EXPERIMENTAL STUDY OF FLEXURAL BEHAVIOUR OF BEAM AS PARTIAL REPLACEMENT OF NATURAL COARSE AGGREGATE WITH RECYCLED CONCRETE AGGREGATE

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Abstract

The effect of utilizing recycled concrete aggregates on the flexural behavior and ultimate ability of reinforced concrete beams is investigated experimentally in this work. Flexural testing was performed of five reinforced concrete beam specimens to failure. The recycled concrete aggregate replacement ratio was one of the parameters studied at 0 percent, 20 percent, 40 percent, 60 percent, and 100 percent. The specimen's test results were compared to standard beam specimens composed of natural coarse aggregates. The investigational findings of recycled concrete aggregate beams were compared to the results of the natural coarse aggregate beam. The conclusions of the tests showed that engaging recycled coarse aggregate had no observable influence on the flexural strength of the tested beams up to 60 percent.

Keywords: Recycled Concrete Aggregates, Natural Coarse Aggregate, Flexural Beam, Construction and Demolition, Interfacial Transition Zones

Introduction

Concrete is the major construction material in the National Capital Region and most countries of the world. However, India suffers from a lack of the natural resources needed for concrete production. It is well known that 60 percent to 75 percent of the concrete volume is made up of aggregates. Approximately 20,000 tons of concrete debris is discarded every day, and half of that quantity is converted to RCA [1]. The use of recycled concrete aggregates (RCA) in concrete applications has major economic and environmental benefits. RCA can partially replace the relatively expensive imported NCA, thus saving on the total cost of the concrete projects. Recycling C&D waste will have a significant environmental impact due to the reduction in demand for natural aggregates. Furthermore, using waste materials would moderately resolve an important environmental concern approximately landfilling the large quantities of C&D waste produced every year. There has been always a general certainty around the unwanted influence of using RCA in concrete production. That is because of the presence of two interfacial transition zones (ITZ) in the RCA concrete ITZ between NCA and residual mortar in RCA and ITZ between the residual mortar and the fresh mortar compared with only one ITZ in the NCA concrete. Though, several publications have contradicted this idea [2-4]. Several researchers have examined the performance of RCA in structural concrete [5–8]. It was stated that RCA has inferior water absorption and porosity characteristics in comparison to NCA [1]. Therefore, a proper mix design is necessary to obtain the required quality of concrete made of RCA [9]. In general, the quality of RCA is governed by the quality of the original concrete it had been recycled. Silva et al. [10] showed that the classification of RCA based on their quality can be used to produce concrete with an expectable performance. McNeil and Kang [11] reported that using RCA resulted in a decrease in the comp. strength, the modulus of rupture, and the modulus of elasticity of RCA concrete compared to normal concrete. In addition, several publications reported the effect of different RCA surface pretreatment methods on fresh and hardened properties of concrete mixtures made with surface-treated RCA [12-14]. Yehia et al. [15] studied the properties of concrete with 100 percent content of RCA in terms of strength and durability. According to the authors, the strength and quality of RCA depend on the condition of exposure and loading condition of demolished structures. A few studies investigated experimentally the flexural properties of RC beams made with RCA. Choi and Yun [16] studied the flexural behavior and long-term deflection of beams made with RCA under sustained loads for 380 days. According to their study, the maximum flexural strength of beams made with NCA was 20 percent higher than that of the beams with RCA. Similar crack patterns were observed regardless of the type of the aggregate. However, more cracks were present in beams made with RCA. The ratios of long-term to instantaneous deflection for beams made with RCA were smaller than the ratio for the beam made with NCA. In addition, a rezoum and et al. [17] reported that deflection corresponding to the ultimate flexural strength of a beam made with RCA is about 13 percent higher than the comparable beam made with NCA. Knaack and Kurama [18] tested beams with both 50 and 100 percent RCA replacement levels. They reported an increase in the deflections as the amount of RCA increased. Similar results were reported by Song et al. [19].

The experimental program comprises two parts: the first part aims at investigating the mechanical properties of concrete made with RCA in terms of compressive and flexural strengths. The second part aims at investigating the flexural behavior of beams content RCA under the four-point loading test.

Research Methodology

Washed sand was used as fine aggregates in all concrete mixes. The cement was an Ordinary Portland Cement was used in the mix. The two coarse aggregates in this research were NCA and RCA with a maximum size of 20 mm. The w/c ratio of the mix was 0.46. The target comp. strength of concrete was 30 MPa. Five different replacement ratios of RCA namely 0 percent, 20 percent, 40 percent, 60 percent, and 100 percent by weight were added. As the RCA is characterized by its higher water absorption due to the attached old Adhared mortar compared with NCA, the amount of free water in the concrete mixture plays a significant role in the development of the hardened properties of the resulting concrete. For this reason, RCA and NCA were washed and immersed in water for 24 hours before mixing, and then the surface moisture was dried with a moistened cloth. This is to ensure that both aggregates were in a saturated surface dry condition at the time of concrete mixing. Water absorbed by saturated aggregates was not included in calculating water to cement content. This is to ensure that the remaining amount of water is approximately the same and is enough to ensure the hydration of the cement particles in the concrete mix. The direct volume replacement (DVR) mix design method was adopted to calculate the concrete mixture proportions.

Results and Discussion

Compression Strength Test and Flexural

The flexural and compression tests were conducted as per IS: 516 1959. For the flexural tensile strength test size of beam 150mm × 150mm × 700 mm were tested, and the average of three specimens for each mix was selected. For the compressive test, three cubes from each mix with a dimension of 150 mm × 150 mm x 150 mm were tested then the average compressive strength was selected. All specimens were cured for 28 days and tested.

To study the flexural behavior of beams content RCA, the test was carried out on large-scale beams with a size of 150 mm × 250 mm × 2550 mm that were loaded until failure under four-point loads, and steel bars were used for the reinforcement in the construction of beams, the bars of diameter 8 mm were used for all transverse steel reinforcement and used as compression reinforcement for all the beams, while the 16 mm bars were used for the main steel reinforcement

There are three stages in the result analysis. There is demographic analysis, online shopping pattern and independent variables analysis.

Figure 3 shows the average compressive strength of three cubes evaluated over 28 days with various RCA replacement percentages (0 percent, 20 percent, 40 percent, 60 percent, and 100 percent). It can be shown that replacing RCA with NCA has a modest influence on compressive strength, even up to 100 percent, and the observed trend is comparable to the compressive strength of concrete with NCA. This is typically due to the use of the weight replacement concrete mix design approach, with RCA in a saturated surface dry condition having the greatest beneficial influence on concrete compressive strength due to the presence of water in RCA. This is because the compressive strength of RCA-based concrete is affected by mix proportions, RCA wetness, and the RCA treatment process.

The average flexural tensile strength of concrete mixes with different RCA replacement percentages. The addition of RCA at various replacement percentage ratios of 0 percent, 20 percent, 40 percent, 60 percent, and 100 percent had a minor influence on the flexural tensile strength of the concrete mixes, according to the testing findings. There is no apparent association between the two factors, as can be shown. There is no apparent association between the two factors, as can be shown. It can be seen that replacing NCA with RCA in concrete resulted in a slight increase of 2.89 percent and 1.35 percent in flexural strength when the replacement ratios of the RCA were increased to 25 percent and 50 percent compared to control prism, and a slight decrease of 1.83 percent when the replacement ratios of the RCA were increased to 100% compared to control concrete beam.

The failure load was reached, all beams were gradually and uniformly loaded. The progression of cracks in each RC beam was constantly monitored and noted. The maximum mid span deflection for each beam, as well as the cracking, yielding, and ultimate loads and moments. The effect of employing RCA on the flexural strength of the tested beams was minimal, as expected. This result agrees well with the concrete compressive strength testing findings provided in section A. As indicated in Figure 5 (a), beams had a somewhat lower ultimate flexural strength and deflection at failure as the RCA replacement ratio rose. The presence of the connecting ancient mortar is the main reason for this. When the replacement ratio of the RCA was increased to 20%, 40%, 60% and 100%, the maximum deflection at failure decreased by 8.57 percent, 11.43 percent, and 14.29 percent, respectively. Figure 5 (b) depicts the load-concrete strain correlations for beams without BMF and various RCA replacement percentages. It was discovered that there is no relationship between concrete strain and the RCA replacement ratio, since raising the RCA replacement ratio had no effect on the concrete compressive strain.

Conclusion

In this research looked at the mechanical characteristics and flexural behaviour of RC beams with various RCA replacement ratios. Based on the outcomes of the experimental inquiry, the following conclusions may be drawn. The addition of RCA to concrete has minimal to no influence on the concrete mix's compressive and flexural tensile strengths. This is mostly due to the employment of the absolute volume concrete mixing technique in conjunction with the saturated surface dry RCA. Even at complete replacement, the impact of employing RCA in concrete mixes on the flexural strength of the tested beams was minimal. Because the negative effect is connected to the fragility of the ancient ITZ in RCA, adding RCA to concrete has minimal influence on the flexural tensile strength of the concrete mix.

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