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Experimental Investigation on Strength and Durability Characteristics of Flyash Concrete by Incoroprating Electric Arc Furnace Dust

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Abstract : Concrete is used widely in infrastructure industries for construction of buildings, water reservoirs and architectural structures. Enhancement of properties of concrete is always aspired for increasing durability and strength of structures. The strength of the concrete can be increased when additives like flyash and electric arc furnace slag is added. This study focuses on replacement of cement by using electric arc furnace dust (EAFD) & flyash. Flyash was kept constant as 30Wt% and electric arc furnace dust was varied as 5Wt% and 7.5Wt%.The mechanical strength characteristics of concrete was determined by conducting compression strength test and split tensile strength test. The compression strength of the concrete was found to be increased when compared with the conventional concrete. Simultaneously there was increase in tensile strength of the concrete. In order to ensure durability characteristics of the concrete alkalinity test and sulphate resistance test was performed. In alkalinity test the pH value of the concrete was between 9.5 to12 and it was ensured that the prepared concrete is alkaline and the concrete offered a better resistance to sulphate attack.
Keywords : Concrete, flyash, electric arc furnace dust, compression strength, split tensile test, alkalinity

1.0 Introduction:

In construction industries cement is used in huge volumes from masonry to huge concrete structure production, hence there is a tremendous demand for cementatious materials in infrastructure industries. An alternative source to fulfill the demand with good mechanical properties and enhanced durability characteristics for future growth of infrastructure industries is required.

Production of cement causes pollution and increases global temperature [2]; hence replacement of cement with available alternate materials is required. Use of by-products such as slag, dust, or sludge from the metallurgical industries as filler materials in concrete helps to conserve natural resources as an economically positive option [1].

Electric arc furnace dust (EAFD) in the form of fine powders is generated during steel making process in electric arc furnace. This consist iron oxide (approx. 50%) and zinc oxide (approx. 21%) and other constituents like oxides of calcium, magnesium, silicon, nickel, chromium, etc. EAFD is commonly solidified by addition of cementatious materials [1]. Earlier studies conducted on (EAFD) have proved that it increases the property of both fresh and hardened concrete [12-13].

Flyash is also a supplement to cement; flyash is produced in thermal power plants when combustion of coal takes place hence this consists particles of coal. When it is mixed with Portland cement and water, it

generates a product similar to that formed by cement hydration but having a denser microstructure that is less permeable [2]. The fly ash concretes yielded better resistance to chloride ion penetration both at 28 and 180 days. Thus, it is possible to design high strength concrete of reduced permeability by including up to 40% Class F fly ash in the total binder [2].

When fly ash is present in the concrete mass, it plays dual role for the strength development. Fly ash reacts with released lime and produces binder and renders additional strength to the concrete mass. The nonreactive portion of fly ash acts as micro aggregates and fills up the matrix to render packing effect and results in increased strength [3].It was observed that at 28 and 56 days in 20% replacement of PPC by fly ash, the strength marginally increased from 1.9% to 3.28% [4].

2.0 MATERIALS:

2.1 Electric arc furnace dust (EAFD):

The Electric arc furnace dust (EAFD) used in this experimental investigation was obtained from Salem Steel Plant (SSP), Tamilnadu and was used as a supplementary material to replace cement. The colour of EAFD was greyish black.

2.2 Flyash:

Low calcium flyash was obtained from Mettur thermal power plant and was used as a supplementary material to replace cement.

2.3 Other materials: 2.3.1Cement:

53 grade ordinary Portland cement conforming to Indian standard code IS 12269-1987 was used.

2.3.2Fine aggregate:

Locally available river sand belonging to zone II of IS 383-1970 with a specific gravity of 2.64 was used as fine aggregate.

2.3.3Coarse aggregate:

Crushed granite stone of size 20mm conforming to IS 383-1970 was used as coarse aggregate.

2.3.4Water:

Potable water was used for casting and curing.

3. Mix design:

Test specimens of grade M20 were prepared as per IS 10262:200.Concrete specimens were prepared by partially replacing cement with electric arc furnace dust (EAFD) and flyash in different compositions as below.

1. Specimen1- Ordinary Portland cement (OPC cement)
2. Specimen 2- (OPC 65%+flyash 30%+EAFD 5%)
3. Specimen3 - (OPC 62.5+ flyash 30%+EAFD 7.5%)

4.0 Test methods:

4.1Mechanical property testing:

The compressive test was carried out to determine the compressive strength of the concrete using compression testing machine. Split tensile test was also done to determine the split tensile strength.

4.1.1 Compressive strength test:

For testing the compressive strength of the concrete test, M20 concrete grade of size 150mmX150mmX150mm was prepared and tested in compression testing machine of 2000kN capacity. The experimental setup is shown in figure1and 2.

Figure 1: Test setup of cube in compression testing machine **Figure 2: Crack formed in the cube**

4.1.2 Split tensile strength test:

For testing the split tensile strength of the concrete, cylindrical specimens M20 concrete grade of size 150mm diameter & 300mm long was prepared and tested in compression testing machine of 2000kN capacity. Specimens were placed horizontally between the loading surfaces and strength of the specimens in intervals of 7^{th}, 28^{th} and 56^{th} day was determined. The experimental setup is shown in figure3 and 4.

Figure 3 & 4: Test setup of cylinder for split tensile strength test & Crack formed in the cylinder.

5.0 Durability test

The durability of the concrete was investigated by using alkalinity test and Sulphate resistance test.

5.1Alkalinity test

For the alkalinity test, the concrete cubes of size 150 mm x 150 mm x 150 mm were prepared and after curing the specimens were dried in an oven for 24 hours at 105˚C and the specimens were allowed to cool under room temperature and were broken to separate the mortar from the concrete. The mortar was powdered and then

sieved in an IS sieve of size 150 m.10 g of the sieved sample was taken and diluted in distilled water by stirring and the pH value of the solution was noted with a pH meter.

Figure 5: Alkalinity Test

5.2 Sulphate Resistance Test

The resistance to sulphate attack was studied by immersing the 28 days cured standard cube specimens (150 × 150 × 150 mm) in a solution containing 7.5% magnesium sulphate for 28, 60, and 90 days. The concentration of the solution was maintained throughout the period by changing the solution periodically. The change in weight during the period of 28, 60, and 90 days was determined.

6.0 Results & Discussion

The compressive strength developed in the cube specimen was partially replaced by electric arc furnace dust (EAFD) & flyash in different proportions is compared with the concrete of control mix and it was found that the compressive strength of the cube with partial replacement of EAFD & flyash increased when compared to the concrete cubes without replacement. After addition of 5% EAFD+30%flyash the compressive strength of concrete was 23% increase after 7 days,30.4% increase after 28 days, 36.19% increase after 56 days and addition of 7.5% EAFD+30%flyash leads to increase of compressive strength as 25.71% increase after 7 days,33.3% increase after 28 days, 40% increase after 56 days.

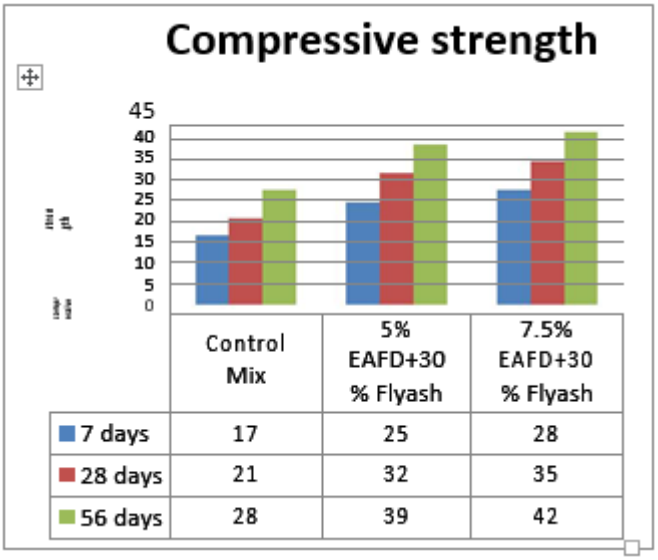


Figure 6: Compressive strength of concrete

The split tensile strength of the cement replaced cylindrical specimen was found to be increased when compared to control mix as like compressive strength of the cube, as the percentage of the electric arc furnace dust along with the flyash is increased, the split tensile strength of the specimen was increased .After addition

of 5% EAFD+30%flyash the split tensile strength of concrete was 20.8% increase after 7 days,34.3% increase after 28 days, 44% increase after 56 days and addition of 7.5% EAFD+30%flyash leads to increase of split tensile strength as 24% increase after 7 days,30% increase after 28 days, 45.7% increase after 56 days shown in (figure7).

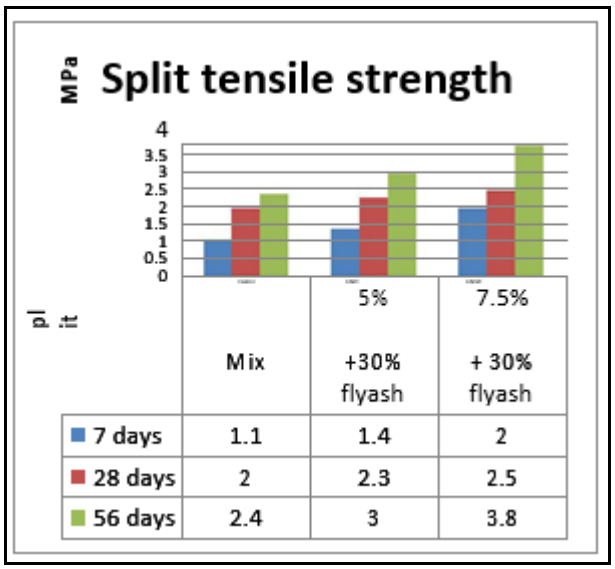
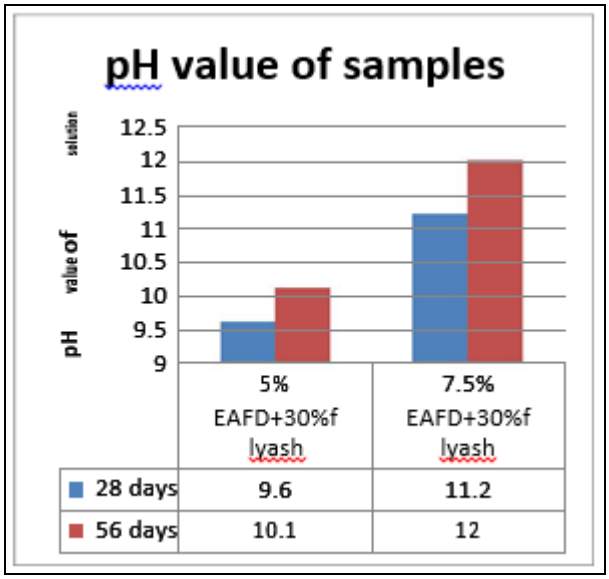


Figure 7: Split tensile strength of concrete

Alkalinity test results indicated that the pH value of concrete made with EAFD and fly ash are within the limits about 9.5 to 12 and therefore the potential for corrosion is low, (Figure 8). For sulphate attack, it was observed that it has got good resistance against sulphate attack with 7.5%+30% replacement of flyash (Figure 9).



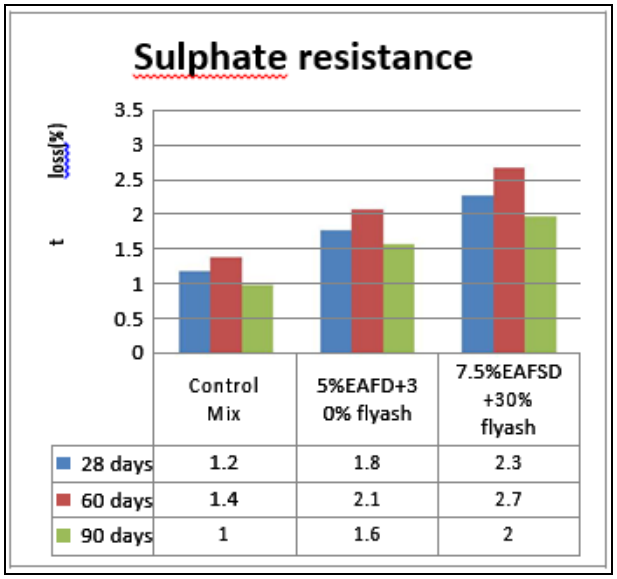


Figure 8: pH value of solution

Fig 9: Sulphate resistance of concrete sample

7.0 Conclusion:

From the observations made in the test it was found that the concrete specimen which was replaced by electric arc furnace dust (EAFD) & flyash as a partial replacement for cement shown a good result in case of increase in strength when compared to conventional concrete. The compressive strength & tensile strength has greatly increased with partially replacing cement with EAFD & flyash when compared to conventional concrete and it has also shown a notable improvement in durability characteristics in comparison with conventional concrete by having high resistance to sulphate attack and increased pH value. Hence the cement required for

preparing the concrete can be minimized by replacing cement with EAFD & flyash and it serves as a good choice for cement replacement and thus reduces the economy and gives adequate strength for the concrete.

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