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Partially replacement of Fresh Aggregate by recycled aggregate and cement by fly ash with admixture for rigid pavement concrete

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Abstract

With impending demand for sustainable development, construction wastes as recycled aggregate (RA) to produce recycled aggregate concrete (RAC) is inevitable. However, RA makes adverse effect on performance of RAC. To enhance its performance, the supplementary cementitious materials (SCM), including ground granulated blast furnace slag, red mud, and glass powder, were used to partially substitute cement. In this investigation, the plain cement concrete and mineral-admixture concrete with four replacement ratios of RA were poured. For each mixture, the compressive strength, dynamic elastic modulus, and resistivity were determined; Besides, chloride penetration test was conducted in a tidal cycling simulation device, in which specimens with dimension of 100×100×400mm³ were used to explore the effect of drying- wetting time ratios Roy on chloride diffusion. It was found concrete with 50%, RA exhibits improved compressive strength and equivalent chloride resistance Through 25% SCM addition, Concrete containing 100% RA achieves equivalent or even superior chloride resistance to control group as SCM added by 45%. With the increase of Row, the diffusion of chloride is more serious. Considering the inhomogeneity of concrete pores, a double-porosity transport model solution was derived based on Fick's second law. Combined with test results, a time- dependent model was then established to predict chloride concentration in concrete containing RA and SCM. Furthermore, an analytical solution of cumulative chloride content diffused into concrete was derived to quantify chloride permeability. Subsequently, a linear correlation between chloride permeability and resistivity is confirmed. This investigation will encourage the use of RA in marine engineering, thereby leading to a more sustainable and cleaner production

Introduction

Nowadays innovative construction materials have been investigated, considering mainly the sustainability issues and the physical-mechanical properties of materials produced considering a minimal level of performance desired. This is the biggest topic of works published worldwide in the last 5 years focusing on the use of different types of waste as aggregate in concrete production, as crushed brick, glass, ceramic waste, tiles and plastic waste (Meng etal., 2018). As an example, all commercial glasses are based on silica, which consists of more than 70% SiO2, it is believed that glass waste can be crushed and classified into desired particle sizes as aggregates or as a pozzolanic material for applications in the construction industry (Ling etal., 2013). The addition of glass powder by up to 20% can be used as a replacement for the cement to improve the long-term mechanical properties of concrete, including compressive, and flexural strength, where the ideal replacement level for powder glass was found as 10% (Mehta and Ashish, 2020), Crushed waste glass (CWG) has the potential to be a suitable replacement for aggregate in asphalt mixtures. Despite this, a maximum of 15% of aggregate can be replaced with crushed waste glass in asphalt mixes to obtain suitable performance and durability of the pavement. Besides, glass powder, when used as filler in asphalt, achieved superior stability values compared to ordinary Portland cement and limestone powder (Mohajerani etal., 2017). The increasing generation of waste from various sources, such as urban renewal and inefficient construction processes, usually causes a major environmental problem, mainly through the production of large quantities of construction and demolition waste (CDW). In this context, recycling CDW for use as aggregates in production of new concrete can help to minimize the disposal problem and thus preserve natural resources (Dakwale and Ralegaonkar, 2014). Currently, three major types of RA are being generated; the concrete recycled aggregate (CRA), the masonry recycled aggregate (MRA) and mixed recycled aggregate (RA). The RA is a waste results from construction activities and total or partial demolition of buildings and infrastructure elements and landslide debris. Its composition consists mainly of concrete, bricks, excavated soil, metals, glass, plaster, wood, plastic and various polymers, many of which can be recycled (Silva et al., 2017). As a rule, many studies have shown that the use of MA in concrete indicates a loss of performance in most of the properties analysed, mainly due to

its low density. poor resistance to abrasion, higher water absorption and porosity, due mainly to the presence of old mortar on the aggregate surface (Li, 2008). In fact, recycled aggregate is routinely used in most countries, however, most applications include use in pavement layers of low-traffic roads and non-structural concrete elements, as their requirements are not as stringent as those of structural elements (Silva etal., 2019).

According to Xu and Shi (2018), the great challenge of pervious concrete is to achieve the adequate balance between the conflicting properties, i.e., to obtain high mechanical properties, permeability and water infiltration with low clogging. In this study, the influence of fly ash and construction and demolition waste in pervious concretes was studied. Therefore, the following performance tests were implemented: compressive and flexural strength, surface abrasion, in addition to permeability coefficient, infiltration rate, clogging, scanning electron microscopy (SEM) and x-ray microtomography. The valorisation of RA and fly ash use can contribute to minimizing the environmental impacts, being important for the development of a new category of construction materials.

Fly Ash

Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases.
Fly ash is also afiller in paints, adhesives, and metal and plastic composites. It's commonly used as structural fill for road construction and fly ash can be used to make bricks, ceramic tiles, plaster, Portland cement, and ready-mix cement.

Recycled aggregate

Recycled aggregate concrete (RAC) is an alternative to using natural aggregate (NA) in concrete. Recycled concrete aggregate (RCA) are aggregates obtained by recycling clean concrete waste wherecontent of otherbuilding waste must be low – below few per cent.

Fly Ash

Recycled Aggregate

Materials characterization

It was used the Brazilian early-age Portland cement CPV, which follows the prescriptions of Brazilian standard NBR 16697 (ABNT, 2015), similar at ASTM Type III cement, that presents a specific gravity equal at 3.07 g/cm³, density of 0.99g/cm³ and compressive strength of 54.2MPaat 28 days. Fly ash was used to replace cement in specific mix proportions of pervious concrete, which has a specific gravity of 1.98g/cm³. Fig. 1 shows the results of the x-ray diffraction (XRD) analysis of the.

Compressive strength and flexural strength

Must be observed the decrease of compressive strength with the increase of RA replacement. The greatest decrease was observed in PC-A-100 samples, (62.5% smaller than reference concrete), whose behavior was already reported in the literature. Özalp etal. (2016) obtained a 20% reduction in compressive strength for a 20% RA replacement. The results of EL-Hassan etal. (2019) showed that for 70% and 100% of RA replacement a...

Conclusions and recommendations for further studies

The main objective of this investigation was to analyze the use of RA from construction and demolition residues and fly ash in pervious concretes. Based on the results obtained; it is possible to draw some relevant conclusions:

- It was found that mechanical properties decrease with smaller w/b ratio. This fact must be associated with the difficulty of water dispersion considering the paste hydration. So, the use of the highest w/b ratio or superplasticizers is recommended for pervious concrete.

TYPE OF TESTS

PROPERTY	TYPE OF TEST	METHOD OF TEST
Specific gravity	Specific gravity	IS:2386(part3)
Toughness	Aggregate impact test	IS:2386(part4)
Hardness	Loss Angeles abrasion test	IS:2386(part5)
Setting time	Consistency test	IS: 4031(part4)
Workability	Slump cone test	IS:1199-1959
Consistency of fresh concrete	Flow table test	IS:1199-1959
Compressive strength	Compressive strength	IS:516-1959
Tensile strength	Split tensile strength	IS:516-1959
Durability test for harden	Acid attack test	IS:516-1959

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CONCLUSION

Based on literature survey It was concluded that waste materials the Recycled Concrete Aggregate (RCA) will be used in the percentage of 0, 20, 25, 30, 35, 40% by the weight of coarse aggregate and (GGBS) will be replaced in the percentage of 0, 20, 25, 30, 35, 40% by the weight of cement is suitable for low cost concreting without affecting strength of the concrete. As per IRC 44, M30 grade was chooses for testing. From literature survey the characters of GGBS and RCA studied. The defects of using RCA like increase water absorption and reducing workability is compensated by GGBS. Because GGBS increase stiffness, reduce porosity in concrete mix.

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