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Study of Modulus of Elasticity of Concrete with Partial Replacement of Cement by Hypo Sludge Waste from Paper Industry

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ABSTRACT

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 million tonnes quantity of paper mill sludge produced in the world. 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, calcium carbonate and china clay and residual chemicals bound up with water. The material is viscous, sticky and hard to dry. To produce low cost concrete by blending various ratios of cement with hypo sludge and to reduce disposal and pollution problems due to hypo sludge it is most essential to develop profitable building materials from hypo sludge. To make good quality paper limited number of times recycled Paper fibres can be used which produces a large amount of solid waste. The innovative use of hypo sludge in concrete formulations as a supplementary cementitious material was tested as an alternative to conventional concrete. The cement has been replaced by hypo sludge accordingly in the range of 0%, 10%, 20%, 30% and 40% by volume for M-25 and M-40 mix.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 were produced to determine the influence of hypo sludge derived from J.K.Papers mill Pvt.Ltd, plant near Songadh, Tappi District in Gujarat State referring to the Modulus of Elasticity.

KEYWORDS: hypo sludge, modulus of elasticity, supplementary cementitious material

1. INTRODUCTION

A use of hypo sludge in the construction industry is in the production of structural concrete. hypo sludge contributes beneficial properties to the concrete while helping to maintain economy. The use of hypo sludge, the paper industrial waste in concrete formulations as a supplementary cementitious material was tested as an alternative to traditional concrete.

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.

Paper making generally produces a large amount of solid waste. Paper fibres can be recycled only a limited number of times before they become too short or 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 emanating from these industrial wastes, it is most essential to develop profitable building materials from them. The quantity of sludge varies from mill to mill. The amount of sludge generated by a recycled paper mill is greatly dependent on the type of furnish being used and end product being manufactured.

Modulus of elasticity of concrete is a very important property to determine the deflection of the structural elements. This study includes different concrete mixtures to determine the influence of hypo sludge derived from J.K.Papers mill Pvt.Ltd, plant near Songadh, Tappi District in Gujarat State. The modulus of elasticity testing is used to determine the deflection of the concrete specimens that having different percentage of hypo sludge replacement. The testing is just carried out after 56 days of casting. The resting specimen was 150mm diameter and 300 mm height. There were total of five batches of concrete mixes, consists of every 10% increment of hypo sludge replacement from 0%, 10%, 20%, 30% and 40% by volume for M-25 and M-40 mix.

2.PERFORMANCE OF TESTS

2.1 Composition of concrete

2.1.1 (a) 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 be use. The Flakiness and Elongation Index were maintained well below 15%.

2.1.1 (b) 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.

2.1.2 Mix proportions

A mix M25 & 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)				Hypo Sludge replacement
		W /C ratio	C	F. A.	C.A.	
1	A1-M25	0.40	1.00	1.01	2.50	-
2	C1-M25	0.40	0.90	1.01	2.50	0.10
3	C2-M25	0.40	0.80	1.01	2.50	0.20
4	C3-M25	0.40	0.70	1.01	2.50	0.30
5	C4-M25	0.40	0.60	1.01	2.50	0.40
6	A2-M40	0.30	1.00	0.44	2.17	-
7	C5-M40	0.30	0.90	0.44	2.17	0.10
8	C6-M40	0.30	0.80	0.44	2.17	0.20
9	C7-M40	0.30	0.70	0.44	2.17	0.30
10	C8-M40	0.30	0.60	0.44	2.17	0.40

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

2.1.3 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

2.1.4 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.

2.1.5 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 building 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/mm2). Fig 1 shows the setup of Modulus of Elasticity.

Fig 1: Setup of Modulus of Elasticity

3. RESULTS

The results of Modulus of Elasticity and % Change of Modulus of Elasticity at 56 days for M25 and M40 the measurement 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
C1-M25	15000	(-) 15.62
C2-M25	13333	(-) 25.00
C3-M25	12000	(-) 32.50
C4-M25	11250	(-) 36.72
A2-M40	18667	0
C5-M40	16667	(-) 10.71
C6-M40	15385	(-) 17.58
C7-M40	13333	(-) 28.57
C8-M40	12100	(-) 35.18

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

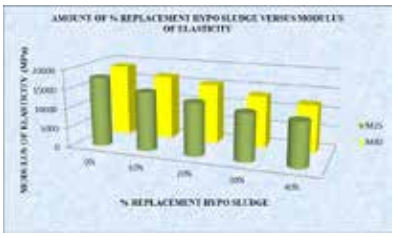

Fig. 2: % replacement hypo sludge versus Modulus of Elasticity

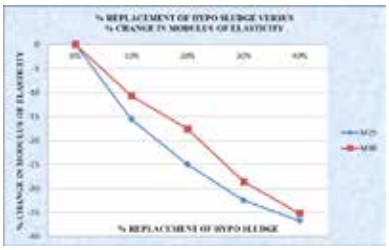

Fig. 3: % replacement hypo sludge versus % change in Modulus of Elasticity

5 CONCLUSIONS

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

(a) Modulus of elasticity decreases with % replacement of hypo sludge.
(b) Use of hypo sludge in concrete can save the disposal costs and produces a 'greener' concrete for construction.
(c) This research concludes that hypo sludge can be used as Construction Material.

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