Remainder	Sieve cell size, mm				
	2.5	1.25	0.63	0.315	0.16
Individual	18.3	10.4	7.1	25.7	22.6
Cumulative	18.3	28.7	35.8	61.5	84.1

* Fineness modulus Mk = 2.3 ; 15.9% of total sample's weight is passing through the sieve # 0.16.

During X-Ray diffraction testing of screenings of waste crushed concrete (Figure 7), following minerals and cement hydration products are identified: 50% of quartz, 30% of calcite, up to 6% of hydrosilicates of calcium and other compounds (see Table. 2).

Table 2. Particle size distribution of screenings of waste crushed concrete

Name of mineral or cement hydration product	Content in screenings, %	Chemical formula
Quartz	50.6	SiO_2
Calcite	30.0	$CaCO_3$
Vaterite	1.5	μ-$CaCO_3$
Ettringite	1	$Ca_6(Al(OH)_6)_2 \cdot 24H_2O \cdot$ $\cdot (SO_4)_3 \cdot 2H_2O$
Not hydrated Portland cement	4	–
Hydrosilicates of calcium	5.6	$x CaO \cdot SiO_2 \cdot y H_2O$; (C-S-H)
Dicalcium aluminate, type with 8 water molecules	0.5	$2CaO \cdot Al_2O_3 \cdot 8H_2O$; ($C_2AH_8$)
Tricalcium aluminate hexahydrate	2.6	$Ca_3Al_2(OH)_{12}$; (C_3AH_6)
Tetracalcium alumino ferrite hexahydrate	2.7	$3CaO \cdot Al_2O_3 \cdot 6H_2O +$ $+ CaO \cdot Fe_2O_3 \cdot x H_2O$; ($C_3(AF)H_6$)
Other inorganic components	1.5	–

In particular, it should be noted that 4 % (by weight) of non-hydrated Portland cement started is approximately 25-30% of weight of an initial Portland cement, was used during production of reinforced concrete units.

Studies were carried out on wastes from crushed concrete units, in which limestone gravel and quartz sand were used as aggregates, which explains comparatively high content of calcite and quartz.

Analysis of chemical composition of screenings of waste crushed concrete indicates a possible presence in the material of compounds, which are capable to harden during an interaction with water.

In order to identify hydraulic activity of screenings of waste crushed concrete, it was ground with an aim to achieve different values specific surface, after that pastes with standard consistency was separately prepared for powders with different fineness of grinding. The results showed, that an increase in fineness of grinding of waste crushed concrete leads to an increase of strength of hardened material. Thus, an additional grinding allows you to use that waste material in a process of hardening. It allows to use it as active mineral filler in manufacturing of highly active composite binders.

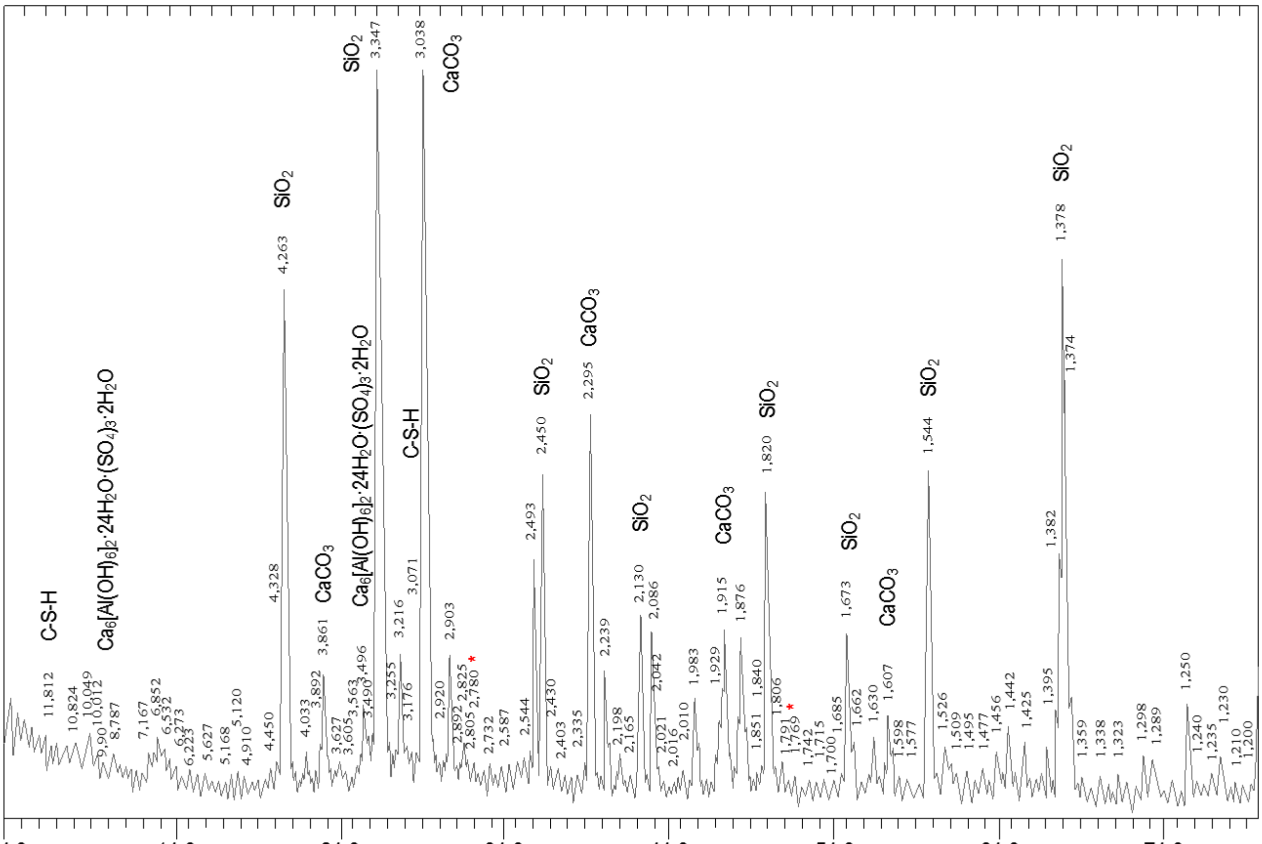

Figure 7. Results of X-Ray diffraction testing of screenings from waste crushed concrete, formed during dismantling of reinforced concrete structural frame in Grozny: * – not hydrated Portland cement

Another feature of screenings of waste crushed concrete is, that its grains consist of fragments of large and small aggregates of crushed "old" concrete, whihc were bound by cement matrix. An important feature of screenings of crushed concrete is a presence of partial or complete shell on a surface of its grains, which consists of cement matrix of crushed concrete, possessing a certain porosity, resulting in an increased water absorption of such aggregate (Figure 8).

It is expected that aggregate, which is characterized by an increased water demand and water absorption, will have a peculiar impact on processes of concrete's structure formation.

Study of concrete's structure formation process using screenings of waste crushed concrete allowed to establish, that, as a result of redistribution of water between a solid, liquid and gaseous phases, rheological properties of concrete mixture, comprising that aggregate, are changing. In a case of an introduction into concrete mixture of aggregates made from waste crushed concrete, firstly, it absorbs liquid phase from the mixture in open pores, and, then, during a process of formation of system of pores and capillaries of cement matrix, it releases it, i.e., there is a peculiar suction of water from pores of aggregate into cement matrix.

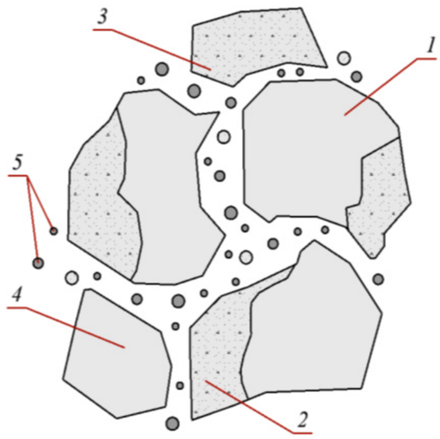

Figure 8. Structure of secondary aggregate, produced from waste crushed concrete: 1, 2 – grains, obtained from cement matrix and aggregate of crushed concrete; 3, 4 – grains, composed separately from cement matrix and coarse aggregate of"old" concrete; 5 – particles with sizes less than 0.16 mm (stone powder)

Results of numerous experiments aimed at an identification of the most rational methods of complex implementation of screenings from waste crushed concrete in concrete engineering, including powdery fractions, a technology of its separate application was developed, i.e., powdery fraction of screenings was used as fine-ground active filler and sand-size fraction was used as fine aggregate for concrete (Lesovik, et al., 2008, pp.11-16; Kireeva, 2010). Fine-ground filler was used used as a part of multicomponent binder (MCB), produced by means of joint milling of powdery fraction of screenings with cement and surfactants.

Data about strength characteristics of cement matrix, produced using proposed multicomponent binders with varied content of the filler is presented in Table 3.

In order to investigate into strength and strain properties of concretes, compositions, based on MCB80, MCB60, MCB40 and Portland cement (control sample), were selected, which had different ratios cement:screenings = 1:2, 1:3, 1:4 and which were produced using screening from waste crushed concrete. Compositions and materials' contents are presented in Table. 4.

Table 3. The composition and properties cement matrix, based on multicomponent binder with filler, produced from screenings of waste crushed concrete

Type of binder	Composition of MCB, % by weight			Standard consistency, %	W/C ratio	Specific surface, m^2/kg	Compressive strength, MPa
	Chiri-Yurt Portland cement	Filler produced from screenings	Addmixture "BIO-NM"				
MCB 100	100	-	2	15	0,18	541	81
MCB 80	80	20	2	16	0.18	548	75
MCB 60	60	40	2	17	0.19	562	60
MCB 40	40	60	2	18	0.19	579	29

Table 4. Compositions of concretes, based on multicomponent binders, comprising fine-ground filler, produced from screenings of waste crushed concrete

No composition	Type of binder	Composition Cement:Screenings	Materials content, kg/m^3 MCB	Screenings	Water	Water/Binder
1	MCB80	1:4	416	1656	146	0.35
2	MCB80	1:3	504	1512	171	0.34
3	MCB80	1:2	679	1358	204	0.30
4	MCB60	1:4	413	1643	149	0.36
5	MCB60	1:3	507	1533	172	0.34

6	MCB60	1:2	685	1370	206	0.30
7	MCB40	1:4	421	1654	156	0.37
8	MCB40	1:3	514	1542	180	0.35
9	MCB40	1:2	682	1364	211	0.31
10	Portland cement	1:3	511	1533	245	0.48

Following properties of concretes were determined: compressive strength, using cube and prism type specimens, elastic modulus, shrinkage, lower and upper limits of cracks formation and longitudinal and transverse strain.

Results demonstrated (Table 5) that concretes based on multi-component binders had strength from 41 to 87 MPa and possessed solid structure. Their compressive strength, tested using prism type specimens, varied from 32 to 70 MPa, and ratio of "prism" strength to 'cube" strength was 0.78 -0.81 in range This is slightly higher, than for concretes based on Portland cement, and a dispersion of results is smaller, which indicates higher homogeneity of properties and increased fragility of the material (Haritonov, 2011, pp. 24-26).

Table 5. Strength and strain properties of concretes based on multicomponent binder

No of composition from Table 4	Compressive strength, MPa		Strain, mm·10 $^{-4}$		Lower limit of crack formation, R_T^o, MPa	Upper limit of crack formation, R_T^v, MPa	Elastic modulus, E, MPa	Shrinkage, mm·10 $^{-4}$
	Cube type specimen R_C	Prism type specimen $R_{Pr.}$	longitudinal ε_1	transverse ε_2				
1	63.5	50,8	13.3	4.0	30.4	48.5	38.6	81
2	78.6	63.7	13.6	4.1	39.3	52.4	54.1	83
3	86.9	70.5	16.5	5.1	45.2	58.7	56.6	84
4	50.1	39.6	15.5	4.1	18.3	34.6	33.7	74
5	61.5	48.8	16.2	4.5	28.9	41.4	37.6	78
6	71.3	57.0	17.5	4.7	35.6	47.8	41.3	79
7	41.8	32.2	13.2	3.8	14.6	27.5	30.1	69
8	52.7	42.1	13.5	4.1	19.5	31.2	34.3	71
9	59.2	46.1	16.6	5.1	23.7	33.8	36.1	73
10	17.5	12.2	10.3	3.2	6.11	11.5	11.6	88

With an increase of screenings' content in concrete, shrinkage strain is decreased, and an increase in content of clinker component in multicomponent binders leads to a certain increase pf shrinkage strain, however, the values doesn't exceed 0.69-0.84 mm/m.

Studies of microcracks formation of concretes, based on multicomponent binders is of practical interest. Lower limit of microcracks formation occurs later for concretes based on multicomponent binders, as compared with the control sample, based on Portland cement, at the same time, relative value of ratio of lower limit of microcracks formation and "cube" strength of concrete is 0.35-0.52 and it increases with increase of strength of specimens and content of clinker component in multicomponent binder. For studied compositions of concrete, it is typical to have a decrease of difference between lower and upper limits of microcracks formation, which also demonstrates uniformity of their properties.

4. Discussion

Based on analysis of the conducted studies it can be stated, that use of modern crushing-and-sorting machinery for recycling of secondary raw materials for concretes, use of super-, hyperplastisizers and other chemical structure modifiers for their manufacture, allows to obtain aggregates from waste crushed concrete, which can be an excellent alternative to costly material natural aggregates, and recommend effective ways of producing concrete mixtures and products based on them.

It seems promising to use anthropogenic raw materials in a form of waste crushed concrete not only as a raw material for a production of secondary aggregates, but also as fine-ground mineral filler, which can be used for production of highly active multicomponent binders. Moreover, a direction of implementation in cement of fine-ground fillers of varying nature recently became topical in a field of binder performance improvement and a production of so-called «green composites», which implies complex utilization of secondary raw material and which is designated for "green" construction.

Use of screenings from waste crushed concrete as aggregate in fine aggregate concretes and fine-ground filler material in binder materials, comprising fillers, allows to effectively influence their strength and strain properties, namely density, strength and shrinkage of concrete, as well as significantly reduce volume of pores in cement matrix of concrete.

5. Conclusion

Thus, the authors conducted analytical and experimental studies with an aim to improve efficiency of recycling of waste products, formed during dismantling of buildings and facilities, in a form of waste crushed concrete, reinforced concrete and brick, to reduce cost of composite construction materials based on secondary raw materials and to improve ecological situation in the region.

Designed and proposed optimal compositions of multicomponent highly active binders with anthropogenic filler, produced from screenings of waste crushed concrete and fine aggregate concretes on their basis, which have improved strength and strength properties.

Study of longitudinal and transverse strain demonstrated, that concretes based on multicomponent binders has higher strain characteristics as compared to the control sample.

Moreover, the study of transitional zone of aggregate and cement matrix showed, that strength of adhesion of grains of screenings from waste crushed concrete with cement matrix is significantly higher, than strength of the grain itself, which indicates the active influence of that kind of aggregate on a formation of both characteristics of structure of cement matrix and dense transitional zone between them.

The manufacturing line is designed and proposed, which aimed at recycling of waste materials, produced during dismantling of buildings and facilities, in a from of waste crushed concrete, reinforced concrete and brick; the manufacturing line is a loop conveyor, which allows to produce fine and coarse aggregate from waste crushed concrete debris of varied fractions.

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