# Impact of Added Chalcedonite Powder on Selected Concrete Properties

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# Impact of Added Chalcedonite Powder on Selected Concrete Properties

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**Abstract**. In recent times, the interest of scientists in new additives has increased, which can be modified by the properties of concrete mixtures and the parameters of hardened concrete. The PN-EN 197-1:2002 standard permits the use of mineral additives for cement, both as a main component (> 5.0% by weight) and as a secondary component (<5.0% by weight). Particular attention is paid to the problem of managing waste materials. The article discusses the results of laboratory tests on the effect of chalcedonite flour on the parameters of hardened concrete and rheological characteristics of the concrete mix. The addition to concrete mixtures was a chalcedonite meal with a diameter of less than 0.1 µm. It is a waste coming from the mine of broken chalcedonite aggregates. The main component of chalcedonite dust is silica. The rheological properties of concrete mixes, i.e. consistency, density, aeration degree and parameters of hardened concrete, including compressive strength, capillary rise and absorbability. The laboratory tests carried out indicate that the use of chalcedonite powder in the composition of a concrete mix has a positive effect on parameters such as capillary rising and water absorption. The addition of 15% of the meal results in a reduction of the compressive strength compared to the reference concrete by 10% on the 28th day of maturation. The use of a concrete additive in the form of chalcedonite powder can solve the problem of storing and managing waste in the production of broken chalcedonite aggregates. Concrete with chalcedonite meal can be used in places exposed to water, humidity and atmospheric conditions, where the compressive strength parameter is of secondary nature.

## 1. Introduction

State The most commonly introduced additives for concrete mixtures are: ground blast furnace slag, fly ash and silica dust [1,2]. They are used as additives for cements, mortars and concrete mixes. Additives should meet the requirements of the standard and be used in accordance with the applicable rules. The proper use of additives has a positive effect on the rheological characteristics of the concrete mix (improvement of workability) and strength parameters of concretes over a longer period of time. In recent years, researchers' interest has increased [3,4,5] with new additions that can modify the properties of concrete mixes and concrete parameters. Many scientists pointed to the problem of managing waste materials created in the production of broken aggregates. Such additives may be: dust and chalcedonite powder. The use of waste additives for the production of concrete mixes is part of the sustainable development strategy [6,7]. The selection of an appropriate amount of the additive to the concrete mix allows for optimizing the consumption of clinker, saving natural resources and limiting the negative impact on the natural environment [3,4,5,8]. The addition to concretes used in laboratory tests is a chalcedonite powder with a diameter of less than 0.1µm. It is a waste product coming from a mine of broken chalcedonite aggregates. Chalcedonite meal consists mainly of silica. In a small amount there are also other elements, i.e. quartz, opal, iron hydroxides, pyrite, manganese compounds and clay minerals. The additive used in the tests is the end product stored in heaps in the aggregate mine. According to data published in the literature, the addition of chalcedonite flour results in the modification of the properties of cement slurries. The size of these changes depends on the additive and, above all, on its type, quantity and properties, the properties of the cement and the presence of other components of the cementitious composite. In the planned tests, the influence of chalcedonite flour on the physical and mechanical properties of hardened concrete, i.e. the change of compressive strength, absorbability, capillary rise, will be checked [2,3,4].

## 2. Laboratory tests

Concrete mixtures were made of Portland cement CEM I 42.5 R with a fixed ratio of w/c = 0,4. (table 1). Chalcedonite meal was added in varying proportions of 5%, 10% and 15% of the aggregate mass in the concrete mix. A study of the chalcedonite meal diffractogram was carried out. The meal consists mainly of quartz. The analysis of the performed test also revealed the form of moganite in the silica sample. This form of silica, however, is difficult to detect, but it is popular with chalcedony.

Particle size of chalcedonite meal was measured by laser diffractometer see Figure 1.

x10= 0.28 μm x50= 3.87 μm x90= 25.53 μm SMD= 0.90 μm VMD= 9.50 μm

x16= 0.44 μm x84= 22.38 μm x 99= 34.99 μm SV= 6.64 m²/cm³ Sm=66392.20cm²/g

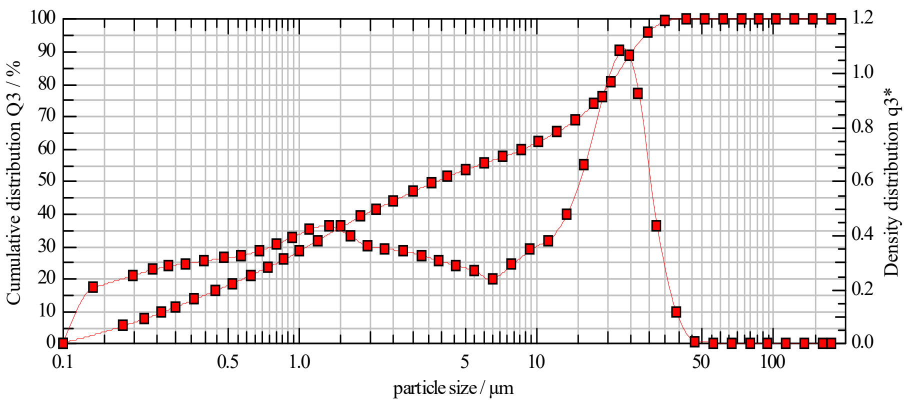


**Figure 1.** Particle size of chalcedonite powder.

**Table 1.** Information on the basic properties of cement.

| Lp. | Cement | Chemical composition, % | | | | | Blaine | fcm, 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 |

The planned laboratory tests included the execution of four concrete series with the composition given in Table 2.

CX ISOFLOW 755 plasticizing and liquefying admixture was used in the tests. It is a highly liquefying admixture that is used to make concretes of even high strength. Concrete mix with admixture is characterized by a long period of consistency maintenance. An admixture should be used in an amount of 0.2 to 3% in relation to the cement mass. The admixture in the tests was dosed into a wet concrete mix. The aeration admixture was used ISOSPHERE 60, which is an admixture with aeration activity. The admixture can be used in combination with plastifying, liquefying and retarding admixtures. It should be used in an amount of 0.1 to 2.5% in relation to the weight of the cement, depending on the expected aeration effect. In laboratory tests, the admixture was added to the finished concrete mix. The obtained aeration of the tested series was: SW = 4.5%, 5% = 4.6%, 10% = 4.5, 15% = 4.7%.

**Table 2.** Compositions of concrete mixes

| Components of concrete [kg/m$^3$] | Reference concrete (SW) | Concrete with the addition of 5% of powder (5%) | Concrete with the addition of 10% of powder (10%) | Concrete with the addition of 15% of powder (15%) |
|---|---|---|---|---|
| cement | 400 | 400 | 400 | 400 |
| water | 160 | 168 | 176 | 184 |
| sand | 598 | 579 | 560 | 541 |
| dolomite 4/8 | 453 | 444 | 435 | 426 |
| dolomite 8/16 | 691 | 682 | 673 | 666 |
| chalcedonite powder | ---- | 86 | 171 | 248 |
| plastisizing admixture | 1.02 | 1.07 | 1.14 | 1.2 |
| air entrainer | 9.4 | 11.17 | 11.19 | 11.21 |

The first test parameter of hardened concrete was the compressive strength determined after 7, 14 and 28 days of maturation. The cubic samples with a side of 10 cm were ripened in water at a temperature of + 18 ° C ± 2 °C throughout the whole period. Compressive strength was tested once on three samples, taking the average result for analysis.

Capillary pull-up was tested on samples of three from each series, which after forming were matured for 7 days in water at + 18 °C. The next 21 days of the samples were stored in air-dry conditions at + 18 ° C. After 28 days of maturation, the samples were placed in a climate chamber and dried to a constant mass. The temperature in the air-conditioning chamber was raised gradually until the temperature reached + 105 ° C. After removal from the chamber, the samples were insulated on the sides to prevent uncontrolled moisture exchange from the environment. All samples were identically protected. The capillary rising test consisted of placing the insulated samples in containers with water on plastic grids. The capillary rising test measures the mass changes of the samples, which were tested with an accuracy of 0.01g.

The absorbability test was performed on cubic samples with a side of 10cm. After forming, the samples matured for 7 days in water at + 18 °C. The next 21 days samples were ripened in an air-dry environment at + 18 ° C ± 2 ° C. After this time, the samples were placed in an air-conditioning chamber where they were dried to constant weight at + 105 °C. The samples were placed in a container with water to half the height of the samples for the first 24 h. In the following days, the samples were completely filled with water up to a height of + 1 cm above the surface of the samples. Samples were weighed every 24h [1,5,6,9,10].

## 3. Results and discussions

Compressive strength was measured 7, 14 and 28 days after formation. The result presented in the chart is the average obtained from the measurements of three cubic samples with each side 10 cm long.

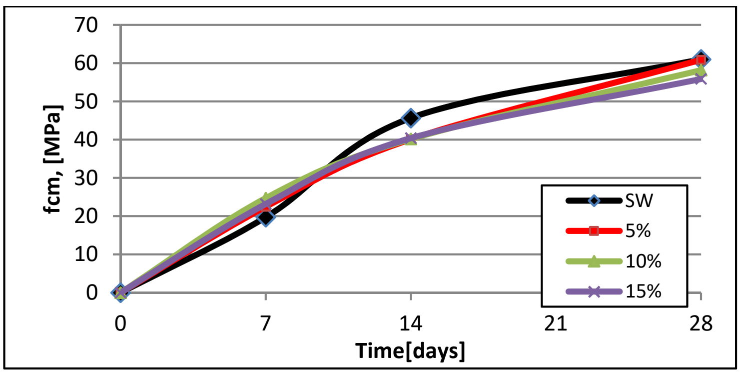


**Figure 2.** The increase in compressive strength of concrete.

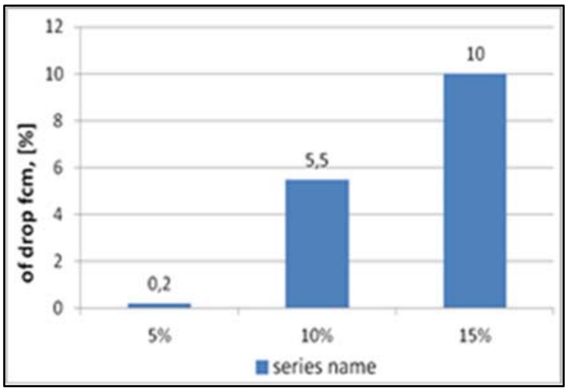


**Figure 3.** Reduction of compressive strength in comparison to the concrete without additive after 28 days.

The analysis of Figures 2 and 3 shows that the highest increase in compressive strength was noted for concrete samples without the addition of chalcedonite powder. Compressive strength after 28 days was 60.9 MPa. Samples with the addition of chalcedonite flour are characterized by a decrease in strength compared to concrete without additive. It can be noticed that the more additive in the form of chalcedonite meal is the greater the decrease in compressive strength. The greatest decrease in compressive strength is characteristic for concretes with the addition of 15% chalcedonite powder and it is 10%. It should also be noted that the increase in compressive strength for samples with the addition of flour in the first 10 days is higher compared to the reference concrete.

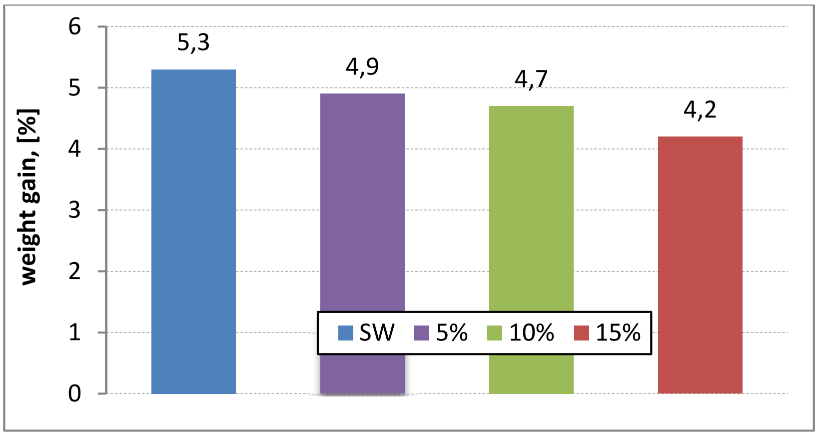


**Figure 4.** Increase in the mass of the samples in the absorption test [%].

In the absorbability test see figures 4,5,6, the comparative concrete showed the highest absorption. The addition of chalcedonite meal causes a decrease in the mass increase of the samples in contact with water. A significant decrease in weight gain can be seen for concrete with an addition of 15% flour. Concrete with 10% meal is a decrease of 11.3% in the mass increase of concrete, while for samples with 15% meal it is a decrease of 20.8% in relation to the reference concrete.

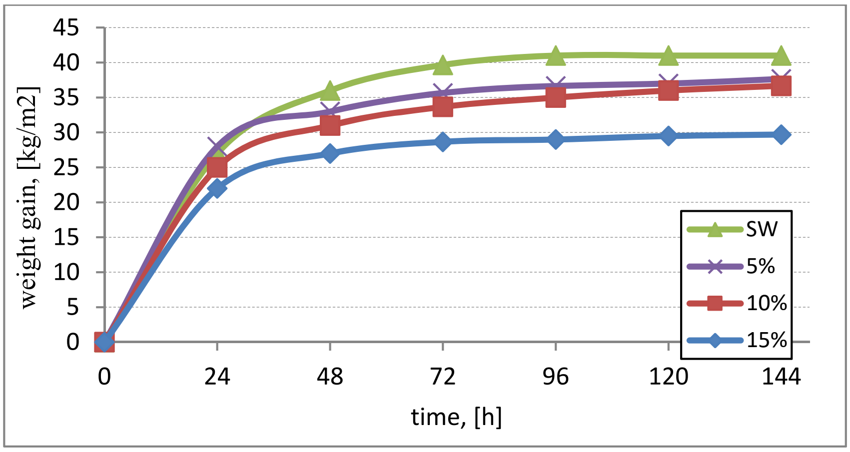


**Figure 5.** Weight increase of samples in the capillary elongation test after 28 days of maturation, [kg/m$^2$]

The analysis of the results indicates that the addition of chalcedonite powder causes a reduction in capillary rising relative to the reference concrete. The smallest increase in weight is found in concretes with the addition of 15% flour. The more the additive, the smaller the weight gain of the samples, although the samples with the addition of 5% and 10% of chalcedonite meal have a similar weight gain. A significant improvement in the parameter is visible for the series with the addition of 15% chalcedonite powder.

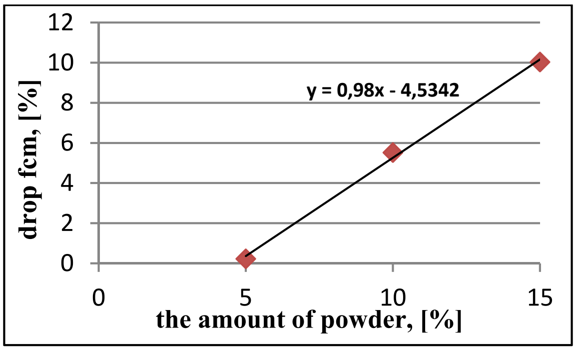


**Figure 6.** The relation between the decrease in $f_{cm}$ and the amount of the powder in concrete

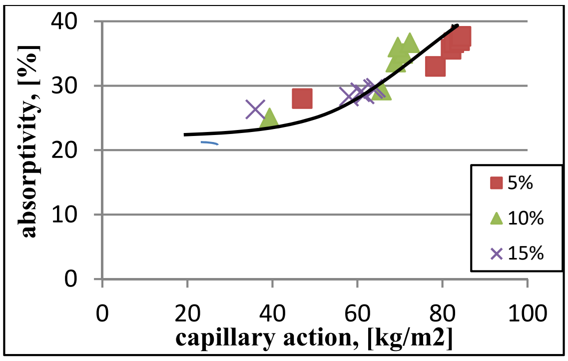


**Figure 7.** The relation between the weight increase in water absorbability test and the weight increase in capillarity test

The amount of chalcedonite powder added has a linear effect on the compressive strength drop. Figure 7 illustrates the polynomial relationship between two parameters of water absorption and capillary rise. Knowing the result of one parameter, we are able to estimate the second size.

During the laboratory tests, the volume density of concrete mixtures was also examined, summarizing the results in Table 3.

**Table 3.** Calculation of density of concrete mixes with chalcedonite meal.

| Lp. | Type of mixture | $m_2$ [kg] | $m_1$ [kg] | Density [kg/m$^3$] |
|---|---|---|---|---|
| 1 | ozn. SW | 7.1 | 19.29 | 2438 |
| 2 | ozn. 5% | 7.1 | 18.18 | 2216 |
| 3 | ozn. 10% | 7.1 | 17.88 | 2156 |
| 4 | ozn. 15% | 7.1 | 17.64 | 2108 |

The obtained data show that the addition of chalcedonite powder to the concrete mix causes a reduction in density.

A test was also carried out to determine the consistency of the concrete mix according to PN-EN 206-1, obtaining the consistency of S2 for all tested series.

## 4. Conclusions

The test results provide the basis for drawing the following conclusions:

- The introduction of 15% chalcedonite powder into the concrete mix results in a reduction of the compressive strength after 28 days by 10% compared to the reference concrete.
- In the capillary lift test, it can be noticed that the weight gain is comparable for the series tested, in which 5% and 10% meal was applied and is about 37 kg / m2 after 28 days of ripening.
- Absorbability after 28 days of ripening is 20.8% lower for a series with 15% chalcedonic powder compared to a series of concretes without additives.
- The use of chalcedonite powder in concrete mixes causes the cement matrix to seal.
- Considering economic and environmental factors, it is advisable to use concrete additive in the form of chalcedonite flour in an amount of up to 15%. The use of chalcedonite powder as a concrete additive could help solve the problem of storage and use of waste from the production of chalcedonite aggregates [11].

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