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EXPERIMENTAL STUDY ON STRENGTH CHARACTERISTICS OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY HYPO SLUDGE

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Abstract - Concrete is strength and hard-hitting material but it is permeable solid also which interacts with the surrounding environment. The durability of concrete depends mostly on the movement of water and gas enters and moves through it. To produce low cost concrete by blending various ratios of cement with hypo sludge & 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 fibers can be used which produces a large amount of solid waste. The innovative use of hypo sludge in concrete formulations as a supplementary cementations material was tested as an alternative to traditional concrete. These tests were carried out to evaluate the mechanical properties like compressive strength up to 28 days. This research work is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 5%, 10%, and 15% of Hypo Sludge. The concrete grade was M25.Keeping all this view, the aim of investigation is the behavior of concrete while adding of waste with different proportions of Hypo sludge in concrete by using tests like compression strength and split strength.
Keywords - Compressive Strength, Deflection, Flexural Strength, Hypo sludge, Split Tensile Strength.

1. INTRODUCTION

The Management of wastes, in particular of industrial waste, in an economically and environmentally acceptable manner is one of the most critical issues facing modern industry, mainly due to the increased difficulties in properly locating disposal works and complying with even more stringent environmental quality requirements imposed by legislation. In addition, in recent years, the need to achieve sustainable strategies has become of greater concern, also because some traditional disposal options, such as landfill, are progressively restricted, and in some cases banned, by legislation. In the industrial, mining, municipal, agricultural and other processes currently in India about 960 million tons of solid waste is being generated annually as by product of which around 350 million tons are organic, around 290 million tons inorganic from industrial and mining sector and around 4.5 million tons are hazardous in nature. Paper making generally produces a large amount of solid waste. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low quality paper fibers are separated out to become waste sludge. All the inks, dyes, coatings, pigments, staples and stickies are also washed off the recycled fibers to join the waste solids. The shiny finish on glossy magazine-type paper is produced using a fine kaolin clay coating, which also becomes solid waste during recycling. The paper mill and fly ash waste consumes a large percentage of local landfill space for each and every year. In order to control, wastages filled in the land and to avoid environmental pollution these wastes are utilized in the construction field.

2. LITERATURE REVIEW

There was an increase in compressive strength of about 7.5% at 28 days for 5% replacement of cement compared to reference mix of M25 concrete. Paper sludge concrete was good in terms of flexural strength and gave higher results for 5% replacement than the reference mix. Waste paper sludge seems to have a more pronounced effect on the flexural strength than the split tensile strength[5] . 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[3]. 5% replacement of cement by waste paper sludge ash showed 10% increase in compressive strength at 7 days and 15% increase in compressive strength at 28 days. Cement in concrete can be replaced by waste paper sludge ash up to 5% by weight showing 15% increase in compressive strength at 28 days[8]. The calcined product obtained from paper waste sludge at optimal conditions of calcinations exhibits high pozzolonic property and permits its possible reuse as a pozzolonic material[12]. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken low quality paper fibers are separated out to become waste sludge. All the inks, dyes,

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coatings, pigments, stapes and “Stickies” (tape, plastic films etc) are also washed off the recycled fibers to join the waste solids(2).

3. MATERIALS AND ITS PROPERTIES

3.1 Cement

Cement is a binding material used in the preparation of concrete. It binds the coarse aggregates and fine aggregates with help of water, to a monolithic matter and also it fills the voids in the concrete. The cement used in this study is OPC 53 grade Cement. Table shows the physical properties of cement. The physical properties are obtained by contacting following tests on cement.

Specific gravity (IS : 1727-1967)
Standard consistency(IS:4031–1968 Part 4)
Initial setting time (IS : 4031 – 1968 Part 5)
Final setting time (IS : 4031 – 1968 Part 5)

S.No	Properties	Value	Standard values
1	Specific gravity	3.15	3.10 - 3.20
2	Standard consistency	30%	25 – 35
3	Initial setting time	35 minutes	<30 min
4	Final setting time	512 minutes	<600 min
5	Compressive strength of mortar cubes at 28 days	53.80 Mpa	53 Mpa

Table 3.1: Physical properties of cement

3.2 Fine Aggregate

Fine aggregate should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silt content and chloride contamination etc. Table 3.2 shows the physical properties of fine aggregate. Table 3.3 shows the Sieve analysis for fine aggregate as per IS 383-1970. The physical properties are obtained by contacting following tests on fine aggregate as per IS: 2386- 1968(iii).

Specific Gravity
Sieve analysis and Fineness Modulus
Bulk density
Water absorption

S.No	Properties	Value	Requirements of IS
1	Specific gravity	2.65	2.5-3.0
2	Percentage of Voids	24.50%	<40%
3	Fineness modulus	2.786	2-3.5
4	Bulk density	1650 kg/m3	-
5	Water absorption	1.20%	<2%

Table 3.2: Properties of Fine aggregate

S.No	Sieve size (gms)	Weight retained (gms)	Cumu lative weight retained	Cumu lative % retained	% finer
1	10	0	0	0	100
2	4.75	14	14	1.4	98.6
3	2.36	35	49	4.9	95.1
4	1.18	185	234	23.4	76.6
5	0.6	339	573	57.3	42.7
6	0.3	357	930	93	7
7	0.15	56	986	98.6	1.4
8	Pan	14	1000	100	0

Table 3.3: Sieve analysis for fine aggregate (as per IS: 383- 1970)

3.3 Coarse Aggregate

Coarse Aggregate consists of natural occurring stones (crushed, uncrushed or broken). It should be hard, strong, dense, durable, and clean. It should be roughly cubical in shape. Flaky pieces should be avoided. Water absorption of aggregate should not more than 10 % of its weight after 24 hours immersion in water. The following tests are carried out on Coarse aggregate as per IS: 2386- 1968(i)

Specific Gravity
Sieve analysis and Fineness Modulus

Bulk density

S.No	Properties	Value	Requirements of IS
1	Specific gravity	2.76	2.5-3.0
2	Fineness modulus	5.67	3.5-6.5
3	Bulk density	1507.5 kg/m3	-
4	Water absorption	0.80%	0.2%-4%

Table 3.4: Properties of Coarse aggregate

S.No	Sieve size (mm)	Weight Retained (gms)	Cumulativeweight retained (gms)	Cumulative% retained	% finer
1	20	0	0	0	100
2	12.5	175	175	8.75	91.25
3	10	1020	1195	59.75	40.25
4	4.75	785	1980	99	1
5	2.36	20	2000	100	0
6	Pan	0	2000	100	0

Table 3.5: Sieve analysis for coarse aggregate (as per IS: 383- 1970)

3.4 Hypo Sludge

Hypo sludge is a material obtained from the chemical recovery process of paper production. Hypo sludge is available abundantly worldwide, but its usage to date is very limited. Each Indian mill produces an average 40 over-dry tone of sludge per day. Hypo sludge is also known as paper Waste.

Properties of Hypo Sludge

Hypo sludge improves the properties of fresh and harden concrete.
Hypo sludge reduces degradation and bleeding.
Hypo sludge improves the durability of concrete.
Hypo sludge improves the setting of concrete due to presence of silica and magnesium.
Hypo sludge is the cheaper substitute to OPC.
Light weight compare to conventional concrete.
Specific gravity of hypo sludge 2.82

Table 3.6: Chemical Properties of Hypo Sludge

S.No	Component	%
1	Moisture	2.97
2	Magnesium Oxide(MgO)	4.64
3	Ferric oxide (Fe2O3)	1.79
4	Silica (SiO2)	3.09
5	Calcium oxide (CaO)	15.12
6	R2O3	9.31
7	Acid Insoluble	13.88

Table 3.6: Chemical Properties of Hypo Sludge

3.5 Water

Water is an important ingredient of cement mortar as it chemically participates in the reactions with cement to form the hydration product, C-S-H gel. The strength of cement mortar depends mainly from the binding action of the hydrated cement paste gel. Higher water cement ratio or water binder ratio will decrease the strength, durability, water tightness and other related properties of cement mortar. For high performance cement mortar mix consideration, it is important to have the compatibility between the given cement and the chemical and mineral admixtures along with water used for mixing.

4. MIX PROPORTIONS

Following IS 10262:1982 mix design was aimed for Ordinary Portland Cement Concrete (OPC) having compressive 28 days strength of M25 for control samples. The data gathered from the experimental procedure on the concrete ingredients are tabulated below.

Material	Quantity(Kg/m3)
Cement	326
Fine Aggregate	756.25
Coarse Aggregate	1285.11
Water	0.43

Table 3.7 : Mix Proportions

5. EXPERIMENTAL PROGRAMME

5.1 Compressive Strength Test

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

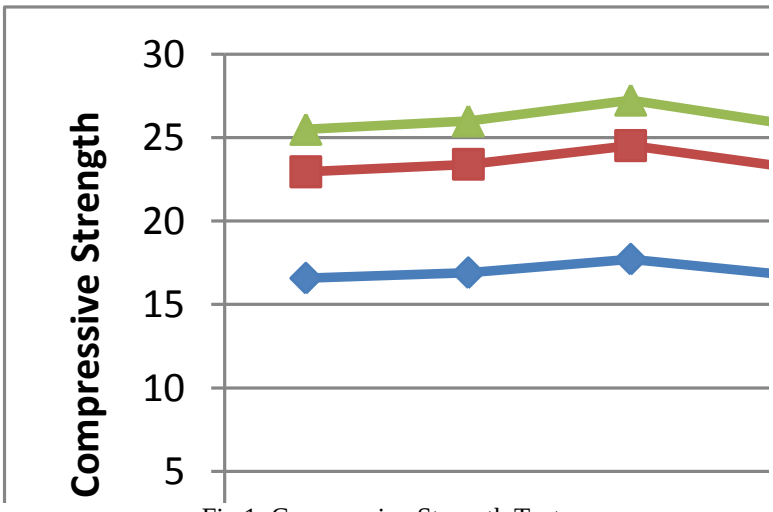

Fig.1: Compressive Strength Test

5.2 Split Tensile Test

Cylinder splitting tension test: this is also sometimes referred as, "Brazilian test". The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, alone the vertical diameter.

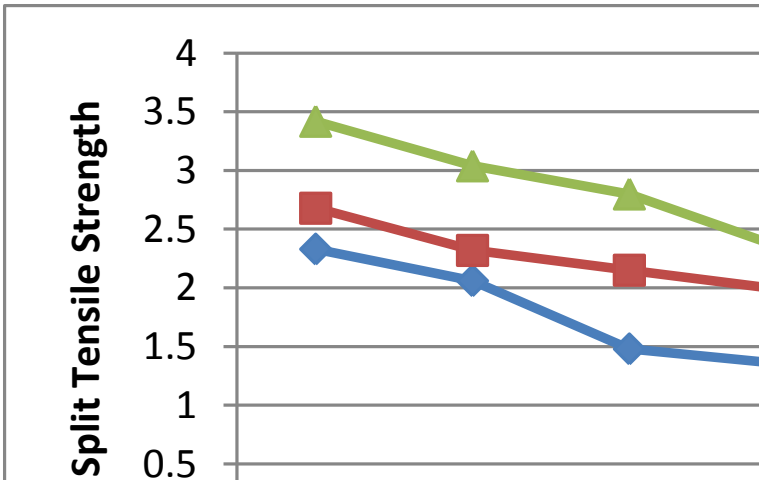

Fig.2: Split Tensile Strength Test.

5.3 Flexural Strength Test

Flexural strength test is used to determine the modulus of rupture of concrete. In this test the beam specimens (23 cm x 14 cm x 110 cm) are used. The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from center to center is 60 cm for 15.0 cm specimens or 40 cm for 10.0 cm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span that is, spaced at 20 or 13.3 cm center to center.

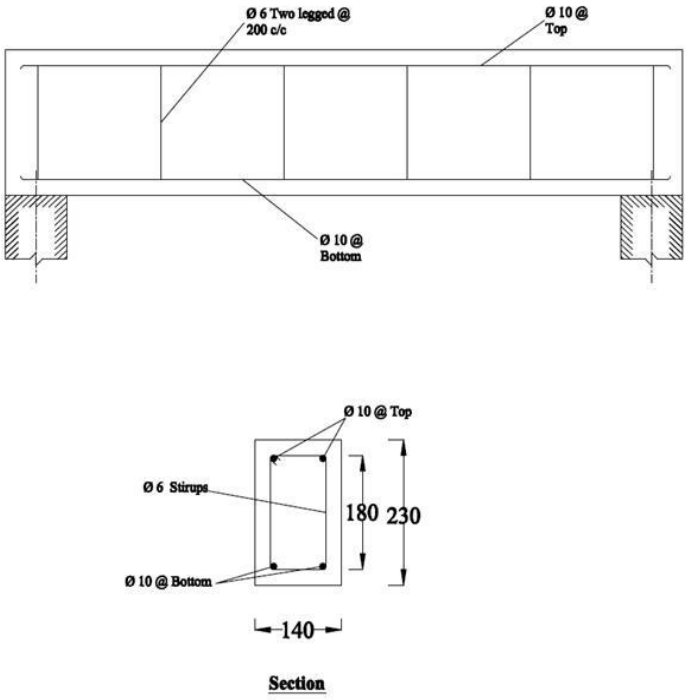

Fig.3: Flexural Strength Test Reinforcement Arrangement.

Fig.4: Flexural Strength Test Arrangement.

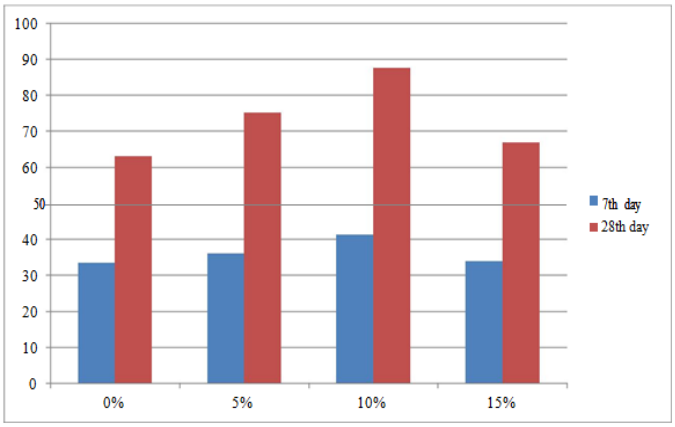

Fig.5: Flexural Strength Test Results.

5.4 Load Vs Deflection Curve For Conventional, 5%, 10 % & 15 % Replaced Beam

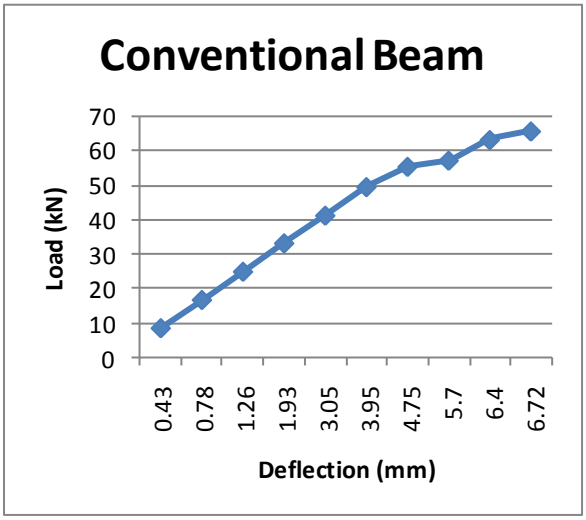

Fig.6: Load Vs Deflection Curve For Conventional beam

The deflection was measured at three points using the dial gauge, one at the mid span and other two at one-third point from the support. The deflection increased according to the load increases. The maximum of 6.71 mm deflection was obtained for RCC Beam, which is for shear span to effective depth ratio of 2.67.

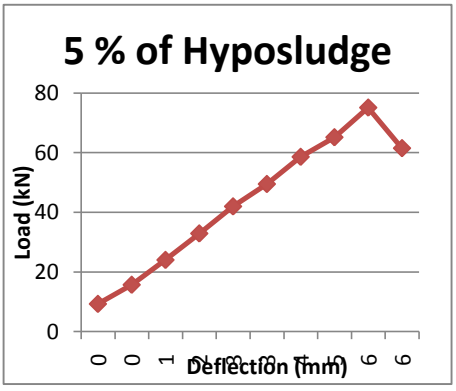

Fig.7: Load Vs Deflection Curve For 5% of Hypo sludge replaced beam

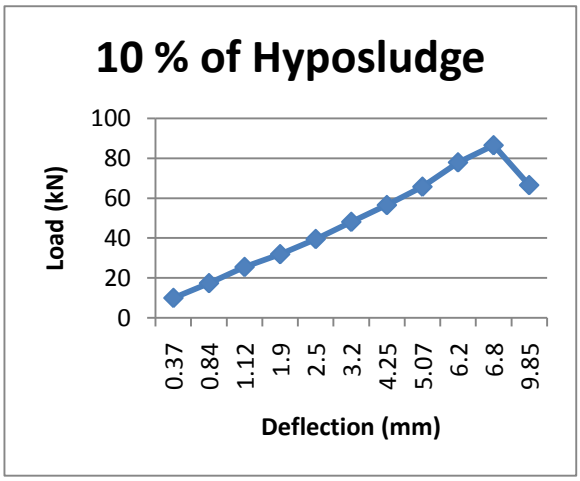

Fig.8: Load Vs Deflection Curve For 10 % of Hypo sludge replaced beam

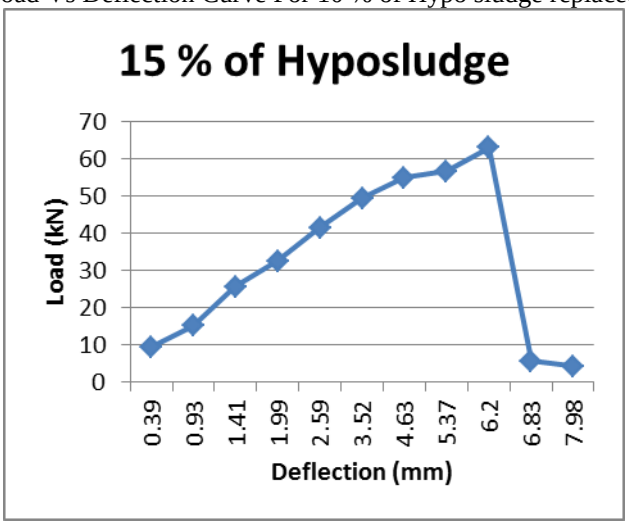

Fig.9: Load Vs Deflection Curve For 15 % of Hypo sludge replaced beam

Compared to Conventional RCC Beam the shear load carrying capacity of RC beam with 15% hypo sludge is equal strength, up to the maximum load carrying capacity the Load vs Displacement relationship is linear. After the maximum load in all three proportions, displacement is reducing gradually and then failure occur in the beam.

6. CONCLUSION

Study on Compressive Strength, Tensile strength and Flexural strength of Concrete replaced Hypo Sludge was done successively.

The Compressive strength of concrete achieves the target strength up to 10% replacement of cement with hypo sludge. Further replacement of cement with hypo sludge there is a decrease in the compressive strength.

The split tensile strength is decreased when the percentage of the replacement is increased. The Tensile strength of concrete achieves the target strength up to 10% replacement of cement with hypo sludge.

Compared to Conventional RCC Beam the shear load carrying capacity of RC beam with 5% hypo sludge is increased.

Compared to Conventional RCC Beam the shear load carrying capacity of RC beam with 10% hypo sludge is Maximum.

Compared to Conventional RCC Beam the shear load carrying capacity of RC beam with 15% hypo sludge is equal strength.

Flexural strength of the concrete increases when the 10% replacement of cement by hypo sludge.

Partial Replacement of Portland Pozzolana Cement (PPC) with about 10% Hypo Sludge in Concrete is acceptable.

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