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RESEARCH ARTICLE

Effect of Demolition Waste on Compressive Strength of Cement Matrix

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Abstract

This study describes the utilization of non-conventional material which is easily available. Recycled aggregates comprise crushed, graded inorganic particles processed from the materials that have been used in the construction. The scope of the present investigation is to determine and compare the compressive strength of mix by using different percentage of recycled aggregates. The investigation was carried out using compressive strength test for total of 5 batches of mixes prepared in which 0%, 20%, 30%, 40% and 50% replacement of fine aggregate by recycled aggregate at water/cement ratio of 0.48. The compressive strength of recycled aggregate matrix up to 40% replacement level is about 7% less than referral mix at 28 d for water cement ratio 0.48. This reduction in strength may be due to the less availability of water for hydration of cement after 7 d since strength at 7 d is more as compared to the referral mix for the same age.

Keywords: Recycled aggregate, fine aggregate, compressive strength, water/cement ratio, referral mix.

Introduction

The use of supplementary fine aggregate materials is fundamental in developing low-cost construction materials and environmental benefits for use in developing countries. It is estimated that the construction industry in India generates about 10-12 million tons of wastes annually. Construction and demolition wastes are generated whenever any construction/demolition activity takes place, such as, building roads, bridges; fly over, subway, remodeling etc. Poon *et al*. (2002) reported that there were not much effect on the compressive strength of specimens with the replacement of 25% and 50% of recycled aggregate. But when the percentage of recycled aggregate replacement increased, the compressive strength of the specimens was reducing. Rammamurthy and Gumaste (1998) stated that the compressive strength of recycled aggregate concrete was relatively lower and variation depends on the strength of parent concrete from the obtained aggregate. Portland cement concrete recycled aggregate are mainly produced from the crushing of concrete pavement and building structures. Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. It is now widely accepted that there is a significant potential for reclaiming and recycling demolished debris for use in value added applications to maximize economic and environmental benefit. For concrete a common misperception is that recycled concrete aggregate should not be used for structural concrete. Australian government guidelines state that up to 30% of recycled aggregate can be used for structural concrete without any noticeable difference in workability and strength compared with virgin aggregate, significant potential for an increase in the use of coarse recycled aggregate in concrete remains.

In some countries, notably Germany, Switzerland and Australia, concrete containing recycled aggregate is now being marketed and used. The strength characteristics of recycled aggregate concrete were influenced by the strength of the original concrete, the ratio of coarse aggregate to fine aggregate in the original concrete and the ratio of top size of the aggregate in the original concrete in the recycled aggregate. It is also reported that water absorption and Los Angeles abrasion loss will influence the water cement ratio and top size ratio for the strength characteristic of recycled aggregate (Tavakoli and Soroushian, 1996).

Sagoe-Crentsil and Brown (1998) stated that the quality of natural aggregate is based on the physical and chemical properties of sources sites, where recycled aggregate depends on contamination of debris sources. It is also stated that natural resources are suitable for multiple product and higher product have larger marketing area, but recycled aggregate have limited product mixes and the lower product mixes may restrain the marketing. Bakoss and Ravindrarajah (1999) stated that there are three methods of sorting and cleaning the recycled aggregate, which are electromagnetic separation, dry separation and wet separation. Electromagnetic separation process is removal of reinforcing steel by the magnet that fitted across the conveyor belt in the primary and secondary crushers. Dry separation process is removing the lighter particles from the heavier stony materials by bowing air. This method always causes lot of dust. Wet separation process is the aquamator, which the low density contaminants are removed by the water jets and float-sink tank and this will produces very clean aggregate.

Mehta (2001) found that the lack of durable materials also has serious environmental consequences. Increasing the service life of products is a long-term and easy solution for preserving the earth's natural resources. Sagoe-Crentsil *et al.* (2002) reported that the difference between the characteristic of fresh and hardened recycled aggregate concrete and natural aggregate concrete is relatively narrower than reported for laboratory crush recycled aggregate concrete mixes. There was no difference at the 5% significance level in concrete compressive and tensile strength of recycled concrete and control normal concrete made from natural aggregate. Mandal *et al*. (2002) found that there was no effect on the concrete strength with the replacement of 30% of recycled aggregate. But the compressive strength was gradually decreasing when the amount replacement of recycled increased and they concluded that the properties and the strength characteristic of recycled aggregate concrete were deficiency when compared to the specimens that made by the natural aggregate.

Mandal (2002) stated that adjusted water/cement ratio when using recycled concrete aggregate during the concrete mixing can improve the strength of the recycled aggregate concrete specimens and recycled aggregate concrete specimens had the same engineering and durability performance when compared to the concrete specimens made by natural aggregate within 28 d design strength. It is also stated that application of fly ash in the recycled concrete aggregate had improved the durability of the recycled aggregate concrete. Chen *et al*. (2003) found that the strength of the concrete specimens was affected by the unwashed recycled aggregate in the concrete. Nelson (2004) recycled aggregate can be applied in the high strength structure, but one issue must not be neglected as recycled aggregate with reduce water content would have low workability. Whenever recycled aggregate is applied, water content in the concrete mix has to be monitored carefully due to the water absorption capacity of recycled aggregate will vary. This type of concrete can only be used under the condition that does not involve a lot of handling works. Zhuang *et al*. (2011) carried out investigations on structural performance of recycled aggregate concrete. RAC elements/members are generally weaker in comparison to those of structures made of NAC. Through proper design, RAC can be used as a structural material from the view point of the loading capacity behaviour. The recycled coarse aggregates (RCAs) are being adopted in building engineering projects as load bearing to realize a safe and economic design of RAC structures. Murali *et al*. (2012) carried out experimental study on the recycled concrete aggregate. The test results showed that the flexural, compressive and split tensile strength of the recycled aggregate concrete is found to be lower than the natural aggregate.

However, the strength of recycled aggregate concrete can be improved by water and acid treatments. Furthermore, recycled aggregate treated with nitric acid displayed the decent result compared to the hydrochloric and sulphuric acid and from economical point of view; water and acid treated recycled aggregates can be used in place of natural aggregates for temporary structures. Berry *et al.* (2012) examined some of the effects of incorporating varying amounts of RCA on the strength and hydraulic properties of pervious concrete and they concluded that density values were generally similar with increasing RCA content; however, 100% replacement of RCA resulted in lower density values. There are several factors including differing aggregate densities and angularities could be the cause of this difference; however further investigation is needed to determine what role these factors play. Pervious concrete incorporating RCA exhibited similar relations between density and compressive strength found by previous studies using conventional aggregate. Increasing RCA generally decreased compressive strength, with 100% RCA content still providing strength values above 10 MPa. In the present study, the effects of recycled concrete materials on strength of concrete are presented. The referral mix was made using Portland Pozzolana Cement (PPC) of Birla make and the mixes were prepared by replacing part of fine aggregate with recycled concrete aggregate. The replacement levels were 20%, 30%, 40% and 50% (by weight) for recycled aggregate cement matrix.

Materials and methods

Experimental design: The fine aggregate used in the investigation was river sand. The properties of fine aggregate found as per IS-383 were: Fineness modulus = 2.76; Specific gravity = 2.54. The gradation of fine aggregate (Zone-III) was maintained throughout the experiment. Recycled concrete aggregate for the present investigation was obtained from the demolished building waste in civil lines Allahabad, UP. The recycled concrete aggregate was sieved and the fraction passing sieve was used in the experiments (4.75 mm). The physical view of demolition waste is shown in Fig. 1.

Fig. 1. Demolition waste.

The binder used in the present investigation was PPC (Birla). The properties of cement were determined in accordance with IS–1489-1991 were: Fineness = 2.5% (<10%, OK); Consistency = 40%; Initial Setting Time = 60 min (>30 min, OK); Final setting time = 310 min (<600 min, OK). For the present investigation mix was carried out using the above fine aggregate and the binder. The proportion of the materials by weight was 1:3 (Cement: Fine aggregate). Water cement ratio of 0.48 has been used. To investigate the effect of inclusion of recycled concrete aggregate (as part replacement of fine aggregate), 70.06 mm cubes were cast for referral and other mixes having variable recycled concrete aggregate content as given. The compressive strength of different mixes was tested at 7 and 28 d as per the procedure laid down in IS: 516-1981.

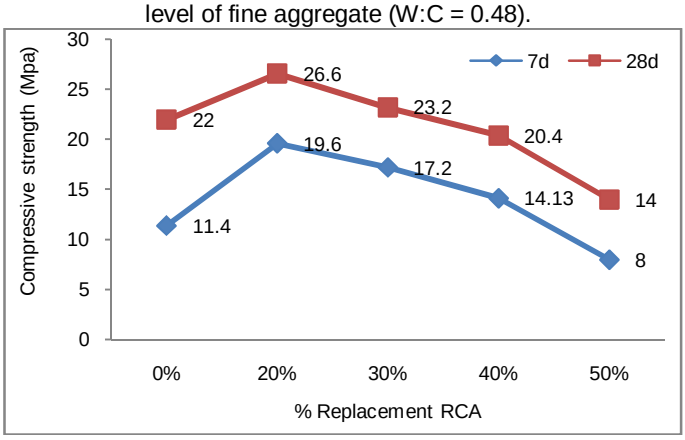
Results and discussion

The compressive strength of the cubes at different ages and different replacement levels of fine aggregate at w/c 0.48 are presented in Table 1. The curves showing the variation of compressive strength and tensile strength, made using recycled concrete aggregate with different content at a specific RCA content are presented in Fig. 2. The curves show the variation of strengths at 7 and 28 d.

Table 1. Compressive strength of mix at different replacement levels.

Replacement level of RCA (%)	Compressive strength (MPa) W:C = 0.48	
	7 d	28 d
0	11.4	22.00
20	19.6	26.60
30	17.2	23.20
40	14.13	20.40
50	8	14.00

Fig. 2. Compressive strength of matrix at different replacement level of fine aggregate (W:C = 0.48).



Conclusion

1. The compressive strength of recycled aggregate matrix up to 20% replacement level is about 72 and 21% more than referral mix at 7 and 28 d respectively for water cement ratio of 0.48.
2. The compressive strength of recycled aggregate mix up to 30% replacement level is about 51 and 6% more than referral mix at 7 and 28 d respectively for water cement ratio of 0.48.
3. The compressive strength of recycled aggregate matrix up to 40% replacement level is about 24% more than referral mix at 7 d for water cement ratio of 0.48.
4. The compressive strength of recycled aggregate matrix up to 40% replacement level is about 7% less than referral mix at 28 d for water cement ratio of 0.48. This reduction in strength may be due to the less availability of water for hydration of cement after 7 d since strength at 7 d is more as compared to the referral mix for the same.

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