Effect of Waste Tile Fillers and Waste Marble Sand on Concrete Performance

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Keywords
- Waste
- Marble
- Sand
- Tile fillers
- Concrete
- Substitution
- Air content
- Compressive strength

Abstract
The current study consists to introduce waste marble sand into the concrete formulation, as replacement of ordinary sand with variable rates (0%, 10%, 20% and 30%); the binder is composed of 90% cement and 10% tile polishing fillers. The properties of the concretes thus produced both in the fresh state (air content, density, and slump test) and in the hardened state (compressive strength) were measured. Obtained results showed that the introduction of 20% of waste marble sand in the presence of tile polishing fillers helps to decrease the air content and to improve compressive strength.

1. Introduction
The prosperity of a country in the construction industry depends on the use of its local resources; which requires designers and builders of civil engineering to take an interest in the recovery of waste or industrial by-products or residues to bridge the gap between production and consumption and to protect the environment. The terrazzo tile is a floor covering, handcrafted for centuries. Its composition strongly looks like traditional concrete. It is a mixture of granules of natural stone or marble with cement, sand and water. Pigments and other materials can be added, once dried it will be polished to give it the shine of a natural stone. It is a material that is extremely resistant to knocks and scratches. Fine dust resulting from the erosion of this material remains suspended in the atmosphere; they can cause respiratory diseases such as asthma, bronchitis, emphysema and lung cancer; they are also harmful to the environment and the climate. Few researches have been carried out on the recovery of tiling waste in the construction sector. Tennich et al, 2015 [1] studied the influence of waste from marble and tile factories as a mineral addition on the hardened properties of Self-Placing Concrete (SCC). The results obtained show a favorable effect of all the additions both on the properties in the hardened state and on the microstructure of the SCC. Marble waste can be used in the form of sand and gravel in the production of concrete. Binici et al. [2], André et al. [3] and Martins et al. [4] all concluded that waste marble used as aggregate can improve the mechanical strengths as well as the durability properties of concrete. Hebhoub et al (2014) [5], used excess sand from waste marble exposed to weathering from the quarry derived from Fil-fila marble (Skikda, east of Algeria) and studied the effect of the substitution in the normal mortar of the sand standardized with rates of (25%, 50%, 75% and 100%) of marble waste sand. The published results have shown that the best performance in compression and in flexural tension is obtained for a substitution rate of 100% in the medium term (28 days). Djebien et al (2018) [6], introduced the marble waste as sand in the formulation of self-consolidating concrete SCC with variable percentages (25%, 50%, 75% and 100%) and found that the sand of Marble waste decreases the density, the air content, the flow in a confined environment as well as the mechanical resistance while giving this self-consolidating concrete a plasticization capacity which ensures cohesion and resistance to segregation.

Table 1. Concrete mixing ratios

<table>
<thead>
<tr>
<th>Control mix</th>
<th>BO cement + 100% crushed sand</th>
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<tbody>
<tr>
<td>B1 (0%)</td>
<td>cement + 10% of tile waste fillers + 100% crushed sand</td>
</tr>
<tr>
<td>B2 (10%)</td>
<td>cement + 10% of tile waste fillers + 90% crushed sand +10% waste marble sand</td>
</tr>
<tr>
<td>B3 (20%)</td>
<td>cement + 10% of tile waste fillers + 80% crushed sand +20% waste marble sand</td>
</tr>
<tr>
<td>B4 (30%)</td>
<td>cement + 10% of tile waste fillers + 70% crushed sand +30% waste marble sand</td>
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</table>
The main objective of this work is to reuse the marble waste as sand and the fillers resulting from the falls of tiles in the composition of concrete, in order to contribute to the elimination of waste that is harmful to the environment and to the economy of natural aggregate deposits.

2. Used materials

- Cement (CPJ-CEM II A-MS-L/42.5N) from cement factory (GICA) HJAR ESSOUD (SKIKDA).
- Tile's fillers, dust obtained after polishing the tiles.
- Quarry sand: crushed, class 0/4, coming from quarry of Laghdir-Skikda.
- Waste marble sand, class 0/4 recovered from derivatives quary marble of Fil-fila -Skikda.
- 4/8 and 8/16 gravel, coming from quarry of Laghdir-Skikda.
- The adjuvant is a high water-reducing super plasticizer «MASTER GLENIUM 3090»
- Mixing water (from tap, T0 = 28°C).

Particle size of aggregates are represented in figure 1.

3. Program

In the composition of common concrete, filler from tile waste has been used as an addition to cement and marble waste as a substitute for ordinary (crushed) sand. The rates tested are: 10%, 20% and 30% respectively. The behaviors of the concretes produced in the fresh state as well as in the hardened state were evaluated and compared with those of a control concrete initially composed of tile filler and ordinary sand.

4. Results and discussions

4.1. Unit weight

Real densities in the fresh state of common concretes are shown in Figure 2. The values shown are the average of three measurements.

4.2. Workability

Class of concrete meadows mixed with FC is fluid. Depending on the subsidence obtained in Figure 3, the consistency (the subsidence varies from 16 to 20 cm).

The introduction of tile polishing fillers as a substitute for cement decreased the workability of the control mix. This is the result of water retention by the particles of tile waste at the start of mixing.

The incorporation of an increasing rate of marble sand decreased the workability of the concrete. This reduction is due to the angular shape of the grains of the waste marble sand which is characterized by a high friction and which decreases the workability values of the concrete. Also, this can be attributed to the water retention by the marble just after mixing.

4.3. Occluded air

The results of the measurements of the occluded air carried out on the concrete are shown in Figure 4.

From figure 4, we notice that all the values recorded in the concretes containing the waste marble sand are included in an interval varying from 2.23 (B4) and 2.41% (B2) which are lower than that of the concrete witness.

The use of tile polishing fillers to decrease the amount of air entrained in the reference composition. This can be attributed to a filling effect on the part of the particles of the fillers.

The decrease in the amount of air trapped in marble sand mixtures is likely the result of the correct arrangement of sand grains in the matrix due to their shapes and smoothness as well as other factors.

The mechanical compressive strengths of all formulated concretes were measured at 7.14 and 28 days. The values of compressive strength thus obtained are represented as a function of the levels of marble sand in FIGS. 5, 6 and 7 respectively. These values are the average of three measurements.

Referring to the results illustrated in the figure opposite, it can be seen that the strengths of the concretes containing the tiling polishing fillers and the marble sand except for the mixture (B2) are lower than that of conventional concrete.

The resistance losses are of the order of: 24% (B1); 33.78 (B2); 3% (B3) and 6% (B4) respectively.
Figure 5. Evolution of compressive strength at 7 days

Figure 6. Evolution of the compressive strength at 14 days as a function of the rate of marble sand.

Almost the same trends seen at 7 days are repeated at the 14 day timeframe. The concrete containing the tile polish fillers and regular sand shows a resistance value that deviates from that of the control of 43%. On the other hand, concretes based on these fillers and marble waste sand show values which are close to those of the control of 26.38% (B2); 7.54% (B3) and 22.84% (B4).

The addition of 10% marble sand in the control concrete in substitution for ordinary sand gave a resistance equivalent to that of B1 but which deviates from that of the control by 25.53%. In addition, the introduction of 20% and 30% of marble sand improves the strengths of these two concretes compared to that of B1. The resistance losses relative to the control mix are of the order of 8.8% (B3) and 14.45% respectively.

The introduction of 10% tile polishing filler reduced the strength of concrete at an early age due to the delay in the hydration reaction. On the other hand, the values obtained at 28 days show that there is an improvement in the compactness of the mixtures as a result of the filling effect and plasticization of the sand of marble waste sand.

5. Conclusion

The results obtained from this experimental study allow us to draw the following conclusions:

- The introduction of waste marble sand in the composition of concrete makes it denser and decreases the value of the air content.
- Marble waste sand decreases the workability of common concrete.
- Concrete based on 10% tile polishing fillers and 20% marble waste sand develops a resistance at 28 days lower than that of the control by 8.8%.

Declaration of Conflict of Interests

They have no competing financial interests or personal relationships that appear to affect the work reported in this document.

References