Durability of a Sand Concrete Made with Marble Waste "Water Absorption by Immersion and Chloride Permeability"

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Abstract
The present work consists in recovering a marble waste (thrown powder exposed to different meteorological phenomena) generated by the marble quarry of Fil-fila, located in the east of Skikda (north-east of Algeria), and added as sand replacement in the composition of sand concrete. Quarry sand and dune sand were used and replaced by waste marble sand, using rates of 25%, 50%, 75% and 100%. The durability characteristics were assessed by evaluating chloride permeability and water absorption by immersion. Obtained results were compared to the control mixes. The results indicated that partial substitution improved the durability parameters.

1. Introduction
In current work, white marble waste sand (thrown powder exposed to different meteorological phenomena) was introduced in the formulation of sand concrete. This waste is obtained from the quarry of the derivatives of Fil-fila located 25km to the East of the city of Skikda in the North-East of Algeria; In addition to ordinary sand, there are also fine limestone recovered from quarry filters. The study is carried out to compare the behavior of different sand concretes produced under the effect of two durability indicators, water absorption by immersion and chloride penetration.

2. Used materials
- The cement is a CEM I with a low C3A content made in Algeria, its absolute density is 3.220 g / cm³ with a specific area Blaine of 3025cm² / g, the chemical and mineralogical composition is shown on the Table 1.
- Dune sand of a class 0/1 siliceous from Oued Z’hor west of Skikda, north-east Algeria;
- Quarry sand of limestone nature and class 0/4 from the Ben Brahimi quarry in Constantine in the North-East of Algeria;
- Limestone waste sand, Class 0/2 from the Fil-fila marble quarry east of Skikda North-East of Algeria.

Table 1. Chemical and mineralogical composition of CEM I cement

<table>
<thead>
<tr>
<th>Chemical components</th>
<th>Percentage</th>
<th>Chemical components</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>63.69</td>
<td>PAF</td>
<td>0.70</td>
</tr>
<tr>
<td>Al2O3</td>
<td>4.55</td>
<td>CaO free</td>
<td>0.75</td>
</tr>
<tr>
<td>Fe2O3</td>
<td>5.03</td>
<td>MS</td>
<td>0.75</td>
</tr>
<tr>
<td>SiO2</td>
<td>20.90</td>
<td>C3S</td>
<td>67.35</td>
</tr>
<tr>
<td>Na2O</td>
<td>0.18</td>
<td>C2S</td>
<td>9.42</td>
</tr>
<tr>
<td>K2O</td>
<td>0.33</td>
<td>C3A</td>
<td>3.33</td>
</tr>
<tr>
<td>Cl</td>
<td>0.001</td>
<td>S03</td>
<td>2.08</td>
</tr>
<tr>
<td>C4AF</td>
<td>16.20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The particle size distribution of the three types of sand is shown in Figure 1;
plasticizer “Polyflow SR5400”, in the form of a light brown liquid with a PH = 5 and a specific gravity of 1.07.

Table 2. Physical characteristics of sands, marble waste and fillers

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Dune sand 0/1</th>
<th>Quarry sand 0/4</th>
<th>Waste marble sand 0/2</th>
<th>Marble fillers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent density (g/cm³)</td>
<td>1.52</td>
<td>1.45</td>
<td>1.68</td>
<td>1.05</td>
</tr>
<tr>
<td>The equivalent of sand (cleanliness %)</td>
<td>2.591</td>
<td>2.611</td>
<td>2.666</td>
<td>2.74</td>
</tr>
<tr>
<td>Water absorption (%)</td>
<td>3.35</td>
<td>2.01</td>
<td>5</td>
<td>2.74</td>
</tr>
<tr>
<td>Fineness modulus Mf</td>
<td>1.95</td>
<td>2.93</td>
<td>1.79</td>
<td>2.74</td>
</tr>
<tr>
<td>Blue methylene MB</td>
<td>0.7</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>

From the characterization tests, it can be seen that:

- The density of marble waste sand is high compared to that of dune sand (Table 2), but it is close to that of quarry sand, therefore marble waste sand is the denser.
- The fineness modulus of marble waste sand is the lowest (Table 2) and indicates a sand with a majority of fine grains, ease of implementation to the probable detriment of strength and high water demand according to Dreux, this result is consistent with that found by Rebiouh et al [1].
- The particle size distribution: the particle size curves indicate that the dune sand has a continuous granularity, the quarry sand is normal while the marble waste sand is mostly fine-grained.
- Fines content: marble waste sand has the highest fines content (6.12%) compared to quarry sand with 0.84% and dune sand with 0.01%.
- According to the chemical analyzes, the marble waste sand is calcareous (98% of CaCO₃) therefore a good matrix / aggregate bonding, this sand is rich in CaO which offers a lot of C₃S generating high resistance at young age.

3. Program

The formulation of the concretes was established according to the experimental method of the SABLOCRETE project [2] based on the determination of the volumes of the different components, the properties of the control concrete, fresh or hardened and the methods of verification of these properties are identical for the concrete of sand [3]. The substitution is made by replacing a volume of ordinary sand with the same volume of marble waste sand and then determining the quantities by weight. We set the W / C ratio, the cement dosage and the amount of admixture, while varying the substitution rates 25%, 50%, 75% and 100% of two types of ordinary sand. The fine content depends on the nature of the ordinary sand.

The names of the mixtures are as follows:

- BSD0%: Dune sand concrete with 0% substitution (control mix)
- BSD25%: Dune sand concrete substituted with 25% marble waste sand
- BSD50%: Dune sand concrete substituted with 50% marble waste sand
- BSD75%: Dune sand concrete substituted with 75% marble waste sand
- BSC0%: Quarry sand concrete with 0% substitution (control)
- BSC25%: Quarry sand concrete substituted with 25% marble waste sand
- BSC50%: Quarry sand concrete substituted with 50% marble waste sand
- BSC75%: Quarry sand concrete substituted with 75% marble waste sand
- BSDM: Marble Waste Sand Concrete, 100% Substitution.

4. Water absorption by immersion

Immersion absorption characterizes the open pores of the cement matrix at 28 days; open porosity is due to the excess water in the mixture which has not entered the cement hydration or absorbed by the aggregates, it also depends on the air trapped after vibration.

The curves in Figure 2 show an unstable trend, because the absorption of water depends on the size of the pores, their distribution and their interconnectivity. The maximum absorption is obtained with the marble waste concrete, an expected result due to its workability in the fresh state (plastic concrete) because of its water absorption capacity. Guldin et al [4] have found that the use of marble waste has positively affected water absorption.

5. Conclusion

Partial substitution negatively influenced chloride permeability, as well as water absorption, so our concretes were shown to be less vulnerable to outdoor environments.
Declaration of Conflict of Interests

The author(s) declare(s) that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References


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