ANNA KOTWA[1]
EDYTA SPYCHAŁ[2]
Kielce University of Technology
[1]e-mail: a.ceglarska@tu.kielce.pl,
[2]e-mail: espychal@tu.kielce.pl

INFLUENCE OF MINERAL ADDITIVES PROPERTIES OF CONCRETE

Abstract

The article discusses the results of laboratory tests on the impact of dolomite mineral dust on the rheological properties of the concrete mix. The addition of mineral dust rise to an overall improvement in the studied parameters (absorption, capillary), by sealing the grout. The impact of their actions on the rheological properties depend largely on the grain composition and the degree of grinding. Rheological properties of concrete mixtures of flours stone depends on the amount and geometrical properties of these additives. The use of additives enforces the need for their treatment by the process of drying, screening and segregation. The effect of the presence of meal stone to change the rheological properties of fresh concrete (density, consistency) and hardened concrete parameters (compressive strength, water absorption, capillary action).

Keywords: compressive strength, water absorption, capillary action, dolomite mineral

1. Introduction

Properties of concrete, such as resistance to compression, absorbability or resistance to freezing depend on many factors. No doubt the most important ones are basic components of concrete mixture, that is cement, aggregate, water. Not only the quantity of those components within the mix matters, but also their quality and properties. These day, along the basic elements of the concrete mix, also present are chemical mixtures and mineral additives, which have beneficial influence on the properties of the mix and the hardened concrete [1-3].

The subject of the study is concrete with addition of dolomite mineral dust quantity 8% and 12% volume of aggregate in the concrete mix. Mineral dust is a by-product resultant from the technological process of production of crushed-stone aggregates. Such powders are not considered dangerous waste, however they are very burdensome to the environment. They are not subject to any significant physical, chemical or biological transformations. The above qualities make them a possible addition to concrete. Currently mineral dust is treated as waste and is not used for production of concretes, especially construction concretes [4]. Concretes with addition of mineral dust may be a valuable alternative for traditional concretes [5].

The goal of the performed laboratory tests was to determine the influence of the mineral additive on the properties of the concrete mix and the hardened concrete. In particular, the density, consistence, pliability and ability to densify of the mix were tested, and also resistance to compression, absorbability and capillary action. Positive test results will allow for usage of mineral dusts for production of concrete with better parameters, which in consequence will allow for better management of this burdensome waste material.

2. Materials and methods

Own research was conducted in two stages.

In stage I laboratory tests were run for concretes made from cement CEM I 42.5R without addition of dust (marked SW), with addition of mineral dusts in quantity of 8% (marked 8%) and 12% (marked 12%) of aggregate quantity in the concrete mix maturing in two habitats:

– in water in temperature of +18°C for a period of 28 days,
– in an air-dry habitat in temperature of +18°C for a period of 28 days.

In stage II the obtained results were compiled and analyzed.

The research concerned class C45/55 concrete with W/C = 0.54 proportion, the contents of which are listed in Table 1.

Table 1. Contents of concrete mixes [kg/m^3]

Mix type:	SW	8%	12%
Cement	334	334	334
Water	181	181	181
Sand	625	575	550
Aggregate 4/8	581	534.52	511.28
Aggregate 8/16	581	534.52	511.28
Plasticizer	6.89	6.89	6.89
Mineral dust	–	131.52	188.71

The program of the laboratory tests encompassed production of three series of concretes with 21 samples each, cube-shaped, with 10 cm side.

After preparation of all ingredients for the concrete mix, they were dosed in the following order:

– coarse aggregate 8/16, fine aggregate 4/8, according to PN-EN 12620:2013,
– sand fraction 0÷4 mm,
– mineral dust,
– CEM I 42.5R cement,
– water,
– superplasticizer Stachement 2750.

All ingredients were weighed up to 0.01 g. The superplasticizer was added to moist concrete mix. The mineral dust used is a waste material from Józefka aggregate mine in Górno.

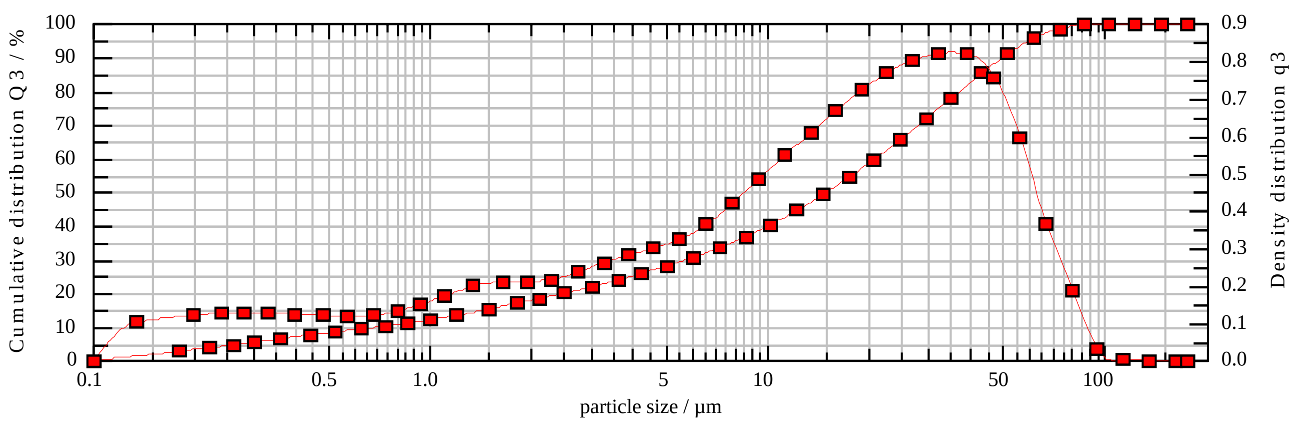

Fig. 1. Mineral dust graining curve

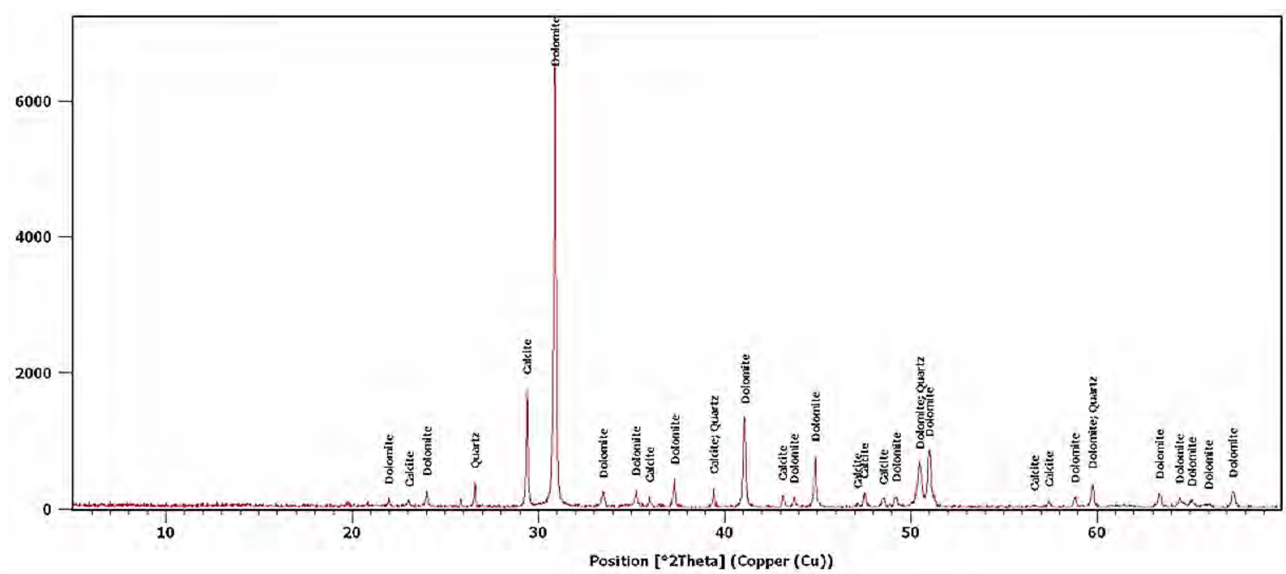

Fig. 2. Mineral dust phase composition

The share of grains with size up to 2 μm is 17.5%. 22.5% is within the range from 2 to 10 μm. The grains within the range from 10 to 40 μm have the biggest share with 42%, and 99% of grains are no bigger than 72 μm.

The phase composition of the tested dust has been determined based on roentgen phase analysis. It has been determined that this dust is composed of dolomite with admixture of calcite and quartz. The qualitative analysis has allowed for determination of approximate shares of individual phases in the mineral dust. Dolomite has the dominant share, with 80%, 16% calcite and 4% quartz.

Table 2. Information on basic properties of the cement

No.	Cement type	Chemical composition [%]					Blaine	Resistance [MPa]	
		SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	cm^2/g	R_2	R_{28}
1	CEM I 42.5R	19.84	63.2	2.08	2.72	4.65	4086	32.0	53.0

Table 3. Density and consistence of concrete mixes

Cement type	Density D [kg/m³]	Slump [cm]	Consistence of concrete mix.
SW	2424	8	Semi-liquid
8%	1962	10	
12%	1774	11	

According to PN-EN 12350-2 norm, the consistence of concrete mixes is determined as semi-liquid. From the tests performed, it appears that the addition of the mineral dust has no significant influence on the change in mix consistence.

3. Results analysis

Laboratory tests were performed on normal concretes and concretes with addition of mineral dust, in accordance with PN-EN 206:2014 [6].

The resistance tests were performed on cube-shaped samples with 10 cm sides. The samples, after molding, were matured in water (I batch) and in an air-dry habitat devoid of water (II batch) in stable temperature of +18°C for a period of 28 days. The resistance to compression was tested after 7, 14, 28 days from molding. The test result is an average from three samples.

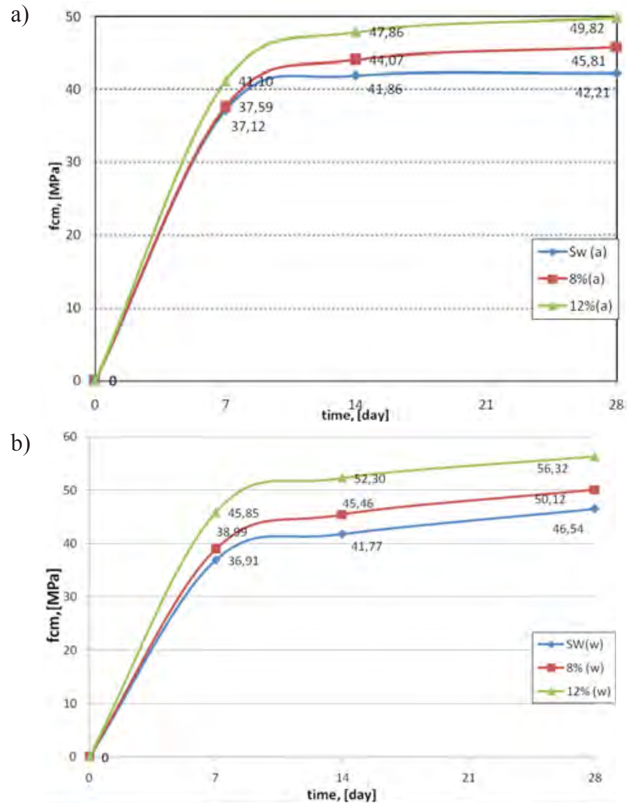

Fig. 3. Increase in resistance to compression for concrete samples maturing in stable temperature of +18°C for a period of 28 days: a) in an air-dry habitat, b) in water

Fig. 4. Percentage increase fcm for concrete samples maturing in water habitat in relation to samples maturing in air-dry habitat for a period of 28 days

The largest increase of resistance to compression was noted for concrete with addition of mineral dust in quantity 12%, which in day 28 stands at 56.32 MPa in water and 49.82 MPa in air-dry habitat. Percentage increase of resistance to compression for concrete samples maturing in water habitat in relation to samples maturing in air-dry habitat stands at 13% at day 28.

The capillary action tests were performed on samples, that matured after molding:
I batch, for the whole period of 28 days, in air-dry habitat in temperature of +18°C.

II batch, for a period of 7 days in water in temperature of +18°C, and then for 21 days matured in air in temperature of +18°C. After this time the samples were placed in an air conditioning chamber, to be dried into dry mass. The temperature in the chamber was gradually increased, up until +105°C. To prevent penetration of humidity from outside, and also vaporization of the water pulled up by capillary action, the sides of the samples were isolated. Many researchers point out the relation between the means of isolation of samples, and the intensity of the process of capillary water transportation, that's why all samples were uniformly secured with polyethylene foil. Next, the samples were placed in a tub container. Synthetic props were placed on the bottom of the container. The samples were immersed in water to the height of 1 ±3 mm. The water was gradually replenished. The test consisted of measuring the changes in the samples' mass up to 0.01 g. The measurements were made after 12 min, 30 min, 4 h, 24 h, etc., since the moment of immersion in water, until uniform results were obtained.

a)

b)

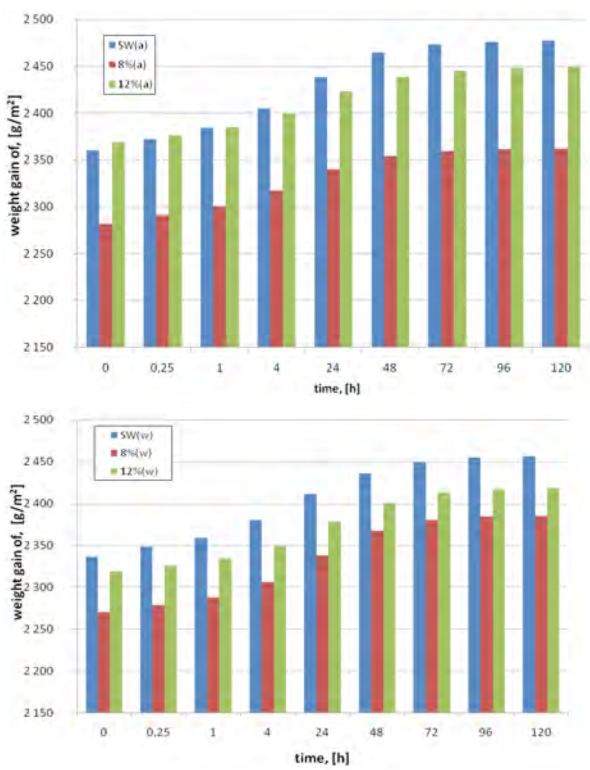

Fig. 5. Increase in mass in tests of capillary action for concrete samples maturing in stable temperature of +18°C for a period of 28 days: a) in an air-dry habitat, b) in water

The diagram analysis shows that the increase in mass of the concrete samples with addition of mineral dust during capillary action is 7% lower in comparison to concrete without the admixture. The samples made of admixture-less concrete absorb much bigger amounts of water. When comparing the habitats, the samples which matured in air-dry habitat showed slightly bigger increases in mass than the samples which matured in water.

Another test performed was determination of absorbability. The tests were performed on samples, that matured after molding:

I batch, for the whole period of 28 days, in air-dry habitat in temperature of +18°C.

II batch, for a period of 7 days in water in temperature of +18°C, and then for 21 days matured in air in temperature of +18°C. After this time the samples were placed in an air conditioning chamber, to be dried into dry mass in temperature of 105°C. After cooling the samples, they were weighed and placed in a tub container with synthetic props placed on the bottom of the container. For the first 24 hours the water level was up to the middle of the samples, then the samples were immersed to +1 cm over the top surface of the samples. The water was gradually replenished. The test of absorbability consisted of measuring the changes in samples' mass up to 0.01 g. The measurement of changes in mass was performed until two uniform results were obtained. The samples were weighed every 24 h. Each batch consisted of three samples [7].

a)

b)

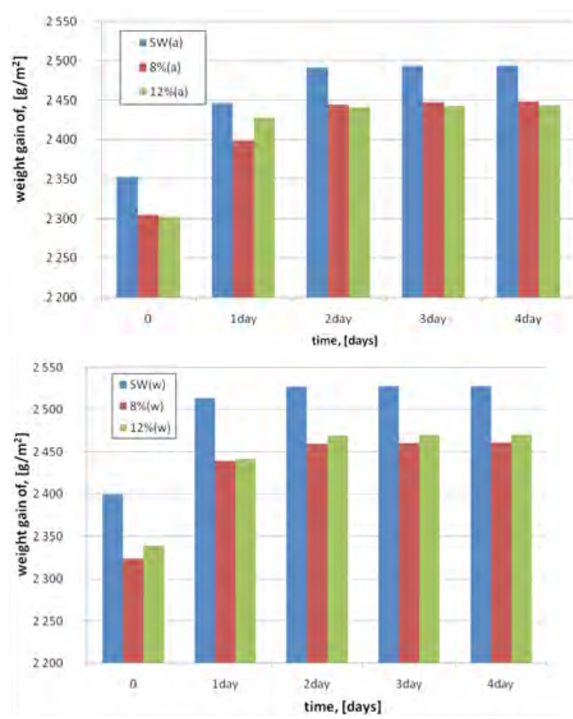

Fig. 6. Increase in mass in tests of absorbability for concrete samples maturing in stable temperature of +18°C for a period of 28 days: a) in an air-dry habitat, b) in water

structure

In case of tests of absorbability, concretes with admixture are characterized by lower water absorption. This is due to hermetization of the cement paste. The decrease in mass growth of the samples with addition of mineral dust maturing in water is 4% in relation to concrete maturing in air-dry environment.

4. Conclusion

The subject of laboratory tests was concrete with admixture of mineral dusts, which is a waste material resultant from production of aggregates. The final goal of the tests was to determine the influence of the mineral admixture on concrete properties. The waste-material mineral dust is characterized by very fine graining with fineness similar to cement, which due to its qualities positively influences the properties of concrete mix and concrete.

The most significant were the tests of hardened concrete, which allowed for objective analysis of validity of addition of waste-material mineral dusts. Those tests pertained especially to determination of the influence of dusts admixture on concrete resistance to compression, absorbability and capillary action. Based on the laboratory tests performed, it was determined that the admixture of mineral dust in quantity 12% of aggregate mass increased the gain in resistance by 18% in relation to admixture-free concrete. Another benefit is the decrease of concrete mass gains for the samples with mineral admixture in the absorbability and capillary action tests in relation to admixture-free concrete. Concretes maturing without proper care are characterized by decrease in physio-mechanical parameters: decrease fcm = 11.65%, increase in sample mass in tests of absorbability and capillary action by 10%.

The laboratory tests performed, concerning possibilities of use of mineral dusts for production of concrete, show positive perspectives. Due to the laboratory tests performed it was determined that mineral dusts may serve as admixture to concrete. However, further determination of usability for concrete technology demands individual approach, additionally including the aspect of recurrence of qualities of mineral dusts.

References

[1] Jamroży Z., *Concrete and its technologies*, Wydawnictwo Naukowe PWN, Warszawa 2005.

[2] Neville A.M., *Properties of concrete*, Polish Cement, Kraków 2012.

[3] Śliwiński J., *Ordinary concrete – Design and basic properties*, Polish Cement, Kraków 1999.

[4] Dobiszewska M., *The properties of concrete with the addition of mineral dust waste*, Concrete Days Conference, Tradition and Modernity, 13-15 October 2014, pp. 519-528.

[5] Urban M., *Rheological bases for obtaining high-resistance, self-compacting concretes*, Cement, Lime, Concrete, 5, pp. 241-253.

[6] PN-EN 206:2014 Concrete – Specification, performance, production and conformity.

[7] Ponikiewski T., *Molding the workability of self-compacting fiber-concrete*, XIII Scientific-technological Symposium, Rheology in concrete Technology, Górażdże, Gliwice 2011, pp. 129-138.

Anna Kotwa
Edyta Spychał

WPŁYW DODATKÓW MINERALNYCH NA WŁAŚCIWOŚCI BETONU

1. Wprowadzenie

Właściwości betonu, takie jak: wytrzymałość na ściskanie, nasiąkliwość czy mrozoodporność zależą od wielu czynników. Dziś obok podstawowych składników mieszanki betonowej obecne są również dodatki mineralne i domieszki chemiczne, które wpływają korzystnie na właściwości mieszanki betonowej i stwardniałego betonu [1-3].

2. Materiały i metody

Badania własne wykonano w dwóch etapach.

W etapie I przeprowadzono badania laboratoryjne betonów wykonanych z cementu CEM I 42,5R bez dodatku pyłu, z dodatkiem pyłów mineralnych w ilości 8% i 12% objętości kruszywa w mieszance betonowej dojrzewających w dwóch środowiskach:

– w wodzie w temperaturze +18°C przez okres 28 dni,
– w środowisku powietrzno-suchym w temperaturze +18°C przez okres 28 dni.

W etapie II opracowano oraz przeanalizowano otrzymane wyniki badań.

Badania dotyczyły betonu klasy C45/55 o stosunku W/C = 0,54.

3. Analiza wyników

Największy przyrost wytrzymałości na ściskanie odnotowano dla betonu z dodatkiem pyłu mineralnego w ilości 12%, który wynosi w 28 dniu w wodzie 56,32 MPa oraz w środowisku powietrzno-suchym 49,82 MPa. Procentowy przyrost wytrzymałości na ściskanie betonu dojrzewającego w wodzie w stosunku do betonu dojrzewającego w środowisku powietrzno-suchym w 28 dniu wynosi 13%. Z analizy wyników odczytano, że przyrost masy próbek betonowych z dodatkami pyłu podczas badania podciągania kapilarnego jest o 7% mniejszy w porównaniu do betonu bez dodatku. Próbki wykonane z betonu bez dodatku pyłu absorbują znacznie większą ilość wody. Porównując środowiska dojrzewania, to próbki, które dojrzewały w środowisku powietrzno-suchym wykazały nieznacznie większy przyrost masy niż próbki, które dojrzewały w wodzie. W przypadku badania nasiąkliwości betony wykonane z dodatkami charakteryzują się mniejszą absorpcją wody. Związane jest to z uszczelnieniem zaczynu cementowego. Spadek przyrostu masy próbek z dodatkiem pyłu dojrzewających w wodzie wynosi 4% w stosunku do betonu dojrzewającego w środowisku powietrzno-suchym.

4. Podsumowanie

Ostatecznym celem badań było ustalenie wpływu dodatku mineralnego na właściwości betonu. Na podstawie przeprowadzonych badań laboratoryjnych ustalono, że dodatek pyłu mineralnego w ilości 12% masy kruszywa zwiększył przyrost wytrzymałości o 18% w stosunku do betonu bez dodatku pyłu. Kolejną zaletą jest zmniejszenie przyrostu masy betonu dla próbek z dodatkiem pyłu mineralnego w badaniu nasiąkliwości i podciągania kapilarnego w stosunku do betonu bez dodatków.