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ScienceDirect

Procedia Engineering 161 (2016) 543 – 548

Procedia Engineering

www.elsevier.com/locate/procedia

World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium 2016, WMCAUS 2016

Durability Properties of Concrete Produced by Marble Waste as Aggregate or Mineral Additives

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Abstract

In recent years, the growth in the industrial production and the consequent increase in the corresponding consumption have led to a fast decline in available natural resources. However, a high volume of the industrial production has generated a considerable amount of waste materials which have a number of adverse impacts on the environment. In this regard, the marble industry produces a huge amount of waste in the last decades and grows significantly in time. The marble waste is generally a highly polluting type of industrial wastes due to its highly alkaline nature and its manufacturing and processing techniques, all of which impose serious health threats to the surroundings. In this study, effects of waste marble on some durability properties such as water absorption and permeability, chloride penetration and carbonation, sulphate attack and abrasion resistance, and lastly performance at high temperature and freezing and thawing cycles of conventional or self-compacting concrete were investigated. As a result, it was found out that the use of waste marble in the conventional or self-compacting concrete mix as an admixture material or aggregate is suitable as it can improve durability properties of the concrete. Especially, properties of water absorption & permeability and resistance of chloride penetration & sulphate attack were improved by incorporation of waste marble in concrete.

Peer-review under responsibility of the organizing committee of WMCAUS 2016

Keywords: Concrete; marble waste; durability; admixture; aggregate; recycling;

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Peer-review under responsibility of the organizing committee of WMCAUS 2016
doi:10.1016/j.proeng.2016.08.689

1. Introduction

Marble has been used as an important building material, especially for decorative purposes for centuries [1]. In processing marble such as cutting to size and polishing etc. for decorative purposes, marble dust and aggregate are created as by products [2]. During sawing, shaping, and polishing process, about 25% of the processed marble turns into dust or powder form [1]. Disposal and re-using of the waste materials of the marble industry is one of the environmental problems all over the world. As a solution to these negative effects, the literature suggests that the marble waste can be used in the construction industry as partial percent substitutes for aggregate, binder and additives in concrete. However, previous studies investigated this issue from different technical viewpoints and it seems necessary to examine the current positive, negative; and contradicting points in the use of marble waste in the concrete. By doing so, this study can have a potential to fill the above-mentioned gap in the literature. Therefore, in the present study, the effect of different usage areas of the marble waste on durability properties of concrete was investigated based on past studies. In this context, durability properties of concrete, such as (i) water absorption and permeability, (ii) chloride penetration and carbonation, (iii) sulphate attack and abrasion resistance and lastly (v) performance at high temperature and freezing and thawing cycles, were examined. Consequently, contributions of the marble waste to durability properties of concrete were presented as a whole in a detailed manner.

Fig.1. (a) Marble extraction [3]; (b) Remnants from plate cutting [3]; (c) Powder heaps [10].

2. Methodology

In this study, considering the previous studies, durability properties of concrete produced waste marble investigated in detailed manner. During the literature review, it was observed that the waste marble powder was used as mineral additives in cement or as fine/coarse aggregate in sand in producing conventional and self-compacting concrete mix. In these studies, effects of waste marble on some durability properties of concrete were investigated. In this study, these properties were grouped into (i) water absorption and permeability, (ii) chloride penetration and carbonation, (iii) sulphate attack and abrasion resistance, and lastly (v) performance at high temperature and freezing and thawing cycles. Consequently, effects of the waste marble on these properties of the concrete were evaluated in a detailed manner and reasons of results were established.

3. Results

3.1. Water Absorption and Permeability

Water absorption and permeability of results were summarized in Table 1. The most suitable replacement ratio of the waste marble was determined as 15-20% for water absorption and permeability of conventional or self-compacting concrete mix produced waste marble as binder or fine aggregate in the previous studies. This ratio has improved the water absorption and the permeability properties of conventional or self-compacting concrete. The reason for improved durability properties of the concrete was explained as filler effect. Waste marble additives fill the gaps within the concrete products, giving less porous structures. Thus, the uses of these wastes resulted in excellent durability, which in effect have positive effects on the concrete formation. Further addition of the waste marble decreased the strength and durability of concrete. This was because the addition of the waste marble beyond 15-20% makes the concrete results in a higher water demand due to its very high specific surface [4]. On the other hand, when