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To Study an Effect of Bond Strength of Recycled Concrete

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Abstract-Sustainable resource management and development have been at the forefront of important issues concerning the construction industry for the past several years. Specifically, the use of sustainable building materials and the reuse and recycling of previously used building materials is gaining acceptance and becoming common place in many areas. As one of the most commonly used building materials in the world, concrete, composed of aggregate, sand, cement and water, can be recycled and reused in a variety of applications. Using crushed concrete as fill and sub-grade material under roads, sidewalks and foundations has been the most common of these applications. However, research has been ongoing over the past 50 years in many countries including Germany, India, Canada, Japan, the United States, China, and Australia investigating the use of crushed concrete from demolished old concrete structures to fully or partially replace the virgin aggregate used to produce new concrete for use in building and pavement applications. Producing concrete using recycled concrete aggregates (RCA) has several advantages, namely, the burden placed on non-renewable aggregate resources may be significantly decreased, the service life and capacity of landfill and waste management facilities can be extended, and the carbon dioxide emissions and traffic congestion associated with the transport of virgin aggregates from remote sites can be reduced. This research investigates the inter-relationships between aggregate properties, concrete properties and the bond properties between reinforcing steel and RCA concrete. Forty pullout tests were carried out in order to investigate the bond behaviour between recycled coarse aggregate concrete and steel bars. Four recycled coarse aggregate (RCA) replacement percentages (i.e., 0%, 50% and 100%) with water-cement ratio 0.43, 0.44, are considered in this paper. Based on the test results, the influences of both recycled coarse aggregate replacement percentages and water- cement ratio on the bond strength between the recycled coarse aggregate concrete and steel rebars were investigate.

Keyword- Recycled concrete Aggregate (RCA), Natural Aggregate (NA), Bond Strength (BS), Compressive Strength (CS), Tensile Strength (TS).

1. INTRODUCTION

The Construction of buildings brides and roadways continues to increase with the time, especially in the area where population is growing fast. At the end of stage of their service life the structure and highways need to repair and replacement. Two attention issues will become clearer to societies an increasing demand for construction material, especially concrete and asphalts aggregate, and an increase production of construction and demolition waste, with such a high demand for new aggregate, the concern arises of the depletion of the current sources of natural aggregates and the availability of new source. Similarly, the construction waste produced is expected to increase the use of demolished concrete would reduce the cost and definitely lead to the conservation of the valuable and non renewable source of energy and hence must be given due importance. Generally to reduce the usage of natural aggregate, recycled aggregate can be used as replacement material. These materials are commonly get from building, road, bridge are some fine even catastrophes such as wars and earthquakes. It is clearly show that the bond behaviour is mainly depend on the i) mechanically properties of the concrete ii) Bar spacing and concrete cover iii) Surface condition of bar and geometry of bar as height, rib, deformation shape and bar diameter. In this work the use of recycled aggregate in varying proportion of 0%, 50%, 100% as a replacement of natural coarse aggregates has been done and we find out the various properties with the time period of 3, 7, 28, 56 & 90 days.

In 1999 Katz, A. [3] studied the bond mechanism of fibre reinforced polymer (FRP) rebar to concrete. Fine different type of 12.7mm and 12.0mm rebar subjected to different surface treatment were tested and the bond mechanism was compared with that of untreated FRP rod and ordinary deformed steel. They observed different pre-peak and post-peak behaviour for the various rods when the entire set of p-s (pull-out load vs. slip) curve was compared. Where the surface was rough, more ductile behaviour was detected. In 2003, Hendricks F. ch. et. al. [4] developed the approach called design for recycling can be used to optimize design of constructions for later tense and the design for disassemble can be used for demolition. For the technical aspects two models were developed concerning degrading process and high graded applications. These models were based on life cycle assessment method. Jianzhuang et. Al [5] in 2005 studied the bond behaviour between RAC and steel rebar. They conducted 36 pull out tests with 3 recycled coarse aggregate (RAC) replacement

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percentages (0%, 50% & 100% and two types of steel bars plain and deformed). They found that under equivalent mix proportions with an increase of RAC replacement percentage, the bond strength between the RAC and plain rebar decreases. Butler, west and tighe [7] in 2011 assessment bond performance by using 24 beam-end test specimens to completely (100%) replacement of naturally aggregate with recycled concrete aggregate. The characteristic of the aggregate which is get from many source of RCA and the various function, environment and were of concrete structures and pavements may be very difficult. Since a little

research on normal concentration has been done. High performance concrete, silica fume concrete, fibre reinforced concrete, SCC and VC. And hence very little literature is available on various properties of RAC with less work on properties like bond strength and carbonation. To balance the force on the surface of the deformed bar, compressive stress and shear stress come in the touching concrete surface. This stress to come into tensile stress which in turn can lead to cracking of the concrete.

2. MATERIAL USED AND THEIR PROPERTIES

In this present investigation material used are cement, aggregate steel, water and sand.

Cement: The cement use for the experimental studies was 43 grade OPC conforming to the specifications of Indian Standard Code IS: 8112-1989 shows in table 1. It was fresh and without any lumps.

S.No.	Characteristics	Specified value as per IS:8112-1989	Experimental value
1	Consistency of cement (%)	---	31.5
2	Specific gravity	3.15	3.01
3	Initial setting time (minutes)	>30	40
4	Final setting time (minutes)	<600	380
5	Compressive strength (N/mm^2) (i) 3 days (ii) 7 days (iii)28days	>23 >33 >43	25.10 36 48.10
6	Soundness (mm)	10	1.05
7	Fineness of Cement (gm)	10	1.5

<u>Table 1.Characterstics Properties of Cement Aggregates</u>

Normal river sand which is locally available in the market and confirming to Zone II as per IS 383 1970 as shown in table 2 and specific gravity of fine sand is 2.614 and coarse aggregates were used in this experiment whose fineness modulus is 2.65. Coarse aggregate used as 20 mm down size. The lumps of clay and other foreign materials were separated out carefully. Sand was washed and dried before testing. The coarse aggregates were washed to remove dirt, dust and then dried to surface dry conditions.

3. LITERATURE REVIEW

In 1996, Walker,P.R.et al studied that effect of Lateral Pressure on the bond strength of deformed reinforcement set in normal weight concrete. The results of the test on beams showed that bond strength developed at the supports was generally greater than that in the pull out tests .

In 1998, Hamad, B.S. et.al. (8) observed the effect of transverse reinforcement on the bond slip characteristics of tension lap slices in high performance silica fume concrete The test results indicated that silica fume decreased the bond strength. Specimens containing silica fume, without transverse reinforcement in the slice region had a brittle, sudden and noisy mode of failure. The use of transverse reinforcement in the splice region increased the bond strength and the ductility of the mode of failure of the beam specimens.

In 1999, Hamad, B.S. et. Al. (9) studied the effect of silica fume on bond-slip characteristics of deformed bars high performance concrete. The effect was to investigate transverse reinforcement on the bond-slip behavior of tension lap splices in silica fume concrgated.Based on the results of this study and the earlier study by hamad et al., it was recommended to remote the ACI limit of 70 Mpa on fc(compressive strength of concrete in lb/sq.inch) while computing development length of bottom or top cast reinforcement

In 2005, Xiao, Jianzhuang et. al. (39) studied that bond behavior between recycled aggregate concrete (RAC) and steel rebars. They conducted 36 pull-out tests with three recycled coarse aggregate (RCA) replacement percentages (0%, 50% & 100%) and two types of steel rebars (plain & deformed).

In 2006 Poon, C.S. et. al. (31) studied the environmental benefits of using recycled aggregates. Concrete mixes with a target compressive strength of 35 MPA prepared with the use of recycled aggregates at the levels from 0 to 100% of the total coarse aggregate. The influence of recycled aggregate on the slump and the bleeding were investigated

4. EXPERIMENTAL PROGRAMME

An experimental setup was performed to study the effect of mix design as per indian standard guidelines on the mechanical and durability properties of concrete. In this study compressive strength, split tensile strength was performed at the age of 28 days. All the tests were performed as per Indian standard codes and Bureau of Indian Standard. Two mixes were taken with first mix (1:1 and 1:2 w/c=0.43) called control mix and second mix (1:1 and 2:2 w/c=0.44). The natural coarse aggregate replaced by recycled coarse aggregate in which ratios of 50% and 100%. The properties as compressive strength, bond strength, indirect tensile strength and carbonation were studied.

4.1. Compressive Strength

Compressive strength is one of the most important mechanical property of concrete. This test was conducted according to IS 516-1959. The cubes that were placed in curing tanks were taken out after completion of 28 days. The cubes taken out were in the moist state. These cubes were surface dried before conducting the test. The cube was placed at right angle to the axis of compressive testing machine. The load was applied gradually at the rate of 140kg/cm^2 per minute until the failure of specimen takes place. thus, the compressive strength of specimen was calculated.

4.2. Split Tensile Strength

The split tensile strength was conducted on cylinders of standard size 300mm*150mm according to IS code 5816-1970. The specimen were taken out of curing tanks after required time and were dried out before testing. The dried specimens were tested on compression testing machine as per requirement given in IS 516-1959. The cylindrical specimen were placed on CTM at right angle to that of casting position. The load was gradually increased at constant rate of 2.4N/mm^2/minute till the failure of specimen took place and thus the split tensile strength of the specimen can be computed.

4.3. Bond Strength by Pull-Out Tests

The Bond Strength was also conducted by embedded a bar in a concrete block and load is applied at the free end of bar. The load is resisted by the resistance to withdrawal of the steel embedded in the block. The pull-out test specimens were tested after 3, 7, 28, 56 & 90 days of wet-curing on universal test machine.

4.4. Carbonation

The role of carbonation is determined by the chemical reaction between $Ca(OH)_2$ and Co_2 in pure water resulting in the formation of $CaCo_3$ as following equation

$$Co_2+Ca(OH)_2 \rightarrow CaCo_3+H_2O$$

5. CONCLUSIONS

1) The compressive strength of NAC mixes is relatively higher than RAC mixes. The compressive strength decreases by 9% and 13% for RAC replacement %age of 50% and 100%, at mix 1:1.1:2.46 and W/C=0.43 at 90 days. In the same ways the compressive strength decreases by 7% and 16% for RAC replacement percentage of 50% and 100%, at mixes 1:1.25:2.48 and W/C=0.44 at 90 days

2) The tensile strength of RAC mixes is relatively lower than that of NAC mixes. The difference in tensile strength varies with cement aggregate ratio. The difference in tensile strength increases with decrease in cement aggregate ratio i.e. for rich mixes. The tensile strength between the recycled aggregate concrete and the plain concrete decreases by 12% and 14% for a RAC replacement percentage of 50% and 100% mix 1:1.1:2.46 and W/C=0.43 at 90 days. In the same way the tensile strength between the recycled aggregate concrete and the plain concrete decreases by 16% and 45% for a RAC replacement percentage of 50% and 100%, at mixes 1:1.25:2.48 and W/C=0.44 at 90 days.

3) The bond strength of RAC mixes is relatively lower than that of NAC mixes. The difference in bond strength varies with cement aggregate ratio. The difference in tensile strength increases with decrease in cement aggregate ratio i.e. for rich mixes. The bond strength between the recycled aggregate concrete and the plain concrete decreases by 8% and 11% for a RAC replacement percentage of 50% and 100% mix 1:1.1:2.46 and W/C=0.43 at 90 days. In the same way the bond strength between the recycled aggregate concrete and the plain concrete decreases by 6% and 9% for a RAC replacement percentage of 50% and 100%, at mixes 1:1.25:2.48 and W/C=0.44 at 90 days. The percentage variation in bond strength increases for 3 days and then decreases afterwards.

6. RESULTS AND DISCUSSION

The various result for mixes of concrete with different values of recycled aggregate are determined and the comparison on the base of the decrease or increase in properties is determined. It is commonly known as the compressive strength, tensile and bond strength of recycled aggregate is less than the natural aggregate because of more water absorption.

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