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Experimental Studies on Partial Replacement of Cement by Using Hypo Sludge Concrete

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Abstract

Over 300 million tones of industrial wastes are being produced per annum by chemical and agricultural process in India. These materials pose problems of disposal and health hazards. The wastes like phosphogypsum, fluorogypsum and red mud contain obnoxious impurities which adversely affect the strength and other properties of building materials based on them. Out of several wastes being produced at present, the use of phosphogypsum, flurogypsum, lime sludge, hypo sludge, red mud, and mine tailing is of paramount significance to protect the environment. 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" (tape, plastic films, etc.) 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. This 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 cropland as a disposal technique, raising concerns about trace contaminants building up in soil 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 essential to develop profitable building materials from them. Keeping this in view, investigations were undertaken to produce low cast concrete by blending various ratios of cement with hypo sludge. This project is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 10%, 20%, 30%, 40%, 50%, 60% and 70% of Hypo Sludge.

Keywords: Paper Industry Waste , Phosphogypsum, Fluorogypsum, Hypo Sludge , Low Cost Concrete

Introduction

General 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 under estimated. During manufacturing of 1 tones of Ordinary Portland Cement of earth resources like limestone, etc. Further during manufacturing of 1 tonnes of Ordinary Portland Cement an equal amount of carbon-di-oxide are released into the atmosphere. The carbon-di-oxide emissions act as a silent Killer in the environment as various forms. In this Backdrop, the search for cheaper substitute to OPC is a needful one.

Solid Waste from Paper Industry

Hypo Sludge Properties

Where, 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.

Need for Hypo Sludge Utilization

While Producing paper the various wastes are comes out from the various processes in paper industries. From the preliminary waste named as hypo

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sludge due to its low calcium is taken out for our project to replace the cement utilization in concrete. Due to the cement production green house gases are emitted in the atmosphere. For producing 4million tones of cement, they emit 1 million ton green house gases are emitted. Also, to reduce the environmental degradation, this sludge has been avoided in mass level disposal in land. To eliminate the ozone layer depletion, production of cement becomes reduced. For this, the hypo sludge is used as partial replacement in the concrete as high performance concrete. By utilizing this waste the strength will be increased and also cost reduction in the concrete is achieved.

Fig.1(a) Paper waste concrete

Fig.1(b) Paper waste concrete block

Objectives

To investigate the utilization of Hypo Sludge as Supplementary Cementitious Materials (SCM) and influence of these hypo sludge on the Strength on concretes made with different Cement replacement levels.

Materials Used

Cement

The most common cement is used is ordinary Portland cement. The Type 1 is preferred according to IS: 269-1976, which is used for general concrete structures. Out of the total production, ordinary Portland cement accounts for about 80-90 percent. Many tests were conducted to cement some of them are consistency tests, setting tests, soundness tests, etc.

Aggregate

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. 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 will mean less quantity of cement and less water, which will further mean increased economy, higher strength, lower shrinkage and greater durability. Aggregate comprises about 55% of the volume of mortar and about 85% volume of mass concrete. Mortar contains of size of 4.75 mm and concrete contains aggregate upto a maximum size of 150 mm.

Coarse Aggregate:

The fractions from 80 mm to 4.75 mm are termed as coarse aggregate.

Fine aggregate:

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate.

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.

Hypo Sludge

The following tables shows the hypo sludge chemical properties and comparison between cement and hypo sludge.

Table – 1 Properties of Raw Hypo Sludge

Sl.No	Constiutent	% Present In Hypo Sludge
1.	Moisture	56.8
2.	Magnesium oxide (MgO)	3.3
3.	Calcium oxide (CaO)	46.2
4.	Loss on ignescent	27.00
5.	Acid insoluble	11.1
6.	Silica (SiO_2)	9.0
7.	R_2O_3	3.6

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Table – 2 Properties of Hypo Sludge As Cement Ingredient

Sl.No	Constituent	% Present In Hypo Sludge
1.	Magnesium oxide (MgO)	3.3
2.	Calcium oxide (CaO)	46.2
3.	Loss on ignescent	27.00
4.	Acid insoluble	11.1
5.	Silica (SiO_2)	9.0
6.	R_2O_3	3.6

Table – 3 Comparisons of Cement and Hypo Sludge

Sl. No	Constituent	Cement (In %)	Hypo Sludge (In %)
1.	Lime(CaO)	62	46.2
2.	Silica(SiO_2)	22	9
3.	Alumina	5	3.6
4.	Magnesium	1	3.33
5.	Calcium sulphate	4	4.05

Table-4 Setting Time for cement and Hypo Sludge

Sl. No	Ingredients	Initial (min)	Final(min)
1.	Cement + 0%hypo sludge	30	600
2.	Cement +10% hypo sludge	31	598
3.	Cement +20% hypo sludge	33	597
4.	Cement +30% hypo sludge	34	595
5.	Cement +40% hypo sludge	36	593
6.	Cement +50% hypo sludge	37	592
7.	Cement + 60%hypo sludge	38	591
8.	Cement +70% hypo sludge	40	590

Mix Design

A mix M25 grade was designed as per Indian Standard method and the same was used to prepare the test samples.

Table 5 The design mix proportion is as follows

	Water	Cement	Fine Aggregate	Coarse Aggregate
By weight(kg)	191.6	547.42	456.96	1255.475
By volume	0.35	1	0.834	2.29

Mix Proportions

Conventional Concrete – 1: 0.834: 2.29
10% replacement – 0.9: 0.834:2.29
20% replacement – 0.80:0.834:2.29
30% replacement- 0.70:0.834:2.29
40%replacement – 0.60:0.834:2.29
50% replacement – 0.50: 0.834: 2.29
60% replacement – 0.40: 0.834: 2.29
70% replacement – 0.30: 0.834: 2.29

Details of the Experimental Study

Compressive strength test:

150 mm X 150mm X 150mm concrete cubes were casting using M25 grade concrete. Specimens with ordinary Portland cement (OPC) and OPC replaced with hypo sludge at 10%, 20%, 30%, 40%, 50%, 60% and 70% levels were cast. During casting the cubes were mechanically vibrated by using a table vibrator. After 24 hours, the specimens were removed from the mould and subjected to water curing for 14 and 28 days. After curing, the specimens were tested for compressive strength using a calibrated compression testing machine of 2000kN capacity.

Split tensile strength test

Split tensile strength of concrete is usually found by testing plain concrete cylinders. Cylinders of size 150mm x 300 mm were casting using M25 grade concrete. Specimen with OPC and OPC replaced by hypo sludge at 10%, 20%, 30%, 40%, 50%, 60% and 70% replacement levels were cast. During molding, the cylinders were mechanically vibrated using a table vibrator. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested for compressive strength using a calibrated compression testing machine of 2000kN capacity.

Results And Discussions

Table -6 Compressive Strength of Cubes at 14 Days

Partial Replacement in %	Number of Specimen	Initial Crack Load (kN)	Ultimate Load (kN)	Ultimate Compressive Strength (N/mm^2)

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0	3	193.000	400.725	17.81
10	3	23.850	577.575	25.67
20	3	328.650	764.100	33.96
30	3	360.550	798.750	35.5
40	3	215.950	499.500	22.2
50	3	173.250	348.750	15.5
60	3	128.650	279.000	12.4
70	3	92.550	193.500	8.6

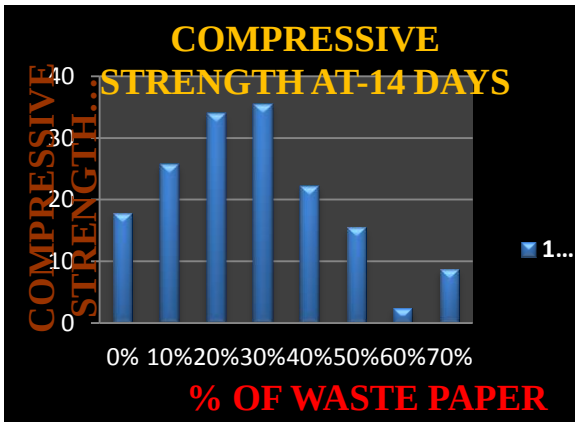

Fig. 2. Compressive Strength of Concrete Specimen at 14 – Days

Table-7 Compressive Strength on Cubes at 28 Days

Partial Replacement in %	Number of Specimen	Initial Crack Load(kN)	Ultimate Load(kN)	Ultimate Compressive Strength (N/mm^2)
0	3	697.100	839.925	37.33
10	3	810.300	908.325	40.37
20	3	948.250	1253.025	55.69
30	3	925.950	1262.475	56.11
40	3	720.00	898.875	39.95
50	3	308.350	412.537	18.335
60	3	175.650	357.075	15.87
70	3	115.850	291.150	12.94

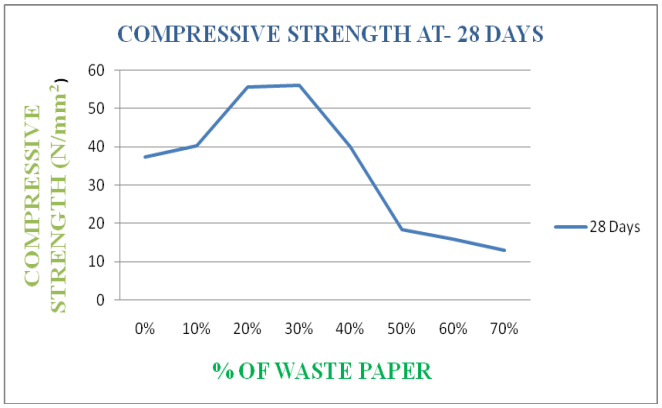

Fig-3 Compressive Strength of Concrete Specimen at 28 – Days

Table-7 Split Tensile Strength of Cylinder at 28- Days

Partial Replacement in %	Number of Specimen	Ultimate Load(kN)	Split tensile Strength (N/mm^2)
0	3	130.061	1.84
10	3	110.269	1.56
20	3	104.615	1.48
30	3	100.373	1.42
40	3	98.253	1.39
50	3	97.546	1.38
60	3	101.080	1.43
70	3	102.494	1.45

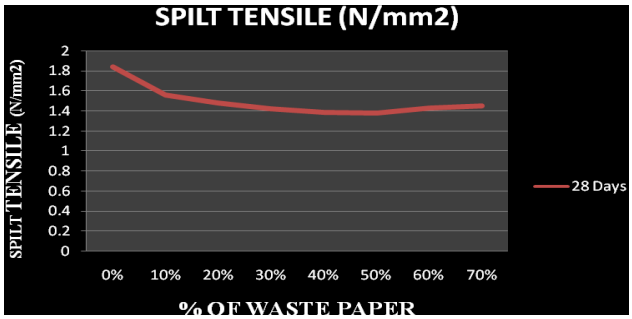

Figure 3 Split tensile Strength of Concrete Specimen at 28 – Days

Economic Feasibility

Cost analysis is carried out for the optimum proportion of percentage of hypo sludge in concrete. This project was carried out in our college campus. The cost is compared to the conventional concrete.

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Cost Of Materials
Cost of cement per bag = Rs.250.00
Cost of sand per m3 = Rs.867.20
Cost of hypo sludge per kg = Rs.0.50
Cost of coarse of aggregate per m3 = Rs.561.40
(All the rates are include with lead charges)

Table-8 Cost of material of normal concrete/ m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	547.42	5/kg	2737.10
Hypo sludge	-	0.50/kg	-
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			3305.14

Table-9 Cost of material of 10% partially replaced concrete/m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	492.678	5/kg	2463.39
Hypo sludge	54.742	0.50/kg	27.37
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			3058.801

Table-10 Cost of material of 20% partially replaced concrete/m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	437.936	5/kg	2189.68
Hypo sludge	109.484	0.50/kg	54.74
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			2812.462

Table-11 Cost of material of 30% partially replaced concrete/m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	383.194	5/kg	1915.97
Hypo sludge	164.226	0.50/kg	82.11
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			2566.12

Table-12 Cost of material of 40% partially replaced concrete/m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	328.452	5/kg	1642.26
Hypo sludge	218.968	0.50/kg	109.484
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			2319.784

Table-13 Cost of material of 50% partially replaced concrete/m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	273.71	5/kg	1368.55
Hypo sludge	273.71	0.50/kg	136.855
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			2073.445

Table-14 Cost of material of 60% partially replaced concrete/m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	218.968	5/kg	1094.84
Hypo sludge	328.452	0.50/kg	164.226
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			1827.106

Table-15 Cost of material of 70% partially replaced concrete/m^3

Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	164.226	5/kg	821.13
Hypo sludge	383.194	0.50/kg	191.597
Sand	456.96	867.20/m^3	247.67
Coarse aggregate	1255.475	561.40/m^3	320.37
Total cost			1580.767

The compared values of cost show gradual decrement in total cost of per cubic meter concrete. The above table shows cost values up to 30%

replacement and the **difference in cost** from normal concrete to partially replaced concrete was **Rs.739.02**

Conclusions

Based on limited experimental investigation on the compressive and split tensile strength of concrete, the following observations are made regarding the resistance of partially replaced hypo sludge.

- Compressive strength of the concrete, should be increased the percentage of replacement is increased up to 40% and replacement increased compressive strength become reduced.
- The split tensile strength should be decreased for the percentage of the replacement is increased.
- Form this level, replacement of cement with this waste of hypo- sludge material provides maximum compressive strength at 30% replacement.
- We find the glory to E.W.S group people by get the 28 days curing test. When government implement the projects for temporary shelters for who those affected by tsunami, E.Q, etc., this material can be use for economical feasibility.
- Cost of cement should become low from this project.
- Environment effects from wastes and maximum amount of cement manufacturing is reduced through this project
- A better measure by a new construction material is formed out through this project.

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