Mechanical Properties of Concrete using Bottom Ash Manufacturing Sand and Metallic Fibres

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Abstract- This study deals with utilisation of concrete containing industrial waste in concrete as cement replacement and manufacturing sand as fine aggregate replacement. The workability of concrete made with fibre showed reduction in workability. The compressive strength of concrete containing (20% bottom ash, 75% manufacturing sand and 0.5% corrugated steel fibre and 0.5% Hooked steel fibre) in mix C5 showed better strength when compared to other mixes and all other mixes shows higher strength when compared to the reference mix C1. Splitting tensile strength of mix C5, C6 and C4 showed better strength compared to other mixes.

I. INTRODUCTION

The infrastructure needs of our country is increasing day by day and with concrete is a main constituent of construction material in a significant portion of this infra-structural system, it is necessary to enhance its characteristics by means of strength and durability. It is also reasonable to compensate concrete in the form of using waste materials and saves in cost by the use of admixtures such as fly ash, silica fume, etc. as partial replacement of cement. Flyash which is a byproduct of the thermal power plant poses a serious problems of its dumping to the environmentalists. Utilization of flyash in concrete as partial replacement with cement not only solves the problems of dumping to some extent but also it is used as mineral admixture in concrete and helps to attain reduction in cost of concrete by saving cement. This pozzolana is beneficially used to attain certain properties in concrete as lower water demand for similar workability, reduced bleeding and lower evolution of heat. It has been used particularly in mass concrete applications and large volume placement to control expansion due to heat of hydration and also helps in reducing cracking at early ages.

Plain concrete is weak in tension and has limited ductility and little resistance to cracking. Microcracks are present in concrete and because of its poor tensile strength; the cracks propagate with the application of load, leading to brittle fracture of concrete. Microcracks in concrete are formed during its hardening stage. When the load is applied, microcracks start developing along the planes, which may experience relatively low tensile strains, at about 25-35% of the ultimate strength in compression. The low tensile strength of concrete is being compensated for in several ways, and this has been achieved by the use of reinforcing bars and also by applying prestressing method. Though these methods provide tensile strength to concrete, they do not increase the inherent tensile strength of concrete itself. Further, conventionally reinforced concrete is not a two phase material in true sense. Conventionally reinforced concrete a true two phase material only after cracking when cracked matrix is held by the reinforcing bars. Existence of one phase (i.e.steel or concrete) does not improve the basic strength characteristics of the other phase and consequently the overall performance of the traditional reinforced concrete composite is dictated by the individual performance of the concrete and steel phase separately. **Holschemacher et al.** (2010) investigated the effect of steel fibres on mechanical properties of high strength concrete. In this different bar reinforcements of 2 numbers of 6mm and 12mm diameter and three types of fibre contents two straight with end hooks with different ultimate strength and one corrugated were used. This experiments show that for all selected fibre contents a more ductile behaviour and higher load levels in the post-cracking range were obtained. They studied on the properties of concrete containing fly ash and steel fibers. Fly ash content used was 0%, 15% and 30% in mass basis, and fiber volume fraction was 0%, 0.25%, 0.5%, 1.0% and 1.5% in volume basis. The laboratory results showed that steel fiber addition, either into Portland cement concrete or fly ash concrete, improve the tensile strength properties, drying shrinkage and freeze–thaw resistance. However, it reduced workability and increase sorptivity coefficient. Although fly ash replacement reduce strength properties, it improves workability, reduces drying shrinkage and increases freeze–thaw resistance of steel fiber reinforced concrete. It show that the behaviour of fly ash concrete is similar to that of Portland cement concrete when flyash is added [8]. They worked on the contribution of hybrid fibres on the properties of high strength concrete having high workability. The different percentages of steel and palm fibre as 2% volume fraction. The result show that the use of 1% of steel fibre increases the compressive strength by about 13%. It also show that the hybrid fibre (1.5% steel+ 0.5% palm) in specimens increases the toughness indices and thus the use of hybrid fibre combinations in reinforced concrete would enhance their flexural toughness and rigidity and enhance their overall performance [7]. There was a on studied on the structural behaviour of steel fiber reinforced fly ash concrete by conducting tests on standard control specimens. The use of steel fibers in fly ash concrete improves its structural properties, especially the flexural tensile strength. Increasing the percentages of fly ash upto 30% and steel fibers upto 1.5% in concrete enhances the flexural tensile strength as well as the compressive strength. Finally, the use of fiber reinforced fly ash concrete is recommended as an alternative to fiber reinforced plain concrete [10]. They worked on experimental investigation on hybrid fiber reinforced concrete.Control and two-fiber hybrid composites were cast using different fiber proportions of steel and polypropylene. Compressive test and split tensile strength were performed and results were extensively analyzed to associated with fiber combinations. Based on experimental studies, the paper identifies fiber combinations that demonstrate maximum compressive and split tensile strength of concrete [9].

II. CONSTITUENT MATERIALS

Cement, fine aggregates, coarse aggregates, flyash, steel fibres and water used throughout the investigation. The type of cement is important mainly through its influence on the rate of development of compressive strength of concrete. The choice of the type of cement depends upon the requirements of performance at hand. The most commonly used cement is called ordinary Portland cement.

A. Cement

Ordinary Portland Cement of grade – 53 conforming to Indian standard IS: 12269-1987 has been used in the present study. The physical and chemical properties are given in Table.

Requirements as per IS12269-1987			
Physical Properties		Chemical Properties	
1. Fineness	225(min)	1. Lime saturation factor	.8-1.02
2. Setting time		2. Alumina Modulus	.66 (min)
Initial (min)	30 minutes	3. Insoluble residue (%)	4 (max)
Final (max)	600 minutes	4. Magnesia (%)	6 (max)
		5. Sulphuric anhydride (%)	3 (max)
		6. Loss on ignition (%)	4 (max)
		7. Chloride (%)	.1 (max)

B. Bottom Ash

Physical Properties		Chemical Properties	
Colour	Whitish gray to gray with slight black	Silica(SiO_2)	40 - 79
Bulk density	1120kg/m^2	Alumina(Al_2O_3)	23 - 33
Specific gravity	2.14-2.42	Ferric Oxide (Fe_2O_3)	0.6 – 4
Fineness	2800-3200 cm^2/gm	Calcium Oxide (CaO)	2.8 - 20
		Magnesia (MgO)	1.5 - 5.0
		Lgnition loss	1.0 - 3.0

C. Fine aggregate

Locally available sand has been used as fine aggregate. In this study it was used the sand of Zone-II, known from the sieve analysis using different sieve sizes (10mm, 4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm) adopting IS 383:1963.

Sieve size	Percentage of passing
10 mm	100
4075 mm	90-100

2.36 mm	75-100
1.18mm	55-90
600µm	35-59
300 µm	Aug-30
150 µm	0-10

D. Manufacturing Sand

Manufacturing Sand	M-sand is crushed aggregates produced from hard granite stone which is cubically shaped with grounded edges, washed and graded with consistency to be used as a substitute of river sand.

E. Coarse Aggregate

Coarse Aggregate	12 to 20 mm size

F Fibres

Steel fibre
Two types - corrugated and hooked types having Aspect ratio = 50 (Length 50mm, diameter 1mm)

III. CASTING DETAILS

The required materials for preparing the concrete were weighed as per the required proportions. The cement and fly ash were thoroughly mixed in the dry state, and the sand was added later to the mixture. The mixture was again thoroughly mixed and gently placed over the coarse aggregate. In case of fiber reinforced concrete, fibers were evenly sprinkled during the mixing. Water was finally added to the dry mixture. Mixing was carried out until a workable mixture was obtained. The entire mixing was carried out on a dry platform. Concreting was done in the moulds while they were on a platform vibrator. Vibrations were continued for one minute to ensure uniform compaction. The specimens were demoulded after 24 hours of casting and placed in a curing tank for 28 days. After the curing period, the specimens were removed from the curing tank and whitewashed for better visibility of cracks. The specimens as IS standards were prepared: 150 mm cubes for compressive strength as per IS 516 – 1999, 100 x 300 mm cylinders for split tensile strength as per IS 5816 -1999

A. Mix Ratio

S.No.	Cement (kg/m^3)	Bottom Ash (kg/m^3)	Fine Aggregate (kg/m^3)	M.Sand (kg/m^3)	Coarse Aggregate (kg/m^3)	Steel Fibres in (1%)	
						Type1 (Corrugated)	Type2 (Hooked)
C1	320	-	822	-	990	-	-
C2	256	64	822	-	990	0.5	0.5
C3	256	64	616.5	205.5	990	0.5	0.5
C4	256	64	411	411	990	0.5	0.5
C5	256	64	205.5	616.5	990	0.5	0.5
C6	256	64	-	822	990	0.5	0.5

IV RESULTS

The following are the results of fresh concrete workability and 28 days cured specimens compressive strength and split tensile strength of harden concrete.

Mix Id	Slump, mm	Compressive Strength, N/mm^2	Split Tensile Strength, N/mm^2
C1	118	24.36	2.02
C2	100	27.42	4.06
C3	110	30.23	4.84
C4	115	33.44	5.10
C5	123	37.42	5.6
C6	130	24.32	5.21

The workability of concrete made with fibre showed reduction in workability. The compressive strength of concrete containing (20% bottom ash, 75% manufacturing sand and 0.5% corrugated steel fibre and 0.5% Hooked steel fibre) in mix C5 showed better strength when compared to other mixes and all other mixes shows higher strength when compared to the reference mix C1. Splitting tensile strength of mix C5, C6 and C4 showed better strength compared to other mixes.

V CONCLUSION

Due to the addition of two different steel fibres there was delay in crack development in the concrete surface, were as the strength has been increased while increase in compressive and splitting tensile strength.

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