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Effects of Green Supplementary Materials on Engineering Properties of Recycled Aggregate Concrete

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Abstract: **In the construction industry, concrete is the most common and useful material. Concrete has contributed to the advancement of civilizations throughout history. In recent years, the accelerating urbanization causes excessive works of destruction and construction activities. Minimizing the construction waste is biggest issue and an important sustainable solution to utilize construction waste is Recycled aggregates concrete (RAC). Partial replacement of natural aggregate with recycled aggregate reduces the need of virgin aggregates in concrete. Use of recycled aggregate in concrete can be one as the key solution for environment protection and economical. With increased environmental awareness utilization of industrial byproducts and waste has become an attractive alternative to disposal. The various green Supplementary materials which are byproducts & waste like slag, fly ash, silica fume, quartz, cement kiln dust, industrial sludge, limestone, quarry dust, rise husk ash are very effective in the design and development of enhancing strength and durability characteristics in performance of concrete. In this paper, the effects of green Supplementary materials are measured to improve the quality of RAC as green concrete.**

Keywords: Byproducts, Green Supplementary Material, Recycled aggregates (RA), Recycled aggregates concrete (RAC)

1. INTRODUCTION

Construction and demolition waste a large amount of waste material was generated, in which includes broken– clay tile or brick, glass and waste concrete in construction site, after process of demolishing, decorating and repairing work as well as new construction project. The effective disposal of such waste materials is extremely to be faced out for almost countries.

Construction also has a major impact on the environment in its consumption of energy, both directly and embodied in the materials that it uses. The large bulk of materials used consume a great deal of energy for transport. Taking into account both direct use and embodied energy, the construction industry consumes about 4.5% of the national total as a consequence of this energy consumption, construction generates over 40 million tonnes of carbon dioxide which contributes to global warming from the greenhouse effect. Acid gases and oxides are also produced which directly cause to acid rain and photochemical smog production. Throughout the construction cycle especially at the end of a structure's life, large quantities of waste are produced. Significant quantities of waste are also generated by the construction process itself. Much of this wastage is avoidable on site, but inattention to design detailing inappropriate material also contributes to waste.

The use of recycled materials is increasing worldwide in the past decades for purposes of environment protection and sustainable development. In fact, a large number of researches have been conducted on employing recycled materials in construction field. One of the main reasons to use RAC in structural concrete is to make construction more ''green'' and environmentally friendly.

Pozzolan materials primarily affect the pore structure refinement of concrete, which leads to higher strength and lower permeability. It has been reported that incorporation of silica fume in concrete produces higher strength and increased durability. Fly ash increases in strength, density, durability, reduced alkali silica reactivity, reduced heat of hydration in concrete. Limestone is a type of rock, mainly composed of calcium carbonate. Limestone is quarried (dug out of the ground) and used as a building material. It is also used in the manufacture of cement, mortar and concrete. Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide. The produced partially burnt husk from the milling plants when used as a fuel also contributes to pollution and efforts are being made to overcome this environmental issue by utilizing this material as a supplementary cementing material. Use of RHA with cement improves workability and stability, reduces heat evolution, thermal cracking and plastic shrinkage. This increases strength development, impermeability and durability by strengthening transition zone, modifying the pore-structure. RHA minimizes alkali-aggregate reaction, reduces expansion, refines pore structure and hinders diffusion of alkali ions to the surface of aggregate by micro porous structure. Slag is a byproduct of an iron blast furnace, part of an integrated steel mill. When molten slag is separated from iron in a blast furnace. Slag cement is generally used to replace Portland cement in concrete, depending on application, job requirements and environmental conditions.it Reduces Portland cement in concrete and save overall cost.

2. OBJECTIVE

To study the various researches conducted on Green Supplementary Materials (Industrial byproducts and Waste) incorporating with RAC.

3. LITERATURE REVIEW

S.C. Kou, C.S. Poon[7] conducted study on use of RA in concrete would reduce its compressive strength as shown in figure 1 and 2 and render the concrete less durable. At the same recycled aggregate replacement level, the use of fly ash as a partial replacement of cement decreased the compressive strength but fly ash as addition of cement with 25% at 90 days increased the compressive strength.

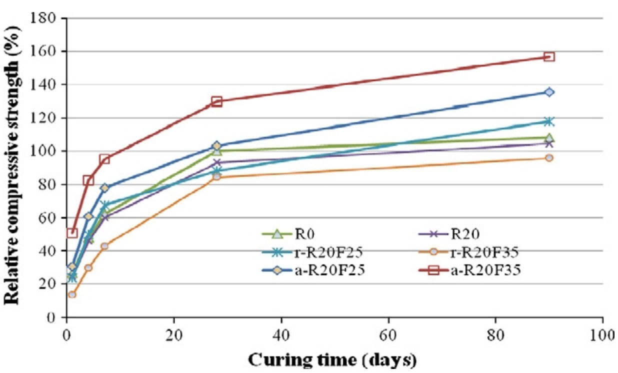

Figure 1 compressive strength of 20% RA with fly ash

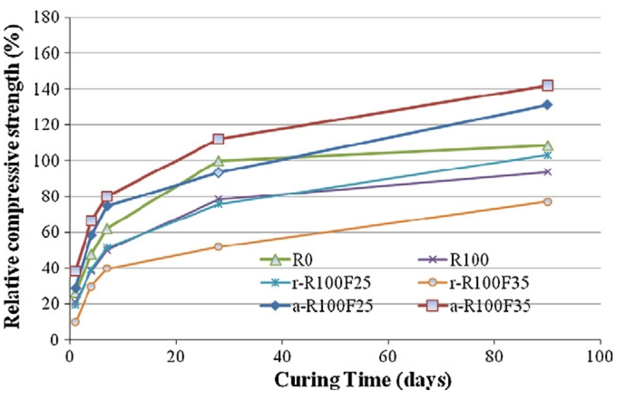

Figure 2 compressive strength of 100% RA with fly ash

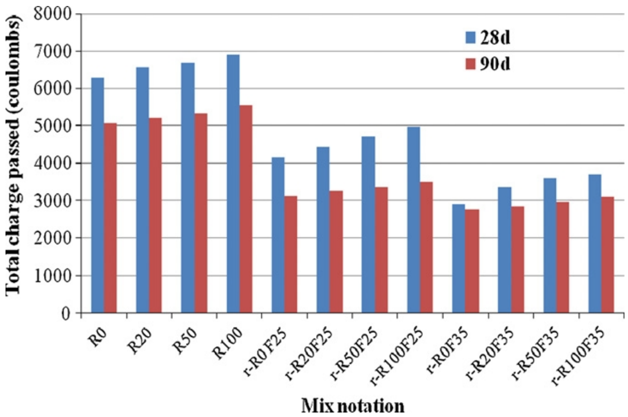

Figure 3 Chloride-ion penetration tests

Also the drying shrinkage of concrete increased with an increase in the RA content. The resistance to chloride ion penetration decreased as the RA content increased as presented in figure 3.However, the resistance was improved by incorporating fly ash in the concrete mixtures. The use of fly ash as a partial of cement and an addition of cement significant decrease the water absorption of RAC.

L. Evangelista, J. de Brito[2] investigated that use of fine recycled concrete aggregates to partially or globally replace natural fine aggregates in the production of structural concrete. To evaluate the viability of this process, an experimental campaign was implemented in order to monitor the mechanical behavior of such concrete. The compressive strength does not affected by the fine aggregate replacement ratio, at least for up to 30% replacement ratios as shown in figure 4. Tensile splitting and modulus of elasticity are reduced with the increase of the replacement ratio but both properties are still acceptable, especially for reasonable levels of the replacement ratio (30%). the abrasion resistance seems to increase with the replacement of fine natural with fine recycled concrete aggregates.

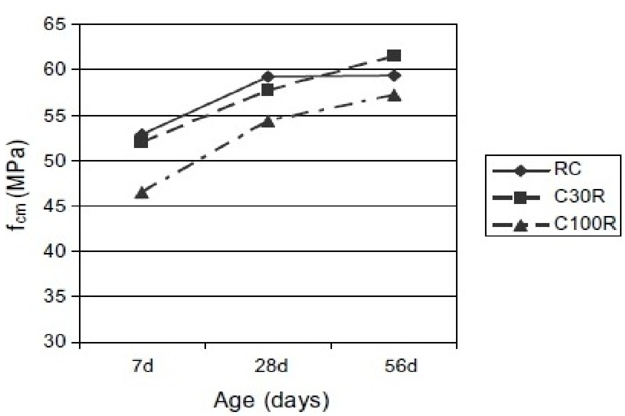

Figure 4 Compressive strength variations

Ozgur Cakır, Omer Ozkan Sofyanlı[5] studied the effects of incorporating silica fume (SF) in the concrete mix design to improve the quality of RA in concrete. Portland cement was replaced with SF at 0%, 5% and 10%. Specimens were manufactured by replacing natural aggregates with RAs. Two size fractions (4/12 mm and 8/22 mm) as RAs were used and four series of concrete mixtures were produced. The compressive strength decreased with increase in the silica fume content. The concrete with 10% SF and having 4/12 mm fraction RA showed a better performance than the other concrete series in terms of the physical and the mechanical properties.

R. Sathish Kumar[6] conducted experimental study to find the suitability of the alternate construction materials such as, rice husk ash, sawdust, recycled aggregate and brickbats as a partial replacement for cement and conventional aggregates. For this concrete cubes of 150mm x150mm were casted with various alternate construction materials in different mix proportion and with different water cement ratios. The compressive strength of rice husk ash concrete was found to be in the range of 70-80% of conventional concrete for a replacement of cement up to 20%. The study shows that the early strength of rice husk ash concrete was found to be less and the strength increased with age. From the cost analysis it was found that the cost of Rice husk ash concrete was less compared to conventional concrete.

M.Courtial, N.deNoirfontaine, F. Dunstetter, M. Signes-Frehel, P. Mounanga, K. Cherkaoui A. Khelidjstudy[4] analyzed study to find an extrudability formulation of Ultra High Performance Concretes (UPSC) usable in an aggressive environment. In this study, the only variable parameters are the polycarboxylate (PCE) dosage and the crushed quartz to micro silica ratio. This paper compares the microstructure of five UHPC formulations intended for extrudability, in order to highlight the macroscopic properties. The varying parameters were (i) the content in polycarboxylate super plasticizer and (ii) the substitution of silica fume (25%) by crushed quartz in UHPC with W/C of 0.16. The macroscopic variations in terms of rheology and extrusion, shrinkage, mechanical properties and durability have been highlighted here at the microscopic scale. No visible change on the microstructure is observed without crushed quartz and within the range of compositions in polycarboxylate from 0.5% to 1.8%, an addition from 1.8% to 2% of polycarboxylate causes strong effects on the microstructure in presence of crushed quartz.

M. Arabani, A.R. Azarhoosh[3] carried out study to determine the mechanical properties of asphalt mixtures with RAC and steel slag aggregates. Six different asphalt mixtures containing three types of aggregate (dacite, recycled concrete and steel slag) were used to prepare Marshall specimens and to determine the optimal asphalt binder content. The mechanical characteristics of the mixtures were evaluated by Marshall Stability, indirect tensile resilient modulus, dynamic creep and indirect tensile fatigue tests. When RCA was used as a fine aggregate (FA) in asphalt mixtures and steel slag was used as a fine or course aggregate (CA), the Marshall Stability increased and flow decreased. In the dynamic creep test, the optimal mixture is contained steel slag coarse aggregates and recycled concrete fine aggregates. As a result, permanent deformation in the optimal mixture was 40% less than the control samples. In the indirect tensile resilient modulus test, the use of RCA fine aggregates and steel slag coarse aggregates significantly increased the resilient modulus as shown in Figure 5.

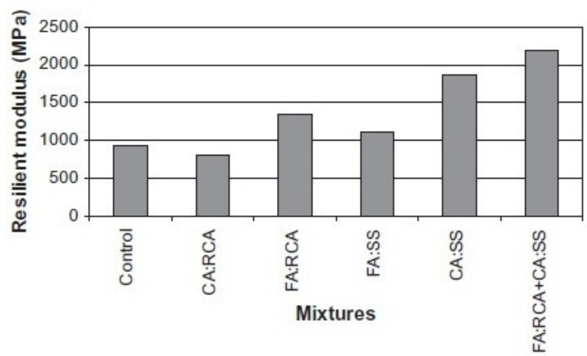

Figure 5 The indirect tensile resilient modulus.

Moreover, the highest modulus was obtained with the FA:RCA + CA:SS mixture, which presented a modulus that was 2.35 times greater than that of the control.

Khalid M. Shaheen, Ehab E. Aziz[1] conducted study on recycling of waste concrete and limestone resulting from processing raw limestone. The recycled concrete and limestone were used as coarse aggregate in concrete mixes. Tests applied on the resulting fresh and hardened concrete were slump, compressive strength, flexural strength, splitting strength and modulus of elasticity tests.

Recycled aggregate concrete has good strength about 53.4 MPa for mix with 100% crushed concrete aggregate and 38.7 MPa at mix with 100% crushed limestone aggregate at 28 days as shown in Figure 6. The strength of concrete with 100% limestone aggregate lower than that of natural aggregate concrete for the same mix proportion. Variation in strength ranged between 25.4% - 36.2% through the ages 7 - 56 days. The absorption in mixe with 100% crushed concrete aggregate and other mix with 100% crushed limestone aggregate greater than that of reference mix with 100% natural aggregate concrete at about 54% and 74%, respectively.

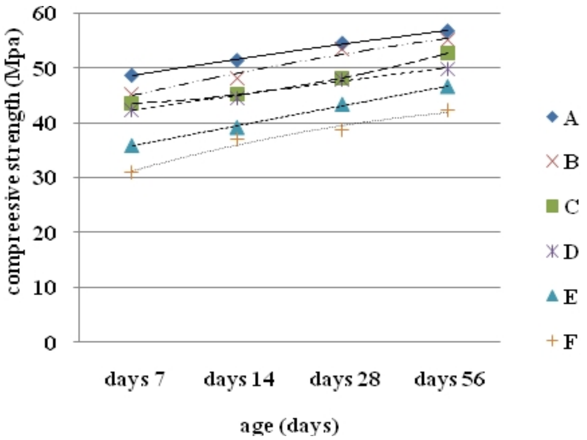

Figure 6 Compressive Strength Development

4. OUTCOME

From the various researches conducted on RAC with Green Supplementary material, the critical outcomes are as follows:

- Use of RA in concrete would reduce its compressive strength but use of fly ash as Supplementary of cement with 25% can give higher compressive strength at longer period.
- Use of recycled fine aggregates to partially or fully replace natural fine aggregates decreases compressive strength, Tensile Splitting and Modulus of Elasticity but still can be to the limit as IS 456:2007.
- The concrete with 10% SF and having 4/12 mm fraction RA showed a better performance in RAC.
- The compressive strength of RH concrete was found to be in the range of 70-80% of conventional concrete for a replacement of cement up to 20% and cost of RH concrete was less compared to conventional concrete.
- Extrudability formulation of Ultra High Performance Concretes with the substitution of SF (25%) by mineral quartz in UHPC with W/C of 0.16 No visible change on the microstructure is observed.
- Use of RCA fine aggregates and steel slag coarse aggregates significantly improve the elastic modulus.
- The compressive strength natural aggregate concrete was found to be 25.4% - 36.2 % greater than that of mix concrete with 100% limestone aggregate concrete.

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