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## Consideration the structure formation properties of crusher run stone screening as a solution of its construction and technological reuse environmental and economic issues

To cite this article: A I Makeev *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **537** 062050

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# Consideration the structure formation properties of crusher run stone screening as a solution of its construction and technological reuse environmental and economic issues

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**Abstract.** The article is dedicated to the search of ways of decreasing environmental damage from the quarry industry, generating crusher screening. Construction and technological reuse is offered as the most effective way of waste dump elimination. In this regard, screening of stone crushing are considered a valuable raw material component of high quality fine grain concretes, having mechanical, mechanical and physical as well as physical and chemical activity, which is effected in the processes of structure formation of concrete on its macro-, meso- and micronanolevels. The results of research of screening genesis, its characteristics, and its influence on the structure formation processes and the properties of fine grain concrete are presented. The suggestions for conditioning of screening with the view to increasing the efficiency of the concrete produced with their use and increasing the demand for screening in the construction market are validated.

## 1. Introduction

One of the most substantial anthropological wastes is quarry industry wastes. The dumps emerging on quarry sites create environmental stress and interfere with the economic turnover of farmland [1-3]. The subject of research of the present work is the screening of stone crushing, the output of which on quarry factories in Russia by estimates [4] currently reaches 50 mio. sq. m/year. Of this volume not more than 12-15 per cent is consumed, with the rest forming poorly structured industrial deposits (figure 1), occupying large territories and polluting the environment.



**Figure 1.** Granite crusher run stone screening (Schkurlatovskoe mining, Voronezh region, Russia).



The accumulating dumps are a major environmental and economic issue [5], the most efficient solution to which is construction and technological reuse of crusher screening.

## 2. Analysis of ways of construction and technological reuse of macadam's crusher run screening

The most obvious way of construction and technological reuse of crusher screening is their use “for intended purpose”, i.e. as fine aggregate in coarse aggregate concrete as an alternative to sand. However, the high content of particles more than 5 mm in size in the screening results in separation of grains of coarse aggregate and an increase in void ratio of their structure, which entails the need to increase the cement consumption rate. Moreover, it has been established, that the content of particles less than 0.16 mm in size in the screening exceeds the standard values and causes increased water requirement of concrete mixture. It also leads to extra cement consumption. As a result, the production of items from coarse aggregate concrete with the use of crusher screening fails to be profitable.

A more promising and widespread option of construction and technological utilization of stone crushing screening is their use as stand-alone aggregates in fine grain concrete. It has been established [6], that the quality of fine grain concretes, produced with the use of screening, is much higher, than that of the concretes on the natural sand basis.

However, on practice conversion factories of small grain size concrete products from natural sand to screening becomes unprofitable because of rising costs of aggregates (screening) and additional costs on its delivery. Moreover, concrete, based on screening has all disadvantages of small grain size non-macadam concretes – increased cement consumption, shrinkage, creep and because of it can't be in competition with large grain size concretes.

For the concrete quality increase, which made on crusher run stone screening and increase of its consumption, by opinion of leading fatherland scientists and engineers [7-11], it needs a conditioning screening on their grain composition (enrichment). By it under the enrichment understood divide from screening dust grains, and in some cases, large grains too. However, enriched screening, as shows practice, remain lack demanded by construction industry factories.

On our opinion, reasonability and direction of conditioning screening should be defined on scientific base with consideration of the role, which could execute crusher run stone screening in the processes of structure formation in the concrete and mortars. To detect this role, we researched the screening's genesis, characteristics and influence on fine aggregate concrete's features. This research was executed under the example of the granite crusher run stone screening, which was taken from the Schkurlatovo mines in Voronezh region.

## 3. Identification of the crushed granite screening

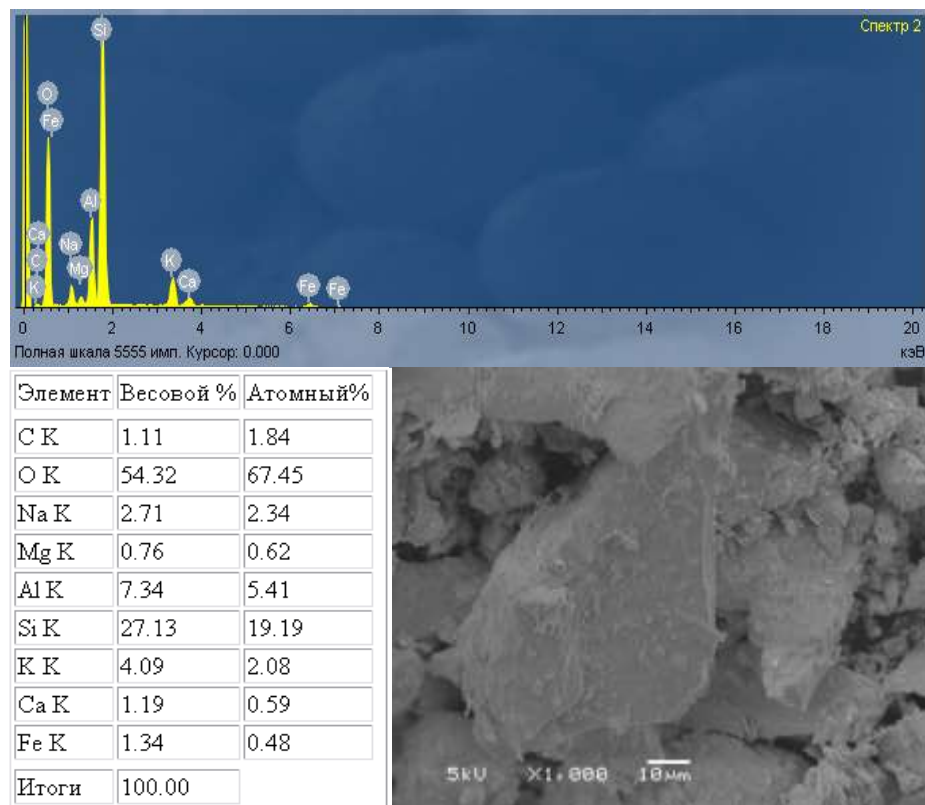
Results of the research of composition, structure and features of granite (Schkurlatovo mines) [12] are presented in the table 1 and on the figure 2 and 3. The screening if crushing granite is polyfraction material, contains grains in the sizes range from macro-(macadam) to micro- and nanoscale (figure 3). The main part of the screening is fraction 2.5-5 mm (30%), about 20% take macro-grains larger than 5 mm (i.e. macadam), about 10% fraction with size lower 0.14 mm. Among dust grains is detected nano-sized grains  $\text{SiO}_2$ . In the chemical composition of screening prevails  $\text{SiO}_2$  (table 1). Mineralogical composition is presented by quartz, biotin and feldspar.

**Table 1.** Chemical composition of grain component.

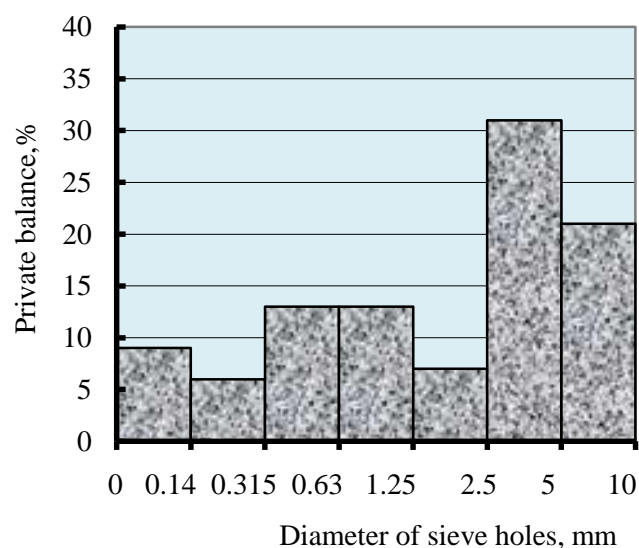
$\text{SiO}_2$	$\text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3$	$\text{CaO}$	$\text{MgO}$	$\text{Na}_2\text{O} + \text{K}_2\text{O}$	$\text{TiO}_2$	$\text{SO}_3$
65.5	14	3.8	2.3	1.1	6.6	0.5	0.5

Screening is a product of deep transformations with explosive, shock, abrasion impacts, which lead to the modification of input rock condition [12-16]. Consequently, the separation of screening to sizes on macro-, micro- and nano-fractions accompany by grains differentiation not only to sizes and shapes,

but on chemical composition, on mineralogy, on morphology, on degree of activated defects and naturally on features.



**Figure 2.** Results of electronic-microscopic research of granite screening research (scanning microscope JSM-6380 LV).

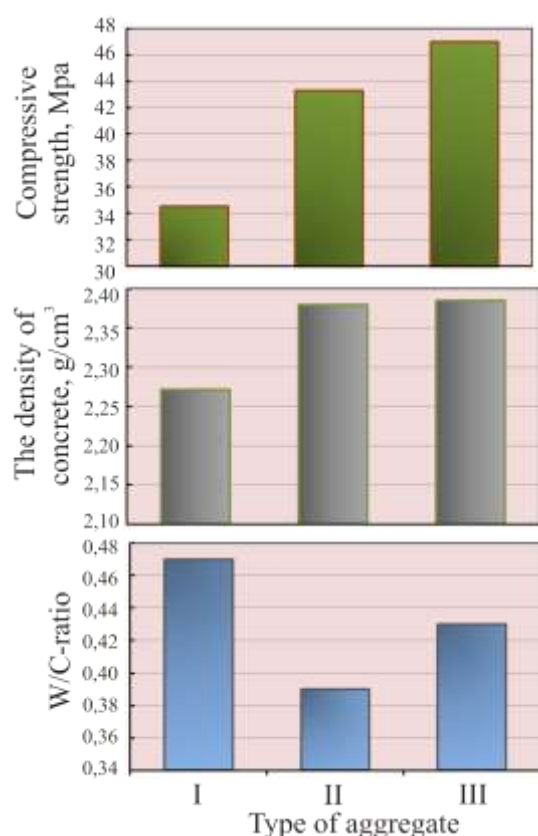


**Figure 3.** Grain content of granite screening.

On this base it could be apriori prognosed, that screening's grains of different fractions will demonstrate different role in processes of concrete's structure formation on the relevant scale level of its structure.

#### 4. Learning the influence of macro-, meso- and micro-fractions of granite crushing screening on the fine aggregates concrete structure and properties formation

For the role's establishment of macro-, meso- and microfractions of granite screening on the structure and properties formation of fine aggregates there were going experiment with fraction composition of aggregates. The granite screening were divided on fractions by the sieving's method with standard set of sieves. The concrete's control samples were made with using of input screening with "natural" continuous grain size (table 2, type 1). In the second series were used twin-fractions aggregates (macro and meso grain sized granite) in the ratio, which provide maximal bulk density (table 2, type 2). In the third – three-fractions (table 2, type 3), which are got by injection into aggregates 2-nd type microparts of dust size. The Cement/Screening ratio was 1:3 in all concrete samples. The Water/Cement ratio was established from the experiment results. This experiment was made under the concrete cubic samples with rib length 5 cm, which were tested on cold crushing strength at the age of 28 days natural hardening. This experiment was going under the consideration, that provided standard's on concrete mix fine aggregates are consistence. Results of tests are shown on figure 4.



**Figure 4.** Characteristics of small grain size concrete and concrete mix mortar on polyfraction aggregates with different composition.

**Table 2** Grain size composition and bulk density of polyfraction aggregates.

Fraction, mm	Grain size composition, % in the aggregates type		
	I	II	III
5-10	23.0	66.3	58.1

2,5-5	29.9	-	-
1,25-2,5	6.5	-	-
0,63-1,25	12.6	33.7	29.5
0,315-0,63	12.7	-	-
0,14-0,315	5.5	-	-
< 0,14	9.8	-	12.4
$\rho_H$ , kg/l	1.56	1.91	1.94

It is established, that concrete on bi-fraction small void ratio aggregates (type 2) has increased on 25% cold crushing strength, by comparison with control sample (type 1). This bi-fraction structure concrete has decreased of Water/Cement relation on 17%. It stipulated by decreased water consumption of aggregates 2-nd type and improving type of cementation of macrostructure of concrete thanks to decreased void ratio of this fraction composition.

The 3-rd type aggregates (three-fractions) provide increased strength on 10 %, in compare of 2-nd type, in spite of justifiably increased water consumption (on those 10% by Water/Cement ratio). These results show a positive role of dust grains in the structure's formation processes despite the conventional opinion.

On the base of executed science data's researches and analysis it could be concluded, that in process of the structure's formation of the fine-aggregate concrete the macro-size (macadam like) grains demonstrate mechanical activity and create a macro-scale frame of the system composition. The role of this frame is in resistance of material to the destruction is in the perception of force load, accumulation of loading energy, braking the main cracks. Sand screening' meso-grains thanks to the high specific surface square and morphology factor demonstrate already physical-mechanical activity [12].

It means, that on meso-scale structure level of concrete should be consider the balance of the forces of inter-grain cooperation. The evaluation of the dust fraction role of granite screening in the concrete microstructure formation gives a suggestion. It could be suggested, that on the range of effect of substitution of cement stone volume, this fraction as carrier of micro- and nano- sized grains of silicon dioxide  $\text{SiO}_2$  [17, 18] can demonstrates physical and chemical activity: make influence on kinetics of phase-formation of hydrates, and bring execution a function of underlay for new formations' crystallization [19]. In this statement particularly micro- and nano-sized grains are most valuable for the processes of structure formation component of screening of granite run of crushing stone. We remind, that present methods of the screening' enrichment consider only dust fraction disposal into the sedimentation ponds.

## 5. Conclusion

The granite crusher run stone screening is potentially valuable component for the high-quality fine aggregate concrete manufacturing. Aggregates after screening play Multiplan-role in processes of the material structure formation as well as demonstrate mechanical, mechanical and physical and physical and chemical activities at all scales of its structure. However, in the "input" fraction composition of granite crushing screening its structure formation role demonstrates not so effective, main part because of "overabundance" of sand meso-fractions, which are: 1) move apart grains of macro-fractions with increasing of void ratio of aggregates and appear of tension concentrators in the concrete structure; 2) increase water consumption of concrete. The present used screening "enrichment" method through the dust-elimination in opposite, leads to its "depletion".

There are two practical recommendations of the screening's ways of reuse. There are construction and technological ways of reuse.

The first way is the manufacturing of fine aggregate concrete on the regular screening needs obligatory usage of plasticizers and water-reduction chemical additions.

The second way is the preliminary conditioning of stone crushing screening under its grain composition during the manufacturing of high-strength resource-effective small grain size concretes. The conditioning should be directed to the side of decreasing the specific content in sand fractions as well as increasing content of large size and dust grains.

These and others scientific based solutions of composition and technological operating modes could be stand as base of high-performance manufacturing of wide kind of products of small and large grain size concrete and steel concrete. The source base of it will be anthropogenic dumps of granite screening. Intensive consumption by the manufacturing of this screening will supply decrease and in further full elimination of dumps in the aims of biosphere compatible and sustainable development of the region.

### Acknowledgments

The research is performed by theme 7.5.4 Plan of fundamental researches of Russian academy of architecture and construction sciences (RAASN) under the leading of academic Dr. E.M. Chernyshov.

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