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Engagement of marble powder in self compacting concrete

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Abstract: This study explores the outcome of using marble powder in the production of self-compacting concrete (SCC) by partial replacement of cement. Waste marble was collected from local workshops and crushed to small particle sizes then sieved on 75 microns. A percentage of cement of 5, 10 and 15 % was replaced by marble power at w/c ratio of 0.5, 0.55 and 0.6. Super-plasticizer was employed for all mixes with addition of sand and coarse aggregate. Fresh concrete workability then measured and compressive strength of self-compacting concrete was determined at 7 and 28 days, finally permeability of 28 days hardened concrete was tested. The results indicated that marble powder can be used as partial replacement of cement in self-compacting concrete with good concrete properties

Keywords: marble powder, super plasticizer, self-compacting concrete, compressive strength.

Introduction

Self-compacting concrete (SCC) is produced by engagement super plasticizers in concrete, the resulted high flow concrete sometimes called flowing concrete Neville, (1995), Due to the wide use of SCC in construction is essential to produce high quantity of cement which impacts on the environment by gas emission. And bad effect on land. Due to the large amount of waste materials like marble waste which become an issue in many countries, for example as what happened in the EU. The European parliament and the European union (2018) decided that waste management should be improved and transformed into sustainable material management. They felt the problem of waste material, especially on the environment and human health which should be protected, at the same time the Union decided to reduce the dependency on the imported resources, according to that, EU published a legislation report to reuse waste materials in the industry. The Partial replacement of cement by some waste materials like marble dust or glass powder is beneficial as that helps in reducing the waste material and minimizes gas emission from cement production, Ganaw et al.(2016). Marble powder was also employed in concrete as a mineral additive and resulted in good concrete mechanical properties as reported by Belouadah et. al.(2014) . Moreover, Khatib and others (2012) replaced cement by waste material powder and reported that concrete slump increases by powder increase with high strength at 10% replacement. Ural and Yaksi (2020) were employed waste marble particles to road construction with other materials and reported that the result is suitable as a base material according to the Technical Specifications of Turkish Highways. Ganaw et al. (2018) also replaced a part of cement by marble powder and proved that concrete strength was satisfied to many applications. Gulmez (2021) was employed waste marble powder and waste steel pieces to concrete and reported that flexural strength of concrete was improved until the powder percentage of 10%. Consequently, the use of waste materials like marble powder can be added to concrete to improve its properties and reducing the quantities of waste materials.

2. Used Materials

Ordinary Portland cement from Elmergib factory- Alkhums was used in concrete production with Blain fineness of 2950 cm2/gm and its initial and final setting times are satisfying to BS EN 196 – 3 (1995).

Water used in all mixes was taken from the school of engineering water network. It is suitable in the production of concrete. Fine aggregate used was imported from Zliten quarries. It was clean and its gradation satisfied the requirements of British standard BS 812:1992. Coarse aggregate was imported from local quarry in Alkhums with max aggregate size of 14 mm. Specific gravity and absorption of aggregate were 2.58 and 0.023 respectively.

All used marble in the research was collected from local marble workshops. Waste marble was collected and crushed in los angles drum machine, then sieved to pass 75 micron. After that all sample was collected and mixed again with the mixer for homogeneity. The material then kept in containers to the time of mixing. Marble powder Blaine surface area was 3500 cm2/gm.

Super plasticizer (Sika-Viscocrete) for SCC was used at 1% for all mixes.

3- Methodology

Concrete mix was first produced at w/c ratios of 0.45, 0.50 and 0.55 without any addition of marble powder, then cement was replaced by marble powder of 5%, 10% and 15% at the same w/c ratios and constant quantity of sand and coarse aggregate and 1% superplasticizer (SP) . Fresh concrete was mixed by the mixer and its workability was measured by the slump flow test according to the EFNARC 2002. Fresh concrete was casted in 150mm cubic moulds. After 24 hours concrete samples then removed from their forms and put in water for 7 and 28 days for permeability and compressive strength tests.

4. Discussion of test results

4.1 SCC workability

Figure 1 shows the relation between fresh SCC seepage and w/c ratio at different marble powder contents. It is clear that concrete seepage decreases with the increase of marble powder content for the same water content. Percentage of 15% marble dust at w/c ratio of 0.45 resulted in the lowest value of diameter of 655 mm and this still in the requirements of self-compacting concrete specifications EFNARC 2002 with (650 mm to 800mm) diameter.

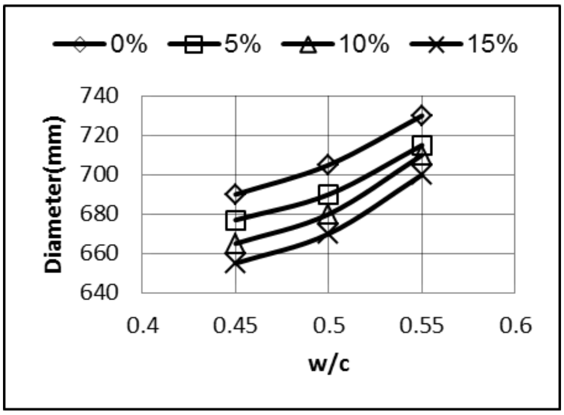

Fig. 1 Concrete seepage at different w/c ratios

4.2 Compressive strength of concrete

Figures 2 and 3 show the relation between hardened concrete compressive strength and w/c ratio at 7 and 28 days respectively for different marble powder contents. SCC compressive strength decreases with the increase in w/c ratio at both ages. Although both graphs show that as the powder content increases the strength decreases for all w/c ratios. It is well observed that compressive strength decreases with the increase in powder content for both ages with good strength especially at 28 days. Figures also show that as the w/c ratio increases the strength of concrete decreases due to the gel voids increase in hardened state.

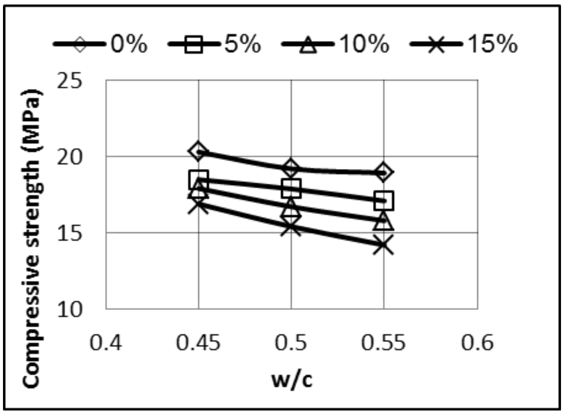

Fig. 2 Compressive strength vs w/c ratio at 7 days

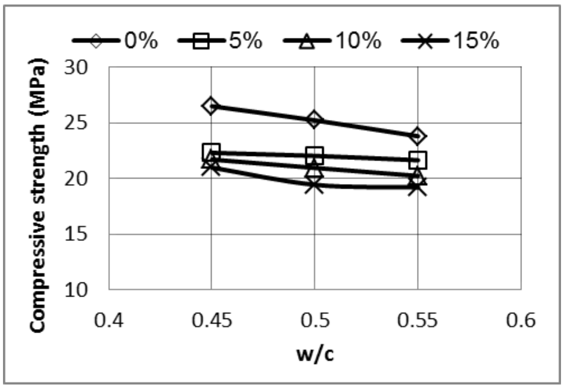

Figure 3 Compressive strength vs w/c ratio at 28 days

4.3 Water permeability depth

Figures 4 shows the relation between permeability depth in concrete and w/c ratio for different marble powder contents. It is very important to notice that water permeability depth decreases with the increase in marble powder content at all w/ ratios. From the relations it can be also noticed that permeability increases with the increase in w/c ratios for all samples. This result can be very useful when durability of SCC for durability is necessary.

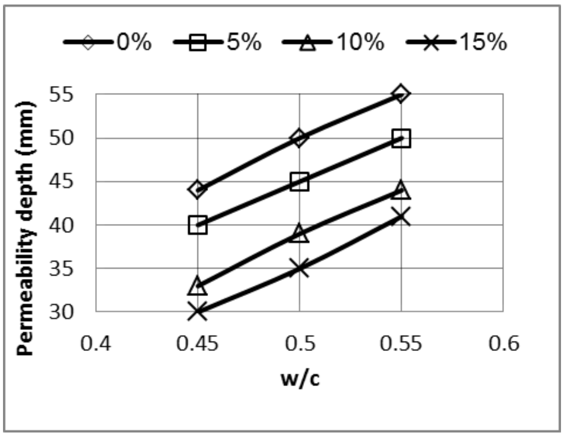

Fig. 4 Water permeability vs w/c ratio

5. Conclusions

From the investigation, it can be concluded that;

1- SCC with satisfied workability can be reached by the use of super plasticizer and a part of cement replaced by marble powder during concrete production.
2- Satisfied compressive strength was obtained even when replacement percentage reached 15% and production.

3- It is very useful to get lower permeability especially when durability is important and this was achieved by cement replacement by marble powder.

As a result, the replacement of cement by part of waste marble powder cement will minimize the cost of concrete production and results in low gas emission during cement production and protect the land from pollution.

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