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EFFECT ON COMPRESSIVE STRENGTH OF CONCRETE INCORPORATING RECYCLED AGGREGATE CONCRETE WITH FLY ASH AS CEMENT REPLACEMENT

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ABSTRACT:

Influence on compressive strength of concrete incorporating recycled aggregate concrete and fly ash as replacement of cement is investigated in this paper. Recycled concrete aggregate (RCA) is replaced by three different percentage 0%, 50%, and 100% with the natural coarse aggregates (NCA). Fly ash (FA) is replaced as 0%, 15% and 30% of cement. Water/cement ratio is taken as 0.45 throughout the experimental programme. The compressive strength of concrete is measured after 7 and 28 days of curing and compared with the normal concrete. The results shows decreased compressive strength of concrete specimens incorporated with recycled aggregate and fly ash.

INTRODUCTION:

The survival of human race is directly related to the protection of environment. Conservation of natural resources is one of the major challenges faced by most of the countries of the world. According to various surveys, construction industry is responsible for various environmental problems because it takes 50% of raw materials from nature along with a consummation of 40% of total energy and produces 50% of total waste. The use of the natural aggregates for the production of the cement as well as concrete causes a depletion of the natural resources. The use of recycled concrete aggregate is encouraged due to following three reasons: Conservation of natural resources, minimization of overall construction cost, and reduction of pollution. . Aggregates are produced by crushing the waste concrete is known as recycled aggregates (RA) are of two types: recycled coarse aggregate (RCA) and recycled fine aggregate (RFA). The RCA is always considered as a small piece of concrete since it is composed of original coarse aggregate (OCA) and adhered mortar (AM). When these pieces of the concrete combine with new cement mortar matrix, the resulting concrete is known as recycled aggregate concrete (RAC).

In order to improve the properties of RAC, it is necessary to enhance the quality of concrete by modifying the weak ITZ of RAC and the bulk matrix of concrete. This can be achieved by incorporating mineral admixtures such as fly ash, meta kaolin, silica fume, ground granulated blast furnace slag (GGBS), and Nano silica which act as micro filler, filling the ITZ between the aggregate surface and the matrix. Thus the concrete led to the enhancement of its compactness through the formation of secondary C–S–H gel that fills up the open pores and empty capillary spaces within the hardened concrete and consequently decreased the porosity of the concrete and helped in enhancing the strength and durability (Limbachiya*et al.* 2012; Kou and Poon 2012;).

Addition of 20% FA reduced the water demand by 12.5% whereas reduced the compressive strength by 5% and splitting tensile strength by 5-10% than the normal concrete(Saravana and Dhinakaran 2012). With 40% FA in RAC showed an acceptable value of compressive strength in utilizing the waste material (Saravana and Dhinakaran 2013). 85% compressive strength of normal concrete was achieved by adding 35% fly ash to RAC (Tangichirapat et al. 2013). 30% fly ash caused 12% reduction in compressive strength than NAC in 91 days and 76% reduction in chloride penetration (Kimet al. 2013).

Utilization of waste products helps in conservation of natural resources, reduction in energy conservation, solves waste disposal crisis. Hence use of RAC and FA proved to be effective in concrete. Therefore a detailed experimental programme is carried out to

check the compressive strength of concrete incorporating RAC and FA and the results are compared with the normal concrete.

EXPERIMENTAL PROGRAMME:

The recycled aggregate (RCA) used in the present research work was produced from the waste railway sleepers. Nominal size of coarse aggregate was taken as 20 mm for both RCA and NCA. River sand was used as natural fine aggregate (NFA). Ordinary Portland cement of grade 43 is used with consistency 32% and specific gravity 3.11. Fly ash used in this study was collected from the Hindalco Alumina ltd. The detailed physical properties of aggregates are given in the Table-1. The mechanical properties of the RCA and NCA are given in the Table- 2.

Table- 1 Properties of aggregates

Property	NFA	NCA	RCA
Bulk density (compact) (kg/l)	1.615	1.622	1.45
Bulk density (Loose) (kg/l)	1.462	1.394	1.311
Specific gravity (SSD)	2.63	2.75	2.53
Water absorption (%)	0.4	0.8	2.2

Table- 2 Mechanical properties of aggregates

Property	NCA	RCA
Los Angeles Abrasion resistance (%)	23.36	21.1
Impact value (%)	22.03	19.18
Crushing value (%)	19.52	17.41

Concrete mixes were prepared with w/c ratio 0.45. RCA was replaced by 50% and 100% of NCA. Whereas FA was replaced by15% and 30% of cement. All the replacement was carried out by weight by volume of the aggregate. Slump value was checked for each mix separately. Concrete cubes of size 150 mm were casted and put under the tap water for curing. Compressive strength of cubes is tested after 7 and 28 days of curing.The cubes are tested in 2000 KN capacity compressive strength machine and the rate of loading is maintained throughout the program as per BIS specification (IS: 516, 1959). The detailed of concrete mix was given in the following Table-3.

Table-3 Detailed proportion of concrete mix per cubic meter of concrete

Mix design ation	FA (%)	RCA (%)	Cement (kg)	FA (kg)	NFA (kg)	NCA (kg)	RCA (kg)
RF1	0	0	425	0	634	1182	0
RF2	0	50	425	0	634	591	552
RF3	0	100	425	0	634	0	1104
RF4	15	0	361	64	634	1182	0
RF5	15	50	361	64	634	591	552
RF6	15	100	361	64	634	0	1104
RF7	30	0	298	128	634	1182	0
RF8	30	50	298	128	634	591	552
RF9	30	100	298	128	634	0	1104

RESULT AND DISCUSSION:

The slump value tested for each mix was presented in the Fig. 1. The compressive strength value tested after 7 and 28 days are represented in the Fig. 2 and 3.

Fig- 1 represents the slump values of different concrete mixes at different percentage of FA and RCA. It is observed that the slump of control concrete mix was 92 mm which decreases to 86 and 81 mm with 50% and 100% addition of RCA at 0% FA respectively. At 15% replacements level of FA with NCA the slump value is 87 mm which is decreased to 80 and 73 mm with addition of 50% and 100% of RCA by NCA. Moreover the slump value of concrete mix at 30% replacement of FA with cement and 0% RCA is 81 mm which is decreased to 77 and 69 mm at 50% and 100% replacement level of RCA by NCA. It is observed that with the increase in FA content the slump value decreases. The lowest slump value is obtained at 30% FA with 0% RCA. Furthermore the slump value is decreased with the addition of RCA content. The decrease in slump value is more in case of 100% RCA and 30% FA. This decrease in slump is due to the high water absorption value of RCA and FA. It is observed that workability of concrete mixes has a decreasing trend by addition of FA and RCA. But this decrease in slump is within the workable limit of the concrete for the field use of concrete mixes.

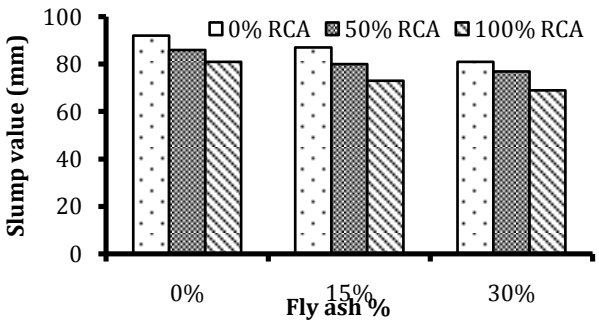

Fig.1 Slump value of different concrete mixes

Fig. 2 represents the compressive strength of concrete specimen after 7 days of curing period.The compressive strength of control concrete mix is 30.45 MPa. It is decreased to 29.4 and 24.96 MPa at 50% and 100% replacement level of RCA for 0% FA replacement. At 15% replacement level of FA with cement the compressive strength is 27.21 MPa for 0% RCA which is 11.9% lower than the control concrete mix. The compressive strengths are 25.39 and 21.8 MPa for 50% and 100% replacement of RCA at 15 % replacement of FA. Furthermore the compressive strength decreased to 23.92 MPa which is 27.3% lower than the control concrete mix which is further decreased to 21.07 and 20.8 MPa at 50% and 100% replacement level of RCA. At 50% RCA replacements the compressive strengths for 15% and 30% FA are 15.7% and 39.5% lower than the compressive strength at 0% FA. At 100% replacement of RCA the compressive strengths for 15% and 30% FA are 14.3% and 20% lower than the compressive strength at 0% FA. The decrease in compressive strength with the increase in the additive percentage is observed. The rate of decreasing percentage of compressive strength is higher in case of FA addition rather than RCA addition. I.e. at constant RCA percentage the strength decrease is more with the increase in the addition of FA.

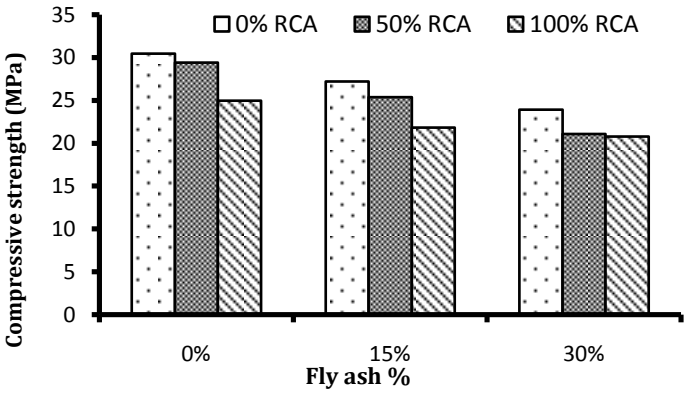

Fig. 2 Variation in 7 days compressive strength

Fig. 3 represents the compressive strength of concrete cubes after 28 days of curing. It is observed that the control mix has compressive strength of 45.68 MPa after 28 days of curing. At 0% replacement of FA the compressive strength at 50% and 100% RCA replacement are 44.33 and 38.21 MPa which are 3.04% and 19.5% lower than the compressive strength of control concrete mix. At 15% replacement level of FA the compressive strengths are 41.09, 37.64 and 32.12 MPa for 0%, 50%, and 100% RCA replacement with NCA. Whereas the compressive strengths are decreased to 36.1, 30.2 and 26.47 MPa for 0%, 50% and 100% replacement of RCA with the NCA. The compressive strength is decreased with the increase in the additive percentage. The rate of decreasing is more in case of addition FA as cement replacement but less in case of RCA addition. The decrease in the compressive strength is due to the less bonding and mechanical properties of RCA. Also due to the adhered mortar in the RCA leads to increased voids which caused decreasing compressive strength. Also due to the less hydration of fly ash with water the compressive strength is decreased.

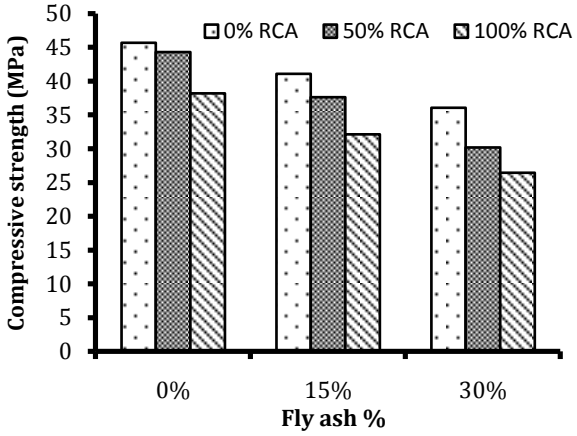

Fig. 3 Variation in 28 days compressive strength

CONCLUSION:

In the present studythe effect of recycled aggregate and fly ash on the compressive strength of concrete is investigated. From the results obtained from the investigation following conclusions are drawn.

- Workability of concrete decreases with the addition of fly ash and recycled aggregate.
- The compressive strength gain is higher in case of early ages.
- The compressive strength decreases with the increase in the FA% and RCA%.
- The rate of decrease is more in case of FA as additive.
- This indicates the addition of RCA increases the voids of concrete specimens which cause decrease in the compressive strength.

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