Parameters of SCC Concrete Supplemented with Chalcedonite Powder

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Abstract

The results of the compressive strength tests, water absorption and rising capillary of SCC concrete modified by chalcedonite powder are presented in the article. The additive used in laboratory research was final waste stored in heaps in the aggregate mine. Chalcedonite powder is composed mainly of silica in crystalline form. It is present in small amounts of other compounds, i.e. opal, iron pyrite hydroxides, manganese compounds and clay minerals. Chalcedonite powder replaced the percentage amount of aggregate in the concrete mix; however, the amount of cement was left unchanged. CEM I 42.5 cement was used in the study. The study indicates that the use of the additive in chalcedonite powder form does not reduce the compressive strength. The addition of chalcedonite powder to the concrete mix reduces the water absorption of concrete samples in contact with the water in the absorption test and the rising capillary. The optimum amount of the additive in chalcedonite powder form is 15% of aggregate weight in the cement mix.

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1. Introduction

There are also mineral additives and chemical admixtures in addition to the basic components of concrete, which deliberately modify the parameters of hardened concrete [1,5]. The aim of the laboratory tests was to determine the effect of powdered chalcedonite to change the compressive strength, water absorption and rising capillarity action. The chalcedonite powder used in laboratory tests is a waste product formed in the chalcedonite aggregate mine. It is a

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by-product, but is has the same properties as the aggregate originating from it. The main component of the powder is chalcedony; however, quartz, opal, hydroxides of iron, pyrite, manganese compounds and clay minerals are present in small amounts. The chemical composition of chalcedonite in the studies demonstrates the same trend and the share of individual compounds is maintained. The object of the study is self-compacting concrete with the addition of powdered chalcedonite with a granulation of 10 $\mu$m ÷ 125 $\mu$m. Existing intermittent and cursory studies [8], point to the advisability of using the additive in the form of powdered chalcedonite for concrete. The addition of powdered waste added to the concrete increases the compressive strength from 12 to 56%. The task that has been placed in the laboratory tests is to check the possibility of using powder as a mineral additive which deliberately modifies the parameters of hardened SCC concrete [6].

2. Primary Headings

The laboratory test plan included carrying out four batches of SCC concrete, which contained 5%, 10% and 15% of powdered chalcedonite in its composition. The addition replaced the aggregate in the concrete mix in percentage terms. CEM I 42,5R concrete was used in the test. Concrete mixes were made with a constant coefficient of water-cement ratio of 0.4. The following assumptions were accepted for projecting the composition of the concrete mix: exposure class - XF4, the consistency of the mixture according to PN-EN 12350-8:2012 - SF2, [3].

A test of the chalcedonite powder was carried out using the XRD method, which was used to investigate the composition of the additive using an X-ray diffractometer.

![Fig. 1. The result of tests of chalcedonite powder using the XRD method.](image)

The analysis of the graph shows that the main component of chalcedonite powder is quartz. Due to an additional (but less intense) reflex range angle 20 from 18 to 22 ° (maximum at 19.923 °), it can be concluded that the sample is in the form of silica moganite. This form of silica is hardly detectable, but often occurs together with chalcedonite [7].

A study of the particle size of chalcedonite powder was carried out using a HELOS KR laser diffractometer.

\[
x_{10} = 0.28 \mu m \quad x_{50} = 3.87 \mu m \quad x_{90} = 25.53 \mu m \quad SMD = 0.90 \mu m \quad VMD = 9.50 \mu m
\]
\[
x_{16} = 0.44 \mu m \quad x_{84} = 22.38 \mu m \quad x_{99} = 34.99 \mu m \quad S_N = 6.64 \text{m}^2/\text{cm}^3 \quad S_m = 66392.20 \text{cm}^2/\text{g}
\]
ISOflow 755 CX was used as a chemical admixture. This is an admixture with strongly plasticizing and dissolving action to SCC concrete. The action of the admixtures is strong liquidation, maintaining consistency over a long period and improving the durability of concrete through the possibility of reducing the mixing water. It should be applied in an amount from 0.2 to 3.0% by weight of cement depending on the desired liquefaction effect. The admixture for all batches tested was dispensed into moisture containing the composition of the concrete mix.

<table>
<thead>
<tr>
<th>Component</th>
<th>Batch 1 ident. SW</th>
<th>Batch 2 ident. 5%</th>
<th>Batch 3 ident. 10%</th>
<th>Batch 4 ident. 15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>cement</td>
<td>520</td>
<td>520</td>
<td>520</td>
<td>520</td>
</tr>
<tr>
<td>water</td>
<td>210</td>
<td>218</td>
<td>229</td>
<td>239</td>
</tr>
<tr>
<td>sand</td>
<td>870</td>
<td>857</td>
<td>844</td>
<td>831</td>
</tr>
<tr>
<td>dolomite 4/8.</td>
<td>544</td>
<td>536</td>
<td>520</td>
<td>514</td>
</tr>
<tr>
<td>dolomite 8/16.</td>
<td>326</td>
<td>321</td>
<td>311</td>
<td>310</td>
</tr>
<tr>
<td>chalcedonite powder</td>
<td>----</td>
<td>26</td>
<td>52</td>
<td>78</td>
</tr>
<tr>
<td>admixture</td>
<td>1.2</td>
<td>1.35</td>
<td>1.45</td>
<td>1.56</td>
</tr>
</tbody>
</table>

After mixing all components of the concrete mix, the diameter of propagation of the mixes in concrete was tested and the results were correlated in Table 2.

<table>
<thead>
<tr>
<th>Type of concrete mix</th>
<th>Diameter of propagation. [cm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ident. SW</td>
<td>68</td>
</tr>
<tr>
<td>ident. 5%</td>
<td>68</td>
</tr>
<tr>
<td>ident. 10%</td>
<td>70</td>
</tr>
<tr>
<td>ident. 15%</td>
<td>70</td>
</tr>
</tbody>
</table>

The established SF2 consistency was achieved in all the batches. Examination of the compressive strength was tested after 7, 14 and 28 days for the formation of the cubic samples of a side of 10 cm. The samples were matured in water at +18 °C ± 2 °C. Simultaneously three samples were examined [2]. The compressive strength test was carried...
out with a TECHNOTEST device and the software of the press manufacturer.

<table>
<thead>
<tr>
<th>Maturity time [days]</th>
<th>ident. sw</th>
<th>ident. 5%</th>
<th>ident. 10%</th>
<th>ident. 15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>25.32</td>
<td>25.22</td>
<td>25.05</td>
<td>24.92</td>
</tr>
<tr>
<td>14</td>
<td>37.53</td>
<td>38.52</td>
<td>37.57</td>
<td>37.97</td>
</tr>
<tr>
<td>28</td>
<td>47.36</td>
<td>48.26</td>
<td>47.31</td>
<td>46.96</td>
</tr>
</tbody>
</table>

The analyses of the studies show that the compressive strength is comparable in all test batches. Replacement of the aggregate parts of the chalcedonite powder does not decrease the compressive strength.

Samples for the absorption test sample after formation matured over a period of 7 days in water at +18 °C. Then 21 days matured dry air at +18 °C ± 2 °C. After this time, the samples were placed in a climate chamber where they were dried to a constant weight at 105 °C. The samples were placed in a pan of water on supports made of plastic. The water was up to half the amount of concrete samples during the first 24 h, then the samples were completely immersed in water to a height of +1 cm above the top surface of the sample. The water was gradually replenished. The absorption study consisted in measuring the change in sample mass to the nearest 0.01 g. The weight change measurement was carried out to obtain two identical results. The samples were weighed every 24 hours. Three regular shaped samples were prepared for each test batch [2].

![Figure 3: The increase in the sample mass during the absorption test. [kg/m²].](image)

The analysis of the realized laboratory tests shows that the addition of chalcedonite powder results in a lower increase in concrete sample mass during the absorption test. The addition of 5% of the powder results in a reduced water absorption of 9.67% compared to the reference concrete. The lowest absorption compared to the reference concrete is characterized by the concrete samples with the addition of 15% chalcedonite powder.

The test was carried out on capillary samples with a regular shape. The samples were prepared for testing in the same way as in the absorption test. After drying, the samples were immersed in water to a height of 1 mm ± 3 mm. The water was gradually replenished. The test consisted in measurement change in the concrete mass to the nearest 0.01 g. Measurements were taken after 15 min, 30 min, 4 h and then every 24 h after contact of the samples with water to obtain two identical mass measurements of the analyzed samples. Three samples each were prepared for each batch [4].
Laboratory tests that were carried out indicate that adding chalcedonite powder reduces the increase of concrete mass in contact with water which is a desirable feature in the construction industry for concrete exposed to a direct contact with water. Replacement of 5% of the aggregate powder results in a lower water absorption as compared to the referenced concrete by 3.84%. The graph shows the tendency that the more the additive in chalcedonite powdered form was added to the concrete mix, the lower the mass increase in the samples in contact with water. This situation is associated with sealing the cement matrix.

The relationship between the absorption and capillary parameters of absorption for SCC concretes with the addition of 5%, 10%, and 15% chalcedonite powder.

Fig. 4. Increase in the mass of concrete samples during the capillary test. [kg/m²].

Fig 5. The relationship between the absorption and capillary parameters was determined.
The specific relationship allows for mutual parameter absorption and capillary estimation for SCC concrete with the addition of chalcedonite powder. In knowing the result of one parameter the second one can be estimated.

3. Conclusions

The aim of the planned laboratory tests was to determine the effect of chalcedonite powder in the amount of 5%, 10%, and 15% in order to change the compressive strength, water absorption and capillary action. Laboratory tests carried out from the analysis indicate that the compressive strength parameter is comparable in all four batches. Replacing a part of the chalcedonite powder aggregates does not reduce the compressive strength. The addition of 5% of chalcedonite powder in the test causes a decreased water absorption of 9.67% compared to the reference concrete. The lowest absorption is characterized by a concrete containing 15% powder. The difference in the increase of sample mass in contact with water as compared to the referenced concrete is 25.97%. Capillary action in the test replacing 5% of powder aggregate has a lower mass increase compared to the referenced concrete by 3.84%. In tests, the visible tendency is that the more additives in chalcedonite powder form are added to the concrete, the lower the mass increase of the tested concrete in contact with water.

The mere replacement of a part of the chalcedonite powder aggregate offers many advantages, among others, a reduction in the price of the concrete mix, improving the performance of hardened concrete, chalcedonite powder utilization, lower production costs of concrete mixes containing powder and the ecological aspect [7].

References