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Investigation of Low Cost Concrete Using Industrial Waste as Supplementary Cementitious Materials

JayrajVinodsinhSolanki[1], Jayeshkumar Pitroda [2]
[1]Student of final year M.E. C E & M, B.V.M. engineering college, Vallabh Vidyanagar
[2] Assistant Professor & Research Scholar, Civil Engg Department, B.V.M. Engineering College, Vallabh Vidhyanagar.

Abstract-This experimental investigation on strength of concrete and optimum percentage of the partial replacement by preparing a mix M20 grade was designed as per Indian Standard method and the same was used to prepare the test samples. The design mix proportion used were Conventional Concrete, 10%, 20%, 30%, 40% replacement of cement by industrial waste like fly ash and hypo sludge.In the test performed,the optimum compressive stress obtained by utilizing paper waste was at 30% replacement. At the place where strength is not of more importance or rather structure is for temporary basis then design mix proportion up to 40% replacement can also be utilized.Test also point towards developing low cost concrete by varying design mix proportion from 10%replacement to 40%replacement. The compared values of cost show gradual decrement in total cost of per cubic meter concrete. The difference in costfrom normal concrete to partially replaced concrete is about Rs.850/-.When government implement the projects for temporary shelters for who those affected by natural disaster, this material can be used for economic feasibility.To investigate the utilization of Hypo Sludge and fly ash as Supplementary Cementitious Materials (SCM) and influence of these hypo sludge and fly ash on the Strength of concretes made with different Cement replacement levels and compare with ordinary concrete. Investigate low cost concrete by using hypo sludge and fly ash as SCM and compare the cost of each per meter cube.

Key words: **Supplementary Cementations Materials, Hypo Sludge, Fly Ash, Workability, Compressive Strength, Cost.**

I. INTRODUCTION

Fly ash is one of the types of coal combustion by- products .The use of these by-products offers environmental advantages divert the material from the waste stream, reduce the energy used in processing virgin materials, use of virgin materials, and decreases pollution.India is a resourceful country for fly ash generation with an annual output of over 110 million tonnes, but utilization is still below 20 % in spite of quantum jump in last three to four years. Availability of consistent quality fly ash across the country and awareness of positive effects of using fly ash in concrete are pre requisite for change of perception of fly ash from a 'A waste material' to 'A resource material. Although fly ash offers environmental advantages, it also improves the performance and quality of concrete. Fly ash affects the plastic properties of concrete by improving workability, reducing water demand, reducing segregation and bleeding, and lowering heat of hydration. Flyash increases strength, reduces permeability, reduces corrosion of reinforcing steel, increases sulphate resistance, and reduces alkali-aggregate reaction. Fly ash reaches its maximum strength more slowly than concrete made with only Portland cement. The techniques for working with this type of concrete are standard for the industry and will not impact the budget of a job. 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. The paper mill sludge consumes a large percentage of local landfill space for each and every year. Worse yet, some of the wastes are land spread on agricultural land or running off into area lakes and streams. Some companies burn their sludge in incinerators, contributing to our serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most desire to develop profitable materials from them. Keeping this in view, investigations were undertaken to produce low cost concrete by blending various ratios of cement with hypo sludge. So we take hypo sludge and fly ash for compare it with cement.

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: 8112-1989 is be use. Many tests were conducted on cement; some of them are Specific gravity, consistency tests, setting tests, etc.

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Fig 1: Cement (53 grade)

TABLE - 1 PROPERTIES OF CEMENT

Sr.no.	Physical properties of cement	Result	Requirements as per IS:8112-1989
1	Specific gravity	3.15	3.10-3.15
2	Standard consistency (%)	31.5 %	30-35
3	Initial setting time (hours, min)	91 min	30 minimum
4	Final setting time (hours, min)	211 min	600 maximum

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

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C. Fine aggregate

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is be use in combination 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.

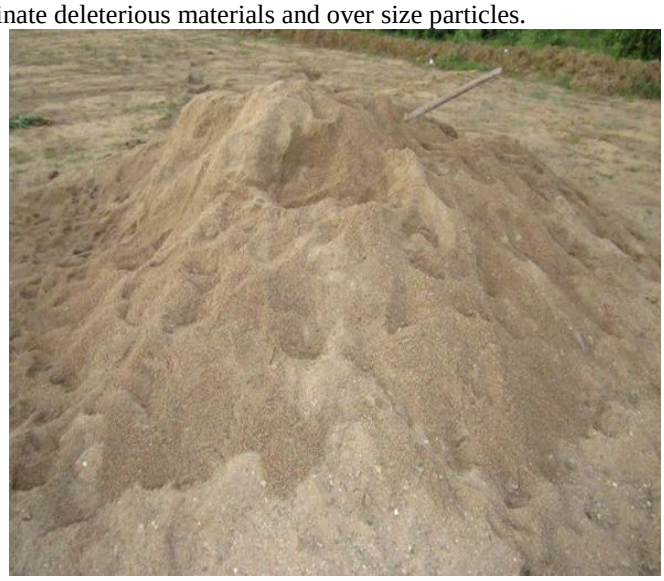

Fig 3: Fine aggregate

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. 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 below shows raw hypo sludge

Fig 4: Hypo sludge

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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 (In %)	Hypo Sludge (In %)
1.	Lime(CaO)	62	37.97
2.	Silica(SiO_2)	22	11.92
3.	Alumina (Al_2O_3)	5	0.671
4.	Magnesium (MgO)	1	1.899
5.	Calcium sulphate	4	0.565

F. 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 shall be conducted initially and only key parameters can be tested for each batch to ensure a consistent quality of fly ash.

Fig 5: Fly ash

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 DESIGNS MIX PROPORTIONS

Sr. No.	Concrete design mix proportion for M20 grade concrete					
	W/C ratio	Cement	Fine Aggregate	Coarse Aggregate	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. EXPERIMENTAL METHODOLOGY

A. Workability of Fresh Concrete by Slump Test

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and tamping rod.

Fig. 6: Concrete slump

B. Compressive Strength Test

150 mm × 150 mm × 150 mm concrete cubes is cast by using M20 grade concrete. Specimens with ordinary Portland cement (OPC) and OPC replaced with hypo sludge and fly ash at 10%, 20%, 30% and 40% levels is cast. During casting the cubes is mechanically vibrated vibrator. After 24 h the specimens is remove from the mould and subjected to water curing for 7 and 28 days. After curing, the specimens tested for compressive strength using a calibrated compression testing machine of 2,000 KN capacity.

Fig 7: Compression Testing Machine

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V. RESULTS

A. Workability of Fresh Concrete

Slump test is used to determine the workability of fresh concrete. In experiment work workability reduces at higher replacement of fly ash with cement and vice versa it increase with higher replacement of hypo sludge as shown in Table 6.

TABLE -6: SLUMP TEST FOR M20 PARTIAL REPLACEMENT IN % FLY ASH & HYPO SLUDGE

% Replacement	Slump in mm (Fly ash)	Slump in mm(Hypo sludge)
0	25	25
10	20	25
20	20	25
30	18	35
40	10	40

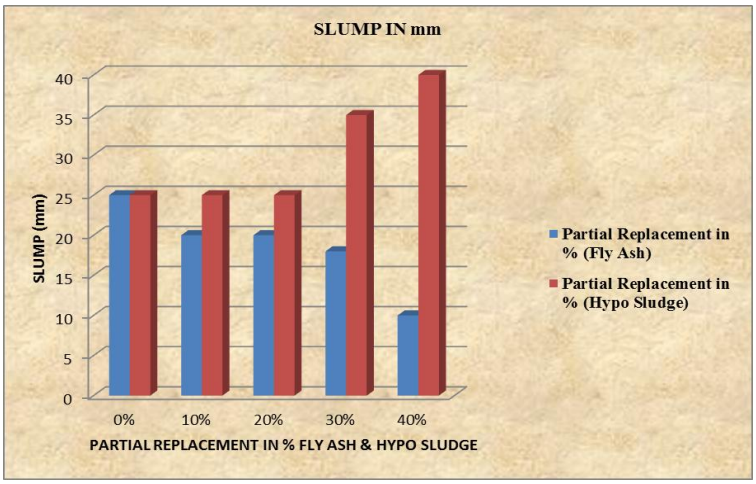

Fig 8: Slump testforM20 Partial Replacement in % Fly ash &Hypo sludge

TABLE -7: COMPRESSIVE STRENGTH OF CUBES FOR M20 AT 7 & 28 DAYS

Partial Replacement in %		Average Ultimate Compressive Strength (N/mm^2)	
		7 Days	28 Days
Flyash	0%	30.24	34.07
	10%	27.85	30.11
	20%	28.45	42.05
	30%	26.60	38.60
	40%	27.43	30.25
Hypo sludge	0%	30.24	30.24
	10%	33.17	35.26
	20%	27.55	32.00
	30%	25.51	27.83
	40%	20.91	25.90

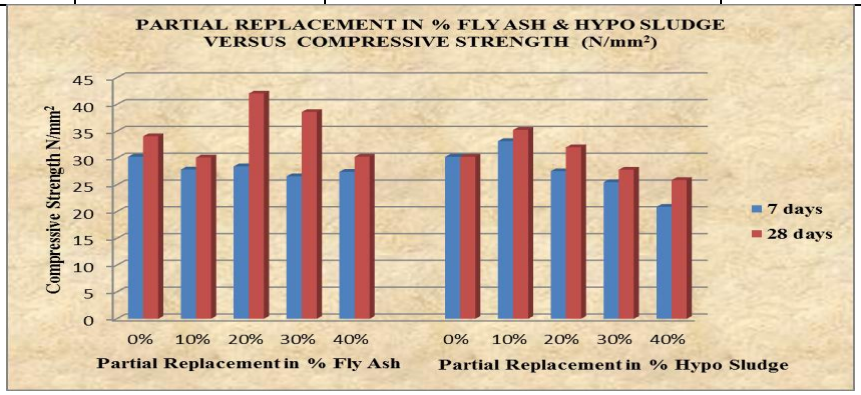

Fig9: Compressive Strength of Cubes forM20 at 7& 28 Days

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VI. ECONOMIC FEASABILITY

TABLE- 8 COSTS OF MATERIALS

Sr. No.	Materials	Rate (Rs/Kg)
1	Cement (OPC 53 grade)	6.00
2	Fly Ash	0.46
3	Hypo sludge	0.50
4	Fine aggregate	0.61
5	Coarse aggregate (20mm Down)	0.65
6	Grit	0.65

TABLE- 9 MATERIALS FOR DESIGNE MIX M20 CONCRETE

Materials	% Reduction in cement	Materials					Total Cost [m^3]	% Change in Cost
		Cement [kg/m^3]	Fine aggregate [kg/m^3]	Coarse aggregate & Grit [kg/m^3]	Fly ash [kg/m^3]	Hypo sludge [kg/m^3]		
Fly ash	0	385.00	727.60	1201.84	0	-	3535.03	0
	10	346.50	727.60	1201.84	38.50	-	3321.74	(-) 6.03
	20	308.00	727.60	1201.84	77.00	-	3108.45	(-) 12.06
	30	269.50	727.60	1201.84	115.50	-	2895.16	(-) 18.10
	40	231.00	727.60	1201.84	154.00	-	2681.87	(-) 24.13
Hypo sludge	0	385.00	727.60	1201.84	-	0	3535.03	0
	10	346.50	727.60	1201.84	-	38.50	3323.28	(-) 5.99
	20	308.00	727.60	1201.84	-	77.00	3111.53	(-) 11.98
	30	269.50	727.60	1201.84	-	115.50	2899.78	(-) 17.97
	40	231.00	727.60	1201.84	-	154.00	2688.03	(-) 23.96

VII. CONCLUSION

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

- Workability reduces at higher replacement of fly ash with cement and vice versa it increase with higher replacement of hypo sludge
- Compressive strength of the concrete measured after 7 days decreases when the percentage of replacement of fly ash increases and if replacement of 10 % hypo sludge compressive strength increases after 7 days.
- Compressive strength of the concrete measured after 28 days increases when the percentage of replacement of fly ash increases up to 30% and if replacements of 20 % hypo sludge compressive strength increases after 28 days.
- When government implement the projects for temporary shelters for who those affected by natural disaster, this material can be used for economic feasibility.
- Environmental effects from wastes and residual amount of cement manufacturing can be reduced through this low cost concrete.
- A better measure by a New Construction Material's formed.

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AUTHOR BIOGRAPHY

JayrajVinodsinhSolanki was born in 1989 in Gandhi Agar City. He received his Bachelor of Engineering degree in Civil Engineering from the C. K. Pithawalla College of engineering and technology, Veer Narmad South Gujarat University, Surat in 2011. At present he is Final year student of Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Gujarat Technological University. He has published paper in International Journal, Global Research Analysis.

Prof. Jayeshkumar R. Pitroda was born in 1977 in Vadodara City. He received his Bachelor of Engineering degree in Civil Engineering from the Birla Vishvakarma Mahavidyalaya, Sardar Patel University in 2000. In 2009 he received his Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Sardar Patel University. He joined Birla Vishvakarma Mahavidyalaya Engineering College as a faculty where he is Assistant Professor of Civil Engineering Department with a total experience of 12 years in field of Research, Designing and education. He has papers published in National Conferences and International Journals.