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Hypo Sludge Management : Opportunities for Developing Low Cost Concrete with Glass Fibres

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ABSTRACT

The use of hypo sludge in concrete formulations as a supplementary cementatious material was tested as an alternative to traditional concrete. The cement has been replaced by hypo sludge accordingly in the range of 0%, 10%, 20%, 30% & 40% by weight for M-25 and M-40 mix. Concrete mixtures were produced, tested and compared in terms of compressive & flexural strength with the conventional concrete. These tests were carried out to evaluate the mechanical properties for up to 28 & 56 days. To improve the engineering properties viz. compressive strength 12mm KDM glass fibre is use at rate of 0.56% by the volume of material. The test results for compressive strength up to 28 days & flexural strength for 56 days are taken. The use of glass fibres has increased the compressive strength. Flexural strength using center point loading also meets the required parameters. In this study trial tests for concrete with 0.56 % glass fibre and increasing% hypo sludge are conducted to indicate the differences in compressive strength and flexural strength by using cubes & beams.

KEYWORDS : Hypo sludge, glass fibre, Compressive Strength, flexural strength, supplementary cementations material

I INTRODUCTION

The concepts of using fibres in concrete are since ancient's times. Initially horse hair was used in mortar and straw in bricks. In 28th century midway variety of materials such as steel, glass, wool and other synthetic material were used in concrete. The concrete without any fibres will develop the cracks due to shrinkage, and other reasons of changes in volume of concrete. The addition of fibres in the plain concrete will control the cracking due to shrinkage and also reduce the bleeding of water. Environmental and economic considerations played a great role in the increase in use of mineral admixtures. It also increases various mechanical properties of concrete. Cement with hypo sludge reduces the permeability of concrete and dense calcium silicate hydrate (C–S–H). Hypo sludge is a byproduct of the paper industry waste.

The present day world is witnessing the construction of very challenging and aesthetic structures. Concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. In the view of the global sustainable developments, it is imperative that fibres like glass, polypropylene and polyester fibres provide improvements in compressive & flexural strength of concrete. The irregular Fibres distributed randomly fills the crack in the composite. Fibres impart energy absorption, toughness and impact resistance properties to fibre reinforced concrete. In the present experimental investigation the KDM glass fibres has been used to study the effect on compressive & flexural strength on M25 & M40 grades of concrete.

II EXPERIMENTAL METHOD

A. Materials

a) Supplementary cementitious material: Hypo sludge

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 1. Hypo sludge

b) Cement

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

Figure 2. HATHI Cement (OPC 53 grade)

TABLE 1
PROPERTIES OF CEMENT

Physical properties of cement	
Physical properties of cement	Value of Cement
specific gravity	3.15
Standard consistency (%)	28%
Initial setting time (hours, min)	35 min
Final setting time (hours, min)	178 min
compressive strength- 7 days	38.49 N/mm^2
compressive strength- 28 days	52.31 N/mm^2

c) Aggregate

Aggregate occupies most of the volume of the concrete show they are the important constituents of concrete. They give body to the concrete, reduce shrinkage and effect economy. Aggregate in concrete is structural filler with important role. One of the most important factors for producing workable concrete is good gradation of aggregates. Good grading implies that a sample fractions of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste is mean less quantity of cement and less water, which is further mean increased economy, higher strength, lower shrinkage and greater durability.

d) 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%.

Figure 3. Coarse aggregate

Figure 4. Grit

e) 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.

Figure 5. Fine aggregate

TABLE 2
PROPERTIES OF FINE AGGREGATE, COURSE AGGREGATE

Property	Fine Aggregate	Coarse Aggregate	
		20 mm down	10 mm down (Grit)
Fineness modulus	3.35	7.54	3.19
Specific Gravity	2.38	2.76	2.69
Bulk Density (gm/cc)	1753	1741	1711

f) 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.

g) Glass fibre

KDM glass fibres filament diameter-14, length 12mm, specific gravity-2.6, density-2.6 t/m3, elastic modulus-73 Gpa, tensile strength-1700 Mpa, No of fibre-220 million/kg

Figure 6. Glass fibre

III DESIGN MIX

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 3

TABLE 3
CONCRETE DESIGN MIX PROPORTIONS

Sr.no.	Concrete type	Concrete design mix proportion (By Volume)					
		W/C ratio	C	F.A.	C.A.	Hypo sludge	Glass Fibre
1	H1-M25	0.40	1.00	1.01	2.50	-	0.56
2	H2-M40	0.30	1.00	0.44	2.17	-	0.56
3	F1-M25	0.40	0.90	1.01	2.50	0.10	0.56
4	F2-M25	0.40	0.80	1.01	2.50	0.20	0.56
5	F3-M25	0.40	0.70	1.01	2.50	0.30	0.56
6	F4-M25	0.40	0.60	1.01	2.50	0.40	0.56
7	F5-M40	0.30	0.90	0.44	2.17	0.10	0.56
8	F6-M40	0.30	0.80	0.44	2.17	0.20	0.56
9	F7-M40	0.30	0.70	0.44	2.17	0.30	0.56
10	F8-M40	0.30	0.60	0.44	2.17	0.40	0.56

IV EXPERIMENTAL SET UP

TABLE 4
DESIGN MIX PROPORTION FOR VARIOUS CONCRETE

Sr.no.	Concrete type	FLY ASH Replacement	GLASS FIBRE
1	H1-M25	Standard Concrete	0.56% by volume
2	H2-M40	Standard Concrete	
3	F1-M25	10% replacement	
4	F2-M25	20% replacement	
5	F3-M25	30% replacement	
6	F4-M25	40% replacement	
7	F5-M40	10% replacement	
8	F6-M40	20% replacement	
9	F7-M40	30% replacement	
10	F8-M40	40% replacement	

V TEST RESULTS

TABLE -5
COMPRESSIVE STRENGTH OF CUBES (150X150X150) AT 7, 14, 28 DAYS FOR M25

Concrete Type	Average Ultimate Compressive Strength at 7 days [N/mm^2]	Average Ultimate Compressive Strength at 14 days [N/mm^2]	Average Ultimate Compressive Strength at 28 days [N/mm^2]
H1-M25	24.44	25.04	29.94
F1-M25	15.56	20.89	21.33
F2-M25	9.48	10.67	15.56
F3-M25	8.89	9.93	13.93
F4-M25	7.70	8.59	9.78

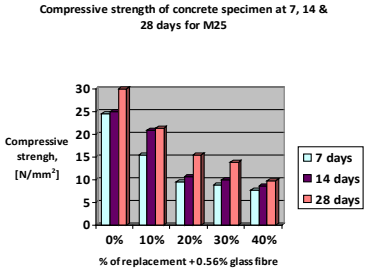

Figure 7. Compressive Strength of Cubes at 7, 14 & 28 Days for M25

TABLE -6
COMPRESSIVE STRENGTH OF CUBES (150X150X150) AT 7, 14, 28 DAYS FOR M40

Concrete Type	Average Ultimate Compressive Strength at 7 days [N/mm^2]	Average Ultimate Compressive Strength at 14 days [N/mm^2]	Average Ultimate Compressive Strength at 28 days [N/mm^2]
H2-M25	27.56	29.04	32.74
F5-M25	26.07	30.96	33.78
F6-M25	16.30	18.07	21.33
F7-M25	9.78	12.74	14.07
F8-M25	5.04	5.63	7.41

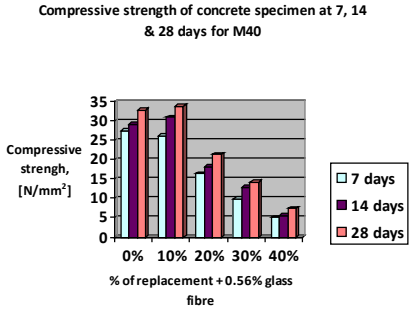

Figure 8. Compressive Strength of Cubes at 7, 14 & 28 Days for M40

TABLE -7
FLEXURAL STRENGTH OF BEAMS (500X100X100) AT 56 DAYS FOR M25 & M40

Concrete Type	Average Flexural Strength for Beam at 56 days [N/mm^2]
H1-M25	5.04
F1-M25	5.02
F2-M25	4.94
F3-M25	3.13
F4-M25	2.40
H2-M40	5.53
F5-M40	4.65
F6-M40	4.47
F7-M40	3.76
F8-M40	2.76

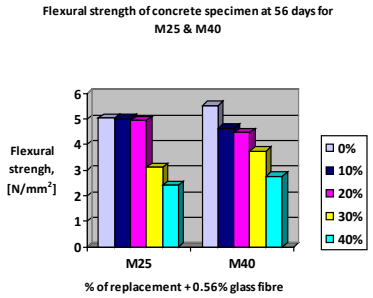

Figure 9. Flexural strength of Beams (500x100x100) at 56 Days for M25 & M40

VI. CONCLUSION

Based on limited experimental investigation concerning the compressive & flexural strength of concrete, the following observations are made regarding the resistance of partially replaced hypo sludge with 0.56% glass fibre:

(a) Compressive strength reduces when replacement of hypo sludge percentage increases when compare to traditional concrete.
(b) From this test, replacement of cement with this paper industries waste material provides maximum compressive strength at 10% replacement but it is lesser than traditional concrete.
(c) Use of hypo sludge in concrete can save the paper industries waste disposal costs and produce a 'greener' concrete for construction.
(d) A better measure by a innovative supplementary cementitious Construction Material is formed through this research.
(e) Flexural strength of beam reduces when replacement of hypo sludge percentage increases when compare to traditional concrete.

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