Partial Replacement of Cement with Fly ash Cenospheres in Cement Concrete

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Abstract - Concrete is one of the important materials of the construction industries. Nowadays due to increase in a population, the demand of infrastructure is increasing day by day. This leads to increase in production of cement. In the present time the world wide cement production is about 1.6 billion tons. This huge amount of production leads to consumption of natural resources and it is also harmful for environment. Large quantity of waste by products are produced from the manufacturing industries such as mineral slag, fly ash, silica fumes etc. Cenosphere is a byproduct obtained from the thermal power plants generated by the burning of coal powder. It is transported by the flue gases which can be further collected by electrostatic precipitator. This is a free flowing powder comprises of hollow sphere, hard shelled and lightweight which is collected from coal ash. This research work deals with the partial replacement of the cement with cenosphere in concrete at various percentage such as 0%, 4%, 8%, 12%, 16% and 20% by mass of cement. The various experimental investigations are carried out to find out the compressive strength, split tensile strength and flexural strength of concrete cube cured for period of 7 and 28 days. The results obtained from the experiments with a suitable replacement of cement with cenosphere are presented in this research paper.

KEYWORDS:- Concrete, Fly ash, Cenospheres, Compressive strength, Split tensile strength, Flexural strength.

1. INTRODUCTION

Concrete is a most widely used construction material. It is, in general, a mixture of cement (binding material), aggregate (filler materials), admixture and water. It can be molded in any required shape, easy to handle and has a wide range of design strength. It is therefore used in approximately all kind construction work. Cement is the most important ingredient of concrete as act as a binding material. But the production of cement causes so many environmental hazards, like cement dust, air pollution solid waste pollution, noise pollution, ground vibrations and resources depletion due to raw material extraction. The main components of the gases emitted from cement industries are CO_2, N_2, O_2, SO_2, water vapors and micro components i.e. CO and NO_x. The cement industry is one of the two largest producers of carbon dioxide (CO_2), creating up to 8% of worldwide man-made emission of this gas, of which 50% is from chemical process and 40% from burning fuel. The CO_2 produced for structural concrete is estimated at 410 kg/m^3. About 900 kg of CO_2 are emitted for the fabrication of each 1 ton of cement. The CO_2 is major green house gas. Thus cement manufacturing contributes green house gases both directly through the decomposition of calcium carbonate and also through use of energy, particularly from the combustion of fossil fuel.

Therefore we are needed to find other optional material for concrete in place of cement. If we able to replace few percentage of cement form concrete, it will helpful to reduce CO_2 emission. From various research works, some industrial wastes are found which can reduce the amount of cement in concrete without compromising its basic properties (like strength). Granulated blast furnace slag, silica fume, rice husk ash, cenospheres and fly ash are some industrial waste that can be used as supplementary cementious materials. Cenosphere is a constituent particle of fly ash which gives some additional benefits when used in concrete. Before further discussion about cenosphere let us briefly discuss about cement.

2. OBJECTIVE OF THE RESEARCH

- To study the beneficial utilization of industrial waste as the cement replacement in construction work.
- To evaluate the optimum proportion of cenosphere as a beneficial replacement with cement in cement concrete

3. MATERIALS USED

3.1 Cement

For this research work, PCC cement of MYCEM Company is used, that is available in nearer construction material shop. While adding cement in concrete mix, it is ensured that cement is moisture free and no lumps are found in cement bag.

3.2 Cenospheres

These particles are hollow, empty and strong which are made up of silicon dioxide aluminium oxide and iron oxide. For this experimental work, Fillit 300S category cenospheres are purchased from a popular and reliable company 'Petra Buildcare Products' situated in Bhavnagar Gujrat.

3.3 Fine Aggregate

Fine aggregate are material passing through an IS sieve 4.75 mm and retain on 150µm gauge. Locally available sand is used as fine aggregate in this a\experimental analyses.

3.4 Coarse Aggregate

The aggregate which may pass through 75mm IS sieve and retained on 4.75mm IS sieve is called coarse aggregate. Size of coarse aggregate may vary from 10mm to 40mm. Locally available coarse aggregate is used for test, that available on nearer construction material shop

3.5 Water

Water having pH value 6.0 to 8.0 is generally used. It is potable water i.e. not containing any salinity and alkalinity

4. METHODOLOGY

4.1 Proportioning

The standard proportion as per IS:456-2000, for M20 grade concrete is 1:1.5:3. Here proportion is adopted 1:1.8011:3.283 which is calculated by mix design method. Cement is replaced with cenosphere at various percentages i.e. 0%, 4%, 8%, 12%, 16% and 20%. The amount of each ingredient used per cubic meter is as follow:-

Cement = 364.497 kg; Fine aggregate = 683.811 kg; Coarse aggregate = 1329.604 kg

4.2 Casting of Samples

Total 108 samples are casted out 36 cubes, 36 cylinders and 36 beams are prepared. Concrete mix is filled in moulds in three layers. Each layer is compacted by tampering rod with 25 number of blow.

4.3 Curing

The sample specimens are marked within 2 to 3 hours of casting and are kept in vibration free place, in nearly 90% relative humid air and at temperature of $27^0 \pm 2^0$ C for 24 ± ½ hours. After this period, the specimens are placed in submerge condition in fresh water in a tank and are kept there just prior to test. The duration of curing of sample is as per their schedule of testing.

4.4 Testing of Samples

Compressive Strength Test

The IS code followed for testing is IS: 516 – 1959. The concrete cubes are casted of size 150mm × 150mm × 150mm. These cubes are tested in UTM (Universal Testing Machine) of capacity 2000KN. a rate of 140 $kg/cm^2/min$. The compressive strength test is performed at the age of 7 days and 28 days.

Split tensile test

This test is an indirect method of finding tensile strength of concrete. The cylinder of dia 150mm and height 300mm is casted and then tested at the age of 7 days and 28 days. The loading rate is kept 1.2 MPa.

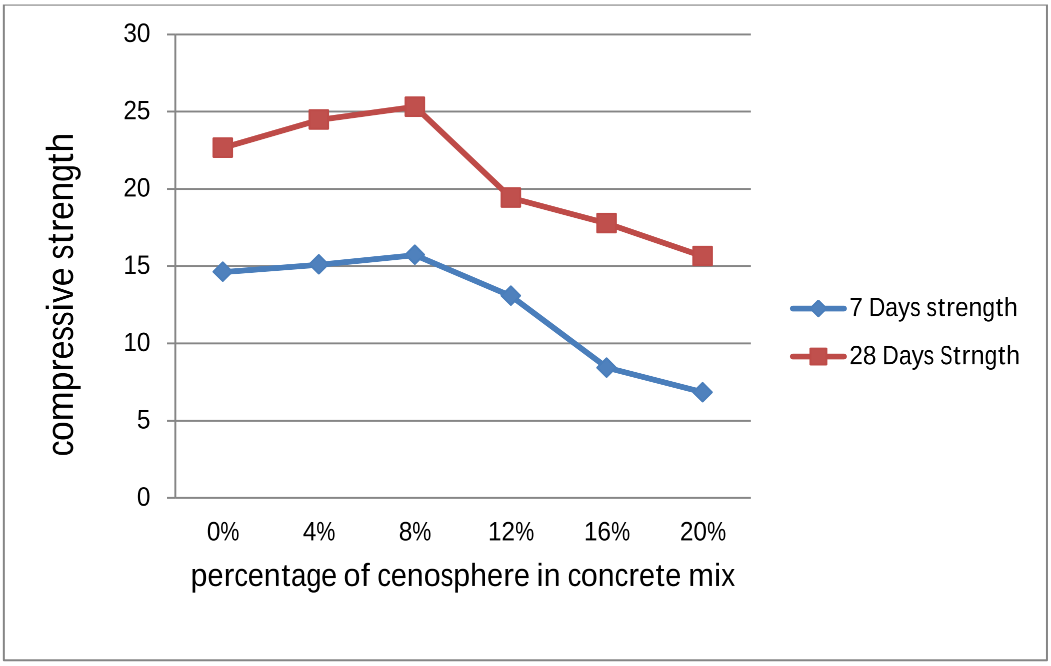
Flexural strength Test

The beams of size 100mm ×100mm ×500m m are casted for this test and centre point loading method is adopted for testing. Tests are performed per the ASTM C 293. The tests are performed at 7 and 28 days.

5. RESULTS AND DISCUSSION

Table-1: Average Compression Test Result of Cube Specimens

Percentage of Cenosphere	7 Days Compressive Strength	28 Days Compressive Strength
0	14.621	22.66
4	15.095	24.47
8	15.718	25.31
12	13.066	19.42
16	8.429	17.77
20	6.829	15.64



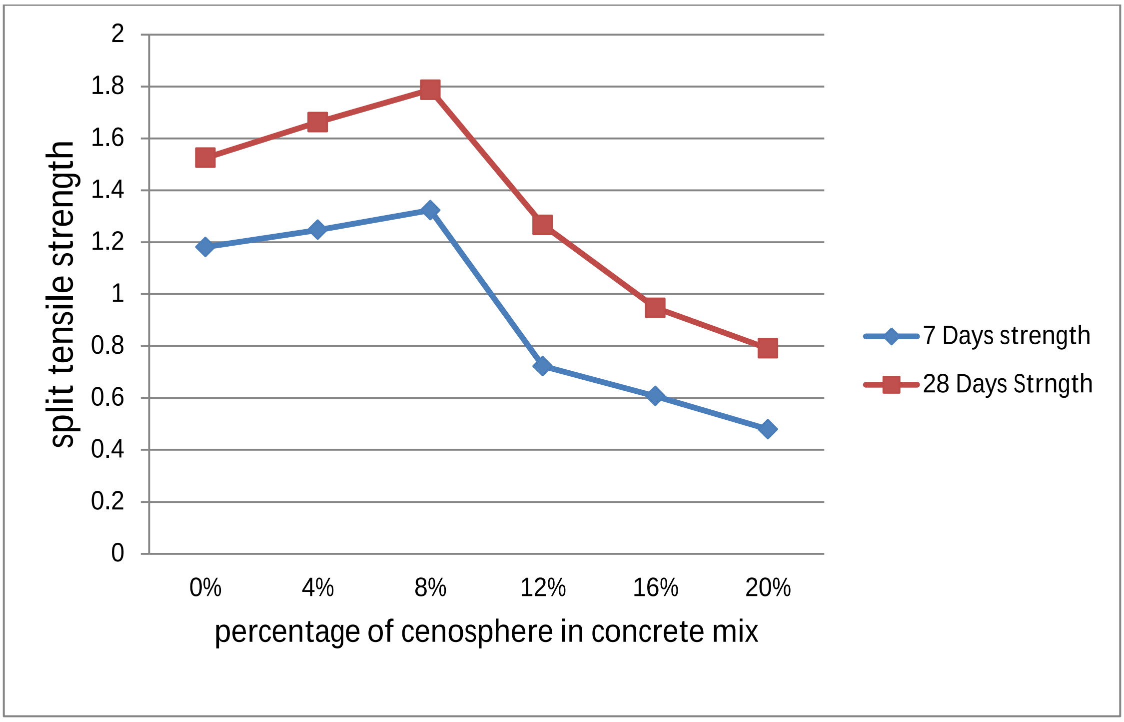
GRAPH 1: Compression Test Analysis

The compression test results are shown in table-1. From GRAPH-1 it is observed that the maximum result is obtained at 8% fly ash cenosphere in concrete. The 28 days compressive strength for conventional concrete is found 22.66 MPa and that for 8% fly ash cenospheres concrete is25.31 MPa. It shows the 11.69% improvement from conventional concrete. For other percentages of fly ash cenospheres the strength is below 20 Mpa, thus optimum use of fly ash cenospheres is 8%.

Table-2: Average Split Tensile Strength of Cylindrical Specimens

Percentage of Cenosphere	7 Days Compressive Strength	28 Days Compressive Strength
0	1.181	1.525
4	1.247	1.662

8	1.323	1.787
12	0.722	1.266
16	0.607	0.947
20	0.479	0.791

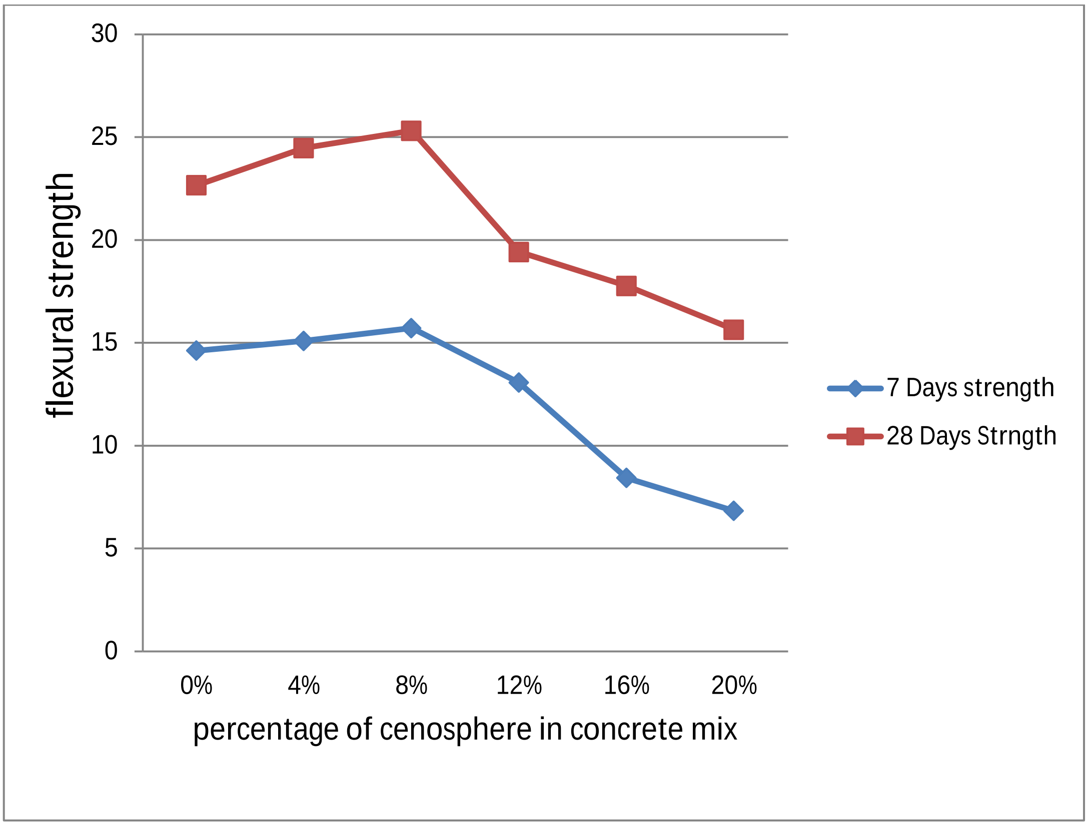


GRAPH 2: Split Tensile Strength Test Analyses

The split tensile test results are shown in table-2. From GRAPH-2 it is observed that the maximum result is obtained at 8% fly ash cenosphere in concrete. The 28 days split tensile strength for conventional concrete is found 1.525 MPa and that for 8% fly ash cenospheres concrete is1.787 MPa. It shows the 26.2%% improvement from conventional concrete. For other percentages of fly ash cenospheres the strength is below limiting strengh for M20 concrete, thus optimum use of fly ash cenospheres is 8%.

Table-3: Average Flexural Test Results of Beam Specimen

Percentage of Cenosphere	7 Days Compressive Strength	28 Days Compressive Strength
0	2.93	4.95
4	3.62	5.85
8	4.49	6.62
12	2.63	4.25
16	2.34	4.02
20	1.97	3.46



GRAPH 3: Flexural Test Analysis

The flexural test results are shown in table-3. From Figure-3 it is observed that the maximum result is obtained at 8% fly ash cenosphere in concrete. The 28 days flexural strength for conventional concrete is found 4.95 MPa and that for 8% flyash cenospheres concrete is 6.662 MPa. It shows the 33.73%% improvement from conventional concrete. For other percentages of fly ash cenospheres the strength is decreasing but not falling below the limiting value for M20 concrete. Thus optimum use of fly ash cenospheres can be say as 20% and best result is obtain at 8% fly ash cenospheres.

6. CONCLUSIONS

The 28 days compressive strength for conventional concrete is found 22.66 MPa and 8% fly ash cenospheres concrete is25.31 MPa, it shows the 11.69% improvement from conventional concrete.

For other percentages of fly ash cenospheres the strength is below 20 Mpa, thus optimum use of fly ash cenospheres is 8%.

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For other percentages of fly ash cenospheres the strength is decreasing but not falling below the limiting value for M20 concrete. Thus optimum use of fly ash cenospheres can be say as 20% in terms of flexural strength. .

Finally it is found the 8% replacement of fly sh cenosphere with cement in cement concrete is the beneficial replacement. If this percentage is increases, the strength of concrete is decreases.

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