ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

Flexural Strength of Beams by Partial Replacement of Cement with Fly Ash and Hypo Sludge in Concrete

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Abstract-fly ash and hypo sludge is obtained as waste product from the thermal and paper industries. Investigations were carried out to explore the possibility of using fly ash and hypo sludge as a replacement of cement in concrete mixtures. This paper presents the results of study undertaken to investigate the feasibility of using fly ash and hypo sludge as cement in concrete. The effects of replacing cement by fly ash and hypo sludge on the flexural strength of beams (500 mm*100 mm*100 mm) are evaluated in this study. Two test groups were constituted with the replacement percentages of 0%, 10%, 20%and 30%.The results showed the effect of fly ash and hypo sludge on concrete beams has a considerable amount of increaseof the flexural strength characteristics. To investigate the utilization of Hypo Sludge as Supplementary Cementitious Materials (SCM) and influence of these hypo sludge on the Strength on concretes made with different Cement replacement levels and also compare with fly ash concrete and ordinary concrete.

Key words: **Supplementary Cementations Materials, Fly Ash, Hypo Sludge, Flexural Strength**

I. INTRODUCTION

Fly ash is a waste by-product from thermal power plants, which use coal as fuel. It is estimated that about 125 million tonnes of fly ash is being produced from different thermal power plants in India. It consumes thousands of hectares of agriculture land for its disposal. It causes serious health and environmental problems. In spite of continuous efforts made and incentives offered by the government, hardly very few percentage of the produced ash is being used for gainful purposes like brick making, cement manufacture, soil stabilization and fill material. In order to utilize fly ash in bulk quantities, ways and means are being explored all over the world to use it for the construction of embankments and roads.

Paper mill sludge is a major economic and environmental problem for the paper and board industry. The material is a by-product of the de-inking and re-pulping of paper. The total quantity of paper mill sludge produced in the world is many million tonnes. The main recycling and disposal routes for paper sludge are land-spreading as agricultural fertiliser, producing paper sludge ash, or disposal to landfill. In functional terms, paper sludge consists of cellulose fibres, fillers such as calcium carbonate and china clay and residual chemicals bound up with water. The moisture content is typically up to40%. The material is viscous, sticky and hard to dry and can vary in viscosity and lumpiness. It has an energy content that makes it a useful candidate as an alternative fuel for the manufacture of Portland cement.

As it is happening in most major areas, the waste management problem has already become severe in the world. The problem is compounded by the rapidly increasing amounts of industrial wastes of complex nature and composition. Energy plays a crucial role in growth of developing countries like India. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for Building Materials like cement, the importance of using industrial waste cannot be underestimated. Many research organizations are doing extensive work on waste materials concerning the viability and environmental suitability.

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II. DESIGN MIX MATERIALS

A. Cement

The most common cement used is an ordinary Portland cement. The Ordinary Portland Cement of 53 grade conforming to IS: 8112 is be use. Many tests were conducted on cement; some of them are consistency tests, setting tests, soundness tests, etc.

Fig 1: Cement (53 grade)

Table 1 Properties of Cement

Property	**Value for cement (OPC)**
Specific Gravity	3.15
Consistency	31.5 %
Initial setting time	91
Final setting time	211
soundness	2.8

B. Coarse Aggregate

The fractions from 80 mm to 4.75 mm are termed as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is be use. The Flakiness and Elongation Index were maintained well below 15%.

Fig 2: Coarse Aggregate

C. Fine aggregate

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand is used as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

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Fig 3: Fine Aggregate

Table 2 Properties of Fine Aggregate, Course Aggregate and Grit

Property	Fine Aggregate	Coarse Aggregate	Grit
Fineness modulus	3.1	7.05	6.3
Specific Gravity	2.767	2.883	2.756
Water absorption (%)	1.2	1.83	1.355
Bulk Density (gm/cc)	1.78	1.329	1.324

D. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

E. Fly ash

Generally fly ash quality is assessed on the basis of some of the key parameters like pozzolanic activity, material retained on 45 micron sieve, loss on ignition and other chemical parameters. It is advisable that to qualify a source of fly ash all the test as specified in IS / ASTM shall be conducted initially and only key parameters can be tested for each batch to ensure a consistent quality of fly ash.

Fig 4: Fly ash

F. Hypo sludge

This hypo sludge contains, low calcium and maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete. Figure 5 shows raw hypo sludge.

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Fig 5: Hypo sludge

The Table 3 shows the hypo sludge chemical properties and comparison between cement and hypo sludge.

Table –3 Comparison of Cement and Hypo Sludge

Sr. No.	Constituents	Cement (%)	Hypo Sludge (%)
1.	Lime(CaO)	62	37.97
2.	Silica(SiO_2)	22	11.92
3.	Alumina	5	0.671
4.	Magnesium	1	1.899
5.	Calcium sulphate	4	0.565

III. DESIGN MIX METHODOLOGY

A mix M20 grade was designed as per IS 10262:2009 method and the same was used to prepare the test samples. The design mix proportion is done in Table 4 and 5.

Table 4 Mix Design Proportions

	Water	Cement	Fine aggregate	Coarse aggregate
By weight, [kg]	186	385	727.6	1201.84
By volume, [m^3]	0.48	1	1.89	3.12

Table 5 Concrete Design Mix Proportions

Sr. No.	Concrete design mix proportion for M20 grade concrete					
	W/C ratio	Cement	F.A.	C.A.	Fly ash	Hypo sludge
1	0.48	1.00	1.89	3.12	0.00	-
2	0.48	0.90	1.89	3.12	0.10	-
3	0.48	0.80	1.89	3.12	0.20	-
4	0.48	0.70	1.89	3.12	0.30	-

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5	0.48	0.60	1.89	3.12	0.40	-
6	0.48	1.00	1.89	3.12	-	0.00
7	0.48	0.90	1.89	3.12	-	0.10
8	0.48	0.80	1.89	3.12	-	0.20
9	0.48	0.70	1.89	3.12	-	0.30
10	0.48	0.60	1.89	3.12	-	0.40

IV. FLEXURAL STRENGTH TEST

Concrete specimen of size 500mm*100 mm*100mm is cast in metal mould. The metal should be of sufficient. Test specimens are stored in water before testing. The bearing surface of support and rollers are wiped, cleared and any loose sand or other material is removed. The specimen is placed in machine shown in fig 6.

Fig 6: set up of Universal Testing Machine for flexural strength

V. RESULT

Table -6: Flexural Strength of Beam for M20 at 28 Days

Partial Replacement in %		Average Flexural Strength of Beam(N/mm^2)	% Change of Flexural Strength of Beam(N/mm^2)
Fly ash	0%	5.05	0
	10%	4.48	- 11.28
	20%	5.61	11.08
	30%	4.46	- 11.68
Hypo sludge	0%	5.05	0
	10%	5.50	8.91
	20%	4.17	- 17.42
	30%	4.18	- 17.22

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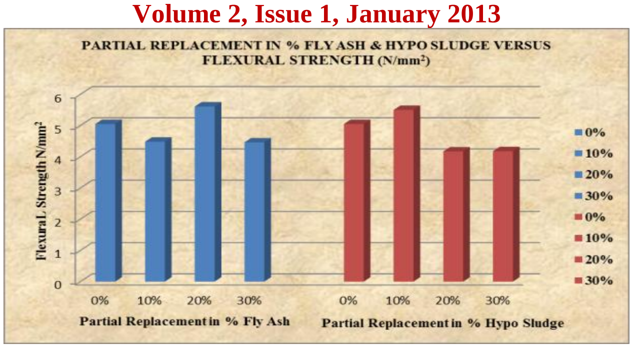

Fig 12: Partial Replacement in % Fly Ash & Hypo Sludge versus Flexural Strength (N/mm^2) at 28 days

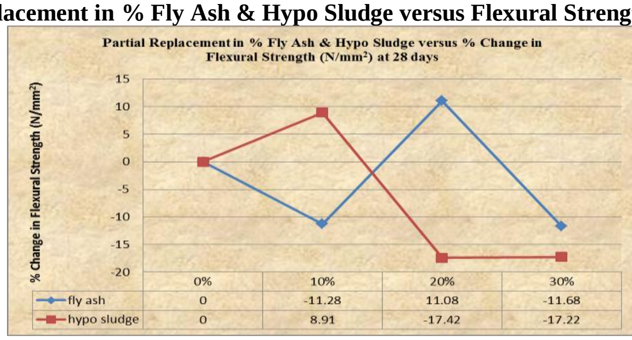

Fig 12: Partial Replacement in % Fly Ash & Hypo Sludge versus % Change in Flexural Strength (N/mm^2) at 28 days

VI. CONCLUSION

Based on limited experimental investigation concerning the flexural strength of concrete, the following observations are made regarding the resistance of partially replaced fly ash and hypo sludge:

(a) Flexural strength of the concrete increases when the 20% replacement of cement by fly ash is increased up to 11.08 %.

(b) Flexural strength of the concrete increases when the 10% replacement of cement by hypo sludge is increased up to 8.91%.

(c) Environmental effects from wastes and residual amount of cement manufacturing can be reduced through this project.

(d) A better measure by a New Construction Materials formed through this project.

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