EUROPEAN JOURNAL OF LIFE SAFETY AND STABILITY (EJLSS)
ISSN 2660-9630
www.ejlss.indexedresearch.org Volume 11, 2021 ||

Physical Properties of High Performance Concrete on Base Wollastonite

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Abstract: *Production high-performance concrete that have to have a water/binder ratio lower then 0.40 , at the cost of this decrease porous and increase durability of matrix of cement stone, owing to their capillary and pore networks cannot be in connect to each other and this situation helps to development of self-drying. Disadvantage of high-performance concrete (HPC) compare ordinary concrete is more intensive autogenic shrinkage, which cause of micro-shrinkage cracking inside of concrete. Wollastonite can be useful in improving fire resistance of HPC which is not as perfect as that of ordinary concrete and make micro- frame inside of material.Several materials or natural minerals have been examined to make durable concrete. Wollastonite is a natural needle-crystal, as a partial substitute of binder in concrete mix at varying replacement levels 5, 10, 15%, 24 concrete sample specimens were tested at two w/b ratio (0.32 and 0.35) for physical properties which are related to durability.*

Keywords: *High-performance concrete, durability, wollastonite, concrete, reinforcing*

Date of Submission: 15-10-2021 ***Date of Acceptance: 30-11-2021***

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1. Introduction

Nowadays, modern life represents its developing in construction and buildings, which widely use high-performance concrete (HPC), called high-tech material enhanced characteristics and durability. High-performance concrete is a concrete composition, compare then ordinary concrete, demonstrated its high strength and durability[1, 2, 3]. So this, can give advantage use some mineral components, such as Wollastonite fibers to improve concrete properties[Fig. 1]

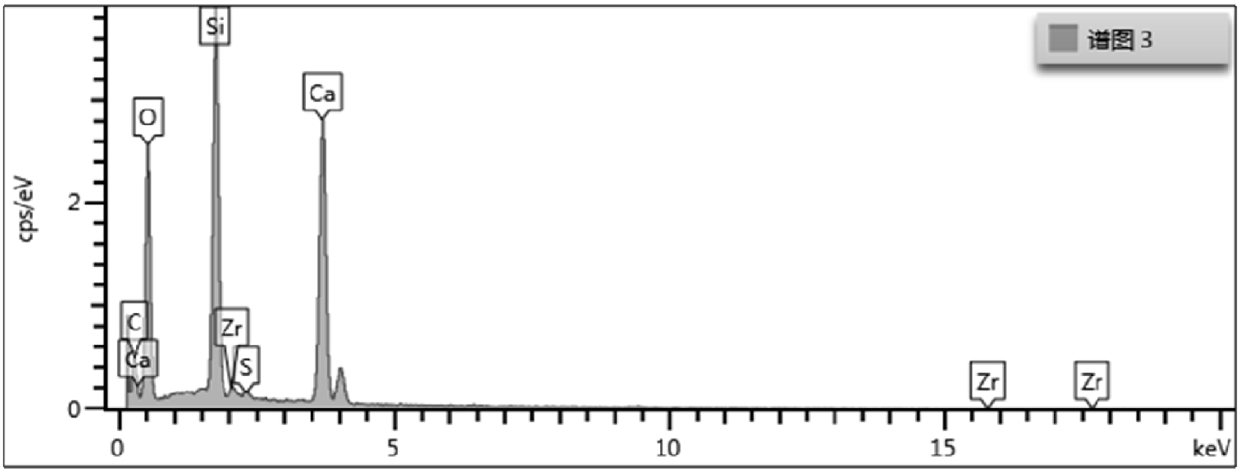
Natural mineral with particles similar to cement particles by size, the so-called wollastonite is a natural calcium silicate of white or light gray color with the chemical formula $CaSiO_3$. Wollastonite - formed in the presence of insoluble residue Cao and SiO_2., also high elastic modulus and its fibers are less expensive than carbon or steel micro-fibers.

So this reason, the objective of this study to research capability of using wollastonite fiber as a part filler of cement, reinforcing structure with size of fibers physical properties of high-performance concrete mixes with different compositions at W/C in correlation0.32 and 0.35 [5, 6, 7].

Fig. 1. Microstructure of wollastonite fiber (x2000).

Materials

The experiments did in the laboratory of Wuhan University of Technology in China (Cement-concrete testing center) and in Termez state university. For the experiments were used Portland cement (CEM I 42.5N) complying with EN 197-1:2016[8],sand ISO (size of sand 0-2 mm,), crushed rock as coarse aggregate (size of aggregate 10-20 mm) and wollastonite from Uzbekistan (Langar field) were used in present study. Fig 2.



元素	wt%	原子百分比
C	15.34	24.06
O	47.52	55.96
Si	13.58	9.11
S	0.36	0.21
Ca	22.28	10.47
Zr	0.93	0.19
总量:	100.00	100.00

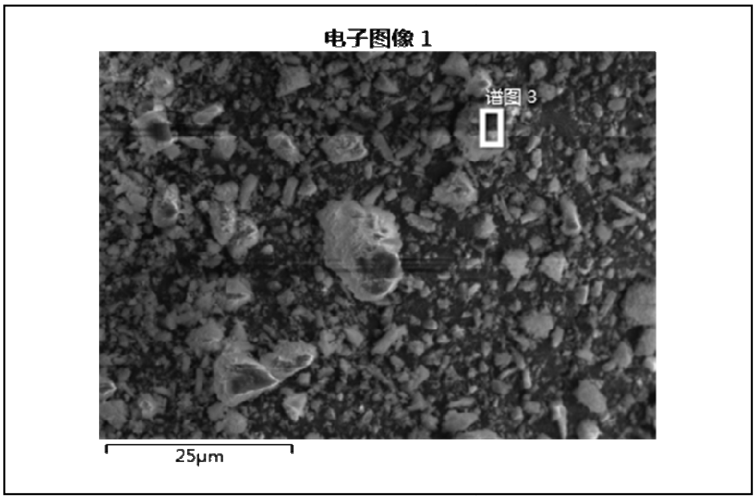


Fig. 2. XRD-test of chemicalcomposition of the used wollastonite

Accordingly, concrete mixture was prepared on requirements of the European standards[9]at two ratios W/C=0.32, W/C=0.35, by replacing cement with wollastonite and the material used for its making ready, including binder (cement), fine (sand) and coarse aggregate, which are the proportions were by weight cement : sand : aggregate = 1:1,5:3,2. Herewith control composition has not Wollastonite fiber, but other two compositions have 5, 10 and 15 % Wollastonite additives. A high-range water reducer (HRWR) was used from mass of binding (without additive Wollastonite). Physical properties (water permeability, porosity) were examined in the study [10].

Methods:

Mercury intrusion porosimetry (MIP) technique of porosity of concrete were researched related to porosity like size, density, volume and distribution of pores in concrete and three concrete cubes of 150 mm dimensions were provided in a constant 0.50 MPa of water pressure for 72 hours and the average depth of water penetration for broken concrete samples. After recorded the maximum penetration depth of the water front and the specimens were split vertically.

Results and discussion

Depth of Penetration of Water under Pressure

The porosity of these mixes prepared with wollastonite was examined using mercury intrusion porosimetry and to reason low permeability of concrete mixes. The water permeability test results are given in Table 5. All tested samples indicated high rate of impermeability and according to DIN 1048 is considered water tightness of concrete of depth penetration should be under 30 mm. It can be noticed that, the lowest amount about 4.7mm was experimented for W10 mixture at 0.32 w/b and 5.1 mm at 0.35 w/b.

Table 5 Water permeability results of concrete mixes

Water/binder =0.32				
Mixes designation	14 days Depth of Penetration		28 days Depth of Penetration	
	mm	%	mm	%
control	5.0	100	5.5	100
W5%	5.0	100	5.2	95
W10%	4.6	92	5.0	91
W15%	4.5	90	4.7	85
Water/binder =0.35				
control	6.1	100	6.91	100
W5%	5.9	97	6.01	87
W10%	5.4	88.5	5.87	85
W15%	5.4	88.5	5.1	74

Porosity

Results of MIP test are shown in Table 6. and MIP results showed that concrete microstructure become more dense and reduce the porous in it due of replacement of cement by wollastonite with size of 45 µm which effectively influence to build close-porous matrix. Especially, high-performance concrete has a low w/b ratio, it can be reduced porosity of mix led to water permeability. It can be noted, that a decrease in porosity up to 5% to 10% cement replacement of W5 and W10 and an increase up to 15% replacement of W15 concrete mixes at 0.32 and 0.35 w/b. W5 and W10 mixes are more impermeable to water than W15 concrete mix.

Table 6 Total Porosity results of concrete mixes

Mixes designation	Water/binder=0.32		Water/ binder =0.35	
	Total porosity, %		Total porosity, %	
control	4.4	100	4.9	100
W5%	3.54	81,8	4.01	81,8
W10%	3.3	71,43	3.5	71,43
W15%	4.1	87,96	4.31	87,96

Discussion and conclusions:

Good durability properties could be found by the usage of wollastonite fiber in W10 mix. It can be noted that needle forms of grain of Wollastonite apply as a micro-reinforcing. The crystals of Wollastonite, having needle forms of surfaces which, possessing certain roughness forms around itself if creative thinking, certain associates from surrounding materials, forming matrix of the main composition of cement compositions. Reducing thereby degree of their mobility independently of one another. So noticeably decrease the processes of the deforming the shrinkage, for instance when repeating over and over again to cement compositions (the concrete at usages). Possessing good adsorptive characteristic, it reduces tap-forming. Micro-reinforcing characteristic of Wollastonite and high adhesion to surface provides increasing straight factors and value of toughness of the traction it with surface.

With physic-chemical standpoint, reinforcing effect is caused that uneven surfaces of Wollastonite possess high chemisorptions characteristic, and crystals of Wollastonite are a centre of the formation association with cement particle of mixture, "constraint " mobility last comparatively each other.

The surface of Wollastonite at contact with water hydrolyze, forming hydroxide calcium, which provides alkalinity of the dispersion of Wollastonite. It possesses the strong buffer effect in tart solution due to liberation ion calcium. The product of hydration and transformations of Wollastonite in harden cement concrete presents itself on structure one-calcium hydro-silicate of calcium. The main mass of lime, standing out at hydrolysis and hydratation the cement, spontaneous accumulate in the manner of hydrate oxide calcium around grain of Wollastonite, forming thick crystalline framework.

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