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Effect on Compressive Strength of Concrete by Partial Replacement of Cement with Fly ash

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Abstract - *The cement is the main ingredient used for concrete. The production of cement involves emission of large amount of carbon dioxide into the atmosphere. Therefore, the search of any other such material which can be used as an alternative to cement should lead to lowest possible environmental impact. The fly ash obtained by combustion of coal can be used as partial replacement for cement owing to its pozzolanic nature, which provides strength to cement. The huge quantity of fly ash being accumulated over the years is likely to pose a serious threat for its disposal and cause environmental problems. In this paper, an effort has been made to determine the effect on compressive strength of concrete by partial replacement of cement with 0%, 10%, 20% and 30% of fly ash for M20 grade of concrete. Test results indicate that workability and durability of concrete increases with increase in fly ash content. It has also been obtained that with increase in fly ash content, there is reduction in compressive strength of concrete. The optimum replacement of cement with fly ash is 30%.*

Key Words: fly ash, workability, durability, partial replacement, pozzolanic, compressive strength.

1. INTRODUCTION

Energy is the main backbone of modern civilization of the world, and the electrical power from thermal stations is a major source of energy on which hinges the functioning and growth of manhood. Energy in the form of electricity is a basic necessity for economic development and social progress. Thermal power electricity is generated from the coal fired thermal stations. Coal based thermal power stations generate electricity on one hand which is essential for our development and growth, on the other hand, these power stations also produce massive quantities of coal ash which could pose serious environmental and other related problems.

Fly ash is one of the coal combustion products, composed of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3) and calcium oxide (CaO).

In the past, fly ash was generally released into the atmosphere as it is difficult to decompose, but air pollution control standards now require that it be captured prior to release by fitting pollution control equipment. Fly ash is generally stored at coal power plants or placed in landfills. Due to the presence of pozzolanic activities, which is responsible for setting of concrete and provide concrete with more protection from wet conditions and chemical attack, fly ash can be used as a partial replacement for cement. Moreover, cement industry is the major contributor of pollution by releasing carbon dioxide. 1 ton of cement produces approximately 1 ton of carbon dioxide. So by partially replacing cement with pozzolanic material such as fly ash, the cement industry can serve both the purposes of meeting the demands of construction industry and at the same time producing green and clean environment. Fly ash is of two types class F and C. Class F fly ash is produced by burning of harder, older anthracite and bituminous coals. This fly ash is pozzolanic in nature and contains less than 7% lime (CaO). However, class C fly ash is produced by burning of younger lignite sub-bituminous coal. It possesses pozzolanic as well as self-cementing properties. In the presence of water, class C fly ash hardens and gets stronger over time. It generally contains more than 20% lime (CaO).

2. LITERATURE REVIEW

The present study aims to study the effect of fly ash on concrete by partial replacement of cement with 0%, 10%, 20% and 30% of fly ash. Various research works have already been conducted to study the effect of fly ash on various properties of concrete at different ages and for different grades of concrete. Some research works were reviewed and are presented in this paper.

C. Marthong [1] studied the effect of fly ash additive on concrete properties and found that the normal consistency increases with increase in the grade of cement and fly ash content. It was also concluded that the use of fly ash improves the workability of concrete. Moreover, it was also

observed that the compressive strength of concrete increases with the grade of cement. As the fly ash content increases in all grades of OPC there is reduction in the strength of concrete. The reduction is more at earlier ages as compared to later ages. Fly ash concrete was also found to be more durable as compared to normal OPC concrete.

Aman Jatale [2] studied the effects on compressive strength when cement is partially replaced by fly ash and observed that the use of fly ash slightly retards the setting time of concrete. It was also found that the rate of strength development at various ages is related to the w/c ratio and percentages of fly ash in the concrete mix. Moreover, the modulus of elasticity of fly ash concrete also reduced with the increase in fly ash percentage for a given w/c ratio.

S.A.K. Reddy [3] studied the effect of fly ash on strength and durability parameters of concrete and found that consistency increases greatly with increase in percentage of fly ash. The optimum 7 and 28 day compressive strength was obtained in the range of 20% fly ash replacement level. It also led to the increase in split tensile strength of concrete.

Tarun Sama [4] studied the effect of strength of concrete by partial replacement of cement with fly ash and addition of steel fibres. The grade of concrete used was M40 with mix proportion of 1:1.62:2.83 and w/c ratio of 0.45. It was observed that the optimum percentage of adding fly ash and steel fibres was determined to be 40% and 2% which showed the maximum improvement in tensile and flexural strength.

Shantmurti Upadhyaya [5] studied the effects of fly ash on compressive strength of M20 mix design concrete and found that till the addition of fly ash upto 10%, there is negligible change in the strength of concrete. It was also observed that at the replacement till 30%, fly ash blocks have shown very low compressive strength in comparison to concrete containing no fly ash. Blocks containing fly ash were lighter in weight than the concrete block containg no fly ash.

P.R. Wankhede [6] studied the effect of fly ash on properties on concrete and found that slump loss of concrete increases with increase in w/c ratio of concrete and increase in quantity of fly ash. It was also concluded that concrete with 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days than normal concrete, but in case of 30% replacement of cement with fly ash ultimate compressive strength of concrete decreases.

Rahul Bansal [7] studied the effect on compressive strength with partial replacement of fly ash and found that by 10% replacement of cement by fly ash, 20% and 50% decrease in compressive strength was observed at the age of 7 and 28 days respectively. At 20% replacement, 7% and 11% increase in compressive strength was observed at the age of 7 and 28 days respectively. In 30% replacement, 23% and 25% increase in compressive strength was observed at the age of 7 and 28 days respectively. It was also observed that with the increase in age the compressive strength also increased for fly ash replaced concrete.

3. MATERIAL USED

The physical properties of cement, fine aggregates, coarse aggregates, fly ash and water used for mix design of M20 grade of concrete were tested in laboratory and are mentioned below.

3.1. Cement

The cement used was OPC53. All properties of cement were in accordance with IS269:1976. The physical properties of the cement used are as listed in table below.

Table-1: Physical Properties of Ordinary Portland Cement

Properties	Test Values
Specific Gravity	30%
Consistency (%)	3.15
Initial Setting Time	60 min.
Final Setting Time	260 min.

3.2. Fine Aggregates

The sand which was locally available and passing through 4.75mm IS sieve size was used as fine aggregate. The physical properties of the fine aggregates are as listed in table below:

Table-2: Physical Properties of Fine Aggregates

Properties	Test Values
Specific Gravity	2.60
Water Absorption	1%
Fineness Modulus	2.5

3.3. Coarse Aggregates

The coarse aggregates with nominal maximum size of aggregates as 20mm (60%) and 10mm (40%) as per Indian standard were used. The physical properties of the coarse aggregates are as listed in table below:

Table-3: Physical Properties of Coarse Aggregates

Properties	CA-20	CA-10
Type	Crushed	Crushed
Specific Gravity	2.65	2.70
Water Absorption	0.50%	0.50%
Fineness Modulus	6.8	6.5

3.4. Fly Ash

The fly ash used was of class F with specific gravity of 2.10.

3.5. Water

The water used for experiments was potable water.

4. METHODOLOGY

The aim of the present study was to study the effect of fly ash on compressive strength of concrete by partial replacement of cement with 0%, 10%, 20% and 30% of fly ash. The concrete mix of M20 grade was prepared as per IS10262:2009 having mix design ratio as 1:1.4:2.96 and w/c ratio of 0.50. To carry out the experimental investigation total 24 cubes of size 150mm x 150mm were casted. 6 cubes were casted to determine the compressive strength of normal concrete with no fly ash. Similarly, each set of 6 cubes were casted to determine the compressive strength for 10%, 20% and 30% replacement of cement with fly ash respectively. From these 6 cubes, 3 cubes were utilized to determine the compressive strength of concrete after 7 days of curing and rest 3 cubes were used to determine the compressive strength of concrete at 28 days. Compression Testing Machine of 2000kN capacity was used to determine the total compressive load taken by concrete at different ages. This ultimate load divided by the cross-sectional area of the cube (150mm x 150mm) yields the compressive strength of concrete.

Figure-1: Curing of specimens

Figure-2: Specimen testing in Compression Testing Machine

Table-4: Material Quantities for Mix Design

Fly Ash (%)	No. of cubes	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	
				CA10	CA20
0	6	9.24	12.94	16.416	10.944
10	6	8.32	12.94	16.416	10.944
20	6	7.4	12.94	16.416	10.944
30	6	6.47	12.94	16.416	10.944

5. RESULTS AND DISCUSSIONS

Each set of 3 cubes of M20 grade of concrete were tested in Compression Testing Machine with 0%, 10%, 20% and 30% replacement of cement with fly ash to determine the compressive strength after 7 and 28 days of curing. Average value of these 3 readings gives the average compressive strength of concrete. The average compressive strength of cubes at the age of 7 days and 28 days were found as 13.86 N/mm^2 and 20.58 N/mm^2 for normal concrete with no fly ash and it reduced to 10.11 N/mm^2 and 16.35 N/mm^2 when 30 % of cement was replaced with fly ash. The decrease in compressive strength of concrete after 28 days of curing was found to be 21%, when 30% of cement was replaced with fly ash. The compressive strength of M20 grade of concrete for different proportions of fly ash after 7 and 28 days of curing are listed below in table 5 and 6 respectively.

Table-5: Compressive Strength of M20 grade of concrete for different proportions of Fly Ash at the age of 7 days

Mix	7 days curing		
	Load (kN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
0% fly ash	296.10 316.80 322.65	13.16 14.08 14.34	13.86
10% fly ash	275.40 279.68 306.22	12.24 12.43 13.61	12.76
20% fly ash	246.15 262.58 268.88	10.94 11.67 11.95	11.52
30% fly ash	210.60 224.32 247.50	9.36 9.97 11.00	10.11

Table-6: Compressive Strength of M20 grade of concrete for different proportions of Fly Ash at the age of 28 days

Mix	28 days curing		
	Load (kN)	Compressive Strength (N/mm²)	Average Compressive Strength (N/mm²)
0% fly ash	456.30 459.68 473.18	20.28 20.43 21.03	20.58
10% fly ash	437.63 441.45 446.85	19.45 19.62 19.86	19.64
20% fly ash	401.85 406.80 411.22	17.86 18.08 18.28	18.07
30% fly ash	358.88 365.85 379.12	15.95 16.26 16.85	16.35

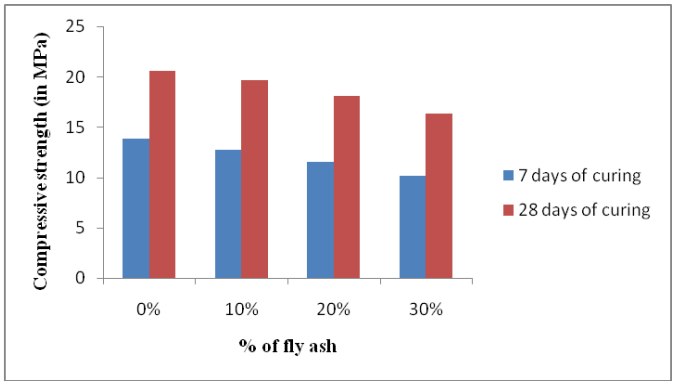

Chart-1: Compressive Strength (MPa) for different proportions of fly ash after 7 and 28 days of curing

6. CONCLUSIONS

From the experimental work carried out for M20 grade of concrete by partial replacement of cement with 10%, 20% and 30% of fly ash, the following conclusions were drawn.

1. The compressive strength of concrete decreases with increase in fly ash content. The reduction in compressive strength of concrete at the age of 28 days was found to be 4.57%, 12.20% and 20.55% for 10%, 20% and 30% replacement of cement with fly ash.
2. As the cement was replaced with fly ash, the reduction in compressive strength of concrete was higher at the age of 7 days as compared to 28 days. This occurs as the secondary hydration due to pozzolanic action is slower at initial stages for fly ash concrete.
3. The workability of concrete improves with the increase in fly ash content.
4. The consistency of cement increases with increase in fly ash content. This happens because the consistency of cement depends upon its fineness, and the fly ash molecules are finer than cement.
5. The increase in fly ash content also leads to retardation in the setting time of concrete. It was observed as the compressive strength for normal concrete with no fly ash at 7 days was 67% of characteristic compressive strength, whereas the compressive strength for concrete with 30% fly ash at 7 days was 60% of characteristic compressive strength.
6. Not more than 30% of cement should be replaced with fly ash; otherwise it may lead to significant reduction in the compressive strength of concrete.

REFERENCES

[1] C. Marthong, T. P. Agrawal, "Effect of Fly Ash Additive on Concrete Properties", International Journal of Engineering Research and Applications, ISSN 2248-9622, Volume 2, Issue 4, July-August 2012, pp 1986-1991.

[2] A. Jatale, K. Tiwari, S. Khandelwal, "Effects on Compressive Strength when Cement is Partially Replaced by Fly Ash", IOSR Journal of Mechanical and Civil Engineering, ISSN 2278-1684, Volume 5, Issue 4, Jan.-Feb. 2013, pp 34-43.

[3] S. A. K. Reddy, K. C. Reddy, "Effect of Fly Ash on Strength and Durability Parameters of Concrete", International Journal of Science and Research, ISSN 2319-7064, Volume 4, Issue 5, May 2015.

[4] T. Sama, D. Lalwani, A. Shukla, A. Sofi, "Effect of Strength of Concrete by Partial Replacement of Cement with Fly Ash and addition of Steel Fibres", Journal of Civil Engineering and Environmental Technology, ISSN 2349-8404, Volume 1, Number 1, August 2014, pp 5-9.

[5] S. Upadhyaya, R. Chandak, "Effect of Fly Ash on Compressive Strength of M20 Mix Design Concrete", International Journal of Advancements in Research & Technology, ISSN 2278-7763, Volume 3, Issue9, September 2014.

[6] P. R. Wankhede, V. A. Fulari, "Effect of Fly Ash on Properties of Concrete", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 4, Issue 7, July 2014.

[7] R. Bansal, V. Singh, R. K. Pareek, "Effect on Compressive Strength with Partial Replacement of Fly Ash", International Journal of Emerging Technologies, ISSN 2249-3255, Volume 6, Issue 1, 2015, pp 1-6.

[8] P. Singh, A. Khan, A. Kumar, "The Effect on Concrete by Partial Replacement of Cement by Silica Fume: A Review", International Research Journal of Engineering and Technology, ISSN 2395-0056, Volume 3, Issue 3, Mar 2016.