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Performance assessment of nano-Silica incorporated recycled aggregate concrete

Bibhuti Bhusan Mukharjee*[1] and Sudhirkumar V Barai[2a]

[1]Department of Civil Engineering, Biju Patnaik University of Technology, Odisha, India
[2]Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur, India

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Abstract. The present study targets to access the consequence of utilization of coarse aggregates retrieved from waste concrete as a substitution of coarse fraction of natural aggregates and silica nano-particles as partial substitution of cement using principles of factorial design. Furthermore, procedures of design of experiments are employed to examine the effect of use of recycled aggregates and nano-silica. In this investigation, compressive strength found after at 7, 28, 90 and 365 days, split and flexural tensile strength, ultrasonic pulse velocity and rebound number and are chosen as responses, whereas the percentages of recycled coarse aggregates (RCA%) and nano-silica (NS(%)) are selected as factors. Analysis of Variance has been conducted on the experimental results for the selected responses with consideration the both factors, which indicates that RCA (%) and NS (%) have substantial impact on the various responses. However, the present analysis depicts that interaction between factors has considerable effect on the chosen parameters of concrete. Furthermore, validation experiments are carried to validate these models for compressive and tensile strength for 100% RCA and 1% NS. The results of comparative study indicates that that the error of the estimation determined using the relevant models are found to be small (±5%) in comparison with the analogous experimental results, which authenticates the calculated models.

Keywords: ANOVA; colloidal nano-silica; recycled aggregate concrete; design of experiments

1. Introduction

The demolition of old concrete infrastructures is causing significant material flows of concrete debris that creates several environmental problems. The non-availability of sufficient space for dumping of these materials, pollution and high cost of waste treatment are such problems faced by many countries (Trankler *et al*. 1996). Simultaneously, lack of natural recourses to mitigate the growing demands of quantity of natural aggregates for concrete industry is another problem faced by human civilization. Moreover, cost of natural aggregates are increased many folds by transporting these from lager distances to construction site. In other words, lack of natural resources for production of aggregates, growing requirements for raw materials and environmental issues associated with waste generated during construction and demolition activity, and shortage of dumping sites encourages researchers for searching an innovative application of these materials.

Therefore, researchers and engineers are trying for effective utilization of recycled waste concrete by generating aggregates for production concrete as it produces enormous environmental benefits, for instance; decrease of emission of CO_2 to air of other pollutants and preservation of natural sources (Taha *et al*. 2014). Aggregates retrieved from waste concrete pieces may be divided into coarse and fine fractions according to their grading. However, previous studies demonstrated that characteristics of these aggregates were poorer to that of natural aggregates because of the existence of old porous attached mortar in it (Rao *et al*. 2011, Mukharjee and Barai 2015b). The effects of using recycled aggregates as a fractional or entire substitution of natural aggregates in making concrete mixes are well explained and extensively documented in literature.

The first collective information about usage of aggregates produced from waste concrete pieces for the generating new concrete was available in the review work by Nixon (1978). De Oliveira and Vazquez (1996) studied experimentally the impact of adsorbed moisture of recycled aggregates on the compressive strength (CS) of newly fabricated RAC. In this study, the influences of varying moisture conditions (dry, saturated and semi-saturated) of recycled aggregates on the CS of RAC were compared. Minor reduction in CS was detected for concrete made from dry and fully saturated Recycled Coarse Aggregates (RCA) as compared to that semi saturated RCA. Batayneh *et al*. (2007) produced RCA by recycling the specimens of previous laboratory investigations and utilized those aggregates as substitution of natural aggregates for fabrication of new concrete. The outcome of this study was that the decrease in CS of concrete made with the 20% substitution of natural aggregates of by recycled crushed concrete was around 13%. Reduction of mechanical properties of concrete with the replacement of Natural

*Corresponding author, Associate Professor
E-mail: capgs.bbmukharjee@bput.ac.in, bibhuti.2222@gmail.com
[a]Professor
E-mail: skbarai@civil.iitkgp.ernet.in

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