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Evaluation of Modulus of Elasticity of Concrete with Partial Replacement of Cement by Thermal Industry Waste (Fly Ash) and Paper Industry Waste (Hypo Sludge)

Jayeshkumar R. Pitroda, Dr F S Umrigar[2]
[1] Assistant Professor & Research Scholar, Civil Engg Department, B.V.M. Engg. College, Vallabh Vidhyanagar
[2]Principal, BVM Engineering College, Vallabh Vidyanagar, Anand, Gujarat 388120.

Abstract-The use of fly ash in replacing cement to certain percentageis accepted in recent years. It saves cement, consumes industrial waste and makes durable concrete. Coal fly ash is a widely used byproduct material. It has been in use as a concrete additive for more than two decades. The material's properties make fly ash a useful material in the construction industry. It is beneficial to relievefrom disposal facilities.It reduces cost for both the fly ash producers and users.Out of the total ash produced, Fly ash contributes to a small percentage, majority being Pond ash and bottom ash. In the past, fly ash for the most part was given off into the air. Now, with new techniques particulate material can be collected for reuse.Other waste material paper mill sludgeisamajor economicandenvironmental problemfor the paper andboard industry. Themain recyclinganddisposalroutesfor paper sludgeare land-spreading, producingpaper sludge ash, ordisposalto any river /stream. In function alters, paper sludge consists of cellulose fibres, calcium carbonate and china clay and residual chemicalsboundupwithwater. To produce low cost concrete by replacing cement with hypo sludge. To reduce disposal and pollution problems due to hypo sludge it is most essential to develop profitable materials used for mankind from it. The innovative use of hypo sludge and fly ash in concrete formulations as a supplementary cementitious material was tested as an alternative to conventional concrete. The cement has been replaced by hypo sludge and fly ash accordingly in the range of 0%, 10%, 20%, 30% and 40% by volume for M-25 and M-40 mix. Concrete mixtures were produced, tested and compared in terms of modulus of elasticity with the conventional concrete. The test was carried out to evaluate the modulus of elasticity after 56 days. This study includes different concrete mixtures which were produced to determine the influence of hypo sludge derived from J.K.Papers mill Pvt.Ltd, plant near Songadh, Tappi District and Maize Products (A division of Sayaji Industries Ltd) Power plant near kathwada, Ahmedabad District in Gujarat Statereferring to the Modulus of Elasticity. The modulus of elasticity of concrete is a very important mechanical parameter reflecting the ability of the concrete to deform elasticity. For concrete material, the secant modulus is defined as the slope of the straight line drawn from the origin of axis to the stress-strain curve at 1/3 of the ultimate strength.

***Key words*-Fly Ash, Hypo Sludge, Modulus of Elasticity, Supplementary Cementitious Material (SCMs).**

I. INTRODUCTION

India at present produces around 120 Million Tonnes of Ash per annum. Energy requirements of the country are rapidly increasing with increase in growth of the industries. India depends on Thermal power as its main source of energy; as a result the quantity of Ash produced shall also increase. This creates big problems to utilize the ash. For the economic development of the country "to save energy" is the backbone of nation's progress. Well-developed technologies by producing carbon credit are the key to development of any nation. Conversion of waste into a resource material is an age-old practice of Indian civilization. The Pozzolanic property of fly ash makes it a resource for making cement and other ash based products.The advancement of concrete technology can reduce the consumption of natural resources and energy sources.In recent years, many researchers have established that the use of supplementary cementations materials (SCMs) like fly ash (FA), blast furnace slag, silica fume, metakaolin (MK), and rice husk ash (RHA), hypo sludge etc. can, not only improve the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs.

Paper making generally produces a large amount of solid waste. Paper fibres can be recycled only a limited number of times before they become weak to make high quality paper. This paper mill sludge consumes a large percentage of local landfill space for each and every year. To reduce disposal and pollution problems from these industrial wastes, it is most essential to develop profitable building materials from them. The amount of sludge generated by a recycled paper mill is greatly dependent on the type of furnish being used and end product being

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manufactured. 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. Paper sludge consists of cellulose fibres, calcium carbonate and china clay and residual chemicals bound up with water. Hypo sludge contributes beneficial properties to the concrete while helping to maintain economy.

This research work describes the feasibility of using the thermal industry waste in concrete production as partial replacement of cement.The use of fly ash and hypo sludge in concrete formulations as a supplementary cementations material was tested as an alternative to traditional concrete. Modulus of elasticity of concrete is a very important property to determine the deflection of the structural elements. This study includes different concrete mixtures were produced to determine the influence of hypo sludge derived from J.K.Papers mill Pvt.Ltd, plant near Songadh, Tappi District and Maize Products (A division of Sayaji Industries Ltd) Power plant near kathwada, Ahmedabad District in Gujarat State referring to the Modulus of Elasticity. The cement has been replaced by fly ash and hypo sludge accordingly in the range of 0% (without fly ash and hypo sludge), 10%, 20%, 30% & 40% by weight of cement for M-25 and M-40 mix. Concrete mixtures were produced, tested and compared in terms of modulus of elasticity with the conventional concrete for 56 days water curing.

II. PERFORMANCE OF TESTS

A. Composition of concrete

- Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is to be used. The Flakiness and Elongation Indices were maintained well below 15%.

- Fine Aggregate

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

- Supplementary cementations material: Fly Ash

Fly ash is composed of the non-combustible mineral portion of coal. Particles are glassy, spherical 'ball bearings' finer than cement particles. Sizes of particle are 0.1µm-150 µm. it is a Pozzolanic material which reacts with free lime in the presence of water, converted into calcium silicate hydrate (C-S-H) which is the strongest and durable portion of the paste in concrete. The fly ash is procured from Maize Products (A division of Sayaji Industries Ltd) Power plant. This plant is located near kathwada in Ahmedabad District in Gujarat State.

- Supplementary cementitious material: Hypo Sludge

The hypo sludge is procured from J.K.Papers mill Pvt.Ltd, plant. This plant is located near Songadh in Tappi District in Gujarat State. 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.

B. Design Mix Proportions

A mix M25 and M40 grade was designed as per IS 10262:2009 and the same was used to prepare the test samples. The design mix proportion is shown in Table 1.

Table 1. Concrete Design Mix Proportions

Sr. No.	Concrete type	Concrete Design Mix Proportion (By volume)				Cement replacement by Fly Ash	Cement replacement by Hypo Sludge
		W /C ratio	C	F. A.	C.A.		
1	A1-M25	0.40	1.00	1.01	2.50	-	-
2	D1-M25	0.40	0.90	1.01	2.50	0.05	0.05
3	D2-M25	0.40	0.80	1.01	2.50	0.10	0.10
4	D3-M25	0.40	0.70	1.01	2.50	0.15	0.15

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5	D4-M25	0.40	0.60	1.01	2.50	0.20	0.20
6	A2-M40	0.30	1.00	0.44	2.17	-	-
7	D5-M40	0.30	0.90	0.44	2.17	0.05	0.05
8	D6-M40	0.30	0.80	0.44	2.17	0.10	0.10
9	D7-M40	0.30	0.70	0.44	2.17	0.15	0.15
10	D8-M40	0.30	0.60	0.44	2.17	0.20	0.20

W= Water, C=Cement, F. A. =Fine Aggregate, C.A. =Coarse Aggregate

As the mix proportion of all different concretes are constant, a change in Modulus of Elasticity is only caused by the different % replacement of fly ash and hypo sludge.

C. Specific data of the cement

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade (Hathi OPC) conforming to IS:8112-1989 is be use. Specific gravity, consistency tests, setting tests, compressive strengths, etc. are conducted on cement. The results are tabulated in Table 2.

Table 2.Properties of Hathi Cement (Opc 53 Grade)

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 (%)	28%	30-35
3	Initial setting time (hours, min)	35 min	30 minimum
4	Final setting time (hours, min)	178 min	600 maximum
5	Compressive strength- 7 days	38.49 N/mm2	43 N/mm2
6	Compressive strength- 28 days	52.31 N/mm2	53 N/mm2

D. Storage of the test samples

After casting, the samples (cylinders, diameter = 150 mm, height = 300 mm) were led in the moulds for 24 hours, stripped and cured in water until the age of 56days.

E. Testing the Modulus of Elasticity: (IS 516 – 1959)

Modulus of elasticity of concrete is a very important property to determine the deflection of the structural elements. Deflection of concrete beams and slabs is a common structural movement. It also mentioned that the deflection is the result of the flexural strains that develop under dead and live loads and this may occur cracking in the tensile zone. The modulus of elasticity testing is used to determine the deflection of the concrete specimens that having different percentage of fly ash replacement. The testing is just carried out after 56 days of casting. The resting specimen was 150mm diameter and 300 mm height. The Modulus of Elasticity can be calculated by the difference of the measured stresses and strains on an upper level (i.e. 1/3 of the value of compressive strength) and a lower level (i.e. 0.5 N/mm^2). Fig 1 shows the setup of Modulus of Elasticity.

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Fig 1: Setup of Modulus of Elasticity

III. RESULTS

The results of Modulus of Elasticity and % Change of Modulus of Elasticity at 56 days for M25 and M40 the measurements are shown in Table 3.

Table 3 Results of Modulus of Elasticity and % Change Of Modulus Of Elasticity at 56 Days For M25 and M40

Mix Type	Modulus of Elasticity (MPa) after 56 days	% Change in Modulus of Elasticity at 56 days
A1-M25	17777	0
D1-M25	16667	(-) 6.24
D2-M25	14000	(-) 21.24
D3-M25	13334	(-) 24.99
D4-M25	12000	(-) 32.49
A2-M40	18667	0
D5-M40	18667	0
D6-M40	16400	(-) 12.14
D7-M40	14000	(-) 25.00
D8-M40	12857	(-) 31.12

In Figure 2 and 3 are given the measured Modulus of Elasticity and % change in Modulus of Elasticity.

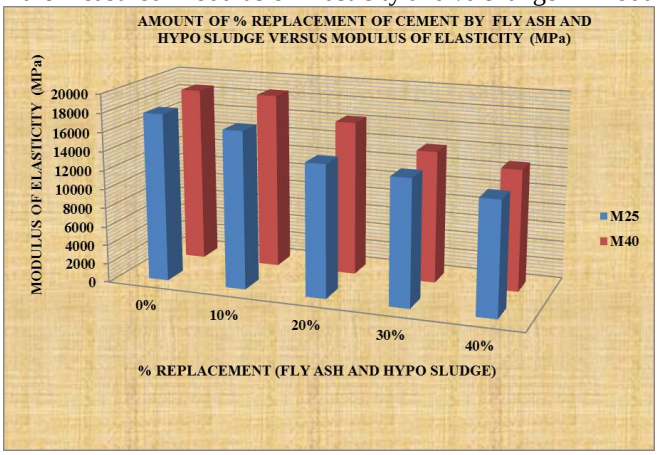

Fig. 2: % Replacement of Cement by Fly Ash and Hypo Sludge versus Modulus of Elasticity

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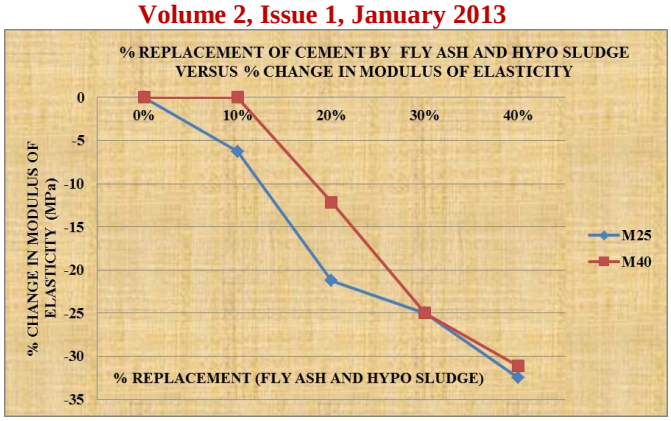

Fig. 3: % Replacement of Cement by Fly Ash and Hypo Sludge versus % change in Modulus of Elasticity

IV. CONCLUSION

Based on limited experimental investigation concerning the modulus of elasticity of concrete, the following conclusions are drawn:

- Modulus of elasticity decreases with % replacement of fly ash and hypo sludge.
- Use of fly ash and hypo sludge in concrete can save the disposal costs and produces a 'greener' concrete for construction.
- For M40 grade 10% replacement with fly ash and hypo sludge gives modulus of elasticity same as M40 grade traditional concrete.
- This research concludes that fly ash and hypo sludge can be used as Construction Material where less strength is required.

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AUTHORS BIOGRAPHY

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.

Dr. Farokh Sorabji Umrigar completed his B.E. (Civil) Engineering from SVNIT in 1976, M.Tech. (civil) Transportation System Engineering from IIT, Kanpur in 1982 and Ph.D with specialization in Transportation Engineering from University of Roorkee, Roorkee in 1990. Dr. Umrigar joined Birla Vishvakarma Mahavidyalaya Engineering College (BVM) in 1978 as Assistant Lecturer and reached to the position of Principal of BVM in April, 2002 with a total experience of 34 years in field of Research, Designing, education and administration. Dr. Umrigar is also Dean, Faculty of Engineering & Technology, Sardar Patel University since April, 2002. Dr. Umrigar has published many papers at National and International level. He is an author of two books of civil engineering. He has guided many students at master's and Ph.D level in the field of civil and transportation planning.