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THE STUDY OF THE MECHANICAL PROPERTIES
OF THE MINERAL CAST MATERIAL

The article presents the results of research of the mechanical properties of mineral cast. Studies have been conducted to verify the literature data about the value of tensile strength, compressive strength, and Young’s modulus. In addition, one more parameter was determined, which has not been encountered anywhere in the analyzed literature (Poisson’s ratio) so far.

Key words: mineral cast, mechanical properties, dynamical properties, cast iron

1. INTRODUCTION

Owing to very good dynamic properties and low density mineral casts are more and more willingly put into the machine tool industry, which is constantly looking for new design solutions. In the future, these new materials thanks to their properties will improve product quality, reduce costs associated with the production process, increase the flexibility of that process, etc. [5]. Mineral cast (PC – polymer concrete) is a complex material composed of fine particles of inorganic aggregates such as basalt, spodumene, fly ash, river gravel, sand, chalk, etc. connected together by two-component, chemically hardened resin (usually epoxy resin) [3, 4]. The volume ratio of filler (aggregates) to the binder (resin) is about 9:1 [1]. Figure 1 shows an exemplary structure of mineral cast which takes into account the grain size of individual aggregates, while it is not taking into account their shape.

Depending on the type and size of the aggregates used in mineral cast and the amount of the resin curing may take from several minutes to several hours. Depending on the requirements for the achieved precision, dimensional tolerances and surface roughness mineral cast can be made in the molds of wood, plastic,

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metal, cast iron or combined from above [2]. Mineral casts have also much better dynamic properties than the commonly used cast iron. The logarithmic decrement of damping of mineral casts is up to 10 times higher than in case of cast iron [4, 5]. Unfortunately, mineral casts have poor mechanical properties. The tensile strength of mineral cast is about 10 MPa [2], while the compressive strength is about 100 MPa [2, 4, 6]. In order to verify the mechanical properties of the mineral cast material the study was carried out.

2. MATERIALS, SAMPLES, TESTING MACHINES AND RESEARCH

2.1. Materials

The material which was used for tests is mineral cast material offered by EPUCRET and commercially available under the name EPUCRET 140/5. This material is used for casting small parts of machines such as the guides, tables or beds, which mass is not exceeding 500 kg. Figure 2 shows a view of mixed aggregates constituting the mineral cast.

Figure 1. Exemplary structure of mineral cast [5]

Figure 2. The view of mixed aggregates of mineral cast
2.2. Samples

In order to carry out the research two types of samples were tested. The first type of sample was used in tensile test whereas the second one in compressive test. In both cases, the preparation of mineral mass was performed in the same way. All components were thoroughly mixed together using a mechanical stirrer for 15 minutes in the proportions provided by the manufacturer. In order to remove samples after curing smoothly, the mold surfaces were previously greased with technical petrolatum (vaseline). Then the mass was placed in molds and further compressed manually in order to get rid of air bubbles. Curing time in molds was about 24 hours. The samples were left for next 3 days in order to get bound well. Figure 3 and 4 show views of the test samples for tensile and compressive strength.

![Figure 3. View of a tensile strength sample](image1)

![Figure 4. View of a compressive strength sample](image2)

2.3. Testing machines

The strength tests were carried out on the typical testing machine Zwick/Roell which is standard equipment of the Chair of Strength of Materials and Constructions of the Mechanical Department at Lodz University of Technology.
2.4. Research

Tests were carried out on ten samples. First samples were tested for tensile strength, and then for compressive strength. Figure 5 shows the view of the sample for tensile strength test. Figure 6 shows the view of the sample for compressive strength test. Both samples were mounted in the test apparatus. During tensile tests on the surface of samples extensometers have been mounted, in order to measure the longitudinal elongation and the transverse elongation of the specimen (shortening).

![Figure 5. View of the tensile strength sample mounted in the apparatus](image1)

![Figure 6. View of the compressive strength sample mounted in the apparatus](image2)

3. TEST RESULTS AND DISCUSSION

The results obtained during the tests are shown in Table 1 and also graphically represented by graphs (Figure 7–10).

As shown in Table 1 parameter values in subsequent trials differ from one another. The degree of variation of results is well presented by the percentage deviation of the average value. The drawings from 7 to 10 present graphs of individual tests of strength parameters. The results of the individual tests are presented by vertical bars. The bold horizontal line represents the average value, while the semitransparent bar shows the standard deviation of the mean value.
Table 1

Results of the research of mechanical properties of mineral casts

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tensile strength [MPa]</th>
<th>Compressive strength [MPa]</th>
<th>Young’s modulus [MPa]</th>
<th>Poisson’s ratio [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.01</td>
<td>119.43</td>
<td>34846</td>
<td>0.224</td>
</tr>
<tr>
<td>2</td>
<td>17.26</td>
<td>111.64</td>
<td>37426</td>
<td>0.248</td>
</tr>
<tr>
<td>3</td>
<td>19.71</td>
<td>114.31</td>
<td>27701</td>
<td>0.209</td>
</tr>
<tr>
<td>4</td>
<td>17.76</td>
<td>109.08</td>
<td>22004</td>
<td>0.159</td>
</tr>
<tr>
<td>5</td>
<td>20.91</td>
<td>105.79</td>
<td>27084</td>
<td>0.197</td>
</tr>
<tr>
<td>6</td>
<td>19.72</td>
<td>87.11</td>
<td>31483</td>
<td>0.237</td>
</tr>
<tr>
<td>7</td>
<td>20.52</td>
<td>106.87</td>
<td>27621</td>
<td>0.289</td>
</tr>
<tr>
<td>8</td>
<td>17.35</td>
<td>114.69</td>
<td>32574</td>
<td>0.259</td>
</tr>
<tr>
<td>9</td>
<td>19.85</td>
<td>107.22</td>
<td>29709</td>
<td>0.220</td>
</tr>
<tr>
<td>10</td>
<td>18.09</td>
<td>89.90</td>
<td>26934</td>
<td>0.178</td>
</tr>
</tbody>
</table>

Average value  | 18.42                  | 106.60                      | 29738                 | 0.222             |

Standard deviation: 2.32 | 10.44 | 4468 | 0.039 |

Percentage deviation of the average value [%]: 12.6 | 9.8 | 15.0 | 17.4 |

Figure 7 presents a graph showing the results of subsequent tests during the tensile test.

![Graph](image)

Figure 7. Results of tensile strength tests

On the basis of performed experiments it was determined that the average tensile strength was 18.42 MPa, while the standard deviation was about
5.37 MPa. It can be seen that the result of the first trial is significantly lower than the rest of the measurements. That was because in a first attempt higher tension velocity was used.

Figure 8 presents a graph of the compressive strength values.

![Figure 8. Results of compressive strength tests](image)

In this case, the average value was obtained at the level 106.60 MPa, while the standard deviation was about 10.44 MPa.

The next Figure (Figure 9) shows a plot of the Young's modulus, obtained in subsequent trials.

![Figure 9. Results of Young’s modulus tests](image)

The average value of the Young's modulus was 29 738 MPa and a standard deviation value reached 4468 MPa. During the second test the value of the Young's modulus was the highest and reached 37 426 MPa, while the fourth trial reached the lowest value of 22 004 MPa. Both values were obtained within
a range of values of Young's modulus posted in the literature [2, 4], which include the values from 15 000 MPa to 40 000 MPa.

Apart from the three basic parameters reported in the literature such as tensile strength, compressive strength and Young's modulus [2, 4, 6], an additional parameter (Poisson's ratio) was determined experimentally, which has not been posted in the literature so far.

Figure 10 shows a graph of Poisson's ratio values for the tests carried out sequentially.

![Figure 10. Results of Poisson’s ratio tests](image)

In this case, the average value obtained during the test was 0.222, and the standard deviation value reached 0.039. It was the biggest value considering the percentage deviation of the average value, which in this case was over 17.4 %.

4. CONCLUSIONS

Table 2 shows a comparison of the results of the authors’ studies with the results published in the literature and obtained by the researchers.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Literature data</th>
<th>Research results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength [MPa]</td>
<td>≈10</td>
<td>18.42</td>
</tr>
<tr>
<td>Compressive strength [MPa]</td>
<td>≈100</td>
<td>106.60</td>
</tr>
<tr>
<td>Young's modulus [MPa]</td>
<td>15 000–40 000</td>
<td>29.738</td>
</tr>
<tr>
<td>Poisson’s ratio [–]</td>
<td>–</td>
<td>0.222</td>
</tr>
</tbody>
</table>

Table 2
Based on the survey it can be claimed that the literature data have been confirmed in case of the mechanical properties of the mineral casts. Furthermore, an additional parameter (Poisson's ratio) was determined which has not been given in the literature of mineral casts yet.

Small differences of results have appeared due to the selection of the tension or compression speed applied during the study because the literature does not specify what rates of speed were used during earlier tests. Reducing the speed of tension and compression can result in slight increase of tensile strength and compressive strength rates.

REFERENCES


BADANIE WŁAŚCIWOŚCI MECHANICZNYCH ODLEWÓW MINERALNYCH

S t re s z c z e n i e

W artykule zamieszczono wyniki badań właściwości mechanicznych odleów mineralnych. Badania prowadzono w celu weryfikacji danych zamieszczonych w literaturze, a dotyczących wartości wytrzymałości na rozciąganie, wytrzymałości na ściskanie, a także modułu Younga. Ponadto wyznaczono dodatkowy parametr, z którym do tej pory nie spotkano się nigdzie w analizowanej literaturze – współczynnik Poissona.

Słowa kluczowe: odlew mineralny, właściwości mechaniczne, właściwości dynamiczne, żeliwo