Academia Journal of Scientific Research 8(5): 180-185, May 2020
DOI: 10.15413/ajsr.2020.0108
ISSN 2315-7712

Research Paper

Partial replacement of cement with fly ash cenospheres in cement concrete

Accepted 14th February 2020

ABSTRACT

Concrete is one of the important materials of the construction industries. At present, due to increase in a population, the demand for infrastructure is increasing day by day. This leads to increase in production of cement. Currently, worldwide 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 that comprises 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 determine the compressive strength, split tensile strength and flexural strength of concrete cube cured for the period of 7 and 28 days. The results obtained from the experiments with a suitable replacement of cement with cenosphere are presented in this study.

Pradeep Kumar

P. G. Student, Department of Civil and Environmental Engineering, National Institute of Technical Teachers Training and Research, Bhopal, India.

*Corresponding author. E-mail: 9009pradeep@gmail.com.

Key words: Concrete, fly ash, cenospheres, compressive strength, split tensile strength, flexural strength.

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 it acts as a binding material. However, the production of cement causes so many environmental hazards, such as 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, that is, 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 to 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, other optional material for concrete in place of cement needs to be determined. If we are able to replace few percentage of cement form concrete, it will be 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.

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.

METHODOLOGY

Material used

Cement

For this research, PCC cement of MYCEM Company was 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.

Cenospheres

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

Fine aggregate

Fine aggregates are material passing through an IS sieve 4.75 mm and retained on 150µm gauge. Locally available sand was used as fine aggregate in the experimental analyses.

Coarse aggregate

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

Water

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

Procedure

Proportioning

The standard proportion as per IS:456-2000, for M20 grade concrete was 1:1.5:3. Here, proportion adopted **1:1.8011:3.283** was calculated using mix design method. Cement was replaced with cenosphere at various percentages, that is, 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

Casting of samples

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

Curing

The sample specimens were marked within 2 to 3 h of casting and were kept in vibration free place, in nearly 90% relative humid air and at temperature of 27° ± 2°C for 24 ± ½ h. After this period, the specimens were placed under submerge condition in fresh water in a tank and were kept there just prior to test. The duration of curing of sample was at per with their schedule of testing.

Testing of samples

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

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

Flexural strength test

The beams of size 100 mm × 100 mm × 500 mm were

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

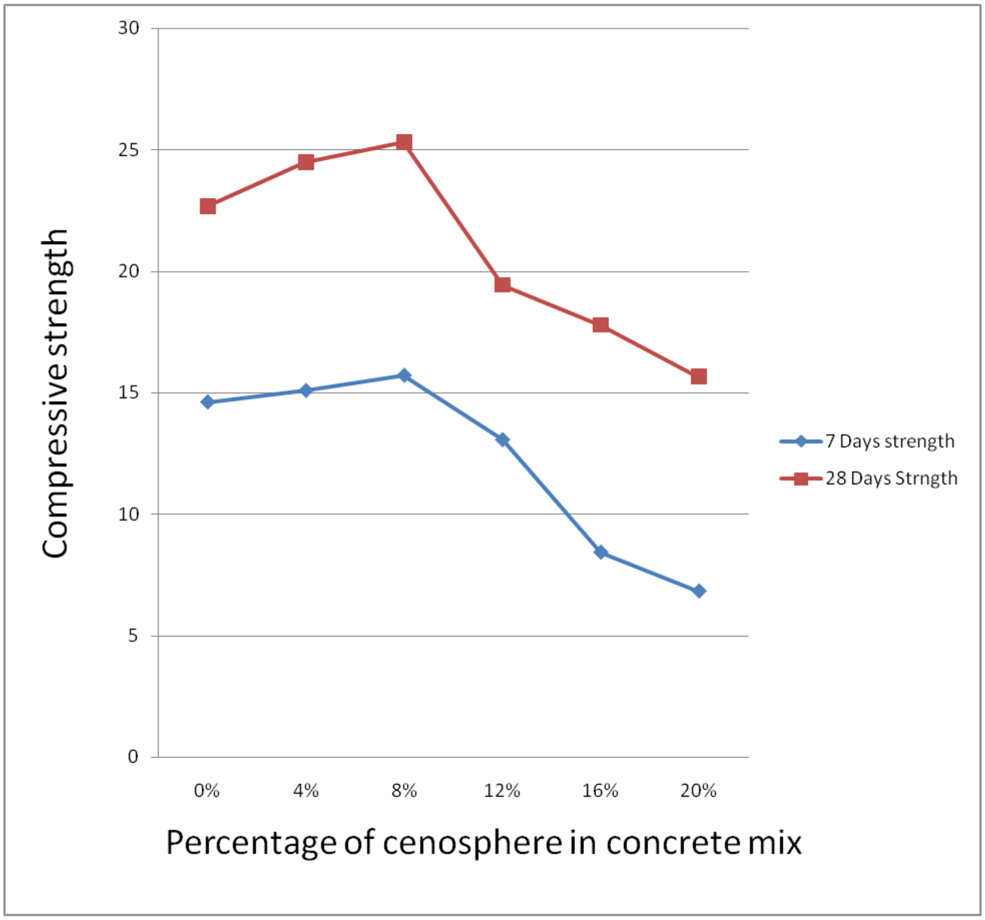

Figure 1: Variation in average compressive strength corresponding to percentage variation.

casted for this test and centre point loading method was adopted for testing. Tests were performed per the ASTM C 293. The tests were performed at 7 and 28 days.

RESULTS AND DISCUSSION

The compression test results are shown in Table 1. From Figure 1, it is observed that the maximum result was obtained at 8% fly ash cenosphere in concrete. The 28 days compressive strength for conventional concrete was found to be 22.66 MPa and that for 8% fly ash cenospheres concrete was 25.31 MPa. This shows 11.69% improvement from conventional concrete. For other percentages of fly ash cenospheres, the strength was below 20 Mpa, thus optimum use of fly ash cenospheres was 8%.

The split tensile test results are shown in Table 2. From Figure 2, it is observed that the maximum result was obtained at 8% fly ash cenosphere in concrete. The 28 days split tensile strength for conventional concrete was found to be 1.525 MPa and that for 8% fly ash cenospheres concrete is 1.787 MPa. This shows 26.2%% improvement

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

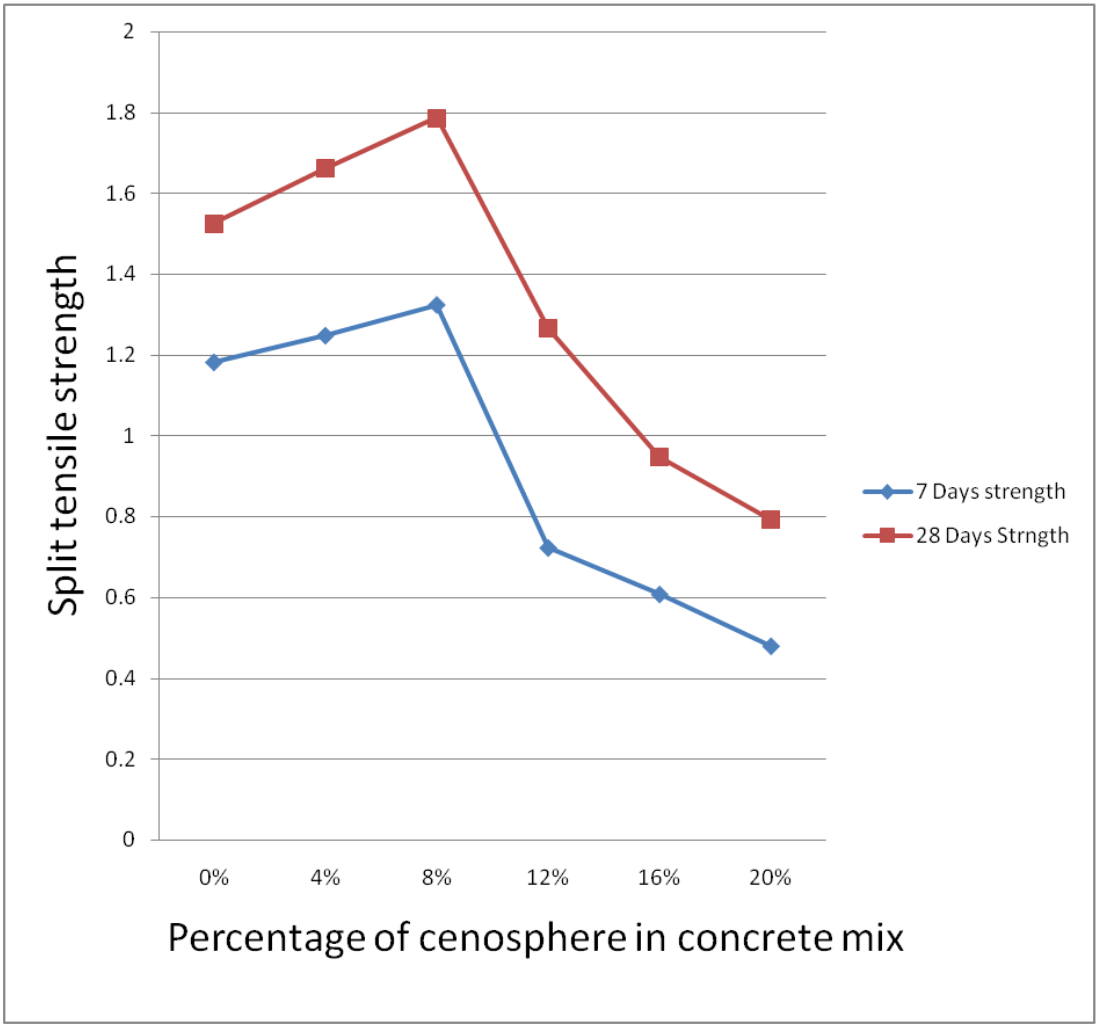

Figure 2: Variation in average split tensile strength corresponding to percentage variation.

from conventional concrete. For other percentages of fly ash cenospheres, the strength was below the limiting strength for M20 concrete, thus optimum use of fly ash cenospheres was 8%.

The flexural test results are shown in Table 3. From Figure 3, it is observed that the maximum result was obtained at 8% fly ash cenosphere in concrete. The 28 days flexural strength for conventional concrete was found to be 4.95 MPa and that for 8% flyash cenospheres concrete was 6.662 MPa. This shows 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 said to be 20% and the

Table 3: Average flexural test results of beam specimens.

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

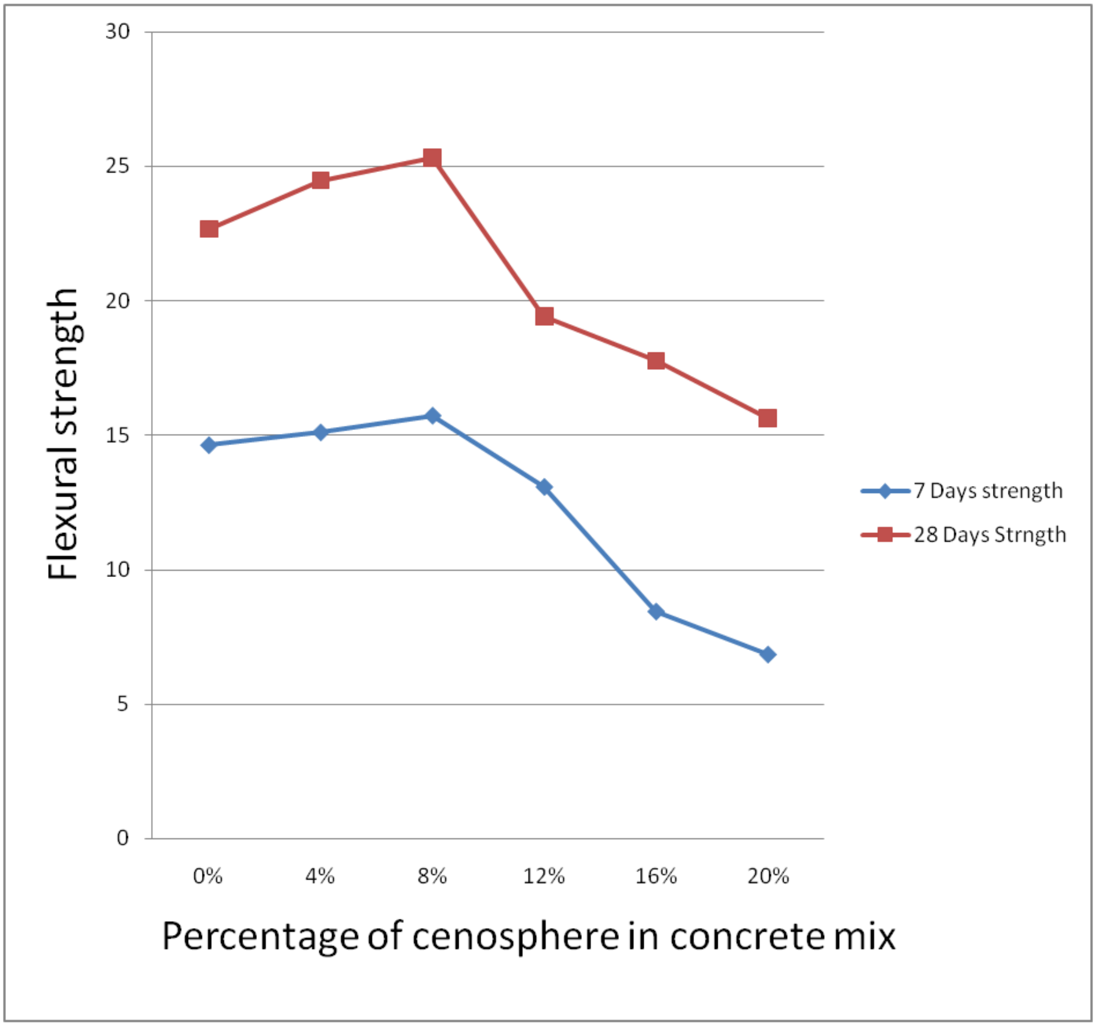

Figure 3: Variation in average flexural strength corresponding to percentage variation.

best result was obtained at 8% fly ash cenospheres.

CONCLUSION

The 28 days compressive strength for conventional concrete was found to be 22.66 MPa and 8% fly ash cenospheres concrete was 25.31 MPa. This shows 11.69% improvement from conventional concrete.

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

The 28 days split tensile strength for conventional concrete was found to be 1.525 MPa and that for 8% fly ash cenospheres concrete was 1.787 MP. This shows 26.2%% improvement from conventional concrete. The optimum use of fly ash cenospheres was 8%.

The 28 days flexural strength for conventional concrete was found to be 4.95 MPa and that for 8% fly ash cenospheres concrete was 6.662 MPa. This shows 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 said to be 20% in terms of flexural strength.

Finally, it was found that the 8% replacement of fly ash cenosphere with cement in cement concrete was the beneficial replacement. As this percentage increases, the strength of concrete decreases.

ACKNOWLEDGEMENTS

The author would like to extend gratitude and sincere thanks to Prof. M. C. Paliwal for his constant motivation and support during the course of the thesis. The author is also grateful to his family members for their care, encouragement and affection. Special thanks to almighty God for everything.

REFERENCES

Aparna Sasi and Reshmi K N (2018). "Experimental Investigation on M55 Grade Concrete Using Industrial Waste", Int. J. Innov. Res. Technol. 5(1): ISSN: 2349-6002.

Md. Shams Tabrez Ansari, Ajay Swarup, Dhananjay Yadav (2018). "Partial Replacement of Cement With Flyash and Silica Fumes", IJARIIE-ISSN(O)-4(4): 2395-4396.

Senthamarai K, Kannam L, Andal M, Shanmugasundaram (2016). "An Investigation on Strength Development of Cement with Cenosphere and Silica Fume as Pozzolanic Replacement", Adv. Mater. Sci. Eng. 1:1-5. :Article 9367619.

Michael Raj I, Robinson J (2018). "Partial Replacement of Cement with Cenosphere as Pozzolanic Material in Concrete", Int. Res.J. Eng. Technol. 5:12. e-ISSN: 2395-0056.

Khushal Chandra Kesharwani, Amit Kumar, Ahsan Rabbani (2017). "Experimental Study on Use of Fly Ash in Concrete", Int. Res. J. Eng. Technol. -4: p-ISSN: 2395-0072.

Corazon C. Corbal (April-September 2019). "Study of the Compressive Strength of Concrete with Selected Shells as Substitute to Fine Aggregate", Int. J. Civil Struct. Eng. Res. 7: ISSN:2384-7607.

Patel AJ, Patel VM, Patel MA (2015). "Review on Partial Replacement of Cement in Concrete", UKIERI Concrete Congress- Concrete Research Driving Profit and Sustainability,

Koyal PK, Singh DN (2000). "Physical, Chemical, Mineralogical and Thermal Properties of Cenospheres form an Ash lagoon", Cement Concr. Res. 31: 539-542.

Subharjit Sen (2017). "Physical properties of cenosphere". Thesis work in Department of Civil Engineering, National Institute Technology, Rourkela

Jun-Yan Wang, Min-Hong Zhang (2012). "Stability of Cenospheres in Lightweight Cement Composites in Term of Alkali-silica Reaction", Cement and Concrete Research.

Cite this article as:

Kumar P (2020). Partial replacement of cement with fly ash cenospheres in cement concrete. Acad. J. Sci. Res. 8(5): 180-185.

Submit your manuscript at

http://www.academiapublishing.org/ajsr