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Mechanical and Durability Performance of Concrete Made with Waste Marble and Fly Ash

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ABSTRACT

In recent years, cement and marble industries have raised concerns regarding the adverse impact on the environment due to the release of carbon di-oxide and disposal of marble sludge, respectively. The amalgamation of marble sludge (fines) and cement-based products is favorable in the manufacturing of sustainable concrete. In this study, marble powder (MP) obtained from nearby cutting and polishing marble industries is used as a partial replacement for sand. Fly ash (FS) used as a partial substitute for cement is acquired from a nearby situated plant of ready mix concrete, Jaipur, Rajasthan, India. MP was added with an interval of five percent as 5%, 10%, 15%, 20% and 25% by weight of sand. FS was added in a percentage range of 0-50% with an interval of ten percent by weight of cement in the concrete blend. Mechanical and durability parameters in terms of slump, density, compressive strength, flexural strength, splitting tensile strength, water absorption, permeability and rapid chloride penetration test (RCPT) were evaluated for control and blended mixes. Scanning electron microscopy (SEM) was also performed for microstructure analysis for control, MP, and FS added to concrete. The results indicate that 10 % MP and 20% FS were the optimum percentages of replacement for sand and cement, respectively. Significant outcome obtained from the results will have a potential impact on the manufacturing of sustainable concrete with a solution to an environmental problem.

KEYWORDS: Marble powder, Fly ash, Mechanical properties, Durability properties, RCPT.

INTRODUCTION

Concrete is an amalgamation of aggregates, cement and water and an admixture that is extensively used in production industry (Gautam et al., 2014). Limestone is a major source in the production of cement. Approx. 0.90 ton of carbon di-oxide is produced in the environment due to the construction of one ton of cement (Woodson, 2012). Manufacturing industries produce around 500 Million tone (Mt) of concrete per year in India (Pathak, 2009). The mandate of cement is probably to accelerate with the petition of concrete in upcoming years. The annual production of cement in 2017 was around 366 (Mt) in India (IBEF India, 2016). CO_2 production due to the manufacturing of cement is of great concern and can be overcome by using mineral admixtures (Naik, 2008). Waste marble causes health and environmental issues due to the emission of $Ca(OH)_2$ in the environment (Yang et al., 2015). In India, production of marble waste is around 3 million metric tons and out of this, 20-25 % is available as waste after quarrying and polishing (Montani, 2016; Aliabad et al., 2014; Aruntaş et al., 2010). Previously, investigators have considered marble waste as an alternative additive for cement in concrete mixes for construction works and building materials (Gesoğlu et al., 2012). The concrete casted with 10% diatomite as sand and 5% MP as partial replacement of cement showed an improvement in compressive strength (Shirazi, 2007). The use of marble dust as a cementitious material in self-compacting concrete showed an improvement in the workability of the blended mix (Ergün, 2011). Investigated use of 10 % of MP as a

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