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Innovative Application of Fly Ash and Foundry Sand in Concrete Mixes

Abhiyant Sharma¹, Tapeshwar Kalra²

¹M.Tech. scholar, Surya World College of Engg. & Tech. Rajpura (Pb.) 140417

²Assistant Professor, Surya World College of Engg. & Tech. Rajpura (Pb.) 140417

Abstract: *Worldwide development in overall Scenario will be carbon lessening and vitality sparing. Most extreme utilization of assets, proficient development, practical development and quality enhancements costs have turned out to be dire issues which advances general monetary improvement endeavors to enhance expectations for everyday comforts and takes care of the issues of deficiencies in assets. Reusing is acknowledged to be one of the vital bases of supportability. Presently days we are attempting to use all sort of item, regardless of whether they are metal, solid, plastic, wood, or even glass, will in the end transform into squanders that must be arranged. The most ideal approach to manage such sort of squanders is to reusing, recuperation and reuses them as crude materials or modifiers. This will lessen the deplete on the common assets of the crude materials, and it will decrease the spaces utilized as landfills. Among all these fly ash debris and waste foundry sand squander create by the Industrial enterprises. In this study fly ash and waste foundry sand were used to replace natural aggregate depending on the fineness of particles. Concrete has become the most widely accepted and used construction material in civil engineering industry, the incorporation of fly ash and foundry sand particles in concrete would be a very good and promising way to utilize the large quantities of wastes like fly ash and foundry sand. Fly ash and waste foundry sand used as particles in concrete would not only make a use of such waste materials but also help to improve some concrete properties. The concrete containing fly ash and foundry sand have excellent ductility and improved mechanical properties as compared with conventional or controlled concrete. This work studies the effects of fly ash and foundry sand as aggregate and filler as a partial replacement of natural aggregate in the cement concrete. The primary aim of this study was to evaluate the strength property of concrete. This Study has shown that replacing some percentage of natural aggregates by fly ash and foundry sand causes significant change in properties of concrete. The properties studied are 7days, 28days compressive strengths and flexural strength, etc.*

Keywords- Fly Ash, Foundry Sand, Compressive Strength, Flexural Strength

I. INTRODUCTION

Global movement in worldwide Scenario is going to be energy saving and carbon reduction. Maximum application of resources, efficient construction, economical construction and quality improvements costs have become urgent issues which promotes overall economic development, strives to improve living standards and solves the problems of shortages in resources. Recycling is accepted to be one of the important bases of sustainability. Now days we are trying to utilize all kind of product, whether they are metal, concrete, plastic, wood, glass or even Industrial waste will eventually turn into wastes that must be disposed. The best possible way to deal with such kind of wastes is to recycle and reuse them as raw materials or modifiers. This will reduce the drain on the natural resources. With the rapid development, higher living standards and higher population growth, the quantities are expected to be sharply increased.

Concrete is most widely used man-made construction material in the world on the planet. Concrete is primarily made up of four fundamental ingredients, i.e. coarse aggregate, fine aggregate (i.e. sand), cement and water. Concrete occupies a unique place among modern construction materials. It gives freedom to mould the structure to any shape. When the concrete mixture is placed in mould and allowed to cure, it hardens into a rock-like mass. The hardening of the mixture is caused by chemical reaction between water and cement and it continues for a long time. More than 90% of the structures ranging from buildings, retaining walls, dams, roads and bridges etc. utilize the concrete as a construction material. Good concrete should be able to resist corrosion; wear and it should be water-tight and economical. The concrete is most important construction material which is manufactured at site. The concrete must be strong enough to withstand all the imposed stresses without injury and the required factor of safety.

II. LITERATURE REVIEW

Brown, J.H. study the replacement of fly ash with cement and fine aggregate at levels of 10-40% by volume. Carette and Malhotra studied in this research they studied the effect of Canadian fly ashes on the mechanical property of concrete mixes. Gebler and Klieger investigated the requirements of Air Entraining Agent for Class-C and Class-F fly ashes. Ho and Lewis investigated the carbonation rates of three types of concrete mixes. J. Virtanen, evaluated the freezing and thawing resistance concrete made with fly ash. Owens in his study reported that with the use of fly ash containing large fraction of particles coarser than $45\mu\text{m}$ or a fly ash with high amount of unburned carbon, exhibiting loss on ignition more than 1%, higher water demand was observed. Joshi and Lohtia in their paper tested a large number of fly concrete mixes made by using three different fly ashes containing about 10% calcium oxide. The replacement level varied between 40 and 60% by weight of cement. Naik in their research evaluated the influence of addition of large amounts (50 and 70% cement replacement) of Class C fly ash on the chloride permeability of concrete. Lohtia et al. studied the creep and creep recovery of plane and fly ash concretes at stress-strength ratios of 20 and 35%. P.K. Mehta concluded that fly ashes are amongst the group of pozzolans that significantly increase the life expectancy of concrete exposed to sulfate attack. R. Siddique, studied the abrasion resistance of concrete proportioned to have four levels of fine aggregate replacement (10 to 40%) with Class F fly ash. Saraswathyetal investigated the influence of activated fly ash on the compressive strength of concrete. R. Siddique, studied the effect of partial replacement of fine aggregate (sand) with varying percentages of Class F fly ash on the compressive strength, splitting tensile strength, flexural strength and modulus of elasticity of concrete up to the age of 365 days. Atis assessed the drying shrinkage of mortar mixtures containing high calcium non standard fly ash up to the age of 5 months. Chalee studied the effect of W/C ratio on covering depth required against the corrosion of embedded steel of fly ash concrete in marine environment up to 4-year exposure. Demirboga investigated the Thermal Conductivity (TC) of HVFA concrete at the age of 28 days. Cement was replaced with 0, 50, 60, and 70% of Class C fly ash.

Khatib and Elliscarried out a research on the compressive strength of concrete prepared with three types of foundry sand as a partial replacement for fine aggregate. Siddique determined the effect of spent foundry sand as partial replacement of fine aggregate on the splitting tensile strength of concrete. Siddique studied the mechanical properties of concrete mixtures in which fine aggregate (regular sand) was partially replaced with used-foundry sand. Guney et al. investigated the potential re-use of waste foundry sand in high-strength concrete production. S. Kolawole, studied the concrete produced at different percentage of foundry sand ranging from 0% to 100% in steps of 25% of dry weight of fine aggregates. Xerses N. Irani studied experimental investigations were performed such as compressive strength test, Split tensile strength test, flexural strength test on the concrete containing (0%, 10% and 100% replacement of e foundry waste sand in place of fine aggregate.

III. PROPERTIES OF MATERIALS

A. Fly Ash

Fly ash used in the study was obtained from Guru Nanak Dev Thermal Power Plant, Bathinda. Its physical and chemical properties are given in Table1 and Table 2 respectively. Fineness modulus of fly ash was $100\mu - 90\mu$.

Table 1 Physical properties of fly ash

Characteristics	Value
Colour	Whitish grey
Bulk density (kg/m^3)	1120
Specific Gravity	2.12
Fineness	2840 cm^2/gm

Table 2 Chemical properties of fly ash

Constituent	Component in %
Silica (SiO_2)	46.8
Alumina (Al_2O_3)	23.7
Ferric Oxide (Fe_2O_3)	13.2
Calcium Oxide (CaO)	1.2
Magnesia (MgO)	1.0

Loss of Ignition	6.9
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B. Foundry Sand

Foundry sand procured from Delux Foundry from Mandi-Gobindgarh, Patiala. For laboratory applications it was crushed using manual means. The physical and chemical properties of the foundry sand used in this investigation are listed in Table 3 and Table 4 respectively. F.M of foundry sand is 1.19.

Table 3 Physical properties of Foundry Sand.

Characteristics	Value
Water absorption	1.79%
Bulk density (kg/m ³)	1440
Specific Gravity	2.63
Porosity	38.27%
Voids Ratio	0.62
Moisture Content %	0.1-10.1

Table 4 Chemical properties of Foundry Sand

Constituent	Value
SiO ₂	87.91
Al ₂ O ₃	4.70
Fe ₂ O ₃	0.94
CaO	0.14
MgO	0.30
SO ₃	0.09
Na ₂ O	0.19
K ₂ O	0.25
TiO ₂	0.15
Mn ₂ O ₃	0.02
SrO	0.03
LOI	5.15
Total	99.87

C. Portland Cement

Portland cement is a fine, grey powder. Cement is mixed with water and materials such as sand, gravel, and crushed stone to make concrete. In this work Birla Plusof 43grade was used for casting cubes and cylinders for all concrete mixes. The various tests conducted on cement are initial and final setting time, specific gravity, fineness and compressive strength. Cement used fulfill requirement as per IS: 8112-1989.

D. Fine Aggregates

The sand used for the work was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand was sieved through 4.75 mm sieve. The various other tests conducted are specific density, bulk density, fineness modulus, water absorption and sieve analysis to meet all the requirements of IS 383-1970. The fine aggregated belonged to grading zone II. This Aggregate has absorption of 0.89 %. The Bulk Specific Gravity of the fine aggregate was 2.60 while its SSD Specific Gravity was 2.59.F.M of fine sand is 2.62.

E. Coarse Aggregates

The material which is retained on IS sieve no. 4.75 is termed as a coarse aggregate. The crushed stone is generally used as a coarse aggregate. The aggregates were tested as per IS: 383-1970. Coarse aggregate having Fineness Modulus is 6.95

IV. RESULT & DISCUSSION

A. Compressive Strength

Cubes were molded with a 150 X 150 X 150 mm in size to determine the compressive strength of the concrete mixtures. The cubes were tested at 7 and 28 days as per IS 516-1959. Figure -1 & 2 shows that the compressive strength of all the specimens at 7 & 28 days. Table 5 provides the compressive strength of concrete for 7 and 28 days for all the specimens.

Table 5: Compressive strength of concrete with Foundry Sand and 5% and 10% Fly ash

Mix	Fly Ash %	Compressive Strength (N/mm ²)		Average Compressive Strength (N/mm ²)	
		7 days	28 days	7 days	28 days
CM	0%	23.79	31.55	24.09	31.72
		24.12	32.87		
		24.36	30.74		
10%	5%	23.77	32.43	23.97	33.47
		24.01	34.37		
		24.15	33.63		
15%	5%	23.87	32.63	24.23	33.85
		24.15	34.49		
		24.67	34.43		
20%	5%	24.45	35.43	24.87	35.84
		24.85	35.47		
		25.31	36.63		
10%	10%	24.78	36.73	25.31	37.34
		25.37	37.47		
		25.79	37.83		
15%	10%	24.91	39.43	25.74	39.21
		25.95	39.07		
		26.38	39.13		
20%	10%	26.17	33.43	27.03	34.19
		26.85	34.47		
		27.54	34.67		

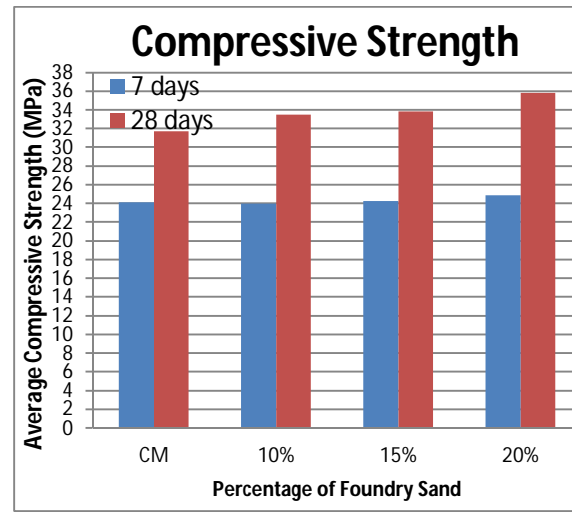


Figure 1 Compressive Strength of Concrete with 5% Fly ash with variation of Foundry sand

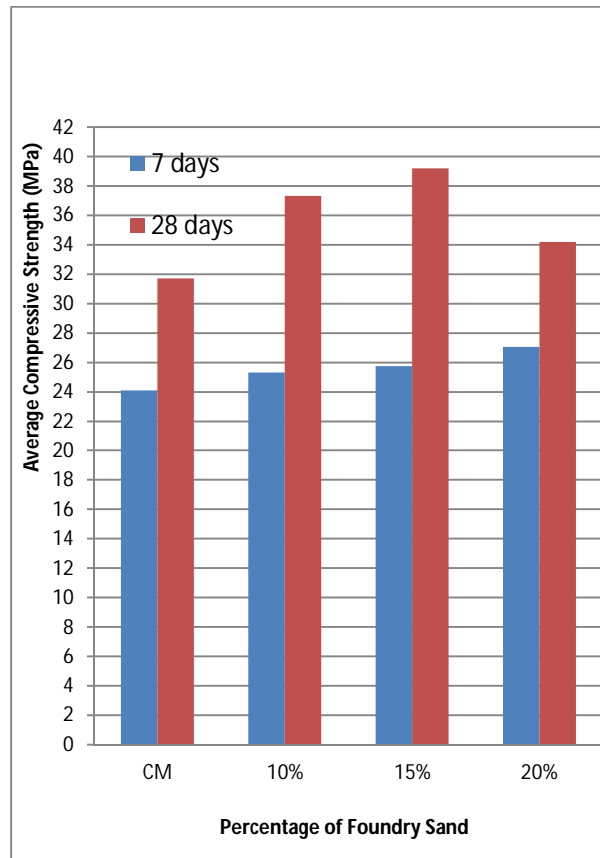


Figure 2 Compressive Strength of Concrete with 10% Fly ash and variation of Foundry sand

B. Splitting Tensile Strength

The splitting tensile strength of the concrete specimens was determined at 7 and 28 days following IS 5816-1999. Cylinders were molded with a diameter of 150 mm and a length of 300 mm. Table 6 shows the 7 and 28 days splitting tensile strength on concrete of all the specimens.

$$\frac{2P}{\pi d} = f_{ctP} = \text{Maximum of applied load in N, } d = \text{diameter of the specimen}$$

Table 6 Split tensile strength of concrete with Foundry Sand and 5% and 10% Fly ash

Mix	Fly Ash %	Split Tensile Strength (N/mm ²)		Average Split Tensile Strength (N/mm ²)	
		7 days	28 days	7 days	28 days
CM	0%	2.55	2.98	2.65	3.04
		2.75	3.02		
		2.67	3.14		
10%	5%	2.43	3.03	2.54	3.08
		2.57	3.11		
		2.62	3.12		
15%	5%	2.67	3.02	2.78	3.16
		2.87	3.19		
		2.82	3.25		
20%	5%	2.87	3.12	2.85	3.29
		2.77	3.29		
		2.89	3.45		
10%	10%	2.77	3.02	2.49	3.27
		2.43	3.41		
		2.27	3.40		
15%	10%	2.97	3.55	3.12	3.70
		3.15	3.64		
		3.22	3.89		
20%	10%	2.17	3.45	2.45	3.28
		2.49	3.14		
		2.69	3.25		

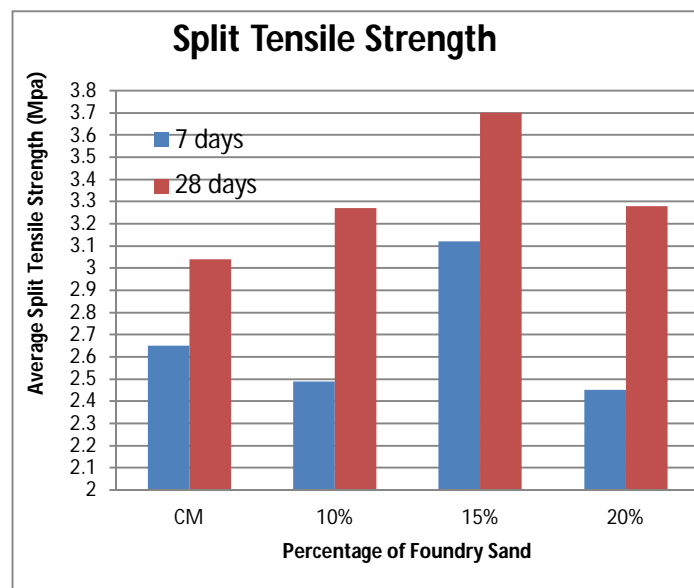


Figure 3 Split Tensile Strength of Concrete with 5% Fly ash and variation of Foundry sand

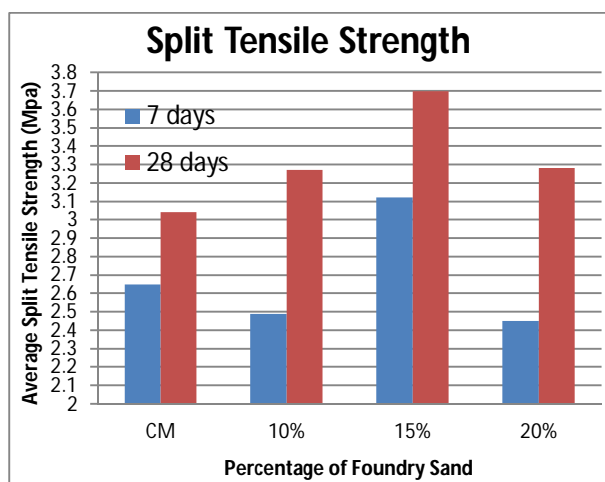


Figure 4 Split Tensile Strength of Concrete with 10% Fly ash and variation of Foundry sand

V. CONCLUSIONS

The strength characteristics of concrete mixtures have been computed in the present work by replacement of fine aggregate and cement by 5% and 10% of fly ash and 10%, 10% and 20% foundry sand with the fine aggregate. On the basis of present study, following conclusions are drawn.

A. Compressive Strength

- 1) The Compressive strength tends to increase with increase percentages of foundry slag in the mix.
- 2) The compressive strength increases as compared to control mix as the percentage of foundry sand is increased with fly ash as constant 5%. After adding 10% foundry sand in the mix, there is an increase of 6% increase after 28 days as compared to the control mix. By adding 15% and 20% foundry sand (fly ash as 5%), there is not such large amount of increase in percentage i.e. 1%, 2% and 7%, 13% after 7 and 28 respectively.
- 3) The results indicate that the strength of design mix goes on increased by 24% as the percentage of foundry sand increases upto 15% at 28 days as compared to that of control mix, but after 15% there is marginal decrease in strength at by 15% as compared to 20% replacement of foundry sand at 28 days. But this value is 8% higher than the control mix.

B. Split Tensile Strength

The Split tensile strength also tends to increase with increase percentages of foundry sand in the mix.

- 1) The split tensile strength increases with the percentage increase of foundry sand at 5% fly ash as replacement of cement as compared to control mix. After adding 10% foundry sand in the mix, there is an increase of 2% increase after 28 days. By adding 15% and 20% foundry sand, there is increase in percentage i.e. 5%, 8% and 4%, 9% after 7 and 28, respectively
- 2) The split tensile strength increases with the percentage increase of foundry sand at 10% fly ash as replacement of cement as compared to control mix. After adding 10% foundry sand in the mix, there is an increase of 8% increase after 28 days. By adding 15% and 20% foundry sand, there is increase in percentage i.e. 18%, -8% and 28%, 8% after 7 and 28, respectively.

VI. FUTUER SCOPE

- A. In the present study only up to 20 per cent replacement of fine aggregate by foundry sand has been considered. The other percentages i.e. 25 and 30 per cent need investigation.
- B. In the present study only design mix w/c ratio have been considered. The other ratios i.e. 0.4, 0.45 and 0.55 need investigation.
- C. Sulphate resistance of concrete containing foundry sand and fly ash needs to be investigated for larger exposure time.
- D. In the present study only up to 10 per cent replacement of cement by fly ash has been considered. The other percentages i.e. 15 and 20 per cent need to be investigation.
- E. Fresh concrete properties of concrete is not studied, need to be more investigation.

F. Durability properties are also not studied in this research work.

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