Development of Low Cost Cement Mortar by Utilizing Paper Industrial Waste Hypo Sludge

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Abstract--- Paper making generally produces a large amount of solid waste. This paper mill sludge consumes a large percentage of local landfill space for each and every year. 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. 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 cost Mortar by blending various rations of cement with Hypo sludge. This paper presents the results of study undertaken to investigate the feasibility of using hypo sludge as cement in Mortar and efforts have been made to check mortar's Mechanical properties by utilizing hypo sludge in to Cement Mortar (1:3) and to find alternatives to enhance the strength and minimize the cost of cubes using paper industry waste hypo sludge. The use of hypo sludge in civil engineering applications enables engineers to obtain significant achievements in the safety and economy of construction. The replacement level is fixed at 0%, 10%, 30% and 50% by weight of Cement. The mix design was carried out for 1:3 proportion cement mortar on the basis of IS 12269:2013.

Keywords: Cement Mortar, Hypo Sludge, Sorptivity, Water Absorption.

I. INTRODUCTION

In building construction different masonry units like stones and bricks are bound together with the help of an intervening layer of cementing material like lime or cement. This paste of cementing materials is termed as a Mortar and is made by mixing together definite quantities of cementing materials, sand and water.In this mix or paste, the cementing martial (Portland cement) is termed the matrix. It binds the grains of the sand and the surfaces of stone or brick in such a way that the adjacent units form a continuous structure offering strong reaction to the loads from above and the sides. The safety and strength and durability of resulting wall or any such structure, there for depends on the quality of the Mortar used as a binding medium.A Mortar mix designed to produce Mortar that can be easily placed at the lowestcost. The mix design must consider the environment that Mortar is be in i.e. exposure to sea water, trucks, cars, forklifts, foot traffic or extremes of hot and cold. 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. Due to the environmental concern and the need to conserve energy, various research efforts have been directed toward the utilization of waste materials.

For this purpose, experimental investigation is carried out to develop the data on the compressive strength development of mortar, water absorption and sorptivity with time and with different percent replacement of Hypo Sludge.

The objectives of the present study are:

- To select the Hypo Sludge mix proportion for cement mortar.
- To perform the experiments on the time-dependent compressive strength of cement mortar with Hypo Sludge. The strengths were measured at the age of 7 & 28 days.
- To perform the experiments on water absorption of cement mortar with Hypo Sludge. The strengths were measured at the age 28 days.
- To perform the experiments on sorptivity of cement mortar with Hypo Sludge. The strengths were measured at the age 28 days.

II. DESIGN MIX MATERIAL

A. Cement

The Ordinary Portland Cement of 53 Grade conforming to IS: 12269-2013 was used. Tests like Consistency tests, Setting Tests, Soundness and Compressive strength (N/mm2) at 28 days were conducted on cement.

Fig. 1: SANGHI OPC 53 Grade Cement
Source: -engineeringcivil.com

Item	Tests	Results Obtained	Requirement as per IS: 12269-2013
1.	Specific gravity	3.15	3.10-3.15
2.	Standard consistency (%)	31.5%	30-35
3.	Initial setting time (hours, min)	91 min	30 minimum
4.	Final setting time (hours, min)	211 min	600 maximum
5.	Soundness	2.8 min	10mm maximum
6.	Compressive strength N/mm^2 at 28Days	58 N/mm^2	53 N/mm^2 minimum

Table. 1: Properties of Cement

B. Hypo Sludge

This Hypo sludge contains, low calcium and maximum calcium chloride and minimum amount of silica. Lime sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the Mortar. Figure below shows row Hypo Sludge

Fig. 2: Hypo Sludge
Source: -engineeringcivil.com

Sr. No.	Tests	Results
1.	(SiO_2)	5.28
2	(MgO)	6.41
3	(SO_3)	0.19
4	(CaO)	47.84
5	Loss on Ignition	38.26
6	(Al_2O_3)	0.09
7	(Fe_2O_3)	0.73

Table. 2: Properties of Hypo Sludge

C. Sand

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river fine aggregate was used as fine aggregate conforming to the requirements of IS: 383-1970. The river fine Aggregate is washed and screened, to eliminate deleterious materials and over size particle.

Fig. 3: Fine aggregate (River sand)
Source: -engineeringcivil.com

Sr. No.	Tests	Results
1	Grading Zone	Zone II
2	Fineness modulus	2.80
3	Specific gravity	2.66
4	Water absorption (%)	1.56 %
5	Silt Content	1 %

Table. 3: Properties of Sand

D. Water

Water is an important ingredient of Mortar 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.

III. DESIGN MIX METHODOLOGY

A Mortar 1:3 was designed as per IS: 12269-2013 method and was used to prepare the test samples. The design mix proportion is done below in the tables.

For 1 Cube	Water	Cement	Fine aggregate (River sand)
By Weight [gm]	86	200	600

Table. 4: Mix Design Proportion for Mortar

Sr. No.	Types of Mortar	Description of Mortar
1.	A1	Standard Mortar (1:3)
2.	F1	10% Replacement By Hypo Sludge
3.	F2	30% Replacement By Hypo Sludge
4.	F3	50% Replacement By Hypo Sludge

Table. 5: % Replacement of Cement by Hypo Sludge

Types of Mortar	W/C ratio	% Replacement of Cement by Hypo Sludge	Design Mix Proportions For Mortar (1:3) (by Weight in gm)		
			C	F.A.R.	Hypo Sludge
A1	0.45	0	200	600	-
F1	0.45	10%	180	600	20
F2	0.45	30%	140	600	60
F3	0.45	50%	100	600	100

Table. 6: Design Mix Proportions for Mortar (1:3)

IV. COMPRESSIVE STRENGTH

Compressive strength test was performed on compression testing machine using cube samples at 7& 28 days. Three samples for each component were casted and then tested. The average strength values are reported in this paper.

Fig. 4: Set up of Compressive Testing Machine
Source: S.N.P.I.T & R.C, Umrakh

V. WATER ABSORPTION TEST

A 70.7 mm x 70.7 mm x 70.7mm size cube after casting were immersed in water for 28 days curing. These specimens were then oven dried for 24 hours at the temperature 85°C until the mass became constant and again weighed. This weight was noted as the dry weight (W1) of the cylinder. After that the specimen was kept in water at 85°c for 24 hours. Then this weight was noted as the wet weight (W2) of the cylinder.

% water absorption = [(W2– W1) / W1] x 100

Where,

W1 = Oven dry weight of cubes in grams
W2 = after 24 hours wet weight of cubes in grams.

VI. SORPTIVITY TEST

Sorptivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid. The cubes after casting were immersed in water for 28 days curing. The specimen size 70.7 mm x 70.7 mm x 70.7mm after drying in oven at temperature of 85°C were drowned with water level not more than 5 mm above the base of specimen and the flow from the peripheral surface is prevented by sealing it properly with non-absorbent coating. The quantity of water absorbed in time period of 30 minutes was measured by weighting the specimen on a top pan balance weighting up to 0.1 mg. surface water on the specimen was wiped off with a dampened tissue andeach weighting operation was completed within 30 seconds.

Sorptivity (S) is a material property which characterizes the tendency of a porous material to absorb and transmit water by capillarity. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed time (t)

I=S.t½ therefore S=I/ t½

Where;

S= Sorptivity in mm,

t= elapsed time in mint.

I=Δw/Ad

Δw= change in weight = W2-W1

W1 = Oven dry weight of cylinder in grams

W2 = Weight of cylinder after 30 minutes capillary suction of water in grams.

A= surface area of the specimen through which water penetrated.

d= density of water

VII. EXPERIMENTAL RESULT

Table-7,8 and 9 gives the Compressive Strength, Water Absorption and Sorptivity test results of % replacement of Hypo Sludge in mortar. The % Replacement of cement by Hypo Sludge v/s % Compressive Strength, Water Absorption and Sorptivity results are graphically shown in figure 6, 7 and 8

Type of Mortar	Average Compressive Strength (N/mm²) at 7 days	Average Compressive Strength (N/mm²) at 28 days
A1	33.81	50.42
F1	24.34	33.01
F2	16.34	21.54
F3	8.00	11.54

Table. 7: Compressive Strength at 7 & 28 days

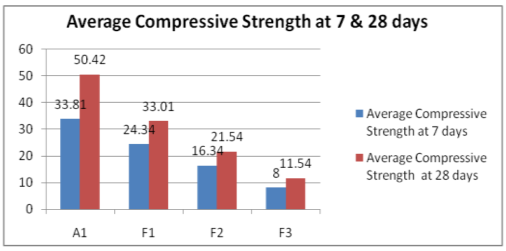

Fig. 6: Average Compressive Strength for Mortar at 7 & 28 days

Types of Mortar	% Replacement of Cement by Hypo Sludge	% Water Absorption
A1	0	2.77
F1	10%	4.95
F2	30%	6.51
F3	50%	9.04

Table. 8: Water Absorption (%) at 28 Days

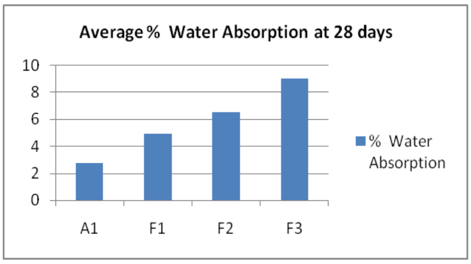

Fig. 7: Average Water Absorption at 28 Days for Hypo Sludge Mortar

Types of Mortar	% Replacement of Cement by Hypo Sludge	Sorptivity value in mm/min$^{0.5}$
A1	0	1.46
F1	10%	1.10
F2	30%	1.34
F3	50%	1.58

Table. 9: Sorptivity (mm/Min$^{0.5}$) At 28 Days

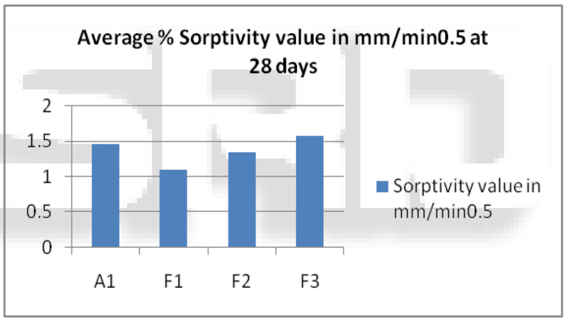

Fig. 8: Average Sorptivity at 28 Days for Hypo Sludge Mortar

VIII. ECONOMIC FEASIBILITY

Sr No.	Materials	Rate (Rs/Kg)
1.	Cement (SANGHI OPC 53 grade)	6.00
2.	Fine aggregate (Regional)	0.61
3.	Hypo Sludge	0.50

Table. 10: Cost of Materials

% Replacement in Cement	Materials			Total Cost [m³]
	Cement [kg/m³]	Fine Aggregate (Regional) [kg/m³]	Hypo Sludge [kg/m³]	
0%	566.57	1699.72	0	4504.24
10%	509.913	1699.72	56.657	4192.62
20%	396.599	1699.72	169.971	3569.40
30%	283.285	1699.72	283.285	2946.17

Table. 11: Materials for Design Mix Mortar (1:3)

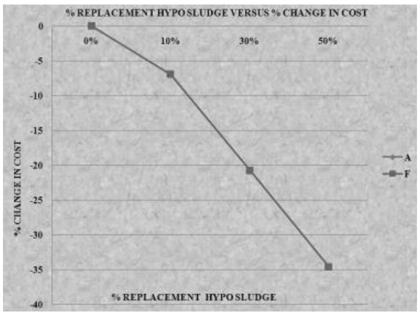

Fig. 9: % Replacement Hypo Sludge versus % Change in Cost

IX. CONCLUSION

- As the % Replacement of Hypo Sludge Increase, Compressive Strength Decrease.
- As the Compressive strength increase Water absorption and Sorptivity Decrease.
- Optimum Replacement level is Found at 10 %
- Test results indicate the decreases in the strength properties of mortar with Hypo Sludge for strength at 7 & 28 days as partial replacement with the cement in the cement mortar 1:3. So this type of mortar can be used in non-structural elements.
- As the cost of Hypo Sludge is less this Mortar can only be used at the place where strength is not of more importance or rather structure is for Temporary basis.
- When government implement the projects for temporary shelters for who those affected by natural disaster, this material can be used for economic feasibility.

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