ABSTRACT

Globally, the utilization of concrete particularly high-strength concrete has been increasing day-by-day due to rapid industrialization and infrastructural developments. An enormous quantity of natural coarse aggregate is required for making concrete to meet the huge demand. The natural resources of coarse aggregate are depleting rapidly all over the world and urgently need to be conserved. On the other hand, millions of tonnes of construction and demolition (C&D) wastes are being generated from different sources. The disposal of these huge quantities of C&D waste is posing a big problem to the local administration and environment. Further, there are areas where the natural coarse aggregates are scarcely available and are hauled from long distances. These issues have to be addressed urgently. A review of the literature suggests that obtaining the coarse aggregates from C&D waste is a possible solution to these issues. Therefore, in the present work, an experimental attempt has been made to utilize the recycled coarse aggregate (RCA) from C&D waste to the maximum possible extent for producing the high-strength concrete.

So far, most researchers utilized the recycled concrete aggregate (RCA) from C&D waste for producing low-strength concrete. Only a few researchers have utilized RCA for making high-strength concrete. The utilization of recycled aggregate (RA) in high-strength concrete has been restricted to 25-30% only because of its poor quality. They have reported that the adherent cement mortar present on the surface of RA is the main cause for poor quality. Researchers in the past have used different processing techniques to reduce the quantity of adhered material. These techniques are; heating and rubbing method, eccentric–shaft rotor method, acid wash method and water wash method. The various mixing approaches; normal mixing approach (NMA), two-stage mixing approach (TSMA) and three-stage mixing approaches have been used for making recycled aggregate concrete (RAC). From a literature review, it is observed that, the performance of RAC can be improved better by using TSMA rather than NMA. While utilizing the TSMA, previous researchers have used six variants where as in the present work, another ten new variants have been tried. In addition, a processing technique called ‘straightforward mechanical grinding’ has been used to find out the maximum possible replacement level of natural aggregates. The main aim of the present work is to utilize the recycled aggregate and to decide the optimum level of replacement quantity for producing high-strength concrete, which performs satisfactorily.
The experimental work has been carried out in two phases: (i) Influence of processing technique on RAC and (ii) Influence of mixing approaches on RAC. The mix proportion of M75 grade was kept constant throughout the study. First, the influence of processing technique on the properties of high-strength RAC has been studied to select the most suitable processed recycled aggregate for making high-strength concrete. In the second phase, the influence of various two-stage mixing approaches on the properties of high-strength RAC has been studied to select the most appropriate two-stage mixing approach.

For processing RA, the Los Angeles abrasion machine with ten steel balls in the revolving drum was used. Four types of recycled aggregate (RA) were generated by adopting the number of revolutions of drum as 0, 200, 500 and 700 in the processing technique. The recycled aggregates, namely: i) un-processed recycled aggregate [PRA(0-RVS)] ii) processed recycled aggregate with 200 revolutions treatment [PRA(200RVS)], iii) processed recycled aggregate with 500 revolutions treatment [PRA(500RVS)] and iv) processed recycled aggregate with 700 revolutions treatment [PRA(700RVS)] were made to replace the natural aggregate in this study. For each type of PRA, the virgin coarse aggregate has been replaced in percentages varying from 0 to 100 in steps of 10. The suitable degree of processing has been decided by comparing the results of processed recycled aggregates with those of un-processed recycled aggregate. Finally, the PRA(500RVS) has been selected as the most suitable processed recycled aggregate based on the workability, mechanical and durability properties of RAC. The normal mixing approach has been used in this phase of the work.

In the second phase, the influence of mixing approaches on the properties of RAC has been studied to select the most appropriate two-stage mixing approach (TSMA). Total ten new variants of two-stage mixing approach (namely: TSMA-1, TSMA-2, TSMA-3, TSMA-4, TSMA-5, TSMA-6, TSMA-7, TSMA-8, TSMA-9 and TSMA-10) were used. The PRA (500 RVS) which was finally selected in the first phase, has been used to replace natural aggregates in all ten two-stage mixing approaches. In each of the two-stage mixing approach, the replacement of virgin aggregate with PRA(500RVS) was varied from 0 to 100% in steps of 10%. The experimental results of each TSMA were compared with the results of normal mixing approach (NMA) to know the influence of mixing approaches on RAC. The two-stage mixing approach-2 (TSMA-2) has been found as the most appropriate variant based on the workability, mechanical and durability properties of RAC.
The various properties of each of the resultant concrete mixes are: i) workability, ii) mechanical properties (density, compressive strength, flexural strength, split tensile strength, modulus of elasticity, ultrasonic pulse velocity and iii) durability properties (water absorption, sorptivity, chloride-ion penetration, drying shrinkage, abrasion resistance) have been studied. The scanning electron microscopy (SEM) has been performed on samples of RAC to study the influence of processing technique and mixing approaches at interfacial transition zones (ITZ).

In conclusion, the two-stage mixing approach, TSMA-2 with processed RA, PRA(500RVS) has been found to produce satisfactory results in respect of all the above properties. In the present case, the 50% replacement of natural aggregate (NA) with processed recycled aggregate (PRA) has been found possible to achieve the target strength of M75 grade concrete mix. This combined technique is simple and easy to adopt in the field to produce high-strength concrete. It obviously solves the problems associated with disposal and environmental impacts of C&D waste and will help conserve the natural resources of aggregates.

This combined processing technique and two-stage mixing approach may be suitable to produce high-strength concrete utilizing RA obtained from C&D waste of different sources.